BORROW SOURCE EVALUATION FOR CLOSURE OF THE OU5 AND OU7 LANDFILLS

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE GOLDEN, COLORADO

Prepared For

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LIST OF ACRONYMS

CDPHE	Colorado Department of Public Health and the Environment
cm	centimeter
CODENR	Colorado Department of Environmental and Natural Resources
DOE	Department of Energy
EIS	Environmental Impact Statement
EG&G	EG&G Rocky Flats, Inc.
E&WM	Ecology and Watershed Management
FWS	U.S. Fish and Wildlife Service
ha	hectares
in	inches
km	kilometers
m^3	cubic meters
mi	miles
NEPA	National Environmental Policy Act
OU	Operable Unit
QA/QC	Quality Assurance/Quality Control
RFETS	Rocky Flats Environmental Technology Site
Varra	Varra Quarry
WA	Western Aggregates, Inc.
yd^3	cubic yards

1.0 INTRODUCTION

As part of the Rocky Flats Environmental Technology Site (RFETS) environmental restoration program activities, a need for soil borrow material for the closure of the Operable Unit (OU) OU5 and OU7 Landfills has been identified. Additionally, borrow material may be required for other OU closures.

The purpose of this report is to:

- Describe the assumed material and volume requirements for the cap/covers at the OU5 and OU7 Landfills
- Assess existing RFETS geologic and geotechnical information to aid in identifying on-site geologic materials for the potential use as cap/cover material
- Describe the landfill cap/cover installation activities conducted at other landfills proximal to RFETS
- Determine the potential location and status of on-site and existing off-site borrow sources in the immediate vicinity of the RFETS and assess the suitability of the material available at these sources as cap/cover material
- Compare and contrast the economic advantages and disadvantages associated with utilizing on-site versus off-site borrow sources for the landfill cap/cover material
- Compare and contrast the additional factors with utilizing on-site versus off-site borrow sources for the landfill cap/cover material
- Recommend additional activities to be conducted to fully assess the potential borrow source locations with respect to achieving landfill closure.

Construction of the landfill cap/cover for the OU5 Landfill is currently scheduled to begin in January 2000. Landfill closure construction for the OU7 Landfill is currently scheduled to begin in November 1997.

This report is organized into the following sections:

- Site description
- Assumed borrow material requirements
- Previous investigations and projects
- Potential borrow sources
- Estimated costs associated with the on-site and off-site locations
- Additional factors related to borrow source locations
- Recommendations for future activities.

2.0 SITE DESCRIPTION

An understanding of the overall physical setting of RFETS and adjacent environs is necessary to determine the potential sources of borrow material for the OU5 and OU7 Landfill caps. This section describes the following elements:

- Location
- Topography
- Geology
- Surface Water Hydrology
- Hydrogeology.

2.1 LOCATION

RFETS is located in northern Jefferson County, Colorado, approximately 26 kilometers (km) [16 miles (mi)] northwest of Denver and consists of approximately 2,650 hectares (ha) (6,550 acres). Major buildings are located within the RFETS security area of approximately 162 ha (400 acres). The security area is surrounded by a buffer zone of approximately 2,490 ha (6,150 acres) (Figure 2-1).

2.2 TOPOGRAPHY

The natural environment of RFETS and vicinity is influenced primarily by its proximity to the Front Range of the Rocky Mountains. The RFETS is located on a broad, eastward sloping pediment surface developed on coalescing alluvial fans deposited along the Front Range. Operational areas at the RFETS are located near the eastern edge of the pediment terrace between two stream-cut, east-trending valleys (North Walnut Creek and Woman Creek).

2.3 GEOLOGY

Geologic units beneath the RFETS consist of unconsolidated surficial units of Quaternary age (Rocky Flats Alluvium, valley-fill alluvium, and colluvium), which unconformably overlie Cretaceous-aged bedrock (Arapahoe Formation, Laramie Formation, and Fox Hills Sandstone).

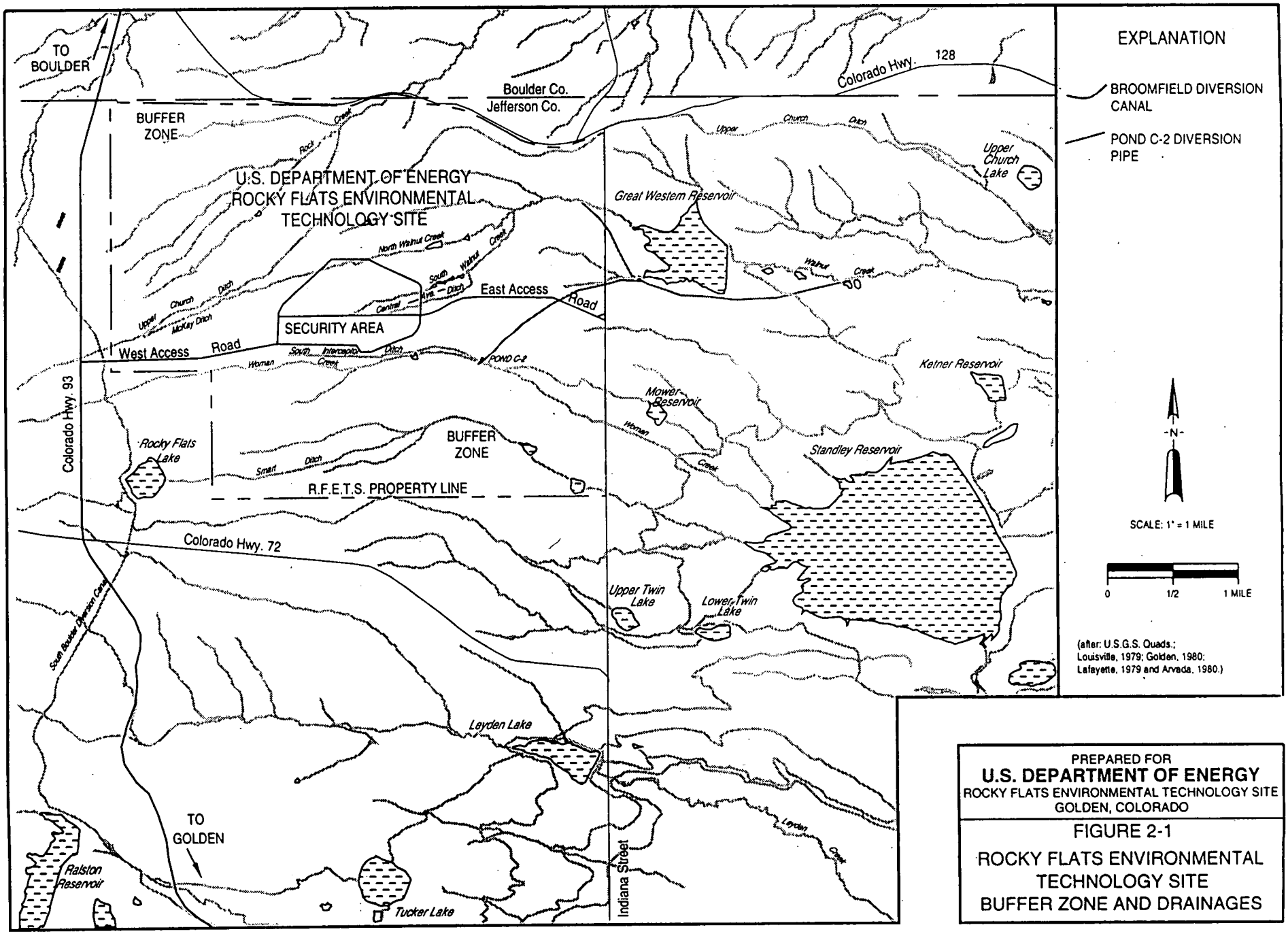

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FIGURE 2-1

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
BUFFER ZONE AND DRAINAGES

The Rocky Flats Alluvium is a gravelly pediment cover of Nebraskan or Aftonian Age (Scott, 1975). This alluvium is composed of poorly sorted, angular to rounded, coarse gravel, sand, and gravelly clays. The colluvial deposits are commonly represented by silty clay and clayey silt with some gravel and sand. The valley-fill alluvial deposits are represented by poor- to well-graded mixtures of reworked Rocky Flats Alluvium, colluvium, and weathered bedrock found in drainages throughout the RFETS.

The Arapahoe is predominantly composed of claystone and siltstone, and at the RFETS it has been shown to contain at least five separate, discontinuous, but mappable sandstone units. Those units have been designated as the Number 1 through Number 5 Sandstones. The configuration of the Arapahoe Formation underlying the RFETS is subject to controversy. One investigation has described the formation as approximately 150 feet thick beneath the central portion of the RFETS, while a more recent investigation has concluded that it is less than 50 feet thick at that location.

The Laramie Formation unconformably underlies the Arapahoe Formation and is approximately 600 to 800 feet thick. The Laramie is subdivided into two members; the upper member is generally much finer grained than the lower member. The upper member is 300 to 500 feet thick and consists primarily of claystone. The lower member of the Laramie Formation is 300 feet thick and is composed of sandstones, claystones, and coal beds.

The Upper Cretaceous Fox Hills Sandstone ranges from 90 to 140 feet in thickness and conformably underlies the Laramie Formation. In general, the Fox Hills Sandstone is a very fine- to medium-grained, angular to subrounded, well-sorted silty sandstone. The Fox Hills Sandstone, which represents an aquifer of regional significance, lies at a depth of 700 to 800 feet below ground surface at the RFETS.

Underlying the Fox Hills Sandstone are several thousand feet of the Pierre Shale. The Pierre Shale is predominately a medium to dark gray, noncalcareous shale located to the west of RFETS. The Pierre Shale is present in the Western Aggregates, Inc. (WA) quarry located adjacent to the northwest corner of RFETS (see Section 5.2.1).

Lithological logs from boreholes drilled in the shallow bedrock material indicates a predominance of claystones and siltstones with lesser amounts of sandstone. In general, the bedrock exhibits a higher percentage of fine-grained material than the overlying unconsolidated surficial deposits, with a lower permeability and volume of ground-water flow.

Also evident from the borehole logs is a weathered zone in the upper portion of bedrock. Fracturing and weathering increase the permeability of bedrock material. The weathered zone is commonly less than 15 feet thick, but may be as thick as 60 feet. The thickness of the weathered bedrock zone is dependent on such factors as relative abundance of fractures, presence of root zones, elevation relative to the water table, and proximity of valley bottoms.

2.4 SURFACE WATER HYDROLOGY

Three intermittent streams drain the RFETS with flow generally from west to east. These drainages are Rock Creek, Walnut Creek, and Woman Creek (Figure 2-1). Rock Creek drains the northwestern corner of the RFETS and flows northeast through the buffer zone to its off-site confluence with Coal Creek. And east-west trending interfluve separates the Walnut Creek and Woman Creek drainages. North and South Walnut Creeks and No Name Gulch drain the northern portion of the RFETS security area. These three forks of Walnut Creek join in the buffer zone and flow toward Great Western Reservoir. Woman Creek drains the southern RFETS buffer zone flowing eastward. The South Interceptor Ditch lies between RFETS security area and Woman Creek. The South Interceptor Ditch collects runoff from the southern RFETS security area and diverts it to Pond C-2 where it is monitored, treated, and then pumped to the Walnut Creek Watershed where it is released to the Broomfield Diversion Canal.

Wetlands are generally adjacent to surface water bodies such as the streams described in this section. The locations of wetlands at the RFETS are shown on the Wetlands Location Map included in the RFETS Land Use Manual (EG&G, 1994).

2.5 HYDROGEOLOGY

Two groundwater flow systems are distinguished in the current conceptual model of the subsurface hydrology of RFETS. The upper flow system is unconfined and lies within the Rocky Flats Alluvium, colluvium, valley-fill alluvium, and weathered bedrock. The lower flow system is confined within unweathered bedrock sandstones of the lower Arapahoe and upper Laramie Formations.

Groundwater levels in the upper flow system rise in response to recharge during the spring and decline during the remainder to the year. In the western portion of RFETS, where the thickness of the alluvial materials is greatest, the depth to the water table is 15 to 21 m (50 to 70 feet) below the surface. The water table becomes shallower to the east (with local variations) as the alluvial material thins.

3.0 ESTIMATED BORROW MATERIAL REQUIREMENTS

As part of the ongoing RFETS environmental restoration program activities, a need for soil volumes on the order of 634,200 cubic meters (m^3) [830,000 cubic yards (yd^3)] has been identified for capping/covering the OU5 and OU7 Landfills. The preliminary estimates of the material type requirements and volumes required for the OU5 and OU7 Landfills are described in this section.

3.1 MATERIAL TYPE REQUIREMENTS

Two primary types of borrow material have been targeted for the closure of the OU5 and OU7 Landfills. These two material types are referred to in this report as "low permeability soil" and "structural fill." Low permeability soil is fine-grained soil with geotechnical properties consistent with its target use as cover/cap material. Structural fill is medium-textured soil with properties that are conducive for structural fill applications, seed germination, and other miscellaneous functions. A nominal amount of drainage material (i.e., rip rap) will also be necessary for closure of the landfills. Because the quantities for this material are relatively small, borrow sources for drainage material are not addressed in this report.

Low-permeability soils consist of fine-grained material or soil types with high clay and silt fractions. The design of a low-permeability soil layer will depend upon site-specific factors including the physical properties and engineering characteristics of the soil being compacted, the degree of compaction obtainable, expected loadings, and expected precipitation.

Soil used as structural borrow material will optimally have the ability to serve miscellaneous functions and be able to support a vegetative cover. Pertinent soil characteristics include grain size, organic content, nutrient levels, pH levels, and water content. Miscellaneous functions of the soil to be used as structural borrow material include its ability to:

- Protect another cap/cover layer during construction
- Serve as a foundation or base for construction
- Distribute load
- Distribute deformation (such as settlement).

3.2 MATERIAL AND VOLUME ESTIMATES

Preliminary estimates of the material types and volumes required for the closure of OU5 and OU7 Landfill are described in this section.

3.2.1 OU5 Landfill

Preliminary estimates of materials and volume requirements made by the OU5 Feasibility Study (FS) Project Team for the OU5 Landfill cap/cover are as follows:

• Structural fill material	
- Miscellaneous fill for regrading	153,000 m^3 (200,000 yd^3)
- Protection layer [61 centimeters (cm) (24 inches (in) thick]	38,000 m^3 (50,000 yd^3)
- Topsoil [15 cm (6 in) thick]	11,500 m^3 (15,000 yd^3)
• Low permeability soil [61 cm (24 in) thick]	38,000 m^3 (50,000 yd^3)
Total estimated OU5 cap/cover requirements	240,500 m^3 (315,000 yd^3)

These volume estimates were based on the assumption that the cover soil will be required for a 6 hectare (15 acres) area.

3.2.2 OU7 Landfill

Preliminary estimates of material and volume requirements made by the OU7 FS Project Team for the cap/cover at the OU7 Landfill are as follows:

• Structural fill material	
- Miscellaneous fill for regrading	261,000 m^3 (341,000 yd^3)
- Protective layer and topsoil	154,000 m^3 (202,000 yd^3)
• Low permeability soil [61 cm (24 in) thick]	103,000 m^3 (135,000 yd^3)
Total estimated OU7 cap/cover requirements	518,000 m^3 (678,000 yd^3)

These volume estimates were based on the assumptions that the area of the cover system will be 16.9 hectares (41.8 acres) and will be graded to a slope of 7%. The OU7 FS Project Team also noted that these volume estimates should be considered upper bound estimates which may decrease.

4.0 PREVIOUS INVESTIGATIONS AND PROJECTS

This section describes investigations previously conducted at the RFETS that provide useful information for identifying potential on-site borrow sources for the OU5 and OU7 Landfill closure projects. This section also describes examples of other landfills proximal to the RFETS that have utilized native materials for landfill caps/covers.

4.1 PREVIOUS INVESTIGATIONS AT RFETS

Numerous soil boring programs have been conducted at the RFETS to describe the lithology of the soil at RFETS. Based on these soil boring investigations it appears that the overburden is thickest at the west side of RFETS near the Front Range and thins towards the east.

A soil boring investigation was conducted at the OU7 Landfill site in 1974 to gain information for the construction of an impervious ring around the OU7 Landfill and to collect information concerning a sampling structure located downstream from the landfill (Zeff, Cogorno, and Sealy, Inc., 1974). Numerous test borings were advanced at and in the vicinity of the OU7 Landfill. Severely weathered claystone was detected at an approximate depth of 1.2 to 1.5 m (4 to 5 feet) below the ground surface to the east of the landfill. Additionally, a figure within the Zeff, Cogorno, and Sealy report indicated the location of a proposed borrow pit area (to the east of OU7 in the No Name Gulch drainage) and an alternate borrow area (to the east of the security area). No mention of these borrow areas were made in the text and it is unknown if these potential borrow areas were ever utilized.

4.2 OFF-SITE LANDFILLS

Marshall/Boulder Landfill, which is proximal to the RFETS, has utilized native material for the landfill cover. Rocky Mountain Arsenal (RMA) is currently evaluating the use of native material for a landfill cap/cover. A description of the landfill cap/cover activities conducted at the Marshall/Boulder Landfill and Rocky Mountain Arsenal landfill are described in the following sections.

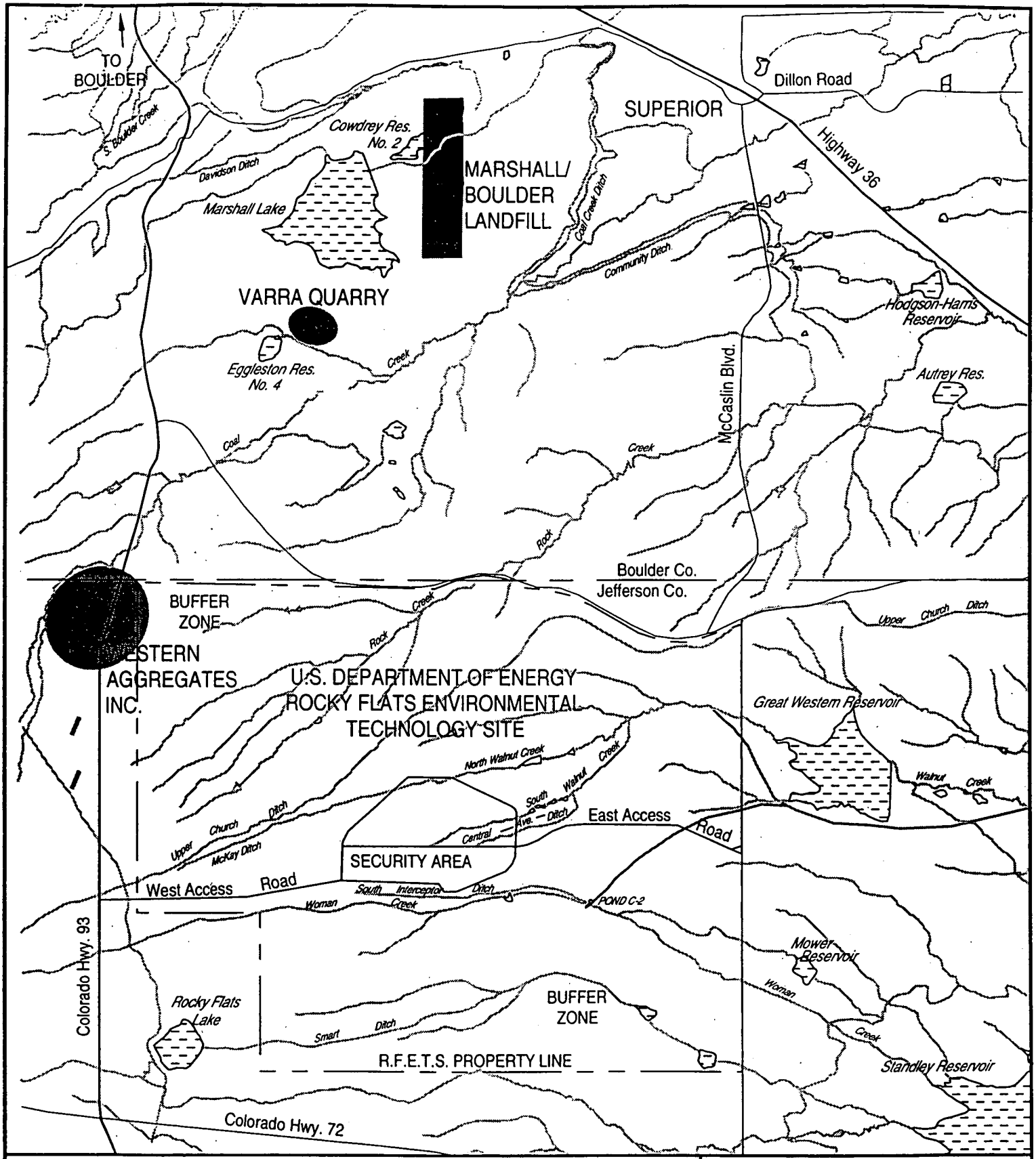
4.2.1 Marshall/Boulder Landfill

At the Marshall/Boulder Landfill Superfund Site (Figure 4-1), Boulder County, Colorado, two recent landfill grading projects have been completed involving the use of native geologic materials. The Marshall/Boulder Landfill National Priority List (NPL) site, is approximately 3.2 km (2 mi) north of RFETS, and has undergone the Superfund remedial design/remedial action phase under the United States Environmental Protection Agency (EPA) Region VIII. In 1989, an interim action was completed during which approximately 61,128 m^3 (80,000 yd^3) of compacted clay material was placed on one portion of the landfill surface. During 1992 through 1993, the remainder of the landfill was covered with over 152,820 m^3 (200,000 yd^3) of compacted clayey material as part of construction of an engineered landfill cover system.

The Record of Decision (ROD) for the Marshall/Boulder Landfill identified the intent of the landfill cover system whereby grading was specified to promote drainage and minimize infiltration. During negotiations with the EPA, the Colorado Department of Public Health and Environment (CDPHE), and the Potentially Responsible Parties (PRPs) in the design phase, an agreement was reached regarding the distinction between grading as a remedial action versus an engineered cap, as described in EPA's Remedial Action Guidance Document (EPA, 1985). As a result of this agreement, no permeability specifications were required for the grading design. Design criteria consisted of the following:

- Minimum and maximum slope requirements were 3 and 15 percent, respectively
- Soil cover material gradation requirements (greater than 50 percent by weight passing the number 200 sieve)
- Relative compaction and moisture requirements for in-place material (compactive effort equal to or greater than 85 percent of modified Proctor and moisture content equal to or greater than 2 percent above optimum).

This gradation specification was applied only to the top 0.6 m (2 feet) of cover material below final grade. Construction quality assurance procedures included control tests of cover material for gradation, compaction, and moisture content, and in-place testing of compacted lifts for compaction and moisture content using a nuclear gauge.



EXPLANATION

SCALE: 1" = 1 MILE

0 1/2 1 MILE

-N-

(after: U.S.G.S. Quads.; Louisville, 1979; Golden, 1980; Lafayette, 1979 and Arvada, 1980.)

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FIGURE 4-1

LOCATION OF MARSHALL/BOULDER LANDFILL, WESTERN AGGREGATES INC., AND VARRA QUARRY

For both the 1989 and 1993 grading actions, plans and specifications were developed by the PRPs and approved by EPA and CDPHE. The projects were competitively bid under procurement systems comparable to those employed by Colorado municipalities. For the 1993 grading action, the PRPs had a permitted borrow source for general fill and structured the bid package for subcontractors to propose a "base bid" for provision of entirely off-site fill material and an "alternate bid" for use of up to 76,410 m^3 (100,000 yd^3) of general fill from the PRPs borrow area. Following contract award in 1992, the PRPs elected the alternate bid option and a combination of off-site material and material from the PRPs borrow area was employed to complete the grading action. Material from the PRPs borrow area was excavated and placed with scrapers, whereas off-site material was trucked in from a borrow area approximately 1.6 km (1 mi) south of the site. In-place bid costs for the two borrow sources ranged from approximately \$1.96/m^3 (\$1.50/yd^3) for the PRPs borrow area to approximately \$5.23/m^3 to \$6.54/m^3 (\$4.00/yd^3 to \$5.00/yd^3) for the off-site borrow area.

The geologic materials employed for the grading actions were similar in nature to geologic materials at RFETS. General fill from the PRPs borrow area was a Quaternary gravel deposit similar in gradation to the Rocky Flats Alluvium. Clayey material from the off-site borrow area (Varra Quarry) was a weathered claystone (Laramie formation). The parent claystone material was partially indurated and exhibited geologic structure in-situ, but was easily excavated and broke down into a clayey material under normal compactive effort during placement. Weathered claystone deposits of the Arapaho formation underlay RFETS, and appears to have identical engineering properties to the claystone used for the Marshall/Boulder Landfill grading actions.

Revegetation of the landfill cover systems at the Marshall/Boulder Landfill was performed following completion of grading. Seeding specifications of the Colorado Department of Highways were substantively incorporated into the design, and included tilling and fertilization, followed by drill seeding and crimping the surface with straw to minimize erosion. Seeding for the 1989 remedial action was performed during the fall and the effort was severely damaged by Chinook winds; reseeding was performed in the following spring season to reestablish a vegetative cover.

On August 30, 1994, representatives from the U.S. Department of Energy (DOE) and EG&G Rocky Flats toured the Marshall/Boulder Landfill cover systems. Observations were made relative to the integrity of the cover, degree of erosion, and status of revegetation. Based on the brief inspection, it appears that the cover had not experienced significant erosion from overland flow, that an adequate vegetative cover had been established, and that the cover system was functioning as intended.

4.2.2 Rocky Mountain Arsenal Landfill

The RMA is an NPL site, located in Commerce City and is currently in the final stages of the Remedial Investigation/Feasibility Study (RI/FS) for the on-post OU. The RMA cleanup is being managed by the Program Manager for Rocky Mountain Arsenal (PMRMA) on behalf of the U.S. Department of Defense (DOD) under joint agreement with Shell Oil. PMRMA is currently evaluating the cost and technical feasibility for use of on-site geologic materials in the final remedy, for cap/cover and landfill liner applications. During 1993, PMRMA initiated a reconnaissance investigation of native soils and geologic materials involving advancement of up to 50 geotechnical borings. This study was completed in 1994 and PMRMA is currently conducting pilot testing of test fills to measure field-achievable permeability of in-place compacted on-site materials. This information is being used in support of the on-post RI/FS.

5.0 POTENTIAL BORROW SOURCES

As described in Section 3.1, the cap/cover for the OU5 and OU7 Landfills will require two types of borrow material, low-permeability soil and structural fill. Weathered claystone deposits located directly beneath the unconsolidated surface units at the RFETS and in the surrounding areas may potentially be suitable for use as the low-permeability material. Weathered claystone from a local borrow area (Varra Quarry) (Figure 4-1) was utilized for the landfill cover at the Marshall/Boulder Landfill (Section 4.2.1). The unconsolidated surface units in the RFETS area appear to be suitable for the structural fill materials; however, these deposits have traditionally been utilized because of their value as a high quality gravel resource on the west side of RFETS.

The proposed potential locations of borrow sources for the cap/cover of the OU5 and OU7 Landfills are described in this section. These borrow source locations and their criteria are divided in to on-site and off-site sources and are described below.

5.1 ON-SITE SOURCES

On-site source areas were chosen proximal to the OU5 and OU7 Landfills. The proposed on-site borrow locations were chosen in areas meeting the following criteria:

- Relatively thin alluvial material above the weathered claystone for ease of excavation of low-permeable materials
- No wetlands within or proximal to the proposed borrow source area which may be affected by borrow excavating activities
- Outside of the potential areas of soil contamination (known IHSs)
- No potential effects on surface water bodies
- Distant from habitat of the Prebles Meadow Jumping Mouse.

The locations of the proposed on-site borrow source are shown on Plate 5-1 and described in the following subsections.

5.1.1 Sources Proximal to the OU5 Landfill

Three potential borrow sources have been identified proximal to the OU5 Landfill (Plate 5-1). Two of the proposed borrow sources are located adjacent to the OU5 Landfill (one source is located approximately 244 m [800 feet] southwest of the landfill and the other is located approximately 61 m [200 feet] south of the landfill). These two proposed borrow sources may be located within the range of the Prebles Meadow Jumping Mouse discussed in Section 7.3; therefore, a third potential borrow source was located approximately 550 m (1,800 feet) to the southeast of the OU5 Landfill. The size of these proposed borrow sources was based on the estimated area required to provide the required amount of material needed for the OU5 Landfill cap/cover (Section 3.2.1).

5.1.2 Sources Proximal to the OU7 Landfill

Three potential borrow sources have been identified proximal to the OU7 Landfill (Plate 5-1). Two of the proposed borrow sources are located approximately 150 m (500 feet) east of the OU7 Landfill. These two proposed borrow sources may be located within the range of the Prebles Meadow Jumping Mouse discussed in Section 7.3; therefore, two additional potential borrow sources were located approximately 1220 m (4000 feet) and 1980 m (6500 feet), respectively, to the northeast of the OU7 Landfill. The size of these proposed borrow sources was based on the estimated area required to provide the amount of material needed for the OU7 Landfill cap/cover (Section 3.2.2).

5.2 OFF-SITE SOURCES

Off-site sources of the borrow material for the OU5 and OU7 Landfills were identified by reviewing the permits for mining properties within a 8-km (5-mi) radius of the RFETS security area. The off-site borrow source area investigation was limited to a 8-km (5-mi) radius due to the anticipated high cost and impact involved with transporting the large amount of material [634,200 m^3 (830,000 yd^3)] for a great distance. Table 5-1 list the mining permits and other pertinent information for properties within an 8-km (5-mi) radius of the RFETS security area. After the permitted mining properties were identified, the contact name for these properties were contacted and inquired about their ability to supply the anticipated types and amounts of borrow material. Based on this investigation, only two off-site sources were identified that could

Table 5-1

Mining Permits Within an 8 km (5 mi) Radius of RFETS

Permit Number	Status/Issue Date	Section Description	Property Name/ Mined Material	Applicant Name	Applicant Address	Contact Name and Telephone Number
		Twp. 2 South, Rng. 70 West				
M-77-328	Active 6/9/80	Section 16	State Clay Mine/ CLAY	Intermountain Brick	Valmont Road Boulder, Colorado 80301	Mike Miller 449-1230
M-79-045	Active 2/28/80	SE/NW/4 Section 9	Church Pit/CLAY	Lakewood Brick & Tile Co.	1325 Jay Street Lakewood, Colorado 80215	Tom Murray 238-5313
M-87-113	In Review 00/00/0000	SE/NE/4 Section 9	Rocky Flats Pit/ CLAY, SAND, GRAVEL	Church Ranch	9030 Yukon Street, #3600 Westminster, Colorado 80030	Chas C. McKay 424-9610
M-88-108	Active 11/29/89	NE/4 Section 4	Lightweight Aggregate Project/ SHALE	Western Aggregates	11728 Highway 93 Boulder, Colorado 80303	Tina Wadle Mob. 589-7983, Off. 499-1010
M-91-035	Active 11/5/91	Section 4	Conda/McKay/ SAND, GRAVEL, CLAY	Western Aggregates	11728 Highway 93 Boulder, Colorado 80303	Tina Wadle Mob. 589-7983, Off. 499-1010
M-75-007	Terminated	SW/SW/4 Section 21	Pit 22/SAND, GRAVEL	Brannan Sand & Gravel	Box 16006 Denver, Colorado 80216	Warren Cruise 426-8438
M-77-327	Terminated	SW/4 Section 4	Spicer Clay Mine/ CLAY	Wesley D. Conda, Inc.	5325 El Dorado Springs Drive Boulder, Colorado 80303	Larry Bullock 494-7597
M-79-151	Terminated	SW/4 Section 5	Wadsworth #1/?	Wadsworth Excav. Co.	5550 Wadsworth Arvada, Colorado 80002	No Name 423-7171
M-86-022	Terminated	Section 16	Old Woman Mine/ SAND, GRAVEL	Cooley Gravel Co.	P.O. Box 5485 Denver, Colorado 80217	Robert B. Laird 989-0300

Table 5-1 (Concluded)

Mining Permits Within an 8 km (5-Mile) Radius of RFETS

Permit Number	Status/Issue Date	Section Description	Property Name/ Mined Material	Applicant Name	Applicant Address	Contact Name and Telephone Number
		Twp. 2 South, Rng. 70 West				
M-88-068	Terminated	SW/NE/4 Section 4	Spicer/CLAY, AGGREGATE	Wesley D. Conda, Inc.	5325 El Dorado Springs Drive Boulder,Colorado 80303	Louis D. Conda 494-7597
		Twp. 1 South Rng. 70 West				
---	Active 00/00/0000	Portions of Section 27	Jenkins Site/SND & GRVL, Plant #3/ AGGREGATE	Varra Companies, Inc.	2130 South 96th Street Broomfield, Colorado 80020	Christopher L. Varra 666-8269
M-77-329	Active 6/9/89	NW/4 Section 30	McCann Clay Mine/ CLAY	Colorado Brick Co.	6032 Valmont Road Boulder, Colorado 80301	Gerald Gunning 449-1230

potentially supply the anticipated borrow material to the OU5 and OU7 Landfills. These two off-site borrow sources are Western Aggregates, Inc. (WA) and Varra Quarry and are described in the following subsections. The locations of these off-site borrow sources are shown on Figure 4-1.

5.2.1 Western Aggregates, Inc.

Western Aggregates, Inc. (WA) is located on Highway 93 adjacent to the northwest corner of the RFETS. According to representatives of WA, the types and volumes of borrow material required for the cap/covers at the OU5 and OU7 Landfills are within the means of the WA facility. Weathered claystone (Pierre Shale) is present at the WA facility and appears to be suitable for the permeable layers anticipated to be required for the landfill cap/cover material. Laboratory geotechnical tests conducted on the weathered claystone at the WA facility are included as Appendix A.

5.2.2 Varra Quarry

The Varra Quarry is located approximately 3.2 km (2-mi) north of the RFETS. According to representatives of the Varra Quarry, the quarry is presently not permitted for the volume of material required for the cap/cover material; however, the types of materials that would be required are present at the quarry. As stated above, the Varra Quarry supplied the low-permeable material (weathered claystones) for the cover at the Marshall/Boulder Landfill (Section 4.2.1).

6.0 ESTIMATED COSTS ASSOCIATED WITH ON-SITE AND OFF-SITE LOCATIONS

This section discusses potential on-site and off-site sources identified within a 8-km (5-mi) radius of the OU5 and OU7 Landfills. It is assumed that the borrow material from the on-site source will not require to be processed prior to use for the landfill caps/covers. Therefore, it is assumed that equipment for processing material from on-site sources is not needed and that volume changes from excavation will be essentially offset by volume changes from compaction. Approximately 240,500 m^3 (315,000 yd^3) of borrow material is required for the cap/cover at the OU5 Landfill (Section 3.2.1) and the cap/cover at the OU7 Landfill will require approximately 518,000 m^3 (678,000 yd^3) of material (Section 3.2.2).

The primary economical differences between the on-site and off-site sources are exploration costs for on-site sources, royalty fees, transportation costs from the sources to the landfills, and reclamation costs of on-site sources. Permitting costs will be a major cost factor for on-site sources unless CDPHE, EPA, DOE, and RFETS agree that this project must comply with only the substantive portions of the permits. It is assumed for this report that this agreement will occur.

Higher costs may be associated with off-site sources because of the lack of reserves within a reasonable distance from the site. The cost will depend on the local construction economy. The bids for off-site material will be more competitive if there are available permitted reserves within a reasonable proximity and not many projects requiring the same material.

This section discusses the following costs associated with the on-site and off-site sources:

- Exploration surveys and royalty fees
- Transportation costs
- Reclamation costs.

6.1 EXPLORATION SURVEYS AND ROYALTY FEES

It is recommended that exploratory surveys be completed for on-site sources to determine the approximate amount of material available for the cover. Surveys may have already been completed for off-site sources or the source may have stockpiled acceptable material so the approximate volume available for the covers should be known. The estimated cost for an on-site

exploratory survey is $150,000 based on professional judgment and experience with other similar types of projects.

Royalty fees for off-site sources are expected to cost $1.31/m^3 ($1/yd^3) based on professional judgment. However, the royalty fees may range significantly depending on competitive conditions. The mineral rights for on-site sources must be researched and the Department of Energy (DOE) will either have to purchase them or negotiate a royalty fee with the owner. The cost of the mineral rights or on-site royalty fees is unknown at this time but it is anticipated that the off-site royalty fees will be higher.

6.2 TRANSPORTATION COSTS

The identified on-site sources are generally less than 1.6 km (1 mi) from the landfills and scrapers can be used to haul borrow material from the source to the landfill. Using scrapers results in a transportation savings that is not detrimental to schedules. The preliminary estimate, from construction vendors, using scrapers to haul material to the landfills is $1.64/m^3 ($1.25/yd^3). The cost estimate for using an on-site source is $394,000 for OU5 and $848,000 for OU7.

Loaders and trucks will be required at off-site sources to haul borrow material to the landfills. State Highways 93 and 128 may be utilized to transport material from an off-site source to the landfills. The preliminary estimate, from construction vendors, for using loaders and trucks to transport the material is $6.54/m^3 ($5 yd^3) for a one-way distance of 1.6 km to 4.8 km (1 to 3 mi). The price could increase to $9.16/m^3 ($7 yd^3) for 8- to 14.4-km (5- to 9-mi) one-way distances. Significant price changes will occur for one-way distances greater than 16 km (10 mi). For OU5, the haul cost estimate using an off-site source located 1.6 to 4.8 km (1 to 3 mi) from the site is $1,575,000. The haul cost estimate over the same distance for OU7 is $3,390,000.

6.3 RECLAMATION COSTS

Off-site borrow material vendors will be responsible for fulfilling the Colorado Department of Environment and Natural Resources (CO DENR) requirements for reclamation of the borrow source. If an on-site source is used, RFETS will be responsible for providing CO DENR a reclamation plan and ensuring that proper reclamation is completed at the borrow area. The surface area that needs to be reclaimed will depend on the clay thickness and the amount of

overburden (soil over the clay layer). Assuming an excavation depth of 3 m (10 feet), the area to be reclaimed is estimated to be 7.7 hectare (19 acres) for OU5 and 17 hectares (42 acres) for OU7.

Topsoil can be stripped from the area, stockpiled, and used for either reclamation or structural fill at the landfill. The preliminary cost from construction vendors for stripping the topsoil and placing it back on the borrow area is $\$1.96/m^2$ ($\$1.50\ yd^2$). The cost estimate for stripping and placing topsoil back on the borrow area is $138,000 for OU5 and $306,000 for OU7.

Reseeding the area as part of the reclamation plan is estimated by construction vendors to cost $1,235/hectare ($500/acre). If the landfills are reseeded, it will cost $9,000 for OU5 and $21,000 for OU7. Reseeding includes ground preparation and planting.

6.4 COMPARISON COSTS

Table 6-1 lists the comparable costs for providing landfill covers for OU5 and OU7 using on-site and off-site borrow areas. These comparable costs are not total costs for providing borrow material but are based on factors that can be compared in order to determine the cost differential between utilizing an on-site source versus an off-site source. On-site comparable costs, anticipated at this time, are estimated at approximately $1.9 million. Royalties for an on-site borrow source are dependent on negotiations between DOE and the owner of the mineral rights at the borrow source. Anticipated comparable costs for the off-site borrow area are estimated at approximately $6.0 million.

The cost differential for use of off-site borrow sources is estimated at approximately $4.1 million. However, this cost differential could be affected by the royalty issues and the factors discussed in Section 7.0.

Table 6-1

Preliminary Comparable Costs for the OU5 and OU7 Landfill Covers

Factor	On-Site Borrow Area	Off-Site Borrow Area
Exploration Survey	$150,000	Not applicable[1]
Royalties	Unknown[2]	$993,000
Transportation[3]	$1,242,000	$4,965,000
Topsoil Work	$444,000	Not applicable[4]
Reseeding	$30,000	Not applicable[4]
Total Identified Costs[5]	$1,866,000	$5,958,000

[1] Assumed that the exploration survey will be the responsibility of the off-site source vendor.

[2] Mineral rights will need to be purchased or a royalty fee negotiated.

[3] On-site borrow material can be transported by scrapers; however, off-site borrow material must be excavated by loaders and transported in trucks.

[4] Topsoil work and reseeding of the off-site borrow area will be the responsibility of the off-site source vendor.

[5] These costs are for comparison purposes only and are of total costs for obtaining the borrow source material.

7.0 ADDITIONAL FACTORS RELATED TO BORROW SOURCE LOCATION

Environmental, technical, and institutional factors related to obtaining borrow material from on-site and off-site sources are described in this section. The Prebles Meadow Jumping Mouse may have a major effect at on-site sources so it is discussed separately.

The issues discussed in this section may affect the cost differential presented in Section 5.0 between on-site and off-site sources because these factors were not taken into account in the cost estimates. A summary of the additional factors affecting the evaluation of on-site versus off-site sources are listed in Table 7-1 and are discussed in the following subsections.

7.1 ON-SITE SOURCES

Environmental issues related to on-site sources include the Prebles Meadow Jumping Mouse (Section 7.3) and other National Environmental Policy Act (NEPA) evaluations, regulatory evaluations, permit research, contamination assessment of borrow material, road construction, wetlands mitigation, potential dewatering of the borrow source, erosion controls, and fugitive dust.

Technical issues include geotechnical analyses, soil boring surveys, and construction activities during the winter.

Institutional factors related to the on-site sources consist of public acceptance for the project, activity around the Prebles Meadow Jumping Mouse habitat, and quality assurance/ quality control (QA/QC).

7.1.1 Environmental Factors

NEPA and the Endangered Species Act will be significant economic, environmental, and institutional issues for on-site sources. If a categorical exclusion is not obtained, an environmental assessment and possibly environmental impact statement (EIS) will have to be conducted to determine the effects of the excavation and transport of the clay material to the landfills. The Prebles Meadow Jumping Mouse will have a significant effect on these reports because RFETS contains some of its prime habitats.

Table 7-1

Environmental, Technical, and Institutional Factors Affecting Borrow Area Evaluations

Factor	On-Site	Off-Site
Environmental		
NEPA	Project effects on the site	Road construction
Endangered Species Act	Prebles Meadow Jumping Mouse	Off-site source vendor liable
Regulatory evaluations	Required	Off-site source vendor liable
Permits	Required	Off-site source vendor liable
Noncontamination certification	Required	Off-site source vendor liable
Wetlands mitigation	Should not be required	Off-site source vendor liable
Dewatering controls	Should not be required	Off-site source vendor liable
Erosion controls	Required	Off-site source vendor liable
Fugitive Dust	Minimal (short haul distances)	Controls required (longer haul distances)
Technical		
Geotechnical Analyses	Required	Required
Boring Surveys	Required	Off-site source vendor liable
Cover construction in winter	May be required	May not be needed

Table 7-1 (Concluded)

Environmental, Technical, and Institutional Factors
Affecting Borrow Area Evaluations

Factor	On-Site	Off-Site
Environmental		
Institutional		
Traffic control	Not Required	Required
Maximum loads per day	None	Regulated
Debris control	Minimal	Required
Public Acceptance of Project	May be favorable	May not be favorable (traffic and air quality issues)
Quality Assurance/ Quality Control	Required	Required
Access to Source	Minimum time and effort	Maximum time and effort
Security	None	Required

Regulatory evaluations will be necessary to determine the types and content of required permits for on-site sources. Table 7-2 lists a preliminary assessment of the permits required for managing an excavation operation. RFETS may incur liability and expense if the search and evaluation is not thorough and a required permit is overlooked.

To minimize health & safety risks and waste disposal requirements, on-site sources need to be verified as uncontaminated before excavation can begin at them. It is assumed that off-site sources are uncontaminated.

Wetlands are not expected to be issues for on-site sources because an effort was made to locate sources away from known wetlands.

Dewatering controls can be significant for areas with a shallow water table, based on the 1993 Well Evaluation Reports, but the amount of ground water anticipated to be encountered is minimal. A high annual precipitation would also require dewatering controls; however, the annual precipitation at RFETS is low and it is not anticipated that local rainfall events will necessitate the use of permanent dewatering controls.

Erosion controls for surface water runoff will be required but are not anticipated to be a major cost. The controls will need to be designed to minimize changes to the current hydrology of the area if the source area is near or upgradient of Prebles Meadow Jumping Mouse habitat.

Fugitive dust controls will be required during excavation of on-site sources. Controls may be as simple as applying water or a dust control compound to the roads.

7.1.2 Technical Factors

RFETS will need to conduct geotechnical analyses to certify that an on-site source can provide material that meets the landfill cap\cover specifications. The required analyses include grain size, Atterberg limits, Proctor density, and compaction. The sources will need to have boring surveys conducted to provide an approximate volume of excavated material available for the caps\covers.

Mitigation measures for on-site sources that are near or contain Prebles Meadow Jumping Mouse habitat may include soil excavation during the mouse's hibernation period. The Denver/RFETS area can usually support a year-round construction season because of its mild winters.

Table 7-2

Identified Permits and Plans for OU5 and OU7

Description	Agency	Lead Time	Reason or Assumption
Financial Surety Bond	Colorado Department of Environment and Natural Resources, Division of Geology & Minerals		Required for excavations
Mining and Reclamation Permit	Colorado Department of Environment and Natural Resources, Division of Geology & Minerals	Prior to start of operations	Required for excavations
Stormwater Permit	Colorado Department of Physical Health and the Environment (CDPHE)	30 days	Runoff and Dewatering Controls
Stormwater Management Plan	CDPHE	Prior to Stormwater Permit application	Runoff and dewatering controls
Air Pollutant Emission Notice	CDPHE	6 months	Dust Control and Road Construction
Construction Permit	CDPHE	90 days	Required if disturbing greater than 10 hectare (25 acres) or excavation lasts longer than 6 months
Endangered and Threatened Species Study	US Fish & Wildlife Service	300 days prior to start of operations	Required of all Federal Agency actions

Table 7-2 (Concluded)

Identified Permits and Plans for OU5 and OU7

Description	Agency	Lead Time	Reason or Assumption
Financial Surety Bond	Colorado Department of Environment and Natural Resources, Division of Geology & Minerals		Required for excavations
Health and Safety Plan	OSHA	Prior to start of operations	
Cultural Resources Study	Historical Society of Colorado	90 days prior to start of operations	Required of all Federal Agency actions
Federal Antiquities Permit	US Department of Transportation	Prior to start of operations	Required of all Federal Agency actions
Section 106 Determination of Historical Objects	US Department of Transportation	Prior to start of operations	Required of all Federal Agency activities

7.1.3 Institutional Factors

It is anticipated that minimal traffic control will be needed because the on-site sources are near existing roads and the OU5 and OU7 Landfills. Additionally, the borrow material will not be transported on public roads; therefore, there will be no restriction on the number of loads of material hauled per day. Debris control will be minimal as compared to transporting the material on public roads.

RFETS may be required to conduct public comment meetings to monitor public acceptance of the borrow source excavation activities. An on-site excavation will not be as noticeable as an off-site source because public traffic control will not be required. The public may be concerned about the Prebles Meadow Jumping Mouse habitat at RFETS. The mouse is being considered for the endangered species list and its habitat is being considered for critical status.

To ensure that the borrow material meets project and contract specifications, the borrow material should be inspected as it is utilized. If QA/QC problems are identified during the project, it will be much more efficient to monitor excavations of on-site sources rather than off-site sources due to the distance the off-site sources will be from the landfills.

7.2 OFF-SITE SOURCES

Environmental issues involved with an off-site source which will be of concern to the RFETS include NEPA evaluations and fugitive dust controls. The other environmental issues noted on Table 7-1 (i.e., regulatory evaluations, permits, wetlands mitigation, etc.) are the responsibility of the off-site borrow source vendor and not discussed in detail. Technical factors consist of geotechnical analyses, boring surveys, and possible winter excavation. Institutional concerns are traffic control, limits on the maximum number of loads that can be transported per day, debris control, public acceptance, QA/QC of the material properties, access to the source, and security at RFETS.

7.2.1 Environmental Factors

To alleviate traffic concerns on highways adjacent to RFETS, additional roads may need to be constructed at RFETS for transporting material from the off-site sources to the landfills. These additional roads may be necessary if the present roads are not able to handle the large number of trucks and loads of material from the off-site source. Any road construction will require a

NEPA evaluation unless a categorical exclusion is obtained. The NEPA evaluation will likely include a task evaluating degradation to the Prebles Meadow Jumping Mouse habitat. Construction would need to be planned to minimize habitat degradation.

Off-site source vendors will be liable for procuring the necessary permits and complying with environmental regulations. Wetlands mitigation, dewatering controls, and erosion controls at the source area will be the responsibility of the off-site source vendor.

Fugitive dust controls will be required for off-site sources. More dust control issues will be encountered utilizing the off-site source relative to the on-site sources because of the longer haul distance and higher possibility of producing dust during transport. The potential for traffic problems due to losing material during transport will increase if public roads are used to haul the material from the off-site sources.

7.2.2 Technical Factors

Off-site source vendors will be required to furnish geotechnical analyses certifying that the source can provide material meeting the cover specifications.

Boring surveys may be required to ensure that the appropriate amounts of suitable material are available at the off-site source; however, this will be the responsibility of the off-site vendor.

Mitigation measures for off-site sources that are near or contain Prebles Meadow Jumping Mouse habitat may include soil excavation during the mouse's hibernation period (winter). The off-site source may not be within the Prebles Meadow Jumping Mouse habitat and may not be affected by this time of excavation problem.

7.2.3 Institutional Factors

Off-site source vendors must solve traffic control and debris control issues if using a primary highway. If these issues are not solved satisfactorily, the project may have problems with the public acceptance. If an off-site source is used, trucks may be using a public highway. Using a public highway requires traffic control, i.e., detour signs (if required), safety cones, flag people, and temporary signs informing motorists of the increased number of trucks entering the transportation system. These precautions will result in an increased cost for the project. In addition, local regulations may require vehicle permits and will limit the number of loads that

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can be transported each day. This will result in an increased cost to the project and a longer time period for hauling the same amount of material to the landfills.

RFETS will need to periodically inspect the operations of an off-site source to ensure that proper procedures are followed and to determine the cause of any QA/QC problems. Material from off-site sources will need to be monitored to ensure that the material meets contract specifications. Because the off-site sources will be further from the landfills than the on-site sources, QA\QC of the source of the borrow material will be more difficult with the off-site materials.

Trucks coming from off-site sources will have to pass through security at RFETS. Security checks may result in longer haul times to the landfills because of the time required to stop, be checked, and start transporting again. The waiting time will increase if the security check is lengthy. Traffic control may be necessary if long lines of trucks occur and it may result in a public acceptance issue for citizens who use the highway often. The cost for security is not expected to be high because current on-site security may be contracted for the task.

7.3 PREBLES MEADOW JUMPING MOUSE

The Prebles Meadow Jumping Mouse may be a limiting factor for evaluating the borrow sources. RFETS is one of four known habitat areas for the mouse in Colorado and has the only known viable and reproducing population. The U.S. Fish and Wildlife Service (FWS) has recently been petitioned to change the status of the mouse from a special concern species to a threatened and endangered species by the Biodiversity Legal Foundation. The petition also requested that known habitat at RFETS be designated as critical habitat. The implication of the petition is that RFETS will consider the mouse as a threatened and endangered species until notified that the petition was denied.

The Prebles Meadow Jumping Mouse requires moist areas and dense ground cover for its habitat. It is found primarily in wetlands and riparian corridors. A major threat to its populations is degradation, fragmentation, and destruction of its habitat. Fragmentation is a problem because the mouse will not move across disturbed areas; populations become isolated and the genetic pool decreases. Fragmentation of habitat at RFETS includes parking lots, roads (temporary and permanent), walkways, trails, and irrigation canals.

The known habitat at RFETS includes the wetlands and riparian corridors along Rock Creek and Woman Creek. The FWS would like to see the habitat protected by designating it as an open space preserve. They believe that the designation would protect the habitat, and therefore the mouse, from hydrological changes and habitat destruction caused by commercial, industrial, urban, and recreational development. They specifically stated a concern for habitat affected by a "sand and gravel operation on the west side of RFETS" with expansion plans into the headwaters of Rock Creek and Woman Creek.

The Ecology and Watershed Management (E&WM) Division at RFETS must be notified, in writing, of any intrusive activity or alteration of such an activity which affects the known habitat of the mouse. The notification must occur before the activity begins and preferably as soon as possible in the planning phase of the activity. Alterations subject to the notification include changes in the size, shape, location, and intensity of an activity or a change in the character, flow pattern, and volume of controlled surface water runoff. Any excavation, construction of roads, and drainage controls required by the project and within or near habitat areas will need to notify the Ecology and NEPA Division at RFETS.

The FWS must be notified if a threatened and endangered or special concern species such as the Prebles Meadow Jumping Mouse is found in the vicinity of a project during any phase. Precautions must be taken to avoid disturbing the mouse or degrading its habitat to the extent that field activities may be shut down.

The following are ways to minimize the project's impact on the Prebles Meadow Jumping Mouse.

- Bias the evaluation towards source areas that do not include critical habitat. Calculate buffer zones to determine the proximity of the source area to the habitat. Use densities derived from live trapping and research the home range value of the Prebles Meadow Jumping Mouse or other species of jumping mice to determine the width of the buffer zone. The home range value is the maximum length that the mouse will venture from its nest.

- Use existing roads and minimize construction of new roads through the habitat.

- Maximize intrusive activities during the hibernation season (October through April).

- Minimize activities in habitat areas during the height of litter production (June through August).

- Minimize the area that is enclosed by or encroaches upon the habitat to decrease disturbances and reclamation costs.

- Provide new habitat next to established habitat when degradation of current habitat cannot be feasibly avoided.

- Design surface water runoff controls so that the hydrologic effect on the habitat is minimal.

7.4 SUMMARY OF ADDITIONAL FACTORS

The use of off-site sources would minimize the need for regulatory analysis and avoid managing an excavation operation at RFETS. NEPA compliance will be required if new on-site road construction is required due to the large truck volume from the off-site source. It is anticipated that fugitive dust will be a stronger issue with off-site source vendors than on-site source vendors because of the longer haul distance and the faster speeds. Debris control, traffic control, and security will also be issues for an off-site source.

There is a more intensive effort for environmental investigations and regulatory research for on-site sources. However, an on-site source would give RFETS more control over the project resulting in better QA/QC and fewer public concern issues with the exception of the Prebles Meadow Jumping Mouse. Public and agency concerns regarding the mouse can be lessened with RFETS taking a proactive stance toward minimizing effects on the mouse's habitat.

Geotechnical tests and boring surveys will need to be completed at the proposed on-site source locations and potentially for the off-site sources to determine the approximate volume of material available, soil properties, and if the source material is contaminated. Seasonal (October through April) construction may be required to decrease any impacts to the Prebles Meadow Jumping Mouse habitat.

8.0 CONCLUSIONS

The availability of proximal borrow material for use in environmental restoration projects at RFETS will be critical to timely and cost-effective implementation of closure plans, corrective measures, and remedial actions. Current estimates of borrow material required are on the order of 120,700 m^3 (158,000 yd^3) for OU5 and 518,000 m^3 (678,000 yd^3) for OU7. Volume requirements for other OUs have not been identified at this time; however, it is reasonable to assume that such needs will be identified in the near future.

With regard to the off-site borrow area, there is a paucity of currently permitted reserves proximal to RFETS. The exception are reserves currently held by WA, who hold reserves of sand and gravel suitable for general fill, as well as weathered claystone/shale (Pierre Shale) that may be suitable for low-permeability material. The reserve that WA has available would seem to provide WA with a significant competitive advantage as a potential supplier of borrow material. Varra is also located relatively proximal to RFETS; however, Varra currently does not have the permitted resources to supply the necessary borrow material. The advantages and disadvantages of the off-site borrow source option have been summarized herein. The principal advantage associated with the off-site borrow source option is that it places the burden upon the construction vendor and off-site material suppliers to provide permitted reserves of material meeting the project specifications. The principal potential disadvantage however, is cost. The costs for use of the off-site borrow source may be significantly greater than for the on-site option. This cost differential could be exacerbated if a competitive environment for material supply does not exist, if rigorous security requirements are identified for its delivery, or if proximal borrow source material is not capable of meeting the project specifications.

The on-site borrow area option has not been fully investigated and its feasibility has not been determined; however, disadvantages and advantages for this option have been identified in this report. The principal disadvantages for the on-site borrow area option are the institutional constraints associated with implementation of on-site excavation. These institutional constraints include the issue of Prebles Jumping Mouse habitat, wetlands protection, air emissions, the potential for existing surficial contamination of potential borrow source areas, and reclamation planning (notwithstanding the potential need for permits). Costs would accrue for the RFETS work force to address these issues. The principal advantage for the on-site option appears to be cost. Because of the sensitivity to unit costs for borrow material to haul distance, the potential savings for use of borrow areas sufficiently proximal to allow use of scrapers for excavation and hauling presents opportunities for significant cost savings. However, additional investigations would be necessary to confirm the technical feasibility for use of on-site borrow material because of the paucity of geotechnical information in or adjacent to potential source areas.

9.0 RECOMMENDATIONS

This section presents recommendations relative to the selection of suitable borrow areas for use in the OU5 and OU7 closure activities. General recommendations are presented first, followed by specific recommendations for the off-site and on-site borrow area alternatives, and finally the recommended field investigations procedures for both the on-site and off-site borrow sources are discussed.

9.1 GENERAL

A general recommendation is for DOE and EG&G to keep their options open relative to both alternatives. We believe that there are competitive advantages to entertaining bids both for the provision of off-site material and for use of a borrow pit on-site. This recommendation is based on considerations relative to engineering feasibility and cost; we believe that the RFETS workforce is best qualified to evaluate and weigh the various advantages and disadvantages of each alternative, many of which are qualitative in nature.

9.2 OFF-SITE ALTERNATIVE

Should DOE choose to implement the off-site alternative for provision of borrow material, we believe that the following activities should occur:

- Continue discussions with off-site borrow material suppliers
- Promote competition
- Perform limited material testing.

Keeping the borrow material supplier informed as to material quantity requirements and specifications will enable the material supplier to plan their operation to make available the types of materials required when needed. Because only one off-site borrow material supplier (WA) was identified with the permitted borrow resources estimated to be necessary, it is recommended that the off-site borrow source investigation be expanded to a 16-km (10-mi) radius.

Should the off-site alternative be implemented, it would be in DOE's best interest to promote competition among prospective material suppliers. This could be accomplished by advertising the upcoming project in construction journals or through trade associations. Initial notification regarding the need for materials could promote competition by giving time to prospective suppliers to plan for the project.

Limited material testing of prospective off-site sources may be advisable to provide OU5 and OU7 specification writers information on the engineering properties of local materials.

9.3 ON-SITE ALTERNATIVE

Should DOE choose to implement the on-site alternative for provision of borrow material, the following activities should occur:

- Select representative sites
- Perform geotechnical investigation
- Secure permits as necessary
- Initiate NEPA review.

Several locations have been identified associated with each OU that may be feasible for the purposes of discussion and costing. Should the on-site alternative be carried forward, it will be necessary to select prospective areas for geotechnical investigation. Prior to investing in exploration, consensus should be developed on which sites best meet the criteria for cost-effectiveness and minimal environmental impacts.

A geotechnical investigation of the selected site(s) will be necessary to identify whether a sufficient quantity of suitable material exists. Specific recommendations in this regard are presented in Section 9.4.

A regulatory evaluation should be performed to assess the needs for permits relative to the borrow areas. This evaluation should identify whether the substantive and/or administrative requirements of regulations promulgated by the State of Colorado, Department of Energy, and Mine Reclamation Bureau, are applicable to development, use, and reclamation of on-site borrow areas.

9.4 FIELD INVESTIGATION

This section presents a representative field program that could be used to further investigate both alternatives.

9.4.1 Field Data Collection

It is assumed that up to four on-site potential borrow source areas will be identified and up to four potential off-site borrow areas will be identified. Because of the location of these areas away from the OUs, there will likely be a paucity of existing information regarding material characteristics in these areas.

Initial criteria for evaluating acceptable low permeability soils are proposed as follows:

Testing Method	Target Values
Atterberg Limits	
Liquid Limit	< 45 or 50 percent
Plasticity Index	> 20 percent
Grain Size Distribution (ASTM D1140)	> 90 percent passing #200 Sieve
Remolded Permeability (U.S. Army Corps of Engineers Procedures ASTM 5084	1 x 10-7 cm/sec

ASTM procedures are not listed for the Atterberg Limits tests because they require that the limits be conducted on air-dried specimens. This method can give very different results than if the limits are conducted at the natural water content.

9.4.1.1 On-Site Geotechnical Boring Program

A geotechnical boring program is proposed for on-site potential borrow source areas. The program would be divided into two distinct stages to (1) confirm presence of potentially suitable borrow material and obtain engineering data on soil/rock types and properties, and to (2) subsequently refine information regarding potential borrow areas. A total of 60 borings is proposed (15 per potential borrow area). A technical memoranda would be prepared to propose specific locations for five borings per area (20 total), which will be used to confirm soil/rock properties and outline the criteria to be used to locate up to 40 additional borings. The two stages of borings would progress as follows:

- **Reconnaissance** - Construction of up to 20 boreholes to confirm presence of soil/rock material most likely to meet both the physical and geotechnical criteria for borrow materials and collection of samples for geotechnical testing. Preliminary material estimates, borrow site locations, and borrow material quantity will be estimated from results of reconnaissance activities.

- **Refinement** - Construction of up to 40 addition boreholes to refine potential borrow areas after a review of the reconnaissance sampling results. Final mapped volumes and any remaining soil quality assurance questions will also be evaluated.

Standard penetration testing would occur during drilling to qualitatively evaluate material construction characteristics (e.g. ability to excavate, remold and compact).

9.4.1.2 Off-Site Borrow Area Field Sampling

Sampling of the four assumed off-site borrow areas is proposed to evaluate geotechnical properties of available materials. A total of 16 samples is proposed (4 per borrow area), which will be collected via steel trowel from existing borrow pit outcrops, with cooperation from off-site borrow pit owners.

9.4.2 Geotechnical Analysis

To evaluate the material properties of the potential on-site and off-site borrow sources, a variety of geotechnical analyses will be performed on the soil samples. The results of the analyses will be compared with the above proposed values and other criteria to be developed in the technical memoranda to evaluate the suitability of the soils to be used for low permeability and structural borrow material.

Evaluation of soil material for the reconnaissance stage will focus on the permeability and shrink/swell properties of the material. The objective for permeability testing will be to simulate compactive effort achievable in the field in remolded samples to identify a range of predicted field permeability values. Shrink/swell potential of the low permeability soil will be evaluated because high shrink/swell potential may compromise the macro-permeability of engineered cover systems by promoting cracking.

It is proposed that two soil samples per on-site boring and two samples per off-site borrow area be submitted for grain size distribution, Atterberg Limits, and moisture content (96 total). It is assumed that four samples per on-site borrow area (16 total) and two sample per off-site borrow area (8 total) will be further evaluated to assess permeability and compaction characteristics. The 24 samples will initially undergo laboratory compaction testing (Standard Proctor). In preparation for permeability testing, samples will then be split and compacted to 95 percent and 100 percent of maximum dry density at a moisture content approximately 2 percent above optimum. This will result in two permeability tests per soil sample (48 total) and will facilitate evaluations of the relationship between remolded permeability and compactive effort.

Additional geotechnical analyses that may be performed on the soils samples collected during the stage two refinement boring program are attached. The stage two analyses will be defined after interpretation of the stage one data and approved by Rocky Flats workforce personnel. Upon completion of the stage one boring program, it is anticipated that the most critical properties of the borrow source material will be identified, and the goals of the stage two analyses will be to better define the vertical and lateral extent of the target soil types, to fill in any data gaps, and to better evaluate additional engineering and physical properties of the targeted soil, including, but not limited to, the following:

- Settlement and consolidation potential
- Strength
- Organic Content
- Soil reaction.

10.0 REFERENCES

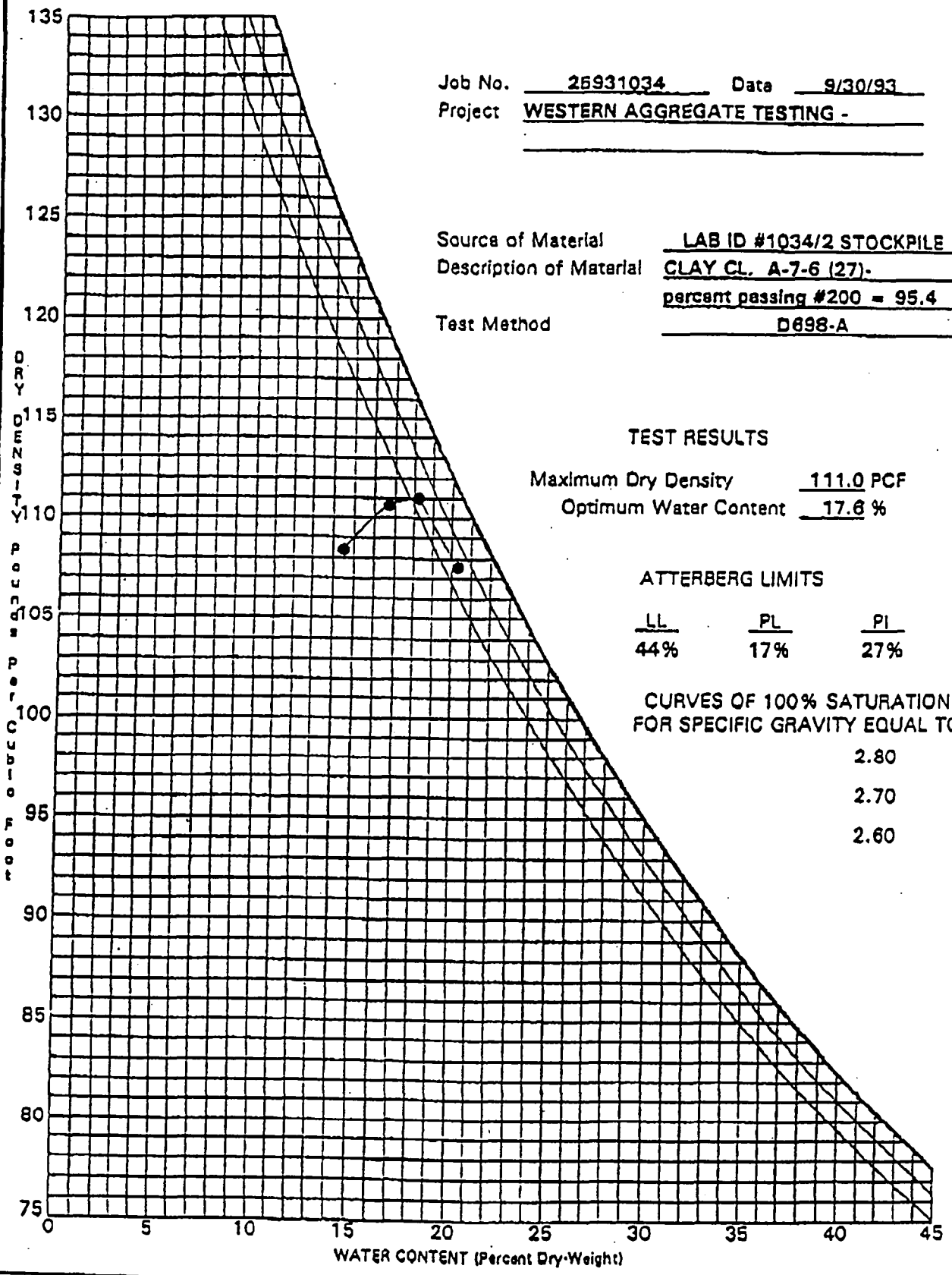
EG&G, 1994. Rocky Flats Environmental Technology Site Land Use Manual, September 1994.

U.S. Environmental Protection Agency, 1985. Handbook - Remedial Action at Waste Disposal Sites (Revised), Office of Research and Development, EPA/625/6-85/006, October.

Zeff, Cogorno, and Sealy, Inc., 1974. Subsurface Studies - Sanitary Landfill Renovations, U.S. Atomic Energy Commission's Rocky Flats Plant, Golden, Jefferson County, Colorado.

APPENDIX A

GEOTECHNICAL DATA ON THE PIERRE FORMATION CLAYSTONES



Job No. 26931034 Date 9/30/93

Project WESTERN AGGREGATE TESTING -

Source of Material LAB ID #1034/2 STOCKPILE

Description of Material CLAY CL. A-7-6 (27)- percent passing #200 = 95.4

Test Method D698-A

TEST RESULTS

Maximum Dry Density 111.0 PCF

Optimum Water Content 17.6 %

ATTERBERG LIMITS

LL	PL	PI
44%	17%	27%

CURVES OF 100% SATURATION FOR SPECIFIC GRAVITY EQUAL TO:

2.80

2.70

2.60

MOISTURE-DENSITY RELATIONSHIP

EMPIRE LABORATORIES, INC.

DENVER, COLORADO

Chen-Northern, Inc.

Consulting Engineers and Scientists

96 South Zuni Street
Denver, Colorado 80223
(303) 744-1105
(303) 744-0507 Fax

April 15, 1992

Western Aggregates, Inc.
11728 Highway 93
Boulder, Colorado 80303

Attention: Mr. Michael DeCew

Subject: Laboratory Testing on Submitted Sample of Raw Shale Fines

Job No. 1 377 92

Dear Mr. DeCew:

As requested, we have conducted laboratory testing on a sample submitted to us, referred to as raw shale fines, obtained from your clay pit located on Highway 93, adjacent to the Rocky Flats plant. The testing was in accordance with the request sent to us, which included three swell-consolidation tests, one performed at the optimum moisture content, one at 3% below the optimum moisture content, and one at 3% above the optimum moisture content. The results of these tests are presented on the attached Figures 1 and 2. These samples were remolded to 95% of the maximum Proctor density, based on the standard Proctor moisture density relationship provided to us. This test, performed by Sergeants Hauskins and Beckwith, indicated the shale had an optimum moisture content of 18.8% and a maximum dry density of 107.4 pounds per cubic foot (pcf).

The swell-consolidation tests indicate that the material when tested at -3% of the optimum moisture content possesses a swell potential of 1.3% with a swell pressure of 3,000 pounds per square foot (psf). When tested at the optimum moisture content, the sample exhibited a slight swell potential (0.3%) with a swelling pressure of 1,700 psf. The sample tested at +3% of the optimum moisture content was moderately compressible and non-expansive.

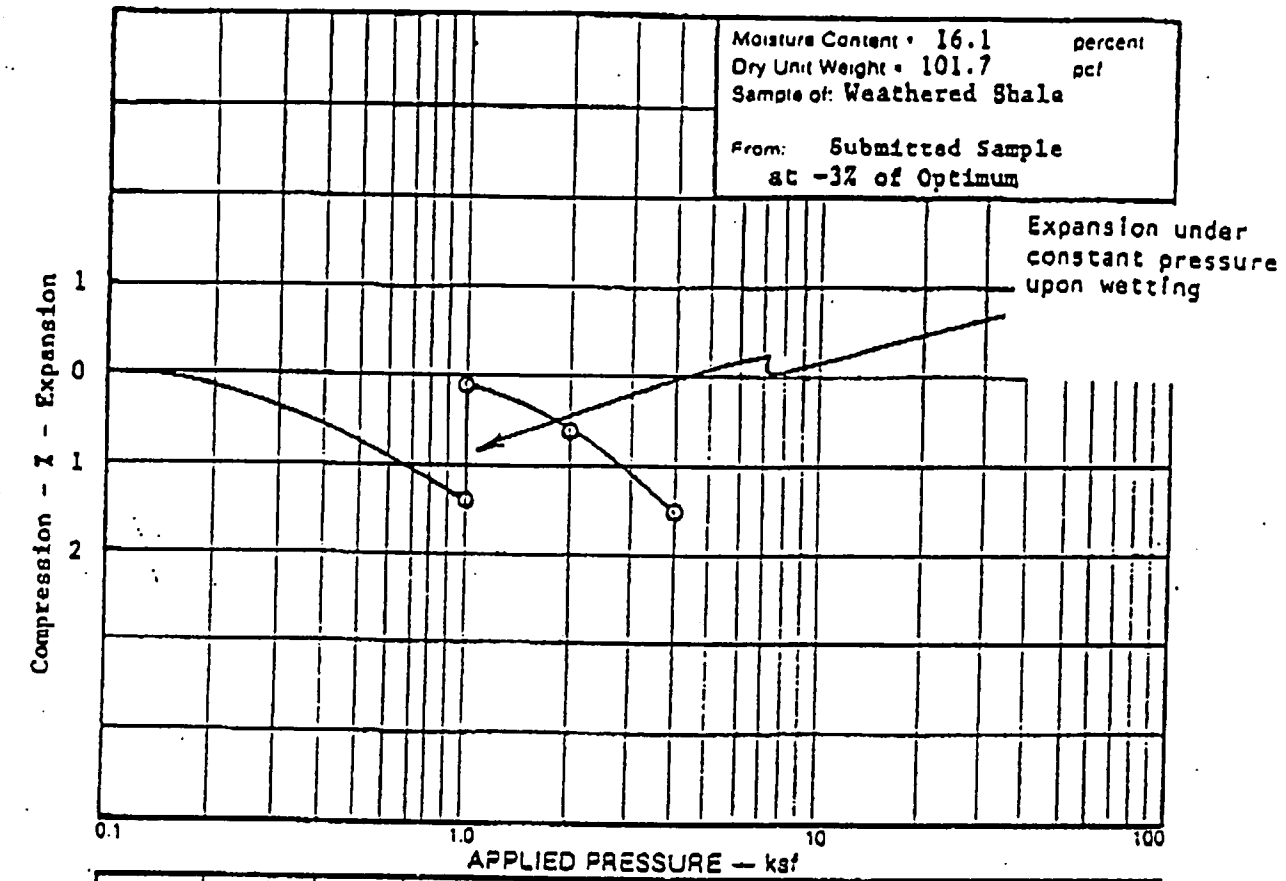
If there are any questions concerning the test procedures or the data presented herein, please call.

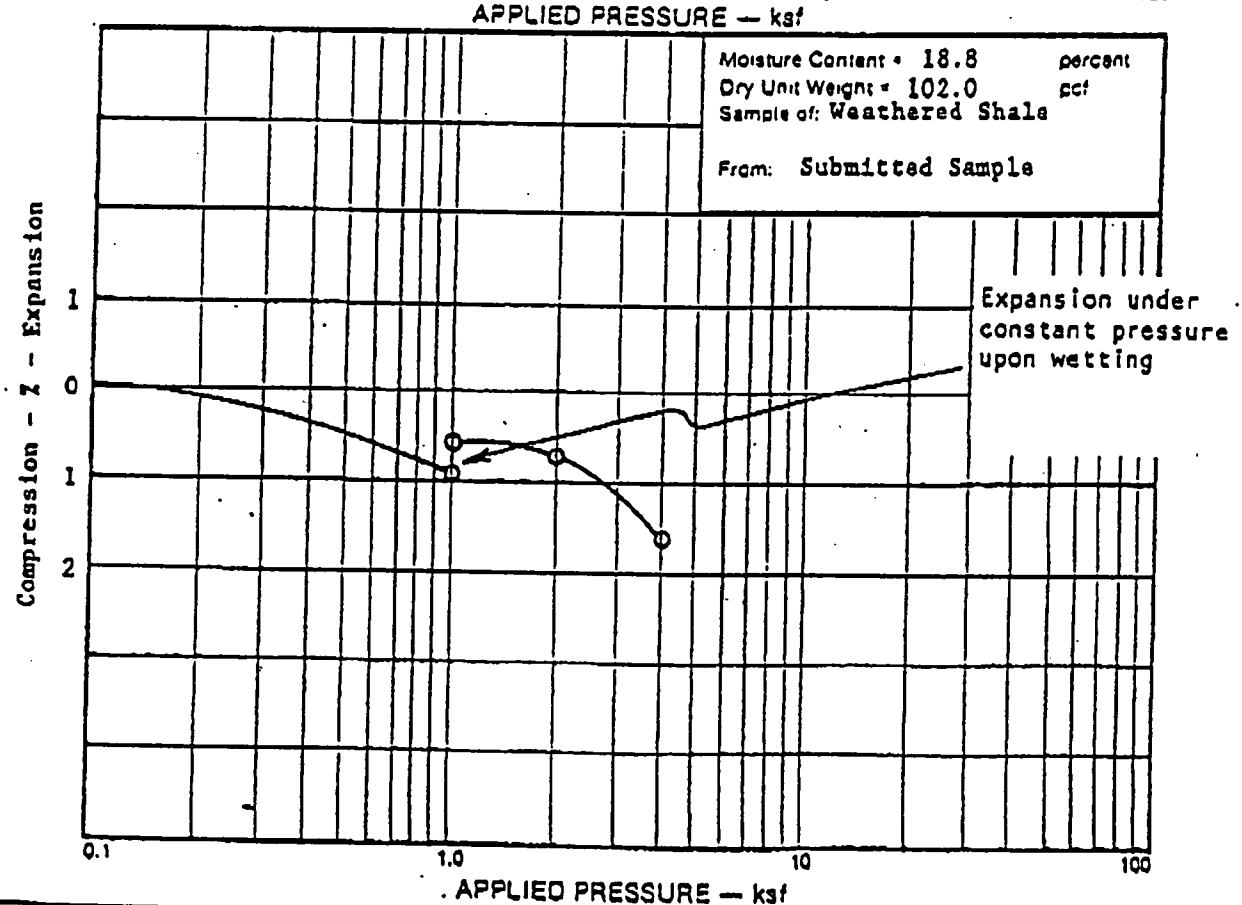
Sincerely,

Chen-Northern, Inc.

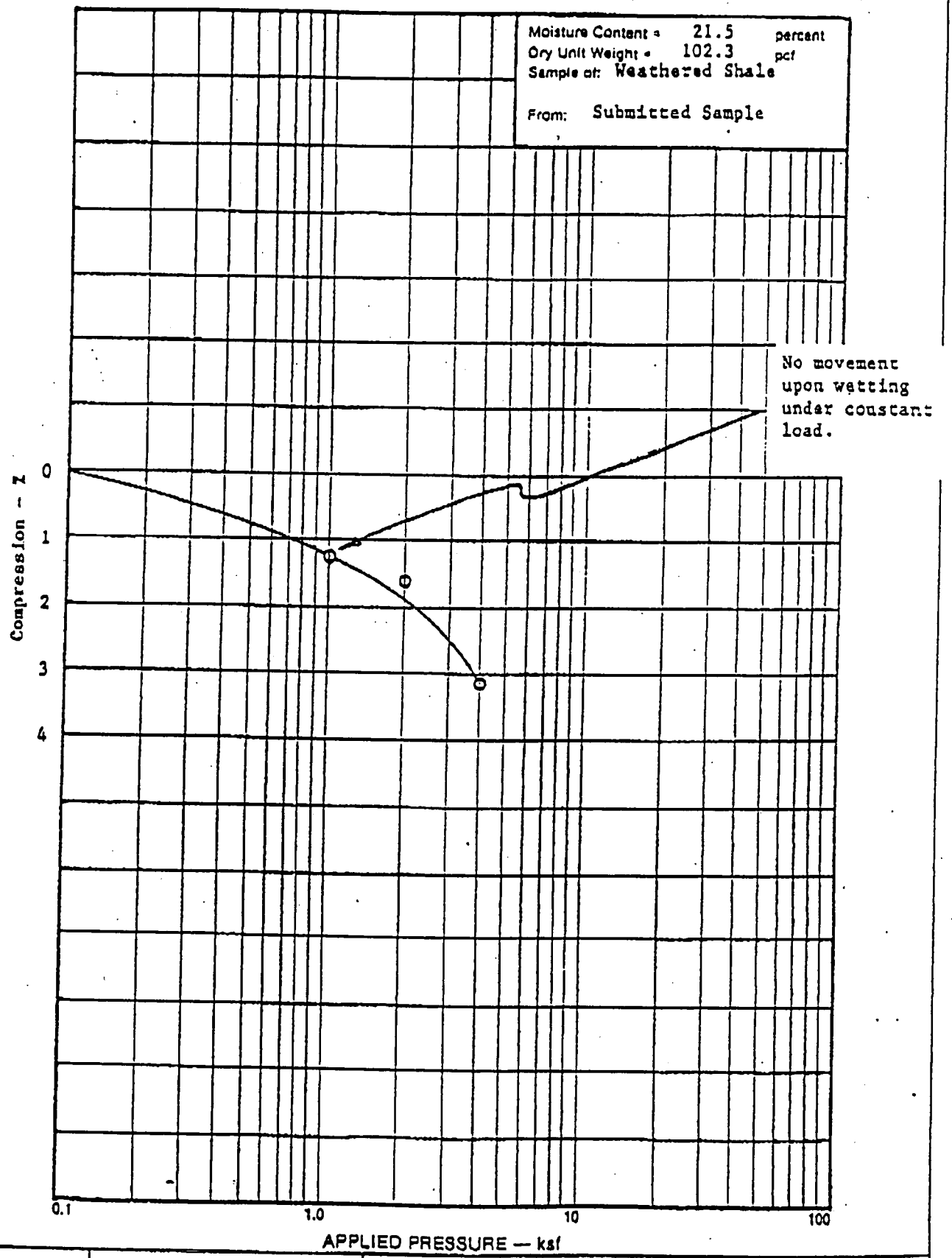
Roger L. Barker

Rev. by: DAG
RLB/kd
Enclosures





1 377 92	*Chen-Northern, Inc.*	SWELL-CONSOLIDATION TEST RESULTS	Fig. 1



1 377 92	*Chen-Northern, Inc.*	SWELL-CONSOLIDATION TEST RESULTS	Fig. 2

CA-1A-79

Empire Laboratories, Inc.
A Division of The Terracon Companies, Inc.

7100 N. Broadway, Suite 7G
Denver, Colorado 80221
Phone (303) 428-4001
Fax (303) 428-4102

Chester C. Smith, P.E.
Donald R. Clark, P.E.
Richard T. Kanemasu, P.E.
John L. Gimple, P.E.

September 23, 1993

Western Aggregates, Inc.
11728 Highway 93
Boulder, Colorado 80303

Attn: Mr. Michael Jones

Re: **Laboratory Test Results, Pierre Shale Material, Western Aggregates Plant, Boulder, Colorado**
ELI Reference No. 25931034

At your request, the sample submitted to our laboratory was tested in accordance with ASTM D-1140-92 (Amount of Material in Soils Finer than the No. 200 Sieve). Test results indicated that 97.5% of the material passed the No. 200 sieve.

We appreciate the opportunity of providing these services to you. If we may be of further assistance or if additional testing is required, please contact us at your convenience.

Sincerely,
EMPIRE LABORATORIES, INC.
A Division of The Terracon Companies, Inc.

Philip E. Broncucia, Jr.
Business Development

Reviewed by:

Donald R. Clark, P.E.
Principal

SUMMARY OF REMOLDED PERMEABILITY TEST RESULTS

Material	Permeability
Screened Reject Liner[1]	
Sample A (RSA- Fill (- 3/4"))	2.1 X 10^{-6} cm/sec
Sample B	1.5 X 10^{-6} cm/sec
Pierre Shale[1]	
Sample A (3/8" screened)	2.2 X 10^{-8} cm/sec
Sample B	2.1 X 10^{-8} cm/sec
80%/20% Ash Composite[2]	1.0 X 10^{-5} cm/sec
80%/20% Ash + 3% Waste Fines[2]	6.6 X 10^{-5} cm/sec
80%/20% Ash + 7% Waste Fines[2]	2.0 X 10^{-5} cm/sec
80%/20% Ash + 11% Waste Fines[2]	4.2 X 10^{-5} cm/sec
HDPE or VLDPE Liner[3]	1.1 X 10^{-12} cm/sec

1) Samples were remolded to 95 percent compaction near optimum moisture content in accordance with ASTM D698. Permeability testing was performed in accordance with ASTM D5084.

2) Samples were remolded to 90 percent compaction near optimum moisture content in accordance with ASTM D698. Permeability testing was performed in accordance with ASTM D5084.

3) Equivalent hydraulic conductivity as determined by the USEPA. Considered a conservative measure of permeation through an intact geomembrane with zero defects (EPA, 1987).

E91-7038\remperm.sum

TABULATION OF TEST RESULTS

Job No.E91-7038

Client: Western Aggregates, Inc.
11728 Highway 93
Boulder, Colorado 80303

Project: Ash Disposal Facility
Jefferson County, Colorado

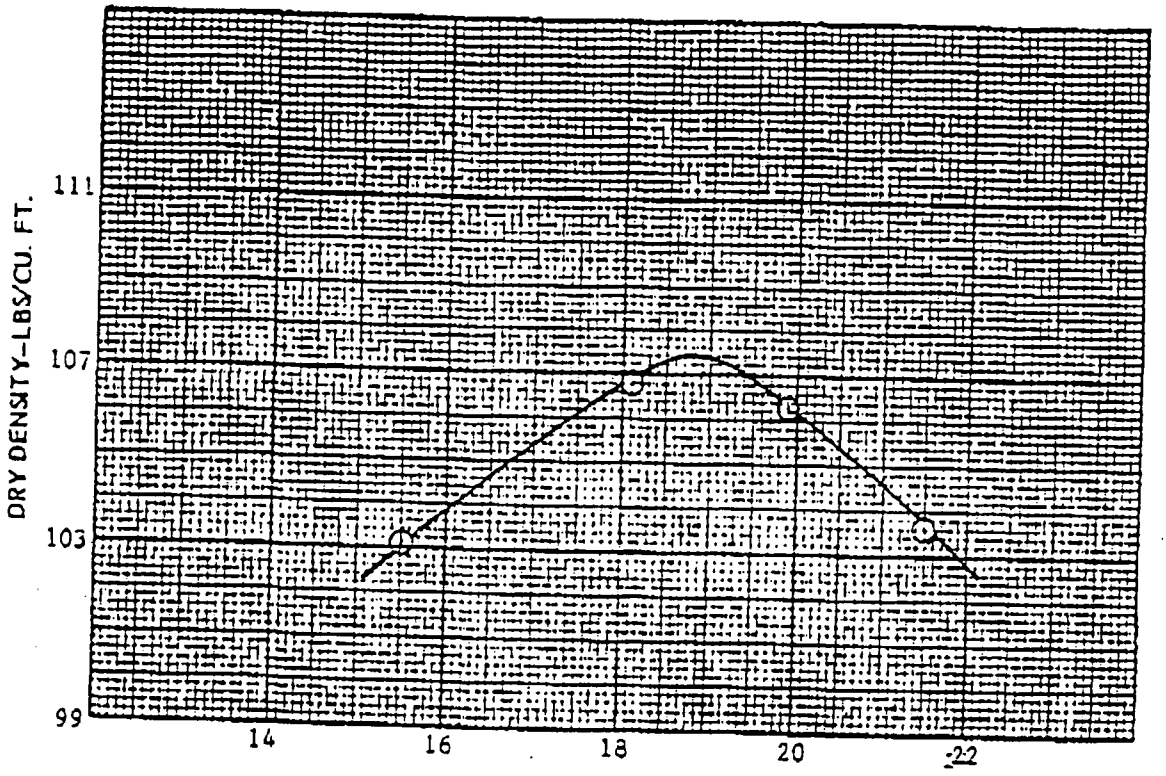
Source: Western Aggregates, Inc.

Material	In-Situ Moisture Content	LL	PI	Sieve Analysis - Accum. % Passing 3/4"	1/2"	3/8"	No.4	No.10	No.16	No.40	No.100	No.200	Unified Class.	Lab No.
Waste Slimes														
Sample A	90.6	65	43		100	99	99	97	96	93	91	89	CH	1-1
Sample B	84.7	65	43			100	99	97	95	93	90	87	CH	1-2
Weathered Shale														
Sample A	10.2	48	26		100	99	99	99	99	99	98	98	CL	2-1
Sample B	10.1	48	27	100	99	99	99	99	99	99	99	97	CL	2-2
Reject Sand														
Sample A	9.4	39	22		100	98	87	70	59	45	25	20	SC	2-3
Sample B	9.3	43	25		100	98	87	69	59	45	26	21	SC	2-4

SERGENT, HAUSKINS & BECKWITH

SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT WAI - Ash Disposal Facility **JOB NO.** E91-7038



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS/CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	Weathered Shale	18.8	107.4	ASTM D698	A	2-1

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD		NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT.LBS/CU.FT.
		DIAMETER	HEIGHT					
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
B	-#4	6"	4.58"	3	56	5.5 LBS.	12"	12,375
C	-3/4	4"	4.58"	3	56	5.5 LBS.	12"	12,317
D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD		NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT.LBS/CU.FT.
		DIAMETER	HEIGHT					
A	-#4	4"	4.58"	5	25	10.0 LBS.	18"	56,250
B	-#4	6"	4.58"	5	56	10.0 LBS.	18"	56,864
C	-3/4	4"	4.58"	5	56	10.0 LBS.	18"	56,864
D	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	56,864

AUG 10 1989

ACCU-LABS RESEARCH, INC.

11485 West 48th Avenue - Wheat Ridge, CO 80033 - (303) 423-2766

A N A L Y S I S R E P O R T
DATE: 08/09/89 PAGE 1

MARTIN JONES
WESTERN AGGREGATES, INC.
11728 HIGHWAY 93
BOULDER, CO 80303

Lab Job Number: 9647-31236-2
Date Samples Received: 08/03/89
Customer PO Number: (none)

These samples to be disposed of 30 days after the date of this report.

	ALR Designation •	9647-31236-2-1	9647-31236-2-2
	Sponsor Designation •	861119 (RAW SHALE)	861119 KILN PROD.
	Comments •	COMP.	
	Date Collected •	10/31/86	10/31/86
Determinations in µg/g unless noted			
Silver - total		3.4	1/4
Arsenic • total		5.8	6.0
Barium • total		92	33
Cadmium • total		<1	<1
Chromium • total		21	13
Iron • total		27,000	15,000
Mercury • total		0.04	<0.04
Lead • total		25	13
Selenium • total		0.7	<0.5
Zinc - total		93	25

REALTZ

By: _____
Steven Callio
Soils/RCRA Supervisor

SC/dh

PLATE 1

ON-SITE BORROW SOURCE LOCATION MAP

29/29

PLATE NOT INCLUDED