APPENDIX B

Feasibility Study Report

DRAFT

Feasibility Study Report
Dresser Industries-Magcobar Mine Site[1]
Hot Spring County, Arkansas

August 20, 2009

Prepared for:

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[1] As named by U.S. EPA

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ADEQ	Arkansas Department of Environmental Quality
APCEC	Arkansas Pollution Control and Ecology Commission
ARARs	Applicable and/or Relevant and Appropriate Requirements
ARD	Acid Rock Drainage
CAO	Consent Administrative Order
CERCLA	Comprehensive Response, Compensation, and Liability Act
COPCs	Contaminants of Potential Concern
EPA	Environmental Protection Agency
FS	Feasibility Study
GRAs	General Response Actions
IASD	Initial Alternatives Screening Document
IC	Institutional Controls
IRM	Interim Remedial Measures
MCL	Maximum Contaminant Levels
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
OSHA	Occupational Safety and Health Administration
PEC	Probable Effects Concentration
PRGs	Preliminary Remediation Goals
RAOs	Remedial Action Alternatives
SI	Site Investigation
TBC	To-Be-Considered
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TRV	Toxicity Reference Value
UAA	Use Attainability Analysis
UAO	Unilateral Administrative Order
UIC	Underground Injection Control
WTS	Water Treatment System

1.0 INTRODUCTION

This Feasibility Study (FS) Report identifies and evaluates a range of remedial alternatives for the Dresser Industries – Magcobar Mine Site ("DIM Mine Site" or "Site") located in Hot Spring County, Arkansas (Figure 1-1). This report has been prepared in accordance with the Revised Feasibility Study ("FS") Plan (NewFields, 2007a) that was submitted to the Arkansas Department of Environmental Quality ("ADEQ") on November 2, 2007 and subsequently approved by ADEQ as well as the Administrative Settlement for Interim Remedial Measures, Site Investigation, and Feasibility Study for the Site ("Administrative Settlement"). Halliburton Energy Services, Inc. ("Halliburton") entered into the Administrative Settlement with ADEQ effective July 7, 2000, pursuant to the Arkansas Remedial Action Trust Fund Act (Ark. Code Ann. § 8-7-501, et seq).[1] In brief, the Administrative Settlement requires that Halliburton conduct Interim Remedial Measures ("IRMs"), a Site Investigation ("SI"), and a FS, and that Halliburton negotiate in good faith with ADEQ regarding the remedial action, if any, that should be taken and the identity of parties that should undertake such measures.

The Site was the location of barite (barium sulfate) ore mining and milling operations from 1939 to 1982. Two companies historically operated the Site: N.L. Industries Incorporated – Baroid Division ("Baroid") and Magnet Cove Barium Corporation ("Magcobar"). The approximate Site boundary is shown on Figure 1-1. This boundary is based on an earlier boundary defined by the EPA (Weston, 1996). The boundary shown on Figure 1-1 includes potential source areas of hazardous substances associated with acid rock drainage ("ARD") at the Site. These primary sources are: (1) spoil, which is overburden rock that was removed from the mine pit and underground workings during active operation of the barite mine to access the ore; and (2) tailings, which are a waste product of the milling process used to refine the barite ore.

1.1 Pro ect istory Summary

As previously discussed, the Administrative Settlement requires the conduct of three major activities at the Site: IRMs, the SI, and the FS. IRMs were implemented shortly after the Administrative Settlement was signed with the construction of Levee #1 to provide additional freeboard for the then-rising level of the mine pit lake. Additional IRMs were implemented from 2000 to 2003, including the construction of two additional levees (#2 and #3), raising the height of levees #1 and #2, the construction and operation of a water treatment system ("WTS") to allow for controlled discharge from the mine pit and improvement of the water quality in Chamberlain Creek, and the installation of Chamberlain Creek capture system that pumps the collected run-off and seepage to the pit lake for subsequent treatment.

[1] A second company, TRE Management, Inc., also signed the Administrative Settlement but withdrew from the project on April 10, 2008. Between the July 7, 2000 effective date of the Administrative Settlement and March 31,2008, project activities were implemented by both Halliburton and TRE.

The majority of the SI activities were performed from 2000 to early 2003 in accordance with the ADEQ-approved Site Study Plan (MFG, 2001a). The draft SI Report was submitted to ADEQ on February 28, 2003. ADEQ and the U.S. Fish and Wildlife Service provided comments on the draft SI Report in late 2003. Those comments were discussed during a January 2004 technical meeting, at which time the need for two deep bedrock monitoring wells was identified. A deep bedrock monitoring well installation plan was prepared and was approved by ADEQ on October 4, 2004. The bedrock monitoring wells were installed, geophysically tested, and sampled during 2005 and 2006.

The Final SI Report, which included monitoring data and related interpretations from the deep bedrock wells, was submitted to ADEQ on April 19, 2007 and approved by ADEQ on June 15, 2007 (NewFields, 2007b). With its approval of the April 19, 2007 Final SI Report, ADEQ identified additional issues that relate to the SI findings. A SI Clarification Technical Memorandum was prepared to address these issues and was submitted to ADEQ on November 30, 2007 (NewFields, 2007c). ADEQ approved the SI Clarification Technical Memorandum and, per the FS Plan, authorized the FS process to commence on December 21, 2007.

An Initial Alternatives Screening Document ("IASD") was prepared and submitted to ADEQ on November 3, 2008. The IASD presented a summary of previous findings regarding environmental issues at the Site and developed a comprehensive suite of remedial alternatives for the Site using a screening method developed by the U.S. Environmental Protection Agency ("EPA") (EPA, 1988). ADEQ approved the IASD, and the site-wide remedial alternatives it presents, on February 3, 2009. The IASD, as modified herein, comprises the first five chapters of this FS Report.

1.2 Purpose and Organization

The DIM Mine Site is not a federally listed Superfund site under the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA"). However, per the approved FS Plan, EPA's guidance for conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA, 1988) was used to prepare the FS for the Site. Use of this guidance is intended to help ensure that the development, screening, and evaluation of remedial alternatives for the Site is complete, uniformly applied from alternative to alternative, and consistent with environmental studies at large-scale Superfund mining sites in the U.S.. In summary, the development of remedial alternatives according to EPA's guidance includes:

1. identifying remedial action objectives and corresponding preliminary remediation goals;
2. identifying general response actions designed to meet the remedial action objectives;
3. identifying potential treatment, resource recovery, containment, and other technologies, with related process options under each technology, that will satisfy these objectives;

4. screening the technologies based on their relative effectiveness, implementability, and cost; and

5. assembling the surviving technologies and their associated containment or disposal requirements into comprehensive alternatives for the contaminated media at the site.

The remedial alternatives are then subjected to a detailed analysis relative to several criteria developed by EPA, both individually and with respect to one another (the "detailed and comparative analyses").

This FS Report is organized as follows. Background and summary characteristics for the Site, based on the findings of the SI Report, are presented in Section 2.0. Section 3.0 presents a summary of Site risks to be addressed by the FS followed by the development of Remedial Action Objectives ("RAOs") and Preliminary Remediation Goals ("PRGs"). The identification of General Response Actions ("GRAs") and the screening of remedial technologies and associated process option are discussed in Section 4.0. Section 5.0 presents the development and screening of remedial alternatives, and concludes with the identification of comprehensive, Site-wide remedial alternatives. Sections 6.0 and 7.0 provide the detailed and comparative analyses of the Site-wide remedial alternatives, respectively. The recommended remedial alternative, based on the detailed and comparative analyses, is identified in Section 8.0. References cited are listed in Section 9.0. Figures and tables cited within a given section are presented at the end of that section. Appendices are provided after the references (Section 9.0).

Section 1 Figures

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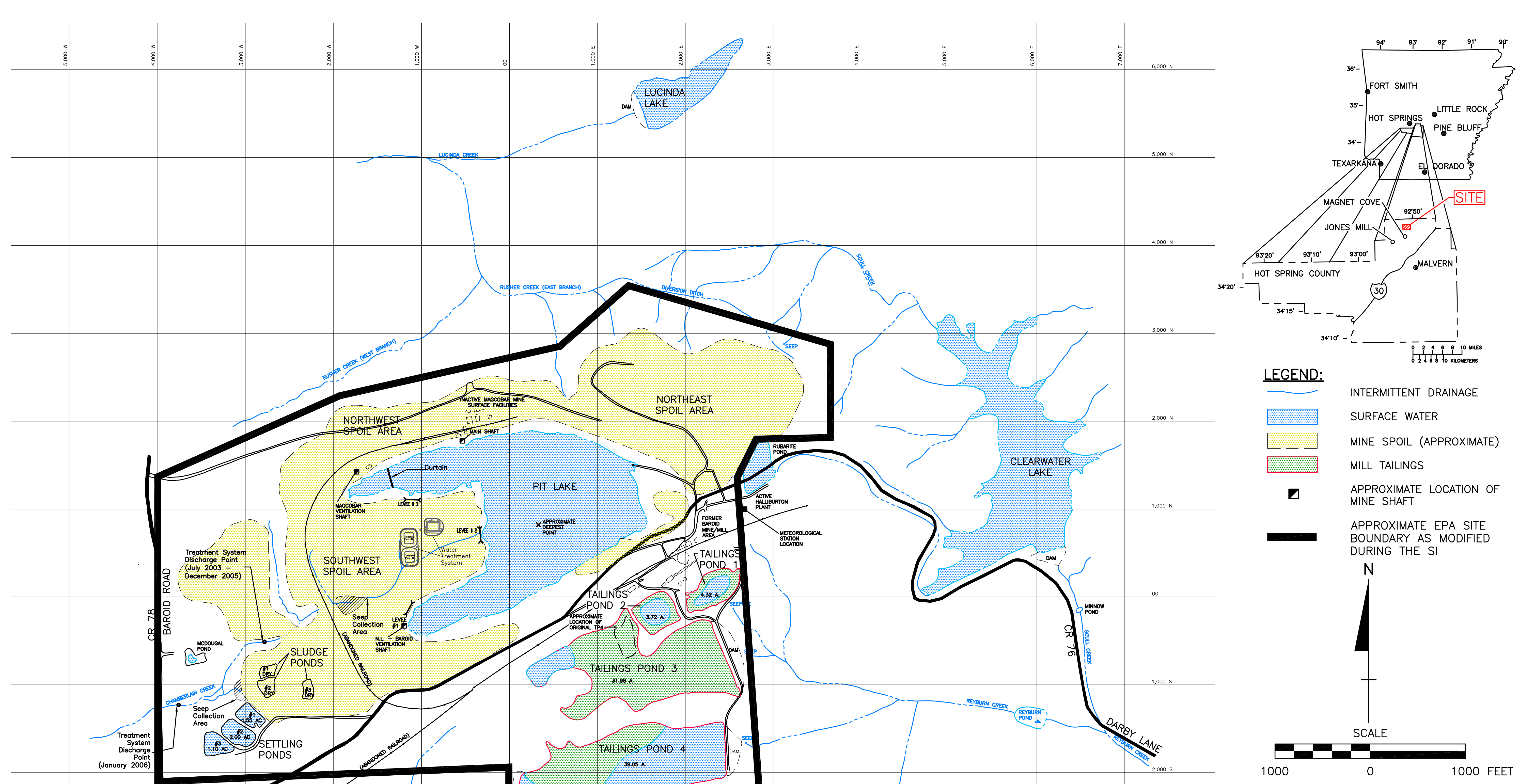

HALLIBURTON
DRESSER INDUSTRIES – MAGCOBAR MINE SITE

FIGURE 1–1

SITE LOCATION MAP WITH SITE FACILITIES

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NEWFIELDS

2.0 BACK ROUND AND SUMMARY C ARACTERISTICS OF T E DIM MINE SITE

The following subsections provide summary discussions of the Site's background/operational history, geology, hydrology, and hydrogeology, and the key findings of the SI, including those related to human health and ecological risk.

2.1 Site Background and Operational istory

Barite was first discovered in the Magnet Cove area as early as 1900, but was not recognized as barite until 1911 (Scull, 1958). Prospecting and exploratory drilling occurred in the Chamberlain Creek area (the site of the present mine pit lake) before approximately 1930 (Scull, 1958). Mining of the deposit began in the years immediately preceding World War II. In 1939, Magcobar began open pit surface mining on the northwest side of the deposit. In 1941, NL-Baroid commenced open pit surface mining to the south and southeast of the Magcobar mine, and by 1943, NL-Baroid began open pit surface mining to the east of the Magcobar mine. As surface mining continued, the multiple pits mined by NL-Baroid and Magcobar gradually merged into a single large pit. Mining eventually moved to underground methods as the near-surface ore was depleted. In 1973, Magcobar ceased mining at the Site. In 1977, NL-Baroid ceased mining but continued to mill stockpiled barite ore and barite ore from Montgomery County, Arkansas at the Site. NL-Baroid discontinued pit dewatering in 1977 and the pit began to fill with water primarily derived from direct precipitation and runoff from the spoil piles in the watershed. Groundwater from the adjacent bedrock system likely also contributed to filling of the pit. NL-Baroid ceased the milling operations by 1982 and no further mining or milling has occurred at the Site since that time.

Magcobar processed its barite ore in a mill located in Malvern, Arkansas whereas NL-Baroid milled its ore at the Site. Tailings from NL-Baroid's milling operations were placed in four tailings impoundments or ponds (TP1, TP2, TP3, and TP4) that are located south-southeast of the mine pit lake (Figure 1-1). Some tailings were subsequently removed from TP1 and TP2 for reprocessing. A portion of the feed water for the NL-Baroid milling process was water reclaimed from its tailings impoundments. However, fresh water was also needed for the milling process, and NL-Baroid subsequently obtained the necessary water rights and constructed Clearwater Lake and Lucinda Lake for this purpose.

The barite ore at the Site occurs at the base of the Stanley Formation. The material from this formation represents most of the overburden rock (spoil) excavated from the mine pit and underground mine and consists predominantly of dark gray to black, metal-rich shale that includes pyrite (iron sulfide). A natural phenomenon known in the mining industry as ARD occurs when air and water contact rocks containing pyrite. This process is facilitated and accelerated by land disturbances, such as mining, that break up and transport pyrite-containing rocks to the surface. The immediate result of this process is acidic water that contains primarily iron and sulfate. Subsequent reactions between the acidic water and the rock dissolves naturally occurring metals (e.g., aluminum, manganese and zinc) and minerals (e.g., total dissolved solids ["TDS"], sulfate, and chloride),[2] resulting in increased concentrations of these metals and minerals in the ARD. The production of ARD, and its subsequent migration to adjacent areas, comprises the primary environmental issue at the Site. ARD generated by the Site accumulated in the mine pit, which was nearly full prior to start-up of the WTS in 2003. It should be noted that the pyritic, metal-rich nature of the Stanley Formation shale is not unique to the Site. The Stanley Formation shale exhibits these characteristics throughout the Ouachita Mountains. In this area of the state wherever the Stanley Formation is disturbed and subjected to accelerated weathering, ARD-generating conditions develop that are similar to those at the Site.

A previous treatment system was installed and operated at the Site during the 1970s to improve the quality of water that was pumped from the mine pit and discharged to Chamberlain Creek to maintain the pit in a dewatered state. Lime was added to water accumulating in the bottom of the mine pit to raise its pH and precipitate metals. This treated water was then pumped to the Settling Ponds (a series of three ponds in the southwest portion of the Site; see Figure 1-1) where metal precipitates were removed from the water by settling. Clarified water from the Settling Ponds was discharged to Chamberlain Creek. Sludge accumulating in the Settling Ponds was periodically removed and placed in the Sludge Ponds for disposal (Figure 1-1). The Settling Ponds and Sludge Ponds were collectively referenced as the Sludge Impoundments during the SI.

As previously discussed, IRMs were implemented shortly after the Settlement Agreement was signed in 2000, primarily to control the level of the mine pit lake. These included the construction of levees to contain the then-rising pit lake waters and the construction of a WTS to allow for controlled discharge of treated mine pit lake water. The WTS, which commenced operation in June 2003, also collects water in the headwaters area of Chamberlain Creek and pumps it to the mine pit lake. The WTS treats the pit lake water using hydroxide precipitation. Under this process, the water is mixed with lime and other chemicals, causing the pH of the water to increase and the metals in the water to precipitate from solution. The metal precipitates are removed from the water in a clarifier. The clarifier solids from the WTS contain the precipitated metals as well as unspent lime and are returned to the mine pit lake. Treated discharge from the WTS is directed to the Chamberlain Creek channel. The levees and features associated with the WTS, including a "curtain" across the north arm of the mine pit lake, are shown on Figure 1-1. The purpose of the curtain is to provide a sequestered pre-treatment area within the pit lake. An additional IRM, implemented in late 2005, extended the discharge point for the treated water approximately 1,000 feet down stream on Chamberlain Creek to reduce the opportunity for clean treatment system discharge water to mix with acidic

[2] Definition of minerals taken from Arkansas Pollution Control and Ecology Commission (APCEC) Regulation 2, April 1998.

shallow groundwater that adds flow to the creek. It also collects shallow groundwater from the Chamberlain Creek channel upstream of the new discharge point for treatment by the WTS. Operation of the WTS is decreasing the elevation of the pit lake surface to a level to preclude overflow. The pit lake surface elevation was at its maximum (623.1 feet above sea level) when the WTS commenced operation in June 2003. The pit lake surface elevation has been reduced to approximately 596 feet above sea level as of August 2009. In conjunction with levee installation, this IRM has eliminated the possibility of an uncontrolled overflow discharge from the pit lake to adjacent water sheds.

The WTS discharge is permitted under the Arkansas Water and Air Pollution Control Act (Permit No. AR0049794). The permit sets discharge limitations for the WTS for several metals as well as minerals. The WTS discharge meets the metals limitations. However, the treatment process employed in the WTS does not affect minerals concentrations and thus the discharge does not achieve the minerals limitations set by the permit. Consent Administrative Order (“CAO”) No. 03-061 provides for temporary minerals standards in Cove Creek downstream of its confluence with Chamberlain Creek. Those temporary in-stream standards are:

Chloride – 60 mg/L;

Sulfate – 860 mg/L; and

TDS – 1,600 mg/L.

Per the CAO, the WTS discharges using a hydrographically controlled release according to the flow rate in the receiving stream (Cove Creek) in order to meet the temporary minerals standards in Cove Creek set by the CAO. When flows in Cove Creek are high, the WTS can discharge at full capacity (approximately 1,500 gallons per minute). However, when flows in Cove Creek are low, discharge from the WTS must be reduced or eliminated such that the temporary minerals standards for the creek are not exceeded..

There are multiple property ownership interests within the Site boundary shown on Figure 1-1. Most of the Site is no longer used for commercial purposes; however, some areas are currently leased for hunting purposes. In addition, unauthorized recreational use by trespassers occurs, primarily as off-road vehicle use. The area surrounding the Site is rural and largely undeveloped with scattered residences and grazing pastures. The closest residences are to the north and west of the Site.

2.2 ydrology

The Site is located in a topographically elevated area on a drainage divide with five related drainage basins (Figure 2-1). These drainage basins are associated with Chamberlain Creek, Rusher Creek (which drains to Lucinda Creek), Scull Creek (including Clearwater Lake), Reyburn Creek, and Stone Quarry Creek. The mine pit lake sub-watershed is located at the head of the Chamberlain Creek watershed. The majority of the mine spoil is present in the Chamberlain Creek/Pit Lake watersheds, with small amounts in the Rusher and Scull creek watersheds. A diversion ditch was constructed during mine operation to the north of the northeast spoil piles to intercept ARD and direct it from the Scull Creek watershed to the East Rusher Creek Watershed (Figure 2-1). The tailings impoundments are present in the Reyburn Creek watershed and, to a much smaller extent, the Stone Quarry Creek watershed. The Rusher Creek, Lucinda Creek, and Chamberlain Creek basins all discharge to Cove Creek, which flows to the Ouachita River approximately five miles downstream of the Site. Stone Quarry Creek flows directly into the Ouachita River about 3.5 miles from the Site. Scull Creek flows into Reyburn Creek about 0.4 miles downstream of Clearwater Lake. Reyburn Creek then flows into Francois Creek approximately seven miles downstream of the Site, and ultimately into the Saline River. Most of the drainages near the Site flow only intermittently during the wet season and storm events, though the larger streams more distant from the Site (e.g., Cove Creek) flow perennially.

2.3 eology

The Site is located in a structurally folded area that contains numerous generally northeast-southwest trending anticlines (upward folds) and synclines (downward folds or troughs). The pit lake and most of the spoil are located within the Chamberlain Creek syncline, which is oriented approximately northeast-southwest and plunges to the southwest. Tailings impoundments TP3 and TP4 are situated on the approximate top of the anticline southeast of the Chamberlain Creek syncline. Sedimentary rocks exposed at the Site, from oldest to youngest, include: the Ordovician Big Fork Chert and Polk Creek Shale; the Silurian Blaylock Sandstone and Missouri Mountain Shale; the Mississippian/Devonian Arkansas Novaculite; and the Mississippian Stanley Formation (Scull, 1958). The Stanley Formation is present at the core of the Chamberlain Creek syncline and therefore represents most of the overburden rock (spoil) excavated from the mine pit and from the underground mine workings.

2.4 ydrogeology

Groundwater flow from most of the Site (including the pit lake and most of the spoil piles) is focused to the southwest along the axis of the Chamberlain Creek syncline by both the Site topography and geology. Topographically, most of the Site is situated at the head of the Chamberlain Creek drainage, which flows to the west. Geologically, the nearly vertical upturned bedding on the flanks of the Chamberlain Creek syncline impedes groundwater flow from the pit lake to the north, east, and south and hydraulically isolates groundwater within the syncline from adjacent groundwater systems. The mine pit lake is the largest and most topographically elevated hydrogeologic feature in the Chamberlain Creek syncline.

Two groundwater zones have been identified within the Chamberlain Creek syncline in the Site vicinity. A shallow groundwater zone exists in the near-surface soil and uppermost weathered bedrock and a deeper system exists in the fractured bedrock. The shallow zone is relatively thin, of low permeability, and is not used as a water supply. The deep bedrock system within the Chamberlain Creek syncline may have historically been used as a water supply, with several water wells located several thousand feet west of the Site within the syncline. The Magnet Cove area municipal water supply system was expanded in 2005. The expanded water supply system serves Magnet Cove area residents, including those residing in the Chamberlain Creek syncline.

2.5 Site Investigation Principal Findings

The principal findings of the SI are summarized below and include refinements based on the information presented in the SI Clarification Technical Memorandum.

2.5.1 eneral Conclusions

- The mine spoil and pit lake are the most environmentally significant features at the Site because most of the ARD is produced in the spoil and enters the pit lake by seepage and runoff. The pit lake serves as a storage reservoir for ARD historically produced by the Site.
- The primary adverse environmental effect caused by the Site involves formation of low pH water (ARD) that exits the Site in surface pathways and lowers pH in off-Site surface water. The low pH ARD formed at the Site results from accelerated weathering processes that generate acidity and can increase the solubility of metals naturally present in some of the rock that was disturbed by mining.

2.5.2 Risk Conclusions

- The Site material (spoil and tailings) generated by mining operations does not pose unacceptable risks to humans based on current land uses.
- There are no unacceptable mining-related human health risks associated with surface water in the off-Site creeks, Clearwater Lake, or the pit lake based on current uses.
- Shallow, on-site groundwater is impacted by ARD from the spoil piles. Though this water does not currently pose risk to humans because it is not used as a water supply (and probably would not provide viable quantities of groundwater due to low permeability), potential future use of this shallow groundwater could pose risks to human health through ingestion.
- Leakage from the pit lake contributes to exceedances of Federal secondary Maximum Contaminant Levels (“MCLs”) and thus has degraded the aesthetic quality

of the bedrock groundwater in the bedrock groundwater system within the Chamberlain Creek syncline. Federal primary MCLs are not exceeded based on the available information.

- There are low risks (e.g., hazard quotients only slightly greater than 1) to mobile terrestrial ecological receptors such as deer, and there are slightly greater but still low risks to more restricted terrestrial species (small mammals) that reside on-Site.

- Unacceptable risks were identified for aquatic receptors in creeks draining the Site.

- Current aquatic life risks in creeks affected by the Site are primarily due to depressed pH and the resulting increase in metal solubility, metal bioavailability, and toxicity (particularly for aluminum). Depressed pH in water bodies near the Site results from seeps and runoff from the spoil piles and tailings impoundments. Recovery of affected streams is anticipated to be nearly immediate when the pH is controlled.

2.5.3 Mine Spoil Conclusions

- Mine spoil consists of native rock (primarily Stanley Formation shale) that was blasted, removed from the mine pit, and stockpiled in areas to the northeast, northwest, and southwest of the pit (Figure 1-1). There are approximately 20.5 million cubic yards of mine spoil at the Site that are primarily located in watersheds that drain either to the pit lake or to Chamberlain Creek. Small amounts of spoil are present in the Rusher and Scull Creek watersheds (Figure 2-1).

- Mine spoil present at the Site will produce ARD for decades, though at a continually decreasing rate. Surficial runoff from the spoil piles produces ARD but more concentrated ARD is produced by infiltration through the spoil piles. The movement of ARD through and from the spoil can be reduced by actions that will minimize infiltration or increase evapotranspiration, such as enhancing vegetation cover. Enhanced vegetation would provide additional benefits in terms of reducing oxygen migration into the spoil, thereby further reducing ARD generation.

- The acid generating potential in the outer surfaces of the spoil piles is depleted to a depth of a few feet due to weathering processes that result from exposure to water.

- The mine spoil piles currently support mature coniferous trees that intercept and transpire precipitation, reducing the amount of water available for infiltration. Removal of the coniferous trees would increase the amount of water available for infiltration and thus the amount of ARD generated by the mine spoil.

- Any freshly exposed spoil surfaces will result in increased ARD production.

2.5.4 Pit Lake Conclusions

- The surface area of the pit lake is approximately 90 acres and its maximum depth is approximately 450 feet. When nearly full, the pit lake held approximately 4.35 billion gallons of acidic water with concentrations of dissolved metals and minerals that are elevated relative to nearby streams and lakes that are not affected by the Site. The amount of water held by the pit lake has been reduced by operation of the WTS (approximately 3.7 billion gallons at a lake surface elevation of 596 feet above sea level in August 2009 based on the stage-volume relationship).

- 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 the pit lake via seepage to the bedrock and/or shallow groundwater systems. The historical rise in the pit lake surface elevation in response to precipitation necessitated interim remedial measures (levee construction and installation of a WTS) to eliminate the possibility of an uncontrolled discharge of pit lake water.

- Water inflows to the pit lake consist primarily of direct precipitation on the lake surface and seepage of water from the adjacent spoil piles. The majority of the water that flows into the pit lake either contributes to the change in storage (pit lake-level rise) or evaporates from the pit lake surface. Relatively little flow occurs from the pit lake to the basal portions of the spoil piles/shallow groundwater system or to the deep bedrock groundwater system.

- In its current, flooded state, the pit floor and the vast majority of the pit walls are not in contact with atmospheric oxygen and thus ARD production from these surfaces has essentially stopped. The exposed portion of the western pit wall, which consists primarily of Stanley Formation rocks, may provide small amounts of ARD to the pit lake. Reduction of the pit lake surface elevation has exposed more of this wall, potentially increasing the amount of ARD it produces. The remaining pit walls are comprised primarily of Arkansas Novaculite which is not acid-generating. Mine spoil drainage is the primary ongoing source of ARD to the pit lake.

- The physical/chemical structure of the pit lake is that of a permanently stratified lake that contains three distinct layers. The top layer, with a thickness of approximately 70 to 80 feet, is separated from bottom layer that is over 300 feet thick by a transition layer that is approximately 60 feet thick. Mixing between the layers occurs only minimally and at the layer boundaries. The bottom layer contains the highest concentrations of dissolved minerals and is, therefore, the densest of the three layers.

- Depletion of acid generation potential in the spoil and corresponding reductions in ARD loadings to the pit lake have contributed to a trend of decreasing concentrations of metals and general water quality analytes, primarily in the upper layer. The concentrations of several metals (e.g., copper, lead, cadmium, and zinc) 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.

- Results from the deep monitoring well MW-20 establish a limited connectivity of the bedrock groundwater system to the mine pit lake. Predicted low connectivity is supported by chloride chemistry results which also serve to provide an additional line of evidence supporting the water balance conclusions for the mine pit lake.

2.5.5 Tailings Impoundment Conclusions

- The four tailings impoundments range in area from less than 4 acres to 39 acres and are estimated to collectively contain 3.9 million cubic yards of flotation tailings, a smaller volume of jig tailings, and 51 million gallons of water.

- Two types of tailings were placed in and around the tailings impoundments. These are classified as jig tailings from the former mill jig circuit and flotation tailings from the former mill flotation circuit. Jig tailings are relatively coarse-grained (sand to fine-gravel size) and flotation tailings are relatively fine-grained (silt to clay sized). The volume of jig tailings produced by the mill was small relative to the volume of flotation tailings. The jig tailings were placed on the dam faces and piled in other areas in and near the tailings impoundments.

- Runoff from the flotation tailings results in ARD that is transported to pooled areas on the tailings impoundments. Water quality in the tailings ponds reflects this source and is acidic with elevated concentrations of metals and sulfate, consistent with ARD that has been diluted by precipitation.

- Flotation tailings in the interior of the impoundments exhibit acid neutralization potential. Surficial ARD (runoff) that infiltrates into the flotation tailings is neutralized by the acid neutralizing potential of the tailings. As a result, the tailings pore water exhibits near-neutral pH and relatively low metals concentrations, but with elevated sulfate and TDS concentrations similar to ARD observed at the Site.

- The amount of weathering and ARD generation that occurs in the flotation tailings contained in TP1 through TP4 is limited by the high pore water levels and high degree of saturation in the tailings.

- In contrast to the flotation tailings, the jig tailings are coarse-grained and are therefore more permeable. They are also situated in locations where they are generally unsaturated, allowing oxygen to contact the remaining sulfide minerals. Accumulations of jig tailings are located primarily on the downstream faces of the tailings dams and near the former mill in the TP1 watershed. ARD in toe seeps at the base of TP3 and TP4, and ARD constituents in shallow groundwater at the toe of the TP3 dam, appear to be related to ARD production in the jig tailings on the dam faces.

- The geotechnical investigation of the tailings dams revealed that tailings dams TP1, TP3 and TP4E are marginally stable with estimated factors of safety less than those recommended by the Soil Conservation Service and the U.S. Army Corps of Engineers. The TP4W dam is acceptably stable in its current configuration.

2.5.6 O Site Sur ace Water Conclusions

- Chamberlain Creek, an intermittent stream, is impacted by low pH surface and subsurface water produced from spoil areas at the Site. Poor water quality (i.e., low pH and elevated dissolved metals) in Chamberlain Creek can adversely affect Cove Creek.

- Effects in Cove Creek that are limited to the stream immediately below its confluence with Chamberlain Creek vary as the result of flow from Chamberlain Creek. Adverse effects were observed in Cove Creek below the confluence when Chamberlain Creek was flowing. Conditions in Cove Creek were observed to improve when Chamberlain Creek was not flowing. The WTS that became operational in June 2003 has improved water quality in Chamberlain and Cove Creeks.

- Data from Chamberlain and Cove Creeks indicate that the water quality in the receiving streams for the Site is improving. Reductions in ARD originating in the spoil piles are a result of the cessation of mining operations, depletion of acid generating potential in the spoil, and the overall increase in vegetation density and mass in the watershed and associated reduction in infiltration of water through the spoil.

- Low pH and elevated dissolved metals are measurable in Scull, Reyburn, Rusher, and Lucinda Creeks, but these effects are much less than those measured in Chamberlain Creek. Stone Quarry Creek is not affected by the Site.

- Water quality in affected creeks improves (i.e., pH increases and metals concentrations decrease) with distance from the Site through mixing with unaffected surface water and base flow groundwater, subsequent dilution, and related buffering reactions. These increases in pH have also led to the attenuation of ARD-related metals (most notably iron and aluminum, but also other trace metals).

2.5.7 O Site roundwater Conclusions

- Wells installed on-Site in the shallow groundwater system downgradient but adjacent to the mine spoil in the western portion of the Site contained ARD-affected groundwater. 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 downgradient from the spoil piles and discharges to Chamberlain Creek within a short distance of the spoil.

- The majority of the mine spoil is present in the Chamberlain Creek and pit lake watersheds. Smaller amounts are present in the Rusher Creek and Scull Creek watersheds and therefore shallow groundwater impacts in these watersheds would likely be correspondingly smaller and more limited than the impacts characterized in the Chamberlain Creek watershed.

- The low hydraulic conductivity and associated low yield of the shallow groundwater zone indicate that it is unlikely that it would serve as a usable potable water supply.

- Historical and current groundwater level measurements in wells around the flank of the Chamberlain Creek syncline to the north, south, and east of the pit lake indicate little or no hydraulic connection between the interior of the Chamberlain Creek syncline (where the pit lake is located) and the exterior of the syncline. These measurements indicate that if any such hydraulic connection is present, potentiometric gradients in the deep bedrock groundwater system would be toward the pit lake (i.e., the groundwater levels in these locations are higher than the pit lake surface).

- A water balance for the pit lake suggests that potential losses from the pit lake to the deep bedrock groundwater system are likely small (an estimated 8 percent of the total estimated inflow to the pit lake or approximately 24 to 44 gpm at a 95 percent confidence level, based on sensitivity analyses). A chloride analysis for deep bedrock monitoring well MW-20 provides additional support that the mine pit lake has low seepage rates to the groundwater system.

- Former domestically used water wells that were believed to tap the bedrock groundwater system are present within the syncline west and downgradient of the pit lake. Some of these wells were sampled in 2000 and the results of these samples do not indicate impacts from the Site. The public water supply system was expanded to include this area in 2005.

- Boreholes were installed at two locations to the west of the pit lake to depths that penetrate the Stanley Shale / Arkansas Novaculite contact.

- Groundwater that includes neutralized ARD is present in bedrock fractures in a borehole located near the axis of the Chamberlain Creek syncline in the western portion of the Site. The probable source of this ARD is the pit lake, but all lines of evidence indicate that limited hydraulic connectivity exists in the fracture system and accounts for predicted low seepage rates from the pit lake.

- The bedrock groundwater containing neutralized ARD likely originating from the pit lake does not contain metals at concentrations in excess of primary MCLs. However, secondary MCLs are exceeded. The secondary MCL are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.

2.6 Areas and olumes o Site Features and Sources

Table 2-1 presents a summary of key statistics for various features and sources present at the Site based on the SI data collection and evaluation activities. Included with the estimated areas and volumes are the approximate time periods the features/sources were constructed.

2.7 Spring 2009 Field Reconnaissance

A field reconnaissance to assess the flow paths of acidic surface water along the west, north, and northeast boundaries of the Site was completed by personnel of NewFields and FTN Associates (FTN) on March 11-12, 2009. The purpose of the reconnaissance was to identify any discrete areas where ARD from the Site was impacting off-Site creeks (i.e., Scull Creek and Rusher Creek). Total dissolved solids and pH were measured at approximately 100 locations surrounding the Site including native soil, spoil, sediment, streams, pools, and puddles, with elevated TDS and low pH being indicative of ARD. The results of the field reconnaissance, which was conducted during wet-weather conditions, are summarized below and illustrated on Figure 2-2.

The TDS and pH measurements were made with hand-held meters. The pH meter was calibrated before the reconnaissance and the calibration was checked at least once a day. Daily rainfall at the Site was 0.50 inches on March 10th, 0.75 inches on March 11th, and 0.50 inches on March 12th. The wet conditions provided an opportunity to identify the pH and TDS of surface runoff emanating from the spoil piles as well as runoff that had collected within shallow puddles and pools.

2.7.1 Scull Creek Drainage

The Scull Creek drainage collects ARD runoff and seepage from the northeast spoil piles which ultimately flows into Clearwater Lake (Figure 2-2). Scull Creek northeast (upstream) of Clearwater Lake has four major ephemeral tributaries: three entering from the southwest (potentially impacted by spoil) and one entering from the northeast. There is also a diversion ditch to the north of the northeast spoil piles that was constructed during mining to convey ARD from the spoil piles to East Rusher Creek rather than allowing the runoff to reach Scull Creek and Clearwater Lake. The diversion ditch was observed to be in generally poor condition and portions of the ditch were observed to be flat and/or to hold ponded water. In addition, a concrete culvert placed to convey ditch water under a primitive access road is crushed and leaking, allowing any captured ARD to flow down the road and into upper Scull Creek.

A seep and drainage emanating northeast of the furthest east spoil pile (and directly below the diversion ditch) was monitored on both March 11th and 12th. On March 11th, the flow was intermittent from the seep area to approximately 100 yards upstream of the confluence with Scull Creek. The pH was approximately 2.8-3.0 and TDS was 400-1,000 mg/L. On March 12th, the flow was continuous from the seep to Scull Creek with the same pH range but TDS reduced as it approached the confluence with Scull Creek to a minimum of 172 mg/L. Scull Creek above the confluence also had a similar TDS concentration (169 mg/L). However, within approximately 100 feet downstream of the confluence, the TDS in Scull Creek increased to 785 mg/L and remained near this concentration until it reached the confluence with the drainage from the north, which was flowing down the road entering Scull Creek just upstream of the road crossing. This increase in TDS within Scull Creek with no apparent surface water inflows suggests that there may be ARD-impacted shallow groundwater entering Scull Creek in this area.

The drainage further west and north of the seep drainage also appeared to be impacted by ARD. However, this drainage did not appear to be a major contributor of ARD to Scull Creek even under the rainy conditions encountered during the reconnaissance. The drainage south and east of the seep drainage was examined on March 12th and no ponded or flowing water was encountered.

The diversion ditch contained various areas of standing water ranging from a few feet across to greater than 10 feet across. The pH of the standing water ranged from 3-5 and the TDS ranged from 30-650 mg/L. The diversion ditch intercepts one major drainage from the spoil piles where a seep was found to have a pH of 3.2 with a TDS of 1,340 mg/L. There was one other drainage from the spoil pile intercepted by the diversion ditch prior to the damaged culvert/road crossing that had a pH of 4.2 and a TDS of 108 mg/L. It appears that very little, if any, runoff currently intercepted by the diversion ditch is conveyed to East Rusher Creek.

2.7.2 Rusher Creek Drainage

The Rusher Creek Drainage collects runoff and seepage from the northern spoil piles. There are two main forks to Rusher Creek (East Rusher Creek and West Rusher Creek; Figures 2-1 and 2-2).

The diversion ditch that was designed to collect runoff from the northeast spoil piles drains into upper East Rusher Creek but, as discussed in the previous subsection, little (if any) diverted water entered upper East Rusher Creek during this sampling event. There are also two tributaries that contribute to East Rusher Creek from the spoil piles. The major tributary to East Rusher Creek from the spoil piles drains the area between the northeast spoil piles and the pit lake and joins East Rusher Creek approximately 500 feet east of its confluence with West Rusher Creek. This major tributary is incised in the area between the spoil piles and the confluence with East Rusher Creek, with exposed Arkansas Novaculite in the drainage floor. The pH of East Rusher Creek was moderately acidic (pH=4-5) with low TDS (<200 mg/L). The major contribution of acidity and dissolved solids was from the two tributaries conveying runoff and seepage from the northeast spoil piles. Where the major tributary to the west was dominated by spoil runoff, the pH was <4 and the TDS was > 150 mg/L. However, the pH and TDS within the other tributary between the spoil piles and East Rusher Creek indicated dilution of acidic spoil runoff with runoff from native ground (i.e., the pH increased and the TDS decreased as the tributary approached East Rusher Creek).

West Rusher Creek collects runoff and seepage from the northwest spoil piles (Figure 2-2). There is one “lobe” of spoil that is within the West Rusher Creek drainage and runoff and seepage from this lobe appears to dominate the water quality of this creek. However, all tributaries entering West Rusher Creek that were carrying water during the sampling event were impacted by spoil (e.g., acidic pH). West Rusher Creek below the prominent lobe had an acidic pH (pH<4) and a moderate TDS (~200-400 mg/L) whereas upstream of the lobe, the pH was 4.7 and the TDS was 14 mg/L.

2.7.3 Chamberlain Creek Drainage

Chamberlain Creek receives runoff and seepage from the western spoil piles as well as discharge from the WTS. During this sampling event, Chamberlain Creek was receiving approximately 1500 gpm of WTS discharge. Upper Chamberlain Creek (above the confluence with the WTS discharge) had an acidic pH (<4) and a high TDS (~500-1500 mg/L). Immediately downstream of the WTS discharge point, the pH increased to 4-5 and the TDS was relatively steady near 1000 mg/L. The pond north of Chamberlain Creek is a man-made impoundment that is fed by a small stream that drains the watershed to the west. The water entering the pond was slightly acidic (pH=5.1) with low TDS (20 mg/L) while the water exiting the pond was more acidic (pH=3.9-4.2) with a higher TDS (163-303 mg/L). The water course below the pond to Chamberlain Creek was a braided stream. Little pooling was evident around the toe of the spoil piles north of Chamberlain Creek but the two puddles sampled were moderately acidic (pH~4) with high TDS (~1000-1500 mg/L).

2.8 Use Attainability Analyses

A Use Attainability Analysis (“UAA”) and third party rulemaking are contemplated in the Consent Administrative Order (03-061: see Section B(2) and (9)) as an integral component to address downstream receiving streams at the Site. The role of the UAA is not as a default 'remedial option;' however, it is a necessary action, in conjunction with certain remedial alternatives, to address downstream protection of aquatic organisms as well as to address 303(d) issues and compliance with Arkansas criteria in order to assure continued protection for existing uses of the receiving streams. The federal Clean Water Act requires regular updates to each State’s 303(d) list in order to identify water bodies not meeting the designated uses. Currently, Cove Creek, Chamberlain Creek, and Lucinda Creek are included on Arkansas’ 2008 303(d) list. Cove Creek is listed for impairments due to zinc, beryllium, sulfate, and TDS. Chamberlain Creek is listed for cadmium, copper, zinc, beryllium, pH, chloride, sulfate, and TDS. Lucinda Creek is listed for pH, sulfate, zinc and beryllium. It is anticipated that the beryllium listings for Cove and Lucinda Creeks will be removed from the 2010 list following the 2007 triennial review of the state water quality regulations.

The UAA is necessary to allow for ongoing discharges, as included in some of the remedial alternatives developed in this draft IASD. The UAA strategy includes proposing dissolved minerals criteria changes for Chamberlain Creek and Cove Creek in order for the treated pit lake water discharge to occur within the range of revised criteria designed to protect existing uses. In addition, dissolved mineral criteria changes may be necessary for other, small area drainages exiting the Site in concert with certain remedial actions to address low pH runoff and to correct default designated uses assigned to these streams (i.e. domestic water supply uses).

Section 2 Tables

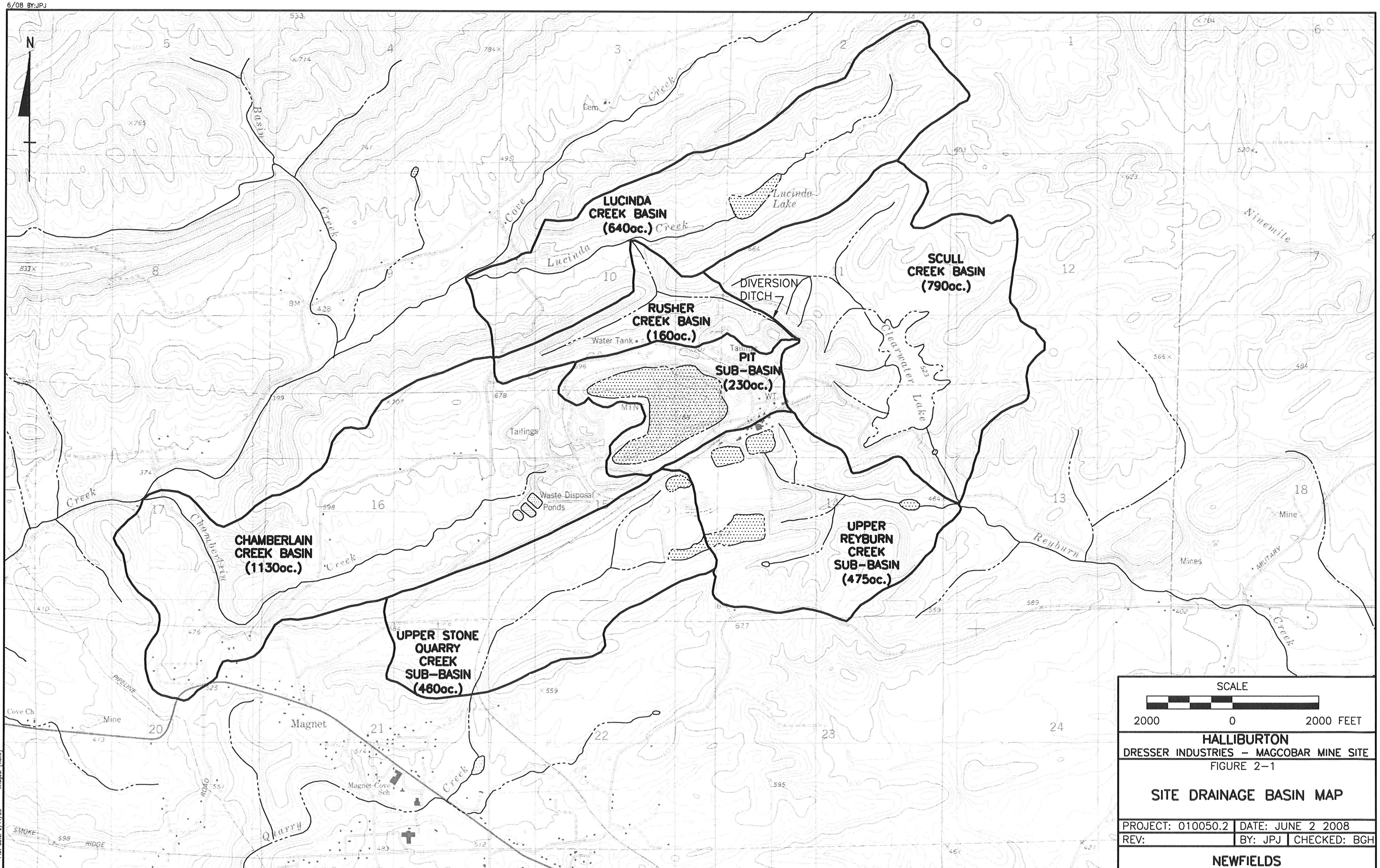
TABLE 2 1

KEY STATISTICS FOR SITE FACILITIES
DRESSER INDUSTRIES MA COBAR MINE SITE IN ESTI ATION REPORT

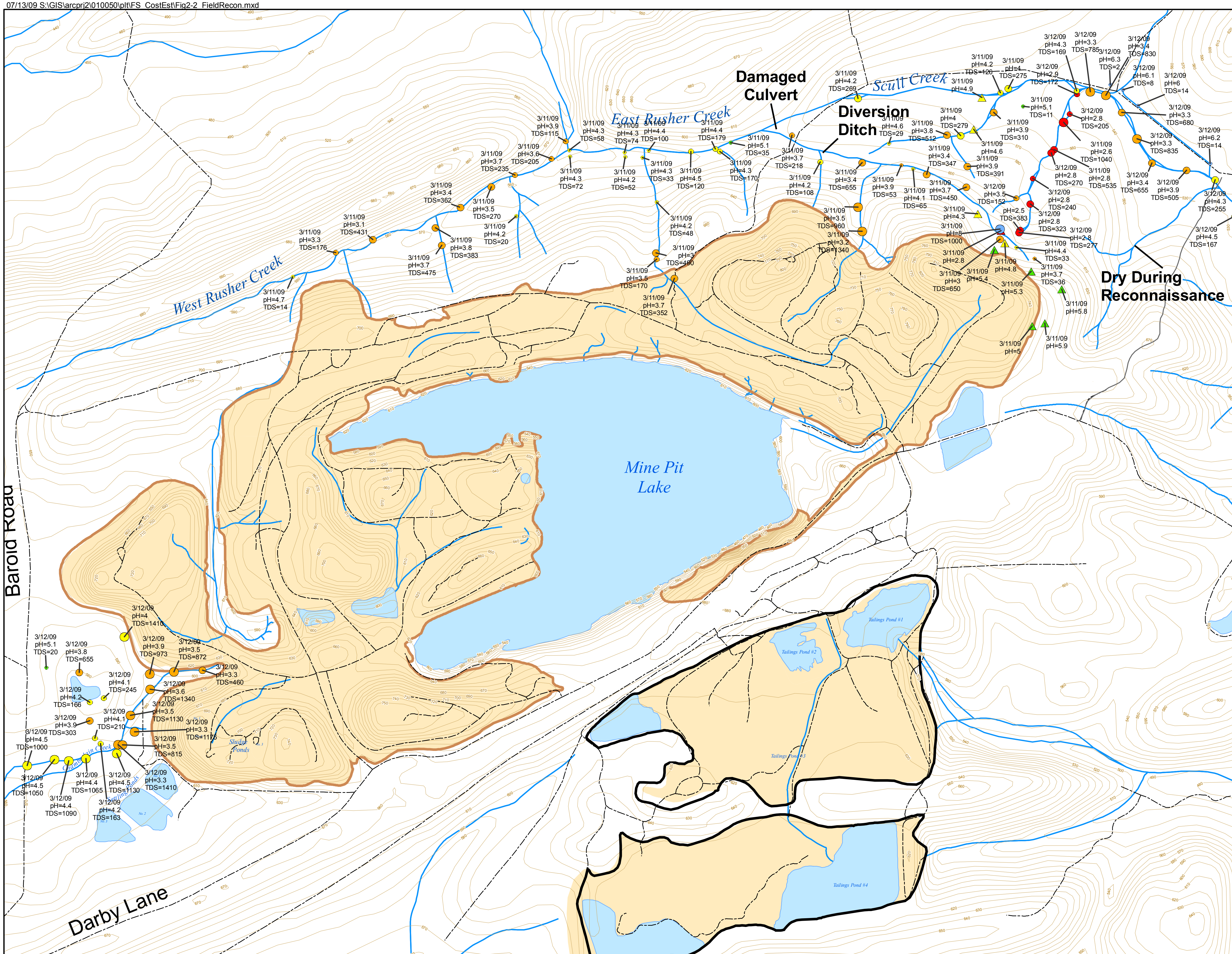
Facility	Year Constructed	Area acres	Depth eet	Estimated olumes: Solids cubic yards	Estimated olumes: Water gallons	Notes
Mine Pit	1939 - 1969	90	455 - 525	Contains some sediment and sludge	**4.35 billion** (October 2002)	Total pit volume = approx. 23.4 to 23.9 million cy.
Spoil Piles						
Southwest 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	
Settling Pond No.2	About 1972	2.00	10-20	11,600	3.9 million	Ponds have 1 to 5 foot thick clay liner.
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.

Section 2 Figures

6/08 BY:JPJ


N
LUCINDA
CREEK BASIN
(640ac.)
RUSHER
CREEK BASIN
(160ac.)
SCULL
CREEK BASIN
(790ac.)
DIVERSION
DITCH
PIT
SUB-BASIN
(230ac.)
CHAMBERLAIN
CREEK BASIN
(1130ac.)
UPPER
REYBURN
CREEK
SUB-BASIN
(475ac.)
UPPER STONE
QUARRY
CREEK
SUB-BASIN
(460ac.)
Lucinda Lake
Clearwater Lake
Water Tank
Tailings
Waste Disposal Ponds
Magnet
Magnet Cove Sch
Cove Ch
Mine
Mines
Ninemile
Reyburn
Quarry
Creek
PIPELINE
ROAD
SMOKE RIDGE
MILITARY
SCALE
2000 0 2000 FEET
HALLIBURTON
DRESSER INDUSTRIES - MAGCOBAR MINE SITE
FIGURE 2-1
SITE DRAINAGE BASIN MAP
PROJECT: 010050.2
DATE: JUNE 2 2008
REV:
BY: JPJ
CHECKED: BGH
NEWFIELDS

07/13/09 S:\GIS\arcprj2\010050\plt\FS_CostEst\Fig2-2_FieldRecon.mxd



Legend

COND

pH = 2-3
- 2 - 100 mg/L TDS
- 101 - 250 mg/L TDS
- 251 - 750 mg/L TDS
- 751 - 2000 mg/L TDS

pH = 3-4
- 2 - 100 mg/L TDS
- 101 - 250 mg/L TDS
- 251 - 750 mg/L TDS
- 751 - 2000 mg/L TDS

pH = 4-5
- 2 - 100 mg/L TDS
- 101 - 250 mg/L TDS
- 251 - 750 mg/L TDS
- 751 - 2000 mg/L TDS

pH = 5-6
- 2 - 100 mg/L TDS
- 101 - 250 mg/L TDS
- 251 - 750 mg/L TDS
- 751 - 2000 mg/L TDS

pH > 6
- 2 - 100 mg/L TDS
- 101 - 250 mg/L TDS
- 251 - 750 mg/L TDS
- 751 - 2000 mg/L TDS

Soil / Sediment pH
- 2-3
- 4-5
- 5-6

N

Feet
0 800 1,600

HALLIBURTON
DRESSER INDUSTRIES - MAGCOBAR MINE SITE

FIGURE 2-2

RESULTS OF SPRING 2009 FIELD RECONNAISSANCE

PRJ: 0133-006-900-20	Jul 13, 2009	
REV: 0	BY: CRL	CHECKED: JJ

NEWFIELDS

3.0 DE ELOPMENT OF REMEDIAL ACTION OB ECTI ES AND PRELIMINARY REMEDIATION OALS

The following subsections first provide a summary of the specific risks posed by the DIM Mine Site that need to be addressed by a remedy. Following this discussion, the remaining subsections identify applicable and/or relevant and appropriate requirements (“ARARs”) and develop RAOS and PRGs for specific areas of the Site identified as posing risks or potential risks to human health and/or the environment. The final subsections provide a summary of the RAOs and PRGs developed for the Site.

3.1 Summary o Risks to be Addressed by the Remedy

The Site risks to be addressed through the remedy process were identified through the human health and ecological risk assessments conducted during the SI, as refined through discussions with ADEQ and documented in the SI Clarification Technical Memorandum (NewFields, 2007b and 2007c). These risks are summarized below.

- Shallow on-site groundwater potentially poses human health risks should it be used as a water supply.
- Bedrock groundwater within the Chamberlain Creek syncline near the Site does not meet aesthetic-based secondary drinking water standards.
- Soil (dried sludge) in the Sludge Ponds may pose risks to certain terrestrial ecological receptors.
- Sediment in Chamberlain Creek, Cove Creek, Reyburn Creek, Scull Creek and Clearwater Lake poses low levels of risk to benthic macroinvertebrates.
- Surface water in Chamberlain Creek, Cove Creek, Lucinda Creek, Rusher Creek,[3] Reyburn Creek, Scull Creek, and Clearwater Lake poses risk to aquatic biota.

3.2 Applicable and/or Relevant and Appropriate Re uirements

As discussed in Section 1.2, the DIM Mine Site is not a federally listed Superfund site under CERCLA. However, per the approved FS Plan, EPA’s guidance for conducting Feasibility Studies under CERCLA (EPA, 1988) was used to prepare the FS for the Site.

[3] The SI concluded that Rusher Creek is ephemeral and does not support aquatic life. However, Rusher Creek is a tributary to Lucinda Creek, which does support aquatic life.

The development of remedial alternatives under CERCLA relies, in part, on the identification of ARARs which any remedial action must meet, unless the requirement(s) are waived. These requirements can be either applicable or relevant and appropriate. Applicable requirements are cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state laws that specifically address a hazardous substance, constituent, removal action, location, or other circumstance found at a site. Section 121(d) of CERCLA requires that on-site remedial actions attain or waive federal environmental ARARs, or more stringent state environmental ARARs, upon completion of the remedial action. The 1990 National Oil and Hazardous Substances Pollution Contingency Plan (NCP) also requires compliance with ARARs during remedial actions to the extent practicable. Relevant and appropriate requirements, while not applicable to a hazardous substance, pollutant, contaminant, removal action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the site that their use is well-suited to the site (40 CFR 300.5). In addition to ARARs, many federal and state environmental and public health programs also have criteria, advisories, and guidance that are not legally binding but may provide useful information or recommended procedures. These To-Be-Considered ("TBC") standards complement ARARs and are identified for use in guiding remedial actions. Compilations of federal and state ARARs for the Site are presented on Tables 3-1 and 3-2, respectively. A detailed description of ARARs, including ARAR type (action-specific, chemical-specific, or location-specific), is provided in Section 6.1.1.2.

3.3 Remedial Action Ob ectives and Preliminary Remediation oals

Remedial action objectives and PRGs consist of specific objectives and goals for protecting human health and the environment impacted by chemicals of potential concern ("COPCs"), as identified through the human health and ecological risk assessments conducted during the SI. Remedial action objectives are concise statements regarding the objectives to be achieved by the remedial action and PRGs are quantifiable goals for environmental media. Remedial action implemented for the purpose of meeting PRGs usually results in attainment of RAOs. They are identified here to guide the development of a range of remedial alternatives in the FS.

3.3.1 On Site Shallow roundwater

The SI data indicate that the shallow on-site groundwater associated with the spoil piles exceeds Federal primary MCLs (also referenced as drinking water standards) for beryllium and cadmium, as well as Federal Action Levels for copper and lead. Thus, these four metals comprise the COPCs for the shallow on-site groundwater system. The approximate lateral extent of the on-site shallow groundwater exhibiting these impacts is shown on Figure 3-1. This extent is controlled by the topographic expression of the Chamberlain Creek syncline to the north, east, and south. The western (downgradient) extent of the impacted shallow groundwater was established by information from shallow groundwater monitoring wells, as discussed in the SI Report.

The RAO for on-site shallow groundwater is as follows:

- Because beryllium and cadmium concentrations exceed primary MCLs and copper and lead concentrations exceed Action Levels, restrict the use of on-site, shallow groundwater as a water supply.

The RAO for on-site shallow groundwater focuses on prevention of its use as a water supply and not on improving its water quality. Therefore, there are no PRGs for the shallow on-site groundwater.

3.3.2 Bedrock roundwater Within Syncline

The SI data indicate that the bedrock groundwater within the eastern portion of the Chamberlain Creek syncline meets Federal primary MCLs but does not meet aesthetic-based Federal secondary MCLs for iron, manganese, sulfate, and TDS due, in part, to leakage from the Site pit lake. Thus, these parameters comprise the COPCs for the bedrock groundwater system in the affected area. The 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 a water supply that is not impacted by the Site. The approximate extent of the bedrock groundwater known to be affected by the Site is shown on Figure 3-2. The northern, eastern, and southern extents of groundwater known to be affected by the Site are based on the location of the mine pit lake and the upturned bedding on the north and south limbs of the Chamberlain Creek syncline. The western extent of groundwater known to be affected by the Site is based on information from a bedrock well in the southern portion of the syncline that exhibited Site effects and information from a bedrock well in the northern flank of the syncline that did not exhibit Site effects.

The RAO for deep bedrock groundwater within the Chamberlain Creek syncline is as follows:

- Verify that affected groundwater users are connected to an alternative water supply that meets applicable drinking water requirements. Provide connection for affected groundwater users if one does not exist.

The RAO for deep bedrock groundwater within the Chamberlain Creek syncline focuses on verification or provision of an alternative water supply and not on improving the aesthetic aspects of its water quality. Therefore, there are no PRGs for the deep bedrock groundwater within the Chamberlain Creek syncline.

3.3.3 Creek Sediment and Clearwater Lake Sediment

The SI data indicate that cadmium, manganese, and/or nickel are present in the sediment of Chamberlain, Cove, Reyburn, and Scull creeks at concentrations that pose low levels of risk to benthic macroinvertebrates. The following table identifies specific creeks and corresponding COPCs that are characterized as posing low levels of risk.

Water Body Sediment	COPCs
Chamberlain Creek	Cadmium
Cove Creek	Manganese, Nickel
Reyburn Creek	Manganese, Nickel
Scull Creek	Manganese
Clearwater Lake	Nickel

These risks are characterized as low because the hazard quotients for each metal are generally only 2 or 3, with manganese in Cove Creek sediment ranging up to a hazard quotient of 5. The approximate extent of impacted sediment in these creeks and Clearwater Lake is shown on Figure 3-3.

The RAO for sediment is as follows:

- Minimize Site ARD such that concentrations of cadmium, manganese, and/or nickel in creek and Clearwater Lake sediment do not pose unacceptable risks to benthic macroinvertebrates.

As detailed in the Ecological Risk Assessment (see Table 7-2, Appendix B of the SI Report), hazard quotients for creek and Clearwater Lake sediment were calculated using one-half of the probable effects level ("PEC") for each COPC.[4] Therefore, for the low level of risks presented by the sediment to fall into the acceptable range (i.e., hazard quotient of 1 or less), the sediment concentrations would need to be equal to or less than one-half of the PEC for each metal COPC. The PRGs for sediment therefore consist of one-half of the respective PEC for each metal COPC:

Cadmium	2.49 mg/kg
Manganese	837 mg/kg
Nickel	24.3 mg/kg

[4] The Ecological Risk Assessment identified hazard quotients greater than 1 for barium in creek sediments. However, as discussed in Section 7.1.2 of the risk assessment, the barium is of low bioavailability, the corresponding hazard quotients are over-predicted, and thus barium is not an issue of concern in the sediment of creeks and Clearwater Lake.

3.3.4 Sludge Ponds

The SI data indicate that cadmium and zinc are present in the Sludge Ponds at concentrations that pose risk to terrestrial receptors (the American Robin and the Deer Mouse). The locations and lateral extents of the Sludge Ponds are shown on Figure 1-1.

The RAO for the Sludge Ponds is as follows:

- Prevent the American Robin and Deer Mouse from ingesting and/or coming into contact with Sludge Pond solids with cadmium and/or zinc at concentrations which present unacceptable levels of risk.

The RAO for the Sludge Ponds focuses on preventing terrestrial receptors from ingesting or coming into contact with the Sludge Pond solids and not on decreasing the concentrations of cadmium and zinc in those solids. Therefore, there are no PRGs for the Sludge Ponds.

3.3.5 Creek and Clearwater Lake Sur ace Water

The SI data indicate that aluminum, beryllium, cobalt, copper, iron, manganese, nickel, and/or zinc are present in the surface water of Chamberlain, Cove, Lucinda, Reyburn, Rusher, and Scull creeks, and/or Clearwater Lake, at concentrations that pose risks to aquatic biota. The following table identifies specific water bodies and corresponding COPCs that are characterized as posing risks.[5]

Water Body	COPCs
Chamberlain Creek	Aluminum, Cadmium, Cobalt, Copper, Iron, Manganese, Nickel, and Zinc
Cove Creek	Aluminum, Manganese, and Zinc
Reyburn Creek	Aluminum, Manganese, and Zinc
Rusher Creek	Aluminum, Copper, Manganese, Nickel, and Zinc
Scull Creek	Aluminum, Cobalt, Manganese, and Zinc
Clearwater Lake	Aluminum, and Manganese

Of all of the metal COPCs, the hazard quotients for aluminum are by far the highest with values in the hundreds or thousands. Hazard quotients for the other metals are much lower (typically

[5] Calculated beryllium hazard quotients for several of the creeks exceeded 1. However, as discussed in the Ecological Risk Assessment (Appendix B to the SI Report), the screening criterion used to calculate the hazard quotient is very conservative and hazard quotients greater than 1 were also calculated for beryllium in areas upstream of and unaffected by the Site. Therefore, beryllium is not an issue of concern in Site surface water.

less than 10). Overall, the concentrations of these metals in surface water are a function of depressed pH. The approximate extent of impacted surface water in these creeks and Clearwater Lake is coincident with the extent of sediment impacts as shown on Figure 3-3.

The RAO for creek and Clearwater Lake surface water is as follows:

- Minimize Site ARD such that pH is increased and concentrations of aluminum, cobalt, copper, iron, manganese, nickel, and/or zinc in creek and/or Clearwater Lake surface water do not pose unacceptable risks to aquatic biota.

The PRGs for surface water in creeks and Clearwater Lake consist of the Arkansas Pollution Control and Ecology Commission (APCEC) Regulation 2 hardness-based chronic criteria for State-regulated metals (copper, nickel, and zinc) calculated using location-specific hardness measurements. Chronic toxicity reference values ("TRVs"), as presented in the Ecological Risk Assessment (Appendix B of the SI Report) will serve as PRGs for metals that are not regulated by the State, unless more current TRVs become available through the scientific literature. The chronic TRVs will also be calculated using location-specific hardness measurements, for those TRVs that are hardness dependent. As discussed in Section 2.8, PRGs for Chamberlain Creek, and possibly other creek affected by the Site may be modified in the future.

3.4 Summary o Remedial Action Ob ectives and Preliminary Remediation oals

Table 3-3 provides a summary of the risks, receptors, COPCs, RAOs, and PRGs for the DIM Mine Site.

Section 3 Tables

TABLE 3-1

Summary of Potential Federal ARARs, Dresser Industries-Magcobar Mine Site, Hot Spring County, Arkansas

Citation	Re uirement/Purpose	ARAR Type	Applicability	Comments
National Historical Preservation Act 16 USC 661 et seq. 36 CFR Part 65	Establishes procedures to provide for preservation of scientific, historical, and archaeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program. If scientific, historical, or archaeological artifacts are discovered at the site, work in the area of the site affected by such discovery will be halted pending the completion of any data recovery and preservation activities required pursuant to the act and its implementing regulations.	Location-Specific	Relevant and Appropriate	May be relevant and appropriate during the remedial activities if scientific, historic, or archaeological artifacts are identified during implementation of the remedy.
Executive Orders 11988 and 11990 40 CFR Part 6, Appendix A	Requires federal agencies to avoid whenever possible, adversely affecting floodplains or wetlands and to evaluate potential effects of actions in these designated areas.	Location-Specific	Applicable	Applicable to any wetlands associated with on- and off-site creeks.
Fish and Wildlife Coordination Act 16 USC 661 et seq. 16 USC 742 a 16 USC 2901 40 CFR 6.302	Requires consultation when a modification of a stream or other water body is proposed or authorized and requires adequate provision of fish and wildlife resources.	Location-Specific	Relevant and Appropriate	Relevant and appropriate if the remedy requires for removal of contaminated sediment or soils along the offsite creeks and/or Clearwater Lake.
Clean Water Act Section 404 40 CFR Parts 230 33 CFR Parts 320 – 330	Prohibits the discharge of dredged or fill material into wetlands without permit	Action-Specific	Applicable	Applicable if wetland areas are impacted by remedy.
Endangered Species Act of 1973 16 USC 1531 et seq. 50 CFR 402–Fish and Wildlife Coordination Act	Requires remedial agency to consult with Fish and Wildlife Service if action may affect endangered species or critical habitat.	Location-Specific	Applicable	Applicable if Fish and Wildlife Service deems area a critical habitat.
Air Regulations				

TABLE 3-1
Summary of Potential Federal ARARs, Dresser Industries-Magcobar Mine Site, Hot Spring County, Arkansas

Citation	Re uirement/Purpose	ARAR Type	Applicability	Comments
Clean Air Act Section 101	Calls for development and implementation of regional air pollution control programs	Chemical-Specific	Applicable	Section 101 of the Clean Air Act delegates primary responsibility for regional air quality management to the states. The rules for implementation of regional air quality plans are contained in 40 CFR 52. Regulations promulgated under the Clean Air Act may apply to possible actions at the site that generate air emissions, but are most applicable to stationary sources such as incinerators.
40 CFR 50–National Primary and Secondary Ambient Air Quality Standards	Establishes Ambient Air Quality Standards	Chemical-Specific	Applicable	Applicable to discharges of toxic substances to the atmosphere during waste handling or treatment.
40 CFR 51–Requirements for Preparation, Adoption, and Submittal of Implementation Plans	Requires excavation activities be controlled to minimize fugitive dust emissions.	Action-Specific	Relevant and Appropriate	Relevant and appropriate to fugitive dust emissions from excavation of contaminated soil.
40 CFR 52–Approval and Promulgation of Implementation Plans	Requires the filing of a notice with the state regarding intent to install a new stationary source for air pollution.	Action-Specific	Relevant and Appropriate	40 CFR 52 concerns the installation of stationary sources of air emissions. Provisions enforceable by the state follow the federal Prevention of Significant Deterioration (PSD) program with modifications to conform to regional and local ambient air quality standards. A CERCLA response action is not required to obtain permits under the PSD program, but must comply with the substantive requirements of a PSD review.
40 CFR 61–National Emission Standards for Hazardous Waste Pollutants	Requires limiting ambient hydrogen sulfide emissions to less than 0.10 ppm. The regulation also includes emission standards for PCP and inorganic arsenic–both of which are designated hazardous air pollutants.	Chemical-Specific	Applicable	Applicable to discharges of toxic substances to the atmosphere during waste handling or treatment.
40 CFR 264.AA–Air Emission Standards for Process Vents	Requires total organic emissions from air strippers or steam strippers to be reduced below 1.4 kg/hr and 2.8 Mg/yr or that total organic emissions be reduced by 95 percent by weight.	Chemical-Specific	Applicable	Applicable to discharges of toxic substances to the atmosphere during waste handling or treatment.

TABLE 3-1
Summary of Potential Federal ARARs, Dresser Industries-Magcobar Mine Site, Hot Spring County, Arkansas

Citation	Re uirement/Purpose	ARAR Type	Applicability	Comments
40 CFR 266104-107–Hazardous Waste Burned in Boilers and Industrial Furnaces	The Boiler and Industrial Furnace Final Rule was promulgated by USEPA on August 21, 1991. This rule expanded control on hazardous waste combustion by regulating the burning of hazardous waste in boilers and industrial furnaces (BIF). BIFs are now subject to essentially the same general facility standards as are other RCRA treatment, storage, and disposal facilities. 40 CFR 266.104 – 107 regulate emission of the following constituents: •Toxic organic compounds •Hydrogen chloride and chlorine gas •Toxic metals (including arsenic and chromium) • Particulate matter From boilers and industrial furnaces that burn hazardous waste.	Chemical-Specific	Applicable	Applicable if thermal treatment is part of the selected remedy.
Water Regulations				
Federal Water Pollution Control Act as amended by the Clean Water Act of 1977, Section 208(b)	The proposed action must be consistent with regional water quality management plans as developed under Section 208 of Clean Water Act.	Chemical-Specific	Applicable	Substantive requirements adopted by the state pursuant to Section 208 of the Clean Water Act would be applicable to direct discharge of treatment system effluent or other discharges to surface water.
Federal Water Pollution Control Act as amended by the Clean Water Act of 1977, Section 304	Establishes water quality criteria for specific pollutants for the protection of human health and for the protection of aquatic life. These federal water quality criteria are non-enforceable guidelines used by the state to set water quality standards for surface water.	Chemical-Specific	Relevant and Appropriate	Water quality criteria may be relevant and appropriate to groundwater or other discharges to surface water.
40 CFR Parts 122, 125	Requires the development and implementation of a stormwater pollution prevention plan or a stormwater best management plan. Also outlines monitoring and reporting requirement for a variety of facilities.	Action-Specific	Applicable	May be applicable to runoff from construction activities depending on the nature of the remedial action selected.
40 CFR 122.41(l)–Monitoring Requirements	Requires monitoring of discharges to ensure compliance. Monitoring programs shall include data on the mass, volume, and frequency of all discharge events.	Action-Specific	Applicable	Administrative requirement applicable only for discharges to off-site surface water.

TABLE 3-1
Summary of Potential Federal ARARs, Dresser Industries-Magcobar Mine Site, Hot Spring County, Arkansas

Citation	Re uirement/Purpose	ARAR Type	Applicability	Comments
40 CFR 131–Water Quality Standards	States are granted enforcement jurisdiction over direct discharges and may adopt reasonable standards to protect or enhance the uses and qualities of surface water bodies in the state.	Chemical-Specific	Applicable	Applicable to direct discharge of treatment system effluent or direct discharges.
40 CFR 136–Guidelines Establishing Test Procedures for the Analysis of [Water] Pollutants (40 CFR 136.1-136.4)	These sections require adherence to sample preservation procedures including container materials and sample holding times.	Action-Specific	Applicable	Applicable to direct discharge of treatment system effluent or direct discharges.
40 CFR 141–National Primary Drinking Water Regulations	Establishes maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) for specific chemicals to protect drinking water quality.	Chemical-Specific	Applicable or Relevant and Appropriate	MCLs and nonzero MCLGs may be applicable or relevant and appropriate as groundwater contaminant concentration goals depending on whether the water in question is to be used for drinking water supply. MCLs are applicable if the water is or will be used for drinking. MCLs are relevant and appropriate if the water could be used for drinking. MCLGs set above zero levels are relevant and appropriate for current or potential sources of drinking water.
Solid and Hazardous Waste Regulations				
42 U.S.C. §§ 6902-6987 40 CFR 261 (b)(7)	Identifies those solid wastes which are subject to regulation as hazardous waste under 40 CFR Parts 262-265, 268 and Parts 124, 270 and 271. Lists exclusions from RCRA subtitle C requirements.	Action-Specific	Applicable	The Solid Waste Amendments of 1984 identify solid waste from the extraction, beneficiation, and processing of ores and minerals as potentially exempt from subtitle C regulations. The SI identified no listed or hazardous wastes at the Site. These regulations would be applicable to any hazardous wastes that may be discovered at the Site.
40 CFR 241–Guidelines for Land Disposal of Solid Wastes	Offsite solid waste land disposal units must meet the federal guidelines for the land disposal of solid wastes.	Action-Specific	Applicable	Applicability depends on waste classification for soil and treatment residuals if they are disposed off-site.

TABLE 3-1
Summary of Potential Federal ARARs, Dresser Industries-Magcobar Mine Site, Hot Spring County, Arkansas

Citation	Re uirement/Purpose	ARAR Type	Applicability	Comments
Subtitle D, 40 CFR 257–Criteria for Classification of Solid Waste Disposal Facility and Practices	Sets standards for land disposal facilities for nonhazardous waste.	Action-Specific	Applicable	Applicable to water treatment residuals and to transport and disposal of any nonhazardous waste offsite.
Subtitle C, 40 CFR 260 through 264	Regulates the generation, transport, storage, treatment, and disposal of hazardous wastes generated in the course of a remedial action. Regulates the construction, design, monitoring, operation, and closure of hazardous waste facilities.	Action-Specific	Relevant and Appropriate	Requirements under these regulations may be relevant and appropriate to storage of certain non-hazardous wastes or treatment system residuals if the risks they present are similar to those associated with hazardous wastes. The criteria and limitations used to identify wastes as being hazardous or nonhazardous are applicable to water treatment residuals.
40 CFR 261–Identification and Listing of Hazardous Waste	Identifies those wastes subject to regulation as hazardous wastes	Action-Specific	Relevant and Appropriate	The criteria and limitations used to identify wastes as being hazardous or nonhazardous in 40 CFR 261 are relevant and appropriate to any actions that manage solid material.
40 CFR 264, Subpart F–Releases from Solid Waste Management Units (Groundwater Protection–40CFR 264.90 – 264.101)	Establishes requirements for detecting, characterizing and responding to releases to the uppermost aquifer. Also establishes the groundwater protection standards for hazardous constituents in the upper-most aquifer underlying a waste management area beyond the point of compliance.	Action-Specific	Relevant and Appropriate	Requirements under these regulations would be relevant and appropriate if contaminated soils or treatment residuals qualifying as hazardous wastes are placed in a waste pile, landfill, or miscellaneous unit onsite. The substantive requirements for permitting would also have to be met. No such materials have been identified at the Site.
40 CFR 264, Subpart G–Closure and Post-Closure (40 CFR 264.110 to 264.120)	Provides technical and procedural closure requirements for hazardous waste facilities. Requires the facility be closed in a manner that controls, minimizes or eliminates to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to the ground or surface water or to the atmosphere.	Action-Specific	Relevant and Appropriate	Consolidation of excavated material or soil treatment residuals that contains listed or characteristic waste may make these requirements relevant and appropriate. No such materials have been identified at the Site.

TABLE 3-1
Summary of Potential Federal ARARs, Dresser Industries-Magcobar Mine Site, Hot Spring County, Arkansas

Citation	Re uirement/Purpose	ARAR Type	Applicability	Comments
40 CFR 264, Subpart K–Surface Impoundments (40 CFR 264.221 to 264.228)	Establishes the design and operating, monitoring and closure requirements for surface impoundments. Requires that all impoundments have a liner system to prevent any migration of wastes out of the impoundment to the adjacent subsurface soil or groundwater or surface water any time during the life of the impoundment.	Action-Specific	Relevant and Appropriate	Use of surface impoundments for consolidation or treatment of excavated material that contains listed or characteristic waste may make these requirements relevant and appropriate. No such actions have been identified as viable for the Site remedy.
40 CFR 264, Subpart L–Waste Piles (40 CFR 264.251 to 264.254)	Establishes the design and operating, monitoring, and closure requirements for waste piles. Requires that all waste piles have a liner system to prevent any migration of wastes out of the impoundment to the adjacent subsurface soil or groundwater or surface water any time during the life of the impoundment.	Action-Specific	Relevant and Appropriate	Use of waste piles for consolidation or treatment of excavated material that contains listed or characteristic waste may make these requirements relevant and appropriate. No such materials have been identified at the Site.
40 CFR 264, Subpart M–Land Treatment (40CFR 264.271 to 264.280)	Establishes the demonstration program, design and operating, monitoring and closure requirements for land treatment units.	Action-Specific	Relevant and Appropriate	Use of land treatment units for the treatment or disposal of excavated material that contains listed or characteristic waste may make these requirements relevant and appropriate. No such materials have been identified at the Site.
40 CFR 264, Subpart N–Landfills (40CFR 264.301 to 264.304)	Establishes the design and operating, monitoring, and closure requirements for landfills. Requires that all landfills have a liner system, a leachate collection and removal system, and leak detection system to prevent any migration of wastes out of the landfill, to the adjacent subsurface soil or groundwater or surface water anytime during the active life of the landfill.	Action-Specific	Relevant and Appropriate	Consolidation of excavated material or soil treatment residuals that contains listed or characteristic waste may make these requirements relevant and appropriate. No such materials have been identified at the Site.
40 CFR 264.310–Closure and Post-Closure Care	Requires landfills to closed with a final cover designed and constructed to: provide long-term minimization of migration of liquids through the capped area: function with minimum maintenance; promote drainage and minimize erosion or abrasion of the cover; accommodate settling and subsistence so that the cover's integrity is maintained; and have a permeability less than or equal to the permeability of any bottom liner system or natural sub-soils present.	Action-Specific	Relevant and Appropriate	Consolidation of excavated material or soil treatment residuals that contains listed or characteristic waste may make these requirements relevant and appropriate. No such materials have been identified at the Site.

TABLE 3-1
Summary of Potential Federal ARARs, Dresser Industries-Magcobar Mine Site, Hot Spring County, Arkansas

Citation	Re uirement/Purpose	ARAR Type	Applicability	Comments
40 CFR 264, Subpart S–Corrective Action for Solid Waste Management Units (Corrective Action Management Units–40 CFR 264.552)	Establishes the requirements for designating an area as a Corrective Action management Unit (CAMU). (1) Placement of remediation wastes into or within a CAMU does not constitute land disposal of hazardous wastes. (2) Consolidation or placement of remediation wastes into or within a CAMU does not constitute creation of a unit subject to minimum technology requirements.	Action-Specific	Relevant and Appropriate	Consolidation of excavated material or soil treatment residuals that contain listed or characteristic waste may require establishment of a CAMU. No such materials have been identified at the Site.
40 CFR 268 Subpart C–Prohibitions on Land Disposal	The land disposal restriction under this subpart prohibits land-based disposal of certain solvent-containing wastes, dioxin-containing wastes, and listed wastes.	Action-Specific	Applicable	The rules in 40 CFR 268 restrict land disposal of several types of hazardous wastes and as such, may affect the implementation of several potential actions, including actions involving disposal of contaminated soils. No hazardous wastes have been identified at the Site. Would be applicable to any hazardous wastes that may be discovered at the Site.
40 CFR 268 Subpart D–Treatment Standards	Materials containing RCRA hazardous waste subject to land disposal restrictions. Some hazardous wastes restricted from land disposal in Subpart C may be land-disposed providing they attain levels achievable by best demonstrated available technologies (BDAT) for each hazardous constituent for each listed waste.	Action-Specific	Applicable	Movement of excavated RCRA hazardous waste materials to new location and placement in or on land will trigger land disposal restrictions for the excavated waste or closure requirements for the unit in which the waste is being placed. No hazardous wastes have been identified at the Site. Would be applicable to any hazardous wastes that may be discovered at the Site.
U.S. EPA and DOT Regulations on Transport of Hazardous Waste				
40 CFR 262 and 263 49 CFR 100 through 199	Establishes responsibilities for transporters of hazardous waste in handling, transportation, and management of the waste. Sets requirements for manifesting, recordkeeping, and emergency response action in case of a spill.	Action-Specific	Applicable	Applicability depends on waste classification of treatment residuals or other materials if transported off Site.

TABLE 3-2

Summary of Potential Arkansas ARARs, Dresser Industries-Magcobar Mine Site, Hot Spring County, Arkansas

Citation	Re uirement/Purpose	ARAR Type	Applicability	Comments
APCEC Regulation 2–Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas				
APCEC Regulation 2–Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas	Establishes water quality standards for surface water/wetlands and implementation procedures for application of the surface water/wetland water quality standards.	Chemical-Specific	Applicable	Applicable to surface water quality standards and discharge criteria.
APCEC Regulation 6-Regulations For State Administration Of The National Pollutant Discharge Elimination System (NPDES)				
APCEC Regulation 6 – Regulations For State Administration Of The National Pollutant Discharge Elimination System (NPDES)	The purpose is to adopt regulations necessary to qualify the State of Arkansas to receive authorization to implement the State water pollution control permitting program in lieu of the federal NPDES program.	Action-Specific	Relevant and Appropriate	Relevant to water treatment system discharge of treated pit lake water.
APCEC Regulation 15-The Arkansas Open-Cut Mining and Land Reclamation Code				
APCEC Regulation 15 – The Arkansas Open-Cut Mining and Land Reclamation Code	The purpose of this Code is to protect the public health, safety, and the environment during and after completion of open-cut or stream bed mining operations.	Action-Specific	Relevant and Appropriate	Relevant to land affected by open cut mining operations after July 1, 1971. Relevant to reclamation activities for which performance standards (15.402) may be applied.
APCEC Regulation 22–Solid Waste Management Requirements				
APCEC Regulation 22–Solid Waste Management Requirements	Specifies design, operation, and maintenance requirements for new solid waste landfills.	Action-Specific	Relevant and Appropriate	Portions may be relevant and appropriate to actions involving consolidation of contaminated soil or mine solid materials.
§22.103(k)–Contaminated Soil Remediation Exclusion	Specifies that the provisions of Regulation Number 22 shall not apply to onsite excavation, handling, treatment, or placement of contaminated soils if: 1. The activities in question are part of an environmental remediation effort being conducted pursuant to an approved written plan or order submitted to the ADEQ 2. The activities are carried out wholly within the boundaries of the site that is the subject of the remediation.	Action-Specific	Relevant and Appropriate	Portions may be relevant and appropriate to actions involving consolidation of contaminated soil or mine solid materials.

TABLE 3-2
Summary of Potential Arkansas ARARs, Dresser Industries-Magcobar Mine Site, Hot Spring County, Arkansas

Citation	Re uirement/Purpose	ARAR Type	Applicability	Comments
APC&E Regulation 23–Hazardous Waste Management				
APC&E Regulation 23–Hazardous Waste Management	Specifies minimum requirements for storage or treatment of hazardous wastes. Standards may also apply to CAMUs, unless determined otherwise under Section 264, Subsection S.	Action-Specific	Relevant and Appropriate	Portions may be relevant and appropriate to actions involving consolidation of contaminated soil or mine solid materials.
Section 261–Identification and Listing of Hazardous Waste	Establishes criteria for the classification of hazardous waste.	Chemical-Specific	Applicable	No such materials have been identified at the Site. Would be applicable to any hazardous wastes that may be discovered at the Site.
§261.24–Toxicity Characteristic	Lists maximum contaminant concentrations for the Toxicity Characteristic	Chemical-Specific	Applicable	See above. Test is applicable for materials that will be disposed offsite.
Section 261, Subsection D–Lists of Hazardous Wastes	Lists hazardous wastes from nonspecific (§261.31) and specific sources (§261.32).	Action-Specific	Applicable	No such materials have been identified at the Site. Would be applicable to any hazardous wastes that may be discovered at the Site.
Section 262–Standards Applicable to Generators of Hazardous Waste	Specifies transportation standards for hazardous waste based on RCRA standards	Action-Specific	Applicable	No such materials have been identified at the Site. Would be applicable to any hazardous wastes that may be discovered at the Site.
Section 264–Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	Specifies the general requirements that apply to the storage, treatment, and disposal of hazardous waste.	Action-Specific	Applicable	No such materials have been identified at the Site. Would be applicable to any hazardous wastes that may be discovered at the Site.
§264.1(j)	Specifies that the General Facilities Standards (Subsection B), Preparedness and Prevention (Subsection C) and Contingency Planning and Emergency Procedures (Subsection D) and Corrective Action for Solid Waste Management Units (§ 264.101) requirements do not apply to remediation waste management sites.	Action-Specific	Applicable	The requirements specified under §264.1 will apply to the storage and treatment of contaminated soils or treatment residual that must be managed as hazardous waste. No such materials have been identified at the Site. Would be applicable to any hazardous wastes that may be discovered at the Site.

TABLE 3-2
Summary of Potential Arkansas ARARs, Dresser Industries-Magcobar Mine Site, Hot Spring County, Arkansas

Citation	Re uirement/Purpose	ARAR Type	Applicability	Comments
Section 264, Subsection F–Releases from Solid Waste Management Units	Specifies concentration limits in the groundwater for hazardous constituents in the uppermost aquifer underlying the waste management area.	Chemical-Specific	Relevant and Appropriate	May be relevant and appropriate if SWMUs are established as part of the remediation.
Section 268–Land Disposal Restrictions	Identifies hazardous wastes that are restricted from land disposal and defines exceptions.	Action-Specific	Applicable	No such materials have been identified at the Site. Would be applicable to any hazardous wastes that may be discovered at the Site.
Arkansas State Groundwater Quality Protection Strategy				
Arkansas State Groundwater Quality Protection Strategy	Formulates and recommends a management program to protect the quality of groundwater resources. Outlines water quality criteria for groundwater (drinking water) within the State.	Chemical-Specific	Applicable	Arkansas has adopted the recommended standards for drinking water set by the SDWA. The Arkansas Department of Health uses the National Primary Drinking Water Standards in setting the criteria to which public water supplies must adhere.

TABLE 3-3
SUMMARY OF RECEPTORS, EXPOSURE PATHWAYS, COPCs, RAOs, AND PRGs - DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILTY STUDY

Environmental Medium	Location	Receptors	Exposure Pathways	Constituents of Potential Concern (COPCs)	Remedial Action Objectives (RAOs)	Preliminary Remediation Goals (PRGs)
HUMAN HEALTH RISKS						
Groundwater	On-Site Areas Between West Spoil Piles and Baroid Road	Future Shallow Water Well Users	Ingestion	Beryllium, Cadmium, Copper, and Lead	Because beryllium and cadmium concentrations exceed primary MCLs and copper and lead concentrations exceed Action Levels, restrict the use of on-site, shallow groundwater as a water supply.	No PRGs for restricting shallow groundwater use as a water supply.
	Within the Chamberlain Creek Syncline West of the Mine Pit Lake	Current and Future Deep Bedrock Water Well Users	Ingestion	Iron, Manganese, Sulfate, and Total Dissolved Solids (TDS)[1]	Verify that affected groundwater users are connected to an alternative water supply that meets applicable drinking water requirements. Provide connection for affected groundwater users if one does not exist.	No PRGs for verification of connection to alternative drinking water supply.
ECOLOGICAL RISKS						
Soil, Sediment, and Solids	Chamberlain Creek, Cove Creek, Reyburn Creek, Scull Creek (Sediment)[2,4]	Benthic Invertebrates	Ingestion, Direct Contact	Cadmium, Manganese, and/or Nickel	Minimize Site ARD such that concentrations of cadmium, manganese, and/or nickel in creek sediment do not pose unacceptable risks to benthic macroinvertebrates.	Arsenic: 16.5 mg/kg[3] Cadmium: 2.49 mg/kg Manganese: 837 mg/kg Nickel: 24.3 mg/kg
	Clearwater Lake (Sediment)[2]	Benthic Invertebrates	Ingestion, Direct Contact	Nickel	Minimize Site ARD such that concentrations of cadmium, manganese, and/or nickel in Clearwater Lake sediment do not pose unacceptable risks to benthic macroinvertebrates.	Nickel: 24.3 mg/kg
	Sludge Ponds	American Robin and Deer Mouse	Ingestion, Direct Contact	Cadmium and Zinc	Prevent the American Robin and Deer Mouse from ingesting and/or coming into contact with Sludge Pond solids with cadmium and/or zinc at concentrations which present unacceptable levels of risk.	No PRGs for preventing ingestion or coming into direct contact with Sludge Pond solids that present unacceptable levels of risk.

[1] Note: data indicate that all primary Maximum Contaminant Levels (MCLs) are met, however, the Site likely contributes to exceedances of aesthetic-based secondary MCLs.
[2] Predicted risks associated with sediment in off-Site creeks and Clearwater Lake are small; hazard quotients are only slightly higher than 1.
HQs >1 at ½ the Probable Effects Concentration (PEC) are considered risks requiring remedial action.
[3] All sediment PRGs correspond to ½ of the PEC.

TABLE 3-3
SUMMARY OF RECEPTORS, EXPOSURE PATHWAYS, COPCs, RAOs, AND PRGs - DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILTY STUDY

Environmental Medium	Location	Receptors	Exposure Pathways	Constituents of Potential Concern (COPCs)	Remedial Action Objectives (RAOs)	Preliminary Remediation Goals (PRGs)
Surface Water	Chamberlain Creek, Cove Creek, Lucinda Creek, Rusher Creek, Reyburn Creek, Scull Creek, and Clearwater Lake.[4]	Aquatic Biota	Ingestion, Direct Contact	Aluminum, Cobalt, Copper, Iron, Manganese, Nickel, and/or Zinc	Minimize Site ARD such that pH is increased and concentrations of aluminum, cobalt, copper, iron, manganese, nickel, and/or zinc in creek and/or Clearwater Lake surface water do not pose unacceptable risks to aquatic biota.	Copper, Nickel, and Zinc: Arkansas Pollution Control And Ecology Commission (APCEC) Regulation 2 hardness-based chronic criteria calculated using location-specific hardness measurements. Aluminum: 0.067 mg/l at pH 5.9-6.5; hardness-based chronic Toxicity Reference Value (TRV) at pH less than 5.9 calculated using location-specific hardness measurements. Manganese: Hardness-based chronic TRV calculated using location-specific hardness measurements. Cobalt: 0.1 mg/l Iron: 1 mg/l[5]

[4] Not all parameters listed result in risks to aquatic receptors in each of the listed water bodies.
[5] .See Table 6-1 of the Ecological Risk Assessment (Appendix B of the SI Report) for surface water TRVs. PRGs for Chamberlain Creek, and possibly other creeks, may be modified through Use Attainability Analysis (UAA).

Section 3 Figures

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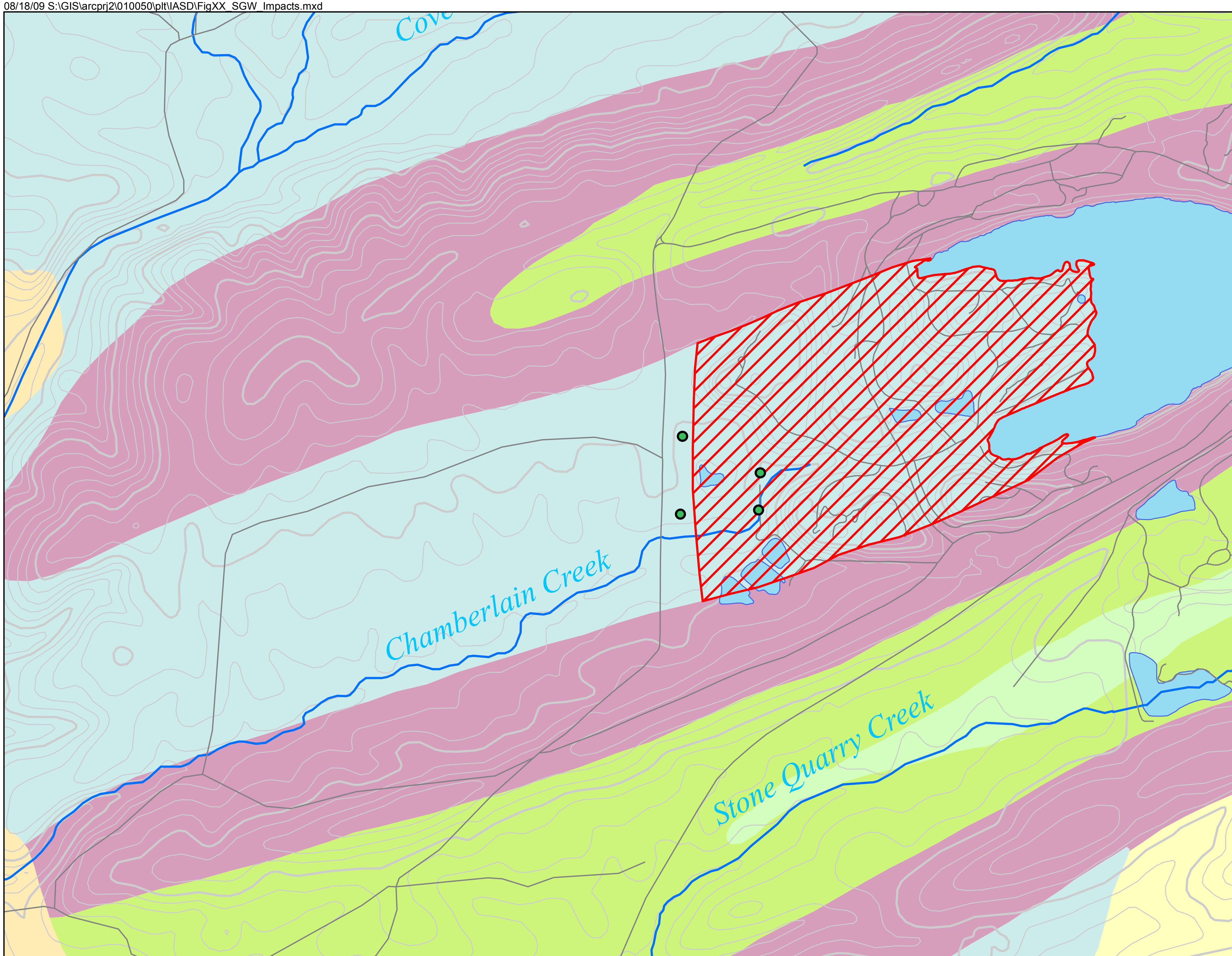

HALLIBURTON

DRESSER INDUSTRIES - MAGCOBAR MINE SITE

FIGURE 3-1

EXTENT OF IMPACTED SHALLOW GROUNDWATER IN THE CHAMBERLAIN CREEK SYNCLINE

PRJ: 0133-003-900	Aug 18, 2009
REV: 0	BY: JPJ / CHK: BGH

NEWFIELDS

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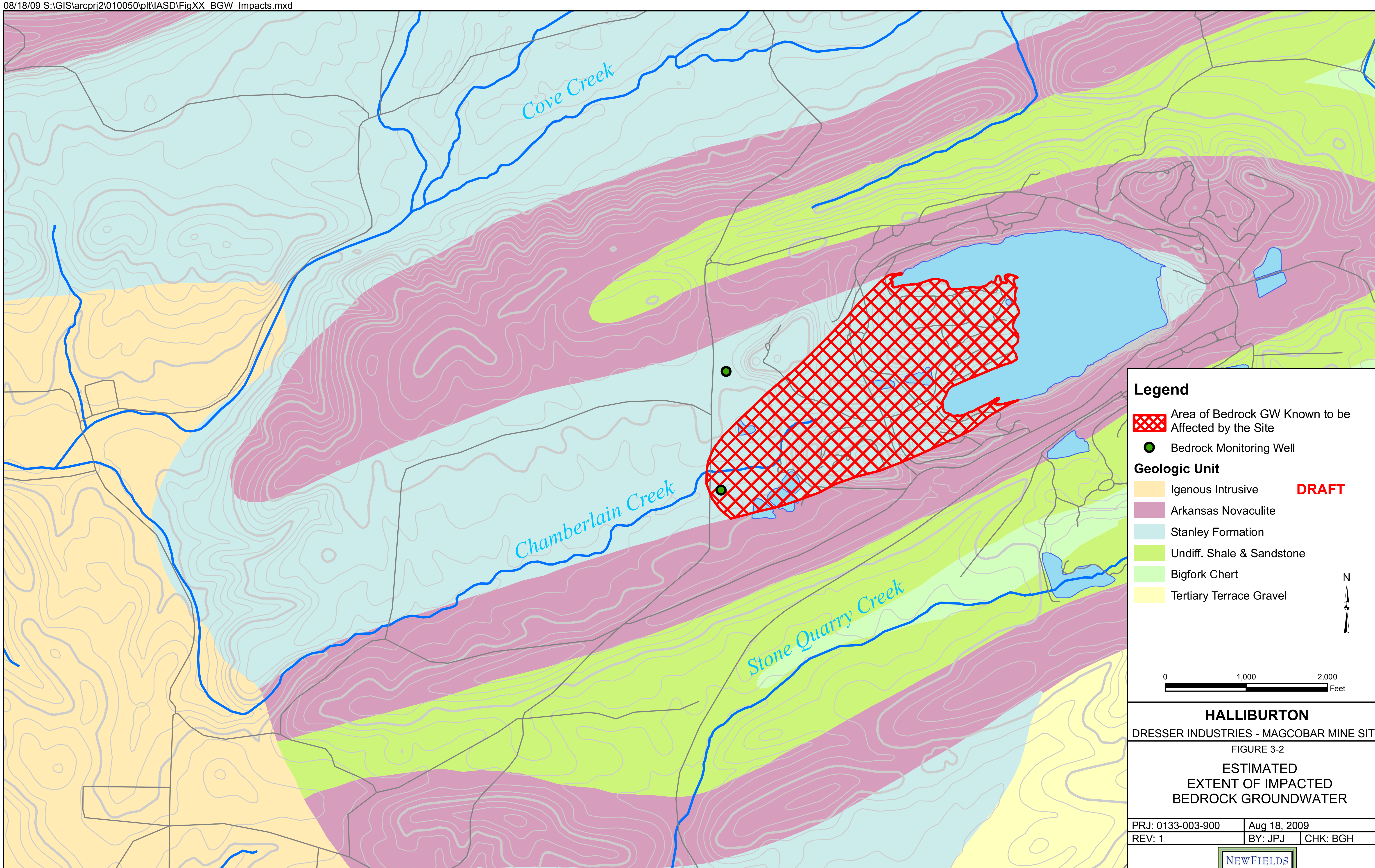

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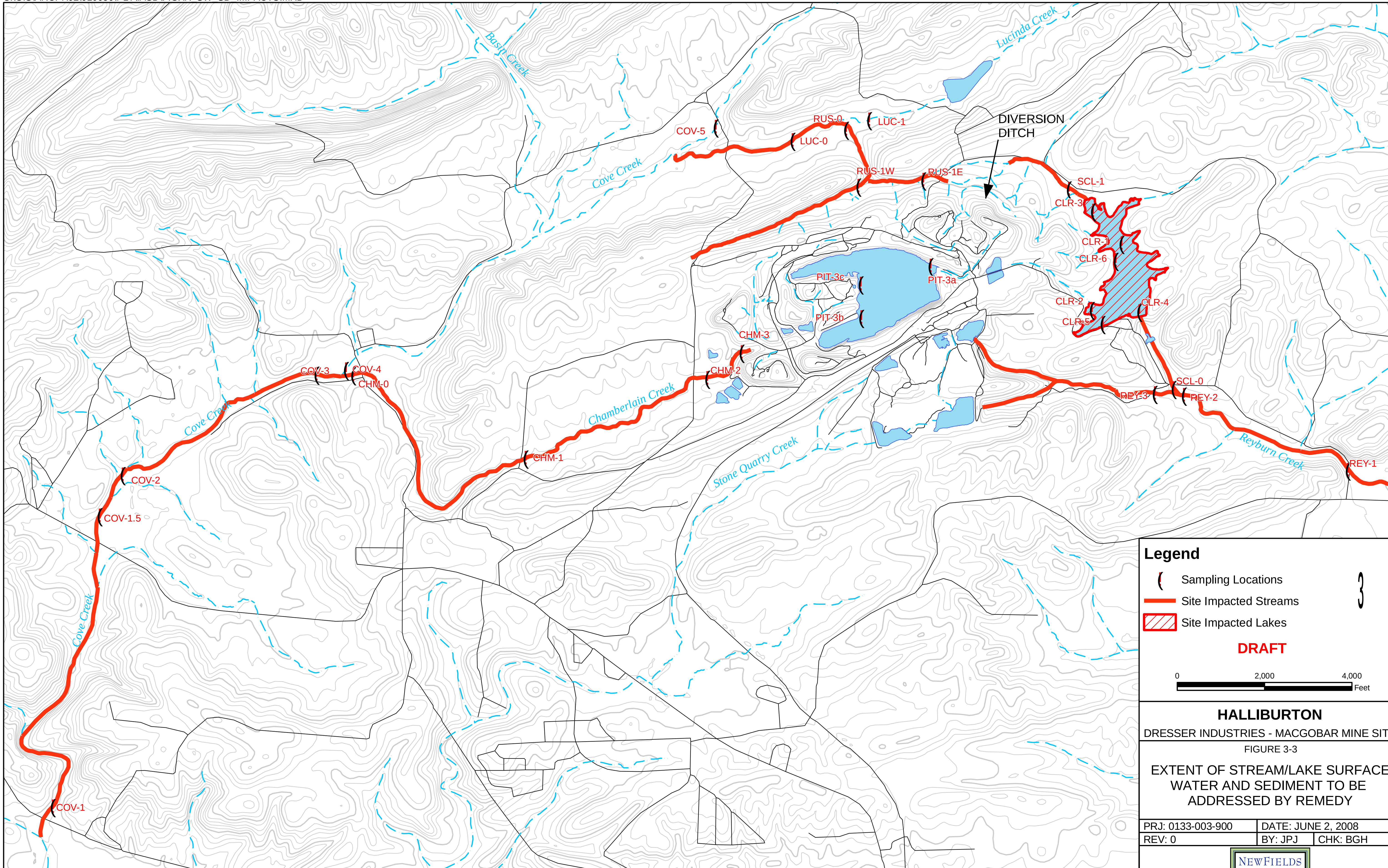


HALLIBURTON

DRESSER INDUSTRIES - MACGOBAR MINE SITE

FIGURE 3-3

EXTENT OF STREAM/LAKE SURFACE WATER AND SEDIMENT TO BE ADDRESSED BY REMEDY

PRJ: 0133-003-900	DATE: JUNE 2, 2008
REV: 0	BY: JPJ CHK: BGH

NEWFIELDS

4.0 IDENTIFICATION AND SCREENIN OF TEC NOLO IES

This section presents the development of General Response Actions (GRAs), and identification and screening of remedial technologies and process options for the Site. GRAs are general categories of remedial activities that may be taken, either singly or in combination, to satisfy RAOs. Remedial technologies and process options are more specific applications of the GRAs. The EPA guidance identifies specific requirements for the development of remedial alternatives during the FS process. These requirements have been applied to the process of identification and screening of technologies presented below and the development of alternatives presented in Section 5.0. Technologies presented in this report are based upon the assessment of the Site as presented in the SI report, including the SI Clarification Technical Memorandum and the RAOs presented in Section 3.0 of this document.

4.1 eneral Response Actions

GRAs describe those actions that alone, or in combination, may be applied to areas of concern. GRAs are used to organize and structure potential remedial actions and are divided into remedial technology groups consisting of specific process options. The purpose of this section is to identify and describe the GRAs that may satisfy the RAOs presented in Section 3.0 of this document. The specific remedial technologies and process options for each GRA are then evaluated and screened in Section 4.2.

There are two media of concern within the Site: solid and aqueous. The aqueous media category includes groundwater and surface water. The solid media category includes mine spoil, tailings, sludge from former water treatment actions during mine operation, contaminated soils, and contaminated sediments. GRAs and remedial technologies have not been developed for the air medium because previously collected data indicate that airborne transport of COPC-bearing particulates within the Site is not a viable pathway (Site Study Plan [MFG 2001]; SI Report).

The GRAs for the Site include:

- No Action;
- Institutional Controls;
- Containment;
- Source Control, Flow Control, and Routing;
- Removal; and,

- Treatment.

Sections 4.1.1 through 4.1.7 present brief descriptions of the GRAs identified above. Figure 4-1 identifies the GRAs and the associated remedial technologies and process options. Detailed descriptions of remedial technologies and process options for each GRA are provided in Section 4.2.

4.1.1 No Action

As previously described, IRMs were implemented shortly after the Administrative Settlement was signed with the construction of Levee #1 to provide additional freeboard for the mine pit lake. Additional IRMs were implemented during the SI period including the enlargement of Levee #1, the construction of two additional levees (#2 and #3), and the construction of a WTS to allow for controlled discharge of treated mine pit lake water. The WTS, which commenced operation in June 2003, also collects water in the headwaters area of Chamberlain Creek and pumps it to the mine pit lake. Treated discharge from the WTS is directed to the Chamberlain Creek channel. An additional IRM, implemented in late 2005, extended the discharge point for the treated water approximately 1,000 feet down stream on Chamberlain Creek. It also collects shallow groundwater from the Chamberlain Creek channel upstream of the new discharge point for treatment by the WTS.

Under the No Action GRA, the levees would remain in place but water treatment and shallow groundwater collection at the headwaters of Chamberlain Creek would cease. The WTS buildings and infrastructure, and the infrastructure associated with the shallow groundwater collection system, would not be decommissioned and would remain in place.

4.1.2 Institutional Controls

Institutional Controls (“ICs”) are non-engineering mechanisms that provide the means by which federal, state and local governments or private parties can prevent or limit access to or use of contaminated environmental media, the use of areas impacted by COPCs, and/or to ensure the integrity and maintenance of engineered remedial components. ICs are meant to supplement engineering controls and may be a necessary component of the selected remedy.

4.1.3 Containment

The containment GRA includes technologies and process options resulting in the physical containment or isolation of wastes or COPC-containing materials to limit exposure and reduce the transport of COPCs. This GRA does not involve treatment. Long-term maintenance requirements, including periodic inspection and monitoring, may be required for containment options.

4.1.4 Source Control, Flow Control, and Routing

The Source Control GRA consists of active measures to provide a means to manage sources and reduce the migration of constituents from source areas into surrounding soils, groundwater, and surface water.

Flow control and routing applies to surface water only. Technologies and process options within this GRA provide the means to manage aqueous migration of COPCs by diversion and regulation of volume, velocity, location, and direction of storm runoff flow, which ultimately assist in minimizing exposure of receptors to COPCs. Long-term maintenance requirements, including periodic inspection and monitoring, may be required for flow control and routing options.

4.1.5 Removal

This GRA entails the removal and disposal of solid or aqueous media containing COPCs exceeding specified action levels or standards. Several technologies and process options exist within the removal GRA for remediation of solid and aqueous media at the Site. This GRA is often combined with other GRAs such as ICs, containment, flow control and routing, or treatment. Long-term maintenance requirements, including periodic inspection and monitoring, may be required for removal options.

4.1.6 Treatment

This GRA implements various treatment technologies to remove or reduce COPCs in the applicable media. Technologies for this GRA may generally be divided into three categories: biological treatment, chemical treatment, and physical treatment. The implementation of most of these technologies would likely be combined with removal technologies as described in Section 4.1.5. This GRA includes both in-situ and ex-situ treatment technologies. Long-term operations and maintenance requirements, including periodic inspection and monitoring, may be required for treatment options.

4.2 Identi ication and Screening o Technology Types and Process Options

This section identifies and screens a range of remedial technologies and process options for their potential applicability to the media and conditions at the Site. The individual remedial technologies evaluated in this section are subsets of the GRAs that were identified and described in Section 4.1. The purpose of the screening process is to select a reasonable number of promising technologies to consider while developing remedial action alternatives based on general suitability for the Site. The technologies are initially evaluated for technical implementability based upon the findings in the SI report with respect to contaminant types, concentrations, and on-site characteristics. Those process options that are evaluated as not implementable, or of low implementability, at the Site are screened from further consideration. Surviving process options for retained remedial technologies are evaluated based on anticipated effectiveness and cost in Section 5.0 (EPA, 1988).

4.2.1 No Action

The No Action GRA is not further divided into technologies and process options. It includes the retention of some of the IRMs and the cessation of other IRMs, as discussed in Section 4.1.1. The No Action GRA provides a basis for comparison of other remedial alternatives and it is therefore retained for the development of remedial alternatives.

4.2.2 Institutional Controls

ICs are administrative mechanisms that limit certain activities thereby preventing or limiting exposure to COPCs. ICs may be used alone or in conjunction with other alternatives as part of an overall site remedy. ICs are meant to supplement engineering controls and may be a necessary component of the selected remedy. Typical options include governmental land use regulations, such as zoning and floodplain regulations, groundwater use controls, restrictive covenants restricting use and access and requiring management of lands, easements, environmental control easements, dedicated developments, and information tools. They may be public controls (such as zoning codes or subdivision restrictions) or they may be private controls (such as restrictive covenants). ICs are applicable to both solid and aqueous media.

There are four main categories of ICs:

- Government land and water use controls;
- Proprietary controls;
- Enforcement and permit tools; and
- Information devices.

A more detailed description of the four categories of ICs identified for potential use at the Site, and their respective options are provided in Sections 4.2.2.1 through 4.2.2.4. ICs are readily implementable. Therefore, each of the described IC options is retained for further consideration in the development of Site remedial alternatives.

4.2.2.1 overnmental Land and Water Use Controls

Governmental land and water use controls may include zoning regulations, groundwater use controls, and surface water use controls. Zoning regulations can protect the health, safety, and general welfare of the people by specifying the level of development allowed on the Site. Application of this IC to the Site could limit access and/or restrict certain land uses and subsequently reduce potential human exposure to COPCs. These regulations could also be used to impose restrictions on groundwater use. Public groundwater use controls may be applied at the local or state level as well as surface water use controls (e.g., irrigation).

4.2.2.2 Proprietary Controls

Proprietary controls relate to property rights that generally are held by private parties but also may be held by governmental entities. Proprietary controls that can limit the potential for human exposure to COPCs include easements, restrictive covenants, environmental control easements, conservation easements, and dedicated developments. Once appropriately applied, this IC process option can preempt other inappropriate land uses and restrict or reduce human exposure to COPCs.

4.2.2.3 En orcement and Permit Tools

Depending on the regulatory setting of a given site, Unilateral Administrative Orders ("UAOs"), Consent Administrative Orders, and consent decrees can be issued or negotiated to compel the land owner to limit certain site activities. Typically, these ICs contain provisions that require the signatories to implement long-term ICs (e.g., informational devices or proprietary controls) and/or they contain documentation that substantiates a regulatory entity's authority to hold the signatories liable for the implementation and enforcement of ICs such as covenants and local ordinances.

4.2.2.4 In ormation Devices

Information devices are typically documents that relay the presence of contamination at a given to current and/or future land users. Information devices may include deed notices, public information programs (including brochure distribution and newspaper ads), and property mapping and cataloging services.

4.2.3 Containment

This GRA consists of containment measures to prevent or limit exposure to impacted media. Several technologies and process options within the Containment GRA are identified and considered for alternative development. Some of the technologies are applicable to both solid and aqueous media while some are applicable to only one media type. The following subsections describe the screening of technologies and process options within this GRA and media sources to which they may be applicable.

4.2.3.1 Engineered Covers

Engineered covers are commonly used to prevent direct contact with materials containing COPCs above levels of concern. They are also used to limit or prevent oxidation in mine spoil material and to reduce infiltration and erosion, thereby reducing the release of metals and acid that may potentially impact groundwater and surface water. There are various types of engineered covers and the most appropriate type for a given setting is dependent on many factors including but not limited to climate, availability of materials, hydrogeology, waste reactivity, and associated risk for release of COPCs. The major types of engineered covers include: soil covers, rock covers, layered covers, multimedia covers, and asphalt or concrete covers. Engineered covers are implementable and this remedial technology is retained for further consideration in the development of Site remedial alternatives.

4.2.3.2 Wet Closure

Wet closure is primarily applicable to solid media and consists of flooding discrete areas of impacted solid media. Wet closure is a potentially effective means of reducing the oxidation and potential mobilization of inorganic constituents. It is frequently incorporated in the design of waste impoundments at new and expanding mining operations. Wet closure areas also provide sediment control by settling particles, thereby limiting the downstream movement of solid material. Wet closure is implementable. The Site topography is generally not amenable to wet closure of large areas of mine spoil or tailings. However, it may be possible to limit ARD production from limited quantities of spoil by placing it in the south arm of the pit lake. Such placement would necessitate consideration of whether the stratification of the pit lake would be disrupted. In addition, previously generated treatment sludge at the Site may appropriately be addressed through wet closure. Therefore, this technology is retained for future consideration in the development of Site remedial alternatives.

4.2.3.3 radient Control

The gradient control remedial technology is applicable to groundwater only. Gradient controls are used to develop a hydraulic barrier to groundwater flow by creating a mound or depression in the water table, thus modifying local groundwater flow patterns. Water may be injected into or extracted from the aquifer using interception trenches or injection/extraction wells. Trenches are more effective for areas with a shallow groundwater table or low-permeability soils, while wells are more feasible for sites with a greater depth to groundwater. Gradient control (shallow groundwater capture) is being used at the Site as an IRM for the Chamberlain Creek headwaters. Gradient control is implementable and is retained for consideration in the development of Site remedial alternatives.

4.2.3.4 Barriers

Vertical barriers can be used to control migration of COPCs in groundwater. Low permeability cutoff walls or diversions may be installed below ground to contain, capture, or redirect groundwater flow. There are three major types of barriers: slurry walls, sheet piling, and rock grouting. Slurry walls are the most common subsurface barriers because they use conventional technology and are a relatively cost-effective means of reducing groundwater flow in unconsolidated earth materials. A slurry wall is constructed by blending a soil mixture with a bentonite slurry and placing the mixture in a vertical trench. Sheet piling is a physical barrier (steel, concrete, or wood) that is placed in the subsurface. It is typically more expensive than a slurry wall and it can be difficult to seal the joints between sheets. Rock grouting or grout curtains are subsurface barriers created in fractured or unconsolidated materials by pressure injection of a low permeability grout mixture.

Due to the structural geology (e.g., fractured bedrock) and topography of the Site, barriers are of low implementability and gradient control, as described in the previous subsection, would be a more viable remedial technology. Therefore, the barrier technology is screened out from further consideration in the development of Site remedial alternatives.

4.2.3.5 Sediment Control Features

Sediment control features may be used to reduce or eliminate the loading of sediment in a stream or to minimize the movement of sediments already in the channel. Process options for the sediment control remedial technology include dikes or berms, detention basins, and coffer dams. Sediment control features are readily implementable and this remedial technology is retained for further consideration in the development of Site remedial alternatives.

4.2.4 Source Control, Flow Control, and Routing

Source control, flow control, and routing GRAs consist of active measures to manage solid and aqueous media that come in contact with source materials. These technologies limit COPC transport to surface water. Source controls, flow control, and routing can be utilized as stand-alone technologies or in conjunction with other technologies. The remedial technologies within in this GRA include:

- Surface controls;
- Slope stabilization; and,
- Diversion

Some of these technologies are applicable to both solid and aqueous media while some are applicable specifically to either solid or aqueous media. The following subsections describe the screening of technologies and process options within this GRA.

4.2.4.1 Sur ace Controls

Surface control process options include grading, erosion control and protection, and vegetation. These process options are applicable to solid media, but can also provide benefits for aqueous media by reducing/eliminating release of metals from the solid media into groundwater or surface water. Surface controls are readily implementable and this remedial technology is retained for further consideration in the development of Site remedial alternatives.

4.2.4.2 Slope Stabilization

Slope stabilization process options include slope reduction and retaining walls. This process option is generally used in conjunction with other technologies or process options in Containment and/or Source Control, Flow Control, and Routing GRAs and is only applicable to solid media. Slope stabilization is implementable and is retained for further consideration in the development of Site remedial alternatives.

4.2.4.3 Diversion

Diversion consists of routing or managing flow within open channels or closed conduits. Flow can be diverted to open surface water bodies, sedimentation basins, or treatment systems. Surface water diversion may increase or decrease flows in specific areas. Additionally, diversion may be used to route treated water to receiving water bodies that have appropriate assimilative capacities and offer mixing zones. This GRA is applicable only to aqueous media. Diversion is implementable and is retained for further consideration in the development of Site remedial alternatives.

4.2.5 Removal

Several removal technologies are potentially available for both solid and aqueous media at the Site:

- Solid media excavation;
- Aqueous media collection; and,
- Aqueous and solid media disposal.

These removal technologies and associated process options are described in Sections 4.2.5.1 through 4.2.5.3. The following subsections also describe the screening of technologies and process options within this GRA.

4.2.5.1 Solid Media E cavation

Excavation involves physical removal and transport of solid or semi-solid materials from one location to another, typically using conventional earthmoving equipment. This technology can be combined with technologies or process options from other GRAs such as containment or treatment. Solid media excavation is implementable and it is retained for further consideration in the development of the Site remedial alternatives.

4.2.5.2 A ueous Media Collection

Process options for aqueous media collection technology include extraction wells and collection trenches. These process options are also discussed in Section 4.2.3.3 (Gradient Control). Once collected, groundwater may be either treated as described in Section 4.2.6, or disposed of as described in Section 4.2.5.3. Aqueous media collection is implementable and is retained for further consideration in the development of Site remedial alternatives.

4.2.5.3 A ueous and Solid Media Disposal

Disposal process options for aqueous and solid media include on-site disposal, on-site consolidation, and off-site disposal. These process options are implementable and are retained for further consideration in the development of Site remedial alternatives.

Deep well injection is also a process option for aqueous media disposal. This process option would primarily pertain to the water in the mine pit lake at the Site. A typical deep well injection system often extends several thousand feet below the ground surface into highly saline (>10,000 mg/L TDS), permeable injection zones that are confined vertically by impermeable strata. The aqueous media is injected under pressure into the permeable injection zone. The Remediation Technologies Screening Matrix (Deuren et al., 2002) lists the generic limitations of this process option:

- The aqueous media injected must be compatible with the mechanical components of the injection well system and the natural formation water;
- It is only implementable if a highly permeable zone is encountered with confining strata above and below capable of accepting the aqueous media volume currently at the Site and what will be generated in the future;
- The aqueous media must have low iron concentrations or fouling/plugging may result due to iron oxidation and precipitation;

- The suspended solids concentration of the aqueous media to be injected must be very low (< 2 ppm) or fouling/plugging may occur;
- Site assessment and aquifer characterization are required to determine if the Site is suitable for deep well injection; and
- Extensive assessments must be completed prior to receiving approval from the regulatory agencies.

The Arkansas Underground Injection Control ("UIC") Code (APCEC 2005) adopts many federal regulations regarding underground injection of hazardous wastes (40 CFR Part 144, 40 CRF Part 145, 40 CFR Part 124 [Subpart A], and 40 CFR Part 146 [Subparts A, B, D, E, F, and G]). The Arkansas UIC Code follows 40 CFR 144.6 in classifying this type of injection well as Class I injection well (i.e., industrial disposal wells which inject fluids beneath the lowermost formation containing, within one-quarter mile of the well bore, an underground source of drinking water). 40CFR144.3 defines an "underground source of drinking water" as "an aquifer or its portion: (a)(1) which supplies any public water system; or (2) which contains a sufficient quantity of ground water to supply a public water system; and (i) currently supplies drinking water for human consumption; or (ii) contains fewer than 10,000 mg/L total dissolved solids; and (b) which is not an exempted aquifer."

It is possible that a permit can be obtained for a Class I injection well at the Site. However, it is unknown if a geologic formation exists beneath the Site that meets the above criteria to operate a Class I injection well for disposal of pit lake water. Evaluation of data from the Arkansas Oil & Gas Commission web site[6] indicates that, though oil and gas wells are located within a few miles of the Site, no associated injection wells for the brines typically produced by oil and gas production are present within 50 miles of the Site. This suggests that a suitable subsurface injection zone is not present in the Site vicinity. In any event, exploratory deep drilling and testing would be required to determine if this process option could be implemented.

Underground injection could be an alternative only for untreated pit lake water because, if cost and effort are expended to initially treat the pit lake water but treatment goals are not achieved, further cost and effort would need to be directed toward further treatment rather than disposal by underground injection. The untreated pit lake water chemistry and the geochemistry of the receiving strata may not be compatible. For instance, the pit lake iron concentrations are relatively high. If the acidic pit lake water were to be introduced to a more circum-neutral groundwater system, precipitation of iron would likely cause fouling/plugging around the injection point and the acidic pit lake water may erode and/or plug the strata (e.g., limestone armoring with gypsum). Additionally, this process option would likely only be implementable for

[6] http://www.aogc.state.ar.us/JDesignerPro/JDPArkansas/default.htm

maintaining the pit lake elevation and not for draining the pit lake due to the significant amount of water that would require injection and the corresponding length of time needed. If the injection system were to fail or shut down due to leakage of injected water into the overlying underground source of drinking water, the pit lake would begin to rise, requiring either a new injection well or implementation an alternative process option (e.g., operation of the existing WTS). Finally, underground injection of the pit lake water would have the undesirable effect of permanently removing this water from the hydrologic cycle. For these reasons, deep well injection will not be retained for further consideration in the development of Site remedial alternatives.

4.2.6 Treatment

Technologies considered for application to impacted Site aqueous and solid media under the Treatment GRA are divided into three categories:

- Biological treatment;
- Chemical treatment; and
- Physical treatment.

Unless performed in-situ, treatment of impacted solid or aqueous media would be preceded by the implementation of one or more of the removal technologies described in Section 4.2.5. Treatment technologies and associated process options considered for development of remedial alternatives are described in Sections 4.2.6.1 through 4.2.6.3.

4.2.6.1 Biological Treatment

Biological treatment is typically used for aqueous media to degrade organic compounds or to degrade or change the chemical state of inorganic compounds to more stable, less mobile, and/or less toxic forms. Bio-sorption and biological sulfide precipitation are biological process options identified and considered for remediation of aqueous media at the Site. This process option is not applicable to solid media because of the difficulty in effectively reducing the diffusion of oxygen through mine spoils and tailings. Biological treatment would be most applicable to the mine pit lake at the Site as an in-situ treatment through the addition of nutrients to stimulate biological activity. However, biological treatment of the pit lake in the absence of pH modification will not be effective. In addition, biological treatment using constructed wetlands or possibly a bioreactor to promote biological sulfide precipitation could be used to treat localized runoff flows from key areas and/or as a polishing step for pit lake water that has been neutralized in situ. Biological treatment is retained as a supplemental option for in-situ neutralization of the pit lake.

4.2.6.2 Chemical Treatment

Several chemical treatment process options are considered for application to both solid and aqueous media. Chemical treatment process options considered for impacted solid media include both ex-situ and in-situ solidification/stabilization and process options considered for impacted aqueous media include hydroxide precipitation, sulfide precipitation, and ion exchange.

Solidification/stabilization reduces the mobility of the contaminants by physical and chemical processes that encapsulate not only the contaminants but also the ‘host’ material with which the contaminants are associated. This process option can be completed both in-situ and ex-situ using techniques such as vitrification in which a high electrical current is forced through the solid media creating extremely high temperatures resulting in conversion of the media to glass thereby trapping the contaminants in a leach-resistant matrix. Due to the large volume of contaminated media at the Site (several million cubic yards), this process option would not be implementable and it is therefore screened out from further consideration in the development of Site remedial alternatives.

Hydroxide precipitation is a process option that removes dissolved inorganics (e.g., metals and metalloids) from aqueous media by raising the pH of the solution and precipitating metal hydroxides. There are many different reagents available for increasing the pH including sodium hydroxide, lime (calcium oxide), and magnesium oxide. Each metal has a specific pH at which it is least soluble as a hydroxide so there are some instances where a multi-stage treatment approach must be taken to achieve water quality objectives. The limitation of this process option is that some metalloids do not form hydroxide precipitates. Although hydroxide precipitation can be applied both in-situ and ex-situ, it is most commonly employed ex-situ within an engineered WTS similar to the current WTS. This process option is implementable and is retained for further consideration in the development of Site remedial alternatives.

Chemical sulfide precipitation removes dissolved inorganics from aqueous media by adding a sulfide reagent (typically sodium sulfide or calcium sulfide) to form insoluble metal sulfides similar to hydroxide precipitation. Sulfide reagent can be added both in-situ and ex-situ, however, the toxicity of hydrogen sulfide gas limits its applications in an in-situ setting to low dosages accompanied by air monitoring. Metal sulfide precipitates are less soluble than their metal hydroxide equivalents and the pH range where they are insoluble, and hence of low mobility, is larger than for metal hydroxides. The major limitations to this process option revolve around the toxicity of sulfide/hydrogen sulfide gas. Due to these limitations, sulfide precipitation is not considered to be implementable and therefore is screened out from further consideration in the development of Site remedial alternatives.

Ion exchange removes dissolved inorganics from aqueous media by adsorbing the metal ions onto reactive media while simultaneously exchanging major cations/anions (e.g. sodium, potassium, chloride, and carbonate). The metal ions have a higher affinity for the ion exchange media than do the major ions, thus metal ions are retained while the major ions are released. Once all of the sorption sites are filled, the media is spent and needs to be regenerated using a major ion brine solution. The metal ions are forced off of the ion exchange media due to the overwhelming presence of the major ions in the brine solution. The metals ions contained in the waste brine solution, which typically comprises up to 30 percent of the volume of the water being treated, must be disposed of as an aqueous solution or treated further. Disposal of this brine is often problematic unless a suitable disposal option exists nearby (e.g., the ocean). Ion exchange is significantly more expensive than either of the precipitation methods described above. Another limitation is that the metal ions compete for the same sorption sites and this competition may reduce the effective regeneration cycle life of the ion exchange media. Due to the difficulties associated with disposal of the brine waste stream and the high reactive media costs compared to hydroxide precipitation, this process option is not implementable and it is screened out from further consideration in the development of Site remedial alternatives.

4.2.6.3 Physical Treatment

Physical treatment encompasses various process options that remove contaminants from the ‘host’ media by separation, soil washing, or solidification/stabilization. Physical treatment methods are most effective when the contaminant has a unique physical property when compared to the ‘host’ medium.

Separation process options include gravity separation, magnetic separation, sieving/physical separation for solid media, and reverse osmosis for aqueous media. All of the process options for solid media revolve around exploiting a physical difference between the contaminant and the ‘host’ medium either by density, magnetic properties, or size. Reverse osmosis uses high pressure and a membrane with a very fine pore size to force water through while retaining all ionic species including both major ions and metal ions. The resulting brine solution containing all of the contaminants, comprising up to 30 percent of the original waste stream, requires disposal. Reverse osmosis can be prone to fouling when the total dissolved solids concentration is high.

Since the contaminants at the Site are found throughout the solid media host material, separation process options for solid media would not be effective and therefore these process options are screened out from further consideration in the development of Site remedial alternatives. Additionally, the high TDS and metals concentrations in the majority of contaminated water at the Site, and the difficulties associated with disposal of the resultant brine stream, preclude the use of reverse osmosis as an effective process option for treatment of aqueous media.

Soil washing process option involves excavating the soil, washing the soil with additives and/or detergents to transfer the contaminants for the host medium to the wash water. This process option is only appropriate where the contaminants are not native to the host medium and are strictly adsorbed. At the Site, the contaminants are native to the geologic formation, thus soil washing would not be an effective process option. Therefore, soil washing is not implementable and this process option is screened out from further consideration in the development of Site remedial alternatives.

4.3 Summary o Retained Technologies and Process Options

A summary of the initial screening process is shown on Figure 4-2. Remedial technologies and process options retained for the development of Site remedial alternatives are shown on Figure 4-2 and listed below:

- No action
- ICs (government controls, proprietary controls, enforcement and permit tools, and information devices)
- Containment (engineered covers, wet closure, gradient control, sediment control)
- Source control, flow control, and routing (surface controls, slope stabilization, and diversion, including potential piping of discharge to mixing zones in relatively large receiving water bodies)
- Removal (solid media excavation, aqueous media collection, aqueous and solid media disposal)
- Treatment (chemical [hydroxide precipitation] and biological [e.g., constructed wetland treatment as a supplement to chemical treatment])

Section 4 Figures

FIGURE 4-1
IDENTIFICATION OF CANDIDATE TECHNOLOGIES
DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILITY STUDY

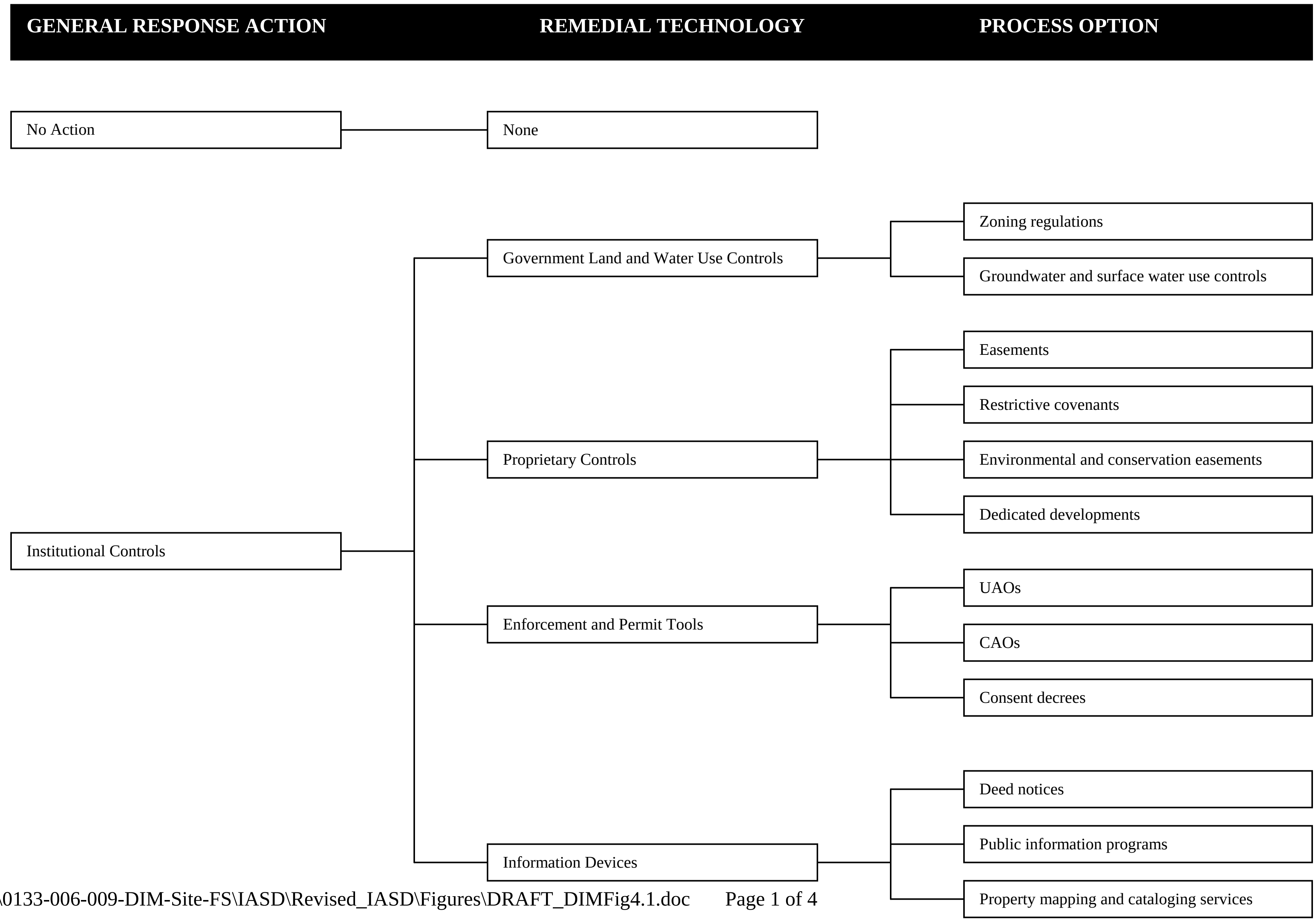


FIGURE 4-1
IDENTIFICATION OF CANDIDATE TECHNOLOGIES
DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILITY STUDY

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION

- Containment
  - Engineered Covers
    - Soil covers
    - Rock covers
    - Layered covers
    - Multimedia covers
    - Asphalt covers
    - Concrete covers
  - Wet Closure
    - Flooding areas of impacted solid material
  - Gradient Control
    - Create mound or depression in water table
  - Barriers
    - Slurry walls
    - Sheet piling
    - Rock grouting
  - Sediment Control Features
    - Dikes or berms
    - Detention basins
    - Coffer dams

FIGURE 4-1
IDENTIFICATION OF CANDIDATE TECHNOLOGIES
DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILITY STUDY

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION

- Source Control, Flow Control and Routing
  - Surface Controls
    - Grading
    - Erosion control and protection
    - Vegetation
  - Slope Stabilization
    - Slope reduction
    - Retaining walls
  - Diversion
    - Routing or managing flow in open channels
    - Routing or managing flow in closed conduits
- Removal
  - Excavation
    - Removal and transport of solid material
  - Collection
    - Extraction wells
    - Collection trenches
  - Aqueous and Solid Media Disposal
    - On-site disposal
    - On-site consolidation
    - Off-site disposal
    - Deep well injection

FIGURE 4-1
IDENTIFICATION OF CANDIDATE TECNOLOGIES
DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILITY STUDY

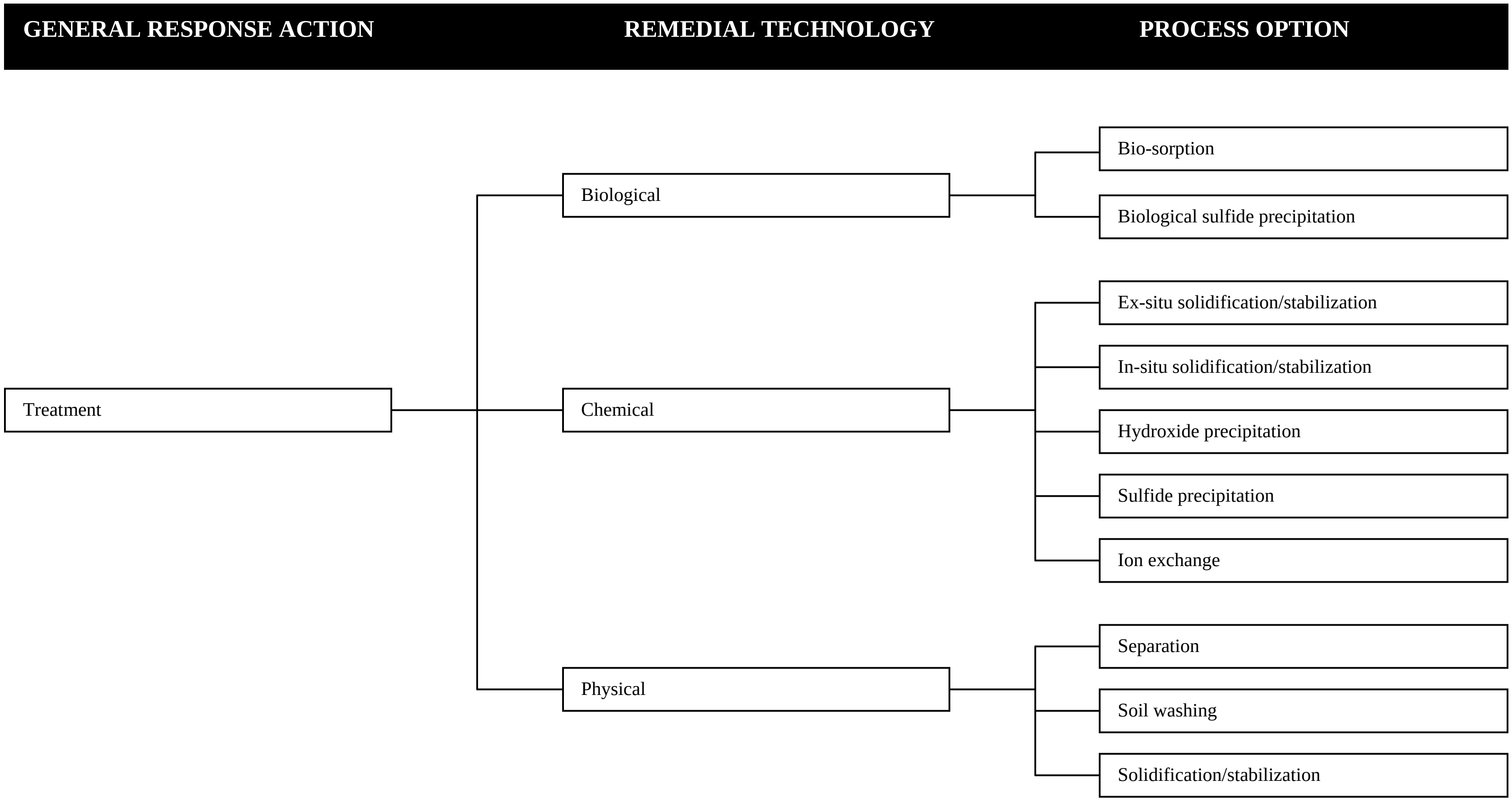


FIGURE 4-2
SCREENING OF CANDIDATE TECHNOLOGIES
DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILITY STUDY

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION

- No Action
  - None
- Institutional Controls
  - Government Land and Water Use Controls
    - Zoning regulations
    - Groundwater and surface water use controls
  - Proprietary Controls
    - Easements
    - Restrictive covenants
    - Environmental and conservation easements
    - Dedicated developments
  - Enforcement and Permit Tools
    - UAOs
    - CAOs
    - Consent decrees
  - Information Devices
    - Deed notices
    - Public information programs
    - Property mapping and cataloging services

FIGURE 4-2
SCREENING OF CANDIDATE TECHNOLOGIES
DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILITY STUDY

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION
Containment	Engineered Covers	Soil covers
		Rock covers
		Layered covers
		Multimedia covers
		Asphalt covers
		Concrete covers
	Wet Closure	Flooding areas of impacted solid material
	Gradient Control	Create mound or depression in water table
	Barriers	Slurry walls
		Sheet piling
		Rock grouting
	Sediment Control Features	Dikes or berms
		Detention basins
		Coffer dams

FIGURE 4-2
SCREENING OF CANDIDATE TECHNOLOGIES
DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILITY STUDY

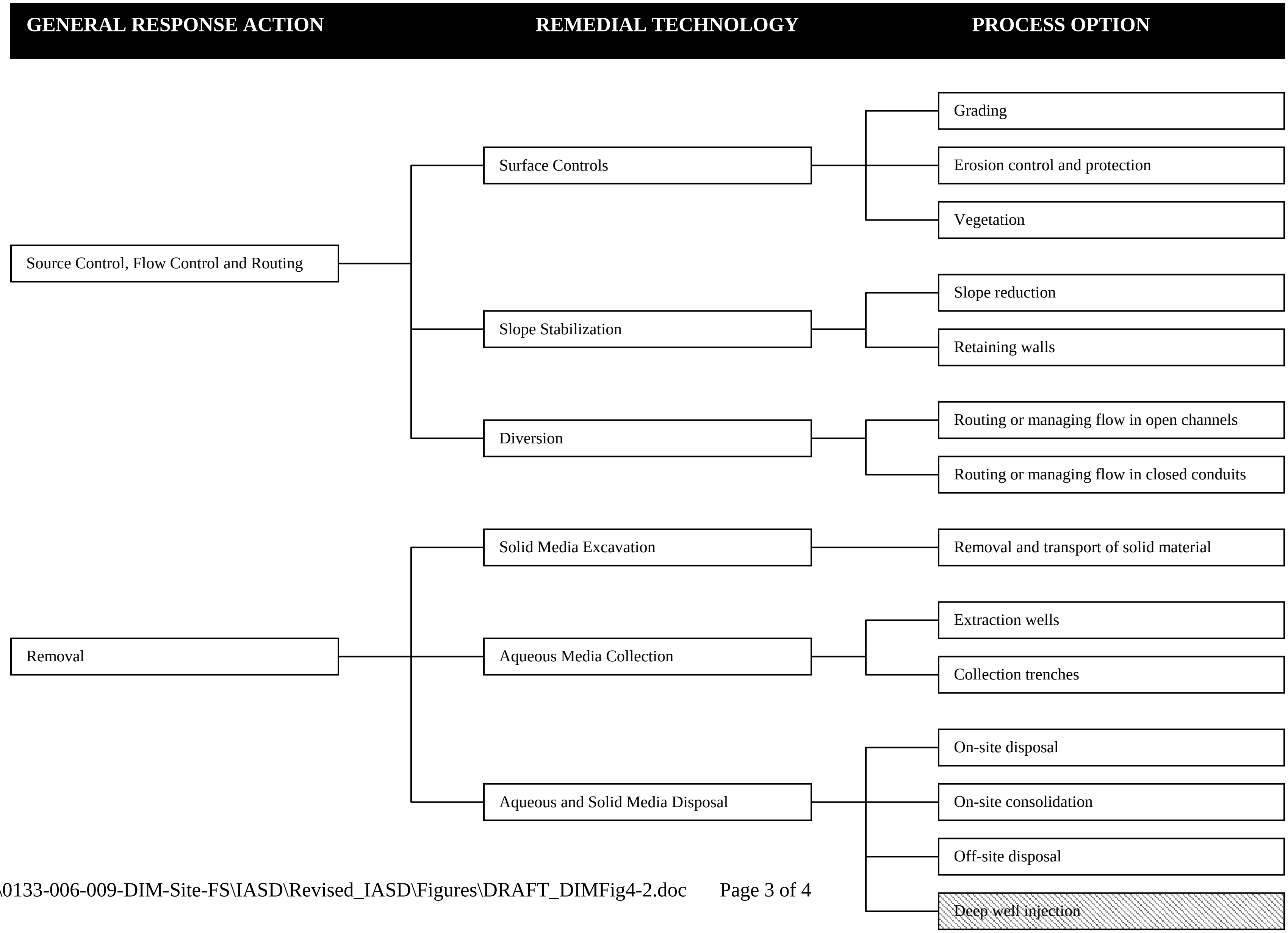
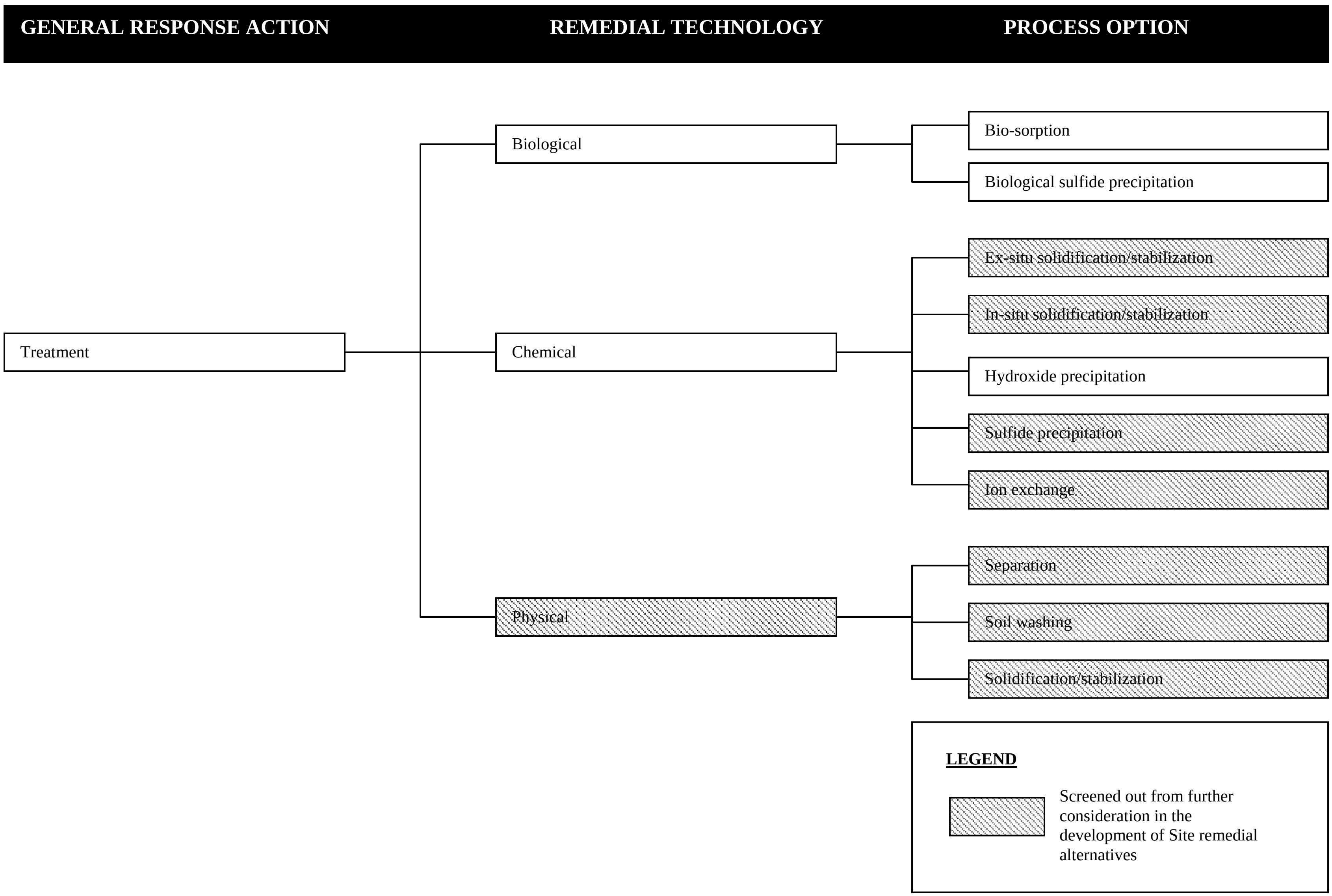


FIGURE 4-2
SCREENING OF CANDIDATE TECHNOLOGIES
DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILTY STUDY



5.0 DE ELOPMENT AND SCREENIN OF ALTERNATI ES

In this section, those technologies and process options that survived the initial screening process presented in Section 4.0 are grouped into area-specific alternatives, which are then screened based on their relative criteria of effectiveness, implementability, and cost (Sections 5.1 and 5.2). Subsequently, a range of remedial alternatives is developed by grouping the area-specific alternatives in accordance with NCP requirements and EPA guidance (Section 5.3).

As described in Section 4.0, technologies and process options were developed to address specific sources of contaminants that may impact human health and/or the environment. The development of remedial alternatives for the Site can most effectively be performed by first developing area-specific alternatives for the contaminant sources identified above within two major areas: within the Pit Lake/Chamberlain Creek Watersheds, and areas outside the Pit Lake/Chamberlain Creek Watersheds. This distinction is maintained because the two most significant Site features, the pit lake and the spoil piles, are located within the Pit Lake/Chamberlain Creek Watersheds.

Within the Pit Lake/Chamberlain Creek Watersheds, there are six areas that will be discussed in Section 5.1 (see Figure 1-1 for Site features and Figures 3-1 and 3-2 for shallow and bedrock groundwater, respectively):

- pit lake,
- spoil piles,
- shallow groundwater,
- bedrock groundwater,
- sludge ponds, and
- Chamberlain Creek.

The settling ponds are also present within the Pit Lake/Chamberlain Creek Watersheds. However, the settling ponds were not identified as a source of risk to either human health or the environment during the SI. Further, treatment sludge present in the bottom of the Settling Ponds is submerged and thus is already addressed through the retained process option of wet closure (see Section 4.2.3.2). Therefore, remedial alternatives are not developed for the settling ponds.

Outside of the Pit Lake/Chamberlain Creek Watersheds, there are three distinct areas to be addressed (see Figure 1-1 for the tailings impoundments and Clearwater Lake and Figure 3-3 for affected streams):

- Tailings impoundments,
- Affected streams, and
- Clearwater Lake.

This section is organized as follows. Section 5.1 describes and screens the area-specific alternatives within the Pit Lake/Chamberlain Creek Watersheds. Section 5.2 describes and screens the area-specific alternatives outside of the Pit Lake/Chamberlain Creek Watersheds. Section 5.3 describes the subsequent development of Site-wide remedial alternatives assembled from the surviving area-specific alternatives.

5.1 Development and Screening o Area Speci ic Alternatives Within Pit Lake/Chamberlain Creek Watersheds

This section identifies and screens remedial alternatives for the six specific areas of concern within the Pit Lake/Chamberlain Creek Watersheds.

- pit lake,
- spoil piles,
- shallow groundwater,
- bedrock groundwater,
- sludge ponds, and
- Chamberlain Creek.

The screening process involves evaluating the defined alternatives against the 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, particularly those with high relative costs.

5.1.1 Pit Lake Alternatives

The pit lake is a dominant feature at the Site containing nearly 4 billion gallons of acidic water with elevated metals and minerals concentrations. The physical/chemical structure of the pit lake is that of a permanently stratified lake that contains three distinct layers. The top layer, with a thickness of approximately 70 to 80 feet, is separated from the 300-foot-thick bottom layer by a transition layer that is approximately 60 feet thick. Mixing between the layers occurs only minimally and at the layer boundaries. The bottom layer contains the highest concentrations of dissolved minerals and is, therefore, the densest of the three layers. There are four alternatives identified for the pit lake: No Action (PL1), Operate Existing WTS and Maintain Pit Level (PL2), In-Situ Neutralization and Maintain Pit 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 5.1.1.4).

5.1.1.1 PL1 No Action

The No Action alternative for the pit lake (PL1) would include cessation of pumping and treatment of the pit lake water. The existing levees installed as IRMs would remain in place. The result of this alternative would be continued natural filling of the pit lake due to direct precipitation, run-on, and seepage from the surrounding spoil piles, culminating in an uncontrolled discharge of the pit lake water into the headwaters of Chamberlain Creek via a surface discharge, likely also impacting shallow groundwater.

The PL1 alternative would not be effective at reducing risk to human health or the environment. However, this alternative would be easily implementable and there would be no cost. It is retained for inclusion in the Site-wide No Action Alternative which will provide a baseline for evaluation of other alternatives.

5.1.1.2 PL2 Operate E isting WTS and Maintain Pit Water Level

The Operate Existing WTS and Maintain Pit Level alternative for the pit lake (PL2) would entail continued pumping and treating of the pit lake water along with continued pumping of the collected groundwater from the Chamberlain Creek headwaters to the pit lake. To maintain a target lake surface elevation, the volume of water treated (on an annual basis) would be approximately equivalent to the net volume added to the pit lake by precipitation and runoff/seepage from adjacent areas during a given year. The target elevation would be lower than the lowest bedrock elevation along the rim of the pit to eliminate seepage through the base of the adjacent spoil piles (estimated to be approximately 605 feet above sea level). A pit lake surface elevation of approximately 595 feet is expected to eliminate such seepage and to also provide approximately 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). The discharge rate 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 current permit limits for metals, but the current temporary standards for minerals in Chamberlain and Cove Creeks would need to be maintained or modified through the UAA process, as contemplated by the existing CAO.

The PL2 alternative has proven to be effective at reducing risk to human health and the environment. This alternative has been implemented (i.e., the capital costs have been expended) and the cost to continue its operation is moderate. This alternative is retained for inclusion in the development of the Site-wide remedial alternatives.

5.1.1.3 PL3 In Situ Neutralization and Maintain Pit Level

The In-Situ Neutralization and Maintain Pit Level alternative for the pit lake (PL3) would entail in-situ chemical treatment using hydrated lime to neutralize the pH of the pit lake's upper layer, addition of fertilizer to promote biological treatment mechanisms, and gravity discharge of the water into the headwaters of Chamberlain Creek via a surface discharge. The existing levees installed as IRMs will remain in place, however operation of the existing WTS would be discontinued. Though neutralization of the upper layer of the pit lake has the potential to reduce metal concentrations to levels that would allow discharge in accordance with approved limits, minerals levels 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 (Cove Creek). Continued dilution by rainwater, however, 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.

The in-situ chemical treatment would not only neutralize the pit lake water but also precipitate/co-precipitate the COPCs which would ultimately settle to the bottom of the 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 the 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 the pit lake 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. The treatment technology (neutralization through lime addition) has been identified as being potentially effective on water from the pit lake through the on-going WTS operation and in-situ treatment of mine pit lakes has been implemented at other sites, though at lakes with significantly smaller water mass than the Site pit lake.

The effectiveness of this technology in terms of consistently meeting permit limits for the Site pit lake 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 (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. This technology could be combined with a polishing treatment step, such as biological sulfide precipitation in a constructed wetland treatment system to effect additional metals removal. However, constructed wetland treatment systems typically perform best when flow rates are relatively uniform. Implementation of a hydrographically controlled release through a constructed wetland treatment system would thus present engineering challenges in terms of storing the large volumes of treated water prior to hydrographically controlled release. Diversion of the neutralized water via pipeline to a larger receiving water body (e.g., Cove Creek) that would provide a mixing zone and correspondingly higher discharge limits for metals could be implemented instead of, or in combination with, polishing in a constructed wetland. 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 is required.

The PL3 alternative is retained for inclusion in the development of the Site-wide remedial alternatives.

5.1.1.4 PL4 Operate E isting 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 lake water. The WTS would treat and discharge the maximum allowable flow rate (hydrographically-controlled, as per Exhibit A of the CAO) 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 to estimate the amount of time that would be required to drain the pit lake. This model is described in Appendix A. Due to the large volume of water within the pit lake (~4 billion gallons) and the hydrographically-controlled release, complete draining of the pit lake would require a minimum of several decades and may not even be possible. As the water level is drawn down, evaporation from the pit lake surface will decrease due to a reduction in surface area and an increase in shelter from wind by the pit walls. Additionally, the newly exposed high walls (formerly below the water level) would contribute additional acidic runoff to the shrinking pit lake. This additional runoff would likely result in further degradation of the pit lake water quality. Higher mineral concentrations in the lower layer of the pit lake, relative to those in the upper layer, would decrease the rate of water withdrawal in order to maintain compliance with discharge requirements. Treated lower layer water with higher mineral concentrations would likely be toxic to aquatic biota and prevent further discharge and draining the pit lake without the benefit of an appropriate mixing zone in the receiving water body to address the higher minerals concentrations.

The PL4 alternative would be effective at reducing the risk the 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, it would take several decades to implement, it would require a diversion pipeline at least to Cove Creek, and it may not be possible to entirely drain the lake, resulting in questionable implementability. The cost of this alternative would be high. Based on these factors, the continuation of generation of ARD, and the likely water quality impact issues associated with placement of the spoil and tailings in the drained pit, (see Sections 5.1.2 and 5.2.1), this alternative (PL4) is eliminated from inclusion in the development of Site-wide remedial alternatives.

5.1.2 Spoil Piles Alternatives

The mine spoil primarily comprises black marine shale of the Stanley Formation that was stripped 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 from the spoil. There are approximately 20.5 million cubic yards of spoil present at the Site, and much of the area (50-70 percent) is now covered in varying densities of vegetation (mostly pine). Little to no grading was performed during or after 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 Watersheds. 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 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). 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 them 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 run-off and infiltration generating acid and dissolved metals that ultimately report to the pit lake, Chamberlain Creek, shallow groundwater within the Chamberlain Creek syncline, and off-site creeks. 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. However, this alternative would be easily implemented and the cost would be minimal. It is retained for inclusion in the Site-wide No Action Alternative which will provide a baseline for evaluation of other alternatives.

5.1.2.2 SP2 Selective Regrading, Augment egetation, and Capture ARD

The Selective Regrading, Augment Vegetation, and Capture ARD alternative for the spoil piles (SP2) would build upon and enhance the natural reclamation of the spoil that has occurred since mining ceased over 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. SP2 would entail selective regrading, where practical, to aid in reducing erosional transport of particles, directing surface runoff toward the 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. Over the short-term, regrading and planting may temporarily cause more infiltration in these specific areas due to the reduction of water being transpired by the pine trees and other existing vegetation. But, in the long-term, transport of contaminants from the spoil piles would be substantially reduced by these remedial measures.

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.[7] 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 prior to impacting 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.

The SP2 alternative would be moderately effective at reducing ARD generation. In the short-term, ARD generation would increase in those areas where regrading occurs but in the long-term ARD would be reduced 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 regrading and vegetation augmentation would be captured for subsequent treatment. This alternative (SP2) will be retained for inclusion of Site-wide remedial alternatives.

5.1.2.3 SP3 E tensive 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

[7] Such collection would actually occur outside of the Pit Lake/Chamberlain Creek Watersheds; however, the collected water would be directed to the pit lake.

generation; (3) applying a soil cover to the consolidated spoil to reduce infiltration, and (4) revegetating the consolidated spoil.

For the purposes of this FS, 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 the 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 14 million cubic yards of spoil because approximately 6.5 million cy of spoil are already present in the repository footprint area (Appendix B). 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 the pit lake. This alternative would require removal of the current coniferous forest from the spoil material before it is relocated/regraded. In the short term, 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. This alternative (SP3) will be retained for further consideration as a component for inclusion in the Site-Wide remedial alternatives.

5.1.2.4 SP4 Remove and Dispose in Drained Pit Lake

The Remove and Dispose in the Drained Pit Lake alternative (SP4) entails excavating all of the spoil material and placing it within the existing mine pit once drained. This alternative is only an option if alternative PL4 (Section 5.2.1.4) is implemented for the pit lake. Once the pit lake is drained (this could take decades if it is even possible; see Section 5.1.1), the spoil piles would be excavated and used to backfill the pit. A soil cover would be used to isolate the spoil material and reduce the mobility of the contaminants. Due to swelling/bulking of the spoils resulting from excavation, the backfilled pit surface would likely be mounded especially if this alternative is combined with alternatives TI3, which includes removal of tailings from the tailings impoundments and placement of the tailings in the drained pit (see Section 5.3.1.3). Runoff from the mounded area would report 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, the risk to the environment would be increased due to the factors discussed in Section 5.1.2.3. The material in the backfilled pit would eventually become saturated with groundwater, which 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 metal salts 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.

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.

Potentially poor water quality emanating from the backfilled pit could be mitigated, to some degree, by amending the spoil with lime or another neutralizing agent as the spoil is being placed in the mine pit. This could 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. Such treatment would increase the volume of material in the mine pit and increase the height of the resultant mound when backfilling is complete. Treatment of the spoil would add significantly to the cost of backfilling the pit both due to the added time needed to implement the amendment as well as the cost of the amendment itself.

Due to these factors and the difficulties, uncertainties, and high cost of draining the pit lake, this alternative (SP4) will not be retained for inclusion in the development of Site-wide remedial alternatives.

5.1.3 Shallow roundwater

The shallow groundwater zone within the Pit Lake/Chamberlain Creek Watersheds is present within the confines of the syncline downgradient from the pit lake, along Chamberlain Creek, and is underlain by the bedrock groundwater zone. Chamberlain Creek is hydraulically connected to the shallow groundwater zone and the creek gains flow from the shallow groundwater system throughout this portion of the Site. There are three 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). The approximate extent of the affected shallow groundwater is shown on Figure 3-1.

5.1.3.1 S W1 No Action

The No Action alternative (SGW1) entails discontinuing the existing capture/treatment system that collects shallow groundwater and pumps it into the 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 sediment.

The SGW1 alternative is not effective at reducing the risks to the environment. This alternative is implementable and it has minimal cost. It is retained for inclusion in the Site-wide No Action alternative which will provide a baseline for evaluation of other alternatives.

5.1.3.2 S W2 Operate E isting 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 to the pit lake. This system reduces the acidic water and COPCs that enter into Chamberlain Creek which would ultimately be transported downstream to Cove Creek or precipitate along the banks and streambeds. 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).

The SGW2 alternative 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 (SGW2) is retained for inclusion in the development of Site-wide alternatives.

5.1.3.3 S W3 E panded Capture/Treatment System

The Expanded Capture/Treatment System alternative (SGW3) would entail extending the existing capture system, or installing a new, larger system, to intercept a larger portion of the impacted shallow groundwater that would otherwise report to Chamberlain Creek. This expanded system would include french drains to collect the groundwater to be pumped to the 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).

The SGW3 alternative 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 reports to 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 (SGW3) is retained for inclusion in the development of Site-Wide remedial alternatives.

5.1.4 Bedrock roundwater

The bedrock groundwater zone within the Pit Lake/Chamberlain Creek Watersheds occurs within the Chamberlain Creek syncline. As discussed in Section 3.3.2, the bedrock groundwater system within the syncline is hydraulically isolated from groundwater systems outside of the syncline. Groundwater flow within the syncline occurs primarily in the Stanley Formation. The flow direction in the bedrock groundwater system is from the pit lake to the southwest, along the and down 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 alternatives considered for the bedrock groundwater zone: No Action (BGW1), Verify Connection to Municipal 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). The approximate extent of the bedrock groundwater system affected by the Site is shown on Figure 3-2.

5.1.4.1 B W1 No Action

The No Action alternative (BGW1) entails no additional activity to address the bedrock groundwater that is affected by the Site. The most recent sampling from two bedrock 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, therefore the BGW1 alternative is effective. This alternative is implementable and has no cost. It is retained for inclusion in the Site-wide No Action alternative which will provide a baseline for evaluation of other alternatives

5.1.4.2 B W2 eri y Connection to Municipal 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. Any residences in the affected area that are not connected to the municipal system would be provided with a connection. All of the residents in the potentially affected area would need to be contacted to implement this alternative.

As previously discussed, the impacts to the bedrock groundwater system are aesthetic in nature (objectionable odor, taste, etc.). 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 (BGW2) is retained for inclusion in the development of Site-wide alternatives.

5.1.4.3 B W3 Drain and Back ill Mine Pit

The Drain and Backfill Mine Pit alternative (BGW3) entails draining the 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 alternatives TI3 (Section 5.2.1.3). Implementation would take decades because of the time it would take to drain the pit lake, backfill it, and allow the water table to rebound within the backfilled material. As discussed in Section 5.1.2.4, the 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.

The BGW3 alternative would not be effective in terms of reducing ARD inputs to bedrock groundwater, would be difficult to implement, and would be of high cost. It will therefore not be retained for further consideration in the development of remedial alternatives.

5.1.5 Sludge Ponds Alternatives

When mining was active, a lime neutralization treatment process was utilized to remove metals from the water pumped from the mine pit prior to discharge. The 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 4.6 acres and comprise approximately 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 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

The No Action alternative (SLU1) 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 with limited ranges.

This alternative (SLU1) is not effective at reducing the risk posed by the sludge to the environment. Since this alternative includes no activities, it is implementable and there is no cost. It is retained for inclusion in the Site-wide No Action alternative which will provide a baseline for evaluation of other alternatives

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. The soil cover will isolate the sludge from contact by terrestrial receptors. The revegetation will limit erosion of the soil cover. This alternative would be effective, readily implementable, and the cost would be low. It is retained for inclusion in the development of Site-wide remedial alternatives.

5.1.5.3 SLU3 Removal with On Site Disposal

The Removal with On-Site Disposal alternative (SLU3) would entail relocation of the sludge to a different part of the Site. This alternative would be effective and it is readily implementable. 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 cost of this alternative, which would be moderate, cannot be justified relative to closing the sludge ponds in place with a revegetated soil cover (alternative SLU2). Therefore, this alternative is screened out from further consideration.

5.1.5.4 SLU4 Removal with O 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 the nearest 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 SI testing indicates the sludge is not particularly prone to leaching.

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. Given that the exposure pathways to the sludge can effectively be eliminated using an on-site soil cap at lower cost than off-site disposal, this alternative (SLU4) is screened from further consideration.

5.1.6 Chamberlain Creek Alternatives

Chamberlain Creek emanates from the southwest spoil area and flows west-southwest from the Site to the confluence with Cove Creek. Chamberlain Creek is a gaining stream in the vicinity of the Site. 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 shallow 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 C M1 No Action

The No Action alternative (CHM1) would entail performing no activities in Chamberlain Creek. This alternative would not be effective at reducing the risk to the environment if implemented with No Action alternatives for spoil piles and the pit lake. Since this alternative includes no activities, it is implementable and there is no cost. It is retained for inclusion in the Site-wide No Action alternative which will provide a baseline for evaluation of other alternatives.

5.1.6.2 C M2 Source Control

The Source Control alternative (CHM2) would include portions of many other area-specific alternatives such as the pit lake alternatives (PL2 or PL3), spoil pile alternatives (SP2 or SP3), and shallow groundwater alternatives (SGW2 or SGW3). All of these associated alternatives will 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.

The effectiveness of this alternative (CHM2) is highly dependent on which of the associated alternatives will be chosen. The same dependency will also dictate the implementability and cost for this alternative. This alternative (CHM2) will be retained as a component for inclusion in the Site-wide alternatives.

5.1.6.3 C M3 Source Control and Sediment Removal

The Source Control and Sediment Removal alternative (CHM3) would include source control measures in areas affecting Chamberlain Creek 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 the sediments would initially destroy any benthic macroinvertebrate communities present in Chamberlain Creek. If the associated alternatives chosen in the 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.

The removal of sediments from Chamberlain Creek could enhance the effectiveness of this alternative (CHM3) relative to alternative CHM2. Overall, the effectiveness of CHM3 is highly dependent on which of the associated alternatives will be chosen for the spoil piles and pit lake. The same dependency will also dictate the implementability and cost for this alternative. As summarized in Section 3.3.3, and discussed in detail in the SI Report, calculated hazard quotients for metals in the sediment of Chamberlain Creek and other streams affected by the Site are low (e.g., cadmium hazard quotient = 2 whereas those for other metals are 1 or less), indicating that, though there is an estimated unacceptable risk (e.g., hazard quotient >1), the potential for adverse effects is small. In addition, though their abundance and diversity are affected by the Site, benthic macroinvertebrates are present in Chamberlain Creek (SI Report and FTN, 2005). 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 Chamberlain Creek would create greater harm to the environment relative to leaving the sediment in place. Further, it is possible that some improvements in sediment quality could occur in Chamberlain Creek, depending on the nature and intensity of remedial actions in the headwaters area. For this reason, alternative CHM3 is eliminated from further consideration as a component for inclusion in the Site-wide alternatives.

5.1.7 Screening Summary Area Speci ic Alternatives Within the Pit Lake/Chamberlain Creek Watersheds

Table 5-1 provides a summary of the screening process for area-specific alternatives within the Pit Lake/Chamberlain Creek Watersheds, as detailed in the preceding subsections.

5.2 Development and Screening o Area Speci ic Alternatives Outside o Pit Lake/Chamberlain Creek Watersheds

Remedial alternatives developed for the portion of the Site outside of the Pit Lake/ Chamberlain Creek Watershed are 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).

The screening process involves evaluating the defined alternatives against the three broad criteria of relative effectiveness, implementability, and cost. The objective of the screening process is to eliminate alternatives of relatively low effectiveness and/or implementability, particularly those with high relative costs.

5.2.1 Tailings Impoundments Alternatives

There are four mill tailings impoundments on the Site (TP1 through TP4; Figure 1-1). They 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 TP4E dams. The impoundments contain both tailings and standing water with good vegetation cover over the dry tailings in most areas. Three of the impoundments are solely within the Reyburn Creek drainage, however, TP4 has two dams since it straddles two drainages (Reyburn Creek and Stone Quarry Creek). The majority of the tailings impoundment embankments are only marginally stable against slope failure based on geotechnical analyses presented in the SI Report. 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 80 acres and contain approximately 3.9 million cubic yards of tailings and 49 million gallons of moderately acidic water (pH~3-6). There are three 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

The No Action alternative (TI1) would entail no activities on the tailings impoundments. The 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 which could result in releasing water and/or tailings into the Reyburn Creek drainage. This alternative (TI1) is not effective at reducing the risk to the environment. This alternative is implementable and there are no costs. It is retained for inclusion in the Site-wide No Action Alternative.

5.2.1.2 TI2 Regrade, Stabilize Dams, Revegetate

The Regrade, Stabilize Dams, and Revegetate alternative (TI2) entails 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 the remedial design phase would be required to determine the most appropriate approach. For the purposes of FS evaluations, it is assumed that the TP3 tailings dam will be stabilized by buttressing since TP3 is full of tailings and the TP1, TP2, TP4E and TP4W dams will be stabilized by regrading since these impoundments are not full of tailings.[8]

This 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 retained for inclusion in the development of Site-wide remedial alternatives.

5.2.1.3 TI3 Remove and Dispose in Drained Pit Lake

The Remove and Dispose in Drained Pit Lake alternative (TI3) entails excavating and transporting all of the tailings (3.9 million cubic yards) into the drained pit lake, regrading the tailings impoundment area to match pre-mining topography, and revegetating the area.

This 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 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 5.1.1.4. Therefore, this alternative (TI3) is also screened out from inclusion in the Site-wide remedial alternatives.

5.2.2 A ected Streams Alternatives

The affected streams outside of the Pit Lake/Chamberlain Creek Watersheds include Rusher Creek, Lucinda Creek, Scull Creek, and Reyburn Creek. The run-off from the northern and northwestern spoil piles drains into Rusher Creek (which reports to Lucinda Creek) while run-off from the northeastern spoil piles reports to Scull Creek (which reports to Clearwater Lake and ultimately Reyburn Creek). During the SI, Rusher Creek was determined to be ephemeral and therefore this creek cannot support aquatic life, though flows in Rusher Creek can affect the water quality in Lucinda Creek. ARD seeps and runoff emanate from the northeast spoil piles, impacting the headwaters to 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 channelized stream with heavily cemented and embedded substrates. 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). The extents of the affected streams are shown on Figure 3-3.

[8] Tailings were removed from TP1 and TP2 for reprocessing whereas TP4 had not reached full capacity at the cessation of mining and milling.

5.2.2.1 AS1 No Action

The No Action alternative (AS1) entails no activities on streams or associated sources of COPCs (run-off from the spoil piles and tailings impoundments). This alternative (AS1) would not be effective at reducing the risk that the contaminants pose to the environment. This alternative is implementable and there is no cost. This alternative (AS1) will be retained as a component for inclusion in the Site-wide No-Action Alternative.

5.2.2.2 AS2 Source Control

The Source Control alternative (AS2) includes reducing or minimizing the contact between run-off and spoil piles or tailings impoundments prior to impacting the off-site streams. As such, the effectiveness of this alternative (AS2) relies on the area-specific alternatives that would be implemented for the spoil piles and the tailings impoundments (see Sections 5.1.2 and 5.2.1, 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 the 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 reports to the Chamberlain Creek/Pit Lake Watershed (Alternative SP3). This alternative (AS2) will be retained as a component for inclusion in the Site-wide alternatives.

5.2.2.3 AS3 Source Control and Sediment Removal

The Source Control and Sediment Removal alternative (AS3) includes minimizing the contact between run-off 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. Effectiveness, implementability, and cost would largely be reliant on the area-specific alternatives chosen for the spoil piles and tailings impoundments. The added component of sediment removal would increase effectiveness while decreasing implementability (primarily due to difficult access) and increasing cost.

As discussed in Section 5.1.7.3 for Chamberlain Creek, estimated risks associated with sediment in the affected streams are low (hazard quotients typically <5), indicating a low potential for adverse effects to environmental receptors. In addition, though their abundance and diversity may be locally affected by the Site, benthic macroinvertebrates are present in these streams (SI Report and FTN, 2005). 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 affected streams would create greater harm to the environment relative to leaving the sediment in place. Further, it is possible that some improvements in sediment quality could occur in the streams, depending on the nature and intensity of remedial actions at the Site. For this reason, alternative AS3 is eliminated from further consideration as a component for inclusion in the Site-wide alternatives.

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 (Figures 1-1 and 3-3). It was used as a fresh water reservoir for make-up water within the milling operations. It covers approximately 62 acres with a maximum depth of approximately 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 in or near the Site, specifically near the spoil piles, and then flow through undeveloped areas. The 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 (CWL3). These alternatives are discussed in detail in the following Sections (5.2.3.1 through 5.2.3.3). The location of Clearwater Lake is shown on Figures 1-1 and 3-3.

5.2.3.1 CWL1 No Action

The No Action alternative (CWL1) for Clearwater Lake entails no actions on the lake or on Site materials that are sources of ARD to the lake. This alternative would not be effective at reducing the risk posed by Clearwater Lake sediment and water to aquatic biota. This alternative is implementable and there is no cost. This alternative (CWL1) is retained for inclusion in the Site-wide No Action Alternative.

5.2.3.2 CWL2 Source Control

The Source Control alternative (CWL2) for Clearwater Lake 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. Sections 5.1.2 and 5.2.2 provide discussion of three alternatives within and outside of the Pit Lake/Chamberlain Creek Watersheds, respectively, and their respective effectiveness, implementability, and cost.

As discussed in Section 5.2.2.2 for affected streams, specific source control options that could benefit Clearwater lake could 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, (3) regrading the spoil piles such that runoff and seepage reports to the Pit Lake watershed (Alternative SP3). This alternative (CWL2) is retained for consideration in the development of Site-wide remedial alternatives.

5.2.3.3 CWL3 Source Control and Sediment Removal

The Source Control and Sediment Removal alternative (CWL4) would entail the elements of alternative CWL2 and adds the removal of sediment with metals concentrations posing risk. This alternative (CWL3) would be effective at reducing the risk posed by the COPCs to the environment. This alternative would be moderately difficult to implement depending on the source control technologies chosen and the amount of sediment that would be dredged from the lake. The cost will be moderate to high.

Sediment removal would be the final step in this alternative because it would not be logical to remove the sediment until the source controls are implemented and have shown significant reduction in contaminant loading to the lake. Estimated risks associated with sediment in Clearwater Lake are low (only nickel was found to pose risk with a hazard quotients of 3), indicating a low potential for adverse effects to environmental receptors. In addition, though their abundance and diversity may be locally affected by the Site, benthic macroinvertebrates are present in Clearwater Lake (SI Report). 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 Clearwater Lake would create greater harm to the environment relative to leaving the sediment in place. Further, it is possible that some improvements in sediment quality could occur in the lake, depending on the nature and intensity of remedial actions at the Site. For this reason, alternative CWL3 is eliminated from further consideration as a component for inclusion in the Site-wide alternatives.

5.2.4 Screening Summary Area Speci ic Alternatives Outside the Pit Lake/Chamberlain Creek Watersheds

Table 5-2 provides a summary of the screening process for area-specific alternatives outside the Pit Lake/Chamberlain Creek Watersheds, as detailed in the preceding subsections.

5.3 Site Remedial Alternatives

This section presents Site remedial alternatives consisting of appropriate combinations of the area-specific alternatives that survived the screening step presented in Sections 5.1 and 5.2. A total of five Site alternatives have been developed to obtain suitable range of remedial alternatives, as required by the NCP and EPA guidance, and to provide a reasonable number of alternatives for evaluation in the detailed and comparative analyses (Sections 6.0 and 7.0, respectively).

Chapter 4 of EPA's guidance (EPA, 1988) describes the requirements for development of a range of remedial alternatives for evaluation under the CERCLA process. In summary, the guidance states that GRAs and process options chosen to represent the technology types of each medium should be combined to form an appropriate range of alternatives (treatment and containment combinations) for a given site as a whole. This range might typically include a no action alternative, a limited action alternative, source containment options with and without treatment, and various levels of treatment. The selection of the alternative components is also to consider the likely interactions and benefits of alternative implementation for one medium on other media for the site-specific conditions.

This process was used to develop combined-media alternatives for the Site. Media-specific alternatives surviving the screening presented in Section 5.1 and 5.2, as summarized in Tables 5-1 and 5-2, have been assembled into Site alternatives that represent an appropriate range of remedial actions and consider the interaction of the media-specific alternatives. Due to the large number of possible combinations of the surviving media-specific alternatives, and the need to develop a reasonable number of alternatives for detailed evaluation, the use of professional judgment was necessary when assembling the alternatives.

In summary, the area-specific alternatives within the Pit Lake/Chamberlain Creek Watersheds that were retained are:

- Pit Lake
    - PL1 – No Action
    - PL2 – Operate Existing WTS, Maintain Pit Level
    - PL3 – In-Situ Neutralization, Maintain Pit Level[9]
- Spoil Piles
    - SP1 – No Action
    - SP2 – Selective Regrading, Augment Vegetation, and Capture ARD
    - SP3 – Extensive Regrading, Amendment, Soil Cover, Revegetation
- Shallow Groundwater
    - SGW1 – No Action
    - SGW2 – Operate Existing Capture/Treatment System
    - SGW3 – Expanded Capture/Treatment System
- Bedrock Groundwater
    - BGW1 – No Action
    - BGW2 – Verify Connection to Municipal System

[9] Depending on the quality of the neutralized discharge, this alternative may also include polishing of the discharge in a constructed wetland treatment system and/or diversion of the discharge to a mixing zone in a relatively large receiving water body such as Cove Creek.

- Sludge Ponds
    - SLU1 – No Action
    - SLU2 – Soil Cover, Revegetate
- Chamberlain Creek
    - CHM1 – No Action
    - CHM2 – Source Control

The area-specific alternatives outside of the Pit Lake/Chamberlain Creek Watersheds that were retained are:

- Tailings Impoundments
    - TI1 – No Action
    - TI2 – Regrade, Stabilize Dams, Revegetate
- Affected Streams
    - AS1 – No Action
    - AS2 – Source Control
- Clearwater Lake
    - CWL1 – No Action
    - CWL2 – Source Control

The retained area-specific alternatives are assembled into a range of five Site remedial alternatives, as detailed in the following subsections.

5.3.1 Alternative 1 No Action

Alternative 1 includes all of the No Action area-specific alternatives.

5.3.1.1 Within Pit Lake/Chamberlain Creek Watersheds

Alternative 1 (No Action) within the Pit Lake/Chamberlain Creek Watersheds includes the following area-specific alternatives:

- PL1 – No Action

  - Cease water treatment and allow the pit lake to discharge untreated water in an uncontrolled manner. WTS would be shut off but would remain in place. Existing levees would remain in place.
- SP1 – No Action
  - Do nothing to the spoil piles.
- SGW1 – No Action
  - Cease existing shallow groundwater collection and treatment system operation. Shallow groundwater collection system would be shut off but would remain in place.
- BGW1 – No Action
  - Do nothing to the bedrock groundwater system.
- SLU1 – No Action
  - Do nothing to the sludge ponds.
- CHM1 – No Action
  - Do nothing to Chamberlain Creek.

Descriptions of these area-specific alternatives are located in Section 5.1.

5.3.1.2 Outside o Pit Lake/Chamberlain Creek Watersheds

Alternative 1 (No Action) outside of the Pit Lake/Chamberlain Creek Watersheds includes the following area-specific alternatives:

- TI1 – No Action
  - Do nothing to the tailings impoundments.
- AS1 – No Action
  - Do nothing to the affected streams.
- CWL1 – No Action
  - Do nothing to Clearwater Lake.

5.3.2 Alternative 2 No Further Action

Alternative 2 (No Further Action) entails continuing operations that were initiated as IRMs including retention of the existing pit lake levees, continued operation of the WTS to achieve and then maintain a specific pit lake elevation (595 feet), and continued operation of the shallow groundwater collection and pumping system. The No Action alternative would be implemented for all other areas of the Site.

5.3.2.1 Within Pit Lake/Chamberlain Creek Watersheds

Alternative 2 (No Further Action) within the Pit Lake/Chamberlain Creek Watersheds includes the following area-specific alternatives:

- PL2 – Operate Existing WTS, Maintain Pit Level
    - Continue pumping and treating utilizing the existing WTS with a hydrographically-controlled discharge rate to maintain the pit lake elevation.
- SP1 – No Action
    - Do nothing to the spoil piles.
- SGW2 – Operate Existing Capture/Treatment System
    - Continue operating the existing capture system that pumps shallow groundwater to the pit lake.
- BGW1 – No Action
    - Do nothing to the bedrock groundwater.
- SLU1 – No Action
    - Do nothing to the sludge ponds.
- CHM1 – No Action
    - Do nothing to Chamberlain Creek.

5.3.2.2 Outside o Pit Lake/Chamberlain Creek Watersheds

Alternative 2 (No Further Action) outside of the Pit Lake/Chamberlain Creek Watersheds includes the following area-specific alternatives:

- TI1 – No Action

  - o Do nothing to the tailings impoundments.

- AS1 – No Action
  - o Do nothing to the affected streams.
- CWL1 – No Action
  - o Do nothing to Clearwater Lake.

5.3.3 Alternative 3 WTS and Source Control

Alternative 3 (WTS and Source Control) includes operating the WTS to maintain a set pit lake elevation, expanding the shallow groundwater capture and treatment system, invoking ICs to restrict well installation in the impacted shallow groundwater system, verifying connection to or providing a connection to a municipal water supply to potentially affected groundwater users (i.e., those residing within the Chamberlain Creek syncline to the west of the Site), and source control measures on the spoil piles and tailings impoundments.

This alternative would reduce ARD generation at the Site and continue to treat ARD within the Pit Lake/Chamberlain Creek Watersheds.

5.3.3.1 Within Pit Lake/Chamberlain Creek Watersheds

Alternative 3 (WTS and Source Control) within the Pit Lake/Chamberlain Creek Watersheds includes the following area-specific alternatives:

- PL2 – Operate Existing WTS, Maintain Pit Level
  - o Continue pumping and treating utilizing the existing WTS with a hydrographically-controlled discharge rate to meet discharge water quality requirements and achieve/maintain the pit lake elevation of approximately 595 feet above sea level.
- SP2 – Selective Regrading, Augment Vegetation, and Capture ARD
  - o Enhance natural reclamation of the spoil that has occurred over the past 30+ years.
  - o Regrade spoil piles where vegetation has not effectively reduced erosion.
  - o Regrade spoil piles to direct ARD to the Pit Lake Watershed, where practical.
  - o Amend soil in key areas to reduce ARD generation.
  - o Vegetate regraded areas and areas currently devoid of vegetation.

  - Capture runoff and shallow groundwater for treatment.
- SGW3 – Expanded Capture/Treatment System
  - Expand existing system, or construct a new, larger system, to intercept a larger portion of the impacted shallow groundwater in the Chamberlain Creek watershed and pump it to the pit lake for treatment.
  - Invoke ICs to restrict well installation in the shallow groundwater system in the affected area.
- BGW2 – Verify Connection to Municipal System
  - Verify that all current residents within the affected areas of Chamberlain Creek syncline have or are provided with a permanent connection to the existing municipal water system.
- SLU2 – Soil Cover, Revegetate
  - Construct a soil cover over the three existing sludge ponds and vegetate.
- CHM2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into Chamberlain Creek by controlling ARD generation and migration from the spoil piles.

5.3.3.2 Outside o Pit Lake/Chamberlain Creek Watersheds

Alternative 3 (WTS and Source Control) outside of the Pit Lake/Chamberlain Creek Watersheds includes the following area-specific alternatives:

- TI2 – Regrade, Stabilize Dams, Revegetate
  - Regrade tailings material to eliminate water storage.
  - Stabilize dams to reduce likelihood of slope failure.
  - Vegetate all regraded tailings impoundment areas.
- AS2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into affected creeks by controlling ARD generation and migration from spoil piles.
- CWL2 – Source Control

- Reduce or eliminate the potential for ARD to enter into Clearwater Lake by controlling ARD generation and migration from spoil piles.

5.3.4 Alternative 4 Pit Lake Neutralization and Source Control

Alternative 4 (Pit Lake Neutralization and Source Control) includes in-situ neutralization of the upper layer of the pit lake, expanding the shallow groundwater capture and treatment system within the Chamberlain Creek watershed, invoking ICs to restrict well installation in the shallow groundwater system, verifying connection to or providing a connection to a municipal water supply to potentially affected groundwater users, selectively regrading/amending and augmenting existing vegetation on the spoil piles, regrading/revegetating the tailing impoundments, stabilizing the tailings dams, and covering and vegetating the sludge ponds. In comparison to Alternative 3, this alternative would substitute in-situ pit lake neutralization for continued operation of the WTS; other aspects of Alternative 3 and Alternative 4 are identical.

5.3.4.1 Within Pit Lake/Chamberlain Creek Watersheds

Alternative 4 (Pit Lake Neutralization and Source Control) within the Pit Lake/Chamberlain Creek Watersheds includes the following area-specific alternatives:

- PL3 – In-Situ Neutralization, Maintain Pit Level
  - In-situ chemical/biological treatment to neutralize pH and enhance biological metals removal mechanisms within the upper pit lake layer.
  - Discharge according to a hydrographically controlled release to maintain the pit lake surface elevation at an appropriate level (approximately 595 feet above sea level).
  - Potential addition of a constructed wetland treatment system to polish the discharge, and/or diversion of the discharge to a relatively larger receiving water body (e.g.,Cove Creek) to provide a mixing zone, depending on the level of metals removal achieved by in-situ treatment.
- SP2 – Selective Regrading, Augment Vegetation, and Capture ARD
  - Enhance natural reclamation of the spoil that has occurred over the past 30+ years.
  - Regrade spoil piles where vegetation has not effectively reduced erosion.
  - Regrade spoil piles to direct ARD to the Pit Lake Watershed, where practical.

- Amend soil in key areas to reduce ARD generation.
- Vegetate regraded areas and areas currently devoid of vegetation.
- Capture runoff and shallow groundwater for treatment.

- SGW3 – Expanded Capture/Treatment System
  - Expand existing system to intercept a larger portion of the impacted shallow groundwater and pump it to the pit lake for treatment.
  - Invoke ICs to restrict well installation in the shallow groundwater system in the affected area.
- BGW2 –Verify Connection to Municipal System
  - Verify that all current residents within the affected areas of Chamberlain Creek syncline have or are provided with a permanent connection to the municipal water system.
- SLU2 – Soil Cover, Revegetate
  - Construct a soil cover over the three existing sludge ponds and vegetate.
- CHM2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into Chamberlain Creek by controlling ARD generation and migration from spoil piles.

5.3.4.2 Outside o Pit Lake/Chamberlain Creek Watersheds

Alternative 4 (Pit Lake Neutralization and Source Control) outside of the Pit Lake/Chamberlain Creek Watersheds includes the following area-specific alternatives:

- TI2 – Regrade, Stabilize Dams, Revegetate
  - Regrade tailings material to eliminate water storage.
  - Stabilize dams to reduce likelihood of slope failure.
  - Vegetate all regraded tailings impoundment areas.
- AS2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into affected creeks by controlling ARD generation and migration from spoil piles.

- CWL2 – Source Control
    - o Reduce or eliminate the potential for ARD to enter into Clearwater Lake by controlling ARD generation and migration from spoil piles.

5.3.5 Alternative 5 Pit Lake Neutralization and E tensive Source Control

Alternative 5 (Pit Lake Neutralization and Extensive Source Control) includes in-situ neutralization of the upper layer of the pit lake; providing a municipal water supply to potentially affected groundwater users; extensive regrading, consolidation, amendment (spoil treatment), soil covering, and vegetation of the spoil piles within a single repository to minimize their footprint area to ensure that any seepage/infiltration occurs within the Chamberlain Creek watershed (i.e., all spoil is removed from the Scull Creek and Rusher Creek watersheds), and to eliminate or minimize continued ARD input to the pit lake; installation of an expanded shallow groundwater capture system; invoking ICs to restrict well installation; regrading/revegetating the tailing impoundments; stabilizing the tailings dams; and incorporation of the sludge pond residue within the spoil repository.

5.3.5.1 Within Pit Lake/Chamberlain Creek Watersheds

Alternative 5 (Pit Lake Neutralization and Extensive Source Control) within the Pit Lake/Chamberlain Creek Watersheds includes the following area-specific alternatives:

- PL3 – In-Situ Neutralization, Maintain Pit Level
    - o The WTS would continue operation until the spoil piles have been addressed (see SP3, below).
    - o After SP3 has been implemented, in-situ chemical/biological treatment to neutralize pH and enhance microbial reduction of sulfate within the upper pit lake layer.
    - o Discharge according to a hydrographically controlled release schedule to maintain the pit lake surface elevation at an acceptable level (approximately 595 feet above sea level).
- SP3 – Extensive Regrading, Amendment, Soil Cover, Revegetation
    - o Regrade/excavate/etc. all of the spoil piles so that the total surface area is minimized, slopes are reduced, and all residual ARD reports to the Chamberlain Creek watershed. The spoil would be relocated to an assumed repository location within the Chamberlain Creek syncline west of the pit lake (between the

WTS and Baroid Road), necessitating relocation of approximately 14 million cubic yards of spoil (6.5 million cy of spoil are already present in the repository footprint; Appendix B). The spoil would be amended (treated) with an alkaline material as it is being placed in the repository to reduce or minimize ARD production. This repository location, which is downgradient of the pit lake, would eliminate the need to re-lime the pit lake because ARD inputs to the lake would be significantly reduced or eliminated. The existing settling ponds would be covered by the repository and therefore would need to be drained in conjunction with repository construction.

- Amend soil in key areas (i.e., former spoil pile locations) with alkaline material to further reduce ARD generation.
- Apply a soil cover to the consolidated spoil.
- Revegetate the consolidated spoil.

- SGW3 – Expanded Capture/Treatment System
  - Implementation of spoil pile alternative SP3 is expected to result in temporary increased impacts to the shallow groundwater system, requiring the installation of an expanded capture system for the shallow groundwater within the Chamberlain Creek syncline. The captured water would be pumped to the pit lake for treatment. However, consolidation, treatment, and capping of the spoil should eventually lead to acceptable water quality in the shallow groundwater system, allowing the expanded capture system to ultimately be decommissioned.
  - Invoke ICs to restrict well installation in the affected area.
- BGW2 –Verify Connection to Municipal System
  - Provide all current residents within the affected areas of Chamberlain Creek syncline a permanent connection to the municipal water system.
- SLU2 – Soil Cover, Revegetate
  - The sludge ponds would become part of the spoil repository constructed under SP3 and any direct contact pathways with the sludge would be eliminated.
- CHM2 – Source Control

- Reduce or eliminate the potential for ARD to enter into Chamberlain Creek by controlling ARD generation and migration from spoil piles.

5.3.5.2 Outside o Pit Lake/Chamberlain Creek Watersheds

Alternative 5 (Pit Lake Neutralization and Extensive Source Control) outside of the Pit Lake/Chamberlain Creek Watersheds includes the following area-specific alternatives:

- TI2 – Regrade, Stabilize Dams, Revegetate
  - Regrade tailings material to eliminate water storage.
  - Stabilize dams to reduce likelihood of slope failure.
  - Vegetate all regraded tailings impoundment areas.
- AS2 – Source Control
  - Eliminate the potential for ARD to enter into affected creeks by eliminating ARD generation and migration from spoil piles.
- CWL2 – Source Control
  - Eliminate the potential for ARD to enter into Clearwater Lake by eliminating ARD generation and migration from spoil piles.

Section 5 Tables

TABLE 5-1
SCREENING SUMMARY: AREA-SPECIFIC ALTERNATIVES WITHIN PIT LAKE/CHAMBERLAIN CREEK WATERSHED
DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILITY STUDY

ALTERNATIVES	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAINED (Y/N)	COMMENTS
Pit Lake Alternatives						
No Action (PL1)	Cessation of pumping and treating of the lake water, however existing levees will remain in place.	Not Effective	Implementable	Minimal	Y	
Operate Existing WTS, Maintain Pit Level (PL2)	Continuation of pumping and treating of lake water along with pumping of Chamberlin Creek headwaters. Ex-situ pit lake treatment would be a hydroxide precipitation WTS.	Effective	Implementable	Moderate	Y	
In-Situ Neutralization, Maintain Pit Level (PL3)	In-situ chemical treatment using hydrated lime or powdered limestone to neutralize pH of water, discontinue treatment of lake, cease pumping of Chamberlin Creek, and allow discharge of surface or groundwater into headwaters of Chamberlin Creek. Existing levees remain in place.	Unknown	Implementable	Moderate	Y	May include polishing with biological treatment (constructed wetlands) and/or diversion to a mixing zone in a relatively large receiving water body.
Operate Existing WTS, Drain Pit (PL4)	Continuation of pumping and treating lake water along with pumping of Chamberlin Creek headwaters. Draining of lake until completely empty and WTS would continue after empty to maintain a dry pit.	Effective	Questionable	High	N	Not retained due uncertainty in implementability and likely high cost.
Spoil Piles Alternatives						
No Action (SP1)	Leave spoils as they are currently.	Not Effective	Implementable	Minimal	Y	
Selective Regrading, Augment Vegetation (SP2)	Regrading portions of the spoils that do not have dense vegetation growing on them, amendment of selected areas to limit ARD generation, and planting vegetation to aid in reducing erosional transport of particles.	Moderately Effective	Implementable	Low	Y	
Extensive Regrading, Amendment, Soil Cover, Revegetation (SP3)	Regrading of all the spoils piles so that ARD reports to Chamberlain Ck. watershed, amendment of spoil and selected areas to limit ARD generation, applying a soil cover to the spoil piles to reduce infiltration, and then revegetating the spoil piles.	Effective	Implementable	High	Y	
Remove and Dispose in Drained Pit Lake (SP4)	The excavated vegetation and spoil piles will be used to backfill the pit once drained. A soil cover will be used to isolate the spoil material. This option can only be used if Pit Lake option 4 is chosen.	Low Effectiveness	Moderately Difficult	High	N	Not retained due to uncertainty in implementability and likely high cost of draining the pit lake.
Shallow Groundwater						
No Action (SGW1)	Turning off the existing capture/treatment system that collects groundwater and pumps it to pit lake for treatment.	Not Effective	Implementable	Minimal	Y	
Operate Existing Capture/Treatment Systems (SGW2)	Continuation of the existing capture system which reduces the acidic water and contaminants that enter Chamberlin Creek. Does not capture all of acidic water from shallow groundwater.	Moderately Effective	Implementable	Low	Y	
Expanded Capture/Treatment System (SGW3)	Extending the existing capture system to intercept a larger portion of the groundwater, and pump it to pit lake. Sub-surface barriers or trenches may be used to minimize the amount of water needed to be captured. ICs included in this option to restrict well installation in area.	Effective	Implementable	Moderate	Y	
Bedrock Groundwater						
No Action (BGW1)	Doing nothing to contain or reduce bedrock groundwater. Future groundwater quality down gradient from pit lake would decrease over time.	Effective	Implementable	None	Y	
Verify Connection to Municipal System (BGW2)	Providing all residents affected or potentially affected by Chamberlin Creek syncline with a connection to the existing municipal water supply. Restricting new well installations within the Chamberlin Creek Syncline.	Effective	Implementable	Low	Y	
Drain and Backfill Mine Pit (BGW3)	Draining and filling the pit lake with mine spoils. Initially pore water quality within backfilled water will be poor. A substantial time lag between when pore water quality is improved and when bedrock groundwater quality is improved.	Not Effective	Difficult to Implement	High	N	Not retained because not effective in terms of reducing ARD to groundwater, difficult implementation, and high cost.

ALTERNATIVES	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAINED (Y/N)	COMMENTS
Sludge Ponds Alternatives						
No Action (SLU1)	Doing nothing to the three existing sludge ponds. Sludge could dry and become transported airborne, and contaminates in sludge could be mobilized by infiltrating water.	Not Effective	Implementable	None	Y	
Soil Cover, Revegetate (SLU2)	Constructing an engineered soil cover over the three existing sludge ponds and revegetating the soil cover. This isolates the contaminated soil media, and reduces infiltration through media.	Effective	Implementable	Low	Y	
Removal with On-Site Disposal (SLU3)	Excavating the sludge from the three ponds and consolidating it in an engineered repository located on-site. The design of the repository would minimize infiltration through contaminated solid media.	Effective	Implementable	Moderate	N	Not retained because cost of relocating the sludge on-site is not justified relative to in-place closure.
Removal with Off-Site Disposal (SLU4)	Excavating the sludge from the three ponds and transporting it off-site to either a hazardous waste landfill or municipal landfill based on the toxicity of the sludge.	Effective	Implementable	Moderate to High	N	Not retained because cost of relocating the sludge to an off-site landfill is not justified relative to in-place closure.
Chamberlain Creek Alternatives						
No Action (CHM1)	Doing nothing to the existing state of Chamberlain Creek.	Not Effective	Implementable	None	Y	
Source Control (CHM2)	Would include portions from the other area specific alternatives such as spoil piles alternatives, pit lake alternatives, and shallow groundwater alternatives.	Dependent on other Area-specific Alternatives	Dependent on other Area-specific Alternatives	Dependent on Alternatives	Y	
Source Control and Sediment Removal (CHM3)	Removal and disposal on-site or off-site of the impacted sediments along with portions of area specific alternatives.	Dependent on other Area-specific Alternatives	Dependent on other Area-specific Alternatives	Dependent on Alternatives	N	Not retained because sediment removal would cause more harm than good to existing benthic macroinvertebrate communities.

TABLE 5-2
SCREENING SUMMARY: AREA-SPECIFIC ALTERNATIVES OUTSIDE OF PIT LAKE/CHAMBERLAIN CREEK WATERSHED
DRESSER INDUSTRIES-MAGCOBAR MINE SITE FEASIBILITY STUDY

ALTERNATIVES	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAINED (Y/N)	COMMENTS
Tailings Impoundments Alternatives						
No Action (TI1)	Doing nothing to the tailings impoundments. The moderately acidic discharge waters will continue flowing into Reyburn Creek, and dams and levees will continue to pose a risk for slope failure.	Not Effective	Implementable	None	Y	
Regrade, Stabilize Dams, Revegetate (TI2)	Regrading tailings to minimize water storage, stabilizing dams to the minimum safety factor, and revegetating all the disturbed tailings impoundments using native species. Regrading would require some excavation of tailings and native material.	Effective	Implementable	Moderate	Y	
Remove and Dispose in Drained Pit (TI3)	Treating all of the standing water, excavating and transporting all of the tailings into the pit lake, regrading of tailings impoundments to match existing topography, and revegetating the area.	Effective	Implementable	High	N	Not retained because this alternative relies on draining of the pit lake; which was screened out due to questionable implementability and high cost.
Affected Streams Alternatives						
No Action (AS1)	Doing nothing to reduce the impact of the Site materials on receiving streams. Run-off from spoils and tailings will continue to transport contaminants downstream.	Not Effective	Implementable	None	Y	
Source Control (AS2)	Minimizing contact between spoils piles and tailings impoundments before it enters one of the affected streams. May include regrading and revegetating tailings impoundments or spoils piles.	Dependent on other Area-specific Alternatives	Dependent on other Area-specific Alternatives	Dependent on other Area-specific Alternatives	Y	
Source Control and Sediment Removal (AS3)	Minimizing contact between spoils piles and tailings impoundments before it enters one of the affected streams, along with removing sediment from those streams which show a significant impact.	Dependent on other Area-specific Alternatives	Dependent on other Area-specific Alternatives	Dependent on other Area-specific Alternatives	N	Not retained because sediment removal would cause more harm than good to existing benthic macroinvertebrate communities.
Clearwater Lake Alternatives						
No Action (CWL1)	Allows the Site-derived ARD to continue entering the lake. Ion precipitation continues which maintains the depressed pH.	Not Effective	Implementable	None	Y	
Source Control (CWL2)	Reducing the ARD spoil pile seepage quantity that enters into upper Scull Creek, and increasing seepage quality.	Effective	Dependent on other Area-specific Alternatives	Dependent on other Area-specific Alternatives	Y	
Source Control and Sediment Removal (CWL3)	Reducing the ARD spoil pile seepage quantity that enters into upper Scull Creek, and increasing seepage quality. Removal of all affected sediment within the lake.	Dependent on other Area-specific Alternatives	Dependent on other Area-specific Alternatives	Dependent on other Area-specific Alternatives	N	Not retained because sediment removal would cause more harm than good to existing benthic macroinvertebrate communities.

TABLE 5-3
SITE-WIDE REMEDIAL ACTION ALTERNATIVES – DRESSER INDUSTRIES-MAGCOBAR MINE SITE

Watershed/Site Feature	Alternative 1 No Action	Alternative 2 No Further Action	Alternative 3 WTS and Source Control	Alternative 4 Pit Lake Neutralization and Source Control	Alternative 5 Pit Lake Neutralization and Extensive Source Control
Pit Lake Watershed					
Pit Lake	Cease WTS operation, retain levees	Continue WTS operation, retain levees	Continue WTS operation	Neutralize upper layer of pit lake in situ, augment with nutrients to stimulate biological activity. Possible polishing in constructed wetlands and/or diversion to mixing zone in large receiving water body.	Neutralize upper layer of pit lake in situ, augment with nutrients to stimulate biological activity. Possible polishing in constructed wetlands and/or diversion to mixing zone in large receiving water body.
Spoil Piles	No action	No action	Augment existing vegetation, selectively amend to reduce ARD generation, and selectively grade to manage/contain ARD	Augment existing vegetation, selectively amend to reduce ARD generation, and selectively grade to manage/contain ARD	Full-scale regrading and consolidation into a repository, amend to minimize ARD generation, soil cover, revegetation
Shallow Groundwater	Cease existing groundwater collection and treatment system operation	Continue existing groundwater collection and treatment system operation	Expand groundwater capture and treatment system and invoke ICs to restrict well installation	Expand groundwater capture and treatment system[1] and invoke ICs to restrict well installation	Expand groundwater capture and treatment (could eventually be decommissioned) and invoke ICs to restrict well installation
Bedrock Groundwater	No action	No action	Verify or provide connection to municipal water supply to potentially affected groundwater users	Verify or provide connection to municipal water supply to potentially affected groundwater users	Verify or provide connection to municipal water supply to potentially affected groundwater users
Sludge Pond	No action	No action	Cover with soil and revegetate	Cover with soil and revegetate	No Action (would be subsumed in spoil repository)
Chamberlain Creek	Cease existing groundwater collection and treatment system operation	Continue existing groundwater collection and treatment system operation	Expand groundwater capture and treatment system	Expand groundwater capture and treatment system	Cease groundwater capture and treatment (full-scale spoil pile reclamation should address shallow groundwater)
Outside Pit Lake Watershed					
Spoil Piles	No action	No action	Augment existing vegetation, selectively amend to reduce ARD generation, selectively regrade to direct ARD to the Pit Lake watershed, capture ARD for treatment.	Augment existing vegetation, selectively amend to reduce ARD generation, selectively regrade to direct ARD to the Pit Lake watershed, capture ARD for treatment.	Full-scale regrading and consolidation to ensure ARD reports only to the Chamberlain Creek watershed, soil cover, revegetation

Tailings Ponds	No action	No action	Regrade/backfill to eliminate areas of standing water, rehabilitate tailings dams, revegetate	Regrade/backfill to eliminate areas of standing water, rehabilitate tailings dams, revegetate	Regrade/backfill to eliminate areas of standing water, rehabilitate tailings dams, revegetate
Affected Streams	No action	No action	Source control in upstream areas	Source control in upstream areas	Source control in upstream areas
Clearwater Lake	No action	No action	Source control in upstream areas	Source control in upstream areas	Source control in upstream areas

6.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATI ES

This section provides a detailed analysis of the Site-wide remedial alternatives developed in Section 5.3. The alternatives are evaluated against the threshold and primary balancing criteria specified in the NCP and the FS Guidance (EPA, 1988) to ensure that the selected remedial alternative will protect human health and the environment, comply with or include a waiver of ARARs, be cost-effective, utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable, and address the statutory preference for treatment as a principal element.[10]

6.1 Evaluation Criteria

The FS evaluation criteria specified for detailed analysis of remedial alternatives in the NCP are:

- Threshold Criteria
  - Overall Protection of Human Health and the Environment
  - Compliance with ARARs

- Primary Balancing Criteria
  - Long-Term Effectiveness and Permanence
  - Reduction of Toxicity, Mobility and Volume Through Treatment
  - Short-Term Effectiveness
  - Implementability
  - Cost

The NCP also includes consideration of “modifying criteria” of state acceptance and community acceptance. This is a state-lead site and therefore the modifying criterion of state acceptance is not applicable. It is expected that ADEQ will address any community acceptance issues through a responsiveness summary that would be issued following public review of the FS

[10] Section 121 of CERCLA, as amended by the Superfund Amendment and Reauthorization Act of 1986, states that, in addition to the requirement for remedies to be both protective of human health and the environment and cost effective, remedy selection considerations should include a preference for remedial actions that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances, pollutants, and contaminants as a principal element.

Report and public notice of a selected remedy for the Site. Therefore, the detailed analysis, as well as the comparative analysis in Section 7.0, focuses on the seven criteria listed above. While all of the criteria are important, they are considered differently in the decision-making process depending on whether they describe a required level of performance (threshold criteria) or provide for consideration of technical merits (primary balancing criteria). Explanations of the criteria are presented below.

6.1.1 Threshold Criteria

6.1.1.1 Overall Protection o uman ealth and the Environment

The evaluation of the overall protection of human health and the environment is based on a composite of factors assessed under the evaluation criteria. The criteria specifically considered are: compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness (see Sections 6.1.1.2, 6.1.2.1, and 6.1.2.3, respectively).

6.1.1.2 Compliance with ARARs

This evaluation analyzes the expected performance of each alternative in meeting the federal and state standards or limitations which constitute “applicable and/or relevant and appropriate requirements” or ARARs. Each alternative will be assessed to determine whether it will attain ARARs under federal and state environmental or facility siting laws. When an ARAR is not expected to be met, the detailed analysis discusses whether one of the six waivers allowed under CERCLA may be appropriate. ARARs for the DIM Mine Site are presented on Table 3-1 (federal ARARs) and Table 3-2 (state ARARs).

"Applicable Requirements" are those cleanup standards, standards of control, or other substantive environmental protection requirements, criteria or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant or contaminant at a CERCLA site. State standards that are more stringent than federal requirements may be applicable (NCP, 40 CFR § 300.5; Compliance with Other Laws Manual, pp. 1-10.)

"Relevant and Appropriate Requirements" are those cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site so that their use is well suited to the particular site. State standards that are more stringent than federal requirements may be relevant and appropriate (NCP, 40 CFR § 300.5; Compliance with Other Laws Manual, pp. 1-10).

The following types of ARARs are considered in the evaluation of each alternative:

- Chemical-specific ARARs: Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values.
- Location-specific ARARs: Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations. These include floodplain, fish and wildlife, streambed, cultural and historic resources, threatened and endangered species and wetlands; and
- Action-specific ARARs: Action-specific ARARs are usually technology or activity based requirements or limitations on actions taken. These requirements are triggered by a particular remedial activity that is selected to accomplish an alternative.

For each alternative, the evaluation of compliance with ARARs addresses whether the ARARs can be met and, if not, whether a waiver is appropriate (EPA, 1988). CERCLA § 121 stipulates provisions under which a waiver may be invoked, such as:

- When interim measures are implemented to be followed within a reasonable time period with complete measures that will attain ARARs. The interim measures waiver may apply to sites at which a final site remedy is divided into several smaller actions.
- When compliance with such requirement will result in greater risk to human health and the environment than alternative options (CERCLA § 121(d) (4) (B)).
- When compliance with such requirement is technically impracticable from an engineering perspective.
- When the remedial action selected will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, criteria, or limitation, through use of another method or approach.

- When, with respect to a State standard, requirement, criteria, or limitation, the State has not consistently applied (or demonstrated the intention to consistently apply) the standard, requirement, criteria, or limitation in similar circumstances at other remedial actions.
- When meeting a requirement would require inordinate cost in relation to the added degree of protection or reduction of risk afforded by that standard that remedial actions at other sites would be hindered.

The NCP also requires the identification of other sources of guidelines that, while not ARARs, may be useful in evaluating appropriate remediation goals or approaches. The TBC category generally is defined to include advisories, criteria, or guidance developed by EPA, other Federal agencies, or states that, while not legally binding requirements, may be useful in developing CERCLA remedies (see Section 300.400 (g)(3)). The NCP provides that, unlike ARARs, the use of TBCs is discretionary and that they are to be evaluated on an "as appropriate" basis. The NCP also confirms that the role of TBCs should not be tantamount to that of cleanup standards. Because TBCs are, by definition, neither promulgated nor enforceable, they do not have the same status under CERCLA as ARARs. TBCs may, however, be useful in evaluating protectiveness or how to carry out certain actions or requirements.

6.1.2 Balancing Criteria

6.1.2.1 Long Term E ectiveness and Permanence

Evaluation of long-term effectiveness and permanence considers the risks remaining after the remedial action has been completed. The Preamble to the Final NCP, 55 Fed. Reg. 8720 (March 8, 1990) states that "*the analysis under this criterion focuses on any residual risk remaining at the site after the completion of the remedial action. This analysis includes consideration of the degree of threat posed by the hazardous substances remaining at the site and the adequacy and reliability of any controls (e.g., engineering or ICs) used to manage the hazardous substances remaining at the site.*" Factors considered, as appropriate, include the following:

- Magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities.

- Adequacy and reliability of controls. This factor assesses the adequacy and suitability of controls, if any, that are used to manage untreated wastes that remain at the site. The long-term reliability of management controls for providing continued protection are also assessed, including the potential need to replace technical components of the alternative, and the potential exposure pathway and the risks, should the remedial action need replacement. In accordance with NCP requirements (40 CFR 300.430) and the FS Guidance (EPA, 1988), the principal factors considered are:
  - The likelihood that the technologies will meet required process efficiencies or performance specifications;
  - The type of long-term management required;
  - Requirements for long-term monitoring;
  - Operation and maintenance functions;
  - Difficulties and uncertainties associated with long-term operation and maintenance;
  - The potential need for replacement of technical components;
  - The magnitude of the threats or risks should the remedial action need replacement;
  - The degree of confidence that controls can adequately handle potential problems; and
  - The uncertainties associated with land disposal of residuals and untreated wastes.

6.1.2.2 Reduction o To icity, Mobility or olume Through Treatment

The FS Guidance (EPA, 1988) identifies the following factors to be considered in the evaluation of the degree to which remedial alternatives reduce the toxicity, mobility or volume of potentially hazardous materials through treatment:

- The treatment processes the alternatives employ and materials they will treat;
- The amount of hazardous materials that will be destroyed or treated, including how the principal threat(s) will be addressed;
- The degree of expected reduction in toxicity, mobility, or volume of the material due to treatment, measured as a percentage of reduction (or order of magnitude);
- The degree to which the treatment is irreversible;

- The type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents; and
- Whether the alternative would satisfy the statutory preference for treatment as a principal element of the remedy.

6.1.2.3 Short Term E ectiveness

This evaluation criterion addresses the effects of the remedial alternative during the construction and implementation phase up to the time that the remedial objectives are met. Alternatives are evaluated with respect to their potential effects on human health and the environment during implementation of the remedial action. As specified in the CERCLA guidance, the short-term impacts of each remedial alternative are assessed considering the following factors:

- Short-term risks that might be posed to the community during implementation of remedial action;
- Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures;
- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; and
- The time until protection is achieved.

6.1.2.4 Implementability

This criterion addresses the technical and administrative feasibility of implementing each remedial alternative and the availability of various services and materials required during its implementation. As specified in the CERCLA guidance, the evaluation of implementability includes three categories of analysis and a total of nine factors:

- Technical Feasibility
    1. Ability to construct and operate the technology
    2. Reliability of the technology
    3. Ease of undertaking additional remedial actions, if necessary
    4. Ability to monitor the effectiveness of the remedy

- Administrative Feasibility
  1. Ability to obtain approvals from other agencies
  2. Coordination with other agencies

- Availability of Services and Materials
  1. Availability of off-site treatment, storage and disposal services and capacity
  2. Availability of necessary equipment and specialists
  3. Availability of new technology under consideration

6.1.2.5 Cost

The NCP states that the types of costs to be assessed in the FS include capital and annual O&M costs. Included under the general categories of capital and O&M costs identified in the NCP are capital, annual O&M, and periodic costs (capital or O&M), as summarized below (detailed descriptions are provided in Appendix B).

Capital Costs

Capital costs are those expenditures that are required to construct a remedial action. They are exclusive of costs required to operate or maintain the action throughout its lifetime. Capital costs also include expenditures for professional/technical services that are necessary to support construction of the remedial action.

Annual O&M Costs

O&M costs are those post-construction costs necessary to ensure or verify the continued effectiveness of a remedial action. These costs are estimated mostly on an annual basis. Annual O&M costs include all labor, equipment, and material costs, including contractor markups such as overhead and profit, associated with activities such as monitoring; operating and maintaining extraction, containment, or treatment systems; and disposal. Annual O&M costs also include expenditures for professional/technical services necessary to support O&M activities.

Periodic Costs

Periodic costs are those costs that occur only once every few years (e.g., five-year reviews, equipment replacement) or expenditures that occur only once during the entire O&M period or remedial timeframe (e.g., site closeout, remedy failure/replacement). These costs may be either capital or O&M costs, but because of their periodic nature, it is more practical to consider them separately from other capital or O&M costs in the estimating process.

Present Value Analysis

Cost estimates for each alternative are based on conceptual engineering and design and are expressed in terms of 2009 dollars. This analysis is used to evaluate the capital, O&M, and periodic costs of a remedial alternative based on its present value (in this case, 2009 dollars). This analysis allows the comparison of remedial alternatives on the basis of a single cost representing an amount that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. The present value calculations are based on the following fundamental equation:

$$P = F / (1+i)^n$$

Where: P = present value ($)
F = future value ($)
i = discount rate (%)
n = time period (years)

A discount rate of 7 percent is used for the present value calculations, consistent with EPA guidance and directives (EPA, 1988 and 2000). The discount rate represents the anticipated difference between the rate of inflation and investment return. Actions that call for regrading and revegetation have been assigned a 5-year O&M period, based on the professional judgment that a good vegetative cover should be established, and erosion sufficiently diminished, after 5 years in the warm, moist climate at the Site. For those action-based remedial alternatives that involve ongoing water collection and treatment, a typical 100-year planned life period is appropriate for this Site.

Detailed cost estimates for each of the comprehensive, Site-wide remedial alternatives (except the No Action Alternative, which has no cost), are presented in Appendix B. These estimates show capital costs, O&M costs, and periodic costs for each of the remedial alternatives as well as the net present value of each remedial alternative based on a discount rate of 7 percent and the expected duration of O&M activities as well as the expected duration and frequency of periodic activities. For those action-based remedial alternatives that involve ongoing water collection and treatment, a typical 100-year planned life period is appropriate for this Site.

Appendix B is structured as follows. Text is provided to describe the bases for the various area, volume, and unit rate estimates used in the cost estimates. This text is followed by a series of tables. A summary of the present value estimates for Alternatives 1 through 5 is presented on Table B-1. Detailed present value cost estimate information for Alternatives 2 through 5 are presented on Tables B-2 through B-5, respectively (there are no costs associated with Alternative 1 – No Action). Detailed cost estimate information for subarea alternatives variously included in Alternatives 2 through 5 is presented on Tables B-6 through B-13, including capital costs, annual O&M costs, and periodic costs. Note that the cost estimates for the subarea alternatives, as presented on Tables B-6 through B-13 do not reflect present value. The present value calculations are applied on the Site-wide alternative tables (Tables B-2 through B-5).

6.2 Detailed Analysis o Alternatives

The detailed analyses of the Site-wide remedial alternatives developed in Section 5.3 are provided in the following subsections. The action-based alternatives (i.e., Alternatives 3, 4, and 5) will include some degree of future monitoring (e.g., water quality sampling and analysis, etc.) and ICs. The costs for monitoring and ICs are expected to be (1) similar for each of the alternatives and (2) small compared to the overall cost of each alternative. Therefore, the costs associated with future monitoring and ICs would not differentiate one alternative from another and thus were not specifically estimated for the purposes of this FS. The various contingencies included in the cost estimates would likely address the nominal costs of monitoring and ICs for each of the alternatives.

6.2.1 Alternative 1 No Action

This section describes the detailed analysis of Alternative 1, the No Action Alternative. A summary of the components of Alternative 1 is shown on Table 5-3. A summary description of the performance of this alternative against the detailed analysis criteria is shown on Table 6-1. The No Action Alternative includes the items listed below.

Within the Pit Lake/Chamberlain Creek Watersheds:

- PL1 – No Action
    - Cease water treatment and allow the pit lake to discharge untreated water in an uncontrolled manner (existing levees would remain in place). The WTS would be shut off but would remain in place.
- SP1 – No Action
    - Do nothing to the spoil piles.
- SGW1 – No Action
    - Cease existing shallow groundwater collection and treatment system operation. The shallow groundwater collection system would be shut off but would remain in place.
- BGW1 – No Action
    - Do nothing to the bedrock groundwater system.
- SLU1 – No Action
    - Do nothing to the sludge ponds.
- CHM1 – No Action
    - Do nothing to Chamberlain Creek.

Outside of the Pit Lake/Chamberlain Creek Watersheds:

- TI1 – No Action
    - Do nothing to the tailings impoundments.
- AS1 – No Action
    - Do nothing to the affected streams.

- CWL1 – No Action
    - o Do nothing to Clearwater Lake.

6.2.1.1 Overall Protection o uman ealth and the Environment

Under the No Action Alternative, cessation of water treatment at the pit lake would result in an increase in the pit lake surface elevation due to precipitation and seepage/runoff from the adjacent spoil piles, with eventual uncontrolled discharge of acidic pit lake water with unacceptably high concentrations of metals and minerals to Chamberlain Creek and thence Cove Creek and the Ouachita River. The spoil piles would continue to contribute ARD to the Pit Lake/Chamberlain Creek Watersheds. Shallow groundwater within the Pit Lake/Chamberlain Creek Watersheds would flow westward, eventually discharging to and further degrading Chamberlain Creek, which would continue to exceed water quality ARARs. The sludge ponds would continue to pose unacceptable levels of risk to terrestrial ecological receptors. The Site would continue to affect any residents within the Chamberlain Creek syncline that rely solely on groundwater as a source of drinking water.

The Rusher and Scull Creek watersheds, including Clearwater Lake, would also continue to receive ARD from the spoil piles under the No Action Alternative and therefore these water bodies would continue to exhibit depressed pH and elevated metals concentrations that pose risk to aquatic biota. Seepage and runoff from the tailings impoundments would continue, as would the corresponding depressed pH and elevated metals concentrations in Reyburn Creek. Low but unacceptable levels of risk would continue to exist in sediments of the Site-affected creeks as well as Clearwater Lake. The TP1, TP3, and TP4E dams would not be stabilized and therefore these dams would continue to exhibit marginal stability.

For the above reasons, the No Action Alternative would not meet the RAOs or PRGs identified in Sections 3.3 and 3.4, respectively. Further, as discussed in the following subsection, ARARs would not be met in off-Site streams. Thus, the No Action Alternative does not provide overall protection of human health and the environment.

6.2.1.2 Compliance with ARARs

After cessation of the groundwater capture and water treatment efforts, no activities would occur at the Site under the No Action Alternative. There would be no additional adverse impacts or development in the floodplains of the affected streams, and no diversions or excavations, under the No Action Alternative. There would be no Site-related activities adversely affecting stream beds and banks. Therefore, no action- or location-specific ARARs would apply.

Chemical-specific water quality ARARs (i.e., APCEC Regulation 2) would be exceeded in Chamberlain Creek, Scull Creek, Reyburn Creek, and Clearwater Lake under the No Action Alternative. Overflow of untreated pit lake water would also result in ARARs violations. Thus, the No Action Alternative would not comply with ARARs and no basis is identified to seek a waiver from these chemical-specific ARARs. For these reasons, the No Action Alternative does not achieve the compliance with ARARs criterion.

6.2.1.3 Long Term E ectiveness and Permanence

No additional controls would be implemented under the No Action Alternative. The magnitude of risk to aquatic biota in affected streams and to terrestrial receptors at the sludge ponds would not be reduced and therefore residual risks to environmental receptors would remain at unacceptable levels after implementation of the No Action Alternative. Thus, the No Action Alternative is neither long-term effective nor permanent.

6.2.1.4 Reduction o To icity, Mobility, or olume Through Treatment

The No Action Alternative does not employ treatment technologies for aqueous or solid media and therefore would not result in a reduction in the toxicity, mobility, or volume of COPCs. Therefore, the No Action Alternative provides no reduction of toxicity, mobility, or volume through treatment.

6.2.1.5 Short Term E ectiveness

The No Action Alternative does not entail any remedial activity and, therefore, no construction or other activities potentially posing risks to on-site workers, nearby residents, and/or the environment will occur. Thus, the short-term effectiveness criterion is not applicable to the No Action alternative.

6.2.1.6 Implementability

The No Action Alternative does not entail any remedial activity. Thus, the implementability criterion is not applicable to the No Action Alternative.

6.2.1.7 Cost

The No Action Alternative entails no activities other than switching off the existing WTS and shallow groundwater extraction system. Water quality monitoring associated with the existing WTS would also cease. Therefore, no capital, annual, or periodic costs are associated with the No Action Alternative.

6.2.2 Alternative 2 No Further Action

This section describes the detailed analysis of Alternative 2, No Further Action. A summary of the components of Alternative 2 is shown on Table 5-3. A summary description of the performance of this alternative against the detailed analysis criteria is shown on Table 6-1. The No Further Action Alternative includes the items listed below.

Within the Pit Lake/Chamberlain Creek Watersheds:

- PL2 – Operate Existing WTS, Maintain Pit Level
    - o Continue pumping and treating utilizing the existing WTS with a hydrographically-controlled discharge to achieve/maintain the Pit Lake at an appropriate elevation (e.g., approximately 595 feet above sea level).
- SP1 – No Action
    - o Do nothing to the spoil piles.

- SGW2 – Operate Existing Capture/Treatment System
  - Continue operating the existing capture system that pumps shallow groundwater to the pit lake.
- BGW1 – No Action
  - Do nothing to the bedrock groundwater.
- SLU1 – No Action
  - Do nothing to the sludge ponds.
- CHM1 – No Action
  - Do nothing to Chamberlain Creek.

Outside of the Pit Lake/Chamberlain Creek Watersheds:

- TI1 – No Action
  - Do nothing to the tailings impoundments.
- AS1 – No Action
  - Do nothing to the affected streams.
- CWL1 – No Action
  - Do nothing to Clearwater Lake.

6.2.2.1 Overall Protection o uman ealth and the Environment

Under Alternative 2, the WTS would continue its current operation until a water surface elevation of approximately 595 feet is achieved. This pit lake water level would be maintained by continued but reduced operation of the WTS and an uncontrolled discharge of untreated pit lake water would therefore be precluded. However, shallow groundwater within the Pit Lake/Chamberlain Creek Watersheds that is not intercepted by the existing shallow groundwater capture system would continue to flow westward and discharge to and degrade Chamberlain Creek, which would continue to exhibit depressed pH and metals concentrations above ARARs. The sludge ponds would continue to pose unacceptable levels of risk to terrestrial ecological receptors. The Site would continue to affect any residents within the Chamberlain Creek syncline that rely solely on groundwater as a source of drinking water.

The Rusher Creek watershed and the Scull Creek watershed, including Clearwater Lake, would continue to receive ARD from the spoil piles and therefore these water bodies would continue to exhibit depressed pH and elevated metals concentrations that exceed ARARs. Seepage and runoff from the tailings impoundments would continue, as would the corresponding depressed pH and elevated metals concentrations in Reyburn Creek. Low but unacceptable levels of risk would continue to exist in sediments of the Site-affected creeks as well as Clearwater Lake. The TP1, TP3, and TP4E dams would not be stabilized and therefore these dams would continue to exhibit marginal stability.

For the above reasons, Alternative 2 would not meet any of the RAOs or PRGs identified in Sections 3.3 and 3.4, respectively. Further, as described in the following subsection, ARARs would continue to be exceeded in off-Site streams, and the residual risks remaining after implementation of Alternative 2 would be unacceptable. Thus, Alternative 2 would not provide overall protection of human health and the environment.

6.2.2.2 Compliance with ARARs

The WTS and shallow groundwater collection system are already in place, operating, and properly permitted. Discharge limitations for metals are consistently met by the WTS. The discharge also meets minerals standards that are temporarily allowed by the CAO, though these temporary standards would need to be permanently adopted under any of the action-based remedial alternatives. Therefore, the WTS and shallow groundwater collection system are compliant with ARARs. There would be no additional adverse impacts or development in the floodplains of the affected streams, and no diversions or excavations, under Alternative 2. There would be no Site-related activities adversely affecting stream beds and banks. Therefore, no action- or location-specific ARARs would apply.

Chemical-specific ARARs regarding water quality (i.e., APCEC Regulation 2) would continue to be exceeded in Chamberlain Creek, Scull Creek, Reyburn Creek, and Clearwater Lake under Alternative 2. Thus, Alternative 2 would not comply with all ARARs and no basis is identified to seek a waiver from the chemical-specific ARARs. For these reasons, Alternative 2 does not achieve the compliance with ARARs criterion.

6.2.2.3 Long Term E ectiveness and Permanence

No additional controls would be implemented under Alternative 2, which relies on ongoing operation of the WTS and existing shallow groundwater collection system to the west of the pit lake. These components of Alternative 2 would have a high level of long-term effectiveness and permanence in terms of addressing the pit lake. However, the magnitude of risk to aquatic biota in affected streams and to terrestrial receptors at the sludge ponds would not be reduced and therefore residual unacceptable risks to environmental receptors would remain after implementation of Alternative 2. Thus, Alternative 2 provides an overall low level of long-term effectiveness and permanence.

6.2.2.4 Reduction o To icity, Mobility, or olume Through Treatment

Continued operation of the WTS would reduce the toxicity of the pit lake water and collected shallow groundwater, prior to discharge. The mobility of the metals removed from these waters would be reduced because the metals will be precipitated as solids and sequestered in the bottom of the pit lake. Therefore, Alternative 2 provides a high level of reduction of toxicity, mobility, or volume through treatment.

6.2.2.5 Short Term E ectiveness

Alternative 2 does not entail any further remedial activity beyond continued operation of the WTS and shallow groundwater collection system. Therefore, no construction or other activities potentially posing risks to on-site workers, nearby residents, and/or the environment would occur. Operation of the WTS and shallow groundwater collection system poses low risk to workers and nearby residents. Thus, Alternative 2 provides a high level of short-term effectiveness.

6.2.2.6 Implementability

The action-based components of Alternative 2 are already constructed, in-place, and operating. Therefore, Alternative 2 is implementable.

6.2.2.7 Cost

Costs associated with Alternative 2 would be the ongoing annual O&M costs of operating the WTS as well as periodic costs associated with replacement of WTS components as they wear out. The WTS began operation in 2003 and has been operating at the fullest capacity allowed under its discharge permit and the CAO to reduce the surface elevation of the pit lake to approximately 595 feet above sea level. As previously discussed, maintenance of this elevation will eliminate seepage through the base of the adjacent spoil piles and also allow freeboard in case treatment and discharge from the pit lake is interrupted for a prolonged period of time. The 595-foot target elevation is expected to be achieved in 2010. After that time, the amount of water that would need to be treated by the WTS will decrease because it will only be necessary to maintain the pit lake surface elevation rather than to further reduce it.

The estimated costs to implement Alternative 2 are summarized on Table 6-1 and detailed in Appendix B. Actual costs to operate the WTS in 2008 were approximately $715,000, including operation of the existing groundwater capture system and monitoring required by the existing discharge permit and CAO. Upon achievement of the target elevation of 595 feet, annual O&M costs for the WTS are expected to drop to approximately $360,000 because lesser discharge volumes and associated amounts of treatment reagent will be needed. Periodic costs associated with the WTS will be associated with the replacement of major WTS components (e.g., clarifier, mixing tanks, etc.). Since the actual need for such replacement cannot be predicted with certainty, the cost estimate for Alternative 2 assumes that periodic costs are $1,000,000 expended every fifth year, beginning in year 15 of the WTS operation. Based on the above, and a WTS operation life of 100 years, the net present value of Alternative 2 is estimated to be $6,910,000.

6.2.3 Alternative 3 WTS and Source Control

This section describes the detailed analysis of Alternative 3, WTS and Source Control. A summary of the components of Alternative 3 is shown on Table 5-3. A summary description of the performance of this alternative against the detailed analysis criteria is shown on Table 6-1. Alternative 3 includes the items listed below.

Within the Pit Lake/Chamberlain Creek Watersheds:

- PL2 – Operate Existing WTS, Maintain Pit Level
    - Continue pumping and treating utilizing the existing WTS with a hydrographically-controlled discharge rate to meet discharge water quality requirements and to achieve/maintain the pit lake elevation.
- SP2 – Selective Regrading, Augment Vegetation, and ARD Capture
    - Enhance natural reclamation of the spoil that has occurred over the past 30+ years.
    - Regrade spoil piles where vegetation has not effectively reduced erosion.
    - Regrade spoil piles to direct ARD to the pit lake watershed, where practical.
    - Amend soil in key areas to reduce ARD generation.
    - Vegetate regraded areas and areas currently devoid of vegetation.

  - Capture runoff and shallow groundwater for treatment.[11]
- SGW3 – Expanded Capture/Treatment System
  - Expand existing system or construct a larger system to intercept a larger portion of the impacted shallow groundwater and pump it to the pit lake for treatment.
  - Invoke ICs to restrict well installation in the shallow groundwater system in the affected area.
- BGW2 – Verify Connection to Municipal System
  - Verify that all current residents within the affected areas of Chamberlain Creek syncline have or are provided with a permanent connection to the existing municipal water system.
- SLU2 – Soil Cover, Revegetate
  - Construct a soil cover over the three existing sludge ponds and vegetate.
- CHM2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into Chamberlain Creek by controlling ARD generation and migration from spoil piles.

Outside of the Pit Lake/Chamberlain Creek Watersheds:

- TI2 – Regrade, Stabilize Dams, Revegetate
  - Regrade tailings material to eliminate water storage.
  - Stabilize dams to reduce likelihood of slope failure.
  - Vegetate all regraded tailings impoundment areas.
- AS2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into affected creeks by controlling ARD generation and migration from spoil piles.
- CWL2 – Source Control

[11] The runoff and shallow groundwater would be collected near the northern base of the northeast spoil piles, which is outside of the Pit Lake/Chamberlain Creek Watersheds. However, the collected water will be directed to the pit lake.

- o Reduce or eliminate the potential for ARD to enter into Clearwater Lake by controlling ARD generation and migration from spoil piles.

6.2.3.1 Overall Protection o uman ealth and the Environment

Under Alternative 3, the WTS would continue its current operation until a water surface elevation of approximately 595 feet is achieved. This pit lake water level would be maintained by continued but reduced operation of the WTS and an uncontrolled discharge of untreated pit lake water would therefore be precluded. The WTS has demonstrated effectiveness in terms of meeting water quality ARARs. An expanded shallow groundwater capture system would intercept a greater volume of groundwater in the Chamberlain Creek watershed than the current system and pump it to the pit lake for treatment, reducing discharge into Chamberlain Creek and thus reducing its degradation in terms of depressed pH and elevated metals concentrations. The sludge ponds would be covered with clean soil and thus would no longer pose unacceptable levels of risk to terrestrial ecological receptors. The Site would not affect any residents within the Chamberlain Creek syncline to the west of the Site because they would be connected to the existing municipal water supply system.

Runoff and seepage from the spoil piles to the Rusher Creek watershed and the Scull Creek watershed, including Clearwater Lake, would be significantly reduced in terms of quantity, and improved in terms of quality, by the regrading, soil amendment, and ARD capture actions included in Alternative 3. Focused regrading of the tailings impoundments to promote drainage, vegetation establishment in currently bare areas, and elimination of the ponded areas would decrease the quantity and improve the quality of seepage entering Reyburn Creek. The TP1, TP3, and TP4E dams would be stabilized by regrading and/or buttressing and therefore these dams would exhibit acceptable stability. Very low but unacceptable levels of risk would continue to exist in sediments of the Site-affected creeks as well as Clearwater Lake at the completion of remedial action. However, significant reductions in ARD entering these water bodies is expected to reduce these risks to acceptable levels over time.

Alternative 3 would meet the RAOs and PRGs identified in Sections 3.3 and 3.4, respectively. Further, as discussed below, Alternative 3 is expected to meet ARARs in off-Site streams and to reduce identified risks to acceptable levels. Thus, Alternative 3 provides overall protection of human health and the environment.

6.2.3.2 Compliance with ARARs

The WTS is already in place, operating, properly permitted, and meeting all ARARs (though the temporary minerals standards currently allowed by the CAO would need to be permanently adopted). The shallow groundwater collection system in the Chamberlain Creek watershed that is currently in place, and part of the properly permitted WTS, would be replaced by a larger system with greater capacity. Therefore, these facilities will be compliant with ARARs under Alternative 3.

Regrading, vegetation augmentation, and capture of residual ARD in the spoil piles area will not impinge on known floodplains and/or to result in the discharged of dredged material or fill into wetlands. The tailings impoundments are industrial facilities and thus regrading of the tailings impoundments to remove ponded water would not affect designated wetlands. Any wetlands that may be present at the toes of the tailings impoundments would be identified prior to construction work and any affected wetlands would be properly mitigated. Therefore, Alternative 3 would meet the ARARs associated with work in floodplains and wetlands. Consultations with Fish and Wildlife Service personnel would be implemented prior to any construction under Alternative 3 to ensure that any endangered species and/or critical habitat are not impacted by the remediation activities.

The activities associated with Alternative 3 comprise standard construction work with that would employ normal dust suppression methods during construction. Therefore, Alternative 3 is expected to be compliant with air-related ARARs. This standard construction work will also be implemented to minimize sediment releases to adjacent waters, and to conduct monitoring to ensure that the releases are minimized, and thus are expected to be in compliance Federal storm water regulations.

Continued operation of the WTS; operation of an expanded shallow groundwater capture system; regrading and revegetating of spoil piles; capture of residual ARD from the spoil piles; and regrading, revegetating, and stabilizing the tailings impoundments are expected to result in significant increases in pH levels, and corresponding reductions in metals concentrations, in Chamberlain Creek, Rusher Creek, Scull Creek, Clearwater Lake, and Reyburn Creek. These improvements are expected to result in achievement of chemical-specific water quality ARARs within a few years of completing the Alternative 3 construction activities as disturbed areas become vegetated and source controls become effective. However, continued modification of the Regulation 2 standard for minerals, as currently allowed by the CAO, will be required for the ARARs to be met under Alternative 3.

All solid waste related ARARs are expected to be met by Alternative 3 because there are no hazardous wastes at the Site and no wastes would be removed for off-Site disposal.

For the reasons outlined above, Alternative 3 achieves the compliance with ARARs criterion.

6.2.3.3 Long Term E ectiveness and Permanence

Alternative 3 relies on ongoing operation of the WTS, expanded shallow groundwater collection system to the west of the pit lake, and a system that collects surface water and shallow groundwater to the north and northeast of the northeastern spoil piles. With proper maintenance, these components of Alternative 3 are expected to have a high level of long-term effectiveness and permanence. Other components of Alternative 3, including regrading and revegetating portions of the spoil piles and tailings impoundments and stabilization of the tailing impoundment dams, are also expected to have a high level of long-term effectiveness and permanence because they rely on standard earthwork construction to reduce contact of waste material with water and, in the case of the sludge ponds, to eliminate direct contact pathways. Finally, connection of potentially affected residents within the Chamberlain Creek syncline to the existing municipal water system, and imposition of ICs to prohibit construction of new wells in the shallow groundwater system affected by the Site, will also provide long-term effectiveness and permanence. Thus, Alternative 3 would provide a high level of long-term effectiveness and permanence.

6.2.3.4 Reduction o To icity, Mobility, or olume Through Treatment

Continued operation of the WTS will reduce the toxicity of the pit lake water and collected shallow groundwater prior to discharge. The mobility of the metals removed from these waters will be reduced because the metals will be precipitated as solids and sequestered in the bottom of the pit lake. Therefore, Alternative 3 provides a high level of reduction of toxicity, mobility, or volume through treatment.

6.2.3.5 Short Term E ectiveness

As previously discussed, the WTS has already been constructed and is operational. The remaining construction activities that would be associated with Alternative 3 primarily consist of routine earthwork. Such activities, when implemented by properly trained workers, have been proven to be safe and should result in little to no risks to the workers, the few residents that live near the Site, or the environment. A significant level of protectiveness is expected to be achieved upon the conclusion of the Alternative 3 construction; full protection should occur within a few years of construction completion as disturbed areas become vegetated, shallow aquifers are purged of metals, and soluble salts are flushed from the Site. Therefore, Alternative 3 provides a high level of short-term effectiveness.

6.2.3.6 Implementability

Alternative 3 is implementable in terms of technical feasibility and the availability of goods and services. However, the implementability of some portions of the alternative could be affected by the need to gain access to privately owned areas of the Site.

6.2.3.7 Cost

The estimated cost to implement Alternative 3 is summarized in Table 6-1. Costs and supporting information for Alternative 3, including specific material volumes, areas to be addressed, and corresponding unit rates, are detailed in Appendix B. The Alternative 3 cost estimate includes a 100-year operation period for the WTS. The net present value of Alternative 3 is estimated to be $18,400,000.

6.2.4 Alternative 4 Pit Lake Neutralization and Source Control

This section describes the detailed analysis of Alternative 4, Pit Lake Neutralization and Source Control. A summary of the components of Alternative 4 is shown on Table 5-3. A summary description of the performance of this alternative against the detailed analysis criteria is shown on Table 6-1. Alternative 4 is identical to Alternative 3 with the exception that Alternative 4 substitutes in-situ neutralization of the upper layer of the pit lake (PL3) for operation of the WTS (PL2), as included in Alternative 3. Alternative 4 includes the items listed below.

Within the Pit Lake/Chamberlain Creek Watersheds:

- PL3 – In-Situ Neutralization, Maintain Pit Level
  - Discontinued operation of the WTS.
  - In-situ chemical/biological treatment to neutralize pH and enhance biological metals removal mechanisms within the upper pit lake layer.
  - Discharge according to a hydrographically controlled release to maintain the pit lake surface elevation at an acceptable level (approximately 595 feet above sea level).
  - Potential addition of a constructed wetland treatment system to polish the discharge, or diversion of the discharge to a larger receiving water body (e.g.,Cove Creek) to provide a mixing zone, depending on the level of metals removal achieved by in-situ treatment.
- SP2 – Selective Regrading, Augment Vegetation, and Capture ARD
  - Enhance natural reclamation of the spoil that has occurred over the past 30+ years.
  - Regrade spoil piles where vegetation has not effectively reduced erosion.
  - Regrade spoil piles to ensure ARD reports only to the Pit Lake Watershed, to the extent feasible.
  - Amend soil in key areas to reduce ARD generation.
  - Vegetate regraded areas and areas currently devoid of vegetation.

  - Capture runoff and shallow groundwater for treatment.[12]
- SGW3 – Expanded Capture/Treatment System
  - Expand existing system to intercept a larger portion of the impacted shallow groundwater and pump it to the pit lake for treatment.
  - Invoke ICs to restrict well installation in the shallow groundwater system in the affected area.
- BGW2 –Verify Connection to Municipal System
  - Verify that all current residents within the affected areas of Chamberlain Creek syncline have or are provided with a permanent connection to the municipal water system.
- SLU2 – Soil Cover, Revegetate
  - Construct a soil cover over the three existing sludge ponds and vegetate.
- CHM2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into Chamberlain Creek by controlling ARD generation and migration from spoil piles.

Outside of the Pit Lake/Chamberlain Creek Watersheds:

- TI2 – Regrade, Stabilize Dams, Revegetate
  - Regrade tailings material to eliminate water storage.
  - Stabilize dams to reduce likelihood of slope failure.
  - Vegetate all regraded tailings impoundment areas.
- AS2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into affected creeks by controlling ARD generation and migration from spoil piles.
- CWL2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into Clearwater Lake by controlling ARD generation and migration from spoil piles.

[12] As previously discussed, this water collection system would be located outside of the Pit Lake/Chamberlain Creek Watersheds, but the collected water would be pumped to the pit lake.

6.2.4.1 Overall Protection o uman ealth and the Environment

Under Alternative 4, the upper layer of the pit lake would be neutralized in-situ by adding and mixing lime using a barge-mounted system. Following neutralization, fertilizer would periodically be added to the upper layer of the pit lake to promote algae growth and associated biological metals removal mechanisms. The pit lake water level would be maintained at 595 feet above sea level through use of a hydrographically controlled release either by pumping or a valved outlet mechanism, thus precluding an uncontrolled discharge of untreated pit lake water.

The effectiveness of this technology in terms of consistently meeting permit limits for the Site pit lake 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 (MFG, 2001b. Once neutralized, ARD inputs from the adjacent spoil piles, and the addition of collected shallow groundwater and runoff from the northern and western spoil areas will decrease the pH of the neutralized lake water. 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. Due to the high level of uncertainty associated with this technology, it may need to be combined with a polishing treatment step such as biological sulfide precipitation in a constructed wetland. Diversion of the neutralized water via pipeline to a larger receiving water body (e.g., Cove Creek) that would provide a mixing zone and correspondingly higher discharge limits could be implemented instead of, or in combination with, polishing in a constructed wetland. Even with these additional steps, however, the ability of in-situ neutralization to meet water quality standards, and thus ARARs, is still unknown.

An expanded shallow groundwater capture system would intercept a greater volume of groundwater in the Chamberlain Creek watershed than the current system and pump it to the pit lake for treatment, reducing discharge into Chamberlain Creek and thus reducing its degradation in terms of depressed pH and elevated metals concentrations. The sludge ponds would be covered with clean soil and thus would no longer pose unacceptable levels of risk to terrestrial ecological receptors. The Site would not affect any residents within the Chamberlain

Creek syncline to the west of the Site because they would be connected to the existing municipal water supply system.

Runoff and seepage from the spoil piles to the Rusher Creek watershed and the Scull Creek watershed, including Clearwater Lake, would be significantly reduced in terms of quantity, and improved in terms of quality, by the regrading, soil amendment, and ARD capture actions included in Alternative 4. Focused regrading of the tailings impoundments to promote drainage, vegetation establishment in currently bare areas, and elimination of the ponded areas would decrease the quantity and improve the quality of seepage entering Reyburn Creek. The TP1, TP3, and TP4E dams would be stabilized by regrading and/or buttressing and therefore these dams would exhibit acceptable stability. Very low but unacceptable levels of risk would continue to exist in sediments of the Site-affected creeks as well as Clearwater Lake at the completion of remedial action. However, significant reductions in ARD entering these water bodies are expected to reduce these risks to acceptable levels over time.

For the above reasons, it is unknown whether Alternative 4 would meet all of the RAOs and PRGs identified in Sections 3.3 and 3.4, respectively. As discussed below, though Alternative 4 is expected to meet ARARs in off-Site streams that do not receive discharge from the pit lake and to reduce identified risks in those streams to acceptable levels, it is unknown whether in-situ neutralization of the upper layer of the pit lake can achieve discharge ARARs on a consistent basis, and thus ARARs in the receiving streams). Therefore, it is unknown whether Alternative 4 will provide overall protection of human health and the environment.

6.2.4.2 Compliance with ARARs

The treatment technology (lime addition) that would comprise the primary treatment mechanism under Alternative 4 has been identified as being effective on water from the pit lake through the on-going WTS operation. However, the effectiveness of this technology, when applied in-situ to a large pit lake, is unknown in terms of whether treatment goals such as permit limits could consistently be met (MFG Inc., 2001b). As previously discussed, the addition of fertilizer could result in collateral effects that would result in non-achievement of ARARs. This technology could be combined with a polishing treatment step, such as biological sulfide precipitation in a constructed wetland, though implementation of a hydrographically controlled release through a constructed wetland could present operational difficulties. Diversion of the neutralized water via pipeline to a larger receiving water body (e.g., Cove Creek) that would provide a mixing zone and correspondingly higher discharge limits could be implemented instead of, or in combination with, polishing in a constructed wetland. However, even if constructed wetland polishing and/or diversion to a large receiving water body are incorporated into Alternative 4, its ability to consistently meet discharge limits remains unknown. Ongoing ARD input from the adjacent spoil piles, and the addition of collected groundwater and runoff, would require periodic re-liming of the upper layer of the pit lake to maintain a neutralized condition. The frequency with which such re-liming would be needed is unknown.

Regrading, vegetation augmentation, and capture of residual ARD in the spoil piles area is not expected to impinge on known floodplains and/or to result in the discharge of dredged material or fill into wetlands. The tailings impoundments themselves are industrial impoundments and not wetlands. Any wetlands that may be present at the toes of the tailings impoundments would be identified prior to construction work and any affected wetlands would be properly mitigated. Therefore, Alternative 4 would meet the ARARs associated with work in floodplains and wetlands. Consultations with Fish and Wildlife Service personnel would be implemented prior to any construction under Alternative 4 to ensure that any endangered species and/or critical habitat are not impacted by the remediation activities.

The activities associated with Alternative 4 comprise standard construction work that would employ normal dust suppression methods during construction. Therefore, Alternative 4 is expected to be compliant with all air-related ARARs. This standard construction work will also be implemented and monitored to minimize sediment releases to adjacent waters to compliance with Federal storm water regulations. There would be no Site-related actions affecting any resources eligible for the Register of Historic Places, historic sites, or any other potential cultural resources.

Regrading and revegetating spoil piles; capture of residual ARD from the spoil piles; and regrading, revegetating, and stabilizing the tailings impoundments are expected to result in significant increases in pH levels, and corresponding reductions in metals concentrations, in Rusher Creek, Scull Creek, Clearwater Lake, and Reyburn Creek. These improvements are expected to result in achievement of chemical-specific water quality ARARs (i.e., APCEC Regulation 2) within a few years of completing the Alternative 4 construction activities as disturbed areas become vegetated, and source controls become effective. However, whether ARARs could be achieved in Chamberlain Creek and Cove Creek would rely on the unknown effectiveness of in-situ pit lake treatment, given that these are the receiving streams for the treated discharge. In any event, continued modification to the Regulation 2 standard for minerals, as currently allowed by the CAO, will be required for the ARARs to be met under Alternative 4.

All solid waste related ARARs are expected to be met by Alternative 4 because there are no hazardous wastes at the Site and no wastes would be removed for off-Site disposal.

For the reasons outlined above, Alternative 4 would achieve compliance with ARARs for all areas of the Site with the potential exception of the pit lake discharge. It is unknown whether in-situ neutralization would consistently improve water quality to allow discharge within the limits set under the existing discharge permit, and thus it is unknown whether these ARARs can be achieved.

6.2.4.3 Long Term E ectiveness and Permanence

Alternative 4 relies on in-situ neutralization of the upper layer of the pit lake, an expanded shallow groundwater collection system to the west of the pit lake, and a surface water and shallow groundwater collection system to the north and northeast of the northeastern spoil piles. The collected waters from this collection system would be directed to the pit lake for in-situ treatment, along with the pit lake water. Other components of Alternative 4, including regrading and revegetating portions of the spoil piles and tailings impoundments and stabilization of the tailing impoundment dams are expected to have a high level of long-term effectiveness and permanence because they rely on standard earthwork construction to reduce contact of waste material with water and, in the case of the sludge ponds, to eliminate direct contact pathways. Finally, connection of potentially affected residents within the Chamberlain Creek syncline to the existing municipal water system, and imposition of institutional controls to prohibit construction of new wells in the shallow groundwater system affected by the Site, will also be long-term effective and permanent. However, the ultimate effectiveness and permanence of in-situ neutralization of the upper layer of the pit lake is unknown. For this reason, Alternative 4 would provide an unknown level of long-term effectiveness and permanence.

6.2.4.4 Reduction o To icity, Mobility, or olume Through Treatment

In-situ neutralization would reduce the toxicity of the upper layer of the pit lake and collected shallow groundwater and runoff prior to discharge. The mobility of the metals removed from these waters would be reduced because the metals will be precipitated as solids and sequestered in the bottom of the pit lake. Therefore, Alternative 4 provides a high level of reduction of toxicity, mobility, or volume through treatment.

6.2.4.5 Short Term E ectiveness

In-situ neutralization of the upper layer of the pit lake using a barge or boat would not pose unacceptable risk to Site workers or nearby residents. Construction of a wetland treatment system and/or pipeline to Cove Creek, if needed to sufficiently improve the quality of the pit lake water prior to discharge, can be accomplished using standard construction methods that also would not pose unacceptable levels of risk. The remaining construction activities that would be associated with Alternative 4 primarily consist of routine earthwork. Such activities, when implemented by properly trained workers, have been proven to be safe and should result in little to no risks to the workers, the few residents that live near the Site, or the environment. A significant level of protectiveness is expected to be achieved upon the conclusion of the Alternative 4 construction; full protection should occur within a few years of construction completion as disturbed areas become vegetated, shallow aquifers are purged of metals, and soluble salts are flushed from the Site. Therefore, Alternative 4 provides a high level of short-term effectiveness.

6.2.4.6 Implementability

Alternative 4 is implementable in terms of technical feasibility and the availability of goods and services. However, the implementability of some portions of the alternative could be affected by the need to gain access to privately owned areas of the Site.

6.2.4.7 Cost

The estimated cost to implement Alternative 4 is summarized in Table 6-1. Costs and supporting information for Alternative 4, including specific material volumes, areas to be addressed, and corresponding unit rates, are detailed in Appendix B. The Alternative 4 cost estimate includes a 100-year operation period for in-situ neutralization of the upper layer of the pit lake. The net present value of Alternative 4 is estimated to be $16,300,000. This estimate does not include a constructed wetland treatment system or a pipeline to Cove Creek for the pit lake discharge in the event that the neutralized water does not meet permit limits. The incremental cost increase to add these components to Alternative 4 would likely be on the order of $1 million to $2 million or more.

6.2.5 Alternative 5 Pit Lake Neutralization and E tensive Source Control

This section describes the detailed analysis of Alternative 5, Pit Lake Neutralization and Extensive Source Control. A summary of the components of Alternative 5 is shown on Table 5-3. A summary description of the performance of this alternative against the detailed analysis criteria is shown on Table 6-1. Alternative 5 includes the items listed below.

Within the Pit Lake/Chamberlain Creek Watersheds:

- PL3 – In-Situ Neutralization, Maintain Pit Level
  - The WTS would continue operation until the spoil piles have been addressed (see SP3, below).
  - After SP3 has been implemented, in-situ chemical/biological treatment to neutralize pH and enhance biological metals removal mechanisms within the upper pit lake layer.
  - Discharge according to a hydrographically controlled release to maintain the pit lake surface elevation at an acceptable level (approximately 595 feet above sea level).

  - Potential addition of a constructed wetland treatment system to polish the discharge, or diversion of the discharge to a relatively large receiving water body (Cove Creek) to provide a mixing zone, depending on the level of metals removal achieved by in-situ treatment.

- SP3 – Extensive Regrading, Amendment, Soil Cover, Revegetation
  - Regrade, relocate, treat spoil through amendment, cover, and revegetate the spoil piles so that the total surface is minimized, slopes are reduced, and all residual ARD reports to the Chamberlain Creek Watershed. The assumed location of the resulting repository would be within the Chamberlain Creek syncline between the WTS and Baroid Road.
  - Treat soil through amendment in key areas (i.e., former spoil pile footprints) to reduce ARD generation.
- SGW3 – Expanded Capture/Treatment System
  - Implementation of spoil pile alternative SP3 is expected to result in short-term increased impacts to the shallow groundwater system, requiring the installation of an expanded capture system for the shallow groundwater. The captured water would be pumped to the pit lake for treatment. However, consolidation, treatment, and capping of the spoil should eventually lead to acceptable water quality in the shallow groundwater system, allowing the expanded capture system to eventually be decommissioned.
  - Invoke ICs to restrict well installation in the affected area.
- BGW2 –Verify Connection to Municipal System
  - Provide all current residents within the affected areas of Chamberlain Creek syncline with a permanent connection to the municipal water system.
- SLU2 – Soil Cover, Revegetate
  - The sludge ponds would become part of the spoil repository constructed under SP3 and any direct contact pathways with the sludge would be eliminated.
- CHM2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into Chamberlain Creek by controlling ARD generation and migration from spoil piles.

Outside of the Pit Lake/Chamberlain Creek Watersheds:

- TI2 – Regrade, Stabilize Dams, Revegetate
  - Regrade tailings material to eliminate water storage.
  - Stabilize dams to reduce likelihood of slope failure.
  - Vegetate all regraded tailings impoundment areas.
- AS2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into affected creeks by controlling ARD generation and migration from spoil piles.
- CWL2 – Source Control
  - Reduce or eliminate the potential for ARD to enter into Clearwater Lake by controlling ARD generation and migration from spoil piles.

6.2.5.1 Overall Protection o uman ealth and the Environment

Under Alternative 5, the WTS would remain in operation until the spoil piles have been placed and amended within a repository. This would effectively eliminate further ARD inputs to the pit lake. Following completion of repository construction, the upper layer of the pit lake would be neutralized in-situ, as discussed for Alternative 4 (Section 6.2.4.1). This pit lake water level would be maintained by discharging as a hydrographically controlled release either by pumping or through a valved outlet mechanism. As previously described, the effectiveness of this technology in terms of consistently meeting treatment goals such as permit limits is unknown, 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. This technology may need to be combined with a polishing treatment step, such as biological sulfide precipitation in a constructed wetland. Diversion of the neutralized water via pipeline to a larger receiving water body (e.g., Cove Creek) that would provide a mixing zone and correspondingly higher discharge limits could be implemented instead of, or in combination with, polishing in a constructed wetland. However, the certainty of achieving protectiveness by in-situ neutralization would be maximized because ongoing inputs of ARD to the pit lake from the spoil piles would be eliminated. Elimination of ARD inputs to the pit lake would also allow cessation of fertilizer application, eliminating potential undesirable increases in total suspended solids, nutrients, and biological oxygen demand in the pit lake discharge.

The mine spoil would be relocated to a single repository to reduce the spoil footprint area. Excavation and relocation of the spoil would eliminate the natural reclamation (e.g., revegetation and weathering of spoil surfaces), resulting in significant short-term increases in ARD production that would affect adjacent streams. Spoil that is relocated to the repository would be treated with an alkaline material as it is placed in the repository to minimize future ARD production. The repository containing the treated spoil would be covered with clean soil and revegetated. The assumed repository location is between the existing WTS and Baroid Road within the Chamberlain Creek syncline. This location is downgradient of the pit lake and thus further ARD input to the lake would be minimized or eliminated due to the repository location and the presence of treated spoil within the repository.

An expanded shallow groundwater capture system would intercept shallow groundwater impacted by the spoil during and for a period after repository during construction activities. Due to the treatment of spoil in the repository, however, it is expected that the groundwater collection system could eventually be decommissioned. The sludge ponds would be incorporated into the spoil repository and thus would no longer pose unacceptable levels of risk to terrestrial ecological receptors. The Site would not affect any residents within the Chamberlain Creek syncline to the west of the Site because they would be connected to the existing municipal water supply system. Placement of the treated mine spoil into a single, consolidated repository will provide an overall improvement in groundwater quality downgradient (west) of the Site.

Runoff and seepage from the spoil piles to the Rusher Creek watershed and the Scull Creek watershed, including Clearwater Lake, would be eliminated by the spoil relocation/repository construction actions included in Alternative 5. Focused regrading of the tailings impoundments to promote drainage, vegetation establishment in currently bare areas, and elimination of the ponded areas would decrease the quantity and improve the quality of seepage entering Reyburn Creek. The TP1, TP3, and TP4E dams would be stabilized by regrading and/or buttressing and therefore these dams would exhibit acceptable stability. Very low but unacceptable levels of risk would continue to exist in sediments of the Site-affected creeks as well as Clearwater Lake; however, significant reductions in ARD entering these water bodies is expected to reduce these risks to acceptable levels over time.

For the above reasons, Alternative 5 would meet the RAOs and PRGs identified in Sections 3.3 and 3.4, respectively. Further, as discussed below, Alternative 5 is expected to meet ARARs in off-Site streams that do not receive pit lake discharge and to reduce identified risks to acceptable levels. However, some uncertainty remains regarding the ability of in-situ neutralization to consistently achieve ARARs associated with discharge requirements for the pit lake (and thus ARARs in the receiving streams). This uncertainty would be most pronounced in the period during and shortly following the remedial construction activities. Given the relocation and treatment of the mine spoil, elimination of ARD inputs to the pit lake, and ongoing dilution of the upper layer of the pit lake by precipitation, however, the certainty of achieving ARARs in the pit lake using in-situ neutralization would increase. Therefore, Alternative 5 would eventually achieve overall protection of human health and the environment.

6.2.5.2 Compliance with ARARs

Under Alternative 5, the WTS would continue operation until the spoil material has been amended and placed in a repository such that it would no longer impact the pit lake. This would eliminate the need to re-lime the pit lake and/or introduce additional fertilizer over the long term. As discussed above, this would eventually lead to achievement of ARARs within the neutralized upper layer of the pit lake over time.

Construction of a spoil repository in the Chamberlain Creek syncline would impinge on the creek floodplain and likely result in the placement of material in wetland areas; appropriate mitigative measures and reporting would need to be implemented to maintain compliance with location-specific ARARs. Any wetlands that may be present at the toes of the tailings impoundments would be identified prior to any construction work and any affected wetlands would be properly mitigated. Therefore, Alternative 5 would meet the ARARs associated with work in floodplains and wetlands. Consultations with Fish and Wildlife Service personnel would be implemented prior to any construction under Alternative 5 to ensure that any endangered species and/or critical habitat are not impacted by the remediation activities.

The activities associated with Alternative 5 comprise standard construction work that employs normal dust suppression methods. Therefore, Alternative 5 is expected to be compliant with all air-related ARARs. This standard construction work will also be implemented to minimize sediment releases to adjacent waters, and to conduct monitoring to ensure that the releases are minimized; therefore, construction work is expected to be in compliance with Federal storm water regulations.

In-situ neutralization of the upper layer of the pit lake; construction of a treated mine spoil repository; temporary operation of an expanded shallow groundwater capture system; and regrading, revegetating, and stabilizing the tailings impoundments are expected to result in significant increases in pH levels, and corresponding reductions in metals concentrations, in Chamberlain Creek, Rusher Creek, Scull Creek, Clearwater Lake, and Reyburn Creek. These improvements are expected to result in achievement of chemical-specific water quality ARARs (i.e., APCEC Regulation 2) within several years of completing the Alternative 5 construction activities as disturbed areas become vegetated, and source controls become effective. In any event, continued relaxation of the Regulation 2 standard for minerals, as currently allowed by the CAO, will be required for the ARARs to be met under Alternative 5.

All solid waste related ARARs are expected to be met by Alternative 5 because there are no hazardous wastes at the Site and no wastes would be removed for off-Site disposal.

For the reasons outlined above, Alternative 5 would eventually achieve compliance with ARARs for all areas of the Site.

6.2.5.3 Long Term E ectiveness and Permanence

Alternative 5 includes consolidation of treated mine spoil in a repository that would be fully within the Chamberlain Creek watershed at a location hydraulically downgradient of the pit lake. Alternative 5 also relies on in-situ neutralization of the upper layer of the pit lake, after ongoing ARD inputs from the spoil piles have been eliminated, and an expanded shallow groundwater collection system to the west of the pit lake and spoil repository. The collected waters would be directed to the pit lake for in-situ treatment, along with the pit lake water. These components of Alternative 5 would have a high level of long-term effectiveness and permanence because ARD inputs to the pit lake would be eliminated through construction of the spoil repository. For this FS evaluation, it was assumed that a one time in-situ neutralization would be necessary given that the mine spoil would be eliminated as a an ongoing source of ARD to the pit lake.

Other components of Alternative 5, including incorporation of the sludge ponds in the spoil repository, regrading and revegetating portions of the tailings impoundments, and stabilization of the tailing impoundment dams, are expected to have a high level of long-term effectiveness and permanence because they rely on standard earthwork construction to reduce contact of waste material with water and, in the case of the sludge ponds, to eliminate direct contact pathways. Finally, connection of potentially affected residents within the Chamberlain Creek syncline to the existing municipal water system, and imposition of institutional controls to prohibit construction of new wells in the shallow groundwater system affected by the Site, are also expected to be long-term effective and permanent. Thus, Alternative 5 provides a high level of long-term effectiveness and permanence.

6.2.5.4 Reduction o To icity, Mobility, or olume Through Treatment

Ongoing WTS operation during remedial construction, followed by in-situ neutralization, would reduce the toxicity of the upper layer of the pit lake and collected shallow groundwater prior to discharge. The mobility of the metals removed from these waters would be reduced because the metals will be precipitated as solids and sequestered in the bottom of the pit lake. ARD generation from the spoil would be minimized due to amendment with alkaline material. Therefore, Alternative 5 provides a high level of reduction of toxicity, mobility, or volume through treatment.

6.2.5.5 Short Term E ectiveness

As discussed in Section 6.2.4.5 for Alternative 4, in-situ neutralization of the upper layer of the pit lake using a barge or boat would not pose undue risk to Site workers or nearby residents. Construction of a wetland treatment system and/or pipeline to Cove Creek, if needed to sufficiently improve the quality of the pit lake water prior to discharge, can be accomplished using standard construction methods that also would not pose unacceptable levels of risk. The remaining construction activities that would be associated with Alternative 5 primarily consist of routine earthwork. However, the significant volume of spoil (approximately 14 million cubic yards) and associated alkaline material that would need to be moved and mixed to create the repository, and the overall duration of construction activity, would inherently increase risks to Site workers due to the increased intensity of the construction actions. Excavation and relocation of approximately 14 million cy of spoil would expose fresh spoil to air and water, significantly increasing ARD production over the short term. The increased ARD production would affect environmental receptors in nearby streams. Therefore, Alternative 5 provides a moderate level of short-term effectiveness.

6.2.5.6 Implementability

Alternative 5 is implementable in terms of technical feasibility and the availability of goods and services. However, the implementability of some portions of the alternative could be affected by the need to gain access to privately owned areas of the Site.

6.2.5.7 Cost

The estimated cost to implement Alternative 5 is summarized in Table 6-1. Costs and supporting information for Alternative 5, including specific material volumes, areas to be addressed, and corresponding unit rates, are detailed in Appendix B. The Alternative 5 cost estimate includes a one-time only application of lime and fertilizer for neutralization of the upper layer of the pit lake and a 20-year operation period for collection of shallow groundwater downgradient of the repository. The net present value of Alternative 5 is estimated to be $285,000,000. The vast majority of this estimate is associated with excavation, relocation, and treatment of mine spoil and placement of the spoil in a repository.

Section 6 Tables

TABLE 6-1
EVALUATION OF REMEDIAL ACTION ALTERNATIVES AGAINST CERCLA CRITERIA
DRESSER INDUSTRIES-MAGCOBAR MINE SITE

Evaluation Criteria[1]	Alternative 1 No Action	Alternative 2 No Further Action	Alternative 3 WTS and Source Control	Alternative 4 Pit Lake Neutralization and Source Control	Alternative 5 Pit Lake Neutralization and Extensive Source Control
Threshold Criteria					
Overall Protection of Human Health and the Environment	Not protective	Not protective	Protective	Unknown. Effectiveness of in-situ neutralization of the upper layer of the Pit Lake is uncertain.	Protective. In-situ neutralization of the upper layer of the Pit Lake should eventually be effective since ARD source material (spoil) will be treated and placed in a repository.
Compliance with Applicable and/or Relevant and Appropriate Requirements (ARARs)	No	No	Yes	Unknown. Effectiveness of in-situ neutralization of the upper layer of the pit lake is uncertain, and consequently some water quality standards may not be met in Chamberlain and/or Cove creeks.	Yes. In-situ neutralization of the upper layer of the Pit Lake should eventually be effective since ARD source material (spoil) will be treated and placed in a repository.
Balancing Criteria					
Long-Term Effectiveness and Permanence	No	Low level of effectiveness and permanence. Water Treatment System (WTS) is effective; however, residual risks would remain in other Site areas.	High level of effectiveness and permanence	Moderate level of effectiveness and permanence; limited ability to control quality of pit lake discharge.	High level of effectiveness and permanence; limited ability to control quality of pit lake discharge over the short term. Need to re-neutralize pit lake and treat shallow groundwater eventually eliminated.
Reduction of Toxicity, Mobility, or Volume Through Treatment	None	High level of reduction. WTS is effective; however, metals are not destroyed and remain in pit lake and ARD would still impact off-site areas.	High level of reduction. WTS is effective; however, metals are not destroyed and would remain in the pit lake.	High level of reduction. In-situ neutralization would reduce the mobility and volume of metal contaminants in the upper layer of the pit lake; however, metals are not destroyed and would remain in the pit lake.	High level of reduction. In-situ neutralization would reduce the mobility and volume of metal contaminants in the upper layer of the pit lake; however, metals are not destroyed and would remain in the pit lake.
Short-Term Effectiveness	Not applicable	High level of short –term effectiveness. No risks to community or environmental impacts; low risks to workers during implementation. However, some identified risks remain unaddressed.	High level of short-term effectiveness. No risks to community or environmental impacts; low risks to workers during implementation.	High level of short-term effectiveness. No risks to community or environmental impacts; low risks to workers during implementation.	Moderate level of short-term effectiveness. No risks to community. Higher risks to workers and greater ARD generation potential during implementation due to extensive Site regrading.

[1] Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA – Interim Final. EPA/540/G-89/004. October 1988.

Evaluation Criteria[1]	**Alternative 1 No Action**	**Alternative 2 No Further Action**	**Alternative 3 WTS and Source Control**	**Alternative 4 Pit Lake Neutralization and Source Control**	**Alternative 5 Pit Lake Neutralization and Extensive Source Control**
Implementability	Not applicable	Technically and administratively implementable.	Technically and administratively implementable. Access to private property could affect implementability.	Technically and administratively implementable. Access to private property could affect implementability.	Technically and administratively implementable. Access to private property could affect implementability.
Cost *Reviewers: cost estimate ranges to be developed as part of the FS.*	$0	$6,900,000	$18,400,000	$16,300,000 (excluding wetlands and pipeline)	$285,000,000

7.0 COMPARATI E ANALYSIS OF REMEDIAL ALTERNATI ES

This section presents a comparative analysis of the remedial alternatives developed for the Site. The purpose of this analysis is to compare the advantages and disadvantages of each remedial alternative brought forth in the detailed analysis against the threshold and primary balancing criteria presented in Section 6.0. The comparison focuses on the significant areas of difference, especially identification of any alternative that is clearly superior in meeting a criterion.

As discussed in Section 6.1.1, Overall Protection of Human Health and the Environment and Compliance with ARARs are the threshold criteria under CERCLA that any remedial alternative must meet in order to be selected for implementation at a given site. Alternative 1 (No Action) and Alternative 2 (No Further Action) do not meet these threshold criteria and therefore cannot be selected for implementation (see Sections 6.2.1.1, 6.2.1.2, 6.2.2.1 and 6.2.2.2). Thus, Alternatives 1 and 2 are not discussed in the comparative analysis of remedial alternatives.

The remedial alternatives under evaluation in this comparative analysis are:

- Alternative 3 – WTS and Source Control
- Alternative 4 – Pit Lake Neutralization and Source Control
- Alternative 5 – Pit Lake Neutralization and Extensive Source Control

7.1 Threshold Criteria Analysis

This section presents the comparative analysis of the three remaining remedial action alternatives (i.e. Alternatives 3, 4, and 5) against the threshold criteria of overall protection of human health and the environment and compliance with ARARs. A summary of the comparative analysis relative to the threshold criteria is provided on Table 7-1.

7.1.1 Overall Protection o uman ealth and the Environment

Alternative 3 is the most protective of human health and the environment of the remedial alternatives over the short term because the WTS is effective at reducing metals concentrations in the pit lake discharge and because other sources of ARD that currently impact off-Site streams would be addressed through regrading, amendment, and revegetation. Alternative 5 would also be protective, but a longer time period would be required to achieve protectiveness relative to Alternative 3 given the large-scale construction activities associated with Alternative 5 as well as the uncertainties associated with in-situ neutralization of the pit lake in the absence of continued ARD inputs. The protectiveness of Alternative 4 is unknown given the uncertainty associated with the ability of in-situ neutralization of the upper layer of the pit lake while ongoing ARD inputs from the spoil piles remain. This results in an unknown ability of Alternative 4 to sufficiently reduce metals concentrations in the pit lake discharge to ensure protection of aquatic biota in the receiving streams.

7.1.2 Compliance with ARARs

Alternative 3 would comply with ARARs because the WTS discharge has been demonstrated to meet all permit limitations. The WTS discharge, in conjunction with source control measures, is expected to result in off-Site streams that will eventually meet water quality standard ARARs. Alternative 3 would result in ARARs compliance more quickly than would Alternative 5.

It is unknown whether Alternative 4 would comply with ARARs due to the uncertainty associated with the ability of in-situ neutralization of the upper layer of the pit lake to sufficiently reduce metals concentrations in the pit lake discharge to ensure ongoing compliance with water quality standard ARARs in the receiving streams. Therefore, Alternative 4 provides a lower level of certainty in terms of ARARs compliance than Alternatives 3 and 5. The source control measures under Alternative 4 should result in off-Site streams that will eventually meet water quality standards, with the potential exception of streams receiving neutralized discharge from the pit lake.

Alternative 5 would eventually comply with ARARs. In-situ neutralization of the upper layer of the pit lake would achieve discharge requirements given that ARD inputs to the pit lake would be eliminated, fertilizer additions could be discontinued, and that ongoing dilution of the pit lake's upper layer would occur. Thus, water quality standard ARARs in the receiving streams would eventually be achieved. The source control measures under Alternative 5 would result in greater certainty of meeting water quality standards in off-Site streams relative to Alternative 3 given that Alternative 5 would remove all spoil material from the Rusher and Scull creek watersheds. However, due to the expected construction duration, the time required to achieve ARARs under Alternative 5 is longer than for Alternative 3.

The temporary minerals criteria currently in place through the CAO would need to be permanently adopted along with revised minerals criteria for Chamberlain Creek and possibly other area streams receiving Site runoff under any of the remedial alternatives in order for full ARARs compliance.

7.2 Primary Balancing Criteria Analysis

This section presents the comparative analysis of the three remedial action alternatives for the primary balancing criteria of long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. A summary of the comparative analysis relative to the primary balancing criteria is provided on Table 7-1.

7.2.1 Long Term E ectiveness and Permanence

Alternative 3 would provide a high level of effectiveness and permanence, provided the WTS and associated groundwater and surface water collection systems are properly maintained and operated over the long term. Alternative 3 is estimated to provide a higher level of effectiveness and permanence than Alternative 4 because the effectiveness of WTS operation has been proven but the effectiveness of in-situ neutralization of the upper layer of the pit lake is uncertain. Alternative 3 provides a lower level of long-term effectiveness and permanence than Alternative 5 because Alternative 5 includes extensive source control measures, including treatment of the majority of the mine spoil, to address ongoing ARD from the spoil piles.

Alternative 4 would provide a moderate level of long-term effectiveness and permanence, but lower than that provided by Alternatives 3 and 5, because Alternative 4 includes the high level of uncertainty associated with in-situ neutralization and less source control actions than Alternative 5.

Alternative 5 would provide the highest high level of long-term effectiveness and permanence. The spoil repository included under Alternative 5 would provide the most permanent means for addressing ARD from the mine spoil and ongoing degradation of the pit lake and off-Site streams. Operation of the WTS until the repository is complete would help to ensure ARARs compliance until pit lake neutralization occurs. Alternative 5 provides added benefits in that 1) the need for periodic re-liming and fertilization of the pit lake would eventually be obviated since the ARD-producing spoil would be relocated to a repository situated downgradient of the pit lake and 2) the expanded shallow groundwater capture system would eventually be decommissioned as ARD seepage from the amended spoil in the repository diminishes.

7.2.2 Reduction o To icity, Mobility, or olume Through Treatment

Alternatives 3, 4, and 5 each rely on lime-based treatment to address metals concentrations in the pit lake and therefore each provides a high level of reduction of toxicity, mobility, or volume through treatment. Alternative 5 adds amendment of most of the mine spoil to limit ARD production. Therefore, Alternative 5 provides the highest reduction of toxicity, mobility, or volume through treatment whereas Alternatives 3 and 4 provide similar, but lower levels of reduction relative to Alternative 5.

7.2.3 Short Term E ectiveness

Alternative 3 would provide a high level of short-term effectiveness because the on-Site construction activities would not result in increased risks to the community or to environmental receptors. Risks to on-Site workers would be low because the source control actions included under Alternative 3 can be implemented using standard construction practices that are routinely conducted in a safe manner and because Site workers will need to conduct the construction activities in compliance with Occupational Safety and Health Administration (OSHA) requirements.

Alternative 4 includes the same remedial actions as Alternative 3 with the exception that in-situ neutralization is included instead of ongoing WTS operation. Therefore, Alternative 4 would also provide a high level of short-term effectiveness for the reasons noted above for Alternative 3.

Alternative 5 would provide a moderate level of short-term effectiveness. This alternative would result in increased risks to the community and environmental receptors relative to Alternatives 3 and 4 due to the magnitude and duration of construction, including excavation and hauling of approximately 14 million cy of spoil over at least three construction seasons. Though these construction activities would be implemented using standard construction practices that are routinely conducted in a safe manner, and the Site workers will conduct the activities in compliance with OSHA requirements, the large volume of material that will be handled, and the correspondingly increased construction duration relative to the other alternatives, increases the risks to on-Site workers relative to Alternatives 3 and 4. In addition, excavation and relocation of 14 million cy of spoil would expose fresh spoil surfaces to air and water, increasing ARD production, and thus impacts to adjacent streams, over the short term.

7.2.4 Implementability

Alternatives 3, 4, and 5 rely on water treatment approaches that are either in-place and operating or should be readily implementable. Other aspects of these alternatives rely on routinely conducted and standard construction practices. The implementability of each of these alternatives could be affected to some degree by access issues associated with privately held land at the Site. Therefore, although the scope of construction activities would vary between the alternatives, Alternatives 3, 4, and 5 are equally implementable.

7.2.5 Cost

The estimated net present values of the remedial action alternatives, in 2009 dollars, are as follows:

- Alternative 3: $18,400,000;
- Alternative 4: $16,300,000; and
- Alternative 5: $285,000,000.

The estimated net present values for Alternatives 3 and 4 are similar given that the only difference between the alternatives is the approach taken to treat and discharge water from the pit lake to maintain a safe pit lake surface elevation. However, the estimated net present value for Alternative 4 does not include construction and operation of a wetland polishing system and/or pipeline, which would increase its costs. The estimated net present values of Alternative

3 and Alternative 4 are approximately 15 to 17 times less than the estimated net present value of Alternative 5.

Section 7 Tables

TABLE 7-1
COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES[1]
DRESSER INDUSTRIES-MAGCOBAR MINE SITE

Evaluation Criteria[2]	Alternative 3 WTS and Source Control	Alternative 4 Pit Lake Neutralization and Source Control	Alternative 5 Pit Lake Neutralization and Extensive Source Control
Overall Protection of Human Health and the Environment	Protective Higher level of protectiveness than Alternative 4. Will achieve protectiveness more quickly than Alternative 5.	Unknown Lower level of protectiveness than Alternative 3 and similar level of protectiveness to Alternative 5.	Protective Higher level of protectiveness than Alternative 4. Will achieve protectiveness more slowly than Alternative 3.
Compliance with Applicable and/or Relevant and Appropriate Requirements (ARARs)	Yes Higher certainty of compliance than Alternative 4.	Unknown Lower certainty of compliance than Alternative 3 and Alternative 5	Yes Higher certainty of compliance than Alternative 4.
Long-Term Effectiveness and Permanence	High Higher level of effectiveness and permanence than Alternative 4 but lower level than Alternative 5.	Moderate Lower level of effectiveness and permanence than Alternative 3 and 5.	High Higher level of effectiveness and permanence than Alternatives 3 and 4.
Reduction of Toxicity, Mobility, or Volume Through Treatment	High level of reduction. Alternatives 3, 4, and 5 achieve similar levels of reduction of toxicity, mobility, or volume through treatment for the pit lake.	High level of reduction. Alternatives 3, 4, and 5 achieve similar levels of reduction of toxicity, mobility, or volume through treatment for the pit lake.	High level of reduction. Alternatives 3, 4, and 5 achieve similar levels of reduction of toxicity, mobility, or volume through treatment for the pit lake. Alternative 5 adds amendment of most of the mine spoil to minimize ARD production.
Short-Term Effectiveness	High Similar level of short-term effectiveness to Alternative 4 but higher level than Alternative 5.	High Similar level of short-term effectiveness to Alternative 3 but higher level than Alternative 5.	Moderate Lower level of short-term effectiveness than Alternative 3 and Alternative 4.
Implementability	Implementable Alternatives 3, 4, and 5 are equally implementable.	Implementable Alternatives 3, 4, and 5 are equally implementable.	Implementable Alternatives 3, 4, and 5 are equally implementable.
Cost	$18,400,000	$16,300,000 (excluding wetland and pipeline)	$285,000,000

[1] Alternatives 1 and 2 do not meet the threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs and therefore are excluded from the comparative analysis.
[2] Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA – Interim Final. EPA/540/G-89/004. October 1988.

8.0 RECOMMENDED REMEDIAL ALTERNATI E

Based on the detailed and comparative analyses of the remedial alternatives (Sections 6.0 and 7.0), Alternative 3 is identified as the recommended remedial alternative.

Alternative 3 will meet the threshold criteria of overall protection of human health and the environment and compliance with ARARs more quickly and with more certainty than the other remedial alternatives. It relies on an in-place WTS to control the water surface elevation of the mine pit lake. The discharge from the WTS has been demonstrated to meet all pertinent ARARs. Alternative 3 also relies on enhancement of ongoing natural reclamation of the mine spoil, rather than excavation and relocation of the spoil which would pose increased short-term risks to nearby residents and environmental receptors. Alternative 3 provides long-term effectiveness and permanence and relies on a significant treatment component to achieve reduction of toxicity. Alternative 3 has a high-level of short-term effectiveness given that it can be implemented in a relatively short time frame and will not result in the disturbance of a large volume of mine spoil, with associated increased ARD production. Alternative 3 is readily implementable. Finally, Alternative 3 is more cost effective because it can achieve the threshold criteria sooner, and with more certainty, at a cost that is 15 times less than the other alternative that would achieve these criteria.

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Appendi   A
Pit Lake Draining Model

Appendix A

Pit Lake Draining Model

Dresser Industries-Magcobar Mine Site Feasibility Study

Draining of the pit lake is a precursor to backfilling with spoil and tailings material. A simple model was developed using spreadsheet software to estimate how long it would take to completely drain the pit lake, treat the water via the water treatment system (WTS), and discharge it to Chamberlain Creek. The model time scale is yearly and therefore inputs and outputs are calculated on an annual basis. The assumptions used to develop the model, and the two scenarios that were evaluated, are detailed below. The drawdown curves for the two scenarios are shown in Figure A-1.

Assumptions:

- The volume of water input to the pit lake each year is the same as reported in the SI Report (Appendix I, Table I-1) and the water quality of this input is identical to the current upper layer of the pit lake. Additionally, the annual water volume added and its water quality do not change with time.
- Evaporation and WTS discharge are the only outputs from the pit lake.
- Average annual rainfall and evaporation rates (gallons/ft^2/yr) throughout the draining period are the same as measured in 2001 and reported in the SI Report (Appendix I, Table I-1)
- WTS discharge is based on the allowable monthly continuous discharge table (Exhibit A of the CAO).
- Sulfate and TDS are not removed or reduced by the WTS
- Since the lower layer of the pit lake has roughly twice the concentration of sulfate and TDS, the WTS discharge rate for the lower layer was assumed to be half of what is listed in Exhibit A of the CAO, since these discharge rates are based on the minerals concentrations in the upper layer.
- Evaporation from the surface is only a function of lake surface area (i.e., surface elevation, water temperature, etc. do not play a role in changes of evaporation rates). Evaporation for the year is based on the starting elevation/surface area.
- The pit lake surface elevation starts at 595ft, the upper layer starts at 80 feet thick, the transition zone (chemocline) is sharp, and the lower layer has consistent water quality to the bottom of the pit lake.

Scenario 1:

In the first scenario, discharge starts with the upper layer and continues until it is depleted (i.e., annual discharge is greater than remaining upper layer volume). The lower layer is discharged next until it is depleted. Finally, the newly formed upper layer (i.e., accumulated precipitation since initial upper layer discharge stopped) is discharged. Following this scenario, the estimated time to drain the pit lake is **63 years**.

Scenario 2:

In the second scenario, discharge starts with the lower layer until it is depleted and then the upper layer is discharged. Following this scenario, the estimated time to drain the pit lake is **59 years**.

Comparison of Scenarios:

The reason for the difference in time to drain the pit lake between the two scenarios is a function of the evaporation rate. In scenario 1, the lower layer is discharged when the pit lake surface area is smaller than in scenario 2. The difference in evaporation effect is evident by comparing the rising slope of the two scenarios in Figure A-1.

Model Limitations:

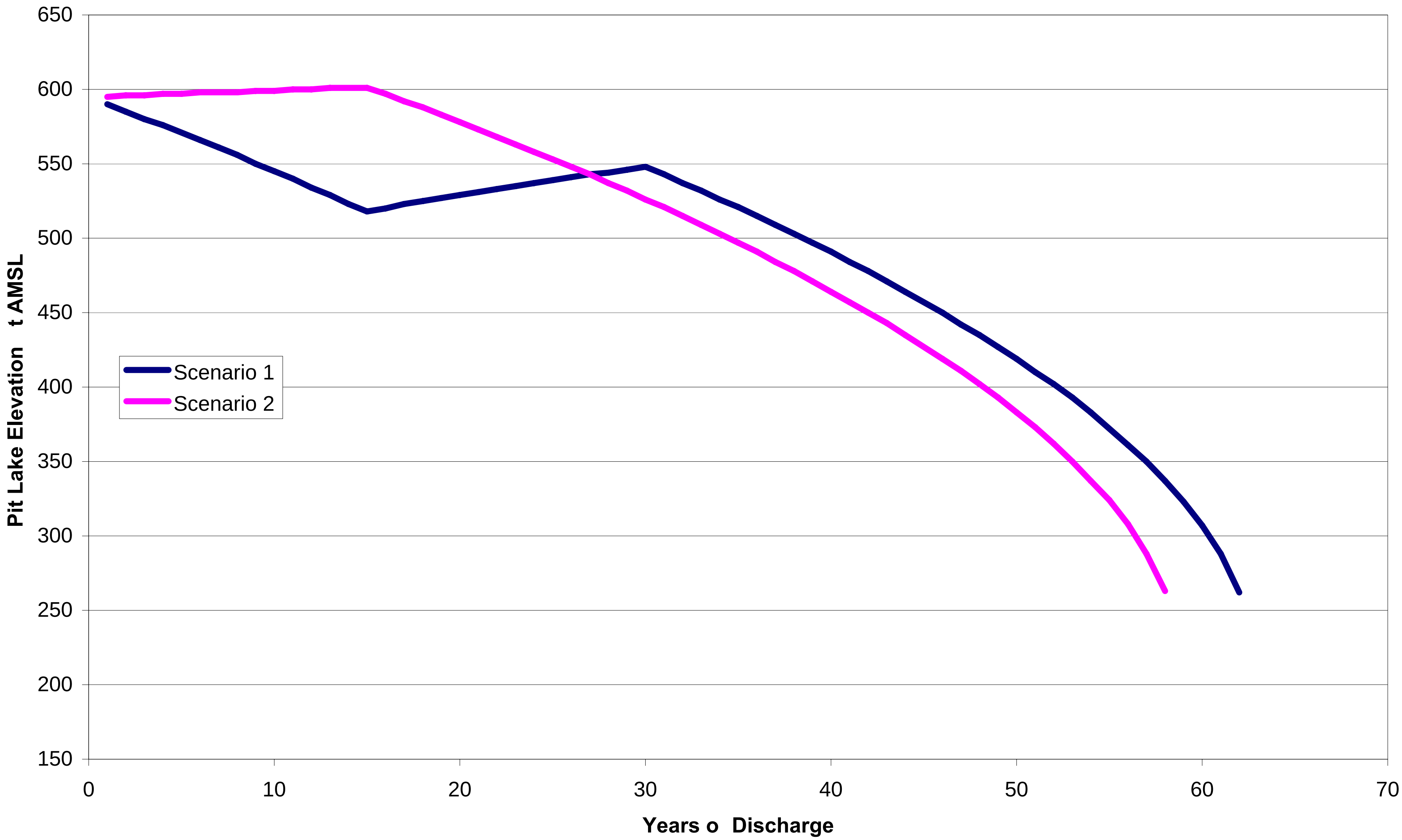
- The model assumes WTS discharge is limited by the allowable monthly continuous discharge as mandated in Exhibit A of the CAO rather than a hydrograph controlled release (HCR) approach. If the HCR approach was used, the drawdown rate would be higher and the period required to drain the pit lake correspondingly shorter. To evaluate the alternative, a long period of record for the Ouachita River and Cove Creek would be needed to understand the hydrographs of these receiving waters and their variability.

- The model assumes 2001 rainfall and evaporation rates are representative of natural inputs/outputs throughout the draining period. In reality, these amounts will naturally vary. To evaluate the applicability of this assumption, the 2001 rates could be compared with a longer period of record for the area. Additionally, evaporation rates could be altered over time to reflect lower temperatures and less wind fetch over the surface. These modifications would result in longer predicted time periods to drain the pit lake.

- The model assumes the quantity and quality of water input to the pit lake does not change with time. There are many remedial activities that could render this assumption invalid. For instance, regrading and covering spoil piles within the pit lake watershed could increase the amount of runoff entering the pit lake. On the other hand, the increased surface area of the exposed pit walls as the pit lake is drawn down could decrease the water quality of water entering the pit lake. The former could reduce the estimated time while the latter could increase it or even make it impossible to completely drain the pit lake. The effects of this assumption would be very difficult to quantify.

- The model assumes the WTS cannot remove any sulfate or TDS. The model represents a conservative approach because it is possible that at the WTS removes at least a fraction of the sulfate (and TDS) from the lower layer due to gypsum precipitation. This assumption could be validated by geochemical modeling and WTS output concentrations.

Figure A 1. Pit Lake Drawdown Curves



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Appendi B
Detailed Remedial Alternative Cost Estimates

Appendi B Detailed Remedial Alternative Cost Estimates

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1.0 INTRODUCTION

This appendix provides discussion and supporting cost estimate tables for the Site-wide remedial action alternatives and various subarea remedial alternatives developed for the Dresser Industries-Magcobar Mine Site. As detailed in the Feasibility Study (FS) Report, the Site-wide remedial alternatives are:

- Alternative 1 – No Action;
- Alternative 2 – No Further Action;
- Alternative 3 – Water Treatment System (WTS) and Source Control;
- Alternative 4 – Pit Lake Neutralization and Source Control; and
- Alternative 5 – Pit Lake Neutralization and Extensive Source Control.

These cost estimates were made in accordance with procedures in the G*uide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000b) and are expected to result in estimates that are within a range of -30 percent to +50 percent of what actual costs may be. The estimates include capital costs, operations and maintenance (O&M) costs, and periodic costs. These cost categories are described below.

Capital Costs

Capital costs are those expenditures that are required to construct a remedial action. They are exclusive of costs required to operate or maintain the action throughout its lifetime. Capital costs consist primarily of expenditures initially incurred to build or install the remedial action (e.g., construction of a groundwater treatment system and related site work). Capital costs include all labor, equipment, and material costs, including contractor markups such as overhead and profit, associated with activities such as mobilization/demobilization; monitoring; site work; installation of extraction, containment, or treatment systems; and disposal. Capital costs also include expenditures for professional/technical services that are necessary to support construction of the remedial action.

Annual O&M Costs

O&M costs are those post-construction costs necessary to ensure or verify the continued effectiveness of a remedial action. These costs are estimated mostly on an annual basis. Annual O&M costs include all labor, equipment, and material costs, including contractor markups such as overhead and profit, associated with activities such as monitoring; operating and maintaining extraction, containment, or treatment systems; and disposal. Annual O&M costs also include expenditures for professional/technical services necessary to support O&M activities.

Periodic Costs

Periodic costs are those costs that occur only once every few years (e.g., five-year reviews, equipment replacement) or expenditures that occur only once during the entire O&M period or remedial timeframe (e.g., site closeout, remedy failure/replacement). These costs may be either capital or O&M costs, but because of their periodic nature, it is more practical to consider them separately from other capital or O&M costs in the estimating process.

Present Value Analysis

For each alternative, a -30 to +50 percent cost estimate is developed in accordance with procedures in the G*uide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000b). Cost estimates for each alternative are based on conceptual engineering and design and are expressed in terms of 2009 dollars. This analysis is used to evaluate the capital, O&M, and periodic costs of a remedial alternative based on its present value. A present value analysis compares expenditures for various alternatives where those expenditures occur over different time periods. By discounting all costs to a common base year, the costs for different remedial action alternatives can be compared based on a single cost figure for each alternative.

The total present value for a single alternative is equal to the full amount of all costs incurred through the end of the first year of operation, plus the series of expenditures in following years reduced by the appropriate future value/present value discount factor. This analysis allows the comparison of remedial alternatives on the basis of a single cost representing an amount that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. The present value calculations are based on the following fundamental equation:

$$P = F / (1+i)^n$$

Where: P = present value ($)
F = future value ($)
i = discount rate (%)
n = time period (years)

A discount rate of 7 percent is used for the present value calculations, consistent with EPA guidance and directives (EPA, 1988 and 2000). The discount rate represents the anticipated difference between the rate of inflation and investment return.

A summary of the present value estimates for Alternatives 1 through 5 is presented on Table B-1. Detailed present value cost estimate information for Alternatives 2 through 5 are presented on Tables B-2 through B-5, respectively (there are no costs associated with Alternative 1 – No Action). Detailed cost estimate information for subarea alternatives variously included in Alternatives 2 through 5 are presented on Tables B-6 through B-13, as described in the subsections below. Note that the cost estimates for the subarea alternatives, as presented on Tables B-6 through B-13 do not reflect present value. The present value calculations are applied on the Site-wide alternative tables (Tables B-2 through B-5).

1.1 Pit Lake Alternative PL1 No Action

The No Action alternative for the pit lake (PL1) would include cessation of pumping and treatment of the pit lake water. The existing levees installed as interim remedial measures (IRMs) would remain in place, as would all infrastructure associated with the existing water treatment system (WTS) and shallow groundwater collection system. This alternative has no cost.

1.2 Pit Lake Alternative PL2 Operate E isting WTS and Maintain Pit Water Level and Shallow roundwater Alternative S W2 Operate E isting Capture/Treatment System

The Operate Existing WTS and Maintain Pit Level alternative for the pit lake (PL2) would entail continued pumping and treating of the pit lake water along with continued pumping of the collected groundwater from Chamberlain Creek headwaters to the pit lake. To maintain a target lake surface elevation, the volume of water treated (on an annual basis) would be approximately equivalent to the net volume added to the pit lake by precipitation and runoff/seepage from adjacent areas during a given year. The target elevation would be lower than the lowest bedrock elevation along the rim of the pit to eliminate seepage through the base of the adjacent spoil piles (estimated to be approximately 605 feet above sea level). A pit lake surface elevation of approximately 595 feet is expected to eliminate such seepage and to also provide approximately 10 feet of free board in the event that an upset of the WTS occurs.
The Operate Existing Capture/Treatment System alternative (SGW2) would entail continued operation of the existing system that collects shallow groundwater near the headwaters of Chamberlain Creek and pumps it to the pit lake. Ongoing costs for SGW2 are incorporated in the reported actual costs for WTS operation, therefore costs for SGW2 are not separately estimated.

Table B-6 presents the cost estimate spreadsheet for PL2/SGW2. Key assumptions and conditions related to the estimated cost for this alternative include:

- Actual operating costs for pre-595 conditions (i.e., before reaching the 595 level) are $715,000 as reported by Halliburton. Post-595 costs are assumed to be approximately half of the current annual costs given that less treatment will be needed to maintain the pit level elevation rather than to reduce it, and are estimated at $360,000 per year (2009 dollars). This cost includes the minor costs associated with Alternative SGW2, which will continue operating as currently.

- No capital costs are assumed for continued operation of the WTS and the existing capture/treatment system. Periodic costs are assumed to be $1 million (2009 dollars) every 5 years beginning in year 10 (i.e., 10 years after remedy selection) to replace WTS and/or shallow groundwater collection equipment as it wears out. A 100-year operating period is assumed for the current facility.

Present value cost estimates for alternative PL2 are listed below.

Present alue Capital Costs	Present alue O M Costs	Present alue Periodic Costs	Net Present alue NP in 2009
$0	$5,136,930	$1,768,304	$6,905,234

1.3 Pit Lake Alternative PL3 In Situ Neutralization and Maintain Pit Level

The In-Situ Neutralization and Maintain Pit Level alternative for the pit lake (PL3) would entail in-situ chemical treatment using hydrated lime to neutralize the pH of the pit lake's upper layer, addition of fertilizer to promote biological treatment mechanisms and alkalinity production, and periodic re-liming to address ongoing ARD input to the pit lake from the adjacent spoil piles as well as from a shallow groundwater collection system in the Chamberlain Creek drainage and run-off and shallow groundwater collection systems in the Scull Creek drainage. The neutralized pit lake water would be discharged to the headwaters of Chamberlain Creek using a hydrographically controlled release (HCR) due to the minerals content of the treated pit lake water. The key aspects related to the estimated cost for this alternative are discussed below. These discussions primarily apply to Alternative 4. Alternative PL3, as included in overall Alternative 5, would be implemented following removal of all mine spoil and placement of the spoil in a repository. Therefore, for the purposes of Alternative 5, it is assumed that only an initial lime/fertilizer application would be required, with no additional dosage of lime or fertilizer.

Initial Pit Lake Liming

The pH of the upper layer of the pit lake is approximately 3 based on SI measurements. Increasing the pH of the upper layer will have the dual benefits of (1) precipitating some of the dissolved trace metals in situ and (2) providing an environment conducive to biological metals removal processes.

The initial neutralization could be implemented quickly, using a barge-mounted lime application/mixing system or more slowly using the excess capacity of the WTS. The estimated cost for the barge system is $350,000 (mobilization/demobilization + lime application), with an additional $140/ton material cost based on March 2009 costs for lime delivered to the WTS. Use of the barge-mounted system was selected for the purposes of this FS due to anticipated better mixing and consequent lower lime requirements. Rapid neutralization should also provide a relatively higher level of metals removal when compared to slow pH adjustment. Monitoring will need to be implemented as liming occurs to check for signs of pit lake destratification. If such signs are detected, the liming operation will cease and alternative methods for lime introduction will be evaluated.

Geochemical modeling of the upper layer of the pit lake was conducted to confirm previously conducted bench-scale tests in terms of assessing how much lime would need to be added to the upper layer to achieve a near-neutral pH. The geochemical model used for the analysis was PHREEQC Interactive (version 2.8.0.0), supplemented with information from the MINTEQ geochemical data base. It was assumed that the water quality in the upper layer of the pit lake is the same as that measured on April 3, 2002, as documented in the SI Report. The results of the modeling effort indicated that approximately 1.4 pounds of lime would be needed to neutralize 1,000 gallons of upper-layer water to a pH of 8, or about 1,400 tons for the 2 billion gallons of water estimated to be present in the upper layer. This estimate is consistent with previously conducted bench-scale tests which indicated that approximately 2 pounds of lime would be needed to neutralize 1,000 gallons of upper-layer water, or approximately 2,000 tons for the entire upper layer. This estimate assumes perfect and complete mixing of the applied lime and the upper layer waters. Since perfect mixing will not be possible and there will be additional acidity that enters the upper layer from the chemocline and lower layer, the amount of lime needed to neutralize the upper layer will be greater than 2,000 tons. For the purposes of this FS, a mixing efficiency of 50 percent is assumed. Therefore, the initial liming of the upper layer of the pit lake is estimated to require 4,000 tons of lime.

Periodic Re-Liming

Once the upper layer of the pit lake is neutralized to pH 8, ARD entering the pit lake from the adjacent spoil piles and collected shallow groundwater and runoff would cause the pH of the upper layer to decline. PHREEQC and MINTEQ were again used to simulate this degradation.

It was assumed that the net water quality entering the upper layer (i.e., the combined water quality of direct precipitation, runoff and seepage from the spoil piles, water pumped from the Chamberlain Creek headwaters and Scull Creek drainage) would be equivalent to that of the upper layer of the pit lake prior to neutralization. The computer simulation used this water chemistry, in an amount equal to the typical net annual input to the pit lake (176 million gallons) to "titrate" the 2 billion gallons of neutralized upper layer water and to estimate the resulting pH and alkalinity of the upper layer in one-year intervals. The following table summarizes the modeled decline in pH and alkalinity in the upper layer of the pit lake.

Year Since Liming	Upper Layer p	Upper Layer Alkalinity mg/L $CaCO_3$
0	8.0	220
1	7.4	200
2	6.9	170
3	6.9	140
4	6.9	110
5	6.8	90
6	6.7	60
7	6.6	40
8	6.4	20
9	5.8	0
10	4.2	-5

The model simulations indicate that the pH of the upper layer of the pit lake should remain near neutral (pH approximately 6.8 to 6.9) for approximately 5 years, after which a more rapid decrease in pH and alkalinity are expected to occur. As explained below, it is possible that this time period could be longer if phytoplankton and algae are encouraged to grow in the remediated upper layer. However, these effects have not been quantified and are uncertain. Therefore, it is conservatively assumed for the purpose of this FS that periodic re-liming of the upper layer of the pit lake will be required every five years. The above table suggests an approximate 10 percent reduction in alkalinity per year. To offset that reduction, approximately 700 tons of lime would need to be added to the upper layer of the pit lake every five years, beginning five years after initial neutralization. The same barge system would be used as for initial lime introduction at a cost of $102,500 (mobilization/ demobilization + lime application), for each period of application, with an additional $140/ton material cost based on March 2009 costs for lime delivered to the WTS. The actual frequency of re-liming, and the amount of lime that would need to be added during each re-liming effort, would be based on actual measurements of pit lake pH and alkalinity.

Nutrient Addition

A near-neutral pH in the upper layer will be conducive to the proliferation of bio-material (e.g., phytoplankton and algae) capable of maintaining the pH (or decreasing the rate of pH degradation) and removing metals through scavenging. Bio-materials can stabilize the pH of surrounding waters through carbon fixation and respiration. Scavenging of metals occurs as bio-material adsorbs metals from the water. When these biota die and descend to the deeper parts of the pit lake, the adsorbed metals will be transported out of the upper layer and into the lower layer. Some of these adsorbed metals will be released when the biomass is consumed by other microorganisms within the lower layer, or because the decreased pH in the lower layer will desorb or re-solubilize the metals. Any adsorbed metals that are not released in the lower layer will be transported to the sediments accumulating at the bottom of the pit lake and along submerged benches at various depths.

Periodic introduction of fertilizer (nitrogen and/or phosphorus) to the upper layer will accelerate the occurrence and increase the density of phytoplankton blooms and algae growth in the upper layer and enhance their beneficial effects in terms of pH maintenance and metals removal. Fertilization of the upper layer of the pit lake may have an ancillary benefit in terms of removing trace metals from anoxic water in the lower layer of the pit lake. Dead phytoplankton descending through the water column will serve as a carbon source for sulfate-reducing bacteria that appear to be active in terms of removing metals near the pit floor. The presence of additional carbon should serve to increase the activity of the sulfate-reducing bacteria, and further decrease trace metals concentrations in the lower layer of the pit lake. In addition, bacterial activity within the water column will increase the flux of carbon dioxide from deeper portions of the pit lake toward the surface which will help to maintain a near-neutral pH in the upper layer. Monitoring for hydrogen sulfide gas formation in the pit lake will need to be implemented in conjunction with fertilizer introduction.

The frequency and amount of fertilizer addition would be based on bench-scale testing and on subsequent observations of the pit lake after in-situ neutralization commences. For the purposes of this FS, it is assumed that a nitrogen:phosphorus mass ratio of 6:1 is needed, that nitrogen would be in the form of urea ammonium nitrate, and that phosphorus would be in the form of ammonium polyphosphate. Based on this, the mass ratio of urea ammonium nitrate to ammonium polyphosphate would be approximately 2.8:1. It is therefore assumed that nutrients would be added at an initial rate of 140 tons urea ammonium nitrate and 50 tons ammonium polyphosphate per year. This material would be added incrementally each month during the first year by adding it to the propeller wash of an outboard motor boat. After the first year, the nutrient addition frequency is assumed to decrease to quarterly applications totaling one fourth of the aforementioned tonnage each year.

Personnel Requirements

In-situ neutralization may provide sufficient metals removal such that the discharge limitations associated with the facility discharge permit are met. However, in-situ neutralization will not affect minerals (i.e., chloride, sulfate, and total dissolved solids) concentrations in the discharge. Therefore, assuming that the current temporary minerals standards in the receiving stream (Cove Creek) are permanently adopted, the discharge from the neutralized upper layer of the pit lake would need to be implemented as a hydrologically controlled release according to the flow in Cove Creek. Implementation of such a release, in addition to other testing requirements associated with discharging treated pit lake water, are expected to require the efforts of at least one full-time employee year-round in addition to security services.

Present value cost estimates for alternative PL3 are listed below. These estimates do not include a constructed wetland treatment system for potential polishing of the neutralized pit lake water or a pipeline to Cove Creek to utilize a larger mixing zone. Addition of these items would increase costs relative to those presented below.

Present alue Capital Costs	Present alue O M Costs	Present alue Periodic Costs	Net Present alue NP in 2009
$1,889,294	$2,409,969	$497,499	$4,796,762

1.4 Spoil Piles Alternative SP1 No Action

The No Action alternative for the spoil piles (SP1) entails leaving them in their current configuration and state of vegetation. Where present, the vegetation will continue to build a thicker litter layer consisting of mostly pine needles while the angle-of-repose faces will continue to weather and erode. Direct precipitation on the spoil piles will continue to result in run-off and infiltration generating acid and dissolved metals that ultimately report to the pit lake, Chamberlain Creek, shallow groundwater within the Chamberlain Creek syncline, and off-site creeks. 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. This alternative has no cost.

1.5 Spoil Piles Alternative SP2 Selective Regrading, Augment egetation, and Capture ARD

The Selective Regrading, Augment Vegetation, and Capture ARD alternative for the spoil piles (SP2) would entail selective regrading, where feasible, to reduce erosional transport of particles, directing surface runoff toward the 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 (ARD) 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 pumping the collected water to the pit lake for treatment prior to discharge (see Figure B-1 *Key Areas of Alternative SP2 – Selective Regrading, Augment Vegetation, and Capture ARD,* and Figure B-2 *Typical Cross-Section for Surface Water Diversion Channel and Groundwater Cutoff Trench – Alternative SP2*). Such collection would involve repair and lining 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 prior to impacting the Scull Creek/Clearwater Lake area. The channel would deliver the collected runoff to the headwaters of East Rusher Creek where it would be pumped to the pit lake for treatment. Tables B-8a and B-8b present the cost estimate spreadsheets.

Key assumptions and conditions related to the estimated cost for this alternative include:

- A 2,700-foot-long groundwater cutoff trench will be installed downgradient from the northeast spoil area and adjacent to the existing surface water diversion ditch. A geomembrane liner will be used on the downgradient side of the trench to prevent groundwater flow from moving beyond the cutoff trench.

- The groundwater trench will be 30 feet deep, which is an assumed but conservatively high value based on observations of erosion features in the area (some bedrock west of the area is at or near ground surface). Its width will be 3 feet and a 4-inch diameter perforated collection pipe will be placed within limestone gravel in the bottom 10 feet of trench with soil backfill above.

- The runoff diversion ditch will be improved to convey the peak runoff flow from the 100-year storm event from the upgradient hillslope composed largely of spoils. The diversion channel will be lined with buried geomembrane to prevent infiltration and the soil cover will be protected from erosion, as necessary.

- The groundwater trench collection pipe and surface water diversion ditch will flow into a holding pond located along East Rusher Creek. The pond will be lined with geomembrane and designed to store 70 percent of the 100-year runoff volume (due to space limitations), with continuous pumping to the pit lake during such an event to reduce the potential for overtopping of the pond embankments. An emergency spillway and diversion of clean water flows around the north side of the holding pond will be provided.

- The water that collects in the pond will be pumped through a 1,900-foot-long 6-inch diameter HDPE pipeline to the pit lake. Pumping requirements are estimated at 18 horsepower (HP) based on a flow rate of 440 gpm, total head of 110 feet, and efficiency of 70 percent. Two pumps would be included, with one as a backup. Stainless steel pumps are required to resist degradation from the low pH water conditions. New electrical service will be installed to provide electrical power for the pumps; this will involve extending the current electrical service from the WTS to the holding pond – 460-volt, 3-phase power.

- Construction of the groundwater trench and diversion channel will include an access road which will extend from the beginning of the channel to the pond; the total affected areas for these actions are approximately 6 acres, which will be cleared and grubbed when work is initiated. At the completion, the disturbed areas will be treated with limestone followed by seeding and mulching.

- The northwest area spoils will be regraded, over an approximately 7.5-acre area, such that the spoil currently draining to West Rusher Creek will be placed in the pit lake drainage near the current location of the spoils. This will involve relocation of approximately 130,000 cubic yards (cy) of spoils. The work areas will be cleared and grubbed when work is initiated. After regrading the spoils, an 18-inch cover will be installed over the remaining spoils which are assumed to cover the 7.5-acre area. At the completion, the disturbed areas will be treated with limestone followed by seeding and mulching. Maintenance of the cover is assumed for the first 5 years after construction.

- Miscellaneous regrading at the northeast spoil area includes: 1) minor filling of existing depressions to promote drainage, and 2) filling an existing drainage southwest of the main northeast spoil pile to redirect drainage towards the Mine Pit Lake. These two actions are further described below.

    - Based on visual assessments of drainage areas currently forming ponds on the northeast spoil area during a rainy period, it is assumed that 10 small areas each approximately 100 by 150 feet may require filling with clean borrow soil. It is assumed that each area will require approximately 2 to 3 feet of soil placed and graded to promote drainage. This is estimated to require approximately 14,000 cy of soil fill with another 6,000 cy required to promote drainage in adjacent areas. Thus, it is estimated that approximately 20,000 cy of borrow soils containing limestone will be required for this portion of the miscellaneous regrading and that approximately 2.9 acres may require clearing and grubbing to achieve this regrading.

    - A drainage approximately 700 feet long currently drains runoff toward the north from the southwest side of the northeast spoil pile toward the Scull Creek watershed. To redirect this runoff, an embankment approximately 20 feet high would be constructed just west of the northeast spoil pile along with infilling the drainage upstream of this with spoil fill. The top surface of the area will then be graded at approximately 1 to 2 percent towards the south to achieve surface drainage to the pit lake. Figure B-1 shows the location of the proposed embankment. This should redirect runoff from approximately 6 to 7 acres back towards the pit lake. It is estimated that approximately 51,000 cy of spoil fill will be required to construct the embankment and fill this small drainage, resulting in redirection of the runoff toward the pit lake. Approximately 2.3 acres of clearing and grubbing is assumed and approximately 4 acres of revegetation is estimated for this work.

Present value cost estimates for alternative SP2 are listed below.

Present alue Capital Costs	Present alue O M Costs	Present alue Periodic Costs	Net Present alue NP in 2009
$5,506,467	$254,515	$130,035	$5,891,017

1.6 Spoil Piles Alternative SP3 E tensive Regrading, Amendment, Soil Cover, Revegetation

The Extensive Regrading, Amendment, 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) treating the consolidated spoil and other key areas, where appropriate, with calcium carbonate to limit acid generation, (3) applying a soil cover to the consolidated spoil to reduce infiltration, and (4) revegetating the consolidated spoil. Table B-9 presents the cost estimate spreadsheet. Key assumptions and conditions related to the estimated cost for this alternative include:

- Spoils are consolidated into a new repository (Figure B-3 *Location of New Repository for Alternative SP3 – Extensive Regrading, Soil Cover, and Revegetation*) located within the Chamberlain Creek syncline west of the pit lake, between the WTS and Baroid Road. The repository footprint covers an estimated 190 acres, and spoil removal areas cover approximately 110 acres. Clearing and grubbing in 60 percent of the area is assumed for removal of trees and other vegetation.

- The entire volume of northwest spoils and northeast spoils will be excavated and placed in the repository; the portion of spoils in the peninsula between the repository and pit lake will also be placed in the repository, except for the spoils under the WTS. The total volume of spoil in these areas to be relocated into the repository is estimated at 14 million cy. Spoil will be hauled from a distance of slightly more than 1 mile to less than 0.5 mile; an average haul distance of 0.5 mile one-way is assumed for cost estimation.

- Approximately 6.5 million cubic yards of spoil are already present in the repository footprint. This material will be regraded, as necessary, to accommodate additional spoil from the current northwest and northeast spoil piles. As that material is moved into the repository, it will be treated with calcium carbonate to minimize further ARD generation from the repository. Treatment would be accomplished by placing the spoil in lifts of a few feet in thickness and incorporating the calcium carbonate (crushed limestone) using the ripping attachment of a bulldozer or a similar method. Based on acid-base accounting information from the Site Investigation, the average net neutralizing potential of the mine spoil is -40 tons calcium carbonate per every 1,000 tons of spoil. This is the amount required to offset the average acid production in the spoil. Therefore, this amount was doubled (80 tons calcium carbonate per 1,000 tons of spoil) to ensure that ARD production from the finished repository is minimized. This equates to approximately 1,600,000 tons of calcium carbonate for the 14 million cy of spoil that would be relocated to the repository. It is assumed that the calcium carbonate would be in the form of crushed limestone.

- The repository will have 3:1 (horizontal:vertical) side slopes and the top surface will be configured to slopes no steeper than 20:1, with top slopes between 2 percent and 5 percent. The total available volume of the repository is in excess of 14 million cy, based on existing topography and a volume analysis performed in a geographic information system (GIS).

- Spoil removal areas will be amended with limestone and seeded/mulched. The material placed in the repository will be compacted with equipment travel, followed by placement of an 18-inch soil cover, and seeding and mulching. Cover maintenance is assumed for the first 5 years after construction.[1]

Present value cost estimates for alternative SP3 are listed below.

Present alue Capital Costs	**Present alue O M Costs**	**Present alue Periodic Costs**	**Net Present alue NP in 2009**
$276,677,726	$295,710	$0	$276,973,436

1.7 Shallow roundwater Alternative S W1 No Action

The No Action alternative for shallow groundwater (SGW1) entails discontinuing the existing capture/treatment system that collects shallow groundwater and pumps it into the 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

[1] A 5-year O&M period was assumed for all reclaimed/revegetated areas (including repository covers) in this FS Report because good vegetative cover should be established within 5 years given the warm, moist climate in the Site area. It is possible that O&M could be required for more than 5 years in some instances. However, the additional costs that would be associated with a longer O&M period would be relatively small compared to the capital costs of the remedial alternatives and therefore would not be a differentiating factor.

Chamberlain Creek and not only transport metals and acidity downstream but also precipitate metal hydroxides in and on top of the creek sediment. This alternative has no cost.

1.8 Shallow roundwater Alternative S W2 Maintain E isting System

Alternative SGW2 entails continued operation of the existing shallow groundwater capture system near Chamberlain Creek in the western portion of the Site. As previously discussed, the costs to operate that system are incorporated with the costs to operate the existing WTS (PL2). Therefore the costs to operate the existing shallow groundwater capture system are not separately estimated here.

1.9 Shallow roundwater Alternative S W3 E panded Capture/Treatment System

The Expanded Capture/Treatment System alternative (SGW3) would entail extending the existing capture system, or installing a new, larger system, to intercept a larger portion of the impacted shallow groundwater that would otherwise report to Chamberlain Creek. This expanded system would include french drains to collect the groundwater to be pumped to the pit lake (Figure B-4 *Expanded Capture/Treatment System – Location and Section, Alternative SGW3*). This alternative is only viable when combined with pit lake alternatives that include treatment and discharge (e.g. PL2 and PL3). Table B-10 presents the cost estimate spreadsheet. Key assumptions and conditions related to the estimated cost for this alternative include:

- The expanded shallow groundwater collection system in the Chamberlain Creek drainage assumes closure of the existing shallow groundwater collection system with an approximately 1,900-foot long collection trench oriented north-south located approximately 150 to 200 feet upstream of, and parallel to, Baroid Road. The existing system is presently undersized and it is estimated that the average flow rate in the existing system is approximately 150 to 200 gpm, based on discussions with the current WTS operator. The expanded shallow groundwater collection system will be required to handle the deficit flow from the existing system plus the additional flow from the area downstream. Therefore, it is assumed that the expanded system will be designed to collect and pump an average of 500 gpm with a maximum flow rate of 1,000 gpm.

- Based on data from monitoring wells MW-17 through MW-20 and piezometers PZ-1, (see Appendix D of the SI Report), the depth of the collection trench is assumed to vary from approximately 3 feet under Chamberlain Creek to a maximum of approximately 20 feet about 700 feet north of Chamberlain Creek. The average depth of the collection trench is assumed to be approximately 12 feet with a 3-foot width. Therefore, it is estimated that approximately 2,600 cy of excavation will be required using a large track-hoe and trench box.

- The lower 5 feet of the shallow groundwater collection trench will have drainage gravel surrounded by non-woven geotextile. A perforated 6-inch plastic pipe is assumed in the base of the trench within the drainage gravel. The subsurface drains will terminate in an 8-foot diameter (minimum) precast concrete sump located approximately 300 feet north of Chamberlain Creek. Two pumps are assumed each with a capacity of 500 gpm at 130 feet total dynamic head (TDH) with motors rated at 25 HP each.

- A buried 8-inch diameter HDPE pipe will convey pumped groundwater approximately 3,000 feet to the southwest corner of the mine pit lake. New 460-volt, 3-phase electrical power is assumed to be required at the new pump location. The pipeline will be able to convey flow rates of 500 to 1,000 gpm and will include access manholes at 1,000 feet for maintenance and an air release valve at the high point of the line.

- Annual O&M costs will primarily consist of the cost of electrical power. It is assumed that the pumps will require replacement, and that pipe cleanout will be required, every five years.

Present value cost estimates for alternative SGW3 are listed below.

Present alue Capital Costs	**Present alue O M Costs**	**Present alue Periodic Costs**	**Net Present alue NP in 2009**
$477,969	$142,693	$90,567	$711,229

1.10 Bedrock roundwater Alternative B W1 No Action

The No Action alternative (BGW1) entails no additional activity to address the bedrock groundwater that is affected by the Site. This alternative has no cost.

1.11 Bedrock roundwater Alternative B W2 eri y Connection to Municipal 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. Any residences in the affected area that are not connected to the municipal system would be provided with a connection. All of the residents in the potentially affected area would need to be contacted to implement this alternative. Table B-11 presents the cost estimate spreadsheet. Key assumptions and conditions related to the estimated cost for this alternative include:

- The cost to evaluate records and meet with residents to assess connection to municipal system or well use is assumed at $10,000.
- A total of 20 new connections are assumed, at a cost of $5,000 each.

Present value cost estimates for alternative BGW2 are listed below.

Present alue Capital Costs	Present alue O M Costs	Present alue Periodic Costs	Net Present alue NP in 2009
$201,163	$0	$0	$201,163

1.12 Sludge Ponds Alternative SLU1 No Action

The No Action alternative (SLU1) would entail performing no activities at the three sludge ponds. This alternative has no cost.

1.13 Sludge Ponds Alternative SLU2 Soil Cover, Revegetate

The Soil Cover and Revegetate alternative (SLU2) entails placing a vegetated soil cover over the three sludge ponds. The soil cover will isolate the sludge from contact by terrestrial receptors. The revegetation will limit erosion of the soil cover. Table B-12 presents the cost estimate spreadsheet. Key assumptions and conditions related to the estimated cost for this alternative include:

- Clearing and grubbing will be done at the initiation of work in the area (Figure B-5 *Location of Sludge Ponds – Soil Cover and Revegetate, Alternative SLU2*); minor regrading of the ponds will be performed as part of the clearing and grubbing operations.

- The soil cover for the sludge ponds covers an area of approximately 4.6 acres, though some of this area actually surrounds the sludge ponds. An 18-inch soil cover will be placed over this area, with an additional 12 inches placed over the central portion of the ponds to address consolidation that could occur over the initial period of time after capping to achieve a final surface drainage from the cover. A total volume of 19,000 cy cover soil is estimated. Seeding and mulching will follow placement of the soil cover.

- Maintenance of the cover is assumed for the first 5 years after construction.

Present value cost estimates for alternative SLU2 are listed below.

Present alue Capital Costs	Present alue O M Costs	Present alue Periodic Costs	Net Present alue NP in 2009
$636,861	$7,544	$0	$644,405

1.14 Chamberlain Creek Alternative C M1 No Action

The No Action alternative (CHM1) would entail performing no activities in Chamberlain Creek. This alternative has no cost.

1.15 Chamberlain Creek Alternative C M2 Source Control

The Source Control alternative (CHM2) would include portions of other area-specific alternatives such as the pit lake alternatives (PL2 or PL3), spoil pile alternatives (SP2 or SP3), and shallow groundwater alternatives (SGW2 or SGW3). Therefore, no costs are estimated specifically for this alternative.

1.16 Tailings Impoundments Alternative TI1 No Action

The No Action alternative (TI1) would entail no activities on the tailings impoundments. This alternative has no cost.

1.17 Tailings Impoundments Alternative TI2 Regrade, Stabilize Dams, Revegetate

The Regrade, Stabilize Dams, and Revegetate alternative (TI2) entails 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. A geotechnical investigation during the remedial design phase may be required to determine the most appropriate approach to improve dam stability. It is assumed that the TP3E tailings dam will be stabilized by buttressing since TP3 is full of tailings and the TP1, TP2, TP3W, TP4E and TP4W dams will be stabilized by regrading. The following figures provide conceptual closure information for the tailings impoundments:

- Figure B-6 - *Location of Tailings Impoundments – Regrade, Stabilize Dams, and Revegetate; Alternative TI2;*
- Figure B-7 - *Regrading Plan for TP1, TP2, TP3E, and TP3W – Alternative TI2*;
- Figure B-8 - *Regrading Plan for TP4E and TP4W – Alternative TI2;*
- Figure B-9 - *Typical Cross-Section TP3E Buttress – Alternative TI2*;
- Figure B-10 - *Typical Cross-Section TP4E – Alternative TI2*.

Table B-13 presents the cost estimate spreadsheet. Key assumptions and conditions related to the estimated cost for this alternative include:

- The 55 million gallons of ponded water within the impoundments will be pumped into the pit lake. Following removal of the water, the tailing surfaces will be graded to drain to prevent future development of ponded water.
- Existing downstream embankment slopes vary from approximately 1.5 to 2.25:1. To achieve long-term stability and provide for a stable slope for revegetation, the downstream embankments will either be buttressed or regraded to slopes of 3:1 to 4:1.
- The embankment between TP1 and TP2 will be regraded to promote drainage and the TP1 embankment will be regraded to a configuration providing long-term stability. Drainage from the closure surface at TP1 and TP2 will be directed towards a rock-lined swale. Requirements for work on TP1 and TP2 include approximately: 5 acres of clearing and grubbing, 35,000 cy of regrading; seeding and mulching on 10 acres, and 1,200 cy of rock for the drainage swale.
- Buttressing of the TP3 east embankment will include placement of a 12- to 18-inch thick limestone drain below the buttress, from the existing embankment toe to the buttress

toe, to neutralize any residual ARD. It is estimated that requirements for these actions include approximately: 7 acres of clearing and grubbing, 80,000 cy of buttress fill, 2,000 cy of limestone drainage material beneath the buttress, 3,600 cy of cover soil over the buttress, and 1,300 cy of spillway rock to convey runoff flows down the south side of the buttress. Minor regrading will be performed on the TP3 surface to promote drainage as possible while maintaining existing large vegetation.

- The TP3W impounded area will be graded to drain west towards a small drainage and the TP3W area of wet tailings will have fill added to promote drainage south towards TP4W and thence to Stone Quarry Creek. It is estimated that this will require approximately 17,000 cy of regrading fill.

- TP4 consists of east and west impoundment areas on the east and west sides of the natural drainage divide between Reyburn Creek on the east and Stone Quarry Creek on the west. When water is removed from the TP4E and TP4W impoundments the embankments may then be regraded down to the approximate top of the tailing surfaces. The top of the regraded TP4 embankments will be at the approximate top of tailings and the downstream slopes will be graded to approximately 4:1. The requirements for required for TP4E and TP4W include approximately: 5 acres of clearing and grubbing on existing embankments, 30,000 cy of regrading, 20,000 cy of cover soil on the regraded slopes, and 900 cy of rock for lining the outfall swales.

- Consolidation of the saturated tailings within the TP4 impoundment will release pore water. Therefore, wick (vertical) drains, totaling a length of 75,000 lineal feet (LF) at TP4E and 33,000 LF at TP4W, will be used to release water and promote consolidation prior to capping with soil. It is estimated that wick drains will be required over approximately 9.2 acres at TP4E and 5 acres at TP4W. An estimated 30,000 cy of granular fill will be required at TP4E and TP4W, along with geosynthetics (geogrid and/or geotextile) to achieve access for the wick drain installation. The granular soil may consist of jig tailings obtained from regrading the embankments, supplemented as necessary with temporary placement of spoil material (to be removed after wick drain installation is complete and possibly after the majority of tailings consolidation has occurred). Tailing pore water removed during wick drain installations will be collected and pumped back to the pit lake. The consolidated tailing surfaces will then be graded to promote drainage into central swales and the surfaces will be prepared with fine-grained limestone, followed by seeding and mulching. The total disturbed area, including the beach areas, will cover approximately 45 acres.

- Maintenance of the cover for all capped areas is assumed for the first 5 years after construction.

Present value cost estimates for alternative TI2 are listed below.

Present alue Capital Costs	Present alue O M Costs	Present alue Periodic Costs	Net Present alue NP in 2009
$3,935,431	$116,572	$0	$4,052,003

1.18 A ected Streams Alternative AS1 No Action

The No Action alternative (AS1) entails no activities on streams or associated sources of COPCs (run-off from the spoil piles and tailings impoundments). This alternative has no cost.

1.19 A ected Streams Alternative AS2 Source Control

The Source Control alternative (AS2) includes reducing or minimizing the contact between run-off and spoil piles or tailings impoundments prior to impacting the off-site streams. As such, the effectiveness of this alternative (AS2) relies on the area-specific alternatives that would be implemented for the spoil piles and the tailings impoundments (see Sections 5.1.2 and 5.2.1, 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 northwest and northeast spoil piles, (2) rerouting of runoff and seeps toward the 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 reports to the Chamberlain Creek/Pit Lake Watershed (Alternative SP3). No costs are estimated specifically for this alternative as actions are included in other alternatives for which costs are estimated.

1.20 Clearwater Lake Alternative CWL1 No Action

The No Action alternative (CWL1) for Clearwater Lake entails no actions on the lake or on Site materials that are sources of ARD to the lake. This alternative has no cost.

1.21 Clearwater Lake Alternative CWL2 Source Control

The Source Control alternative (CWL2) for Clearwater Lake 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, including: (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, (3) regrading the spoil piles such that runoff and seepage reports to the Pit Lake watershed (Alternative SP3). No costs are estimated specifically for this alternative as actions are included in other alternatives for which costs are estimated.

TABLE B 1
NET PRESENT ALUE ESTIMATES FOR COMBINED SITE WIDE ALTERNATI ES 1 T ROU 5

Site Wide Remedial Alternative	Component Sub Alternatives
Alternative 1 - No Action	PL1, SP1, SGW1, BGW1, SLU1, CHM1, TI1, AS1, CWL1
Alternative 2 - No Further Action	PL2, SP1, SGW2, BGW1, SLU1, CHM1, TI1, AS1, CWL1
Alternative 3 - WTS and Source Control	PL2, SP2, SGW3, BGW2, SLU2, CHM2, TI2, AS2, CWL2
Alternative 4 - Pit Lake Neutralization and Source Control	PL3, SP2, SGW3, BGW2, SLU2, CHM2, TI2, AS2, CWL2
Alternative 5 - Pit Lake Neutralization and Extensive Source Control	PL3, SP3, SGW3, BGW2, SLU2, CHM2, TI2, AS2, CWL2

Present Value Discount Rate = 7%

Alternative 1 No Action	
Capital Costs	$0
O&M Costs	$0
Periodic Costs	$0
Total Net Present alue	**0**

Alternative 2 No Further Action	
Capital Costs	$0
O&M Costs	$5,136,930
Periodic Costs	$1,768,304
Total Net Present alue	**6,905,234**

Alternative 3 WTS and Source Control	
Capital Costs	$10,757,889
O&M Costs	$5,658,254
Periodic Costs	$1,988,906
Total Net Present alue	**18,405,049**

Alternative 4 Pit Lake Neutralization and Source Control	
Capital Costs	$12,644,184
O&M Costs	$2,931,293
Periodic Costs	$718,101
Total Net Present alue	**16,293,578**

Alternative 5 Pit Lake Neutralization and E tensive Source Control	
Capital Costs	$283,368,194
O&M Costs	$1,830,520
Periodic Costs	$90,567
Total Net Present alue	**285,289,281**

TABLE B 2
PRESENT   ALUE OF REMEDIAL ALTERNATI E 2   NO FURT ER ACTION

Item	Estimated Cost [3]	Notes	Start Year [1]	End Year [2]	Fre uency years	Present alue [4]
Capital Costs						
Pit Lake Alternative PL2 (post-595 only)/SGW2	$0	Table B-6	0	0	n.a.	$0
Total Capital Costs, Present Value						$0
Annual O M Costs						
Pit Lake Alternative PL2 (post-595 only)/SGW2	$360,000	Table B-6	1	100	n.a.	$5,136,930
Total Annual O&M Costs, Present Value						$5,136,930
Periodic Costs						
Pit Lake Alternative PL2 (post-595 only)/SGW2	$1,000,000	Table B-6	10	100	5	$1,768,304
Total Periodic Costs, Present Value						$1,768,304
TOTAL OF CAPITAL, O M, AND PERIODIC COSTS, PRESENT ALUE						**6,905,234**

Notes:
For Present Value calculations, the Discount Rate used is.... 7%
Costs and Present Value are based on "constant" or "real" 2009 dollars not adjusted for future inflation.
Unless identified separately, burden and profits are included in unit costs.
(1) Start Year is the year during which the capital construction or the O&M activities begin. Costs are assumed to be incurred on the first day of the year indicated.
(2) End Year is the year during which the capital construction or the O&M activities are completed. Costs are assumed to be incurred on the first day of the year indicated.
(3) Capital Costs are totals for the activity, not annualized; Annual O&M Costs are annualized to represent one year only; Periodic Costs are one-time or repeating (not annual) costs.
(4) Present Value represents the total cost over the project life based on a discount rate applied to the estimated cost for each year after Year 0 (2009).

TABLE B 3
PRESENT ALUE OF REMEDIAL ALTERNATI E 3 WTS AND SOURCE CONTROL

Item	Estimated Cost [3]	Notes	Start Year [1]	End Year [2]	Fre uency years	Present alue [4]
Capital Costs						
Pit Lake Alternative PL2 (post-595 only)	$0	Table B-6	0	0	n.a.	$0
Spoil Pile Alternative SP2	$5,692,676	Tables B-8a, b	0	1	n.a.	$5,506,467
Shallow Groundwater Alternative SGW3	$477,969	Table B-10	0	0	n.a.	$477,969
Bedrock Groundwater Alternative BGW2	$201,163	Table B-11	0	0	n.a.	$201,163
Sludge Pond Alternative SLU2	$636,861	Table B-12	0	0	n.a.	$636,861
Tailings Impoundment Alternative TI2	$4,204,493	Tables B-13a, b, c	0	2	n.a.	$3,935,431
Total Capital Costs, Present Value						$10,757,889
Annual O M Costs						
Pit Lake Alternative PL2 (post-595 only)/SGW2	$360,000	Table B-6	1	100	n.a.	$5,136,930
Spoil Pile Alternative SP2 (cover maintenance)	$27,200	Tables B-8a,b	2	7	n.a.	$121,168
Spoil Pile Alternative SP2 (power for pump system)	$10,000	Table B-8a	2	100	n.a.	$133,347
Shallow Groundwater Alternative SGW3	$10,000	Table B-10	1	100	n.a.	$142,693
Bedrock Groundwater Alternative BGW2	$0	Table B-11	1	5	n.a.	$0
Sludge Pond Alternative SLU2	$1,840	Table B-12	1	5	n.a.	$7,544
Tailings Impoundment Alternative TI2	$28,000	Tables B-13a, b, c	3	8	n.a.	$116,572
Total Annual O&M Costs, Present Value						$5,658,254
Periodic Costs						
Pit Lake Alternative PL2 (post-595 only)/SGW2	$1,000,000	Table B-6	10	100	5	$1,768,304
Spoil Pile Alternative SP2	$60,000	Table B-8a	2	100	5	$130,035
Shallow Groundwater Alternative SGW3	$36,500	Table B-10	5	100	5	$90,567
Bedrock Groundwater Alternative BGW2	$0	Table B-11	1	5	0	$0
Sludge Pond Alternative SLU2	$0	Table B-12	1	5	0	$0
Tailings Impoundment Alternative TI2	$0	Table B-13	3	8	0	$0
Total Periodic Costs, Present Value						$1,988,906

TOTAL OF CAPITAL, O M, AND PERIODIC COSTS, PRESENT ALUE	**18,405,049**

Notes:
For Present Value calculations, the Discount Rate used is…. 7%
Costs and Present Value are based on "constant" or "real" 2009 dollars not adjusted for future inflation.
Unless identified separately, burden and profits are included in unit costs.

(1) Start Year is the year during which the capital construction or the O&M activities begin. Costs are assumed to be incurred on the first day of the year indicated.

(2) End Year is the year during which the capital construction or the O&M activities are completed. Costs are assumed to be incurred on the first day of the year indicated.

(3) Capital Costs are totals for the activity, not annualized; Annual O&M Costs are annualized to represent one year only; Periodic Costs are one-time or repeating (not annual) costs.

(4) Present Value represents the total cost over the project life based on a discount rate applied to the estimated cost for each year after Year 0 (2009).

TABLE B 4
PRESENT ALUE OF REMEDIAL ALTERNATI E 4 PIT LAKE NEUTRALI ATION AND SOURCE CONTROL

Item	Estimated Cost [3]	Notes	Start Year [1]	End Year [2]	Fre uency years	Present alue [4]
Capital Costs						
Pit Lake Alternative PL3	$1,886,294	Tables B-7a, b	0	0	n.a.	$1,886,294
Spoil Pile Alternative SP2	$5,692,676	Tables B-8a, b	0	1	n.a.	$5,506,467
Shallow Groundwater Alternative SGW3	$477,969	Table B-10	0	0	n.a.	$477,969
Bedrock Groundwater Alternative BGW2	$201,163	Table B-11	0	0	n.a.	$201,163
Sludge Pond Alternative SLU2	$636,861	Table B-12	0	0	n.a.	$636,861
Tailings Impoundment Alternative TI2	$4,204,493	Tables B-13a, b, c	0	2	n.a.	$3,935,431
Total Capital Costs, Present Value						$12,644,184
Annual O M Costs						
Pit Lake Alternative PL3	$168,893	Table B-7b	1	100	n.a.	$2,409,969
Spoil Pile Alternative SP2 (cover maintenance)	$27,200	Tables B-8a,b	2	7	n.a.	$121,168
Spoil Pile Alternative SP2 (power for pump system)	$10,000	Table B-8a	2	100	n.a.	$133,347
Shallow Groundwater Alternative SGW3	$10,000	Table B-10	1	100	n.a.	$142,693
Bedrock Groundwater Alternative BGW2	$0	Table B-11	1	5	n.a.	$0
Sludge Pond Alternative SLU2	$1,840	Table B-12	1	5	n.a.	$7,544
Tailings Impoundment Alternative TI2	$28,000	Tables B-13a, b, c	3	8	n.a.	$116,572
Total Annual O&M Costs, Present Value						$2,931,293
Periodic Costs						
Pit Lake Alternative PL3	$200,500	Table B-7a	5	100	5	$497,499
Spoil Pile Alternative SP2	$60,000	Table B-8a	2	100	5	$130,035
Shallow Groundwater Alternative SGW3	$36,500	Table B-10	5	100	5	$90,567
Bedrock Groundwater Alternative BGW2	$0	Table B-11	1	5	0	$0
Sludge Pond Alternative SLU2	$0	Table B-12	1	5	0	$0
Tailings Impoundment Alternative TI2	$0	Table B-13	3	8	0	$0
Total Periodic Costs, Present Value						$718,101

TOTAL OF CAPITAL, O M, AND PERIODIC COSTS, PRESENT ALUE	**16,293,578**

Notes:
For Present Value calculations, the Discount Rate used is…. 7%
Costs and Present Value are based on "constant" or "real" 2009 dollars not adjusted for future inflation.
Unless identified separately, burden and profits are included in unit costs.

(1) Start Year is the year during which the capital construction or the O&M activities begin. Costs are assumed to be incurred on the first day of the year indicated.
(2) End Year is the year during which the capital construction or the O&M activities are completed. Costs are assumed to be incurred on the first day of the year indicated.
(3) Capital Costs are totals for the activity, not annualized; Annual O&M Costs are annualized to represent one year only; Periodic Costs are one-time or repeating (not annual) costs.
(4) Present Value represents the total cost over the project life based on a discount rate applied to the estimated cost for each year after Year 0 (2009).

TABLE B 5
PRESENT ALUE OF REMEDIAL ALTERNATI E 5 PIT LAKE NEUTRALI ATION AND E TENSI E SOURCE CONTROL

Item	Estimated Cost [3]	Notes	Start Year [1]	End Year [2]	Fre uency years	Present alue [4]
Capital Costs						
Pit Lake Alternative PL2 - no capital costs	$0	Tables B-6	0	3	n.a.	$0
Pit Lake Alternative PL3 - 1-time neutralization only	$1,886,294	Tables B-7a, b	4	4	n.a.	$1,439,045
Spoil Pile Alternative SP3	$305,357,174	Table B-9	0	3	n.a.	$276,677,726
Shallow Groundwater Alternative SGW3	$477,969	Table B-10	0	0	n.a.	$477,969
Bedrock Groundwater Alternative BGW2	$201,163	Table B-11	0	0	n.a.	$201,163
Sludge Pond Alternative SLU2	$636,861	Table B-12	0	0	n.a.	$636,861
Tailings Impoundment Alternative TI2	$4,204,493	Tables B-13a, b, c	0	2	n.a.	$3,935,431
Total Capital Costs, Present Value						$283,368,194
Annual O M Costs						
Pit Lake Alternative PL2 - WTS operation until SP3 done	$360,000	Tables B-6	0	3	n.a.	$1,304,754
Pit Lake Alternative PL3 - no annual O&M (1-time only)	$0	Table B-7a, b	0	0	n.a.	$0
Spoil Pile Alternative SP3	$76,000	Table B-9	4	9	n.a.	$295,710
Shallow Groundwater Alternative SGW3	$10,000	Table B-10	1	20	n.a.	$105,940
Bedrock Groundwater Alternative BGW2	$0	Table B-11	0	0	n.a.	$0
Sludge Pond Alternative SLU2	$1,840	Table B-12	1	5	n.a.	$7,544
Tailings Impoundment Alternative TI2	$28,000	Tables B-13a, b, c	3	8	n.a.	$116,572
Total Annual O&M Costs, Present Value						$1,830,520
Periodic Costs						
Pit Lake Alternative PL2 - no periodic costs applicable	$0	Tables B-6	0	0	0	$0
Pit Lake Alternative PL3 - no periodic costs applicable	$0	Table B-7a, b	0	0	0	$0
Spoil Pile Alternative SP3	$0	Table B-9	4	9	0	$0
Shallow Groundwater Alternative SGW3	$36,500	Table B-10	5	20	5	$90,567
Bedrock Groundwater Alternative BGW2	$0	Table B-11	0	0	0	$0
Sludge Pond Alternative SLU2	$0	Table B-12	0	0	0	$0
Tailings Impoundment Alternative TI2	$0	Table B-13	0	0	0	$0
Total Periodic Costs, Present Value						$90,567
TOTAL OF CAPITAL, O M, AND PERIODIC COSTS, PRESENT ALUE						**285,289,281**

Notes:
For Present Value calculations, the Discount Rate used is…. 7%
Costs and Present Value are based on "constant" or "real" 2009 dollars not adjusted for future inflation.
Unless identified separately, burden and profits are included in unit costs.

(1) Start Year is the year during which the capital construction or the O&M activities begin. Costs are assumed to be incurred on the first day of the year indicated.

(2) End Year is the year during which the capital construction or the O&M activities are completed. Costs are assumed to be incurred on the first day of the year indicated.

(3) Capital Costs are totals for the activity, not annualized; Annual O&M Costs are annualized to represent one year only; Periodic Costs are one-time or repeating (not annual) costs.

(4) Present Value represents the total cost over the project life based on a discount rate applied to the estimated cost for each year after Year 0 (2009).

TABLE B 6
PIT LAKE ALTERNATI E PL2 and S ALLOW ROUNDWATER ALTERNATI E S W2 [a]
CONTINUED OPERATION OF WTS AND E ISTIN PUMPBACK SYSTEM

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs	b				
TOTAL CAPITAL COSTS					**0**
Annual O M Costs post 595					
WTS Operation	c	1	LS	$360,000	$360,000
Annual O M Costs Subtotal					**360,000**
TOTAL ANNUAL O M COSTS					**360,000**
PERIODIC COSTS					
Equipment Replacement - every 5 yrs	d	1	LS	$1,000,000	$1,000,000

Notes

a Estimated costs for PL2 and SGW2 are combined; SGW2 costs are insignificant and not itemized.
b There are no capital costs associated with continued operation of the existing WTS/pumpback.
c Average annual costs are $715,000 based on information provided by Halliburton.
Costs include labor, supplies, chemicals, security, power, water, etc for both PL2 and SGW2.
Future costs assume post-595 conditions with avg annual costs reduced by 50% from current costs.
Current operator may be able to provide a better cost estimate than the assumption listed here.
d Equipment will need to be replaced as it wears out. Assumed 30-year life span of current facility.
For periodic costs assumed $1,000,000 expended every 5th year.

TABLE B 7a
PIT LAKE ALTERNATI E PL3
COSTS FOR IN SITU PIT LAKE NEUTRALI ATION

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Direct Construction					
Lime (CaO)	a	4,000	tons	$140	$560,000
Barge Delivery System	b	1	LS	$350,000	$350,000
Boat Ramp Improvement	c	1	LS	$20,000	$20,000
Security	d	1	LS	$97,200	$97,200
On-Site Labor	e	1,040	hr	$50	$52,000
Direct Construction Subtotal					**1,079,200**
Indirect Construction					
Mobilization/Demobilization	f	0%			$0
Water/Sediment Control		0%			$0
Indirect Construction Subtotal					$0
Construction Subtotal					**1,079,200**
Contingencies					
Scope	g	10%			$107,920
Bid	g	10%			$107,920
Subtotal					$1,295,040
Project Management	g	6%			$77,702
Remedial Design	g	2%			$25,901
Construction Management	g	8%			$103,603
TOTAL CAPITAL COSTS					**1,502,246**

TOTAL ANNUAL O M COSTS					**0**

Periodic Costs every 5 years					
Lime (CaO)	a	700	ton/yr	$140	$98,000
Barge Delivery System	b	1	LS	$102,500	$102,500
Subtotal					**200,500**
Indirect Periodic Costs					
Mobilization/Demobilization	b	0%			$0
Water/Sediment Control		0%			$0
Indirect Periodic Costs Subt.					$0
TOTAL PERIODIC COSTS					**200,500**

Notes

a Calculated 4,000 tons first year of neutralization, assuming 50% mixing efficiency; 700 tons every 5 yrs after.
a Based on current price for lime (with tax) delivered to WTS - provided by Halliburton (March 2009 invoice detail).
b Verbal quotation obtained from Sweetwater - July 2009.
c Boat ramp improvement cost from 2005 estimate + cost escalation.
d Security cost based on March 2009 charges of $8,100 (x 12 = annual cost).
e On-site labor cost assumes one half-time person.
f Mobilization/demobilzation costs included in Sweetwater bid
g Percentages from EPA FS Guidance, except RD - decreased from 12% to 2% for minimal required design.

TABLE B 7b
PIT LAKE ALTERNATI E PL3
COSTS FOR INITIAL AND ON OIN PIT NUTRIENT ADDITION

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Direct Construction					
Boat	a	1	LS	$6,200	$6,200
Ammonium Polyphosphate	b	50	ton/yr	$260	$13,000
Urea ammonium nitrate	b	140	ton/yr	$240	$33,600
Security	c	1	LS	$97,200	$97,200
Fertilizer App, Etc Labor	d	2,080	hr	$50	$104,000
Direct Construction Subtotal					**254,000**
Indirect Construction					
Mobilization/Demobilization		5%			$12,700
Water/Sediment Control		0%			$0
Indirect Construction Subtotal					$12,700
Construction Subtotal					**266,700**
Contingencies					
Scope	e	10%			$26,670
Bid	e	10%			$26,670
Subtotal					$320,040
Project Management	e	8%			$25,603
Remedial Design	e	2%			$6,401
Construction Management	e	10%			$32,004
TOTAL CAPITAL COSTS					**384,048**
Annual O M Costs					
Ammonium Polyphosphate	f	12.5	ton/yr	$260	$3,250
Urea ammonium nitrate	f	35	ton/yr	$240	$8,400
Security	c	1	LS	$97,200	$97,200
Fertilizer App, Etc Labor	g	1,040	hr	$50	$52,000
Subtotal					**160,850**
Indirect Annual O&M Costs					
Mobilization/Demobilization		5%			$8,043
Water/Sediment Control		0%			$0
Indirect Annual O M Costs Subt.					$8,043
TOTAL ANNUAL O M COSTS					**168,893**
TOTAL PERIODIC COSTS					**0**

Notes

a Fertilizers will be applied monthly for the first year by piloting the boat around lake - Year 1.
b Unit rates (2005) for delivery to Little Rock area from Simplot, ID; cost escalation by 1.23 index.
b A N:P ratio of 6:1 (mass:mass) is necessary.
c Security cost based on March 2009 charges of $8,100 (x 12 = annual cost).
d Assume full-time labor required for one year (2005 labor rate was increased by 1.23 index).
e Percentages from EPA FS Guidance, except RD - decreased from 15% to 2% for minimal required design.
f Fertilizers applied quarterly every year after Year 1; annual rate is 25% of Year 1 rate.
g Assume half-time labor required each year.

TABLE B 8a
SPOIL PILE ALTERNATI E SP2
CLEAWATER LAKE / RUS ER CREEK
NORT EAST SPOIL AREA W CUTOFF, RUNON C ANNEL, POND, PIPIN TO PIT LAKE

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Direct Construction					
Clearing and Grubbing	a	6	acre	$8,980	$53,880
Excavate GW trench	a	9,000	cy	$12	$108,000
Install GW collection 4" drain pipe	a	2,700	ft	$6.00	$16,200
Install GW collection liner	b	81,000	sf	$6.20	$502,200
Place limestone in bottom 10'	c	3,000	cy	$210	$630,000
Backfill GW trench with soil	a	6,000	cy	$5.35	$32,100
Install GW sump at new pond	d	1	LS	$10,000	$10,000
Excav runon collection channel	a	8,100	cy	$5.35	$43,335
Install channel liner	b	54,000	sf	$0.60	$32,400
Construct adjacent access road	a	1,400	cy	$5.35	$7,490
Split E Rusher from Scull Cr	a	500	cy	$5.35	$2,675
Excavate for detention pond	a	18,000	cy	$5.35	$96,300
Install pond liner	b	50,000	sf	$0.80	$40,000
Install pump station at pond	e	1	LS	$150,000	$150,000
Pipeline from pond to Pit Lake	a	1,900	ft	$18.40	$34,960
Spread lime in disturbed areas	a	6	acre	$2,300	$13,800
Revegetate disturbed areas	a	6	acre	$2,400	$14,400
Direct Construction Subtotal					**1,787,740**
Indirect Construction					
Mobilization/Demobilization	f	5%			$89,387
Water/Sediment Control	f	3%			$44,694
Indirect Construction Subtotal					$134,081
Construction Subtotal					**1,921,821**
Contingencies					
Scope	g	10%			$192,182
Bid	g	15%			$288,273
Subtotal					$2,402,276
Project Management	g	6%			$144,137
Remedial Design	g	12%			$288,273
Construction Management	g	8%			$192,182
TOTAL CAPITAL COSTS					**3,026,867**
Annual O M Costs					
Power (100 years)	f	1	LS	$10,000	$10,000
Cover Maintenance (5 years)	h	55	acre	$400	$22,000
TOTAL ANNUAL O M COSTS		**Years 1 5**			**32,000**
		Years 6 100			**10,000**
PERIODIC COSTS every 5 yrs					
Pump replacement	f	1	LS	$ 50,000	$50,000
Pipe cleaning	f	1	LS	$ 5,000	$5,000
Misc.	f	1	LS	$ 5,000	$5,000
TOTAL PERIODIC COSTS					**60,000**

Notes

a Developed from RS Means data - 2009 or escalated 2005 costs.
b Developed from GSE Lining Technology liner prices - June 2009.
c Lime price based on Mar 09 EEMA delivered cost at $140/ton (1.5 ton/cy).
d Assumed ballpark cost.
e Includes 2 stainless 18 HP pumps + access to site + electric power to pump station.
f Assumed values/professional judgment; power and periodic costs required for 100 years
g Based on EPA FS Cost Guidance.
h Maintenance of cover for 5 years.

TABLE B 8b
SPOIL PILE ALTERNATI E SP2
CLEAWATER LAKE / RUS ER CREEK
NORT WEST AND NORT EAST SPOIL AREA, ETC RE RADIN , CO ER, RE E ETATE

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Direct Construction					
Clearing and grubbing	a	13	acre	$8,980	$116,740
Regrade spoils to Pit Lake drainage	a	128,000	cy	$5.35	$684,800
Selective regrading in low areas	a	20,000	cy	$5.35	$107,000
Redirecting manor drainage to pit lake	a	51,000	cy	$5.35	$272,850
Spread crushed gravel/limestone in areas	b	2,000	cy	$30	$60,000
Spread/incorporate limestone	a	13	acre	$2,300	$29,900
Place soil cover	a	17,000	cy	$16	$272,000
Seeding and mulching	a	13	acre	$2,400	$31,200
Direct Construction Subtotal					**1,574,490**
Indirect Construction					
Mobilization/Demobilization	c	5%			$78,725
Water/Sediment Control	c	3%			$39,362
Indirect Construction Subtotal					$118,087
Construction Subtotal					**1,692,577**
Contingencies					
Scope	d	10%			$169,258
Bid	d	15%			$253,887
Subtotal					$2,115,721
Project Management	d	6%			$126,943
Remedial Design	d	12%			$253,887
Construction Management	d	8%			$169,258
TOTAL CAPITAL COSTS					**2,665,808**
Annual O M Costs					
Cover Maintenance	e	13	acre	$400	$5,200
Annual O M Costs Subtotal					**5,200**
TOTAL ANNUAL O M COSTS					**5,200**
TOTAL PERIODIC COSTS					**0**

Notes

a Developed from RS Means data - 2009 or escalated 2005 costs.
b Assumed limestone material similar to crushed gravel, ballpark cost.
c Assumed values/professional judgment.
d Based on EPA FS Cost Guidance.
e Maintenance of cover for 5 years.

TABLE B 9
SPOIL PILE ALTERNATI E SP3
CLEAWATER LAKE / RUS ER CREEK
SPOIL PILE RECLAMATION E TENSI E RE RADIN , SOIL CO ER, RE E

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Direct Construction					
Clearing and grubbing	a	180	acre	$8,980	$1,616,400
Excavate spoils	b	14,000,000	cy	$2.70	$37,800,000
Load spoils	b	14,000,000	cy	$4.50	$63,000,000
Haul spoils	b	14,000,000	cy	$1.80	$25,200,000
Place spoils in repository	b	14,000,000	cy	$1.50	$21,000,000
Mix CaCO3 with spoils during placement	c	1,600,000	ton	$25	$40,000,000
Apply limestone to removal areas	a	110	acre	$2,300	$253,000
Place soil cover on repository	b	450,000	cy	$10.30	$4,635,000
Seeding and mulching all areas	a	300	acre	$2,400	$720,000
Direct Construction Subtotal					**194,224,400**
Indirect Construction					
Mobilization/Demobilization	d	5%			$9,711,220
Water/Sediment Control	d	3%			$4,855,610
Indirect Construction Subtotal					$14,566,830
Construction Subtotal					**208,791,230**
Contingencies					
Scope	e	10%			$20,879,123
Bid	e	15%			$31,318,685
Subtotal					$260,989,038
Project Management	e	5%			$13,049,452
Remedial Design	e	6%			$15,659,342
Construction Management	e	6%			$15,659,342
TOTAL CAPITAL COSTS					**305,357,174**
Annual O M Costs					
Cover Maintenance	f	190	acre	$400	$76,000
Annual O M Costs Subtotal					**76,000**
TOTAL ANNUAL O M COSTS					**76,000**
TOTAL PERIODIC COSTS					**0**

Notes

a Developed from RS Means data - 2009 or escalated 2005 costs.
b Developed from RS Means data with volume discount (economies of scale).
c Estimated amount of crushed limestone based on SI acid-base accounting information; Unit rate based on professional judgment.
d Assumed values/professional judgment.
e Based on EPA FS Cost Guidance.
f Maintenance of cover for 5 years.

TABLE B 10
S ALLOW ROUNDWATER ALTERNATI E S W3
C AMBERLAIN CREEK
PUMP BACK WIT LAR ER EN INEERED SYSTEM

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Direct Construction					
French Drain	a	1,900	lf	$50	$95,000
Manhole/sump (precast)	a	1	LS	$25,000	$25,000
Pump (incl. standby) + power	b	1	LS	$70,000	$70,000
Piping	a	3,000	lf	$20	$60,000
Direct Construction Subtotal					**250,000**
Indirect Construction					
Mobilization/Demobilization	c	10%			$25,000
Water/Sediment Control	c	5%			$12,500
Indirect Construction Subtotal					$37,500
Construction Subtotal					**287,500**
Contingencies					
Scope	d	10%			$28,750
Bid	d	15%			$43,125
Subtotal					$359,375
Project Management	d	8%			$28,750
Remedial Design	d	15%			$53,906
Construction Management	d	10%			$35,938
TOTAL CAPITAL COSTS					**477,969**
Annual O M Costs					
Power	c	1	LS	$10,000	$10,000
Annual O M Costs Subtotal					**10,000**
TOTAL ANNUAL O M COSTS					**10,000**
PERIODIC COSTS every 5 yrs					
Pump replacement	c	1	LS	$ 30,000	$30,000
Pipe cleaning	c	1	LS	$ 3,500	$3,500
Misc.	c	1	LS	$ 3,000	$3,000
TOTAL PERIODIC COSTS					**36,500**

Notes

a Developed from RS Means data - 2009 or escalated 2005 costs.
b Developed from mechanical engineering professional judgment/estimate.
c Assumed values/professional judgment.
d Based on EPA FS Cost Guidance.

TABLE B 11
BEDROCK ROUNDWATER ALTERNATI E B W2
ERIFY CONNECTION TO MUNICIPAL SYSTEM/CONNECT AS NEEDED

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Direct Construction					
Review well data/verify connection	a	1	LS	$10,000	$10,000
Connect to municipal supply	b	20	LS	$5,000	$100,000
Direct Construction Subtotal					**110,000**
Indirect Construction					
Mobilization/Demobilization	c	10%			$11,000
Water/Sediment Control	c	0%			$0
Indirect Construction Subtotal					$11,000
Construction Subtotal					**121,000**
Contingencies					
Scope	d	10%			$12,100
Bid	d	15%			$18,150
Subtotal					$151,250
Project Management	d	8%			$12,100
Remedial Design	d	10%			$15,125
Construction Management	d	15%			$22,688
TOTAL CAPITAL COSTS					**201,163**
TOTAL ANNUAL O M COSTS					**0**

TOTAL PERIODIC COSTS					**0**

Notes

a Identify wells in area and verify yes/no existing connection to municipal system.
b Assume 20 new connections required @ $5,000/well connection.
c Assumed values/professional judgment.
d Based on EPA FS Cost Guidance.

TABLE B 12
SLUD E POND ALTERNATI E SLU2
SLUD E IMPOUNDMENTS
ON SITE REPOSITORY CLOSE IN PLACE

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Direct Construction					
Clearing and grubbing	a	4.6	acre	$8,980	$41,308
Place soil cover	a	19,000	cy	$16	$304,000
Seeding and mulching	a	4.6	acre	$2,400	$11,040
Direct Construction Subtotal					**356,348**
Indirect Construction					
Mobilization/Demobilization	b	5%			$17,817
Water/Sediment Control	b	3%			$8,909
Indirect Construction Subtotal					$26,726
Construction Subtotal					**383,074**
Contingencies					
Scope	c	10%			$38,307
Bid	c	15%			$57,461
Subtotal					$478,843
Project Management	c	8%			$38,307
Remedial Design	c	15%			$71,826
Construction Management	c	10%			$47,884
TOTAL CAPITAL COSTS					**636,861**
Annual O M Costs					
Cover maintenance	d	4.6	acre	$400	$1,840
Annual O M Costs Subtotal					**1,840**
TOTAL ANNUAL O M COSTS					**1,840**
TOTAL PERIODIC COSTS					**0**

Notes

a Developed from RS Means data - 2009 or escalated 2005 costs.
b Assumed values/professional judgment.
c Based on EPA FS Cost Guidance.
d Maintenance of cover for 5 years.

TABLE B 13a
TAILIN S IMPOUNDMENT ALTERNATI E TI2
TAILIN S PONDS 1 2 CLOSURE

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Direct Construction					
Remove ponded water	a	1	LS	$35,000	$35,000
Clear and grub	b	10	acre	$8,980	$89,800
Rough grading	a	10	acre	$6,000	$60,000
TP-1 Embankment Regrade	b	10,000	cy	$5.35	$53,500
Crushed limestone surface prep	b	10	acre	$2,300	$23,000
Seeding/mulching	b	10	acre	$2,400	$24,000
Direct Construction Subtotal					**285,300**
Indirect Construction					
Mobilization/Demobilization	a	10%			$28,530
Water/Sediment Control	a	2%			$5,706
Indirect Construction Subtotal					$34,236
Construction Subtotal					**319,536**
Contingencies					
Scope	c	10%			$31,954
Bid	c	15%			$47,930
Subtotal					$399,420
Project Management	c	8%			$31,954
Remedial Design	c	15%			$59,913
Construction Management	c	10%			$39,942
TOTAL CAPITAL COSTS					**531,229**
Annual O M Costs					
Cover maintenance	d	10	ac	$400	$4,000
Annual O M Costs Subtotal					**4,000**
TOTAL ANNUAL O M COSTS					**4,000**
TOTAL PERIODIC COSTS					**0**

Notes

a Assumed values/professional judgment.
b Developed from RS Means data - 2009 or escalated 2005 costs.
c Based on EPA FS Cost Guidance.
d Maintenance of cover for 5 years.

TABLE B 13b
TAILIN S IMPOUNDMENT ALTERNATI E TI2
TAILIN S POND 3 CLOSURE
BUTTRESS DAM

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Direct Construction					
Remove ponded water	a	1	LS	$2,500	$2,500
Clear and grub	b	7	acre	$8,980	$62,860
Place Limestone Drain at Toe	b	2,000	cy	$35	$70,000
Place and compact buttress fill	b	80,000	cy	$8.50	$680,000
Place cover soil on buttress fill	b	3,600	cy	$16	$57,600
Regrading Fill - west area	b	17,000	cy	$5.35	$90,950
Seeding/mulching	b	15	acre	$2,400	$36,000
Direct Construction Subtotal					**999,910**
Indirect Construction					
Mobilization/Demobilization	a	10%			$99,991
Water/Sediment Control	a	2%			$19,998
Indirect Construction Subtotal					$119,989
Construction Subtotal					**1,119,899**
Contingencies					
Scope	c	10%			$111,990
Bid	c	15%			$167,985
Subtotal					$1,399,874
Project Management	c	6%			$83,992
Remedial Design	c	12%			$167,985
Construction Management	c	8%			$111,990
TOTAL CAPITAL COSTS					**1,763,841**
Annual O M Costs					
Cover maintenance	d	15	ac	$400	$6,000
Annual O M Costs Subtotal					**6,000**
TOTAL ANNUAL O M COSTS					**6,000**

TOTAL PERIODIC COSTS		**0**

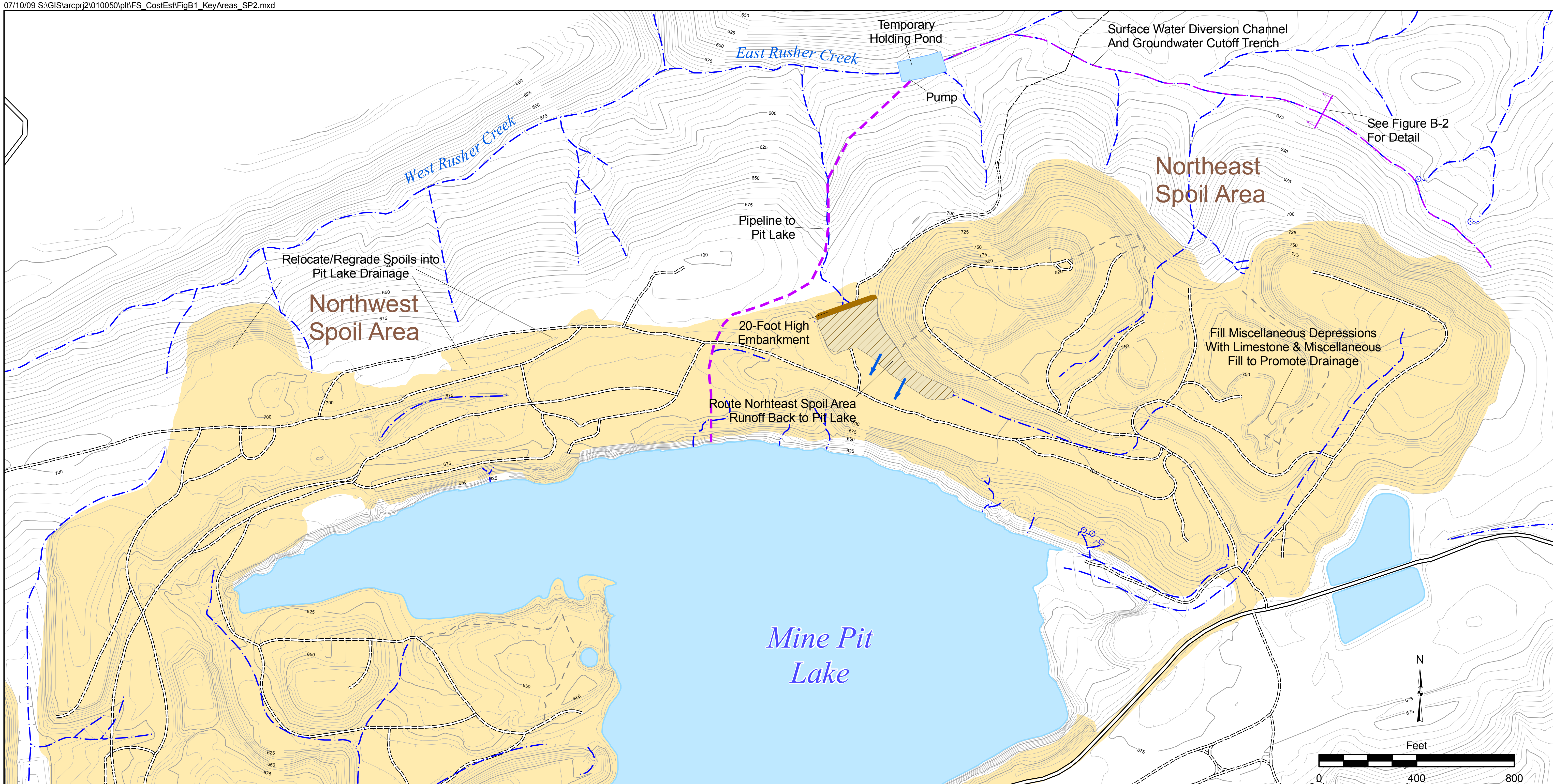
Notes
a Assumed values/professional judgment.
b Developed from RS Means data - 2009 or escalated 2005 costs.
c Based on EPA FS Cost Guidance.
d Maintenance of cover for 5 years.

TABLE B 13c
TAILIN S IMPOUNDMENT ALTERNATI E TI2
TAILIN S POND 4 CLOSURE
BUTTRESS DAM

Item	Notes	Quantity	Unit	Unit Cost	Total Cost
Capital Costs					
Direct Construction					
Remove ponded water	a	1	LS	$70,000	$70,000
Clear and grub	b	5	acre	$8,980	$44,900
Embankment Regrading	b	30,000	cy	$5.35	$160,500
Place cover soil on buttress fill	b	20,000	cy	$16	$320,000
Wick Drainage/Consol. of Tailings	c	15	acre	$17,000	$255,000
Limestone surface prep	b	30	acre	$2,300	$69,000
Revegetation	b	45	acre	$2,400	$108,000
Direct Construction Subtotal					**1,027,400**
Indirect Construction					
Mobilization/Demobilization	a	10%			$102,740
Water/Sediment Control	a	8%			$82,192
Indirect Construction Subtotal					$184,932
Construction Subtotal					**1,212,332**
Contingencies					
Scope	d	10%			$121,233
Bid	d	15%			$181,850
Subtotal					$1,515,415
Project Management	d	6%			$90,925
Remedial Design	d	12%			$181,850
Construction Management	d	8%			$121,233
TOTAL CAPITAL COSTS					**1,909,423**
Annual O M Costs					
Cover maintenance	e	45	ac	$400	$18,000
Annual O M Costs Subtotal					**18,000**
TOTAL ANNUAL O M COSTS					**18,000**
TOTAL PERIODIC COSTS					**0**

Notes
a Assumed values/professional judgment.
b Developed from RS Means data - 2009 or escalated 2005 costs.
c Developed from TerraSystems, Inc. info - June 2009.
d Based on EPA FS Cost Guidance.
e Maintenance of cover for 5 years.

07/10/09 S:\GIS\arcprj2\010050\plt\FS_CostEst\FigB1_KeyAreas_SP2.mxd



Legend

Surface Water Drainage	Maintained Gravel Road	Cross Section B2
Pond	Gravel Road	Surface Water Diversion Channel
Spoil Piles	ATV Track	Pipeline
Fill	Index Contour	
	Intermediate Contour	

HALLIBURTON
DRESSER INDUSTRIES - MAGCOBAR MINE SITE

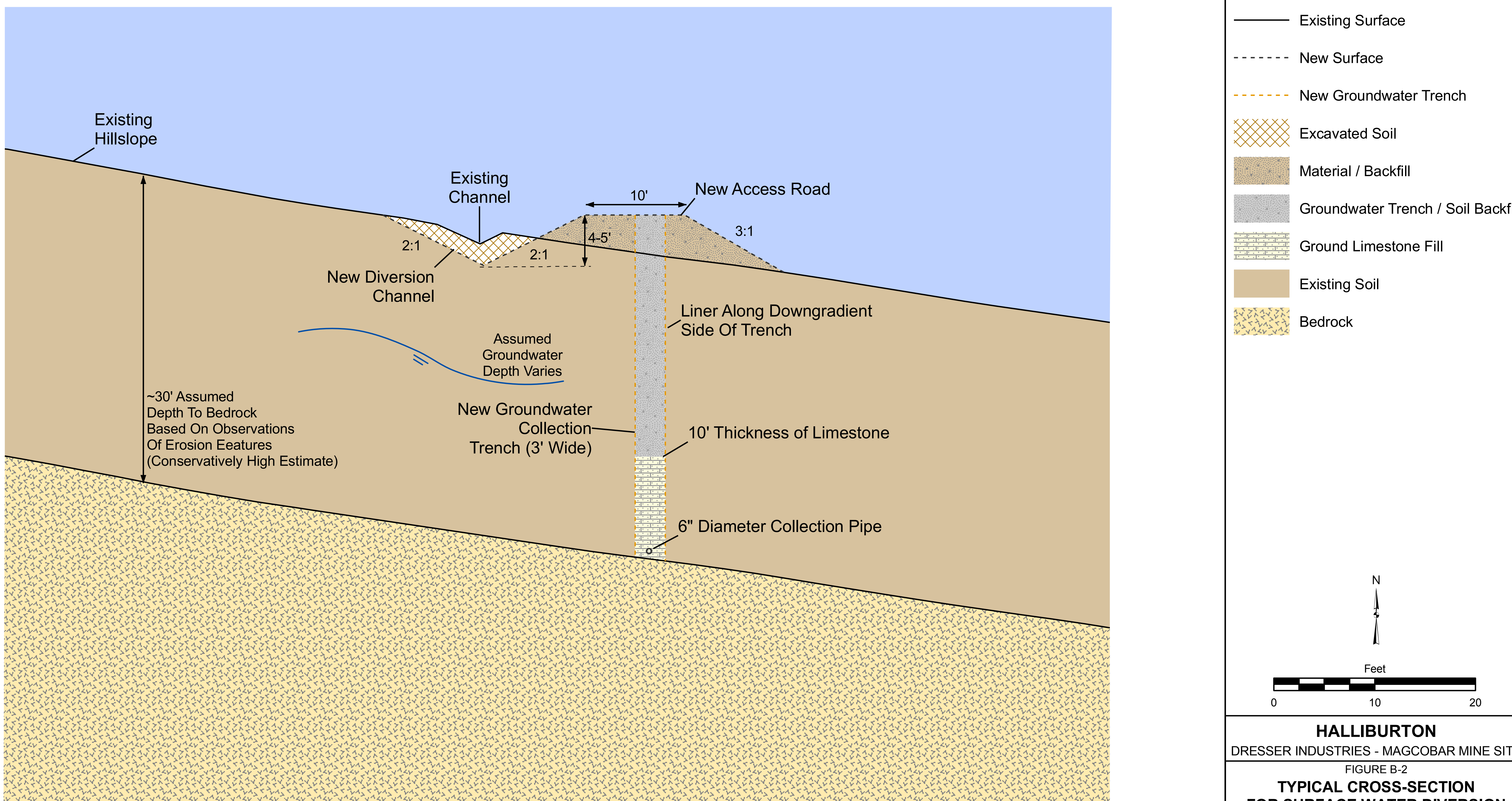
Figure B-1

KEY AREAS OF ALTERNATIVE SP2

PRJ: 0133-006-900	Jul 10, 2009	
REV: 0	BY: CRL	CHECKED: FLC

NEWFIELDS

07/10/09 S:\GIS\arcprj2\010050\plt\FS_CostEst\FigB2_CrossSection.mxd



HALLIBURTON

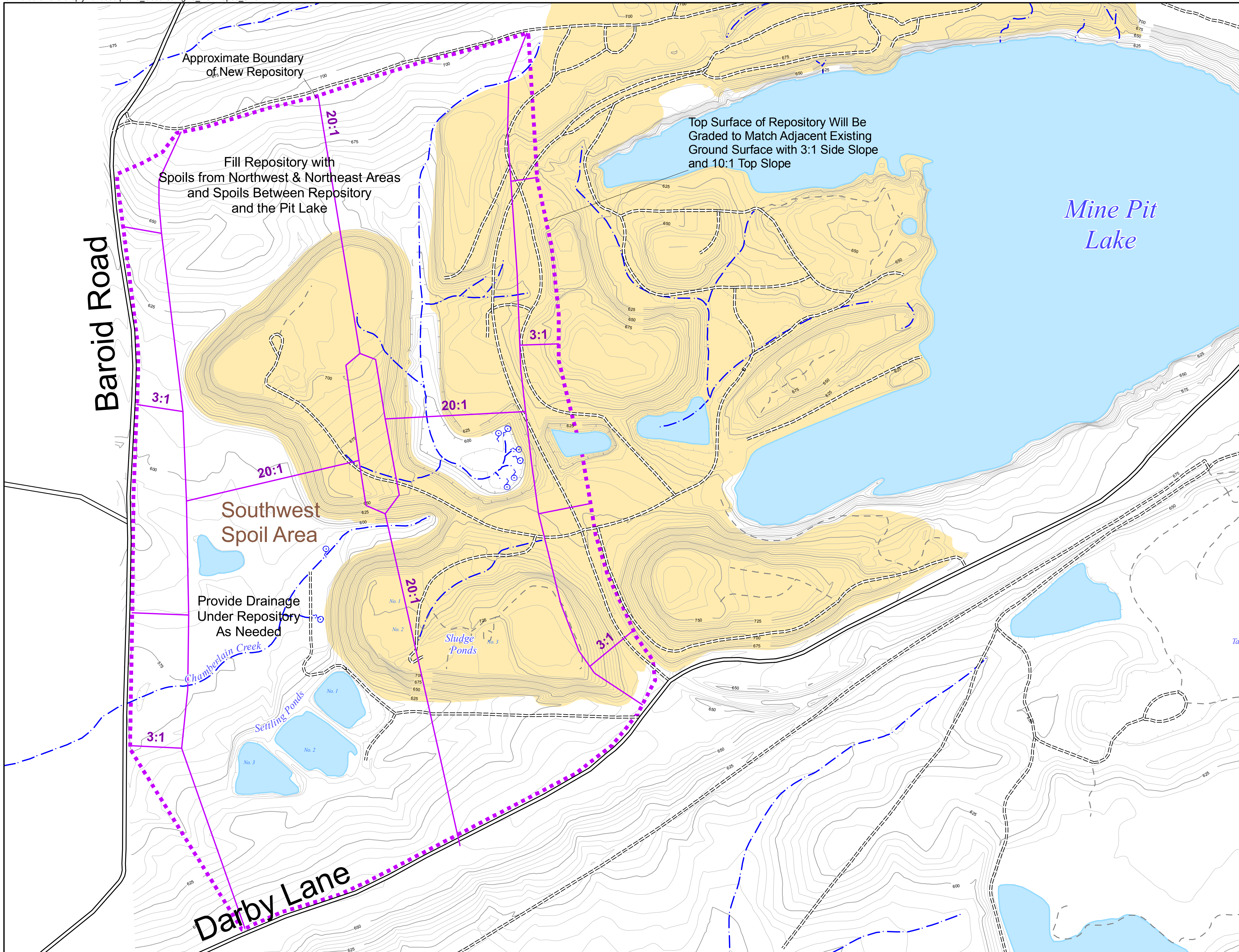
DRESSER INDUSTRIES - MAGCOBAR MINE SITE

FIGURE B-2

TYPICAL CROSS-SECTION FOR SURFACE WATER DIVERSION CHANNEL AND GROUNDWATER CUTOFF TRENCH - ALTERNATIVE SP2

PRJ: 0133-006-900-20	Jul 10, 2009	
REV: 0	BY: CRL	CHECKED: FLC

NEWFIELDS



Legend

- Surface Water Drainage
- Pond
- Seep
- Maintained Gravel Road
- Gravel Road
- ATV Track
- Index Contour
- Intermediate Contour
- Spoil Piles
- Approximate Boundary of New Repository

N

Feet

0 450 900

HALLIBURTON

DRESSER INDUSTRIES - MAGCOBAR MINE SITE

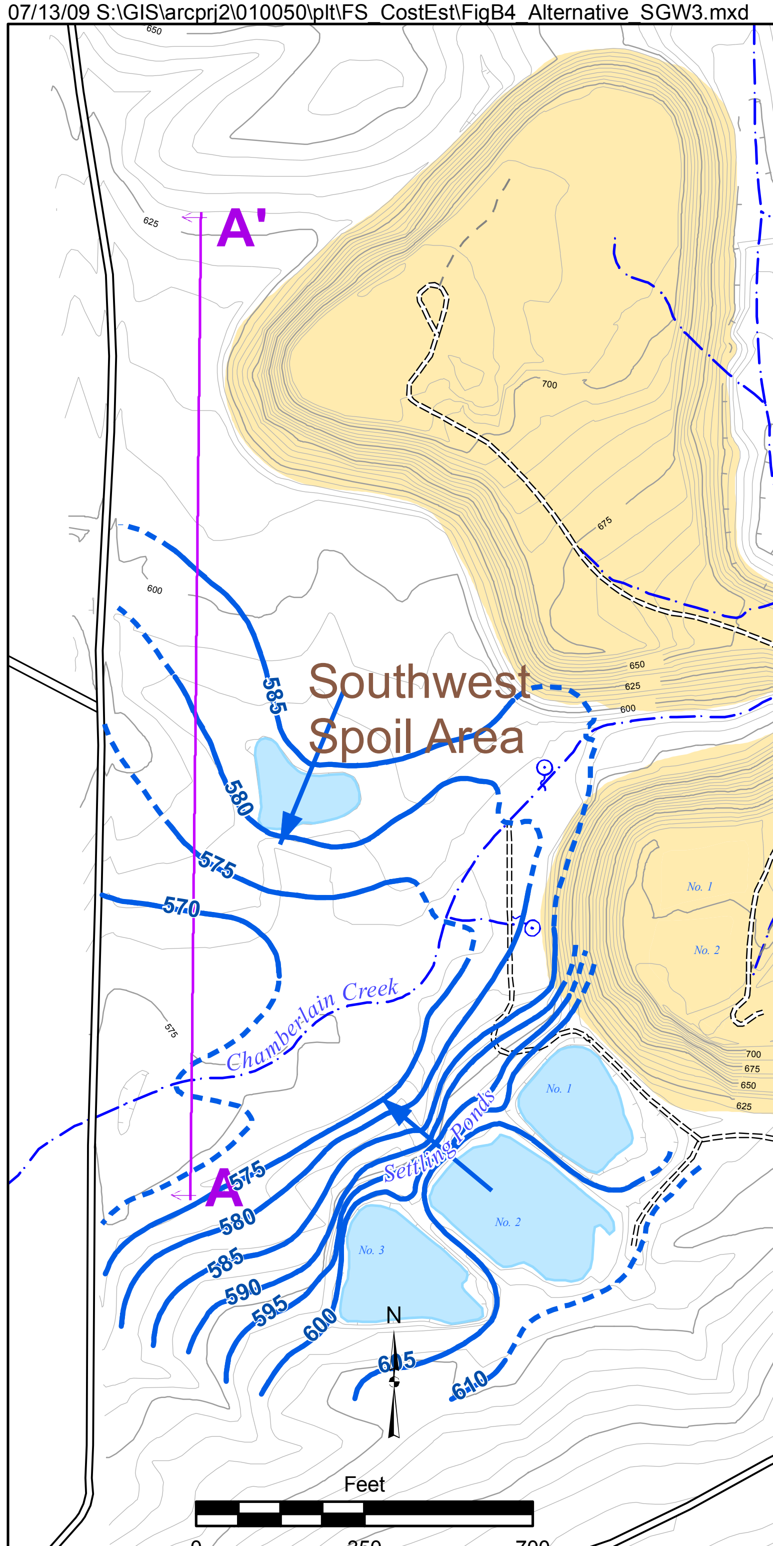
Figure B-3

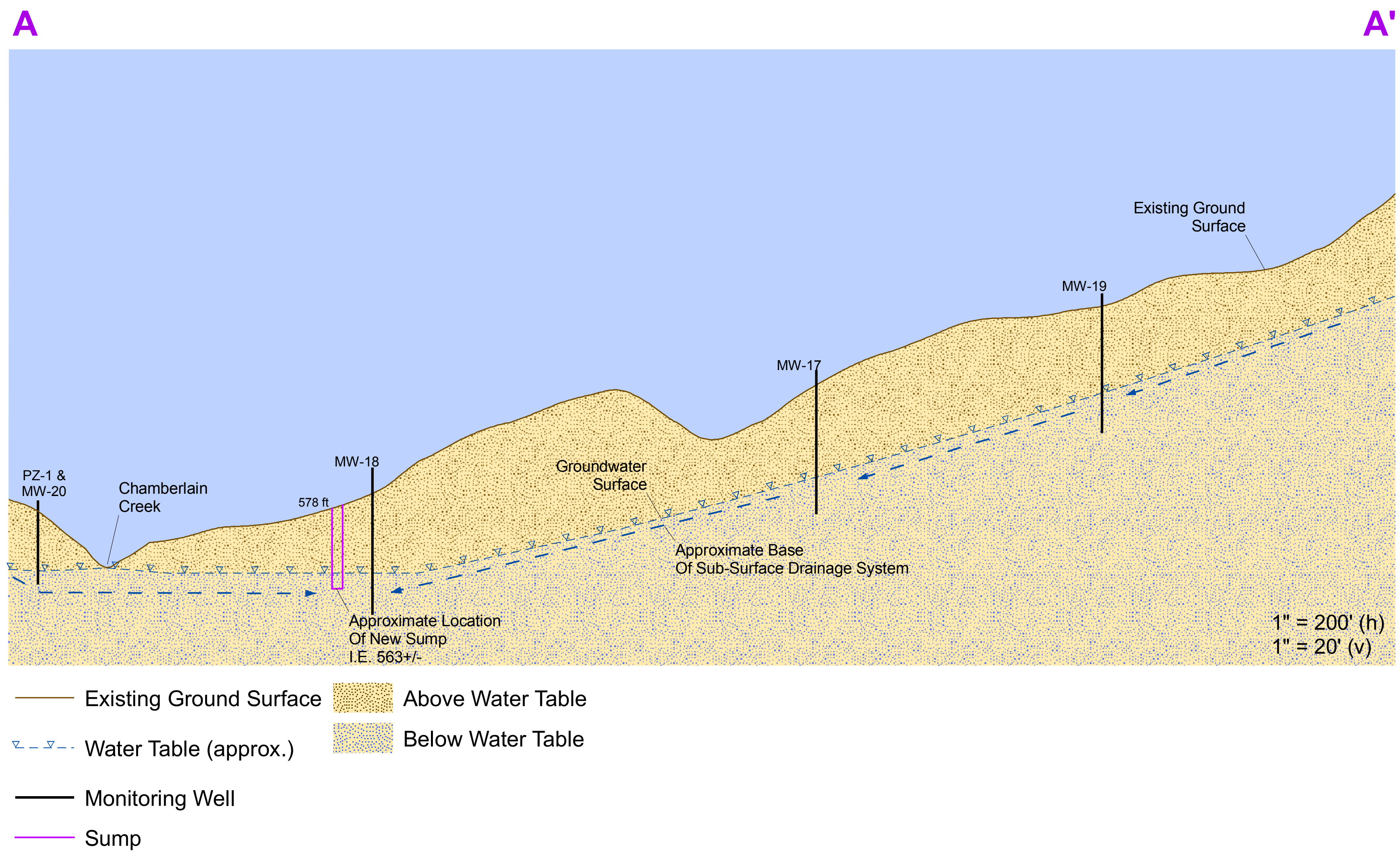
LOCATION OF NEW REPOSITORY FOR ALTERNATIVE SP3

PRJ: 0133-006-900-20	Jul 10, 2009	
REV: 0	BY: CRL	CHECKED: FLC

NEWFIELDS

07/13/09 S:\GIS\arcprj2\010050\plt\FS_CostEst\FigB4_Alternative_SGW3.mxd





EXPLANATION

- Surface Water Drainage
- Seep
- Maintained Gravel Road
- Gravel Road
- ATV Track
- Index Contour
- Intermediate Contour

HALLIBURTON

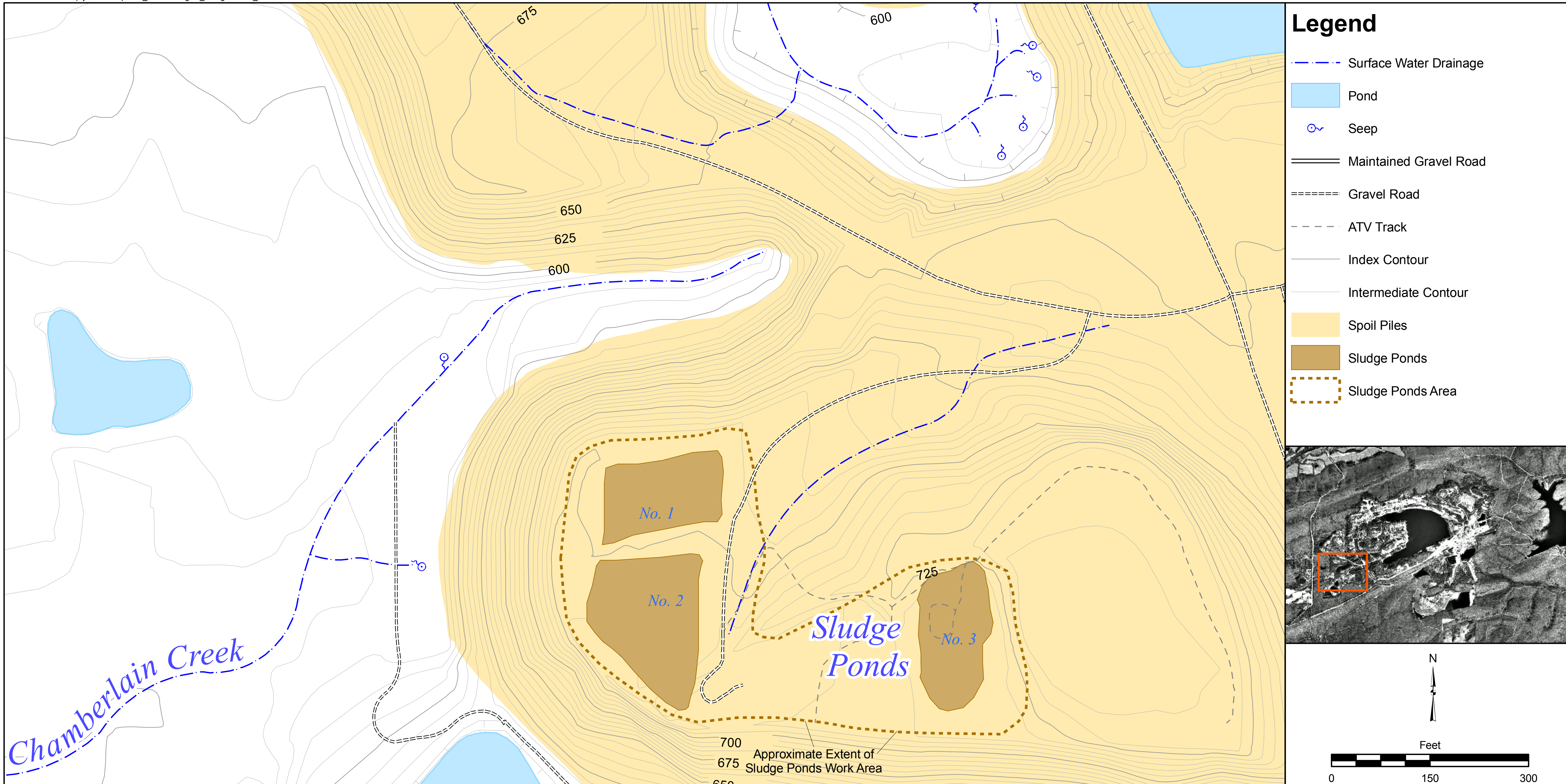
DRESSER INDUSTRIES - MAGCOBAR MINE SITE

Figure B-4

LOCATION OF
ALTERNATIVE SGW3 -
EXPANDED CAPTURE/
TREATMENT SYSTEM

PRJ: 0133-006-900-20	Jul 13, 2009
REV: 0	BY: CRL / CHECKED: FLC

NEWFIELDS



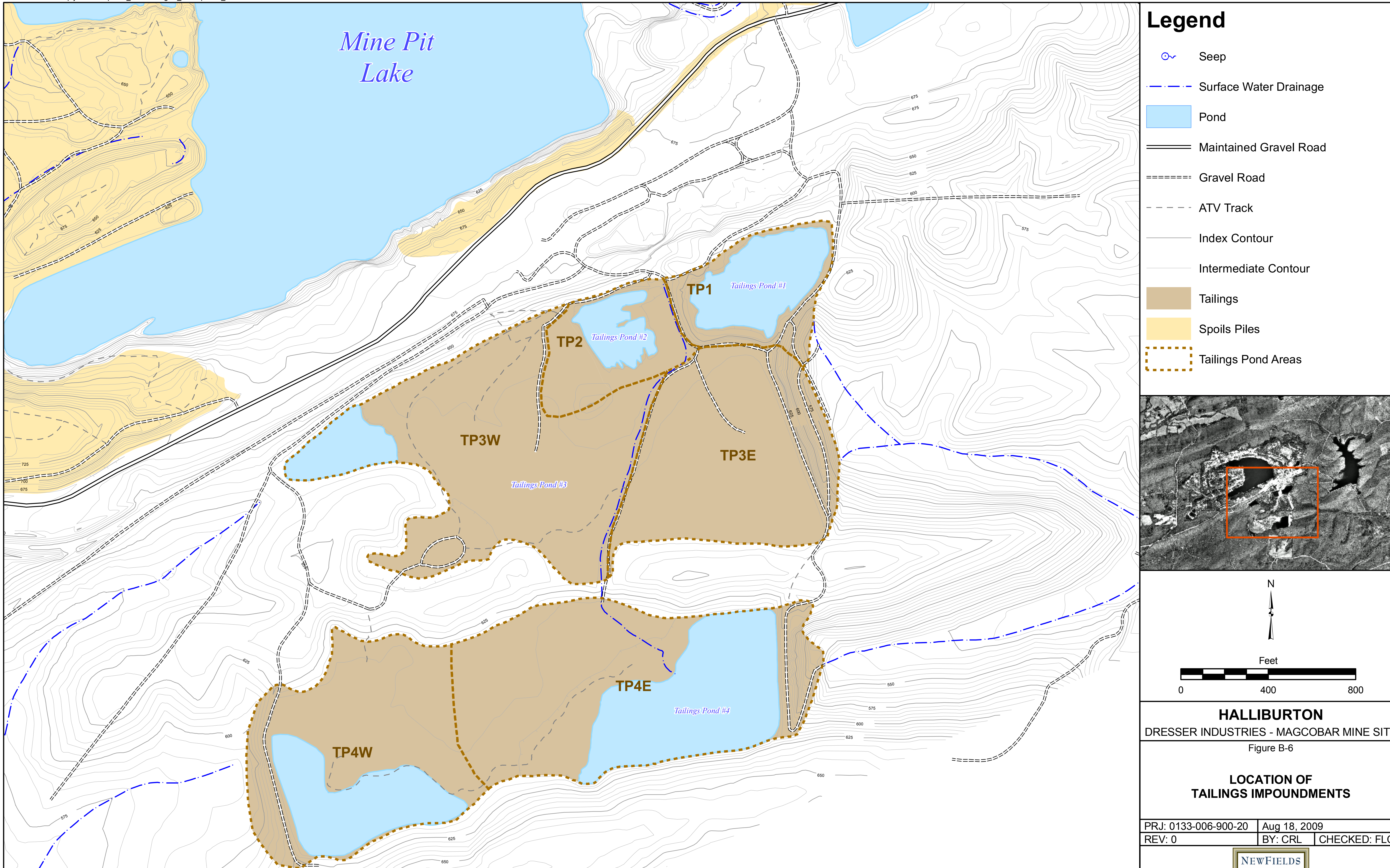
HALLIBURTON
DRESSER INDUSTRIES - MAGCOBAR MINE SITE

Figure B-5
LOCATION OF SLUDGE PONDS - SOIL COVER AND REVEGETATE, ALTERNATIVE SLU2

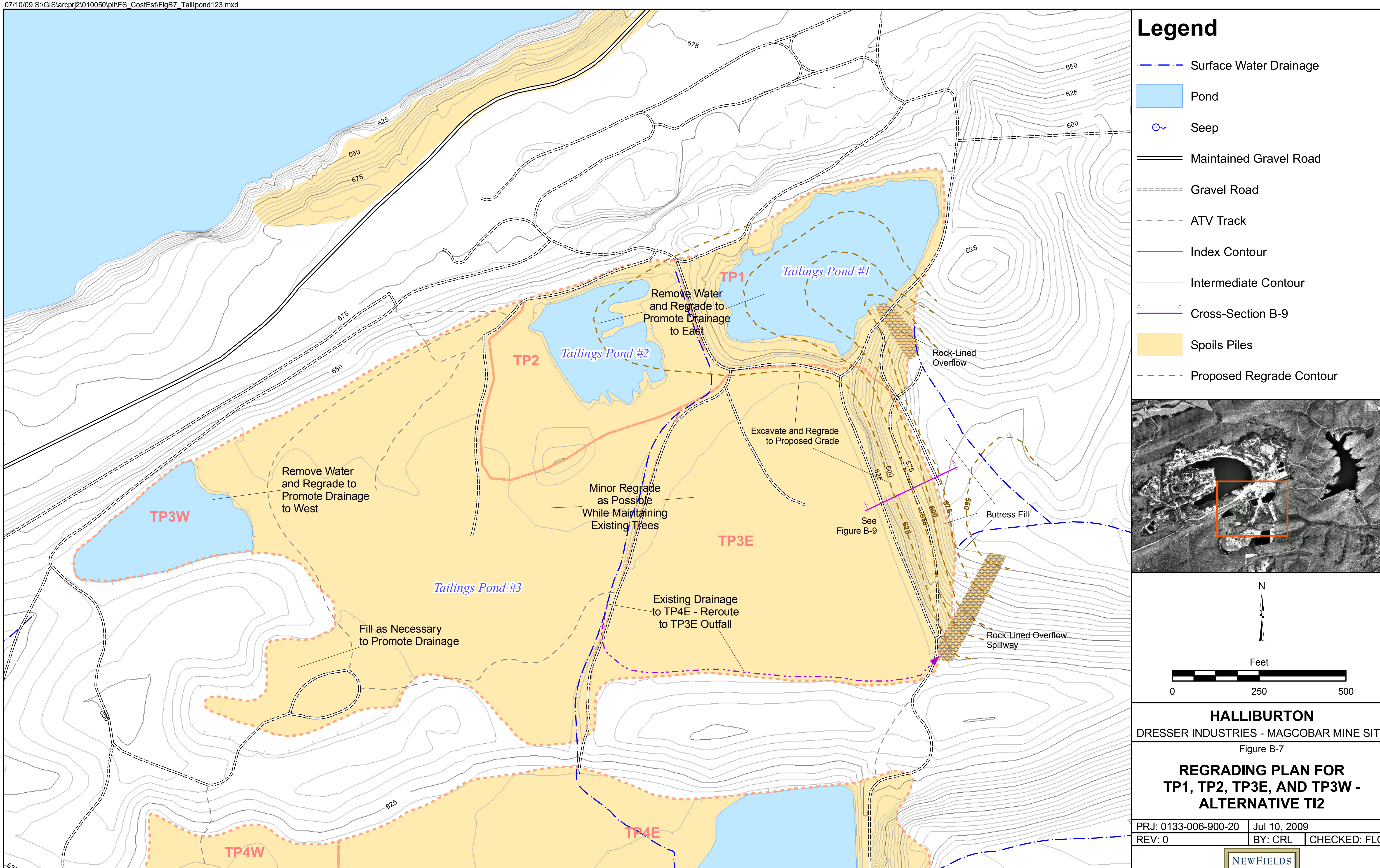
PRJ: 0133-006-900-20	Jul 10, 2009
REV: 0	BY: CRL / CHECKED: FLC

NEWFIELDS

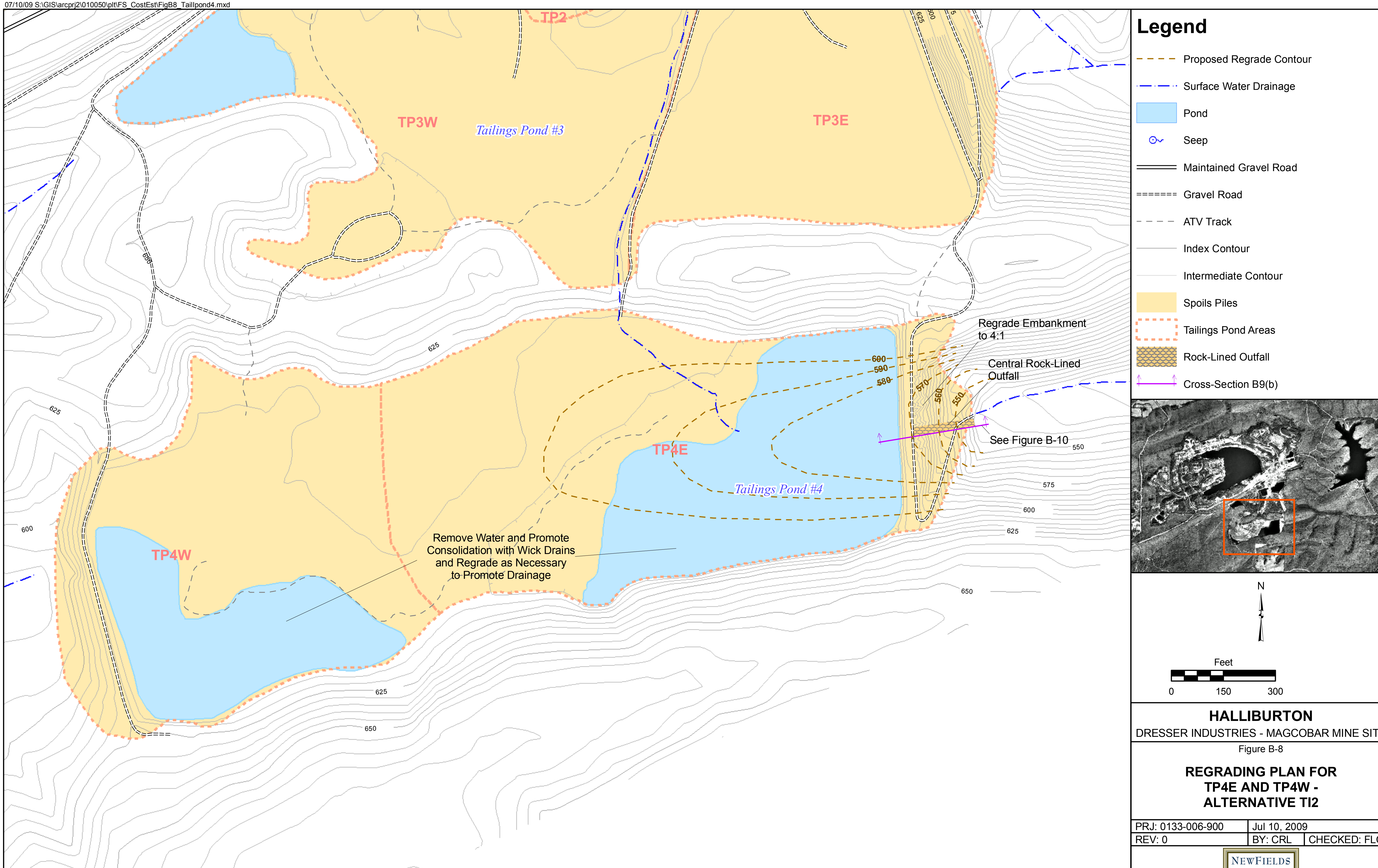
08/18/09 S:\GIS\arcprj2\010050\plt\FS_CostEst\FigB6_TailImpound_TI2.mxd



07/10/09 S:\GIS\arcprj2\010050\plt\FS_CostEst\FigB7_Taillpond123.mxd



07/10/09 S:\GIS\arcprj2\010050\plt\FS_CostEst\FigB8_Tailpond4.mxd



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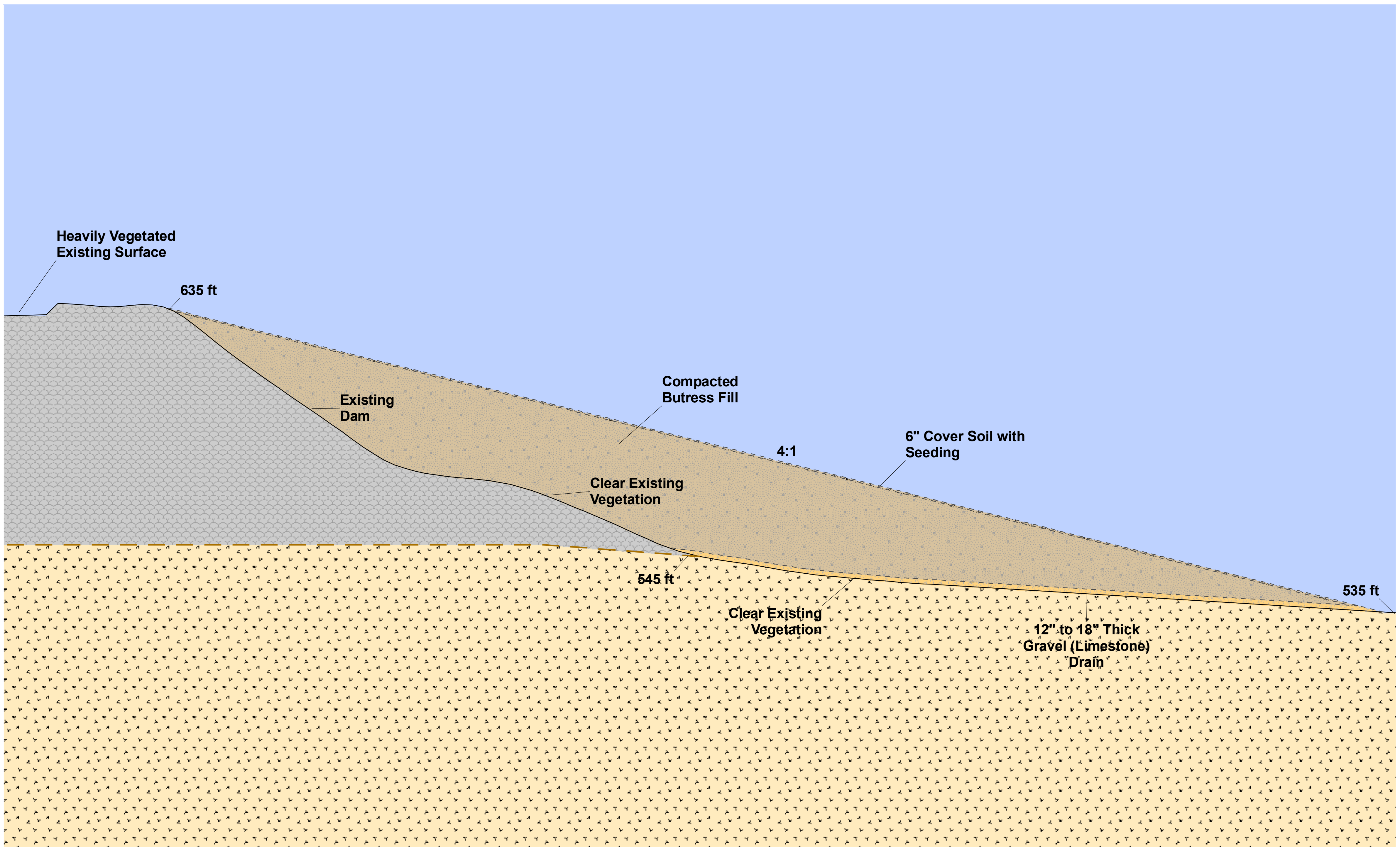
DRESSER INDUSTRIES - MAGCOBAR MINE SITE

Figure B-8

REGRADING PLAN FOR TP4E AND TP4W - ALTERNATIVE TI2

PRJ: 0133-006-900	Jul 10, 2009	
REV: 0	BY: CRL	CHECKED: FLC

NEWFIELDS



Legend

- New Surface
- Existing Surface
- Unknown Pre-Mine Surface
- Tailings
- Compacted Butress Fill
- Gravel Drain
- Native Material

N

Feet

0 35 70

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DRESSER INDUSTRIES - MAGCOBAR MINE SITE

FIGURE B9

TYPICAL CROSS-SECTION TP3E BUTTRESS - ALTERNATIVE TI2

PRJ: 0133-006-900-20	Jul 10, 2009	
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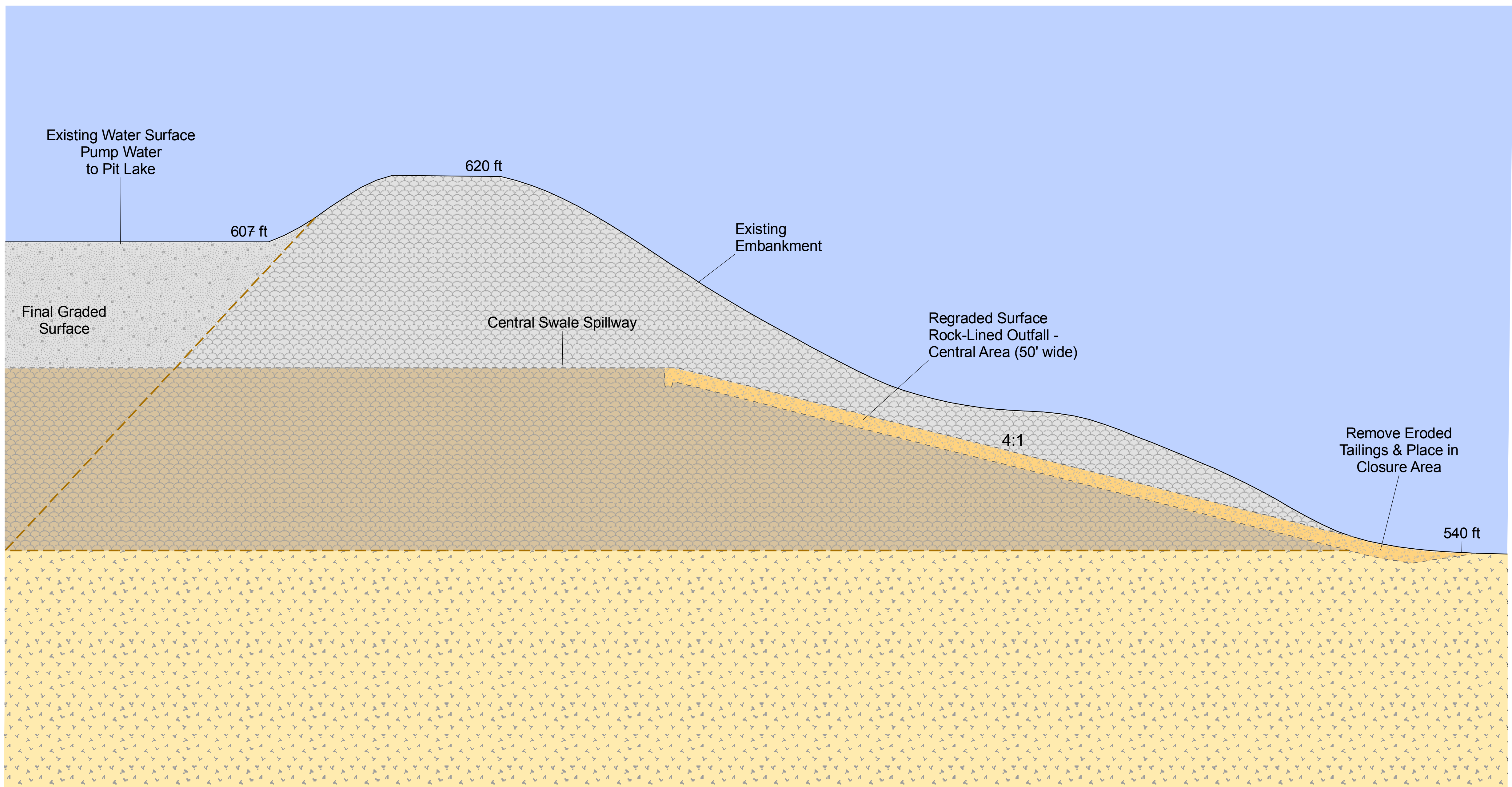
NEWFIELDS

07/10/09 S:\GIS\arcprj2\010050\plt\FS_CostEst\FigB10_CrossSection.mxd



Legend

- Existing Surface
- New Surface
- Unknown Previous Surface
- Tailings to be Regraded
- Slimes
- Rock Outfall
- Tailings Left in Place
- Native Material

N

Feet
0 25 50

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DRESSER INDUSTRIES - MAGCOBAR MINE SITE
FIGURE B10

TYPICAL CROSS-SECTION TP4E - ALTERNATIVE TI2

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NEWFIELDS