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CUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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ation is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson 02 and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

2. REPORT DATE 09/00/84		3. REPORT TYPE AND DATES COVERED	
4. TITLE AND SUBTITLE CONCEPT DESIGN OF HAZARDOUS WASTE LANDFILL FACILITY		5. FUNDING NUMBERS	
6. AUTHOR(S)			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) IT CORPORATION		8. PERFORMING ORGANIZATION REPORT NUMBER 85127R08	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) BUILDING TECHNOLOGY INC.		10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION / AVAILABILITY STATEMENT APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) THIS REPORT PRESENTS THE CONCEPT DESIGN FOR A PROPOSED HAZARDOUS WASTE LANDFILL FACILITY LOCATED ON THE ROCKY MOUNTAIN ARSENAL, COMMERCE CITY, COLORADO. THE LANDFILL FACILITY CONCEPT DESIGN PROJECT INVOLVED THE FOLLOWING TASKS: (1) EVALUATION OF ALTERNATIVE WASTE CELL CONCEPTS INCLUDING TYPES OF CELLS, LOCATION WITH RESPECT TO THE GROUND SURFACE, AND TYPES OF LINER, (2) CONCEPT DESIGN OF THE LANDFILL FACILITY AND WASTE CELL INCLUDING NUMBER OF CELLS, LAYOUT, OPERATION AND WASTE HAULING ALTERNATIVES EVALUATION, (3) PREPARATION OF A REPORT DESCRIBING THE EVALUATIONS, FACILITY AND WASTE CELL CONCEPT DESIGNS, ESTIMATED CONSTRUCTION QUANTITIES AND COST, GUIDELINE CONSTRUCTION SPECIFICATIONS AND QUALITY CONTROL PROCEDURES, AND CLOSURE AND POST CLOSURE PLANS. THE PROPOSED LANDFILL FACILITY WILL CONTAIN HAZARDOUS WASTES GENERATED FROM THE CLOSURE OF BASIN F.			
14. SUBJECT TERMS COST, LINER		15. NUMBER OF PAGES	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

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ITT CORPORATION

Project No. 831641
September 1984

Report

Concept Design of Hazardous Waste Landfill Facility

Rocky Mountain Arsenal Commerce City, Colorado

Prepared For:

Department of the Army
Rocky Mountain Arsenal
Commerce City, Colorado
and
U.S. Army Toxic and Hazardous
Materials Agency
Aberdeen Proving Ground, Maryland

Under Contract With:
Battelle Columbus Laboratories
Research Triangle Park Office
Research Triangle Park,
North Carolina

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93-23754



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Report

Concept Design of Hazardous Waste Landfill Facility

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PREFACE

The concept design for a proposed hazardous waste landfill facility located on the Rocky Mountain Arsenal involved consideration of siting, permitting, and regulatory issues in addition to design and construction type factors. Criteria and approaches used in developing the concept design, were provided by Rocky Mountain Arsenal, U.S. Army Toxic and Hazardous Materials Agency, and U.S. Army Engineer Waterways Experiment Station personnel.

Specific individuals acknowledged for their contribution to this project are:

Edwin W. Berry --	Chief, Compliance and Resources Branch, Rocky Mountain Arsenal
Douglas W. Thompson --	Environmental Engineering Division, Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station
Charles Scharmann --	U.S. Army Toxic and Hazardous Materials Agency

1.0 INTRODUCTION AND SUMMARY

This report presents the concept design for a proposed hazardous waste landfill facility located on the Rocky Mountain Arsenal, Commerce City, Colorado. This project has been conducted for the Department of the Army (Rocky Mountain Arsenal and U.S. Army Toxic and Hazardous Materials Agency), under contract with Battelle Columbus Laboratories. The following sections present a description of the project including scope of work, project background and a summary of the landfill facility concept design.

1.1 SCOPE OF WORK

The landfill facility concept design project involved the following tasks:

- o Evaluation of alternative waste cell concepts including types of cells, location with respect to the ground surface, and types of liners.
- o Concept design of the landfill facility and waste cell including number of cells, layout, operation and waste hauling alternatives evaluation.
- o Preparation of a report describing the evaluations, facility and waste cell concept designs, estimated construction quantities and costs, guideline construction specifications and quality control procedures, and closure and post-closure plans.

Results of the waste cell evaluations and facility design factors are presented in Chapter 2. The landfill facility concept design is presented in Chapter 3. Details of the waste cell concept design are presented in Chapter 4. Chapter 5 presents the estimated construction quantities and costs. Guideline construction specifications and quality control procedures are presented in Appendix A and closure and post-closure plans are presented in Appendix B.

1.2 PROJECT BACKGROUND

The proposed landfill facility will contain hazardous wastes generated from the closure of Basin F. Basin F is 93-acre surface impoundment located in Section 26, in the northwest central part of Rocky Mountain Arsenal (RMA) as shown in Figure 1. The Army has committed to closing Basin F under RCRA regulations as part of the RMA Contamination Control Program. A closure plan including final waste disposal in a landfill has been prepared by Rocky Mountain Arsenal personnel (RMA, 1983) and submitted to the EPA.

Basin F was constructed in 1957 to contain liquids generated from operations conducted on RMA. It contains toxic and hazardous liquids, sediment or sludge, and soil. The basin was lined with an asphalt liner. During the last several years it has been determined that some leakage has occurred through defects in the liner. This leakage has resulted in contamination of soils underlying the basin. Closure of Basin F will involve (1) removal of liquids and solids within the basin and contaminated soil underlying the basin; (2) solidification of these materials to remove free liquids; and (3) placement of the solidified wastes in a RCRA licensed landfill facility.

The Army has conducted several studies related to the proposed landfill facility and the Basin F closure program. A landfill site selection study was conducted by U.S. Army Engineer Waterways Experiment Station personnel (WES, 1983b) to determine the most suitable site for location of the landfill facility. The site selected is located in Sections 25 and 36 about one mile southeast of Basin F, as shown in Figures 1 and 2.

RCRA regulations prohibit landfilling of liquids, therefore, a program to evaluate various liquid solidification methods has been conducted. Testing of various liquid solidification processes and evaluation of

solidified liquid waste material characteristics were reported in WES, 1983a. Solidified waste material characteristics considered in the concept design were obtained from that report.

1.3 PROJECT SUMMARY

The landfill facility concept design is a multi-cell facility with earthen type (truncated prism) waste cells, a leachate control system, a surface water runoff and runoff control system, monitoring wells, and ancillary support facilities. The primary objective of the concept design is to eliminate leachate from the waste cells and provide the maximum possible protection to the environment (particularly ground water) and human health.

The earthen type waste cell was selected from evaluation of several waste cell types because it (1) can utilize the lowest permeability liners available; (2) is flexible with regard to location; and (3) can be constructed with common earthmoving equipment and procedures.

Primary evaluation/design criteria on which the facility concept design was based are as follows:

- o Use multiple waste cells.
- o Cover the waste cells during operation to minimize generation of leachate from direct precipitation.
- o Use multiple liners in the waste cell liner/leachate system.
- o Construct the leachate control system at grade, utilizing gravity drainage.

The landfill facility concept design has six waste cells (each about 5 acres in size) located on a 120 acre site. Six cells were determined to

be a realistic number for operation of the facility and for an individual cell size which can be covered during operation. The cells are located generally on the existing ground surface except for some site grading, excavation and filling. The facility was conceptually designed to be operational for about four years which includes a three-year period of waste disposal and one-half year periods for both initial facility development and final facility decontamination and cleanup. Each of the waste cells will be operational for six months under this concept design.

Other aspects of the facility which were conceptually designed are a 40 by 40 feet permanent administration building; personnel decontamination/cleaning trailers; "clean" versus "contaminated" zones; and a surface water runoff control system.

Four alternative methods for hauling the waste from the solidification facility and Basin F to the landfill facility were evaluated. The alternative considered most suitable is a haul road which is considered contaminated and will be removed (when waste placement is completed) and placed in a waste cell. The primary advantage of this alternative was the elimination of operational procedures, personnel and equipment involved in the other alternatives to maintain the haul road in an uncontaminated condition.

The waste cell concept design is a 250 foot wide by 880 feet long cell with a waste height of 25 feet, 4H:1V side slopes and a side slope bench. During development and operation, the cells will be covered with an air-supported type building 320 feet wide by 990 feet long. The cell bottoms will slope at four percent across the width so that any leachate generated will drain by gravity from the cells.

The liner/leachate system is a "sawtooth" type shape with four percent slopes to collect potential leachate into the collection pipes for rapid removal from the cell. The system includes three liners: two 100 mil HDPE (high density polyethylene) synthetics and a single two-foot thick compacted clay liner. Leachate collection and leak detection layers are located on top of the two synthetic liners.

The cover system is a triple lined system to meet regulations requiring the cover system to have a permeability equal to or lower than the liner/leachate system. The cover system includes two 100 mil HDPE synthetic liners, and a single two-foot thick compacted clay liner, a vented gas collection layer, drainage layer, and a soil cap.

The leachate control system consists of secondary containment collection pipes, a compacted clay "bulkhead" for additional protection against leakage, at-grade lined steel collection tanks underlain by an HDPE liner, and collection sumps. If generated, leachate will drain by gravity from the waste cells to the tanks.

The concept facility design total estimated cost for construction/capital items and operation and maintenance during the estimated four year active facility life is about \$26 million. This cost includes six waste cells at about \$3 million each and operation and maintenance costs of about \$400,000 per year for the four year period. The estimated closure and post-closure operation and maintenance costs are about \$110,000 and \$50,000 per year, respectively.

2.0 FACILITY CONCEPT DESIGN FACTORS

Facility concept design factors include site area characteristics, waste material characteristics, waste cell type, location and liner evaluations, and specified design criteria. The most suitable type of cell, its location and type of liners were determined. The following sections discuss site area characteristics, waste material characteristics, waste cell evaluations, the design criteria and the selected general landfill facility concept design.

2.1 SITE AREA

2.1.1 Selection Methodology

The site area was determined by the site selection study (WES, 1983b) from evaluation of the entire RMA. The site area is shown in Figures 1 and 2. Site evaluation criteria used in the WES, 1983b study were as follows:

- o Site must be at least one mile from the RMA boundary.
- o Depth to the ground water table must be at least 40 feet.
- o Site must not be underlain by saturated alluvium.
- o Site must be outside the standard project floodplain (100-yr.) limits.
- o Depth to bedrock must be less than 30 feet.
- o Site must not be underlain by sand channels in the top of bedrock.

Application of these six criteria to RMA resulted in the identification of two areas which met the criteria. Both of the acceptable areas were investigated by subsurface boring programs and the area shown in Figures 1 and 2 was determined to be the most suitable. The second area was located about one-quarter mile north of the area used in this program.

2.1.2 Site Area Characteristics

The original site area covered about 40 acres. It is located on a topographic high or hill resulting in ground surface relief of about 50 feet over the site area (see Figure 2). Minor excavation of soils for activities at RMA may have been conducted after the topographic map shown in Figure 2 (dated 1978) was made. Therefore, the current topography may be slightly different and lower around the top of the hill than as shown in Figure 2. However, for purposes of this project the possible differences in topography were not considered critical and the area was not resurveyed.

Geologic conditions in the site area are presented in cross-section in Figure 3. The stratigraphy consists of the following units:

- o Residual/Alluvial Soils - Silty sands, sandy silts and caliche materials varying from 3 to 20 feet thick.
- o Clayshale - 0 to 15 feet thick.
- o Silty Sandstone - 0 to 15 feet thick.
- o Clayshale - 0 to 15 feet thick.

The bedrock units have been eroded by alluvial channels and subcrop as indicated in Cross-Section A-A' (see Figure 3). Structurally, the bedrock dips at about 1 foot per 100 feet to the southeast.

The ground water table is about 35 to 45 feet below the ground surface (see Figure 3). It is located in the bedrock, in the site area, and in the alluvium-filled channels west of the site. The site area is a ground water recharge area which means precipitation infiltrates to the ground water table (WES, 1983b). Therefore, the flow of ground water is generally away from the site in all directions. A perched water table located on top of the upper clayshale unit was also detected in Well N-5 (see Figure 3).

A potential contamination site is located partially within the site area. Site 36-7, shown in Figure 2, is identified in the report "Decontamination Assessment for Lands and Facilities at RMA", prepared by the Contamination Control Program Management Team (CCPMT, 1984). The site includes sanitary disposal sites and Shell Chemical Company disposal sites which may contain organic, inorganic, and heavy metals contamination.

2.2 WASTE MATERIAL CHARACTERISTICS

Waste materials which are proposed to be placed in the disposal cells include solidified liquids, overburden, soils and other contaminated debris from Basin F. Material volumes were estimated in the "Selection of a Contamination Control Strategy for RMA" report (CCPMT, 1983). The estimated volumes are as follows:

- o Solidified liquids - 78,000 cubic yards.
- o Overburden from within Basin F (solidified) - 290,000 cubic yards.
- o Contaminated soils from beneath and around Basin F - 164,000 cubic yards

The estimated total volume of waste is 532,000 cubic yards. The liquid will be pumped from Basin F to a solidification process facility which is currently proposed to be located on the east side of Basin F (see Figure 2). At the solidification facility the liquid will be solidified by mixing with materials such as kiln dust, fly ash, soil, and possibly some chemical additives. Various solidification mixes have been tested and evaluated in a laboratory-scale testing program conducted by Waterways Experiment Station personnel (WES, 1983a). Additional testing is planned before a specific mix formula or specification for the solidified material is defined.

The solidified liquid mixture typically undergoes a curing process involving hydration or chemical reaction of the additives with the liquids. For the mixtures which were tested, the majority of the curing process occurred in about one to three days. A small amount of curing continued up to 28 days. Typical characteristics of the cured, solidified liquid are as follows:

- o Passed the EP toxicity test.
- o Bulk weight of 80 to 100 pounds per cubic foot.
- o Permeability of 10^{-4} to 10^{-6} centimeters per second.
- o Ammonia gas generated during mixing and curing.
- o If leachate is generated, it will be high in pH, total organic carbon and specific conductance, and contain chloride, arsenic and copper.

Overburden from within Basin F includes sediment, sludge, soil cover placed over the liner and the liner itself. The liner is an asphaltic material about 3/8 inches thick. During excavation, it will be broken up and mixed with the other overburden materials. The overburden is expected to be solidified with kiln dust, 25 percent by volume, to eliminate any free liquid and make the material easier to handle.

The soils underlying Basin F are fine grained alluvial soils, composed predominately of clays, silts, and sandy silts (USCS designation CL, ML and SM). Soils which are determined to be contaminated will be excavated, solidified (if necessary) and hauled to the landfill facility.

2.3 WASTE CELL EVALUATION

Evaluation of the waste cell type, location and type of liners was performed in a series of steps. First, waste cell types were evaluated and the most suitable type selected. Second, waste cell location alternatives (above, below or above/below grade) were evaluated with

regard to the selected cell type. Third, types of liners were evaluated with regard to the selected cell type. In the second and third steps, the most suitable alternative(s) were also identified. Fourth, the types and location selected in steps one through three were combined and a general concept design for the facility developed.

2.3.1 Type of Waste Cell

Three waste cell types were evaluated for suitability to this project: an earthen cell, a reinforced concrete cell, and a slurry trench cell. Evaluation factors are provided in Table 1 and included consideration of the type of liner(s), location, shape, and economics. Based on evaluation of the information in Table 1 (overall suitability) the earthen type waste cell was determined to be the most suitable for the landfill facility. Reasons for selection of the earthen type are summarized below:

- o The earthen type is most flexible with regard to location and type of liner. The lowest permeability type of liners available can be used with this cell type.
- o Common earth construction equipment and methods are used.
- o Construction costs are lower than for the other types.

2.3.2 Location of Waste Cell

Three locations of an earthen type waste cell relative to the ground surface were evaluated: above grade, below grade, and above/below grade. Factors evaluated with regard to the location were distance of the waste from the ground water table, economics, construction, maintenance, long-term integrity, long-term accessibility and aesthetics. Discussion of each evaluation factor is presented in Table 2.

Both the above and above/below grade alternatives were considered most suitable for this facility concept design. Below grade was eliminated

because it does not fit well into the site topography and would place the wastes nearer the ground water table. The above grade alternative was considered more suitable than the above/below grade location because it maximizes the distance of the waste above the ground water table.

2.3.3 Type of Waste Cell Liner

Three types of liners were evaluated for use in the waste cell: clay, synthetic, and soil-cement. Evaluation factors considered were permeability, leachate compatibility, integrity (long and short term), construction, and economics. Discussion of these factors and overall suitability of each liner type is provided in Table 3.

Both clay and synthetic liner types were considered suitable for this waste cell concept design. A soil-cement liner was not considered suitable because it has a higher permeability, is more expensive and is not a well proven technology for use in hazardous waste disposal facilities.

The clay and synthetic types were considered suitable, but with certain restrictions. A synthetic liner was considered the most suitable for the upper liner in a multiple liner system because it is more resistant to concentrated leachate. Clay material was considered more suitable than a synthetic for the lower liner because clays are known to have a better long-term life than synthetics. Clay is naturally self-healing and will maintain a low permeability indefinitely. Synthetics may deteriorate with time since they are man-made materials. Field seams may be particular long-term integrity weak points. The useful life of synthetics is not well known because they are relatively new and long-term installation case histories are not available.

However, some clays are also known to be affected by selected chemicals. Clay minerals may be altered by contact with chemical compounds and result in significant increases in permeability.

Therefore, the compatibility of the clay minerals in a clay liner material with expected leachate from the waste must be evaluated as part of a clay liner final design.

2.4 EVALUATION/DESIGN CRITERIA

Evaluation and design criteria used in developing the facility concept design were based on input from the Army and applicable regulations. The criteria considered areas as follows:

o Army Criteria

- Use the facility site selected by the WES (1983b) study (see Section 2.1)
- Total estimated waste volume for disposal is 532,000 cubic yards.
- Eliminate, to the maximum extent possible, liquid from the waste cells. To facilitate this goal, use a cover over the cells to prevent direct precipitation in the cells.
- Evaluate use of multiple waste cells (2 or more).
- Use multiple liners in the cell liner/leachate system with a "sawtooth" type configuration for added potential leak containment and ground water protection.
- Evaluate use of gravity type leachate collection systems with above ground collection tanks.
- Provide support building(s) for administration, visitors, and personnel management.
- Potential contamination Site 36-7 will be removed prior to facility construction.

o Regulatory Criteria

- Locate liner/leachate system above the ground water table [40 CFR §264.302(a)(1)].
- Provide a leachate collection system located on top of the upper liner [40 CFR §264.302 (a)(4)].
- Provide a leak detection system located between the upper and lower liners [40 CFR §264.302 (a)(3)].
- The leachate collection system must be designed so the maximum leachate head acting on the liner is one foot [40 CFR §264.301 (a)(2)].
- Cover system permeability must be less than or equal to the liner/leachate system permeability [40 CFR §264.310(a)(5)].

The above noted Army criteria were considered as given conditions in the concept design. The criteria were reviewed, evaluated, and determined to be appropriate.

The regulatory criteria are RCRA regulations 40 CFR Part 264, Subpart N - Landfills. Most of the RCRA regulations are given as performance standards which were not cited above, but were considered in the concept design.

Regulations governing hazardous waste disposal have also been promulgated by the State of Colorado, Department of Health (CDH, 1981; CDH, 1983). The rules and regulations (CDH, 1983) specify requirements for siting hazardous waste disposal sites. These requirements are generally presented in the form of performance criteria or standards to insure that disposal sites meet certain minimum conditions. One specific criteria which is included in the rules and regulations is a disposal site (including the landfill design) shall provide reasonable assurance that the waste will be isolated within the disposal site and away from

natural environmental pathways which could result in exposure to the public for 1,000 years. This requirement has been addressed for the concept design by the Army criteria identified above which will prevent to the maximum extent possible (1) the generation of leachate, and (2) the potential for contamination of ground water through the use of multiple containment liners. As part of the final landfill facility design, the containment life of the waste cell should be determined based upon final waste material characteristics, waste cell design (liner/leachate and cover systems) and detailed facility site subsurface characteristics. Factors such as permeability, thickness, and/or sequence of the liner/leachate and cover system layers, may need to be modified to meet the 1,000 year containment requirement.

The CDH, 1983, regulations specify design criteria applicable to hazardous waste management. These regulations define the state program equivalent to the federal RCRA regulations cited above. These regulations are not yet in force and the management of hazardous waste in Colorado are still regulated by the EPA. However, the CDH regulations were reviewed to determine differences which could affect the facility design. Only a few, minor differences exist between the RCRA and CDH regulations in relation to landfills. These differences do not significantly affect the facility design.

2.5 GENERAL LANDFILL FACILITY CONCEPT DESIGN

Based on the factors discussed in Section 2.3 and the evaluation/design criteria provided in Section 2.4, the general landfill facility concept design was developed. The general concept design is as follows:

- o Use a total waste volume of 600,000 cubic yards for concept design. This volume is about 110 percent of the estimated total volume (see Section 2.2) and provides additional capacity for extra waste volumes.
- o Use multiple (2 or more) waste cells.

- o Use earthen type (truncated prism) waste cells located at and above the ground surface.
- o Use multiple liners in the liner/leachate system with gravity drainage of leachate. Synthetic liners are most suitable for the upper liner(s) and clay for the lower liner.
- o Use a building to cover the waste cell during construction and filling operation.
- o Assume that the potential contamination Site 36-7 has been removed.
- o Provide a support building for administration, visitors, and personnel management.

3.0 FACILITY CONCEPT DESIGN

The landfill facility concept design includes the waste cells, haul and access roads, support buildings, surface water control system, security fencing and ground water monitoring wells. The primary component affecting the concept design is the size and number of waste cells and their location. The other components were conceptually designed after the waste cells were laid out.

Section 3.1 discusses the waste cell concept design. Section 3.2 discusses the determination of the number of waste cells and Section 3.3 discusses the facility concept design. The concept design discussion includes the layout, operation, support buildings, surface water control system, and waste transportation alternatives for the facility.

3.1 WASTE CELL CONCEPT DESIGN

The waste cell concept design was based on the design criteria and evaluation of the waste cell size, side slope angle and waste height. The design criteria were presented in Section 2.4 and the evaluations of the other considerations are provided in the following sections.

The length of each waste cell was determined by consideration of the number of cells in the facility. The number of cells was determined by evaluation of operational and siting features as discussed in Section 3.2.

3.1.1 Waste Cell Size, Shape, and Number Relationship

The relationship between the number of waste cells and their size and shape was evaluated. For a total waste volume of 600,000 cubic yards (see Section 2.5), a definite relationship between the number of waste cells, the cell capacity and the cell size and shape exists. The results of this evaluation are shown as plots of waste height versus cell length for three different side slope angles and four to eight

total number of cells. Figures 4, 5, and 6 present the plots for cell widths of 200, 250 and 300 feet, respectively. Definition of the variables and the capacity of each cell for the range of number of cells evaluated is given in Figure 7. The plots covered the range of cell widths which reflected the cell building sizes available.

Analysis of the plots in Figures 4, 5, and 6 illustrates the effects of the side slope angle of the waste, waste height, cell width, and number of cells on the length of the waste cell. For example, with a cell width of 200 feet (see Figure 4), the cell length is greater than 1000 feet in all cases except for 6 or more cells and 3H:1V side slopes.

3.1.2 Cell Width

The concept design cell width was based on the cell building widths available and the liner/leachate system concept design. Several types of buildings were evaluated with regard to suitability for the landfill facility. Table 4 summarizes the building types and their pertinent characteristics. The width of the building was determined to be the critical dimension in determining the available size of the building. Typically, the buildings are designed in sections with a specific length and width. The total building length can be specified as a multiple of the section length, so theoretically, there is no limit to the total building length. However, each building section is specifically designed for a fixed width.

Based on the building characteristics presented in Table 4, an air-supported type building was determined, for the concept design, to be the most suitable type for covering for the waste cells. The primary determining characteristics were the available building width and portability. The building width considered appropriate was between 200 to 400 feet based on general design considerations. However, the building width specified in the concept design also includes a requirement for working room around the cell.

Another aspect pertinent to the facility design which became apparent from the building evaluation was that the building would probably be a custom designed structure. Therefore, to optimize the investment it was decided that all the waste cells should be the same width to fully utilize the selected building(s).

The liner/leachate system design is discussed in detail in Section 4.3. The system design factor which is critical to determination of the overall cell width is the length of synthetic liner panels available. For the liner/leachate system concept design, the length of the synthetic liner panels runs across the width of the cell. One of the advantages of the "sawtooth" liner/leachate system concept design is that leachate drains by gravity and does not collect on the seams between the synthetic liner panels. Therefore, to be consistent with this approach and to avoid placing a seam in the area where leachate may collect on the liner, the width of the waste cell was assumed to be equal to the maximum liner panel length.

The maximum panel length of the synthetic liners used in the liner/leachate system concept design varies from 250 to 600 feet depending on the manufacturer. The liner panels are produced as rolls and the length limit is based on the weight of the roll. A liner panel length of 250 feet was selected for use in the concept design for several reasons: this length is available from more than one supplier; a lighter weight roll will be easier to handle and place in the field since the liners will be placed by pulling the roll across the cell width to avoid rutting the bedding layer by driving equipment on the sloped surface; and this length is in the same range as the cell building widths available.

A cell width up to a maximum of about 350 feet (400 foot wide building with 50 foot working room allowance) could be used if only the building width factor was considered.

3.1.3 Waste Side Slope Angle

The angle and shape of the side slope on the waste pile is important with regard to ease of construction, stability, and long-term erosion protection of the cover system. The slope angle also affects the capacity of the waste cell as shown in Figures 4, 5, and 6.

Construction of a layered cover system is possible on a slope of about 3H:1V maximum. On slopes steeper than about 3H:1V, the cover materials would have to be spread by pushing up or down the slope and control would become difficult. Construction becomes easier as the slope angle decreases.

Stability of a layered cover system is a potential concern on slopes steeper than 3H:1V. The synthetic liners form smooth, planar, low-friction surfaces along which mass sliding of the cover materials could occur. As the slope angle decreases the potential for instability decreases.

Long-term erosion of side slope cover material was evaluated using the Universal Soil Loss Equation (USLE). Several components are considered in the USLE, however, for evaluation of the effect of the slope angle only the "LS" factor (slope length x slope angle) is critical. The effect of the slope angle and slope length on the "LS" factor was demonstrated by comparing this factor for slope angles of 3H:1V, 4H:1V and 5H:1V and slope lengths equivalent to a height of 25 feet. The "LS" factor was also determined for a bench located at one-half the height. The bench effectively reduces the slope length by one-half. The "LS" factor for slopes of 3H:1V, 4H:1V and 5H:1V both with and without a bench is as follows:

<u>SLOPE</u>	<u>NORMALIZED "LS" FACTORS</u>	
	<u>WITH BENCH</u>	<u>WITHOUT BENCH</u>
5H:1V	1.00	1.42
4H:1V	1.31	1.84
3H:1V	1.77	2.54

These "LS" factors are normalized to the value for a 5H:1V slope with a bench. The relative decrease in the "LS" factor from 3H:1V to 5H:1V slopes with a bench is 77 percent, and 112 percent on slopes without a bench. A lower "LS" factor indicates lower erosion rates. Comparison of the normalized "LS" factors also shows that the addition of a bench reduces the "LS" factor significantly more than simply lowering the slope angle. Finally, the comparison shows that the relative decrease in "LS" factor becomes less as the slope angle decreases. Considering the soil erosion rate only, the lower the slope angle and shorter the slope, the better.

Another consideration with regard to long-term stability is vegetation growth on the slope. Growth is inhibited on steeper slopes because of erosion and increased runoff versus infiltration. A slope angle of 4H:1V maximum is considered necessary to provide good vegetation growth and stability.

A side slope angle of 4H:1V with a bench was selected for use in the concept design because it will provide an acceptable vegetation growth surface, acceptable long term erosion (especially if vegetation is established and maintained), and easy cover construction. Also, the 4H:1V slope angle does not result in excessively long waste cells (see Figures 4, 5, and 6). Additional benches or other variations in the side slope may be specified based on final design cover system calculations using specific cover soil properties to determine the erosion rates. However, based on this concept design, a 4H:1V side slope with a single bench is suggested.

3.1.4 Waste Height

The waste height was determined based on the waste pile geometry and construction considerations. For a specified cell width and side slope angle, the maximum possible waste height is determined by the side slopes from both sides meeting at the top of the pile. Since construction equipment will be operating on top of the waste pile, a minimum waste pile top width of 20 feet was specified for safety. The maximum height possible, with a 20 foot top width minimum value, is shown by the curves in Figures 4, 5, and 6. For a cell width of 250 feet and side slope angle of 4H:1V, the maximum waste height is about 27 feet (see Figure 5). A value of 25 feet was used in the cell concept design.

3.2 NUMBER OF WASTE CELLS

The number of waste cells used in the facility concept design was based on consideration of operational factors and site characteristics. These considerations are discussed in Sections 3.2.1 and 3.2.2, respectively. Section 3.2.3 discusses three layouts with different numbers of cells and the selection of the most suitable number of cells for this concept facility design.

3.2.1 Operational Factors

Operational factors which have an effect on the number of waste cells include the sequence of cell construction, waste placement and covering, control of clean versus contaminated activities, weather conditions and the active life of the facility.

Evaluation of the above factors resulted in the following facility concept design aspects:

- o Concurrent construction of one cell while waste placement and covering are occurring in another cell.
- o Use of two buildings to cover two cells at all times during the active facility life.

- o Use of two crews of construction personnel and equipment, with one performing "clean" activities, and the other "contaminated" activities.
- o Completion of two waste cells per year.
- o Concept facility design with four, five or six waste cells.

The basis for determining each of the above aspects is discussed in the following paragraphs.

The sequence of waste cell construction, waste placement, and waste cell covering was evaluated to assess the effect on the number of waste cells. It was assumed for the concept design that these activities occur concurrently with the sequence moving from cell to cell. Sequencing in this manner will permit continual placement of waste, operation of the solidification facility, and excavation of waste from Basin F. Continual waste placement should result in minimizing the time required for closure of Basin F and operation of the landfill facility. Also, the need for double handling of excavated materials should be minimized by using material excavated for site grading from a future cell area as soil cover (if suitable) on a cell being completed. Sequencing in this manner requires that a new cell be complete and ready to receive waste as soon as the active cell is filled. The use of two buildings is necessary using this approach.

Also, it was determined that two buildings would be desirable for several other reasons. The criterion to totally eliminate liquid from the waste cell (see Section 2.4) would be achieved more fully by constructing the liner/leachate and cover systems within the building, thereby preventing possible saturation of these systems from direct precipitation. Also, construction of the systems would be enhanced and the quality improved by construction within the building. The compacted clay layers would not be subject to rapid drying and cracking from

direct sunlight and the synthetic liners would be seamed in a more controlled environment.

Control of "clean" versus "contaminated" operations is desirable to prevent uncontrolled contamination of areas outside the waste cell limits. Operations which will be required to be performed using clean materials, equipment, and personnel include: site grading and construction of the liner/leachate, cover, and leachate control systems. These "clean" activities will be conducted in one covered cell concurrent with waste placement in the other covered cell. For the concurrent performance of the "clean" activities and "contaminated" activity (waste placement), two crews of personnel and equipment will be necessary.

Completion of two waste cells per year was determined based upon (a) weather related construction constraints; and (b) the more efficient use of personnel. Consideration of the potential for severe winter weather, i.e., freezing temperatures and heavy snowfalls (precipitation), resulted in the conclusion that only one or two building moves should be planned per year. The building moves relate directly to the completion of a cell, so one or two cell completions per year were considered appropriate based on weather related considerations. Utilization of the "clean" crew will be enhanced with two versus one cell completions per year. The activities performed by the "clean" crew (as discussed above) were estimated to require about four to six months per cell. Therefore, the "clean" crew would be occupied on a nearly full-time basis with the two cell per year plan.

A four, five or six cell facility concept design was determined to be appropriate based on the above factors and an estimated active facility life of two to three years (e.g., two cells per year for 2, 2-1/2 or 3 years).

3.2.2 Site Conditions

The landfill site location is provided in Figure 2. Site conditions which affect the number of waste cells are the size of the site and existing topography. Site characteristics were discussed in Section 2.1. Layout of the waste cells utilized the existing topography as much as possible to minimize the required amount of site grading earthwork. The topography slopes from the topographic high to all directions therefore, the cells were located to take maximum advantage of the existing slopes.

The site originally identified is about 40 acres in size (see Section 2.1). Based on evaluations of cell size versus capacity (see Section 3.1.1) and the criterion of multiple cells, it was considered probable that additional area outside the original site boundary would be required to locate the waste cells. The limit of the lower clayshale unit was selected to provide a larger site for facility layout, as necessary.

The limit of the lower clayshale unit is shown in Figure 2, in plan and in Figure 3, in section. The rationale used in selecting this boundary was the assumption that the clayshale will provide a low permeability layer which would slow the movement of a potential leak away from the facility. The integrity and in situ permeability of the lower clayshale unit must be investigated during the final design program to determine if this assumption is valid. Placement of waste cells above the lower clayshale unit also avoids the alluvial channel deposits located to the west and south of the site. The channel deposits have a much higher permeability than the bedrock units.

3.2.3 Layout Evaluation

Based on the considerations discussed in the preceding sections, layouts of four, five and six waste cell landfill facilities were prepared. The cell sizes for each layout were based on the concept waste cell design

discussed in Section 3.1 and a cell length determined from Figure 5, for the appropriate number of cells.

The proposed waste cell layouts are shown in Figures 8, 9 and 10 for four, five and six cells, respectively. The waste cell areas shown in these figures include allowances for working room inside the building and for the leachate control system located along the downslope side of each cell. The layouts were prepared with regard to the site conditions discussed above. The three layouts illustrate the size of the facility required for multiple cells. It is apparent that as the number of cells increases, the site area required for the facility increases because of the need for access between the cells and the existing topography.

The six waste cell facility layout was selected as the most suitable for concept design because the shorter cells may require less site grading earthwork and greater flexibility in operation is provided with more cells. Also, the cell capacity of 100,000 cubic yards for a six cell plan (see Figure 7) is closer to the estimated volume of waste liquid (see Section 2.2).

The six cell layout was selected to use in this concept facility design. However, for final design facility layouts with either four, five, six or more cells should still be evaluated in detail.

3.3 CONCEPT DESIGN

The concept design for the six cell landfill facility is shown in plan view in Figure 11 and in a perspective view in Figure 12. Components of the design including the layout, operation, surface water control system, support buildings, and ground water monitoring wells are discussed in the following sections. Alternative methods of waste transportation to the facility are discussed in Section 3.3.6. Waste cell concept design details are discussed in Chapter 4.

The facility concept design was prepared to illustrate a layout for the landfill facility. The concept design is not necessarily the optimum waste cell layout. Additional site investigation and facility design/operations evaluations are necessary to optimize the final facility design.

3.3.1 Layout

The concept facility layout (Figure 11) shows the location of the six waste cells, site grading, major haul roads, surface water runoff and runoff control ditches and ponds, and the support buildings. The proposed facility area (within the security fence) is about 120 acres, extending beyond the original site boundary primarily along the north side by about 700 to 1,000 feet. The dimensions of each waste cell are about 1,000 feet long by 400 feet wide (about 9 acres) including the access roads and leachate control system for each cell. The dimensions of the actual waste pile are only 250 by 880 feet or about 5 acres. Therefore, only about 25 percent (30 acres) of the total proposed facility area will actually contain waste.

The cells were generally laid out to slope in the same direction as the existing topography to reduce site grading needs. Each cell area will be graded at a four percent slope across its width. The elevations shown around the cells in Figure 11 correspond to the surface formed by the bottom of the waste pile. Since the slope of the existing topography varies from about three to greater than 15 percent, considerable site grading will be required to prepare the cell areas. During final design attention should be given to soil material quality and design requirements and where possible a balanced cut and fill should be developed.

Cells 1, 3, 4, and 6 were located with the downslope side of the cell at or near the existing ground surface, while Cells 2 and 5 are excavated below the existing ground surface along their downslope side. Cells 2

and 5 were located in this manner to avoid the need for extensive fills to bring existing ground surface up to the required grade. Cells 3, 4, 5 and 6 are predominantly located mostly on fills above the existing ground surface while Cells 1 and 2 are located on cuts below the existing ground surface. The depth of excavation required is minimal, placing only portions of Cells 1 and 2 in the upper clayshale bedrock unit (see Figure 3). It is likely that borrow material would be required to construct the site grading shown in Figure 11. The material characteristics are not critical and fine grained soils available elsewhere on RMA will be suitable. The fills constructed for site grading should be compacted to provide a stable foundation for the waste cells.

About 11,000 feet of major haul roads, shown in Figure 11, provide access to each cell for construction, waste placement, and covering. A typical haul road section is shown in Figure 13. The haul road from the solidification facility is proposed to enter the landfill facility at the northwest corner. This road is about 4,000 feet long and is considered contaminated, as discussed in Section 3.3.6. A separate entrance for hauling clean materials (liner/leachate, cover, and leachate control system materials) is also proposed. The entrances are located near each other for easier monitoring of activities. The haul roads were laid out to provide "clean" and "contaminated" access routes to each cell. The sequence of operation and control of "clean" and "contaminated" areas is discussed in Section 3.3.2.

The support buildings are located between the haul road entrances to facilitate monitoring the facility operations. Areas for vehicle parking outside the facility and equipment parking inside the facility, are also shown.

The major surface water runoff control ditches and collection ponds are located, mostly, along the outside of the haul roads to control runoff from the entire facility and roads.

The purpose of the facility fence, with gates only on the haul roads, is to limit or restrict access.

3.3.2 Operation

A general operations plan and related procedures for the active facility life were developed based on the concept design shown in Figures 11 and 12 and factors discussed in Section 3.2.1. The following paragraphs discuss the facility operations plan, waste cell construction, waste placement, and covering procedures, and personnel health and safety procedures.

The facility operations plan for the active life includes the sequence of facility development, a schedule of development and "clean" versus "contaminated" area controls. The sequence and schedule of facility development is shown in Table 5. The sequence of waste cell development is indicated on Figure 11 by the cell numbers. Initial facility development (see Table 5) includes general site grading, surface water control system construction, support building construction (with utilities), ground water monitoring well installation, Cell 1 construction, initial haul road construction, and security fence installation. The initial facility development activities will be "clean" activities conducted prior to any waste placement.

After initial facility development, the sequence of waste cell construction will continue and waste placement and covering will commence. This sequence is presented in Table 5 for the concept design. The "clean" crew will perform site grading, cell construction, cell building moves, and cell covering activities. The "contaminated" crew will place waste in the active cell. The sequence of waste cell operation was developed with a strong emphasis on controlling and minimizing the area or zone of the facility considered contaminated. The "contaminated" zone was considered the active cell and haul roads used to transport waste to the

active cell. Table 5 identifies the "contaminated" zone and how it changes during the facility operation. The direction of access to each cell for the "clean" and "contaminated" activities is also shown in Table 5.

The operating sequence allows hauling "clean" cell construction and cover materials over roads which are not used for hauling waste. During the facility operation, some haul roads will be decontaminated (see Table 5) after waste hauling over these roads is completed. Temporary barriers will be erected across the roads at a few locations to prevent travel on "clean" roads by "contaminated" equipment and visa versa.

An illustration of the sequence of waste cell construction, waste placement and covering for Years 1.0 through 1.5 (see Table 5) follows:

- o "Contaminated" crew completes waste placement in Cell 2 (into the west end) and moves its operation to Cell 3 (hauling into the east end).
- o "Clean" crew decontaminates the haul road used for waste hauling along the west side of Cells 1, 2, and 4 by testing the road surface and scraping off contaminated areas. "Contaminated" road material placed in Cell 2. A barrier is erected on the north end of the road.
- o "Clean" crew places cover on Cell 2 from the west end. Materials are hauled on clean roads. Soil cover hauled from soil stockpiled from Cell 1 and 2 excavations, if available. Otherwise, soil is hauled from off-site borrow areas.
- o "Clean" crew completes site grading in Cell 4 area, hauling in fill material from off-site borrow area.
- o "Clean" crew moves building from Cell 2 to 4.
- o "Clean" crew constructs liner/leachate system and leachate control system for Cell 4.

Equipment for the "contaminated" crew will probably include four or five haul trucks (20-ton), a bulldozer, a compactor and a pickup truck. Personnel will include equipment operators (six to seven) and one laborer setting grade stakes on the waste pile fill. Equipment for the "clean" crew will include probably two or three scrapers (for site grading, and clay and soil borrow excavating and hauling), two or three haul trucks (for sand and gravel hauling and possibly clay and/or soil if borrow areas are distant), a grader, a front end loader, a bulldozer, a compactor, and a pickup truck. Personnel will include equipment operators (five or six) and operator/laborers (five to six). The "clean" crew activities are varied and not all the equipment will be operating for any one activity. Also, several of the activities will require hand labor (e.g., liner, fabric, and pipe installation), therefore, the "clean" crew personnel will be required to perform laborer tasks and operate equipment.

A comprehensive health and safety program will be required as part of the facility operation. The program will include at a minimum training in decontamination and emergency response procedures and personnel physicals. A health and safety officer will be necessary to manage this program. All personnel working at the facility should be required to have the training and physicals.

Both "contaminated" and "clean" crew personnel will be required to use specified decontamination procedures and wear protective clothing (boots, gloves, coveralls). In addition, "contaminated" crew personnel will probably be required to wear respirators or possibly self contained breathing apparatus (SCBA's) while working inside the cell buildings. If SCBA's are required, then the equipment will be supplied with air bottles and possibly sealed cabs. SCBA's may be required for safety because of the characteristics of the waste, even though the building will be ventilated. The amount of personnel protection necessary will need to be determined during final design and actual conduct of the project (through monitoring).

"Clean" crew personnel may be required to wear the same amount of protection as the "contaminated" crew while removing the contaminated road areas. Otherwise, it is anticipated that the "clean" crew will only be required to wear protective clothing.

Post-closure activities after completion of waste placement will also be necessary. These post-closure operations will involve maintenance of the facility including waste cell covers (soil and vegetation) drainage ditches and access roads, and the leachate control systems.

3.3.3 Surface Water Control System

Surface water control of runoff to the facility and runoff from the facility is required under RCRA and CDH regulations. Control of surface water from a 25-year storm is required by RCRA and from a 100-year storm by CDH (CDH, 1983).

Runoff control will be provided by diversion of surface flows which would otherwise naturally flow overland onto the facility area. For the concept design, diversion ditches and site grading are used to either collect and divert water around the facility or redirect the flow of water away from the facility. Diversion ditches and the site grading are shown in Figure 11.

For the concept design, runoff control of water from within the facility area is achieved by ditches and collection ponds. The runoff water is considered contaminated since some contact with waste materials during operations is possible. As areas of the facility are decontaminated with the sequenced waste cell construction, operation, and covering (see Table 5), the likelihood for contamination will become even lower.

Runoff water is collected in ditches located along the haul roads, as shown in Figure 11. These ditches route the water to three ponds

located around the facility (see Figure 11). Three ponds are required because the existing topography slopes in all directions. A cross-section through a typical pond is shown in Figure 13. The ponds are designed with a synthetic liner and a leak detection and collection system to minimize the potential for leakage moving away from the pond if a leak were to occur.

For the concept design, the runoff water will be held in the collection ponds and evaporated. If the level in the ponds increases to the maximum design storage level, then the water will be removed. The water will be tested prior to removal and if the tests indicate it is not contaminated, which is likely, then the water would be pumped out of the pond into the nearest natural drainage. If the water is contaminated, then it would be pumped into a tanker truck and hauled to either the solidification plant or to an off-site, licensed facility for treatment and disposal.

The ponds will be removed as part of facility closure after completion of waste placement. The areas will be first tested. If found to be contaminated the pond liners and related materials will be placed in Cell 6 and the areas will be backfilled after test results indicate that there is no remaining contamination. The ditches will also be checked and decontaminated, as necessary. Generally, however, the ditches will remain in place to control surface drainage on the facility.

3.3.4 Support Buildings

Support buildings included in the concept design are a permanent administration building and temporary personnel decontamination/cleaning trailers. These buildings are located in the northwest corner of the facility, as shown in Figures 11 and 12. The administration building will be a one story pre-engineered metal building, conceptually, about 40 x 40 feet in plan, on a concrete floor slab with utilities (electricity, water, heat, air-conditioning, telephones). This building will

function as the control center for landfill operations. The building will contain the following:

- o Reception area.
- o Offices for the facility manager, health and safety director, and security guards.
- o Meeting room for personnel training and orientation.
- o Storage for health and safety equipment.

Access to the landfill facility will be controlled by requiring passage through the building. Access through the "clean" gate south of the building will be by vehicle only and will be controlled by the security guards. The administration building will remain after closure of the landfill. It will function primarily as a security office and also support maintenance and monitoring activities ongoing during the post-closure period.

The personnel decontamination/cleaning trailers will contain the facilities for removing contaminated work clothes, cleaning and dressing in street clothes. Three trailers about 12 x 40 feet each connected with covered walkways are included in the concept design. The clean trailer (southern trailer in Figure 11) will contain lockers for street clothes. The middle trailer will contain showers, sinks, and toilets. The decontamination trailer (northern trailer in Figure 11) will contain lockers for worker equipment (coveralls, boots, hard hats) and supplies of disposable equipment (gloves, coveralls). Personnel entering the facility will change out of their street clothes in the clean trailer, move through the middle trailer into the decontamination trailer where they will put on work coveralls, boots, gloves, etc. When workers leave the facility, they will remove work clothes in the decontamination trailer (placing boots, etc. in lockers and disposing of other items), move to the middle trailer for showering, and then to the clean trailer

for dressing in street clothes. All personnel entering or leaving the landfill facility will be required to go through this sequence for health and safety reasons.

The trailers will be supplied with utilities, and water from the showers and sinks will be held in a tank for analysis to determine if it is clean before releasing it to RMA's sewer system. If the water is contaminated, then it will be taken to the solidification facility or to a licensed an off-site facility for treatment and disposal. The trailers will be decontaminated and removed during closure of the landfill.

3.3.5 Monitor Wells

Monitor wells will be located around the facility to provide a means of monitoring ground water levels and to obtain water quality samples. Since the waste cells have triple liners, the facility is actually exempt from the ground water monitoring requirements (40 CFR Part 264, Subpart F). However, monitoring may be desirable as a matter of routine operation and facility safety. Existing wells may be suitable for use as monitoring wells. The existing and potential additional monitoring wells are shown in Figure 11. Any new wells will be drilled to and completed in the ground water table, about 30 to 40 feet deep, as shown in Figure 3.

3.3.6 Waste Hauling Alternatives

Four alternatives for hauling waste from the solidification facility or Basin F to the landfill facility were conceptually evaluated. The alternatives are as follows:

- o Alternative 1 -- Truck haul on a clean haul road and use truck washes.
- o Alternative 2 -- Truck haul on a clean haul road and use transfer stations.
- o Alternative 3 -- Truck haul on a contaminated haul road. Control of runoff, and final excava-

tion and disposal of the haul road in a waste cell will be required.

- o Alternative 4 — Conveyor transport with transfer stations.

More detailed descriptions including advantages and disadvantages of each alternative are presented in Table 6. Alternative 1 requires additional personnel to operate the truck washes, storage tanks or ponds for the wash water (contaminated) and probably treatment and/or disposal of some wash water. The 3,600 gallons of wash water per day (see Table 6) was estimated assuming 30, 20-ton truckloads per day. This rate of waste hauling would move 100,000 cubic yards (one cell volume for a six cell facility) in about six months.

Wash water from the truck washes would be stored either in tanks or a lined pond and recycled. Some water would be lost through evaporation and some would be contained in the sludge generated from washing. The estimated volume required to replace the lost water is about 300 to 400 gallons per day (approximately 10 percent). The sludge (settled solids and water) would require solidification and placement in a waste cell. The need to operate the truck washes and handle the sludge are considered significant disadvantages of this alternative. Also, it is likely that during closure cleanup, the haul road would need to be closely examined and tested to insure that it was not contaminated.

Alternative 2 requires additional personnel and equipment to double-handle the waste from the transfer station to the waste cells. The transfer stations would be covered to protect the waste from precipitation and would have runoff controls. The additional handling, equipment, and personnel required for this alternative are considered significant disadvantages. As with Alternative 1, it is likely that during closure, close examination and testing of the haul road would be required.

Alternative 3 requires construction and operation of runoff collection ditches and pond(s) along the haul road, final excavation of the haul road and ponds, and disposal in a waste cell. The estimated 20,000 cubic yards (see Table 6) of material was based on a haul road 4,000 feet long, 40 feet wide and 3 feet thick and 2,000 cubic yards for a collection pond. The volume of material is not considered a significant amount and could be handled by the "clean" crew and/or the crew performing the Basin F excavation.

Alternative 4 would require the capital cost for a conveyor, conveyor maintenance, transfer stations, runoff controls along the conveyor and final cleanup along the conveyor route. The estimated rate of material movement, 600 tons per day (30, 20-ton truckloads) is relatively low for a typical conveyor operation. This alternative is not considered attractive because of the capital cost and cleanup required.

Alternative 3, the use of a contaminated haul road, is considered the most attractive alternative because it requires no additional operating personnel, equipment, or handling of the waste. The haul road route and collection pond location for this alternative are shown in Figure 2. The route would also be fenced along its entire length to restrict access.

4.0 WASTE CELL CONCEPT DESIGN DETAILS

The waste cell concept design details were developed with consideration of the design criteria presented in Section 2.4 and construction, chemical compatibility, and operation considerations. The concept design of the waste cell was presented in Section 3.1. This chapter presents details of the following components of a waste cell:

- o Cell Building
- o Liner/Leachate System
- o Cover System
- o Leachate Control System

4.1 WASTE CELL DESCRIPTION

The waste cell concept design is shown in Figure 14. The proposed cell design is 250 feet wide by 880 feet long with waste 25 feet high. Determination of the size and shape of the cell was discussed in Section 3.1. The liner/leachate system is a "sawtooth" shape, triple liner, multiple layer system with an overall thickness of about five feet. It is designed with a four percent slope across the cell width to drain any potential leachate from the waste by gravity and meet the design criteria (see Section 2.4). The cover system is also a triple liner, multiple layer system with an overall thickness of about seven feet. The cover system will be constructed on top of the completed waste pile and tied into the liner/leachate system around the cell edges. Concept details illustrating how the liner/leachate system and cover system will meet at the cell edges are provided in Figures 15 and 16.

The leachate control system is located along the downslope side of the cell. It will collect and contain any leachate which may be collected in the liner/leachate system. The leachate control system consists of tanks, pipes, leak protection liners, and sumps which were conceptually designed to safely carry leachate out of the cell. Monitoring and maintenance considerations were also included in development of the

concept design. The conceptual layout of the leachate control system is shown in Figure 16.

4.2 CELL BUILDING

As discussed in Section 3.1, the building selected to enclose the waste cells is proposed to be an air supported structure. The conceptual sizing of the building is 990 feet long by 320 feet wide (see Figure 14). This size was based on the waste cell size and allowances for about 30 to 50 feet of working room inside the building between the active cell and the building wall. In addition to the canopy which forms the building, other components of the building include:

- o Vehicle access air lock doors located at both ends of the building. These doors allow construction equipment to move in and out of the building with controlled air loss.
- o Personnel access air lock doors and emergency exit doors. The access doors are a revolving type doors which control air losses from the building.
- o Foundation support consisting of either earth anchors or concrete ballast dead weights which are tied to the canopy cable system. The foundation provides anchorage to resist uplift forces which will be acting against the canopy.
- o Inflation system consisting of blowers which will maintain the canopy in an inflated condition. Emergency standby generators and blowers are also provided to backup the regular equipment if a breakdown or power failure occurs. The equipment will be skid mounted for easy movement from cell to cell. For coverage of the waste cell, the blowers will be oversized to accommodate the additional air volume changes required to minimize the buildup of vapors inside the building.
- o Heating equipment to heat the air blown into the building may be necessary to maintain a comfortable working environment and to melt snow which falls on the canopy. If snow is not removed, it

may collapse the canopy. The heating equipment could also be skid mounted.

- o Vents located in the roof and/or sides of the building may be required to remove vapors and allow air volume changes. The vent openings should be adjustable and interlocked to the cell inflation system so the vents close automatically if an inflation system equipment problem develops. During final design, it may be determined that adequate ventilation can be provided by leaving the vehicle access doors open.

The size and number of blowers required for maintaining the air supported building will probably be greater than normal because of the need for ventilation to prevent or minimize the accumulation of vapors in the building. Depending on the characteristics of the wastes (solidified and non-solidified), the building may be designed to have a complete air volume change every few minutes if vapors are generated rapidly. Detailed data on the waste materials and an economic evaluation of the cost for additional inflation equipment (capital and operation) versus having personnel work in self-contained breathing apparatus (SCBA's) should be performed as part of the final design. In addition, the expected nature of vapors should be evaluated relative to treatment or permitting requirements.

4.3 LINER/LEACHATE SYSTEM

The liner/leachate system concept design was based on the criteria discussed in Section 2.4 and the waste cell concept design presented in Section 3.1. The system concept design consists of three liners, two upper synthetic liners and one lower compacted clay liner; a leachate collection layer; and a leak detection layer. Three liners provide additional protection and redundancy against possible leachate movement away from the waste cells. The collection and detection layers are required by regulation (see Section 2.4). The following sections evaluate two types of systems and discuss, in detail, components of the concept design system.

4.3.1 Alternative System Evaluation

Alternative liner/leachate system configurations were evaluated as part of the concept design process. The two systems considered were the "sawtooth" and the "fishbone." The two systems are shown in Details C and E, Figure 15, respectively. The "sawtooth" type has v-shaped "sawtooths" to concentrate drainage of leachate by gravity flow. The "fishbone" type has leachate collection and leak detection layer pipe networks oriented in "fishbone" patterns to collect and carry the leachate by gravity flow. The "sawtooth type" was specified in the concept design (see Section 2.4). However, evaluation of the two alternatives was conducted to determine if this criterion was appropriate.

Advantages and disadvantages of the two systems are as follows:

- o Construction of the "sawtooth" type will be more difficult than the "fishbone" type because of the complex sloping surfaces. Placement of the liners will also be more difficult since the rolls may need to be pulled across the cell width to avoid causing ruts in the "sawtooth" surfaces.
- o The "sawtooth" type directs leachate away from liner seams; the "fishbone" type allows leachate to potentially come in contact with seam areas.
- o The "fishbone" type requires more pipe than the "sawtooth" type. The laterals on "fishbone" type piping networks are more difficult to maintain; the "sawtooth" pipes are single, straight lengths of pipe which could be cleaned out, if necessary.

For this project, the "sawtooth" type was determined to be the most suitable liner/leachate system. The primary reasons that the "sawtooth" type was considered more suitable are (1) the positive, gravity drainage over the liner; (2) the avoidance of leachate concentrations on the liner seam areas; and (3) the ability to maintain the pipes.

4.3.2 System Components

The "sawtooth" liner/leachate concept system consists of six components. These components are shown in Detail C, Figure 15 and discussed below. The dimensions of the system were determined based on component sizes available and design criteria. The width of the "sawtooths" for the concept design was determined by the width of the liner panels commonly available. The seam between panels must be located on the side of the "sawtooth" so it does not occur in the lower areas where leachate could collect. Maximum panel widths for 100 mil HDPE typically vary from 22.5 to 34 feet from different manufacturers. A panel width of 22.5 feet was used in the concept design because it (1) results in a closer collection pipe spacing; (2) is available from more than one manufacturer; and (3) is more consistent with the 250 foot long liner panel length used in the cell width design (see Section 3.1). The spacing between "sawtooths" using a 22.5 foot wide panel is 43 feet (allowing for a 1 foot seam overlap).

The four percent slope on the "sawtooths" was selected for the concept design because (1) the top of the collection pipe is below the liner seam on the side of the "sawtooth" (if the pipe is full, the seam will not be in contact with leachate); (2) the thickness of the leachate collection layer and tertiary liner are not excessive; and (3) the grade is the same as the cell slope so the potential for construction errors or confusion is reduced.

The components of the concept design "sawtooth" liner/leachate system, in descending order are as follows (Figure 15):

- o Filter Fabric -- separates the waste from the leachate collection layer sand.
- o Leachate Collection Layer -- is a coarse, clean sand 1.0 to 1.8 feet thick, geogrid drain mesh at the bottom of the layer, and 3 inch diameter

collection pipes. The bottom of the layer is sloped at four percent both across the "saw-tooths" and along the cell width for gravity drainage of leachate.

- o Primary Liner -- is a 100 mil (0.10 inch) thick HDPE (high density polyethylene) synthetic liner.
- o Leak Detection Layer -- is identical to the leachate collection layer except that it is 1.0 foot thick and does not have a geogrid drain mesh.
- o Secondary Liner -- is a 100 mil, HDPE liner the same as the primary liner.
- o Tertiary Liner -- is a compacted clay liner 2.0 to 2.8 feet thick.

The following paragraphs discuss each of the liner/leachate components in detail.

Filter Fabric

The filter fabric layer on top of the leachate collection layer provides a barrier against mixing or clogging the sand with overlying waste materials. The potential for clogging of the sand will be greatest during construction and initial waste placement. Although the fabric is not required to have long term resistance to leachate, this would be a desirable characteristic. Many types of fabric are available including synthetic materials such as polyethylene which are resistant to many chemicals. As part of final design, compatibility testing should be conducted to determine reactivity between the fabric and leachate. A nonwoven type of fabric is more suitable for use in the waste cell design because it typically has a higher porosity and a greater range of pore sizes than a woven fabric. Although not a critical factor in this application, the strength of nonwoven fabric is typically less than woven fabric.

Leachate Collection and Leak Detection Layers

Although the two layers serve different functions, the leachate collection and leak detection layers are similar in design and are discussed together. Both layers are required by RCRA regulations (see Section 2.4). However, the regulations are mostly performance-type standards and the only specific design criterion is that the leachate head on the liners be less than or equal to one foot.

Major factors which must be considered in the design of either layer are as follows:

- o Determine the layer flow characteristics based on some prediction of leachate volume.
- o Because the layers are difficult to access and repair use a conservative design with low potential for failure (clogging).
- o Use materials that are non-reactive to potential leachates.
- o Use easily installed and reliable materials.

The leachate collection and leak detection layers each consist of a 1.0 to 1.8 foot thick layer of sand placed over a synthetic liner. The thickness of each layer was determined based on "sawtooth" geometry, flow capacity and pipe protection considerations. A 1.0 foot minimum layer thickness will provide about 0.8 feet of material above the pipes which will be sufficient to protect the pipes during construction and initial waste placement activities. This thickness is also easily constructed and will provide more than adequate leachate flow capacity.

The sand material will be a coarse, well graded, clean sand, with some fine gravel and a minimum particle size greater than a No. 100 sieve. The sand should be spread evenly and rolled to form a smooth, firm surface. The sand should not be compacted because it will reduce permeability of the material to flow.

The collection pipes in the bottom of each layer must be large enough to handle the leachate volume. They also must be constructed of a material resistant to leachate and be strong enough to prevent crushing. A three inch diameter pipe of polyvinyl chloride (PVC) or high density polyethylene (HDPE) both of which are resistant to most chemicals, is considered suitable for this design. PVC pipe is readily available and is relatively inexpensive. HDPE pipe is more expensive than PVC, but it is more chemically resistant than PVC. The type of pipe proposed for this design is HDPE because it is compatible with the liner material, strong and chemically inert.

The geogrid drain mesh at the base of the leachate collection layer will provide a high permeability flow zone which will rapidly carry leachate (if generated) to the collection pipes and out of the cell. The geogrid is included only in the leachate collection layer because only small volumes of leachate are expected in the leak detection layer and they can be transmitted easily by the sand. The geogrid is also proposed to be made of HDPE and will be compatible with the liner and collection pipe.

Primary and Secondary Liners

The primary and secondary liners are synthetic liners. The basis for using synthetic liners was high chemical resistance to leachate and minimal construction activity on top of the leak detection layer. The liners are located below the leachate collection and the leak detection layers. The liners will be anchored around the edge of the cell as shown in Figure 15. General liner installation specifications and quality control procedures are provided in Appendix A.

Synthetic liners are made from many types of materials. Factors which must be considered in determining the most suitable type of synthetic liner are: resistance to leachate, high-quality field seams which are

easily obtained, and the ability to withstand installation stresses and waste loads. A high density polyethylene (HDPE) liner 100 mils (0.10 inches) thick is considered most suitable for the primary and secondary liners based on discussions presented in the following paragraphs.

Results of compatibility testing conducted over the past several years (Folkes, 1982) indicate that of the liner materials tested, polyvinyl chloride (PVC-oil resistant) and polyethylene are the most resistant to chemicals, leachate absorption, and tensile strength changes. PVC is known to frequently become stiff and brittle with time due to loss of plasticizer and thus, PVC may not be considered suitable for this application. Several types of polyethylene liners are available (chlorinated, chlorosulfonated, low density, linear low density, and high density). Of these types, chlorosulfonated (CSPE or Hypalon which is registered trademark of DuPont) and high density polyethylene (HDPE) are generally considered the least chemically reactive and are proposed for this design. An HDPE type synthetic liner was selected for this design because it is manufactured in the thickest liner section available (100-mils) which will provide an additional high degree of resistance to punctures. Also, HDPE field seams are typically considered more reliable than liner type field seams.

Tertiary Liner

The tertiary liner is a compacted clay material. The clay is used because its long-term resistance to leachate seepage may be superior to a synthetic liner. However, compatibility of the clay liner material with the potential leachate must be thoroughly evaluated as part of the detailed design.

A two-foot thick, (minimum) tertiary liner was considered suitable for use in the concept design since the primary purpose of this liner is to provide a barrier for any leachate which leaks through the secondary liner. A two-foot thick layer is constructable with common earth moving

equipment and its permeability would be expected to be on the order of 10^{-7} centimeters per second or less. The 1,000 year containment criteria discussed in Section 2.4, may require the tertiary liner thickness and/or permeability to be adjusted depending on the final waste cell design and subsurface characteristics.

The tertiary liner will be placed below the secondary liner. Potential installation details are presented in Figures 15 and 16 and general construction specifications are provided in Appendix A. Some clay may be obtained from clayshale bedrock excavated from the cell areas. However, most of the clay for this liner will need to be obtained from borrow areas located on RMA or elsewhere.

4.4 COVER SYSTEM

The cover system concept design was based on the criteria presented in Section 2.4. The proposed system is shown in Detail D of Figure 15. The regulatory requirement of a cover system permeability equal to or less than the liner/leachate system permeability are met for the concept design by placing three liners in the cover system. Components of the concept design cover system, in descending order are as follows:

- o Soil Cap -- is 3 feet thick with the top 6 to 12 inches topsoil and the remainder a fine grained soil.
- o Filter Fabric -- separates the overlying soils from the underlying drainage layer and reduces the potential for migration of soil particles into the sandy gravel.
- o Drainage Layer -- is a sandy gravel layer 1.0 foot thick with a geogrid drain mesh at the base of the layer. It provides drainage for precipitation which may infiltrate through the soil cap and otherwise collect on top of primary cover. Also, the gravel material will impede penetration to or through the primary cover by roots and burrowing animals.

- o Primary Cover -- is a 100 mil thick HDPE synthetic identical to the liner/leachate system liners.
- o Secondary Cover -- is a compacted clay layer 2.0 feet thick. It is equivalent to the tertiary liner of the liner/leachate system.
- o Stabilizer -- is a geogrid mesh which is spot welded to the underlying tertiary cover to increase the frictional resistance between the overlying compacted clay and the underlying synthetic.
- o Tertiary Cover -- is a synthetic identical to the primary cover.
- o Gas Collection Layer -- is a coarse, clean sand layer 1.0 feet thick. It will collect gas generated from the waste. Vents are placed in this layer along the top of the cell to remove gas from the cell.
- o Filter Fabric -- separates the overlying sand from the waste to reduce the potential for clogging of the sand and to provide a good working surface for placing the cover system.

The order of the cover system components was based on construction considerations and tying the cover system to the liner/leachate system at the cell edges. Concept design details of the cover and liner/leachate system intersection at the cell edges are shown in Figures 15 and 16. The following paragraphs describe in detail each of the cover system components.

Soil Cap

A three-foot thick soil cap layer forms the top layer of the cover system. The soil should be a fine grained material with about 20 to 30 percent clay size particles. A higher percentage of clay is not desirable because cracking may occur as the cover loses moisture. The material best suited for use as soil cover is a clayey sand (USCS designation SC or SP).

The thickness of the layer was based on consideration of ease of construction, long-term erosion and frost penetration depth. The 3 foot thickness was determined primarily by the frost penetration depth. Cases have been reported where ice lenses were formed, by capillary action, below a synthetic liner and when the lenses thawed, sliding along the liner occurred. The 3 foot soil cap thickness will reduce the potential for freezing below the cover system synthetics.

Some soil cap material will be obtained from the cell excavations and site grading. Most of the material will have to be obtained from borrow areas. A sufficient quantity of suitable material should be available on RMA.

The soil cap will be placed on the side slopes and top in horizontal lifts or layers and compacted. Placement of the layer will require close control of materials and equipment operation to obtain a uniform, quality cover. Relatively thin lifts (6-8 inches thick uncompactd) will be necessary to obtain good compaction because large equipment will not be able to be used.

A layer of topsoil about 6- to 12-inches thick will be spread over the soil cover layer. Topsoil stripped from the landfill area and other facility areas will be available and should be suitable to cover the waste cell. The topsoil will be fertilized, mulched and seeded with shallow rooted grasses (introduced rapid germinating and native types) for rapidly establishing a vegetation cover and for long-term growth to minimize erosion of the cover. Fertilizer, mulch and seed types or mixtures, application rates, methods of placement and maintenance should be specified in the final design.

Filter Fabric

Filter fabric in the cover system provides separation of dissimilar materials. The type of fabric is the same as discussed in Section 4.3.2 for the liner/leachate system.

Drainage Layer

The drainage layer will be placed under the soil cap to collect and remove water which may infiltrate through the cap. This layer will reduce the potential for water to pond on the primary cover which could then possibly leak through the covers and into the waste and generate leachate. This layer will also impede most roots and burrowing animals from penetrating to the primary cover.

The material is a sandy gravel (3 inch maximum size) for high permeability and rapid drainage. The layer will drain around the edge of the cell, as shown in Figures 15 and 16.

Primary and Tertiary Covers

The primary and tertiary covers are 100-mil thick HDPE synthetics. The covers are identical to the primary and secondary liners of the liner/leachate system to meet the system permeability requirement (see Section 2.4). Section 4.3.2 discusses the basis for selection of the primary and secondary liners.

As shown in Details F and G on Figures 15 and 16, the tertiary cover will be seamed to the primary liner at the cell edge to fully enclose the waste material and the primary cover will be anchored beyond the edge of the tertiary liner to prevent infiltration into the waste around the cell edge.

Secondary Cover

The secondary cover is a compacted clay layer 2.0 feet thick. It is also based on the system permeability requirement and is equivalent to

the tertiary liner of the liner/leachate system. The material for the secondary cover is the same as the tertiary liner, as discussed in Section 4.3.2.

The secondary cover was placed between the synthetics to reduce the potential for the clay to lose moisture and crack. Also, this sequence matched the clays in the secondary cover and tertiary liner at the cell edge (see Details F and G on Figures 15 and 16).

Gas Collection Layer and Vents

The waste may generate gas after it is placed in the cells. Ammonia gas has been generated during bench-scale solidification processes. If gas is generated it must be removed; otherwise, it will accumulate under the cover system layers and could exert enough pressure to lift and damage the system. The gas collection layer and vents are included in the concept design to control gas which may be generated.

The gas collection layer is a one-foot thick layer of coarse, clean, well graded sand which will be spread on the final waste surface. The sand will be placed on both the top and side slopes of the waste and it will be separated from the waste by a nonwoven filter fabric to minimize clogging. Filter fabrics typically have a high porosity and will also enhance the flow and collection of gas from the waste.

The sand used in the gas collection layer is the same as the leachate, collection and leak detection layer sand discussed in Section 4.3.2.

Gas vents will be installed on the top of the landfill, to remove gas collected in the layer. Vents are only required in the middle of the landfill top because the gas will flow naturally up the side slopes and the sloped top surface and collect in the middle.

Each gas vent consists of a 3-inch diameter HDPE pipe extending from the filter fabric on top of the waste, to about 2 feet above the top of the cover. A typical gas vent is shown in Detail J, Figure 16. The gas vent will be slotted in the gas collection sand layer and connected to a pipe running the length of the waste cell to aid in collecting gas between the vent locations. The gas vents will be installed as the cover system is placed. Guideline installation specifications are contained in Appendix A.

4.5 LEACHATE CONTROL SYSTEM

The leachate control system concept design is shown in Details G and H on Figure 16. The system components are as follows:

- o Collection Pipe Secondary Containment -- is six-inch diameter HDPE pipes (unslotted) which encase the 3-inch diameter leachate collection and detection pipes, providing containment in the event of a leak in a 3-inch pipe.
- o Clay bulkhead -- is a berm along the downslope waste cell side through which the 6 inch diameter pipes pass. The berm forms the edge of the liner/leachate system and provides additional protection against system leaks.
- o Steel collection tank -- located on the ground surface. The tank is lined and has a baffle, which divides the tank into two parts. One tank is used for each set of collection pipes which emerge from the bulkhead, One half of the tank receives leachate from the collection layer, the other half receives any leachate from the leak detection layer.
- o Collection sump -- which collects any accidental spillage or leakage from the tank, or runoff from the tank access road. A sump is provided for each tank. The sump is gravel-filled and provided with a slotted sump-out pipe.

The leachate control system was designed to meet the criteria set forth by the Army (see Section 2.4) of at-grade collection tanks and gravity

drainage of leachate. Other alternatives, such as a sump-type leachate control system were examined but discarded since they could not meet the design criteria.

Each of the system components is described in detail in the following paragraphs.

Collection Pipe Secondary Containment

Six-inch diameter HDPE pipes enclose the three-inch diameter collection pipes as backup protection against leakage from the three-inch pipes. The six-inch diameter pipes pierce the primary and secondary liners and are welded to the liners since they are comprised of the same material. In addition, a protective liner is welded to each six-inch diameter pipe and the primary and secondary liners to prevent ponding of leachate against the pipes and liners as shown in Detail H (Figure 16). The three-inch solid pipes pass inside these protective six-inch pipes to the steel collection tanks (described below).

Clay Bulkhead

The two foot thick liner/leachate system tertiary liner extends to the leachate control system tanks as shown in Detail G on Figure 16. The top of the bulkhead is at the same elevation as the top of the liner/leachate system, and is wide enough for the cell building and a 10 foot wide building maintenance road outside the building. The collection pipes will be compacted in the clay bulkhead, with the pipes maintaining a 4 percent slope away from the cell. The clay bulkhead will provide additional containment if leakage should occur from a collection pipe outside the waste cell. A clay bulkhead was selected for the concept design because it meshes with the tertiary liner and will be easily constructed. The exposed surface of the clay bulkhead adjacent to the leachate collection tanks will be top soiled, and vegetated after construction to minimize erosion. A portion of the clay near the surface will lose moisture and may crack. However, this condition was

not considered critical to the function of the system, since if a leak occurred near the surface it would probably be visible on the surface and/or it would be prevented from moving vertically by the liner which underlies the collection tanks.

Steel Collection Tanks

Each tank is fitted with an internal baffle which divides the tank into two equal parts. Each half is fully lined with 100 mil HDPE. The three-inch pipes are fitted with elbows so that liquid from the leachate collection system is diverted to one half of the tank, and liquid from the leak detection system is diverted to the opposite half. The tanks are approximately four feet deep and five feet square fitted with steel lids which can be unbolted and removed for inspection and possible cleanout with a vacuum truck.

The collection tanks sit on a prepared gravel pad roughly 25 by 45 feet, underlain by a 100 mil HDPE liner to protect against tank leakage or spillage by the vacuum truck. An access road 15 feet wide occupies most of the gravel pad area adjacent to the tanks for easy access. The road bed slopes to drain toward the tank and collection sump (described below) to prevent accidental spillage by a vacuum truck from leaving the lined gravel pad area. The HDPE liner is anchored on the outer edge of the access road bed, as shown in Detail G.

Collection Sump

Immediately adjacent to each collection tank is a collection sump designed to collect any leakage or spillage from the tank. The sump is three-feet deep and lined with the same 100 mil HDPE liner which underlies the tank and access road. The sump is filled with gravel and completed with a six-inch diameter slotted HDPE sump out pipe for removal of any collected liquids (see Detail G on Figure 16).

5.0 ESTIMATED FACILITY QUANTITIES AND COSTS

Estimated quantities and costs are based on the facility concept design presented in Chapter 3.0 and the waste cell concept design presented in Chapter 4.0. Estimates of quantities and costs are presented in Tables 7 through 11 for: (1) construction/capital; (2) active facility life operation and maintenance; (3) facility closure and (4) post-closure operation and maintenance. The unit costs are based on manufacturer estimates, published information, and/or previous experience. The costs are presented in 1984 dollars with no allowance for inflation during the life of the project.

5.1 CONSTRUCTION/CAPITAL QUANTITIES AND COSTS

Estimated quantities and costs for construction of the concept design facility including costs for hauling and placing the waste in the cells are provided in Table 7. The estimated total cost is about \$24 million. The construction/capital items included in Table 7 represent the major facility structures and waste placement activities which will be constructed or performed during the estimated four year (see Section 3.3.2) active life of the facility. The costs given in Table 7 do not include final facility design investigations and engineering, permitting of the facility, or removal of potential contamination from Site 36-7. Labor and equipment costs for construction of the waste cells ("clean" crew) and waste placement ("contaminated" crew) are included in the unit costs.

Table 8 shows the detailed breakdown of estimated quantities and costs for a single waste cell. The estimated cost of a waste cell is about \$3 million for the liner/leachate, cover, and leachate control systems. Costs for the cell building and waste placement in a cell are included in the construction/capital costs shown in Table 7. The estimated unit costs shown in Table 8 include where appropriate materials and/or labor and equipment ("clean" crew) costs.

5.2 ACTIVE FACILITY LIFE -- OPERATION AND MAINTENANCE COSTS

The estimated annual operation and maintenance costs during the active facility life are shown in Table 9. The total estimated costs are \$361,000 and \$37,000 per year for operation and maintenance, respectively. These costs include utilities (i.e., gas, electricity); maintaining and repairing items (i.e., roads, ponds); monitoring, testing and maintaining items (i.e., wells, leachate control system); and salaries for administration personnel.

5.3 CLOSURE/QUANTITIES AND COSTS

The estimated quantities and costs for closure of the facility involving decontamination or removal of items not required after completion of the waste placement are shown in Table 10. The total estimated closure cost are \$105,000. This amount may seem small, however the costs do not include the waste cell cover systems which are considered construction/capital costs and are included in Table 7. Also, it is assumed (see concept facility operation discussion, Section 3.3.2) that the facility would be decontaminated as waste placement proceeded during the active life of the facility. Therefore, the areas requiring decontamination at closure should be small.

5.4 POST-CLOSURE PERIOD OPERATION AND MAINTENANCE COSTS

The estimated annual operation and maintenance costs for the post-closure period are \$47,000 and \$5,000, respectively, as shown in Table 11. These costs include items such as monitoring/testing of wells and the leachate control systems, waste cell cover system maintenance, and post-closure administration personnel.

5.5 SUMMARY

The total estimated cost for construction/capital items and operation and maintenance during the four year active facility life is about \$26

million based on the costs presented in Table 7 and 9. The total estimated costs for closure are \$105,000, while post-closure maintenance is estimated to cost about \$52,000 per year. It is emphasized that the estimated costs are given in 1984 dollars and no allowance for inflation over the active life of the facility has been included.

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TABLE 1
EVALUATION OF WASTE CELL TYPE

TYPE OF VAULT	EVALUATION FACTORS			OVERALL SUITABILITY	
	LINER	LOCATION	SHAPE		
EARTHEN	Clay, synthetic, and other types are commonly used and accepted by regulatory agencies. Permeability for clay is typically 10^{-7} cm/sec or less and synthetic is 10^{-6} cm/sec or less. Many factors affect the evaluation of liners. Table 3 and Section 2.3.3 address the type of liners.	Above, below, and above/below grade locations are commonly used and accepted. Many factors must be considered in evaluating the location. Table 2 and Section 2.3.2 address the location evaluation.	Rectangular in plan with sloping sides, flat top and bottom surfaces. This shape is commonly referred to as a truncated prism.	Construction is easily accomplished with commonly used earthwork equipment and construction methods.	This type of vault is considered suitable because of its flexibility in type of liner and location. It is also typically less costly than the other types.
REINFORCED CONCRETE	Reinforced concrete walls and a slab serve as the side and bottom liner, respectively. Since concrete is permeable, additional waterproofing would also be required. This type has limited use for hazardous waste landfills, mostly in special situations.	Above grade only.	Rectangular in plan with vertical side walls.	Construction is easily accomplished with common materials, equipment, and methods. Construction costs are high, however, because of the liner type. Maintenance (repair) of the concrete may also be required.	A reinforced concrete type landfill is applicable for sites with a near surface ground water table, for wastes which will be recovered in the future, or for sites where the more common liners are determined to be unsuitable. Since the above items are not applicable to this project and this type is more expensive it is not considered suitable for further evaluation.
SLURRY WALLS	Slurry walls serve as a second or backup liner on the sides of the landfill. This type is applicable for conditions where isolation from the ground water is critical. Permeability is typically 10^{-6} cm/sec. or less.	Below grade only.	Rectangular in plan with vertical side walls.	Construction is relatively easy using common equipment and techniques. Costs are high because of slurry wall construction which is in addition to the cell excavation within the slurry wall perimeter.	A slurry wall type landfill is suited to sites with a high ground water table. Because this condition does not exist for this project and the costs are high this type it is not considered suitable for further evaluation.

TABLE 2
EVALUATION OF WASTE CELL LOCATION

LOCATION	EVALUATION FACTORS					OVERALL SUITABILITY	
	GROUND WATER	ECONOMICS	CONSTRUCTION	MAINTENANCE/ LONG-TERM INTEGRITY	LONG-TERM ACCESSIBILITY		AESTHETICS
Above Grade	Maximizes distance from the ground water table. Well suited for this site because the water table is fairly near the surface and the project is sensitive to potential ground water contamination.	Overall cost is probably highest of the three types. Excavation costs are eliminated and surface construction costs may be slightly less than below grade costs. However, plan area is larger because of the lower waste height resulting in higher liner and cover system costs. Also, cover material must be obtained from borrow areas.	Easily constructed.	Susceptible to erosion, therefore requires maintenance and the potential is high for remedial repairs to maintain long-term integrity.	Easily accessed, monitored, and wastes retrieved.	Potential negative aesthetic impacts because of visual presence.	Above grade is considered suitable for further evaluation. Maintenance/long-term integrity is the main unfavorable concern.
Below Grade	Not especially well suited because of the ground water table location and the design criteria.	Overall cost is probably between above grade and above/below grade types. Excavation costs are incurred, but may be offset by lower cover system costs if material from excavation is used.	Easily constructed.	Not susceptible to erosion. Long-term maintenance and potential remedial repairs are minimized.	Not easily accessed or monitored. Waste retrieval is more difficult.	Positive aesthetic impact.	Below grade is not considered suitable for further evaluation because of the ground water table location and design criteria.
Above/Below Grade	Well suited because an acceptable distance from the ground water table can be maintained.	Overall cost is probably lowest of three types. Excavation costs are incurred, but minimized. Thickness of waste in landfill is maximized resulting in minimum plan area and liner/cover system costs. Cover material borrow excavation minimized or eliminated if excavated material is used.	Easily constructed.	Susceptible to erosion on above grade portion therefore maintenance is necessary. Potential for remedial repair is lower because above grade portion is smaller.	Positive aspects of above grade evaluation, but also negative aspects of below grade.	Lower potential for negative impacts.	Above/below grade is considered suitable for further evaluation. Closer proximity to the ground water table is the main unfavorable concern.

TABLE 3

EVALUATION OF LINER TYPE

TYPE OF LINER	EVALUATION FACTORS			SUITABILITY	
	PERMEABILITY/LEACHATE COMPATIBILITY	INTEGRITY (SHORT AND LONG TERM)	CONSTRUCTION		ECONOMICS
CLAY	Permeability typically 10^{-7} cm/sec. or less. However, the permeability of some clays is known to be increased by reaction with high pH and organic chemicals. Testing must be conducted to determine suitability for specific conditions. If the concentration of organics in the leachate is relatively low, then the potential for clay alteration is also low. Also, previous testing of soils with Basin F liquid indicated little change in clay permeability (D'Appolonia, 1980).	Clays are considered better long-term liner materials than synthetics. The short-term integrity is questionable for concentrated leachate and large leachate volume conditions.	Construction is easily performed with common equipment and methods. Some clay may be available from excavations on the facility. Potential clay borrow areas may exist on RMA.	Estimated cost for excavating, placing, and compacting a clay liner is \$0.30 to \$0.70 per square foot for a liner 2 to 5 feet thick, respectively, assuming the clay is available from nearby borrow areas.	Clay is considered suitable because it has better long-term integrity, is easily constructed and is less expensive. However, compatibility tests may indicate the clay is unsuitable.
SYNTHETIC	Permeability typically 10^{-9} cm/sec. or less. However, some synthetic liners may be altered by certain chemicals. Compatibility data for different synthetics is available. Specific testing must be conducted to determine compatibility.	Synthetics are questionable for long-term integrity. Seams are especially questionable. The effective synthetic liner life ranges from 10 to 30 years. Short-term synthetic liner integrity is considered excellent.	Synthetic liners are available locally. Preparation of a uniform, suitable bedding layer is necessary. Liner placement and field seaming require careful construction procedures to obtain a defect-free installation.	Synthetic liner material costs (including installation) are about \$0.80 to \$1.50 per square foot for suitable types (i.e. Hypalon or HDPE).	Synthetics are considered suitable because leachate compatibility is well known, they are readily accepted by regulatory agencies, and they have excellent short-term integrity.
SOIL-CEMENT	Permeability typically 10^{-6} to 10^{-7} cm/sec. Soil-cement is also likely to be altered by chemicals, however little data is available.	Soil-cement liner data for waste retention is limited.	Soil for use in liner is available. Cement is available locally. Mixing cement into the soil requires careful construction procedures and controls.	Costs for soil-cement are high because of cement and construction methods required.	Soil-cement is not considered suitable because it has a higher permeability, it is expensive and its compatibility is generally unknown.

TABLE 4

CELL BUILDING TYPES AND CHARACTERISTICS

TYPE	BUILDING MATERIALS	MAXIMUM WIDTH (FEET)	FOUNDATION REQUIREMENTS	PORTABILITY	RELATIVE COST
Fabric on Frame	PVC Based Fabric to 120 Covering Aluminum Frame.	120 (Standard)	None	Very Good	Low
Rigid frame	Steel Columns and Roof Beams With Panel (Steel, Aluminum, or Fibreglass) Siding and Roofing.	70-150 (Standard) 360 (Custom)	Structural Footings on Larger Widths	Good on Smaller Widths. Poor on Larger Widths	High
Space Frame	Steel Columns and Girders With Panel Coverings.	600 (Custom)	Structural Footings	Poor	High
Arch	Corriganated Metal Panels.	150 (Standard)	Structural Footings	Good	Moderate
Air-Supported	Fabric With Cables.	240 (Standard) 400 Custom	None, but Anchorage Necessary	Good	Moderate
Dome	Aluminum Geodesic Frame and Panels.	400 ft. Diameter	Structural Footings	Poor	High

TABLE 5

OPERATIONS PLAN
FACILITY CONCEPT DESIGN

TIME (YEARS)	CELL BUILDING LOCATION/MOVES(1)	WASTE CELL NUMBER/ACCESS DIRECTION		CONTAMINATED ZONE	REMARKS
		WASTE PLACEMENT	COVER		
-0.5	A-Cell 1	1/West	--	None	Also initial facility development including buildings, surface water control system, major haul roads, monitor wells, and security fence.
0.0	A-Cell 1 B-Cell 2	2/East	--	Cell 1; west road.	--
0.5	A-Cell 1 to 3 B-Cell 2	3/West	1/East	Cell 2; west road	--
1.0	A-Cell 3 B-Cell 2 to 4	4/West	2/West	Cell 3; north and east roads	Decontaminate west road along Cells 1, 2, an 4.
1.5	A-Cell 3 to 5 B-Cell 4	5/South	3/West	Cell 4; north and east roads	Decontaminate east roads between south end of Cells 5 and 6 and east end of Cell 3.
2.0	A-Cell 5 B-Cell 4 to 6	6/South	4/West	Cell 5; north and east roads	--
2.5	A-Cell 5 then removed B-Cell 6	--	5/South	Cell 6; north and east roads	--
3.0	B-Cell 6 then removed	--	6/South	North and east roads	Also general facility and haul road decontamination.
3.5					

(1) Two cell buildings referred to as A and B.

TABLE 6

EVALUATION OF WASTE HAULING ALTERNATIVES

ALTERNATIVE	DESCRIPTION	ADVANTAGES	DISADVANTAGES
1	Use clean haul road a truck wash at both the landfill and solidification facilities. Estimated volume of wash water is 120 gallons per truck or 3,600 gallons per day (30 truck loads per day).	No double handling of waste. No spread of contamination outside the landfill facility.	Handling of wash water will require a large pond at both facilities. The water may be recycled, but some treatment and disposal at the solidification or a licensed off-site facility will be required. Operation of truck washes will require two additional personnel.
2	Use clean haul road with a transfer station at the landfill. Haul trucks would dump at the transfer station without the wheels becoming contaminated. Waste would be loaded into other trucks and hauled to the cell.	No handling of wash water. No spread of contamination outside the landfill facility.	Double handling of waste. Additional equipment and personnel (1 front end loader and 2 trucks) required to haul waste to the cells.
3	Use contaminated haul road. Haul trucks would only be decontaminated periodically during maintenance and haul road would be assumed to be contaminated. Haul road would be removed at completion and placed in a cell. Runoff from the haul road would be controlled in ditches and collected in ponds. Estimated volume of haul road and ponds is about 20,000 cubic yards.	No additional operational equipment or personnel required. No double handling of waste. No wash water generated.	Contamination outside the landfill facility. Additional ponds required.
4	Use conveyor from solidification facility to landfill transfer station. Estimated cost for 4,000 foot, 18 inch wide belt, covered conveyor is \$0.5 to 0.8 million.	No haul truck operation and related maintenance costs.	Contamination along the conveyor route likely. Double handling of waste required. Transfer station operation personnel and equipment required. High capital cost.

TABLE 7
 CONSTRUCTION/CAPITAL
 ESTIMATED QUANTITIES AND COSTS
 FACILITY CONCEPT DESIGN

ITEM	QUALITY	ESTIMATED UNIT COST	ESTIMATED COST
Site Preparation			
- Clearing	70 ac. ⁽¹⁾	\$1,000/acre ⁽¹⁾	\$ 70,000
- Grading	500,000 cy.	0.50/cy	250,000
Support Building and Equipment			
- Administration Bldg.	1 ea.	50,000/bldg.	50,000
- Personnel Decon/Clean Trailer	3 ea.	30,000/trailer	90,000
Haul Road	15,000 ft.	50/ft.	750,000
Surface Water Control System			
- Ditch	20,000 ft.	2.00/ft.	40,000
- Pond	3 ea.	10,000/pond	30,000
Monitor Well	5 ea.	2,000/well	10,000
Security Fence	9,500 ft.	\$20.00/ft.	190,000
Waste Cell (see Table 8)	6 ea.	3,058/cell	18,348,000
Waste Cell Buildings	2 ea.	1,500,000/bldg.	3,000,000
Waste Placement	600,000 cy.	2.00/cy.	<u>1,200,000</u>
TOTAL			\$24,028,000 ⁽²⁾

(1) ac. = acres
 cy. = cubic yards
 ft. = feet/foot
 bldg. = building

(2) Does not include final design investigations and engineering, permitting, and potential contamination removal from Site 36-7.

TABLE 8

WASTE CELL CONCEPT DESIGN
ESTIMATED CONSTRUCTION QUANTITIES AND COSTS

<u>ITEM</u>	<u>QUANTITY</u>	<u>UNIT COST</u>	<u>ESTIMATED COST</u>
Excavation/fill	100,000 cy	\$2.00/cy	\$200,000
Liner/leachate system:			
Tertiary liner-clay (including bulkhead)	25,000 cy	3.00/cy	75,000
Secondary liner 100 mil HDPE	229,000 sf	1.50/sf	343,500
Leak detection layer-sand	8,000 cy	12.00/cy	96,000
Leak detection layer-3" Ø HDPE, slotted pipes	7,000 ft	1.00/ft	7,000
Primary liner-100 mil HDPE	224,000 sf	1.50/sf	336,000
Drain - HDPE geogrid	220,000 sf	0.30/sf	66,000
Leachate collection layer - sand	10,000 cy	12.00/cy	120,000
Leachate collection layer- 3" Ø HDPE slotted pipes	7,000 ft	1.00/ft	7,000
Filter fabric	220,000 sf	0.50/sf	110,000
Cover System:			
Filter fabric	230,000 sf	0.50/sf	115,000
Gas flow layer - sand	10,000 cy	12.00/cy	120,000
Tertiary cover-100 mil HDPE	238,000 sf	1.50/sf	357,000
Stabilizer-HDPE mesh	238,000 sf	0.50/sf	119,000
Secondary cover - clay	20,000 cy	3.00/cy	60,000
Primary cover - 100 mil HDPE	248,000 sf	1.50/sf	372,000
Drain - HDPE geogrid	248,000 sf	0.30/sf	74,400
Drainage layer - sandy gravel	12,000 cy	12.00/cy	144,000
Filter fabric	248,000 sf	0.50/sf	124,000
Soil cap (including seeding)	29,000 cy	4.00/cy	116,000
Leachate Control System:			
Pipe-6" Ø HDPE with insulation	3,000 ft	4.00/ft	12,000
Tanks	21 ea	1,500/tank	31,500
Collection Sumps	21 ea	2,500/samp	52,500
TOTAL			<u>\$3,057,900</u>

TABLE 9

ACTIVE FACILITY LIFE
ESTIMATED OPERATION AND MAINTENANCE COSTS
FACILITY CONCEPT DESIGN

ITEM	ESTIMATED COSTS PER YEAR	
	OPERATION	MAINTENANCE
Support Building and Equipment		
- Administration Building	\$ 5,000	\$ 1,000
- Personnel Decon/Clean Trailers	9,000	1,000
Haul Roads	2,000	5,000
Surface Water Control System		
- Ditch	--	2,000
- Ponds	5,000	2,000
Monitor Well	5,000	--
Security Fence	--	1,000
Waste Cell Leachate Control System	10,000	5,000
Waste Cell Building	120,000	20,000
Administration Personnel		
2 managers (facility, health/safety)	80,000	--
2 security guards	60,000	--
2 technicians	50,000	--
1 secretary	15,000	--
TOTALS	\$361,000	\$37,000

TABLE 10

CLOSURE
ESTIMATED QUANTITIES AND COSTS
FACILITY CONCEPT DESIGN

ITEM	QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST
Support Buildings			
Personnel Decon/Clean Trailers (decontamination)	3 ea	\$5,000/trailer	\$15,000
Haul Road			
- Decontaminate	5,000 ft	1.00/ft	5,000
- Remove (Basin F to Facility)	4,000 ft	5.00/ft	20,000
Surface Water Control System			
- Ditch (decontaminate)	20,000 ft	0.50/ft	10,000
- Pond (remove)	3 ea	5,000/pond	15,000
Waste Cell Building (decontaminate)	2 ea	10,000/bldg	20,000
Equipment (decontaminate)	--	lump sum	<u>20,000</u>
TOTAL			\$105,000

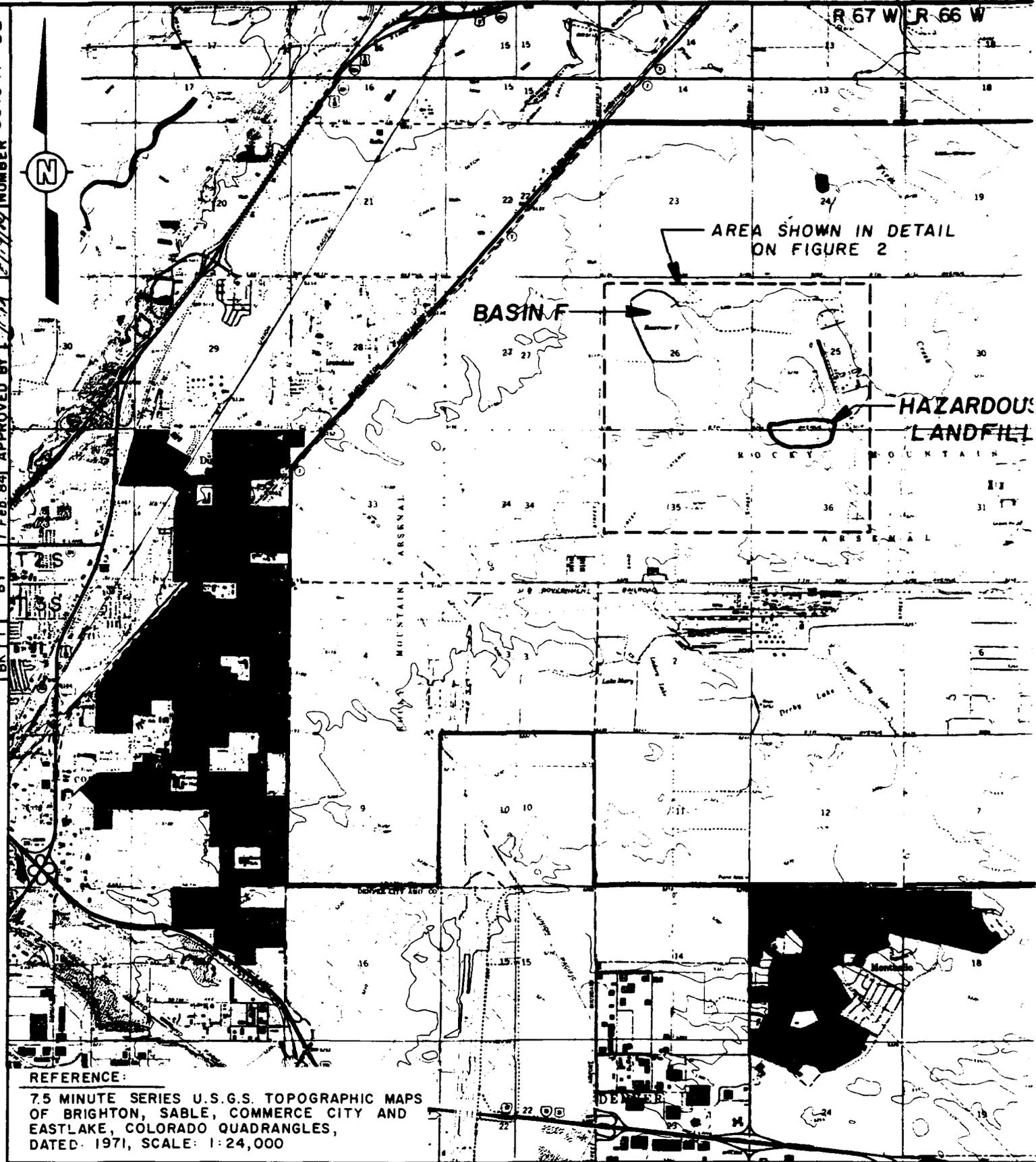
TABLE 11
 POST-CLOSURE PERIOD
 ESTIMATED OPERATION AND MAINTENANCE COSTS
 FACILITY CONCEPT DESIGN

ITEM	ESTIMATED COSTS PER YEAR	
	OPERATION	MAINTENANCE
Support Building and Equipment - Administration Building	\$ 2,000	\$1,000
Surface Water Control System - Ditch	--	1,000
Monitor Well	5,000	--
Waste Cell Leachate Control System	5,000	1,000
Waste Cell Building	--	2,000
Administration Personnel		
1 manager (part time)	20,000	--
1 security guard (part time)	<u>15,000</u>	<u>--</u>
TOTALS	\$47,000	\$5,000

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CHECKED BY
APPROVED BY
R. Bricker
1 Feb 84
P-H-84
DRAWING NUMBER
831641 - B2

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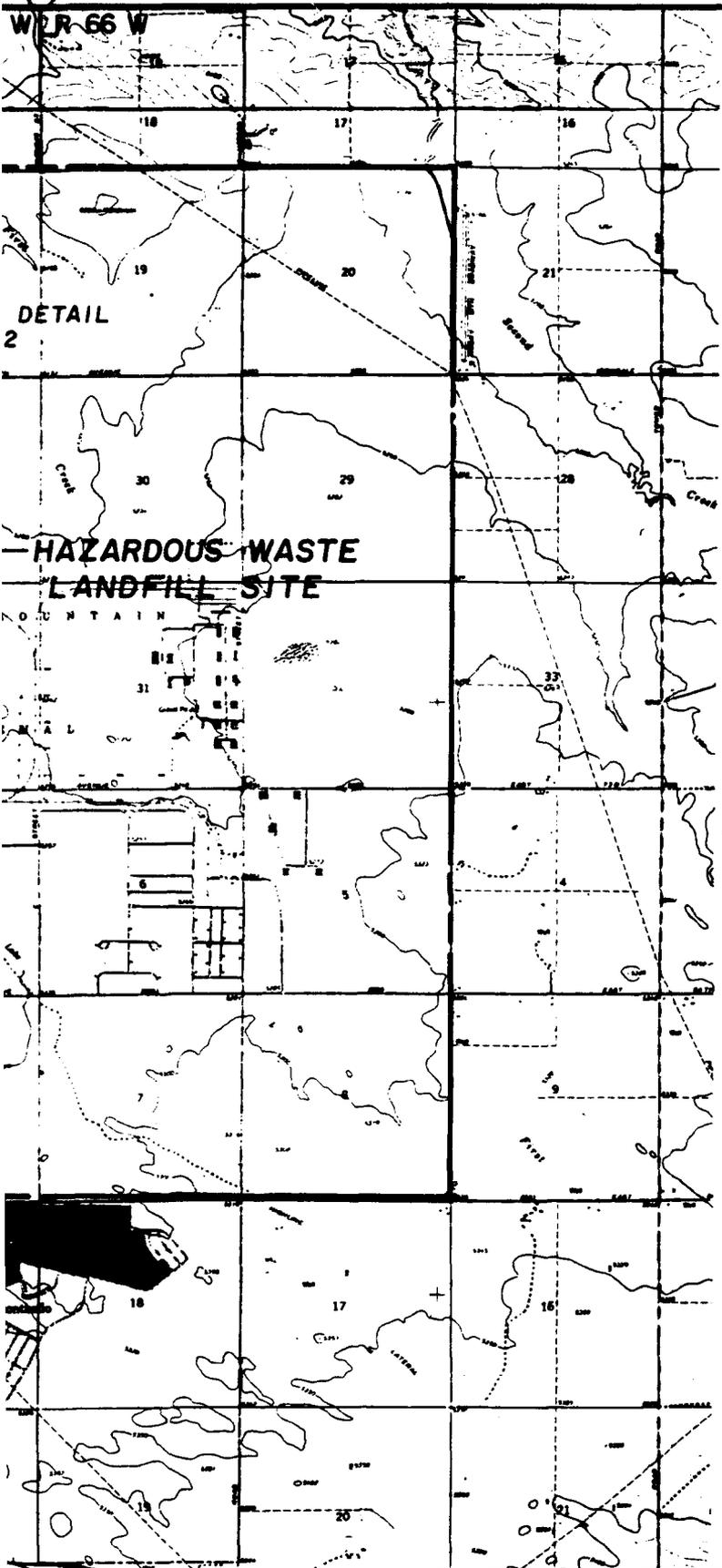
R 67 W R 66 W



REFERENCE:
7.5 MINUTE SERIES U.S.G.S. TOPOGRAPHIC MAPS
OF BRIGHTON, SABLE, COMMERCE CITY AND
EASTLAKE, COLORADO QUADRANGLES,
DATED 1971, SCALE: 1:24,000

19 1253 HERCULENE, ABB SMITH CO., PGM., PA

1002



LEGEND:

----- ROCKY MOUNTAIN ARSENAL BOUNDARY

SCALE



FIGURE 1

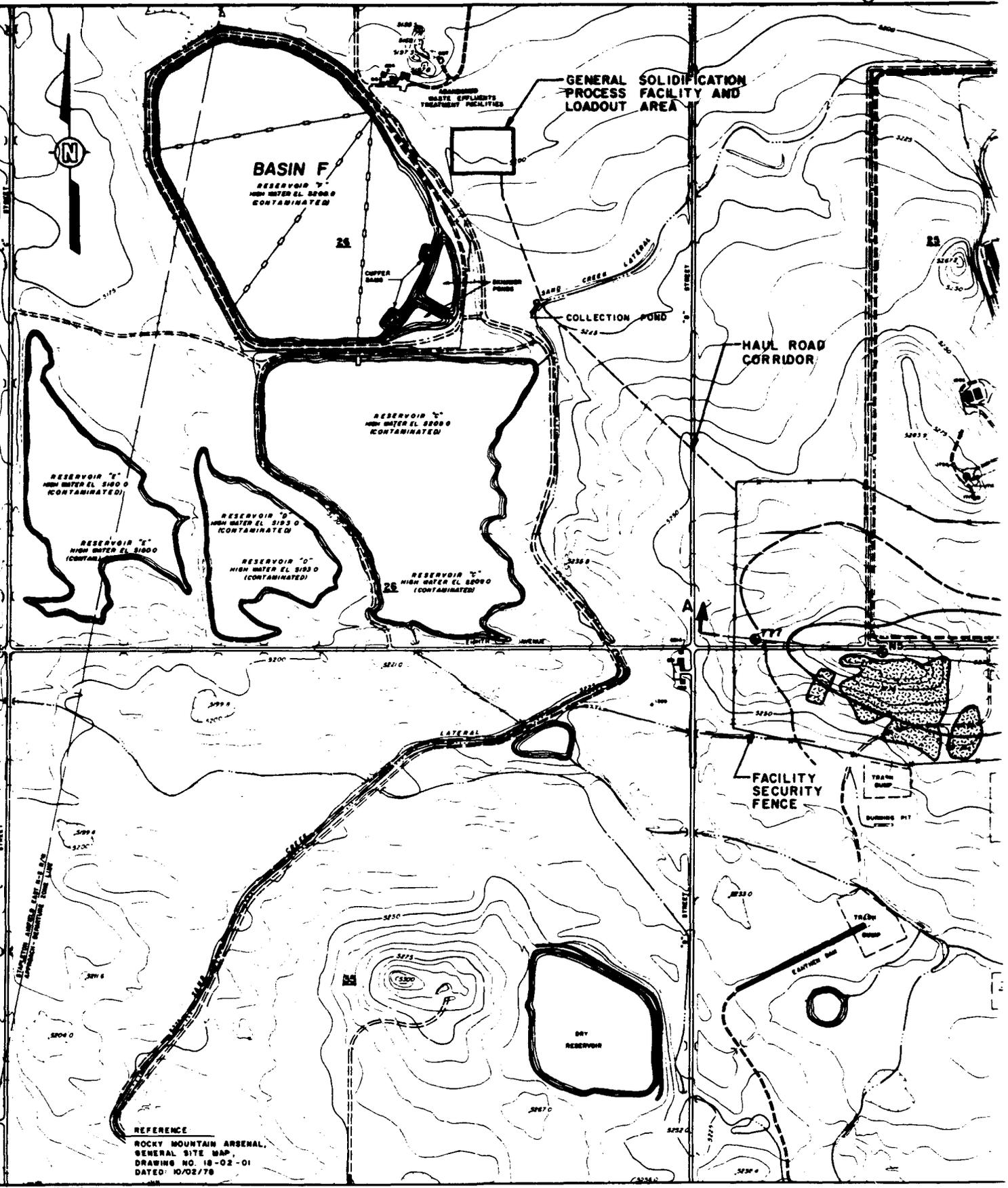
LOCATION MAP

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 COMMERCE CITY, COLORADO



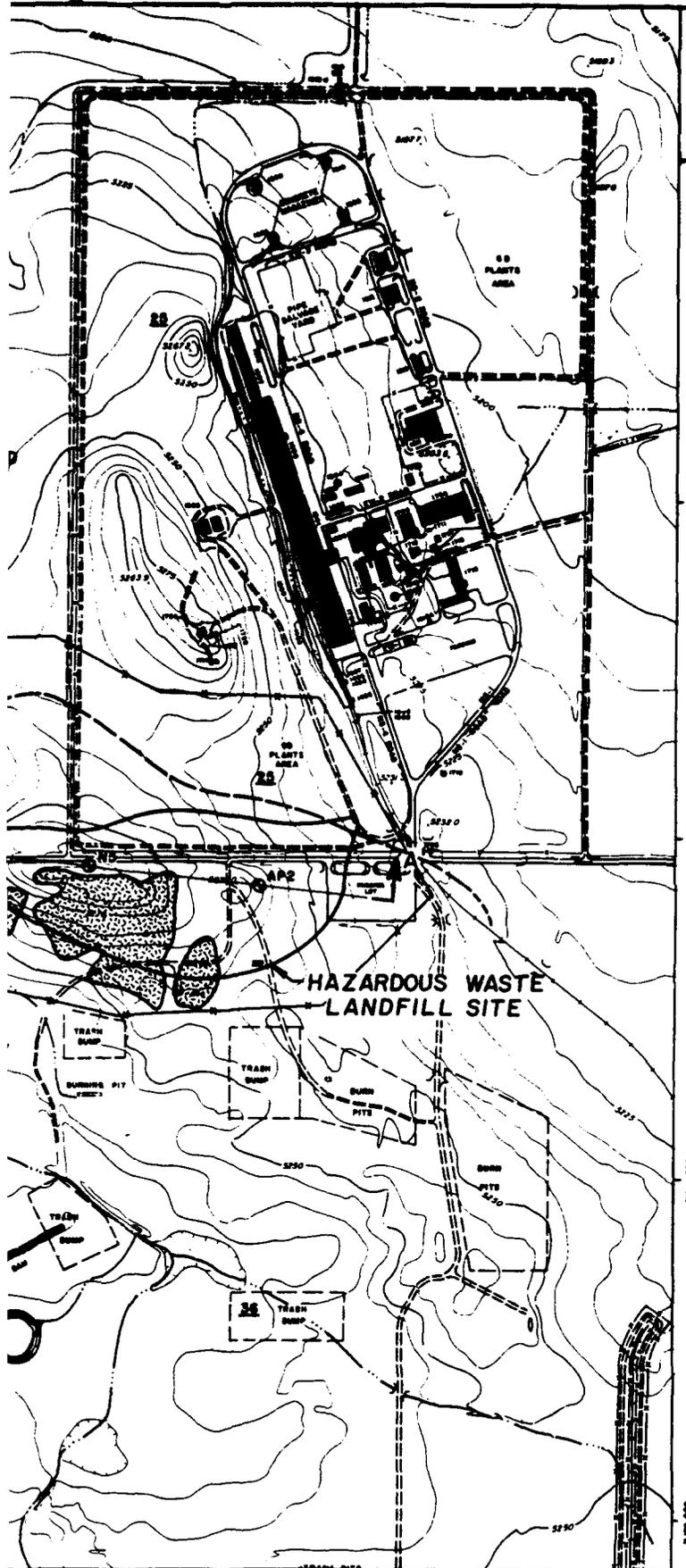
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 APPROVED BY JAM
 7-7-84
 8-14-84
 DRAWING NUMBER 831641-E11



REFERENCE
 ROCKY MOUNTAIN ARSENAL
 GENERAL SITE MAP
 DRAWING NO. 18-02-01
 DATED: 10/02/78

1082



LEGEND:

-  POTENTIAL CONTAMINATION SITE 36-7 (FROM CCPMT, 1983)
-  EXTENT OF LOWER CLAYSHALE UNIT (SEE FIGURE 3)
-  BORINGS AND WELLS USED TO CONSTRUCT SECTION A-A'

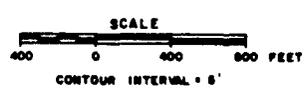


FIGURE 2

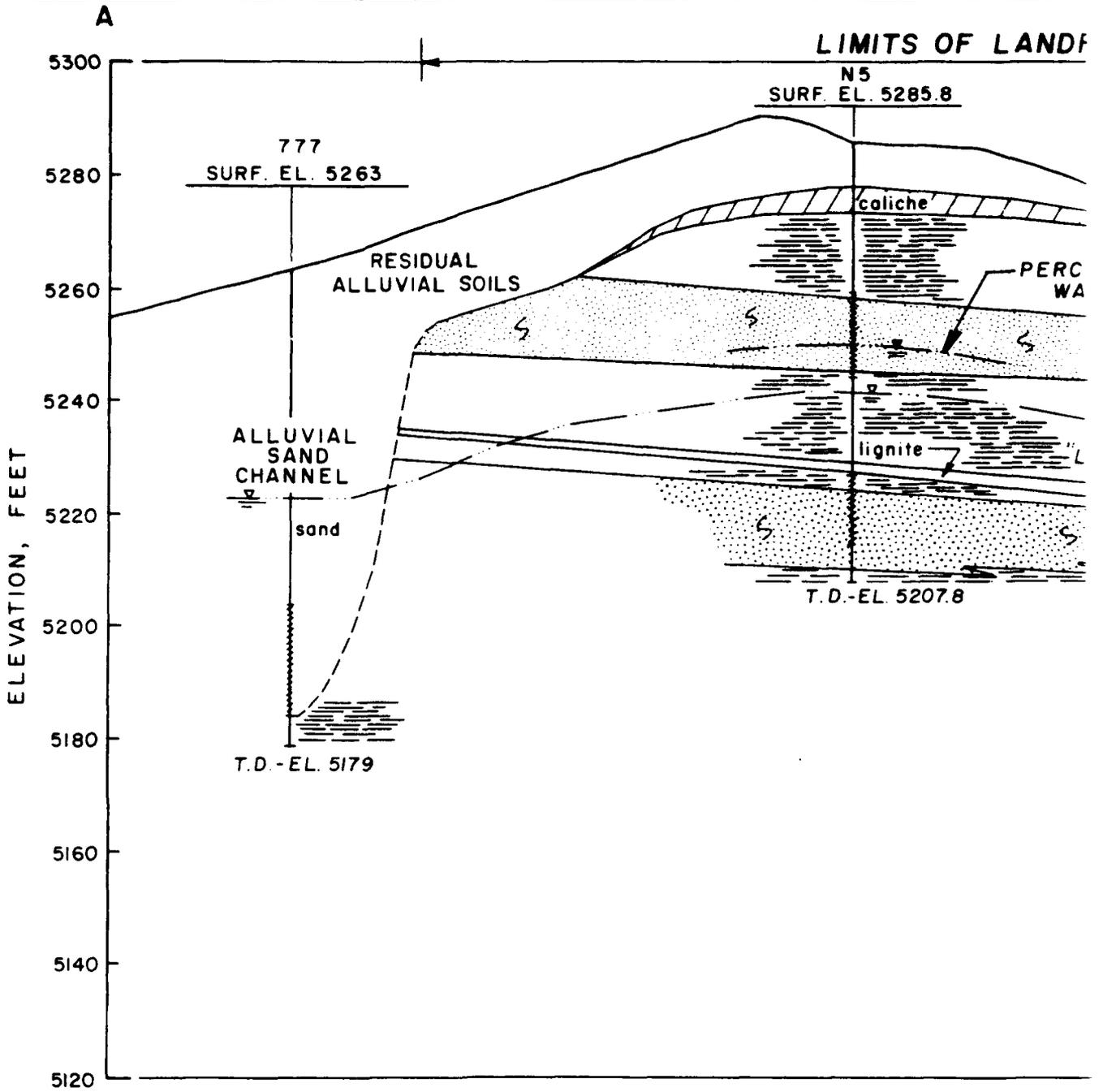
SITE AREA MAP

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COMMERCE CITY, COLORADO



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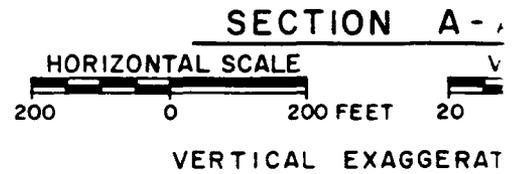
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 2-4-84
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LEGEND:

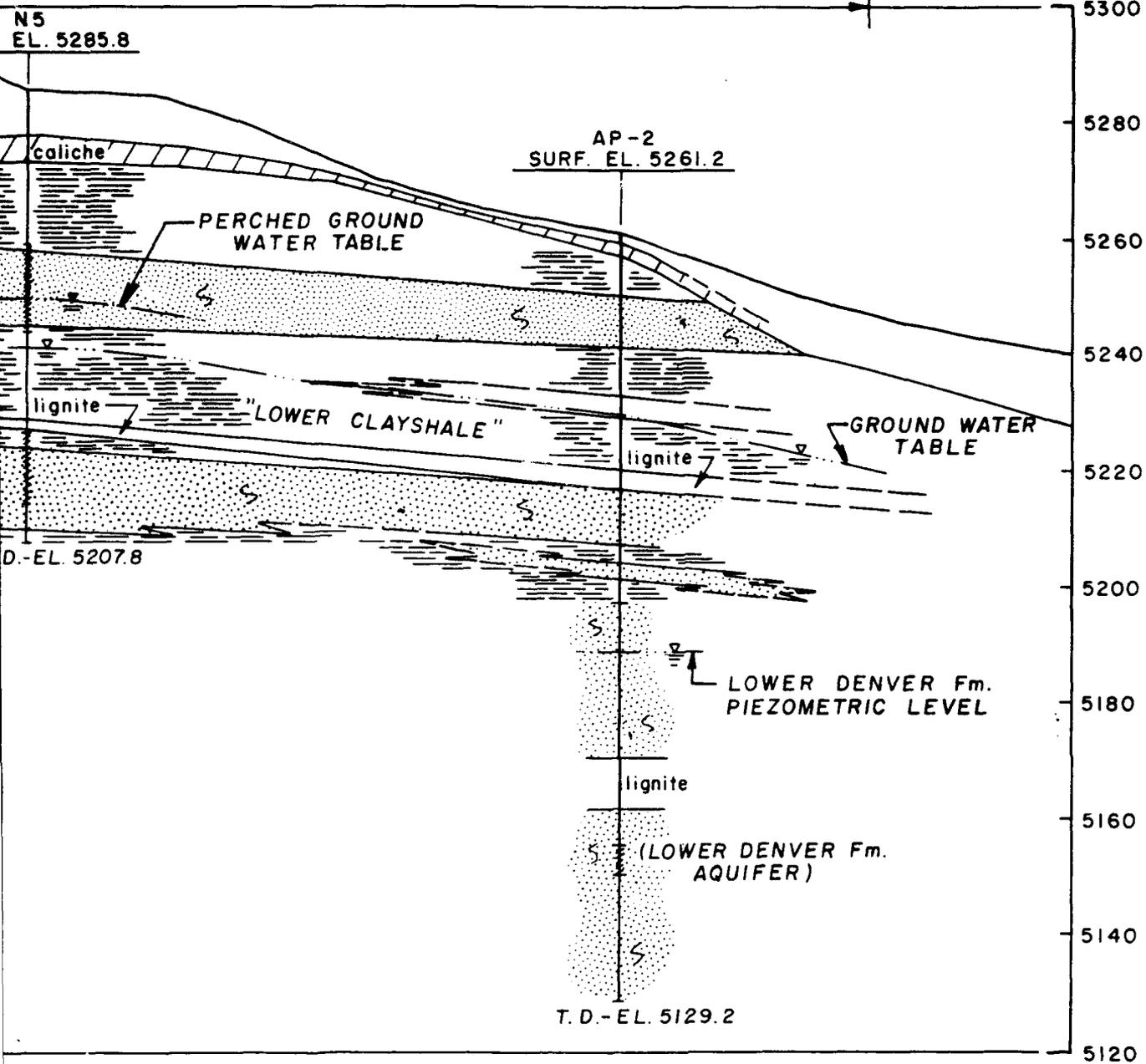
- CLAYSHALE
- SILTY SANDSTONE
- SCREENED INTERVAL

NOTE: SEE FIGURE 2 FOR LOCATION OF CROSS SECTION

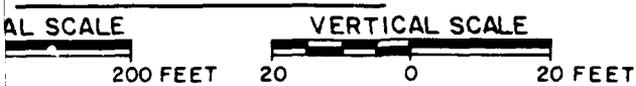


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LIMITS OF LANDFILL SITE



SECTION A-A'



VERTICAL EXAGGERATION = 10X

FIGURE 3
SITE AREA
GEOLOGIC SECTION

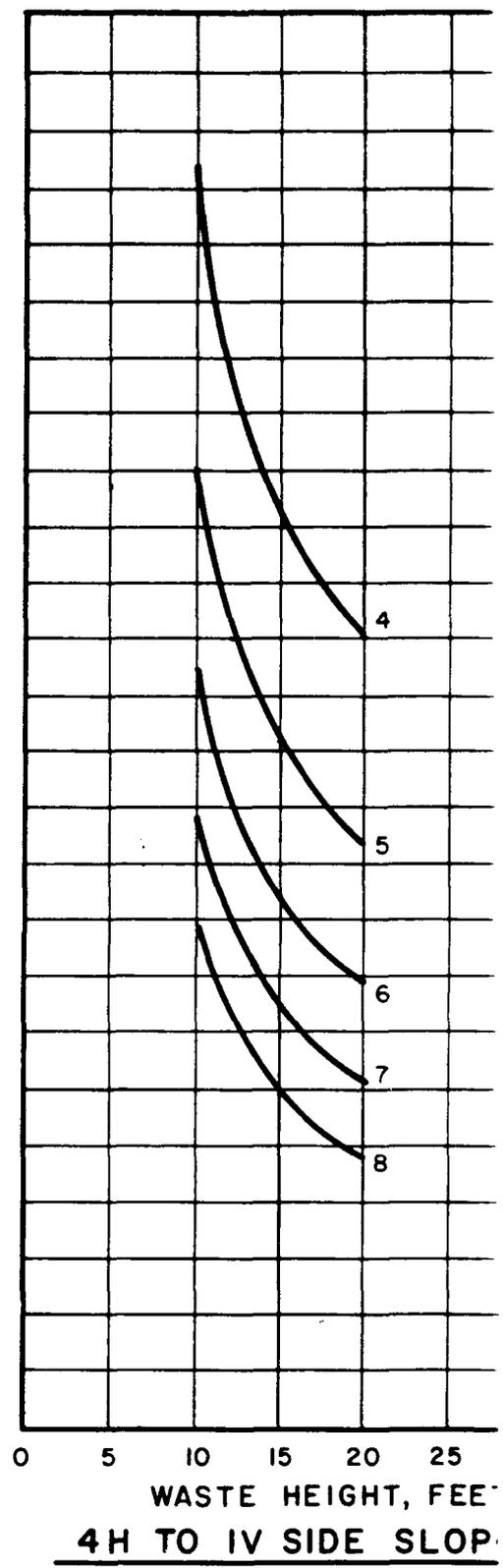
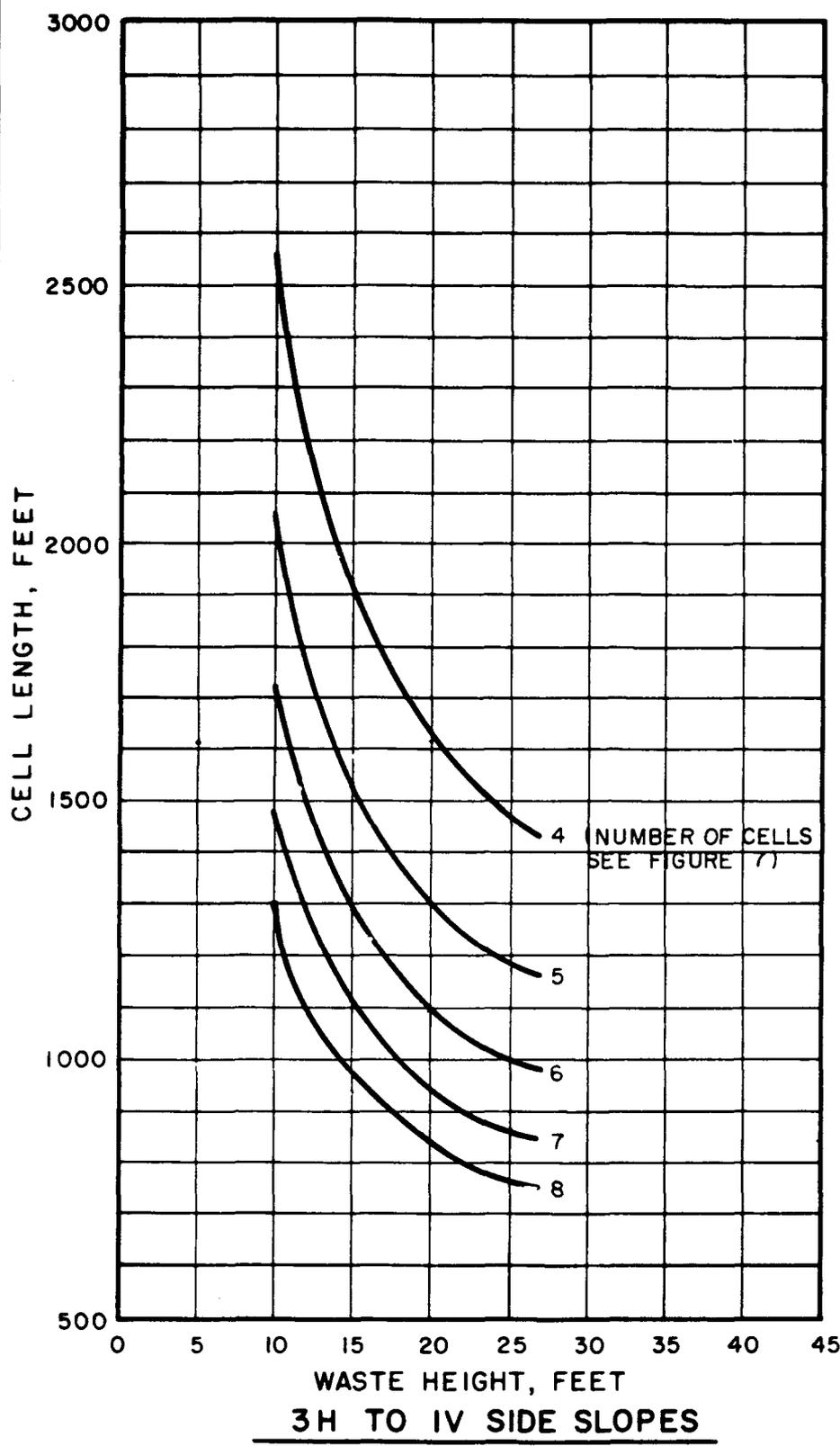
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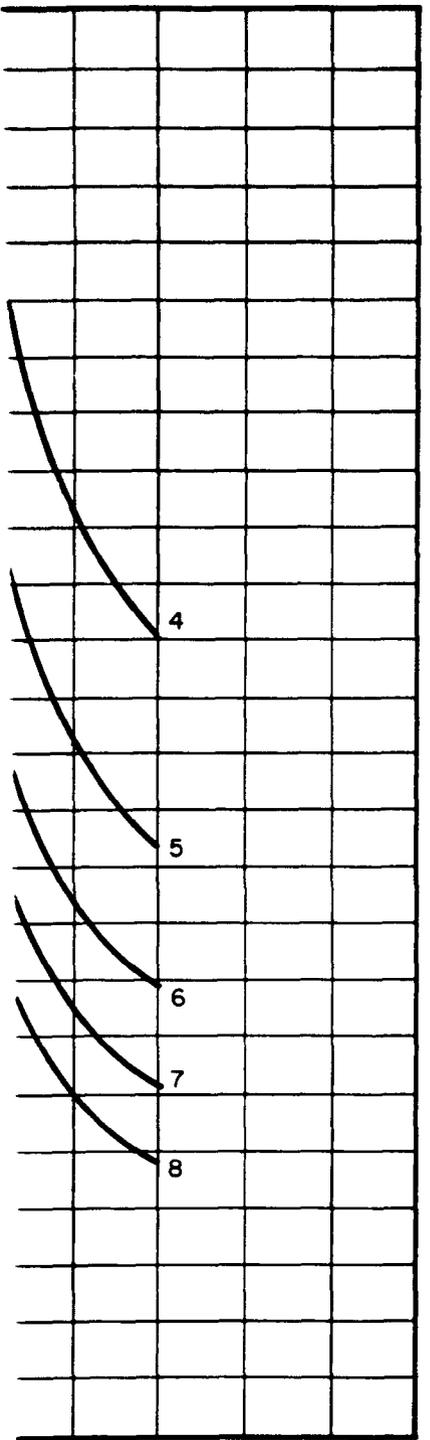
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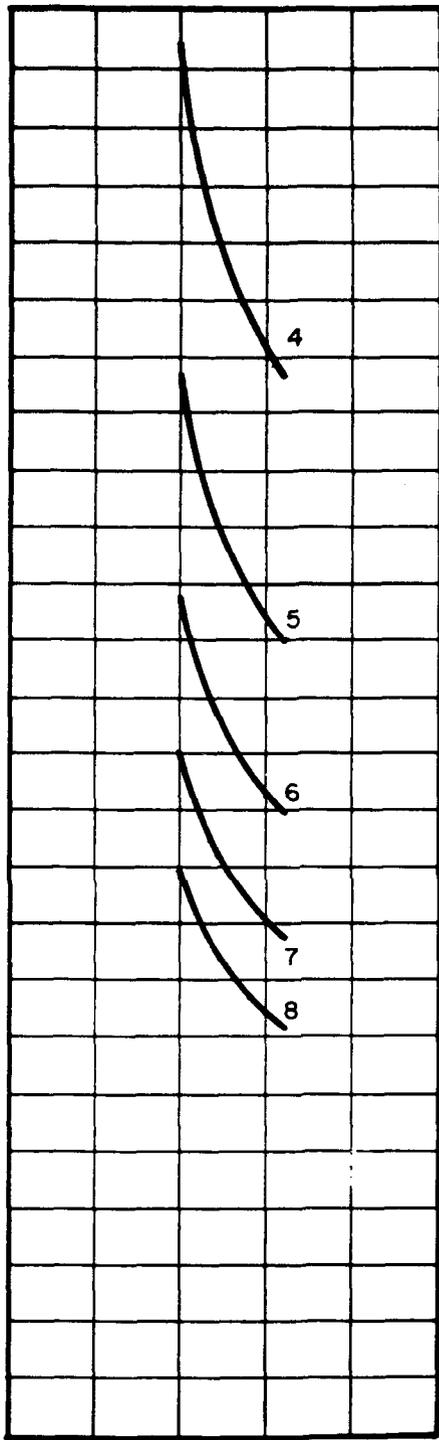
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WASTE HEIGHT, FEET
IV SIDE SLOPES



WASTE HEIGHT, FEET
5H TO IV SIDE SLOPES

NOTE:

WASTE CELL SHAPE IS A TRUNCATED PRISM WITH BENCH. SEE FIGURE 7 FOR VIEW OF TYPICAL CELL.

FIGURE 4

WASTE CELL CAPACITY CURVES
 CELL WIDTH - 200 FEET

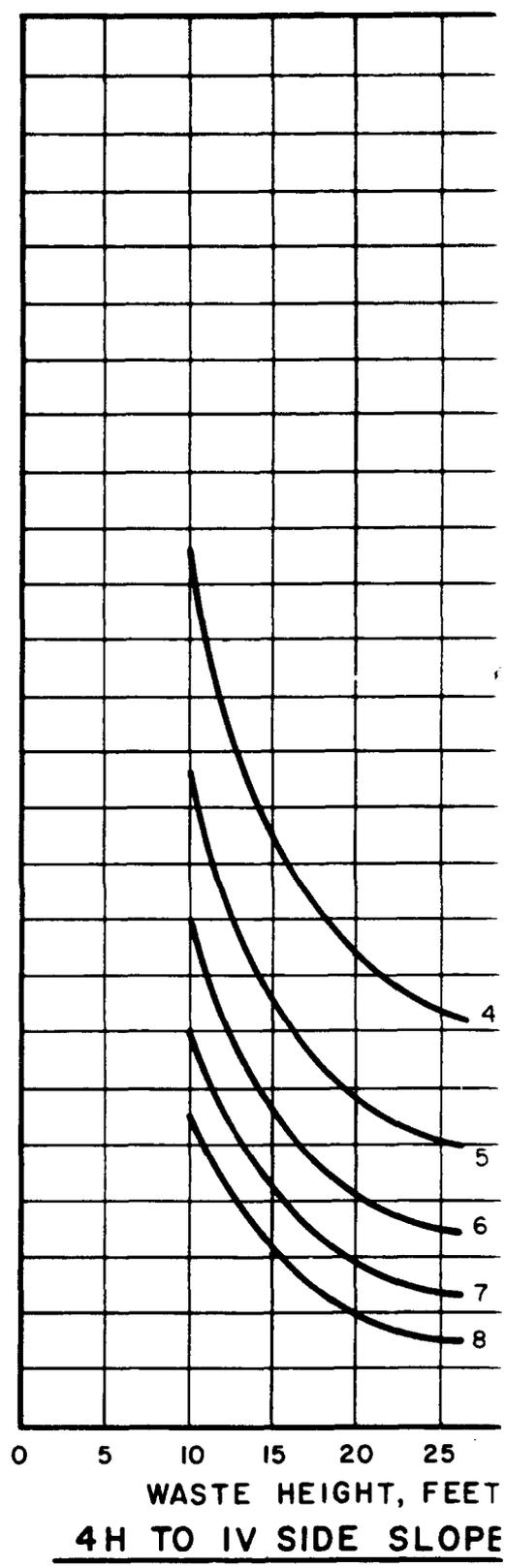
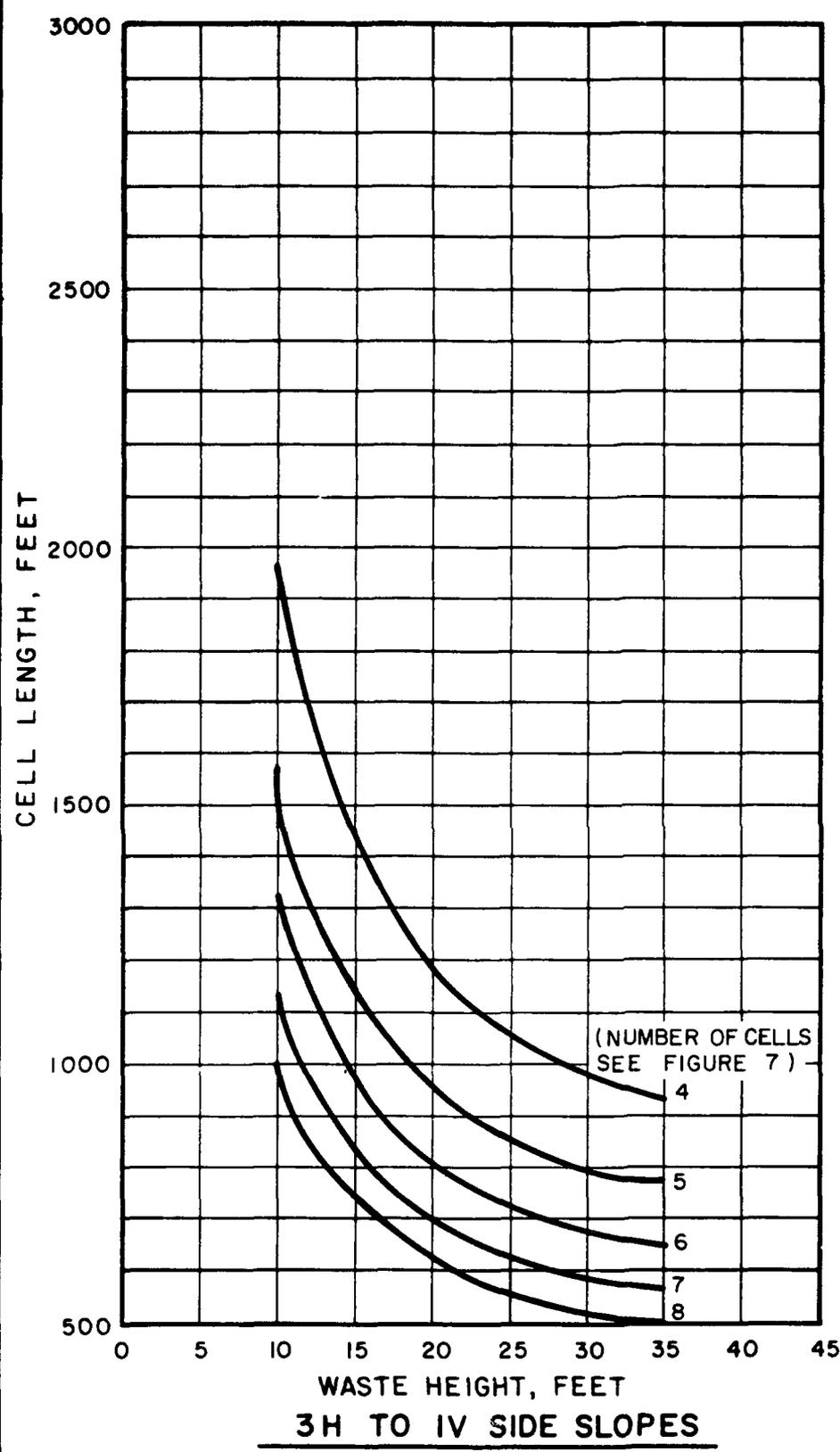
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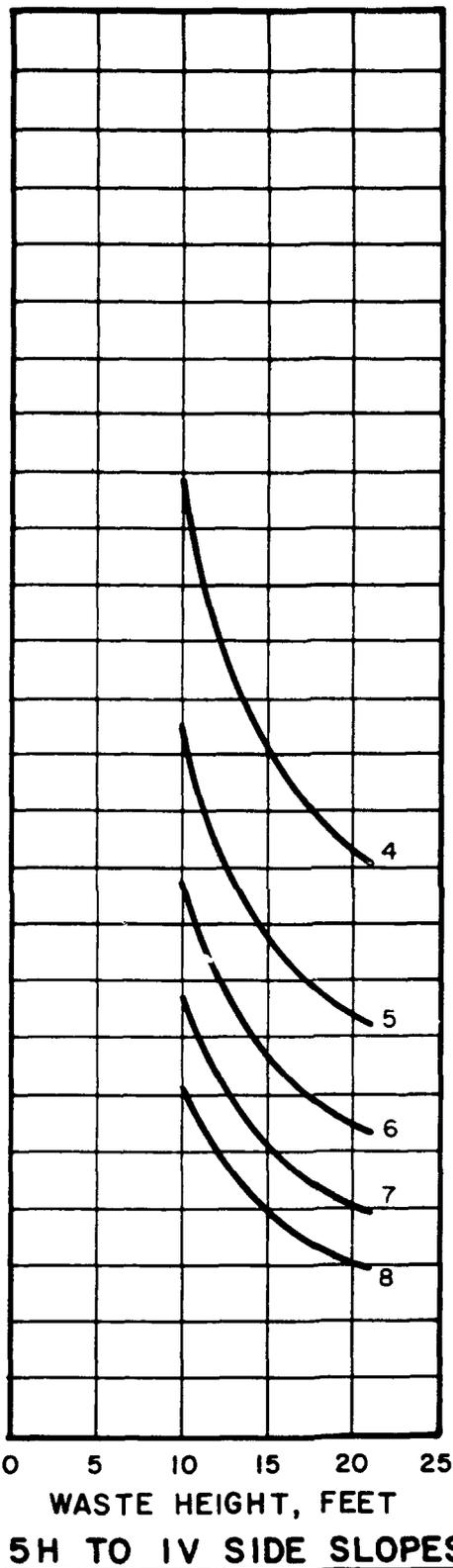
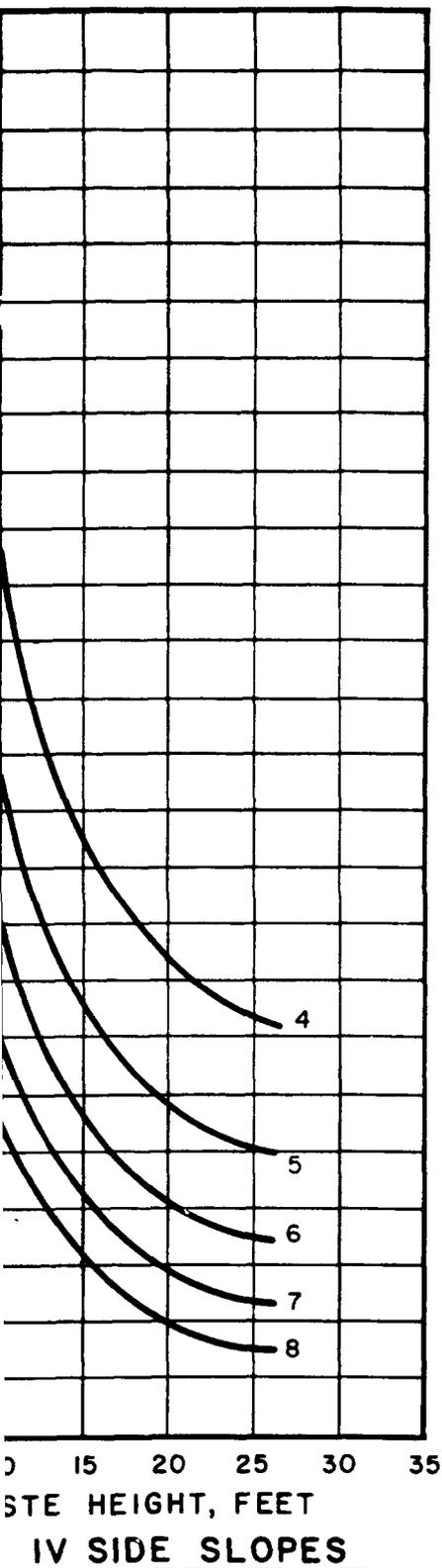


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6-27-84 DRAWING NUMBER 831641-B5



10/12



NOTE:

WASTE CELL SHAPE IS A TRUNCATED PRISM WITH BENCH. SEE FIGURE 7 FOR VIEW OF TYPICAL CELL.

FIGURE 5

WASTE CELL CAPACITY CURVES
CELL WIDTH - 250 FEET

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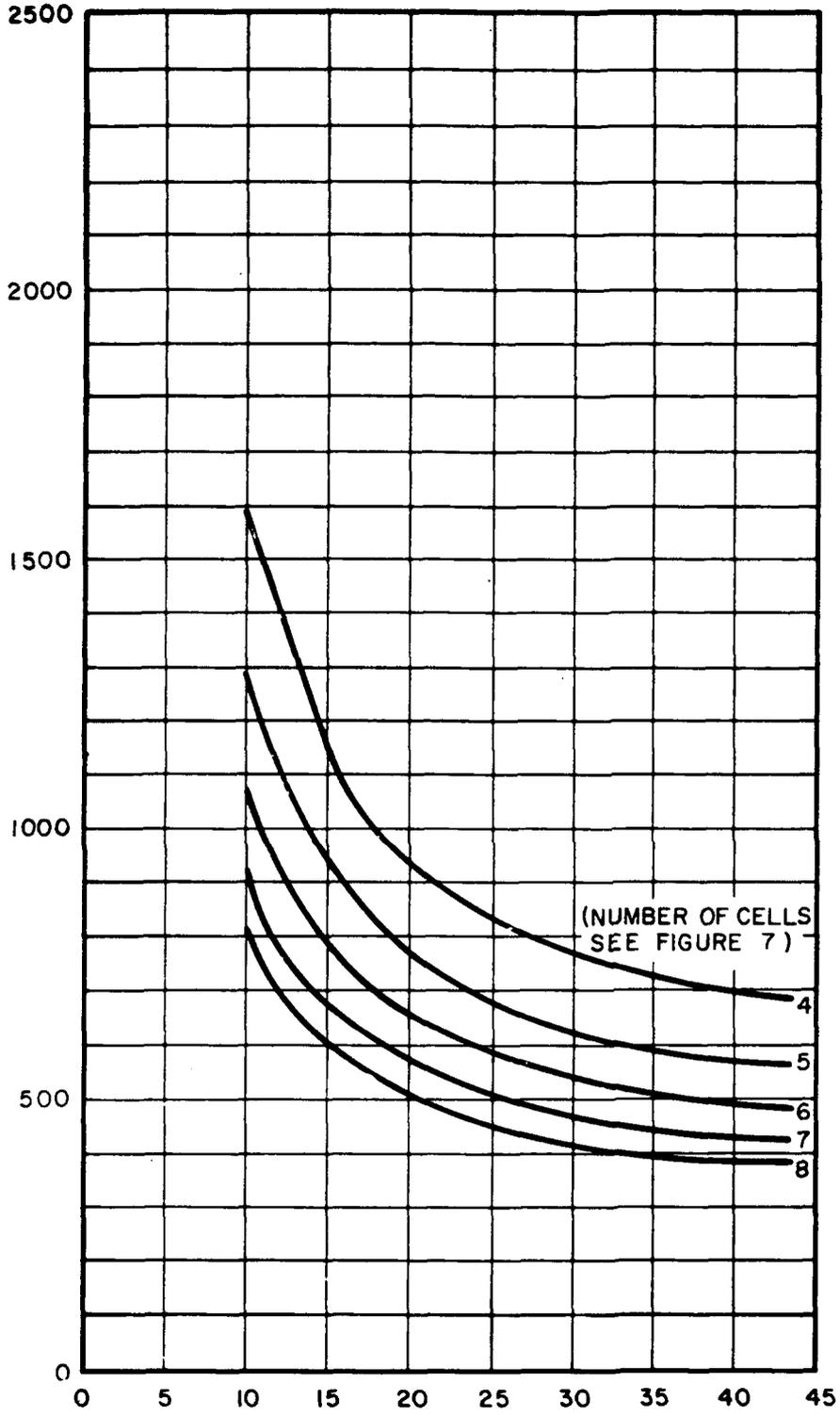
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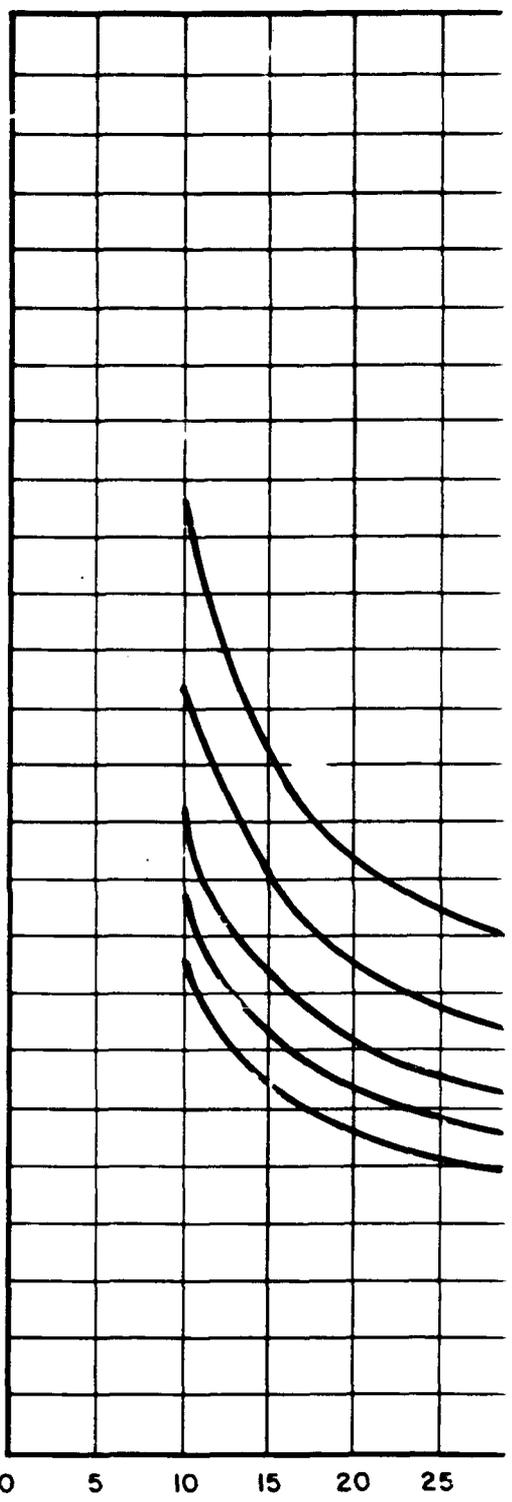
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CELL LENGTH, FEET

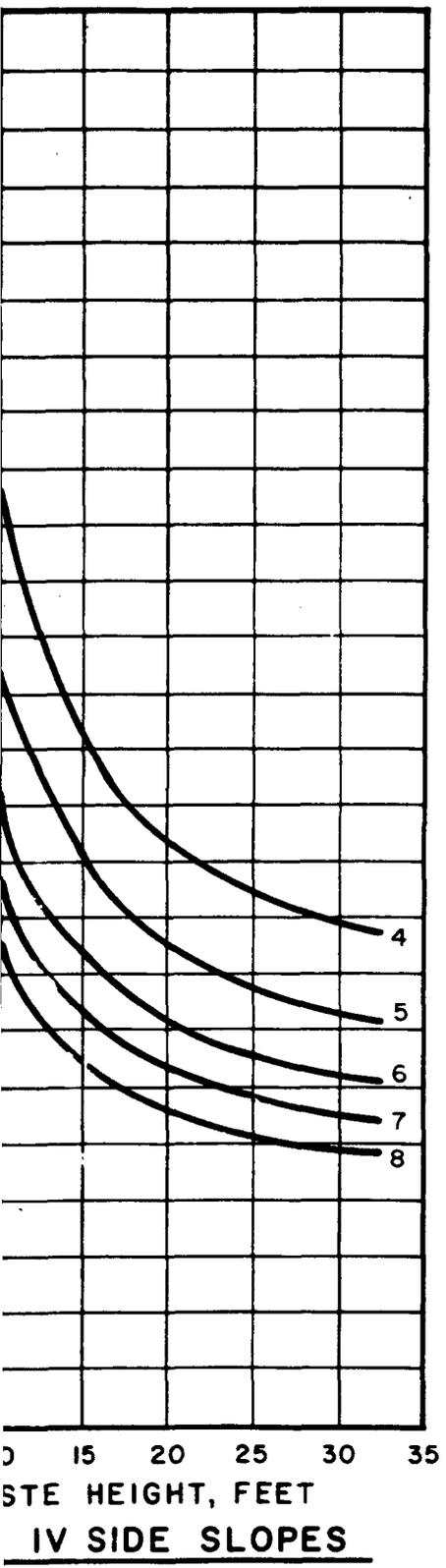


3H TO IV SIDE SLOPES

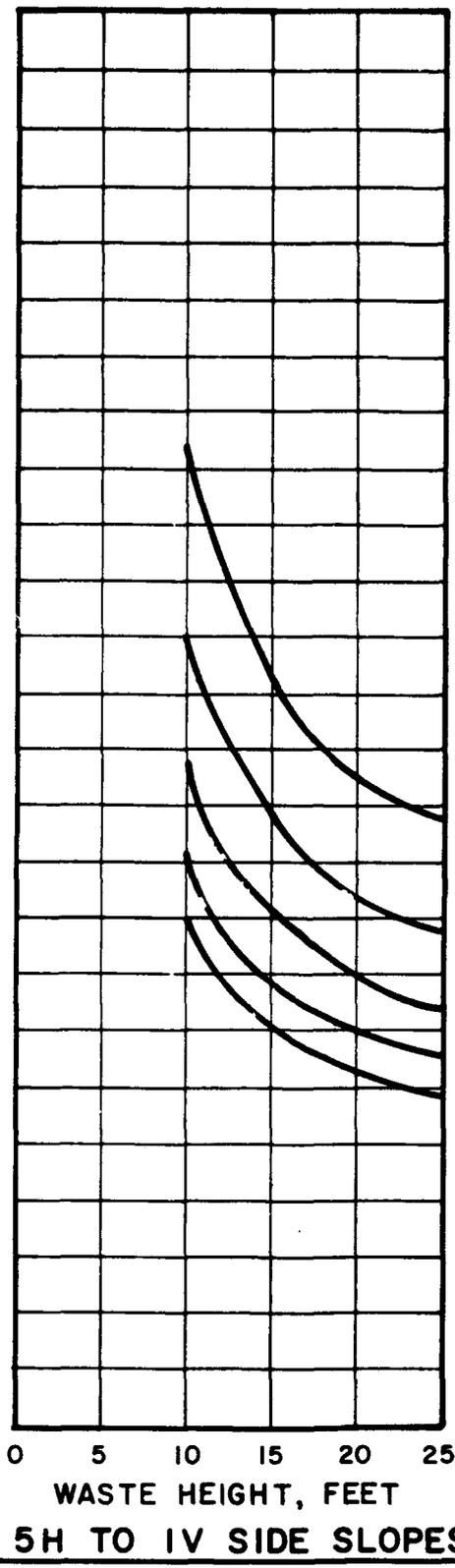


4H TO IV SIDE SLOPE

10/2



WASTE HEIGHT, FEET
IV SIDE SLOPES



WASTE HEIGHT, FEET
5H TO IV SIDE SLOPES

NOTE:

WASTE CELL SHAPE IS A TRUNCATED PRISM WITH BENCH. SEE FIGURE 7 FOR VIEW OF TYPICAL CELL.

FIGURE 6

WASTE CELL CAPACITY CURVES
CELL WIDTH - 300 FEET

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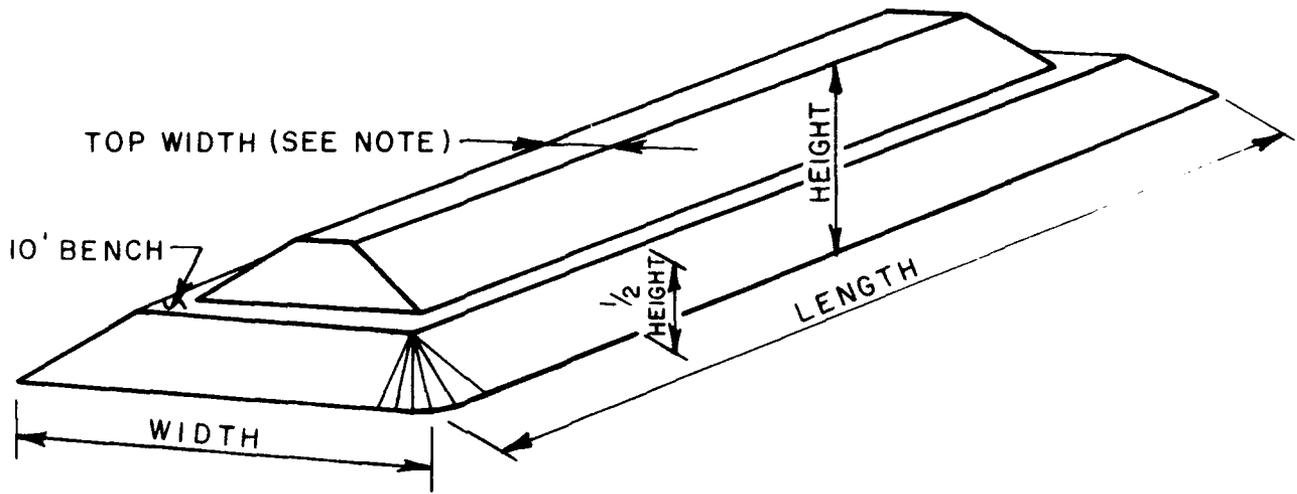
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 8/14/84

C.E.C.
 J.M.

CHECKED BY
 APPROVED BY

R.D.B.
 7-6-84

DRAWN BY



NUMBER OF CELLS	INDIVIDUAL CELL VOLUME (CUBIC YARDS)	TOTAL WASTE VOLUME (CUBIC YARDS)
4	150,000	↑ 600,000 ↓
5	120,000	
6	100,000	
7	85,714	
8	75,000	

NOTE:

MAXIMUM WASTE HEIGHTS SHOWN ON FIGURES 4, 5 & 6 DETERMINED FOR A MINIMUM TOP WIDTH OF 20 FEET.

FIGURE 7

SCHEMATIC WASTE CELL GEOMETRY

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 COMMERCE CITY, COLORADO



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 8/14/84
 DRAWING NUMBER 831641-A2

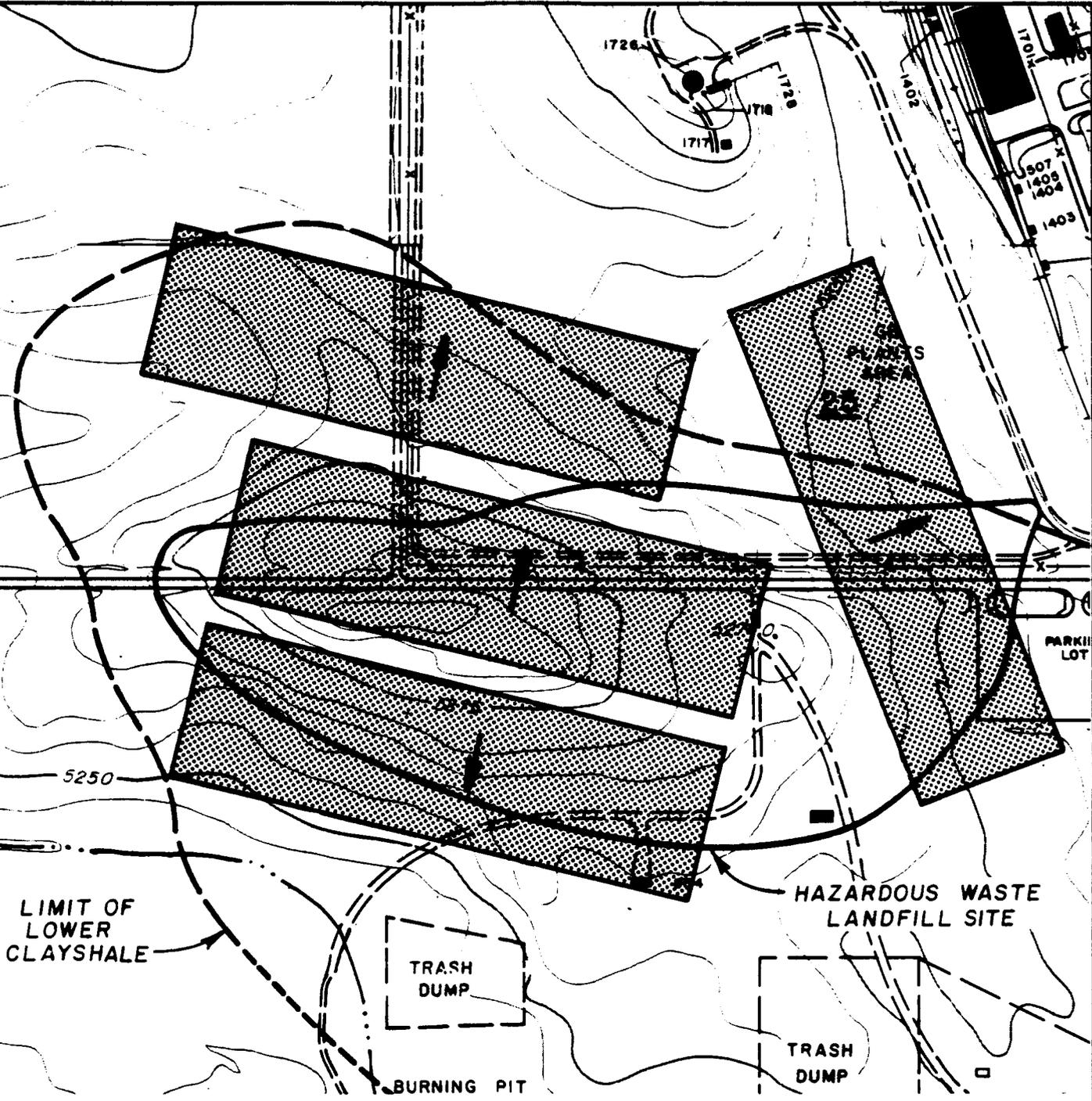


FIGURE 8

WASTE CELL LAYOUT
FOUR CELLS

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 ROCKY MOUNTAIN ARSENAL
 COMMERCE CITY, COLORADO

SCALE
 0 400 FEET

REFERENCE:
 ROCKY MOUNTAIN ARSENAL
 GENERAL SITE MAP, AREAS 4 & 5,
 SHEET NO.s 24 & 33 OF 67. DATED 10/2/78.



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7-2-84 APPROVED BY JEM 8/14/84

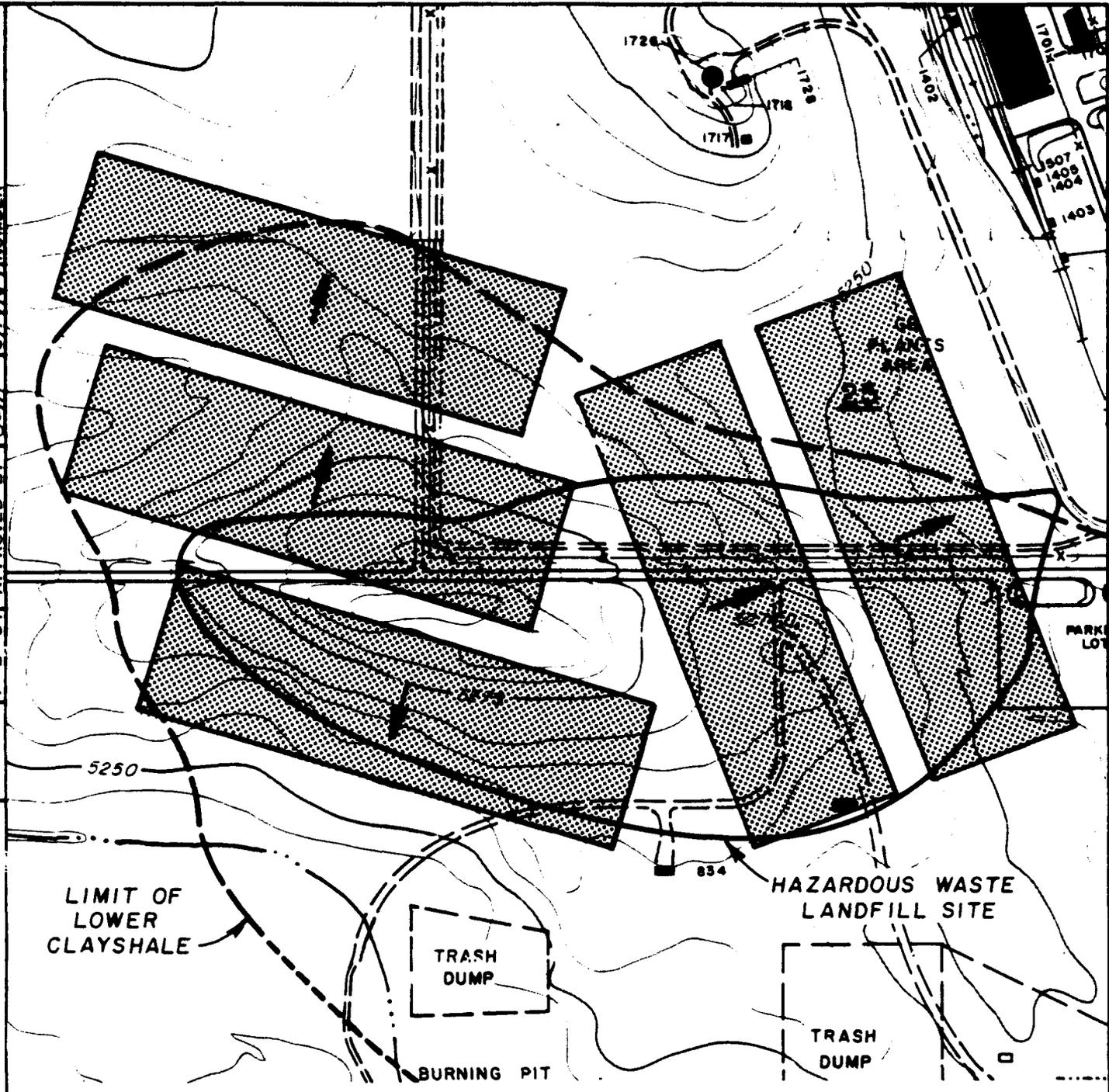


FIGURE 9

WASTE CELL LAYOUT
FIVE CELLS

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ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO

SCALE
0 400 FEET

REFERENCE:
ROCKY MOUNTAIN ARSENAL
GENERAL SITE MAP, AREAS 4 & 5,
SHEET NO.s 24 & 33 OF 67. DATED 10/2/78.



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NUMBER 831641

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APPROVED BY SDR

T.K.
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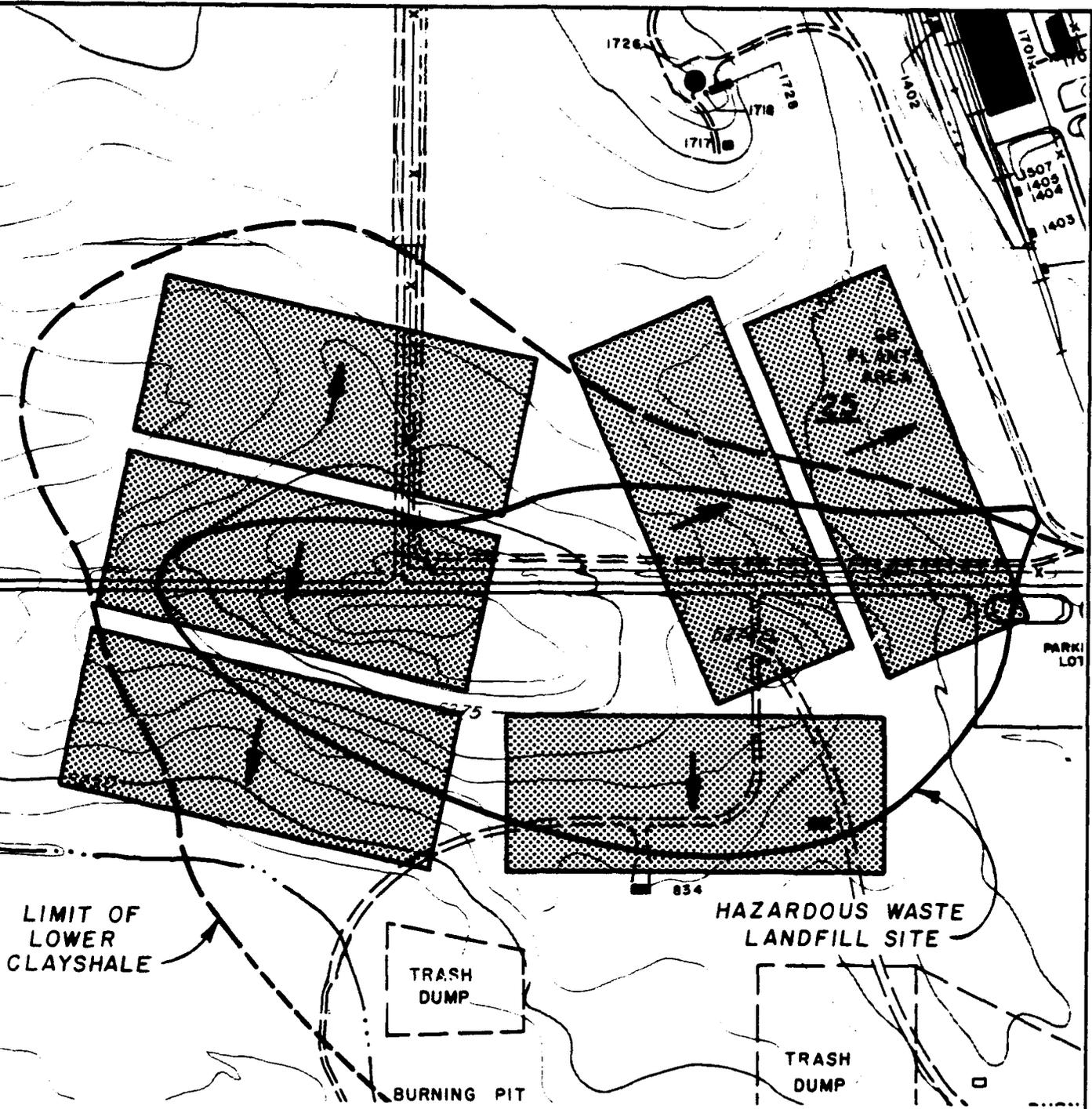


FIGURE 10

WASTE CELL LAYOUT
SIX CELLS

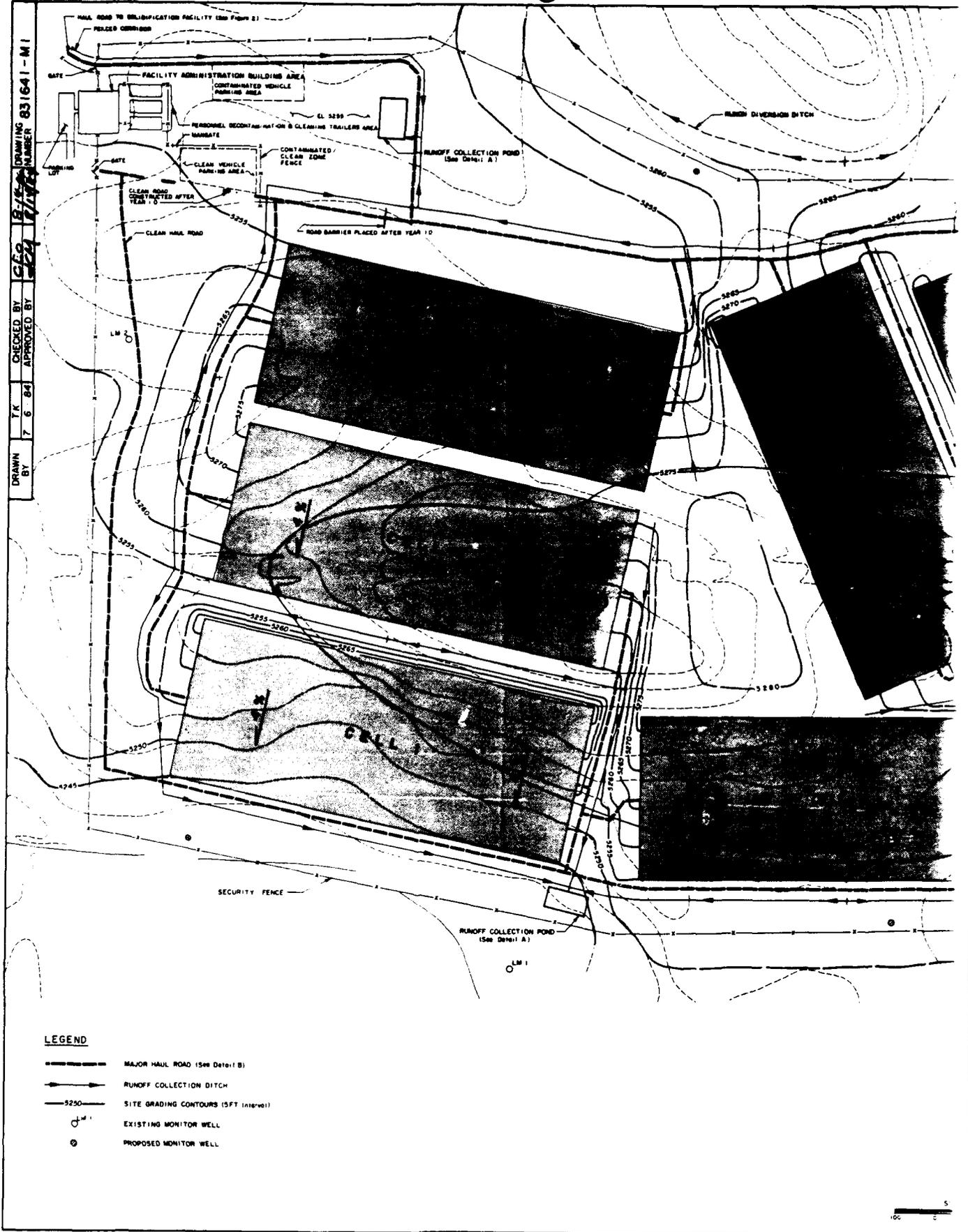
PREPARED FOR
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ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO

SCALE
0 400 FEET

REFERENCE:
ROCKY MOUNTAIN ARSENAL
GENERAL SITE MAP, AREAS 4 & 5,
SHEET Nos. 24 & 33 OF 67. DATED 10/2/78.



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 APPROVED BY [Signature]
 DRAWN BY TK
 7 6 84



- LEGEND**
- MAJOR HAUL ROAD (See Detail B)
 - RUNOFF COLLECTION DITCH
 - 3250— SITE GRADING CONTOURS (5FT Interval)
 - EXISTING MONITOR WELL
 - PROPOSED MONITOR WELL



1062

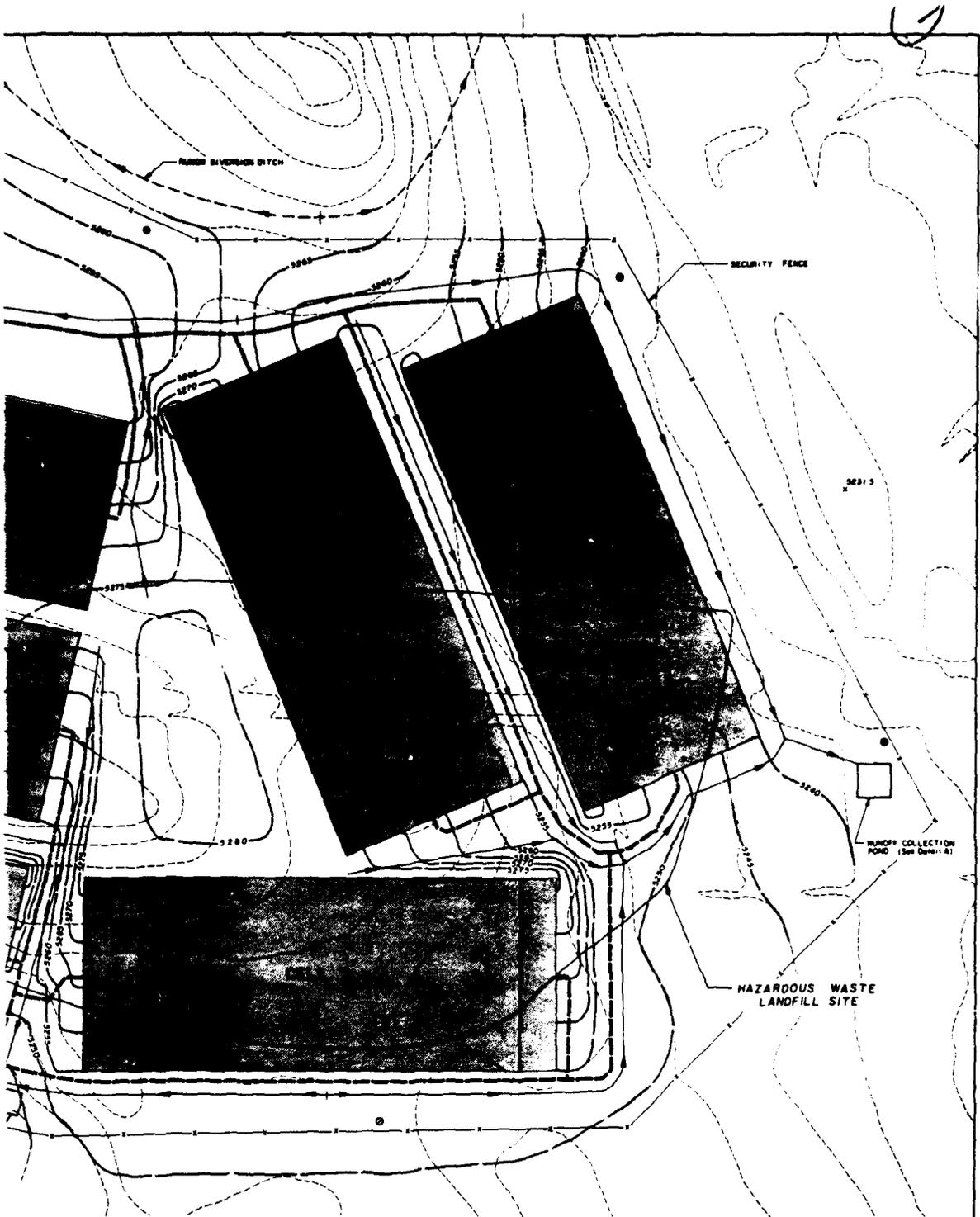
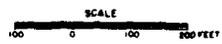


FIGURE 11

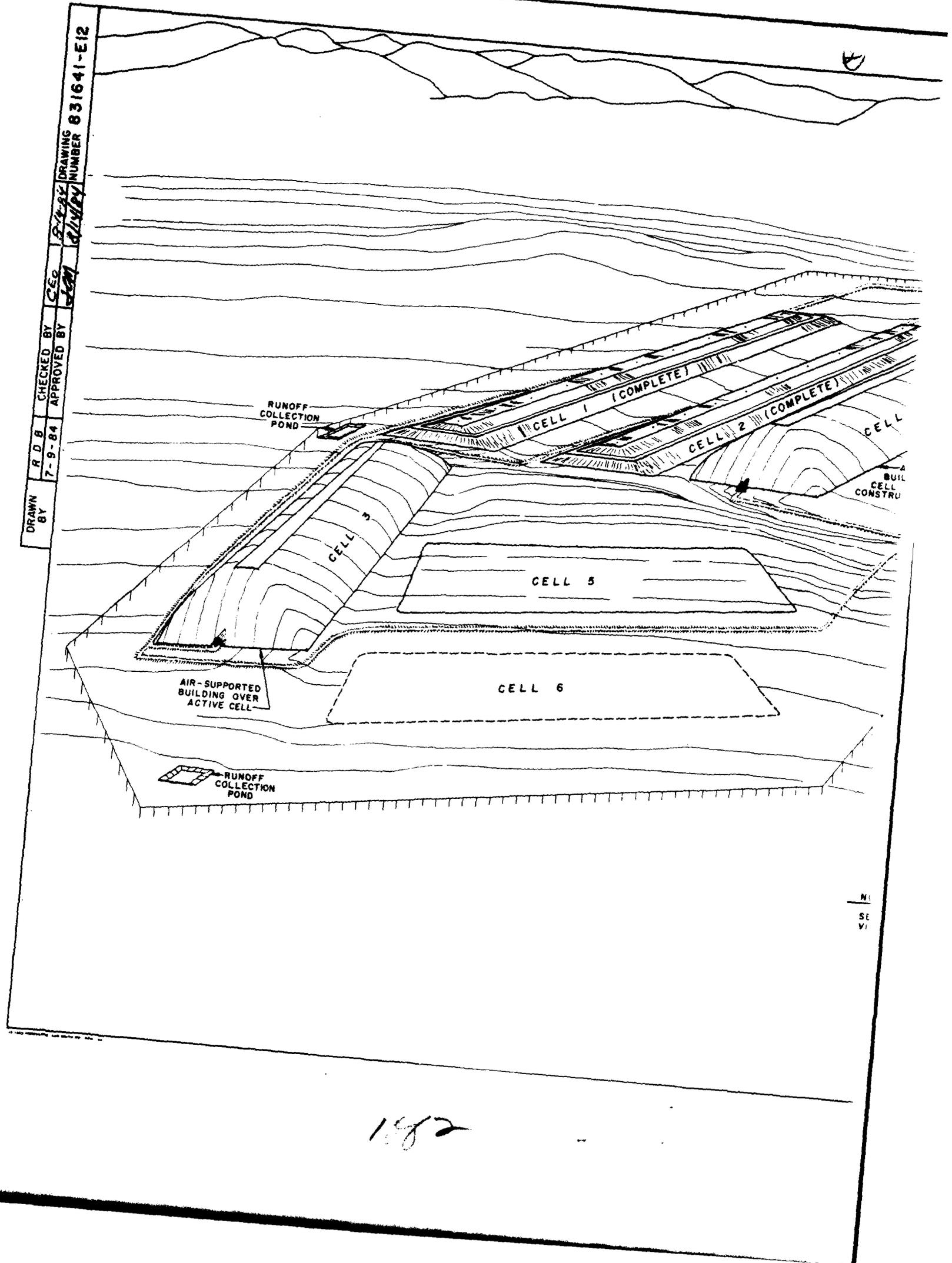
LANDFILL FACILITY
CONCEPT DESIGN

PREPARED FOR
DEPARTMENT OF THE ARMY
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO

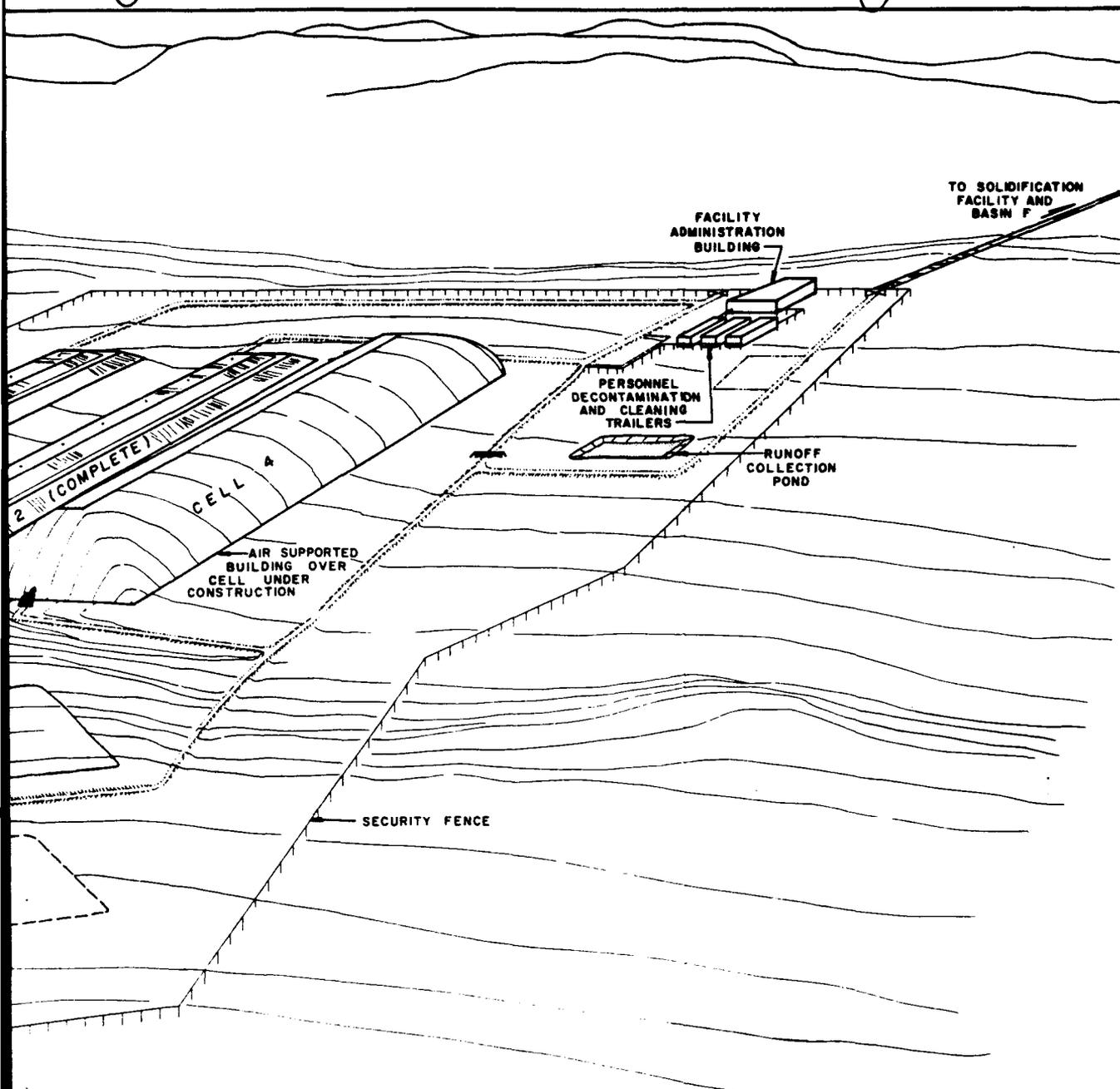


202

DRAWN BY R.D.B.
 CHECKED BY C.E.P.
 APPROVED BY [Signature]
 DRAWING NUMBER 831641-E12



1882



NOTE:
SEE FIGURE 11 FOR PLAN
VIEW OF LANDFILL FACILITY.

FIGURE 12
PERSPECTIVE VIEW
LANDFILL FACILITY
CONCEPT DESIGN
YEAR 1.0 THROUGH 1.5

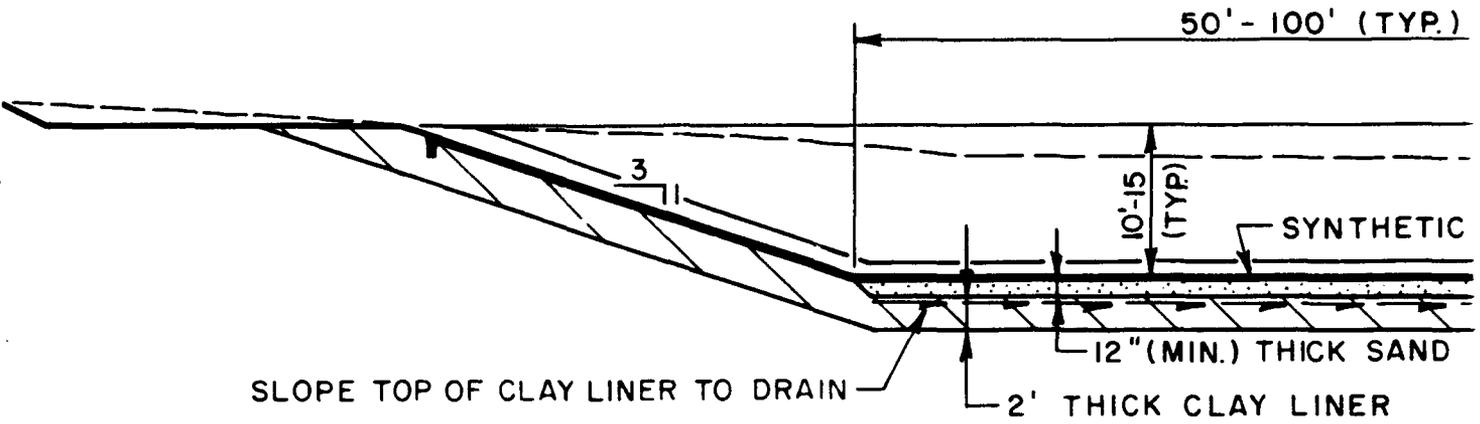
PREPARED FOR
DEPARTMENT OF THE ARMY
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO



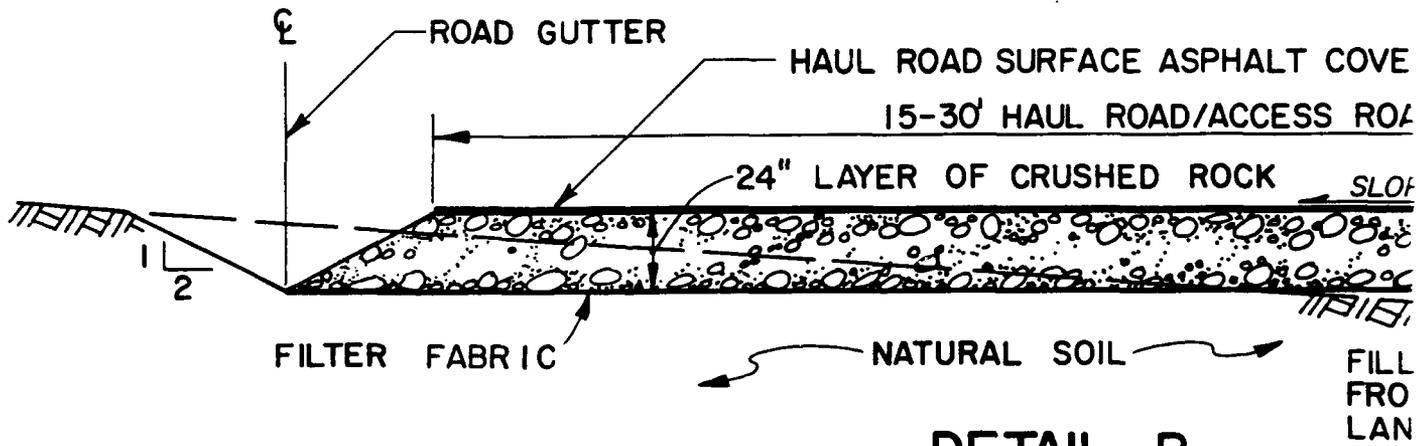
2062

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BY	7.9.84	APPROVED BY	SM	DATE	8/14/84

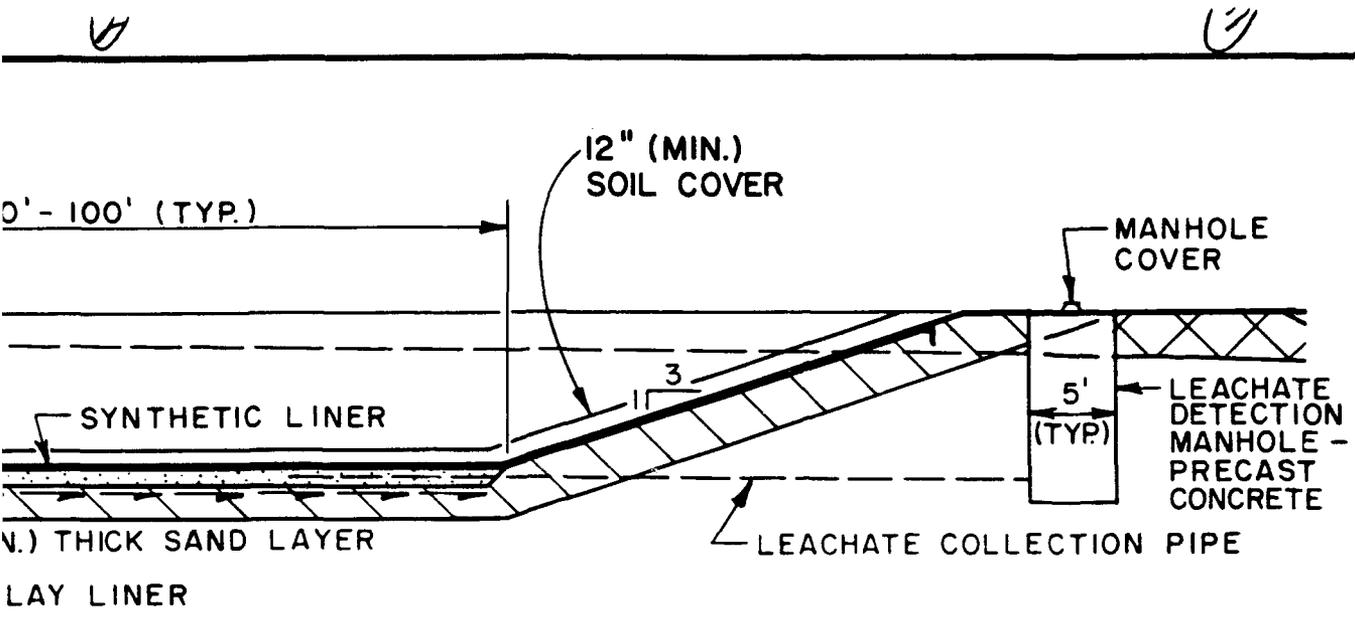


DETAIL A
TYPICAL SECTION-RUNOFF

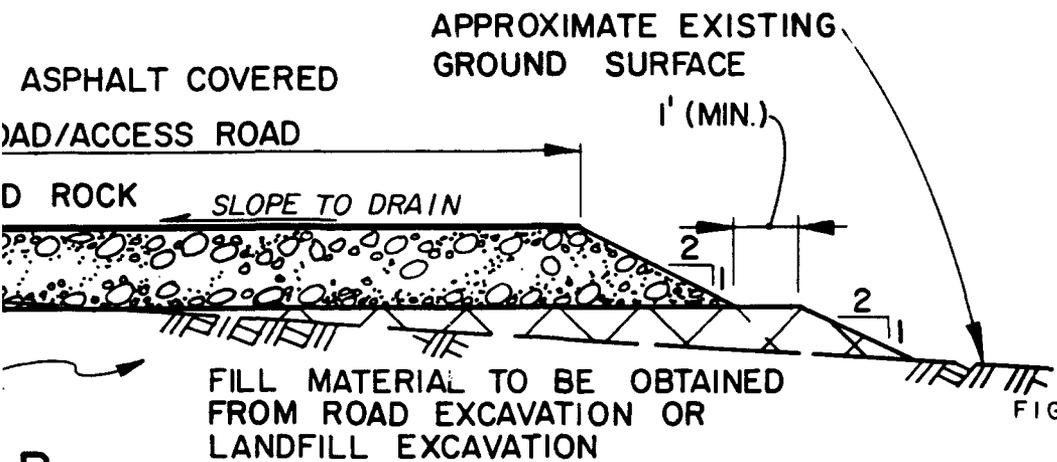


DETAIL B
TYPICAL HAUL ROAD/ACCESS
(NOT TO SCALE)

172



DETAIL A
-RUNOFF COLLECTION POND



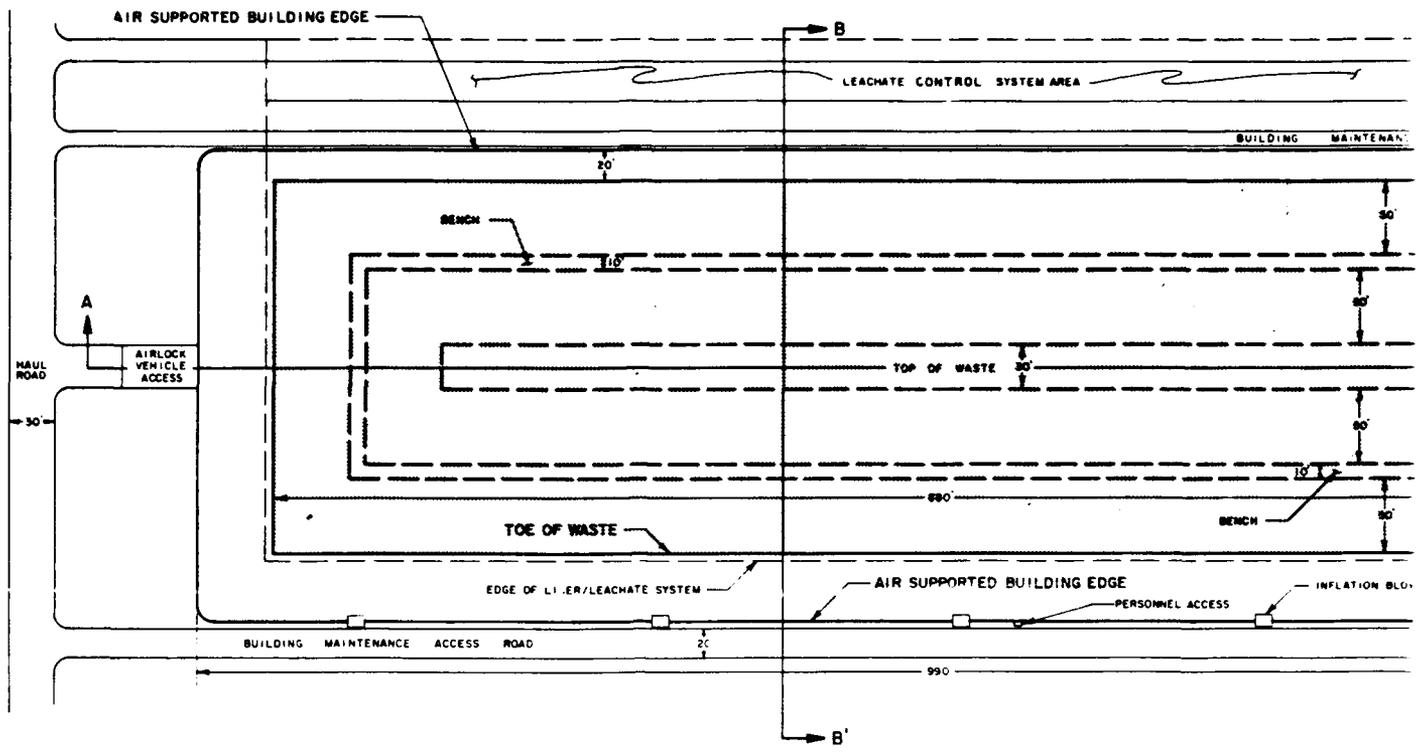
B
AD/ACCESS ROAD
 (SCALE)

FIGURE 13

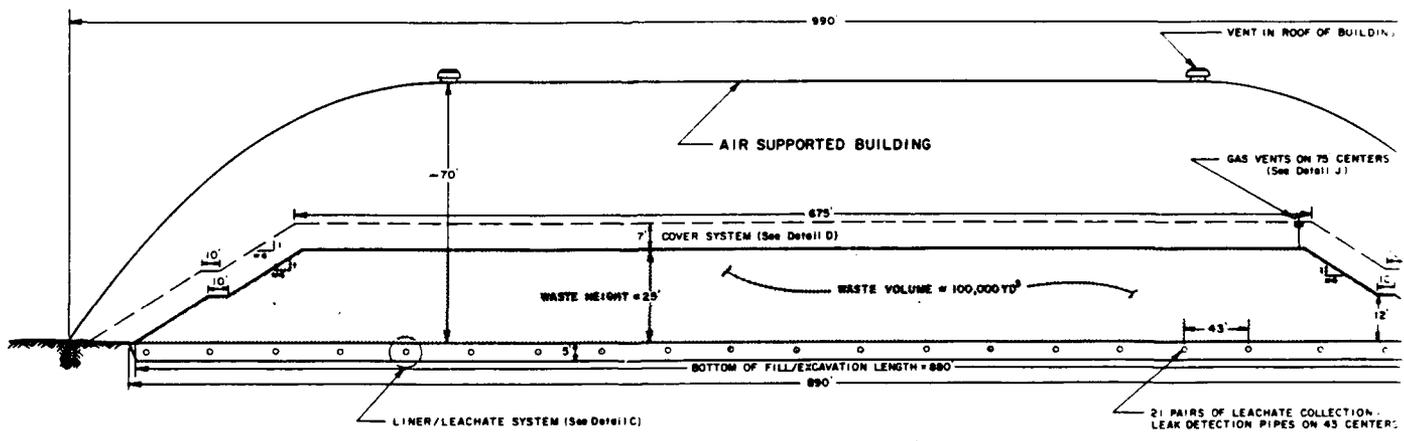
DETAILS
 FACILITY CONCEPT DESIGN
 PREPARED FOR
 DEPARTMENT OF THE ARMY
 ROCKY MOUNTAIN ARSENAL
 COMMERCE CITY, COLORADO

2182

DRAWN BY T.K. 7.5.84
 CHECKED BY C.L.O. APPROVED BY
 DRAWING NUMBER 831641-E10
 8/11/84

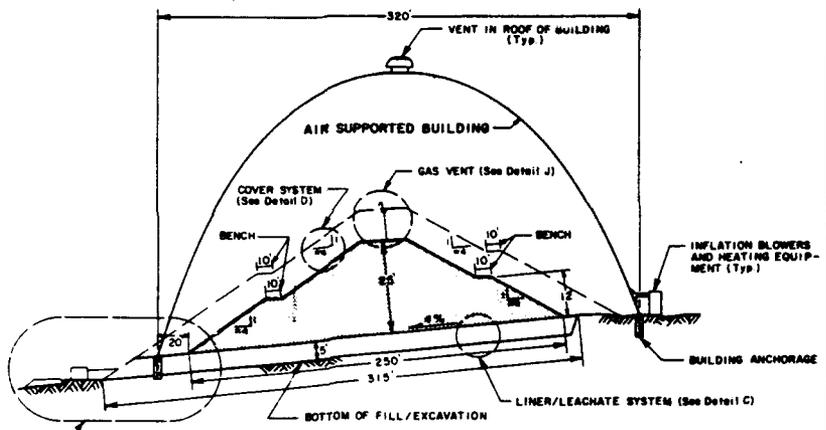
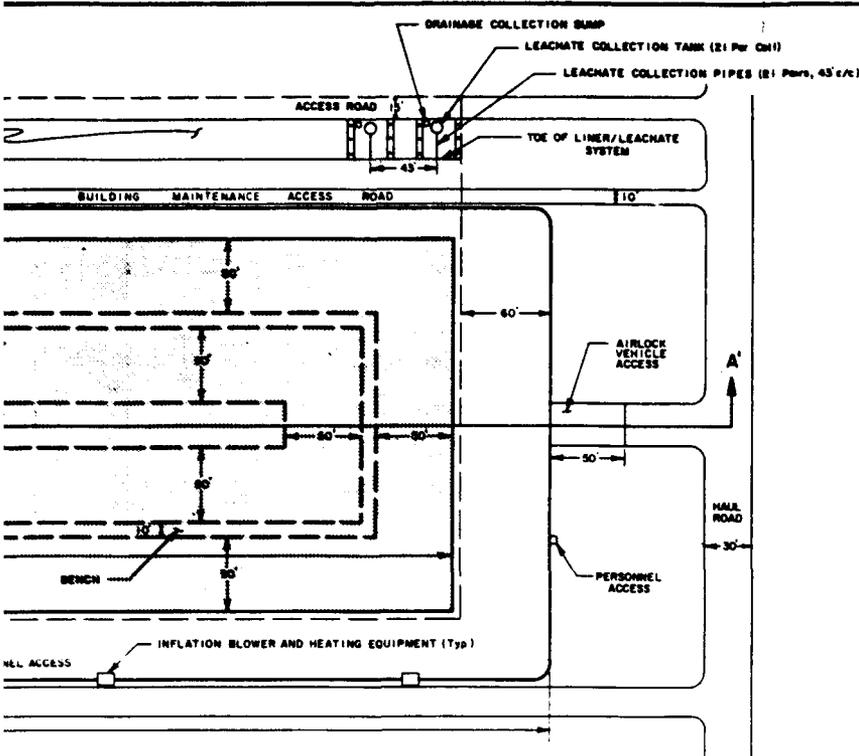


WASTE CELL PLAN



SECTION A-A'

1182

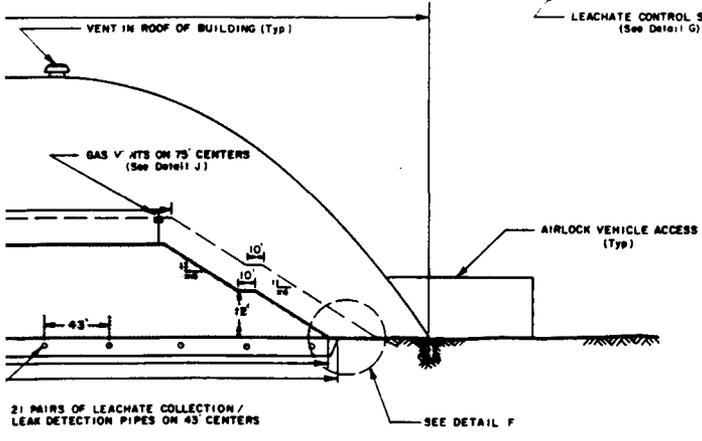


SECTION B-B'

FIGURE 14

**WASTE CELL CONCEPT DESIGN
PLAN AND SECTIONS**

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2182

DRAWING NUMBER 831641-E13

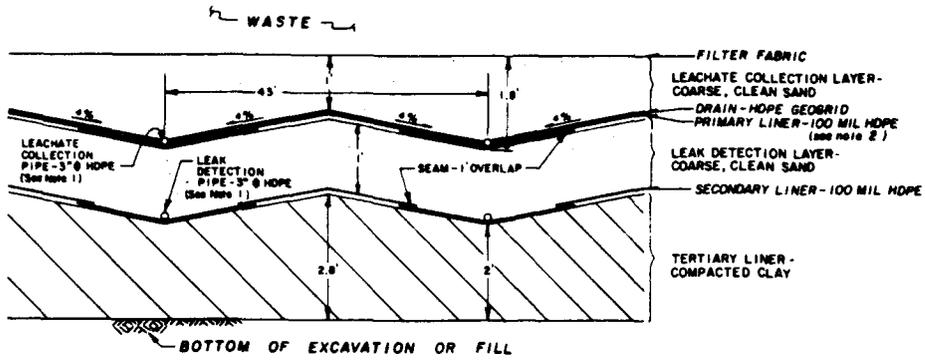
8/14/84

CEG

CHECKED BY APPROVED BY

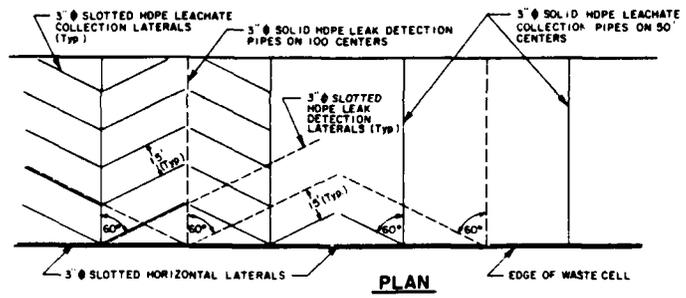
TK 7.10.84

DRAWN BY

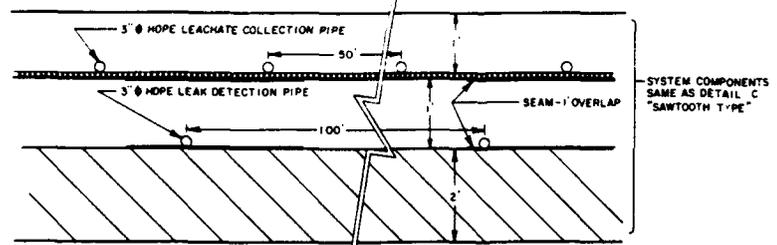


- NOTES
- 250 FOOT SLOTTED PIPES, UNDERLAIN BY 1-FOOT WIDE STRIPS OF 100 MIL HDPE, AND WRAPPED IN FILTER FABRIC
 - HDPE SHOWN IS 22.5 FEET WIDE WITH IS VARIABLE TO 34 FEET MAXIMUM.

DETAIL C
LINER/LEACHATE SYSTEM
"SAWTOOTH" TYPE
 (NOT TO SCALE)

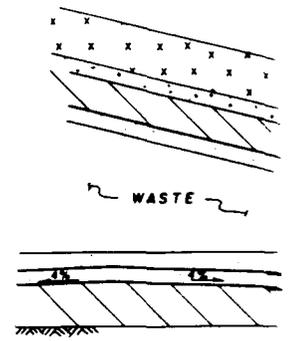


PLAN

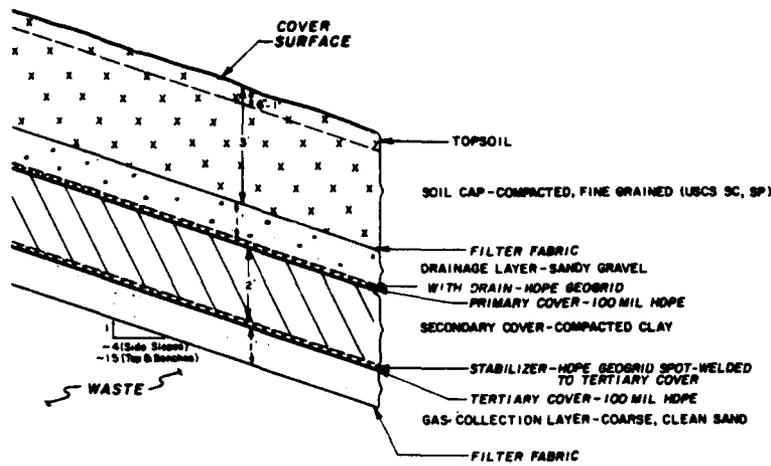


SECTION

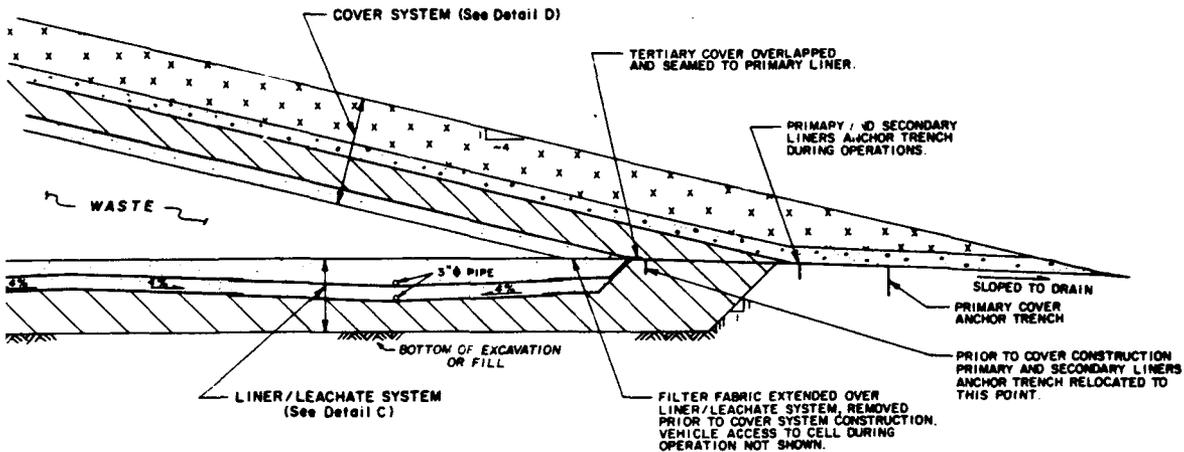
DETAIL E
LINER/LEACHATE SYSTEM
"FISHBONE" TYPE
 (NOT TO SCALE)



1482



DETAIL D
COVER SYSTEM
(NOT TO SCALE)



SCALE
5 0 5 FEET

DETAIL F
TYPICAL CELL EDGE

FIGURE 15

WASTE CELL DETAILS
SHEET 1 OF 2

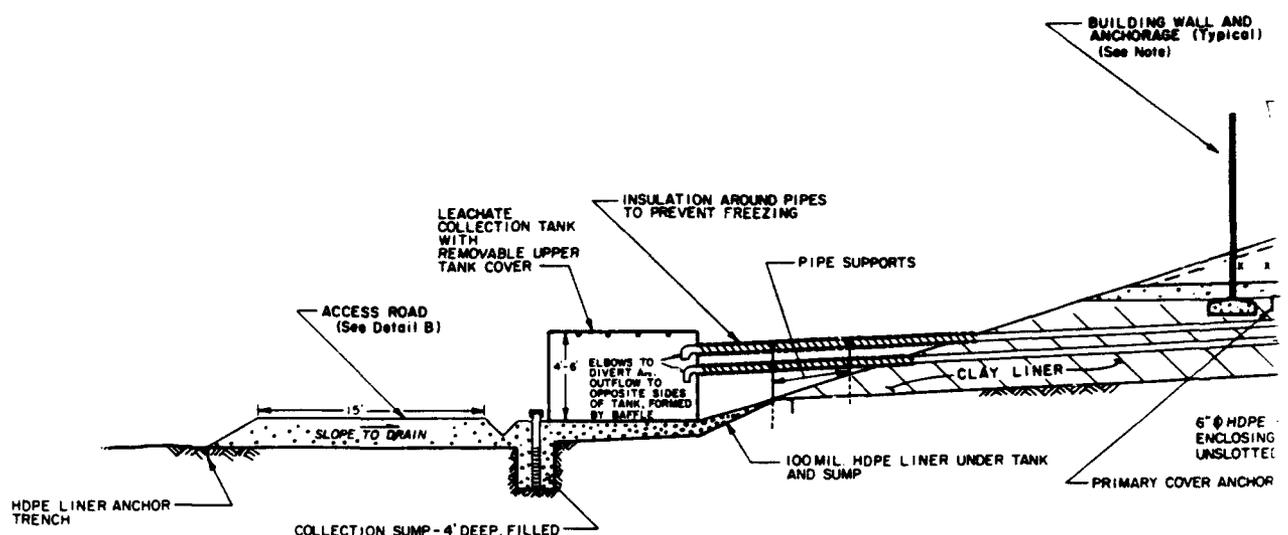
PREPARED FOR

DEPARTMENT OF THE ARMY
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO



2062

DRAWING NUMBER 831641-E14
 CHECKED BY [Signature]
 APPROVED BY [Signature]
 TK 7.10.84
 DRAWN BY [Signature]

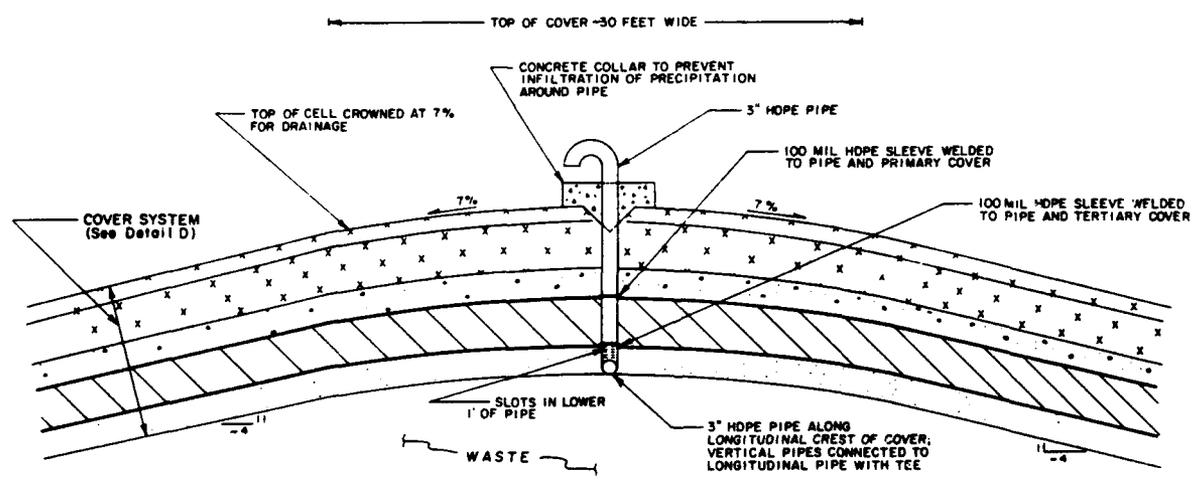
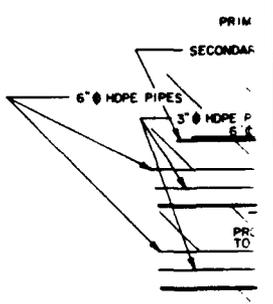


DETAIL G

TYPICAL CELL EDGE WITH LEACHATE CO



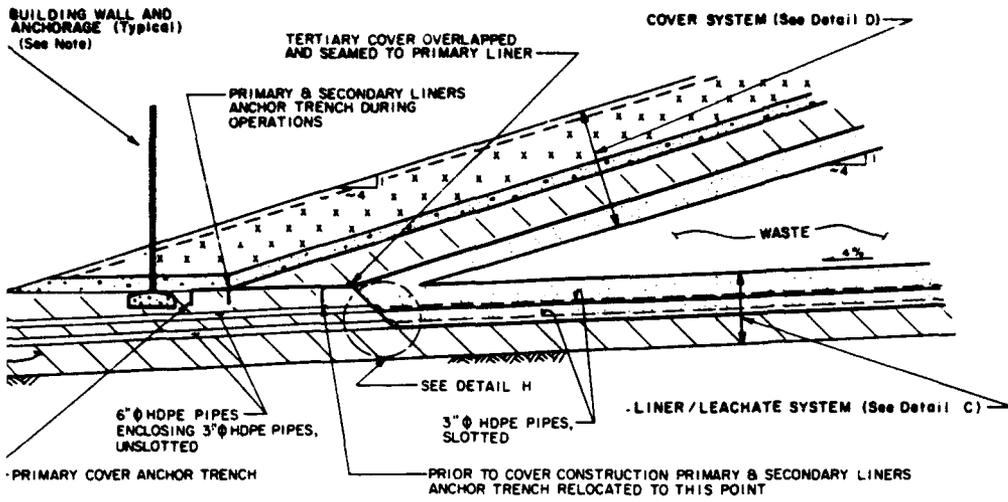
NOTE: BUILDING REMOVED AFTER MAJORITY OF COVER PLACEMENT BUT BEFORE FINAL SOIL PLACEMENT



NOTE: VERTICAL GAS VENT PIPES ON 75' CENTERS ALONG LANDFILL CREST

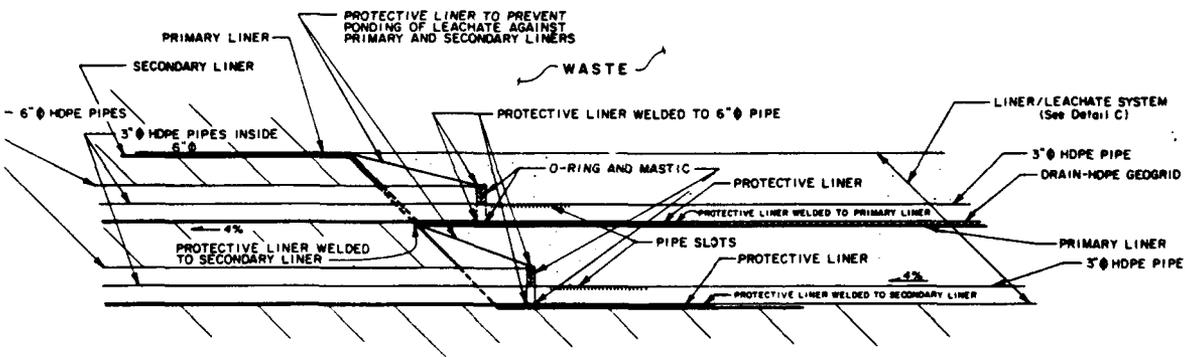
DETAIL J
TYPICAL GAS VENT IN TOP OF COVER
 (NOT TO SCALE)

1182



1L 6
LEACHATE CONTROL SYSTEM

SCALE
 0 3 FEET



DETAIL H
 (NOT TO SCALE)

FIGURE 16

WASTE CELL DETAILS
 SHEET 2 OF 2

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APPENDIX A
GUIDELINE WASTE CELL
CONSTRUCTION SPECIFICATIONS
AND
QUALITY ASSURANCE PROCEDURES

APPENDIX A

GUIDELINE WASTE CELL CONSTRUCTION SPECIFICATIONS
AND QUALITY ASSURANCE PROCEDURESSECTION A.1
SITE PREPARATIONPART 1 - GENERAL1.01 DESCRIPTIONA. Scope of Work

1. The Work covered by this Section consists of furnishing all plant, labor and equipment and performing all operations in connection with clearing and grubbing in accordance with the Drawings and these Specifications.

B. Limits of Clearing and Grubbing

1. The limits for clearing and grubbing shall be five (5) feet outside the limit of work for the construction as indicated on the Drawings.

PART 2 - PRODUCTS

Not required

PART 3 - EXECUTION3.01 CLEARINGA. General

1. Clearing shall consist of the removal and disposition of boulders, trees, brush, down timber, logs, trash and other growth and objects on or above the ground surface. Within the limits of excavation operations. Brush at the top of cut slopes, the roots or parts of which are exposed by the excavation operations, shall be removed completely.
2. Brush, stumps, down timber, and partially buried logs and snags shall be removed completely from all areas to be occupied by fill and these areas shall be stripped. On areas outside of and contiguous to the top of the cut

slopes and the toe lines of fill sections, brush shall be cut off and the areas shall be grubbed as specified for areas to be occupied by fill. Cleared material shall be disposed of as specified hereafter. Cleared materials shall not be placed in the fill sections or left on the Work area.

3.02 GRUBBING

A. General

1. Grubbing shall be done in all areas to be occupied by fill. Grubbing shall consist of the removal and deposition of stumps, roots, buried logs, boulders, and other objectionable material below the ground surface. Stumps, roots over 1-1/2 inches in diameter, buried logs and boulders shall be removed completely. Roots 1-1/2 inches and under in diameter shall be removed to a depth of 2 feet below the surface of the ground in the area. Excavations made for removal of stumps, roots, and buried material shall be backfilled to the ground surface with suitable material, and the areas shall be graded to present a neat and pleasing appearance. Within the limits of excavations, grubbing may be done during excavation operations.

3.03 MATERIAL DISPOSAL

A. General

1. All brush, logs, roots, trash and other combustible debris from the clearing, and grubbing operations shall be disposed of by burning (with an approved permit) and/or hauling to an approved disposal site. No such material shall be placed in the fill sections. All durable stone and boulders from clearing and grubbing may be salvaged for use in construction.

SECTION A.2
GENERAL EARTHWORK

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope of Work

1. The Work covered under this section includes the furnishing of labor, materials, required equipment and performing all operations for the following items of work:
 - a. Removal of plants and stripping and stockpiling topsoil, where appropriate.
 - b. All excavation, stockpiling, filling and rough grading for site work required by the Drawings and Specifications.
 - c. Placing and compacting fills as required.

B. Project Survey Layout

1. The project work shall be staked out by a qualified surveyor, including establishing elevations and all other layout work required. He shall also establish a datum point from which all grades are to be taken.

C. Safety Precautions

1. All barricades, fences, red lights, torches and enclosures necessary to protect construction personnel from injury due to the Work set forth herein shall be erected, maintained as required and removed when the need for them no longer exists.

PART 2 - PRODUCTS

Not required

PART 3 - EXECUTION

3.01 STRIPPING AND SITE PREPARATION

A. General

1. All topsoil in the area of work shall be stripped to its full depth, where appropriate, and stockpiled in areas as shown in Drawings, where it will not interfere with the Work. Topsoil shall be reused in reclamation work.
2. Topsoil is defined as that material having a significant organic content which will readily support vegetation and is approximately 12 inches thick at this site.

3.02 EXCAVATION

A. General

1. All open-cut excavations shall be performed to the lines, grades, and dimensions shown on the Drawings. All necessary precautions shall be taken to preserve the material below and beyond the lines of all excavations in the soundest possible condition. Where required to complete the Work, all excess excavation and overexcavation shall be refilled with suitable materials acceptable to the Engineer as specified herein.
2. Rock excavation shall be achieved by mechanical means unless blasting of hard lenses or areas of rock is approved. A detailed blasting plan must be approved for blasting. All blasting shall be conducted in accordance with applicable federal, state, and local laws and regulations.
3. All suitable materials removed from all types of excavations embraced in the Specification shall be used appropriately in the formation of fills, as cover material or other uses as indicated on the Drawings or as directed. Material suitability for these various uses is discussed in these Specifications. Materials to be used as cover shall be placed in designated stockpile areas shown on the Drawings.
4. Where practical, suitable materials shall be excavated separately from unsuitable materials. All materials removed from all excavations which are considered unsuitable shall be disposed of as discussed in these Specifications.

B. Unsuitable Material

1. Excavated materials shall be considered unsuitable for use in fills or cover if they have expansive properties, are highly calcareous, or other unsuitable properties. Materials with these properties may be mixed with other material and used as suitable material only with the approval of the Engineer. Materials not so mixed shall be stockpiled in the soil stockpile area separately from suitable materials.
2. Excavated materials containing rubbish or other foreign material shall be considered unsuitable for any use and shall be wasted as directed by the Engineer.

C. Stockpiling

1. Excess excavated materials or materials considered unsuitable shall be hauled to stockpile areas as shown on the Drawings or as directed by the Engineer.

3.03 PREPARATION OF FILL AREAS

A. Stripping

1. The areas to be filled shall be stripped of all topsoil, frozen soil, organic material, rubbish, and other foreign material prior to filling. These materials shall be stockpiled or wasted as directed by the Engineer.

B. Fill Foundations

1. Prior to the placement of any fill the stripped areas shall be inspected by the Engineer for wet materials, soft spots, small local zones or pockets of soft silts or clays, or other unsuitable materials that were not defined during the course of the exploration program. Areas of unsuitable materials shall be overexcavated and replaced with suitable earthfill compacted in accordance with the Specifications. The determination of unsuitable materials shall be made by the Engineer.

3.04 FILLS

A. Earthfill

1. The fills shall be constructed to the lines, grades and cross-sections indicated on the Drawings.

2. All fills shall be constructed of suitable material from excavations. All excavated material is considered suitable unless it has unsuitable properties as discussed in Paragraph 3.02. Also, the material shall contain no large rocks, frozen or organic material, topsoil, rubbish or other foreign material.
3. All earthfills shall be compacted as specified in Paragraphs 3.05 or 3.06 depending on type of materials.
4. The distribution of materials throughout the compacted earthfill shall be such that it will be free from lenses, pockets, streaks and layers of material differing substantially in texture or gradation from surrounding fill material.
5. Where fill is to be placed on natural slopes steeper than one vertical to seven horizontal, the existing slope shall be benched prior to placing fill. The width of any bench should not be greater than 25 feet or less than 5 feet. The width of each bench should be maintained within the specified limits, and the height of the cut face varied in accordance with the slope of the natural ground surface. The height of cut at the face should not exceed 5 feet. The slope of the temporary cut face should be no steeper than one vertical to one horizontal. All benches should be sloped at a minimum of 1 percent away from the cut face to maintain proper drainage.
6. After specified benches have been cut, the fill should proceed. The lowest elevations shall be filled first, in horizontal layers with a thickness no greater than specified limits and sloped to the outer edge of the fill. As each layer is spread it shall be thoroughly compacted with proper rollers. The top and bottom of all fills shall be rounded or eased to form a pleasing transition in change of grade.
7. Particles larger than 5 inches, but less than 10 inches in maximum dimensions shall be worked into the fill in such a manner as will disintegrate friable material and orient and distribute resistant particles to effect a compact well-knit mass with spaces between larger particles thoroughly choked with compact finer materials. To aid in accomplishing this, material containing more than 20 percent (by volume) of particles exceeding 6 inches in maximum dimensions, shall be spread in lifts not exceeding 8 inches in thickness (loose measure). Each lift shall be tracked with at least four passes of the treads of a crawler type tractor. Second and subsequent passes of the

treads shall not be made until each pass, as defined above, is completed. If the size and content of resistant particles in the fill material precludes proper compaction, the material shall be disposed of or mixed with finer materials before placement.

8. The fill on each side of structures shall be kept at approximately the same level as placement of the fill progresses.

3.05 COMPACTION SPECIFICATION - EARTHFILL-GRANULAR MATERIAL

A. General

1. All granular fill placed at the site shall be spread in one-foot lifts (loose material) and each lift compacted to 75 percent relative density (ASTM-D2049-69) as defined by:

$$D_D = \frac{E_1 - E_N}{E_1 - E_D} \text{ (percent)}$$

where:

D_D = relative density in percent.

E_1 = void ratio of the granular soil in its loosest state
(minimum dry density)

E_D = void ratio of the granular soil in its most dense state
(maximum dry density)

E_N = void ratio of the soil in its natural state.

2. All granular fill shall be clean, nonexpansive, free of trash, rubble, debris, frozen, and other foreign materials.
3. For uniformity, a minimum of five passes of a 10-ton vibratory roller or its equivalent shall be required on each lift of fill.

3.06 COMPACTION SPECIFICATION - EARTHFILL-COHESIVE MATERIAL

A. General

1. All cohesive fill placed at the site shall be spread uniformly in six- to eight-inch lifts (loose material) and compacted to approximately 95 percent of the standard Proctor density (ASTM-698). Upon placement and compaction of a lift of cohesive material, the surface shall be scarified to a depth of 2 inches prior to the placement of the next lift unless the compaction equipment leaves a surface sufficiently roughened to tie the two lifts together. Cohesive earth embankment material shall be compacted at a water content of between 1 and 2 percent above optimum water content as determined by the standard Proctor method (ASTM-D698).
2. All cohesive fill shall be free of trash, rubble, debris, roots, organic, frozen, and other foreign material. Fill shall not be placed on any subgrade that is under water, muddy, frozen, or contains frost.
3. For uniformity, a minimum of four passes of a sheeps-foot or segmented wheel roller in the 20- to 30-ton class shall be required on each lift.

3.07 WORK AREA DRAINAGE

A. Fill Protection

1. To protect the surface of the fill, the top of all fill areas shall be crowned and sealed at the end of each working day to minimize the infiltration of water in the event of rainfall.
2. All fill saturated due to precipitation shall be dried or removed prior to placement of additional fill.
3. All impervious fills which become dried and/or cracked due to exposure, shall be wetted and reworked prior to application of additional fill.

B. Slope Protection

1. As interim protection of the cut and fill slopes, adequate surface drains shall be provided at both the top and bottom of slopes to intercept and conduct runoff from the developed areas and to reduce saturation and erosion of the slopes.

3.08 ACCURACY OF COMPLETED GRADING

A. General

1. The grades as shown on the Drawings or as specified shall be met within 6 inches at the completion of the site grading.

SECTION A.3
LINER/LEACHATE SYSTEM

A.3.1 TERTIARY LINER

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope of Work

1. The work covered under this section includes the furnishing of all labor, materials and equipment required to perform the work.

PART 2 - PRODUCTS

2.01 CLAY MATERIAL

A. General

1. Clay material shall be obtained from the excavation or approved borrow areas as required.
2. All material shall be approved for use in the tertiary liner by the Engineer.

B. Properties

1. The material shall have a USCS designation of CL or CH. Materials with different designations shall be mixed together to obtain a uniform material. The material shall also have a minimum of 30 percent by weight of clay size particles.
2. The materials shall be tested by an approved laboratory to determine the material characteristics. The testing shall include Plastic Limit (ASTM D424), Liquid Limit (ASTM D423), and grain size analysis, sieve and hydrometer (ASTM D422). One test series shall be conducted for a maximum of each 1000 cubic yards of material. Materials which do not pass the test series shall be mixed with other material until it passes the tests or not used in the tertiary liner.

PART 3 - EXECUTION3.01 PREPARATION OF TERTIARY LINER SUBGRADEA. General

1. The subgrade shall be excavated to the lines and grades shown on the Drawings.
2. The subgrade shall consist of firm, dry material. Areas of soft, wet or otherwise unsuitable material shall be removed by overexcavation and replaced with compacted suitable material.
3. The subgrade surface shall be approved by the Engineer prior to tertiary liner placement.

3.02 CONSTRUCTIONA. Placement

1. The material shall be placed in horizontal layers 6 to 8 inches thick uncompacted.
2. Each layer shall be compacted prior to placement of the next layer.
3. The surface of each layer shall be scarified prior to placement of the next layer.
4. The liner thickness shall be brought up evenly over large areas. The ends of layers shall be tapered smoothly into adjacent layers to form a smooth, regular surface.
5. The material shall be placed to at least 6 inches above the design grade and graded down to the design grade.
6. All completed liner areas shall be approved by the Engineer prior to being covered by the leak detection layer.

B. Compaction

1. Each layer of material shall be compacted by at least four passes of a sheeps-foot or tamping foot compactor.
2. Each layer must be compacted to at least 98 percent of the standard Proctor maximum dry density. The material water content must be at or above the optimum water content as determined by the Standard Proctor density test.

3. A field density and water content quality control tests shall be conducted for each 500 cubic yards of material placed. The tests shall be well distributed over the entire liner area with at least one test per 10,000 square feet of liner surface.
4. If a tested material fails to meet the compaction specifications, the material shall be reworked, recompact and retested until the specifications are met.

C. Liner Protection

1. Completed liner areas shall be protected from damage such as erosion or drying prior to being covered by the leak detection layer.
2. Liner areas which do become damaged shall be repaired prior to being covered.

A.3.2 PRIMARY AND SECONDARY LINERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope of Work

1. The work covered under this section includes the furnishing of all labor, materials, and equipment to perform all operations required under the following items of work:
 - a. Provide a technical representative experienced in synthetic liner handling and installation.
 - b. Installation of the synthetic liner.
 - c. Digging of the anchor trenches.

PART 2 - PRODUCTS

2.01 SYNTHETIC LINER

A. General

1. The synthetic liner shall be manufactured from sheet roll goods. The lining shall be made from the highest quality materials and manufactured, fabricated and installed by qualified, well known companies.

B. Lining Material Requirements

1. The liner material specifications shall be supplied by the manufacturer and approved by the Engineer.

PART 3 - INSTALLATION REQUIREMENTS

3.01 INSTALLATION SUPERVISOR

A. General

1. A technical representative from the liner manufacturer shall be present at all times during the installation of the liner. The representative shall be experienced in the proper handling, preparation, and installation methods for the liner.

B. Duties

1. The technical representative shall supervise all aspects of the liner installation including but not limited to, storage, handling, spreading, seaming, anchoring and covering.
2. The representative shall provide expert advice and recommendations to the Engineer concerning liner subgrade preparation, and other liner aspects. Field inspection of earthwork items associated with the liner shall be required as requested by the Engineer.

3.02 LINER SUBGRADE

A. General

1. The prepared subgrade surface shall be inspected by the Engineer and the technical representative and approved by the Engineer prior to placement of liner on that surface.

3.03 LINER HANDLING

A. Packaging

1. The liner rolls shall be packaged, by the manufacturer, such that damage during shipment, handling, or storage is prevented. Packaging shall prevent damage by any physical, chemical, and environmental means.

B. On-Site Storage

1. The liner shall be stored as necessary such that damage will not occur.
2. The liner shall be kept at temperatures above 50°F and out of direct sunlight except for short time periods unless covered by protective material.

3.04 LINER INSTALLATION

A. General

1. The liner rolls shall be handled such that no damage to them will occur. The rolls shall be inspected prior to placement within the cell for damage. Damaged rolls shall not be placed within the cell.
2. The rolls shall be located at one side of the cell such that the correct amount of overlap for seaming is provided.
3. The lining shall be placed only on subgrade surfaces that have been inspected and approved by the Engineer.
4. The liner shall be placed by pulling the loose end of the roll across the cell. The roll shall be held at the cell side such that it is free to roll, but not move onto the cell.
5. The liner panels in the bottom of these "sawtooths" shall be placed first so the correct direction of seam overlap is obtained.

B. Field Seams

1. The method and procedure for field seams joining liner panels shall be specified by the lining installer and approved by the Engineer.
2. Field seams shall be made only on liner surfaces that are cleaned of dirt, dust, moisture, or other foreign matter. The seaming shall be made on a firm surface.
3. All field seams shall provide a film tearing bond at least equal to the tear strength of the parent material. All field seams shall be inspected and approved by the Engineer. Seams not approved shall be repaired to the satisfaction of the Engineer.

C. Joints to Pipes

1. Liner joints to pipes shall be made where indicated on the Drawings.
2. The joints shall be made with the manufacturer's approved boot and seaming method.

3. The method of joining shall be supplied by the installer and approved by the Engineer.

D. Anchor Trenches

1. The liner shall be installed in anchor trenches as shown on the Drawings. The trench locations shall be marked by others.
2. The installation of the liner in the anchor trenches shall be inspected and approved by the Engineer.
3. The trenches shall be backfilled with suitable material and compacted.

PART 4 - QUALITY CONTROL AND ASSURANCE

4.01 QUALITY CONTROL

A. Liner Tests

1. Liner tests shall be conducted on the liner panels.
2. The results of these tests shall meet or exceed the liner specifications supplied by the manufacturer.
3. The test results shall be identified by a unique designation to the panel(s) from which the tested material was taken.
4. The test results shall be supplied to the Engineer prior to the installation of the liner.

B. Field Seam Testing

1. A sample of the field seam shall be cut from the installed liner for each 50,000 ft² of liner installed. The sample shall be tested immediately for tear strength.
2. The test results shall be supplied to the Engineer within 24 hours of the test.
3. Any test which does not meet or exceed the specifications shall result in the area of that sample being reseamed. Also, additional test samples for every 25,000 ft² of liner installed shall be taken and tested for tear strength.
4. Placement of the liner cover shall not be delayed awaiting seam test results. Seams that fail the test will require removal of the cover to repair.

4.02 QUALITY ASSURANCE

A. Liner Guarantee

1. The liner manufacturer will supply pertinent information regarding the material guarantee of its product.
2. The liner installer shall supply pertinent information regarding the workmanship guarantee of its product.

B. Test Results

1. All liner tests shall be conducted by a qualified laboratory or personnel approved by the Engineer.
2. All test procedures and methods shall be reported as part of the test result.
3. As a minimum, the test results shall be signed, dated, and uniquely identified to the lining from which the test sample was taken.

A.3.3 LEACHATE COLLECTION AND LEAK DETECTION LAYERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope of Work

1. The work covered under this section includes the furnishing of all labor and materials to install the following:
 - a. Filter fabric layers
 - b. Sand layers
 - c. Piping

PART 2 - PRODUCTS

2.01 FILTER FABRIC

A. General

1. The filter fabric shall be a nonwoven type fabric of polyethylene or other approved synthetic material.
2. The filter fabric shall have a range of pore sizes and a porosity of at least 60 percent.

2.02 SANDA. General

1. The sand shall be a coarse, clean, well graded sand.
2. The minimum particle size shall be greater than a No. 100 sieve.

2.03 PIPEA. General

1. The pipe shall be high density polyethylene (HDPE) pipe.
2. The HDPE pipe shall be 3 inch and 6 inch diameter as shown on the drawings.

B. Slots

1. The slotted lengths of pipe shall be factory slotted with 0.040 inch wide slots, on approximately 0.25 inch spacing along the pipe.
2. The slots shall be placed on three rows equally spaced around the pipe circumference.

PART 3 - INSTALLATION3.01 FILTER FABRICA. General

1. The fabric shall be installed on a smooth firm surface approved by the Engineer.
2. The fabric shall be overlapped a minimum of 12 inches.
3. The fabric shall be installed according to the manufacturers' instructions as approved by the Engineer.

3.02 SANDA. General

1. The sand shall be placed on a prepared surface approved by the Engineer.
2. The sand shall be placed to the required thickness on the cell bottom and side slopes and rolled with a smooth drum to produce a smooth firm surface.

3. Equipment used to place the sand shall be suited for the work and shall be operated to not cause damage to the underlying materials.
4. Underlying materials which do become damaged during sand placement shall be repaired by the Contractor at no additional cost to the Owner.

3.03 PIPE

A. General

1. The pipes shall be installed on the prepared surface prior to sand placement.
2. The pipes shall be laid out according to the Drawings.
3. The pipes shall be joined using the thermal welding method solvent according to the manufacturers instructions, as approved by the Engineer.
4. The pipes shall be covered with sand after they have been joined and accepted by the Engineer.

A.3.4 COVER SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope of Work

1. The work covered under this section includes the furnishing of all labor and materials to install the following:
 - a. Filter fabric layers
 - b. Sand layers
 - c. Primary and tertiary covers
 - d. Secondary cover
 - e. Soil cap
 - f. Gas vents

PART 2 - PRODUCTS2.01 FILTER FABRICA. General

1. The filter fabric shall meet the same specifications given in Section A.3.3, Part 2.01.

2.02 SANDA. General

1. The sand shall meet the same specifications given in Section A.3.3, Part 2.02.

2.03 PRIMARY AND TERTIARY COVERA. General

1. The primary and tertiary covers shall be a synthetic liner with the same specifications given in Section A.3.2, Part 2.01.

2.04 SECONDARY COVERA. General

1. The secondary cover shall be a clay material with the same specifications as the tertiary liner given in Section A.3.1, Part 2.01.

2.05 SOIL CAPA. General

1. The soil cap material shall be a fine grained material meeting the Unified Soil Classification System (USCS) designation SC or SP.
2. The clay content shall be between 10 and 30 percent by weight.
3. The material shall be obtained and mixed as necessary from the excavation or approved borrow.

2.06 GAS VENTSA. General

1. Gas vents shall consist of HDPE pipe with a 3-inch diameter.
2. The pipe shall be slotted for a 12 inch length on one end of the pipe.

PART 3 - INSTALLATION3.01 FILTER FABRICA. General

1. Filter fabric shall be installed according to the same specifications given in Section A.3.3, Part 3.01.

3.02 SANDA. General

1. Sand shall be installed according to the same specifications given in Section A.3.3, Part 3.02.

3.03 PRIMARY AND TERTIARY COVERSA. General

1. The primary and tertiary covers shall be installed according to the same specifications given in Section A.3.2, Part 3.

3.04 SECONDARY COVERA. General

1. The secondary cover shall be installed according to the same specifications given in Section A.3.1, Part 3.

3.05 SOIL CAPA. General

1. The soil cap shall be installed according to the same specifications given in Section A.3.1, Part 3.02, Paragraph A.

B. Compaction

1. The soil cap shall be compacted according to the same specifications given in Section A.3.1, Part 3.02, Paragraph B, except the density shall be 90 percent of the standard Proctor maximum dry density.

3.06 GAS VENTS

A. General

1. The gas vents shall be installed during placement of the cover system.
2. The gas vents shall be installed as shown on the Drawings.
3. The contractor shall use the correct equipment and methods to install the gas vents, so damage to cover system materials is not incurred. Materials which are damaged shall be repaired or replaced at no additional cost to the owner.

APPENDIX B
CONCEPT DESIGN
CLOSURE AND POST-CLOSURE PLANS

APPENDIX B
CONCEPT DESIGN CLOSURE AND POST-CLOSURE PLANS

The closure and post-closure plans have been prepared based on the landfill facility concept design presented in Chapters 2, 3 and 4. The plans reflect the concept design and regulatory requirements. Some information presented in the plans is generic because specific data is unavailable for the concept design. Specific data such as dates of completion and closure and responsible individuals must be included in the final closure plan.

Since the landfill will be a federal facility, financial requirements as per RCRA regulations Part 264 Subpart H are not required.

B.1 CLOSURE PLAN

This closure plan is submitted in accordance with pertinent rules of the EPA and identifies the procedures to be implemented to partially close the landfill facility at interim development stages and for final closure activities when the facility reaches the end of its operating life. The plan addresses conditions under which partial closure will occur.

A copy of the approved closure plan and all revisions will be maintained on-site until certification of satisfactory final closure has been approved by the EPA. The EPA will be notified a minimum of 180 days in advance of commencing final closure operations. Upon completion of closure, certification from an independent registered professional engineer will be submitted to the EPA that the facility has been closed in compliance with the specifications in the approved plan. The closure plan will be amended, as needed, due to operating contingencies, new technology, rule changes, or altered monitoring requirements.

B.1.1 Closure Performance Standard

Closure of the facility has been designed to minimize potential hazards to the environment and health. Closure activities will isolate hazardous waste, waste constituents, leachates, and contaminated precipitation (i.e., run-off). Potential breaches of the landfill systems' integrity will be investigated by analysis of soil and/or water and the extent of contamination determined. The completed landfill area will be graded, vegetated and a surface drainage system will be constructed to control erosion on and around waste cells. The following sections provide details of the closure procedures to be undertaken.

B.1.2 Partial and Final Closure Activities

Partial Closure

The landfill will be developed as six waste cells as shown in Figure 11. Cell 1 will be developed first with initial controlled waste placement inside an air-supported building. As waste placement in Cell 1 proceeds, the second air-supported building will be placed over cell 2, and liner/leachate system construction will commence. This covered, sequenced cell development method will minimize waste area exposed, and eliminate runoff precipitation volume from within the cell and subsequent leachate volumes. The facility will operate in this sequence through Cell 6. Drainage within the facility areas will be routed to runoff collection ponds sized to hold run-off from a 25-year (RCRA) or 100-year (CDH) storm. The water collected will be evaporated, removed for treatment/disposal if contaminated, or discharged to adjacent drainages if clean.

Final Closure

Final closure of the facility involves several aspects, including completion of the last waste cell cover system, final site decontamination and grading, and revegetation of the areas adjacent to the waste cells. Cover system design, shown in Figure 15, incorporates three liners: compacted clay (2 feet thick) and two synthetic liners of

100 mil HDPE. This design meets the EPA regulations requiring a cover of equal or lower permeability than the liner system. The cover system is comprised of the following components:

- o A 12-inch thick gas flow and collection layer (sand) and vents to control gases generated from the waste.
- o A 100 mil HDPE synthetic membrane as the tertiary cover.
- o A compacted clay layer two feet thick, as the secondary cover.
- o A 100 mil synthetic membrane above the clay, which acts as the primary cover.
- o A 12-inch sandy gravel layer to provide a subsurface drainage flow zone, which incorporates a HDPE geogrid drain.
- o A 3-foot thick layer of compacted soil as an additional low-permeability infiltration barrier and protection from freeze-thaw effects.
- o A 6 to 12-inch thick topsoil layer to support revegetation growth.

The high density polyethylene (HDPE) type of synthetic membrane has been determined to be most suitable based on its durability and integrity. The sandy gravel (drainage) layer and geogrid to be placed atop the primary cover will have a saturated permeability not less than 1×10^{-3} centimeters per second to promote rapid drainage of accumulated water. Filter fabrics will be placed on top of the waste and the water layer to prevent clogging of the sands.

Natural soils available from the excavation or nearby borrow areas will be placed and compacted to provide a low permeability 3-foot thick soil cover layer. Six to twelve inches of topsoil will be placed over the soil cover to provide a suitable layer for vegetation growth. A shallow rooted native grass mixture will be seeded using hydraulic or other

methods to provide immediate as well as long-term cover. Seeding will minimize cover erosion and long-term maintenance. Fertilization and mulching will be conducted concurrent with seeding.

Collection ditches which control runoff from the landfill facility will remain as drainage control for access roads. The ponds will be removed after the facility decontamination has been completed. Ancillary facilities not required during post-closure (e.g., some haul roads, personnel trailers) will be removed from the site at closure.

The maximum extent of the landfill that will remain open during operation will be roughly one cell, about 1200 by 300 feet.

The expected final closure is about 3.5 years after waste placement begins.

B.1.3 Maximum Waste Inventory

Maximum waste inventory on site is expected to be approximately 600,000 cubic yards of material upon completion of the landfill.

B.1.4 Equipment Decontamination

Equipment decontamination is expected to consist of the following major tasks:

- o Cleaning of contaminated or potentially contaminated equipment, primarily construction vehicles used in hauling and placing waste.
- o Removal and disposal of contaminated or potentially contaminated soil from haul roads.
- o Disposal of contaminated wastewater and runoff water.
- o Disposal or cleanup of any additional materials determined to be contaminated.

Construction equipment potentially contaminated during closure of the facility may include front-end loaders, bulldozers, scrapers, backhoes, and trucks. These vehicles will be subjected to a thorough decontamination by high-pressure washes, steam cleaning, or other appropriate procedures. After cleaning, the vehicles will be visually inspected for evidence of remaining waste materials. The number of potentially contaminated vehicles will be minimized by strictly controlling access to waste and contaminated areas during operation of the landfill.

Contaminated wash waters from vehicle cleanup will be collected in a holding tank and taken to an off-site facility for disposal.

Traffic on haulage/access roads will be controlled during operations to provide "clean" and contaminated routes. During final closure, any contaminated surface soil materials will be removed from the roadways within the facility and placed in the landfill. Soil samples from roadways will be analyzed for waste constituents to verify that decontamination is complete.

Major decontamination efforts, other than those previously indicated, are not anticipated. However, should miscellaneous items such as hand tools, piping, pumps, and similar materials be exposed to waste or leachate, these items will also be decontaminated by flushing, steam cleaning, high pressure washes, or will be disposed in the landfill.

All decontamination activities will be conducted under the supervision of the Corps of Engineers utilizing a labor force trained in health and safety programs. Workers who may be subjected to potentially deleterious exposure levels will have respiratory and skin contact protective equipment.

B.1.5 Closure Schedule

Closure activities are anticipated to be completed within 180 days of receipt of the final waste volume. Major aspects of closure activities relative to receipt of the final waste volume include the following:

- o Completion of waste emplacement within 30 days.
- o Decontamination and completion of the cover on the final waste cell within 90 days.
- o Decommissioning of ancillary facilities, final site grading, site cleanup, and revegetation within 180 days.
- o The post-closure care period will extend for 30 years following the date of final closure.
- o The leachate control system will be inspected for presence of leachate at least quarterly during the first year and until leachate is no longer detected. Collected leachate will be transferred to a tank truck as necessary for shipment to a permitted water treatment system with a capability to receive the leachate. The leachate control system will be maintained in a free-flowing condition, free from debris, and the collection tanks will be checked at least semiannually after the first year.
- o If liquid is detected in the leak detection system and is determined to be more than would realistically be expected from normal condensation, then the Regional Administrator or equivalent will be notified in writing within seven days; and ground water monitoring requirements will be initiated.
- o The final cover system on all waste cells will be checked for erosion and settling by an engineer semiannually and after major hydrologic events. Any indication of cover erosion or vegetation disruption due to soil contour changes will be corrected. Vegetation will be maintained and reseeded will be performed if necessary.