Report
Volume 1 of 3

Removal Action Options Analysis
Colorado School of Mines Research Institute
Golden, Colorado

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U.S. Environmental Protection Agency
Region VIII
Denver, Colorado

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Removal Action Options Analysis
Colorado School of Mines Research Institute
Golden, Colorado

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Removal Action Options Analysis
Colorado School of Mines Research Institute
Golden, Colorado

Executive Summary

Introduction, Site Description, and Site History

This report is prepared in compliance with the Unilateral Administrative Order (UAO), Docket No. CERCLA - VIII - 95 - 06, which was issued by the Environmental Protection Agency (EPA) effective on December 22, 1994. Some of the respondents listed in the UAO did not participate in the preparation of this report. A listing of the respondents and those that did participate is provided at the end of this Executive Summary. This report is prepared consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

The Colorado School of Mines Research Institute site is located on the west side of the City of Golden, Jefferson County, Colorado. The site is directly south of Clear Creek approximately one-half mile east of the intersection of U.S. Highway 6 and State Highway 58.

From 1912 to 1985, a wide variety of mining related research was conducted at the site. Research activities included developing and improving processes for recovering of natural resources from ore, including copper, nickel, silver, lead, uranium and others. During the period of operation private companies and the federal government also sponsored or conducted research at the site. Several buildings and research facilities were constructed and operated, and activities eventually caused contamination of many of the buildings and surrounding soils. Radiological contamination of the site was the result of work conducted on ores; there is no indication that any other radiological work was performed at the site.

On January 25, 1992, a City of Golden water main on the site broke and began discharging a large volume of water onto a historic tailings pond. The pond contained sediment and soils which were radiological and heavy metals contaminated due to past research activities. The EPA's Emergency Response Branch responded and performed a number of activities to stabilize conditions at the site. The most important potential risk was the treat that the pond would break and release the contamination into Clear Creek. There are a number of downstream users of Clear Creek water.

EPA's activities at the site included:

- excavation of the contaminated sediments and soil and stockpiling of the material on-site but away from Clear Creek
- decontamination of building drains
- consolidation of existing drums of waste which had been stored at the site
- disposal of compressed gas cylinders
- sampling of sediments and water

Since the EPA considers the stockpiled sediments and soils remaining as a long-term risk to human health, EPA wants the long-term risks associated with ingestion and inhalation of contaminants in the soils addressed.

EPA contacted many of the companies who sent materials to the site, the Federal Bureau of Mines, the Colorado School of Mines and CSMRI, and requested that the site be cleaned up. This culminated in the issuance of the UAO effective December 22, 1994.

The UAO requires the respondents to evaluate disposal options for the approximately 20,000 cubic yards of contaminated stockpiled soil and ultimately implement the selected disposal alternative. The respondents through this Removal Action Options Analysis report have identified, evaluated, and recommended to EPA the preferred disposal option for this site. The final decision for the selected alternative for disposal of the contaminated stockpiled soil will be made by EPA after considering public comment.

Summary of the Findings Presented in the Removal Action Options Analysis

Additional sampling of the contaminated stockpiled soil was conducted in early 1995. The objective of the sampling was to confirm previous sampling conducted by EPA and to obtain enough data to perform a regulatory evaluation of the soil and to evaluated various options for disposal. The results of the sampling (Section 2.3) and a review of the operational history of the CSMRI site were then used to determine the appropriate regulatory classifications of the stockpiled soil (Section 2.5). The results of the evaluation indicate that the stockpiled soil can be classified and disposed of a "special solid waste" as defined under Colorado Solid Waste Regulations. Both on-site and off-site disposal options were evaluated consistent with EPA guidance for performing Engineering Evaluation/Cost Analysis (EE/CA).

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The no action/institutional controls alternative was evaluated to provide a baseline against which to compare other alternatives. In addition, the following disposal option alternatives were evaluated and compared:

- Two on-site alternatives were evaluated (disposal of the stockpile at its current location);
- Two nearby off-site alternatives were evaluated (disposal in an engineered disposal cell located below the Colorado School of Mines baseball field or the adjacent practice field) and;
- Five off-site alternatives, which would involve excavation, transportation, and disposal of the contaminated soil outside of the City of Golden, were evaluated.

The recommended removal action disposal alternative for the contaminated stockpile soil is Alternative 4C - Off-Site Disposal at an Approved Solid Waste Disposal Facility. This preferred alternative was selected because it provides a high overall protection of human health and the environment, complies with the legally applicable or relevant and appropriate requirements for the site, has low short-term risks during implementation, provides a permanent solution, is cost effective and is expected to have community acceptance.

All of the off-site disposal alternatives provide adequate protection of human health and the environment, but are either more costly and/or likely to have lower community acceptance than the preferred alternative. The on-site disposal options were not selected because it is not known at this time if they are fully protective of human health and the environment and may not comply with the applicable or relevant and appropriate requirement for the site. The detailed reasons for selecting Alternative 4C - Off-Site Disposal at an Approved Solid Waste Disposal Facility as the preferred alternative is provided in Chapters 5.0 and 6.0 of the report.

This report is a consensus document, jointly submitted to the EPA by a large number of respondents who received the above referenced UAO requiring its submission. While each individual respondent adopts and supports the conclusions in this report, individual respondents reserve the right to disagree with specific statements made in the report.

The UAO was issued to the following entities: ASARCO Incorporated; Bear Creek Mining; the State of Colorado; Colorado School of Mines; Colorado School of Mines Research Institute (CSMRI), Cotter Corporation; Cyprus Amax Mineral Company; El Paso Natural Gas Company;

EXXON Corporation; Inspiration Consolidated Copper Company; Kennecott Corporation; NL Industries, Inc; Phelps Dodge Corporation; QMC Mining Corporation; Terra Industries, Inc.; Texas Gulf; Western Nuclear [collectively referred to as the respondents]. The report was prepared and is being submitted by the following respondents:

ASARCO Incorporated
The State of Colorado
Colorado School of Mines
Colorado School of Mines Research Institute
Cotter Corporation
Cyprus Amax Minerals Corporation
El Paso Natural Gas Company
Exxon Coal and Minerals (a division of Exxon Corporation)
Inspiration Consolidated Copper Company
Kennecott Corporation on its own behalf and on behalf of
    Kennecott Utah Copper Corporation
NL Industries, Inc.
Elf Aquitaine, Inc. on behalf of Texasgulf Inc. and
    Texasgulf Minerals and Metals, Inc.
Phelps Dodge on its own behalf and on behalf of Western Nuclear, Inc.

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Removal Action Options Analysis
Colorado School of Mines Research Institute
Golden, Colorado

1.0 Introduction

This report provides the results of the removal action options analyses (RAOA) performed for approximately 20,000 cubic yards of stockpiled soil (stockpile) at the Colorado School of Mines Research Institute (CSMRI) site in Golden and unincorporated Jefferson County, Colorado (Figure 1-1). The stockpile is the subject of a Removal Action (RA) being performed under a Unilateral Administrative Order (UAO) issued to a number of respondents (respondents) with an effective date of December 22, 1994. The Statement of Work (SOW) attached to the UAO requires a detailed analysis of off-site RA options for the stockpile. This report provides, consistent with the National Contingency Plan (NCP), the results of the RAOA for the off-site as well as the on-site RA alternatives in order to provide a more complete set of disposal alternatives for the stockpile.

The analysis has been performed in general conformance with EPA's Engineering Evaluation and Costs Analysis (EE/CA) guidance for Non-Time Critical Removal Actions and is in compliance with CERCLA, 42 U.S.C. § 9601 et. seq., and the provisions of the National Contingency Plan set forth in 40 CFR 300. The broad categories of information that are provided in this report include the following:

- Site characterization information including the site description and background, the nature and extent of the contamination associated with the stockpile, results of analytical data obtained during the study, and the results of risk assessments performed for each RA alternative.
- Identification of RA objectives including location-specific, chemical-specific, and action-specific applicable or relevant and appropriate requirements (ARARs).
- Identification and analysis of the RA alternatives including detailed descriptions and analyses of each alternative with respect to effectiveness, implementability, and cost.
- Comparative analysis of RA alternatives including evaluations of the relative performance of each alternative in relation to each of the criteria, identification of advantages and disadvantages for each alternative, and key tradeoffs which would effect remedy selection.
- Identification of the preferred alternative(s) that best satisfies the evaluation criteria based on the comparative analysis.

In accordance with the EE/CA guidance, existing information has been utilized to the extent practical in order to meet the demanding project schedules. Supplemental information has been developed during the study to augment and verify the existing data as appropriate so that an objective engineering evaluation of the disposal options and costs could be performed.

The following removal action (RA) alternatives have been developed to abate the potential health hazard presented by the stockpile:

Alternative 1 - No Action/Institutional Controls

Alternative 2 - On-Site Options

- Alternative 2A - In-Place Closure - This alternative leaves the stockpile in the same location and includes an in-place closure with a capping system and a subsurface vertical barrier to prevent contamination of groundwater.

- Alternative 2B - Above-Ground Repository - This alternative includes the development of an engineered repository at the current stockpile location that has both a bottom liner system and a top capping system.

Alternative 3 - Nearby Off-Site Options

- Alternative 3A - Below-Ground Repository - This alternative includes the development of a below-grade engineered repository in the baseball field just east of the stockpile or alternatively in the western-most practice field just southeast of the stockpile.

- Alternative 3B - Below-Ground Repository with Waste Stabilization/Solidification - This alternative includes the development of a below-grade engineered repository in the baseball field just east of the stockpile or alternatively in the western-most practice field just southeast of the stockpile. It also includes treatment of the waste prior to placement using a mixture of cement and fly ash for stabilization/ solidification (S/S) to reduce toxicity and mobility of the contaminants.

Alternative 4 - Off-Site Commercial Disposal Facility Options

- Alternative 4A - Envirocare of Utah, Inc. - This alternative includes the removal of the stockpile from its current location, transportation of the waste on public roads and/or railroads, and disposal at this licensed facility in Clive, Utah.

- Alternative 4B - Umetco Minerals Corporation - This alternative includes the removal of the stockpile from its current location, transportation of the waste on public roads, and disposal at this licensed facility in Uravan, Colorado.

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- Alternative 4C - Solid Waste Landfills - This alternative includes the removal of the stockpile from its current location, transportation of the waste on public roads, and disposal as a special solid waste at licensed facilities in Colorado.

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2.0 Site Characterization

This chapter provides the following background information regarding the CSMRI site and the stockpile, which was used in the selection and evaluation of the RA alternatives:

- Site description and background information including location, history, topography and utilities, hydrology, geology, surface water and groundwater uses, surrounding land use and populations, sensitive ecosystems, and meteorology.
- Nature and extent of the contamination as set forth in the Final Risk Assessment for the CSMRI Waste Pile prepared by Ecology and Environment, Inc. (E&E) for EPA (Final Risk Assessment).
- Analytical data developed during the RAOA including the results of the stockpile characterization, treatability study, and subsurface investigation activities.
- Results of the risk assessments for the various RA alternatives under consideration.
- Results of the regulatory classification evaluation of the stockpile materials.

2.1 Site Description and Background

2.1.1 Location

The CSMRI site is located on the south side of Clear Creek in the northeast quarter of the northwest quarter of Section 33, Township 3 South, Range 70 West as shown in Figure 1-1. The "site" is currently defined by EPA as the boundary shown in Figure 2-1A. Under CERCLA and the NCP, 40 CFR Parts 300.5 and 300.400(e), the term "on-site" is defined as the areal extent of contamination and all suitable areas in proximity to the contamination necessary for implementation of the response action. Consequently, the "site" boundary may be modified or expanded.

The stockpile was created during the RA conducted by EPA in 1992 at the CSMRI site which resulted in the transfer of tailings, related embankment materials, and adjacent soils and debris from the former impoundment area and vicinity to the location shown in Figure 1-1. The stockpile is currently located immediately west of the baseball field and northwest of the western-most practice field on the CSM property (Figure 2-1B). The majority of the CSMRI site is within the limits of the city of Golden, Colorado. However, the western part of the baseball field and the stockpile itself are located in unincorporated Jefferson County as shown in Figure 2-1B.

2.1.2 History

Mining-related research and development (R&D) operations commenced on the CSMRI site in 1912. The R&D projects involved mineral extraction and beneficiation activities that ranged from small-scale laboratory testing to operation of pilot-scale plants. The U.S. Bureau of Mines conducted experiments with radioactive materials at the CSMRI site during its early years of operation. In 1949, the Colorado School of Mines Research Foundation was established as a private non-profit corporation on the site of the original experimental plant. Later renamed CSMRI, the facilities expanded to a total of 17 buildings. During the 1980's, the CSMRI facilities were closed due to lack of business.

As an enhancement to the R&D activities, an impoundment was constructed between the CSMRI building complex and Clear Creek to hold process wastewater generated in the laboratories and pilot plants. Waste discharged from the buildings entered the impoundment by a system of sumps and drains in the buildings.

On January 25, 1992, a municipal water main ruptured beneath a building on the CSMRI site and resulted in the release of large amounts of water into the impoundment. The surge of water threatened overtopping of the impoundment and the release of water and sediments into Clear Creek. EPA responded to this event by initiating a RA under CERCLA. Damage to the impoundment was temporarily repaired and sampling of Clear Creek, the impoundment area, and the CSMRI buildings was performed by EPA. During the summer of 1992, EPA washed the buildings and drained the water into the impoundment. Impoundment liquids were pumped into frac tanks, treated, and later discharged to the sanitary sewer system. EPA excavated 15,000 to 20,000 cubic yards of impoundment sediment, soil, and debris from the embankments in the immediate vicinity and stockpiled it in the current location.

2.1.3 <u>Topography and Utilities</u>

The stockpile is approximately 35 feet high and covers an area of approximately 1.4 acres as shown in plan view on Figure 2-2. Stockpile sideslopes are approximately 5 horizontal to 1 vertical on the south side and 1 horizontal to 1 vertical on the east, north, and west sides. The stockpile sits on a 1-foot thick clay liner that was constructed by EPA during the initial removal action to control leachate migration. Surface water runoff is contained within a berm surrounding the stockpile and a 6-foot chain link fence around the perimeter restricts access to the waste. Vegetation on the stockpile consists primarily of weeds. There are no buildings in the vicinity of the stockpile.

Utilities in the area of the stockpile include power and water supply lines (Figure 2-1B). Public Service has a power line located between U.S. Highway 6 and the stockpile with the closest pole approximately 50 feet south of the south fence line surrounding the stockpile. A 16-inch, high pressure water main, owned by the City of Golden, passes directly under a portion of the stockpile. The City also has a 10-inch water main crossing east of the baseball field and across the practice fields (Figure 2-1B).

2.1.4 Surface Water Hydrology

The northern edge of the stockpile is located 160 feet south of Clear Creek, the primary surface water conveyance in the area. Clear Creek is a perennial tributary of the South Platte River with a drainage basin area above the site of approximately 400 square miles. The upper reaches of the drainage basin, west of the City of Golden, are typically very steep. East of Golden, Clear Creek flows through the plains for 14 miles to its confluence with the South Platte River in Denver, Colorado.

Discharge information for flood analysis of Clear Creek was developed by Gingery and Associates, Inc. (1979). Peak flows calculated for the reach of Clear Creek up to the western edge of the City of Golden are listed below:

Return Period	Peak Flow (cfs)
10-year	3300
50-year	8000
100-year	12500
500-year	25000

In the vicinity of the stockpile, the 100-year flood elevation is 5,688 feet (see Apppendix A). Based on work summarized in Advanced Sciences, Inc. (1989), the 500-year flood level is about 5 feet higher than the 100-year elevation or about 5,693 feet. The elevation at the lowest point of the stockpile is approximately 5,724 feet which is 36 feet above the 100-year flood level and 29 feet above the 500-year flood level.

Chimney Gulch is a small drainage that passes approximately 100 feet west of the stockpile (Figures 1-1 and 2-1B). Chimney Gulch is a tributary of Clear Creek with a drainage basin of approximately 482 acres. This tributary's headwaters begin on Lookout Mountain and its confluence with Clear Creek is approximately 160 feet north of the stockpile. During most of the year, Chimney Gulch is dry. However, when the Welch Ditch is being used, excess water in the ditch is routinely drained into Chimney Gulch and thus back into Clear Creek.

2.1.5 Geology

The CSMRI site is located in the foothills of the Front Range of the Rocky Mountains. The Front Range is a complexly faulted anticlinal arch of primarily Precambrian crystalline rocks which reach elevations of over 14,000 feet. The foothills consist of steeply dipping to flat-lying younger sedimentary and igneous rocks along the eastern flank of the Front Range. The Golden fault, a high-angle reverse fault, is present along the eastern edge of the foothills (Figure 2-3).

2.1.5.1 Bedrock Structure

Figure 2-3 is a Surficial/Bedrock Geologic Map of the area showing the stockpile location and surrounding features. A geologic cross section in the approximate area of the site was developed by Weimer (1976). Weimer's cross section is presented in Figure 2-4 and shows that the geologic strata are overturned and steeply dipping. Measurements of the strike of the beds in the claypits area show a North 37° West trend with dips ranging from about 70° to 80° to the west (James L. Grant & Associates, Inc., April 1990). Further east the beds become vertical and then east dipping. As shown in Figures 2-3 and 2-4, the stockpile is currently located in the Pierre Shale unit, a sequence that is at least 2,000 feet thick at this location.

As is evident on Figure 2-3, the Golden fault cuts through the area just west of the stockpile. Van Horn (1976) characterizes the fault as a moderately to steeply west-dipping reverse fault of large displacement. This fault was extensively evaluated as part of investigations at the Rocky Flats Plant to the north. As a result of these evaluations (summarized in Appendix B) the Golden fault is not an active fault, i.e., movement has not occurred in the past 35,000 years and multiple movements have not occurred in the past 500,000 years.

2.1.5.2 Bedrock Stratigraphy

The stratigraphic units present in Figure 2-3 are described below in order of decreasing age, oldest to youngest. These summaries are primarily from Van Horn (1976), Weimer (1976), and Van Horn (1995, personal communication).

Precambrian (pC) - These metamorphic rocks are resistant but mostly covered by colluvium west of the stockpile and form the eastern-most slopes of the Front Range. Although outcrops are present, individual units are generally difficult to follow for any distance. In this area, these rocks are believed to be overlain with angular unconformity by the Fountain Formation.

Fountain Formation (PPf) - This sedimentary unit is not exposed in the immediate vicinity of the stockpile but is believed to be present on the west side of the Golden fault under the alluvial fan materials shown in Figure 2-3. The Fountain is a pink to reddish-orange, coarse- to fine-grained, arkosic conglomeratic sandstone and conglomerate interbedded with lenticular, dark-reddish-brown, silty, indurated mudstone and pinkish-gray, fine-grained, quartzose sandstone.

Pierre Shale (Kp) - The Pierre Shale is also not exposed in the immediate vicinity of the stockpile. Elsewhere on the CSM properties, Weimer (1976) characterized the unit as consisting of dark gray shale with minor, thin laminae of tan-weathered limonitic siltstone and silty, very fine-grained sandstone. This unit underlies the stockpile and the area immediately to the east (baseball field and western-most practice field). It also extends under much of the CSMRI complex including part of the parking area. As mentioned above, the Pierre Shale is at least 2,000 feet thick beneath the stockpile site.

Fox Hills Sandstone (Kfh) - In the immediate vicinity, exposures of the Fox Hills are limited because of localized faulting. Where exposed, the sandstone is tan to yellow, fine-grained, subrounded, friable, calcareous sandstone with thin beds or laminae of siltstone and gray montmorillonitic claystone. The exposed thickness of the Fox Hills near 12th Street (Figure 2-3) is about 40 feet; however, the exact thickness is questionable because of faulting and could be as much as 75 feet (Weimer 1976). As shown in Figure 2-3, the Fox Hills underlies a part of the eastern-most practice field and some of the CSMRI buildings and parking area. The outcrop of this formation is approximately 800 feet east of the current stockpile toe.

Laramie Formation (Kl) - The Laramie is well exposed in a clay excavation south of 12th Street. The thickness of the Laramie is about 350 feet and the formation is subdivided into two stratigraphic units. The lower unit (western-most unit) is about 190 feet thick near 12th Street and consists of four major sandstones which alternate with mineable kaolinitic claystone. The thickness of the individual sandstones and claystones varies from 20 to 40 feet. The sandstones are light gray to buff, fine-to coarse-grained, poorly sorted, subangular, and silty. The kaolinitic claystone units contain light- to medium-gray, blocky weathering claystone with lesser amounts of dark gray to black carbonaceous claystone and thin coal streaks. Additionally, the lower Laramie contains a mineable coal seam. A monument over the Old White Ash coal mine is located at the west end of 12th Street. The surface trace of the main worked seam is located to the east of the monument and is 8 feet thick; a second mined and seam, 10 to 20 feet to the west of the primary seam, is 3 feet thick (Emmons, et. al., 1896). These seams were mined to a distance of about one mile north of Clear Creek and several hundred feet south of 12th Street. The surface trace of the coal mine is presented in Figure 2-3.

The upper Laramie is about 160 feet thick and is similar in lithology to the lower Laramie, except that the sandstones are much thinner and finer grained. Neither coal nor carbonaceous shale is associated with the upper Laramie claystone. As is evident from Figure 2-3, the Laramie underlies the western half of Brooks Field and the former CSMRI impoundment.

Arapahoe Formation (Ka) - The Arapahoe overlies the Laramie to the east and is 300 to 500 feet thick. It is composed of discontinuous beds of sandstone and claystone. The exposure in the claypits south of Brooks Field show the lower Arapahoe is predominantly a conglomerate and conglomeratic sandstone with minor intercalations of gray claystone and siltstone. The upper Arapahoe is not exposed in the immediate area. As is evident in Figure 2-3, the Arapahoe underlies the eastern half of Brooks Field.

Denver Formation (TKdv) - To the east of the Arapahoe lies the Denver Formation which is not exposed in the immediate vicinity. The Denver consists of light-gray to brown tuffaceous silty claystone, tuffaceous arkose, and andesitic conglomerate. The base is marked by the first appearance of volcanic material.

2.1.5.3 Geologic Characteristics of the Surficial Deposits

The surficial deposits that overlie the bedrock in the area covered by Figure 2-3 include the following (the order presented below does not show the age relationship):

- Louviers Alluvium
- Younger Alluvial Fan
- Colluvium
- Post-Piney Creek Alluvium
- Artificial Fill

More information, e.g., thickness on these surficial deposits can be found in Appendix C.

Louviers Alluvium (Qlo) - The Louviers forms a well defined terrace in the Clear Creek valley and is the oldest of the alluvial deposits present in the area shown in Figure 2-3. The deposit is typically a coarse cobbly sand and gravel that is poorly sorted. Generally, there is less than 10 percent silt and clay present. Just east of the area shown in Figure 2-3, the Louviers has subround to round pebbles and cobbles of granitic rocks. Boulders as large as one-foot across are present, but the common large size is 6 inches. Based on the subsurface work performed at this location

(Section 2.3.3), this unit is about 10 feet thick and extends south under the baseball and practice fields to the approximate location shown where it pinches out against the bedrock. The Louviers is overlain by younger alluvial fan, colluvium, and artificial fill deposits. Locally, the post-Piney Creek Alluvium overlies eroded Louviers deposits.

Younger Alluvial Fan (Qyf) - In the location shown in Figure 2-3, this unit is associated with the current Chimney Gulch drainage and overlies the Louviers. This deposit is believed to have formed before the deposition of the post-Piney Creek Alluvium. The materials present in the deposit associated with the Chimney Gulch drainage consist of a poorly-sorted, heterogeneous mixture ranging from boulders to clay. The upper few feet are clayey silt grading downward to coarser materials. The thickness of this unit varies but is expected to be as much as 40 feet in the area mapped in Figure 2-3.

Colluvium (Qco) - Colluvium consists of materials that have been moved down steep slopes by creep and sheet wash, and, at a few places, they represent minor alluvial fan deposits. The colluvial deposits grade into, and interfinger with, alluvial terrace deposits and the younger alluvial fan deposits. It is mostly a massive to crudely bedded sandy to clayey silt but locally either sand or clay can predominate. Colluvial deposits generally overlie very irregularly sloping bedrock surfaces. While this may be typical at many locations, they are known to overlie the Louviers deposits over a portion of the area covered in Figure 2-3 as discussed above.

Subsurface drilling activities were performed as part of the work described in Section 2.3.3. In the geotechnical boreholes, the colluvium was up to 48 feet thick and consisted of material that ranged from a light brown slightly sandy clay to a reddish-brown, fine, slightly clayey sand to a brown sand with some gravel. These differences reflect the origin of the colluvium. Potentially, the clay materials have been derived from the Pierre Shale; the reddish-brown sand from the Fountain Formation (present on the west side of the Golden fault); and the brown sand from the Fox Hills formation.

Post-Piney Creek Alluvium (Qpp) - This alluvial unit is present along the edge of Clear Creek, is relatively thin, and the youngest alluvial unit in the area mapped in Figure 2-3. It consists of coarse sand and gravel deposits.

Artificial Fill (af) - The artificial fills shown in Figure 2-3 were placed for highway construction and for enhancing the usable area of the athletic fields and the adjacent area where the stockpile is located. The fills in the athletic fields are tan to brown clay, medium to stiff, silty, sandy, and slightly gravelly. Under the stockpile, the artificial fill consists of silty clay to clayey sand with some gravel and construction debris.

To assist in understanding the nature and extent of the artificial fills, a comparative analysis of the topographic changes that have occurred in the last several decades was performed using the 1939 topographic map and more recent topographic maps. This evaluation shows that the artificial fills in the baseball field and western-most practice field may be associated with excavations in the infield portions of the baseball field where up to 15 feet of soil have been removed to prepare the baseball field at its current elevation.

The topographic evaluation also shows that the channel of Chimney Gulch formerly may have been located about 130 feet east of its current location which would place the old channel beneath the stockpile. When coupled with the other topographic data, this information suggests that the volume of artificial fill underlying the stockpile could be significant (10,000 to 20,000 cubic yards).

2.1.5.4 Water-Bearing Units

In the area shown in Figure 2-3, groundwater is present in the following bedrock units: the Laramie/Fox Hills units, the Arapahoe, and some of the Denver. Groundwater is also present in the Louviers Alluvium and post-Piney Creek Alluvium. The Laramie/Fox Hills and the Arapahoe are important aquifers of regional significance and the Louviers Alluvium, post-Piney Creek Alluvium, and the Denver Formation can be locally significant. Regional studies by Robson (1983 and 1984) and Robson, et. al., (1981a and 1981b) indicate that the outcrop areas for these units in the area covered in Figure 2-3 are part of the recharge area. Recharge is primarily expected to occur from direct rainfall and snowmelt infiltration and by percolation from Clear Creek directly through the alluvium. Recharge to the alluvium also occurs from the bedrock units. Groundwater in the area of the baseball field is approximately 30 feet below the ground surface. In the practice field area groundwater averages about 54 feet below the ground surface. More detailed discussions of the subsurface conditions including groundwater are provided in Section 2.3.3.

2.1.6 Surface Water and Groundwater Uses

Surface water diverted from Clear Creek is primarily used for water supply and secondarily for recreation and irrigation purposes. Diversions present within approximately one mile of the stockpile are shown on Figure 2-5 and are discussed in the following sections.

2.1.6.1 Welch Ditch Diversion

This ditch originates just over one mile west (upstream) of the stockpile on the south side of Clear Creek. The Welch Ditch passes approximately 400 feet south of the south end of the stockpile. The water from the ditch is used for irrigation and there are no domestic uses from the ditch. The ditch is unlined and flows along the side of the hill above the stockpile to the east, through a tunnel and culverts in the vicinity of CSM student housing and the claypits. From here, it flows around the southern perimeter of Golden, along the north side of South Table Mountain above the Coors' brewery, and then to the east into the Federal Center.

2.1.6.2 Church Ditch/City of Golden Diversions

This ditch originates about 4,200 feet west (upstream) of the stockpile on the north side of Clear Creek. The major water users served by the Church Ditch include the Cities of Broomfield, Northglenn, Thornton, Westminster, and Arvada. Water is used for municipal purposes including drinking water. The City of Golden also diverts some of its municipal water at the Church Ditch headgate and that water is incorporated into the city's drinking water supply. Treatment facilities for Golden are located north of the stockpile across Clear Creek.

2.1.6.3 Agricultural Ditch Diversion

This diversion is located about 4,200 feet east (downstream) of the stockpile on the south side of Clear Creek. The Agricultural Ditch is the first surface water diversion downstream of the site. The major water users served by the Agricultural Ditch include a major municipal supplier to the Cities of Lakewood and Wheat Ridge. Some of the water is also used by Arvada, Golden, and unincorporated areas of Jefferson County. There are a number of other smaller industrial and agricultural users as well.

2.1.6.4 Farmers' Highline Canal and Ditch

This diversion is located about 4,700 feet east (downstream) of the stockpile on the north side of Clear Creek. The major water users served by the Farmers Highline diversion include the cities of Westminster, Thornton, Northglenn, and Arvada. Water is used for municipal purposes including drinking water. Coors and several small irrigation users also divert from the ditch.

2.1.6.5 Groundwater Uses

Groundwater wells, applications, and permits were identified for a one-mile radius around the stockpile from information provided by the Colorado Division of Water Resources. A copy of that information is included in Appendix D. An evaluation of that information shows that there may be as many as 20 wells in use within a 1-mile radius of the stockpile. The identified uses include nine for industrial, 10 for domestic, and one for household purposes. Yields range from 1 gallon per minute to as much as 85 gallons per minute. The nearest wells are located on the north side of Clear Creek within 500 to 1,000 feet of the stockpile. The nearest well on the south side of Clear Creek is over 2,000 feet away. All of the 9 industrial use wells are owned by Coors and are to the northeast of the stockpile at distances in excess of about 2,000 feet in locations believed near Clear Creek. Water taken from the industrial use wells, as well as the domestic and household wells, may be used for drinking water purposes according to the Colorado Division of Water Resources use classification.

2.1.7 Surrounding Land Use and Populations

Land usage in the vicinity of the stockpile includes residential, commercial, and rangeland. A large portion of the surrounding area is owned by the CSM and has a variety of university-related uses including athletic fields, classrooms, recreational facilities, maintenance, and administration. Additionally, the City of Golden has offices and a water treatment plant on the north side of Clear Creek across from the site. The residential, commercial, municipal, and agricultural facilities and their distances from the stockpile as obtained by direct field reconnaissance and map measurements are as follows:

- West - Condominiums along Clear Creek are located about 1,000 feet west of the stockpile.
- South - A new housing area is being developed along Parfet Drive. The closest lot is 1,150 feet from the stockpile. The closest existing house in this direction is on Mount Zion Drive at about 1,600 feet.
- North - A public campground is located 250 feet from the stockpile on the north side of Clear Creek. The City of Golden's water treatment plant is 400 feet away. The City of Golden's offices are about 650 feet away. A restaurant is present about 1,100 feet away. An apartment building with approximately 40 units is 1,100 feet away. The nearest dairy is about 19,000 feet (3.6 miles) away. Some beef cattle are located about 11,500 feet (2.2 miles) to the north of the stockpile.
- East - The CSM baseball field and practice fields are within 100 feet of the edge of the stockpile. There are condominiums on the west side of Maple Drive at a distance of 1,600 feet. The closest house on 12th Street is about 1,450 feet from the stockpile. The closest CSM building is 1,650 feet to the east.

2.1.7.1 Local Population

In 1990, the population of the City of Golden was 13,116 based on the U.S. Census. The estimated populations of the City of Golden in the years 2000 and 2010 are 15,700 and 17,500, respectively (City of Golden et. al., 1990). The Golden city limits extend approximately 1.7 miles to the north of the site, 1.5 miles to the east of the site, and 3.2 miles south of the site.

2.1.7.2 National Historic Preservation Act Considerations

Potential historical and archeological resources were evaluated for impacts to the RA alternatives being considered. The Colorado Historical Society advised that no significant historical or archeological resources are known in the immediate vicinity of the stockpile. Additionally, the City of Golden's Planning Department also advised that there are no known historical or archeological resources that would impact the RA alternatives evaluation or selection process.

2.1.8 Sensitive Ecosystems

The ecosystem of the area surrounding Golden is a very diverse habitat influenced by a range in elevations that encompasses the plains, foothills, and mountains. The channelization of Clear Creek, construction of artificial ponds, grading projects, changes in vegetation, and other works of man have created new habitats by altering the natural habitat in the vicinity. Extensive residential development has also occurred over the years, and new development is continuing to the north and south of the CSMRI site.

The U.S. Fish and Wildlife Service was contacted to determine if sensitive ecosystems or species are present in the area. They indicated that a federally threatened plant species, the Ute Ladies'-Tresses Orchid (Spiranthes diluvialis) is present in the Clear Creek area in the vicinity of the site. Based on that information, a local botanical expert, recommended by the Fish and Wildlife Service, performed a survey of the area adjacent to the stockpile for potential habitat. The surveyed areas included Chimney Gulch below U.S. Highway 6 and a tributary of Chimney Gulch that runs parallel to U.S. Highway 6 on the north. The results of that survey showed that neither Chimney Gulch nor its tributary provide adequate habitat for Spiranthes diluvialis and that both drainage courses are in poor condition relative to natural habitats. A copy of the habitat survey report is provided in Appendix E.

2.1.9 Meteorology

Historical weather data has been collected and evaluated from three locations near the site. A station in Wheat Ridge collected meteorological data between 1981 and 1988. Data were collected at a station in Lakewood from 1962 through 1988. The Solar Energy Research Institute (SERI) operates a weather station on South Table Mountain near Golden and data are available from 1989 to the present. Wind direction information which is representative for the CSMRI site is available for a location about 3,500 feet to the west in Clear Creek Canyon (Figure 2-6) that was operated during the period May 1979 to March 1980.

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2.1.9.1 Precipitation

Average annual rainfall in the area ranges from 15.82 to 19.59 inches. About 70 to 80 percent of the total annual precipitation occurs between April and September due to moist air moving upslope and thunderstorm activity. The greatest amounts of precipitation typically occur in July and August when the average monthly totals exceed two inches. Precipitation minimums occur in January and February when the average monthly precipitation is generally less than one inch. Evaporation potential in the area exceeds the annual total precipitation. Total annual pan evaporation averages about 60 inches and total annual lake evaporation averages about 41 inches. Approximately 71 percent of the evaporation occurs between May and October.

2.1.9.2 Temperature

The average annual temperature ranges from 49.8 to 51.2 degrees Fahrenheit. The highest average monthly temperatures typically occur in July and August and range between 69.8 and 75.2 degrees Fahrenheit. In December and January, the lowest average monthly temperatures are generally observed and range between 30.4 and 35.6 degrees Fahrenheit.

2.1.9.3 Wind Direction and Speed

Average wind speed information collected from the three weather stations varied little from month to month. The data indicate, however, that maximum winds and wind gusts are higher in the winter than in the summer. Increased wind speeds in the winter are probably due to the passage of storm fronts causing strong downslope conditions. Average annual wind speed is about 7 miles per hour. The maximum hourly wind speeds observed at the SERI site range between 20 and 47 miles per hour.

Basically, there are two major meteorological conditions that determine the direction of air movements in the Golden area: (1) synoptic flows and (2) local flows. Synoptic flows are wind patterns that affect areas on the order of several thousands of square miles that are characterized by meteorological systems on the scale of high and low pressure systems as shown on weather maps. In the absence of a dominant synoptic flow, local flows become the prevalent factor in the air movement. These winds by and large follow the topography of an area with air flows draining from higher elevations toward the lower elevations.

The stockpile site area is in a unique location relative to wind direction that is best represented by the wind direction information from the meteorological monitoring location shown in Figure 2-6. The wind direction information from that location was evaluated and a wind rose developed for that data (Figure 2-7). The wind rose in Figure 2-7 shows the percentage of time that the wind blew from each of the 16 wind directions monitored. The wind was calm for only about 1.4 percent of the time during the measurement period. Based on a review of Figure 2-7, the predominant wind directions are from the west and east and reflective of drainage flows which are common along the Front Range. On an annual basis the wind actually blows from the west approximately 60 percent of the time and from the east approximately 35 percent of the time with minor excursions from the north and south. During much of the day, the wind pattern is typically from the east due to warming by the sun which creates an upslope flow along the Front Range. During the night, the cooler air flows down the mountain side across Golden and into the Denver Basin to the east. The night time flows can start early in the evening and persist into the midmorning and early afternoon.

2.2 Nature and Extent of Contamination

As part of stockpile characterization activities, E&E obtained 19 surface and subsurface soil samples from the stockpile in March 1993 using standard EPA sampling methodologies and quality assurance/quality control procedures. All samples obtained were analyzed for radionuclides using gamma spectroscopy and, in addition, six samples were analyzed for the full suite of Toxicity Characteristic Leaching Procedure (TCLP) analytes; base neutral and acid compounds (BNAs); volatile organic compounds; and total metals. Five of the six samples evaluated for the full analytical suite were composited from individual samples obtained at the surface and at depth (10 feet) in five separate test pits in the stockpile. Three of E&E's test pits (Test Pits 1, 2, and 8) were located in areas in which "tailings" materials were encountered at depths of 8 feet or less during the stockpile characterization activities performed during the RAOA. Therefore, E&E's composite samples (CSSP01, CSSP02, and CSSP08) obtained from these test pits are believed to be representative of the overall stockpile.

Summary data for those constituents identified as contaminants of concern (COCs) by EPA are provided in Table 2-1 and indicate that low levels of radioactivity, heavy metals, and residual chemicals are present in the CSMRI stockpile. The radioactivity in the stockpile is due to the presence of radionuclides from the Uranium-238 decay series with contributions from the Thorium-232 and Uranium-235 series. Trichloroethylene (TCE) and tetrachloroethylene (perchloroethylene or PCE) were present in total concentrations orders of magnitude below the TCLP leachability standards for disposal. None of the analytes in the TCLP leachate exceeded the regulatory levels indicating that the stockpile does not pose a threat through leaching of metals or organic materials. The EPA Final Risk Assessment has additional details regarding the sampling and analysis performed.

2.3 Analytical Data

The EPA data provided baseline information which was used to develop the sampling and analysis program implemented during the RAOA in accordance with the Final Sampling and Analysis Plan for the Removal Action Activities (SAP) approved on an "interim basis" by EPA on January 17, 1995. The objectives of the additional analytical data collection activities included the following:

- Obtain the necessary data to determine the regulatory classification of the waste for the purpose of determining eligibility of off-site disposal facilities.
- Further define the baseline chemical and physical characteristics of the waste,
- Estimate the volume of soil in the stockpile,
- Evaluate the materials underlying the stockpile,
- Evaluate the suitability of the waste for on-site (or nearby off-site) disposal with and without treatment by stabilization and solidification (S/S),
- Develop sufficient data to determine the suitability of the waste for the off-site disposal facilities under consideration,
- Determine the viability of physical waste volume reduction.

The additional data collection activities included (1) stockpile characterization work, (2) treatability study activities to evaluate the effects of S/S treatment on the mobility of the COCs, and (3) subsurface investigations of suitable on-site (or nearby off-site) repository locations for disposal of the stockpile.

Data validation activities were performed in accordance with the SAP. Appropriate qualifiers have been added to the data tables presented in this section. The data validation reports are provided in Appendix F.

2.3.1 Stockpile Characterization

The stockpile characterization, which will be discussed in detail in this section, consisted of the following activities:

- Excavating test pits and trenches within the stockpile,
- Estimating the volume of material in the stockpile,
- Sampling the stockpile,
- Developing and analyzing an overall composite stockpile sample,
- Performing supplemental sampling of the waste and underlying materials, and
- Performing waste volume reduction evaluations.

Additional information on these activities can be found in Appendix G.

2.3.1.1 Excavation of Test Pits/Trenches

Four test pits (TP-1 through TP-4) and 10 test trenches (TT-1 through TT-10) were excavated using a trackhoe in the locations shown on Figure 2-8. Based on the construction sequence for the stockpile, it was believed that the majority of the "tailings" material would be located at the bottom of the pile with a surface layer or "cover" material placed on top of the "tailings". Cover material consists of a mixture of embankment materials and adjacent soil and debris. The test pit/trench locations and depths were designed to evaluate both shallow and deep locations within the stockpile in order to define the general subsurface profile, delineate specific material types, and to determine the extent of the "tailings" material. Logs of the test pits and trenches are provided in Figures 2-9A, 2-9B, and 2-9C and show the overall depth of each test pit and trench as well as the depth(s) at which "tailings" and "cover" materials were encountered. In accordance with the SAP, each test trench was evaluated for the following parameters:

- Soil classification
- In-place bulk density (ASTM D 1556)

The results of the testing and visual classification activities indicate that the "cover" consists of a brown to reddish-brown, clayey sand that forms the surface layer on the entire stockpile. The clayey sand contained approximately three to four percent cobbles and approximately one percent debris consisting of plastic, glass, wood, pipes, tubes, concrete block, rebar, bricks, and other miscellaneous items. The "tailings", which were generally black in color with yellowish streaks, appeared in TP-2, TP-3, and TP-4 and in TT-8, TT-6, TT-4E, and TT-3. This material was encountered at depths from approximately two to nine feet below the surface. The "tailings" generally had a similar physical composition but typically contained less debris than the "cover" material. The surface of the clay liner was encountered at the bottoms of TP-2, TP-4, TT-4E, TT-8, and TT-10.

Ten sand cone tests (ASTM D1556) were conducted in the excavated test trenches to measure the in-place densities of the waste materials. The sand cone test locations and results are summarized in Table 2-2. The results indicate that the moisture content of the stockpile ranged between 2.8 and 13.7 percent and the dry density of the waste ranged between 75.5 and 115.3 pounds per cubic foot. These physical properties are important to evaluating and designing all of the remedial alternatives.

2.3.1.2 Stockpile Volume Estimates

The overall volume of the stockpile and the volumes of the "tailings", "cover", and "hot spot" material within the stockpile (described in Section 2.3.1.3) were estimated based on measured cross sections, visual observations, and direct measurements within the test pits and trenches. Using this data, the volume of the stockpile was estimated to be 19,500 cubic yards consisting of approximately 56 percent "cover" (10,900 cubic yards), 43 percent "tailings" (8,400 cubic yards), and less than 1 percent "hot spot" material (200 cubic yards). An AutoCAD drawing of the stockpile prepared by Merrick Architects and Engineers was obtained from E&E and used to independently calculate the volume of material in the stockpile and showed that approximately 20,000 cubic yards of material were present. There is approximately a 5,000 cubic yard discrepancy between the volume calculated by EPA (15,000 cubic yards) in March 1993 subsequent to the removal action and recent volume estimates. A volume estimate of 20,000 cubic yards will be used during the RAOA. However, in light of the discrepancies regarding the volume of the waste, a cost versus volume sensitivity analysis will be performed for the various RA options under consideration (Refer to Section 5.1.0).

2.3.1.3 Stockpile Sampling

Soil samples were obtained at approximately 10 lineal-foot intervals from the "tailings" (when present) and "cover" material within each test pit/trench. Each test trench was surveyed for gamma activity using a hand-held gamma scintillometer. Typical gamma activity levels on the stockpile ranged from 100 to 200 microRoentgens per hour. Samples were obtained from the two "hot" spots on the stockpile (TT-8 and TT-5 on Figure 2-8) which exhibited elevated gamma activity (approximately 400 microRoentgens per hour). There was no visible difference noted in the areas with elevated gamma activity. The individual sampling locations (66 total) are identified on Figure 2-8. Two 5-gallon pails of soil were obtained from each sampling location. One pail was used to develop composite samples and the other pail was archived for future use.

Individual samples of "tailings" and "cover" from each test pit or trench were composited separately by placing them on plastic sheeting within the bermed area and thoroughly mixing the resulting two stockpiles. Representative samples, one each of "tailings" and "cover" material from the stockpiles were obtained using mechanical splitters and/or coning and quartering techniques and were evaluated for the following parameters:

- Specific gravity (ASTM D 854 and C 127)
- Particle size distribution (ASTM D 422 and D 1140)

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- Standard Proctor (ASTM D 698)
- Atterberg limits (ASTM D 4318)
- Total arsenic (EPA SOW ILM 1.0 - Inorganics)
- Radium-226 (EPA 901.1 modified)

Additionally, a composite sample from the "hot spot" material was analyzed for Radium-226 and arsenic concentrations. The results of the physical and chemical analyses provided in Tables 2-3 and 2-4 were used to define a representative range for the physical properties as well as the Radium-226 and arsenic concentrations of the stockpile. Figure 2-10 shows grain size distribution curves for theses materials.

The results of the chemical analyses indicated that the Radium-226 concentrations in the "tailings", "cover", and "hot spot" materials were 26.8, 23.4, and 93.2 picocuries per gram, respectively (average of the sample and field duplicate). The arsenic concentrations in the "tailings", "cover", and "hot spot" materials were 169, 66, and 142 milligrams per kilogram, respectively (average of the sample and field duplicate). The representative Radium-226 and arsenic concentrations were 25.6 picocuries per gram and 111 milligrams per kilogram, respectively, which are consistent with the concentrations obtained during E&E's stockpile sampling activities.

Physical test results showed that the Atterberg limits index properties of the "cover" and "tailings" materials were essentially the same. The liquid limits were 29 and 30 percent; the plastic limits were 19 and 22 percent; the plasticity indices were 10 and 8 percent; and the weighted average specific gravity was 2.63 for both soil units. The maximum dry densities and optimum moisture contents were 119.0 and 114.0 pounds per cubic foot and 13.0 and 15.8 percent for the "cover" and "tailings" material, respectively.

2.3.1.4 <u>Developing the "Biased" Sample</u>

In order to help address community concerns regarding on-site or nearby off-site disposal of the waste, stockpile samples that were intentionally "biased" toward the high end of the contaminant concentrations were used in the evaluation of these options. It would have been difficult or impossible to locate materials within the stockpile with elevated levels of <u>all</u> of the COCs identified in the Final Risk Assessment. Therefore, representative samples of the overall stockpile were biased, to the extent practical, toward the upper end of the range of concentrations for Radium-226 and arsenic, the two primary COCs identified in the Final Risk Assessment.

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The average Radium-226 and arsenic concentrations for the stockpile (calculated using the analytical results and the volume estimates for the "cover", "tailings", and "hot spot" materials) are 25.6 picocuries per gram and 111 milligrams per kilogram, respectively. In an attempt to upwardly "bias" the concentrations of the Radium-226 and arsenic for use in the study, the "biased" sample was prepared using approximately 43 percent "tailings" material, 40 percent "cover", and 17 percent "hot spot " material on a volume basis. This is in contrast to the 43 percent "tailings", 56 percent "cover", and less than 1 percent "hot spot" material which would actually be representative of the waste (Section 2.3.1.2).

The expectation was that the resulting "biased" sample would have Radium-226 and arsenic concentrations of approximately 36 picocuries per gram and 122 milligrams per kilogram, respectively. The SAP established target concentrations of 40 to 70 picocuries per gram for Radium-226 and 90 to 150 milligrams per kilogram for arsenic in the "biased" sample. Due to the limited number and volume of "hot spots" in the stockpile and the fact that the arsenic concentrations in the "hot spot" material were lower than in the "tailings" material, it was not possible to achieve the target concentration range for Radium-226 by adding more "hot spot" material without reducing the concentration of arsenic in the "biased" sample. Therefore, based on the generally-accepted concept that the COCs would be concentrated in the finer-grained fractions within the waste, the sample was further "biased" by separating the top fraction of the waste (3/4-inch plus) prior to conducting the Treatability Study. Separation of the 3/4-inch plus fraction is also consistent with the physical waste volume reduction evaluations performed for the off-site disposal options.

2.3.1.5 <u>Analysis of the "Biased" Sample</u>

Composite samples of the 3/4-inch minus fraction from the "biased" sample were evaluated for the following physical and chemical characteristics:

- Specific gravity
- Particle size distribution
- Standard Proctor
- Atterberg limits
- Total arsenic, barium, cadmium, chromium, lead, manganese, nickel, silver, vanadium, reactive cyanide, total mercury
- Radium-226, Lead-210, Uranium-238, Uranium-235, Uranium-234, Thorium-232, Radium-228, and Thorium-230

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The results of the physical testing of the "biased" material (Figure 2-10) were essentially the same as the results obtained for the "cover" and "tailings" materials individually. The liquid and plastic limits of the materials were 32 percent and 22 percent, respectively; the plasticity index was 10 percent; the specific gravity was 2.69; and the maximum dry density and optimum moisture content were 116.0 pounds per cubic foot and 14.0 percent.

The results of the radionuclide analysis are summarized in Table 2-5 and include CEC's "biased" data, E&E's representative data (CSSP01, CSSP02, and CSSP08), and CEC's 3/4-inch plus data for comparison. The results indicate that low levels of radioactivity, primarily due to the presence of radionuclides from the Uranium-238 decay series with smaller contributions from the Thorium-232 and Uranium-235 series, are present within the stockpile. The ratio of Uranium-234 to Uranium-238 in the waste is approximately one indicating that the stockpile material has not been technologically-enhanced through enrichment or depletion of the Uranium-235 content. The Uranium-235 concentrations were generally a small fraction of the Uranium-238 concentration as would be expected in nature. The concentrations of the uranium and thorium isotopes in the Uranium-238 series are slightly lower than the concentrations of Radium-226 and other isotopes in the chain.

The results of the organic analysis performed by E&E on the representative samples are summarized in Table 2-6. As stated in E&E (August 1993), the acetone and bis(2-ethylhexyl)phthalate results are probably due to laboratory contaminants. Total TCE and PCE were present in concentrations substantially below the TCLP leachability standards for disposal. No organic constituents were detected in the TCLP leachate from any of the stockpile samples analyzed by E&E indicating that leaching of organic materials in the stockpile is not a concern.

The results of the inorganic analysis are summarized in Table 2-7 and include CEC's "biased" data and E&E's representative data. The results indicate that arsenic, lead, and other heavy metals are present within the stockpile in low concentrations.

2.3.1.6 Supplemental Sampling Activities

In addition to the stockpile characterization activities described in Section 2.3.1.5, a composite sample of stockpile material was collected on May 8, 1995 from the 66 archived stockpile samples collected in January 1995. The objective of the sampling program was to further characterize the stockpile material. A representative composite sample of the stockpile material was generated based on relative proportions of "tailings" and "cover" materials.

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The "cover" materials account for approximately 56 percent of the stockpile volume. "Tailings" material account for less than 43 percent of the stockpile volume. Less than one percent of the stockpile consists of "hot" tailings material. The sampling procedure was designed to obtain the ratio of 56 percent "cover" material, 43 percent "tailings", and approximately 1 percent "hot" tailings. The sampling procedure employed is as follows:

- One volume (8-ounce jar) of material was collected from each archive container (bucket) designated as "tailings" material and placed in a clean bucket, which was labeled "Archive Composite - May 10, 1995". Twelve 8-ounce volumes of "tailings" material were composited.

- Material was collected from each archive container of "cover" material and placed in a clean bucket for temporary storage. Fifty-two 8-ounce volumes of "cover" material were composited. The composite sample of "cover" material was mixed to assure consistency.

- Two 8-ounce volumes of material were collected from each archive container of "hot" material and placed in a clean plastic bag which was labeled "hot" material. The composite sample of "hot" material was mixed to assure consistency.

- Sixteen 8-ounce volumes were collected from the composite sample of "cover" material and were then added to the composite sample of “tailings.” A 2-ounce volume of material was collected from the composite sample of "hot" material and added to the Archive Composite bucket. The Archive Composite sample was mixed to assure consistency. The Archive Composite sample contained approximately 56.6 percent "cover" material, 42.5 percent "tailings" material, and 0.9 percent"hot" material.

Three 500 cubic centimeters samples were collected from the Archive Composite and sent to analytical laboratories for analysis. The sample number assigned to each split sample was CSMRI-1.

Two laboratories were used to analyze the Archive Composite samples. The radiochemical analyses and organic (TCE, PCE) analyses were performed by AccuLabs Research, Inc. RCRA metals analyses, the Synthetic Acid Leach Test, TCLP analyses and the Acid Potential Test were performed by Core Laboratories. The results of analytical tests are summarized in Table 2-8. Analytical data presented in Table 2-8 are consistent with other analyses of the stockpile material presented in Tables 2-5 through 2-7.

Some of the methods employed in analyzing the composite sample are not standard EPA procedures. References for methods for which the EPA does not have standard methods are provided below:

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- The Acid-Base Potential Test method used by Core Laboratories is described in EPA Document 600/2-78-054, March 1978, entitled "Field and Laboratory Methods Applicable to Overburden and Mine Soils".

- The method used by AccuLabs Research, Inc. for analyzing thorium is adapted from the following references:

  - Atomic Energy Commission, 1970. "Handbook of Analytical Procedure", AEC Report No. RMO-3008.

  - EPA, 1979. "Radiochemical Analytical Procedures for Analysis of Environmental Samples", EPA Report No. EMSL-LV-0539-17.

- The method used by AccuLabs Research, Inc. for analyzing plutonium is adapted from the following references:

  - EPA, 1979. "Acid Dissolution Method for the Analysis of Plutonium in Soil", EPA Report No. 600/7-79-081.

  - HASL Procedure Manual, 1982. "Radiochemical Analysis of Plutonium in Large-Size Soil Samples.

2.3.1.7 Waste Volume Reduction Evaluations

The technical feasibility of performing physical separation of the larger-size fractions of the stockpile material using screening technologies was evaluated as a process to reduce the amount of material which could potentially require disposal at an off-site licensed radioactive waste disposal facility. Screening technology has been implemented successfully on many other programs involving similar materials.

The results of the particle size distribution tests performed for the “cover”, “tailings”, and “biased” materials are provided in Figure 2-10. The results suggest that it may be technically feasible to separate the stockpile material into plus 3/8 inch and minus 3/8 inch piles. However, Figure 2-10 also shows that approximately 35 percent of the stockpile consists of a very fine-grained material (less than 200 mesh) which could potentially result in operational problems, such as the formation of clayballs and clogging of the screens, during physical separation activities. In the absence of a field screening demonstration using several hundred cubic yards of stockpile material, one cannot reliably expect separation of 3/8-inch plus material, however it is reasonable to assume that separation at the 3/4-inch size is appropriate for the disposal options evaluations. This would result in an approximate 15 percent reduction (or 3,000 cubic yards) in the volume of stockpile material which could potentially require disposal at an off-site licensed radioactive waste disposal facility. Separation of the stockpile material at the 3/8-inch size, if shown to be technically

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feasible, would result in an additional 1,000 cubic yard reduction in the volume of the radioactive material.

Samples of the 3/4-inch minus and 3/8-inch minus fractions of the "biased" stockpile material were analyzed in the laboratory for arsenic, barium, cadmium, chromium, lead, selenium, silver, and mercury using the TCLP to determine if removal of the top-size fraction of the waste would result in concentration of the metals in the lower-size fraction to levels above the regulatory standards for classification as a hazardous waste. The results of the TCLP testing for the "biased" samples are provided in Table 2-9.

The concentrations of the eight RCRA metals in the TCLP leachate were below the regulatory limits for the 3/4-inch minus "biased" waste fraction. The results show that leaching of the eight RCRA metals in the stockpile is not a concern. The lead concentration in the TCLP leachate from the 3/8-inch minus "biased" waste fraction duplicate sample was 8.04 milligrams per liter which is higher than the allowable regulatory limit of 5.0 milligrams per liter. The Data Validation Report (see Appendix F) suggest that this sample may not have been representative. This result indicates that if it is technically feasible to separate the 3/8-inch fraction of the stockpile, it may not be advisable since the resulting lower-size fraction could thus require additional testing to determine if the waste could be classified as hazardous or mixed waste.

Composite samples from the 3/4-inch plus fraction were analyzed for total arsenic, barium, cadmium, chromium, lead, manganese, nickel, silver, vanadium, reactive cyanide, mercury, Radium-226, Lead-210, Uranium-238, Uranium-235, Uranium-234, Thorium-232, Radium-228, and Thorium-230. The results of the analyses are provided in Table 2-10 and are compared to the results of E&E's analyses of a background sample obtained 300 feet west of the stockpile during the March 1993 sampling activities. This was done to determine if the larger (3/4-inch plus) stockpile materials would be allowed to remain on site.

The results indicate that the concentrations of both the inorganics and radionuclides in the 3/4-inch plus fraction are generally higher than the concentrations in the background sample. This is probably due to the adherence of finer-grained material to the larger-sized fraction. If desirable, a washing step could be added to the full-scale screening operation during the RA to reduce the concentrations of chemical and radiological constituents in the 3/4-inch plus fraction to near background levels. This fraction could then be used as fill on the CSM property.

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2.3.1.8 Summary of Stockpile Characterization Activities

The specific objectives of the stockpile characterization activities were met during the RAOA. The baseline physical properties and chemical characteristics of the waste were determined and used to evaluate on-site and off-site disposal options for the stockpile. Good agreement between E&E's data and CEC's data was generally established for the stockpile constituents. The following calculations of the radionuclide and inorganics concentrations were performed using the stockpile data generated to date:

- Arithmetic mean and 95 percent upper confidence limit (UCL) Radium-226 and arsenic concentrations for the combined distinct units in proportion to the 56 percent "cover", 43 percent "tailings, and 1 percent "hot spot" volumes in the stockpile (Section 2.3.1.2).

- Arithmetic mean and 95 percent UCL for the EPA data generated for the Final Risk Assessment (all samples). In some instances, when EPA calculated the mean and 95 percent UCL they ignored the "Not Detected" data which artificially inflates the statistics. CEC's revised calculations use one-half of the lowest detected value for "Not Detected" data. A normal distribution for radionuclide concentrations and a lognormal distribution for metals concentrations were assumed which is consistent with EPA's approach.

- Arithmetic mean and 95 percent UCL for the "biased" data (both CEC's and SRK's) after combining the 3/4-inch plus fraction results with the 3/4-inch minus results in CEC's data.

- Arithmetic mean and 95 percent UCL for all of the data combined.

The summary data for radionuclides and inorganics within the stockpile are provided in Tables 2-11 and 2-12. When the 95 percent UCL exceeded the maximum concentration, the maximum concentration is reported in the 95 percent UCL column.

The "All Data Combined" inorganic concentrations (95 percent UCL) are equal to or greater than the "Biased/Supplemental Data" inorganic concentrations (95 percent UCL). This is due to the fact that the maximum concentration data are often encountered in EPA's samples rather than in CEC's or SRK's data. The radionuclide concentrations are generally higher in the "Biased/Supplemental Data" columns than in the "All Data Combined" columns due to the intentional biasing of the Radium-226 concentrations in these samples.

The following data on COCs (Tables 2-11 and 2-12) were used in the risk assessments of the various RA alternatives:

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- Off-Site Disposal Options - Use the "All Data Combined" 95 percent UCL values for both metals and radionuclides.

- On-Site/Nearby Off-Site Disposal Options - Use the "Biased/Supplemental Data" 95 percent UCL concentrations for evaluation of radionuclides and the "All Data Combined" 95 UCL concentrations for evaluation of metals.

The volume of material in the stockpile was estimated to be 20,000 cubic yards based on field measurements and an AutoCAD drawing provided by E&E. Physical waste volume reduction was shown to be technically feasible by separating the 3/4-inch fraction of the stockpile for disposal at appropriate facilities.

2.3.1.9 Evaluation of Fill Materials Underlying Stockpile

On May 8, 1995, a shallow test pit investigation was conducted outside of the chain-link fence surrounding the stockpile. Four test pits were excavated and three soil samples were submitted for laboratory analysis.

Sampling was performed in accordance with the requirements and guidelines set forth in the Safety, Health, and Emergency Response Plan-Removal Action Activities. Samples were collected with a clean stainless-steel trowel and placed into 500 ml glass sample containers. Radiation screening was performed using an Eberline PRM-7C meter at each test pit location. Scans were conducted on an approximate 6-inch depth interval in each test pit. Background values for the survey area varied from 21 to 28 microRoentgen per hour.

Test Pit 1, located immediately west of the stockpile midpoint, was excavated to an approximate depth of 4 feet. Gamma readings in this test pit varied from 18 to 30 microRoentgen per hour. Sample CSMRI-3 was collected from the bottom of the test pit.

Test Pit 2, located near the southwest boundary of the stockpile (approximately 70 feet south of Test Pit 1), was excavated to an approximate depth of 3.5 feet. Gamma readings in this test pit varied from 18 to 26 microRoentgen per hour. Sample CSMRI-4 was collected from the bottom of the test pit.

Test Pit 3, located near the northern boundary of the stockpile, was excavated to an approximate depth of 4.5 feet. Gamma readings between a depth of 1.5 to 2.5 feet varied between 65 to 75 microRoentgen per hour. Gamma readings between 2.5 to 4.0 feet in depth approached a maximum of 45 microRoentgen per hour. Below a depth of 4.0 feet, gamma readings were not noted to be elevated. Sample CSMRI-2 was collected from the north side wall as a composite representing the 0.5- to 2.5-foot depth interval.

A fourth test pit was excavated approximately 20 feet east of Test Pit 3 to assess the lateral extent of material exhibiting above-background levels of gamma activity. The depth of this pit was approximately 5.5 feet. Gamma readings were below background. No sample was collected at this location.

The three test pit samples were sent to AccuLabs Research, Inc. for analysis of Radium-226 and RCRA metals. Analytical results are summarized in Table 2-13. Concentrations of analytes in the test pit samples are either non-detect or detected lower than the stockpile material, except for elevated lead concentrations in samples CSMRI-3 and CSMRI-4 (1,800 milligrams per kilogram and 59,000 milligrams per kilogram, respectively).

The soil samples were analyzed for Radium-226 and RCRA metals to determine whether the fill in the vicinity of the stockpile contains contaminated material. Elevated lead concentrations were detected in two of the three test pit samples. The results indicate that the fill in the vicinity of the stockpile is chemically different than that of the stockpile material. The EPA Risk Assessment for the CSMRI stockpile identified arsenic ingestion and Radon-222 inhalation as the primary exposure pathways of concern associated with the waste material. The elevated lead concentrations detected in the fill material do not appear to be associated with the stockpile materials. During implementation of the selected removal action, care will be taken to ensure that any elevated lead levels, if encountered, will be isolated from potential future direct contact.

2.3.2 Treatability Study

The results of the gradation analyses, Atterberg limits, and specific gravity measurements obtained during the stockpile characterization activities, were used to develop S/S design mixtures with different cement contents (10, 14, and 18 percent by weight) to achieve the goal of the highest mix strength after 28 days. Fly ash at 20 percent of the selected cement content (2, 2.8, and 3.6 percent by weight respectively) was added to each design which increased the total cementitious material to 12, 16.8, and 21.6 percent by weight, respectively. In accordance with Section 2.3 of the Field Sampling Plan included in the SAP, the following chemical parameters which can affect the S/S treatment of waste were evaluated using the 3/4-inch minus "biased" stockpile material:

- pH
- Oil and grease

- Fluoride, chloride, nitrate, and sulfate content
- Ammonia content

The results of these analyses are provided in Table 2-14. The results indicate that the pH was approximately neutral with an average value of 7.49; the average oil and grease concentration was 169 milligrams per kilogram; the average fluoride concentration was 22 milligrams per kilogram; the average chloride concentration was 79 milligrams per kilogram; the average nitrate concentration was 17 milligrams per kilogram; the average sulfate concentration was 7,640 milligrams per kilogram; and the average ammonia content was 5.9 milligrams per kilogram. An evaluation of this information indicates that none of the constituents will have an adverse impact on S/S treatment of the waste and that the use of Type II Portland cement with the addition of fly ash is expected to produce a stable durable soil-cement.

The S/S testing was conducted in general conformance with the Portland Cement Association's publication "Soil-Cement for Water Control: Laboratory Test" (Portland Cement Association, 1976). Stockpile material from the 3/4-inch minus "biased" sample stockpile was used in the S/S testing. The design mixes were prepared using Type II Portland Cement and fly ash and Standard Proctor tests (ASTM D 698) were conducted on the stabilized material. The results are summarized in Table 2-15. The maximum dry densities for the three design mixes ranged from 118.2 to 119.0 pounds per cubic foot and the optimum moisture contents (OMC) ranged from 13.5 to 15.0 percent. Thirteen test cylinders were prepared for each design mixture at the approximate OMC and at least 95 percent of the maximum dry density. Compaction and OMC data for the test cylinders are summarized in Tables 2-16 through 2-18. The prepared cylinders were moisture cured in a cure tank in an on-site soils laboratory. The following physical tests were performed on the test cylinders from each of the three design mixes:

- Unconfined compressive strength (UCS) after 7, 14, and 28 day cure times (ASTM D 2166), and
- Permeability/hydraulic conductivity (ASTM D 5084).

These tests are identified in the Technical Resource Document for Stabilization and Solidification and Its Application to Waste Materials (EPA/530/R-93/012) and are intended to evaluate how well the S/S treatment will meet the long-term structural integrity requirements of an S/S monolith.

The following tests were performed using test specimens prepared with the 18 percent cement and 3.6 percent fly ash content S/S mix design:

- American National Standards Institute/American Nuclear Society (ANSI/ANS) 16.1 Measurement of the Leachability of Solidified Low-level Radioactive Waste, and
- Synthetic Acid Precipitation Leach Test (EPA SW-846 Method 1312).

These tests are also identified in EPA/530/R-93/012 and are intended to evaluate how well S/S treatment of the waste reduces the mobility of the COCs.

2.3.2.1 Results of the Unconfined Compressive Strength Tests

The unconfined compressive strength is a measure of the structural integrity and the ability of the S/S treated waste to withstand construction traffic. The minimum acceptable unconfined compressive strength for treated soil is 50 pounds per square inch (EPA, 1986a). Two cylinders from each of the three design mixes were subjected to UCS testing after 7-, 14-, and 28-day cure times. The results of the UCS testing are provided in Table 2-19 and show that the UCS of the S/S mixes generally increased with higher cement contents and with longer cure times. The average 28-day UCS values were 523, 506, and 593 pounds per square inch for the 10, 14, and 18 percent cement mixes, respectively. Therefore, for all three S/S mixes, the measured strength of the test cylinders exceeded EPA's strength requirement by at least an order of magnitude after 28 days.

2.3.2.2 Results of the Permeability/Hydraulic Conductivity Tests

The permeability/hydraulic conductivity tests measure the rate at which water will pass through the S/S treated waste. A material is considered impermeable if its measured permeability is less than 1×10^{-7} centimeter per second. Constant-head permeability tests were conducted by Advanced Terra Testing in Lakewood, Colorado on a single 4-inch diameter test cylinder from each of the three mix designs. The 14 and 18 percent cement content test cylinders had cured for 93 days and the 10 percent cement content test cylinder had cured for 86 days prior to conducting the permeability tests. The samples were saturated and allowed to consolidate under an effective confining pressure of 20 to 50 pounds per square inch for a period of 6 hours. Following the consolidation phase, the permeability tests were conducted using a driving head of 2 pounds per square inch. The volumetric flow rate through the sample was measured on a daily basis until the change in permeability for four consecutive daily measurements was within 25 percent of the mean value for permeability greater than 1×10^{-8} centimeter per second.

The results of the permeability tests are provided in Table 2-20. The measured permeability of the 10, 14, and 18 percent cement design mixes were 9×10^{-7}, 2.6×10^{-7}, and 1.4×10^{-7} centimeter per second, respectively, indicating that the S/S treated waste is essentially impermeable and that surface water infiltration into an S/S monolith (even without a cap/cover system) is not a concern.

2.3.2.3 Results of the Synthetic Acid Precipitation Test

The Synthetic Acid Precipitation Test (SAPT) is essentially the same as the TCLP except that the leaching fluid is sulfuric acid and nitric acid in a 60:40 weight percent mix. The pH of the leaching fluid is adjusted with deionized water to 5.0 for sites west of the Mississippi River to simulate acid rain conditions. The standard TCLP applies to disposal in a sanitary or municipal landfill where large concentrations of low molecular weight organic acids (unlike the CSMRI stockpile) are usually present. The SAPT simulates acid rain conditions which is more representative of the disposal environment anticipated at a nonmunicipal waste disposal site (EPA/530/R-93/012).

The SAPT was performed on a composite sample from the 3/4-inch minus "biased" stockpile. The concentrations of the constituents identified as groundwater ARARs were measured in the SAPT leachate. The results of the analysis are provided in Table 2-21. The concentrations of all of the constituents in the leachate were below the groundwater ARARs except Radium-226, total uranium, manganese, and molybdenum which were slightly above the reference limits.

The SAPT was also performed on a single S/S test cylinder prepared with the 18 percent cement and 3.6 percent fly ash content after the cylinder has cured for 93 days. One of the concerns with the SAPT test relative to the S/S processing is that it requires the sample to be finely ground to pass a 9.5-millimeter sieve. This process substantially eliminates the effects of solidification in a cementitious matrix and significantly increases the surface area of the sample which can be attacked by the leaching medium. Additionally, the sulfate and nitrate anions present in the sulfuric and nitric acids used in the leachate, adversely affect the S/S process making this test an extremely conservative method for evaluating the leachability of the S/S treated waste.

The concentrations of the constituents identified as groundwater ARARs were measured in the SAPT leachate from the S/S treated sample. The results of the analysis are provided in Table 2-21. The concentrations of all of the constituents in the leachate were below the groundwater ARARs except gross alpha, Radium-226, and molybdenum which were slightly above the allowable limits. The uranium was completely immobilized through the S/S treatment as it was not detected in the SAPT leachate.

Groundwater modelling, using the SAPT values (both treated and S/S treated) as the source terms for the waste, could be performed and would probably show attenuation of all the constituents to below the groundwater ARARs at the site boundary. However, in the absence of groundwater modelling and as an added precautionary measure, each on-site or nearby off-site RA design incorporates a cap/cover system which would reduce surface water infiltration into the waste. In addition, each on-site or nearby off-site RA design includes an engineered barrier (either a slurry wall or liner system) between the waste and the groundwater which would reduce any potential contamination of the groundwater from these disposal facilities.

2.3.2.4 Results of the ANSI/ANS 16.1 Leaching Test

In 1986, the American Nuclear Society published a procedure for "Measurement of the Leachability of Solidified Low-Level Radioactive Waste by a Short Term Test Procedure". The test utilizes 10 stages for contact between the extraction fluid, deionized water, and the solid test specimen. The leachate volume is equal to 10 times the surface area of the specimen. At 2, 7, and 24 hours from the initiation of the test, the leachate is sampled and completely replaced. Thereafter, for an additional 4 days, the leachate is sampled and replaced at the end of each 24-hour period. Three additional leachate sampling and replacement intervals of 14, 28, and 43 days extends the entire test duration to 90 days.

A leach index (LI) is calculated by first determining the effective diffusivity (D) based on a mass transfer equation. Then the LI for each stage for each radionuclide is:

$$LI = \text{Log}\,(D)^{-1}$$

Because the LI is a logarithmic function, an increase of one in the LI corresponds to a decrease by a factor of 10 in the leachability of the material. The overall LI is the summation of the LI for each stage divided by the number of stages. In several published reports by the Nuclear Regulatory Commission et al (ASTM STE 1033), the authors stated that an overall LI of 6 or greater indicates a stable solid with low leachability.

The ANSI/ANS 16.1 leaching test was performed on a single test cylinder prepared with 18 percent cement and 3.6 percent fly ash after the cylinder had cured for 93 days. The concentrations of Radium-226, Radium-228, Thorium-230, Thorium-232, and total uranium were measured in the leachate after each extraction. The results of the first seven extractions are provided in Table 2-22. The data indicate that the S/S treatment was successful in immobilizing the radionuclides in the "biased" stockpile material as the test cylinders show a LI of 9.5 or greater for each radionuclide. This value exceeds the minimum standard by three orders of magnitude indicating that the S/S treated material is a stable solid with low leachability.

The ANSI/ANS 16.1 test is still in progress and data from the three remaining stages will be provided to EPA in addenda to this report on June 20, 1995 for the eighth extraction, on July 21, 1995 for the ninth extraction, and September 4, 1995 for the final extraction. Because the overall LI is the summation of the LI for each stage divided by the number of stages, it is unlikely that the LI for the three remaining stages will significantly lower the overall LI for the material.

Although the ANSI/ANS 16.1 tests are primarily used for evaluating the leachability of radionuclides in solidified waste materials, evaluation of the inorganics identified as groundwater ARARs would be a useful measure of the leaching rates for these constituents. Therefore, all of the constituents identified as groundwater ARARs in Chapter 3.0 will be evaluated in the 28-day leachate (ninth extraction) obtained during the ANSI/ANS 16.1 testing. The results of these analyses will be provided to EPA in the July 21, 1995 addendum to this report.

2.3.2.5 Comparison of Treatability Study Results with Denver Radium Site Operable Unit VIII

A pilot-scale treatability study was conducted at The S. W. Shattuck Chemical Company, Inc. facility located at 1805 South Bannock Street in Denver, Colorado (Denver Radium Site Operable Unit VIII). The study was conducted in accordance with an Unilateral Administrative Order issued to Shattuck by EPA in August 1992. Based on the results of the RI/FS and the bench-scale tests performed on the waste, the UAO specified S/S treatment of the Shattuck waste using cement and fly ash combined with on-site burial. The Operable Unit VIII (OU8) pilot-scale treatability study was conducted to verify the S/S results obtained during bench-scale tests conducted during the RI/FS.

There are many physical and chemical similarities between the CSMRI waste and the OU8 waste. Both wastes are classified as clayey sand in accordance with the USCS. The CSMRI waste contains approximately 35 percent fines and the OU8 contains approximately 27 percent fines. Seventy-five percent of the CSMRI soil passes the No. 4 sieve compared to 82 percent for the OU8 soil. A comparison of other physical properties presented in Table 2-23 indicates that from a physical perspective, the wastes are nearly identical and would respond to S/S treatment similarly .

Comparisons of the chemical characteristics of the CSMRI waste and the OU8 waste are also useful. The average concentrations of Radium-226, Thorium-230, Thorium-232, gross alpha, and gross beta were significantly higher in the OU8 waste than in the CSMRI waste. The maximum Radium-226, Thorium-230, and natural uranium concentrations at OU8 were in the thousands of picocuries per gram compared to tens of picocuries per gram for these same constituents in the CSMRI waste.

The concentrations of the inorganic constituents in the CSMRI waste were generally higher than in the OU8 waste. However, even at the higher concentrations found in the CSMRI waste, the concentrations of the inorganics in the SAPT leachate for the S/S treated sample were below the groundwater ARARs except molybdenum which was slightly above the allowable limits. As stated previously, the on-site and nearby-off site RA designs incorporate a cap/cover system which would prevent surface water infiltration into the waste and also include an engineered barrier (either a slurry wall or liner system) between the waste and the groundwater which would reduce any potential contamination of the groundwater from an on-site or a nearby off-site facility.

During the OU8 pilot-scale treatability study, three test monoliths were placed using roller-compacted concrete techniques. The percentages of cement and fly ash added to the waste were 15.3 and 7.7, respectively. Monolith testing consisted of physical and chemical evaluations similar to those performed during the RAOA. The following is a summary of the results of the testing:

- Monolith UCS exceeded the 50 pounds per square inch EPA standard by approximately an order of magnitude in all cases, with an average UCS of 429 pounds per square inch.
- Average monolith permeabilities were 9.1 x 10^{-8} centimeter per second indicating that the placed S/S materials are essentially impermeable.
- Average percent losses from the 12 wet-dry cycles and freeze-thaw cycles were 3.9 and 5.0 percent, respectively, indicating exceptional durability and resistance to freeze-thaw for the S/S materials.
- Concentrations of the eight RCRA metals in the TCLP leachate were an order of magnitude less than the regulatory limits and no organics were detected in the leachate.
- ANSI/ANS 16.1 leach index test results exceeded the minimum standard of 6 by six orders of magnitude indicating a stable solid with low leachability in all cases.
- Average measured radon flux of 8 picocuries per square meter per second from the test monoliths was well below the standard of 20 picocuries per square meter per second above background set forth in 40 CFR 192.
- Results of modelling showed that the maximum radon concentration at the edge of an average monolith would be 0.37 picocuries per liter including background which is well below the standard of 0.5 picocuries per liter plus background set forth in 40 CFR 192.

These results can be directly compared to the CSMRI waste and add a significant amount of pertinent data which supports S/S treatment as a technically feasible and protective disposal alternative for the CSMRI stockpile (Earth Sciences Consultants, Inc., 1993)

2.3.3 Subsurface Investigation

The primary objectives of subsurface investigation activity at the site were to better describe subsurface lithology and to identify the extent of the upper groundwater formation at the site. Data collected during the investigation activities were used to assess the following:

- Completion of a geotechnical evaluation for potential nearby off-site above-grade and below-grade repository facilities;
- Assessment of the direction of groundwater flow in the upper groundwater formation; and
- Characterization of groundwater quality in the upper groundwater formation.

Further discussion on the results of the subsurface investigations follows below.

2.3.3.1 Geotechnical Evaluation

The geotechnical evaluation focused on the following potential geotechnical issues:

- Liquefaction induced by seismic loading
- Stability, both static and dynamic
- Consolidation behavior
- Potential for volume changes in the shale bedrock

Appendix B includes the complete text and associated calculation briefs for the geotechnical evaluation. A summary of the findings of the evaluation is presented below.

As shown in Figure 2-3, the Golden fault is located near the present stockpile. The Golden fault has been extensively studied as part of ongoing investigation activities at the Department of Energy's Rocky Flats Plant to the north. Existing data indicate that the Golden fault is not active (i.e., movement has not occurred in the past 35,000 years and multiple movements have not occurred in the last 500,000 years). Data from the previous investigations were used to estimate the peak ground acceleration for earthquate ground motion at the site.

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Earthquake-induced liquefaction requires an earthquake of sufficient magnitude to cause a volume change in the soil and the development of excess pore water pressures. Furthermore, the earthquake must be of sufficient duration for large excess pore water pressures to develop and liquefaction to occur.

In general, soils which are susceptible to liquefaction are in a relatively loose state and saturated. The presence of saturated soils at the site is limited to a thin zone of saturated sand and gravel above the shale bedrock. Calculation of the minimum threshold acceleration for liquefaction to occur in the thin sand and gravel layer indicates that the minimum threshold value is greater than the predicted peak ground acceleration. Therefore, the liquefaction potential for the sand and gravel zone is considered negligible.

Seismic stability evaluations were performed for the above-grade repository and below-grade repository which are potential on-site and nearby off-site alternatives. The results of the evaluations suggest that each facility could be designed in a manner which is stable under potential design earthquake loadings.

Potential settlement associated with the above-grade repository would likely be negligible due to the small incremental load on the foundation soils caused by the limited repository height. Potential settlement associated with the below-grade repository is also negligible as the net load on the foundation soils will remain relatively unchanged.

Shale bedrock, which is common throughout the Denver area, causes frequent foundation problems. These problems are due to the volume change behavior of the clay minerals in the shale as a result of changes in moisture content. In the vicinity of the potential nearby off-site below-grade repository at the baseball field, weathering of the shale formation is limited and the shale has been and will continue to be exposed to free water. Therefore, there would be little potential for swelling in the shale to compromise the integrity of the facility through foundation movements.

2.3.3.2 Direction of Groundwater Flow

A total of thirteen test borings were advanced in the vicinity of the CSM baseball field, the adjacent practice field and the softball diamond. Figure 2-11 presents the location of each test boring. Appendices B and C present a detailed description of the baseball field and practice field investigations, respectively.

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Test borings TH-2, TH-2A, TH-3, PFMW-01 and PFMW-03 were completed as groundwater monitoring wells. Well TH-2 is completed within the Pierre Shale Formation underlying the alluvial and colluvial deposits at the site. The remaining monitoring wells were completed within alluvial or colluvial material.

The surficial aquifer consists predominantly of coarse-grained Louviers alluvium and overlying sandy colluvium. It is limited in areal extent and is bounded by low-permeability clay colluvium and by the bedrock surface. There are some areas in which the Louviers Alluvium is absent but saturated colluvial sand exists above the bedrock surface. These areas are likely to be in hydraulic connection with the Louviers Alluvium.

Two sets of water level measurements were taken to assess the approximate direction of groundwater flow. The first measurements were taken 24 hours after the installation of Wells PFMW-01 and PFMW-03. A second set of measurements measurements, which included the five monitoring wells, was taken on May 24, 1995.

Horizontal and vertical survey control was established for each monitoring well. Table 2-24 summarizes groundwater elevation data for each measurement event. The temporal variation reflected in the recent water level data suggest that flow rates as well as recharge rates may be dependent on the intensity of precipitation or on some other seasonal phenomenon. During the months of April and May of 1995, the site experienced a considerable amount of precipitation.

The approximate direction of groundwater flow in the surficial aquifer is toward the northeast. The hydraulic gradient in this area is approximately 0.02 foot per foot and the direction of groundwater flow is to the northeast where groundwater likely discharges to Clear Creek.

2.3.3.3 Characterization of Groundwater Quality

On May 24, 1995, groundwater samples were collected from monitoring wells TH-2 and TH-3. Groundwater in well TH-3 occurs in the alluvium above the bedrock surface. Based on the estimated groundwater flow direction discussed in Section 2.3.3.2, well TH-3 appears to be hydraulically at lateral gradient from the stockpile. The results of the groundwater sample analyses are provided in Table 2-25.

Well TH-2 was completed in the Pierre Shale approximately 11 feet below the bedrock surface. The bedrock was dry at the time of drilling; however, water was encountered during the

May 24, 1995 sampling event. Water quality in Well TH-2 may not be representative of ground water (if present) in the Pierre Shale bedrock.

In addition to the natural groundwater samples, the following quality assurance/quality control samples were collected:

- Duplicate sample for well TH-3
- Bottle blank
- Rinsate blank

The aqueous samples were submitted for analysis of RCRA metals (i.e., arsenic, cadmium, chromium, lead, mercury, selenium and silver), natural uranium, gross alpha and gross beta activity. The analytical results are presented in Table 2-25.

The laboratory results for the natural groundwater samples indicate that the RCRA metals are present at or near method detection limits. Gross alpha and gross beta activity are elevated in the alluvial groundwater well TH-3. The duplicate analyses for well TH-3 compares favorably with the natural groundwater sample.

The bottle blank sample results suggest that contamination due to field sample handling procedures is not evident. The rinsate blank sample results suggest that cross-contamination from sampling equipment (e.g., submersible pump) is also not evident.

2.4 Risk Assessments

Acceptable exposures to known or suspected carcinogens are generally those that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}. In addition, EPA uses the 10^{-6} risk level as the point of departure for determining remediation goals for the National Priority List (NPL) sites. For noncarcinogens, the EPA defines acceptable exposure levels as those to which the human population, including sensitive subgroups, may be exposed without adverse effects during a lifetime or part of a lifetime, incorporating an adequate margin of safety. This acceptable exposure level is best approximated by a hazard index (HI) of 1. If the HI is less than 1, adverse effects usually would not be expected. As the HI increases beyond 1, the possibility of adverse health effects also increases.

2.4.1 EPA's Final Risk Assessment

The Final Risk Assessment performed by E&E is the baseline risk assessment for the stockpile and is a conservative analysis of the current and future potential adverse health effects caused by the stockpile for the No-Action/Instutional Controls Alternative. EPA identified eleven inorganic and seven radionuclide COCs for the stockpile (Table 2-1). The routes of exposure evaluated in the Final Risk Assessment included ingestion of radioisotopes and inorganic contaminants; inhalation of radioisotopes, radon decay products, and inorganics; and direct exposure to gamma radiation. The Final Risk Assessment did not evaluate the groundwater or surface water pathways due to the presence of the clay liner under the pile and the surface water retention berm constructed around the stockpile. Four exposure scenarios including current and future on-site worker, current off-site resident, and future resident were evaluated (Gradient Report).

2.4.1.1 Summary of Chemical Contamination Risks

The results of the Final Risk Assessment estimated that cancer risks from chemical contamination in the stockpile to current on-site workers was 1.8×10^{-5} for the typical case. The cancer risk of the soil ingestion pathway was 1.8×10^{-5} primarily attributed to the presence of arsenic. Under reasonable maximum exposure conditions (RME) the cancer risk for arsenic and the receptor total was 9.2×10^{-5}. The cancer risks for the soil particulate inhalation pathway ranged from 2.3×10^{-8} to 5.7×10^{-10}, therefore did not contribute significantly to the overall cancer risk. The receptor total noncancer HI was 0.41 and 0.82 for the typical and RME case exposures, respectively, which indicates that workers at the site are at little risk of noncarcinogenic adverse health effects from exposure to site contaminants. These same cancer risks and HI's also apply to future on-site workers.

For the current off-site resident exposed to the particulate inhalation pathway, the cancer risks for both typical and RME were 5.5×10^{-9} and 2.8×10^{-8}, respectively. The particulate inhalation route HI for the typical and RME case scenarios were 1.7×10^{-4} and 2.6×10^{-4} respectively.

For the future on-site resident and the soil ingestion exposure route, the estimated total cancer risk to both adults and children under RME conditions was 4.1×10^{-4}. The majority of the cancer risk was attributed to ingestion of arsenic in soil. The total estimated cancer risk for the typical exposure case was 4.3×10^{-5} with the only contaminant being arsenic. The particulate inhalation exposure route did not contribute significantly to the overall cancer risk for either the typical or RME case scenarios.

The overall HI's for future residential receptors from the soil ingestion pathway were greater than 1 for both the typical (1.1) and the RME (3.0) exposure cases, indicating that adverse health effects would be expected. For the soil ingestion route exposure pathway, the HI for arsenic was 0.64 for the typical case and 1.8 for RME conditions.

Soil particulate inhalation did not contribute significantly to the health risks for any of the four scenarios evaluated.

2.4.1.2 Summary of Radiological Risks

According to the Final Risk Assessment, the radiological risks were dominated by Radium-226 and its daughters. In almost every scenario (current on-site worker, current off-site resident, and future on-site resident), inhalation of radon and direct gamma exposure risks from this chain are orders of magnitude greater than the risks from other radionuclides ranging in value from 10^{-3} to 10^{-4}. Radionuclides from the Uranium-235 decay series also made significant contributions to these gamma exposure risks. Ingestion of Lead-210 has a greater risk than ingestion of Radium-226 for both typical and REM cases in the current and future worker scenario for the soil ingestion exposure route. The risks from dust inhalation generally did not contribute significantly to the overall radiological risks posed by the waste.

2.4.2 Risk Assessments for Removal Action Alternatives

The methods used in the risk assessments for the RA alternatives are consistent with EPA guidance (EPA 1989 and EPA 1991) and incorporate EPA and U.S. Nuclear Regulatory Commission (NRC) approved models and conversion factors. EPA recommends the use of the RME to express the highest exposure that could reasonably occur at a site. The RME is an estimate of a conservative exposure case that is within the range of possible exposures, but still above the average case. To estimate RMEs, exposure point concentrations for all alternatives evaluated were calculated as already described in Section 2.3.1.8. The exposure point concentrations of COCs used in the risk assessments appear in Tables 2-11 and 2-12 for both the on-site and off-site disposal options.

To assess the present and future exposures (and health effects) from the RA activities to critical members of the general population and workers at, and in the vicinity of the CSMRI site, the following analyses have been performed:

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- Source analyses to establish concentrations and rates of release of inorganic and radionuclide contaminants into the environment. The rates of release are established by the source concentrations, the geometry of the contaminated zone, the ingrowth and decay rates of the radionuclides, and the removal rates by erosion.
- Exposure scenario analyses in which the various phases of each RA alternative and future site use options are assessed. Specific parameters and patterns of human activities that control the rate of contaminant release into the environment and the severity and duration of human exposure are also assessed.
- Environmental transport analyses that identify the pathways for each exposure scenario for migration of contaminants to human receptors and determination of the migration rates along these pathways.
- Dose/exposure analyses in which the concentrations of contaminants at a human exposure location are converted to a rate of exposure and uptake by a human receptor and of the degree of toxicological risk (health effect) is assessed.

2.4.2.1 Exposure Setting

Pertinent data provided in Section 2.1 of this report regarding the exposure setting including population distributions, surface water characteristics, and site geology and topography were used in the risk assessments. The site meteorology data provided in Section 2.1.9 were used in the risk assessments except that, in the absence of wind stability class data for the CSMRI site, neutral stability (Class D) was assumed. The wind rose data provided in Figure 2-7 show that, on an annual basis, the wind generally blows from the west approximately 60 percent of the time and from the east approximately 35 percent of the time with minor excursions from the north and south with the wind blowing in any one direction on 24 percent of the time. The highly conservative assumption that the wind blows in the direction of the off-site resident at risk 100 percent of the time was used in the risk assessments giving a correction factor of 28 percent as stated in the Final Risk Assessment.

2.4.2.2 Exposure Pathways

The exposure pathways for each RA alternative and receptor are provided in Table 2-26. The routes of exposure evaluated in the risk assessments of the proposed RA alternatives included ingestion of radionuclides and inorganic contaminants; inhalation of particulates with adhering radioisotopes and inorganics; radon and radon decay products; and direct exposure to gamma radiation. The risk assessments did not address the surface water or groundwater pathways for the following reasons:

- An engineered barrier (either a liner or slurry wall) was included between the waste and the groundwater in the all of the on-site and nearby off-site alternatives (except the No-Action/Instutional Controls Alternative).

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- An engineered cap/cover system which will prevent contact of surface water with the waste was included in all of the on-site and nearby off-site alternatives (except the No-Action/Instutional Controls Alternative).
- The 500-year flood elevation is 27 feet below the base of either of the on-site alternatives and 17 to 30 feet below either of the nearby off-site below-ground alternatives. Therefore, flooding was not considered a potential release mechanism.
- Surface water retention systems including berms, silt fences, and basins will be implemented during all of the RA alternatives as necessary to prevent runoff of potentially contaminated surface water from the site.
- Groundwater impacts are not anticipated during the RA because groundwater at the site is located a minimum of 17 feet below the base of any anticipated excavations in the RA alternatives.
- Dust suppression activities implemented during the RA will reduce the deposition of particulates into Clear Creek to insignificant levels. Any small quantity of particulates deposited in Clear Creek would be rapidly diluted to background levels and downstream users (closest is 4,200 feet) will not be adversely affected.

The post-closure soil ingestion and particulate inhalation pathways were not considered for the on-site alternatives (except the No-Action/Instutional Controls Alternative), because the multi-barrier cap/cover system will prevent intrusion into the waste materials and releases of particulates into the air. All of the on-site post-closure assessments included evaluations of the direct gamma and radon inhalation exposure pathways.

During routine off-site transport of the waste, only short-term direct gamma exposures from the waste represent a viable transport mechanism. Particulate release and transport is prevented by using tarps to cover the truck beds and decontaminating the vehicle exteriors (as necessary) prior to leaving the site and again prior to returning from the disposal facility. However, in the event of an accident resulting in a spill of the waste materials, particulate and radon release and transport is likely to occur and, therefore, has been evaluated in the risk assessment.

2.4.2.3 Toxicity Assessments

The toxicity profiles of the COCs (radionuclides and inorganics) have been adequately addressed and presented in Section 4.0 of EPA's Final Risk Assessment and are not repeated in this section.

2.4.2.4 Contaminant Fate and Transport

The fate and transport of contaminants from the pile have been discussed for the No-Action/Instutional Controls Alternative in the EPA's Final Risk Assessment. This section supplements the data provided in the Final Risk Assessment and relates specifically to the fate and transport of contaminants during the on-site remedial activities including excavation, movement, and emplacement of the waste; off-site vehicular transport; and potential post-closure intrusion into the waste. In addition, transport mechanisms resulting from an off-site vehicular accident are considered.

The COCs at the CSMRI site are radionuclides in the Uranium-238, Uranium-235, and Thorium-232 decay chains as well as a number of inorganics. These constituents can be mobilized for release from the waste matrix by mechanisms associated with the remediation processes. Release and transport of particulates and radon in the air may result from waste handling operations and wind erosion of exposed waste surfaces.

Radon gas is released at varying rates into the air after diffusing through the waste and cover materials. The radon release rate and subsequent airborne concentrations depend on the amount of radium in the waste, physical properties of the waste, and ventilation rates. For outdoor releases, material specific properties such as radium concentrations, porosity and moisture content of the waste, and assumed wind conditions were used in conjunction with a radon model to calculate radon emanation rates (see Appendix H) for the various RA alternatives (Berlin, 1989). Risks to off-site residents are calculated by using the .28 dispersion factor used by EPA's Final Risk Assessment. This likely overestimates risks by at least a factor of approximately 40 times. This is because the wind rose data (Figure 2-7) shows that the wind blows in any one direction no more than 24 percent of the time (not the 100 percent assumed by EPA) and the nearest resident is actually at 1,000 feet rather than the 100 meters used by EPA to set the .28 dispersion factor. Correction factors were used to account for the reduction in radon flux by the cap/cover system and fill material (if present). Indoor concentrations, used for residential scenarios, were estimated based on generic waste and foundation properties which are consistent with those properties used in the Final Risk Assessment.

Direct gamma exposure results from the radioactive decay of the various radionuclides contained in the stockpile. Risks from gamma exposure were estimated by applying a risk factor to the radionuclide concentrations within the waste with modifying factors for shielding, distance, and duration of exposure (see Appendix H). The existence of barriers (shielding) such as a cap/cover system and overlying fill as well as distance of the receptor from the radiation source act to reduce the direct gamma exposure levels. Shielding factors for the cap and fill were calculated using the ISOSHLD-II program (Rockwell 1987). Corrections for distance were based on the fact that the exposure levels are inversely proportional to the square of the distance from the source. Estimated exposure durations consistent with RA schedules for the alternatives were used to produce the time factors.

Particulate concentrations were estimated based on typical levels encountered at landfills (NUREG/CR 5517) and considered the dust suppression measures planned for the RA activities. For Alternative 2A (In-Place Closure), a low particulate concentration of 0.1 milligrams per cubic meter was assumed. For Alternatives 2B through 3B, which involve more extensive waste material handling, a moderate particulate concentration of 0.2 milligrams per cubic meter was assumed. For the off-site transportation accident scenario, no control will take place and, therefore, a high particulate concentration of 0.4 milligrams per cubic meter was assumed. Dilution of airborne concentrations of contaminants at off-site locations were estimated based on a fixed factor regardless of the direction or distance from the source.

2.4.2.5 Risk Characterization Methodology

Calculations of internal doses from radionuclides only depend on the radioactivity inhaled or ingested. Chemical doses were normalized to intake rates in milligrams per kilogram per day. Risk estimates were based on the intake amount divided by the body weight and the averaging time. For carcinogenic effects, the averaging time is 70 years; for noncarcinogenic effects the averaging time is the duration of the exposure. The implementing equations and parameters used in the risk assessments of the RA alternatives are provided in Appendix H.

2.4.2.6 Summary of the Risk Assessment Results

The results of the detailed risk assessments including chemical and radiological risks for each COC are provided in Appendix H. Summaries of the chemical risks (carcinogenic and noncarcinogenic) for each RA alternative are provided in Table 2-27. For each RA alternative the chemical carcinogenic risks were below 10^{-6} except the No-Action/Instutional Controls Alternative. The HI for the chemical noncarcinogenic risks were all less than 1.0 except the postulated off-site transportation accident which had a HI of 2.0 and the future on-site residents in the No-Action/Instutional Controls Alternative which had an HI of 3.0. The accident risks are based on a highly conservative scenario of a person exposed to high levels for 24 hours. Any limited dust control, quicker cleanup period, or a greater distance to a potential receptor will substantially decrease the HI for the transportation accident scenario to acceptable levels.

Summaries of the radiological risks are provided in Tables 2-28 through 2-33. For each on-site or near-site RA alternative (except the No-Action/Institutional Controls Alternative) the radiological risks were below 10^{-4} except for radon inhalation in the future on-site resident scenario. This risk is evaluated for a future on-site resident literally over the remediated area. However, for a resident adjacent to the remediated area, the risk drops to below 10^{-4}. The risk will further drop to less than 10^{-6} for a future resident on the current site boundary. Deed restrictions could be used if desired to restrict residential use of the repository location. Radiological risks for the off-site alternatives were less than 10^{-6} for all of the scenarios evaluated.

2.5 Regulatory Classification of Contaminated Stockpiled Soils

2.5.1 Introduction

The overall objective of this section of the RAOA is to classify and explain the basis and rationale for the regulatory classification of the contaminated stockpiled soil. The appropriate regulatory classification of the stockpiled soil is dependent on both the operational history of the CSMRI research facility and results of analytical data (see section 2.3) collected on the stockpiled soils. Based on these considerations, all parties conclude that the stockpiled soil can be safely managed as "special waste" and can and should be classified as "special waste" which may be disposed of at a permitted solid waste facility that can demonstrate the ability to safely accept and dispose of this type of material.

The conclusions drawn regarding the regulatory classification of the contaminated stockpiled soils will be used to determine which specific statutory and regulatory requirements and/or ARARs apply to the stockpiled soil. More specifically the regulatory classification will be used to:
(1) determine eligibility for currently licensed or permitted off-site disposal facilities for acceptance of the stockpiled soils for disposal, (2) determine engineering design, performance criteria and administrative permitting or licensing requirements for construction of a new disposal facility, and (3) determine design and performance criteria for on-site disposal.

Regulatory classification of the stockpiled soil is complicated by the fact that the site operated as a research facility for nearly 70 years (1916 to 1985) involving thousands of projects. Therefore, in order to specifically determine the appropriate regulatory classification it is necessary to evaluate a large "universe" of potential regulatory classifications.

Three general overall regulatory schemes could potentially govern the handling of the stockpiled soil: (1) Solid Waste, (2) Hazardous Waste, and (3) Radioactive Material.

These general regulatory schemes further breakdown into several specific material/waste definitions which include: radioactive material, naturally occurring radioactive material, low-level radioactive waste, special nuclear radioactive material, source material, 11(e)(2) byproduct material, transuranic radioactive material, hazardous waste, mixed waste, and special solid waste. Each of these potential regulatory classifications are discussed in detail in the subsections following the discussion of the operational history.

Relevant definitions pertaining to radioactive material (wastes) in Colorado include:

"Radioactive material" means any material, solid, liquid, or gas, which emits ionizing radiation spontaneously. CRS 25-11-101(3).

"Naturally occurring radioactive material" means any nuclide that is radioactive in its natural physical state and is not manufactured. "Naturally occurring radioactive material" does not include source material, special nuclear material, or by-products of fossil fuel combustion, including but not limited to bottom ash, fly ash, and flue-gas emission byproducts. CRS 25-11-101(2.7).

"Source material" means material, in any physical or chemical form, including ores, that contain by weight one-twentieth of 1 percent (0.05 percent) or more of uranium, thorium or any combination thereof. Source material does not include special nuclear material.

"Byproduct material" means:

- Any radioactive material, except special nuclear material, yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material. 6 CCR 1007-1, 1.4.; and

- The tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium or thorium solution extraction processes. Underground ore bodies depleted by these solution extraction operations do not constitute "byproduct material" within this definition. 6 CCR 1007-1, 1.4.

"Waste" means those low-level radioactive wastes that are acceptable for disposal in a land disposal facility. For the purposes of this definition, low-level waste has the same meaning as in the Low-Level Radioactive Waste Policy Act, P.L. 96-573, as amended by P.L. 99-240, effective January 15, 1986; that is, radioactive waste (a) not classified as high-level radioactive waste, spent nuclear fuel, or byproduct material as defined in Section 11.e.(2) of the Atomic Energy Act (uranium or thorium tailings and waste) and (b) classified as low-level radioactive waste consistent with existing law and in accordance with (a) by the U.S. Nuclear Regulatory Commission. 6 CCR 1007-1, 1.4.

"Waste" is also defined in Part 14 of the radiation regulations as radioactive waste other than:

- Waste generated as a result of the defense activities of the federal government or federal research and development activities;
- High-level waste such as irradiated reactor fuel, liquid waste from reprocessing irradiated reactor fuel, or solids into which any such liquid waste has been converted;
- Waste materials containing transuranic elements with contamination levels greater than one hundred nanocuries (3700 bq) per grain of material;
- Byproduct material as defined in Section 11(e)(2) of the "Atomic Energy Act of 1954", as amended on November 8, 1978; or
- Waste from mining, milling, smelting, or similar processing of ores and mineral--bearing material primarily for minerals other than radium; 6 CCR 1007-1, 14.2.

2.5.2 Operational History

Overview

The Experimental Plant, also known as "Building 101," was constructed at the site in 1912. It was a research and education facility only. Actual mining was not conducted at the site. There were no production facilities at the site.

For many years the Experimental Plant was the only building at the site. Its purpose was to provide a research facility for the mining industry and an educational center to provide practical work experience for students. The Experimental Plant is now one of 14 buildings at the site.

Mr. Arthur J. Weinig was the director of the Experimental Plant from 1923 to 1949. In 1949, CSMRI was founded as a non-profit organization. CSMRI conducted research for private industry and government at the site between 1949 and the mid 1980s.

The operational history described below is based upon the State of Colorado's partial review of certain CSMRI organizational and financial records, certain documents produced to EPA from various entities identified as potentially responsible parties (PRPs), interviews (including former CSMRI employees), state and national archives, periodicals, and other records. Some of the documents are included in Appendix I and are referred to as Attachments in the following discussion.

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1912-1920

The Experimental Plant was seldom used between 1912 and 1916. A 1912 document states that the Plant was not fully equipped when it opened in 1912. Attachment 1 at 5. Upon arrival to the Experimental Plant for the first time, one researcher writes in a May 1916 letter:

> ... the water capacity of the building is absolutely inadequate for any operation, and upon talking to Dr. Phillips, he realized fully that the mill had evidently never been tried out on any scale whatsoever with the view of working same successfully.

Attachment 2 at 1.

In 1916, the United States Bureau of Mines (BOM) moved its Denver Experiment Station to the CSM Physics Building/Engineering Hall. Attachment 3 at 4. Although this building is separate from the Experimental Plant, BOM used the Experimental Plant. Attachment 3 at 4. The attached agreements indicate that the BOM investigations at the Experimental Plant were under the supervision and direction of BOM. Attachment 4, 1916 Agreement at 2 ¶ 3, 1917 Agreement at 1 ¶ 2, 1918 Agreement at 1 ¶ 2, 1919 Agreement at 1 ¶ 2.

BOM used the Experimental Plant in 1916 for the mechanical concentration of over 200,000 pounds of pitchblende ore. Attachments 3 at 4. This pitchblende beneficiation project is critical for purposes of whether wastes emanating from this project are "low-level radioactive waste." (The definition of "low level radioactive waste" in Colorado radiation control regulations excludes (1) waste generated from federal research and development activities; (2) waste generated from federal defense activities; and (3) wastes from the processing of ores for minerals other than radium.)

The pitchblende beneficiation project involved several parties. BOM contracted with a mining company in Colorado, the National Radium Institute in Denver, and a philanthropist (Mr. Alfred Dupont) in Philadelphia. Attachment 5. The mining company provided the pitchblende ore to the National Radium Institute in Denver and paid the costs of the research. BOM provided all the labor and supervision for the research in exchange for pure uranium oxide extracted from the pitchblende. BOM used the uranium oxide for experimentation on "its possible utilization for special steels which we [i.e. BOM] hope may find a use in ordnance." Attachments 5. BOM's goal was to research national defense related matters. Id. The National Radium Institute gave the extracted radium to Mr. Dupont who in turn donated the radium to several hospitals for medicinal therapeutic uses. Attachment 6.

It is important to explain where the various components of the pitchblende work were conducted. The mining company delivered the pitchblende ore to the National Radium Institute in Denver. Attachment 6. BOM brought the pitchblende ore to the Experimental Plant in Golden only for concentration purposes to produce higher grade material. Attachment 2. The concentrates were then delivered to the National Radium Institute in Denver for the extraction of radium and high grade uranium oxide. Attachment 7. The concentration process conducted at the School of Mines Experimental Plant was mechanical, according to BOM.

BOM also used the Experimental Plant for experiments using a separator for the elimination of impurities from pyrrhotite in order to produce sulfur. Attachment 3 at 4-5.

The BOM Experiment Station moved from CSM to the University of Nevada at Reno in 1920.

1920-1949

There is no known information on how the Experimental Plant was used between 1920 and 1923. The Bureau of Mines left CSM in 1920. It is likely that the Experimental Plant was seldom used during this time.

From 1923 to 1949, Mr. Arthur J. Weinig was director of the Experimental Plant. He also ran a consulting business from the Experimental Plant for private industry. Attachment 8.

There are few specifics on the type of research conducted at the Experimental Plant under Mr. Weinig's direction. Some understanding, however, can be inferred by an understanding of the general use of the facility.

In general, Mr. Weinig researched special problems related to mining and metallurgy, including the testing and examination of ores. Attachment 19. The School of Mines may have used the Experimental Plant for laboratory classes during this time period.

Mr. Weinig's clients included Climax Molybdenum Company, American Metal Company, John J. Raskob et. al., London Gold Mining Co., Shenandoah Dives Mining Co., Cuban American Manganese Co., Potash Company of America, Basic Magnesium Inc., and others. Attachment 8.

Mr. Weinig had inventions in the following areas: flotation processes for treatment of molybdenum ore, sulfide ore flotation processes, cement manufacturing flotation processes, gold and silver concentrate cyanide treatments, apparatus and process inventions on ball mills, classifiers, screens, tables, meters, flotation machines and cyanidation equipment and a process for treating magnesium ores. Attachment 8. Mr. Weinig also wrote a prominent 1933 article, "A Functional Size-Analysis of Ore Grinds." Attachment 8. These types of activities likely occurred at the Experimental Plant during his tenure.

A major client of Mr. Weinig's was Climax Molybdenum Company (Climax). Climax's involvement at the Experimental Plant for this time period indicates that much of the research likely involved issues related to the Climax molybdenum mine near Leadville. Mr. Weinig developed the flotation system for the mine (Appendix I, Attachment 8) so significant amounts of flotation studies were likely conducted at the Experimental Plant. Also, it is likewise probable that many of the ores involved in the research were likely associated with molybdenum.

U.S. Bureau of Mines Operation for 1937-1950

The United States Bureau of Mines (BOM) used portions of the site for a coal experimental station during the 1937-1950 timeframe. Attachment 4 at 5-11. BOM used Building 104, which is adjacent to the Experimental Plant, as well as other adjacent structures and pilot plants for various studies and experiments involving subbituminous coal and lignite. Attachment 4 at 5, 12-13. The primary significance of the BOM coal experiment station for waste classification purposes is that byproducts of fossil fuel combustion, including ashes, are excluded from the definition of Naturally Occurring Radioactive Material (NORM).

BOM describes 18 different studies during this 14-year time period. BOM's 18 studies focused on coal. Arsenic, thorium, and uranium, which are the contaminants of concern at this site, are hazardous substances generally common to coal and coal fly ash.

An estimate of the weight of the coal materials used by BOM during this time period is between 20.7 million pounds and 5.8 million pounds. Attachment 3.

1949-Present

In 1949, CSMRI was founded as a non-profit corporation. CSMRI was first incorporated as the Colorado School of Mines Research Foundation, Inc. (CSMRF). In 1969, CSMRF changed its name to the Colorado School of Mines Research Institute (CSMRI). For this report, the organization will be referred to as CSMRI for all time periods.

The CSMRI Articles of Incorporation state that the objects and purposes of CSMRI are, in part, to:

Promote, prosecute, encourage and aid scientific and technological investigation and research and to provide or assist in providing the means and facilities by which scientific and technological discoveries, inventions and processes may be developed.

Attachment 9.

To accomplish these objects and purposes, CSMRI was "to conduct research, investigation, studies and tests in the fields related to the mineral industries as well as such other fields as may from time to time be deemed advantageous..." Attachment 9.

CSMRI used the CSMRI research facility for mining research. CSMRI also allowed some portions of the CSMRI research facility to be used by private industry for research.

Although CSMRI was a fledgling organization in 1949 with few employees, it grew to a large research organization with over 300 employees. By 1987, CSMRI ceased all research operations at the site and continued remedial activities that addressed certain environmental matters at the site.

As previously discussed, in 1992 a City of Golden water main broke at the site, releasing millions of gallons of water into the former tailings pond and into Clear Creek. EPA commenced a CERCLA removal action, resulting in the excavation of the tailings pond and surrounding soils. Prior to excavation, EPA flushed out remaining contamination from the interior of the buildings into the tailings pond. The excavated materials, which are temporarily stored at the site by EPA, are known as the stockpile that is the subject of EPA's UAO. The volume of the stockpile is approximately 15,000 to 20,000 cubic yards.

Unlike the time period from 1920 to 1949, many of the specific projects conducted by CSMRI at the site between 1949 and the mid-1980s are known. CSMRI's research projects are known through "project files" and corporate records that exist today. There are over 30 large filing cabinets full of CSMRI project files located at CSM. Most of these project files contain detailed records of projects conducted in the 1980s and 1970s, with a few records for the 1960s. The CSMRI annual reports from the 1950s and the early 1960s contain a list of the research projects performed by CSMRI.

After the water main broke in 1992, EPA reviewed the CSMRI project files and created a working "waste-in-list" (the EPA Waste-in-List). The EPA Waste-in-List includes the entities EPA believes to be potentially responsible for the cleanup costs at the site, as well as a description of the hazardous substances and the type of research performed. Attached to this report are decade-by-decade summaries of the EPA Waste-in-List. Attachments 10-12.

EPA listed 863 projects from projects files from the 1960s through the 1980s. By far, the majority of projects involved minerals unrelated to uranium, thorium, or radium. Only 89 of these projects, or 10 percent, were described as uranium leaching, separation, process developing, upgrading, or flotation projects. Only 9 of these projects, or 1 percent, were listed as uranium concentration or extraction projects. The difference between these two categories is that a uranium "leaching" project, for example, can simply be a leaching feasibility or amenability study in which the primary objective of the project is to determine the physical or chemical feasibility of leaching, or process development, as opposed to an actual extraction or concentration project. There was only one project, or less than 1 percent, described as a thorium extraction or concentration project. There were no projects for radium extraction. Below is a chart summarizing the results discussed:

<u>1960, 1970, 1980 CSMRI Projects</u>
<u>(from EPA's Waste-in-List)</u>

Total Projects Listed	863	
Total Uranium Projects Titled "Leaching", "Separation", "Process Developing", "Upgrading", and "Flotation"	89	10%
Total Uranium Projects Titled "Concentration" or "Extraction"	9	1%
Total Thorium Projects Titled "Leaching", "Separation", "Process Developing", "Upgrading", and "Flotation"	0	0%
Total Thorium Projects Titled "Concentration" or "Extraction"	1	< 1%
Total Radium Related Projects	0	0%

In addition to summaries of EPA's Waste-in-List, attached to this report are all of the discovered annual reports for projects conducted by CSMRI for specific years during the 1950s and 1960s. Attachments 13-20. These lists are copied from CSMRI annual reports and corporate records and are referred to as the "Annual Report Lists."

As compared to the EPA Waste-in-List a lower frequency of uranium, thorium, and radium projects is seen in the Annual Reports. There are 1,408 projects listed in the Annual Report Lists. Of these, only 11 projects, or less than 1 percent, are listed as uranium projects related to leaching, separation, process developing, upgrading, and flotation. Of the 1,408 projects, only one is listed as a uranium concentration project. For thorium, only 2 are listed as thorium leaching, separation, process development, upgrading, or flotation projects. And there are no projects listed for thorium concentration or extraction. Finally, there are no radium-related projects. Below is a chart summarizing the results discussed:

<u>1952, 1953, 1954, 1958,</u>
<u>1960, 1961, 1962, 1963</u>
<u>(Taken from the Annual Reports)</u>

Total Projects	1408	
Total Uranium Projects Titled "Leaching", "Separation", "Process Developing", "Upgrading", and "Flotation"	11	< 1%
Total Uranium Projects Titled "Concentration" or "Extraction"	1	< 1%
Total Thorium Projects Titled "Leaching", "Separation", "Process Development", "Upgrading", and "Flotation"	2	< 1%
Total Thorium Projects Titled "Concentration" or "Extraction"	0	0%
Total Radium Related Projects	0	0%

Combining the Waste-in-List and the Annual Reports indicates that CSMRI conducted at least 2,271 projects from the 1950s to the 1980s. While these two sources of information are not complete for all the projects conducted at the site by CSMRI, they would certainly pass any statistical test for capturing a representative random sample of all the projects conducted by CSMRI.

Of the 2,271 projects, there are <u>no</u> projects related to radium. Only 100, or 4 percent, are related to uranium leaching, separation, process development, upgrading, and flotation. Only 10 projects, or less than 1 percent, are related to uranium concentration or extraction. Of the 2,271 projects, only two are related to thorium leaching, separation, process development, upgrading, and flotation. Only one is related to thorium extraction or concentration. Below is a chart summarizing the results discussed:

<u>FOR 1952, 1953, 1954,
1958, AND 1960s TO 1980s
(COMBINED LISTS)</u>

Total Projects	2271	
Total Uranium Projects Titled "Leaching", "Separation", "Process Development", "Upgrading", and "Flotation"	100	4%
Total Uranium Projects Titled "Concentration" or "Extraction"	10	< 1%
Total Thorium Projects Titled "Leaching", "Separation", "Process Development", "Upgrading", and "Flotation"	2	< 1%
Total Thorium Projects Titles "Concentration" or "Extraction"	1	< 1%
Total Radium Projects	0	0%

These summaries indicate that the vast majority of research conducted at the facility was <u>not</u> conducted for the study of radioactive materials.

When evaluating the two databases and the statistics, the word "uranium" appeared in 240 of the 2,271 total projects, or 11 percent of the total. The 110 uranium related projects listed in the above chart are a subset of the 240 projects. However, the other 130 uranium projects did not fall into the categories of leaching, separation, process development, upgrading, flotation, concentration, or extraction. Instead, these uranium projects were, for example, feasibility studies, literature studies, grinding projects, or projects performed at the sponsor's mining site (not CSMRI) and should be excluded from the relevant statistics. Similarly, of the 2,271 projects, the word "thorium" appeared in 9 projects, or less than 1 percent of the total.

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Another issue relevant to the waste characterization issue is the disposition of uranium and thorium after the materials were extracted in the few extraction projects. None of the former CSMRI employees interviewed so far recall sending just the extracted materials back to the sponsors. This is further supported by the absence of manifests or licenses to transport extracted materials off-site. The main purpose for conducting extraction research at the site was to develop the technology and process for extraction. It appears that after the extracted materials were analyzed by a laboratory to determine the level of success, the extracted materials would have been discarded into the tailings pond or wherever all of the waste materials went after completion of the research.

A review of the above-referenced research databases indicates that the vast majority of projects involved copper, lead, nickel, iron, zinc, coal, oil shale, and gold. The research issues varied widely across a broad range of technical mining-related areas, including the following areas: development of mining exploration techniques, mineralogical laboratory analyses, refraction techniques, hydraulic transportation methods, rock mechanics, metallurgical processing methods, flotation systems, consulting services to mining sites and mining operations, sulfur studies, pyrometalurgical reactions, liquid ion exchange processing, copper electrolysis, smelting process technologies, halogenation of ores and metallurgical products, fused salt electrolysis, economic feasibility studies, phosphate studies and analysis, handling of limestone, geophysical, petrographic, and stratographic studies, spectrographic studies, x-ray diffraction studies, instrument calibration and construction, fatty acid studies, well log studies, sand heat treatment methods, evaluation of different clays, among other studies. From this partial list it is clear that relatively little work with radiological materials occurred at the site.

<u>Site Licensing History</u>

The CSMRI site licensing and permitting history shows that the stockpiled soils were regulated material. The stockpiled soils are from the former impoundment area at the facility and certain adjacent areas. The impoundment area was regulated as a RCRA solid waste facility, not a hazardous waste facility.

CSMRI was careful and conservative when obtaining licenses and permits. In doing so, the regulatory programs which provided oversight of the facility determined which regulatory program(s) was most appropriate for the activities conducted at the site. It was concluded that regulation of the facility, specifically the tailing impoundment which is now the stockpiled soils, would be under the authority of the Solid Waste Disposal sites and Facilities Act and associated regulations. This conclusion is supported by the analysis provided in this section of the TDOA showing that the stockpiled soils are <u>not</u> hazardous wastes.

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Prior to this determination CSMRI applied for permits under the RCRA, Subtitle C, which regulates hazardous waste management including the permitting for treatment, storage and disposal facilities of hazardous materials.

Obtaining a RCRA hazardous waste permit requires a two part application process. On November 17, 1980 CSMRI applied for and received a Part A permit. On August 24, 1984 EPA requested that CSMRI complete the permitting process by submitting a Part B permit. In undertaking the more detailed Part B application it became apparent that CSMRI had filed the original Part A application in error and that the facility was not subject to RCRA, Subtitle C, hazardous waste regulations. CSMRI submitted a request for exemption from Subtitle C as provided in 40 C.F.R part 261.4(b)(7) (this point is discussed in more detail in Section 2.5.3). The Colorado Department of Health reviewed this information and determined the facility was exempt from Subtitle C of RCRA. Attachment 21 contains four letters which discuss the RCRA history at the site.

Although most of the research at the site was not related to the study of radioactive materials, CSMRI possessed, and continues to possess, a license for the storage, handling and possession of radioactive materials (Colorado Radioactive Materials License Number 617-01S).

The following is a chronological summary of the U.S. Atomic Energy Commission ("U.S. AEC") and the State of Colorado licensing actions at the Colorado School of Mines Research Institute site:

Summary of U.S. AEC Licensing Actions at CSMRI

The State has records of U.S. Atomic Energy Commission ("U.S. AEC") licensing actions dating from January 1958 through December 1967.

January 1958 - December 1967 U.S. AEC Byproduct Material License Number: 5-4607-1 (including amendment #1 through amendment #23)

issued to: Colorado School of Mines Research Foundation, Inc.
authorized uses: laboratory research; teaching of industrial radioisotopic courses; as a component of a neutron generator for activation analysis; calibration of instruments; measurement of specific gravity of slurry in a pipeline; laboratory tracer studies; monitoring of solutions and slurries; metallurgical studies; neutron generator for activation analysis; experimental curing of thin plastic films deposited on ceramics; studies of molybdenum; geochemical research; to measure wear rate

of experimental pipelines and machines and similar laboratory studies; and for the determination of solubility constants.

August 1966 U.S. AEC Special Nuclear Materials License Number: SNM-972 (for Plutonium)

issued to: Colorado School of Mines Research Foundation, Inc.
authorized uses: for use in accordance with the procedures described in the licensee's application dated July 20, 1966. Storage only of soil samples.

Please Note: On-site Disposal of radioactive material has never been authorized as far as State records indicate.

Summary of State of Colorado Licensing Actions at CSMRI

October 24, 1968 Colorado Radioactive Materials License Number: Colo. 08 - 01 (F)
issued to: Colorado School of Mines Research Foundation, Inc. and Colorado School of Mines
authorized uses: Research, development, and teaching.

March 7, 1969 Amendment No. 1 to License Number: Colo. 08 - 01 (F).
May 25, 1971 Amendment No. 2 to License Number: Colo. 08 - 01 (F).
September 29, 1971 Amendment No. 3 to License Number: Colo. 08 - 01 (F).
February 25, 1972 Amendment No. 4 to License Number: Colo. 08 - 01 (F).
August 16, 1974 Amendment No. 5 to License Number: Colo. 08 - 01 (F).
October 31, 1975 Amendment No. 6 to License Number: Colo. 08 - 01 (F).

Note: The State does not have record(s) of licensing actions between November 1975 and March 1985.

April 10, 1985 Colorado Radioactive Materials License Number: Colo. 617-01S

issued to: Colorado School of Mines Research Institute.
authorized uses: Possess, use, and store.

March 25, 1986 Amendment No. 1 to License Number: Colo. 617-01S.

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Current Status of the CSMRI License is :

September 11, 1990 Amendment No. 2 to License Number: Colo. 617-01S.

issued to: Colorado School of Mines Research Institute.

authorized uses: Possess, use, and store.

Please Note: On-site Disposal of radioative material has never been authorized by the State. Copies of licenses are available for review.

The site was licensed by both the Atomic Energy Commission (AEC) and the State of Colorado for numerous types of radioactive materials over several decades. The current license includes NORM, source material, and byproduct material. Previous licenses authorized possession and use of any radioactive materials having atomic numbers 3 through 88 inclusive, americium, and plutonium. The scant available records related to plutonium materials indicate that disposal of certain plutonium materials occurred at Rocky Flats west of Denver. Attachment 22. The licenses authorizing the use of americium state that the americium was for the calibration of instruments and for gauges. The amounts of americium for these instruments must have been minute. There are no records related to the disposal of americium.

The AEC sponsored some research projects at CSMRI. See Annual Reports, Attachments 13-20. In response to EPA's 104(e) request, the successor to the AEC stated that it could find no records related to any AEC-sponsored projects at CSMRI. Notwithstanding the claim of ignorance to EPA, the U.S. Department of Energy (DOE) admitted that the AEC used the site for research. DOE admitted this several years ago when the CSMRI site was considered for remedial action by a federal program administered by DOE. This program, the Formerly Utilized Sites Remedial Action Program (FUSRAP), was created to remediate sites used under the Manhattan Engineer District and the AEC during the early years of nuclear development. In 1987, DOE wrote to CSMRI concluding that the CSMRI site did not qualify for the FUSRAP program because it could not be determined if the radiological contamination originated from the federal-sponsored work or work conducted under the State radioactive materials license. Attachment 23.

There are also numerous general references to defense-related projects at CSMRI, but we have found no project files on them and the United States has not produced applicable documents. See April 28, 1995 letter from A. Iatridis to L. Gunderson of EPA.

2.5.3 Summary Of Analytical Data In Regard To Regulatory Classification Of The Stockpiled Soil

As previously discussed, the analytical results from sampling of the contaminated stockpiled soils comes from three sources. The three data sources are:

- EPA data associated with the 1992 removal action. EPA contractors collected extensive data on the contaminated soils in the historic tailings pond. Some of this data is summarized in Ecology and Environment's "Sample Activities Report" dated August 1993. EPA's data is further summarized in the "Final Risk Assessment CSMRI site", December 1993, prepared by Ecology and Environment Inc. Both of these documents are in the Administrative Record for the site and therefore the data summaries are not included in this report.

- CEC collected soil samples from the stockpiled soils in January and February 1995. This sampling was conducted in accordance with the Sample and Analysis Plans for the CSMRI site, dated January and February 1995.

- Supplemental sampling to CEC work collected in May 1995 by the State of Colorado and Steffen Robertson and Kirsten, Consulting Engineers and Scientists (SRK).

The reader is referred back to Section 2.3.1.8 to review this data.

In reviewing and evaluating the data it is clear that all three sources of data are remarkably consistent, especially considering the fact that the analyzed matrix is soil (soil contamination is commonly highly variable) and the data was collected over several years and analyzed by different laboratories. General conclusions regarding the data with respect to possible waste classification are presented below.

Radiochemistry - CEC's radiochemistry results show that radiological isotopes present in the stockpile soils are in secular equilibrium. Beginning with the Uranium-238 decay chain, this conclusion of secular equilibrium is supported by the fact that the Uranium-238, Uranium-234 and Thorium-230 are at approximately the same activity level. Additionally, the Radium-226 and the Lead-210 are at approximately the same activity level. Furthermore, even though the data is from different sample volumes, a review of EPA's risk assessment data (Table B.1) shows that the Lead-214 average activity level (30.6 picocuries per gram) is approximately equal to CEC's Radium-226 data taken on the distinct physical units (average 25 picocuries per gram).

CEC's Uranium-238, Uranium-234, and Thorium-230 versus the Radium-226 data shows a difference in activity level (since this data was biased to increase the activity level of the soil sample this data set should be viewed in that context i.e., the Radium-226 value is much lower for a non-biased sample). This data suggests that some extraction and removal of uranium and thorium or the addition of radium could have taken place. However, this disequilibrium could also be explained by natural weathering or by a natural disequilibrium in specific ores brought to the site. This indicates that some research and experimentation with small quantities of source material occurred (see also operational history regarding the quantity of uranium and thorium work in comparison to other mineralogical work). However, the fact that there are still elevated concentrations of uranium and thorium in the samples, coupled with the fact that many of the companies that sponsored research did not receive extracted product, indicates that some source materials are present in the stockpiles soils (Note - many of the companies that sponsored research received literature reports summarizing the results of the research not product; see for example CERCLA 104(e) information response from Exxon Coal and Minerals). The data on total percent weight uranium and thorium in the stockpile shows that the concentration of these two elements are below the .05 percent (500 milligrams per kilogram) threshold for defining source material. The .05 percent threshold is also the criterion for exemptions of Source material from Part 3 of the State radiation regulations.

The higher activity level of Radium-226 with respect to thorium and uranium isotopes further supports the conclusion that radium extraction processing was not occurring at the CSMRI site (see also operational history especially the section regarding the BOM 1916-1920 work at the CSMRI site).

Turning to the Thorium-232 decay chain, CEC's data shows that the Thorium-232 and Radium-228 activity levels are approximately the same. Since some of CEC's values are reported as "less than" a comparison to the EPA data also shows that the Actinium-228 (average 3 picocuries per gram) is approximately equal to the Radium-228 and Thorium-228. Again this data indicates that these isotopes are in secular equilibrium.

Finally, in looking at the Uranium-235 decay chain the data confirms that there is no evidence of enrichment or depletion of Uranium-235 with respect to the contaminated stockpiled soils. In addition, during the years of CSMRI's operation the technologies for concentrating Uranium-235 would also concentrate Uranium-234 and Uranium-233. The data for Uranium-234 shows this isotope to be approximately equal in activity to Uranium-238. This further supports the fact that there is no known evidence of projects at the CSMRI site involving the concentration of uranium for enrichment purposes.

As mentioned above in the operational history section there has been several unsubstantiated rumors that plutonium may have been disposed of at the site. CSMRI held licenses allowing the possession of americium and plutonium.

It appears, based on the AEC license, that the limited quantity of americium (less than 0.001 microcurie) which may have been at the site was for instrument calibration. Attachment 38. Therefore, the disposal of americium at the site is very unlikely.

In regard to plutonium use at the site it appears that limited plutonium research did occur with regard to a project known as Rollercoaster. Project Rollercoaster appears to have involved evaluation of soils samples which contained small amounts of plutonium. The purpose of the project according to a June 10, 1968 letter (Attachment 38) was to "determine some of the affects that might be anticipated in... an HE explosion of devices containing nuclear material." The letter also describes that some plutonium in solution (0.1 millicurie) was on-site for use in instrument calibration. As mentioned in the operational history it appears that this plutonium was transported and disposed of at the Rocky Flat plants west of Denver. Nevertheless, to be conservative in the event that there where other unreported experiments using plutonium a composite soil sample from the stockpiled soils was taken and shows that the Plutonium-239 and Plutonium-240 are not in the stockpiled soil.

Organic Substances - EPA's sampling of the contaminated soils is summarized in Ecology and Environment Inc., "Sample Activities Report", August 1993. The reader is referred to this report to review all of the substances which were analyzed and not detected. EPA summarized the few organic substances which where detected in Table A.3 of the Final Risk Assessment. EPA concluded in the Final Risk Assessment for the site that these compounds were below the Preliminary Remediation Goals as calculated in EPA's Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual, Part B. Therefore, the substances in Table A.3 were not retained as contaminants of concern for EPA's Risk Assessment.

Nevertheless, from a waste definition perspective the presence of trichloroethylene (TCE) (maximum detected concentration 25 parts per billion) and tetrachloroethylene (PCE) (maximum concentration detected 9 parts per billion) are important in determining if the stockpiled soils contains Resource Conservation and Recovery Act (RCRA) regulated hazardous wastes.

The supplemental data collected by the State of Colorado and SRK show that TCE and PCE are not detected at or above 5 parts per billion in a composite sample.

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Even though the mere presence of TCE and PCE does not mean that F001 or F002 wastes were disposed of in the stockpiled soils, the EPA data does raise a question as to whether the stockpiled soils might contain RCRA listed hazardous wastes. In reviewing Ecology and Environments data summary one is struck by the fact that there are essentially no other organic compounds detected. This suggests that the TCE and PCE would likely have been used with an inorganic compound and not as a solvent for degreasing purposes. Oils and greases commonly contain organic constituents which are equally or more persistent in the environment than TCE and PCE ("F" listed RCRA waste). Moreover, CSMRI's documented compliance history with RCRA suggests that TCE or PCE which may have been used for its solvent properties or any spills were disposed of at off-site locations. Attachment 47.

Based on this data and information on the operational history and previous regulatory determinations for the CSMRI site it is reasonable to conclude that the TCE and PCE were most likely used in conjunction with the beneficiation of ore during research and experimentation (see also the summary of operational history). At the time of use the TCE and PCE were exempt from regulation under RCRA as provided in the 40 C.F.R. 261.4 (b) (7) also commonly known as the "Bevill Amendment" exclusion. This point is discussed in more detail in the waste classification section.

Additionally, based on CSMRI RCRA inspection and compliance history there is no evidence to suggest that TCE or PCE were discarded commercial products, off-specification species, container residues, and spill residues thereof ("U" listed RCRA wastes).

Toxicity Characteristic Leaching Procedure (TCLP) tests were conducted by EPA on several samples and the data indicates that no organic substances were detected in the contaminated soils.

<u>Inorganic Substances</u> - Inorganic data collected on the contaminated soil shows consistency among all data sets. Overall the concentration of inorganic substances in the stockpile are low. The site-specific risk assessment will establish the remedial action objectives/action levels for the direct ingestion exposure pathway for inorganic contaminants of concern. All proposed cleanup alternatives, other than the no further action alternative, will effectively eliminate both the ingestion and inhalation pathway for inorganic contaminants of concern.

TCLP tests for inorganic substances were conducted by EPA on several samples. Results indicate that inorganic substances are well below the regulatory concentrations established under RCRA.

for metals. The only exception is for lead which slightly exceeded the TCLP test on one of two samples tested on the finer grained portion of the stockpile (i.e., if one were to perform volume reduction there would be a risk of failing TCLP if 3/8 inch and larger soil fractions of the stockpile where separated from the 3/8 inch and smaller fraction).

The supplemental data collected on a non-biased composite sample shows that the stockpile is below the regulatory limits for TCLP metals.

Based on the above discussion and the results of the data collected on the stockpiled soils it is clear that the stockpiled contaminated soils would not be considered hazardous waste even if RCRA was applicable or relevant and appropriate to the stockpiled soil.

2.5.4 Stockpiled Contaminated Soil Regulatory Classification

As can be seen from the extensive and complex operational history the task of classifying the contaminated stockpiled soil is complex. The following discussion will evaluate all reasonable possible regulatory classifications. The universe of possible regulatory classifications include: radiactive material; special nuclear; transuranic; source material; naturally occurring radioactive material (NORM); byproduct material (11(e)(1) and 11(e)(2); low-level radioactive waste; hazardous waste; mixed waste; and solid waste. Each of these possible regulatory classifications for the stockpiled soils are discussed below in the context of the preceding operational history, analytical results, and regulatory history at the site.

The State of Colorado's environmental statutes and regulations regarding the management, storage, treatment, and disposal of solid waste, hazardous waste, and radioactive material are all based on the principle of protecting and improving the health and environment of the people of Colorado. It is important that the regulatory classification(s) applied to the stockpile ensure that the most significant hazards of the waste/material are adequately controlled.

Radioactive Material

Radioactive material is defined in the Colorado Radiation Control Act. The term means: any material, solid, liquid, or gas, which emits ionizing radiation spontaneously.

Radioactive material is also defined under RH 1.4 as any solid, liquid or gas which emits radiation spontaneously. This definition is much broader than the U.S. NRC's definition of radioactive material derived from the Uranium Fuel Cycle. The State of Colorado was given "primacy" for Colorado's radiation control program in 1968. With the exception of Nuclear Power Plants and

Radioactive material is also defined under RH 1.4 as any solid, liquid or gas which emits radiation spontaneously. This definition is much broader than the U.S. NRC's definition of radioactive material derived from the Uranium Fuel Cycle. The State of Colorado was given "primacy" for Colorado's radiation control program in 1968. With the exception of Nuclear Power Plants and Federal Facilities, the Colorado Department of Public Health and Environment, Radiation Control Division ("CDPHE-RCD") has the complete (not delegated) responsibility for the licensing of radioactive material in the State of Colorado. The provisions for licensing of radioactive material are contained in Part 3 of Colorado's Radiation Regulations.

Part 3 of Colorado's Radiation Regulations pertains to all radioactive materials with specific exemption of source material, byproduct material and certain other specific materials.

Based upon historic records the CSMRI stockpile may contain source material, byproduct material, and/or other radioactive materials. CSMRI was licensed to possess, use, and store: NORM, source material and byproduct material. The definition of NORM was added into State statute in 1993, after the term had been used in CSMRI's license.

The site operational history, EPA's and CEC's analytical data on the historic tailings pond and the stockpile, clearly show that the stockpile has solid material which emits ionizing radiation spontaneously.

The site was licensed by both the U.S. Atomic Energy Commission and the State of Colorado for numerous types of radioactive materials over several decades. CSMRI's current license (Colorado Radioactive Materials License No. 617-01S) authorizes the possession, use, and storage of NORM, source material, and byproduct material. Disposal is not authorized under CSMRI's current license. Previous licenses authorized possession and use of any radioactive materials having atomic numbers 3 through 88 inclusive, americium, and plutonium.

Source material likely has gone into the historic tailings pond, thus into the CSMRI stockpile. Depending on the interpretation of the definition of byproduct material, one can argue that some byproduct also went into the tailings. While one could argue endlessly about the entire pile being classified as one or the other, other wastes are also present.

In order for this material to be disposed of, the risks associated with the management of this material must be addressed such that workers and the public are protected in compliance with the requirements of Part 4 of the Radiation Regulations. Thus, a dose/risk assessment will need to be conducted in order for CDPHE-RCD to authorize disposal of this material.

Based upon the laboratory analyses of the material, there is a radioactive component that exists throughout the waste. The preceding operational history of the site and abundant historical regulatory actions at the site further demonstrate that the stockpile contains regulated radioactive material. The stockpile is radioactive material.

Special Nuclear Material

Special nuclear material is defined as:

- plutonium, Uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the U.S. Nuclear Regulatory Commission, pursuant to the provision of Section 51 of the Atomic Energy Act of 1954, as amended, determines to be special nuclear material, but does not include source material;

- any material artificially enriched by any of the forgoing but does not include source material. 6 CCR 1007-1, 1.4.

The data obtained by CEC and EPA indicates that the activity level of Uranium-234 and Uranium-238 are approximately equal. The data also shows that the stockpile is not enriched in Uranium-235. Therefore, the contaminated stockpiled soils do not show enrichment or depletion of key uranium isotopes.

Plutonium show is not present in the stockpiled soil.

The operational history and CERCLA 104(e) information responses do not indicate activity that special nuclear material was disposed of in the historic tailings pond.

Based on this information, the stockpiled soil is not special nuclear material.

Transuranic Waste Material

Although not specifically defined there is a provision in Part 14 of the radiation regulations which defines in part, by exclusion, the term "waste" as follows:

3. Waste materials containing transuranic elements with contamination levels greater than one hundred nanocuries (3700 bq) per gram of material;

"Transuranic" is defined as: "radionuclides with atomic numbers greater than 92. C.R.S 25-11-201 (3)(b).

The licensing history for the CSMRI site shows a very inclusive range of radioactive substances which could be possessed under the license. Specifically, the licenses Included any substances with atomic numbers 3 - 88, uranium and thorium bearing substances, plutonium and americium. Attachment 38. Plutonium and americium were the only transuranic substances authorized for use at the site. Therefore, there is no reason to believe that any transuranic elements (other than plutonium and americium) were used or authorized to be used at the site.

Based on the preceding discussion, the result showing no plutonium, and the apparent limited amounts of americium (instrument calibration sources and measuring devices), it is concluded that the 3rd provision under the "waste" definition in Part 14 of the Colorado radiation regulations does not apply to the stockpiled soils.

The stockpiled soil is not transuranic material.

Source Material

"Source material" means material, in any physical or chemical form, including ores, that contain by weight one-twentieth of 1 percent (0.05 percent) or more of uranium, thorium or any combination thereof. R.H. 1.4. Source material does not include special nuclear material. R.H. 1.4.

"Source material" likely went into the stockpile. For example, Exxon sent Source material to the site. In 1977, Exxon Minerals Company sent 189,600 pounds of sandstone ores containing .087 percent uranium oxide. These ores were sent for grinding studies only, and most was returned. Since they did not send the Source material for the extraction of uranium or thorium, the grinding research did not convert the Source material to "byproduct material."

Part 18 of Colorado's Radiation Regulations establishes procedures, criteria, and terms and conditions upon which the CDPHE issues licenses for the operation of source material milling facilities and for the disposition of byproduct material resulting from milling activities.

It could also be argued that the uranium and thorium concentration of the stockpiled soils is below the threshold required for exemption under Part 3 of the State radiation regulations.

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Based on the preceding discussion the stockpile likely contains a component of Source material. The physical reality of the stockpile does not allow for the the separation and removal of discrete amounts of Source material. Therefore, the stockpile could be classified as Source material.

NORM

NORM, or "naturally occurring radioactive material," is defined by Colorado statute as:

> any nuclide that is radioactive in its natural physical state and is not manufactured. [NORM] does not include source material, special nuclear material, or by-products of fossil fuel combustion, including but not limited to bottom ash, fly ash, and flue-gas emission by-products.

C.R.S. § 25-11-101(2.7).

There are no state regulations implementing the NORM definition. There are no federal laws regulating NORM either.

Assuming that NORM could apply to the characterization analysis for the CSMRI stockpile, the stockpile should not be classified as NORM. The statutory definition of NORM excludes source material and by-products of fossil fuel combustion. As discussed in detail above, Source material likely was placed into the historical pond and thus into the stockpile. The stockpile is also likely comprised of the by-products from the BOM coal experiment station described above. Most of the BOM activities involved the combustion of millions of pounds of coal over many years. Thus, the stockpile is not NORM.

Byproduct Material

Part 18 of Colorado's Radiation Regulations establishes procedures, criteria, and terms and conditions upon which the CDPHE issues licenses for the operation of source material milling facilities and for the disposition of byproduct material Part 18 of the state radiation regulations provide licensing requirements for the "disposition of byproduct material from milling activities." R.H. 18.1.1. The state radiation regulations define "Byproduct material" in two ways:

- Any radioactive material, except special nuclear material, yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material; and

- The tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium or thorium solution extraction processes. Underground ore bodies depleted by these solution extraction operations do not constitute "byproduct material" within this definition.

R.H. 1.4.

The State definition is modeled after the federal Atomic Energy Act of 1954 (AEA) and its definition of byproduct material. 42 U.S.C. § 2014(e). Material regulated under the first part of the definition is commonly referred to as "11(e)(1) material," while material regulated by the second part of the definition is commonly referred to as "11(e)(2) material." These references are based on the definitional sections of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), which amended the AEA and added these two definitions of by-product material.

Based on the discussion in the "special nuclear material" section above, the stockpile is not 11(e)(1) material.

The main issue for determining whether the stockpile contains 11(e)(2) material is whether "ore processed primarily for its source material content." It is clear that there was some extraction and concentration of uranium and thorium at the site throughout its history for research purposes. Whether this was "primarily" for its source material content is open to argument.

The Experimental Plant and the CSMRI facility were operations that experimented and researched many different types of ores for many purposes. As explained in the operational history, only 11 of 2,271 projects were listed as for uranium or thorium extraction or concentration from Source material. That is less than 1 percent or .00048 percent of all projects. Given that this is a random sample, it should be representative of the materials found in the stockpile. Based on the preceding discussion, it could be argued that the stockpile contains a component of 11(e)(2). By-product material.

Given the statistical evaluation and the general operational history described above, it is clear that extraction of uranium and thorium was a <u>very small</u> part of the research conducted at the site. However, the physical reality of the stockpile does not allow for the the separation and removal of discrete amounts of by-product material. The stockpile could potentially be classified as By-product material. The radium concentration in the stockpile from that potential byproduct material may be less than 5 picocuries per gram over background. However, the total radium 226 concentration is high enough to justify special handling.

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Low Level Radioactive Material

Part 14 of the Colorado radiation regulations establishes licensing requirements for land disposal of low level radioactive waste. R.H. 14.2 states that: "waste" means radioactive waste other than:

- Waste generated as a result of the defense activities of the federal government or federal research and development activities;
- High level waste such as irradiated reactor fuel, liquid waste from reprocessing irradiated reactor fuel, or solids into which any such liquid waste has been converted;
- Waste materials containing transuranic elements with contamination levels greater than one hundred nanocuries (3700 bq) per gram of material;
- Byproduct material as defined in Section 11(e)(2) of the "Atomic Energy Act of 1954", as amended on November 8, 1978:* or
- Waste from the mining, milling, smelting, or similar processing of ores and mineral-bearing material primarily for mineral other than radium;*

*The disposal of these material is licensed under Part III of the regulations.

In evaluating the elements of this definition of waste it is apparent that elements 1 and 5 are important with respect to the stockpiled soils. Regarding element 1 of the definition, it is clear from the operational history that much of the work conducted at CSMRI was for federal research and development activities. In fact 33 different federal agencies where clients of CSMRI and many of these clients had multiple projects. This exclusion of federal research and development is especially relevant to the 1916-1920 BOM work. Of equal importance regarding the BOM work is the fact that the pitchblende ore work at the experimental plant was not primarily for the purposes of radium extraction. As discussed in the operational history, the Experimental Plant was only used to grind and separate higher grade pitchblende ore from lower grade ore. No processing or extraction of radium took place at the site.

The beneficiated pitchblende ore was sent to the National Radium Institute in Denver. Once at the National Radium Institute the BOM processed the ore; removing uranium oxide for its possible utilization in special steels for ordnance. The National Radium Institute also gave extracted radium to Mr. Dupont who in turn donated the radium to hospitals.

In addition, as shown in the operational history, there are no other known projects which involved radium work. Under element 5 of the definition of waste there is a clear exclusion of ores and mineral-bearing material work on substances other than radium. The operational history shows thousands of projects on ores and mineral-bearing substances which are not for radium processing. Finally as previously discussed the analytical data on the stockpiled soils supports the operational history in that the data shows the radium isotopes to be approximately equal to or greater than corresponding uranium and thorium isotopes. No extraction of radium took place at the site.

Based on the above discussion and the other information presented in this document it is abundantly clear that the stockpiled soils at the CSMRI site fit the exclusion under the definition of waste provided in Part 14. Therefore, the stockpiled soils are not low level radioactive waste.

Hazardous Waste

The federal statute governing the treatment, storage and disposal of hazardous wastes is the Federal Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act (RCRA) of 1976, as amended. The regulation for implementing the hazardous waste portion of RCRA are known as the Subtitle C regulations. Subtitle C regulations became effective on May 19, 1980.

There are many criteria and exemptions which affect the implementation of Subtitle C of RCRA. Of particular significance with regard to the CSMRI stockpiled soil is an amendment of November 19, 1980 which excluded "solid waste from the extraction, beneficiation and processing of ores and minerals (including coal), including phosphate rock and overburden from mining of uranium ore." This amendment is commonly known as the Bevill Amendment and was put into place until EPA could make a final determination on how to handle certain mining related wastes. Since 1980 there have been several studies and actions to delineate which mining related wastes would remain exempt from being regulated as hazardous waste. From 1980 to 1989 the Bevill exclusion exempted all solid waste from the exploration, mining, milling, smelting, and refining of ores and mineral. In September 1989 EPA promulgated a final rule which removed all but 20 mineral processing wastes from exclusion from being regulated as a hazardous waste. CSMRI operations at the site ceased by 1987. Currently, all extraction and beneficiation processes relating to ore and mineral bearing substances are still excluded from being regulated as hazardous waste.

Under RCRA Subtitle C a non-exempt waste can be considered hazardous if any of the following factors apply to the substance if: it is a listed hazardous waste; it shows the characteristic of ignitability; it shows the characteristic of corrosivity; it shows the characteristic of reactivity; or it shows the toxicity characteristic.

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With regard to the CSMRI stockpiled soils, at the time of disposal all of the activities described in the operational history of the site indicate that the contaminated soils are covered by the Bevill exemption and are therefore not defined as hazardous waste. This conclusion that the stockpiled soils meet the criteria for exemption from regulation as a hazardous waste was previously independently determined by the Colorado Department of Health between 1985 and 1988. Attachment 21.

Notwithstanding the fact that the stockpiled soils are excluded from being regulated as hazardous waste a review of the factors that apply to non-exempt materials shows that the stockpiled soils still would not be classified as hazardous waste. Specifically, the stockpiled soils do not contain listed wastes. The stockpiled soil does not have enough organic material to be considered ignitable. The stockpiled soils are not corrosive. The stockpiled soils do not have high enough level of sulfide to be considered reactive. The stockpile soils do not show characteristics of toxicity (i.e., are below TCLP limits).

Based on the above discussion the stockpiled soils are not hazardous waste.

Mixed Waste

The preceding discussions regarding hazardous waste applicability to the stockpiled soils adequately shown that the stockpiled soils are not hazardous waste and do not fall within the any specific definition of radioactive material or waste. Therefore, the stockpiled soils are not mixed waste.

Special Solid Waste

The federal and state solid waste laws and regulations are very broad in scope and can govern almost any discarded material. Under Colorado state regulations solid waste means:

> "any garbage, refuse, sludge from waste treatment plant, water supply treatment plant, air pollution control facility, or other discarded material..". 6 CCR 1007-2, 1.2.

The contaminated stockpiled soil meets this definition.

The definition of solid waste goes on to exclude " .. materials handled at facilities licensed pursuant to the provisions on "Radiation Control Act" in Title 25, Article 11, Colorado Revised Statutes..". 6 CCR 1007-2, 1.2.

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This provision of the definition eliminates duplicative regulation of a single facility. While the CSMRI facility did have general licenses to handle, store and possess radioactive materials, the facility did not have a license to dispose of radioactive material. Therefore, the stockpiled soils are not currently subject to a disposal license and are not excluded from the definition of a solid waste. In addition, this exclusion language in the solid waste regulation does not exclude all solid wastes handled or generated at a licensed facility. It only excludes those materials which are regulated under the radiation control act and regulations.

From the operational history it is very apparent that the site was a mining and mineralogical research facility. The solid waste regulations can govern mining and milling wastes. However, the definitions of mining and milling waste are premised on the fact that the solid waste must be an industrial waste. Under the solid waste regulations "Industrial waste" means:

> " ... all solid wastes, including mill tailings and mining wastes, resulting from the manufacture of products or goods by mechanical or chemical processes.." (emphasis added). 6 CCR 1007-2, 1.2.

The CSMRI site did not develop or generate products or goods. Therefore, the residual materials that went into the tailings impoundment/current stockpiled soil are not industrial waste and therefore can not be considered mining or milling waste.

The solid waste regulations define the term "residual sludge" as:

> "... solids, semi-solids or liquids remaining in a waste impoundment after final evaporation or other treatment or storage of the waste is completed, or which may be dredged out during the active life." 6 CCR 1007-2, 1.2. The stockpiled soils can be considered as residual sludge under the state solid waste regulations.

In addition, the stockpiled soils can be defined as "special waste. Special waste means:

> "... a solid waste which may require chemical analysis prior to acceptance which may require special handling or disposal procedures. Special wastes include but are not limited to: asbestos, bulk tires or other bulk materials, biomedical wastes, SLUDGES and CONTAMINATED SOIL." (emphasis added). 6 CCR 1007-2, 1.2.

The term "special waste" does not mean that the waste is a hazardous waste. Special wastes are simply those wastes which need to be more thoroughly evaluated and handled prior to disposal. This special handling ensures that disposal can be done in a manner protective of human health and the environment.

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It is clear that the stockpiled soils contain low concentrations of radioactive materials. For this reason it would not be appropriate to simply handle the stockpiled soils as residual sludges. Rather the stockpiled soils could be handled as a special solid waste to protect human health and the environment. The stockpiled soils could be classified as special waste.

Conclusion

The preceding discussion outlines complex regulatory, operational and technical information regarding the contaminated stockpiled soils. The lengthy and varied operational history makes it difficult to narrowly classify the stockpiled soils. This does not in any way indicate that the stockpiled soil somehow escapes being safely and properly regulated. On the contrary, it simply means that a more broad definition is needed to most accurately classify and manage the stockpiled soils.

The preceding analysis has shown the following:

- The stockpiled soils contain radioactive material at very low concentrations.
- The stockpiled soils are not special nuclear, transuranic with respect to plutonium and americium, low-level radioactive waste, NORM, hazardous waste, or mixed waste.
- Portions of the stockpiled soils could potentially be considered source material and/or by-product material.
- The stockpiled soils could be considered special solid waste.

This report recommends that the stockpiled soils be managed and classified as special solid waste. The two driving factors are the minimal amount and concentration of source and possibly by-product material in the stockpile and the relatively low concentrations of radiactivity in the stockpile. The stockpile is composed of materials that could be exempted from the radiation control regulations. With certain conditions, radiation hazards are able to be addressed in disposing of the material as a special solid waste.

Both federal and state laws and regulations allow considerable discretion in applying the laws and regulations governing radiological matierials. The analysis performed here provides adequate rationale and justification to utilize this discretion and to allow disposal of the stockpile soils as special solid waste. This descretionary approval is contingent on the assessment of the dose and risk to workers and the public for the location where ultimate disposal will take place. Once this evaluation is approved, then under the existing radioactive materials license and Section 3.22, 4.33, and 4.34 of the radiation control regulations, disposal of the stockpiled soils can be authorized.

Under both federal and state law the broad general authority to protect human health and the environment is provided under the regulatory authority of the federal RCRA Subtitle D regulations and the state regulations pertaining to solid waste disposal facilities. These regulations allow those technical measures to be put into place which prevent risks to human health and the environment. In essence the solid waste rules and regulations allow the stockpiled soils to be handled and disposed of utilizing a risk-based approach which is consistent with the mandates established in CERCLA and the NCP.

Solid waste disposal sites and facilities must comply with the health laws and standards, rules and regulations of the Colorado Department of Public Health and Environment, the Water Quality Control Commission, the Air Quality Control Commission, and all applicable local laws and ordinance. 6 CCR 1007-2, Section 2.1.1. No facility shall constitute a hazard to human health. 6 CCR 1007-2, Section 2.1.3. Consequently, in order to ensure protection of human health and the environment, and to be consistent with the discretionary authority provided under the radiation control regulations, the disposal of the stockpiled soil at an approved solid waste facility will require the application of certain substantive portions of the radiation control regulations during the handling, transportation, and disposal of the stockpiled soil.

The stockpiled soil consists of materials that may not require a radioactive materials license to be disposed of. However, the removal action must be performed in compliance with certain substantive sections of the radiation control regulations. The solid waste disposal act and regulations can provide the general framework to be used in determining the appropriate technical and procedural disposal criteria for both on-site and off-site alternatives. The radiation control regulations will be used to modify the technical and procedural requirements of the solid waste regulation to ensure protection of human health and the environment for the radioactive elements in the stockpiled soils. The necessary modifications to the technical requirements of the solid waste regulations will require that the radiation control regulations be used as a guide for determining technical and procedural disposal criteria. This will ensure protection of human health and the environment.

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3.0 Identification of Removal Action Objectives

3.1 Scope of the Removal Action

In accordance with UAO, the scope of the RA is to abate the release or threat of release of hazardous constituents from the waste pile. The UAO specifies a goal of off-site disposal for the waste. However, several on-site and near-site RA alternatives could be implemented to abate the release or threat of release of hazardous constituents from the waste pile. Therefore, this RAOA report also includes on-site RA alternatives.

3.2 Removal Action Schedule

The RA schedule provided in Figure 3-1 is consistent with the UAO schedule as amended by the March 27, 1995 letter from EPA to Mr. Rick Brown. The public review and comment period is assumed to begin 14 days after issuance of the RAOA Report on June 12, 1995 and last for 30 days. The EPA review and approval cycles are generally assumed to be 14 days in duration.

3.3 Applicable or Relevant and Appropriate Requirements

The tables in the following sections summarize the federal and state applicable or relevant and appropriate requirements (ARARs) which have been incorporated into the RAOA. In a time-critical RA such as this one, ARARs are to be attained to the extent practicable considering the exigencies of the situation involved (40 CFR 300.415). For the convenience of the reader, the ARARs are separated for the off-site and on-site RA alternatives. The methods of attainment of the specific ARARs are addressed in Chapter 4.0 for each RA alternative under consideration.

3.3.1 Off-Site Removal Action Alternatives

The ARARs for the off-site RA alternatives including the action-specific and chemical-specific requirements for all media are provided in Tables 3-1 and 3-2. Several requirements, which are not strictly ARARs because they constrain activities which take place off site, are included for the convenience of the reader. An example of this would be the inclusion of the regulations under 6 CCR 1007-1 Part 18 pertaining to the disposal of uranium mill tailings within the State.

3.3.2 On-Site and Nearby Off-Site Removal Action Alternatives

The ARARs for the on-site and nearby off-site RA alternatives including the chemical-specific, action-specific, and location-specific requirements for all media are provided in Tables 3-3 through 3-6.

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4.0 Identification and Analysis of Removal Action Alternatives

The following removal action (RA) alternatives have been developed to abate the potential health hazard presented by the stockpile:

Alternative 1 - No Action/Institutional Controls

Alternative 2 - On-Site Options

- Alternative 2A - In-Place Closure - This alternative leaves the stockpile in the same location and includes an in-place closure with a capping system and a subsurface vertical barrier to prevent contamination of groundwater (Figure 4-1).

- Alternative 2B - Above-Ground Repository - This alternative includes the development of an engineered repository at the current stockpile location that has both a bottom liner system and a top capping system (Figure 4-2).

Alternative 3 - Nearby Off-Site Options

- Alternative 3A - Below-Ground Repository - This alternative includes the development of a below-grade engineered repository in the baseball field just east of the stockpile (Figure 4-3) or alternatively in the western most practice field just southeast of the stockpile.

- Alternative 3B - Below-Ground Repository with Waste Stabilization/Solidification - This alternative includes the development of a below-grade engineered repository in the baseball field just east of the stockpile (Figure 4-4) or alternatively in the western most practice field just southeast of the stockpile. It also includes treatment of the waste prior to placement using a mixture of cement and fly ash for stabilization/solidification (S/S) to reduce toxicity and mobility of the contaminants.

Alternative 4 - Off-Site Commercial Disposal Facility Options

- Alternative 4A - Envirocare of Utah, Inc. - This alternative includes the removal of the stockpile from its current location, transportation of the waste on public roads and/or railroads, and disposal at this licensed facility in Clive, Utah.

- Alternative 4B - Umetco Minerals Corporation - This alternative includes the removal of the stockpile from its current location, transportation of the waste on public roads, and disposal at this licensed facility in Uravan, Colorado.

- Alternative 4C - Solid Waste Landfills - This alternative includes the removal of the stockpile from its current location, transportation of the waste on public roads, and disposal as a special solid waste at licensed facilities in Colorado. Specific licensed facilities currently being considered include Browning Ferris Industries' (BFI) Foothills Landfill, approximately 6 miles north of Golden; Conservation Services Inc.'s (CSI) industrial waste landfill about 50 miles east near Bennett; and Laidlaw Waste Systems' (Laidlaw) Denver Regional Landfill about 40 miles north in Weld

County. In addition, other eligible solid waste disposal facilities may request consideration for disposal of the stockpiled materials at their facility. Consequently, solid waste disposal facilities listed above should be considered as representative for comparison purposes but are not inclusive of all potential off-site disposal options.

4.1 Common Removal Action Elements

Elements that are common to most of the RA alternatives (except for Alternative 1 - No Action/ Institutional Controls) are presented below.

4.1.1 Work Plan Preparation - Once EPA selects the RA, a Work Plan will be required to be submitted to EPA. The elements of that Work Plan will vary with the selected alternative but will, at a minimum, include the following:

- Materials handling and storage including on-site handling and excavation of the waste materials, equipment to be used, work/staging areas, and equipment and personnel decontamination areas.
- Confirmatory sampling, analysis, and disposal plans for the stockpile and underlying material including sampling methodology, air monitoring, radiation monitoring, equipment and personnel decontamination criteria and procedures, analytical procedures, quality assurance/quality control, and data validation.
- Health and safety plan update including training and medical monitoring requirements for workers, personal protective equipment, evacuation procedures, emergency response, site security, access, and organization and responsibility.
- Engineering designs including, at a minimum, specifications, plans, final configuration of the affected areas, dust suppression, erosion control, and revegetation.
- Community participation plan update including measures to be taken for dissemination of information to relevant agencies, organizations, groups, and communities; schedule of public meetings; and measures to receive comments regarding the RA.
- Transportation approaches including work force access, deliveries of supplies and materials, and transportation of waste materials from the site (if off-site removal action selected) including proposed routes, placarding, dust suppression, and permit requirements.
- Reporting requirements including periodic reports detailing site activities, project schedule, summary of materials handled, health and safety activities, and injury/accidents on site, and a final report providing the details of the RA and results of all confirmatory samples.

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4.1.2 Mobilization Activities - Mobilization activities for each alternative will typically include the following:

- Installation of trailers for site personnel and equipment associated with RA contractor, project management, health and safety, personnel decontamination, and oversight activities.
- Modification of temporary fencing system to accommodate work area needs.
- Installation of temporary utilities such as electricity, telephone, etc., as necessary.
- Installation of the perimeter air monitoring system.
- Installation of temporary bench marks and land survey grid points.
- Modification of the site security and access system.
- Construction of a temporary access from U.S. Highway 6 to the site if appropriate.
- Implementation of a vehicle parking policy.
- Construction of an equipment and vehicle decontamination pad.
- Construction of a storm water management system including temporary erosion and sedimentation control measures (silt fences, catch basins, etc.).

4.1.3 Dust Suppression/Perimeter Air Monitoring

Regardless of the RA alternative selected, dust suppression activities and perimeter air monitoring will be performed. Dust control procedures that will be used during excavation and handling of materials, stockpile development, and S/S processing (if selected) will include the following:

- Using water hoses with mist or fog nozzles to spray light applications of water over the work area during excavation activities.
- Using water hoses or water trucks to spray areas which are extensively used by equipment and enforcing reduced speed limits for construction equipment.
- Minimizing use of disturbed areas during extended nonoperational periods.

Fresh water or water collected during storm water management or volume reduction activities will be used for dust control on areas containing contaminated soil. Only fresh water will be used on areas that are uncontaminated.

A perimeter air monitoring system will be designed and installed. With the exception of Alternative 1, the system will require electricity (generators or an electric line) around the perimeter of the site and will consist of high-volume particulate air samplers to monitor particulate emissions and regulated air samplers to monitor radioactivity emissions. Alternative 1 will use a passive canister type air monitoring system for gamma and radon measurement.

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4.1.4 Material Transportation

Each of the alternatives, other than no-action/institutional controls, requires a significant amount of material transportation to and from the site. Expectations are that access will occur via U.S. Highway 6. If that access is not secured, then access will be required via 12th Street and other public roads within the City of Golden. A summary of the minimum estimated truck visits to the site are as follows:

- Alternative 1 - No Action/Institutional Controls - Less than 10 trucks will be necessary to implement this alternative.
- Alternative 2A - In Place Closure - 1,300 trucks bringing equipment/materials and liner/cover materials to the site. About 800 trucks will be required for clay, 300 for sand/filter material, 180 for rock, and the remainder for equipment and other materials.
- Alternative 2B - Above-Ground Repository - 2,000 trucks bringing equipment/materials and liner/cover materials to the site. About 1,100 trucks will be required for clay, 700 trucks for sand/filter material, 180 trucks for rock, and the remainder for equipment and other materials.
- Alternative 3A - Below-Ground Repository - 2,200 trucks bringing equipment/materials and liner/cover materials to the site. About 950 trucks will be required for clay, 650 trucks for sand/filter material, 150 trucks for rock, 450 trucks for topsoil, and the remainder for equipment and materials.
- Alternative 3B - Below-Ground Repository with Waste Stabilization/Solidification - 2,500 trucks bringing equipment/materials, cement/fly ash, and liner/cover materials to the site. About 950 trucks will be required for clay, 650 trucks for sand/filter material, 150 trucks for rock, 450 trucks for topsoil, 250 for cement, 50 for fly ash, and the remainder for equipment and materials.
- Alternative 4 - Off-Site Commercial Disposal Facilities - 1,300 to 1,500 trucks bringing equipment/materials and removing waste from the site.

The truck visits identified above are to the stockpile location. The numbers provided above must be doubled to assess the numbers of trucks that will pass any particular location along the access route selected. The number of trips to and from the stockpile will range from about 2,600 to over 5,000 as a function of the RA alternative selected.

Two potential alternative access routes to the stockpile are presented in Figure 4-5. Route A travels through the 12th Street historical district and downtown Golden, whereas Route B would have a direct access to Highway 6.

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The 12th Street historical district is a residential community. Truck access through the residential community may require limited operating hours depending on local and county ordinances. Excess noise and vibration impacts may occur to the local residential community.

Route A exits the site at the 12th Street and Maple Street access point, travels north on Maple Street to 11th Street, and then east on 11th Street to Washington Avenue. Truck traffic would then continue north on Washington Avenue and exit eastbound on Highway 58 toward Interstate 70.

Route B includes construction of a temporary road and access point south of the stockpile along U.S. Highway 6. The south edge of the stockpile is located within 200 feet of U.S. Highway 6. Access can be accomplished by placing a culvert in the tributary of Chimney Gulch which parallels the highway. Preliminary sizing indicates that a 36-inch culvert will be adequate to maintain drainage. Once the culvert is placed, a crushed rock road base material can be used to construct the fill and the access road to the highway.

U.S. Highway 6 is a Category 2 highway with heavy traffic which will require deceleration and acceleration lanes before and after the access point, respectively. Heavy traffic, along with the sharp curve and steep grade conditions, may pose a safety risk, although flagmen and possibly a temporary traffic light may reduce the safety concerns. The CSMRI Remedial Project Manager for the State of Colorado (Mr. Rick Brown) met with a Colorado Department of Transportation (CDOT) representative (Mr. Philip B. Demosthenes) in May 1995 to discuss the feasibility of obtaining a permit to build a temporary access road to the site from U.S. Highway 6. The initial reaction of CDOT was that the access road was feasible; however, additional study would be required.

If Route B is approved by CDOT, the trucks would enter and exit the site directly from and onto westbound U.S. Highway 6. From U.S. Highway 6, transportation routes to each disposal facility vary according to location.

4.1.5 Groundwater Monitoring System - Element Common to Alternatives 1, 2, and 3

Four groundwater monitoring wells will be installed as part of Alternatives 1, 2, and 3. One monitoring well will be placed hydrogeologically upgradient of the stockpile or selected repository and three wells will be placed downgradient. Groundwater sampling will occur on a quarterly basis. After the first 5-year review period, the frequency of sampling and the suite of analytes will be assessed and reduced appropriately. The groundwater monitoring program will be conducted for a 30-year remedy operation and maintenance (O&M) period with reviews every five years.

4.1.6 Water Main Relocation - Element Common to Alternatives 1 and 2

As is evident from Figure 2-1B, there is a 16-inch high pressure water main under the stockpile. It is owned and maintained by the City of Golden and is part of their raw water supply to their potable water treatment system. The line will have to be relocated if Alternative 1 or 2 is selected. For Alternative 1, the relocation will mean that 450 feet of pipe will be replaced and for the Alternative 2 options, the relocation will mean that 850 feet of pipe will be replaced. For any of the other alternatives, the line will be monitored in conjunction with the City of Golden to prevent its damage or rupture during the RA.

4.1.7 Liner/Capping Systems - Elements Common for Alternatives 2 and 3

In Alternative 2A, the existing 1-foot thick clay liner under the stockpile will be extended laterally and waste material will be placed on it out to the limits shown in Figure 4-1. The conceptual design detail for that liner extension is presented in Figure 4-6 (Detail A) and consists of subgrade preparation (including compaction to prevent settlement), placement of a compacted clay liner unit, and careful placement of about a foot of stockpile material over the clay liner to protect it from equipment damage during controlled placement and compaction of additional stockpile materials.

For Alternatives 2B, 3A, and 3B, a composite multimedia liner system will be constructed which has the following elements (from bottom to top):

- A prepared subgrade of worked and compacted native soil.
- A 12-inch layer of compacted clay that achieves a maximum permeability of 1×10^{-7} centimeters per second.
- A composite synthetic liner system with a textured 60-mil high density polyethylene (HDPE) secondary liner, drainage net, and textured 60-mil primary liner. The drainage net will provide for leachate detection. In lieu of a compacted soil liner with an overlying geomembrane synthetic liner, the secondary liner system may be comprised of a geosynthetic clay liner which is composed of a bentonite clay layer bonded to a geomembrane.
- A protective soil cover over the composite liner system consisting of 18 inches of material having a minimum permeability of 1×10^{-2} centimeters per second. A leachate collection system will be installed into this protective cover.

An alternative design approach to this liner system could be a 24-inch thick compacted clay liner with no synthetic liner system. The system used in these conceptual design efforts is the more costly of the alternatives considered. In any event, the liner system will be designed to drain to a sump that will collect any leachate, so that it could be removed and treated off site.

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The conceptual design detail for this composite synthetic liner system is presented in Figure 4-6, (Detail B -Typical Liner System). HDPE liners have been used routinely during the last 20 years and have been studied extensively relative to their durability. An EPA ad hoc committee on the durability of polymeric landfill lining materials has concluded that polymeric landfill lining materials should maintain their integrity in waste disposal facility environments in "terms of hundreds of years" (Haxo and Haxo, 1988). Based on their investigations, Tisinger and Giroud (1993) concluded that in a properly designed and constructed facility, HDPE geomembranes should be able to protect groundwater from leachate for hundreds of years. Regardless, there are varying opinions regarding the longevity of synthetic liners. Consequently, the use of both HDPE and compacted clay in the liner and capping systems is appropriate for this conceptual design, particularly if the facility must have a minimum effective life of 200 years.

Lastly, a capping system as described in Figure 4-6 (Detail C - Typical Engineered Capping System) will be constructed for Alternatives 2 and 3. This system is designed to:

- Mitigate radon gas emanation.
- Protect the waste materials from surface water erosion.
- Promote runoff of precipitation and protect the waste from infiltration of surface water.
- Provide resistance to damage of the cover and stockpile integrity from burrowing animals or root penetration (biointrusion).

The components of the capping system include the following (from bottom to top):

- A 32-inch compacted clay layer.
- A textured 40-mil HDPE liner with geotextile fabric above and below.
- A 12-inch layer of sand/filter material.
- A 6-inch layer of rock armor (riprap) with a d_{50} of 3-inches.

The 32-inch compacted clay layer will be impervious and serve as a radon barrier and as a bedding unit for the HDPE liner. The 32-inch thick layer of compacted clay was modeled using RESRAD a commonly used model which is designed to determine the extent that the capping layer will mitigate radon migration. The results of that analysis are provided in Appendix H and demonstrate that this thickness is adequate for use in this conceptual design. Compacted clay will provide an adequate barrier to radon emanation, is durable, and will meet the longevity requirements for the disposal repository. The HDPE liner unit is a conservative feature of the capping system that will augment the clay layer for radon gas mitigation and further reduce the potential for surface water infiltration into the underlying materials. As discussed above, HDPE liners are durable and if designed and constructed properly will last for hundreds of years.

The 12-inch layer of sand/filter material will serve to protect the HDPE liner from damage and as a drain for any precipitation that falls on the disposal facility. This layer will also serve as bedding material for the surface armor covering.

The surface layer of the capping system is proposed to be a 6-inch layer of riprap with a d_{50} of 3-inches. Based on preliminary surface water runoff calculations, this layer is more than adequate to protect against erosion by precipitation or related runoff and will serve to protect the underlying layers over time. Collectively, the 12-inch sand/filter layer plus the 6-inch crushed rock layer are effective drainage layers and an effective unit to prevent biointrusion into the waste materials.

4.1.8 Institutional Controls and Operation and Maintenance Activities - Elements Common for Alternatives 1, 2 and 3

Institutional controls for the on-site or nearby off-site RA options will be developed during a final design effort, but would be expected to include deed restrictions and access restrictions to the waste at a minimum. Other examples of controls could include fencing and signage.

The period of active O&M for Alternatives 1 through 3 will be 30 years. Primary O&M activities will consist of the following:

- Groundwater Monitoring - This activity will include the periodic measurement of groundwater levels and collection of water samples for laboratory analysis. Initially, these activities will occur on a quarterly basis. However, as data are accumulated and trends become established and more predictable, the monitoring wells will be sampled less frequently and for fewer parameters (only representative target parameters).

- Periodic Inspections/Maintenance - Inspections and maintenance activities will be performed on a quarterly basis to confirm that the fencing and related signage is intact, the capping system is undisturbed and in proper condition, and to remove any trash/vegetation that has accumulated within the fenced enclosure, and to check if sumps associated with the liner systems contain any leachate. For Alternatives 2B, 3A, and 3B, the leachate detection and collection systems will be examined to determine if and how much leachate has been generated. For Alternatives 3A and 3B that result in repositories in the baseball field or alternatively in the western most practice field, a number of the O&M activities will be abbreviated because there will be no maintenance or replacement of fencing necessary and the capping system will not be exposed.

- Fencing Replacement - For Alternatives 1 and 2, the perimeter fencing will be replaced every 15 years.

- Five-Year Reviews - There will be five-year reviews necessary to assess the effectiveness of the selected removal action during the 30-year O&M period.

Additionally, for Alternative 1, a gamma and radon monitoring system will be installed and maintained monthly to measure the levels of these types of radiation at the boundaries of the stockpile for comparison with a background station.

4.2 Removal Action Alternatives

4.2.1 Alternative 1 - No Action/Institutional Controls

This alternative provides a baseline against which to compare other alternatives. However, for this site, some action will be required which can occur in a two week period. Specifically, the following institutional controls and air and groundwater monitoring activities will occur as part of the no-action/institutional controls alternative:

- Relocation of the water main.
- Installation of a permanent security fence in lieu of the temporary fencing that currently surrounds the site to prevent public access.
- Implementation of other institutional controls such as prohibition of construction and selected land uses on or immediately adjacent the stockpile.
- Implementation of an air monitoring program to provide information regarding potential exposures to nearby residents or users of the adjacent recreational facilities and to use in the periodic reviews.
- Installation of a groundwater monitoring system to provide information regarding potential contamination of the groundwater and to use in the periodic reviews.

4.2.2 Alternative 2 - On-Site Options

4.2.2.1 Alternative 2A - In-Place Closure

This alternative limits the need for extensive materials handling or disturbance of the stockpile. Components include grading to minimize erosion potential, placement of a vertical subsurface barrier (slurry wall) to minimize lateral migration and contact with groundwater by any leachate that may develop, and installation of a capping system that addresses surface water infiltration into the stockpile and/or fill materials underlying the stockpile and meets the long-term stability requirements. This alternative is described in plan and cross-section views in Figure 4-1 and can be constructed in eight weeks. It consists of the following activities, sequence, and features:

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- Relocate the water main.
- Mobilize as described in Section 4.1.2 including setting of temporary fencing to include the appropriate work areas for this RA alternative.
- Relocate Chimney Gulch.
- Construct a slurry wall around the perimeter of the stockpile shown in Figure 4-1.
- Extend the clay liner currently under the stockpile to the limits shown in Figure 4-1 (Figure 4-6, Detail A) and tie the liner to the slurry wall.
- Regrade and compact the pile to achieve 3 horizontal to 1 vertical side slopes in the general configuration shown in Figure 4-1.
- Construct the capping system (Figure 4-6, Detail C).
- Install a groundwater monitoring system inside and outside of the subsurface barrier system.
- Install the permanent security fencing and signage.
- Demobilize.
- Implement institutional controls.
- Initiate O&M activities.

As shown in Figure 4-1, Chimney Gulch will be impacted by this alternative. As discussed in Section 2.1.4, Surface Water Hydrology, the Chimney Gulch channel is eroding in the reach adjacent the stockpile. Additionally, in order to develop the in-place closure with the slopes shown in Figure 4-1, the channel will have to be moved up to 40 feet to the west so that it does not encroach on the repository. As a consequence of these factors, the channel will require long-term stabilization in the form of regrading, paving and placement of a riprap lining.

A soil-bentonite slurry wall is proposed as part of this alternative to control any leachate that may develop from the stockpile or underlying fill materials. Although, there is no detailed subsurface information available for the proposed slurry wall alignment, the subsurface investigation work that occurred in the baseball and practice fields show that conditions in that area to about 100 feet to the east may be acceptable for slurry wall construction. The slurry wall will be constructed from the ground surface and keyed into the underlying Pierre Shale to form an impervious barrier to the groundwater flow. The slurry wall will be constructed before regrading work occurs on the stockpile.

Once slurry wall construction is completed, the foot print of the stockpile will be extended to the limits shown in Figure 4-1. This will be accomplished by grading and subbase compaction, and by the extension of the 1-foot clay liner that underlies the stockpile. A typical cross section of the clay liner extension is provided in Figure 4-6 (Detail A - Typical Liner Extension).

When the clay liner extension is constructed, the stockpile will be regraded into a more stable configuration with benches and maximum side slopes of 3 horizontal to 1 vertical. This configuration will meet the long-term stability requirements, but may be susceptible to long-term erosion by surface water. As part of the regrading activities, the materials will be compacted to eliminate the potential for significant settlement of either the waste or the overlying capping system.

As grading is completed in an area, the capping system identified in Figure 4-6 (Detail C - Typical Engineered Capping System) will be installed. The clay layer in the capping system will be tied into the slurry wall to maximize containment. The final topographic configuration for this alternative is presented in Figure 4-1. In this RA, the waste is retained "on-site" as defined under CERCLA. However, a 404 permit may be necessary for the relocation of Chimney Gulch.

Lastly, groundwater monitoring wells will be installed outside the slurry wall in upgradient and downgradient locations. A single monitoring well will be placed inside the slurry wall to monitor the potentiometric surface and water quality of any leachate present, and for removal of leachate that may accumulate within the slurry wall containment.

4.2.2.2 Alternative 2B - Above-Ground Repository

This alternative is currently on-site with respect to the CERCLA permitting exemption. Components include excavation of the waste and underlying fill materials, sorting and off-site disposal of any solid waste encountered, installation of a liner system, placement of waste materials in the engineered repository, and installation of a capping system that eliminates surface water infiltration into the waste. This alternative is described in plan and cross-section views in Figure 4-2 and includes both below-ground and above-ground components. This alternative can be constructed in 12 weeks. It consists of the following activities, sequence, and features:

- Relocate the water.
- Mobilize as described in Section 4.1.2 including setting of temporary fencing to include the appropriate work areas for this removal action alternative.
- Relocate Chimney Gulch.
- Excavate an area along the south side of the stockpile and prepare it for a liner system.
- Place the liner system in the initial prepared area (Figure 4-6, Detail B).

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- Place and compact the waste in the initial prepared area.
- Continue the excavation and repository development to the north with segregation of the waste material from the underlying fill materials. The underlying fill materials will be tested and managed according to the analytical data.
- Progress the excavation and repository construction to the north.
- Grade and compact the stockpile materials to achieve 3 horizontal to 1 vertical above-grade side slopes in the general configuration shown in Figure 4-2.
- Construct the capping system (Figure 4-6, Detail C).
- Install a groundwater monitoring system on the perimeter of the repository.
- Install the permanent security fencing and signage.
- Demobilize.
- Implement institutional controls.
- Initiate O&M activities.

As shown in Figure 4-2, Chimney Gulch will be impacted by this alternative and addressed in the same manner as discussed in Section 4.2.2.1 above. Construction will commence for the repository from the south side and progress to the north. The initial excavation subgrade will be prepared and the composite multimedia liner system described in Figure 4-6 (Detail B - Typical Liner System) will be constructed.

When liner construction is completed in an area, the waste materials will be moved onto the lined area and compacted into a more stable configuration with benches and maximum above-grade side slopes of 3 horizontal to 1 vertical. As part of the detailed design a sump will be developed to collect any leachate that might be generated. During excavation, placement and grading activities, the materials will be compacted to eliminate the potential for significant settlement of either the waste or the overlying capping system. As the excavation progresses to the north, the amount of fill underlying the stockpile increases. This underlying fill will be excavated and managed according to its chemical and radiological characteristics. Underlying fill materials that are clearly solid waste will either be incorporated into the waste repository (if volume is available) or placed elsewhere. The configuration shown in Figure 4-2 is the result of a rough estimate based on an analysis using the previous topography. Additionally, as referenced in Section 2.1.5.3, the Chimney Gulch channel may have been moved more than 130 feet to the west. An evaluation of the 1939 topographic map was made with respect to more recent maps and suggests that there may be up to 10,000 to 20,000 cubic yards of fill under the stockpile. In any event, the repository configuration shown will have capacity for up to 7,500 cubic yards of the underlying fill and can be modified to account for additional fill materials by excavation of clean fill.

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As grading is completed in an area, the capping system identified in Figure 4-6 (Detail C - Typical Engineered Capping System) will be installed. The clay layer in the capping system will be tied into the liner system to maximize containment. The final topographic configuration anticipated for this alternative is presented in Figure 4-2. In this removal action, the waste is retained "on-site" as defined under CERCLA. However, a 404 permit may be necessary for the relocation of Chimney Gulch.

Lastly, groundwater monitoring wells will be placed around the perimeter of the repository in both upgradient and downgradient locations. In addition to a groundwater monitoring system in both upgradient and downgradient locations, there will be access by piping to sumps in the leachate collection and detection systems within the liner. Any leachate that collects in the sumps will be removed through this piping.

4.2.3 Alternative 3 - Nearby Off-Site Options

4.2.3.1 Alternative 3A - Below-Ground Repository

This nearby off-site option includes preparation of the repository location in the baseball field just east of the stockpile or alternatively the western most practice field southeast of the stockpile, installation of a liner system, placement of the waste materials, installation of a capping system, placement of clean fill, and return of baseball or practice field to its former use. This alternative is described in plan and cross-section views in Figure 4-3 and can be constructed in 12 weeks. It consists of the following activities, sequence, and features:

- Mobilize as described in Section 4.1.2 including setting of temporary fencing to include the appropriate work areas for this removal action alternative.
- Clear the repository site, excavate the repository, prepare the subgrade (over excavate and compact) and construct the liner system (Figure 4-6, Detail B).
- Excavate the waste, transport it to the repository, and compact it in place.
- Construct the capping system (Figure 4-6, Detail C).
- Place overlying fill and restore the baseball field.
- Install a groundwater monitoring system.
- Revegetate the former stockpile site.
- Demobilize.
- Implement institutional controls.
- Initiate O&M activities.

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As described above, the current land use is a baseball field or alternatively a practice field for the Colorado School of Mines. It is expected that after the repository is constructed it will be returned to that usage. In that regard, the capping system for the repository will be separated from the baseball field playing surface by 50 inches of clean capping material and a minimum of five feet of clean soil (including 1-foot of topsoil), and institutional controls will not require perimeter fencing or active repository capping system maintenance. Although the post-RA land use will result in sprinkler irrigation of the field to keep the grass surface green and in good condition, these activities will have little affect on the underlying repository. First, the field will be sloped to drain excess water and prevent ponding on the surface and the underlying capping system will also be sloped. Second, sprinkler irrigation typically occurs during the growing season which is also the period of time when evapotranspiration rates are highest. Third, any water that infiltrates to the capping system will be diverted laterally by the sand/filter layer to the edges of the repository. With 32 inches of compacted clay and the synthetic liner included in the capping system and the presence of an adequate slope, there will be little risk of vertical infiltration into the repository. Finally, the maintenance of a vegetative cover, such as sod, will act as a barrier to erosion and ultimately protect the underlying cap.

In addition to a groundwater monitoring system in both upgradient and downgradient locations, there will be access by piping to sumps in the leachate collection and detection systems within the liner. Any leachate that collects in the sumps will be removed through this piping.

4.2.3.2 Alternative 3B - Below-Ground Repository with Waste Stabilization/Solidification

This nearby off-site option includes components that are the same as Alternative 3A with the addition of S/S treatment activities. This alternative is described in plan and cross-section views in Figure 4-4 and can be constructed in 16 weeks. It consists of the following activities, sequence, and features:

- Mobilize as described in Section 4.1.2 including setting of temporary fencing to include the appropriate work areas for this removal action alternative.
- Clear the repository site, excavate the repository, prepare the subgrade (over excavate and compact) and construct the liner system (Figure 4-6, Detail B).
- Excavate the waste, transport it to the repository, stabilize it with S/S treatment, and compact it in place.
- Construct the capping system (Figure 4-6, Detail C).
- Place overlying fill and restore the baseball field.
- Install a groundwater monitoring system.
- Revegetate the former stockpile site.

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- Demobilize.
- Implement institutional controls.
- Initiate O&M activities.

The S/S process will require the excavation and preparation of the waste material. Preparation activities will include removal of any debris and oversized materials by screening. Debris will be surveyed using radiation survey meters, decontaminated if necessary, and released for disposal in a solid waste disposal facility or suitably packaged and disposed at a site licensed for disposal of radioactive materials. Oversized rock materials will be crushed to 2-inch minus size so that they can be fed through the pug mill treatment plant. Once prepared, the waste material will be mixed in the pug mill with water, cement and fly ash. For cost estimating purposes, the S/S treatment mixture will consist of 18 percent Portland cement and 3.6 percent fly ash.

Once mixed, the treated material will exit the pug mill, be transported to the repository by trucks or conveyors, and be compacted in the repository in 12-inch thick lifts. Subsequent to completing a section of the repository, the capping system will be constructed and the remainder of the fill placed on top of the cap. As described in Section 4.2.4, the post-RA land use will include sprinkler irrigation which will not adversely impact the long-term performance of the RA.

As described above, institutional controls will not require perimeter fencing or active capping system maintenance. In addition to a groundwater monitoring system in both upgradient and downgradient locations, there will be access by piping to sumps in the leachate collection and detection systems within the liner. Any leachate that collects in the sumps will be removed through this piping.

4.2.4 Alternative 4 - Off-Site Commercial Disposal Facility Options

Off-site landfill disposal consists of the excavation, off-site transport, and off-site disposal of the stockpile material at a licensed commercial disposal facility. Disposal of the material at an appropriate disposal facility is protective of human health and the environment in that it meets the ARARs. However, short-term impacts, particularly to human health may be realized during the material handling and transportation.

Common activities associated with the off-site disposal options include the following:

- Mobilize to the removal site, erect a temporary on-site office trailer, and fence the appropriate work areas

- Excavate the stockpile material, following appropriate health and safety measures (e.g., traffic control, dust control/air monitoring etc.)
- Determine transport methods and routes, transport the stockpile material to selected disposal facility
- Regrade and revegetate the excavation and work area(s)
- Demobilize

For the purposes of this study several representative off-site commercial disposal facilities which may accept the CSMRI stockpile material were identified. Additional off-site disposal facilities which are also suitable for off-site disposal of the stockpile material may be identified during the development of the work plan for implementation of the selected Removal Action alternative. The facilities discussed herein are intended to represent a range of potential off-site disposal alternatives.

The locations of the off-site disposal facilities range from less than 10 miles to 630 miles from the site. The disposal facilities have various licenses. Some of the facilities have licenses to accept NORM and/or by-product [11(e)-2] material, and some are solid waste landfills which can accept special solid waste.

Off-site disposal facilities which may potentially accept the CSMRI stockpile material include the following:

- Envirocare Facility in Clive, Utah
- Umetco Minerals Corporation Facility in Uravan, Colorado
- Industrial landfill [e.g., Conservation Services, Inc. (CSI) in Bennett, Colorado]
- Solid waste landfill (e.g., BFI Facility in Golden, Colorado and Laidlaw Facility in Erie, Colorado)

In addition to cost data for transportation and disposal of the stockpile material, some of the facilities provided the following:

- Facility description
- Site suitability
- Facility design and operation
- Licensing information
- Financial resources

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- Contractual information
- Qualification of key personnel and potential subcontractors

Confidential proposals received from each facility are in the State of Colorado's and private PRP's possession. Some of these proposals provided turn-key costs including work plan development, health and safety, and other direct and indirect capital costs associated with removal and disposal of the stockpile material. Others provided only disposal and transportation costs. Each of these facilities made variable assumptions for transport (e.g., number of trucks necessary to transport the stockpile material out of the site, or estimates of the bulk density of the stockpile material (ranging from 1.2 to 1.5 tons per cubic yard).

To assist the comparison of each off-site disposal facility, assumptions were made and applied to normalize the cost estimate for each facility, including:

- Maximum volume of the stockpile is 20,000 cubic yards; and
- Average bulk density of the stockpile is 1.5 tons per cubic yard.

4.2.4.1 Alternative 4A - Envirocare of Utah, Inc. Facility

The Envirocare facility is located near Clive, Utah, approximately 630 miles west of the CSMRI site. The facility is licensed to accept either NORM and/or 11(e)-2 by-product waste materials (among other waste types).

Off-site disposal of stockpile material at the Envirocare facility includes intermediate truck transport to a rail loadout facility in Denver, Colorado. Trucks leaving the site (either exit through the City of Golden [Route A on Figure 4-5] or exit directly to Highway 6 [Route B on Figure 4-5]) would travel to eastbound Interstate 70 and continue for approximately 10.5 miles to the Colorado Boulevard exit. From this exit, the trucks will travel south on Colorado Boulevard for approximately 0.5 miles, then turn west on 40th Avenue and travel approximately one mile. The intermodal container loadout for the Union Pacific (UP) rail spur is located at 1851 40th Avenue. The rail route would proceed north of Denver to Cheyenne, Wyoming and then head west to Utah. The UP rail line leads directly to the facility near Clive, Utah.

The rail option requires that the stockpile material be loaded into intermodal containers at the site using front-end loaders. Based on our May 30, 1995 conversation with Mr. Al Rafati of Envirocare (after the community meeting), Envirocare would screen and set aside oversize material prior to shipment to Clive, Utah. Clean oversize materials would be shipped to a nearby sanitary landfill. Envirocare would assume responsibility for preventing and controlling potential fugitive dust generation during the remedial activities.

The intermodal containers are large steel boxes with either a tarped cover or hinged steel lid. The exterior of the containers would be decontaminated as required and loaded onto flat bed trucks using a fork lift. The intermodal container has a capacity of 22.5 tons. Envirocare anticipates that up to 24 intermodal containers (i.e., truckloads) will be loaded and transported per day (120 containers per week). Based on a 5 day work week, a maximum of 2,700 tons of stockpile material may be removed per week from the site. Each flat bed truck would perform five round trips per day taking approximately 2 hours per trip.

Six intermodal containers would be loaded onto each rail car by Union Pacific. Twenty rail cars per week would be shipped to the Envirocare facility. Each rail car would return to the Denver rail yard approximately 12 to 14 days after departure.

Assuming a maximum of 20,000 cubic yards of stockpile material and an average bulk density of 1.5 tons per cubic yard of stockpile material, a total of approximately 1,334 intermodal shipments (223 rail car shipments) would occur over the life of the project. On average, a total of 48 inward (empty) and outward (loaded) bound trucks per day would be required. Based on an average of 120 intermodal containers per week, approximately twelve weeks would be required to transport the stockpile material. Additional time would be required for site preparation, mobilization and demobilization activities.

4.2.4.2 Alternative 4B - Umetco Minerals Corporation Facility

The Umetco facility is located in Uravan, Colorado. The site is licensed for storage of 11(e)-2 material and is regulated by the Radiation Control Division, Colorado Department of Public Health and Environment under Radioactive Materials License 660-02. The facility is located approximately 300 miles west of the site.

Transport of stockpile material to the Umetco facility would be completed by truck. Trucks leaving the site would travel to westbound Interstate 70 and continue toward Grand Junction and Highway 141 south. The route turns south on Highway 141 and continues for approximately 80 miles to the Umetco facility.

Stockpile material would be loaded into 20-ton trucks at the site via a front-end loader. The trucks would be decontaminated as required and then driven to Umetco. Each truck is anticipated to have a carrying capacity of 20 tons or approximately 13.3 cubic yards, (assuming an average weight of 1.5 tons per cubic yard of stockpile material). Assuming a maximum of 20,000 cubic yards of stockpile material, a total of approximately 1,500 loaded trucks would be required to transport the material.

Based on a 15-minute cycle time to load each truck, 32 trucks would be loaded during an eight hour shift. On average, a loaded truck would leave the site every 15 minutes and an empty truck would enter the site (total of 64 inward and outward bound trucks per day). One eight-hour shift is assumed per day. Approximately 160 truckloads would be removed per week.

The Umetco facility could potentially schedule receipt of shipments based on 24 hour operation at the project site. Dependent upon scheduling and operating hours at the Umetco facility, the duration of removal/transport activity would be approximately ten weeks. Additional time would be required for site preparation, mobilization and demobilization activities.

4.2.4.3 Alternative 4C - Solid Waste Landfill

Solid waste landfill facilities may accept the stockpile material as a special solid waste. Approval of the special solid waste classification is required. Potential solid waste landfills suitable for disposal of the stockpile material include, but are not limited to, the following:

- Conservation Services, Inc. industrial landfill in Bennett, Colorado
- Browning-Ferris (BFI) Foothills Landfill approximately six miles north of Golden, Colorado
- Laidlaw Waste Systems, Inc. (Laidlaw) Denver Regional Landfill near Erie, Colorado

The list of solid waste facilities qualified for disposal of the stockpile material may expand in the event that Alternative 4C is the preferred alternative selected by EPA. Further discussion on the initial list of solid waste disposal facilities follows below.

4.2.4.3.1 Conservation Services, Inc.

The CSI facility is located in Bennett, Colorado, approximately 50 miles northeast of the site.

Similar to off-site disposal at the Umetco facility, transport of stockpile material to the CSI facility would be accomplished by trucking. The duration of the trip for trucks leaving the site, dumping the stockpile material at the facility and returning to the site is estimated to be approximately three hours. Trucks leaving the site would travel to eastbound Interstate 70 and continue toward Highway 79. The route turns north on Highway 79 and continues to Bennett, Colorado. The CSI disposal facility is located approximately 8 miles northwest of Bennett.

Stockpile material would be loaded onto trucks via a front-end loader. Following loading activity, each truck would be decontaminated as required prior to travel to CSI. Each truck would have a capacity of 20 tons or approximately 13.3 cy, assuming a weight of 1.5 tons per cubic yard of stockpile material. A total of approximately 1,500 loaded trucks would be required to transport the material.

Assuming 15 minutes to load each truck, 36 trucks could be loaded during a nine hour shift. On average, a loaded truck would leave the site every 15 minutes and an empty truck would enter the site (total of 72 inward and outward bound trucks per day). An average of 2,394 cubic yards of stockpile material would be removed per week.

Currently, the CSI facility operates from 6:00 a.m. to 7:00 p.m., and therefore a nine-hour work shift at the project site is reasonable. However, CSI has stated that operating hours could be extended to handle the incoming waste material from the CSMRI site. Depending on extended operating hours at the CSI facility, the duration of removal/transport activity would be approximately nine to ten weeks. Additional time would be required for site preparation, mobilization and demobilization activities.

4.2.4.3.2 BFI Foothills Landfill

Transport of stockpile material to the Foothills Landfill would be accomplished by trucking. The haul route from the site would access Highway 93 via Highway 6 (Route A) or Highway 58 (Route B). Trucks would continue north on Highway 93 approximately 6 miles to the landfill.

Stockpile material would be loaded onto trucks at the site via a front-end loader. Following loading activity, each truck would be decontaminated as required prior to travel to the landfill. Each truck would have a capacity of 20 tons or approximately 13.3 cubic yards, assuming a weight of 1.5 tons per cubic yard of stockpile material. A total of approximately 1,500 loaded trucks would be required to transport the material.

Assuming 15 minutes to load each truck, 32 trucks could be loaded during an eight hour shift. On average, a loaded truck would leave the site every 15 minutes and an empty truck would enter the site (total of 64 inward and outward bound trucks per day). An average of 2,128 cubic yards of stockpile material would be removed per week.

Depending on extended operating hours at the landfill facility, the duration of removal/transport activity would be approximately ten weeks. Additional time would be required for site preparation, mobilization and demobilization activities.

4.2.4.3.3 Laidlaw Denver Regional Landfill

Truck transport of the stockpile material to the Denver Regional Landfill would be required. The haul route from the site would access Interstate 70 eastbound to Interstate 25. Truck traffic would continue northbound on Interstate 25 to Highway 7 westbound. Trucks will exit onto Highway 7 westbound continue to Weld County Road 5 northbound to the landfill entrance. The landfill is approximately 40 miles north of the site.

Stockpile material would be loaded onto end-dump trucks at the site via a front-end loader. Following loading activity, each truck would be decontaminated as required prior to travel to the landfill. A fleet of eight 20-ton capacity tractor-trailer combinations would be used with each truck making approximately four round trips per day. Based on an average unit weight of 1.5 tons per cubic yard, a total of approximately 1,500 loaded trucks would be required to transport the stockpile material.

Assuming 15 minutes to load each truck, 32 trucks could be loaded during an eight hour shift. On average, a loaded truck would leave the site every 15 minutes and an empty truck would enter the site (total of 64 inward and outward bound trucks per day). An average of 2,128 cubic yards of stockpile material would be removed per week.

Depending on extended operating hours at the landfill facility, the duration of removal/transport activity would be approximately ten weeks. Additional time would be required for site preparation, mobilization and demobilization activities.

4.3 Description of Removal Action Evaluation Criteria

Following the development of removal action alternatives presented in Section 4.2, each removal alternative is then evaluated based on specific evaluation criteria. The Comprehensive Environmental Response, Compensation and Liability Act and the National Oil and Hazardous Substances Contingency Plan (NCP) require that remedial action alternatives be profiled against nine evaluation criteria. The activities at the CSMRI site and the Unilateral Order was issued by the EPA under the agency's removal action authority. One of the practical implications of the

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difference between a remedial versus a removal action is the method by which the cleanup alternatives are compared against evaluation criteria.

Under the removal program, EPA guidance requires an evaluation of each removal action alternative according to the following broad criteria:

- Effectiveness
- Implementability
- Cost

These three broad evaluation criteria include specific factors which must be included in the evaluation and comparison of removal action alternatives. The removal action criteria encompass the same criteria which are required to be evaluated under the remedial program. A description of the specific evaluation factors is provided below. The description is summarized in a manner which illustrates the relationship between removal action evaluation criteria and the nine remedial action evaluation criteria.

4.3.1 Effectiveness

In accordance with Section 300.430(e)(7)(i) of the NCP, this criterion focuses on the following:

- Overall protection of human health and the environment offered by the alternative
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of the toxicity, mobility, or volume of the waste material through treatment
- Short-term effectiveness

4.3.1.1 Overall Protection of Human Health and the Environment

Alternatives are evaluated to determine whether the cleanup alternative can adequately protect human health and the environment from unacceptable risks posed by hazardous substances, pollutants or contaminants present at the site. Protection may be provided by elimination, reduction or control of exposures to acceptable levels. Overall protection of human health and the environment draws on the assessment of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs (Section 400.430(e)(9)(A) of the NCP).

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4.3.1.2 Compliance with ARARs

Each alternative is assessed to determine whether the alternative attains ARARs under federal environmental laws and state environmental or facility siting laws or provide grounds for a waiver (Section 400.430(e)(9)(B) of the NCP), and other applicable federal, state or local regulations. Tables 4-3 and 4-4 address the methods that are required to attain specific ARARs for the off-site RA alternatives. Tables 4-5 through 4-8 address the methods that are required to attain specific ARARs for the on-site RA alternatives. In a removal action, ARARs are to be attained as closely as practicable.

4.3.1.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence includes an assessment of the magnitude of residual risk associated with the site and the adequacy and reliability of engineering or institutional controls under the alternative (Section 400.430(e)(9)(C) of the NCP).

4.3.1.4 Reduction of the Toxicity, Mobility, or Volume Through Treatment

This criterion assesses the degree to which an alternative employs recycling or treatment to reduce the toxicity, mobility or volume (Section 400.430(e)(9)(D) of the NCP).

4.3.1.5 Short-Term Effectiveness

Specific short-term impacts addressed under this criterion include short-term risks that might be posed to the community during implementation of an alternative, potential impacts on workers during remedial action, potential environmental impacts of remedial action, and time until protection is achieved (Section 400.430(e)(9)(E) of the NCP).

4.3.2 Implementability

In accordance with Section 300.430(e)(7)(ii) of the NCP, this criterion focuses on the following:

- Technical feasibility
- Administrative feasibility
- Availability of services and materials

Alternatives that are technically or administratively infeasible or that would require equipment, specialists, or facilities that are not available within a reasonable period of time may be eliminated from further consideration. Regulatory definitions of the components of the implementability criterion follow below.

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4.3.2.1 Technical Feasibility

Technical feasibility includes the technical difficulties and unknowns associated with construction and operation of a technology, reliability of a technology, ease of undertaking additional remedial actions and the ability to monitor the effectiveness of the remedy (Section 400.430(e)(9)(F)(1) of the NCP).

4.3.2.2 Administrative Feasibility

This criterion includes an assessment of the required coordination with lead regulatory agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (Section 400.430(e)(9)(F)(2) of the NCP).

4.3.2.3 Availability of Services and Materials

Each alternative should be evaluated to assess the availability of adequate off-site treatment, storage, and disposal capacity and services, the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources (Section 400.430(e)(9)(F)(3) of the NCP).

4.3.3 Community Acceptance

Each alternative should be evaluated to determine which components of the alternatives interested persons in the community support, have reservations about, or oppose.

4.3.4 Cost

As stated in Section 400.430(e)(7)(iii) of the NCP, the cost criterion includes the projected costs of construction and any long-term costs to operate and maintain the alternative. Costs that are grossly excessive compared to the overall effectiveness of alternatives may be considered as one of several factors used to eliminate alternatives. Alternatives providing a effectiveness and implementability similar to that of another alternative by employing a similar method of treatment or engineering control, but at greater cost, may be eliminated.

4.3.5 State's Acceptance

The State's acceptance indicates whether the State of Colorado agrees with or opposes the alternatives developed. Since the State of Colorado is identified as one of the PRPs and has an authorship of this document along with other PRPs, the State's acceptance criteria is not included in this report.

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4.3.6 Comparison of Remedial Program vs. Removal Program under the NCP

The NCP assigns different levels of importance to the preceding nine evaluation criteria under the remedial program. The first two criterion, overall protection of human health and the environment and compliance with ARARs, are considered threshold criteria. This means that in order for a cleanup alternative to be considered for implementation it must, at a minimum satisfy these two criteria or provide justification for invoking a waiver of requirement(s).

Excluding State and Community Acceptance, the remaining criterion are known as primary balancing criteria and are used to identify the alternative(s) which provide the best combination of individual criteria. State and Community Acceptance are known as modifying criteria and are used in conjunction with the primary balancing criteria to identify the preferred cleanup alternative. The modifying criteria are generally determined after public comment and may be used to modify the preferred cleanup alternative.

4.4 Analysis of Removal Action Alternatives

Section 4.2 describes the following potential removal action alternatives for the stockpile material:

- Alternative 1 - No Action/Institutional Controls
- Alternative 2 - On-Site Options
  - Alternative 2A - In-Place Closure
  - Alternative 2B - Above-Ground Repository
- Alternative 3 - Nearby Off-Site Options
  - Alternative 3A - Below-Grade Repository
  - Alternative 3B - Below-Grade Repository with Waste S/S
- Alternative 4 - Off-Site Commercial Disposal Facility Options
  - Alternative 4A - Envirocare of Utah, Inc.
  - Alternative 4B - Umetco Minerals Corporation
  - Alternative 4C - Solid Waste Landfills

Tables 4-1 and 4-2 presents a summary of the evaluation of each removal action alternative based on the NCP criterion of effectiveness, implementability and cost. Further discussion on each removal alternative follows below.

4.4.1 Alternative 1 - No Action/Institutional Controls

Alternative 1 includes long-term monitoring and institutional controls of the stockpile without remedial action. Consideration of the no action alternative is required by NCP.

4.4.1.1 Effectiveness

Alternative 1, the No-Action/Institutional Controls Alternative, does not provide adequate protection of human health and the environment because it does not address the risks associated with potential contact or inhalation of contaminants from the stockpile material. Further it does not address mitigation measures to prevent potential migration of contaminants from the stockpile to surface water and groundwater.

Alternative 1 also does not attain the ARARs for the site. In addition, it would provide no reduction in risk and does not reduce toxicity, mobility, or volume of site contaminants. The no action alternative also does not provide source removal and/or treatment through remediation.

The short-term impacts of the no-action/institutional controls alternative would be unchanged from the current risks posed by the stockpile. No elevated short term risks would result from the implementation of this alternative. However, the existing potential for human and environmental exposure would not be reduced and remedial action objectives would not be achieved.

4.4.1.2 Implementability

Alternative 1 is technically feasible; however, the administrative feasibility of this alternative is high.

4.4.1.3 Cost

Cost elements associated with the no action/institutional controls alternative are described in Section 4.2.1. The total present value of Alternative 1, including a 20 percent contingency, is approximately $1,399,000 (see Cost Information in Tables 4-1 and 4-2).

4.4.2 Alternative 2 - On-Site Options

In-Place Closure (Alternative 2A) and Above Ground Repository (Alternative 2B) alternatives were developed for On-Site Removal Alternatives in this study.

4.4.2.1 Effectiveness

For the on-site alternatives (Alternatives 2A and 2B), additional data gathering and collection are required to demonstrate whether these remedial alternatives fully protect human health and the environment and comply with ARARs. In addition, the complex geology and topography in the area of the stockpile make it difficult to conclude that these alternatives fully comply with ARARs and protect human health and the environment.

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The containment features associated with Alternative 2A and 2B would effectively reduce the mobility of contaminants by limiting radon gas release and reducing the wind or surface erosion potential of stockpile. However, the engineering cover does not reduce the toxicity or volume of the stockpile material, and therefore, long-term maintenance and monitoring would be required. In addition this alternative relies on institutional controls to ensure the effectiveness of the alternative.

4.4.2.2 Implementability

The technical feasibility of on-site removal alternatives is not as good as the nearby off-site and off-site alternatives due to unknown conditions underneath the stockpile. As described in Section 4.2.2.1 the sideslopes for Alternatives 2A (In-Place Closure) and 2B (Above Ground Repository) would require regrading to at least 3H:1V before placement of the engineering cover. A regraded sideslope of 3H:1V may be susceptible to long-term erosion by surface water. Potentially applicable regulations (i.e., 6CCR 1007-1, Part 18, Appendix A) for long term disposal may require adequate erosion protection measures with less steep sideslopes. Administrative feasibility is higher than Alternatives 3, 4B, and 4C.

In the event that access to Highway 6 is not available, truck traffic through the 12th Street Historic District will likely result in public annoyance due to short-term noise and vibration in a residential area.

4.4.2.3 Cost

Cost elements associated with Alternatives 2A and 2B are described in Sections 4.2.2.1 and 4.2.2.2. The total present value of Alternative 2A and Alternative 2B, including a 20 percent contingency, is approximately \$3,099,000 and \$3,276,000, respectively.

4.4.3 Alternative 3 - Nearby Off-Site Options

Two removal alternatives were developed for the nearby off-site disposal (Alternative 3A-Below Ground Repository; Alternative 3B-Below Ground Repository with Stabilization/Solidification). Conceptual designs for below ground repository for the nearby off-site alternatives were developed for the baseball field shown in Figures 4-3 and 4-4. However, the nearby practice field can also be utilized for the similar repository design and would be as effective or better siting than the baseball field, because of the greater vertical distance to groundwater.

Since Alternative 3A and Alternative 3B are similar in nature with an exception of S/S element in Alternative 3B, they are evaluated together.

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4.4.3.1 Effectiveness

Alternatives 3A and 3B are protective of overall human health and the environment through reducing ingestion and inhalation risk posed by the stockpile material. Under Alternatives 3A and 3B, the engineering controls provided via construction of a lined and capped disposal cell reduces the risk to human health and the environment by: 1) reducing migration of surface water into the disposal cell, 2) reduction of the potential for migration of contaminates into the groundwater, 3) prevention of direct contact by human and ecological receptors, and 4) reducing the radon gas release from the stockpile soils. Alternative 3B also includes S/S of the soils prior to placement in the engineered disposal cell and is therefore even more protective than Alternative 3A.

These alternatives rely on institutional controls to ensure long term effectiveness. Both alternatives meet risk based air and soils levels and attain ARARs.

Alternative 3B, through S/S reduces the mobility of contaminants. This alternative complies with the statutory preference for treatment as a primary element. Residual site risk following completion of this alternative would be minimal.

Short-term risk associated with Alternatives 3A and 3B include direct contact and/or inhalation of fugitive dusts during remediation. Fugitive dust would include stockpile material, and dry cement/fly ash (for Alternative 3B). Direct exposure by workers during system operation can be minimized through the use of appropriate safety equipment. Risks associated with inhalation of fugitive dusts are controllable through air monitoring, the use of appropriate health and safety equipment and dust suppression techniques. Air monitoring would also be used to identify potential off-site risks to the community.

In the event that access to Highway 6 is not available, truck traffic through the 12th Street Historic District will likely result in public annoyance due to short-term noise and vibration in a residential area.

4.4.3.2 Implementability

Alternatives 3A and 3B are technically feasible. They both involve standard construction and earth moving techniques. Nearby baseball field and the practice field are suitable for below ground repositories. However, construction of a repository in these areas will require institutional controls (e.g., long term monitoring and maintenance, land use restrictions, etc.).

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The administrative feasibility of these alternatives is moderate. The licensing requirements are dependent on the regulatory classification of the stockpile.

4.4.3.3 Cost

The cost elements associated with Alternatives 3A and 3B are described in Sections 4.2.3.1 and 4.2.3.2. The total present value of Alternative 3A and 3B, including a 20 percent contingency, is approximately $3,363,000 and $4,411,000, respectively.

4.4.4 Alternative 4 - Off-Site Commercial Disposal Facility Options

4.4.4.1 Envirocare Disposal Alternative

4.4.4.1.1 Effectiveness

This alternative is protective of overall human health and the environment through elimination of potential exposure risks at the site. Excavation of the waste pile and off-site disposal of the material at a licensed disposal facility eliminates the potential for adverse on-site exposure of human health or the environment.

Off-site disposal complies with ARARs for on-site removal activities. Disposal at Envirocare mitigates the potential long-term impacts associated with the stockpile. The long-term effectiveness of disposal at Envirocare is based on current licensed design standards for disposal of NORM and 11(e)(2) by-product materials (among other waste types).

This alternative does not reduce the toxicity, mobility, or volume of waste material through treatment; however, the on-site volume of waste material is reduced. Excavation and transport activities pose an elevated short-term exposure risk to on-site workers and nearby residents due to airborne particulate generation. Direct exposure by workers during implementation of this alternative would be minimized through use of appropriate safety measures. Risks associated with inhalation of fugitive dusts are controllable through air monitoring, the use of appropriate health and safety equipment and dust suppression techniques. Air monitoring would also be used to identify potential off-site risks to the neighboring community.

In the event that access to Highway 6 is not available, truck traffic through the 12th Street Historic District will likely result in public annoyance due to short-term noise and vibration in a residential area.

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4.4.4.1.2 Implementability

The technical feasibility of off-site disposal at Envirocare relies on use of conventional excavation and transport technology. Necessary equipment is readily available for implementation of this alternative. Envirocare is currently licensed to receive NORM and 11(e)(2) waste materials (among other waste types) which improves the administrative feasibility of this alternative.

4.4.4.1.3 Cost

Total project costs associated with disposal of the stockpile material at Envirocare are projected to be $5,500,000 for 20,000 cubic yards of material. Operations and maintenance costs under this alternative are included in the off-site disposal fee for Envirocare.

4.4.4.2 Alternative 4B - Off-Site Commercial Disposal Facility, Umetco Minerals Corporation

4.4.4.2.1 Effectiveness

This alternative is protective of overall human health and the environment through elimination of potential exposure risks at the site. Excavation of the waste pile and off-site disposal of the material at licensed disposal facility such as Umetco eliminates the potential for adverse on-site exposure of human health or the environment.

Off-site disposal meets the ARARs for on-site removal activities. Disposal at Umetco successfully mitigates the potential long-term impacts associated with the stockpile on-site. The long-term effectiveness of disposal at Umetco is based on current design standards for 11(e)2 by-product materials.

This alternative does not reduce the toxicity, mobility, or volume of waste material through treatment; however, the on-site volume of waste material is reduced. Excavation and transport activities pose an elevated short-term exposure risk to on-site workers and nearby residents due to airborne particulate generation.

Direct exposure by workers during implementation of this alternative would be minimized through the use of appropriate safety measures. Risks associated with inhalation of fugutive dusts are contollable through air monitoring, the use of appropriate health and safety equipment, and dust suppression techniques. Air monitoring would also be used to identify potential off-site risks to the neighboring communities. Additionally, in the event that access to Highway 6 is not available, truck traffic through the 12th Street Historic District will likely result in public annoyance due to short-term noise and vibration in a residential area.

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4.4.4.2.2 Implementability

The technical feasibility of off-site disposal at Umetco relies on use of conventional excavation and transport technology. Necessary equipment is readily available for implementation of this alternative. There are administrative (legal) questions regarding Umetco's ability to receive the CSMRI stockpile soils, which limit the administrative feasibility of this alternative depending on the ultimate waste classification of the stockpile material.

4.4.4.2.3 Cost

Total project costs associated with disposal of the stockpile material at Umetco are projected to be $5,000,000 for 20,000 cubic yards of material. Operations and maintenance costs under this alternative are included in the off-site disposal fee for Umetco.

4.4.4.3 Alternative 4C - Off-Site Commercial Disposal Facility, Solid Waste Landfill

4.4.4.3.1 Effectiveness

This alternative is protective of overall human health and the environment through elimination of potential exposure risks at the site. Excavation of the waste pile and off-site disposal of the material at solid waste landfill facility eliminates the potential for adverse on-site exposure of human health or the environment.

Off-site disposal meets the ARARs for on-site removal activities. Disposal at a solid waste landfill successfully mitigates the potential long-term impacts associated with the stockpile on-site. The long-term effectiveness of disposal at a solid waste landfill is based on current design standards for special solid wastes. Solid waste disposal facilities which specialize in industrial waste disposal (e.g., Conservation Services, Inc.) may have more effective long-term engineering controls for disposal of the waste material in comparison to general solid waste disposal facilities (e.g., BFI Foothills Landfill or Laidlaw's Denver Regional Landfill).

This alternative does not reduce the toxicity, mobility, or volume of waste material through treatment; however, the on-site volume of waste material is reduced. Excavation and transport activities pose an elevated short-term exposure risk to on-site workers and nearby residents due to airborne particulate generation.

Direct exposure by workers during implementation of this alternative would be minimized through the use of appropriate safety measures. Risks associated with inhalation of fugutive dusts are contollable through air monitoring, the use of appropriate health and safety equipment, and dust suppression techniques. Air monitoring would also be used to identify potential off-site risks to the neighboring communities. Additionally, in the event that access to Highway 6 is not available, truck traffic through the 12th Street Historic District will likely result in public annoyance due to short-term noise and vibration in a residential area.

4.4.4.3.2 Implementability

The technical feasibility of off-site disposal at a solid waste landfill relies on use of conventional excavation and transport technology. Necessary equipment is readily available for implementation of this alternative. CSI, BFI, Laidlaw and other solid waste landfill facilities may accept special solid waste materials with the approval of state and county regulatory authorities. Depending on the ultimate waste classification of the stockpile material, the administrative feasibility of this alternative may be limited.

4.4.4.3.3 Cost

Total project costs associated with disposal of the stockpile material at a typical solid waste landfill are projected to vary between $715,000 and $2,500,000 for 20,000 cubic yards of material. Operations and maintenance costs under this alternative are included in the off-site disposal fee.

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5.0 Comparative Analysis of Removal Action Alternatives

This section of the report describes the relative performance of each individual RA alternative in relation to the evaluation criteria described in Section 4.3. The cleanup alternatives for the CSMRI site were profiled against the nine evaluation criteria, and the results are summarized in Tables 4-1 and 4-2. Some of the key differences between the alternatives are discussed in greater detail below.

5.1 Overall Protection of Human Health and the Environment

Alternative 1, the no-action/institutional controls alternative, does not provide adequate protection of human health or the environment because it does not adequately address the risks posed by direct contact or inhalation of contaminates within the stockpiled soil. Further, it does not adequately prevent potential migration of the contamination into surface and/or groundwater.

Alternative 2A - In-Place Closure and Alternative 2B Above Ground Closure may not adequately protect human health and the environment. As previously mentioned the following factors prevent this alternative from being fully evaluated: 1) the complex geography, topography and geology in the area of the stockpile and 2) the time frames imposed by the UAO and the lack of information on subsurface conditions in the area of the current stockpile, for technical reasons, also make it difficult to conclude whether this alternative is protective of human health and the environment and complies with ARARs.

As shown in Tables 4-1 and 4-2, Alternatives 3 and 4 are effective in reducing ingestion and inhalation risks posed by stockpiled material. Under Alternatives 3A and 3B, the engineering controls provided via construction of a lined and capped disposal cell reduces the risk to human health and the environment by: 1) reducing migration of surface water into the disposal cell, 2) reduction of the potential for migration of contaminates into the ground water, 3) prevention of direct contact by humans and 4) reducing the radon gas release from the stockpile soils. Alternative 3B also includes solidification of the soil prior to placement in the engineered disposal cell and is therefore even more protective than Alternative 4. Alternative 3A and 3B also rely on institutional controls (such as zoning and land-use restrictions) to prevent future residential land use of the disposal area.

Alternative 4 is considered to be the most effective in reducing human health and environmental risks because the stockpiled soil would be transported and disposed at an approved off-site disposal facility. Alternative 4 does not rely on in-place institutional controls to reduce risks to human health or the environment.

5.2 Compliance With Applicable or Relevant and Appropriate Requirements

Tables 4-3 and 4-4 outline the methods that are required to attain the specific ARARs for off-site RA alternatives (Alternative 4). Tables 4-5 through 4-8 outline the methods required to attain the specific ARARs for the on-site (Alternatives 1, 2A, and 2B) and nearby off-site alternatives (Alternatives 3A and 3B).

Alternative 1, the no-action/institutional controls alternative, does not attain the ARARs for the site.

It is uncertain whether Alternatives 2A and 2B, as currently proposed, meet all disposal site criteria and minimum design criteria. For this reason, Alternatives 2A and 2B may not meet ARARs for the site. Additional investigation is required to make this determination.

Alternatives 3 and 4 meet risk-based air and soils levels. As stated above Alternatives 3A and 3B also rely on institutional controls. Alternatives 3A, 3B, and 4 attain all ARARs for the site.

5.3 Long-Term Effectiveness and Permanence

This evaluation criteria includes the effectiveness of controls required to manage human health and environmental risks associated with the untreated or treated stockpile soils that remain on-site.

Alternative 1 is least effective because it does not manage or reduce risk.

Alternatives 2A and 2B provide a low degree of reliability of risk reduction because it is uncertain at this time whether these alternatives fully comply with ARARs or is protective of human health and the environment. The inclusion of a slurry wall to protect groundwater and contaminant migration as a component to Alternative 2A reduces the reliability of Alternative 2A in comparison to Alternative 2B.

Alternatives 3A and 3B provide moderate to high reliability in reducing risk. Alternative 3B provides higher reliability than Alternative 3A because it includes solidification of the soil prior to disposal. The necessity to include and monitor institutional controls reduces the long-term reliability of Alternatives 3A and 3B in comparison to Alternative 4.

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Alternative 4 provides the highest reliability of long-term risk reduction because the stockpiled soil would be disposed of at an approved off-site disposal facility at a more remote location.

5.4 Reduction of Toxicity, Mobility or Volume Through Treatment

Alternative 1, the no-action/institutional controls alternative, does not implement any action to reduce the toxicity, mobility or volume of contaminants.

Alternative 2A and 2B should reduce the mobility of contaminants in the stockpile. Alternative 2A includes a slurry wall to reduces risk of migration via ground water and Alternative 2B includes a full liner under the stockpile at its current location.

Alternatives 3A and 3B reduce the mobility of contaminants in the pile. Alternative 3B would reduce toxicity and mobility of contaminants in the pile to the greatest extent because of the treatment of the soil with cement and fly ash which chemically stabilizes the contamination, a process which reduces the permeability and leachability of the contaminated soil. The volume of the stockpile soils would increase (approximately 20 percent) during stabilization.

Two options under Alternative 4 (4A and 4B) would include volume reduction of the stockpile to reduce cost. It is expected that a minimum of 3,000 cubic yards of uncontaminated material could be removed from the stockpile.

5.5 Short-Term Effectiveness

For each RA alternative being considered, there is a short-term potential risk to the community and RA workers. The potential for air emissions during construction of the selected RA will be controlled by dust control measures. Control measures will be monitored by the installation of perimeter air monitoring to evaluate controls on a day-to-day basis.

There is low to moderate short-term traffic safety risk to the community and the environment during implementation of all the alternatives, with the exception of Alternative 1. All on-site and off-site alternatives, except Alternative 4B (Umetco), involve approximately the same number of truck highway miles. Depending on the RA alternative selected there will be between 1,300 and 2,500 trucks entering and then leaving the site (see section 4.1.4 Material Transportation for specific traffic information for each alternative). Optimally, an access to U.S. 6 will be secured. If not, then access will be necessary via 12th street.

Alternative 4B (Umetco) would involve truck transportation to the Umetco site, which is located approximately 300 miles west of the CSMRI site. The additional highway miles traveled make the short-term traffic safety risks of this alternative higher than other alternatives.

Based on risk assessment evaluations performed in Section 4.4 there is a short-term risk of potential adverse health and environmental consequences to bystanders during a transportation-related accident. The conservative assumption used is that an accident would expose people to contamination for a full 24-hours. In reality, if an accident were to occur, any human which could be potentially exposed would be evacuated from the accident area until the area is cleaned.

During all construction activities at the site, engineering controls will be implemented to prevent contamination of surface water and to minimize airborne dust.

The following is a summary, by alternative, of the estimated duration of activities anticipated for the RA:

• Alternative 1 - No Action/Institutional Controls	2 weeks
• Alternative 2A - In-Place Closure	8 weeks
• Alternative 2B - Above-Ground Repository (in-place)	12 weeks
• Alternative 3A - Below-Ground Repository	12 weeks
• Alternative 3B - Below Ground Repository (with S/S)	16 weeks
• Alternative 6A - Envirocare	12 weeks
• Alternative 6B - Umetco	10 weeks
• Alternative 6C - Solid Waste Landfill	9-10 weeks

5.6 Implementability

5.6.1 Technical Feasibility

Alternative 1, no-action/institutional controls alternative, is relatively easy to implement because it primarily involves monitoring requirements.

Alternatives 2A and 2B are also technically implementable. However, for Alternative 2A the uncertainty of construction of a slurry wall, the close proximity to Chimney Gulch, and the need to relocate a large City of Golden watermain make this alternative more difficult implement. For Alternative 2B, the sequencing of excavation and replacement of the stockpile makes this alternative more difficult to implement in comparison to Alternatives 3A, 3B, and 4.

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Alternatives 3 and 4 are all technically feasible. Each alternative involves standard construction and earth moving techniques. Alternatives 3A and 3B are slightly more difficult to implement than Alternative 4. In addition, Alternative 3B requires solidification of the soil prior to placement.

All RA alternatives, except no-action/institutional controls, will be sensitive to implementation during the winter months. Inclement weather conditions will reduce the ability to work efficiently. Additionally, none of the alternatives can be performed effectively if soils are excessively wet or frozen. These conditions make it difficult to handle the soils and to perform the necessary compaction during placement in either a on-site or off-site disposal location. In addition, Alternatives 2 and 3 require liner placement operations which are temperature and moisture dependent. Further, Alternative 3B, with solidification and stabilization, will require sustained day-time temperatures above 50 degrees Fahrenheit for preparation and placement of the treated soil.

5.6.2 Administrative Feasibility: Licensing Process

Alternatives 2, 3 and 4 require truck access to the site. Two alternative routes are being evaluated, and one will be selected after the public comment period. Approval by the Colorado Department of Transportation will be required for the selected access route. This approval will not affect the comparative analysis because it is an element common to each alternative.

Alternative 1, the no-action/institutional controls alternative, and the on-site alternatives (Alternatives 2A and 2B) do not require a license because CERCLA exempts on-site remedies from licensing requirements, although certain substantive requirements must be met. The administrative feasibility for these alternatives is high.

The licensing requirements for off-site Alternatives 3A and 3B will depend upon the regulatory classification of the stockpiled soils. Colorado's radiation control, hazardous materials, and solid waste regulations may apply to near-site disposal alternatives.

All radiation control license applications must contain general information as specified in Part 3 of the Colorado Rules and Regulations Pertaining to Radiation Control, 6 CCR 1007-1 (Radiation Regulations), as well as information on worker exposure, public exposure, and radiation safety programs as specified in Part 4 of the Radiation Regulations. The data needed in support of a license application for Naturally Occurring Radioactive Material (NORM) are described in Part 3 of the Radiation Regulations (RH 3.8.8, Environmental Impact Assessment), while data requirements for byproduct material are described in Appendix A of Part 18 of the Radiation Regulations. Data needed in support of a license application for disposal of low level radioactive waste are described in Part 14 of the Radiation Regulations.

Colorado's licensing process is the same for byproduct, source material, or NORM. For low-level radioactive waste an additional step, approval by the Rocky Mountain Low-Level Radioactive Waste Compact Board, may be required.

There are no regulatory requirements regarding time frames for a Colorado Radioactive Materials License application review and approval, other than for new medical licenses. An application must be filed with the Radiation Control Division (RCD) at least nine months prior to construction (RH 3.8.7.1).

Experience with byproduct materials license applications in Colorado would indicate that a nine month to three year time period for application approval is required depending upon the quality of the application received. The RCD performs a completeness review of the application followed by an adequacy review. Once RCD determines that an application is both complete and adequate, the RCD writes its technical and regulatory analysis in the form of a Preliminary Licensing Statement/Proposed License ("PLS/PL"). The PLS/PL is then issued and made available for public comment (generally for 90 days) and the opportunity for a formal public hearing is provided.

For purposes of time frame comparison, Umetco Minerals Corporation submitted a license amendment application for its Uravan facility to RCD in June 1992. The amendment was issued by the RCD, but was challenged in judicial review. That review is pending in June 1995, as this report is written.

Along with the application, the applicant must submit an environmental report. RH 3.8.8. If the RCD deems it necessary, it transmits the environmental report for review of federal, state, and local government agencies having expertise or jurisdiction over the proposed project or activity. RH 3.8.8.2. This process may add an unknown length of time to the process while the other agencies comment on the environmental report and the RCD considers those comments.

With regard to low-level radioactive waste, the Low-Level Radioactive Waste Compact prohibits disposal unless that disposal is in a facility which is on the generator's property and was in use for disposal of low-level radioactive waste prior to January 1, 1982, or on a "regional facility" within the Compact states and approved by the Commission board. Such regional facilities must accept waste from within the region pursuant to the Compact terms. Review of such proposed facilities by the board must occur within 90 days of a request from the state which proposes to develop such a facility.

Part 18 of the RCD's regulations requires that, for one full year prior to any major site construction, the applicant shall conduct a preoperational monitoring program to provide complete baseline information on the site. RH 18.3.3. Prior to issuance of a license, financial assurance arrangements and a long term care fund must be established.

An environmental impact analysis is prepared by the RCD based upon information provided by the applicant under RH 3.8.8. The Part 18 applicant must demonstrate compliance with the criteria in Appendix A or propose an alternative that achieves the same level of stabilization and containment and a level of protection of public health, safety and the environment from radiological and non-radiological hazards associated with the site. The criteria in Appendix A of Part 18 relate to siting, cell design and to long term maintenance.

A hazardous materials facility must meet the licensing requirements found in the Colorado Hazardous Waste Regulations, 6 CCR 1007-3, Part 100. Within 60 days of receipt of a state RCRA permit application, a review for completeness of application is performed. Part 100.500(a). Within 6 months of receipt of application, a decision is made to issue a draft permit or to deny the application. Part 100.502. There is a 45-day public comment period after notice of the draft permit. Part 100.506. A final permit decision is rendered within 90 days of the close of the public comment period. Part 100.511. The permit becomes effective 30 days after notice of the final permit decision. Part 100.511. Thus, the entire permitting process may take up to a year, but a license cannot be issued sooner than 75 days after submittal of the application.

A solid waste facility must meet the requirements in the Colorado Solid Waste Disposal Sites and Facilities Regulations, 6 CCR 1007-2, if applicable. A person proposing a solid waste facility in an unincorporated portion of a county applies to the county commissioners for a certificate of designation. § 1.6.1. A person proposing a solid waste facility within a corporate boundary of a municipality applies to the governing body of the municipality. § 1.6.1. The county or municipality receiving the application for a certificate of designation forwards the application to the CDPHE for a recommendation. CDPHE completes a comprehensive review within 180 days of submission of the application. § 1.6.6. The local governing body then approves or disapproves the application.

Thus, for any of the regulatory classifications of the stockpiled soil, the time frames associated with obtaining a license or permit reduce the administrative feasibility for Alternatives 3A and 3B. Specific issues related to the administrative feasibility depend in part upon the classification of the waste materials and the applicable requirements. However, based upon the time frames associated with any of the classifications, the administrative feasibility of Alternatives 3A and 3B (nearby off-site) is lower than Alternatives 1 and 2 (on-site disposal) and Alternative 4 (off-site disposal).

The administrative feasibility of off-site disposal permitting depends on the off-site facility and the classification of the stockpiled soils.

The Envirocare facility in Utah is licensed to take 11(e)(2) material and NORM. It needs no disposal permits for these materials.

The Umetco Mineral Corporation's facility in Uravan is licensed to possess, store, and dispose of approximately 12.5 million tons of uranium mill tailings and associated contaminated residues and refuse (byproduct materials) that currently reside at the Umetco-Uravan Site in Montrose County, Colorado. Umetco is also authorized to take 900,000 tons of radioactive materials from DOE's Naturita UMTRCA Title I site. The State of Colorado authorized an amendment to the Umetco license to accept certain off-site radioactive waste materials (non-11(e)(2) byproduct material). The state's decision is currently on appeal and the status of Umetco's ability to take this material is at issue. The Umetco-Uravan Final Consent Decree, Order, Judgment and Reference to Special Master, U.S. District Court, Civil Action No. 83-C-2384, effective Feb. 1987, provides that Umetco shall provide an area at the Uravan facility to dispose of certain radioactive materials from the Colorado School of Mines. If this consent decree were used for disposal, a radioactive materials license or an amendment to the existing radioactive materials license might be required. Therefore, the administrative feasibility of this off-site option is uncertain, and is considered low for the purposes of this report.

Existing industrial solid waste facilities which are authorized to accept special wastes and demonstrate the ability to protect human health and the environment follow applicable local certificate of designation procedures and do not need additional permits to accept the stockpiled soils. The administrative feasibility for these sites to accept the stockpiled soils is medium to high.

5.7 Availability of Service and Materials

No limitations would be expected for the availability of any of the services or materials anticipated for any of the RA alternative, with one exception. As previously mentioned, access to and from the stockpiled soil to U.S. Highway 6 may not be available due to the high traffic, limited sight distance, and sharp curve at the point where an access would be required. If this access is not provided by CDOT, then the construction traffic for any RA alternative will have to be routed through the nearby community.

5.8 Community Acceptance

During the preparation of this RAOA, a community participation program has been implemented. Status meetings have been held approximately every two weeks, during which community attendees have been updated relative to technical progress and schedule. It is clear from these meetings that there is a strong interest in the disposition of the stockpiled soil. The participants in general remain open minded and are expected to provide comments to this report during the formal public comment period.

5.9 Cost

5.9.1 Detailed Cost Estimates

Cost estimates have been prepared for each of the RA alternatives under consideration. The detailed cost information for the on-site and nearby off-site RA alternatives is presented in Appendix F. Detailed cost information for the off-site RA alternatives were provided by the disposal facility and details are confidential business information claimed by the disposal facilities. Some of the cost information obtained from the disposal facilities do not include detailed breakdowns of direct and indirect capital costs, and rates are stated as a turnkey approach and lump sum cost. Therefore, detailed cost breakdowns for off-site commercial disposal alternatives are not included in this report.

Cost estimates for no-action/institutional controls, on-site, and nearby off-site have been prepared in accordance with EE/CA guidance and are provided in Appendix J. Specifically, the following items have been included in the cost estimates for each RA alternative:

- Direct capital costs using vendor information, cost estimating references, engineer estimates or combinations of these approaches for the construction activities and installation of any O&M elements.

- Indirect capital costs including engineering and design costs (15 percent of direct capital cost), construction supervision (10 percent of direct capital cost), and health and safety costs.

- Post-Removal Site Costs (O&M) that are associated with the on-site or near-site RA alternatives.

- A 20 percent contingency has also been added to each of the RA alternatives to account for uncertainties that are typical of RA activities.

In the case of the off-site RA alternatives, cost estimates have been provided by each of the disposal companies being considered. Those cost estimates have been evaluated and augmented so that valid comparisons among the RA alternatives can be made. The following is a cost summary for each of the RA alternatives that assumes a waste pile volume of 20,000 cubic yards:

- Alternative 1 - No Action/Institutional Controls $1,174,000
- Alternative 2A - In-Place Closure $2,815,000
- Alternative 2B - Above-Ground Repository $3,110,000
- Alternative 3A - Below-Ground Repository $3,139,000
- Alternative 3B - Below-Ground Repository with S/S $4,177,000
- Alternative 4A - Envirocare $5,528,700
- Alternative 4B - Umetco $5,044,000
- Alternative 4C - Solid Waste Landfill $712,000-$2,500,000

The costs provided reflect land valuation estimate of $800,000 for Alternatives 1, 2, and 3. Some of the parties on whose behalf this report is submitted disagree with this estimate and the appropriateness of including land valuation as a component in estimating the costs of implementing the RA alternative. In particular some parties believe the land valuation component is not applicable to Alternatives 1, 2A, and 2B.

These costs are the estimated thirty year net present worth of the alternatives including direct and indirect capital costs, monitoring costs, and annual operation and maintenance costs. A seven percent annual discount rate was used for calculating total present worth.

5.10 Cost Sensitivity Analysis

Cost sensitivity to stockpile volume was calculated for all alternatives. Costs were estimated for stockpile volumes of 15,000 cubic yards and 20,000 cubic yards. A graphical representation of the variability of cost versus stockpile volume is provided in Figure 5-1.

Alternative 1 - No Action/Institutional Controls and Alternative 2A - In-Place Closure display no variability of cost due to stockpile volume. Alternative 1 does not involve the excavation, compaction or transportation of any of the stockpile material. Alternative 2A involves regrading of the stockpile to a more stable configuration, but the amount of material moved will not vary with stockpile volume.

Alternatives 2B - Above-Ground Repository, 3A - Below-Ground Repository, and 3B - Below-Ground Repository with S/S show little variability in cost due to stockpile volume. The variability in Alternative 2B, $98,000, is due only to the amount of stockpile material that is being excavated and recompacted. Alternative 3A varies by $105,000, which includes variability in excavation of the repository, excavation of the stockpile material, placement of the stockpile material in the

Alternative 2B - Above-Ground Repository, 3A - Below-Ground Repository, and 3B - Below-Ground Repository with S/S show little variability in cost due to stockpile volume. The variability in Alternative 2B, $98,000, is due only to the amount of stockpile material that is being excavated and recompacted. Alternative 3A varies by $105,000, which includes variability in excavation of the repository, excavation of the stockpile material, placement of the stockpile material in the repository, and regrading of the clean fill from the repository excavation. Cost variability for Alternative 3B includes the same elements as Alternative 3A plus variability in cement, fly ash, and water required for S/S operations for a variance of $288,000.

The Off-Site Commercial Disposal Facility alternatives display a much greater variability of cost due to stockpile volume than the On-Site or Nearby Off-Site alternatives. Alternative 4A - Envirocare varies by $1,300,000, Alternative 4B - Umetco varies by $1,200,000, and Alternative 6C - Solid Waste Facilities varies between $65,000 and $600,000 depending on the selected option.

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6.0 Recommended Removal Action Alternative

RAs selected as the preferred cleanup alternative must be protective of human health and the environment. CERCLA also requires that the selected cleanup for the site comply with legally applicable or relevant and appropriate requirements established under State and Federal laws, to the extent practicable, or justify a waiver of the requirement. The selected RA alternative must be cost effective and utilize permanent treatment technologies or resource recovery technologies to the maximum extent practicable. CERCLA also contains a preference for cleanups which include treatment as a principal element.

The preferred alternative for disposal of the CSMRI stockpile soil is Alternative 4C - Off-Site Disposal at an Approved Solid Waste Disposal Facility. Alternative 4C provides overall protection of human health and the environment, complies with the ARARs for the site, and is cost effective. Alternatives 3A, 3B, 4A and 4B also provide overall protection of human health and the environment but are more costly and/or are less acceptable to the community.

The following sections discuss the basis for selecting the recommended RA alternative in more detail.

6.1 Alternative 1 - No Action/Institutional Controls

As outlined in the comparison of alternatives the no action alternative is included as baseline against which all other alternatives can be compared. Alternative 1 - No Action/Institutional Controls is not deemed protective of human health and the environment and does not fully attain the ARARs for the site. Therefore, Alternative 1 was eliminated from further consideration as a potential alternative for the site.

6.2 Alternative 2A - In-Place Closure and Alternative 2B Above-Ground Repository (In-Place)

At this time it is not known if these alternatives are fully protective of human health and the environment. Due to time constraints and technical difficulties obtaining data beneath the stockpile, subsurface information could not be gathered. This effort was complicated by the complex geography and geology in the area of the stockpile. Therefore, issues of compliance with ARARs and overall protection of human health and the environment are inconclusive at this time. Since the potential implementation of these alternatives will require additional data collection and evaluation, Alternatives 2A and 2B are not considered as preferred alternatives for the site.

6.3 Alternative 3A - Below-Ground Repository (nearby off-site)

This alternative involves final disposal of the stockpiled soils in and engineered disposal cell below the current CSM baseball field. This alternative is protective of human health and the environment and complies with ARARs for the site. The alternative is easily implemented technically, provides long-term effectiveness, is cost effective and has minimal short-term risks during implementation. This alternative does not include treatment of the stockpile soil and there may be difficulties obtaining the necessary permits/license and approval and therefore is ranked lower for administrative feasibility. This alternative meets the minimum criteria for selecting the preferred RA. However, it was not selected as the preferred RA alternative because there is a more protective, cost effective and easily implementable alternative. In addition, it is expected that there may be lower community acceptance of Alternative 3A in comparison to other off-site disposal options.

6.4 Alternative 3B -Below Ground Repository with Soil S/S (nearby off-site)

This alternative is the same as Alternative 3A except it adds stabilization/solidification of the soil with cement and fly ash. Therefore, in terms of the evaluation criteria Alternative 3A is very similar to Alternative 3B. The main differences are that this alternative (3B) is more costly (approximately 1 million dollars), and it provides treatment of the soils and reduces toxicity and mobility of the contamination in the soil. For these reason Alternatives 3A and 3B are considered essentially equal in terms of the primary evaluation criteria. Alternative 3B is not selected as the preferred RA alternative because there is a more protective, cost effective and readily implementable alternative.

6.5 Alternative 4A - Off-Site Disposal - Envirocare, Utah

This alternative is protective of human health and the environment and complies with the ARARs for the site. It is readily implementable, technically and administratively feasible. The short-term risks are only slightly higher than the other alternatives (except 4B, Umetco which has the highest short term risk) because of the more complex handling (both truck and rail handling and the longer distance from the site (630 miles west of the site near Clive, Utah). The high cost associate with this alternative in comparison to other off-site alternatives is the significant factor which eliminates Alternative 4A from being selected as the preferred RA alternative. The cost for this alternative is between 3 to 4 million dollars more than other off-site disposal options.

6.6 Alternative 4B - Off-Site Disposal - Umetco, Colorado

This alternative is protective of human health and the environment and meets the ARARs for the site. This alternative has the highest short-term risks in comparison to all other alternatives because of the long highway transportation required to transport the stockpile soils to the Umetco site (320 miles one way). In addition, due to administrative difficulties (Umetco's ability to accept the soil under their license is questionable) and the higher cost associated with this option (2 to 4 million dollars more than other off-site options) are the main factors which eliminate this alternative from being selected as the preferred RA option.

6.7 Alternative 4C - Approved Solid Waste Disposal Facility - BFI, Colorado; CSI, Colorado; and Laidlaw, Colorado

This alternative involves the transportation and disposal of the stockpile soils at an approved solid waste disposal facility. Under this alternative the stockpile soil would be handled as a "special solid waste." This alternative is protective of human health and the environment and complies with the ARARs for the site. This alternative removes the contaminated soils from the site and disposes of them in an approved disposal facility and is therefore achieve high effectiveness and permanence with regard to eliminating risks at the site. This alternative has low short-term risks and is technically simple to implement. The administrative feasibility associated with implementation of this alternative is higher than Alternatives 3A and 3B, but slightly lower than Alternatives 2A, 2B, and 4A because final approval of specific handling procedures for the "special solid waste" (stockpile soil) must be provided. The significantly lower cost of this alternative and the anticipated high community acceptance of this alternative are the key driving factors which lead to the selection of Alternative 4C as the preferred RA option. Alternative 4C - Off-Site Disposal at an Approved Solid Waste Facility is between 2 and 4 million dollars less than other off-site alternatives and is equally protective of human health and the environment and fully complies with the ARARs for the site. The selection of Alternative 4C as the preferred disposal option for the CSMRI stockpiles soil is consistent with the statutory mandates of CERCLA and is in compliance with the NCP.

The facilities listed under this alternative are representative solid waste facilities which requested inclusion in this report. In addition to these representative facilities, there may be other solid waste disposal facilities which are eligible and interested in being approved to accept the stockpile soils for disposal. The respondents at the CSMRI site and EPA will make the final determination of the specific selected off-site disposal facility during the development of the work plan for implementation of the selected RA. The final selection of the disposal facility will be based on a formal bidding process in which eligible facilities will competitively bid for the award of a disposal contract.

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Tables

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Table 2-1
Summary of EPA's Contaminants of Concern Concentration Data
CSMRI Stockpile Characterization

Constituent	Maximum	Arithmetic Mean	Upper 95% Confidence Limit
Inorganics	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Arsenic	150	75	150
Barium	500	410	500
Cadmium	6	3.4	6
Chromium	41	25.6	40
Reactive Cyanide	6.3	1.7	4.9
Lead	1,000	378	936
Manganese	1,200	752	1,200
Mercury	18	8	18
Nickel	83	37	83
Silver	7	3.2	7
Vanadium	69	58	68
Radionuclides	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**
Uranium-238 [(1)]	27	11	17
Thorium-230 [(2)]	70	30	36
Radium-226+D [(3)]	70	30	36
Lead-210+D [(2)]	70	30	36
Uranium-235 [(4)]	3.9	1.5	2.0
Protactinium-231 [(4)]	3.9	1.5	2.0
Actinium-227+D [(4)]	3.9	1.5	2.0

(1) Uranium-238 concentrations inferred from Thorium-234 concentrations

(2) Thorium-230 and Lead-210 assumed to be at same activity as Radium-226

(3) Radium-226 concentrations inferred from Lead-214 and Bismuth-214 concentrations

(4) Uranium-235, Protactinium-231, and Actinium-227 concentrations inferred from Thorium-227 concentrations. EPA's Final Risk Assessment states that Uranium-235 was measured directly. However, E&E's CSMRI Stockpile Sampling Activities Report does not include any Uranium-235 data.

Table 2-2
Sand Cone Test Results
CSMRI Stockpile Characterization

Location	Elevation	Moisture Content (%)	Dry Density (pcf)
TT-1 (~29′ N of S end)	~1.5′ below surface	2.8	108.9
TT-1 (~27′ N of S end)	~3.5′ below surface	13.7	110.4
TT-2 (~5.5′ S of N end)	~2.0′ below surface	8.8	115.3
TT-2 (~24′ N of S end)	~4.0′ below surface	10.5	108.5
TT-3 (~11′ N of S end)	~4.0′ below surface	9.5	87.4
TT-4E (~12′ W of berm)	~3.0′ below surface	13.7	75.5
TT-4W (~12′ E of berm)	~4.0′ below surface	10.3	103.7
TT-7 (~15′ S of berm)	~2.0′ below surface	9.4	85.6
TT-10 (~13′ W of berm)	~3.0′ below surface	9.8	94.1
TP-3 (~10′ S of S end)	~1.0′ below surface	11.5	97.7

Table 2-3
Physical Characteristics
CSMRI Stockpile Characterization

Soil Unit	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Specific Gravity (1)	Maximum Dry Density (2) (pcf)	Optimum Moisture Content (2) (%)
Cover	29	19	10	2.63	119.0	13.0
Tailings	30	22	8	2.63	114.0	15.8

(1) Specific gravity determined for portion passing 3-inch sieve.

(2) Standard Proctor test for "cover" and "tailings" conducted on portion passing 3/8-inch sieve.

Table 2-4
Radium-226 and Arsenic Concentrations
CSMRI Stockpile Characterization

Constituent	"Tailings"	"Cover"	"Hot Spot"	Representative (1)
Radium-226 (pCi/g)				
Sample	28.6±1.5	22.5±1.3	87.2±3.4	25.8±1.4
Field Duplicate	25.0±1.6	24.3±1.4	99.1±4.1	25.3±1.5
Arsenic (mg/kg)				
Sample	180	72	119	119
Field Duplicate	157	60	165	103

(1) Representative concentrations are based on weighted averages in proportion to the volume of each type of material within the stockpile (See Section 2.3.1.3)

Table 2-5
Radionuclide Concentrations[1]
CSMRI Stockpile Characterization

Sample ID	CP-4A	CP-3C	Duplicate	CSSP01	CSSP02	CSSP08
Contractor	CEC	CEC	CEC	E&E	E&E	E&E
Waste Fraction	3/4"+ Biased	3/4"- Biased	3/4"- Biased	Full Unbiased	Full Unbiased	Full Unbiased
Radionuclide	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Gross Alpha	-	-	-	39±13	65±15	220±26
Gross Beta	-	-	-	64±8.0	120±9.7	230±12
Uranium-238	2.5±0.5	14.1±1.4	11.2±1.2	-	-	-
Thorium-234	-			ND	2.5±4.4	15±2.3
Uranium-234	2.6±0.5	13.4±1.4	11.5±1.2	-	-	-
Thorium-230	0.6±0.6	19.3±2.6	5.4±1.0	-	-	-
Radium-226	6.0±0.8	46.6±2.7	43.3±2.8	-	-	-
Lead-214	-	-	-	19±1.0	34±1.3	57±0.9
Bismuth-214	-	-	-	17±1.8	35±2.4	57±1.3
Lead-210	<25.8J	56.7±8.2 J	<43.3 J	-	-	-
Thorium-232	2.0±0.5	1.6±0.5	0.6±0.2	-	-	-
Radium-228	4.4±0.8	<1.4	<2.1	-	-	-
Actinium-228	-	-	-	2.0±0.9	2.2±0.9	2.5±0.7
Thorium-228	2.2±0.5	1.8±0.5	0.4±0.2 UB.01	-	-	-
Lead-212	-	-	-	1.6±0.3	1.9±0.4	1.2±0.4
Thallium-208	-	-	-	0.69±0.3	0.98±0.4	0.72±0.3
Uranium-235	0.1±0.1	0.4±0.2	0.2±0.1	-	-	-
Thorium-227	-	-	-	ND	ND	3.2±0.7

(1) See Table 2-10 for 3/4-inch plus duplicate results and E&E background data

ND - Not Detected

J - High detection limit for Lead-210 may be due to the use of gamma spectroscopy rather than gas proportional counting (preferred method).

UB.01 - Blanks were reported with values greater than the instrument detection limit.

Table 2-6
Organic Concentrations
CSMRI Stockpile Characterization

Sample ID	CSSP01	CSSP02	CSSP08
Contractor	E&E	E&E	E&E
Waste Fraction	Full Unbiased	Full Unbiased	Full Unbiased
Organics	**(ppb)**	**(ppb)**	**(ppb)**
Acetone	62 J	49 J	28 J
Bis(2-ethylhexyl) phthalate	1,000	ND	ND
Trichloroethylene	ND	12	25
Tetrachloroethylene	ND	7	9
Dibromoethene	ND	ND	5 NJ

ND - Not Detected

NJ - Presumptive evidence of the presence of the material at an estimated quantity

J - The associated numerical value is an estimated quantity because QC criteria were not met.

Table 2-7
Inorganic Concentrations
CSMRI Stockpile Characterization

Sample ID	CP-3A	Duplicate	CSSP01	CSSP02	CSSP08
Contractor	CEC	CEC	E&E	E&E	E&E
Waste Fraction	3/4"- Biased	3/4"- Biased	Full Unbiased	Full Unbiased	Full Unbiased
Inorganics	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Aluminum	-	-	6,000	8,400	12,000
Antimony	-	-	10 U	10 U	10 U
Arsenic	138	126	42	53	150
Barium	653	810	480	280	480
Beryllium	-	-	0.4	0.4	0.6
Cadmium	6 JS72	5 JS72	3	4	6
Calcium	-	-	7200	18,000	17,000
Chromium	36	39	20	23	41
Cobalt	-	-	10	10	27
Copper	-	-	650	620	1,800
Reactive Cyanide	<1	<1	6.3	0.5 U	0.5 U
Iron	-	-	17,000	20,000	34,000
Lead	559	504	200	220	280
Magnesium	-	-	2,800	4,500	5,300
Manganese	871	916	340	1,000	1,200
Mercury	12.8	78.9	18	7.1	5.7
Nickel	46	46	30	20	83
Potassium	-	-	1,800	2,800	2,000
Selenium	-	-	0.24	0.1	2.7
Silver	14	14	7	4	2
Sodium	-	-	680	400	400
Reactive Sulfide	-	-	80	50 U	50 U
Thallium	-	-	0.26 J	0.1 J	0.4 J
Vanadium	79	71	53	47	62
Zinc	-	-	510	410	1,000

ND - Not Detected
J - The associated numerical value is an estimated quantity because QC criteria were not met.
JS72 - The percent recovery was 72%. The acceptable limit is 75%. Cadmium data could be low by 28%.

Table 2-8
Analytical Results for Stockpile Composite Sample

Constituent	Test Method	Result
Radium-226 (pCi/g)	EPA 903.1	47+1.3
Thorium-228 (pCi/g)	AccuLab (1)	2.8+0.3
Thorium-230 (pCi/g)	AccuLab (1)	24+1.0
Thorium-232 (pCi/g)	AccuLab (1)	3.8+0.4
Uranium (natural) (µg/kg)	EPA 908.1	46
Plutonium-239+240 (pCi/g)	Acculab (2)	0.00+0.03
TCE (µg/kg)	EPA 8010	<5
PCE (µg/kg)	EPA 8010	<5
Total Sulfur (%)	D 4239-85 C (14)	.38
Total Sulfur (tons/kt)	D 4239-85 C (14)	11.9
ANP (tons/kt)	3.2.3 (15)	49.7
Arsenic (mg/kg)	EPA 6010 (total)	92
Barium (mg/kg)	EPA 6010 (total)	705
Cadmium (mg/kg)	EPA 6010 (total)	4.1
Chromium (mg/kg)	EPA 6010 (total)	25
Lead (mg/kg)	EPA 6010 (total)	328
Mercury (mg/kg)	EPA 7470 (total)	15
Selenium (mg/kg)	EPA 6010 (total)	<10
Silver (mg/kg)	EPA 6010 (total)	4
Arsenic (mg/l)	EPA 1312, 6010 (SAPT)	<0.05
Barium (mg/l)	EPA 1312, 6010 (SAPT)	0.07
Cadmium (mg/l)	EPA 1312, 6010 (SAPT)	<0.005
Chromium (mg/l)	EPA 1312, 6010 (SAPT)	<0.01
Lead (mg/l)	EPA 1312, 6010 (SAPT)	<0.05
Mercury (mg/l)	EPA 1312, 7470 (SAPT)	0.0004
Selenium (mg/l)	EPA 1312, 6010 (SAPT)	<0.1
Silver (mg/l)	EPA 1312, 6010 (SAPT)	<0.01
Arsenic (mg/l)	EPA 1311, 6010 (TCLP)	0.07
Barium (mg/l)	EPA 1311, 6010 (TCLP)	<0.5
Cadmium (mg/l)	EPA 1311, 6010 (TCLP)	0.06
Chromium (mg/l)	EPA 1311, 6010 (TCLP)	<0.01
Lead (mg/l)	EPA 1311, 6010 (TCLP)	0.50
Mercury (mg/l)	EPA 1311, 7470 (TCLP)	<0.003
Selenium (mg/l)	EPA 1311, 6010 (TCLP)	<0.1
Silver (mg/l)	EPA 1311, 6010 (TCLP)	<0.01

Note: Total thorium expressed as milligrams/kilogram is approximately 2.2.

Table 2-9
TCLP Metals Test Results
CSMRI Stockpile Characterization

Sample ID	**CP-1A**	**Duplicate**	**CP-2A**	**Duplicate**	**RCRA Regulatory Limit**
Waste Fraction	**3/4"-Biased**	**3/4"-Biased**	**3/8"-Biased**	**3/8"-Biased**	
Metal	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**
Arsenic	0.05	<0.05	<0.05	<0.05	5.0
Barium	<0.5	<0.5	<0.5	<0.5	100.0
Cadmium	0.06	0.07	0.06	0.06	1.0
Chromium	<0.01	<0.01	<0.01	<0.01	5.0
Lead	0.80	1.65	2.70	**8.04**	5.0
Mercury	<0.003	<0.003	<0.003	<0.003	0.2
Selenium	<0.1	<0.1	<0.1	<0.1	1.0
Silver	<0.01	<0.01	0.01	0.13	5.0

Note: Concentrations which exceed the regulatory limits are in bold print.

Table 2-10
Constituent Concentrations in the 3/4-Inch Plus Fraction and Background Sample
CSMRI Stockpile Characterization

Sample ID	CP-4A	Duplicate	CSSP10
Contractor	**CEC**	**CEC**	**E&E**
Waste Fraction	**3/4" plus "Biased"**	**3/4"plus "Biased"**	**Background**
Inorganics	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Arsenic	24	34	1.5
Barium	331	216	96
Cadmium	1 JS72	1.0 JS72	1 U
Chromium	41	27	10
Reactive Cyanide	<1	<1	0.5 U
Lead	493	62	110
Manganese	946	273	310
Mercury	1.86	3.16	0.1 U
Nickel	26	17	6
Silver	10	7	2 U
Vanadium	44	21.7	21
Radionuclides	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**
Uranium-238	2.5±0.5	(1)	-
Thorium-234	-	-	ND
Uranium-234	2.6±0.5	(1)	-
Thorium-230	0.6±0.6	(1)	-
Radium-226	6.0±0.8	(1)	-
Lead-214(2)	-	-	0.56±0.2
Bismuth-214(2)	-	-	0.34±0.7
Lead-210	<25.8 J	(1)	-
Thorium-232	2.0±0.5	(1)	-
Radium-228	4.4±0.8	(1)	-
Actinium-228	-	-	1.4±0.3
Thorium-228	2.2±0.5	(1)	-
Lead-212	-	-	1.1±0.2
Thallium-208	-	-	0.40±0.1
Uranium-235	0.1±0.1	(1)	-
Thorium-227	-	-	ND

(1) - Duplicate sample container for radionuclide analyses broken during transport to laboratory.

(2) - EPA assumed secular equilibrium and used these values to estimate uranium and thorium concentrations (see EPA's Final Risk Assessment for specifics on this procedure).

JS72 - The percent recovery was 72%. The acceptable limit is 75%. Cadmium data for these samples could be low by 28%.

J - High detection limit for Lead-210 may be due to the use of gamma spectroscopy rather than gas proportional counting (preferred method).

Table 2-11
Summary of Radionuclide Contaminants of Concern Concentrations
CSMRI Stockpile Characterization

Constituent	Radionuclide Concentrations (pCi/g)											
	Representative Data (CEC)			Representative Data (EPA)			Biased and Supplemental Data (CEC/SRK)			All Data Combined		
	Mean	Max	95% UCL	Mean	Max	95% UCL	Mean	Max	95% UCL[1]	Mean	Max	95% UCL[2]
Ra-226	26	26	26	30	70	35	42	47	47	31	70	35
Pb-210	-	-	-	30	70	35	42	47	47	31	70	35
U-238	-	-	-	5.2	27	8.6	11	12	12	6.3	27	9.3
Th-234	-	-	-	5.2	27	8.6	11	12	12	6.3	27	9.3
U-234	-	-	-	5.2	27	8.6	11	12	12	6.3	27	9.3
Th-230	-	-	-	-	-	-	14	21	21	14	21	21
Th-232	-	-	-	-	-	-	1.6	2.4	2.4	1.6	2.4	2.4
Ra-228	-	-	-	-	-	-	<0.9	<1.1	<1.1	<0.9	<1.1	<1.1
Ac-228	-	-	-	2.5	4.7	2.9	-	-	-	2.5	4.7	2.9
Th-228	-	-	-	-	-	-	1.7	2.4	2.4	1.7	2.4	2.4
Pb-212	-	-	-	2.2	4.2	2.5	-	-	-	2.2	4.2	2.5
Tl-208	-	-	-	0.76	1.6	0.93	-	-	-	0.76	1.6	0.93
Pa-231	-	-	-	1.5	3.9	2.0[1] [2]	-	-	-	-	-	-
Ac-227+D	-	-	-	1.5	3.9	2.0[1] [2]	-	-	-	-	-	-
U-235	-	-	-	-	-	-	0.3	0.4	0.4	0.3	0.4	0.4
Th-227	-	-	-	1.5	3.9	2.0	-	-	-	1.5	3.9	2.0

[1] These COC data were used for the risk assessment of RA alternatives for on-site/nearby off-site disposal options.
[2] These COC data were used for the risk assessment of RA alternatives for off-site disposal options

Table 2-12
Summary of Inorganic Contaminants of Concern Concentrations
CSMRI Stockpile Characterization

Constituent	Inorganic Concentrations (pCi/g)											
	Representative Data (CEC)			Representative Data (EPA)			Biased and Supplemental Data (CEC/SRK)			All Data Combined		
	Mean	Max	95% UCL	Mean	Max	95% UCL	Mean	Max	95% UCL	Mean	Max	95% UCL[1]
Arsenic	111	119	119	75	150	150	108	122	122	92	150	150
Barium	-	-	-	410	500	500	677	730	730	510	730	730
Cadmium	-	-	-	3	6	6	5	5.3	5.3	4	6	6
Chromium	-	-	-	26	41	40	33	38	38	28	41	41
Reactive Cyanide	-	-	-	1.7	6.3	4.9	0.5	0.5	0.5	1.3	6.3	3.6
Lead	-	-	-	378	1,000	936	442	517	517	402	1,000	883
Manganese	-	-	-	752	1,200	1,200	851	870	870	780	1,200	1,200
Mercury	-	-	-	8.1	18	18	31	67	67	17	67	67
Nickel	-	-	-	37	83	82	42	42	42	38	83	77
Silver	-	-	-	3.2	7	7	10	13	13	5.7	13	13
Vanadium	-	-	-	58.2	69	68.2	69	72	72	61	72	72

[1] These COC data were used for the risk assessment of RA alternatives for both off-site and on-site/nearby off-site disposal options.

Table 2-13
Analytical Results for Test Pit Samples

Constituent	Sample ID CSMRI-2	CSMRI-3	CSMRI-4	EPA Test Method
Radium-226 (pCi/g)	7.4±0.6	1.1±0.3	1.1±0.3	903.1
Arsenic (mg/kg)	<5	<5	11	6010
Barium (mg/kg)	130	130	93	6010
Cadmium (mg/kg)	<0.5	<0.5	<0.5	6010
Chromium (mg/kg)	14	13	11	6010
Lead (mg/kg)	110	1,800	59,000	6010
Mercury (mg/kg)	0.14	0.14	0.12	7471
Selenium (mg/kg)	<5	<5	<5	6010
Silver (mg/kg)	<0.5	0.6	2.0	6010

Table 2-14
Results of Chemical Parameters Which Affect S/S Treatment

Sample ID	CP-3A	Duplicate
Waste Fraction	3/4" minus Biased	3/4" minus Biased
pH	7.47	7.51
Constituent	**(mg/kg)**	**(mg/kg)**
Oil/Grease	212	125
Fluoride	22	22
Chloride	77	80
Nitrate	18	15
Sulfate	7,860	7,420
Ammonia	5.7	6.0

Table 2-15
Summary of Proctor Test Results on Cement Treated Soil

Cement-Fly Ash Content	Maximum Dry Density (pcf)	Optimum Moisture Content (%)
10% cement 2% fly ash	119.0	13.5
14% cement 2.8% fly ash	118.5	14.5
18% cement 3.6% fly ash	118.2	15.0

Table 2-16
Data for the Cylinders Prepared at 10% Cement, 2% Fly Ash

Cylinder No.	Moisture Content (%)	Dry Density (pcf)	Percent Compaction
1	13.8	117.6	98.8
2	13.8	117.3	98.6
3	13.8	117.0	98.3
4	13.8	116.3	97.7
5	14.0	117.6	98.8
6	14.0	117.6	98.8
7	14.0	116.3	97.7
8	14.0	117.4	98.6
9	14.5	116.6	98.0
10	14.5	117.4	98.7
11	14.5	115.8	97.3
12	14.5	116.9	98.2
13	14.0	118.2	99.3

Table 2-17
Data for the Cylinders Prepared at 14% Cement, 2.8% Fly Ash

Cylinder No.	Moisture Content (%)	Dry Density (pcf)	Percent Compaction
1	12.7	117.4	99.1
2	12.7	117.4	99.1
3	13.9	117.7	99.4
4	13.9	118.8	100.2
5	13.9	118.0	99.6
6	13.9	118.8	100.2
7	14.8	118.1	99.7
8	14.8	118.4	99.9
9	14.8	117.1	98.8
10	14.8	117.9	99.5
11	14.2	118.7	100.2
12	14.2	118.5	100.0
13	14.2	118.7	100.2

Table 2-18
Data for the Cylinders Prepared at 18% Cement, 3.6% Fly Ash

Cylinder No.	Moisture Content (%)	Dry Density (pcf)	Percent Compaction
1	12.6	117.5	99.4
2	12.6	117.8	99.6
3	14.5	116.9	98.9
4	14.5	117.4	99.3
5	14.5	115.5	97.7
6	14.5	117.9	99.7
7	12.7	119.3	100.9
8	12.7	119.0	100.7
9	12.7	118.2	100.0
10	12.7	118.7	100.4
11	12.9	119.0	100.7
12	12.9	119.0	100.7
13	12.9	117.2	99.1

Table 2-19
Summary of Unconfined Compressive Strength Test Results

Cement-Fly Ash Content	Cylinder No.	Unconfined Compressive Strength (psi)		
		7-Day	14-Day	28-Day
10% Cement 2% Fly Ash	1	372	-	-
	2	363	-	-
	3	-	364	-
	4	-	363	-
	5	-	-	491
	6	-	-	554
14% Cement 2.8% Fly Ash	3	356	-	-
	4	418	-	-
	5	-	505	-
	6	-	581	-
	7	-	-	451
	8	-	-	561
18% Cement 3.6% Fly Ash	3	475	-	-
	4	442	-	-
	5	-	435	-
	6	-	536	-
	7	-	-	570
	8	-	-	616

Table 2-20
Permeability Test Results

Cement-Fly Ash Content	Measured Permeability (cm/sec)
10% Cement 2% Fly Ash	9.0 E-07
14% Cement 2.8% Fly Ash	2.6 E-07
18% Cement 3.6% Fly Ash	1.4 E-07

Table 2-1
Summary of EPA's Contaminants of Concern Concentration Data
CSMRI Stockpile Characterization

Constituent	Maximum	Arithmetic Mean	Upper 95% Confidence Limit
Inorganics	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Arsenic	150	75	150
Barium	500	410	500
Cadmium	6	3.4	6
Chromium	41	25.6	40
Reactive Cyanide	6.3	1.7	4.9
Lead	1,000	378	936
Manganese	1,200	752	1,200
Mercury	18	8	18
Nickel	83	37	83
Silver	7	3.2	7
Vanadium	69	58	68
Radionuclides	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**
Uranium-238 (1)	27	11	17
Thorium-230 (2)	70	30	36
Radium-226+D (3)	70	30	36
Lead-210+D (2)	70	30	36
Uranium-235 (4)	3.9	1.5	2.0
Protactinium-231 (4)	3.9	1.5	2.0
Actinium-227+D (4)	3.9	1.5	2.0

(1) Uranium-238 concentrations inferred from Thorium-234 concentrations

(2) Thorium-230 and Lead-210 assumed to be at same activity as Radium-226

(3) Radium-226 concentrations inferred from Lead-214 and Bismuth-214 concentrations

(4) Uranium-235, Protactinium-231, and Actinium-227 concentrations inferred from Thorium-227 concentrations. EPA's Final Risk Assessment states that Uranium-235 was measured directly. However, E&E's CSMRI Stockpile Sampling Activities Report does not include any Uranium-235 data.

Table 2-2
Sand Cone Test Results
CSMRI Stockpile Characterization

Location	Elevation	Moisture Content (%)	Dry Density (pcf)
TT-1 (~29′ N of S end)	~1.5′ below surface	2.8	108.9
TT-1 (~27′ N of S end)	~3.5′ below surface	13.7	110.4
TT-2 (~5.5′ S of N end)	~2.0′ below surface	8.8	115.3
TT-2 (~24′ N of S end)	~4.0′ below surface	10.5	108.5
TT-3 (~11′ N of S end)	~4.0′ below surface	9.5	87.4
TT-4E (~12′ W of berm)	~3.0′ below surface	13.7	75.5
TT-4W (~12′ E of berm)	~4.0′ below surface	10.3	103.7
TT-7 (~15′ S of berm)	~2.0′ below surface	9.4	85.6
TT-10 (~13′ W of berm)	~3.0′ below surface	9.8	94.1
TP-3 (~10′ S of S end)	~1.0′ below surface	11.5	97.7

Table 2-3
Physical Characteristics
CSMRI Stockpile Characterization

Soil Unit	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Specific Gravity (1)	Maximum Dry Density (2) (pcf)	Optimum Moisture Content (2) (%)
Cover	29	19	10	2.63	119.0	13.0
Tailings	30	22	8	2.63	114.0	15.8

(1) Specific gravity determined for portion passing 3-inch sieve.
(2) Standard Proctor test for "cover" and "tailings" conducted on portion passing 3/8-inch sieve.

Table 2-4
Radium-226 and Arsenic Concentrations
CSMRI Stockpile Characterization

Constituent	"Tailings"	"Cover"	"Hot Spot"	Representative (1)
Radium-226 (pCi/g)				
Sample	28.6±1.5	22.5±1.3	87.2±3.4	25.8±1.4
Field Duplicate	25.0±1.6	24.3±1.4	99.1±4.1	25.3±1.5
Arsenic (mg/kg)				
Sample	180	72	119	119
Field Duplicate	157	60	165	103

(1) Representative concentrations are based on weighted averages in proportion to the volume of each type of material within the stockpile (See Section 2.3.1.3)

Table 2-5
Radionuclide Concentrations[1]
CSMRI Stockpile Characterization

Sample ID	**CP-4A**	**CP-3C**	**Duplicate**	**CSSP01**	**CSSP02**	**CSSP08**
Contractor	**CEC**	**CEC**	**CEC**	**E&E**	**E&E**	**E&E**
Waste Fraction	**3/4"+ Biased**	**3/4"- Biased**	**3/4"- Biased**	**Full Unbiased**	**Full Unbiased**	**Full Unbiased**
Radionuclide	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**
Gross Alpha	-	-	-	39±13	65±15	220±26
Gross Beta	-	-	-	64±8.0	120±9.7	230±12
Uranium-238	2.5±0.5	14.1±1.4	11.2±1.2	-	-	-
Thorium-234	-			ND	2.5±4.4	15±2.3
Uranium-234	2.6±0.5	13.4±1.4	11.5±1.2	-	-	-
Thorium-230	0.6±0.6	19.3±2.6	5.4±1.0	-	-	-
Radium-226	6.0±0.8	46.6±2.7	43.3±2.8	-	-	-
Lead-214	-	-	-	19±1.0	34±1.3	57±0.9
Bismuth-214	-	-	-	17±1.8	35±2.4	57±1.3
Lead-210	<25.8J	56.7±8.2 J	<43.3 J	-	-	-
Thorium-232	2.0±0.5	1.6±0.5	0.6±0.2	-	-	-
Radium-228	4.4±0.8	<1.4	<2.1	-	-	-
Actinium-228	-	-	-	2.0±0.9	2.2±0.9	2.5±0.7
Thorium-228	2.2±0.5	1.8±0.5	0.4±0.2 UB.01	-	-	-
Lead-212	-	-	-	1.6±0.3	1.9±0.4	1.2±0.4
Thallium-208	-	-	-	0.69±0.3	0.98±0.4	0.72±0.3
Uranium-235	0.1±0.1	0.4±0.2	0.2±0.1	-	-	-
Thorium-227	-	-	-	ND	ND	3.2±0.7

(1) See Table 2-10 for 3/4-inch plus duplicate results and E&E background data

ND - Not Detected

J - High detection limit for Lead-210 may be due to the use of gamma spectroscopy rather than gas proportional counting (preferred method).

UB.01 - Blanks were reported with values greater than the instrument detection limit.

Table 2-6
Organic Concentrations
CSMRI Stockpile Characterization

Sample ID	**CSSP01**	**CSSP02**	**CSSP08**
Contractor	**E&E**	**E&E**	**E&E**
Waste Fraction	**Full Unbiased**	**Full Unbiased**	**Full Unbiased**
Organics	**(ppb)**	**(ppb)**	**(ppb)**
Acetone	62 J	49 J	28 J
Bis(2-ethylhexyl) phthalate	1,000	ND	ND
Trichloroethylene	ND	12	25
Tetrachloroethylene	ND	7	9
Dibromoethene	ND	ND	5 NJ

ND - Not Detected
NJ - Presumptive evidence of the presence of the material at an estimated quantity
J - The associated numerical value is an estimated quantity because QC criteria were not met.

Table 2-7
Inorganic Concentrations
CSMRI Stockpile Characterization

Sample ID	CP-3A	Duplicate	CSSP01	CSSP02	CSSP08
Contractor	CEC	CEC	E&E	E&E	E&E
Waste Fraction	3/4"-Biased	3/4"-Biased	Full Unbiased	Full Unbiased	Full Unbiased
Inorganics	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Aluminum	-	-	6,000	8,400	12,000
Antimony	-	-	10 U	10 U	10 U
Arsenic	138	126	42	53	150
Barium	653	810	480	280	480
Beryllium	-	-	0.4	0.4	0.6
Cadmium	6 JS72	5 JS72	3	4	6
Calcium	-	-	7200	18,000	17,000
Chromium	36	39	20	23	41
Cobalt	-	-	10	10	27
Copper	-	-	650	620	1,800
Reactive Cyanide	<1	<1	6.3	0.5 U	0.5 U
Iron	-	-	17,000	20,000	34,000
Lead	559	504	200	220	280
Magnesium	-	-	2,800	4,500	5,300
Manganese	871	916	340	1,000	1,200
Mercury	12.8	78.9	18	7.1	5.7
Nickel	46	46	30	20	83
Potassium	-	-	1,800	2,800	2,000
Selenium	-	-	0.24	0.1	2.7
Silver	14	14	7	4	2
Sodium	-	-	680	400	400
Reactive Sulfide	-	-	80	50 U	50 U
Thallium	-	-	0.26 J	0.1 J	0.4 J
Vanadium	79	71	53	47	62
Zinc	-	-	510	410	1,000

ND - Not Detected

J - The associated numerical value is an estimated quantity because QC criteria were not met.

JS72 - The percent recovery was 72%. The acceptable limit is 75%. Cadmium data could be low by 28%.

Table 2-8
Analytical Results for Stockpile Composite Sample

Constituent	Test Method	Result
Radium-226 (pCi/g)	EPA 903.1	47+1.3
Thorium-228 (pCi/g)	AccuLab (1)	2.8+0.3
Thorium-230 (pCi/g)	AccuLab (1)	24+1.0
Thorium-232 (pCi/g)	AccuLab (1)	3.8+0.4
Uranium (natural) (μg/kg)	EPA 908.1	46
Plutonium-239+240 (pCi/g)	Acculab (2)	0.00+0.03
TCE (μg/kg)	EPA 8010	<5
PCE (μg/kg)	EPA 8010	<5
Total Sulfur (%)	D 4239-85 C (14)	.38
Total Sulfur (tons/kt)	D 4239-85 C (14)	11.9
ANP (tons/kt)	3.2.3 (15)	49.7
Arsenic (mg/kg)	EPA 6010 (total)	92
Barium (mg/kg)	EPA 6010 (total)	705
Cadmium (mg/kg)	EPA 6010 (total)	4.1
Chromium (mg/kg)	EPA 6010 (total)	25
Lead (mg/kg)	EPA 6010 (total)	328
Mercury (mg/kg)	EPA 7470 (total)	15
Selenium (mg/kg)	EPA 6010 (total)	<10
Silver (mg/kg)	EPA 6010 (total)	4
Arsenic (mg/l)	EPA 1312, 6010 (SAPT)	<0.05
Barium (mg/l)	EPA 1312, 6010 (SAPT)	0.07
Cadmium (mg/l)	EPA 1312, 6010 (SAPT)	<0.005
Chromium (mg/l)	EPA 1312, 6010 (SAPT)	<0.01
Lead (mg/l)	EPA 1312, 6010 (SAPT)	<0.05
Mercury (mg/l)	EPA 1312, 7470 (SAPT)	0.0004
Selenium (mg/l)	EPA 1312, 6010 (SAPT)	<0.1
Silver (mg/l)	EPA 1312, 6010 (SAPT)	<0.01
Arsenic (mg/l)	EPA 1311, 6010 (TCLP)	0.07
Barium (mg/l)	EPA 1311, 6010 (TCLP)	<0.5
Cadmium (mg/l)	EPA 1311, 6010 (TCLP)	0.06
Chromium (mg/l)	EPA 1311, 6010 (TCLP)	<0.01
Lead (mg/l)	EPA 1311, 6010 (TCLP)	0.50
Mercury (mg/l)	EPA 1311, 7470 (TCLP)	<0.003
Selenium (mg/l)	EPA 1311, 6010 (TCLP)	<0.1
Silver (mg/l)	EPA 1311, 6010 (TCLP)	<0.01

Note: Total thorium expressed as milligrams/kilogram is approximately 2.2.

Table 2-9
TCLP Metals Test Results
CSMRI Stockpile Characterization

Sample ID	**CP-1A**	**Duplicate**	**CP-2A**	**Duplicate**	**RCRA Regulatory Limit**
Waste Fraction	**3/4"-Biased**	**3/4"-Biased**	**3/8"-Biased**	**3/8"-Biased**	
Metal	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**
Arsenic	0.05	<0.05	<0.05	<0.05	5.0
Barium	<0.5	<0.5	<0.5	<0.5	100.0
Cadmium	0.06	0.07	0.06	0.06	1.0
Chromium	<0.01	<0.01	<0.01	<0.01	5.0
Lead	0.80	1.65	2.70	**8.04**	5.0
Mercury	<0.003	<0.003	<0.003	<0.003	0.2
Selenium	<0.1	<0.1	<0.1	<0.1	1.0
Silver	<0.01	<0.01	0.01	0.13	5.0

Note: Concentrations which exceed the regulatory limits are in bold print.

Table 2-10
Constituent Concentrations in the 3/4-Inch Plus Fraction and Background Sample
CSMRI Stockpile Characterization

Sample ID	CP-4A	Duplicate	CSSP10
Contractor	**CEC**	**CEC**	**E&E**
Waste Fraction	**3/4" plus "Biased"**	**3/4"plus "Biased"**	**Background**
Inorganics	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Arsenic	24	34	1.5
Barium	331	216	96
Cadmium	1 JS72	1.0 JS72	1 U
Chromium	41	27	10
Reactive Cyanide	<1	<1	0.5 U
Lead	493	62	110
Manganese	946	273	310
Mercury	1.86	3.16	0.1 U
Nickel	26	17	6
Silver	10	7	2 U
Vanadium	44	21.7	21
Radionuclides	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**
Uranium-238	2.5±0.5	(1)	-
Thorium-234	-	-	ND
Uranium-234	2.6±0.5	(1)	-
Thorium-230	0.6±0.6	(1)	-
Radium-226	6.0±0.8	(1)	-
Lead-214(2)	-	-	0.56±0.2
Bismuth-214(2)	-	-	0.34±0.7
Lead-210	<25.8 J	(1)	-
Thorium-232	2.0±0.5	(1)	-
Radium-228	4.4±0.8	(1)	-
Actinium-228	-	-	1.4±0.3
Thorium-228	2.2±0.5	(1)	-
Lead-212	-	-	1.1±0.2
Thallium-208	-	-	0.40±0.1
Uranium-235	0.1±0.1	(1)	-
Thorium-227	-	-	ND

(1) - Duplicate sample container for radionuclide analyses broken during transport to laboratory.

(2) - EPA assumed secular equilibrium and used these values to estimate uranium and thorium concentrations (see EPA's Final Risk Assessment for specifics on this procedure).

JS72 - The percent recovery was 72%. The acceptable limit is 75%. Cadmium data for these samples could be low by 28%.

J - High detection limit for Lead-210 may be due to the use of gamma spectroscopy rather than gas proportional counting (preferred method).

Table 2-11
Summary of Radionuclide Contaminants of Concern Concentrations
CSMRI Stockpile Characterization

Constituent	Radionuclide Concentrations (pCi/g)											
	Representative Data (CEC)			Representative Data (EPA)			Biased and Supplemental Data (CEC/SRK)			All Data Combined		
	Mean	Max	95% UCL	Mean	Max	95% UCL	Mean	Max	95% UCL[1]	Mean	Max	95% UCL[2]
Ra-226	26	26	26	30	70	35	42	47	47	31	70	35
Pb-210	-	-	-	30	70	35	42	47	47	31	70	35
U-238	-	-	-	5.2	27	8.6	11	12	12	6.3	27	9.3
Th-234	-	-	-	5.2	27	8.6	11	12	12	6.3	27	9.3
U-234	-	-	-	5.2	27	8.6	11	12	12	6.3	27	9.3
Th-230	-	-	-	-	-	-	14	21	21	14	21	21
Th-232	-	-	-	-	-	-	1.6	2.4	2.4	1.6	2.4	2.4
Ra-228	-	-	-	-	-	-	<0.9	<1.1	<1.1	<0.9	<1.1	<1.1
Ac-228	-	-	-	2.5	4.7	2.9	-	-	-	2.5	4.7	2.9
Th-228	-	-	-	-	-	-	1.7	2.4	2.4	1.7	2.4	2.4
Pb-212	-	-	-	2.2	4.2	2.5	-	-	-	2.2	4.2	2.5
Tl-208	-	-	-	0.76	1.6	0.93	-	-	-	0.76	1.6	0.93
Pa-231	-	-	-	1.5	3.9	2.0[1][2]	-	-	-	-	-	-
Ac-227+D	-	-	-	1.5	3.9	2.0[1][2]	-	-	-	-	-	-
U-235	-	-	-	-	-	-	0.3	0.4	0.4	0.3	0.4	0.4
Th-227	-	-	-	1.5	3.9	2.0	-	-	-	1.5	3.9	2.0

[1] These COC data were used for the risk assessment of RA alternatives for on-site/nearby off-site disposal options.
[2] These COC data were used for the risk assessment of RA alternatives for off-site disposal options

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Table 2-12
Summary of Inorganic Contaminants of Concern Concentrations
CSMRI Stockpile Characterization

Constituent	Inorganic Concentrations (pCi/g)											
	Representative Data (CEC)			Representative Data (EPA)			Biased and Supplemental Data (CEC/SRK)			All Data Combined		
	Mean	Max	95% UCL	Mean	Max	95% UCL	Mean	Max	95% UCL	Mean	Max	95% UCL[1]
Arsenic	111	119	119	75	150	150	108	122	122	92	150	150
Barium	-	-	-	410	500	500	677	730	730	510	730	730
Cadmium	-	-	-	3	6	6	5	5.3	5.3	4	6	6
Chromium	-	-	-	26	41	40	33	38	38	28	41	41
Reactive Cyanide	-	-	-	1.7	6.3	4.9	0.5	0.5	0.5	1.3	6.3	3.6
Lead	-	-	-	378	1,000	936	442	517	517	402	1,000	883
Manganese	-	-	-	752	1,200	1,200	851	870	870	780	1,200	1,200
Mercury	-	-	-	8.1	18	18	31	67	67	17	67	67
Nickel	-	-	-	37	83	82	42	42	42	38	83	77
Silver	-	-	-	3.2	7	7	10	13	13	5.7	13	13
Vanadium	-	-	-	58.2	69	68.2	69	72	72	61	72	72

(1) These COC data were used for the risk assessment of RA alternatives for both off-site and on-site/nearby off-site disposal options.

Table 2-13
Analytical Results for Test Pit Samples

Constituent	Sample ID CSMRI-2	CSMRI-3	CSMRI-4	EPA Test Method
Radium-226 (pCi/g)	7.4±0.6	1.1±0.3	1.1±0.3	903.1
Arsenic (mg/kg)	<5	<5	11	6010
Barium (mg/kg)	130	130	93	6010
Cadmium (mg/kg)	<0.5	<0.5	<0.5	6010
Chromium (mg/kg)	14	13	11	6010
Lead (mg/kg)	110	1,800	59,000	6010
Mercury (mg/kg)	0.14	0.14	0.12	7471
Selenium (mg/kg)	<5	<5	<5	6010
Silver (mg/kg)	<0.5	0.6	2.0	6010

Table 2-14
Results of Chemical Parameters Which Affect S/S Treatment

Sample ID	CP-3A	Duplicate
Waste Fraction	**3/4" minus Biased**	**3/4" minus Biased**
pH	7.47	7.51
Constituent	**(mg/kg)**	**(mg/kg)**
Oil/Grease	212	125
Fluoride	22	22
Chloride	77	80
Nitrate	18	15
Sulfate	7,860	7,420
Ammonia	5.7	6.0

Table 2-15
Summary of Proctor Test Results on Cement Treated Soil

Cement-Fly Ash Content	Maximum Dry Density (pcf)	Optimum Moisture Content (%)
10% cement 2% fly ash	119.0	13.5
14% cement 2.8% fly ash	118.5	14.5
18% cement 3.6% fly ash	118.2	15.0

Table 2-16
Data for the Cylinders Prepared at 10% Cement, 2% Fly Ash

Cylinder No.	Moisture Content (%)	Dry Density (pcf)	Percent Compaction
1	13.8	117.6	98.8
2	13.8	117.3	98.6
3	13.8	117.0	98.3
4	13.8	116.3	97.7
5	14.0	117.6	98.8
6	14.0	117.6	98.8
7	14.0	116.3	97.7
8	14.0	117.4	98.6
9	14.5	116.6	98.0
10	14.5	117.4	98.7
11	14.5	115.8	97.3
12	14.5	116.9	98.2
13	14.0	118.2	99.3

Table 2-17
Data for the Cylinders Prepared at 14% Cement, 2.8% Fly Ash

Cylinder No.	Moisture Content (%)	Dry Density (pcf)	Percent Compaction
1	12.7	117.4	99.1
2	12.7	117.4	99.1
3	13.9	117.7	99.4
4	13.9	118.8	100.2
5	13.9	118.0	99.6
6	13.9	118.8	100.2
7	14.8	118.1	99.7
8	14.8	118.4	99.9
9	14.8	117.1	98.8
10	14.8	117.9	99.5
11	14.2	118.7	100.2
12	14.2	118.5	100.0
13	14.2	118.7	100.2

Table 2-18
Data for the Cylinders Prepared at 18% Cement, 3.6% Fly Ash

Cylinder No.	Moisture Content (%)	Dry Density (pcf)	Percent Compaction
1	12.6	117.5	99.4
2	12.6	117.8	99.6
3	14.5	116.9	98.9
4	14.5	117.4	99.3
5	14.5	115.5	97.7
6	14.5	117.9	99.7
7	12.7	119.3	100.9
8	12.7	119.0	100.7
9	12.7	118.2	100.0
10	12.7	118.7	100.4
11	12.9	119.0	100.7
12	12.9	119.0	100.7
13	12.9	117.2	99.1

Table 2-19
Summary of Unconfined Compressive Strength Test Results

Cement-Fly Ash Content	Cylinder No.	Unconfined Compressive Strength (psi)		
		7-Day	14-Day	28-Day
10% Cement	1	372	-	-
2% Fly Ash	2	363	-	-
	3	-	364	-
	4	-	363	-
	5	-	-	491
	6	-	-	554
14% Cement	3	356	-	-
2.8% Fly Ash	4	418	-	-
	5	-	505	-
	6	-	581	-
	7	-	-	451
	8	-	-	561
18% Cement	3	475	-	-
3.6% Fly Ash	4	442	-	-
	5	-	435	-
	6	-	536	-
	7	-	-	570
	8	-	-	616

Table 2-20
Permeability Test Results

Cement-Fly Ash Content	Measured Permeability (cm/sec)
10% Cement 2% Fly Ash	9.0 E-07
14% Cement 2.8% Fly Ash	2.6 E-07
18% Cement 3.6% Fly Ash	1.4 E-07

Table 2-21
Synthetic Acid Precipitation Test Results

Sample ID	CP-3A/B	18%-7	
Soil Matrix	Untreated	S/S Treated	
Waste Fraction	3/4" minus Biased	3/4" minus Biased	Groundwater ARAR
Radionuclides	**(pCi/l)**	**(pCi/l)**	**(pCi/l)**
Radium-226 and Radium-228	**9.6±1.0** **0.0±1.5**	**22.3±1.9** **0.0±1.6**	5
Thorium-230 and Thorium-232	1.3±0.8 UB.4 1.2±0.7 UJB1.4	0.8±0.7 0.3±0.3	60
Gross Alpha	65.6±8.1	**45.8±17.7**	15 (1)
Beta/Photon Emitters	11.0±2.7	38.8±12.6	60 (2)
Uranium (total)	**57.4**	ND	30
Organics	**(mg/l)**	**(mg/l)**	**(mg/l)**
Trichloroethylene	ND	-	0.005
Tetrachloroethylene	ND	-	0.005
Inorganics	**(mg/l)**	**(mg/l)**	**(mg/l)**
Aluminum	<0.05	0.48	5.0
Arsenic	<0.01	<0.01	0.05
Barium	0.10	0.58	1.0
Beryllium	<0.005	<0.005	0.1
Cadmium	<0.005	<0.005	0.005
Chloride	1.6	2.8	250
Chromium	<0.01	0.04	0.05
Cobalt	<0.03	<0.03	0.05
Copper	<0.01	0.19	0.2
Total Cyanide	<0.02	<0.02	0.20
Fluoride	1.6	0.5	2.0
Iron	<0.03	<0.03	0.3
Lead	<0.01	0.01	0.015
Manganese	**0.22**	<0.01	0.05
Mercury	<0.0002	<0.0002	0.002
Molybdenum	**0.19**	**0.37**	0.10
Nickel	<0.04	<0.04	0.20
Nitrate	0.3	<0.1	10.0
Nitrite	0.01	0.01	1.0
Selenium	<0.005	0.003	0.01
Silver	<0.01	<0.01	0.05
Sulfate	241	25	250
Vanadium	<0.05	<0.05	0.1
Zinc	0.04	0.02	2.0

(1) - Gross alpha standard minus the contributions from uranium and radon

(2) - Approximately equivalent to the 4 mrem/year standard

Note: Values which exceed the groundwater ARAR are in bold print.

UB.4 - Blanks were reported with values greater than the instrument detection limit.

UJB1.4 - Thorium-232 detected in preparation blank. The reported value should be considered to be undetected due to the background found in the leach solution.

Table 2-22
ANSI/ANS 16.1 Leach Index Test Results

3/4"-minus "Biased" Sample	Stage 1 2 Hrs.	Stage 2 5 Hrs.	Stage 3 17 Hrs.	Stage 4 24 Hrs.	Stage 5 24 Hrs.	Stage 6 24 Hrs.	Stage 7 24 Hrs.	Stage 8 14 Days	Stage 9 28 Days	Stage 10 43 Days	Overall Leach Index
Radium-226	12.0	11.7	13.0	13.6	13.1	12.7	12.0				12.6
Radium-228	10.7	10.8	10.1	9.7	11.4	9.5	8.8				10.1
Uranium (total)	11.9	12.1	13.3	12.9	12.7	12.6	12.5				12.6
Thorium-230	11.6	10.7	12.2	11.6	10.9	11.5	12.5				11.6
Thorium-232	10.1	10.1	11.5	10.8	10.2	10.8	10.4				10.6

Table 2-23
Comparison of Physical Characteristics
CSMRI and OU8 Materials

Waste	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Specific Gravity (1)	Percent Passing #200 Sieve	Percent Passing #4 Sieve
CSMRI	32	22	10	2.69	35	75
OU8	31	19	12	2.70	27	82

(1) Specific gravity determined for portion passing 3-inch sieve.

(2) Standard Proctor test conducted on portion passing 3/8 inch sieve.

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Table 2-24
Summary of Groundwater Elevation Data

Well ID	Datum Elevation (feet)	Depth to Water (feet)	Water Table Elevation (feet)	Date of Measurement
TH-2	5,722.51	30.30	5,692.21	5/24/95
TH-2A	5,722.53	28.77	5,693.76	5/24/95
TH-3	5,722.28	32.35	5,689.93	5/24/95
PFMW-01	5,744.38	54.10 50.80	5,690.28 5,693.58	5/12/95 5/24/95
PFMW-03	5,741.47	56.85 56.10	5,684.62 5,685.37	5/12/95 5/24/95

Table 2-25
Summary of Groundwater Analyses

Constituent	Units	TH-3	TH-3 (Duplicate)	TH-2	Bottle Blank	Rinsate Blank
Arsenic	mg/l	<0.05	<0.05	0.05	<0.05	<0.05
Baruim	mg/l	0.61	0.34	0.08	<0.01	0.01
Cadmium	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	mg/l	0.08	0.03	<0.01	<0.01	<0.01
Lead	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	mg/l	0.0002	0.0002	0.0002	0.0002	0.0002
Selenium	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Silver	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	µCi/l	3.25	3.55	2.07	<0.89	<0.89
Gross Alpha	pCi/l	65.2±12.8	71.2±13	4.9±3.2	2.4±1.6	1.4±1.4
Bross Beta	pCi/l	90.1±8.8	56.5±7.2	11.5±3.1	3.1±2.2	7.3±2.3

Concentrations reported above are total analyte concentrations with the exception of well TH-2 (dissolved analyte concentrations)

Uranium is reported as dissolved.

Table 2-26
Potential Exposure Pathways for Each Remedial Alternative and Receptor

Alternative/ Receptor	Inhalation		Soil Ingestion	Direct External Gamma Exposure
	Particulates	Radon		
Alternative 1 - No Action (from EPA's Final Risk Assessment)				
Current Off-Site Resident	X	X		X
Current On-Site Worker	X	X	X	X
Future On-Site Worker	X	X		X
Future On-site Resident	X	X	X	X
Alternative 2A - In-Place Closure				
Remedial Worker	X	X		X
Current Off-Site Resident	X	X		X
Future Nearby Worker		X		X
Future On-Site Resident		X		X
Alternative 2B - Above-Ground Repository				
Remedial worker	X	X		X
Current Off-Site Resident	X	X		X
Future Nearby Worker		X		X
Future On-Site Resident		X		X
Alternative 3A - Below-Ground Repository				
Remedial Worker	X	X		X
Current Off-Site Resident	X	X		X
Future Nearby Worker		X		X
Future On-Site Resident		X		X
Recreational User		X		X
Alternative 3B - Below-Ground Repository with S/S				
Remedial Worker	X	X		X
Current Off-Site Resident	X	X		X
Future Nearby Worker		X		X
Future On-Site Resident		X		X
Recreational User		X		X
Alternative 4 - Off-Site Disposal				
Remedial Worker	X	X		X
Current Off-Site Resident	X	X		X
Transport Worker (Driver)				X
Resident Along Transport Route (Normal)				X
Resident Along Transport Route (Accident)	X	X		X

Table 2-27
Summary of Chemical Risks for Each Remedial Alternative and Receptor

Alternative/ Receptor	Pathway	Carcinogenic Risk (RME)	Noncarcinogenic Risk (RME)
Alternative 1 - No Action (from EPA's Final Risk Assessment)			
Current/Future On-Site Worker	Ingestion	9.2 E-05	8.2 E-01
	Inhalation	5.9 E-08	6.6 E-04
	Total	9.2 E-05	8.2 E-01
Current Off-Site Resident	Inhalation	2.8 E-08	2.6 E-04
	Total	2.8 E-08	2.6 E-04
Future On-Site Resident	Ingestion	4.1 E-04	3.0 E+00
	Inhalation	9.9 E-08	9.2 E-04
	Total	4.1 E-04	3.0 E+00
Alternative 2A - In-Place Closure			
Remedial worker	Inhalation	2.6 E-07	2.5 E-01
	Total	2.6 E-07	2.5 E-01
Current Off-Site Resident	Inhalation	4.7 E-08	1.4 E-01
	Total	4.7 E-08	1.4 E-01
Alternative 2B - Above-Ground Repository			
Remedial Worker	Inhalation	4.7 E-08	5.0 E-02
	Total	4.7 E-08	5.0 E-02
Current Off-Site Resident	Inhalation	3.7 E-07	2.8 E-01
	Total	3.7 E-07	2.8 E-01
Alternative 3A - Below-Ground Repository			
Remedial Worker	Inhalation	3.5 E-07	5.0 E-01
	Total	3.5 E-07	5.0 E-01
Current Off-Site Resident	Inhalation	2.8 E-07	2.8 E-01
	Total	2.8 E-07	2.8 E-01
Alternative 3B - Below-Ground Repository with S/S			
Remedial Worker	Inhalation	5.3 E-07	5.0 E-01
	Total	5.3 E-07	5.0 E-01
Current Off-Site Resident	Inhalation	4.2 E-07	2.8 E-01
	Total	4.2 E-07	2.8 E-01
Alternative 4 - Off-Site Disposal			
Remedial Worker	Inhalation	2.9 E-07	5.0 E-01
	Total	2.9 E-07	5.0 E-01
Current Off-Site Resident	Inhalation	2.3 E-07	2.8 E-01
	Total	2.3 E-07	2.8 E-01
Resident Along Transport Route (Accident)	Inhalation	4.7 E-08	2.0E+00
	Total	4.7 E-08	2.0 E+00

Table 2-28
Summary of Radiological Exposure Risks
Alternative 1 - No Action/Institutional Controls
(From EPA's Final Risk Assessment)

Receptor	Pathway	Risk (RME)
Current On-Site Worker	Ingestion	1.9 E-05
	Inhalation	6.1 E-08
	Gamma Exposure	1.3 E-03
	Radon (Outdoor)	4.3 E-03
	Total	5.7 E-03
Current Off-Site Resident	Inhalation	2.9 E-08
	Radon (Outdoor)	2.0 E-03
	Total	2.0 E-03
Future On-Site Worker	Ingestion	1.9 E-05
	Inhalation	6.1 E-08
	Gamma Exposure	1.3 E-03
	Radon (Outdoor)	4.3 E-03
	Radon (Indoor)	1.9 E-02
	Total with Outdoor Radon	5.7 E-03
	Total with Indoor Radon	2.0 E-02
Future On-Site Resident	Ingestion	2.9 E-03
	Inhalation	1.7 E-07
	Gamma Exposure	5.3 E-03
	Radon (Outdoor)	7.3 E-03
	Radon (Indoor)	3.2 E-02
	Total with Outdoor Radon	1.5 E-02
	Total with Indoor Radon	4.0 E-02

Table 2-29
Summary of Radiological Exposure Risks
Alternative 2A - In-Place Closure

Receptor	Pathway	Risk (RME)
Remedial worker	Inhalation	2.1 E-08
	Gamma Exposure	2.0 E-07
	Radon (outdoor)	2.6 E-07
	Total	4.8 E-07
Current off-site resident	Inhalation	1.6 E-08
	Gamma Exposure	9.0 E-12
	Radon (outdoor)	2.0 E-07
	Total	2.2 E-07
Future nearby worker	Gamma Exposure	5.9 E-14
	Radon (outdoor)	5.9 E-06
	Total	5.9 E-06
Future on-site resident	Gamma Exposure	1.9 E-09
	Radon (indoor)	2.0 E-03
	Total	2.0 E-03

Table 2-30
Summary of Radiological Exposure Risks
Alternative 2B - Above-Ground Repository

Receptor	Pathway	Risk (RME)
Remedial worker	Inhalation	1.6 E-07
	Gamma Exposure	8.1 E-07
	Radon (outdoor)	9.4 E-07
	Total	1.9 E-06
Current off-site resident	Inhalation	1.3 E-07
	Gamma Exposure	3.7 E-11
	Radon (outdoor)	7.5 E-07
	Total	7.5 E-07
Future nearby worker	Gamma Exposure	5.9 E-14
	Radon (outdoor)	5.9 E-06
	Total	5.9 E-06
Future on-site resident	Gamma Exposure	1.9 E-09
	Radon (indoor)	2.0 E-03
	Total	2.0 E-03

Table 2-31
Summary of Radiological Exposure Risks
Alternative 3A - Below-Ground Repository

Receptor	Pathway	Risk (RME)
Remedial worker	Inhalation	1.2 E-07
	Gamma Exposure	5.8 E-07
	Radon (outdoor)	7.1 E-07
	Total	1.4 E-08
Current off-site resident	Inhalation	9.6 E-08
	Gamma Exposure	2.6 E-11
	Radon (outdoor)	5.6 E-07
	Total	6.6 E-07
Future nearby worker	Gamma Exposure	3.5 E-17
	Radon (outdoor)	2.2 E-06
	Total	2.2 E-06
Future on-site resident	Gamma Exposure	1.1 E-12
	Radon (indoor)	6.6 E-04
	Total	6.6 E-04
Recreational user	Gamma Exposure	3.3 E-14
	Radon (outdoor)	7.8 E-07
	Total	7.8 E-07

Table 2-32
Summary of Radiological Exposure Risks
Alternative 3B - Below-Ground Repository with S/S

Receptor	Pathway	Risk (RME)
Remedial worker	Inhalation	1.8 E-07
	Gamma Exposure	9.0 E-07
	Radon (outdoor)	1.1 E-06
	Total	2.2 E-06
Current off-site resident	Inhalation	1.5 E-07
	Gamma Exposure	4.1 E-11
	Radon (outdoor)	8.6 E-07
	Total	1.0 E-06
Future nearby worker	Gamma Exposure	3.1 E-17
	Radon (outdoor)	1.8 E-06
	Total	1.8 E-06
Future on-site resident	Gamma Exposure	9.4 E-13
	Radon (indoor)	5.5 E-04
	Total	5.5 E-04
Recreational user	Gamma Exposure	2.9 E-14
	Radon (outdoor)	6.5 E-07
	Total	6.5 E-07

Table 2-33
Summary of Radiological Exposure Risks
Alternative 4 - Off-Site Disposal

Receptor	Pathway	Risk (RME)
Remedial worker	Inhalation	1.0 E-07
	Gamma Exposure	5.0 E-07
	Radon (outdoor)	5.7 E-07
	Total	1.2 E-06
Current off-site resident	Inhalation	8.0 E-08
	Gamma Exposure	2.2 E-11
	Radon (outdoor)	1.6 E-06
	Total	1.7 E-06
Driver for transport	Gamma Exposure	1.7 E-07
	Total	1.7 E-07
Resident along transport route (Normal)	Gamma Exposure	3.4 E-09
	Total	3.4 E-09
Resident along transport route (Accident)	Inhalation	1.5 E-08
	Gamma Exposure	5.7 E-10
	Radon (outdoor)	4.5 E-08
	Total	6.1 E-08

Table 3-1
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
Off-Site Removal Action Alternatives

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media
Clean Air Act	40 CFR 50 to 69				
New Source Performance Requirements	40 CFR 60	Establishes emission standards for new air emissions	Potentially relevant and appropriate	If temporary air pollution sources that are sufficiently similar to those sources covered by these regulations are part of the remedy, the regulations may be relevant and appropriate.	Air
Colorado Air Quality Control Act	CRS 25-7-101-512				
Common Provision Regulations	5 CCR 1001-2 Section II	Conduct performance tests, applicable emissions monitoring, and recordkeeping	Applicable	Substantive requirements are applicable to air emission component of the remedy.	Air
Regulation No. 1	5 CCR 1001-3, Regulation No. 1	Establishes emission control regulations for particulates, smoke, carbon monoxide, sulfur oxides and fugitive particulate emissions.	Portions are Applicable	See below for description of specific provisions.	Air
Regulation No. 1	5 CCR 1001-3, Regulation No. 1, Section II.A.1	Comply with opacity limitations.	Applicable	Less than 20% opacity emitted, specific sources may have other limitations.	Air
Regulation No. 1	5 CCR 1001-3, Regulation No. 1, Section III.D	Minimize fugitive particulate emissions.	Applicable, Relevant and Appropriate	Applicable to construction activities, storage and handling operations, haul roads and haul trucks, and tailings piles. Relevant and appropriate to non-specific sources.	Air
Regulation No. 2	5 CCR 1001-4	Establishes odor emission regulations.	Applicable	If odor emissions become a potential concern, the substantive requirements are applicable.	Air
Regulation No. 3	5 CCR 1001-5 Regulation No. 3, Section II	File APEN including estimation of emission rates.	Applicable	Substantive portions are applicable to all sources including earthwork and existing sources unless specifically exempt.	Air
Regulation No. 7	5 CCR 1001-9, Regulation No. 7, Section IV.D.3	Establishes regulations to control emissions of VOCs (new and existing sources).	Applicable	If VOC emissions become a concern, apply Reasonably Available Control Technology. Section V requirements regarding using evaporation for disposal are applicable.	Air
Ambient Air Quality Standards	5 CCR 1001-14	Sets ambient standards for total suspended particulates, sulfur dioxide, oxidant, carbon monoxide, nitrogen dioxide.	Applicable	Would be applicable if remedy would cause emission of regulated constituents	Air
Hazardous Materials Transportation Act	49 USC 1801 to 1813				
Transportation Regulations	49 CFR Parts 107, 171 to 174, and 177	Regulates transportation of hazardous materials. Part 173 is specific to radioactive materials.	Applicable	Portions applicable to off-site transportation of radioactive wastes.	Soils, Solids
Colorado Hazardous Waste Regulations, Waste Characterization	6 CCR 1007-3 Parts 260, 261, 262.11	Defines hazardous wastes, requires waste characterization.	Applicable	Characterization required to determine if the waste pile contains characteristic or listed RCRA waste.	Soils

Table 3-1
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
Off-Site Removal Action Alternatives
(continued)

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media
Colorado Hazardous Waste Regulations, Waste Characterization	6 CCR 1007-3, Part 264	Standards for owners and operators of hazardous waste treatment, storage, and disposal facilities. Requirements for managing hazardous waste based upon the mode of management, i.e., container storage, waste piles, impoundments, etc.	Portions Potentially Applicable.	Potentially applicable if RCRA hazardous wastes are present within the waste. Current data indicates that RCRA hazardous wastes are not present so these requirements are not applicable.	Soils
Land Disposal Restrictions	40 CFR Part 268 6 CCR 1007-3 Part 268	Establishes treatment standards for land disposal of selected hazardous wastes.	Potentially Applicable	Potentially applicable to off-site disposal if restricted RCRA wastes are encountered.	Soil
Radiation Control Act	CRS 25-11-101-305				
Rules and Regulations Pertaining to Radiation Control	6 CCR 1007-1, Part 1	General provisions (including definitions) for 6 CCR 1007-1.	Applicable		All Media
	6 CCR 1007-1, Part 3	Regulations concerning licensing of radioactive materials.	Portions Applicable.	Applicable to off-site disposal facilities within the State.	All Media
	6 CCR 1007-1, Part 4	Establishes standards for protection against radiation hazards.	Applicable or Relevant and Appropriate.	Substantive portions are applicable to licensed areas, relevant and appropriate to non-licensed areas.	All Media
	6 CCR 1007-1, Part 10	Notes, instructions, and reports to workers.	Applicable or Relevant and Appropriate	Substantive portions are applicable to licensed areas, relevant and appropriate to nonlicensed areas.	All Media
	6 CCR 1007-1, Part 17	Transportation of radioactive materials	Applicable or Relevant and Appropriate	Substantive portions are applicable or relevant and appropriate	All Media
	6 CCR 1007-1, Part 18	Licensing requirements for milling facilities and the disposition of products of milling operations for uranium, thorium and related materials.	Potentially Applicable	Potentially applicable to off-site disposal facilities within the State. Substantive portions become applicable through 6 CCR 1007-2.	All Media
Solid Wastes Disposal Sites and Facilities Act	CRS 30-20-101 to 118				
Solid Wastes Disposal Sites and Facilities Regulations	6 CCR 1007-2	Establishes minimum standards, closure requirements, site standards and engineering design standards for solid waste disposal facilities.	Potentially Applicable	Potentially applicable to off-site disposal facilities within the State	Soil
Prohibition on burial of sludge	6 CCR 1007-2, 2.2.11-2.2.12	Prohibits both on-site and off-site burial of waste containing free liquids.	Potentially applicable	If liquid wastes are present, applicable to remedies which dispose of the materials within the State.	Soil
Clean Water Act	33 USC 1251 to 1376				
Standards for Fill or Excavation in Waters of the United States	33 CFR 320, 323, 328, and 330		Substantive portions potentially relevant and appropriate	Substantive portions potentially relevant and appropriate to fill and excavation in Chimney Gulch	Surface Water

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Table 3-1
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
Off-Site Removal Action Alternatives
(continued)

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media
Storm Water Discharge Regulations	40 CFR 122.28	Regulates discharges of storm water and runoff water.	Applicable	Storm water discharge is covered by the general permit for discharge from construction sites. Utilize Best Available Technology (BAT) and Best Conventional Pollutant Control Technology.	Surface Water
Colorado Water Quality Control Act.	CRS 28-8 101 to 703				
Basic Standards and Methodologies for Surface Water	5 CCR 1002-8 Section 3.1.0	Establishes basic standards, anti-degradation standard, system for classifying state waters.	Applicable or Relevant and Appropriate	Applicable or relevant and appropriate to component of remedy impacting surface water.	Surface Water
Classifications and Numeric Standards, South Platte River Basin, et al.	5 CCR 1002-8 Section 3.8.0	Used in conjunction with basic standards and methodologies (Section 3.1.0)	Applicable	For any surface water discharge identified, compliance is required for Segment 11 and 14 of South Platte River	Surface Water
State Discharge Permit Regulations	5 CCR 1002-2 Section 6.1.0	Requires a permit for the discharge of pollutants from a point source into waters of the State.	Potentially Applicable	Must comply with substantive requirements.	Surface Water
Storm Sewer Discharge Regulations	5 CCR 1002-7	Establishes requirements relating to discharges into storm sewers.	Applicable	Storm sewer regulations are applicable to run-off from the site.	Surface water
Occupational Safety and Health Act	29 USC 651-678 29 CFR 1910.96 29 CFR 1926	Regulates worker health and safety.	Applicable	Independently applicable. Requirements of this act apply to all response actions under the NCP.	N/A

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Table 3-2
Chemical-Specific State and Federal Applicable or Relevant and Appropriate Requirements
Off-Site Removal Action Alternatives

Contaminant	Standard	Citation	Applicable or Relevant and Appropriate or TBC	Comments	Media
Radium-226	Less than or equal to 5 pCi/g above background within 15 cm of the surface averaged over 100 square meter area. Less than or equal to 15 pCi/g above background within subsequent 15 cm layers of soil averaged over 100 square meter area.	40 CFR 192.12(a)	Relevant and Appropriate	Standard for clean-up of land at inactive uranium processing sites. Relevant and appropriate to excavation of clay liner under the waste pile due to waste similarities.	Soils
Thorium-230	Clean-up level calculated using initial Ra-226 concentration and assuming period for Th-230 ingrowth; depth of backfill may be considered.	Generic protocol for excavation of Th–230, DOE, January 15, 1989	TBC	DOE standard modified by EPA's January 16, 1992 letter. To be considered for excavation of clay liner under the waste pile.	Soils
Radon Decay Products	Objectives of remedial action to achieve an annual average not to exceed 0.02 WL. In any case, not to exceed 0.03 WL.	40 CFR 192.12(b)(1)	Relevant and Appropriate	Standard for clean-up of inactive uranium processing sites. Relevant and appropriate if occupied or habitable buildings planned for site.	Air
Radiation	Gamma radiation shall not exceed background levels by more than 20 microR per hour.	40 CFR 192.12(b)(2)	Relevant and Appropriate	Standard for clean-up of inactive uranium processing sites. Relevant and appropriate if occupied or habitable buildings planned for site.	Soils
Radiation	Standards for protection against radiation.	10 CFR 20 6 CCR 1004-1 Part 4	Applicable	Applicable to all NRC and/or State licensees and registrants of radioactive materials. Substantive portions are relevant and appropriate to non-licensed areas.	All Media
Radiation Dose	ICRP Publication 30 provides recommended Annual Limits on Intake and Derived Air Concentrations designed to limit the intake of radioactive materials by workers.	ICRP 30	TBC	To the extent that workers may have radioactive material intakes due to the presence of site wastes, this international guidance is to be considered.	All Media
Radiation Dose	Federal Guidance Report No. 11 provides Annual Limits on Intake and Derived Air Concentrations to be implemented by federal agencies to limit the intake of radioactive materials by workers.	Federal Guidance Report No. 11	TBC	To the extent that workers may have radioactive material intakes due to the presence of site wastes, this Federal guidance is to be considered.	All Media
Air Pollutants	National Emission Standards for Hazardous Air Pollutants (NESHAP)	40 CFR 61	Relevant and Appropriate	To the extent the removal activities involve the emission of regulated constituents and activities similar to those addressed in these regulations, they may be relevant and appropriate.	Air

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Table 3-3
Chemical-Specific State and Federal Applicable or Relevant and Appropriate Requirements
On-Site and Nearby Off-Site Removal Action Alternatives

Contaminant	Standard	Citation	Applicable or Relevant and Appropriate or TBC	Comments	Media
Radium-226	Less than or equal to 5 pCi/g above background within 15 cm of the surface averaged over 100 square meter area. Less than or equal to 15 pCi/g above background within subsequent 15 cm layers of soil averaged over 100 square meter area.	40 CFR 192.12(a)	Relevant and Appropriate	Standard for clean-up of land at inactive uranium processing sites. Relevant and appropriate to excavation of clay liner under the waste pile due to waste similarities.	Soils
Thorium-230	Clean-up level calculated using initial Ra-226 concentration and assuming period for Th-230 ingrowth; depth of backfill may be considered.	Generic protocol for excavation of Th–230, DOE, January 15, 1989	TBC	DOE standard modified by EPA's January 16, 1992 letter. To be considered for excavation of clay liner under the waste pile.	Soils
Radon Decay Products	Objectives of remedial action to achieve an annual average not to exceed 0.02 WL. In any case, not to exceed 0.03 WL.	40 CFR 192.12(b)(1)	Relevant and Appropriate	Standard for clean-up of inactive uranium processing sites. Relevant and appropriate if occupied or habitable buildings planned for site.	Air
Radon-222 Radon-220	Average release rate of radon from uranium or thorium materials not to exceed 20 pCi per square meter per second or increase the annual average concentration of radon by more than 0.5 pCi per liter outside disposal site boundary.	40 CFR 192.02(b)(1),(2) 40 CFR 192.32(b)(1)(ii)	Relevant and Appropriate	Standard for post-closure management of uranium or thorium materials. Relevant and appropriate to on-site disposal.	Air
Radiation	Gamma radiation shall not exceed background levels by more than 20 microR per hour.	40 CFR 192.12(b)(2)	Relevant and Appropriate	Standard for clean-up of inactive uranium processing sites. Relevant and appropriate if occupied or habitable buildings planned for site.	Soils
Radiation	Standards for protection against radiation.	10 CFR 20 6 CCR 1004-1 Part 4	Applicable	Applicable to all NRC and/or State licensees and registrants of radioactive materials. Substantive portions are relevant and appropriate to non-licensed areas.	All Media
Radiation	Annual dose equivalent shall not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as a result of release of radioactive materials to the general public.	40 CFR 192.32(a) 40 CFR 192.41(d)	Relevant and Appropriate	Standard for management of thorium materials. Relevant and appropriate to on-site disposal.	Soils
Radiation Dose	Federal Radiation Protection Guidance (25 FR 4402, May 13, 1960) as implemented by the Federal Radiation Council (FRC) recommends limiting doses to members of the general public to less than 0.5 rem per year.	FRC 1960	TBC	To the extent that members of the general public receive doses from site wastes, this Federal guidance is to be considered.	All Media

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Table 3-3
Chemical-Specific State and Federal Applicable or Relevant and Appropriate Requirements
On-Site and Nearby Off-Site Removal Action Alternatives
(Continued)

Contaminant	Standard	Citation	Applicable or Relevant and Appropriate or TBC	Comments	Media
Radiation Dose	ICRP Publication 26 recommends a whole body dose equivalent limit of 0.5 rem per year as applied to critical groups of the public. In any case where the doses were actually found to be received at high rates over prolonged periods, ICRP recommends restriction of the lifetime dose to the individual member of the public to a value that corresponds to 0.1 rem per year.	ICRP 26	TBC	To the extent that members of the general public receive doses from site wastes, this international guidance is to be considered.	All Media
Radiation Dose	ICRP Publication 30 provides recommended Annual Limits on Intake and Derived Air Concentrations designed to limit the intake of radioactive materials by workers.	ICRP 30	TBC	To the extent that workers may have radioactive material intakes due to the presence of site wastes, this international guidance is to be considered.	All Media
Radiation Dose	Federal Guidance Report No. 11 provides Annual Limits on Intake and Derived Air Concentrations to be implemented by federal agencies to limit the intake of radioactive materials by workers.	Federal Guidance Report No. 11	TBC	To the extent that workers may have radioactive material intakes due to the presence of site wastes, this Federal guidance is to be considered.	All Media
Air Pollutants	National Emission Standards for Hazardous Air Pollutants (NESHAP)	40 CFR 61	Relevant and Appropriate	To the extent the removal activities involve the emission of regulated constituents and activities similar to those addressed in these regulations, they may be relevant and appropriate.	Air

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Table 3-4
Chemical-Specific State and Federal Applicable or Relevant and Appropriate Requirements for Groundwater On-Site and Nearby Off-Site Removal Action Alternatives

Contaminant	Standard	Applicable or Relevant and Appropriate	Comments
Ra-226 and Ra-228	5 pCi/l	Applicable	Statewide standard[1] (also MCL)
Th-230 and Th-232	60 pCi/l	Applicable	Statewide standard[1] (also MCL)
Gross Alpha	15 pCi/l [2]	Applicable	Statewide standard[1] (also MCL)
Beta/Photon Emitters	4 mrem/year [3]	Applicable	Statewide standard[1] (also MCL)
Uranium	30 pCi/l	Applicable	40 CFR 192 standard
Trichloroethylene	0.005 mg/l	Applicable	Statewide standard[1] (also MCL)
Tetrachloroethylene	0.005 mg/l	Applicable	Statewide standard[1] (also MCL)
Arsenic	0.05 mgl	Relevant and Appropriate	MCL
Barium	1.0 mg/l	Relevant and Appropriate	MCL
Cadmium	0.005 mg/l	Relevant and Appropriate	Human health standard[1]
Cyanide (Free)	0.20 mg/l	Relevant and Appropriate	Human health standard[1]
Chromium	0.05 mg/l	Relevant and Appropriate	MCL
Fluoride	2.0 mg/l	Relevant and Appropriate	Agricultural standard[1]
Lead	0.015 mg/l	Relevant and Appropriate	MCL
Mercury	0.002 mg/l	Relevant and Appropriate	MCL
Nitrate	10.0 mg/l	Relevant and Appropriate	MCL
Nitrite	1.0 mg/l	Relevant and Appropriate	Human health standard[1]
Selenium	0.01 mg/l	Relevant and Appropriate	MCL
Silver	0.05 mg/l	Relevant and Appropriate	MCL
Chloride	250 mg/l	Relevant and Appropriate	Secondary drinking water[1]
Copper	0.2 mg/l	Relevant and Appropriate	Agricultural standard[1]
Iron	0.3 mg/l	Relevant and Appropriate	Secondary drinking water[1]
Manganese	0.05 mg/l	Relevant and Appropriate	Secondary drinking water[1]
Sulfate	250 mg/l	Relevant and Appropriate	Secondary drinking water[1]
Zinc	2.0 mg/l	Relevant and Appropriate	Agricultural standard[1]
Aluminum	5.0 mg/l	Relevant and Appropriate	Agricultural standard[1]
Beryllium	0.1 mg/l	Relevant and Appropriate	Agricultural standard[1]
Cobalt	0.05 mg/l	Relevant and Appropriate	Agricultural standard[1]
Molybdenum	0.10 mg/l	Relevant and Appropriate	40 CFR 192 standard
Nickel	0.20 mg/l	Relevant and Appropriate	Agricultural standard[1]
Vanadium	0.1 mg/l	Relevant and Appropriate	Agricultural standard[1]

(1) 5 CCR 1002-8 Section 3.11.0 (2) Excludes contributions from radon and uranium (3) Applicable only to man-made radionuclides

Table 3-5
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
On-Site and Nearby Off-Site Removal Action Alternatives

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media
Clean Air Act	40 CFR 50 to 69				
New Source Performance Requirements	40 CFR 60	Establishes emission standards for new air emissions.	Potentially Relevant and Appropriate	If temporary air pollution sources that are sufficiently similar to those sources covered by the regulations are part of the remedy, the regulations may be relevant and appropriate.	Air
Colorado Air Quality Control Act	CRS 25-7-101-512				
Common Provision Regulations	5 CCR 1001-2 Section II	Conduct performance tests, applicable emissions monitoring, and recordkeeping	Applicable	Substantive requirements are applicable to air emission component of the remedy.	Air
Regulation No. 1	5 CCR 1001-3, Regulation No. 1	Establishes emission control regulations for particulates, smokes, carbon monoxide, sulfur oxides and fugitive particulate emissions.	Portions are Applicable	See below for description of specific provisions.	Air
Regulation No. 1	5 CCR 1001-3, Regulation No. 1 Section II.A.1	Comply with opacity limitations.	Applicable	Less than 20% opacity emitted, specific sources may have other limitations.	Air
Regulation No. 1	5 CCR 1001-3, Regulation No. 1 Section III.D	Minimize fugitive particulate emissions.	Applicable, Relevant and Appropriate	Applicable to construction activities, storage and handling operations, haul roads and haul trucks, and tailings piles. Relevant and appropriate to non-specific sources.	Air
Regulation No. 2	5 CCR 1001-4	Establishes odor emission regulations.	Applicable	If odor emission become a potential concern, the substantive portions are applicable.	Air
Regulation No. 3	5 CCR 1001-5 Regulation No. 3 Section II	File APEN including estimation of emissions rates.	Applicable	Substantive portions are applicable to all sources including earthwork and existing sources unless specifically exempt.	
Regulation No. 7	5 CCR 1001-9 Regulation No. 7 Section IV.D.3	Establishes regulations to control emissions of VOCs (new and existing sources).	Applicable	If VOCs become a concern, apply Reasonably Available Control Technology. Section V requirements regarding using evaporation for disposal are applicable.	Air
Ambient Air Quality Standards	5 CCR 1001-14	Sets ambient standards for total suspended particulates, sulfur dioxide, oxidant, carbon monoxide, nitrogen dioxide.	Applicable	Would be applicable if the remedy would cause emission of regulated constituents.	Air
Hazardous Materials Transportation Act	49 USC 1801 to 1813				
Transportation Regulations	49 CFR Parts 107, 171 to 174, and 177	Regulates transportation of hazardous materials. Part 173 is specific to radioactive materials.	Applicable	Portions applicable to off-site transportation of radioactive wastes.	Soils, Solids
Colorado Hazardous Waste Regulations, Waste Characterization	6 CCR 1007-3 Parts 260, 261, 262.11	Defines hazardous wastes, requires waste characterization.	Applicable	Characterization required to determine if the waste pile contains characteristic or listed RCRA waste.	Soils

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Table 3-5
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
On-Site and Nearby Off-Site Removal Action Alternatives
(continued)

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media
Colorado Hazardous Waste Regulations	6 CCR 1003-3 Part 264	Standards for owners and operators of hazardous waste treatment, storage, and disposal Facilities. Requirements for managing hazardous waste based upon the mode of management, i.e. container storage, waste piles, impoundments, etc.	Portions Potentially Applicable or Relevant and Appropriate.	Potentially applicable or relevant and appropriate if RCRA hazardous wastes are present within the waste. Current data indicates that RCRA hazardous wastes are not present so these requirements are not applicable.	Soils
Land Disposal Restrictions	40 CFR Part 268 6 CCR 1007-3 Part 268	Establishes treatment standards for land disposal of selected hazardous wastes.	Potentially Applicable	Potentially appliacble to on-site disposal if restricted RCRA wastes are encountered.	Soil
Radiation Control Act	CRS 25-11-101 to 305				
Rules and Regulations Pertaining to Radiation Control	6 CCR 1007-1 Part 1	General provisions (including definitions) for 6 CCR 1007-1	Applicable		All Media
	6 CCR 1007-1 Part 3	Regulations concerning licensing of radioactive materials.	Portions applicable, Relevant and Appropriate.	Substantive portions are applicable or relevant and appropriate for remedies which dispose of radioactive materials on-site.	All Media
	6 CCR 1007-1 Part 4	Establishes standards for protection against radiation hazards.	Applicable or Relevant and Appropriate.	Applicable to licensed areas. Substantive portions are relevant and appropriate to non-licensed areas.	All Media
	6 CCR 1007-1 Part 10	Notes, instructions, and reports to workers.	Applicable or Relevant and Appropriate	Substantive requirements are applicable to licensed areas. Relevant and appropriate to nonlicensed areas.	All Media
	6 CCR 1007-1 Part 17	Transportation of radioactive materials	Applicable or Relevant and Appropriate	Substantive portions are applicable or relevant and appropriate	All Media
	6 CCR 1007-1 Part 18	Licensing requirements for the disposition of products of milling operations for uranium, thorium and related materials.	Relevant and Appropriate	Relevant and appropriate to nearby off-site disposal of the waste. Only substantive portions are relevant and appropriate to on-site disposal of the waste.	All Media
Solid Wastes Disposal Sites and Facilities Act	CRS 30-20-101 to 118				
Solid Wastes Disposal Sites and Facilities Regulations	6 CCR 1007-2	Establishes minimum standards, closure requirements, site standards and engineering design standards for solid waste disposal facilities.	Potentially Applicable	Applicable to on-site disposal of solid waste.	Soil Groundwater
Prohibition on burial of sludge	6 CCR 1007-2 Sections 2.2.11-2.2.12	Prohibits both on-site and off-site burial of waste containing free liquids.	Potentially applicable		Soil Groundwater

Table 3-5
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
On-Site and Nearby Off-Site Removal Action Alternatives
(continued)

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media
Clean Water Act	33 USC 1251 to 1376				
Standards for Fills or Excavation in waters of the United States	33 CFR 320, 323, 325, and 330		Substantive portions potentially relevant and appropriate	Substantive portions potentially relevant and appropriate to fills and excavations wihtin Chminey Gulch.	Surface Water
Storm Water Discharge Regulations	40 CFR 122.28	Regulates discharges of storm water and runoff water.	Applicable	Storm water discharge is covered by the General Permit for Discharge from Construction sites (§122.28). Utilize Best Available Technology (BAT) and Best Conventional Pollutant Control Technology.	Surface Water
Colorado Water Quality Control Act.	CRS 28-8 101 to 703				
Basic Standards and Methodologies for Surface Water	5 CCR 1002-8 Section 3.1.0	Establishes basic standards, anti-degradation standard, system for classifying state waters.	Applicable or Relevant and Appropriate	Applicable to component of remedy impacting surface water.	Surface Water
Classifications and Numeric Standards, South Platte River Basin, et al.	5 CCR 1002-8 Section 3.8.0	Used in conjunction with basic standards and methodologies (Section 3.1.0)	Applicable	For any surface water discharge identified, compliance is required for Segments 11 and 14 of the South Platte River.	Surface Water
State Discharge Permit Regulations	5 CCR 1002-2 Section 6.1.0	Requires a permit for the discharge of pollutants from a point source into waters of the State.	Potentially Applicable	Must comply with substantive requirements.	Surface Water
Storm Sewer Discharge Regulations	5 CCR 1002-7	Establishes requirements relating to discharges into storm sewers.	Applicable	Storm sewer regulations are applicable to run-off from the site.	Surface water
Basic Standards for Ground Water	5 CCR 1002-8 Section 3.11.0	Establishes a system for classifying groundwater and adopting water quality control standards to protect existing and potential beneficial uses.	Portions Applicable, Portions Relevant and Appropriate.	Establishes framework, site-specific classifications, and standards. Statewide standards are applicable. Standards based on classification are relevant and appropriate.	Groundwater
Classification and Water Quality Standards for Groundwater	5CCR 1002-8 Section 3.12.0	Specifies interim narrative standards for the Laramie-Fox Hills aquifer and the area around Clear Creek as it exits the mountains in Golden.	Portions applicable	To be used in conjunction with the basic standards (Section 3.11.0).	Groundwater
Water Well and Pump Installation Contractors Regulations.	2 CCR 402-2	License requirements for well construction and pump installation contractors and minimum standards for well construction and abandon-ment.	Applicable	Establishes regulations for construction and abandonment of wells.	Groundwater
Occupational Safety and Health Act	29 USC 651-678 29 CFR 1910.96 29 CFR 1926	Regulates worker health and safety	Applicable	Independently applicable. Requirements of this act apply to all response activities under the NCP.	N/A

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Table 3-6
Location-Specific Applicable or Relevant and Appropriate Requirements
On-Site and Nearby Off-Site Removal Action Alternatives

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media
Colorado Hazardous Waste Act	CRS 25-15-101 to 313	Establishes broad siting criteria and site evaluation procedures for individual storage or disposal units.	Potentially Applicable	Applicable to nearby off-site disposal if RCRA hazardous wastes are present within the waste pile. Only substantive portions are applicable to on-site disposal if RCRA hazardous wastes are present within the waste pile.	Soils
Milling of Uranium, Thorium, and Related Radioactive Materials	6 CCR 1007-1 Part 18	Siting and design criteria for the disposition of products of milling operations for uranium, thorium, and related products.	Relevant and Appropriate	Relevant and appropriate to nearby off-site disposal of the waste. Only substantive portions are relevant and appropriate to on-site disposal of the waste.	Soils
Solid Waste Regulations, Siting Requirements	6 CCR 1007-2 Sections 1.1, 1.2, 1.3.2, 2.1.1	Siting requirements for solid waste disposal sites.	Potentially Applicable	Applicable to nearby off-site disposal if the waste is defined as solid waste. Only substantive portions are applicable to on-site disposal if the waste is defined as solid waste.	Soils

Table 4-1
Summary of On-Site and Nearby Off-Site Removal Action Alternatives

	Alternative 1 No Action/ Institutional Controls	Alternative 2A In-Place Closure	Alternative 2B Above-Ground Repository	Alternative 3A Below-Ground Repository	Alternative 3B Below-Ground Repository with S/S
Effectiveness:					
Overall Protection of Public Health and Environment	• Long-term exposure risks to near-site workers and nearby residents • Does not provide adequate protection of human health or the environment	• Requires additional information to insure overall protection of human health and the environment	• Requires additional information to insure overall protection of human health and the environment	• Provides adequate protection of human health and the environment	• Provides adequate protection of human health and the environment
Compliance with ARARs	Does not attain ARARs	Requires additional information to ensure compliance with ARARs	Requires additional information to ensure compliance with ARARs	Attains ARARs	Attains ARARs
Long-Term Effectiveness and Permanence	No mitigation of long-term impacts: soil ingestion, air migration, biointrusion, surface water runoff, or groundwater into leaching.	• Can mitigate the potential long-term impacts associated with the material off-site • Requires additional information to ensure long-term effectiveness and permanence • Would require deed restrictions to prevent intrusion	• Can mitigate the potential long-term impacts associated with the material off-site • Requires additional information to ensure long-term effectiveness and permanence • Would require deed restrictions to prevent intrusion	• Mitigates the potential long-term impacts associated with the material off-site • Would require deed restrictions to prevent intrusion	• Mitigates the potential long-term impacts associated with the material off-site • Would require deed restrictions to prevent intrusion
Reduction of Toxicity, Mobility or Volume Through Treatment	No reduction.	No reduction, through treatment, mobility is reduced	No reduction, through treatment, mobility is reduced	No reduction, through treatment, mobility is reduced	• Reduction of toxicity and mobility • Increase in volume

Table 4-1
Summary of On-Site and Nearby Off-Site
Removal Action Alternatives
(continued)

	Alternative 1 No Action/ Institutional Controls	Alternative 2A In-Place Closure	Alternative 2B Above-Ground Repository	Alternative 3A Below-Ground Repository	Alternative 3B Below-Ground Repository with S/S
Effectiveness (cont):					
Short-Term Effectiveness	Short-term exposure risks to near-site workers and nearby residents	• Short-term exposure risks to on-site workers and nearby residents • Would require adequate dust suppression • Some potential for off-site traffic accidents • Short-term noise and vibration causing public annoyance in residential areas along truck Route A	• Short-term exposure risks to on-site workers and nearby residents • Would require adequate dust suppression • Some potential for off-site traffic accidents • Short-term noise and vibration causing public annoyance in residential areas along truck Route A	• Short-term exposure risks to on-site workers and nearby residents • Would require adequate dust suppression • Some potential for off-site traffic accidents • Short-term noise and vibration causing public annoyance in residential areas along truck Route A	• Short-term exposure risks to on-site workers and nearby residents • Would require adequate dust suppression • Some potential for off-site traffic accidents • Short-term noise and vibration causing public annoyance in residential areas along truck Route A
Implementability:					
Technical Feasibility	Good	Lower than Alts. 3 and 4	Lower than Alts. 3 and 4	Good	Good
Administrative Feasibility	High	High	High	Lower than Alts. 1,2,4A, or 4B	Lower than Alts. 1,2,4A, or 4B
Availability of Services and Materials	Good	Good	Good	Good	Good
Community Acceptance	Expected to be low	Expected to be low	Expected to be low	Expected to be moderate	Expected to be moderate
Cost(1) :					
15,000 cubic yards	$1,399,000	$3,099,000	3,178,000	$3,258,000	$4,123,000
20,000 cubic yards	$1,399,000	$3,099,000	3,276,000	$3,363,000	$4,411,000

(1) This amount reflects a land valuation estimate of $800,000. Some parties on whose behalf this report is submitted disagree with this estimate and the appropriateness of including land valuation as a component in estimating the costs of implementing the possible RA alternatives. In particular, some parties believe that the land valuation component is not applicable to Alternatives 1, 2A, or 2B.

Table 4-2
Summary of Off-Site Commercial Disposal Facility Removal Action Alternatives

	Alternative 4A	Alternative 4B	Alternative 4C		
	Envirocare Facility	Umetco Facility	CSI Facility	BFI Facility	Laidlaw Facility
Effectiveness:					
Overall Protection of Public Health and Environment	• Provides adequate protection of human health and the environment	• Provides adequate protection of human health and the environment	• Provides adequate protection of human health and the environment	• Provides adequate protection of human health and the environment	• Provides adequate protection of human health and the environment
Compliance with ARARs	Attains ARARs for on-site removal action	Attains ARARs for on-site removal action	Attains ARARs for on-site removal action	Attains ARARs for on-site removal action	Attains ARARs for on-site removal action
Long-Term Effectiveness and Permanence	• Successfully mitigates the potential long-term impacts associated with the stockpile on-site, however, off-site impacts are still present and pose long-term liability to PRPs • Mitigates on-site soil ingestion and air migration pathway; off-site unknown and uncontrollable	• Successfully mitigates the potential long-term impacts associated with the stockpile on-site, however, off-site impacts are still present and pose long-term liability to PRPs • Mitigates on-site soil ingestion and air migration pathway; off-site unknown and uncontrollable	• Successfully mitigates the potential long-term impacts associated with the stockpile on-site, however, off-site impacts are still present and pose long-term liability to PRPs • Mitigates on-site soil ingestion and air migration pathway; off-site unknown and uncontrollable	• Successfully mitigates the potential long-term impacts associated with the stockpile on-site, however, off-site impacts are still present and pose long-term liability to PRPs • Mitigates on-site soil ingestion and air migration pathway; off-site unknown and uncontrollable	• Successfully mitigates the potential long-term impacts associated with the stockpile on-site, however, off-site impacts are still present and pose long-term liability to PRPs • Mitigates on-site soil ingestion and air migration pathway; off-site unknown and uncontrollable
Reduction of Toxicity, Mobility or Volume Through Treatment	Does not reduce toxicity, mobility or volume through treatment, but reduces on-site contaminant volume	Does not reduce toxicity, mobility or volume through treatment, but reduces on-site contaminant volume	Does not reduce toxicity, mobility or volume through treatment, but reduces on-site contaminant volume	Does not reduce toxicity, mobility or volume through treatment, but reduces on-site contaminant volume	Does not reduce toxicity, mobility or volume through treatment, but reduces on-site contaminant volume

Table 4-2
Summary of Off-Site Commercial Disposal Facility
Removal Action Alternatives
(continued)

	Alternative 4A Envirocare Facility	Alternative 4B Umetco Facility	Alternative 4C CSI Facility	Alternative 4C BFI Facility	Alternative 4C Laidlaw Facility
Effectiveness (cont):					
Short-Term Effectiveness	• Short-term exposure risks to on-site workers and nearby residents • Would require adequate dust suppression • Some potential for off-site traffic accidents • Short-term noise and vibration causing public annoyance in residential areas along truck Route A	• Short-term exposure risks to on-site workers and nearby residents • Would require adequate dust suppression • Higher potential for off-site traffic accidents due to haul distance • Short-term noise and vibration causing public annoyance in residential areas along truck Route A	• Short-term exposure risks to on-site workers and nearby residents • Would require adequate dust suppression • Some potential for off-site traffic accidents • Short-term noise and vibration causing public annoyance in residential areas along truck Route A	• Short-term exposure risks to on-site workers and nearby residents • Would require adequate dust suppression • Some potential for off-site traffic accidents • Short-term noise and vibration causing public annoyance in residential areas along truck Route A	• Short-term exposure risks to on-site workers and nearby residents • Would require adequate dust suppression • Some potential for off-site traffic accidents • Short-term noise and vibration causing public annoyance in residential areas along truck Route A
Implementability:					
Technical Feasibility	Good, readily implemented using conventional construction technology	Good, readily implemented using conventional construction technology	Good, readily implemented using conventional construction technology	Good, readily implemented using conventional construction technology	Good, readily implemented using conventional construction technology
Administrative Feasibility	Good	Uncertain, pending resolultion of licencing issues	Good if approval is given to accept the stockpile. Have initiated risk assessment procedures to accept stockpile	Good if approval is given to accept the stockpile	Good if approval is given to accept the stockpile
Availability of Services and Materials	Good	Good	Good	Good	Good
Community Acceptance	Expected to be high	Expected to be high	Expected to be high	Expected to be high	Expected to be high
Cost:					
15,000 cubic yards	$4,200,000	$3,800,000	$650,000 to $1,900,000		
20,000 cubic yards	$5,500,000	$5,000,000	$715,000 to $2,500,000		

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Table 4-3
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
Compliance Evaluation for Off-Site Removal Action Alternatives

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media	Method of Attainment
Clean Air Act	40 CFR 50 to 69					
New Source Performance Requirements	40 CFR 60	Establishes emission standards for new air emissions	Potentially relevant and appropriate	If temporary air pollution sources that are sufficiently similar to those sources covered by these regulations are part of the remedy, the regulations may be relevant and appropriate.	Air	None of the off-site RA alternatives will use new air emission sources that are sufficiently similar to those sources covered by the regulations. Therefore, this standard is not applicable or relevant and appropriate.
Colorado Air Quality Control Act	CRS 25-7-101-512					
Common Provision Regulations	5 CCR 1001-2 Section II	Conduct performance tests, applicable emissions monitoring, and recordkeeping	Applicable	Substantive requirements are applicable to air emission component of the remedy.	Air	Perimeter air monitoring as set forth in Section 4.1.3 will be a component of the off-site RA alternatives during construction. This monitoring satisfies the performance testing required by the Air Quality Control Division for stationary sources. The results of the perimeter air monitoring will be recorded and maintained on-site or at another suitable location.
Regulation No. 1	5 CCR 1001-3, Reg No. 1	Establishes emission control regulations for particulates, smoke, carbon monoxide, sulfur oxides and fugitive particulate emissions.	Portions are Applicable	See below for description of specific provisions.	Air	See below for attainment of specific provisions.
Regulation No. 1	5 CCR 1001-3, Reg No. 1, Section II.A.1	Comply with opacity limitations.	Applicable	Less than 20% opacity emitted, specific sources may have other limitations.	Air	None of the off-site RA alternatives include an air emissions source which would require monitoring for opacity limitations.
Regulation No. 1	5 CCR 1001-3, Reg No. 1, Section III.D	Minimize fugitive particulate emissions.	Applicable, Relevant and Appropriate	Applicable to construction activities, storage and handling operations, haul roads and haul trucks, and tailings piles. Relevant and appropriate to non-specific sources.	Air	For all of the off-site RA alternatives, fugitive particulate emissions will be minimized during remediation by implementing the dust control procedures identified in Section 4.1.3. In addition, fugitive particulate emissions from storage and handling operations will be minimized by covering soil stockpiles with geotextile when not is use and implementing the dust control procedures set forth in Section 4.1.3.
Regulation No. 2	5 CCR 1001-4	Establishes odor emission regulations.	Applicable	If odor emissions become a potential concern, the substantive requirements are applicable.	Air	If odorous emissions become a potential concern for any of the off-site RA alternatives, the substantive requirements of this regulation can be met through the implementation of engineering controls.
Regulation No. 3	5 CCR 1001-5 Reg No. 3, Section II	File APEN including estimation of emission rates.	Applicable	Substantive portions are applicable to all sources including earthwork and existing sources unless specifically exempt.	Air	APENs are an administrative requirements and are thus not applicable under CERCLA. However, air monitoring data and other related information pertaining to implementation of the off-site RA alternatives will be provided to EPA as necessary.

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Table 4-3
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements Compliance Evaluations for Off-Site Removal Action Alternatives (continued)

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media	Method of Attainment
Regulation No. 7	5 CCR 1001-9, Reg No. 7	Establishes regulations to control emissions of VOCs (new and existing sources).	Applicable	If VOC emissions become a concern, apply Reasonably Available Control Technology. Section V requirements regarding using evaporation for disposal are applicable.	Air	If VOC emissions become a potential concern for any of the off-site RA alternatives, the substantive requirements of this regulation can be met through the implementation of engineering controls.
Ambient Air Quality Standards	5 CCR 1001-14	Sets ambient standards for total suspended particulates, sulfur dioxide, oxidant, carbon monoxide, nitrogen dioxide.	Applicable	Would be applicable if remedy would cause emission of regulated constituents	Air	Emission of regulated constituents other than small amounts of total suspended particulates is not anticipated during the implementation of any of the off-site RA alternatives. Dust control measures set forth in Section 4.1.3 will be used to attain the requirements of this regulation.
Hazardous Materials Transportation Act	49 USC 1801 to 1813					
Transportation Regulations	49 CFR Parts 107, 171 to 174, and 177	Regulates transportation of hazardous materials. Part 173 is specific to radioactive materials.	Applicable	Portions applicable to off-site transportation of radioactive wastes.	Soils, Solids	Packaging and transportation of radioactive materials will meet these standards for all of the off-site RA alternatives.
Colorado Hazardous Waste Regulations, Waste Characterization	6 CCR 1007-3 Parts 260, 261, 262.11	Defines hazardous wastes, requires waste characterization.	Applicable	Characterization required to determine if the waste pile contains characteristic or listed RCRA waste.	Soils	Waste pile has already been adequately characterized for the presence of RCRA hazardous wastes. Additional characterization activities are not required to meet these regulations for any of the off-site RA alternatives.
Colorado Hazardous Waste Regulations, Waste Characterization	6 CCR 1007-3, Part 264	Standards for owners and operators of hazardous waste treatment, storage, and disposal facilities. Requirements for managing hazardous waste based upon the mode of management, i.e., container storage, waste piles, impoundments, etc.	Portions Potentially Applicable.	Potentially applicable if RCRA hazardous wastes are present within the waste.	Soils	Current data indicates that RCRA hazardous wastes are not present so these requirements are not applicable to any of the off-site RA alternatives.
Land Disposal Restrictions	40 CFR Part 268 6 CCR 1007-3 Part 268	Establishes treatment standards for land disposal of selected hazardous wastes.	Potentially Applicable	Potentially applicable to off-site disposal if restricted RCRA wastes are encountered.	Soil	If restricted RCRA wastes are encountered, they will be managed in accordance with these regulations for all of the off-site RA alternatives.

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Table 4-3
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
Compliance Evaluations for Off-Site Removal Action Alternatives
(continued)

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media	Method of Attainment
Radiation Control Act	CRS 25-11-101-305					
Rules and Regulations Pertaining to Radiation Control	6 CCR 1007-1, Part 1 All Sections with emphasis on 1.5, 1.6, and 1.7	General provisions (including definitions, exemptions, recordkeeping, and inspections).	Applicable		All Media	The pertinent requirements (primarily administrative) set forth in these regulations will be met for each of the off-site RA alternatives within the State.
	6 CCR 1007-1, Part 3	Regulations concerning licensing of radioactive materials.	Portions Applicable.	Applicable to off-site disposal facilities within the State.	All Media	The pertinent requirements (primarily administrative) set forth in these regulations will be met for each of the off-site alternatives within the State.
	6 CCR 1007-1, Part 4	Establishes standards for protection against radiation hazards.	Applicable or Relevant and Appropriate.	Substantive portions are applicable to licensed areas, relevant and appropriate to non-licensed areas.	All Media	Requirements of this standard will be met for each of the off-site alternatives including meeting permissible doses, levels, and concentration standards through the use of PPE, environmental monitoring, and dosimetry programs.
	6 CCR 1007-1, Part 10	Notes, instructions, and reports to workers.	Applicable or Relevant and Appropriate	Substantive portions are applicable to licensed areas, relevant and appropriate to nonlicensed areas.	All Media	The pertinent requirements (primarily administrative) set forth in these regulations will be met for each of the off-site alternatives within the State.
	6 CCR 1007-1, Part 17	Transportation of radioactive materials	Applicable or Relevant and Appropriate	Substantive portions are applicable or relevant and appropriate	All Media	Packaging and transportation of radioactive materials will meet these standards for all of the off-site RA alternatives.
	6 CCR 1007-1, Part 18	Licensing requirements for milling facilities and the disposition of products of milling operations for uranium, thorium and related materials.	Potentially Applicable	Potentially applicable to off-site disposal facilities within the State. Substantive portions become applicable through 6 CCR 1007-2.	All Media	Risk-based evaluations will be or have been performed for each of the off-site RA alternatives within the State. Off-site RA alternatives must meet the substantive requirements set forth in Appendix A of this regulation.
Solid Wastes Disposal Sites and Facilities Act	CRS 30-20-101 to 118					
Solid Wastes Disposal Sites and Facilities Regulations	6 CCR 1007-2	Establishes minimum standards, closure requirements, site standards and engineering design standards for solid waste disposal facilities.	Potentially Applicable	Potentially applicable to off-site disposal facilities within the State	Soil	For off-site RA alternatives which include disposal at a licensed solid waste disposal facility within the State, the requirements of this part will be met in addition to the substantive portions of Part 18.
Prohibition on burial of sludge	6 CCR 1007-2, Sections 2.2.11-2.2.12	Prohibits both on-site and off-site burial of waste containing free liquids.	Potentially applicable	If liquid wastes are present, applicable to remedies which dispose of the materials within the State.	Soil	There will be no off-site disposal of raw sludges from wastewater treatment plants, septic tank pumpings or chemical toilet wastes as part of any of the off-site RA alternatives.

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Table 4-3
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
Compliance Evaluations for Off-Site Removal Action Alternatives
(continued)

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media	Method of Attainment
Clean Water Act	33 USC 1251 to 1376					
Standards for Fill or Excavation in Waters of the United States	33 CFR 320, 323, 328, and 330		Substantive portions potentially relevant and appropriate	Substantive portions potentially relevant and appropriate to fill and excavation in Chimney Gulch	Surface Water	None of the off-site RA alternatives will include fills or excavations within Chimey Gulch and, therefore, these regulations are not applicable or relevant and appropriate.
Storm Water Discharge Regulations	40 CFR 122.28	Regulates discharges of storm water and runoff water.	Applicable	Storm water discharge is covered by the general permit for discharge from construction sites. Utilize Best Available Technology (BAT) and Best Conventional Pollutant Control Technology.	Surface Water	For all of the off-site RA alternatives, storm water discharge is covered by the General Permit for Discharge from Construction Sites. The substantive requirements of the general permit will be met by implementing storm water controls such as berms, silt fences, and retention basins as necessary to reduce the pollutants in storm water discharges for each of the off-site RA alternatives.
Colorado Water Quality Control Act.	CRS 28-8 101 to 703					
Basic Standards and Methodologies for Surface Water	5 CCR 1002-8 Section 3.1.0	Establishes basic standards, anti-degradation standard, system for classifying state waters.	Applicable or Relevant and Appropriate	Applicable or relevant and appropriate to component of remedy impacting surface water.	Surface Water	The substantive requirements of the section will be met by implementing storm water controls such as berms, silt fences, and retention basins as necessary to reduce the pollutants in storm water discharges for each of the off-site RA alternatives.
Classifications and Numeric Standards, South Platte River Basin, et al.	5 CCR 1002-8 Section 3.8.0	Used in conjunction with basic standards and methodologies (Section 3.1.0)	Applicable	For any surface water discharge identified, compliance is required for Segment 11 and 14 of South Platte River	Surface Water	The substantive requirements of the section will be met by implementing storm water controls such as berms, silt fences, and retention basins as necessary to reduce the pollutants in storm water discharges for each of the off-site RA alternatives.
State Discharge Permit Regulations	5 CCR 1002-2 Section 6.1.0	Requires a permit for the discharge of pollutants from a point source into waters of the State.	Potentially Applicable	Must comply with substantive requirements.	Surface Water	The substantive requirements of the section will be met by implementing storm water controls such as berms, silt fences, and retention basins as necessary to reduce the pollutants in storm water discharges for each of the off-site RA alternatives.
Storm Sewer Discharge Regulations	5 CCR 1002-7	Establishes requirements relating to discharges into storm sewers.	Applicable	Storm sewer regulations are applicable to run-off from the site.	Surface water	The substantive requirements of the section will be met by implementing storm water controls such as berms, silt fences, and retention basins as necessary to reduce the pollutants in storm water discharges for each of the off-site RA alternatives.
Occupational Safety and Health Act	29 USC 651-678 29 CFR 1910.96 29 CFR 1926	Regulates worker health and safety.	Applicable	Independently applicable. Requirements of this act apply to all response actions under the NCP.	N/A	The Safety, Health, and Emergency Response Plan sets forth the health and safety program to be implmented during the RA. Adherence to this plan satisfies these standards.

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Table 4-4
Chemical-Specific State and Federal Applicable or Relevant and Appropriate Requirements
Compliance Evaluation for Off-Site Removal Action Alternatives

Contaminant	Standard	Citation	Applicable or Relevant and Appropriate or TBC	Comments	Media	Method of Attainment
Radium-226	Less than or equal to 5 pCi/g above background within 15 cm of the surface averaged over 100 square meter area. Less than or equal to 15 pCi/g above background within subsequent 15 cm layers of soil averaged over 100 square meter area.	40 CFR 192.12(a)	Relevant and Appropriate	Standard for clean-up of land at inactive uranium processing sites. Relevant and appropriate to excavation of clay liner under the waste pile due to waste similarities.	Soils	Confirmatory sampling will be performed to ensure that this standard is attained for each off-site RA alternative. Background Radium-226 concentrations between 1.0 and 2.0 picocuries per gram will be used as they are typical for the area.
Thorium-230	Clean-up level calculated using initial Ra-226 concentration and assuming period for Th-230 ingrowth; depth of backfill may be considered.	Generic protocol for excavation of Th–230, DOE, January 15, 1989	TBC	DOE standard modified by EPA's January 16, 1992 letter. To be considered for excavation of clay liner under the waste pile.	Soils	Confirmatory sampling will be performed to ensure that this standard is attained for each off-site RA alternative. Based on the waste pile sampling, Thorium-230 concentrations in excess of the protocol are not anticipated in the waste pile.
Radon Decay Products	Objectives of remedial action to achieve an annual average not to exceed 0.02 WL. In any case, not to exceed 0.03 WL.	40 CFR 192.12(b)(1)	Relevant and Appropriate	Standard for clean-up of inactive uranium processing sites. Relevant and appropriate if occupied or habitable buildings planned for site.	Air	Confirmatory sampling will be performed to ensure that this standard is attained for each off-site RA alternative.
Radiation	Gamma radiation shall not exceed background levels by more than 20 microR per hour.	40 CFR 192.12(b)(2)	Relevant and Appropriate	Standard for clean-up of inactive uranium processing sites. Relevant and appropriate if occupied or habitable buildings planned for site.	Soils	Confirmatory sampling will be performed to ensure that this standard is attained for each off-site RA alternative.
Radiation	Standards for protection against radiation.	10 CFR 20 6 CCR 1004-1 Part 4	Applicable	Applicable to all NRC and/or State licensees and registrants of radioactive materials. Substantive portions are relevant and appropriate to non-licensed areas.	All Media	Requirements of this standard will be met for each of the off-site RA alternatives including meeting permissible doses, levels, and concentration standards through the use of PPE, environmental monitoring, and dosimetry programs.
Radiation Dose	ICRP Publication 30 provides recommended Annual Limits on Intake and Derived Air Concentrations designed to limit the intake of radioactive materials by workers.	ICRP 30	TBC	To the extent that workers may have radioactive material intakes due to the presence of site wastes, this international guidance is to be considered.	All Media	The appropriate selection of respiratory protection procedures will meet the criteria set forth in this guidance for all of the off-site RA alternatives.

Table 4-4
Chemical-Specific State and Federal Applicable or Relevant and Appropriate Requirements
Compliance Evaluations for Off-Site RA Alternatives
(Continued)

Contaminant	Standard	Citation	Applicable or Relevant and Appropriate or TBC	Comments	Media	Method of Attainment
Radiation Dose	Federal Guidance Report No. 11 provides Annual Limits on Intake and Derived Air Concentrations to be implemented by federal agencies to limit the intake of radioactive materials by workers.	Federal Guidance Report No. 11	TBC	To the extent that workers may have radioactive material intakes due to the presence of site wastes, this Federal guidance is to be considered.	All Media	The appropriate selection of respiratory protection procedures will meet the criteria set forth in this guidance for all of the off-site RA alternatives.
Air Pollutants	National Emission Standards for Hazardous Air Pollutants (NESHAP)	40 CFR 61	Relevant and Appropriate	To the extent the removal activities involve the emission of regulated constituents and activities similar to those addressed in these regulations, they may be relevant and appropriate.	Air	Perimeter air monitoring (including radionuclides) and dust control measures as set forth in Section 4.1.3 will be a component of all of the off-site RA alternatives to ensure that the potentially relevant and appropriate NESHAPs are being met.

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Table 4-5
Chemical-Specific State and Federal Applicable or Relevant and Appropriate Requirements
Compliance Evaluations for On-Site and Nearby Off-Site Removal Action Alternatives

Contaminant	Standard	Citation	Applicable or Relevant and Appropriate or TBC	Comments	Media	Method of Attainment
Radium-226	Less than or equal to 5 pCi/g above background within 15 cm of the surface averaged over 100 square meter area. Less than or equal to 15 pCi/g above background within subsequent 15 cm layers of soil averaged over 100 square meter area.	40 CFR 192.12(a)	Relevant and Appropriate	Standard for clean-up of land at inactive uranium processing sites. Relevant and appropriate to excavation of clay liner under the waste pile due to waste similarities.	Soils	Confirmatory sampling will be performed to ensure that this standard is attained for each on-site or nearby off-site RA alternative. Background Radium-226 concentrations between 1.0 and 2.0 picocuries per gram will be used as they are typical for the area.
Thorium-230	Clean-up level calculated using initial Ra-226 concentration and assuming period for Th-230 ingrowth; depth of backfill may be considered.	Generic protocol for excavation of Th-230, DOE, January 15, 1989	TBC	DOE standard modified by EPA's January 16, 1992 letter. To be considered for excavation of clay liner under the waste pile.	Soils	Confirmatory sampling will be performed to ensure that this standard is attained for each on-site or nearby off-site RA alternative. Based on the waste pile sampling, Thorium-230 concentrations in excess of the protocol are not anticipated in the waste pile.
Radon Decay Products	Objectives of remedial action to achieve an annual average not to exceed 0.02 WL. In any case, not to exceed 0.03 WL.	40 CFR 192.12(b)(1)	Relevant and Appropriate	Standard for clean-up of inactive uranium processing sites. Relevant and appropriate if occupied or habitable buildings planned for site.	Air	Confirmatory sampling will be performed to ensure that this standard is attained for each on-site or nearby off-site RA alternative.
Radon-222 Radon-220	Average release rate of radon from uranium or thorium materials not to exceed 20 pCi per square meter per second or increase the annual average concentration of radon by more than 0.5 pCi per liter outside disposal site boundary.	40 CFR 192.02(b)(1), (2) 40 CFR 192.32(b)(1)(ii)	Relevant and Appropriate	Standard for post-closure management of uranium or thorium materials. Relevant and appropriate to on-site disposal.	Air	An adequately designed and engineered cap and cover system will meet these requirements for each on-site or nearby off-site RA alternative except the no-action alternative.
Radiation	Gamma radiation shall not exceed background levels by more than 20 microR per hour.	40 CFR 192.12(b)(2)	Relevant and Appropriate	Standard for clean-up of inactive uranium processing sites. Relevant and appropriate if occupied or habitable buildings planned for site.	Soils	Confirmatory sampling will be performed to ensure that this standard is attained for each on-site or nearby off-site RA alternative.
Radiation	Standards for protection against radiation.	10 CFR 20 6 CCR 1007-1 Part 4	Applicable	Applicable to all NRC and/or State licensees and registrants of radioactive materials. Substantive portions are relevant and appropriate to non-licensed areas.	All Media	Requirements of these standards will be met for each of the on-site and nearby off-site RA alternatives including meeting permissible doses, levels, and concentration standards through the use of PPE, environmental monitoring, and dosimetry programs.

Table 4-5
Chemical-Specific State and Federal Applicable or Relevant and Appropriate Requirements Compliance Evaluations for On-Site and Nearby Off-Site Removal Action Alternatives (Continued)

Contaminant	Standard	Citation	Applicable or Relevant and Appropriate or TBC	Comments	Media	Method of Attainment
Radiation	Annual dose equivalent shall not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as a result of release of radioactive materials to the general public.	40 CFR 192.32(a) 40 CFR 192.41(d)	Relevant and Appropriate	Standard for management of thorium materials. Relevant and appropriate to on-site disposal.	Soils	An adequately designed and engineered cap and cover system will meet these requirements for each on-site or nearby off-site RA alternative except the no-action alternative.
Radiation Dose	Federal Radiation Protection Guidance (25 FR 4402, May 13, 1960) as implemented by the Federal Radiation Council (FRC) recommends limiting doses to members of the general public to less than 0.5 rem per year.	FRC 1960	TBC	To the extent that members of the general public receive doses from site wastes, this Federal guidance is to be considered.	All Media	An adequately designed and engineered cap and cover system will meet the criteria set forth in this guidance for each on-site or nearby off-site RA alternative except the no-action alternative.
Radiation Dose	ICRP Publication 26 recommends a whole body dose equivalent limit of 0.5 rem per year as applied to critical groups of the public. In any case where the doses were actually found to be received at high rates over prolonged periods, ICRP recommends restriction of the lifetime dose to the individual member of the public to a value that corresponds to 0.1 rem per year.	ICRP 26	TBC	To the extent that members of the general public receive doses from site wastes, this international guidance is to be considered.	All Media	An adequately designed and engineered cap and cover system will meet the criteria set forth in this guidance for each on-site or nearby off-site RA alternative except the no-action alternative.
Radiation Dose	ICRP Publication 30 provides recommended Annual Limits on Intake and Derived Air Concentrations designed to limit the intake of radioactive materials by workers.	ICRP 30	TBC	To the extent that workers may have radioactive material intakes due to the presence of site wastes, this international guidance is to be considered.	All Media	The appropriate selection of respiratory protection procedures will meet the criteria set forth in this guidance for all of the on-site and nearby off-site RA alternatives.
Radiation Dose	Federal Guidance Report No. 11 provides Annual Limits on Intake and Derived Air Concentrations to be implemented by federal agencies to limit the intake of radioactive materials by workers.	Federal Guidance Report No. 11	TBC	To the extent that workers may have radioactive material intakes due to the presence of site wastes, this Federal guidance is to be considered.	All Media	The appropriate selection of respiratory protection procedures will meet the criteria set forth in this guidance for all of the on-site and nearby off-site RA alternatives.

PLA 805

Table 4-5
Chemical-Specific State and Federal Applicable or Relevant and Appropriate Requirements Compliance Evaluations for On-Site and Nearby Off-Site Removal Action Alternatives (Continued)

Contaminant	Standard	Citation	Applicable or Relevant and Appropriate or TBC	Comments	Media	Method of Attainment
Air Pollutants	National Emission Standards for Hazardous Air Pollutants (NESHAP)	40 CFR 61	Relevant and Appropriate	To the extent the removal activities involve the emission of regulated constituents and activities similar to those addressed in these regulations, they may be relevant and appropriate.	Air	Perimeter air monitoring (including radionuclides) and dust control measures as set forth in Section 4.1.3 will be a component of all of the on-site and nearby off-site RA alternatives to ensure that the potentially relevant and appropriate NESHAPs are being met.

PLA 806

Table 4-6
Chemical-Specific State and Federal ARARs for Groundwater Compliance Evaluations for On-Site and Nearby Off-Site Removal Action Alternatives

Contaminant	Standard	Applicable or R&A	Comments	Method of Attainment
Ra-226 and Ra-228	5 pCi/l	Applicable	Statewide standard[1] (also MCL)	The results of the treatability study indicate that leaching of the contaminants in the waste pile is not a concern with the potential exceptions of Radium-226, manganese, molybdenum, and total uranium in the untreated waste and Radium-226, gross alpha, and molydenum in the S/S treated waste. Groundwater modelling which used the results of the Synthetic Acid Precipitation Tests as source terms in the waste would probably show that the ARARs for these contaminants could be attained at the disposal site boundary. Additionally, all of the on-site and nearby off-site RA alternatives include an engineered barrier (multi-layer liner or slurry wall) between the waste and the groundwater to prevent migration of contaminants into the groundwater.
Th-230 and Th-232	60 pCi/l	Applicable	Statewide standard[1] (also MCL)	
Gross Alpha	15 pCi/l [2]	Applicable	Statewide standard[1](also MCL)	
Beta/Photon Emitters	4 mrem/year [3]	Applicable	Statewide standard[1] (also MCL)	
Uranium	30 pCi/l	Applicable	40 CFR 192 standard	
Trichloroethylene	0.005 mg/l	Applicable	Statewide standard[1] (also MCL)	
Tetrachloroethylene	0.005 mg/l	Applicable	Statewide standard[1] (also MCL)	
Arsenic	0.05 mgl	R&A	MCL	
Barium	1.0 mg/l	R&A	MCL	
Cadmium	0.005 mg/l	R&A	Human health standard[1]	
Cyanide (Free)	0.20 mg/l	R&A	Human health standard[1]	
Chromium	0.05 mg/l	R&A	MCL	
Fluoride	2.0 mg/l	R&A	Agricultural standard[1]	
Lead	0.015 mg/l	R&A	MCL	
Mercury	0.002 mg/l	R&A	MCL	
Nitrate	10.0 mg/l	R&A	MCL	
Nitrite	1.0 mg/l	R&A	Human health standard[1]	
Selenium	0.01 mg/l	R&A	MCL	
Silver	0.05 mg/l	R&A	MCL	
Chloride	250 mg/l	R&A	Secondary drinking water[1]	
Copper	0.2 mg/l	R&A	Agricultural standard[1]	
Iron	0.3 mg/l	R&A	Secondary drinking water[1]	
Manganese	0.05 mg/l	R&A	Secondary drinking water[1]	
Sulfate	250 mg/l	R&A	Secondary drinking water[1]	
Zinc	2.0 mg/l	R&A	Agricultural standard[1]	
Aluminum	5.0 mg/l	R&A	Agricultural standard[1]	
Beryllium	0.1 mg/l	R&A	Agricultural standard[1]	
Cobalt	0.05 mg/l	R&A	Agricultural standard[1]	
Molybdenum	0.10 mg/l	R&A	40 CFR 192 standard	
Nickel	0.20 mg/l	R&A	Agricultural standard[1]	
Vanadium	0.1 mg/l	R&A	Agricultural standard[1]	

(1) 5 CCR 1002-8 Section 3.11.0
(2) Excludes contributions from radon and uranium
(3) Applicable only to man-made radionuclides

PLA 807

Table 4-7
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
On-Site and Nearby Off-Site Removal Action Alternatives

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media	Method of Attainment
Clean Air Act	40 CFR 50 to 69					
New Source Performance Requirements	40 CFR 60	Establishes emission standards for new air emissions.	Potentially Relevant and Appropriate	If temporary air pollution sources that are sufficiently similar to those sources covered by the regulations are part of the remedy, the regulations may be relevant and appropriate.	Air	None of the on-site or nearby off-site RA alternatives will use new air emission sources that are sufficiently similar to those sources covered by the regulations. Therefore, this standard is not applicable or relevant and appropriate.
Colorado Air Quality Control Act	CRS 25-7-101-512					
Common Provision Regulations	5 CCR 1001-2 Section II	Conduct performance tests, applicable emissions monitoring, and recordkeeping	Applicable	Substantive requirements are applicable to air emission component of the remedy.	Air	Perimeter air monitoring as set forth in Section 4.1.3 will be a component of the on-site and nearby off-site RA alternatives during construction. This monitoring satisfies the performance testing required by the Air Quality Control Division for stationary sources. The results of the perimeter air monitoring will be recorded and maintained on-site or at another suitable location.
Regulation No. 1	5 CCR 1001-3, Regulation No. 1	Establishes emission control regulations for particulates, smokes, carbon monoxide, sulfur oxides and fugitive particulate emissions.	Portions are Applicable	See below for description of specific provisions.	Air	See below for attainment of specific provisions.
Regulation No. 1	5 CCR 1001-3, Reg No. 1 Sec II.A.1	Comply with opacity limitations.	Applicable	Less than 20% opacity emitted, specific sources may have other limitations.	Air	Alternative 5 is the only on-site or nearby off-site RA alternatives which includes an air emissions source (i.e. pugmill) which would require monitoring for opacity limitations. Based on previous opacity observations for pugmills with similar wastes, the 20 percent opacity limitation will be readily attainable.
Regulation No. 1	5 CCR 1001-3, Reg No. 1 Sec III.D	Minimize fugitive particulate emissions.	Applicable, Relevant and Appropriate	Applicable to construction activities, storage and handling operations, haul roads and haul trucks, and tailings piles. Relevant and appropriate to non-specific sources.	Air	For all of the on-site and nearby off-site RA alternatives, fugitive particulate emissions will be minimized during remediation by implementing the dust control procedures identified in Section 4.1.3. In addition, fugitive particulate emissions from storage and handling operations will be minimized by covering soil stockpiles with geotextile when not is use and implementing the dust control procedures set forth in Section 4.1.3.
Regulation No. 2	5 CCR 1001-4	Establishes odor emission regulations.	Applicable	If odor emission become a potential concern, the substantive portions are applicable.	Air	If odorous emissions become a potential concern for any of the on-site or nearby off-site RA alternatives, the substantive requirements of this regulation can be met through the implementation of engineering controls.
Regulation No. 3	5 CCR 1001-5 Regulation No. 3 Section II	File APEN including estimation of emissions rates.	Applicable	Substantive portions are applicable to all sources including earthwork and existing sources unless specifically exempt.		APENs are an administrative requirements and are thus not applicable under CERCLA. However, air monitoring data and other related information pertaining to implementation of the on-site and nearby off-site RA alternatives will be provided to EPA as necessary.
Regulation No. 7	5 CCR 1001-9 Reg No. 7 Sec IV.D.3	Establishes regulations to control emissions of VOCs (new and existing sources).	Applicable	If VOCs become a concern, apply Reasonably Available Control Technology. Section V requirements regarding using evaporation for disposal are applicable.	Air	If VOC emissions become a potential concern for any of the on-site or nearby off-site RA alternatives, the substantive requirements of this regulation can be met through the implementation of engineering controls.

PLA 808

Table 4-7
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
On-Site and Nearby Off-Site Removal Action Alternatives
(continued)

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media	Method of Attainment
Ambient Air Quality Standards	5 CCR 1001-14	Sets ambient standards for total suspended particulates, sulfur dioxide, oxidant, carbon monoxide, nitrogen dioxide.	Applicable	Would be applicable if the remedy would cause emission of regulated constituents.	Air	Emission of regulated constituents other than small amounts of total suspended particulates is not anticipated during the implementation of any of the on-site or nearby off-site RA alternatives. Dust control measures set forth in Section 4.1.3 will be used to attain the requirements of this regulation.
Hazardous Materials Transportation Act	49 USC 1801 to 1813					
Transportation Regulations	49 CFR Parts 107, 171 to 174, and 177	Regulates transportation of hazardous materials. Part 173 is specific to radioactive materials.	Applicable	Portions applicable to off-site transportation of radioactive wastes.	Soils, Solids	If transportation of radioactive material is necessary, packaging and transportation of radioactive materials will meet these standards for all of the on-site or nearby off-site RA alternatives.
Colorado Hazardous Waste Regulations, Waste Characterization	6 CCR 1007-3 Parts 260, 261, 262.11	Defines hazardous wastes, requires waste characterization.	Applicable	Characterization required to determine if the waste pile contains characteristic or listed RCRA waste.	Soils	Waste pile has already been adequately characterized for the presence of RCRA hazardous wastes. Additional characterization activities are not required to meet these regulations for any of the on-site or nearby off-site RA alternatives.
Colorado Hazardous Waste Regulations	6 CCR 1003-3 Part 264	Standards for owners and operators of hazardous waste treatment, storage, and disposal Facilities. Requirements for managing hazardous waste based upon the mode of management, i.e. container storage, waste piles, impoundments, etc.	Portions Potentially Applicable or Relevant and Appropriate.	Potentially applicable or relevant and appropriate if RCRA hazardous wastes are present within the waste. Current data indicates that RCRA hazardous wastes are not present so these requirements are not applicable.	Soils	Current data indicates that RCRA hazardous wastes are not present so these requirements are not applicable to any of the on-site or nearby off-site RA alternatives.
Land Disposal Restrictions	40 CFR Part 268 6 CCR 1007-3 Part 268	Establishes treatment standards for land disposal of selected hazardous wastes.	Potentially Applicable	Potentially appliacble to on-site disposal if restricted RCRA wastes are encountered.	Soil	If restricted RCRA wastes are encountered, they will be managed in accordance with these regulations for all of the on-site or nearby off-site RA alternatives.
Radiation Control Act	CRS 25-11-101 to 305					
Rules and Regulations Pertaining to Radiation Control	6 CCR 1007-1 Part 1	General provisions (including definitions) for 6 CCR 1007-1	Applicable		All Media	The pertinent requirements (primarily administrative) set forth in these regulations will be met for each of the nearby off-site RA alternatives. Substantive requirements will be met for the on-site RA alternatives.
	6 CCR 1007-1 Part 3	Regulations concerning licensing of radioactive materials.	Portions applicable, Relevant and Appropriate.	Substantive portions are applicable or relevant and appropriate for remedies which dispose of radioactive materials on-site.	All Media	The pertinent requirements (primarily administrative) set forth in these regulations will be met for each of the nearby off-site alternatives. Substantive requirements will be met for the on-site RA alternatives.
	6 CCR 1007-1 Part 4	Establishes standards for protection against radiation hazards.	Applicable or Relevant and Appropriate.	Applicable to licensed areas. Substantive portions are relevant and appropriate to non-licensed areas.	All Media	Requirements of these standards will be met for each of the on-site and nearby off-site RA alternatives including meeting permissible doses, levels, and concentration standards through the use of PPE, environmental monitoring, and dosimetry programs.

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Table 4-7
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
On-Site and Nearby Off-Site Removal Action Alternatives
(continued)

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media	Method of Attainment
	6 CCR 1007-1 Part 10	Notes, instructions, and reports to workers.	Applicable or Relevant and Appropriate	Substantive requirements are applicable to licensed areas. Relevant and appropriate to nonlicensed areas.	All Media	The pertinent requirements (primarily administrative) set forth in these regulations will be met for each of the nearby off-site alternatives. Substantive requirements will be met for the on-site RA alternatives.
	6 CCR 1007-1 Part 17	Transportation of radioactive materials	Applicable or Relevant and Appropriate	Substantive portions are applicable or relevant and appropriate	All Media	Packaging and transportation of radioactive materials (if required) will meet these standards for all of the on-site and nearby off-site RA alternatives.
	6 CCR 1007-1 Part 18	Licensing requirements for the disposition of products of milling operations for uranium, thorium and related materials.	Relevant and Appropriate	Relevant and appropriate to nearby off-site disposal of the waste. Only substantive portions are relevant and appropriate to on-site disposal of the waste.	All Media	The pertinent requirements set forth in these regulations will be met for each of the nearby off-site alternatives. Substantive requirements will be met for the on-site RA alternatives.
Solid Wastes Disposal Sites and Facilities Act	CRS 30-20-101 to 118					
Solid Wastes Disposal Sites and Facilities Regulations	6 CCR 1007-2	Establishes minimum standards, closure requirements, site standards and engineering design standards for solid waste disposal facilities.	Potentially Applicable	Applicable to on-site disposal of solid waste.	Soil Groundwater	For nearby off-site RA alternatives, the pertinent requirements of this part will be met. For on-site RA alternatives, the substantive requirements of this part will be met.
Prohibition on burial of sludge	6 CCR 1007-2 Sections 2.2.11-2.2.12	Prohibits both on-site and off-site burial of waste containing free liquids.	Potentially applicable		Soil Groundwater	There will be no off-site disposal of raw sludges from wastewater treatment plants, septic tank pumpings or chemical toilet wastes as part of any of the on-site or nearby off-site RA alternatives.
Clean Water Act	33 USC 1251 to 1376					
Standards for Fills or Excavation in waters of the United States	33 CFR 320, 323, 325, and 330		Substantive portions potentially relevant and appropriate	Substantive portions potentially relevant and appropriate to fills and excavations wihtin Chminey Gulch.	Surface Water	Alternative 2 and 3 will include fills or excavations within Chimey Gulch in which the requirements of this regulation will be met.
Storm Water Discharge Regulations	40 CFR 122.28	Regulates discharges of storm water and runoff water.	Applicable	Storm water discharge is covered by the General Permit for Discharge from Construction sites (§122.28). Utilize Best Available Technology (BAT) and Best Conventional Pollutant Control Technology.	Surface Water	For all of the on-site or nearby off-site RA alternatives, storm water discharge is covered by the General Permit for Discharge from Construction Sites. The substantive requirements of the general permit will be met by implementing storm water controls such as berms, silt fences, and retention basins as necessary to reduce the pollutants in storm water discharges for each of the off-site RA alternatives.
Colorado Water Quality Control Act.	CRS 28-8 101 to 703					
Basic Standards and Methodologies for Surface Water	5 CCR 1002-8 Section 3.1.0	Establishes basic standards, anti-degradation standard, system for classifying state waters.	Applicable or Relevant and Appropriate	Applicable to component of remedy impacting surface water.	Surface Water	The substantive requirements of the section will be met by implementing storm water controls such as berms, silt fences, and retention basins as necessary to reduce the pollutants in storm water discharges for each of the on-site and nearby off-site RA alternatives.

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Table 4-7
Action-Specific State and Federal Applicable or Relevant and Appropriate Requirements
On-Site and Nearby Off-Site Removal Action Alternatives
(continued)

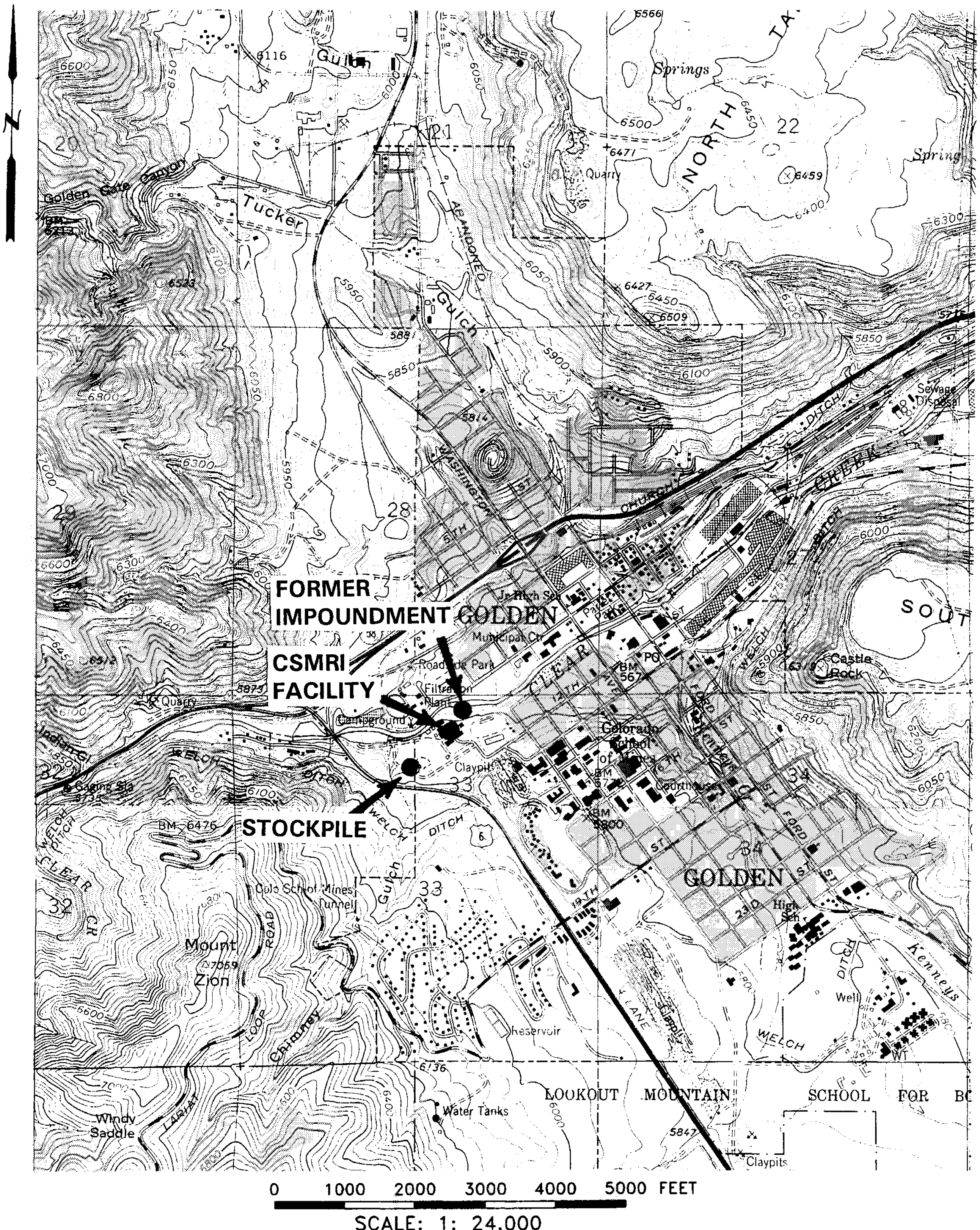
Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media	Method of Attainment
Classifications and Numeric Standards, South Platte River Basin, et al.	5 CCR 1002-8 Section 3.8.0	Used in conjunction with basic standards and methodologies (Section 3.1.0)	Applicable	For any surface water discharge identified, compliance is required for Segments 11 and 14 of the South Platte River.	Surface Water	The substantive requirements of the section will be met by implementing storm water controls such as berms, silt fences, and retention basins as necessary to reduce the pollutants in storm water discharges for each of the on-site or nearby off-site RA alternatives.
State Discharge Permit Regulations	5 CCR 1002-2 Section 6.1.0	Requires a permit for the discharge of pollutants from a point source into waters of the State.	Potentially Applicable	Must comply with substantive requirements.	Surface Water	The substantive requirements of the section will be met by implementing storm water controls such as berms, silt fences, and retention basins as necessary to reduce the pollutants in storm water discharges for each of the on-site or nearby off-site RA alternatives.
Storm Sewer Discharge Regulations	5 CCR 1002-7	Establishes requirements relating to discharges into storm sewers.	Applicable	Storm sewer regulations are applicable to run-off from the site.	Surface water	The substantive requirements of the section will be met by implementing storm water controls such as berms, silt fences, and retention basins as necessary to reduce the pollutants in storm water discharges for each of the on-site or nearby off-site RA alternatives.
Basic Standards for Ground Water	5 CCR 1002-8 Section 3.11.0	Establishes a system for classifying groundwater and adopting water quality control standards to protect existing and potential beneficial uses.	Portions Applicable, Portions Relevant and Appropriate.	Establishes framework, site-specific classifications, and standards. Statewide standards are applicable. Standards based on classification are relevant and appropriate.	Groundwater	The results of the treatability study indicate that leaching of the contaminants in the waste pile is not a concern with the potential exceptions of Radium-226, manganese, molybdenum, and total uranium in the untreated waste and Radium-226, gross alpha, and molydenum in the S/S treated waste. Groundwater modelling which used the results of the Synthetic Acid Precipitation Tests as source terms in the waste would probably show that the ARARs for these contaminants could be attained at the disposal site boundary. Additionally, all of the on-site and nearby off-site RA alternatives include an engineered barrier (multi-layer liner or slurry wall) between the waste and the groundwater to prevent migration of contaminants into the groundwater.
Classification and Water Quality Standards for Groundwater	5CCR 1002-8 Section 3.12.0	Specifies interim narrative standards for the Laramie-Fox Hills aquifer and the area around Clear Creek as it exits the mountains in Golden.	Portions applicable	To be used in conjunction with the basic standards (Section 3.11.0).	Groundwater	The results of the treatability study indicate that leaching of the contaminants in the waste pile is not a concern with the potential exceptions of Radium-226, manganese, molybdenum, and total uranium in the untreated waste and Radium-226, gross alpha, and molydenum in the S/S treated waste. Groundwater modelling which used the results of the Synthetic Acid Precipitation Tests as source terms in the waste would probably show that the ARARs for these contaminants could be attained at the disposal site boundary. Additionally, all of the on-site and nearby off-site RA alternatives include an engineered barrier (multi-layer liner or slurry wall) between the waste and the groundwater to prevent migration of contaminants into the groundwater.
Water Well and Pump Installation Contractors Regulations.	2 CCR 402-2	License requirements for well construction and pump installation contractors and minimum standards for well construction and abandonment.	Applicable	Establishes regulations for construction and abandonment of wells.	Groundwater	Substantive portions will be met during installation and abandonment of wells for any of the on-site or nearby off-site RA alternatives.
Occupational Safety and Health Act	29 USC 651-678 29 CFR 1910.96 29 CFR 1926	Regulates worker health and safety	Applicable	Independently applicable. Requirements of this act apply to all response activities under the NCP.	N/A	The Safety, Health, and Emergency Response Plan sets forth the health and safety program to be implmented during the RA. Adherence to this plan satisfies these standards.

PLA 811

Table 4-8
Location-Specific Applicable or Relevant and Appropriate Requirements
Compliance Evaluations for On-Site and Nearby Off-Site Removal Action Alternatives

Standard Requirement, Criteria or Limitation	Citation	Description or Requirements	Applicable or Relevant and Appropriate	Comments	Media	Method of Attainment
Colorado Hazardous Waste Act	CRS 25-15-101 to 313	Establishes broad siting criteria and site evaluation procedures for individual storage or disposal units.	Potentially Applicable	Applicable to nearby off-site disposal if RCRA hazardous wastes are present within the waste pile. Only substantive portions are applicable to on-site disposal if RCRA hazardous wastes are present within the waste pile.	Soils	See Table 4-7, Action-Specific ARARs
Milling of Uranium, Thorium, and Related Radioactive Materials	6 CCR 1007-1 Part 18	Siting and design criteria for the disposition of products of milling operations for uranium, thorium, and related products.	Relevant and Appropriate	Relevant and appropriate to nearby off-site disposal of the waste. Only substantive portions are relevant and appropriate to on-site disposal of the waste.	Soils	See Table 4-7, Action-Specific ARARs
Solid Waste Regulations, Siting Requirements	6 CCR 1007-2 Sections 1.1, 1.2, 1.3.2, 2.1.1	Siting requirements for solid waste disposal sites.	Potentially Applicable	Applicable to nearby off-site disposal if the waste is defined as solid waste. Only substantive portions are applicable to on-site disposal if the waste is defined as solid waste.	Soils	See Table 4-7, Action-Specific ARARs

Figures



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Approved by: JCM 06/09/95

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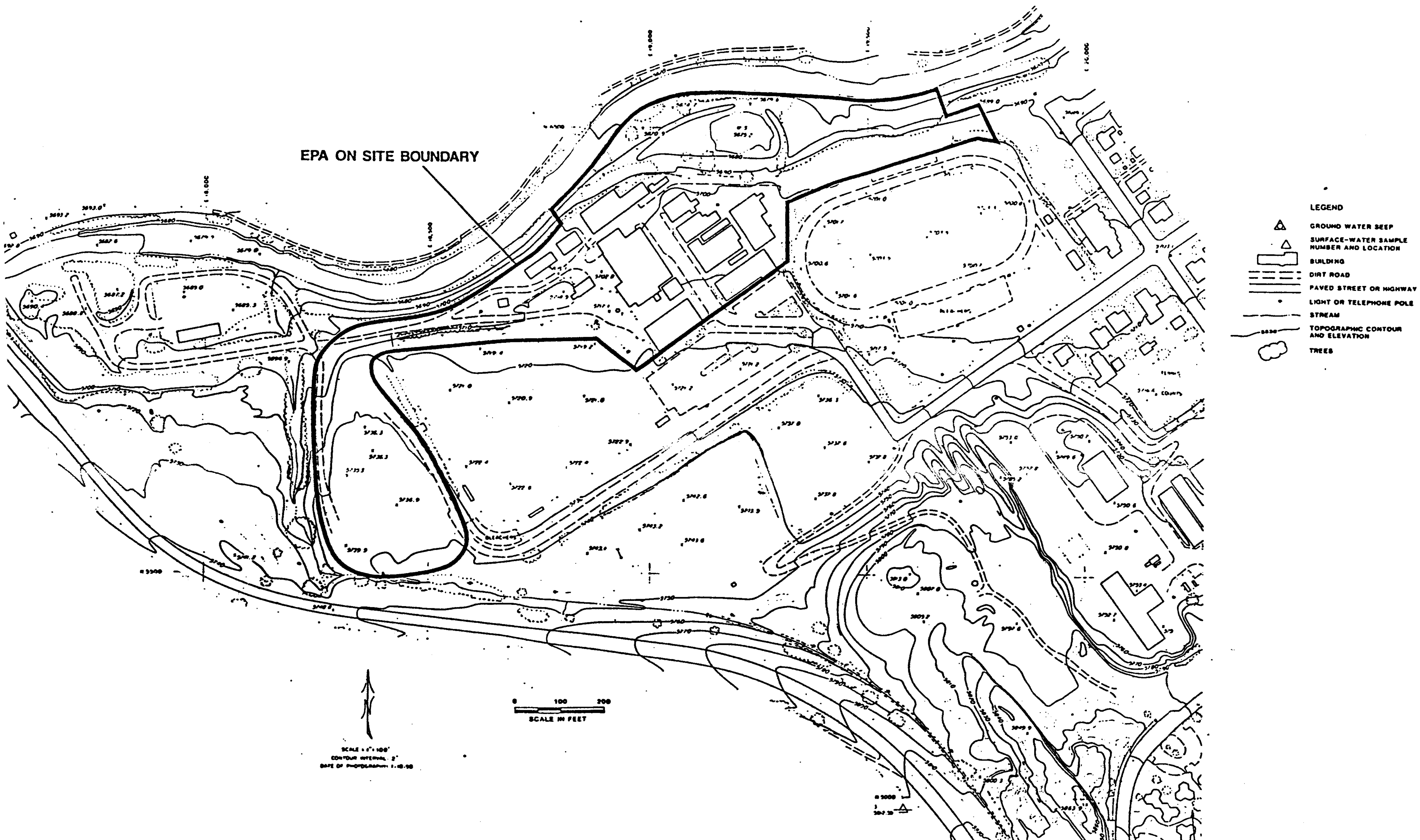
Stockpile
Removal Action Options Analysis

Figure 1-1
Location Map

CROUSE



PLA 815

Source: James L. Grant and Associates - Prepared by Intra Search Denver, Colorado, January 19, 1995

Modified by Ecology & Environment, Inc., February 1, 1995

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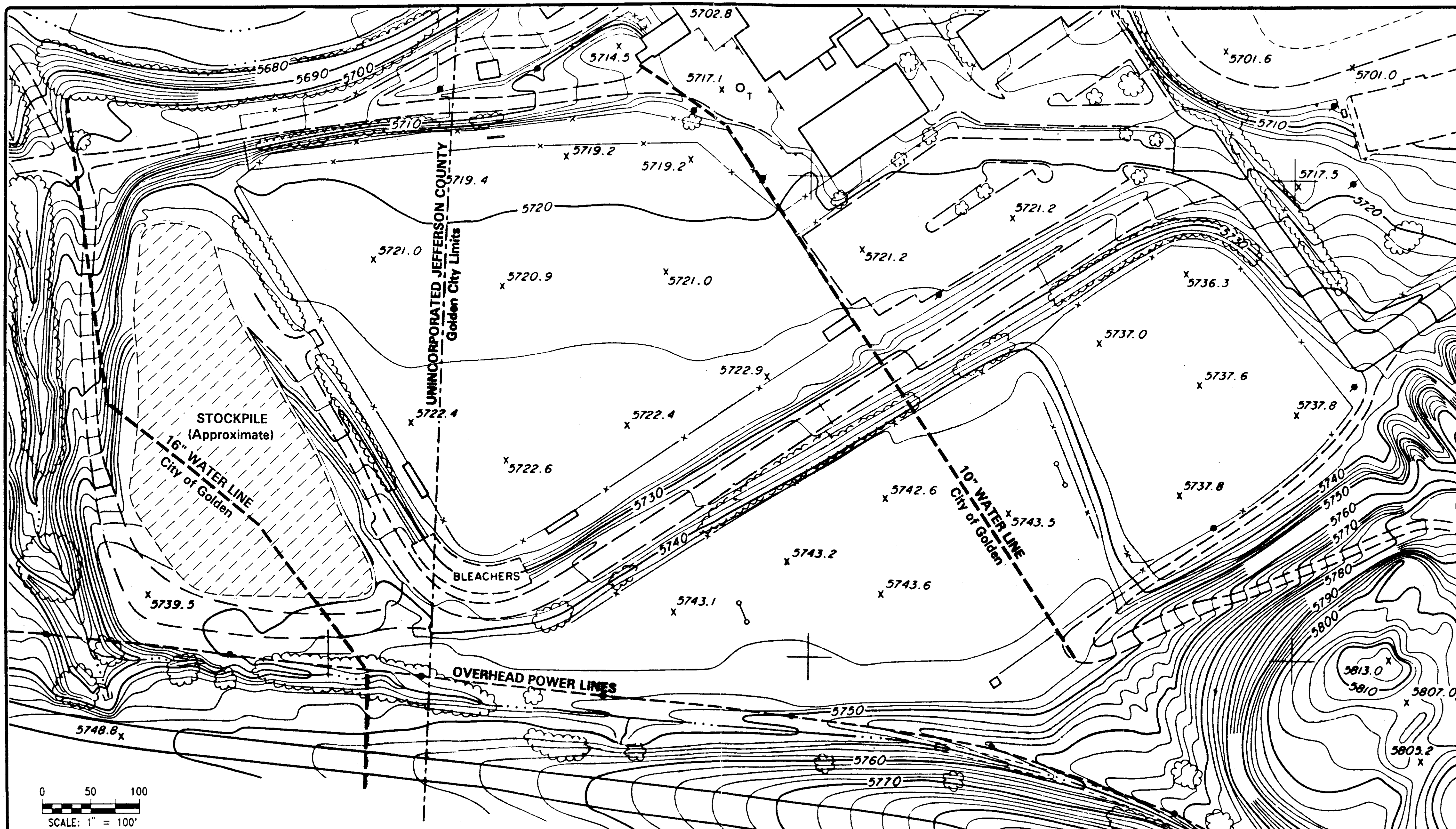
Stockpile
Removal Action Options Analysis

Figure 2-1A
EPA Site Map

CROUSE



NOTE: Existing topography provided by the Colorado School of Mines based on aerial photography dated 1/10/90.

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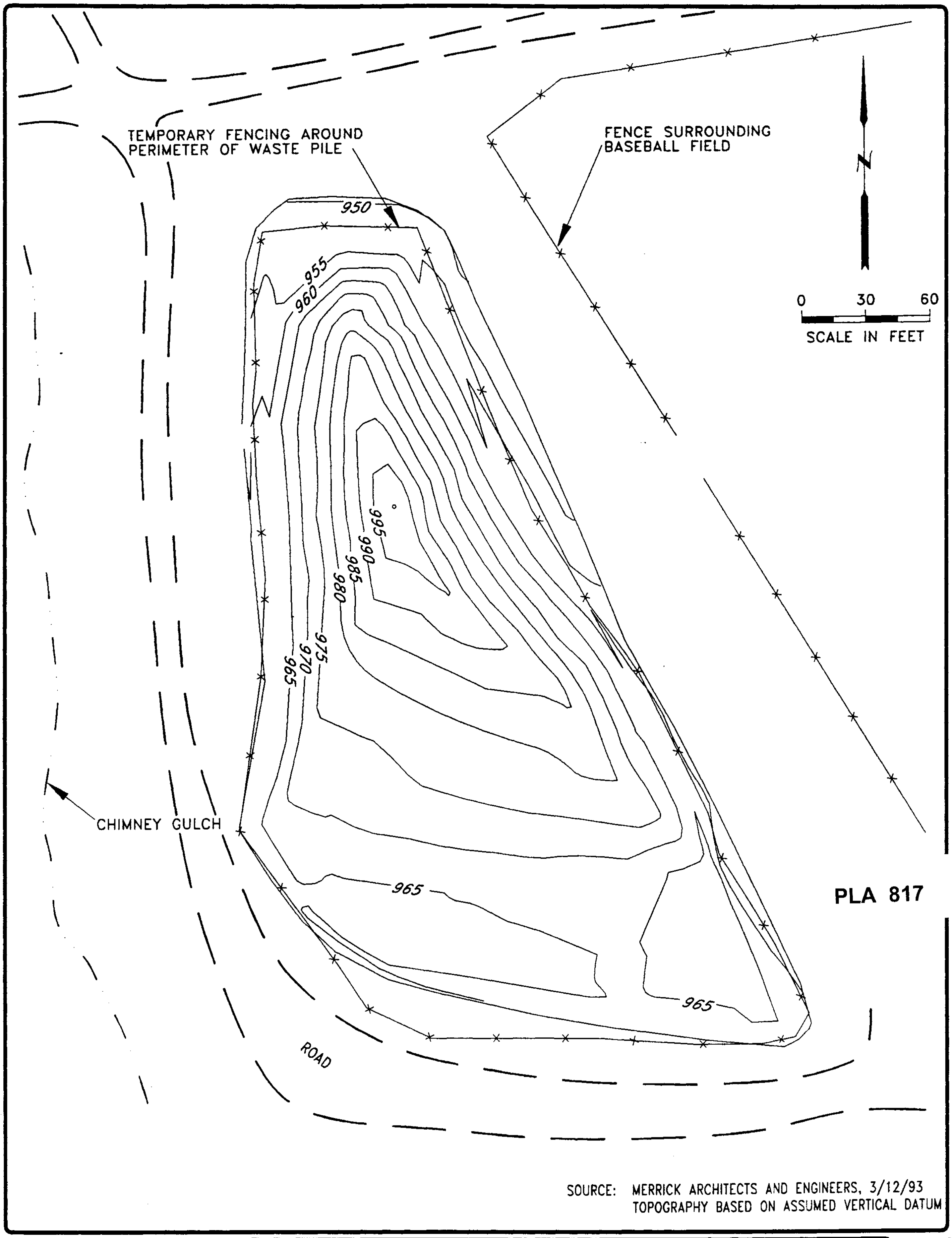
Stockpile
Removal Action Options Analysis

Figure 2-1B
Site Map

CROUSE

PLA 816



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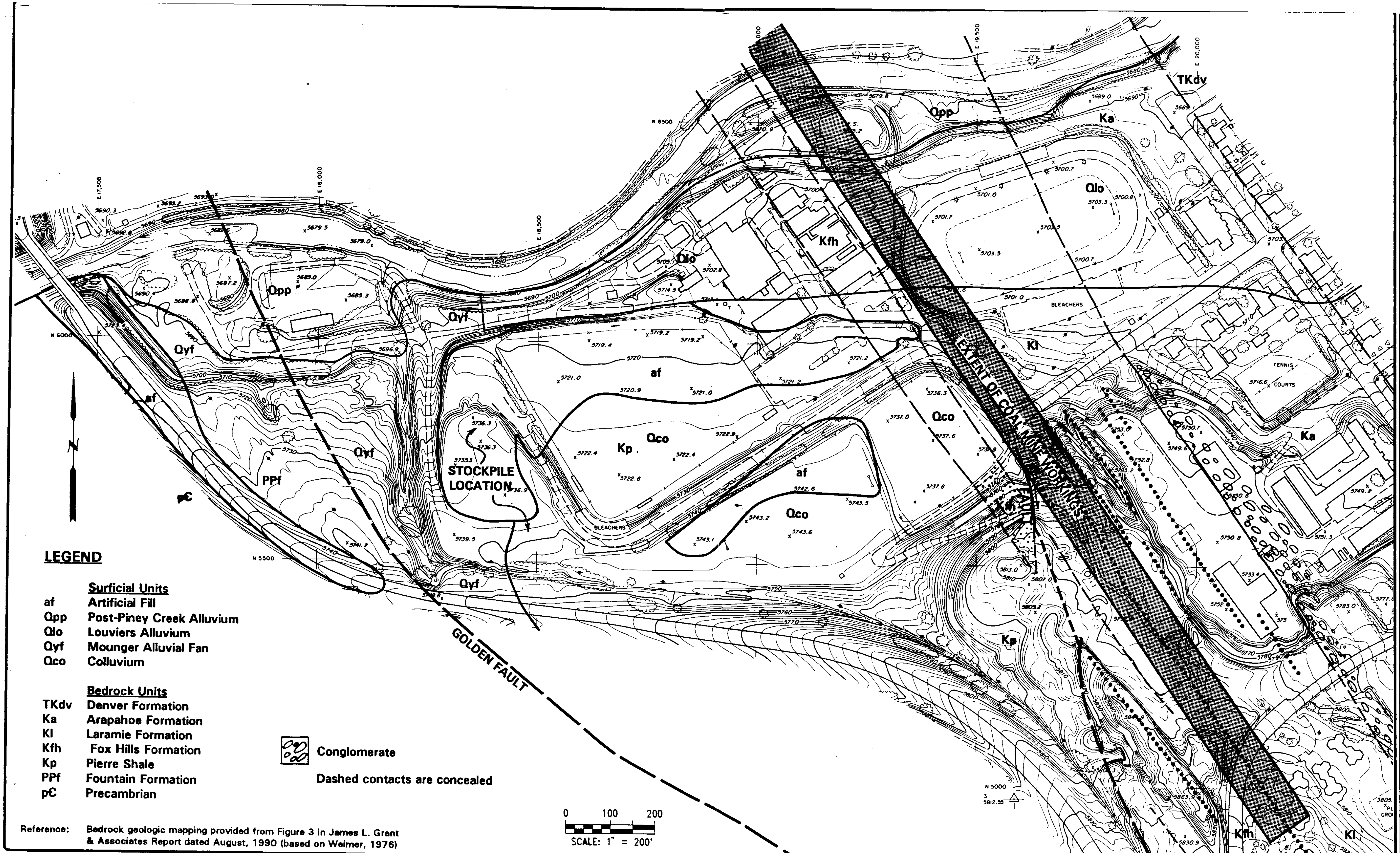
Stockpile
Removal Action Options Analysis

Figure 2-2

Stockpile
Plan View



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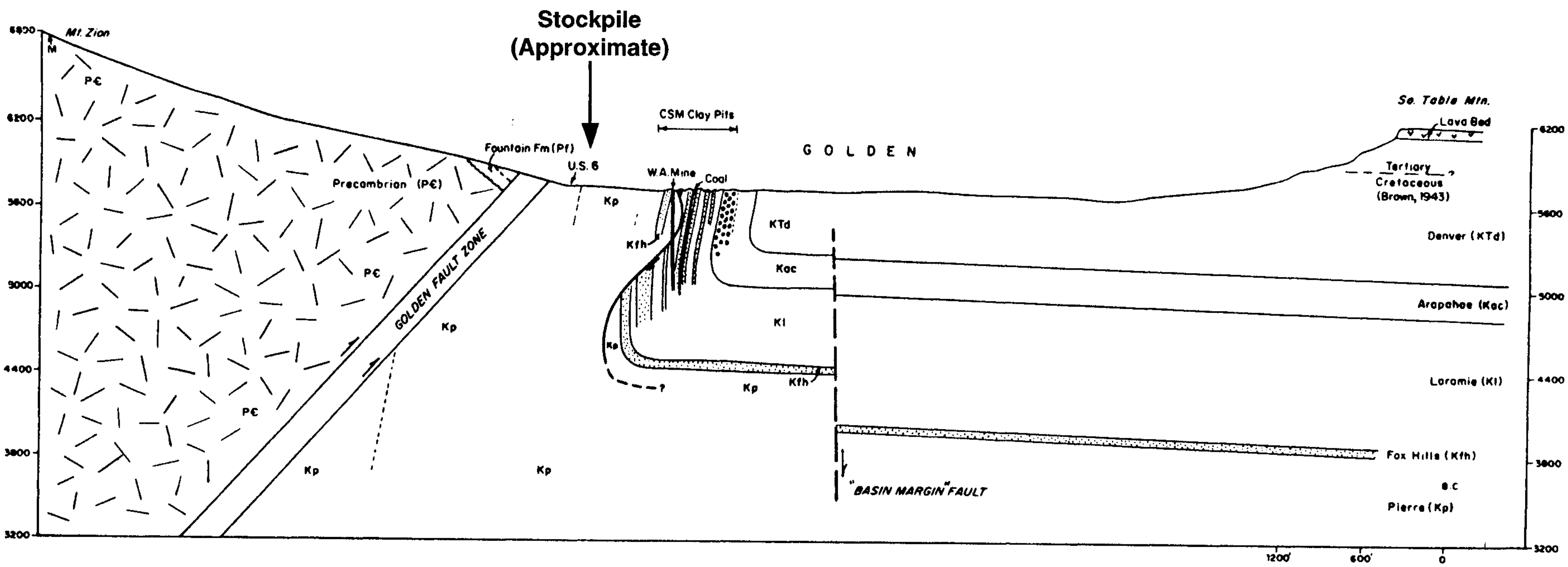
Stockpile
Removal Action Options Analysis

Figure 2-3
Surficial/Bedrock
Geologic Map

CROUSE

PLA 818



Reference: Weimer, 1976, Cretaceous Stratigraphy, Tectonics and Energy Resources, Western Denver Basin (Figure 16)

PLA 819

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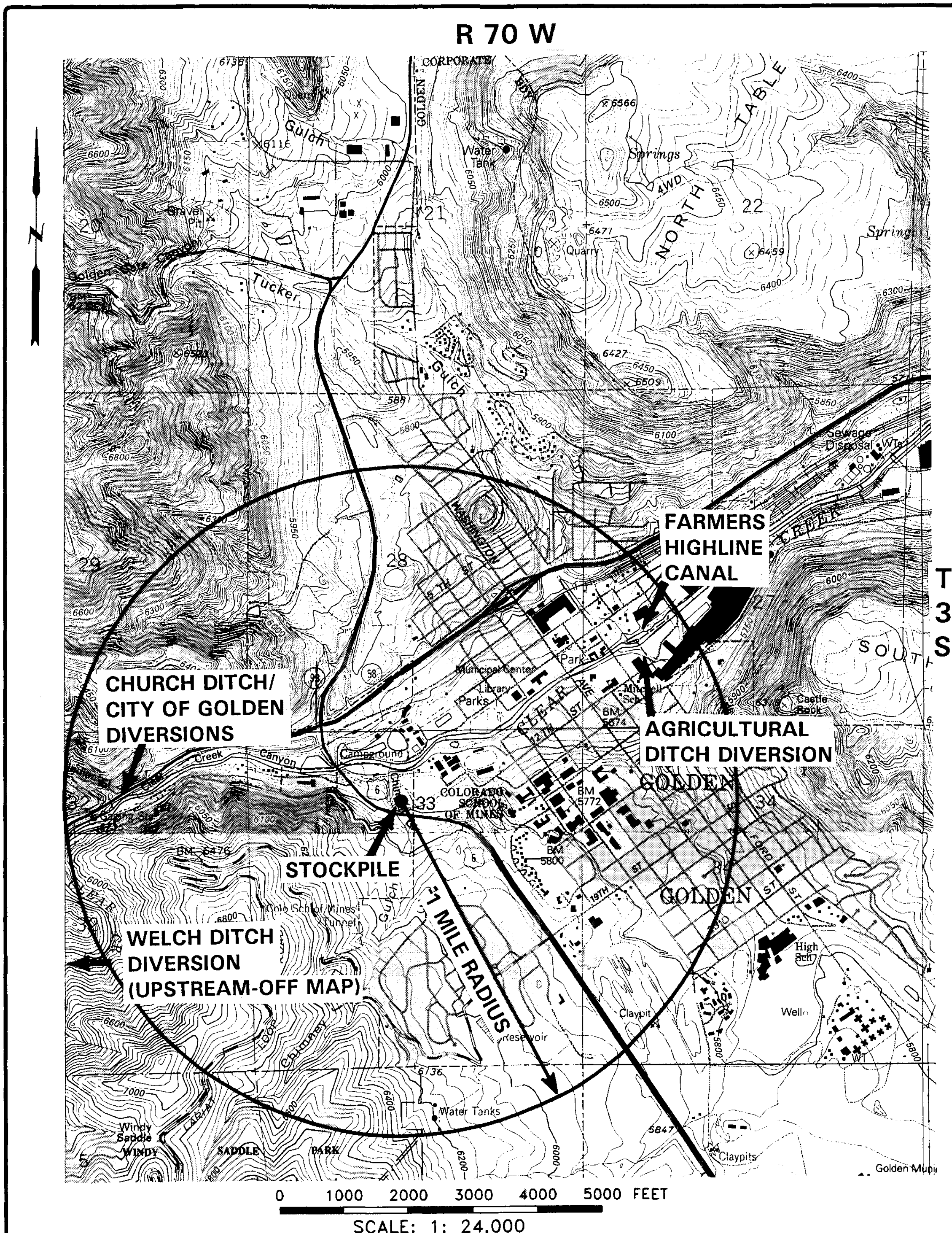
Stockpile
Removal Action Options Analysis

Figure 2-4

Geologic Cross Section

CROUSE



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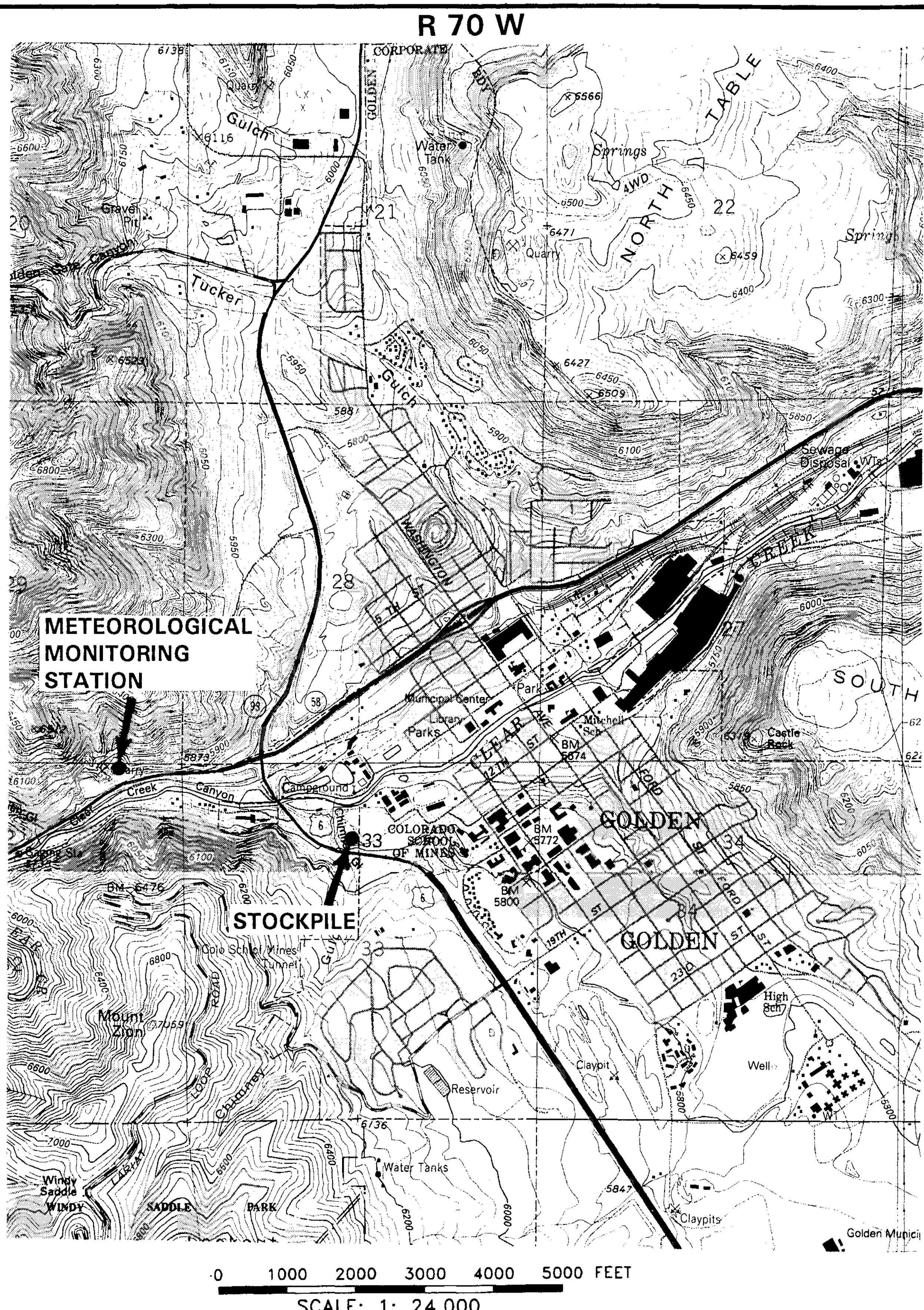
Stockpile
Removal Action Options Analysis

Figure 2-5

Location of Surface Water Diversions

CROUSE

PLA 820



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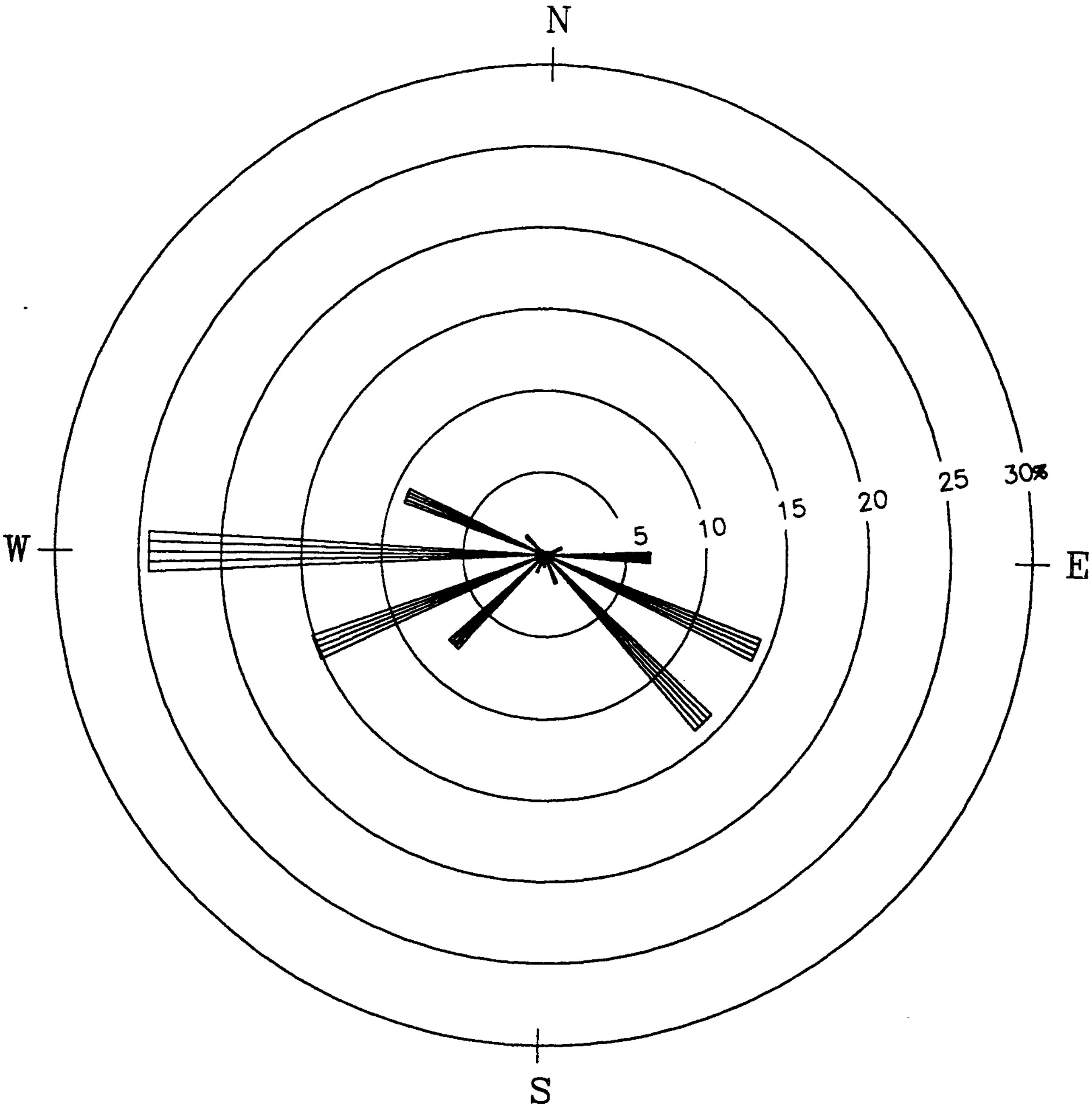
Stockpile
Removal Action Options Analysis

Figure 2-6

Location of Meteorological Monitoring Station

CROUSE

PLA 821



PLA 822

Note: Wind rose data collected in Clear Creek Canyon for period May 1979 to March 1980.

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Stockpile
Removal Action Options Analysis

Figure 2-7

Wind Rose

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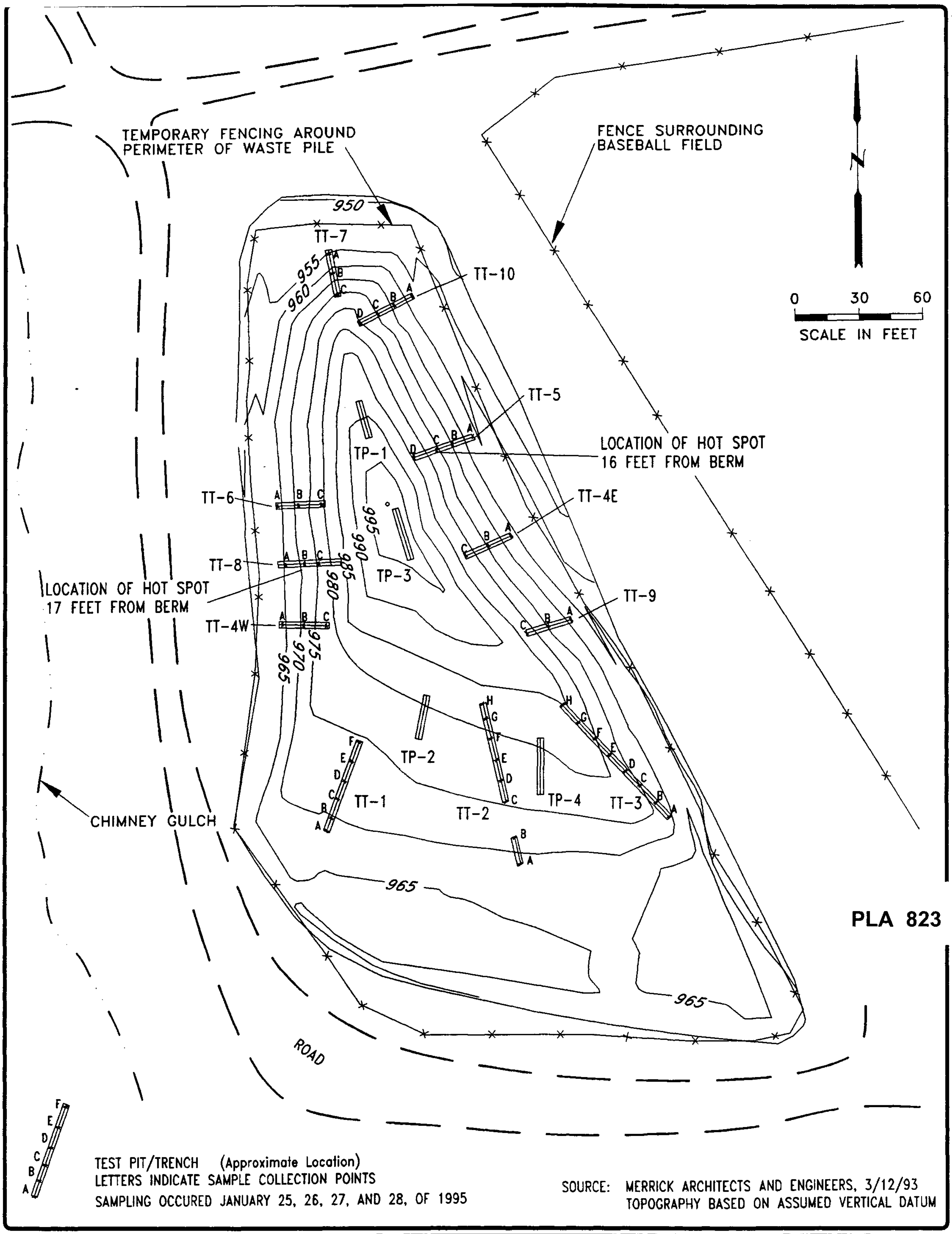
CROUSE



PLA 823

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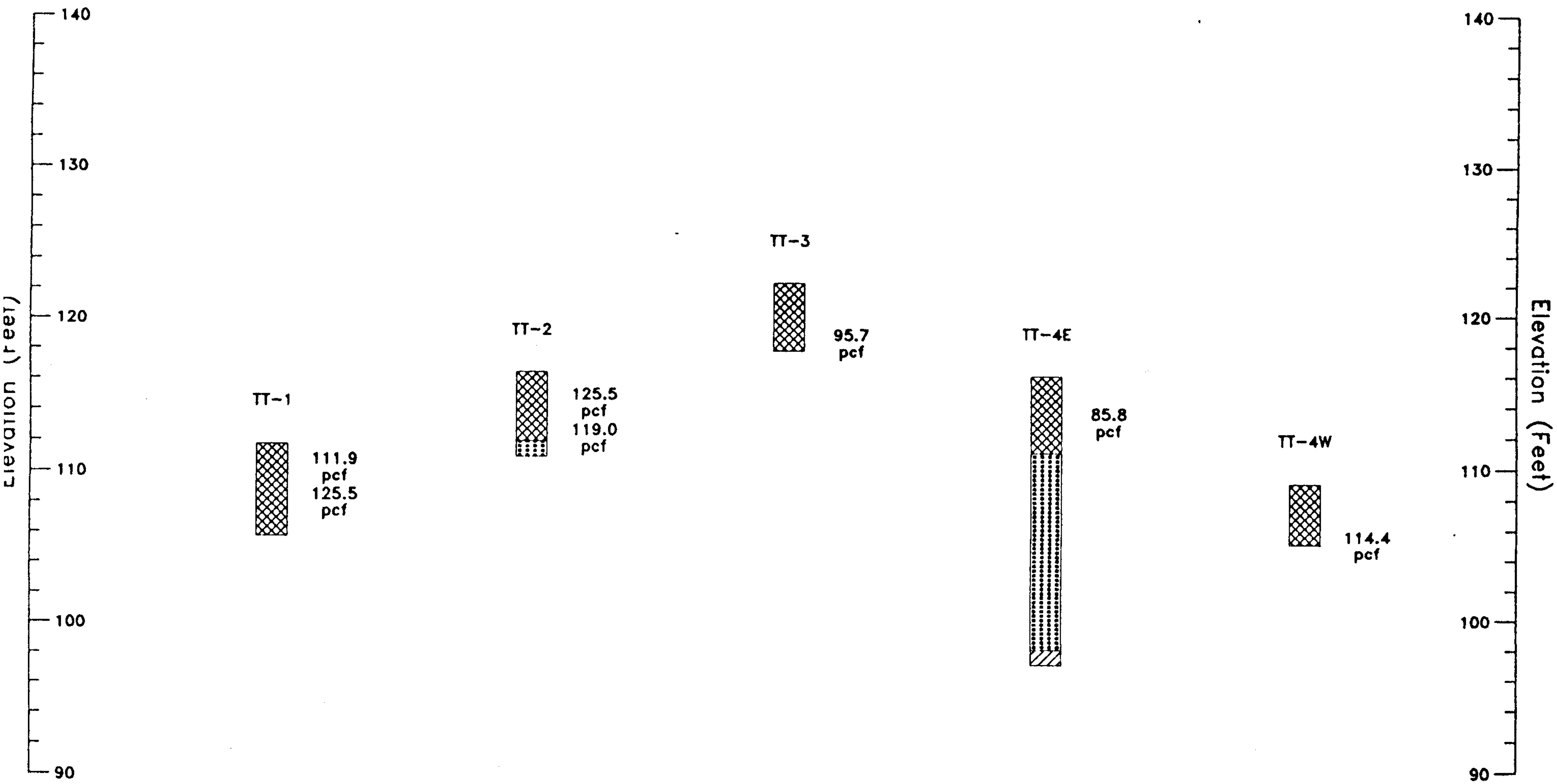
Stockpile
Removal Action Options Analysis

Figure 2-8

Stockpile
Sampling Locations

CROUSE



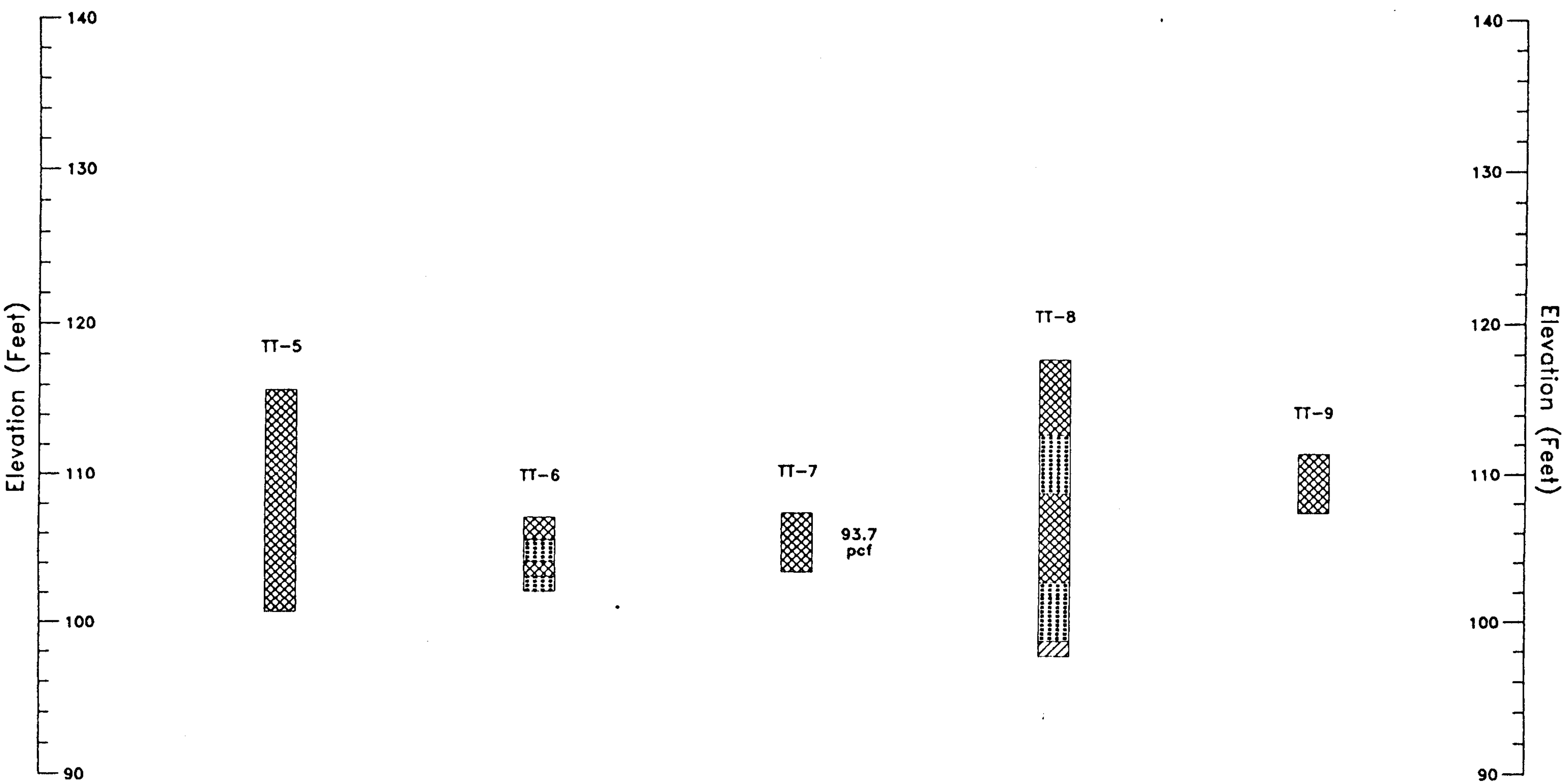
Symbol	Description
(cross-hatched)	FILL, clayey sand with cobbles, debris containing roots, plastic, glass, concrete blocks, red bricks, wires, tubes, scrape metals, wood chips, tree trunks, etc. dry to moist, brown to reddish brown (SC).
(dotted)	FILL, clayey sand with cobbles and tailing materials, traces of debris, moist, grey to black with streaks of white to yellow to grey tailings (SC).
(diagonal hatched)	CLAYLINER, low plasticity clay with claystone pieces.

Notes:

1. Test trenches and test pits were excavated on January 25, 26, 27, and 28, 1995 using a John Deere D690ELC track hoe.
2. No free water was encountered during the entire excavation operation.
3. Test trench/pit locations were referenced from a power pole located to the southeast of the waste pile and elevations were based on an assumed elevation of 100 ft on the top of a CDOT R.O.W. rebar located to the southwest of the waste pile. CE consultants selected the test trench/pit locations.

PLA 824

CLIENT	CE consultants	DATE:	6/9/1995
PROJECT	CSMRI	JOB NO.:	94.128
DESCRIPTION	Logs of Test Holes	FIGURE:	2-9A



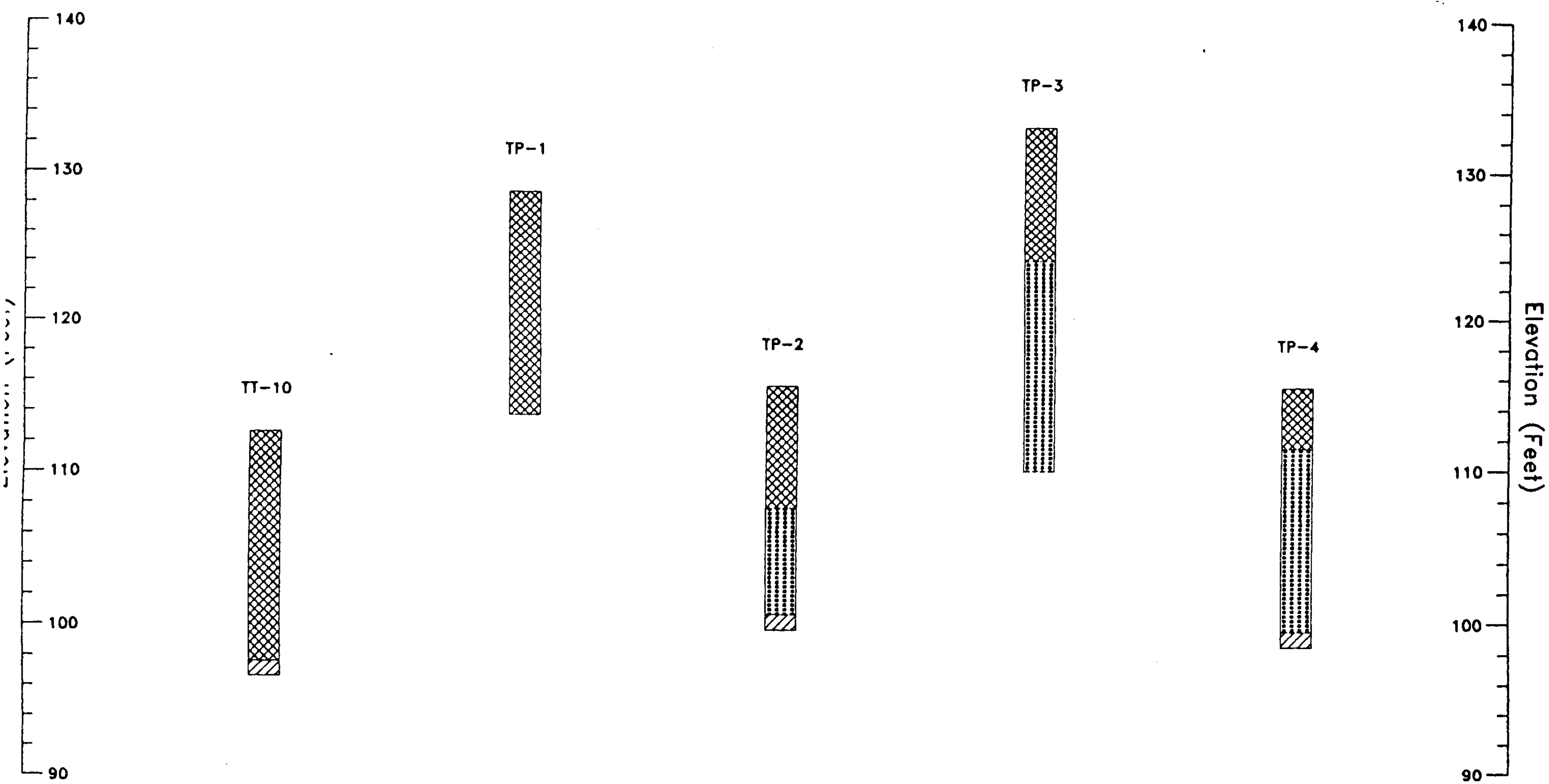
Symbol	Description
(cross-hatch)	FILL, clayey sand with cobbles, debris containing roots, plastic, glass, concrete blocks, red bricks, wires, tubes, scrape metals, wood chips, tree trunks, etc. dry to moist, brown to reddish brown (SC).
(dotted)	FILL, clayey sand with cobbles and tailing materials, traces of debris, moist, grey to black with streaks of white to yellow to grey tailings (SC).
(diagonal hatch)	CLAYLINER, low plasticity clay with claystone pieces.

Notes:

1. Test trenches and test pits were excavated on January 25, 26, 27, and 28, 1995 using a John Deere D690ELC track hoe.
2. No free water was encountered during the entire excavation operation.
3. Test trench/pit locations were referenced from a power pole located to the southeast of the waste pile and elevations were based on an assumed elevation of 100 ft on the top of a CDOT R.O.W. rebar located to the southwest of the waste pile. CE consultants selected the test trench/pit locations.

PLA 825

CLIENT	CE consultants	DATE:	6/9/1995
PROJECT	CSMRI	JOB NO.:	94.128
DESCRIPTION	Logs of Test Holes	FIGURE:	2-9B



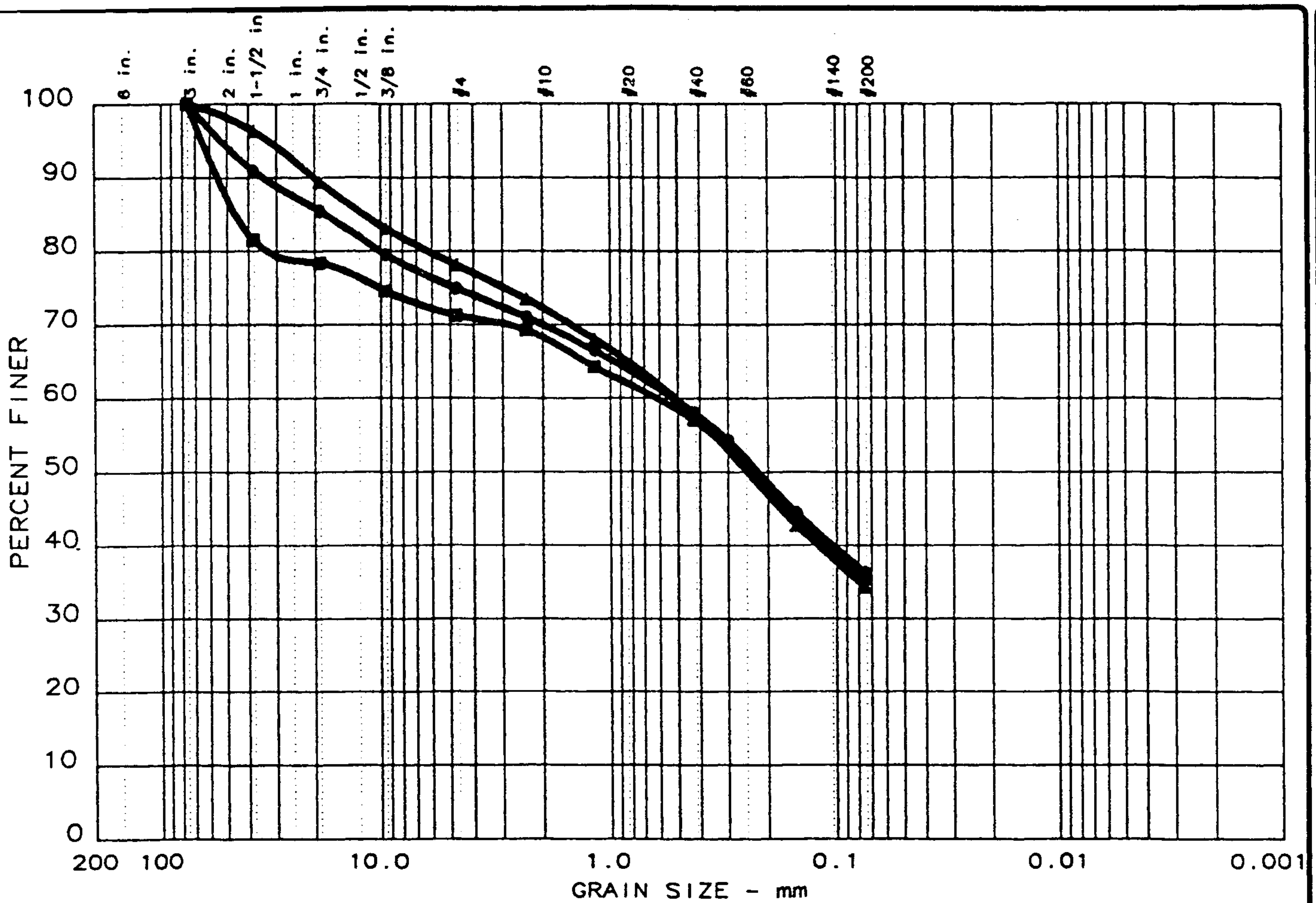
Symbol	Description
(cross-hatched)	FILL, clayey sand with cobbles, debris containing roots, plastic, glass, concrete blocks, red bricks, wires, tubes, scrape metals, wood chips, tree trunks, etc. dry to moist, brown to reddish brown (SC).
(dotted)	FILL, clayey sand with cobbles and tailing materials, traces of debris, moist, grey to black with streaks of white to yellow to grey tailings (SC).
(diagonal hatched)	CLAYLINER, low plasticity clay with claystone pieces.

<u>Notes:</u>

1. Test trenches and test pits were excavated on January 25, 26, 27, and 28, 1995 using a John Deere D690ELC track hoe.
2. No free water was encountered during the entire excavation operation.
3. Test trench/pit locations were referenced from a power pole located to the southeast of the waste pile and elevations were based on an assumed elevation of 100 ft on the top of a CDOT R.O.W. rebar located to the southwest of the waste pile. CE consultants selected the test trench/pit locations.

CLIENT	CE consultants	DATE:	6/9/1995
PROJECT	CSMRI	JOB NO.:	94.128
DESCRIPTION	Logs of Test Holes	FIGURE:	2-9 C

PLA 826



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	25.1	38.6	36.3	
▲	6	0.0	21.9	43.8	34.3	
■	7	0.0	28.7	35.8	35.5	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	32	10	18.0	0.519	0.219					
▲	30	11	11.9	0.507	0.245					
■	30	13	45.7	0.610	0.237					

MATERIAL DESCRIPTION	USCS	AASHTO
● Composite of brown and dark material	SC	
▲ Brown cover material	SC	
■ Dark tailing material	SC	

Project No.: 94.128
Project: CSMRI
● Location: Waste pile
▲ Location: Waste pile
■ Location: Waste pile
Date: 3-3-95

Remarks:

GRAIN SIZE DISTRIBUTION TEST REPORT

JOSEPH A. CESARE & ASSOCIATES, INC.

PLA 827

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Stockpile
Removal Action Options Analysis

Figure 2-10
Grain Size Distribution
Test Report

CROUSE

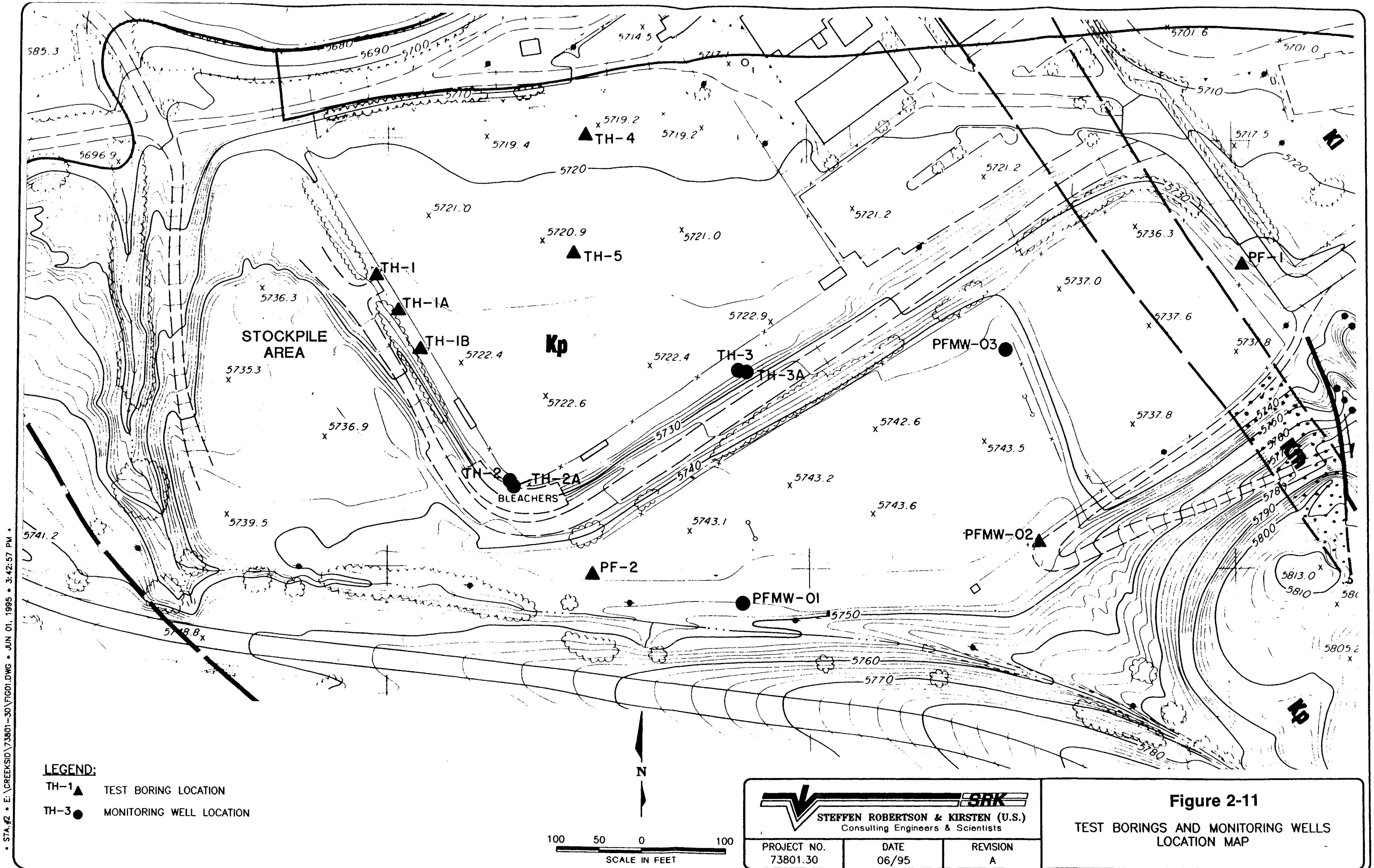
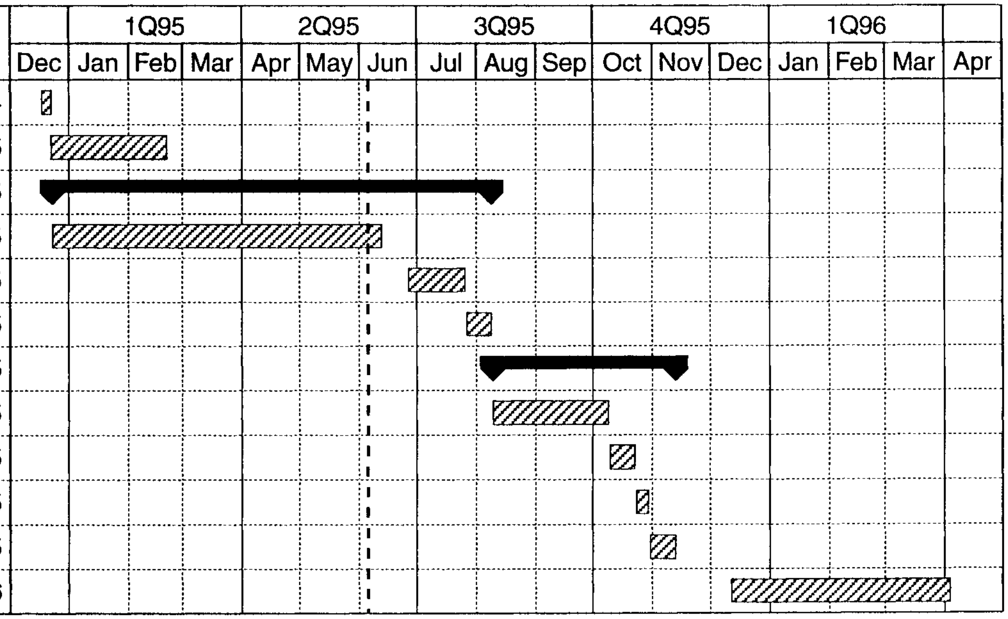


Figure 2-11

TEST BORINGS AND MONITORING WELLS LOCATION MAP

Task/Activity	Duration	Start	Finish
Issuance of UAO	6d	12/17/94	12/22/94
Prepare/Submit SAP/SHERP	60d	12/22/94	2/20/95
Removal Action Options Analysis	228d	12/23/94	8/8/95
Draft Report to EPA	171d	12/23/94	6/12/95
Public Comment Period	30d	6/26/95	7/25/95
EPA Remedy Selection	14d	7/26/95	8/8/95
Removal Action Work Plan	95d	8/9/95	11/12/95
Draft Work Plan to EPA	60d	8/9/95	10/8/95
EPA Review/Comments	14d	10/9/95	10/22/95
Final Work Plan to EPA	7d	10/23/95	10/29/95
EPA Approval	14d	10/30/95	11/12/95
Implement Removal Action	107d	12/11/95	4/3/96



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PLA 829

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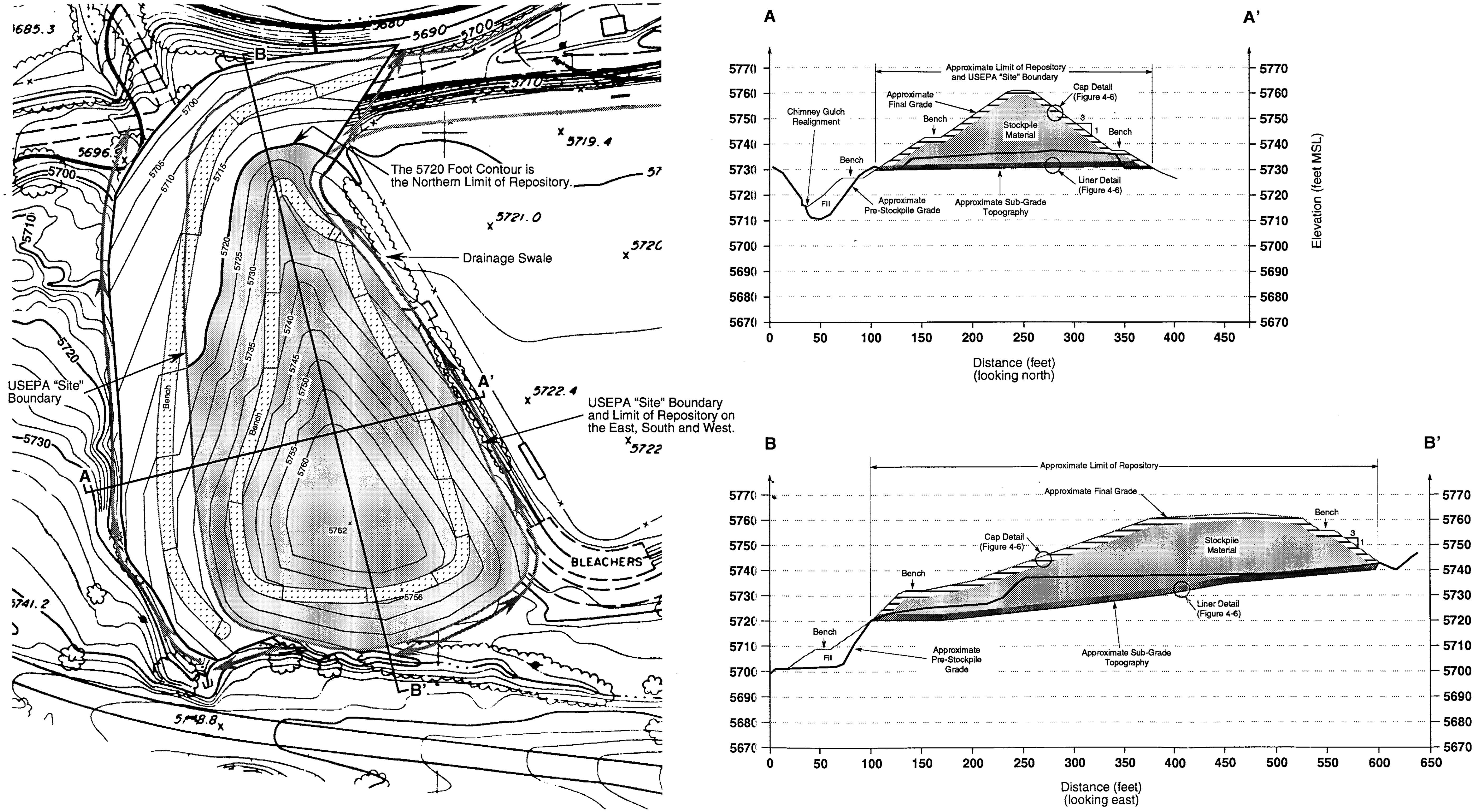
Stockpile
Removal Action Options Analysis

Figure 3-1
Removal Action
Project Schedule

CROUSE



Note
Vertical exaggeration of cross-sections is 2.5.

NOTE: Existing topography and planimetrics shown in the above plan view where taken from mapping provided by the Colorado School of Mines that was prepared by IntraSearch of Denver, CO based on aerial photography dated 1/10/90.

PLA 830

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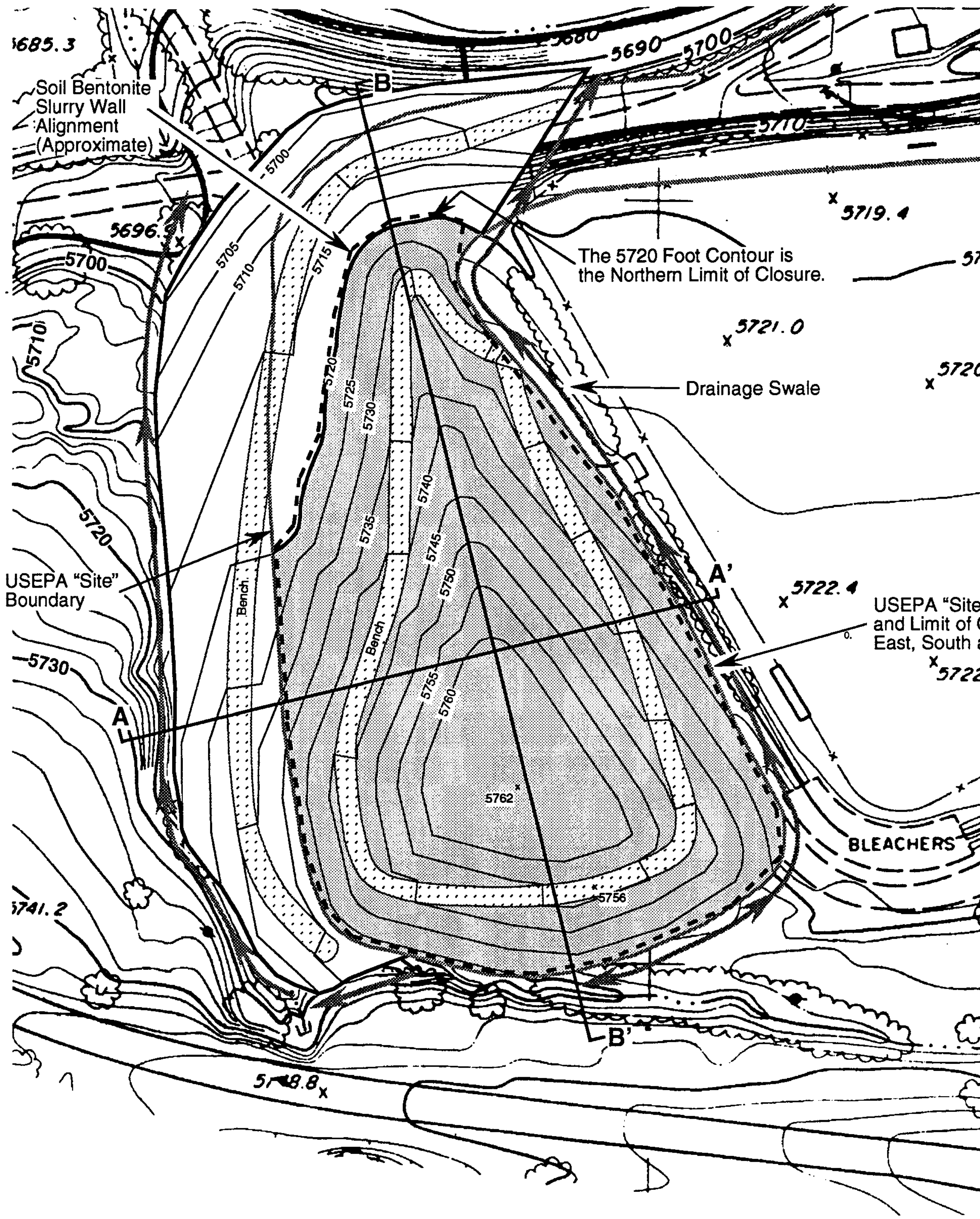
Scale: 1"=100'

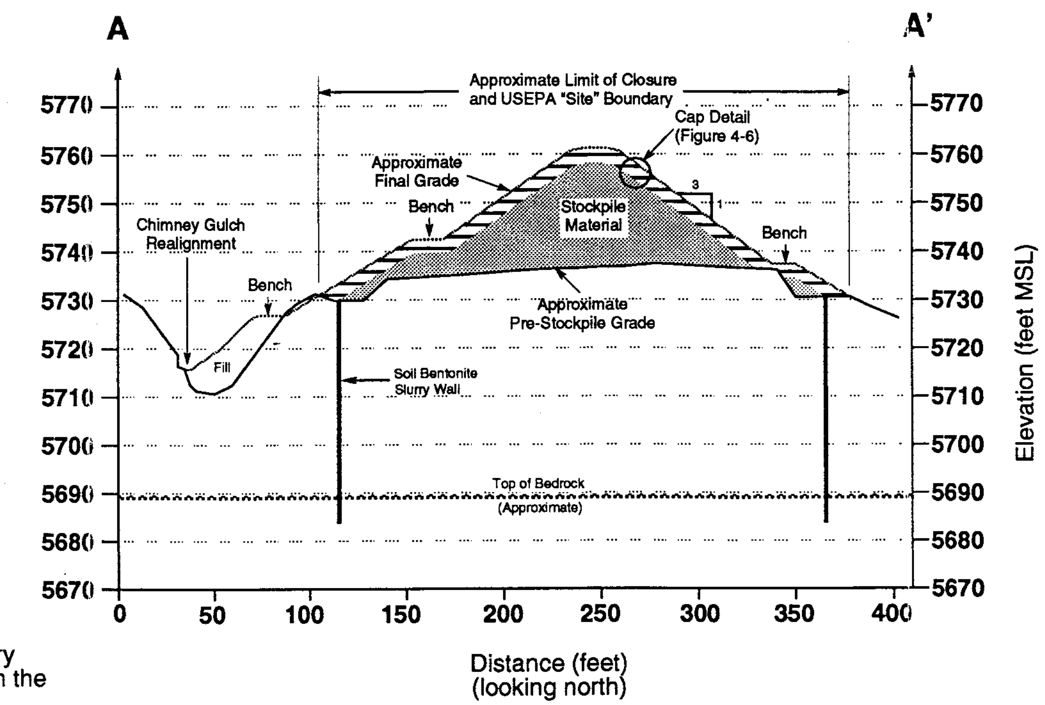
Colorado School of Mines Research Institute
Stockpile
Removal Action Options Analysis

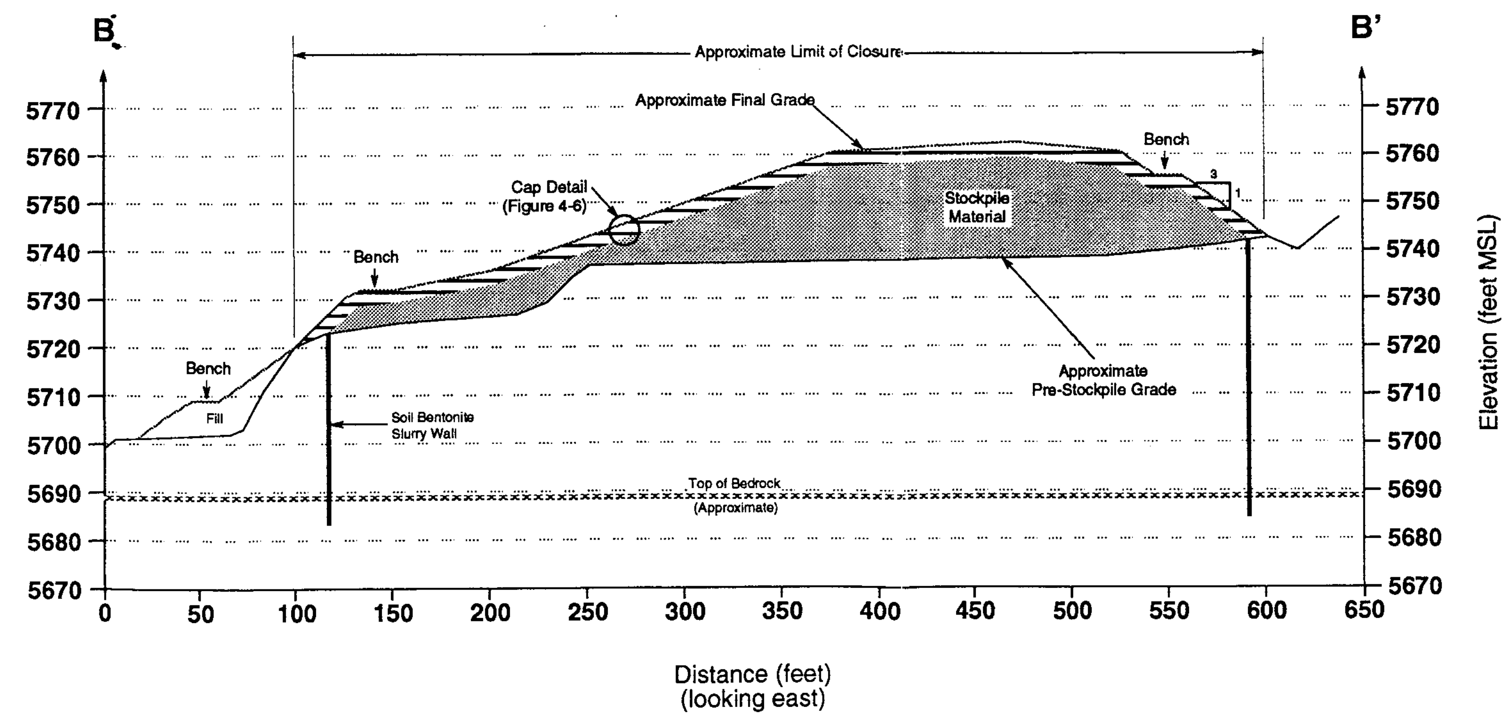
Golden, CO

Figure 4-2
Above-Ground Repository Alternative
Plan and Cross-Section Views

CROUSE







NOTE: Existing topography and planimetrics shown in the above plan view where taken from mapping provided by the Colorado School of Mines that was prepared by IntraSearch of Denver, CO based on aerial photography dated 1/10/90.

Note
Vertical exaggeration of cross-sections is 2.5.

PLA 831

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50 0 50
Scale: 1"=100'

N

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Stockpile
Removal Action Options Analysis

Golden, CO

Figure 4-1
In-Place Closure Alternative
Plan and Cross-Section Views

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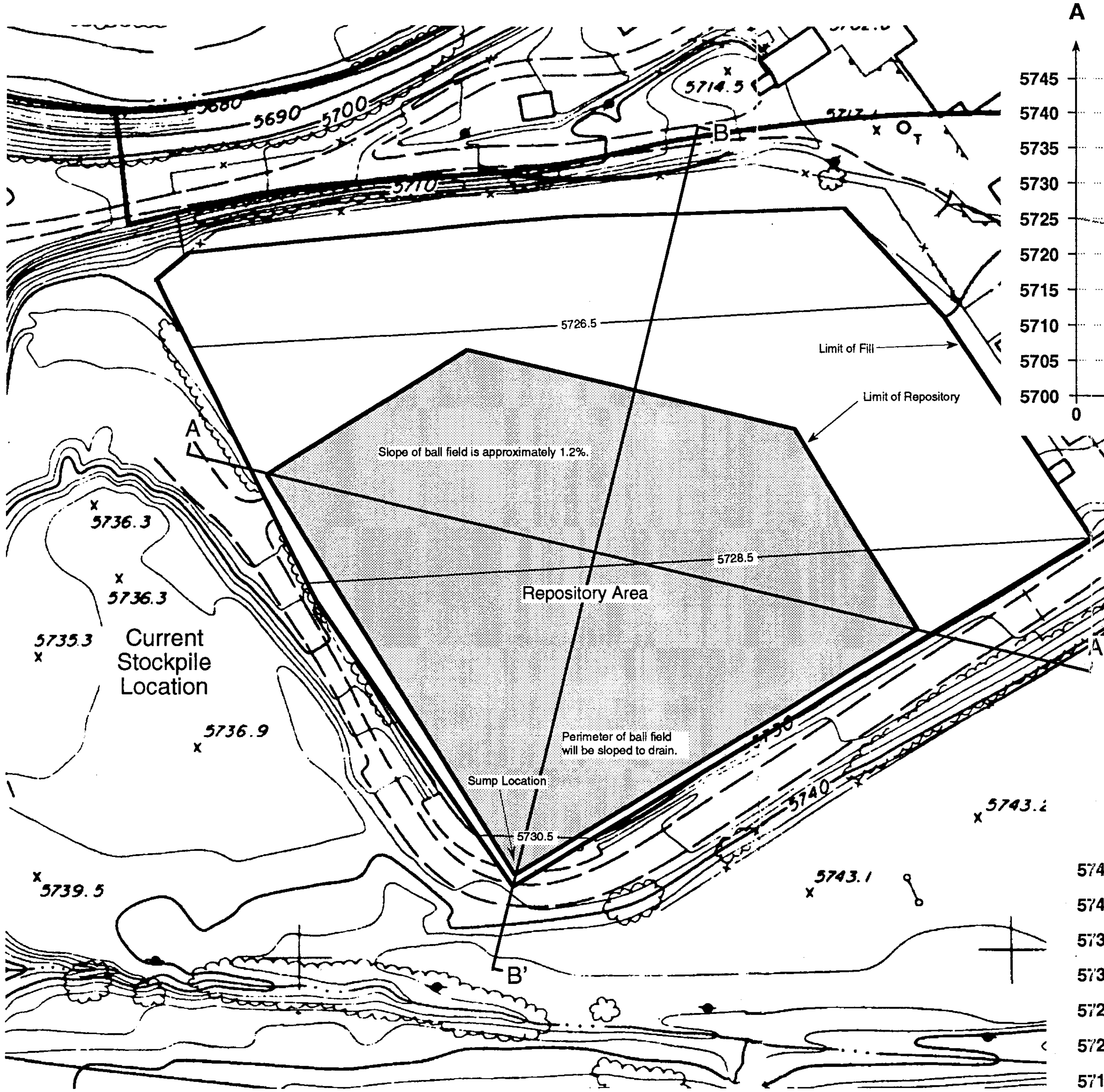

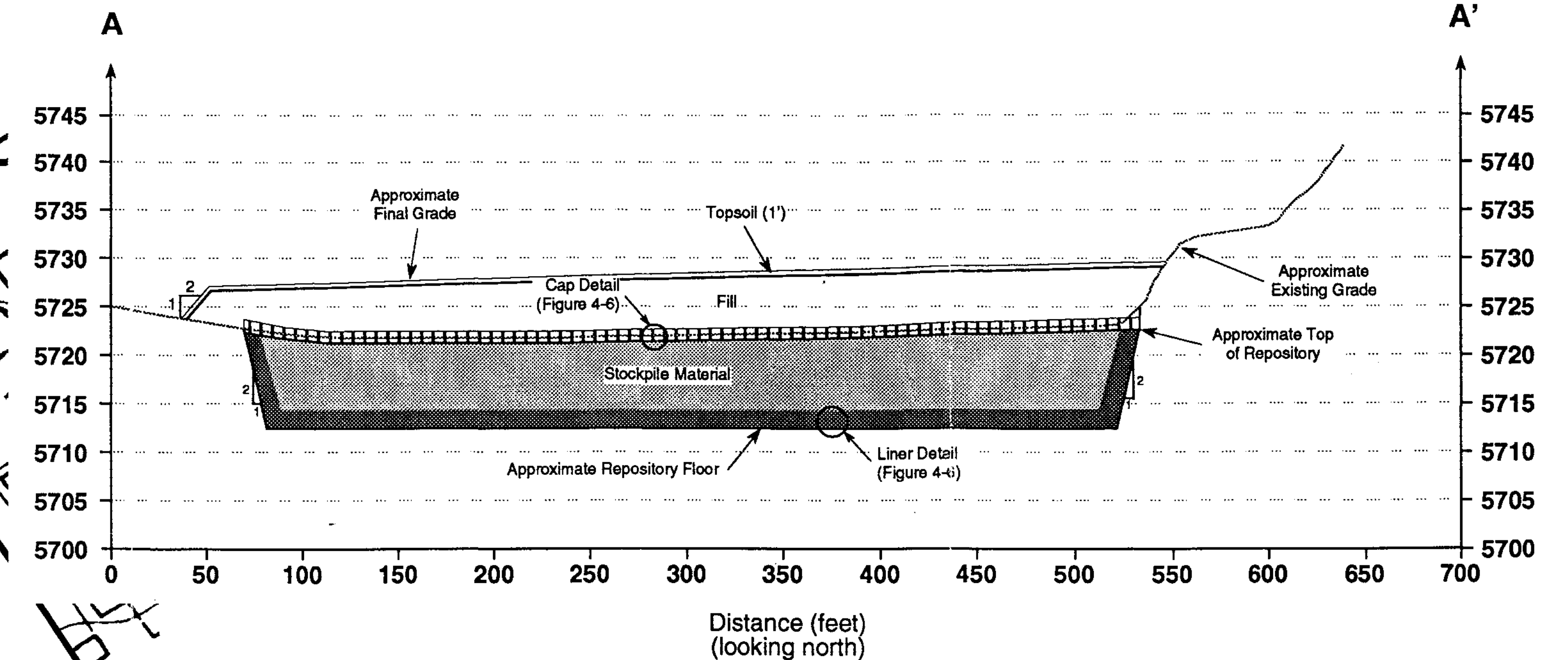

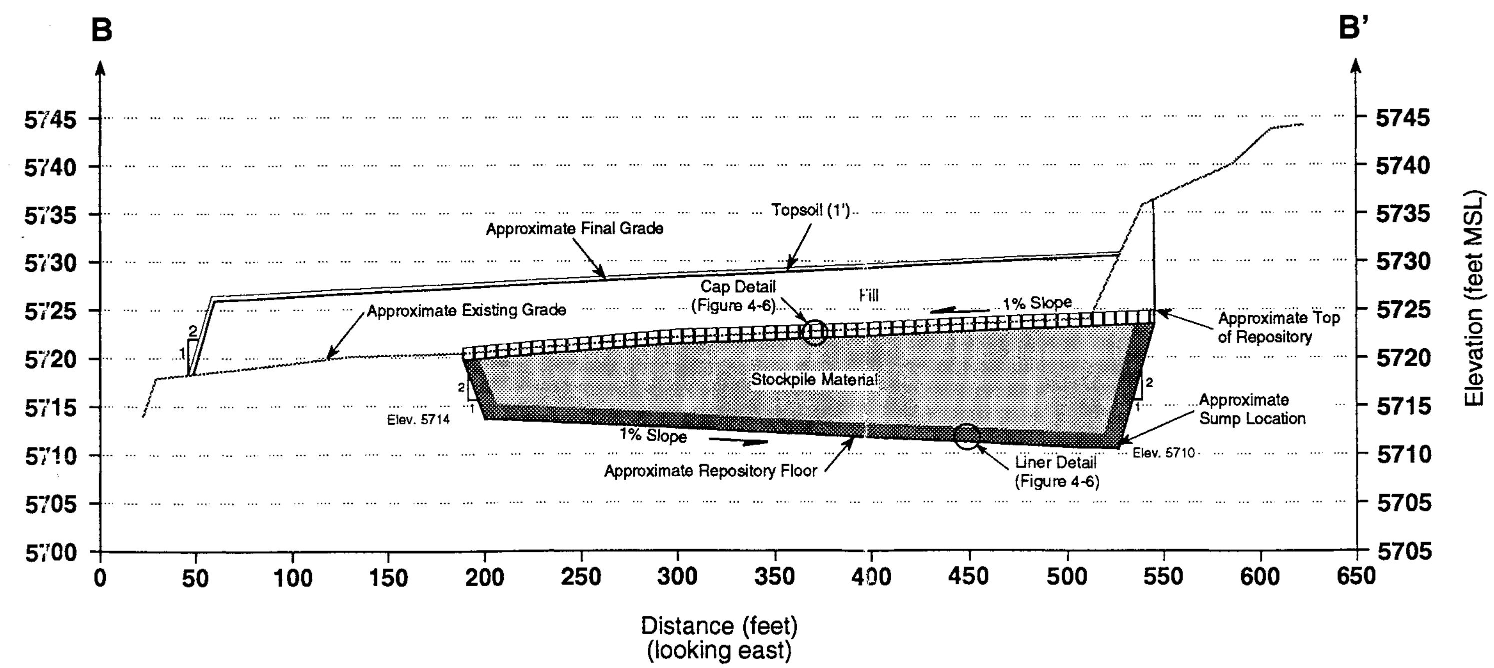

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50 0 50
Scale: 1"=100'

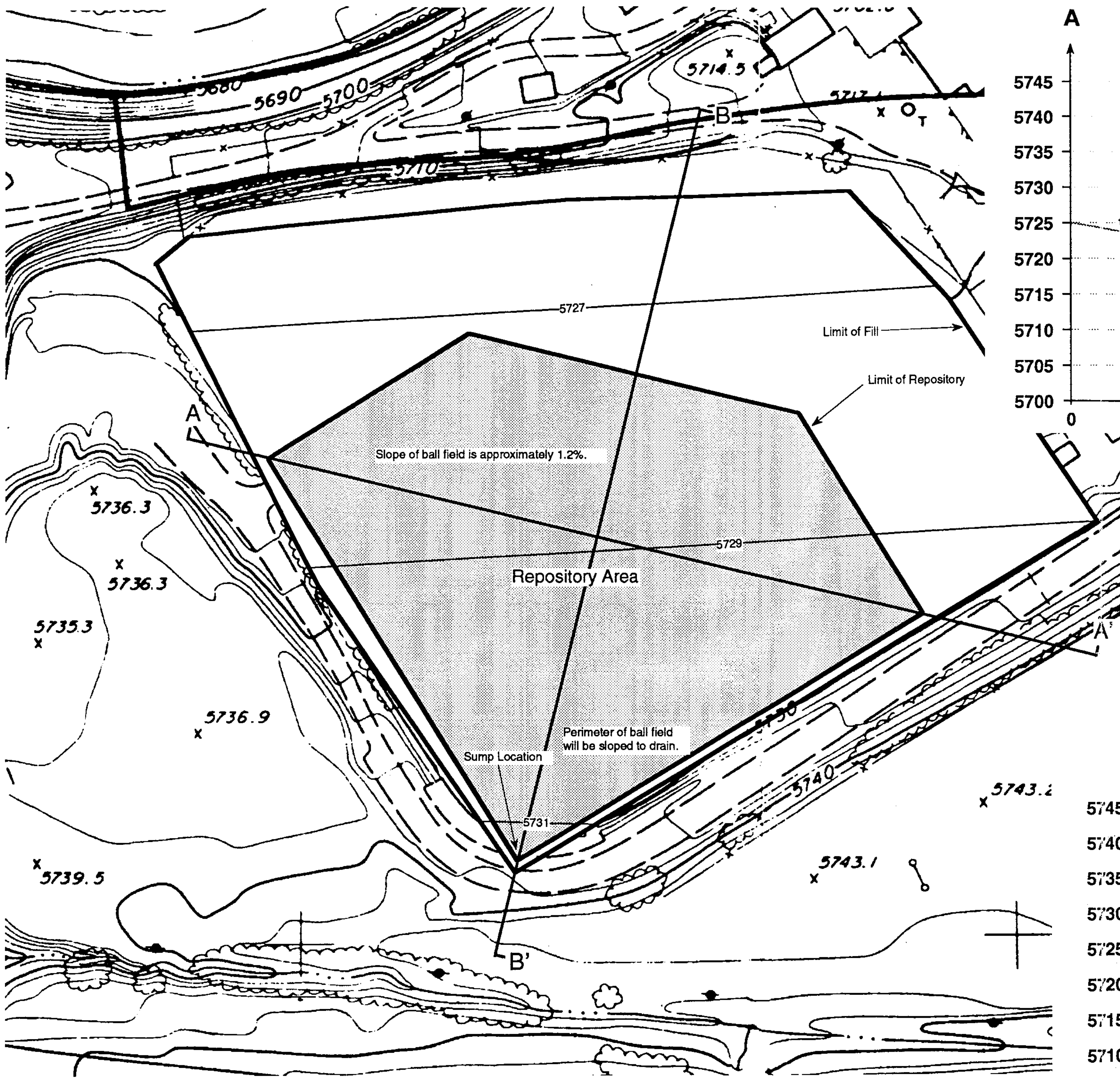
N

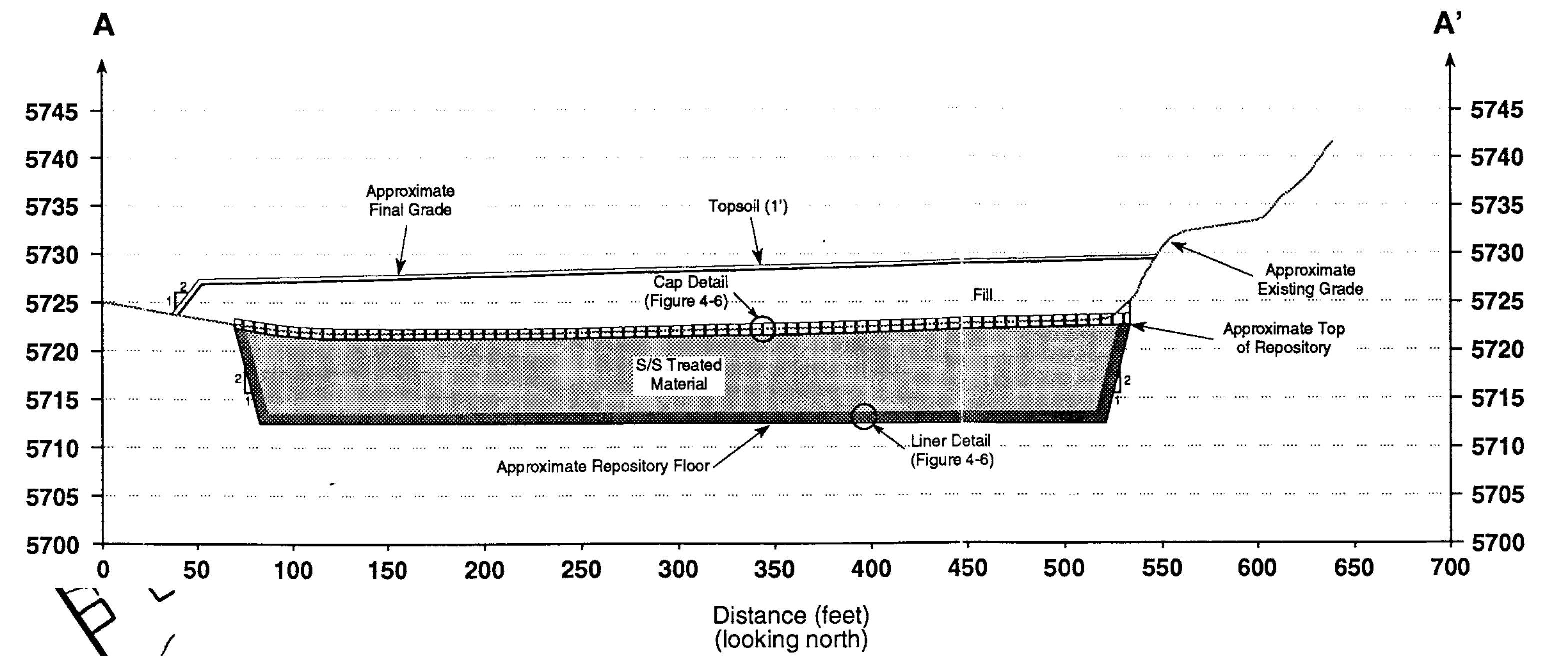
Colorado School of Mines Research Institute
Stockpile
Removal Action Options Analysis

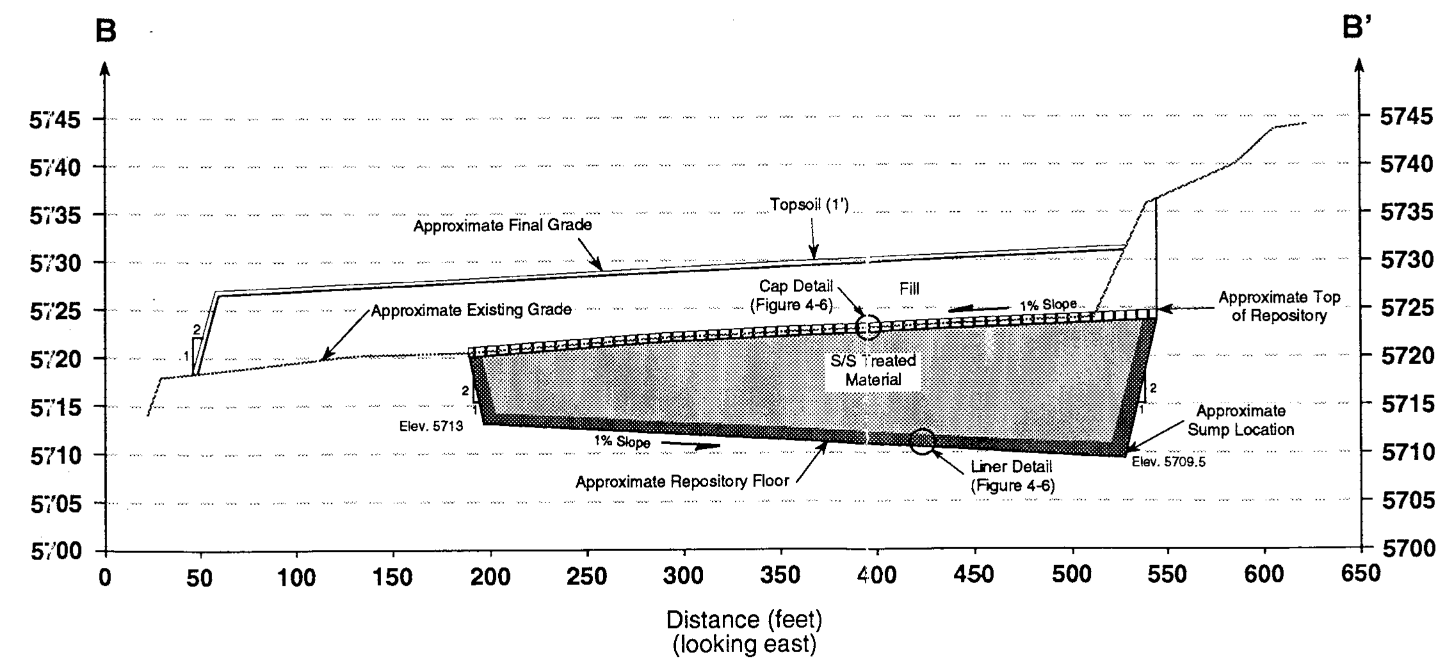
Golden, CO

Figure 4-3
Below-Ground Repository Alternative
Plan and Cross-Section Views

CROUSE







NOTE: Existing topography and planimetrics shown in the above plan view where taken from mapping provided by the Colorado School of Mines and was prepared by IntraSearch of Denver, CO based on aerial photography dated 1/10/90.

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Scale: 1"=100'

Colorado School of Mines Research Institute
Stockpile
Removal Action Options Analysis

Golden, CO

Figure 4-4
Below-Ground Stabilization/Solidification Alternative
Plan and Cross-Section Views

CROUSE

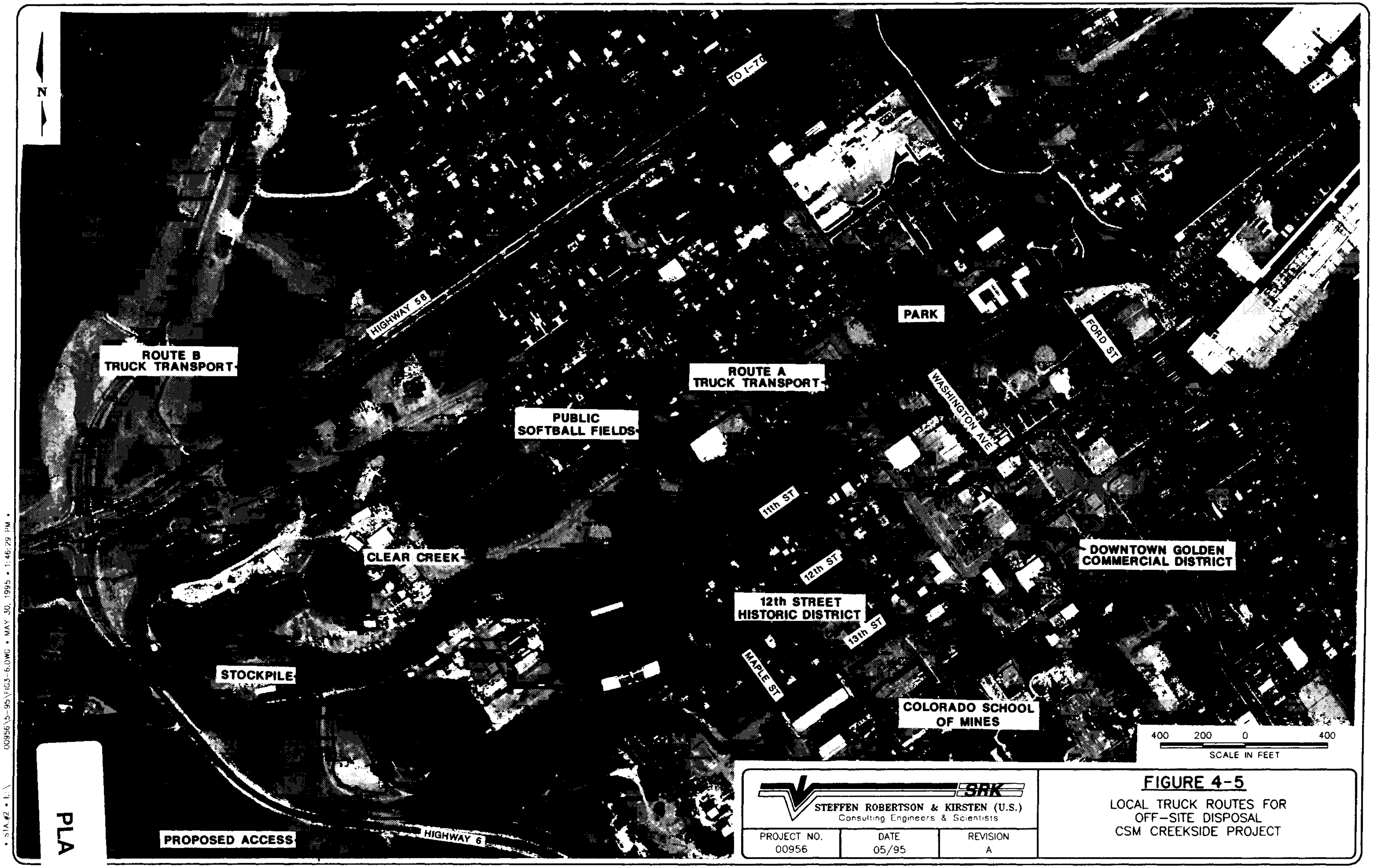
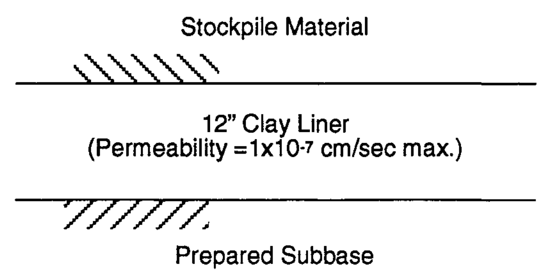
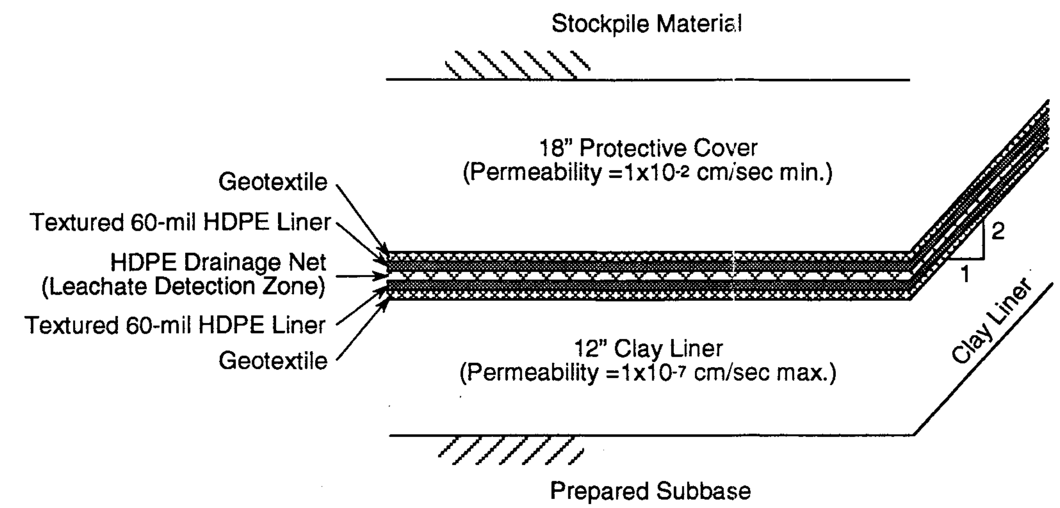


FIGURE 4-5
LOCAL TRUCK ROUTES FOR
OFF-SITE DISPOSAL
CSM CREEKSIDE PROJECT



Detail A - Typical Liner Extension
(In-Place Closure)

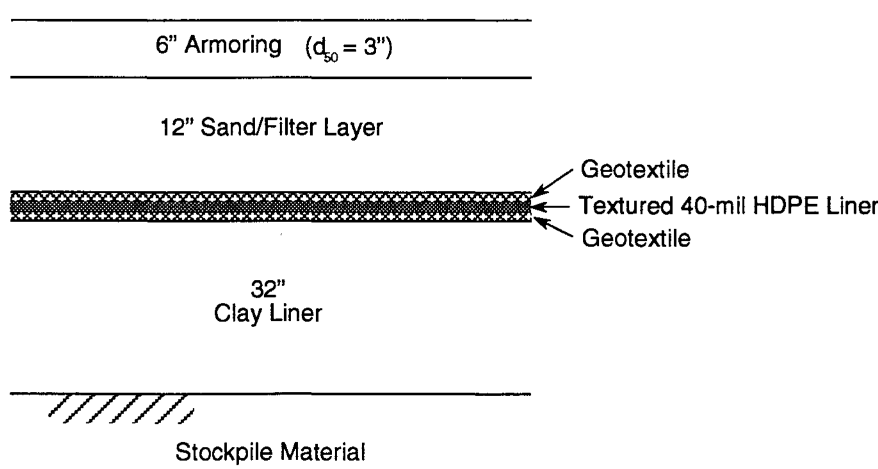
Not to Scale



Detail B - Typical Liner System
(Above-Ground and Below-Ground Repositories)

Not to Scale

Note: Alternative design approach is 24" clay liner without synthetic liners.



Detail C - Typical Engineered Capping System
for All On-Site Disposal Alternatives

Not to Scale

PLA 835

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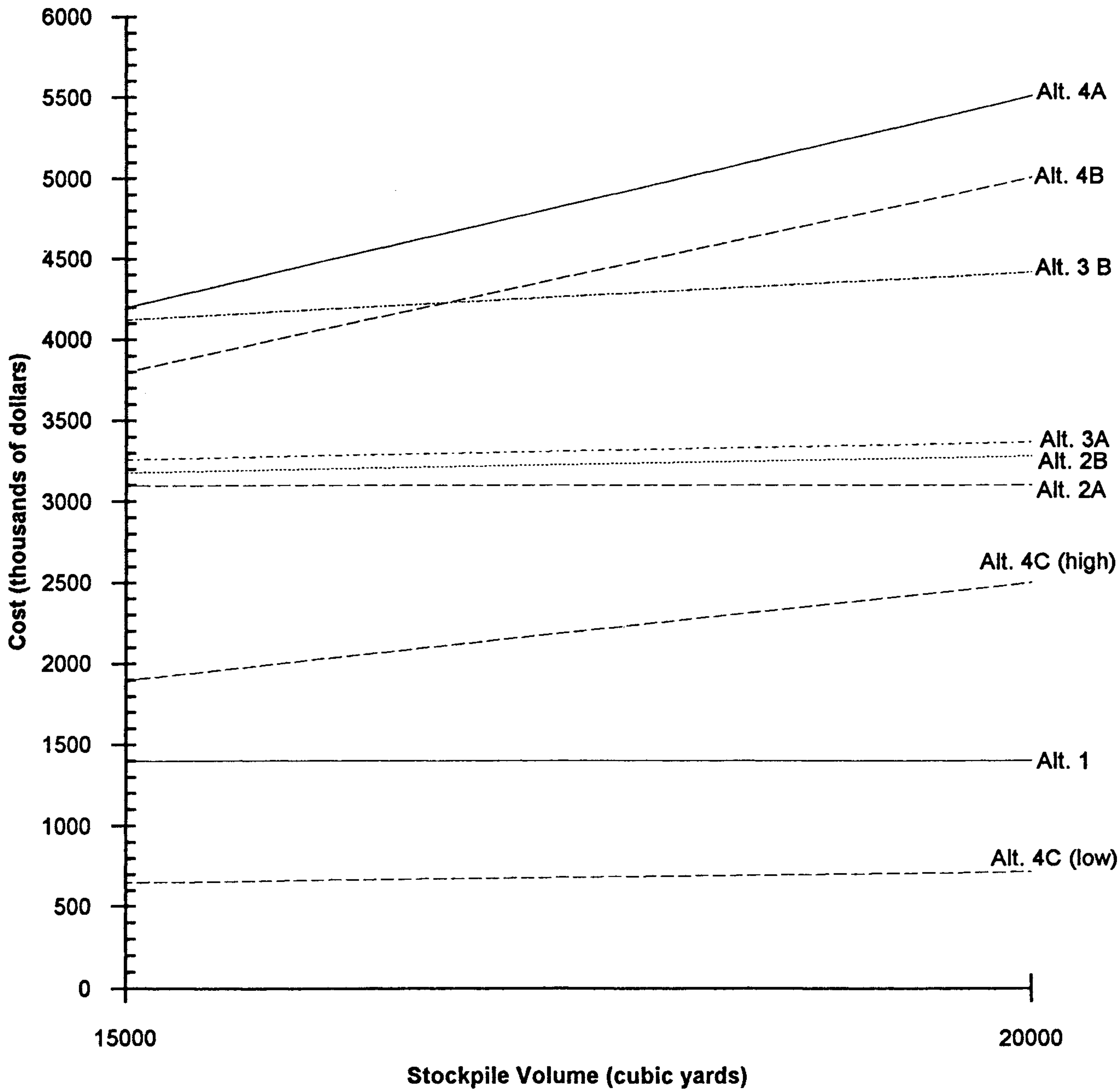
Colorado School of Mines Research Institute
Stockpile
Removal Action Options Analysis

Golden, CO

Figure 4-6
Capping and Liner Details

CROUSE



PLA 836

Stockpile Volume (cy)	ESTIMATED PROJECT COST							
	Alt. 1 ($1000's)	Alt. 2A ($1000's)	Alt. 2B ($1000's)	Alt. 3A ($1000's)	Alt. 3B ($1000's)	Alt. 4A ($1000's)	Alt. 4B ($1000's)	Alt. 4C ($1000's)	
15000	1399	3099	3178	3258	4123	4200	3800	650	1900
20000	1399	3099	3276	3363	4411	5500	5000	715	2500

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Colorado School of Mines Research Institute
Stockpile
Removal Action Options Analysis

Figure 5-1

Sensitivity of Cost to Stockpile Volume

CROUSE