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Prototype Hanford Surface Barrier: Design Basis Document

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EXECUTIVE SUMMARY

The Hanford Site Surface Barrier Development Program (BDP) was organized in 1985 to develop the technology needed to provide a long-term surface barrier capability for the Hanford Site and other arid sites. A Barrier Development Team (BDT) was established to develop and test various barrier design configurations for application in the arid southeastern Washington climate. Fifteen groups of tasks were identified by the BDT to resolve the technical concerns and complete the development and design of protective barriers for the Hanford Site. The major barrier development task groups that were identified are as follows:

- Project management
- Biointrusion control
- Water infiltration control
- Erosion/deposition control
- Physical stability testing
- Human interference control
- Barrier construction materials procurement
- Prototype barrier designs and testing
- Model applications and validation
- Natural analog studies
- Long-term climate change effects
- Interface with regulatory agencies
- *Resource Conservation and Recovery Act* (RCRA) equivalency
- Technology integration and transfer
- Final design.

The information and data generated within each task group enabled the BDP to design and construct a prototype barrier, which has been extensively peer reviewed. This information was combined into a comprehensive, state-of-the-art, barrier design for testing and monitoring barrier performance. A BDT and Barrier Technical Advisory Board (BTAB) were formed in 1990 to transform the work done in the task groups into a prototype barrier design that could be tested and monitored to verify barrier performance. The BDT was composed of engineers and scientists from the task groups and a design engineer from the onsite architect and engineering contractor. The design of the prototype barrier was initiated in 1990, delayed in 1991 because of a lack of funding, and was completed in 1992. The site for the construction of the barrier was changed in this time period from a location near the Hanford Meteorological Station to the 200-BP-1 Operable Unit, which necessitated redesigning the prototype barrier. Construction was initiated in 1993 and completed in 1994. The goal of the Design Basis Document is to record the decisions made by the BDT and to explain the reasoning, logic, and regulatory and technical basis for the design features and characteristics of the prototype barrier.

The regulations that govern the design and performance of the Hanford Protective Isolation Surface Barrier and that are reflected in the design of the prototype barrier are contained in the following five documents.

- "Licensing Requirements for the Disposal of Low-Level Radioactive Waste" (10 CFR 61)
- "Guidelines for Disposal of Solid Waste" (40 CFR 241)
- "Regulations for Owners and Operators of Permitted Hazardous Waste Facilities" (40 CFR 264)
- The State of Washington *Dangerous Waste Regulations* (WAC 173-303)
- The U.S. Department of Energy's Order on Waste Management (DOE Order 5820.2A).

The final design of a surface cover is determined by the application of the regulations to a specific situation. Some of the key requirements contained in the regulations include the following: (1) provide long-term minimization of migration of liquids through the closed landfill, (2) function with minimum maintenance, (3) promote drainage and minimize erosion or abrasion of the cover, (4) accommodate settling and subsidence so that the cover integrity is maintained, (5) have a permeability less than or equal to the permeability of any liner systems or natural subsoils present, (6) provide a minimum of 5 m (16.4 ft) of cover over the waste, (7) limit exposure to the inadvertent intruder, and (8) for wastes that remain hazardous beyond 100 years, use passive controls (e.g., appropriate markers and barrier systems) to warn and deter inadvertent intruders from disturbing the site for up to 500 years.

A preliminary set of performance objectives was defined to help guide the design of the prototype barrier. The performance objectives are intended to encompass the various regulatory requirements for the types of wastes anticipated to be disposed of using barriers at the Hanford Site and elsewhere. The preliminary performance objectives are as follows:

- To function in a semiarid to subhumid climate
- To limit the migration of water through the waste to near zero amounts (0.05 cm [0.02 in.] of water per year [1.6×10^{-9} cm/s (6.3 in./s)] was the design objective selected based on preliminary performance assessments)
- To be maintenance free (no institutional control)

- To minimize the likelihood of plant, animal, and human intrusion
- To limit the exhalation of noxious gases
- To minimize erosion-related problems
- To meet or exceed RCRA cover performance requirements
- To isolate wastes for a minimum of 1,000 years
- To be regulatorily and publicly acceptable.

A design life of 1,000 years and the performance objective to isolate wastes for 1,000 years were chosen based on a review of the regulatory drivers, the radioactive and biological half-lives of the contaminants of concern, a value engineering workshop for the BDP, and the design lives that are being required across the nation for other waste disposal facilities. Some facilities are even being required to consider a design life of 10,000 years. This does not appear to be reasonable for the prototype barrier given the uncertainty in the assumptions that are required to analyze barrier performance over a 10,000-year period and the likelihood of significant advances in the area of waste treatment technology.

The performance objective to limit the migration of water through the waste to near zero amounts and to minimize erosion-related problems is dependent on the amount of precipitation that the barrier receives. To predict the average annual precipitation over the design life of the barrier, a probabilistic projection of the long-term variability of the Hanford Site's climate was conducted. The results indicate that the mean annual precipitation has ranged from 25 to 50% below to 28% above present day levels. Consequently, a conservative estimate of three times the annual average precipitation (3 x 16 cm [1.2 x 6.3 in.]) has been used as the upper limit for the average annual precipitation for the design and testing of the prototype barrier.

The prototype barrier design uses a multilayer concept and has multiple layers of earthen and asphaltic materials. The top layer is 2 m (6.6 ft) of fine soil, which allows runoff of precipitation and also acts as a water storage medium to store the water until it can be evaporated or transpired back into the atmosphere. The top surface of the soil has a 2-percent slope for runoff and the top 1 m (3.3 ft) of the soil has 15-wt% pea gravel added to the soil to prevent erosion. The bottom of the soil layer uses the capillary break between the soil and underlying coarser materials to enhance the water retention capabilities of the soil layer. The fine soil layer is underlain by a gravel filter. The gravel filter is composed of a layer of fine sand and a layer of minus 16 mm (0.63 in.) road surfacing material. The gravel filter provides the capillary break and prevents the fine soil from sifting down into the coarser material under the gravel filter. The layer under the gravel filter is

1.5 m (4.9 ft) of minus 25 cm (10 in.) basalt riprap. The riprap serves to deter biointrusion from human, animal, and plant activities and forms a significant part of the required thickness of the barrier. Under the riprap is a layer of 10 to 25 mm (0.39-0.98 in.) drainage rock that protects the underlying layer of asphaltic concrete from the riprap and provides a layer for water drainage. The next layer of the barrier is a composite layer made of asphaltic concrete overlain by a polymer modified asphalt. The composite asphalt layer is the final hydrologic barrier in the prototype barrier, and is designed to divert the water to the sides of the barrier away from the waste zone should water breakthrough the fine soil layer. The composite asphalt layer consists of 15 cm (6 in.) of high oil content asphaltic concrete overlain by a 5 mm (0.2 in.) layer of fluid applied asphalt that is designed to be a very low permeability barrier to the migration of water. The last and bottom layer of the barrier is a layer of minus 16 mm (0.63 in.) road surfacing material that is the foundation or subgrade material for the composite asphalt layer.

Two side slope configurations are being tested in the prototype barrier. One is a relatively flat slope of naturally occurring soil (sand and gravel) placed at approximately a 10:1 slope. This slope is called a clean fill dike in the barrier design. The second is a relatively steep embankment of basalt riprap placed at approximately a 2:1 slope. The clean-fill dike concept uses readily available materials (such as pitrun gravel) to create a relatively flat apron around the periphery of the barrier. This flat apron provides a more gentle transition from the shoulder of the barrier to the surrounding topography than does the steep side slope. The steep side slope design uses basalt riprap (minus 25 cm [10 in.]), which consists of relatively large angular rocks. The angularity of the riprap provides many interlocking surfaces between adjacent rocks, which allows the creation of a relatively steep, yet stable side slope.

The acquisition of barrier construction materials is a significant issue on the Hanford Site. Substantial quantities of fine soil are available at a location outside the Yakima Barricade known as McGee Ranch. The Hanford Site has several basalt outcroppings and formations that can be developed into sources for the basalt riprap used in the barrier design. The sand and gravel that are used in the barrier are available from several onsite gravel pits. Significant work is needed to resolve cultural resource issues between the Department of Energy and the Native American Tribes before these sources of materials can be used. The alternative is higher costs for barrier construction materials.

The prototype barrier will be tested and monitored to evaluate its performance over a range of conditions representative of those expected to be experienced during the design life of a long-term surface barrier. A number of tests and experiments are planned to be conducted on the prototype barrier to assess its performance with respect to water infiltration, biointrusion, wind and water erosion, and physical stability. Because only a finite amount of time exists to test a prototype barrier that is intended to function for a minimum of 1,000 years, the testing program has been designed to "stress" the prototype so that barrier performance can be determined within a reasonable time frame. Other BDP elements (e.g., natural analogs, long-term climate change, modeling, etc.) provide data necessary to increase confidence in long-term surface barrier performance. Testing and monitoring of the prototype barrier will assess the adequacy of this barrier design and indicate which tasks, if any, require additional effort. A full-scale prototype barrier enables engineers and scientists to gain insights and experience with issues regarding barrier design, construction, and performance that have not been possible with the individual tests and experiments conducted to date in the program. The testing and monitoring of the prototype barrier is planned to be conducted for a minimum of 3 years, commencing immediately following construction.

The BDP engineers and scientists have momentarily "frozen" evolving barrier design work and incorporated the latest findings from BDP tasks. The design and construction of the prototype barrier has required that all of the various components of the barrier be brought together into an integrated system. This integration is particularly important because some of the components of the protective barrier have been developed independently of other barrier components. The prototype barrier and the testing and monitoring program will determine how effectively this integrated barrier/cover system functions. The prototype barrier is a giant step forward toward the BDP's goal of providing a long-term cover system that can be used on the Hanford Site for the inplace isolation and stabilization of Hanford Site wastes.

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CONTENTS

FIGURES

ACRONYMS

ARARs	Applicable or Relevant and Appropriate Requirements
BDP	Barrier Development Program
BDT	Barrier Development Team
BTAB	Barrier Technical Advisory Board
BWIP	Basalt Waste Isolation Project
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EDE	Effective Dose Equivalent
EM	Electromagnetic Induction
EPA	U.S. Environmental Protection Agency
ET	Evapotranspiration
FAA	Fluid-Applied Asphalt
FLTF	Field Lysimeter Test Facility
FS	Feasibility Study
GCL	Geosynthetic Clay Liners
GPR	Ground Penetrating Radar
ha	Hectare
HMAC	Hot-Mix Asphalt Concrete
HMS	Hanford Meteorological Station
LLW-MW	Low Level Waste - Municiple Waste
NAS	National Academy of Sciences
NEPA	*National Environmental Policy Act*
NRC	Nuclear Regulatory Commission
OU	Operable Unit
PCB	Polychlorinated biphenyl
PNL	Pacific Northwest Laboratory
RCRA	*Resource Conservation and Recovery Act of 1976*
RL	Richland Operations Office
RLID	RL Implementing Directive
SARA	*Superfund Amendments and Reauthorization Act of 1986*
SDRIs	Sealed Double-Ring Infiltrometers
SER	Site Evaluation Report
SR	State Route
STLF	Small-Tube Lysimeter Facility
TDR	Time Domain Reflectometry
VE	Value Engineering
WAC	*Washington Administrative Code*
WHC	Westinghouse Hanford Company
WIPP	Waste Isolation Pilot Plant
WSDOT	Washington State Department of Transportation

1.0 INTRODUCTION

Long-term surface barriers have been proposed for use at the U.S. Department of Energy's (DOE) Hanford Site near Richland, Washington to isolate and dispose of certain types of waste in place. It is assumed that the implementation of an in-place disposal alternative will require the use of a protective cover or surface barrier that will provide long-term isolation of the wastes from the accessible environment. If the wastes are exhumed and treated, a long-term protective barrier may still be required to dispose of the wastes in an acceptable manner. Currently, no proven long-term barrier is available. The Hanford Site Surface Barrier Development Program (BDP) was organized to develop the technology needed to provide a long-term surface barrier capability for the Hanford Site and elsewhere.

Existing short-term barrier designs currently are available (U.S. Environmental Protection Agency [EPA] 1982, 1990). In general, the design life of these covers is for relatively short periods--such as the 30-year post-closure period specified by the *Resource Conservation and Recovery Act of 1976* (RCRA). The performance of barriers during this relatively short period can be monitored, and maintenance activities can be performed to correct any problems that might be encountered. However, some waste management situations make it desirable to isolate wastes for much longer than the 30-year post-closure period (i.e., up to or beyond a millennium). For these waste management situations, the relatively short-term (i.e., RCRA) designs might not be satisfactory. For example, many synthetic construction materials that might be effective for decades (e.g., geosynthetics) cannot be relied on to perform satisfactorily (or even exist) more than 1,000 years. Consequently, a need arises for a long-term, isolated barrier. The objective of the work being conducted by the BDP is to develop and assess the performance of permanent isolation barriers.

The current BDP was organized in 1985 to develop, test, and evaluate the effectiveness of various barrier designs. The BDP is supported by DOE and consists of a team of engineers and scientists from Westinghouse Hanford Company (WHC), the Pacific Northwest Laboratory (PNL), ICF Kaiser (Kaiser) and Bechtel Hanford Incorporated (BHI)[1].

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[1] Bechtel Hanford Incorporated now administers the Environmental Restoration Funding for the Barrier Development Program, formerly administered by Westinghouse Hanford Company.

Fifteen groups of tasks were identified by the barrier development team to resolve the technical concerns and complete the development and design of protective barriers (Wing 1994). These major barrier development task groups are as follows:

1. Project management
2. Biointrusion control
3. Water infiltration control
4. Erosion/deposition control
5. Physical stability testing
6. Human interference control
7. Barrier construction materials procurement
8. Prototype barrier designs and testing
9. Model applications and validation
10. Natural analog studies
11. Long-term climate change effects
12. Interface with regulatory agencies
13. *Resource Conservation and Recovery Act of 1976* (RCRA) equivalency
14. Technology integration and transfer
15. Final design.

The information and data generated within each of these task groups are input into barrier designs.

The information and insights gained from the development tasks previously mentioned have enabled the barrier program to progress so that the design and construction of a prototype long-term surface barrier (from here on referred to as the prototype barrier) is now vital to continued barrier development. Although the results of development and testing efforts conducted previously are not final, and additional work needs to be performed, enough information and data exist to allow the design and construction of a prototype barrier. A full-scale prototype barrier enables engineers and scientists to gain insights and experience with issues regarding barrier design, construction, and performance that have not been possible with the individual tests and experiments conducted to date in the program.

The design of the prototype barrier was completed in 1993, and construction was completed in 1994. The testing and monitoring of the prototype barrier is planned to be conducted for a minimum of 3 years, commencing immediately after construction.

The prototype barrier will be tested and monitored to evaluate its performance over a range of conditions representative of those expected to be experienced during the design life of a long-term surface barrier. Many tests and experiments are planned to be conducted on the prototype barrier to assess its performance with respect to water infiltration, biointrusion, erosion, and physical stability. Because only a finite amount of time exists to test a prototype barrier that is intended to function for a minimum of 1,000 years, the testing program has been designed to "stress" the prototype so that barrier performance can be determined within a reasonable time frame. Other BDP elements (e.g., natural analogs, long-term climate change, modeling, etc.) provide data necessary to increase confidence in long-term surface barrier performance.

This document provides the basis for the design of the prototype barrier. Engineers and scientists have momentarily "frozen" evolving barrier designs and incorporated the latest findings from BDP tasks. The design and construction of the prototype barrier has required that all of the various components of the barrier be brought together into an integrated system. This integration is particularly important because some of the components of the protective barrier have been developed independently of other barrier components. This document serves as the baseline by which future modifications or other barrier designs can be compared. The document will provide a basis for material choices in the prototype barrier design, the design of the layers of the barrier, and barrier performance testing and monitoring. A discussion of long-term barrier issues and concerns will be provided. Also, this document contains the minutes of meetings convened during the definitive design process in which critical decisions affecting the prototype barrier's design were made (Appendix A) and the construction drawings (Appendix B). Another complementary document (DOE-RL 1994) has been published that describes the lessons learned from the construction phase of the prototype barrier project.

2.0 HISTORY OF THE PROTOTYPE BARRIER DESIGN EFFORT

The prototype barrier originally was designed to be constructed on a radiologically "clean" site located near the Hanford Meteorological Station (HMS). The prototype barrier design effort was initiated during FY 1990 but had to be terminated prior to completion because of funding constraints. Funding was restored during FY 1992 and the design of the prototype was completed in September 1992. Efforts during FY 1992 focused on (1) preparing a draft project management plan, (2) preparing a functions and requirements draft document, (3) preparing a design basis draft document, (4) preparing a draft prototype barrier testing and monitoring plan, (5) completing the appropriate level of *National Environmental Policy Act* (NEPA) documentation (for the prototype construction site and for the borrow pits from which construction materials would be obtained), (6) completing definitive design drawings, and (7) developing detailed construction specifications.

A Barrier Design Team (BDT) was assembled to lead the design of the prototype barrier. The BDT consisted of representatives from WHC, PNL, and Kaiser. The BDT met frequently with and received technical support from the Barrier Technical Advisory Board (BTAB), which is a group of engineers and scientists on the barrier development team who represent the various areas of technical expertise. Review comments and design suggestions from other barrier development team members also were solicited and incorporated as appropriate.

Kaiser was responsible for transforming conceptual ideas from the BDT/BTAB into definitive, detailed construction drawings. These drawings were subjected to numerous technical reviews, including an offsite expert technical peer review panel. The completed drawings represented the optimal design for meeting the objectives of the prototype barrier project.

In August of 1992, the U.S. Environmental Protection Agency (EPA), in conjunction with the DOE Richland Operations Office (RL) and WHC, discussed moving the prototype barrier from the original uncontaminated site located near the HMS to a location situated on top of a contaminated crib (216-B-57) within the 200-BP-1 operable unit (OU). WHC's initial position was to construct the prototype barrier at the HMS, as originally envisioned, and construct a second barrier over the 200-BP-1 OU, based on the recommendations of the ongoing *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) feasibility study (FS). After several meetings among WHC, RL, and the EPA, the decision was made to construct one prototype barrier over a portion and possibly all of the 216-B-57 Crib as a technology demonstration. Provisions were made to monitor barrier performance for a minimum of 3 years, followed by an option to conduct partial or full destructive testing of the barrier to determine overall performance. Formal change control was initiated in October 1992, and a change request (M-15-92-5) was written to document these and other changes to the 200-BP-1 OU work scope. Kaiser was directed to complete a site-specific engineering study to redesign the prototype barrier for construction over the 216-B-57 Crib and to identify the associated costs.

The final remediation option for the 200-BP-1 OU will be determined through the ongoing CERCLA FS process. Although numerous in situ and ex situ treatment alternatives are being considered, preliminary indications from the FS strongly suggest that some type of protective barrier or cover system will be the preferred alternative. The protective barrier option reduces personnel exposure to hazardous contaminants, minimizes secondary waste handling requirements, and establishes an important precedent for in-place disposal of wastes.

Although not the most desirable construction site from a research and development perspective, construction of the prototype barrier over the 216-B-57 Crib will provide insights into barrier constructibility over actual waste sites and under radiologically controlled conditions. While actual barrier performance data will not be available for several years after the completion of barrier construction, lessons learned during the construction of the prototype barrier and actual costs incurred will provide information in support of the final "Record of Decision" for remediation of the 200-BP-1 source area and the subsequent remedial design. Also, the prototype barrier demonstration will constitute the first full-scale test of the integrated barrier design and will allow collection of data necessary to verify barrier performance or provide a basis for design modifications.

The prototype barrier alone, is not expected to provide all of the evidence required to demonstrate barrier performance over its intended design life of 1,000+ years. Other tasks within the BDP (e.g., natural analog studies, climate change studies, asphalt degradation studies, subsidence studies) are designed to provide the data needed to increase confidence in the barrier's ability to perform over its design life.

3.0 JUSTIFICATION - REGULATORY DRIVERS

Some type of cover and/or surface barrier probably will be placed over burial grounds, landfills, and other similar areas, at the time of closure. The promulgation of the various regulations that govern the disposal of these various waste materials has reflected this logic. Currently, many potentially applicable or relevant and appropriate requirements (ARARs) exist that have been promulgated and many are currently being enforced. Although some variation exists in the actual enforcement and implementation of the law (i.e., specific practice), there appears to be little if any disagreement on the intent of the law as it relates to the functional need for covers or surface barriers. These structures are emplaced both to limit the amount of water and rate at which water enters the zone of contamination and to limit intrusion. For some waste, the function of limiting intrusion through biological and human activities is considered as important if not more important than limiting contaminant migration via water infiltration (For example; 10 CFR 61.51 (a) paragraphs (4) through (6) vs. 10 CFR 61.52 (a) paragraphs (4) through (11)).

The regulations that govern the design and performance of the Hanford Protective Isolation Surface Barrier and that are reflected in the design of the prototype barrier are contained in the following five documents:

- "Licensing Requirements for the Disposal of Low-Level Radioactive Waste" (10 CFR 61)
- "Guidelines for Disposal of Solid Waste" (40 CFR 241)
- "Regulations for Owners and Operators of Permitted Hazardous Waste Facilities" (40 CFR 264)
- The State of Washington *Dangerous Waste Regulations* (WAC 173-303)
- The U.S. Department of Energy's Order on Waste Management (DOE Order 5820.2A).

The relevant sections of these regulations as they relate to cover design and performance are summarized in the following paragraphs.

3.1 Code of Federal Regulations

[10 CFR Part 61 Subpart D - "Technical Requirements for Land Disposal Facilities"]

61.51 (a) Disposal site design for near-surface disposal.

(4) Covers must be designed to minimize, to the extent practicable, water infiltration, to redirect percolation or surface water away from the disposed waste, and to resist deterioration by surface geologic processes and biotic activity.

(5) Surface features must direct surface water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance in the future.

(6) The disposal site must be designed to minimize to the extent practicable the contact of standing water with waste during disposal, and the contact of percolating or standing water after disposal.

61.52 Land disposal facility operations and disposal site closure. Wastes designated as Class C must be disposed of so that the top of the waste is a minimum of 5 m below the top surface of the cover or must be disposed of with intruder barriers that are designed to protect against an inadvertent intrusion for at least 500 years.

[40 CFR Part 241 - "Guideline for the Land Disposal of Solid Waste"]

40 CFR 241.209 Cover Material.

40 CFR 241.209-1 Requirement.

Cover material shall be applied as necessary to minimize fire hazards, infiltration of precipitation, odors, and blowing litter; control gas venting and vectors; discourage scavenging; and provide a pleasing appearance.

[40 CFR Part 264 - "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities"]

40 CFR 264.310 Closure and post-closure care

(a) At final closure of the landfill or upon closure of any cell, the owner or operator must cover the landfill or cell with a final cover designed and constructed to:

(1) Provide long-term minimization of migration of liquids through the closed landfill;
(2) Function with minimum maintenance;
(3) Promote drainage and minimize erosion or abrasion of the cover;
(4) Accommodate settling and subsidence so that the cover's integrity is maintained; and
(5) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

3.2 Washington Administrative Code

[WAC 173-303 - *Dangerous Waste Regulations*]

WAC 173-303-610 "Closure and post-closure."

(2) Closure performance standard. The owner or operator must close the facility in a manner that:
(a) (i) Minimizes the need for further maintenance
(ii) Controls, minimizes, or eliminates to the extent necessary to protect human health and the environment, post-closure escape of dangerous waste, dangerous constituents, leachate, contaminated run-off, or dangerous decomposition products to the ground, surface water, groundwater, or the atmosphere
(iii) Returns the land to the appearance and use of surrounding land areas to the degree possible given the nature of the previous waste activity.

WAC 173-303-665 "Landfills."

(6) (a) At final closure of the landfill or upon closure of any cell, the owner or operator must cover the landfill or cell with a final cover designed and constructed to:
(i) Provide long-term minimization of migration of liquids through the closed landfill
(ii) Function with minimum maintenance
(iii) Promote drainage and minimize erosion or abrasion of the cover
(iv) Accommodate settling and subsidence so that the cover's integrity is maintained
(v) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

3.3 Department of Energy Order

In addition to the specific requirements on cover design and performance, other criteria exists within the DOE complex that could increase the performance requirements of surface barriers and covers. Included in this category is the list of DOE orders and EPA guidance documents.

The DOE requirements for the management of radioactive wastes, mixed wastes, and contaminated facilities are contained in DOE Order 5820.2A, "Radioactive Waste Management." The high-level and transuranic wastes are managed in accordance with applicable EPA and NRC rulings. The chapter on the management of low-level waste does not address the issue of design life. However, RLID 5820.2A supplements DOE Order 5820.2A by establishing Hanford Site-specific policies, guidelines, and requirements for waste management.

DOE Order 5820.2A *Radioactive Waste Management*

Chapter 3: Management of Solid Low-Level Waste

3. Requirements
a. Performance Objectives.
(4) Intruder Protection. Disposal closure systems shall be designed to ensure that exposure to individuals who inadvertently intrude the closed facility after the active institutional control period shall not exceed 100 mrem/year for continuous exposure, or 500 mrem for a single acute exposure. For wastes that may remain hazardous to inadvertent intruders beyond 100 years, passive controls (e.g., appropriate markers and barrier systems) shall be incorporated to provide reasonable assurance that inadvertent intruders will be warned and deterred from disturbing the site for up to 500 years.

k. Disposal.

(4) Disposal sites for solid LLW-MW (non-PCB) shall be located and designed in compliance with the applicable requirements in WAC 173-303, 40 CFR 264, 265, and 268, and the RCRA Dangerous Waste Permit.

Other materials to be considered include design criteria and codes that have been established but are neither promulgated by law nor included as DOE orders. These design materials are related to surface barriers and covers and are contained in numerous references. The primary impetus for the use of surface barriers and covers has resulted from the promulgation of the waste disposal regulations found in RCRA and CERCLA. In support of these regulations, EPA has prepared numerous guideline documents on the use and design of these structures.

4.0 PRELIMINARY PERFORMANCE OBJECTIVES

To aid in the development of surface barriers, a preliminary set of performance objectives for the barriers has been defined. These objectives are intended to encompass the various regulatory requirements for the types of wastes anticipated to be disposed of using barriers at the Hanford Site (and elsewhere). The objective of current designs is to develop a long-term surface barrier with the following features:

- To function in a semiarid to subhumid climate
- To limit the recharge of water through the waste to the water table to near-zero amounts (0.05 cm of water per year [1.6 by 10^{-9} cm/s] was the design objective selected, based on preliminary performance assessments)
- To be maintenance free (no institutional control)
- To minimize the likelihood of plant, animal, and human intrusion
- To limit the exhalation of noxious gases
- To minimize erosion-related problems
- To meet or exceed RCRA cover performance requirements
- To isolate wastes for a minimum of 1,000 years
- To be regulatorily and publicly acceptable.

These objectives have provided the basis for formulating a barrier development program and for evaluating the adequacy of various barrier designs. These objectives also have been used in the preparation of a statement (provided below) that summarizes the goals of the BDP.

The BDP goal is to provide defensible evidence that barrier designs will control water infiltration; plant and animal intrusion; and wind and water erosion for a minimum of 1,000 years; and protect human health and the environment in accordance with ARARs. Conceptual designs for a warning marker system that would be used to inform inadvertent human intruders will be provided for scenarios in which institutional control is assumed to be lost.

Evidence of barrier performance will be obtained by conducting laboratory experiments, field tests, computer modeling, and other studies that establish confidence in the barrier's ability to meet its 1,000+ year design life. The stability and performance of natural analogs that have existed for millennia, and reconstruction of climate changes during the past 10,000 years will establish bounding conditions of possible future changes and serve to focus experimental designs and increase confidence in the barrier's ability to meet its design life.

5.0 PREDICTIONS OF LONG-TERM CLIMATE CHANGE

The control of water infiltration and percolation through the barrier is dependent on the amount of water available. The amount of water available is dependent on the climate. Because of the long time frame during which surface barriers must function (1,000+ years), the climatic conditions acting on the barrier may change.

5.1 Current Climatic Conditions

Since 1945, the amount of precipitation collected at the HMS has averaged 160 mm (6.30 in.) annually (Stone 1983). Most of this precipitation (44%) is received between November through January while only 13% is received between July through September. About 38 percent of the precipitation during the December through February time frame is in the form of snow. Total annual snowfall averages 335 mm (13.2 in.) based on records from 1912 to 1980. Based on extreme-value analysis of Hanford Site climatological records from 1947 through 1969, the 60-minute, 100-year storm would result in 20.6 mm (0.81 in.) of precipitation and the 60-minute, 1,000-year storm would result in 28.2 mm (1.11 in.) of precipitation. No records have been kept for time periods less than 60 minutes. However, the rain gauge chart for June 12, 1969 shows that 14.0 mm (0.55 in.) of precipitation was collected during a 20-minute period. In addition, an afternoon thunderstorm on June 29, 1991 dumped 11.2 mm (0.44 in.) of rain at the HMS in only 10 minutes. A 24-hour maximum accumulation for a 100-year return period is 50.5 mm (1.99 in.) and the 1,000-year return is 68.1 mm (2.68 in.).

The average monthly temperature at the HMS is 11.7 °C (53.0 °F). However, January monthly temperatures average -1.5 °C (29.3 °F), and July monthly temperatures average 24.7 °C (76.4 °F). Temperatures reach 32.2 °C (90 °F) or above an average of 55 days/year while minimum temperatures of 21.1 °C (70 °F) or above occur only an average of 8 days/year.

The prevailing wind direction at the Hanford Site is either WNW or NW in every month of the year. The strongest winds are from the SSW, SW, and WSW. June, the month of highest average wind speed, has fewer instances of hourly averages exceeding 13.9 m/s (31 mph) than December, which has the lowest average wind speed. When extreme value analysis of peak gusts is performed on data from 1945 through 1980 (collected at an elevation of 15.2 m [50 ft] at the HMS), the 100-year return period for a peak wind gust is estimated to be 38 m/s (85 mph). The maximum gust recorded in the data set was measured in January 1972 at 35.8 m/s (80 mph). The 1,000-year peak gust is estimated to be 44 m/s (99 mph).

5.2 Projected Climatic Conditions

A task within the BDP, the "Long-Term Climate Change Effects Task," has been established to obtain probabilistic projections of the long-term variability in the Hanford Site's climate so that analyses of barrier performance during its projected design life (1,000+ years) could be made (Petersen et al. 1993). One of many activities that has been performed as part of the climate change task is the extraction of a pollen record from the lake bottom sediments of Carp Lake. Carp Lake is located near Goldendale, Washington, southwest of the Hanford Site. This pollen record, dating back 75,000 years or more, enables scientists to determine the types of vegetation that once grew in the vicinity of the lake. With an understanding of the vegetation species' history, scientists are then able to predict the climatic conditions necessary to support the growth of the types of vegetation determined from the pollen record.

Referring to the climatic conditions of the Columbia Basin inferred from the Carp Lake pollen record, Petersen (1993) states the following.

- Throughout the record, mean annual precipitation ranged from 25 to 50% below modern levels...to 28% above...At no time did precipitation levels reach three times that of present day. Three times modern precipitation has been taken as an upward bounding condition of precipitation to be used in barrier performance assessment...

The three-times-average annual precipitation (3X) projection has been used since FY 1991 as the upper bound when applying supplemental precipitation to field test plots. This 3X amount also will be used during the testing of the prototype barrier.

6.0 DESIGN LIFE

6.1 Background

Design life is defined as that period of time over which an engineered system or structure is expected to remain operational and perform its intended function. Conventional, modern design-life criteria for humanmade structures tend to range from a few decades to possibly several hundred years, with the application of appropriate "safety factors." The design life criteria tend to be influenced by our knowledge of the physical, chemical, and biological properties of humanmade and natural materials; our experience in the use of such materials under a variety of conditions and applications; and the intended useful life of the engineered structure. While design life criteria of several decades to a few hundred years are adequate for most commonly used engineered structures or systems, the long-term disposal of radioactive and hazardous waste materials poses new design life challenges to ensure proper protection of human health and the environment during the period that the wastes will remain hazardous.

The radioactive and biological half-lives of the contaminants of concern are such that their life expectancies can range from several hundreds of years to tens of millennia. The ability to protect human health and the environment is further complicated by the common assumption of possible loss of institutional control at waste disposal sites after a period of 100 years. Consequently, waste disposal structures must be capable of performing without maintenance and be designed to withstand maximum credible events such as high winds, high rainfall, seismic disturbances, and other natural phenomena that could occur during the life of the disposal structure. Accurately predicting the occurrence of natural phenomena and their impact on the integrity of waste disposal systems is difficult (if not impossible) because of the multitude of uncertainties that can exist, especially over periods of time up to the tens of millennia. Alvin Weinberg (1985) characterized this situation by coining the phrase "transscientific" to describe certain environmental problems that, while requiring close evaluation by engineers and scientists, are not likely to be solved by science because of the enormous uncertainties and lack of geotechnical experience.

A "defense in depth" logic is commonly applied to the isolation of radioactive and hazardous wastes, wherein numerous barrier systems are employed to control surface and subsurface phenomena. For example, surface covers are typically used to control water infiltration, biointrusion, erosion, and noxious gas emissions. The waste materials can be encased in cement or glass monoliths to provide physical stability and leach resistance. Subsurface barriers can be deployed around the wastes to control advective and diffusive flow of contaminants away from their place of disposal or to provide capabilities for leachate collection and removal.

The extent to which any one or a combination of these barrier systems are applied is driven particularly by the outcome of risk assessments, and public and regulatory expectations.

Despite the multitude of uncertainties and a general lack of geotechnical experience, design life criteria ranging from 1,000 to 10,000 years are becoming commonplace in the design and selection of radioactive and hazardous waste disposal facilities across the nation. Because our understanding of material properties and behavior over long periods of time is limited, the study of natural and humanmade analogs of barrier systems increasingly is relied on to provide qualitative evidence of long-term performance. This qualitative evidence of long-term barrier performance obtained through the study of natural analogs is supplemented with a more quantitative understanding derived from field and laboratory testing, and computer modeling. The qualitative and quantitative information together provides the evidence needed to support the hypothesis that protective barrier systems can isolate radioactive and hazardous wastes effectively for the period of time that the wastes are considered potentially harmful to human health and the environment.

6.2 Regulatory Drivers Affecting Design Life

There have been several developments in promulgated regulations that address the design life of waste disposal systems. Generally, requirements for waste disposal system performance are expressed in terms of dose to humans, contaminant concentrations, environmental releases, or risk to human health and the environment. Over the past decade, DOE, U.S. Environmental Protection Agency (EPA), and Nuclear Regulatory Commission (NRC) regulations have cited waste disposal design life criteria of 1,000 years and 10,000 years. The major difference in the design life criteria for the waste disposal system concerned designation of the wastes as low-level radioactive wastes or high-level radioactive wastes. In addition to radioactive wastes, some of the wastes also contain a hazardous chemical component and are referred to as mixed wastes. The current direction of applicable regulations tends to be converging on the 10,000-year design life for all nuclear waste disposal systems, regardless of waste origin.

The EPA has two primary rules governing the disposal of low-level and high-level radioactive wastes: 40 CFR 193 and 40 CFR 191, respectively. 40 CFR 191 was promulgated in 1985 and contains limits on integrated releases during a 10,000-year period. 40 CFR 191 also establishes limits on individual dose for 1,000 years. 40 CFR 191 was remanded in 1987, partially because the 1,000-year time frame for individual dose limits was not considered to be sufficiently justified and the regulation had not been subjected to public review and comment. However, the courts ruled that the 10,000-year integrated release limit was adequately justified.

The final ruling for the nations' transuranic waste repository, the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, and any other transuranic or high-level waste repository (except the Yucca Mountain Site) was reissued on December 20, 1993 (58 FR 66398). This final ruling states that the performance time frame for both integrated releases and individual doses will be 10,000 years. The EPA ruling for the nation's high-level waste repository, the Yucca Mountain Site, will not be prepared until the National Academy of Sciences (NAS) completes its review and provides recommendations. The NAS recommendations are due by January 1995. Although 40 CFR 191 does not apply to the disposal of low-level radioactive wastes, recent rulings by U.S. courts provide insight for the direction in which the EPA is heading.

Currently, EPA regulations governing the disposal of low-level radioactive wastes from the Uranium Mill-Tailings Remedial Action Program require waste disposal sites to remain physically stable (not susceptible to subsidence) and chemically isolated (no migration of waste materials from their place of disposal) for periods up to 1,000 years (40 CFR Part 192.02). However, EPA's move toward a 10,000-year performance requirement will undoubtedly influence the future rule for low-level waste disposal (40 CFR 193), which has been remanded and is being rewritten.

The EPA also has promulgated regulations on underground injection (40 CFR 148) and land disposal restrictions (40 CFR 268), which may have some bearing on the determination of waste disposal system design life. In both rulings, provisions exist for a "no-migration" variance. The no-migration variance is granted if the licensee can provide an analysis of the waste disposal system showing that no contaminants will migrate beyond their place of disposal for a period of 10,000 years. The WIPP has applied to the EPA for a no-migration variance.

The Hanford Site-specific requirements for the performance of the waste disposal system addresses the need to protect the general public, the groundwater, and inadvertent intruders. For the safety of the general public, disposal systems must be designed to limit exposure to no more than 25 mrem/year "Effective Dose Equivalent" (EDE) through all exposure pathways for at least 1,000 years. The groundwater protection requirements reflect the need to meet the *Clean Water Act* and the *Safe Drinking Water Act*. The groundwater protection requirements also ensure that the EDE, through the groundwater pathway, does not exceed 4 mrem/year to any person who might drink 2 liters of water per day from a well drilled into the underlying aquifer. Compliance is necessary for a minimum of 1,000 years after the disposal of the wastes. Intruder-protection requirements limit exposure to inadvertent intruders to 100 mrem/year for continuous exposure, or 500 mrem for a single acute exposure, for up to 500 years.

The DOE is in the process of revising DOE Order 5820.2A, which will be superseded by DOE Order 5820.2B. Existing drafts of DOE Order 5820.2B contain a 10,000-year time frame for compliance with the individual dose limit. However, some debate remains regarding the need to conduct performance assessments beyond the 10,000-year time frame to analyze the point of maximum contaminant release, where warranted.

The NRC ruling on the disposal of low-level radioactive waste is contained in 10 CFR 61. Low-level waste disposal sites are required to demonstrate long-term stability for approximately 300 to 500 years (10 CFR 61.44). However, recent license applications for waste disposal in the state of California contained performance and risk assessments extending to 10,000 years. This may indicate future NRC direction for the disposal requirements of low-level radioactive wastes and the design life of waste disposal facilities.

In addition to the waste disposal regulations promulgated by the DOE, EPA, and NRC, waste disposal systems will be subject to the requirements of RCRA and CERCLA. RCRA establishes requirements for generators and transporters of hazardous waste materials and provides a permitting process that regulates the treatment, storage, and/or disposal of hazardous chemical wastes. Radioactive wastes that are also considered hazardous under RCRA (mixed wastes) are subject to regulation under Subtitle C of RCRA. RCRA has a shorter-term mentality in terms of the design life of surface covers for landfills and other surface impoundments. After the actual closure of a waste disposal cell, RCRA requires a 30-year post-closure care period. The potentially harmful effects of waste disposal operations on human health and the environment are mitigated through an extensive program of final cover maintenance, operation of a leachate collection and removal system, and establishment of a groundwater monitoring system. Because the 30-year post-closure care period is typically well within the realm of active institutional control, periodic maintenance can be conducted to ensure that the cover system continues to perform as designed.

CERCLA provides for liability, compensation, emergency response, and cleanup of hazardous substances released to the environment. CERCLA was amended by the *Superfund Amendments and Reauthorization Act of 1986* (SARA). CERCLA, as amended, requires that remedial actions taken at a waste disposal site must attain minimum ARARs based on state and federal laws. RCRA Subtitle C requirements for hazardous waste treatment, storage, and/or disposal facilities frequently become ARARs for CERCLA actions, mostly because RCRA regulates the same or similar wastes typically found at CERCLA sites. Consequently, the 30-year post-closure care period specified under RCRA becomes a minimum requirement in the closure of CERCLA sites. CERCLA legislation also discusses the need for "permanency" of closure actions to ensure protection of human health and the environment for as long as the wastes remain hazardous. This CERCLA requirement and the radioactive nature of wastes at the majority of CERCLA sites at Hanford tend to drive the design life of surface covers into the range of 1,000 to 10,000 years, depending upon the specific radionuclides of concern.

6.3 Value Engineering Workshop

A Value Engineering (VE) workshop for the Hanford Site Long-Term Surface Barrier Development Program was convened the week of February 8 to 12, 1993 (DOE-RL 1993b). The VE workshop was attended by all the potential stakeholders in surface barrier technology and included technology developers, technology end-users, and the regulators. In general, the VE workshop was designed to review barrier development progress to date, to review plans for remaining barrier development activities, and to reach stakeholder consensus regarding the need to conduct the remaining planned development activities to ensure public and regulatory acceptance of surface barrier technology. Several specific issues also were addressed during the VE workshop to ensure that stakeholder expectations were articulated clearly and understood. One of these issues was the design life for long-term surface barriers.

After a lengthy discussion of existing and emerging regulatory requirements and stakeholder expectations, a minimum design life of 1,000 years was selected. The planned application of the barrier at Hanford will be predominantly over low-level radioactive or mixed waste disposal sites. Consequently, a 1,000-year minimum design life adequately addresses protection against the majority of the contaminants of concern, which have half-lives less than 100 years (radionuclides decay to innocuous levels after 10 half-lives) and tends to conform to existing regulatory guidance for the disposal of low-level radioactive and hazardous chemical wastes. Also, a 1,000-year design life tends to be approaching the upper range of credible and defensible extrapolations of surface barrier performance results, given our limited understanding of natural and humanmade materials and general lack of geotechnical experience. A 10,000-year time frame is considered to be "transscientific" and tends to be difficult, if not impossible, to prove given the great many uncertainties in the assumptions required to conduct engineering analyses of surface barrier performance over long periods of time. Finally, a 1,000-year design life was recognized as being ample time to allow technological advancements in the area of waste treatment. In this regard, the surface barrier would adequately protect human health and the environment until new and innovative waste treatment technologies are developed and demonstrated. Removal of the surface barrier and deployment of new waste treatment technologies would be relatively simple.

7.0 MULTI-LAYER BARRIER CONCEPT

7.1 Functional Performance of Surface Barriers

The protective barrier design consists of a fine-soil layer overlying other layers of coarser materials such as sands, gravels, and basalt riprap (Figure 7-1). Each layer serves a distinct purpose.

The fine-soil surface of the protective barrier has been engineered for two major purposes: to maximize runoff while minimizing erosion, and to evapotranspire water that has infiltrated the barrier's surface back to the atmosphere. The surface of the protective barrier has been engineered with a slight slope or crown. This slight grade is intended to maximize the runoff of meteoric water and to reduce the amount of precipitation available for infiltration and percolation. The amount of water available for infiltration and percolation is a function of the amount of precipitation that falls on the barrier surface, minus the amount of water that runs off of the barrier surface and away from the structure. The current barrier design uses a 2-percent sloped surface to allow runoff and minimize erosion.

The fine-soil layer also acts as a medium in which moisture is stored until the processes of evaporation and transpiration recycle any excess water to the atmosphere. The protective barrier is designed and constructed with a fine-soil layer overlying a layer of coarser materials (e.g., sands and/or gravels). The differences in textures between the barrier materials at this interface provide a capillary barrier for percolating water.

In an unsaturated system, the capillary pressures are much less than atmospheric pressure. The overlying fine-textured soils must become nearly saturated for the water pressure to approach atmospheric pressure and allow water to flow into the underlying coarse layers. This resistance to drainage increases the storage capacity of the overlying fine-textured soil. Keeping the water in the fine-textured layer provides time for the processes of evaporation and transpiration to remove it.

The critical component of the capillary barrier is the fine-soil layer. The fine-soil layer must be able to retain infiltrating precipitation until the processes of evaporation and transpiration can recycle the water back to the atmosphere. The removal of water from a barrier's fine-soil layer is increased significantly by the presence of vegetation. After the construction of a barrier, desired stands of vegetation on the barrier surface are to be engineered and cultivated. However, during a barrier's design life, periods may exist when the engineered vegetative cover is disturbed by range fires, drought, disease, or some other phenomenon. Because the design objective is to create a maintenance-free barrier, revegetating

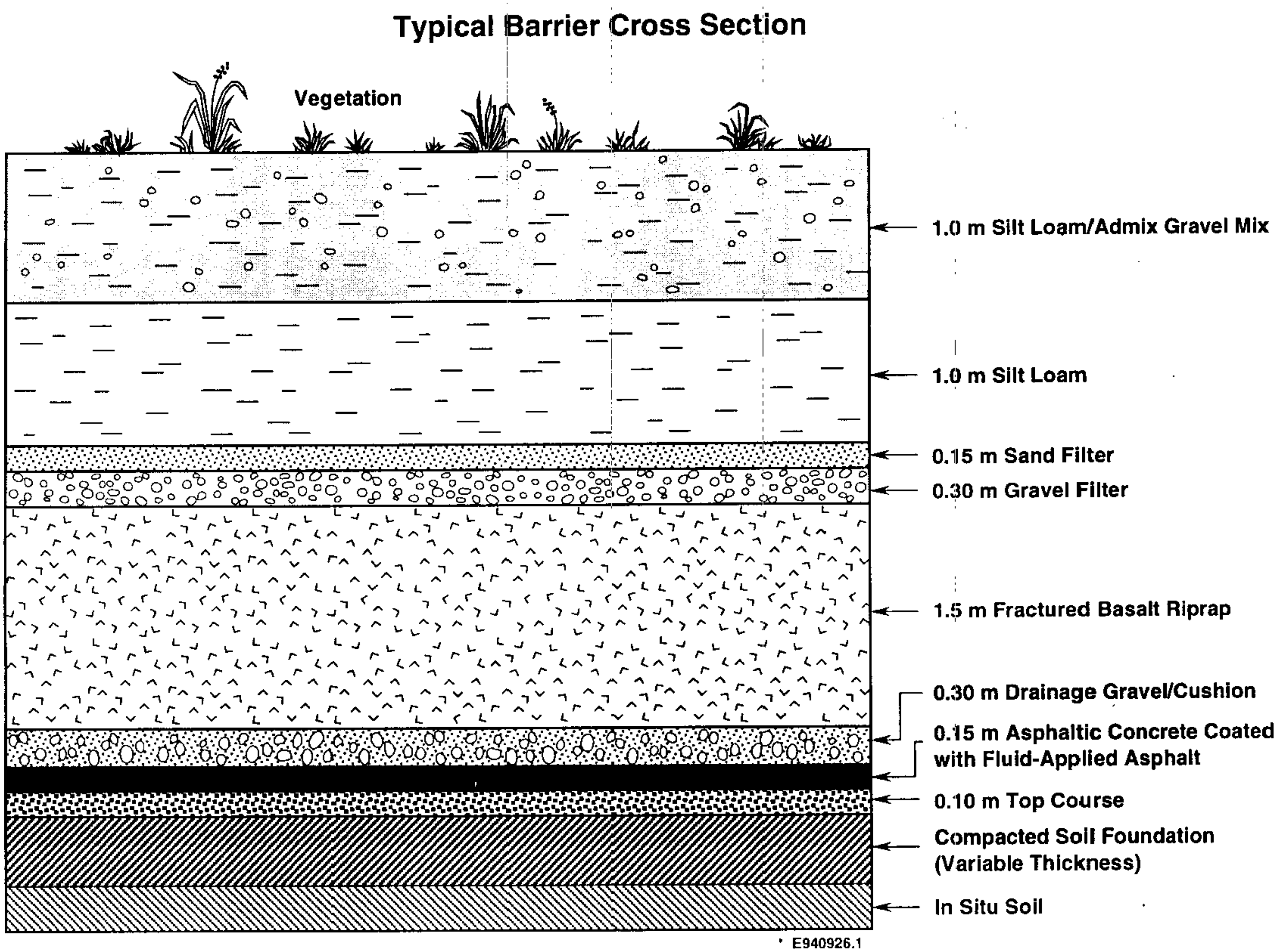


Figure 7-1. Typical Barrier Cross Section.

the barrier surface with the desired plant species may not always be possible. A long period of time may elapse before a climax community of vegetation reestablishes itself on the barrier surface in these circumstances. Although the presence of vegetation on the barrier surface is ideal, the results of lysimeter tests provide evidence that the capillary barrier concept performs effectively even in the absence of vegetation (Wing 1993b).

In addition to transpiring water back to the atmosphere, the presence of vegetation on the barrier surface will significantly reduce the amount of fine soil lost from the barrier by wind and water erosion. As discussed previously, vegetation is expected to be growing on the surface of the barrier throughout the majority of its design life. However, periods of time may exist when the vegetative cover is not present. To protect the barrier surface during these times, surface gravels will be admixed into the surface of the protective barrier. Wind tunnel tests have demonstrated that admixtures and layers of 3- to 7-mm gravels provide superior surface protection. The best gravel admixtures reduced surface deflation rates by greater than 96 percent (compared to unprotected soil). In addition, rounded river rock and angular crushed-rock gravel provided equal surface protection, thereby expanding the possibilities of finding adequate source materials for the least expense (Ligotke and Klopfer 1990; Ligotke 1993).

The placement of the silt loam directly over the coarser materials also creates an environment that encourages plants and animals to limit their natural biological activities to the upper, fine-soil portion of the barrier, thereby reducing biointrusion into the lower layers. The coarser materials help to deter plant and animal intrusion as well as the inadvertent intrusion by humans.

Low-permeability asphalt layers, placed in the barrier profile below the capillary break, also are used in the surface barriers. The purposes of the low-permeability asphalt layers include (1) diverting any percolating water that gets through the capillary break from the waste zone, and (2) limiting the upward movement of noxious gases from the waste zone.

Several types of asphalt have been studied in tests conducted by the BDP. One promising asphalt formulation currently being tested consists of a composite layer of asphaltic concrete (with 7 to 8 percent asphalt and low voids) overlain by a layer (5.1 mm [0.2 in.] thick) of polymer modified asphalt. Two major advantages to this asphalt formulation include its high mechanical strength and its use of composite layers, which have been shown to provide much lower permeabilities than one layer alone. The low permeability and longevity of asphalt, along with its low water content, make asphalt ideally suited not only to prevent water intrusion but biotic intrusion as well. The coarse materials, above the low-permeability asphalt layers, also serve as a drainage medium to channel any percolating water to the edges of the barrier.

Two side slope configurations are being considered in long-term surface barrier designs: (1) a relatively flat apron of clean-fill materials (commonly called a clean-fill dike) and (2) a relatively steep embankment of fractured basalt riprap. The clean-fill dike concept uses readily available borrow materials (such as pitrun gravels) to create a relatively flat apron around the periphery of the barrier. This relatively flat apron provides a more gentle transition from the shoulder of the barrier to the surrounding environment than does the steep side slope. The steep side-slope design uses fractured basalt riprap, which consists of relatively large angular rocks. The angularity of the riprap provides many interlocking surfaces between adjacent rocks, which allows the creation of a relatively steep, yet stable, side slope.

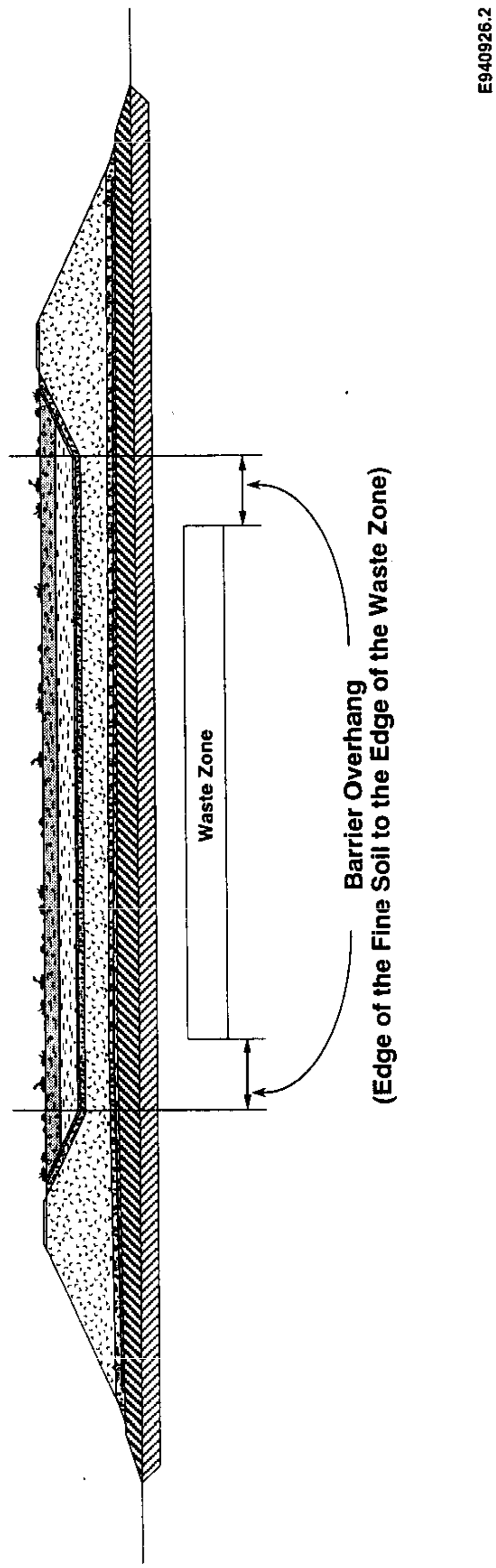
The control of water infiltration at the periphery of the barrier is a significant design feature that must be considered for both clean-fill dike and fractured basalt side slopes. Protective barriers are designed with sloped fine-soil surfaces and low-permeability subsurface components. Consequently, water will be channeled to the side slopes and toe of the barrier. Because of this channeling, a significant amount of water is expected to accumulate at the periphery of the barrier. This accumulation of water poses two major design considerations: (1) What effect does the additional water have on side slope stability and erosion? and (2) How can the additional water be kept from contacting buried wastes?

Many different approaches exist for controlling potential water infiltration problems at the side slope and toe of a surface barrier. Three key options include: (1) allowing an adequate amount of barrier overhang, (2) using vertical asphalt or grout curtains, and (3) designing the toe of the barrier to remove water passively via evapotranspiration.

"Barrier overhang" (Figure 7-2) is the terminology used to describe the projection of the functional barrier surface (outer edge of the fine-soil layer) beyond the perimeter of the waste zone. Barrier designs use overhang to control the lateral flow of water from the toe of the barrier (where water accumulates) to the waste zone. If the barrier overhang is great enough, the amount of water (if any) that gains access to the waste zone via lateral flow would be sufficiently minimized to reduce the potential for contaminant leaching and subsequent transport. The prototype barrier is testing this concept.

The asphalt or grout curtains (Figure 7-3) would consist of a vertical ring or band of low-permeability materials that completely encircles a waste site. The curtain would be constructed such that runoff water from the barrier would be diverted onto the side of the curtain opposite the waste zone.

Figure 7-2. Barrier Overhang.



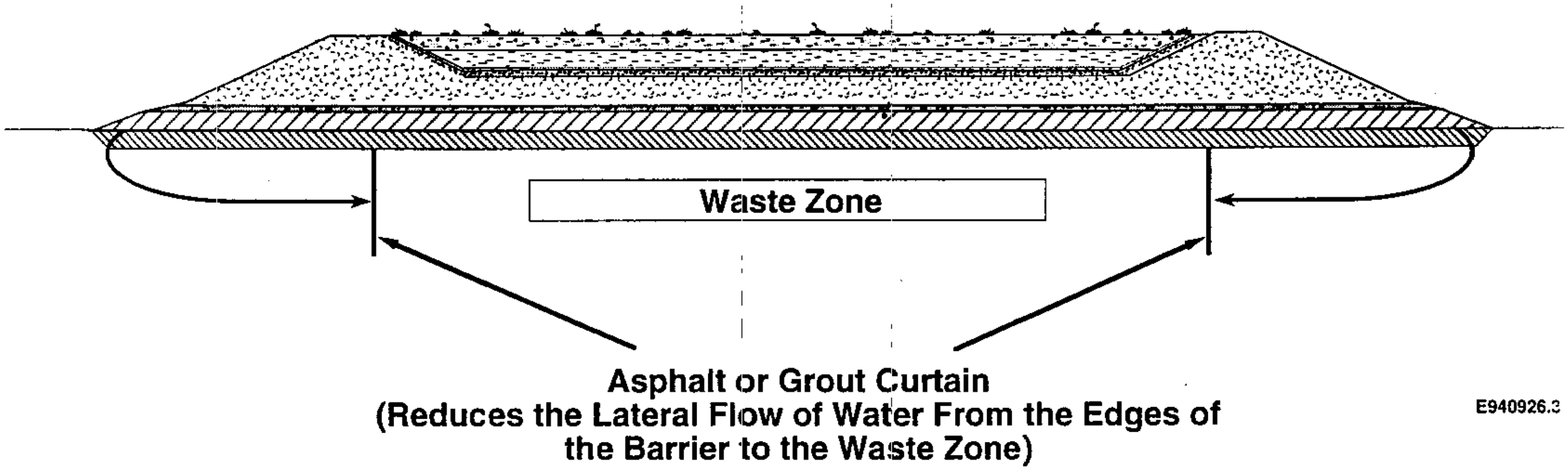


Figure 7-3. Asphalt or Grout Curtain.

The barrier toe could be designed to intercept and retain runoff water from the barrier until the water can be passively recycled to the atmosphere via evapotranspiration. One concept being evaluated is the construction of a retention-pond type of structure. This feature is constructed by extending the subsurface asphalt layer in the prototype barrier into a shallow trench dug along the periphery of the toe of the barrier. The asphalt layer serves as a liner in the trench. Gravel and silt-loam fine soil are backfilled over the asphalt liner. The silt-loam fine soils are vegetated to take advantage of the transpiration capabilities of plants. Runoff water from the prototype barrier is allowed to flow into the soil in the retention pond system. Based on lysimeter studies, the fine-soils will store moisture during the fall and winter months. This stored water subsequently will be removed from the soil by evapotranspirational processes during the warmer spring and summer months, reducing the amount of water available for recharge. This concept is being tested in the prototype barrier.

7.2 Barrier Material Availability

7.2.1 Description

The prototype barrier design calls for the use of a number of naturally occurring materials that contribute important functions to the overall barrier performance. The wide variety of functions that these materials will provide range from water storage and drainage to biointrusion control and erosion control.

7.2.2 Background

To aid in the initial barrier design, a set of performance objectives were established that encompassed regulatory issues and technical concerns. Task groups were organized to focus on resolving specific technical concerns regarding the performance of a protective surface barrier in the arid environment found at the Hanford Site. Subsequently, the task groups identified the need to use a variety of materials to perform functions required for successful barrier performance (Wing 1994). These materials include fine silt, pea gravel, sand, drainage gravel, basalt riprap, and asphalt. Of these materials, the fine-silts and basalt riprap comprise most of the volume required to construct the prototype barrier.

7.2.3 Design Basis

If suitable materials are not located near the barrier construction site, they might be available from a nearby region outside the local area. However, if the transportation costs for moving the material from outside the local area to the barrier construction site are prohibitive, either a change in barrier design is required or the minimum acceptable properties for the given material as outlined in the construction specifications must be lowered. In the latter case, performance will be sacrificed, and the design may no longer follow the objectives first established for the original barrier design. Design changes may dictate using greater quantities of inferior materials to accomplish the same function or substituting materials that do not have well-known or well-documented long-term properties. For example, one of a variety of humanmade products, such as geosynthetic membranes, may have a well-known set of properties resulting from tests conducted over several years; however, the performance of these materials over many decades or centuries is not known.

Fortunately, the Hanford Site encompasses a large area, so abundant barrier construction material resources exist within its boundaries. Basalt outcrops, gravels, and sands, are commonly found within the boundaries of the Hanford Site. Fine silts are also found in abundant, but limited supply, northwest of the Yakima Barricade on the McGee Ranch Site, within Hanford Site boundaries.

Factors such as transportation costs, material suitability, and material quantity are not the only factors that can affect the availability of desired resources. Because Hanford property is Federally owned, additional considerations are given to cultural and historical significance of the ground and structures that are proposed to be disturbed. Many basalt outcrops located on Hanford property are considered culturally or religiously significant to the Native Americans who once inhabited the Site. Detailed cultural resource information about the Hanford Site can be found in Chatters (1989).

Abundant materials identified as suitable and available for use in barrier construction from an engineering perspective may not be suitable or available for use from a cultural or historical perspective. Such conflicts will require negotiation between the DOE, Native American Indians, and appropriate state agencies to mitigate the issues. However, if no solution can be reached that is acceptable to both parties, alternate material resources must be identified on Hanford property as close as possible to the barrier construction site. If materials cannot be secured within Hanford boundaries, the materials must be identified and secured from an offsite source. In addition to the considerable costs for transporting materials from offsite, costs will be accrued for procuring materials from private parties.

7.2.3.1 Basalt Resources. Basalt riprap is a major component in the prototype barrier design. The barrier design includes a 1.5-m- (4.9-ft-) thick layer of riprap in the barrier core and an armoring layer of riprap used to stabilize the steep barrier side slopes against the erosive forces of wind and water.

A Site Evaluation Report (SER) (Myers 1985) identified suitable locations of basalt resources on the Hanford Site at Gable Mountain, Gable Butte, and West Haven that could be used to support barrier construction. After analyzing the sites, the preferred location was Gable Butte, which is located closer to expected barrier construction sites of all the basalt sources considered. This nearly unlimited supply of basalt also is located near rail lines and paved roads, which would facilitate transportation of the riprap. However, subsequent comments regarding the cultural significance of Gable Butte to the Native American Indians suspended immediate plans to develop a large-scale quarry at this site. Similar issues exist for the other basalt outcrops identified in the aforementioned materials study.

Permission was granted to obtain a small quantity of basalt from the Vernita Quarry for use in construction of the prototype barrier. Approximately 10,700 m^3 (14,000 yd^3) of basalt riprap was removed from this site for use in constructing the prototype barrier.

7.2.3.2 Fine-Soil Resources. Four locations across the Hanford Site were originally identified as candidate sites for developing a fine-soils borrow site (Myers 1985). In 1985, a location west of the 200 West Area was selected from the four alternatives as the preferred site for securing fine soils for barrier construction. However, quarry activities in this area would have interfered with the reference repository location monitoring activities for the Basalt Waste Isolation Project (BWIP).

Later, a siting study (Skelly and Wing 1992) identified extensive deposits of fine soils at McGee Ranch and subsequently selected it as the preferred site to borrow fine soils. Surface soils found at McGee Ranch were originally classified in 1919 as Sagemore fine sand, very fine sand, or silt loam. However, after grouping of some soil series and applying new names, the Sagemore soils listed above were reclassified as a Warden silt loam (Hajek 1966).

Recent characterization activities at McGee Ranch identified approximately 3.4 million m^3 (4.5 million yd^3) of fine soils (Last et al. 1987) in an area east of McGee Well referred to as Area A. Area A encompasses an area south of McGee Well and is bounded on the east and south side by SR 24. Surface features of Area A consists primarily of fields that were farmed before 1943, and a small area of native shrubs. Fine-soils used during construction of the prototype barrier were acquired from an existing borrow pit immediately south of McGee Well in Area A.

7.2.3.3 Sand and Gravel Resources. A variety of sand and gravel resources required for use in constructing the prototype barrier were obtained from Pit 30, located in the 200 Area corridor between the 200 West and the 200 East Areas. In addition to the advantages of this pit supplying pea gravel, sand, and drainage gravels, the prototype and many potential barrier construction sites are nearby in the 200 West and 200 East Areas.

7.2.4 Testing and Monitoring

The prototype barrier will be constructed using the same native materials, available on the Hanford Site, that will be used for constructing large-scale barriers. This provides the opportunity to test and monitor the performance of readily available native barrier materials as they are stressed over time by forces such as water erosion, wind erosion, biointrusion, moisture migration, freeze-thaw cycles, settlement, and vegetation growth.

The prototype barrier design is expected to perform well under the tests planned during the next several years because of the supporting data and information collected over many years from field tests, laboratory experiments, and numerical modeling. However, based on results from these testing and monitoring activities, some adjustments could be made in the arrangement, specification, or quantity of readily available native materials used in subsequent surface barrier designs.

7.3 Fine Soil Layer

7.3.1 Description

The fine-soil layer is a composite of two layers. The bottom layer is 1.0 m (3.3 ft) thick and comprises silt-rich material (e.g., Warden Silt Loam Soil) obtained from the McGee Ranch Site located immediately northwest of the Yakima Barricade on the Hanford Site. The silt material is naturally occurring and well graded, with more than 30 percent by weight passing through a No. 230 sieve. Moisture may be added before or during transport to facilitate handling. The top layer is also 1.0 m (3.3 ft) thick and is comprised of Warden Silt Loam soil, to which 15 percent (by weight) pea gravel has been added.

7.3.2 Background

A surface barrier designed to minimize water intrusion into waste must meet certain criteria. These criteria focus on the properties of the soil layers but also consider climatic and biotic factors that combine to affect water intrusion.

In arid climates, where precipitation is limited, evapotranspiration (ET) is often sufficient to limit water from percolating through the cover and intruding into underlying wastes. The potential for all of the annual precipitation (rain and snow) to be removed by evaporation is high in arid climates because the theoretical limit for evaporation is often 10 times the precipitation (Gee and Hillel 1988). In this respect the water balance is favorable for preventing drainage and optimizing evaporation losses of incoming precipitation. However, the critical consideration is the distribution of the precipitation and the ability of the soil cover to store and retransmit water to the atmosphere so that drainage is prevented. In addition to climatic variables and soil properties, biological factors (including plants and animals) combine to influence the water balance. Plant root depth and density influence the water extraction rates. Animal burrowing provides pathways (macropores) for water infiltration and for advective vapor flow (evaporative losses). Thus, biotic factors can influence the soil water balance significantly and, in many cases, control the ultimate water balance of an earthen cover system.

The water balance of an earthen cover in an arid site for any given period can be written as:

$$P = ET + S + D + RO \qquad (1)$$

where:

P is precipitation
ET is evapotranspiration
S is soil water storage change
D is drainage
RO is runoff.

The design criteria for an earthen cover is to minimize the drainage, D, considering all factors that influence the remaining terms of the water balance. For the Hanford Site, much information is now available regarding earthen cover water balance (Gee et al. 1992, 1993, 1994). This information has been used in current design features and will be described in the following paragraphs. The incorporation of this information into specifications for the surface soil and the choice of materials used in the selection of the top 2 m (6.6 ft) of the prototype Hanford barrier.

7.3.3 Design Basis

The purpose of the fine-soil layer is to act as a root zone for plants and a confinement zone for animals. The water storage of the soil is sufficient so that extreme water infiltration events can be accommodated and minimal drainage occurs (averaging less than 0.5 mm/year [0.13 in./year]). The purpose of the gravel admix is to minimize soil erosion by wind and water. Justification for this design is found in the following sections.

7.3.3.1 Precipitation. The Hanford Site is located in an arid climate where winters are cool and wet and the summers are hot and dry. During the past 80 years, annual precipitation has varied from 76 mm to 291 mm (3.0 in. to 11.5 in.). Snow contributes about 20% of the annual precipitation, and is also highly variable. For example, in 1992 to 1993, a record snowfall (1425 mm [56 in.] snow) occurred with a water equivalent of about 140 mm (5.5 in.) or more, half of the annual precipitation (Gee et al. 1993). In contrast, during this past winter (1993 to 1994), only 104 mm (4.1 in.) of snow fell compared to a long-term average of 348 mm (13.7 in.) based on records from 1951 to 1980. Also, periods of extreme dryness have occurred. Within the past 6 years, two summers have experienced more than 65 days without rain. Additional climate information can be found in Section 5.0.

The design features of a protective surface barrier at Hanford should accommodate all expected extremes in precipitation (both extreme wetness and extreme drought). In the prototype design, extremes in precipitation have been accommodated for by providing an adequate water storage zone in the top 2 m (6.6 ft) of surface soil. Lysimeter tests (Gee et al. 1993) show that when plants (perennial shrubs and annual grasses) are present on a silt loam soil surface, all the annual precipitation under both ambient climate (past 6 years) and elevated precipitation conditions (3 years of 320 mm/year [12.6 in./year] water application, plus 3 years of 480 mm/year [18.9 in./year] water application) is removed. Drought may increase the potential for wind erosion of the soil surface. Such erosion can be minimized by incorporating pea gravel in the top meter of soil. Pea gravel additions in the soil will assist in stabilizing the surface against both wind and water erosion (Ligotke and Klopfer 1990; Gilmore and Walters 1993).

7.3.3.2 Evapotranspiration. Evaporation from plant and soil surfaces is a function of applied water and associated surface climatic parameters. When water is available, either at the soil surface or readily available to plant roots, evaporation processes proceed at or above the potential evaporation rate under arid climate conditions.

For the field lysimeter testing (Gee et al. 1993), irrigation was applied to both bare-surface and vegetated lysimeters. The water application was confined to a set of 11 lysimeters, while the remaining 13 lysimeters were not irrigated. Evaporation and ET were always highest on the irrigated lysimeters. For the vegetated lysimeters, the ET rates were always equal to or greater than the applied water (whether irrigated or not). This observation confirms that ET rates in arid climates are variable and depend significantly on the available precipitation.

For our combination of soils and plants (silt loam soil and sagebrush vegetation), the water removal rates have been entirely adequate to remove up to 480 mm/year (18.9 in./year) (3 times the average annual precipitation). This amount of annual precipitation has never been observed naturally at Hanford and is expected only if an extreme climate change occurs, causing wetter conditions to persist for an extended period of time (see Section 5.2).

Based on these observations, the 1.5 m (4.9 ft) of silt loam soil tested in the lysimeter should be adequate to store and transmit all of the applied water via ET, even during years with extreme (up to 3X) precipitation. For these reasons and those discussed in the following sections, the ET rates from the 2-m (6.6-ft) deep prototype barrier soil should remove all applied water annually for any of the test conditions (up to 3X precipitation) imposed.

7.3.3.3 Storage. Water stored in silt loam soil has been documented for profiles up to 1.5 m (4.9 ft) deep. The computed water storage for 1.5 m (4.9 ft) is approximately 500 mm (19.7 in.). For a 2.0 m (6.6 ft) deep soil profile, nearly linear increase is expected in storage for a silt loam soil, thus a 2.0 m (6.6 ft) deep silt loam profile should store up to 667 mm (26.3 in.) of water or about 4 times the annual average precipitation. While no direct measure of the influence of a pea-gravel addition exists, a potential reduction of water storage probably will occur because of the pea gravel. Because of the addition of 15 wt percentage pea gravel to the top 1.0 m (3.3 ft) of soil, the water storage in the 2.0 m (6.6 ft) prototype soil surface will be approximately 600 mm (23.6 in.). This water storage limit will be tested during the next 3 years in the Field Lysimeter Test Facility (FLTF) (Gee et al. 1993). A storage limit of 600 mm (23.6 in.) is expected to provide sufficient water storage capacity to fully accommodate any extreme precipitation event during the next 1,000 years or more. Thus, more than three times the annual average precipitation can be stored in the soil during the year, and all of the water will be removed annually by ET.

7.3.3.4 Drainage. The design objective for water infiltration control for the prototype is to limit drainage to less than 0.5 mm/year (0.02 in./year). A similar objective was met in the FLTF, where 1.5 m (4.9 ft) of silt loam soil has been tested in vegetated and irrigated conditions. The FLTF tests also show that sagebrush roots penetrate at least 2.0 m (6.6 ft) deep when adequate soil water exists. The entire 2.0 m (6.6 ft) profile of the prototype barrier probably will be penetrated by sagebrush roots, and water will be extracted from the entire profile. Such a system, which removes water effectively from the entire profile, severely limits drainage. The drainage criteria of 0.5 mm/year (0.02 in./year) or less should be possible using the fine soil (silt loam) surface.

The performance objective of 0.5 mm/yr for recharge (drainage) was initially obtained from a performance assessment related to cover designs for buried waste at Hanford (Gee 1987). The performance assessment suggested that at 0.5 cm/yr, buried contaminants in the 200 Areas (where water table is at least 60 m (197 ft) below the waste) would reach the water table only after 10,000 years. As discussed in the previous sections, cover design life for LLW is currently set at 1,000 years, thus, the barrier design has considered features that have a high probability of lasting 1,000 years or more. If the recharge performance objective is met, a Hanford Barrier in the 200 Areas (i.e., where waste is 60 m [197 ft] or more above the water table) should provide a 10 fold margin of safety against increasing the aquifer contamination.

There is still some uncertainty about the length of the cover design life required in the "final" regulations. Also there is the possibility that waste sites in other areas (with much shallower water tables) might be considered as candidate cover sites, or the possibility that some covers will require longer design lives than 1,000 years. Because of these considerations, we have chosen to leave the design objective at 0.5 mm/yr.

7.3.3.5 Runoff. Runoff is not expected to be a major component of the water balance at the Hanford Site. However, runoff can be expected at certain times as a result of rapid snowmelt (with or without superimposed rainfall) and high-intensity storms (current climate capabilities). On the gentle sloping (2 percent) surfaces of the prototype barrier, runoff is not anticipated under normal precipitation events for two reasons. First, the vegetation provides a microrelief feature that tends to trap water and generally increases the infiltration capacity of the soil (Wishmeier and Smith 1978; Marshall and Holmes 1979). Second, gravel admixtures, which were designed for wind erosion control (Ligotke and Klopfer 1990; Ligotke 1988; Cadwell et al. 1993) may also aid in stabilizing the surface. This may increase water infiltration in winter by modifying the thermal regime sufficiently to limit freezing depths and speed the thawing of surfaces that otherwise might remain frozen, resulting in the water permeability.

The dominant effect on runoff control is expected to be the vegetation. Based on field studies of water-sediment yield, we would expect very little sediment to be eroded from a vegetated barrier surface, but varying amounts of water yield are possible depending upon precipitation intensity and duration. Shrubs or grass will act to enhance the macropore structure of the surface soil, and the infiltration rates will tend to be higher in soils with the most vegetation. The plan for monitoring is to determine the volume of water that leaves the barrier surface as runoff and the associated sediment load (if any).

7.4 Graded Filter

7.4.1 Description

The graded filter consists of two layers, a 0.15-m (0.5-ft) layer of naturally occurring or blended sand overlying a 0.30-m (1.0-ft) gravel drainage layer. These layers lie between an overlying surface layer of McGee Ranch silts and an underlying layer of fractured basalt.

The gravel filter layer was constructed of commercially available, 16-mm (0.63-in.) maximum, crushed surfacing, top course, meeting the requirements of the Washington State Department of Transportation (WSDOT) Standard Specifications for Road, Bridge, and Municipal Construction (M41-10, 9-03.9[3]). This particular gravel blend was selected because it allows the use of a sand filter (between the silt and gravel filter) with a broad range of gradations and is readily available. The criteria used to select the gravel filter were based on its ability to prevent the transport of fine particles from the overlying sand filter under saturated flow conditions. Laboratory tests determined the hydraulic conductivity of the gravel as approximately 0.57 cm/second (0.22 in./second).

The thickness of the gravel filter is 0.30 m (1.0 ft) based on half the value of the largest dimension of the particles in the fractured basalt layer beneath the filter, plus 0.15 m (0.5 ft), to ensure an adequate layer thickness at all locations. Placement and compaction in horizontal areas was in accordance with WSDOT M41-10, 2-03.3(14). The steeply sloped area of the gravel filter at the inside face of the barrier edges could not be compacted.

Naturally occurring sands having a gradation meeting the standards established by the U.S. Army Corp of Engineers for a soil filter under saturated flow conditions were used for the sand filter. Placement and compaction in horizontal areas (15 cm [6.0 in.] thick) was in accordance with WSDOT M41-10, 2-03.3(14). The steeply sloped area of the sand filter at the inside face of the barrier edges could not be compacted. For this reason, the design thickness measured normal to slope was increased to a minimum of 26.8 cm.

Railroad ballast (meeting the requirements of WSDOT M 41-10, Section 9-03.9[2]) was used to level the surface of the fractured basalt layer.

7.4.2 Background

A change in side slope design during the barrier's development affected the design of the side slopes of the filter layers. In the 1990 design, the portion of the sand filter on the side slopes was to be placed in horizontal layers to support a portion of the basalt side slopes. This required a width in excess of 2.4 m (8 ft) to accommodate standard compaction equipment. The sand filter no longer supports the side slope structure so compaction is no longer critical.

The design of a surface barrier (final cover) according to the EPA requirements includes a surface layer of fine-grained soil (to store precipitation and support vegetation), an underlying drainage layer, and a low-permeability layer (to direct percolating water away from the underlying waste form). The prototype design also includes a biointrusion impediment layer of fractured basalt to inhibit deep animal burrowing, root penetration, and inadvertent human intrusion. The fractured basalt layer underlies the graded filter layer. A graded filter was needed between the fine-soil surface layer and the fractured basalt layer to impede the movement of silt into the large pore spaces of the coarser grained materials. Each filter media must not clog the pore spaces of each successive filter yet the abrupt change in grain size between the silt and the underlying filter must be maintained to provide a capillary break. Moisture in the silt will tend to move laterally along the fine-soil/filter interface, being retained by the higher tension in the pores of the fine-soil compared with the coarse sediments. In addition to water loss by evaporation from the soil, the plant community that develops in the silt also can extract soil water and transport it into the air by transpiration.

Criteria for the filter media is given in *Seepage, Drainage, and Flow Nets* (Cedergren 1977). The criteria was used to calculate the range of grain sizes required for the sand and gravel layers to function as filters under saturated flow conditions and conforms to the gradation standards established by the U.S. Army Corp of Engineers. Because saturated flow is unlikely, the selection was conservative.

7.4.3 Design Basis

The materials chosen for the graded filter depended on the materials chosen for the surface layer and the position of the fractured basalt layer in the stratigraphy of the barrier. The fine fraction of the gravel filter did not meet the third design criteria when evaluated with respect to the coarsest ranges possible in the basalt layer (see calculations in Appendix C). Another filter media was required between the basalt and the overlying drainage gravel to ensure conformance with the filter criteria. Leveling the surface of the basalt with railroad ballast satisfied the design criteria. The railroad ballast also served to aid construction in controlling the thickness of the gravel filter.

7.5 Basalt Riprap Layer

7.5.1 Description

The basalt riprap layer is composed of well blasted basalt fragments obtained from a local quarry. The design specification for the basalt riprap is a maximum particle size of 25 cm (10 in.) and an average particle size by weight of 10 cm (4 in.). The riprap layer is 1.5-m (4.9 ft) thick and is sandwiched between the gravel drainage layer which overlays the composite asphalt and the graded filter which is under the fine-soil. The gradation specification for the riprap is 100% smaller than 25 cm (10 in.), 50 to 70% smaller than 13 cm (5 in.), 30 to 50% smaller than 8 cm (3 in.), and 0 to 5% smaller than 1.5 cm (0.6 in.).

7.5.2 Background

Early barrier designs placed a great deal of emphasis on preventing biointrusion into the buried wastes from plants, animals, and humans, especially in scenarios where there was no institutional control and no maintenance. Consequently, the bottom layer of early barrier designs was a thick layer of basalt riprap, which was incorporated into the basalt side slopes at the edges of the barrier and formed the entire outer perimeter of the barrier. The graded filter and the fine soil was placed in the depression or "bathtub" formed by the riprap bottom layer and the riprap side slopes. The fine soils placed over the underlying coarse materials created a capillary break and was the only hydrologic barrier in this early design. The basalt riprap layer formed the biointrusion barrier (i.e., plant roots, burrowing animals, and human intrusion activities such as digging and well drilling).

The philosophy of the early designs was that the fine-soil layer would reduce the amount of water available for drainage into the buried waste by using runoff, evaporation, and transpiration. A low-permeability clay layer was considered for use in the barrier because the fine soil could become saturated under severe conditions and a break-through of the water through the bottom of the soil layer could occur. The clay layer was placed between the soil and the riprap to provide a redundant hydrologic barrier. However, upon reviewing the published literature and obtaining information from users of clay layers in covers, it was found that the clay could desiccate and crack in an arid environment. This led to the clay layer being replaced with a composite layer of asphaltic concrete and fluid-applied, polymer-modified asphalt. The composite layer of asphalt is intended to replace the typical composite layer of clay overlain by a geomembrane that is used in many RCRA cover designs.

The design for the barrier was reviewed by an expert peer review panel to verify that the Hanford BDT had not inadvertently overlooked any necessary design features and to add credibility to the barrier design from experts with a national perspective. One of the recommendations of the peer review panel was to move the low-permeability asphalt layer to the bottom of the barrier and place the riprap between the fine soil and the asphalt. This would result in the riprap layer protecting the low permeability asphalt layer and the buried wastes. The barrier design was modified as recommended and has resulted in the layer configuration that is currently in the prototype barrier.

7.5.3 Design Basis

The function of the basalt riprap layer is to impede biointrusion (human, plant, and animal) into the waste disposal site and protect the composite asphalt layer. The thickness of the barrier is used as a deterrent to biointrusion and 10 CFR 61, as explained in the previous section on Justification - Regulatory Drivers, specifies a

5-m (16-ft) distance from the top of the waste to the top of the barrier. The thickness of the riprap layer is 1.5 m (4.9 ft) and contributes a significant part of the 5-m (16-ft) thickness of the entire barrier. Resistance to biointrusion is based not only on the total thickness of the layers but also on the characteristics of the materials in the layers. A layer of riprap is more resistant to root penetration, animal burrowing, and intrusive human activities than is a layer of sand or gravel. The basalt riprap layer is needed in the barrier to protect the low-permeability asphalt layer and to deter biointrusion into the buried wastes. The riprap layer performs this function by creating a dry rocky environment that is not conducive to root penetration and by providing a layer of large rocks that are a barrier to burrowing, digging, and well drilling.

The maximum particle size of the riprap is based on the maximum size of particle that a burrowing animal, such as a badger, can remove from a burrow; this size was doubled to arrive at the maximum particle for the riprap. The maximum particle size for the riprap is 25 cm (10 in.) based on a maximum particle that can be removed from an animal burrow is approximately 13 cm (5 in.). These design decisions were made during BDT meetings and discussions about animal burrowing activities. The riprap needs to be large enough to discourage small animal burrowing and reasonable in size to facilitate material handing. The gradation of the riprap was selected to facilitate the placement of a graded filter.

7.5.4 Testing and Monitoring

The construction of the prototype barrier will determine the constructability of the basalt riprap layer. The ongoing testing and monitoring of the prototype barrier will help to determine the effectiveness of the riprap layer in terms of plant and animal intrusion and the effectiveness of riprap and graded filter layers in supporting the fine-soil layer.

7.6 Asphalt Layer

7.6.1 Description

The asphalt layer is a composite layer composed of a 15-cm (5.9 in.) layer of asphaltic concrete overlain with a 5 mm (0.2 in.) layer of fluid-applied asphalt (FAA). The specification also contains directions for the heating, mixing, and applying the aggregate and asphalt.

The mix design developed for the hot-mix asphalt concrete (HMAC) component used in the prototype is quite different from HMAC mixes designed for use in roadway paving applications. There are major differences between the two mix designs in asphalt content, aggregate gradation and air voids. The asphalt (AR-4000W) content of the HMAC used in the prototype was specified at 7.5 +/- 0.5 percent. Asphalt contents in HMAC used in paving applications typically range from 4.0 to 6.0 percent. Variations in the aggregate gradation represent the most significant difference between the HMAC designed for the prototype and that for paving applications. The aggregate gradation used in the prototype HMAC contains no aggregate greater than 0.5 inches in diameter and is comprised of a high fines (-200 mesh) content. Controlling these two process variables makes it possible to achieve extremely low air voids, after field compaction, in the in-place HMAC used in the prototype.

The asphaltic concrete in the prototype is placed and compacted in two lifts to reach the 15-cm (5.9 in.) minimum thickness. Each loose layer may be up to 10 cm (3.9 in.) thick and is compacted to 96 percent of maximum density. The number of passes required to compact the asphaltic concrete is determined on a test pad and the seams in the upper and lower layers are offset to minimize preferential pathways for water movement. The asphaltic concrete is a high-asphalt content product designed to minimize the void spaces in the concrete and to result in a layer with a permeability equal to or less than 10^{-7} cm/second (10^{-8} in./second).

The FAA is a styrene-butadiene polymer-modified asphalt that is sprayed onto the surface of the asphaltic concrete. The FAA is very elastic and can be subjected to a very large amount of deformation while maintaining the ability to return to the same shape. The specification calls for the FAA to be applied in two 2.5-mm (0.1 in.) layers to achieve a final minimum thickness of 5-mm (0.2 in.). The FAA is designed to provide a low-permeability coating for the surface of the asphaltic concrete, forming a composite layer. The permeability of the FAA is expected to be as low as 10^{-10}-10^{-11} cm/second (10^{-11}-10^{-12} in./second).

7.6.2 Background

Early barrier designs placed a great deal of emphasis on preventing biointrusion into the buried wastes from plants, animals, and humans, especially in scenarios where there was no institutional control and no maintenance. Consequently, the bottom layer of early barrier designs was a thick layer of basalt riprap, which was incorporated into the basalt side slopes at the edges of the barrier and formed the entire outer perimeter of the barrier. The graded filter and the fine soil was placed in the depression or "bathtub" formed by the riprap bottom layer and the riprap side slopes. The fine soil in early barrier designs was the only hydrologic barrier and the basalt riprap layer formed the biointrusion barrier (i.e., plant roots, burrowing animals, and human intrusion activities such as digging and well drilling).

The fine soil layer is designed to divert as much water as possible away from the buried waste by using runoff, evaporation, and transpiration. A low-permeability clay layer was added to the barrier because the fine soil could become saturated under severe conditions and a break-through of the water through the bottom of the soil layer could occur. The clay layer was placed between the soil and the riprap and provided a redundant hydrologic barrier. After the clay layer was added to barrier design reviews of published literature and the information from users of clay layers in covers revealed that the clay could desiccate and crack in an arid environment. This led to the clay layer being replaced with a composite layer of asphaltic concrete and fluid-applied, polymer-modified asphalt. The composite layer of asphalt is intended to replace the typical composite layer of clay overlain by a geomembrane used in many cover designs.

The basic premise of the capillary barrier concept is that most, if not all, of the meteoric water that infiltrates the barrier surface can be returned to the atmosphere by surface evaporation and plant transpiration. However, for periods of unusually heavy, intense, and/or prolonged precipitation, the water-holding capacity of the fine-soils may be exceeded, thereby allowing water to break through the capillary barrier before it can be recycled back to the atmosphere. Unless checked in some way, the water would be free to migrate down through the barrier and into the waste zone. In addition, coarse-textured, sparsely vegetated side slopes will allow significant water infiltration. (Please refer to Section 7.7 for a more detailed discussion of water infiltration through side slope materials.) To restrict the percolating water from the waste zone, a low-permeability component is placed strategically within the barrier profile below the capillary barrier to divert percolating water away from the buried waste. This diversion barrier is constructed of low-permeability material(s), such as asphalt.

Two types of asphalt have been used in tests being conducted by the BDP. Based on recommendations supported by laboratory test results, lysimeter studies at the Small-Tube Lysimeter Facility (STLF) have used two asphalt formulations: (1) hot rubberized asphalt and (2) an admixture of cationic asphalt emulsion and concrete sand containing 24 wt percent residual asphalt. These asphalt formulations have been effective in limiting percolation (Freeman et al. 1989). A third type of formulation, hot mix asphalt concrete with ~8 percent asphalt, also is being evaluated for use in barrier designs. This formulation was originally developed for use as a diffusion barrier around the grout vaults at Hanford. The formulation had to have a high mechanical strength to prevent slumping under its own mass. Changes in the specifications included substituting a smaller gravel and removing the requirement for lime coating the gravel. The larger gravel, used to increase mechanical strength, was not needed because much thinner layers are used in the surface barriers than around the grout vaults. Also, the lime coating used as an anti-slipping agent in the grout vault application was required only because of the higher expected temperatures, up to 80 °C (176 °F).

Compacted clay layers will be used sparingly, if at all, in long-term isolation barriers at the Hanford Site. This reticence to use compacted clay layers is caused primarily by the hot, arid climatic conditions at the Hanford Site. The construction of compacted clay layers requires relatively close control of moisture content and/or compactive energy imparted to the clay to achieve the desired degree of impermeability. The level of control required to achieve the desired low hydraulic conductivities may be difficult to realize and maintain during the Hanford Site's hot, dry summers and for the extremely large barriers planned for the Hanford Site's disposal needs. In addition, concerns have been raised regarding the potential for desiccation cracking of clay layers in arid sites following construction.

Geosynthetic clay liners (GCLs) may provide an effective alternative to the compacted clay layers. GCLs are easy to install and, because they are placed in an unhydrated condition, the problems associated with drying and desiccation cracking during construction are minimized.

A particularly promising application of GCLs are their use in tandem with an asphalt layer to form a composite low-permeability layer. The composite layer concept has been shown to provide much lower permeabilities than using one layer alone (Daniel and Trautwein 1991). One concept currently being considered is to place a GCL directly on top of an asphalt layer. Any cracks or holes that may develop (but are not expected) in the asphalt would be "plugged" by hydrated clay from the GCL above. Another composite layer concept currently being considered is to apply a layer(s) of hot rubberized asphalt directly on top of a layer(s) of asphaltic concrete.

Additional research and testing needs to be conducted to verify the effectiveness of these concepts. Physical properties of various types and blends of asphaltic concrete and FAA being considered for use in long-term isolation barriers need to be understood. These physical properties include large-scale permeability, shear strength, cohesion, friction angle, and the stress-strain relationships associated with various forces acting on the barrier, such as three-dimensional deformation. Another area requiring further study pertains to the longevity of asphalt as a low-permeability component. The asphaltic layers need to be durable enough to provide the level of impermeability needed over the design life of the long-term isolation barriers. Asphalt longevity studies were initiated in 1992.

The low-permeability layers, together with the engineered surface that maximizes runoff and the capillary barrier (which blocks the downward movement of percolating water) is expected to perform in such a way that near-zero drainage rates through the barrier can be achieved.

7.6.3 Design Basis

The design for the barrier was reviewed by an expert peer review panel to verify that the Hanford BDT had not inadvertently overlooked any necessary design features and to add credibility to the barrier design from experts with a national perspective. One of the recommendations of the peer review panel was to move the low-permeability asphalt layer to the bottom of the barrier and place the riprap between the fine soil and the asphalt. This would result in the riprap layer protecting the low permeability asphalt layer and the buried wastes. The barrier design was modified as recommended and has resulted in the layer configuration that is currently in the prototype barrier.

The function of the asphalt layer is to provide a hydrologic barrier to movement of water through the barrier to the buried wastes, to impede biointrusion, and to limit the upward movement of noxious gases from the waste zone (Wing 1993). The low-permeability composite asphalt layer is analogous to the composite layer found in RCRA-compliant barriers. Many RCRA barriers have a layer of compacted clay that is covered by a geomembrane. The FAA over the asphaltic concrete is expected to provide the same function as the geomembrane used over the compacted clay in the semi-arid climate of the Hanford Site. The asphalt layer is separated from the basalt riprap layer by a 30-cm (1 ft) layer of drainage rock. The drainage rock protects the asphalt layer from the riprap and allows any water that may percolate through the barrier to be diverted to and drain towards the outer edges of the asphalt layer, away from the buried wastes.

The asphalt layer is also a barrier to biointrusion and gas movement. The asphaltic concrete is expected to remain free of cracks in the subsurface environment and should prevent root penetration and inhibit upward movement of noxious gases. The 15 cm (6 in.) layer of asphaltic concrete is also a barrier to burrowing animals and inadvertent human intrusion.

The effectiveness of inhibiting upward gas movement was demonstrated when nearly eight years after construction, a post-mortem examination was performed on the Grand Junction protective barriers (Wing 1994). The results of the post-mortem showed that the protective barriers constructed with low-permeability asphaltic layers performed the best in inhibiting the diffusion of radon gas. The results also suggested that asphaltic layer constructed in the field with conventional equipment can performed as designed for an extended period of time (Gee et al. 1989).

7.6.4 Testing and Monitoring

A pan-type lysimeter with a self-contained sump collector for water was placed below a portion of the asphalt layers in the prototype barrier. This lysimeter will collect any water that passes through the composite asphalt layer, although none is expected. Horizontal neutron probe access tubes, placed below the asphalt layers, also will enable the detection of any moisture that passes through the low-permeability component.

An asphalt test pad (18 m by 8.5 m [59 ft by 28 ft]) will be constructed adjacent to the prototype barrier. This test pad is designed such that the performance of the asphalt layers can be tested using sealed double-ring infiltrometers (SDRIs) (or equivalent) and lysimeters. The SDRIs will be embedded into the surface of the asphalt layer while a 6.5-m-by-6.5-m (21 ft by 21 ft) lysimeter will be constructed under the asphalt layers.

The pan lysimeter and neutron probe access tubes placed under the prototype barrier and adjacent test pad will provide an effective means of measuring the performance of the asphalt layers over a large area. In addition core samples of the asphaltic concrete in the barrier and the test pad will be taken for laboratory testing. The cores will be used to conduct permeability and aging tests of the asphaltic concrete used in the prototype barrier.

7.7 Side Slopes

7.7.1 Description

The control of water infiltration at the periphery of the barrier is a significant design feature that must be considered. Protective barriers are designed with sloped fine-soil surfaces and low-permeability subsurface components. Consequently, water will be channeled to the side slopes and toe of the barrier. The side slopes and toes of surface barriers are generally designed and constructed with material in such a manner that long-term stability can be achieved and water accumulation can be controlled. Two radically different side slope designs are being considered: (1) a relatively flat apron of clean-fill materials (commonly called a clean-filled dike) and (2) a relatively steep embankment of fractured basalt riprap.

7.7.2 Background

Early design developments called for placing basalt riprap at the natural angle (4H:3V) of repose for the side slopes of the prototype (Fort 1993). Considerable concern was expressed that this might not be stable or safe, especially for individuals testing and monitoring the prototype and for visitors to the site. The purpose of the side slope, from a human intrusion perspective, needed to be decided. Initially, the side slope was envisioned as a potential deterrent to humans climbing up the barrier sides. Subsequent discussion suggested that the side slopes could only deter the public, not prevent access. Therefore, the best strategy would be to warn the public and not rely on the side slopes to completely prevent access. If human intrusion were not one of the primary issues, then safety and stability would be the primary concern. It was suggested that a backhoe be used to pull down the riprap to a 2H:1V side slope, which would be more stable than the 4H:3V.

In March 1993, a peer review panel visited the Hanford Site to review the surface barrier work performed to date. They recommended that the prototype barrier be used to test different edge effects (Wing 1992). The term "edge effects," refers to the influence of the barrier side slope and toe on the overall performance of the barrier. They suggested that the design include an edge with a sloped and vegetated surface. They wrote,

> Foremost among the panel's concerns regarding the design of the prototype is the need to test a variety of configurations and performance characteristics. The prototype barrier should not be a monolithic, uniform, or symmetrical structure. Rather, is should include a variety of configurations ... A number of edge configurations should be tested, including abrupt, steep-sided configurations such as currently proposed as well as subdued, gently-sloped aprons of native material that will blend into the landscape and extend the zone of positive water control (Wing 1992).

During the ensuing weeks, the BDT met to consider options for barrier side slopes. The option selected was constructing half the prototype with a clean-fill dike side slope and the other half with a basalt riprap side slope (Wing 1993).

7.7.3 Design Basis

The clean-fill dike concept uses readily available borrow materials (such as pitrun gravels) to create a relatively flat apron around the periphery of the barrier. This relatively flat apron provides a more gentle transition from the shoulder of the barrier to the surrounding environment than does the steep fractured basalt side slope.

A clean-fill dike side slope is desirable for several reasons. First, the clean-fill dike is aesthetically appealing and tends to blend in with the surrounding environment. Second, the pitrun gravels used to create the clean-fill dike will provide a relatively erosion-resistant surface. Third, the pitrun gravels used in construction of the clean-fill dike probably will support the growth of vegetation. Vegetation already has been described as a desirable barrier feature for the removal of undesirable, excess water from waste sites. Also, the pitrun gravels used in the design of the clean-fill dike side slope may be more effective in transmitting runoff water farther away from the waste zone than the fractured basalt riprap used in the other side slope design configuration. Pitrun gravels are also very plentiful on the Hanford Site (Wing 1993).

A disadvantage of the clean-fill dike concept is that its gentle slope could significantly increase the surface area, or "footprint," of the barrier. If significantly more construction materials are needed to create the gently sloping apron, the costs of the clean-fill dike concept may be greater than for a steeper side slope, despite the fact that the unit cost of pitrun ravels is considerably less expensive than for fractured basalt riprap. (An engineering evaluation should be performed to assess the cost effectiveness of these concepts.) The subtle blending of the barrier with the surrounding topography may also pose some challenging human intrusion design considerations and compromises (Wing 1993).

The steep side slope design uses fractured basalt riprap, which consists of relatively large angular rocks (see Section 7.5). The angularity of the riprap provides many interlocking surfaces between adjacent rocks, enabling relatively steep, yet stable, side slopes to be created. This steep, rocky side slope provides several desirable design features. First, steeper side slopes help to minimize the total surface area of the barrier. Second, the steep, rocky side slope clearly delineates the boundaries of the surface barrier. Third, the basalt riprap is an effective erosion-control feature because the mass of the riprap pieces makes them stable against wind and water erosion. Fourth, the large-particle basalt serves as an impediment to animal and inadvertent human intrusion (Wing 1993).

However, in addition to its positive features, the limitations of a riprap side slope also must be understood and considered. For example, the procurement of basalt riprap at the Hanford Site can be expensive and difficult to obtain. Costs associated with drilling, blasting, crushing, screening, and hauling the basalt riprap from the quarry to the barrier construction site can be significant. In addition, cultural resource and other environmental concerns associated with basalt outcrops must be considered. In certain circumstances, these cultural and environmental concerns can prohibit the procurement of basal riprap from specific locations (Wing 1993).

Another potential problem with basalt riprap is that, in some circumstances, it can encourage the invasion and establishment of deep-rooted perennial plants (Wing 1993; Wing 1992). These deep-rooted plants could encroach into undesirable locations of the barrier or the waste zone. Potential remedies for this problem include burying the riprap side slopes beneath clean-fill dikes constructed with soils that promote favorable plant growth, or using a chocked-rock design to fill the interstices of the outermost riprap surfaces.

Fractured basalt riprap has many relatively large pore spaces between adjacent rocks. Consequently, surface water that comes in contact with the fractured basalt side slope materials will readily drain through the pore spaces between rocks and onto the native soils over which the barrier has been constructed. So, the basalt riprap will do little to divert the movement of any infiltrating water (Wing 1993).

The control of water infiltration at the periphery of the barrier is a significant design feature that must be considered for both clean-fill dike and fractured basalt side slopes. As discussed previously in this document, protective barriers are designed with sloped fine-soil surfaces and low-permeability subsurface components. Consequently, water will be channeled to the side slopes and toe of the barrier. As a result of this channeling, a significant amount of water could accumulate at the periphery of the barrier. This accumulation of water poses two major design considerations: (1) What effect does the additional water have on side slope stability and erosion? and (2) How can the additional water be kept from contacting buried wastes (Wing 1993)?

Using either side slope design carries both positive and negative possibilities in relation to human intrusion. A clean-fill dike side slope is aesthetically appealing because it blends in with the surrounding landscape. However, if surface markers are lost for any reason, blending the waste sites in with the local topography might tend to hide the location of the waste sites, making it possible for someone to stumble inadvertently onto the sites. Barriers that employ the basalt riprap side slopes are obviously structures that have been engineered and constructed by humans. The basalt riprap side slope designs make no attempt to blend the barrier in with the appearance of the surrounding landscape; consequently, these barriers are readily noticeable. The obvious barrier designs possibly could become an attractive nuisance (similar to the subsurface markers) that draws curious individuals to the mounds. This has been the experience with other (ancient) barrier systems that have been totally or partially breached (e.g., the Egyptian pyramids). Another potential problem is that the relatively flat surfaces of the barriers, which contain excellent fine soils, may attract future farmers to the barriers. In addition, curious individuals may think that valuables have been buried beneath the mounded soils and subsequently may want to excavate it.

7.7.4 Testing and Monitoring

The prototype barrier is an ideal facility for testing the effectiveness of water infiltration control. Two major issues must be addressed in the prototype testing: (1) the effects that extreme precipitation events have on water infiltration, and (2) the effects of water infiltration on side slope stability and subsurface water content changes (Gee et al. 1993).

The second issue (side slope infiltration) is one for which the prototype will provide unique and important data for the final design of the protective barrier system. One of the main reasons for building the prototype barrier is to test the performance of side slope/toe design concepts because they could not be modeled in the lysimeter facilities. A key consideration in the final barrier design is the side slope performance in protecting against erosion and internal water drainage (Gee et al. 1993).

Two philosophies exist about barrier appearance and inadvertent human intrusion: one is that the barrier remain highly visible to warn of danger; the other is to camouflage the barrier so that it will not attract curious visitors. Because the prototype barrier will be an experiment, the BDT decided to test the two types of slide slopes (Wing 1993; Wing 1994).

The two side slope configurations being investigated on the prototype for application in long-term surface barrier designs include: (1) a relatively steep embankment of fractured basalt riprap and (2) a relatively flat apron of clean-fill materials (commonly called a clean-fill dike) (Fort 1993; Wing 1993; Wing 1994).

One half of the prototype barrier side slopes will be constructed of fractured basalts. A stable 2H:1V side slope ratio was chosen for the fractured basalt after clarification of the criteria for resistance to human intrusion. The steep side-slope design uses fractured basalt riprap, which consists of relatively large angular rocks. The angularity of the riprap provides many interlocking surfaces between adjacent rocks, which creates a relatively steep, yet stable, side slope. Barrier markers and warnings will deter inadvertent human intruders (Fort 1993; Wing 1993; Wing 1994).

The clean-fill dike concept uses readily available borrow materials (such as pitrun gravels) to create a relatively flat apron around the periphery of the barrier. With a slope of 10H:1V, this relatively flat apron provides a more gentle transition from the shoulder of the barrier to the surrounding environment than does the steep side slope. This side slope will blend into the landscape to camouflage the barrier (Fort 1993; Wing 1993; Wing 1994).

A water collection system will be installed (asphalt barrier and collection pipes, etc.) under rock side slopes to measure drainage. Minimizing water penetration through the asphalt layer is important, so documenting the amount of water, if any, that seeps through the asphalt layer directly under the rock side slope (where maximum water infiltration is expected to occur) is equally important. To accomplish this, a specially constructed pan lysimeter will be located under a section of the rock side slope (Fort 1993; Gee et al. 1993) (see Section 8.0).

Based on their performance, the side slope/toe designs can be adopted or modified, as necessary. The identification of the type of side slope to be used in the design of future barriers will be deferred to federal and state regulators.

8.0 PROTOTYPE DESIGN FEATURES FOR TESTING AND MONITORING

8.1 Instrumentation and Monitoring

Each of the testing and monitoring features discussed in the following sections are needed to understand barrier performance and to demonstrate that the performance of the barrier meets or exceeds regulatory requirements of a RCRA cover system. Appendix B contains barrier construction drawings that include the instrumentation discussed below.

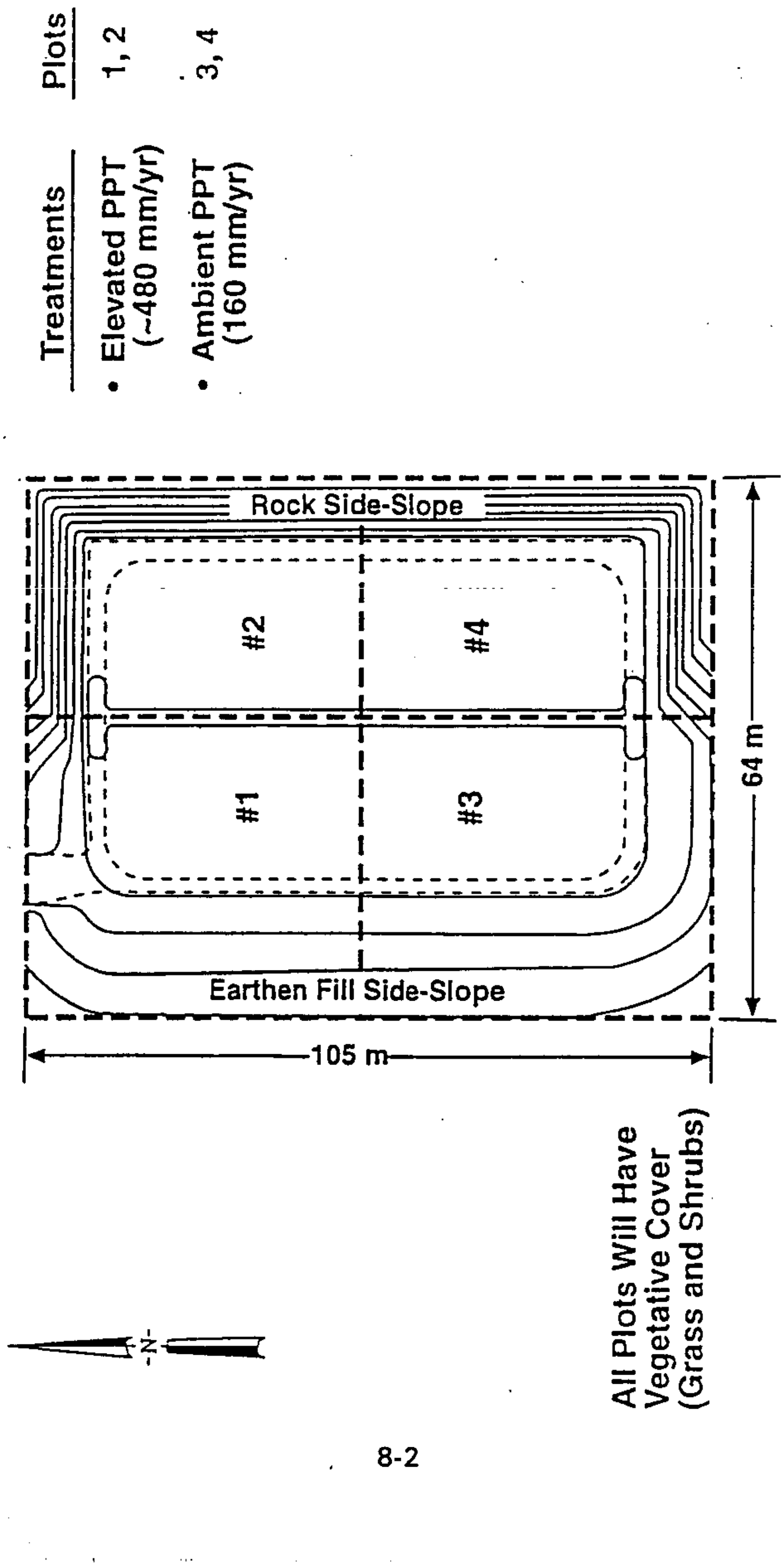
The prototype barrier is a unique facility for studying the water balance of a surface cover under both normal and stressed (extreme climate) conditions. The facility will allow comparison of both intrusive and nonintrusive measures of soil water content and water storage, important and necessary parameters in evaluating surface barrier performance. Further, the barrier will be unique in allowing us to quantify the drainage (recharge) that will come from the soil and the side slope surfaces under ambient and elevated precipitation (extreme event) conditions. Such tests are necessary to evaluate long-term performance of surface barriers. Measures of water reaching the asphalt layer to levels of less than 0.05 mm/yr are easily achievable with our large lysimeter system. In addition to water balance, plant intrusion, wind erosion and water erosion features will also be quantified during the three year test period.

8.1.1 Water Infiltration

A suite of tests are planned for monitoring fine soil performance on the prototype barrier. General features of the tests are described in Gee et al. (1993). The following is a brief outline of the selected testing that is planned for the prototype.

Water will be applied to the north half of the barrier via irrigation and snow. Application rates will be similar to those used in testing Hanford covers at the FLTF. Plans call for application of water at the rate of 480 mm/yr for the next three years on two test plots of the prototype barrier (Figure 8-1). The application will include irrigation on a biweekly basis except in winter. In winter, snow applications will be made at rates that will be 3 times the normal snow fall of 130 mm/yr (5.1 in./yr.), i.e., three applications of 130 mm (5.1 in.) each. The times for delivery will be weather dependent but will occur between November and March each year. In late March of each year there will be an irrigation at a rate equivalent to a 1,000 year storm. Over a 24-hour period we will deliver 68 mm (2.7 in.) of irrigation to the north side of the barrier.

Figure 8-1. Prototype Barrier Test Plots.



The water balance of the barrier, under ambient and irrigated conditions will be measured with a variety of instruments. Precipitation will be measured with a specially constructed mini-lysimeter that will act as a raingage and snowpillow combination. This will allow measurement of both rainfall and snow with one instrument. Fourteen units will be used to measure the spatial distribution of the precipitation over the barrier surface.

Snow depth will also be measured with gauging instruments both electronically and manually. Irrigation will also be measured with the mini-lysimeters.

A series of instruments will be used to measure the soil water content and soil water storage. These instruments include neutron-neutron devices, electrical capacitance, and time domain reflectometry.

Neutron probe (neutron-neutron logs) will be used to measure the volumetric water content of the soil profile. These water contents will be converted to soil water storage and the water storage compared as a function of irrigation treatment and time. Water content underneath the barrier (below the asphalt layer) and at the bottom of the fine-soil layer (just above the fine-soil/sand interface) will also be measured. These monitoring points will be used to help determine the depth of water penetration in the barrier along selected transects. These data will also be useful in quantifying increases and decreases in storage associated with potential recharge (drainage) conditions. These instruments require manual operation and routine measurements (taken at least monthly). The neutron probe requires field calibration.

Data from the lysimeters at the FLTF located in the 200 Plateau Area near the HMS will be used initially for water content estimates. Cores taken during the installation of the access tubes will be sampled for gravimetric water content and bulk density. These data will be used to determine the volumetric water content of the soil. Neutron probe counts will be compared to the water contents and, subsequently, a calibration for the prototype barrier will be established. These data will then be compared to the FLTF calibration.

Electrical capacitance will also be used to measure volumetric water content. This will be accomplished by using a commercially available capacitance probe to log 2-m (6.6-ft) deep soil profiles by lowering a cylindrical probe down small 5-cm (2-in.) diameter plastic access tubes. The electrical capacitance of a soil is dependent upon both salt and water content of the soil. If the salt content remains constant, the changes in capacitance can be calibrated in terms of the soil water content alone. The access tubes will be located adjacent to the neutron-probe access tubes. The capacitance calibration will be accomplished by measuring water content and bulk density of the soil during the coring and placement of the access tubes. Some additional water content and bulk density samples may be taken if the range of water contents obtained in the initial coring is not sufficient to cover the expected range of water contents.

Time domain reflectometry (Hook et al. 1992) will also be used to measure volumetric water content in the soil profile. Time domain reflectometry (TDR) uses an electronic pulse that is transmitted through the soil along a transmission cable and reflected back to a detector at a speed dependent upon the dielectric properties of the soil. The dielectric constant of the soil is highly dependent upon the soil water content. Because the dielectric constant for water is about 80 and about 5 for mineral soil, the measured time for a reflected pulse can be uniquely related to the effective soil dielectric, which in turn is a measure of water content. The advantage of TDR over conventional neutron probe logging is that TDR can be automatically logged on virtually a continuous basis and the data collected remotely through electronic means. Further, there is no radioactivity, nor associated radiation safety concerns with this instrument.

A series of 15 TDR units will be installed. These units are specially constructed transmission rods containing shorting diodes, that allow for measurements of water content across seven segments of a 185-cm-long rod, buried vertically in the ground. The units will be connected together and, by means of electronic switching, all units will be logged on at least a daily basis. Thus, profiles of water content across the irrigated and nonirrigated (ambient) sections of the prototype will be displayed and documented. Both profiles and water storage (integrated profile data) will be stored in the data base. Weekly summaries of these data will be provided for review and analysis.

Thermal profiles will also be measured using copper-constantan thermocouples. Thermal heat dissipation units (Campbell and Gee 1986) will also be used to document the soil water suction. The temperature will be monitored on an hourly basis and the soil water suction will be monitored daily.

Noninvasive measures of water content planned for the prototype include the use of electromagnetic induction (EM) meters and ground penetrating radar (GPR). Both methods are currently available and have been used for vadose zone characterization work at Hanford, primarily for detecting buried objects. However, the use of these systems for profiling water content in the vadose zone has not been evaluated. Because of the noninvasive features of these devices they could be useful for routine monitoring of surface barriers at the Hanford Site and throughout the DOE-complex. Collaboration with New Mexico Tech (Dr. Jan Hendrickx) is underway to develop an appropriate calibration for EM meters to monitor the surface of the prototype for water content. When this work is completed it should be possible to correlate the water content profiles obtained from neutron probes, capacitance probes, and TDR with the signal characteristics from both the EM meters and GPR units. Thus the prototype barrier, because of its well defined surface features, will provide an excellent facility for calibration of noninvasive devices for monitoring water content profiles and evaluate water storage of surface barriers.

8.1.2 Water Erosion

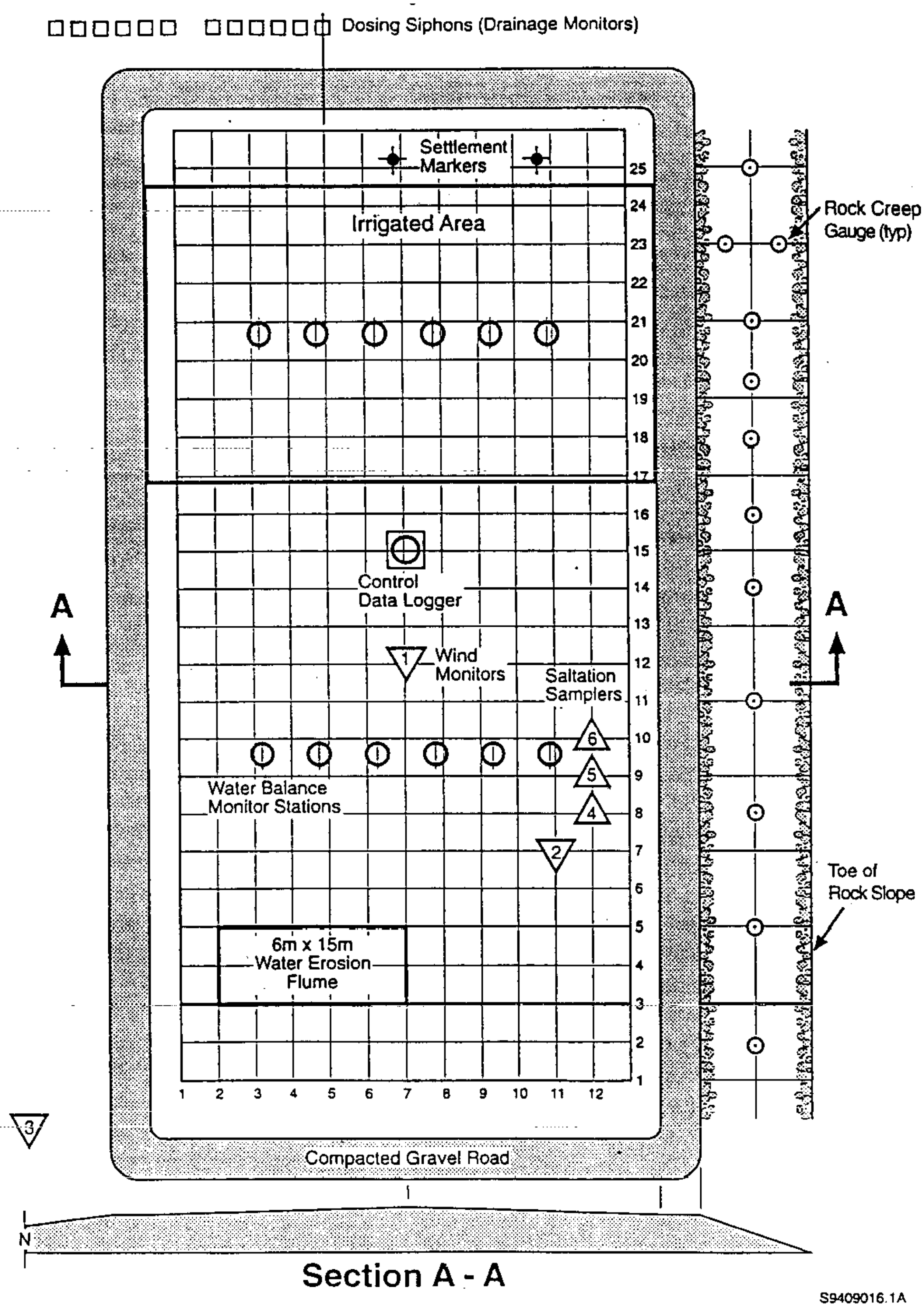
The monitoring plan proposes to collect data and information on the erosional behavior of the soil under natural rainfall and snowmelt conditions to evaluate the effectiveness of the admix and vegetation in stabilizing the soil surface. The plan consists of two separate data collection efforts: (1) the measurement of runoff and sediment yield from a 6 by 15 m (20 by 50 ft) flume installed on the soil surface (controlled-area monitoring) and (2) the observation and documentation of the effects of precipitation over the larger remaining surface area (barrier-surface monitoring).

The controlled-area monitoring will measure water and sediment runoff from the 6 by 15 m (20 by 50 ft) flume with an automated flow measurement and sediment sampler operating on the occurrence of rainfall and snowmelt events. Soil moisture probes, thermocouple temperature indicators, and a snow gauge will record snowmelt events. A rain gauge will serve as a backup system to validate rainfall at specific locations. Time-varying data of overland runoff from rainfall and snowmelt events and corresponding sediment yield will be used to analyze erosion from precipitation falling on the barrier surface and the corresponding changes in erosivity as the surface ages over the 3-year monitoring period.

The barrier-surface monitoring approach uses a 3 by 3 m (10 by 10 ft) grid system established on the soil surface that provides a ready field reference system to map surface changes. The system was established by setting four corner markers composed of steel rebar enclosed in 7.6-cm (3-in.) PVC that defines a 36 by 75 m (118 by 246 ft) rectangle centered within the perimeter of the compacted gravel roadway. Interior grid points were located using painted wood surveying stakes and numbered for grid coordinate identification. The rock creep gauges were installed at 11 locations along the rock slope. Figure 8-2 shows the grid system and flume location.

Profile leveling will be used to determine the elevations at each grid point and gauge. The gauge plan positions will be surveyed with EDM surveying equipment. All elevations and positions will be checked on a seasonal schedule during each year. Soil properties, such as density and moisture content, will be measured monthly or seasonally. Soil surface changes, such as cracking and rill development, will be monitored with photography and located with respect to the grid layout.

Figure 8-2. General Surface Instrumentation Layout (one square = 3 by 3 m).



Maps of the soil surface elevations and postconstruction soil properties will be developed. Seasonal or annual changes in the elevations and properties will be documented over the life of the prototype barrier. Maps of changes in vegetation cover and animal burrowing will be developed to relate those changes to erosional trends. This will be a cooperative effort with other tasks. The mapping will document the degree of nonuniformity of near-surface moisture (localized accumulations) together with the other soil properties and changes in those properties over the monitoring timeframe. Their relationship to erosion and infiltration will be investigated in cooperation with other tasks.

8.1.3 Wind Erosion

Monitoring work has been initiated to study the influence of eolian stresses on the stability and function of the admixture surface of the prototype barrier. Data are being generated to develop correlations between surface characteristics and deflation, inflation, and surface shear stresses (wind and sand saltation). As a part of this effort, measurements are being performed to validate the selection of test parameters in past wind tunnel tests that provided design-basis information for the surface layer (Ligotke and Klopfer 1990; Ligotke 1993). Most measurements are being made over the south, nonirrigated portion of the prototype barrier (see Figure 8-2) where erosive stresses are maximized and most closely represent the worst-case conditions needed for wind erosion monitoring. While normal erosion events are of interest, monitoring systems were designed for continuous use to ensure data are obtained if high-intensity wind storms occur (> 10 year return period).

The scope and objective of actual wind erosion monitoring activities were listed and described briefly by Gee et al. (1993), and include the following: (1) monitor the influence of eolian stresses on the composition of the surface layer as it ages; (2) measure actual rates of surface deflation or inflation; (3) obtain micrometeorological information about erosive shear stresses that are present on the surface; and (4) measure the intensity and affect of abrasive sand particle scouring (saltation). Additional testing and monitoring objectives may include the creating a sand dune (erosion, plant viability, water infiltration) and removing vegetation to simulate a range fire (erosion).

Eolian erosion testing and monitoring activities were initiated in August 1994. Pea gravel concentration from surface samples was measured as the mass of pea gravel per the combined mass of dried soil and pea gravel. The average of 24 samples indicated a pea gravel composition of 14 ± 2 wt%. Continued sampling of surface layers is planned annually or more often if the appearance of the surface changes significantly. Two wind boundary layer stations were installed on the top-center and top-edge of the barrier in August. Wind speed sensors were installed at each station at elevations of 0.25, 0.50, 1.0, and 2.0 m (0.8, 1.6, 3.3, 6.6 ft, respectively) above the surface. Wind direction and air temperature sensors were installed at each station. Three multisensor saltation stations were installed on the eastern side of the southeast quadrant of the barrier surface. The stations consist of saltation sensors and dust traps located at elevations of 0.125, 0.25, 0.50, and 1.0 m (0.41, 0.82, 3.3, 6.6 ft, respectively) above the surface of the barrier. Data acquisition from the wind and saltation stations is obtained continuously at rates dependent on a threshold wind speed.

8.1.4 Barrier Stability

Disruptive natural event analyses have identified the FAA as a displacement plane during seismic loading conditions (see Section 9.6). This analysis determined the displacement plane is within the wedge of the basalt riprap side slope and extends vertically downward to the FAA to just below the basalt side slope toe.

To monitor barrier stability, a number of survey points have been installed along the 2:1 basalt side slope on the east side of the prototype barrier (see Figure 8-2). These points will be surveyed periodically during the testing and monitoring phase to determine if there has been movement along the displacement plane.

8.1.5 Water Collection System

The surface of the composite asphalt layer was divided into four collection zones delineated by concrete curbs arranged beneath the test plots, side slopes and buffer zone on the surface of the barrier. This portion is beneath the compliment of barrier layers. Four additional zones are located beneath the area of transition between the test plots and side slopes of the barrier. Another four zones are located beneath the side slopes. Three zones correspond to the two end zones and the central buffer zone between the test plot applications. Each of these zones, defined by the curbing, drains into a separate set of gutters and piping.

The composite asphalt layer was constructed in terraces to facilitate water collection from each of the collection zones. Any water reaching the asphalt will flow off the edge of a zone terrace and into the adjacent angle iron gutter. Each gutter is sloped and lined with concrete to channel water to the attached piping. The piping is 75 mm (3 in.) galvanized steel at the point where it attaches to the gutter. The portion of the piping extending beyond the edge of the asphalt surface and that at the toe of the barrier are made of polyvinyl chloride. The piping leads to vaults containing dosing siphons used to measure the volume of water that infiltrates through the corresponding zone.

Supplemental water applied to the prototype barrier for testing purposes must be collected and removed from the vicinity of the 216-B-57 crib because of concerns about remobilizing contamination. Any water reaching the composite asphalt layer is channeled to the measurement and disposal system, except for the northeastern corner. Measurements of collected water volumes can be used in the water balance study. The water-collection system design allows for its abandonment and later extension of the barrier according to the needs of adjacent facilities.

8.1.6 Pan Lysimeter

A lysimeter, shaped like an inverted pyramid, constructed of a GCL sandwiched between two geomembranes underlies a portion of the northeastern section of the composite asphalt layer. The perimeter of the lysimeter is sealed to the underside of the asphaltic concrete. The pan lysimeter was placed beneath the area of asphalt most likely to be stressed by infiltrating water to test the performance of the composite layer of asphaltic concrete. This area is located beneath the basalt side slope at the test plot receiving three times the average annual precipitation from an overhead sprinkler system. Tubes for siphoning moisture from the bottom of the lysimeter are constructed of 1.65-mm (0.065 in.) 304L stainless steel.

Another lysimeter is located beneath the asphalt test pad located immediately north of the prototype barrier. A series of tests to be performed on this test pad will be used in an effort to demonstrate the equivalency of the composite asphalt layer to clay.

8.1.7 Neutron Probe Access Tubes

Two horizontal neutron probe access tubes were installed near the base of the first lift of silt for each set of test plots. The access tubes were installed by paring a shallow trench in the first layer of silt then backfilling. Movement of moisture can be evaluated for areas receiving ambient precipitation and three times the average annual precipitation. The sections of the tubes that project through the side slopes were encased in 100 mm (4 in.) polyvinyl chloride piping to protect the access tubes from crushing by the riprap or gravel side slopes.

Three access tubes, placed horizontally one above the other, were installed beneath the northeastern portion of the composite asphalt layer, which receives three times the average annual precipitation. Each tube was shaped as a rectangular loop (i.e., hairpin) with the open ends on the eastern side slope of the barrier. Probes drawn through these access tubes are used to monitor lateral moisture migration back under the barrier from the side slopes. Conditions of high recharge (uncollected percolating water) and nominal recharge at the side slope toe can each be evaluated. The tubes are made of 64 mm (2.5 in.) nominal-diameter, rigid aluminum conduit.

8.1.8 Subsidence Posts

Two posts were placed in the barrier to measure subsidence in the subgrade below the asphaltic concrete. Specifically, these subsidence posts were used to measure subsidence during construction of the layers as they were placed and will be used to measure settling and soil loss as the barrier ages.

The posts are made of galvanized steel rods, one placed in the center of the north end of the barrier and the other placed in the northeastern corner. The portions of the rods extending from the gravel filter down to the surface of the asphaltic concrete are encased in 100 mm (4 in.) galvanized steel pipe to prevent binding between the larger fractured basalt particles. The rods are welded to a 600 mm (24 in.) square plate, bearing on the asphalt surface and covered by drainage gravel. Any movement of the asphalt surface would be detected by conducting periodic surveys of the top ends of the rods.

8.2 Design

The BDT originally decided on a design that had six test plots on the barrier's surface separated by 5 m (16 ft) buffer zones. The final design for the barrier's surface includes four test plots arranged in two sets of two, separated by a 10 m (33 ft) buffer zone. Each set is oriented in such a manner to facilitate comparison of edge effects from the two side slope designs (see Section 7.7). One of the main reasons for building the prototype was to test the performance of side slopes because this could not be modeled with the lysimeters. Three times the average annual precipitation will be applied to one set of test plots while the other set will receive ambient precipitation. The applied precipitation will also include snow from a snow machine. One plot may be tested to failure (i.e., water breaking through the capillary interface between the silt and the underlying filter layer) to determine the limit of the prototype barrier performance.

There were a number of reasons for selecting only four test plots for monitoring barrier performance. Large surface areas were preferred for erosion testing and the roughly square dimensions of the test plots minimize boundary effects. Also, the proposal to test one plot with a 1,000-year storm can be performed after other testing is completed, so additional plots are unnecessary. Finally, additional vegetative cover options would only duplicate the work already in progress at the lysimeter stations.

In the original prototype barrier designed for placement on a clean site, the neutron probe tubes were to have been placed beneath the entire asphaltic concrete layer. However, in the design for the 216-B-57 crib, the placement of the tubes was restricted to the area beneath the northern end of the prototype. Access tubes placed below the southern end of the prototype would have required excavation into potentially contaminated soils. Also, at the southern end of the prototype barrier, the slope required to keep the tubes drained would have placed the ends of the tubes too far below the grade for safe and economical access vaults.

Because the prototype has been placed over existing contamination, the access tubes could provide a potential pathway for water movement, even when sloped to drain outward (should ponding ever occur at the barrier toe). Because the long tubing length would have made it difficult to pull a neutron probe from one side of the barrier to the other, access tubes shaped like rectangular hairpins were selected because of the shorter tubing length requirement. However, the slope required for drainage limits their penetration to only half of the barrier. The option to use other devices, such as gypsum blocks, to monitor moisture migration beneath the barrier was evaluated and found unsatisfactory. After consulting with regulatory agencies, the Operating Contractor decided to use neutron probe tubes in the soils beneath the northeast corner of the barrier--an area located away from the contaminated soils.

9.0 ISSUES AND CONCERNS

9.1 Barrier Construction Materials

Existing short-term barrier designs currently are available (U.S. Environmental Protection Agency [EPA] 1982, 1990). In general, the design life of these covers is for relatively short periods--such as the 30-year post-closure period specified by the *Resource Conservation and Recovery Act of 1976 (RCRA)*. The performance of barriers during this relatively short period can be monitored, and maintenance activities can be performed to correct any problems that might be encountered. However, some waste management situations make it desirable to isolate wastes for much longer than the 30-year post-closure period (i.e., up to or beyond a millennia). For these waste management situations, the relatively short-term (i.e., RCRA) designs might not be satisfactory. For example, many synthetic construction materials that might be effective for decades (e.g., geosynthetics) cannot be relied on to perform satisfactorily (or even exist) more than 1,000 years. Because of the need for the barrier to perform for at least 1,000 years without maintenance, natural construction materials (e.g., fine soil, sand, gravel, cobble, crushed basalt riprap, asphalt, etc.) have been selected to optimize barrier performance and longevity. Most of these natural construction materials are available in large quantities on the Hanford Site and are known to have existed in place for a millennia or longer (e.g., basalt).

9.2 Barrier Material Availability

Availability and location of sufficient quantities of materials with acceptable properties and qualities can be a controlling factor in the design of protective surface barriers and covers. This issue will be further compounded by a barrier design that requires multiple materials with widely varying physical and hydrologic properties rather than a barrier requiring only one or two different materials.

Costs associated with transporting the material from its source to the barrier construction site can be significant if the material must be hauled over great distances. For barrier construction projects requiring large quantities of materials, additional distance could easily add tens of millions of dollars to the total project costs. A design for a surface barrier must consider what materials are available for use in its construction. So locating sufficient quantities of acceptable material as near as possible to the construction site is desirable.

The infrastructure required to support large material volume transport operations could be inadequate or may not exist at all. Consideration must be given to the capital money required to add necessary rail lines, improve existing roads, build new roads, or secure the appropriate trucks or rail cars. These factors could add significantly to the total barrier construction cost.

9.2.1 Basalt

An SER (Duranceau 1994) (currently in draft) focused on the evaluation of seven basalt sources, including the three sources of Myers (1985), where a quarry could be developed to produce riprap for use in surface barrier construction projects. Upon evaluating the seven sites against a set of engineering criteria, Gable Butte received the best score, as it did in Myers (1985).

Of the four sites not included in Myers (1985), the top candidate site for developing a quarry surrounds a small existing quarry immediately east of SR 24 on a ridge south of the Columbia River overlooking the Vernita Bridge. The origins of this small quarry are believed to be associated with an earlier highway construction project in the area. This is the same quarry that was used to obtain a small quantity of riprap for constructing the prototype barrier.

Even though the precedent has been set for obtaining riprap from this quarry for the prototype barrier construction, permission to develop a large-scale quarry at this site has not been given. Availability of this site for large-scale quarry development depends on the outcome of cultural resource surveys, threatened and endangered species surveys, and formal consultation, through the DOE, with the appropriate Native American tribal councils and state agencies.

Several other alternate sources of basalt, in addition to the Vernita Quarry, also have been identified for potential quarry development, but they are located farther from the construction site, which will result in higher transportation costs. Additionally, several of these sources are at or slightly below grade and do not have the large exposed benches of basalt that are associated with outcrops such as those found at the Vernita Quarry, Gable Butte, or Gable Mountain.

Subgrade basalt sources would have to be developed as open pit or surface mines, which would impact a large surface area. After the required volume of basalt is removed from a surface mine, a large pit will remain on the landscape--an obvious anomaly that will be out of character with the surrounding landscape.

An advantage to developing an exposed basalt bench, such as Vernita Quarry or Gable Butte, is that after the mining operation is complete, an exposed bench will remain, although it will be translocated farther into the basalt formation. Restoring such a site to conditions similar to those that existed before the quarry operation, such that the quarry site will blend with the surrounding landscape, will have a greater chance for success than the effort directed toward restoring an open-pit mine. Of course, the degree of restoration required for future borrow sites probably will be the result of regulatory obligation or will be decided through negotiation with affected Native American tribes and state agencies.

9.2.2 Fine-Soils

Phase II characterization activities conducted in 1993 at McGee Ranch (Lindberg 1994) identified 32.7 million m^3 (42.8 million yd^3) of fine soil west of McGee Well in an area referred to as Area B. This substantial volume of soil is expected to meet any future surface barrier fine soil requirements currently planned. The surface of Area B consists of native shrubs interspersed with fields that were farmed before 1943. The old fields in Area B are primarily dominated by cheatgrass and are essentially devoid of shrubs.

A number of potentially historic and cultural resources exist within the boundaries of Area B at McGee Ranch. A cultural resource mitigation plan is currently under preparation that will address the measures required to mitigate cultural and historic resources that are determined to be significant. The cost and extent of mitigation is not known at this time, but will certainly be realized before beginning large-scale excavation activities.

9.2.3 Sand and Gravel

An extensive area consisting of nearly 129 ha (320 acres) around Pit 30 has been reserved to accommodate future sand and gravel requirements of barrier construction projects. However, because of the varied nature of the sand and gravel deposits at this site, some general characterization work will be required to establish efficient operations for securing and stockpiling appropriate sand and gravel. This characterization could be as simple as running core samples through a standard sieve stack to obtain gradation data for locations throughout the pit. A stacking conveyor can be used for bulk material screening to segregate the sand and gravel components into the size fractions stipulated in the barrier construction specifications.

A number of groups have an interest in the land in or around Pit 30 that could create a variety of potential conflicts with a sand and gravel operation. Careful coordination through Site Planning is necessary to resolve these potential conflicts ahead of time. An additional conflict may exist with the Pit 30 expansion encroaching upon the HMS and air monitoring equipment. Investigation of the potential impacts to the HMS and resolution of related concerns will be required.

9.2.4 Impact of Barrier Design Change

Specific information resulting from design and development activities for particular barrier layers is found in Sections 7.3 through 7.6. However, the next several paragraphs illustrate how a design change in one material component can increase the volume of material required in the barrier cross section. With this under consideration, it is easily seen how the issue of availability of native materials could potentially become a limiting factor in the design, size, and/or number of future barriers constructed.

Fine-soil from McGee Ranch was selected for use as a component in construction of the prototype barrier because of its favorable characteristics, such as moisture retention, ability to support vegetation, and relative close proximity to the barrier construction site. Modeling results (Fayer 1987) suggest that a 1.5-m- (4.9-ft-) thick layer of pure silt soil should be used at the barrier surface to provide moisture retention for the climatic conditions expected at Hanford.

However, observations at field test plots indicate that animals can burrow below the 30-cm (12-in.) depth, at which admix gravels were originally placed, and that the animals can cast unarmored soil to the barrier surface (Wing 1993). This type of disturbance is undesirable because the admix gravels serve to armor the barrier surface against the erosional forces of wind and water. If unarmored soils on the barrier surface are eroded by these forces, significant deflation and loss of function of the fine-soil layer can be expected over time.

To resolve this issue, the prototype barrier final design was changed to require that gravel admix be placed in the top 1.0 m (3.3 ft) of soil, a depth to which most animal burrowing activities are confined. To regain the moisture retention capacity lost by increasing the gravel content in the top 1.0 m (3.3) of silt, an additional 0.5 m (1.6 ft) of silt was added to the profile. The net result is 1.0 m (3.3 ft) of gravel admix overlying 1.0 m (3.3 ft) of pure silt, a 33-percent increase in the volume of fine-silt soil. Fortunately, the additional volume requirement for silt material in the final prototype barrier design was supplied from the fine-soil reserves identified at McGee Ranch. However, similar design changes in future large-scale barriers that cover hundreds of acres may not be as easily accommodated by nearby material reserves. Future barrier designs must consider the availability of material reserves on the Hanford Site and the supporting infrastructure required if materials must be procured from offsite sources.

9.3 Verifying and Monitoring Long-Term Barrier Performance

9.3.1 Passive Versus Active Systems

The need for a maintenance-free barrier that lasts for a minimum of 1,000 years necessitates the use of passive systems for achieving the preliminary performance objectives. Active systems are impractical because they require human involvement to operate, monitor, and maintain. For example, the use of active water collection and removal systems may require the use of piping networks, pumps, or other similar devices. These types of components are not intended to last for long periods of time and require periodic maintenance as well. This level of human activity over extremely long periods of time is impractical and would mean passing on this generation's legacy of waste to future generations, which is an undesirable option. Hence, the design of long-term surface barriers is biased toward passive systems.

9.3.2 Long-Term Monitoring Issues

The monitoring of a long-term surface barrier presents several interesting challenges. Quantitative "proof" cannot realistically be acquired to guarantee that surface barriers will perform as designed for at least 1,000 years. The term "transscientific" has been used to "describe certain environmental problems that, while requiring the close attention of scientists and engineers, are not likely to be solved by science" (Winograd 1986). While definitive proof of long-term barrier performance may be unrealistic, various scientific and engineering methods or techniques exist for projecting barrier performance over its long design life. Five methods for determining the long-term performance of surface barriers over the range of conditions expected to act on the barriers during their design life are listed as follows:

(1) Test the performance of individual barrier components

(2) Use validated computer simulation models to predict future barrier performance

(3) Evaluate natural geologic formations and ancient humanmade structures that are analogous to various barrier components

(4) Design, construct, and test prototype long-term surface barriers

(5) Provide access for replaceable monitoring instruments and transducers. (The life expectancy of most monitoring instruments and transducers is significantly less than the design life of long-term surface barriers. Consequently, placing the monitoring instruments and transducers within the surface barrier will only provide valuable data as long as they remain operational. Once the instruments and transducers cease functioning properly, performance data are no longer available unless the monitoring equipment is retrieved and/or replaced, which could entail undesirable actions such as excavating the barrier.)

The BDP is currently employing all five methods for evaluating surface barrier performance. (For more information on these approaches, please refer to Wing, [1994] and Gee et al. 1993.) Strengths and weaknesses are associated with each of these techniques; however, when combined, these methods provide a comprehensive approach for projecting barrier performance during extremely long periods of time.

9.4 Human Intrusion

To deter the inadvertent intrusion of humans into a waste site, a marker system concept has been designed to warn future generations of the dangers of the buried waste. The DOE fully intends to maintain active control of the Hanford Site (using fences, patrols, alarms, monitoring instruments, etc.) for the foreseeable future. However, if active control should ever cease, passive measures (i.e., those requiring no maintenance) may be needed to warn the inadvertent intruder of the potentially hazardous materials disposed of beneath the barrier. These passive measures may include recognizable warning markers, engineered features, and widely dispersed information (e.g., in U.S. Geological Survey maps, libraries, and other information repositories).

Passive measures will not provide absolute protection to every individual for all postulated events during the barrier's design life, nor will such measures prevent intentional intrusion. However, recognition of this limitation is consistent with the history of rulemaking for the disposal of radioactive waste.

A preliminary human-intrusion deterrent concept for Hanford Site barriers was developed during the early 1980s. This concept included built-in redundancies: offsite records, surface markers, subsurface markers, and barrier designs. An approach for developing this concept to deter intrusion by humans was prepared. This approach involved (1) the definition and design of marker materials, configurations, and messages; (2) the testing of selected materials; and (3) the procurement and testing of marker prototypes.

The human-intrusion issue presents a difficult design challenge because of the unpredictability of human behavior. Whatever humans construct also can be destroyed. Consequently, the human intrusion issue becomes one of where to "draw the line," i.e., what should the barrier be designed to prevent or to deter?

The DOE has not yet decided on the approach that will be used to deter inadvertent human intrusion at the Hanford Site or across the DOE Complex. The concept proposed in the early 1980s represents just one approach and the effectiveness of some aspects of this approach has been questioned. For example, the use of the subsurface markers has been challenged repeatedly. Some individuals have viewed the subsurface markers as an attractive nuisance that could draw curious individuals to the protective barrier instead of deterring them.

Many opinions regarding barrier design exist, with regard to human intrusion. For example, two different side slope designs are being considered by the BDP: a relatively gently sloping (10H:1V) clean-fill dike of pitrun gravels and a relatively steep (2H:1V) embankment of fractured basalt riprap. The clean-fill dike provides a gentle transition from the shoulder of the barrier to the surrounding environment. Essentially, the clean-fill dike concept blends the barrier into the topography of the surrounding landscape. Conversely, the steep, rocky side slope of the basalt riprap clearly delineates the boundaries of the surface barrier by providing a stark contrast with the surrounding environment.

Both side slope designs have positive and negative features with respect to human intrusion. A clean-fill dike side slope is aesthetically appealing because it blends with the surrounding landscape. However, if surface markers are lost for any reason, blending the waste sites with the local topography might tend to hide the location of the waste sites, making it possible for someone to inadvertently access the sites. Barriers that employ the basalt riprap side slopes are obviously structures that have been engineered and constructed by humans. The basalt riprap side slope designs make no attempt to blend the barrier in with the appearance of the surrounding landscape; consequently, these barriers are readily noticeable. The obvious barrier designs possibly could become an attractive nuisance (similar to the subsurface markers) that draws curious individuals to the mounds. This has been the experience with other (ancient) barrier systems that have been totally or partially breached (e.g., the Egyptian pyramids). Another potential problem is that the relatively flat surfaces of the barriers, which contain excellent fine soils, may attract future farmers to the barriers. In addition, curious individuals may think that valuables have been buried beneath the mounded soils and subsequently may want to excavate it.

Warning marker designs other than those proposed at the Hanford Site have been developed. For example, the Sandia National Laboratory recently has assembled national experts in a workshop setting to develop, at least conceptually, various warning marker concepts for the Waste Isolation Pilot Plant (Guzowski et al. 1991; Hora et al. 1991; Ast et al. 1992; Givens et al. 1992). Many different concepts were considered, some quite different from the concepts proposed at the Hanford Site.

The warning marker issue is not one of which design/concept is "right" or "wrong." Rather, the critical concern is the assumption(s) upon which the warning marker designs/concepts are based. Without a clearly delineated set of assumptions and policies to guide the development of warning marker systems, incorporating "unofficial" warning marker concepts into barriers currently being constructed may be not only counterproductive but also may be unwise. For example, the premature selection of a warning marker system design before a human-intrusion policy decision has been reached may be worse and more costly in the long term than purposely leaving out human-intrusion deterrent features completely. For instance, the prototype barrier constructed over the 216-B-57 crib is intended to be the final remediation for that particular site (provided that the barrier performs as designed). If subsurface markers were used in the prototype, they would have needed to be placed within the various layers of the barrier early in FY 1994 to meet schedule commitments. Because DOE did not have a human-intrusion policy in time to support the prototype's construction, no warning markers were used. This decision was made because if markers had been used in the prototype barrier as a human-intrusion deterrent (such as subsurface markers) and were later determined to be unwanted or inappropriate, the fate of the barrier over the 216-B-57 crib would be in question. The multimillion-dollar barrier then might have to be removed or rebuilt.

Perhaps the worst possible scenario would be for every project at the Hanford Site, or across the DOE Complex, to decide independently of each other which human-intrusion deterrent designs/concepts would be used. This scenario could result in many different designs/concepts that make it difficult, if not impossible, to discern what is going on. The lack of consistency among warning marker schemes could exacerbate a situation that the warning markers were intended to ameliorate. Until a DOE policy decision has been made, all BDP activities designed to address the human-intrusion problem have been discontinued. However, when a human-intrusion policy has been made and a warning marker approach selected, it should be uniformly and consistently applied across the Hanford Site (and probably across the entire DOE Complex).

9.5 Physical Stability

The performance of long-term surface barriers may be adversely affected by the physical, chemical, and radiological characteristics of certain types of waste. In addition, the susceptibility of certain types of waste to biological attack or biodegradation also may have an impact on barrier performance. Of specific concern are the magnitude of subsidence events occurring below the barrier (size and rate of subsidence); and the volumes, concentrations, and types of noxious gases that could be generated by the waste.

The 216-B-57 crib is a rock-filled crib; consequently, little subsidence is expected to be experienced. During the definitive design process, Kaiser ICF commissioned Dr. Edgar Becker to perform an analysis of the subsidence potential of the crib over which the prototype barrier was constructed. Dr. Becker's analysis concluded that after filling the crib's distribution pipe with grout, the maximum amount of subsidence that could be expected was ~1 in. (please refer to Appendix D to review Dr. Becker's analysis). Subsidence posts also have been constructed into the north end of the prototype barrier to monitor the settling (if any) of the compacted fill material used to support the testing of various components of the prototype. In addition, because of the wastes that were disposed of in the 216-B-57 crib, no noxious gases are expected to be generated that in turn would act on the prototype barrier.

Tasks within the BDP currently are being conducted to determine the maximum allowable subsidence that a barrier can withstand and still remain functional. Although the use of subsidence control measures (e.g., dynamic compaction and in situ grouting) are expected to significantly reduce the magnitude of subsidence experienced, subsidence events for certain types of waste cannot be expected to be reduced to zero. Consequently, the magnitude of subsidence that a barrier is capable of withstanding and still function as designed must be determined.

The subsidence control tasks are focusing on the low-permeability asphalt layers because they are the last line of defense against infiltrating water. These tasks will determine the ability of asphalt to deform and remain functional following a subsidence event. The stress/strain relationships associated with three-dimensional deformation of the asphalt layers will be studied. In addition, methods to enhance the tensile and shear strength of the asphalt layers will be tested and assessed. For example, does the incorporation of a woven fiberglass fabric or other highly durable and strong product into the asphalt layers increase the tensile and shear strength of the low-permeability layer? As data and information from these tasks becomes available, they will be incorporated into future barrier designs.

Tasks also may be performed to assess the barrier's ability to mitigate potential problems associated with the emanation of noxious gases from the waste zone. Depending on the type of waste being disposed of, noxious gases from the wastes could be generated and subsequently diffuse from the waste zone to the accessible environment. Unless controlled in some way, the noxious gases could pose a potential threat to human health and the environment.

The potential for problems with noxious gases is not unique to the Hanford Site. For example, uranium mill-tailings sites are often challenged with the emanation of elevated concentrations of radon gas. One such site is located in Grand Junction, Colorado. Many years ago, scientists and engineers (several of whom are currently serving on the BDP) were requested to participate in finding a solution to the elevated radon gas concentrations at the Grand Junction uranium mill-tailings sites. Various barrier designs that used several different barrier construction materials were developed and tested. In general, the designs consisted of a multilayer barrier of compacted soils and gravels with a low-permeability component (asphalt or clay) incorporated into the barrier profile. In 1979, full-scale protective barriers were constructed over the uranium mill-tailings sites (Baker et al. 1984).

Nearly 8 years after the protective barriers had been constructed, a post-mortem examination was performed on the performance of the Grand Junction protective barriers. The results of the post-mortem showed that the protective barriers that were constructed with low-permeability, asphaltic layers performed the best in inhibiting the diffusion of radon gas to the surface of the barrier. Control of radon exhalation was effective using low-permeability asphalt because radon has a short half-life (less than 4 days). Restricting radon flux allows for radon decay. In addition, radon has a low partial pressure, so gas pressure build up did not occur; hence, the cover was not disrupted by excessive pressures. The results also suggested that asphaltic layers constructed in the field with conventional equipment can perform as designed for an extended period of time (Gee et al. 1989).

The BDP will use the experience and expertise gained at Grand Junction, Colorado, and elsewhere in the design of barriers that mitigate problems associated with the release of gaseous wastes. A test plan has been developed to address the various technical issues associated with the emanation of noxious gases that were identified previously. Engineers and scientists will assess the barrier's ability to inhibit the diffusion of noxious gases to the accessible environment. In addition, concerns have been raised regarding the potential for gases to be trapped under various barrier layers, particularly the low-permeability components. These gases could induce elevated pressures on the barrier components of concern. In addition, concerns have been raised regarding the accumulation of water vapor under the low-permeability components. Some of these concerns will be addressed on the prototype barrier by using an array of instruments and transducers to measure parameters such as soil moisture, temperature, and air pressure just below the asphalt layer. Another concern requiring assessment is the potential harmful effects of organic vapors (solvents) on the low-permeability asphalt layers.

The use of computer simulation models will be used as appropriate (1) to assess the barrier's ability to withstand subsidence events of various magnitudes, (2) to assess the barrier's ability to control the emanation of noxious gases, and (3) to assess the impact on barrier performance of gas accumulation under low-permeability components. Field and laboratory tests also will be performed to enhance understanding and corroborate the results of the computer simulation models (if used). The test results will be used to formulate barrier design standards. To employ a long-term isolation barrier, end users would be required to provide waste forms that comply with the established barrier design standards for subsidence and noxious gas emanation.

9.6 Assessment of Potentially Disruptive Natural Events

Those disruptive events determined to have a reasonable probability of occurring during the 1,000-year design life of the Hanford Protective Barrier are being assessed to determine their consequences on the performance of the Hanford Barrier. Specifically, the assessment covers tornados and other high-wind conditions; high-intensity precipitation; earthquakes; the deposition of volcanic ash; and any other possible disruptive events that could act on the Hanford Barrier. The following summarizes the results found to date; full documentation is forthcoming.

The testing and monitoring of the prototype barrier is planned to be conducted for a minimum of 3 years, commencing immediately following construction. Data on extremes for wind and precipitation will provide bounding ranges to be used for the testing and monitoring.

The wind data collected at the Hanford Site and surrounding locations have been used to develop probabilistic straight-wind and tornado hazard assessments for the Hanford Site. Straight wind velocities that equal or exceed tornado velocities are at return periods of less than 100,000 years. Tornado winds are expected to be extremely rare on the Hanford Site.

During the 48-year period of record at the Hanford Meteorological Station (1945 to 1993) only 2 days have had more than 2.5 cm (1 in.) precipitation (October 10, 1957 with 4.0 cm [1.6 in.]; June 17, 1950 with 2.77 cm [1.1 in.]). The most intense storms in the region are warm season thunderstorms. The 6-hour duration storm amounts are more indicative of this type of storm. For prototype barrier testing, it can be noted that according to calculations examined, the 1,000-year storm at the Hanford Site would accumulate 5.59 cm (2.2 in.) of precipitation in 6 hours (compared to a maximum record of 4.2 cm [1.65 in.]) and to have accumulated 6.8 cm (2.68 in.) of precipitation in 24 hours (compared to a maximum record of 4.85 cm [1.9 in.] during October 10-11, 1957). The 1,000-year, 6.8 cm (2.68 in.) 24-hour amount is 42% of the entire annual mean precipitation of 16 cm (6.3 in.). The 16 cm (6.3 in.) is the 30-year normal precipitation amount.

The maximum annual precipitation received at Hanford through 1993 is 29 cm (11.4 in.), 181% or normal, which occurred in 1950 (the next high is 28 cm [11.0 in.], 176% of normal, which occurred in 1983). Thus, it would seem that for prototype testing that 200% of normal is probably not conservative enough on scales of 1,000 years. However, for the following reasons, it is believed that 300% of normal is conservative. Calculations indicate that the probability that the annual precipitation amount will not exceed 31 cm/yr (12.2 in./yr), 193% of normal, is 1 in 100 years; that it will not exceed 41 cm/yr (16.1 in./yr), 256% of normal, is 1 in 1,000 years; and that it will not exceed 51 cm/yr (20.1 in./yr), 319% of normal, is 1 in 10,000 years. The current upper bound for testing the prototype is 300% of normal (i.e., 48 cm/yr [18.9 in./yr]) (see Section 2.2).

As noted maximum amount of precipitation ever recorded on the Hanford Site in any 24-hour period was 4.8 cm (1.89 in.). And as noted above, the accumulation of precipitation over 24-hours with a 1,000-year return period is 6.8 cm (2.67 in.) or 125% of the record. The Probable Maximum Precipitation (PMP) is theoretically the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of year. The PMP precipitation that could fall on the Hanford Site within a 24-hour period has been calculated to be 28.8 cm (11.34 in.) or 175% of the average annual precipitation, but all received in one 24-hour period. The probability of exceeding this amount has been estimated to be 1 in 1,000,000.

Although there is some stratigraphic evidence for the occurrence of extreme precipitation events during the past 2,000 years from buried evidence of past Columbia River floods, there is much more paleoclimatic data on long-term precipitation averages. A 75,000 plus-year pollen record from Carp Lake near Goldendale, Washington, provides evidence for estimates that the mean annual precipitation in the Columbia River Basin ranged between 50 to 75% of modern and 128% of modern levels. For the majority of the pollen record (almost 65,000 years out of the 75,000 years), the climate in the Columbia Basin was drier than at present (i.e., averaged less than 16 cm/yr [6.3 in./yr] in the Hanford Site region). Based on the Carp Lake data and others, it can be concluded that there is no evidence that the long-term precipitation average ever reached 300% of modern levels, which has been taken as the upper bounding annual amount to test the prototype barrier.

The nearest Cascade Volcano is more than 100 km (62 miles) from the Hanford Site. Tephra from the Cascade Volcanoes has been found in the sediments in and around the Hanford Site. During the 1980 eruption of Mount St. Helens, about 1 cm (0.39 in.) of ash fell on the northern part of the Hanford Site. The volcanic hazard is dependent upon the probability and type of renewed Cascade eruptive activity and the meteorological conditions that control the direction and distance of air transport. Current design load for volcanic ash at the Hanford Site is a ground loading of 165 kPa (24 lb/ft^2) to be applied to Safety Class 1 structures. The potential impact of such an occurrence on the Protective Barrier has not as of yet been examined in the Protective Barrier Development Program.

The Columbia River Plateau region, including the Pasco Basin, is an area of low magnitude seismicity when compared to the rest of the western United States. The closest regions of historic moderate-to-large earthquake generation are in western Washington and Oregon and western Montana and eastern Idaho. The most significant event relative to the Hanford Site is the 1936 Milton-Freewater, Oregon, earthquake that had a magnitude of 5.75 and that occurred more than 90 km (56 miles) away. The largest Modified Mercalli Intensity was felt at Walla Walla, Washington, and was VI. This event was approximately 105 km (65 miles) from the Hanford Site.

A static slope stability analysis, and associated earthquake deformation analyses was performed by Adam Saleh and David Daniels of the University of Texas, for the Prototype Barrier at the 200 BP-1 site. For a 1,000-year prototype design life, the average site seismic response spectra with structure damping curves of 5, 10, and 12% the ground acceleration is 0.14 g and is 0.38 g for 10,000 years. The corresponding, equivalent Richter Earthquake Magnitude for both is 6.0 at a distance of 15 kilometers (9.3 miles).

A summary of significant findings from the static slope stability and seismic deformation analyses are presented below:

- The minimum static safety factor for the Prototype Barrier is on the order of 1.5, occurring along the 2 Horizontal to 1 Vertical (2:1) basalt side slopes.

- For a 1,000-year return period, seismic loading conditions, estimated, permanent seismic deformations are estimated to be on the order of 0 to 0.08 cm (0 to 0.031 in.). The displacement plane for the most critical surface is within the wedge of the basalt side slope, starting from the top of the slope extending vertically downward to the FAA layer, then extending horizontally, essentially along the FAA to just below the toe of the basalt side slope. The estimated resulting mode, magnitude, and location of deformation is not anticipated to significantly impact the functional performance of the barrier.

- For a 10,000-year return period for seismic loading conditions, permanent seismic deformations are estimated to be on the order of 0 to 2.05 cm (0 to 0.81 in.). The displacement plane for the most critical surface is within the wedge of the basalt side slope, starting from the top of the slope extending vertically downward to the FAA layer, then extending horizontally, essentially along the FAA to just below the toe of the basalt side slope. The estimated resulting mode, magnitude, and location of deformation is not anticipated to significantly impact the functional performance of the barrier.

- Under nonseismic, static loading conditions, the potential for downhill movement creep effect of the Fluid Applied Asphalt Materials, and overlying materials has been identified.

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Appendix A

Definitive Design Process Meeting Minutes

file: [illegible] Barrier

KAISER ENGINEERS HANFORD

MINUTES OF MEETING

BHI-00007
Rev. 00

Type: Barrier Design Team	Meeting No.: 1	Date: June 25, 1990

Project or Work Order No. and Title
ER0736 Prototype Barrier for the Hanford Site

References

Attendees
DL Fort
GW Gee
MT Janskey
DR Myers
NR Wing

Distribution
Attendees
JW Cammann
SD Consort
SJ Phillips
JJ Verderber
Eng Doc Control

1.) Discussed Barrier Team Protocol. NR Wing distributed protocol outline with list of task group leaders.

2.) Discussed field trip of June 20, 1990, and proposed Basalt Borrow Pit. Proposed Basalt Borrow Pit lies north of McGee Ranch. Dual access is available to minimize SR240 traffic impacts. Feedback from Hanford Security indicates problems with access permission. May require stationing of Patrol Guards during operations. Discussed improved safety aspects of using two points of access to proposed site, namely visibility of approaching traffic. Discussed high quality of basalt available at proposed site.

3.) Discussed KEH ROM Estimate of concept presented 6/11/90. Unit price cost of basalt $25.30/cu. yard in place when taken from proposed borrow pit. Option to purchase basalt in Kennewick and haul to site of Prototype Barrier would be $25 to $28/cu. yard in place.

Prepared By: DL Fort dlf	Approved By:
Title:	Title:

HPM613 1/20/89

MINUTES OF MEETING - CONTINUED

Type	Meeting No.	Date
Barrier Design Team	1	June 25, 1990
Project or Work Order No. and Title	**Page No.**	
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Minutes Continued

4.) Discussed proposed site of Prototype Barrier. Site slopes downward to the northeast approximately 2 meters. Discussed using uniform slope across top of Prototype Barrier to minimize costs. No decision was made.

5.) Discussed ways to lessen cost of prototype. Design as proposed on 6/11/90 is estimated to cost $1.26 Million without any test equipment. Discussed using monitoring/access vaults which would lessen amount of basalt needed. Discussed access vault and tunnel concepts and costs, (use of existing vaults verses new). Discussed basalt thickness in barrier necessary for required function. Further discussion deferred to Barrier Development Workshop to be held 6/26/90.

Prepared By	Approved By
DL Fort	
Title	Title

HPM614 1/20/89

KAISER ENGINEERS HANFORD

MINUTES OF MEETING

BHI-00007
Rev. 00

Type	Meeting No.	Date
Barrier Design Team	2	July 16, 1990

Project or Work Order No. and Title

~~ER0736~~ Prototype Barrier for the Hanford Site

References

Attendees

JW Camman
DL Fort
GW Gee
MT Janskey
JJ Verderber
NR Wing

Distribution

Attendees
SD Consort
DR Meyers
SJ Phillips
Eng Doc Control

1.) Read minutes of 6/25/90 BDT meeting.

2.) Discussed use of excess material located at west end of Gable Mountain. During decommissioning of the Gable Mountain Near Surface Test Facility, excess basalt was spoiled in an area near the existing basalt barrow pit. Spoil contains a lot of soil fines and was determined not to be suitable for the prototype barrier.

3.) Discussed the cost differences between establishing a borrow pit or hauling from pit in south Kennewick. KEH estimating maintains cost differential is slight.

ACTION ITEM: KEH to research into most cost affective source of basalt.

Prepared By

DL Fort *dlf*

Title

Approved By

Title

IPM613 1/20/89

MINUTES OF MEETING - CONTINUED

Type	Meeting No.	Date
Barrier Design Team	2	July 16, 1990
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3.) Discussed sources of custom blended material, (filter). 200 Area batch plant currently does not have the capability of screening and mixing materials. KEH estimate was based on hauling material from a Richland Batch Plant.

ACTION ITEM: KEH to find most cost affective source of screened and blended material.

4.) NEPA documentation has been submitted to DOE. Beginning FY 1991 all NEPA documentation will be approved by Admiral Watkins Staff. An EA or EIS will be required on all future projects.

5.) Discussion of the Pinch Theory continued. Bring up problems as they arise. Resolve them, do not hold them until they become too difficult to resolve.

6.) Discussed BDT/BTAB Protocol. NR Wing stressed the importance of attendance in meetings of BDT team members or their representatives.

7.) JW Camman handed out a "Summary of Design Considerations from Barrier Workshop". Discussion of the items given within followed.

GW Gee mentioned additional items to those listed under the Water Infiltration Control Group heading in the above handout:

- o Place pressure sensors in the basalt side slopes to determine wind effects in the open pore basalt.
- o Place temperature probes throughout barrier.
- o Installation of devices should occur during construction of the barrier so that installation does not disturb the barrier.
- o Install a viewing trench across the barrier to actually see the features of the barrier. PNL is planning a barrier concept test at the lysimeter station. A small scale example of the barrier may suffice for the viewing trench.
- o Something to measure side slope charging of the barrier is needed.
- o Section lysimeters or free draining lysimeters should be installed at the interface between the fine soil and the sand/gravel filters. Could be installed post barrier construction as it disturbs only the fine soils.

Discussed the Erosion Control Group input.

- o Group wasn't against supplemental treatments of rainfall, just didn't need them for their studies.
- o Recommended the establishment of subplot divisions for various treatments.

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DL Fort	
Title	Title

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Barrier Design Team	2	July 16, 1990

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- o Recommended consideration of barrier being square instead of rectangular as that would minimize edge effects on the barrier.
- o The recommended pea-gravel surface layer would represent a weathered surface.
- o If supplemental precipitation tests are performed recommend testing side slopes and evaluate runoff erosion of the side filter into the basalt.

Discussed Biointrusion Control Group Input.

- o Compacted silt layer would inhibit but not prevent root intrusion. Discussed blending clay, (25% bentonite), with silt and compacting to above 1.8 gm/cc density.
- o Plant growth improves evapotranspiration of the soil and 1.5 meters of minimally compacted soil is necessary to allow plant growth.

8.) Discussed various security or personnel barriers to control access to the prototype barrier. Levels of security needed discussed.

9.) Discussed the generation of maps showing walkways so that those who do access the barrier surface do not damage the tested surface.

10.) Concerns were aired about over-loading the proto-barrier with test concepts that could be tested at smaller scales. One item that could be tested on a smaller plot would be the pea-gravel surface layer.

11.) Discussed placing monuments on top of the barrier for measurements for subsidence and wind/water surface erosion.

12.) Extreme event testing was discussed. Group consensus was that extreme event testing should be performed, especially rainfall and runoff.

13.) Discussed testing layout and separation. Barrier construction methods to be the same or at a maximum two or three different methods.

Prepared By	Approved By
DL Fort	
Title	Title

KAISER ENGINEERS HANFORD

MINUTES OF MEETING

BHI-00007
Rev. 00

Type	Meeting No.	Date
Barrier Design Team	3	July 24, 1990

Project or Work Order No. and Title
ER0736 Prototype Barrier for the Hanford Site

References

Distribution
Attendees
Eng Doc Control
M.T. Janskey
S.J. Phillips
J.J. Verderber

Attendees
L.L. Cadwell
J.W. Cammann
S.D. Consort
D.L. Fort
G.W. Gee
D.R. Myers
K.L. Petersen
N.R. Wing

Read minutes of July 16, 1990 meeting.

1.) KEH given action item to perform ROM estimate on a viewing port inside the barrier, (trench, vault, etc.).

2.) Larry Cadwell discussed horizontal viewing and neutron sensing tubes. The Bio-intrusion Group requests that some vertical tubes be installed for plant root inspection. These tubes can be installed in a manner to minimize impacts to the system.

3.) Larry Cadwell discussed the addition of a tracer chemical placed at different interfaces to allow testing of surface plants to check zone penetration by roots.

4.) Discussed Barrier Concept #2 construction sequence and materials, reasons for such, etc. Sketches passed out. Discussed 2.0M thickness of silt (0.5M

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DL Fort
Title

Approved By

Title

HPM613 1/20/89

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Barrier Design Team	3	July 24, 1990

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compacted, 10" of surface having pea gravel blend, balance in loose placed silt). Discussed 8 feet wide sand filter at side slope interface with silt layers. Consensus that BDT agreed on concept.

5.) Jerry Camman passed out an updated "Summary of Design Considerations for Prototype Barrier, (July 23, 1990 update)". The summary sheet will be regularly updated as the design progresses.

6.) Discussed collection of side slope and internal drainage for sampling purposes. Use of asphalt curbs on asphaltic concrete layer and asphalt emulsion coating of side slopes as a means to collect drainage was advanced. The lysimeters (having 5 feet of silt), have yet to show breakthrough on double annual rainfall. The maximum condition for water intrusion would be a rapid snow melt. There are difficulties in simulating the occurrence of rapid snow melt. Side slope infiltration testing is of major interest for such an occurrence.

7.) Discussed erosion measurement and the use of electronic surveying equipment, their capabilities and accuracy. The prototype barrier must have several monuments placed on it to assist in the monitoring of the barrier.

Prepared By	Approved By
DL Fort	
Title	Title

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Type	Meeting No.	Date
Barrier Design Team	4	July 31, 1990

Project or Work Order No. and Title

ER0736 Prototype Barrier for the Hanford Site

References

Distribution

Attendees
Eng Doc Control
M.J. Fayer
K.A. Hoover
M.T. Janskey

Attendees

L.L. Cadwell
J.W. Cammann
S.D. Consort
D.L. Fort
G.W. Gee
D.R. Myers
K.L. Petersen
S.J. Phillips
N.R. Wing

Read minutes of July 24, 1990 meeting.

1.) Discussed improvements to Barrier Design Concept #2 as suggested by the BDT at last meeting. Passed out sketches of Design Concept 2A. Discussed use of Hoosier Style dumping in the placement of the silty soil to minimize compaction, allowing plant growth.

2.) Discussed 7-8 percent oil content asphaltic concrete verses spray applied asphalt emulsions. A contact for additional information about asphalt emulsions would be Bob Dunning who has been a past consultant to WHC. Discussed use of asphalt emulsion on side slopes to collect infiltration from rip-rap and side filters.

3.) Glenden Gee presented methodology in applying extreme rainfall to barrier and side slopes. He also passed on concerns by the water infiltration group in the abilities of the drainage material in transporting excess water over the

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DL Fort	
Title	Title

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surface of the asphalt layer. Raised concerns about the barrier recharging adjoining barrier sites with the edge treatment of the barrier. BDT discussed means of minimizing this problem. .One recommendation is to channeling the collected water to the toe of the barrier by the use of an emulsified asphalt coated slope under drainage material. The collected water would then be absorbed into a suitable depth of local soil that would enable plant growth.

4.) Discussed size of prototype and the ratio of area used by side slope treatment to actual barrier area. Consensus of BDT was that in an actual barrier the ratio of side slope area to barrier area would be much smaller and of little concern.

5.) Discussed slope orientation of prototype barrier and the possibility of using an asymmetrical centerline to simulate greater barrier width. BDT consensus that the number of treatment areas available for testing by the various barrier technical groups is more important than minimizing side slope effects on rainfall infiltration.

6.) Discussed concepts to test infiltration from extreme events. Namely placing a pair of curbs, (spaced 2 feet apart), on the asphalt layer and centered on each test plot. Run the curbs longitudinally and collect the accumulated water at a low point.

7.) Discussed dividing the 34Mx64M barrier into zones of 5M width. The outside zones to be used as buffers to side slope effects. Seven zones each side of the barrier centerline, (14 total), could then be apportioned to the various technical groups for testing programs. Consensus of BDT agreed with concept.

8.) Discussed placing asphalt emulsion on side slopes of barrier and collecting infiltrated water. A curb would be added under the outer edge of the silt layer to divide the collection zones from side slope and the silt barrier. Consensus to place asphalt emulsion on only half of the barrier to allow monitoring of effects sans asphalt emulsion treated side slopes.

9.) Dick Wing handed out an Action Item List for barrier test plans. BDT members are to respond with answers by the end of August.

10.) NEPA documentation due back from DOE later today.

11.) Barrier Workshop to be held on August 9 and 10, 1990. KEH to prepare media for presentation to attendees at workshop. As some attendees will be from offsite, media must be cleared by appropriate levels of management.

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DL Fort	
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12.) KEH also to proceed with ROM cost estimate on latest concept, (2A).

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DL Fort	
Title	Title

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Type	Meeting No.	Date
BARRIER DESIGN TEAM	5	August 7, 1990

Project or Work Order No. and Title

ER0736 Prototype Barrier for the Hanford Site

References

Attendees

L.L. Cadwell
S.D. Consort
M.J. Fayer
D.L. Fort
G.W. Gee
K.A. Hoover
D.R. Myers
K.L. Petersen
S.J. Phillips
N.R. Wing

Distribution

Attendees
Eng Doc Control
J.W. Cammann
J.J. Verderber
M.T. Janskey
S.O. Link
H.D. Freeman
J.C. Chatters

Read minutes of meeting for July 31, 1990.

1) Discussed construction sequence of barrier. Distributed sketch ES-736-E1, version 4.

2) Discussed seismicity of Hanford Site and potential for separation of certain layers within the barrier. Testing may be performed using a shake table to determine effects on layers. Discussed finding assistance or examples of effects of seismic events on earthwork (dams). Mentioned WHC support group (Tom Conrads and Ann Tallman).

3) Modified top of asphalt emulsion slope to coat earth fill only.

4) Added geotextile at the interface between the silt and the sand filter as an aid in construction.

Prepared By	Approved By
D.L..FORT	
Title	Title

HPM613 1/20/89

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BARRIER DESIGN TEAM	5	August 7, 1990
Project or Work Order No. and Title: ER0736 Prototype Barrier for the Hanford Site	Page No.: Page 2 of	

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5) Discussed moving access road to northwest of prototype barrier so that access could be used for possible future barrier.

6) Consensus that tumbleweed growth in gravel covered sand filter is not a problem.

7) Dick Wing distributed a cross section of the Durango Cover (noted vegetative cover and 1-5 side slopes of basalt). Area has 50 cm of precipitation and is at an elevation of 7000 feet. Much of the precipitation is snow. Vegetation includes coniferous forest. The cover design is an UMTRA (Uranium Mill Tailings Remedial Action) cover.

8) Lysimeter was saturated until breakthrough - contact Melvin Campbell.

Prepared By	Approved By
D.L. FORT	
Title	Title

Type	Meeting No.	Date
BARRIER DESIGN TEAM	6	August 14, 1990

Project or Work Order No. and Title

ER0736 Prototype Barrier for the Hanford Site

References

Attendees

L.L. Cadwell
J.W. Cammann
S.D. Consort
M.J. Fayer
D.L. Fort
H.D. Freeman
G.W. Gee
K.A. Hoover
S.O. Link
D.R. Myers
N.R. Wing

Distribution

Attendees
Eng Doc Control
J.C. Chatters
M.T. Janskey
K.L. Petersen
S.J. Phillips
J.J. Verderber

1) Discussed items of concern from last meeting - seismic events causing separation in the layers of the barrier and the breakthrough in one of the lysimeters at saturation.

2) Several new ideas were expressed at the workshop held on 8/9/90. Jerry Cammann suggested sending a letter to the participants of the workshop asking for comments on the design presented by the Barrier Design Team (BDT).

3) Glendon Gee raised the subject of integrated demonstrations. The Grout Facility has been working on items that may lead to such. A paper will be presented in a seminar this fall that studies a natural analog where ice formations are created in basalt rubble. The passive functions of this ice formation could reduce water condensation on waste forms by lowering the vapor pressure in the surrounding soil. Several similar conditions exist at sites in the Northwest. The engineering and construction of this feature would be difficult primarily because this phenomenon is not clearly understood.

Prepared By	Approved By
D.L. FORT	
Title	Title

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4) Jerry Cammann attended a meeting last Friday on stabilizing single shell waste tanks. A project is being developed to study this and it has been proposed that the Prototype Barrier be placed on top of a simulated single tank to create an integrated demonstration. Funding for an integrated demonstration may be justified more easily than separate demonstrations. An aggressive schedule has been requested by RL to demonstrate a major success in selection of an in-situ disposal process. The current proposal consists of two mock-ups with different treatments. One mock-up consists of a single shell tank that will be filled with grout to stabilize the simulated waste. Vitrification will be used to treat the other tank's simulated waste and the surrounding soil. The Prototype Barrier would be installed over the grouted tank. The two systems would then be compared.

Larry Cadwell suggested that the integrated demonstration be used on the "second" prototype barrier (1993). Otherwise the "first" prototype would be postponed until the initial stages of the integrated demonstration have been designed, constructed and demonstrated. Several BDT members suggested that the proposal to RL about the integrated demonstration be advanced with this idea.

Dennis Myers expressed concern that care be taken in addressing the regulatory authorities about some of these treatment systems such as in-situ grout.

5) The Barrier Program may be changing in the near future. Proposals are due this week on goals and milestones and are to include integrated demonstrations. Some of these demonstrations (proposed) have not been funded, so funding wars may develop. Care must be taken in establishing the milestones and having strong evidence and technical support in the program activities.

6) Dick Wing presented an approach to provide design basis for the selection of materials and thickness and the selection of criteria to validate materials. (i.e. M.W. Ligotke's study using different admix concentrations which provides documentation for prevention of wind erosion.)

7) Design considerations for the various features of the Prototype Barrier were advanced:

- o 5 meter thickness requirement - in what document is this specified?
- o Climate - 3x annual precipitation - probable maximum (from L.L. Cadwell)
  - worst or extreme case is a rainstorm following rapidly melting snow in a year with 3x the annual precipitation (approximately 70% of the annual precipitation occurs during the cool season)
  - these conditions may create the worst case infiltration
  - * Action - L. Cadwell will write report on worst case scenario

Prepared By	Approved By
D.L. FORT	
Title	Title

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- o Subsidence - assumed that this will not be a problem - will be studied at a later time

8) Each BDT member given the task of bringing written input to the next BDT meeting to begin definitive detailing and documentation of the Prototype Barrier.

9) Goals are to develop definitive design documents and specifications by the end of the fiscal year. Construction should be performed early in 1991 to minimize moisture loss in handling silts.

Prepared By	Approved By
D.L. FORT	
Title	Title

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Type	Meeting No.	Date
BARRIER DESIGN TEAM	7	August 21, 1990

Project or Work Order No. and Title

ER0736 Prototype Barrier for the Hanford Site

References

Attendees

L.L. Cadwell
J.W. Cammann
J.C. Chatters
S.D. Consort
M.J. Fayer
D.L. Fort
H.D. Freeman
G.W. Gee
S.O. Link
K.L. Petersen
S.J. Phillips
N.R. Wing

Distribution

Attendees
Eng Doc Control
K.A. Hoover
M.T. Janskey
D.R. Myers
J.J. Verderber

1) Dick Wing presented elements learned from a seminar on RCRA/CERCLA closures. The arrangement of various low permeability layers could enhance or detract from performance. Care should be taken here. An application of this principle as it applies to the Barrier would be to put an asphalt coating on a Claymax layer over the asphalt layer.

Another issue of concern raised at the seminar was the preferential pathways created at the interface between lifts of soil (the concern is for lifts in a liner). Hoosier dumping may create preferential vertical pathways. Glendon Gee expressed concern that we not place the silt using the standard practice of compaction of the primary liner soil. Plant root penetration is necessary for the long term functioning of the barrier. Higher density placement would greatly inhibit plant growth. The interface created by the Hoosier dumping may enhance root penetration.

Prepared By	Approved By
D.L. FORT	
Title	Title

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Also, in the RCRA seminar, questions were raised about the use of asphalt in barrier designs. Names were obtained to collect additional information. Dick Wing will follow up on this issue.

Dick Wing recommended that the BDT invite some of the specialists involved in presenting the RCRA seminar (August 15,16) to review the final design for the Prototype Barrier prior to construction. The BDT supported the idea.

2) KEH distributed copies of sketches of the current design concept (copies of slides used at the Barrier Design Workshop of August 6th).

3) Ken Petersen distributed a summary of the Hanford climate from the records and the evidence for the past 8,000 years. Three times the current average annual precipitation would exceed the maximum annual precipitation that has occurred in the past 8,000 to 10,000 years. Use of the Thompson Valley precipitation record may provide a good analog for modelling three times the average annual precipitation for Hanford.

J.C. Chatters stated that approximately 2,000 years ago the amount of precipitation changed the aquifer. Further study is ongoing.

The BDT consensus was that three times the annual precipitation is the bounding scenario. Values over time for duration, intensity and magnitude of precipitation need to be established for both two and three times the average annual precipitation.

Maximum run-off conditions would be three times average annual precipitation for December, January and February as snow followed by 24 hours of melting (chinook conditions) on frozen ground. 44% of the annual precipitation occurs in these three months.

Six inches of water was applied over 48 hours in tests at the McGee Ranch. The intensity was controlled to minimize ponding. The wetting boundary moved to 120 cm in depth. No run-off occurred.

The BDT consensus was to analyze the present barrier design for its capacities, then compare the results to the determined probable weather conditions. Construction practices will govern media thicknesses.

1.35 to 1.4 gm/cm is the requirement for placement of McGee silt. Mike Fayer has data on McGee silts and AP tank farm sands.

Prepared By	Approved By
D.L. FORT	
Title	Title

KAISER ENGINEERS HANFORD	**MINUTES OF MEETING**	BHI-00007 Rev. 00

Type	Meeting No.	Date
Barrier Design Team	8	Sept. 4, 1990

Project or Work Order No. and Title

ER0736 Prototype Barrier for the Hanford Site

References

Attendees

J.D. Axford
L.L. Cadwell
J.C. Chatters
M.J. Fayer
D.L. Fort
G.W. Gee
M.W. Ligotke
D.R. Myers
K.L. Petersen
N.R. Wing

Distribution

Attendees
Eng Doc Control
J.W. Cammann
S.D. Consort
K.A. Hoover
M.T. Janskey
S.J. Phillips

Minutes were not read in an effort to conserve time.

1.) Water infiltration components testing questions need to be addressed. This subject was deferred to a later time.

2.) Conceptual Design drawings will be developed by the end of this fiscal year. A comprehensive outline specification will be part of this effort. The completion of and conversion of the conceptual design documents to full definitive design documents will take place the first part of FY 1991.

KEH will provide the BDT copies of the preliminary conceptual design drawings and outline specification for review by 9/18/90. Comments will need to be returned by 9/27/90 for incorporation into an Engineering Report to be issued 9/30/90.

Prepared By	Approved By
DL Fort	
Title	Title

HPM613 1/20/89

MINUTES OF MEETING - CONTINUED

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Barrier Design Team	8	Sept. 4, 1990
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Minutes Continued

3.) Concerns currently outstanding:

a.) M. Ligotke recommends that a final thin layer of 2cm (3/8") pea gravel be placed on the surface of the barrier <u>after</u> the admixture surface is prepared. This is to provide an armor to minimize wind erosion on the freshly tilled silts. Currently the BDT has decided against the installation of this armor.

b.) The complexity of the current barrier design will require documented defence. Earlier reports developed by other organizations at Hanford mearly placed a large basalt mound over the in-situ disposal sites, (reference 241A Cover Report by P.K. Brockman , et al.).

4.) J. Chatters mentioned that native American mounds that date back 3,000 to 4,000 years were constructed using fine soils and have withstood wind and rain erosion effects quite well. Those with a very thin veneer of shells or gravel survived the best. A report on this subject is currently in editing that discusses the findings of a research team.

5.) Constructability issues raise concerns as to how to place a final veneer without compacting the barrier surface, thus inhibiting plant growth. A discussion continued that the admixture, part of the current design concept, would eventually create this veneer and may satisfy the need for the veneer application. Consensus of BDT was to forgo the final veneer on the first prototype barrier.

6.) KEH was given an action item to study methods and special equipment to install a 2cm veneer. KEH is to report back at next weeks BDT meeting with findings.

7.) J. Chatters presented the design basis weather conditions to be used in the barrier design. (Handout given). There is potential for up to 6" of water run-off over a 12 hour period.

Prepared By	Approved By
DL Fort	
Title	Title

HPM614 1/20/89

KAISER ENGINEERS HANFORD

MINUTES OF MEETING

BHI-00007
Rev. 00

Type	Meeting No.	Date
Barrier Design Team	9	Sept. 11, 1990

Project or Work Order No. and Title

ER0736 Prototype Barrier for the Hanford Site

References

Attendees

J.W. Cammann
L.L. Cadwell
S.D. Consort
D.L. Fort
G.W. Gee
D.R. Myers
W.H. Walters
N.R. Wing

Distribution

Attendees
Eng Doc Control
M.J. Fayer
K.A. Hoover
M.T. Janskey
M.W. Ligotke
K.L. Petersen
S.J. Phillips

1.) The planning of this months BDT activities was discussed. Approval of conceptual design documents by the members of the BDT will be by signature on a form or letter.

2.) Discussed placement of McGee Silts in dense and loose layers. Percent of moisture content critical in achieving low hydraulic conductivity and/or to minimize compaction of the plant bearing layer.

Discussed Hoosier Style dumping. The method would possibly create near vertical planes where preferential pathways for water would develop. G.W. Gee mentioned that the root development of plants has not indicated this to be a problem in studies of the McGee Silts. Hoosier style dumping should enhance root penetration better than the layered methods of placement.

Subsurface marker placement would be easier using the layered method in placement. J. Cammaan suggested that subsurface marker configuration can be modified.

Prepared By	Approved By
DL Fort	
Title	Title

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MINUTES OF MEETING - CONTINUED

Type	Meeting No.	Date
Barrier Design Team	9	Sept. 11, 1990
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Minutes Continued

Subsidence in the loosely placed silts, (Hoosier style placement), should not be a concern as the in place density at McGee Ranch is near the same density achieved when the silt is poured into a test cylinder.

Dumping of the upper silt layers in Hoosier style placement, then spreading in horizontal lifts as thick as possible, was suggested by D. Myers and the BDT agreed by consensus. Smoothing and shaping of the silt layers by Caterpillar will minimize compaction. Use of LPD dozers will keep compaction at a minimum.

3.) Discussed maximum density of McGee Silts (1.88 gm/cc), at optimum moisture content (about 14 percent). Maintaining the moisture content of the silts at less than optimum moisture may help limit compaction to less than than the 1.6 gm/cc density ceiling where plant root penetration would be inhibited. G.W. Gee has performed studies and will provide KEH with data to assist in determining if moisture content greatly affects silt compaction. The field lysimeters had silt placed and compacted by hand at a moisture content of 12 percent by weight. Density achieved was 1.4 gm/cc with little effort.

4.) The addition of water to the in-situ McGee soils prior to the excavation of the borrow pit was discussed. The use of the existing well to supply an irrigation system was proposed. A permit from the State of WA will be necessary to use the McGee Ranch well. The existing well will <u>not</u> deliver 60 gpm. A lined pond may be required to store enough water to be able to use standard irrigation equipment in an effort to wet down the borrow area.

5.) Fertilizing of the final layer of McGee Silts was then discussed. The re-vegetation of a surface is enhanced by nitrogen and phosphorus addition similar to standard farming practices. A natural mycorrhizae is necessary for sagebrush growth in the silts. This fungal-root association is found concentrated in the top 12 inches of in-situ soil. In developing the borrow area the top soil should be stock piled for placement at the final lift of silt.

To minimize the surface area impacted at the McGee Ranch borrow area, the mycorrhizae should be injected in the top layer of silt. The McGee Ranch borrow area must be returned to a natural appearing state, therefore the microrhize must be injected at one of the sites anyway.

6.) KEH passed out an overview of the Barrier design reasoning to the BDT and requested input from team members by the following BDT meeting, (Sep. 18, 1990).

7.) Discussed QC requirements for barrier construction. Development of definitive spec will address this issue. To be done next FY.

Prepared By	Approved By
DL Fort	
Title	Title

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8.) KEH reported to BDT on spreaders available to place a thin veneer of pea gravel as a final layer on the barrier. A chip spreader on a dump truck is commonly used in Bituminous Surface Treated (BST) road construction. It will require the driving of a loaded dump truck over the final surface. No other application equipment is known of. Perhaps if moisture content is controlled to minimize compaction, this final pass will not harm the barriers ability to grow plant life. The BDT will consider applying the pea gravel with a chip spreader on one or more of the special treatment zones that will be established on the surface.

9.) Last week KEH requested WHC perform certain standard soil tests on some of the constituents of the proposed prototype barrier. KEH is to supply WHC with a sample of 5/8 inch crushed gravel for testing.

Prepared By	Approved By
DL Fort	
Title	Title

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KAISER ENGINEERS HANFORD	MINUTES OF MEETING	BHI-00007 Rev. 00

Type	Meeting No.	Date
BARRIER DESIGN TEAM	10	Sept. 18, 1990

Project or Work Order No. and Title

ER0736 Prototype Barrier for the Hanford Site

References

Attendees

L.L. Cadwell
S.D. Consort
M.J. Fayer
D.L. Fort
G.W. Gee
D.R. Myers
K.L. Petersen
W.H. Walters
N.R. Wing

Distribution

Attendees

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EngDoc Control
J.W. Cammann
J.C. Chatters
H.D. Freeman
K.A. Hoover
M.T. Jansky
S.O. Link
S.J. Phillips
J.J. Verderber

Read minutes of 9/11/90.

Discussed overview: received written comments - very little discussion.

Issued drawings to Barrier Design Team (BDT). Discussed drawings.
The site preparation plan shows an economized design. Soils excavated from the uphill side of the site are used to level the downhill side. The effect is to place the windward (high intensity winds) side of the barrier about one meter below grade. This feature should be reviewed by M. Ligotke for modeling problems.

Discussed toe lysimeter. Will asphalt heal small penetrations caused by crushed gravel. Feeling is that it would. Collection of infiltration to a common point by a ditch was a suggestion offered by D. Wing.

Dave Fort explained the drawings showing the construction of the barrier. Some soils on the upside slope may not have to be moved to construct the earthen core. This will save on compaction. Section A was missing a dimension from the toe of the slope to the center of the lysimeter.

Prepared By	Approved By
D.L. FORT	
Title	Title

HPM_613.KEH 9/1/90

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Basalt/Filer/Asphalt Layers - shows neutron probe access tubes. Dave explained the location of the lower probe access to determine if there is condensation beneath the asphalt. The lower access tubes are 0.5 meter down in the earthen core to be able to detect moisture. The tubes could not be placed in riprap.

To collect any drainage that reaches the asphalt, trenches constructed of gravel between two asphalt curbs will slope across the asphalt centered on each treatment. The pipe for drainage does not extend through the trenches. Mike Fayer commented that the greatest water accumulation might be near the edge of the barrier. Dennis Myers commented that a localized piping breakthrough might not be identified. M. Fayer asked the reason for area of the curb trench underlying only 10% of the treatment area. Dave said that this area was to minimize edge effects.

Silt/Sand Layers - Section F shows the maximum single lift possible (Hoosier Style). Section G has more detail of ramp construction in relation to barrier construction.

Neutron probe access tubes will be placed at the interface between the compacted and uncompacted silts. The material and dimensions of the access tubes was discussed. The access tubes will need to be 2 1/2 inches diameter because the neutron probes are 2 inches O.D. Also, EMT will be used for the tube instead of PVC pipe. Joints are critical so that the 18 inch long probe does not get stuck in the tube.

The tubes in the silts will be located directly above the lower access tubes. Ramps will be needed to reach the access tubes especially since the tubes in the silts will extend out from the side of the barrier 13 feet above grade. Something like a vacuum will be needed to pull a line (with a probe attached) through the access tube. Access will be needed at both ends of the tubes. A stairway would be difficult to anchor.

W. Walters asked why the riprap is being dumped at the angle of repose. Riprap is usually reworked for stability. The riprap is not designed to maintain its slope over the long term. People will probably try to walk on it when the site is open for demonstration.

Petersen pointed out that the riprap is to discourage people from climbing onto the barrier.

D. Myers noted that mining dumps of similar composition have maintained steep slopes for a century or more.

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D.L. FORT	
Title	Title

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Minutes Continued

Dave Fort said that backhoes could be used to pull down the riprap to a 2:1 slope from the 4:3 slope.

S. Consort suggested that since this barrier is an experiment, part of the riprap could be left at 4:3 and part stabilized at 2:1.

W. Walter's concern is for long term stability of the barrier. D. Myers' concern is that the goal of the barrier is to keep humans, burrowing animals, plants and water out of the wastes.

G. Gee state that we cannot have a collapse of the riprap with visitors at the prototype barrier. Also, the riprap protects the layers of the barrier.

W. Walters said that there is no safety factor at the angle of repose, and it will not prevent humans climbing or digging into the barrier. If the riprap does not prevent human intrusion, could use river rock instead. But would river rock protect the silts.

At present design, face failure is possible, but not slip failure. The dashed line on the drawing shows the worst case face failure. There would still be enough armor, but that point may never be reached. The 4:3 slope should remain long term.

Should the human intrusion factor be revisited? Humans may use the riprap as a borrow area in the future. Should the slopes of the protype barrier be fenced off?

Finished Site Plan - Dave described building the sand filter around the silts.

The finalized drawings are to be to DOE by 9/28/90.

Dave distributed the specification outline and the calulations for filter gradation and explained the specification.

Prepared By	Approved By
D.L. FORT	
Title	Title

SUMMARY OF DESIGN CONSIDERATIONS FROM BARRIER WORKSHOP

- Supplemental precipitation

Water Infiltration Control Group

- suction or free-drainage lysimeters (if funding, yes) — can be post construction
- Temperature and pressure sensors (in side slopes)
- Reduce basalt base layer to 0.5 meters
- Use horizontal access tubes for neutron hydroprobes (3 through fine soil, 1 through basalt base layer) — use clear plastic tube sections
- Install water collection media under riprap side slopes to evaluate recharge (e.g., HDPE or other polymeric membrane to a collection trough)
- Viewing systems

Erosion Control Group

- Put long axis of barrier on wind rose (e.g., SW-NE orientation)
- Consider making barrier square instead of rectangular
- Keep 5 meter overall height; reduce basalt base layer and replace with native soils
- Eliminate the berm along the top of the barrier
- Reduce the thickness of the basalt side slopes by 1/4 to 1/3 of the total riprap
- Extend riprap at top of side slope roughly 3 feet onto the surface of the McGee Ranch silt loam; use small layer (~3 inches thick) of 3 inch minus gravel to protect against runoff erosion
- Surface slopes of 2-3% desirable (2-5% acceptable)
- Group voted against the use of supplemental precipitation treatments (not needed for erosion tests but the group was not opposed to supplemental precipitation for other tests)
- Recommend the use of pea-gravel admix; 30 cm depth (minimum), 15-20% by mass — subplots
- Recommend surface layer of pea-gravel (10-15 kg/sq. meter)
- Install erosion pins to monitor surface deflation (large nails anchored in concrete base)
- Install 3 anemometer towers; 1-2 on barrier, 1 off barrier; 10-30 meter height
- Install runoff catchment and measurement system
- Add supplemental precipitation on side slopes and evaluate runoff erosion (interface between fine soils and basalt riprap side slopes)

To be addressed elsewhere, not on prototype.

Biointrusion Control

- Transplant surface rather than seeding (e.g., native grasses, shrubs, etc.)
- Use irrigation to establish plants; no supplemental precipitation treatments needed
- Reduce basalt base layer thickness; no impact to biointrusion over the test period
- Layer F (compacted layer of McGee Ranch silt loam) will not necessarily be effective against biointrusion; recommend additional 1.5 feet of McGee Ranch silt loam compacted to 80% proctor
  - 2 m total thickness

(We could consider adding bentonite to the McGee soils and then compacting this layer.)

- Provide permanent access to the top of the prototype barrier for manpower and small equipment
- Perform compaction treatments on various sectors of the barrier surface; use rhizatrons to look at impact of percent compaction on plant rooting depths and distributions
- Establish permanent walkways across the barrier surface to minimize surface disturbances and resultant impacts on vegetation
- Signs, administrative fences, roadmaps

SUMMARY OF DESIGN CONSIDERATIONS FOR PROTOTYPE BARRIER
(July 23, 1990 update)

Water Infiltration Control Group

- Reduce basalt base layer to 0.5 meters
- Use horizontal access tubes to measure soil moisture with neutron hydroprobes
  - lexan, lucite, or aluminum
  - 3 through McGee Ranch silt loam; 1 through basalt base layer
  - lexan or lucite allow additional use as rhizotrons

  MULTIPLE TUBES AT EACH LEVEL
- Install water collection media under riprap side slopes to evaluate recharge (e.g., HDPE or other polymeric membrane liner which drains to a collection trough)
- Install capability to separate drainage through riprap side slope from drainage through McGee Ranch silt loam (e.g., may be achieved with the use of curbing along the asphalt layer)
- Install pressure sensors in the basalt riprap side slope
- Install temperature sensors along the horizontal access tubes
- Install suction lysimeters, moisture blocks, or equivalent at soil interfaces (optional)
- Recommend supplemental precipitation treatments (make provisions for subplots)
- Evaluate the use of subterranean access (trenches, vaults, etc.) to facilitate collection of data and monitor barrier performance (undecided; cost issue) -- EQUIVALENT (i.e., PHYSICAL MODEL)

Erosion Control Group

- Put long axis of barrier on wind rose (e.g., SW-NE orientation)
- Consider making barrier square instead of rectangular (optional)
- Maintain 5 meter overall height; reduce basalt base layer and replace with native soils
- Eliminate the basalt riprap berm along the top edge of the barrier
- Reduce the thickness of the basalt side slopes by 1/4 to 1/3 of the total riprap
- Extend rock cover from top edge of basalt side slope roughly 3 feet onto the surface of the McGee Ranch silt loam; use small layer (~3 inches thick) of 3 inch minus gravel to protect against runoff erosion

- Surface slopes of 2-3% are desirable (2-5% are acceptable)
- No need for supplemental precipitation treatments to evaluate erosion; better addressed through small-scale field testing
- Recommend the use of pea-gravel admixture; minimum depth of 30 centimeters, 15-20% by mass
- Recommend surface layer of pea-gravel (10-15 kg./sq. meter) to represent weathered surface (defer to small-scale field plots)
- Install erosion pins to monitor surface deflation (large nails anchored in concrete base; could become part of anemometer tower base)
- Install 3 anemometer towers
    - 1-2 on barrier
    - 1 off barrier
    - 10-30 meters in height (each)
- Install runoff catchment and measurement system
- Add supplemental precipitation on side slopes to evaluate runoff erosion and undermining of fine soils under the side slope (candidate for small-scale field testing)

Biointrusion Control

- Transplant surface rather than seeding (e.g., native grasses, shrubs, etc.)
- Use irrigation to establish plants; no supplemental precipitation treatments to evaluate biointrusion control
- Reduce basalt base layer thickness; no impact on biointrusion control over the planned testing period
- Layer "F" (95% proctor compacted McGee Ranch silt loam) may no be an effective biointrusion control medium; in addition to layer "F", recommend an additional 1.5 feet of McGee Ranch silt loam compacted to 80% proctor
- Consider replacing layer "F" with an amended McGee Ranch silt loam/bentonite clay mix (25% bentonite by weight; candidate for small-scale field testing or could be incorporated as a subplot)
- Provide permanent access to the top of the prototype barrier for manpower and small equipment; provide locking, swinging gate across access to inhibit unauthorized vehicular travel

- Perform compaction treatments on various sectors of the barrier surface; use rhizotrons to look at impact of percent compaction on plant rooting depths and densities (candidate for small-field scale testing)
- Establish permanent walkways across the barrier surface to minimize surface disturbances and impacts on vegetative growth
- No animal intrusion testing planned for the prototype at this time
- Place signs and chain barricades around the site to establish administrative control over site access
- VERTICAL η-PROBE ACCESS TUBES
- CHEMICAL TRACER LAYERS FOR BIOINTRUSION

12/30

KAISER ENGINEERS HANFORD

MINUTES OF MEETING

BHI-00007
Rev. 00

Type	Meeting No.	Date
Project Kickoff	ER2502-1	12/17/91

Project or Work Order No. and Title

ER 2502, Prototype Surface Barrier Design

References

Attendees

KEH

SD Consort - E6-40
DL Fort - E6-50
JD Payne - E2-10
RI Watkins - E6-41

WHC

NR Wing - H4-14

PNL

GW Gee - K6-7

Distribution

Attendees

K Burgard - E6-41
JW Cammann - H4-14
AJ Eirich - E6-41
KL Reis - E6-04
Eng Doc Cntrl - E6-24

[stamp, partly legible:] ...26 1991

The purpose of the meeting was get the project team together for an initial discussion of the project scope and to begin project planning activities. The project team is still being formed. L. K. Henley will have to be replaced as civil engineer since she is leaving KEH. We have been assured by Ken Burgard that the Grout Project can supply civil engineering support as long as it does not require a full time person.

Estimating support has been proposed to be provided by K. L. Reis, although estimating was not in attendance at the kickoff meeting.

R. I. Watkins discussed the proposed approach to engineering design: Phase I design will consist of a Design Basis Document, Project Estimate and schedule. The Design Basis Document will be an expanded version of D. L. Fort's letter report of September, 1990. No additional drawings will be prepared. The estimate will consist of a detailed estimate for the design phase, and an update of the previous construction estimate.

Prepared By	Approved By
R. I. Watkins *[signature]*	
Title: Project Manager	Title:

HPM_613.KEH 9/1/90

Type	Meeting No.	Date
Project Kickoff	ER2502-1	12/17/91
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ER 2502, Prototype Surface Barrier Design	Page 2 of 2	

Minutes Continued

Phase II design will start about February 1st and will be completed by September 30, 1992 with the following deliverables:

* Construction Plan
* Construction Estimate & Schedule
* Construction Specifications
* Construction Drawings

An integral part of Phase II design will be 3 cycles of external reviews and an internal constructibility review.

The draft Work Breakdown Structure was discussed (attached). Preparations of Work Element Planning Sheets by all KEH team members was requested by December 31st. An estimate for the Phase I design will be provided to WHC first week in January.

RIW/tlp

Attachment

Prepared By	Approved By
R. I. Watkins	
Title Project Manager	Title

HPM_614.KEH 9/1/90

PROTOTYPE SURFACE BARRIER

WORK BREAKDOWN STRUCTURE

1.0 Engineering

1.1 Design

1.1.01.01 Planning

1.1.10.00 Phase I Design (CDR Equivalent)

10.01 Design Basis Document
10.02 Project Estimate
10.03 Engr./Project Schedule

1.1.20.00 Phase II Design (DD Equivalent)

20.01 Construction Plan
20.02 Construction Estimate
20.03 Construction Schedule
20.04 Construction Specifications
20.05 Construction Drawings
20.06 Constructibility Review
20.07 Outside Consultants

1.1.77.00 Project Support

1.2 Engineering/Inspection

1.2.01.01 Planning

1.2.10.00 Engineering/Inspection During Construction

10.01 Earth Fill Inspection
10.02 Toe Drain
10.03 12" Basalt
10.04 Crushed Basalt
10.05 Asphalt Concrete
10.06 Sand Filters
10.07 Silt Layers
10.08 Marker Installation

2.0 Procurement

2.1.10.00 Bid Package Preparation

2.1.20.00 Contract Bid and Award

3.0 Construction

3.2 Construction Management

3.2.01.01 Planning

3.2.10.00 Construction Management

3.2.20.00 Subcontract

20.01 Clearing/Grubbing/Site Prep
20.02 Supply & Placement of Earth Fill
20.03 Supply & Placement of Spray - Applied Asphalt
20.04 Furnishment of Crushed Basalt
20.05 Furnishment of 12" Pitrun Basalt
20.06 Placement of Basalt
20.07 Supply & Placement of Asphaltic Concrete
20.08 Supply & Placement of Sand Filter Material
20.09 Supply & Placement of Geotextile
20.10 Furnishment of Silt Materials
20.11 Placement of Silt Materials
20.12 Supply & Placement of Protective Markers
20.13 Supply & Installation of Instrumentation Tubing/Conduits

20.20 Site Roads & Parking
20.21 Site Utilities
20.22 Construction Offices/Facilities
20.23 Revegetation - Borrow Areas

3.2.21.00 S/C Overhead

3.2.77.00 Project Support

BARRIER DESIGN - PHASE I

DETAILED WORK PACKAGES

Scope: Develop preliminary project WBS. Prepare Design Basis Document for Prototype Surface Protective Barrier. Prepare cost estimate for engineering design - Phase II, and update previous construction estimate. Prepare schedule for engineering design and preliminary schedule for construction.

Work Package Description:		Responsible to:
1.1.01.01	Planning	Watkins
	* Planning Sheets by Discipline - Phase I	All
	* Cost Estimate for Phase I	Watkins
	* Schedule for Phase I	Watkins
1.1.10.01	Design Basis Document	Fort
	* Prepare Outline	Fort
	* Research Prior Work	Fort/Consort
	* Draft by Sections	Fort/Consort
	* Compile & Review Document	Fort/Consort
1.1.10.02	Project Estimate	
	* Preliminary WBS	Watkins
	* Engineering SOW Descriptions by WBS	Fort/Consort
	* Prepare Basis/Assumptions	Watkins
	* Planning Sheets Preparation - Phase II Design	All
	* Prepare Engineering Estimate	
	* Update Construction Estimate	
	* Estimate Review	
	* Final Estimate	
1.1.10.03	Engineering/Project Schedule	Payne
	* Engineering Logic Diagram	Payne/Fort
	* Engineering Duration Estimates	Payne/Fort
	* Procurement Logic/Schedule	Payne
	* Construction Logic Diagram	Payne/Watkins
	* Const. Duration Estimates	Payne/Watkins
	* Schedule Review	
	* Final Schedule	
1.1.77.00	Project Support	Watkins
	* Project Management	Watkins
	* Project Control	Payne
	* Document Control	Watkins
	* Clerical/Word Processing	Watkins
	* Quality Assurance	Watkins

KAISER ENGINEERS HANFORD	MINUTES OF MEETING	BHI-00007 Rev. 00

Type	Meeting No.	Date
BARRIER DESIGN TEAM	12	April 7, 1992

Project or Work Order No. and Title
ER2502 Prototype Barrier for the Hanford Site

Distribution
Attendees
Eng.Doc. Control
J.C. Chatters
S.O. Link
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References

Attendees
L.L. Cadwell
J.W. Cammann
S.D. Consort
M.J. Fayer
H.D. Freeman
D.L. Fort
G.W. Gee
M.W. Ligotke
D.R. Myers
~~K.L. Petersen~~
W.H. Walters
R.I. Watkins
N.R. Wing

No minutes for 3/31/92. Everyone received copies of minutes from 1990 meetings.

D. Wing explained the problem of technical concerns being discussed at meetings and then the concern not being resolved. The person with the unresolved concern should present a statement to the task group leader who can address the concern. The decision on the concern will be documented. J. Cammann mentioned that we can use the RCR form. L. Cadwell noted that both PNL and WHC have forms. The Barrier Design Team (BDT) decided to use the WHC form.

The meetings are scheduled to occur from 9-11:00 AM each Tuesday in room 28 of 345 Hills Street.

D. Wing contacted Don Wood about guidance on human intrusion and regulations.

Task Groups were not all able to meet about objectives for testing and monitoring. Group Leader input:

M. Ligotke said that he would run surface shear tests. He would need three masts for equipment to measure wind speed. One mast would be placed in the

Prepared By	Approved By
S.D. CONSORT	
Title	Title

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BARRIER DESIGN TEAM	12	April 7, 1992
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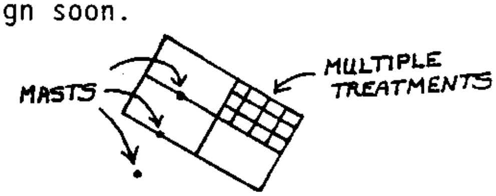
Minutes Continued

center of the prototype barrier, one on the edge, and one out away from the barrier. L. Cadwell noted that the shape and orientation of the barrier are important to the wind erosion tests. M. Ligotke would prefer the barrier to be oriented SW-NE instead of NW-SE as it is in the present design. Also, he favors a single surface treatment.

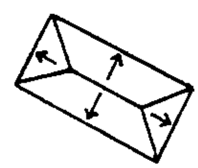
W. Walters would like more surface treatments. He is concerned about cracking due to settlement. He would want to measure soil properties, etc. of the prototype immediately after construction. He is going to contact D. Hoitink for daily weather data. W. Walters would like to design some sediment traps to monitor rates of soil erosion.

L. Cadwell stated that we need to decide on a basic design soon.

M. Ligotke presented a surface treatment idea showing where the masts for test equipment would be placed.

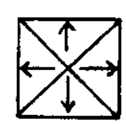


D. Fort drew a structure that could maintain compression during subsidence and be used for a gas collection test. The structure might also require less building material.



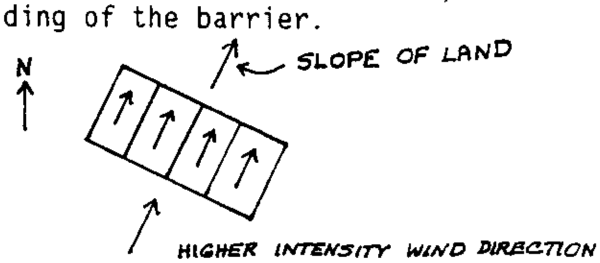
W. Walters noted that water erosion studies would require more length per treatment area than M. Ligotke's version provided.

L. Cadwell drew a square version of D. Fort's drawing. He recommended testing extreme events on one quadrant and leaving the other quadrants to ambient conditions.



D. Fort suggested blending the upslope side of the barrier into the terrain, or at least part of the slope to demonstrate the hiding of the barrier.

D. Myers asked whether the treatments would be more functional if the barrier surface sloped with the direction of the wind. The difficulty is that the wind blows at a higher intensity in a direction different than the predominant wind direction.



M. Ligotke suggested arranging treatment areas on D. Fort's version so that there would be no interference between treatments.

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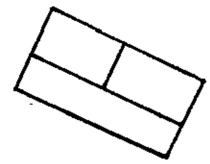
W. Walters prefers to test extreme events on test plots. L. Cadwell agreed, but only if side slopes will not be tested.

J. Cammann drew another version of the barrier surface suggesting that erosion could be performed on the longer rectangle.



R. Watkins stated that the BDT must determine the criteria for each portion and make the design fit the need. D. Wing asked what our objectives were. H. Freeman said that everyone must agree on the major objectives. D. Myers suggested that the major task groups gather and decide on their individual objectives.

J. Cammann pointed out that the data obtained from the prototype barrier must prove to the regulators that the Hanford barrier design is better than a RCRA cover. The BDT may want to construct a section of the barrier like a RCRA cover. The data from the barrier will still need the support of data from the test plots according to W. Walters. Also, J. Cammann said that quality control of construction must be shown. D. Fort mentioned that the prototype should not include a RCRA cover, but demonstrate that our design will withstand three times the annual precipitation, etc. There are examples of RCRA covers failing in humid climates and UMTRA covers failing in arid climates. RCRA covers must last for only 30 years with maintenance. The Hanford barrier must survive much longer with no maintenance.

D. Wing gave a brief overview of the four objectives for the prototype from 1990.

1) integrate components
2) test constructibility
3) evaluate barrier's performance - (needs to be more specific)
4) document design, construction, and testing process for sharing

Even though surface treatments can be measured on test plots, L. Cadwell noted that surface tests are still needed to prove that construction will produce a prototype barrier that behaves as the lysimeters predict.

D. Fort said that the BDT must decide on the configuration of the barrier components and whether side slopes will be constructed. The design must also demonstrate methods for monitoring the performance of an actual barrier according to the regulations. D. Wing asked what can be done with the prototype that cannot be done with the test plots.

M. Fayer volunteered to have all task group leaders send a list of their technical needs to him. He will compile the information so that it can be presented at the next meeting.

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H. Freeman noted that the four objectives from 1990 are not current. D. Wing, G. Gee, and L. Cadwell will go over these major objectives.

D. Fort explained that the required time span for the barrier's performance according to 40 CFR 191 is 1000 years. The 10,000 year criteria is for preventing exposure to individuals of >25 mrem from high level radioactive waste, TRU, and spent fuel. 10 CFR 61 is for NRC, not DOE facilities. J. Cammann is talking with the regulators.

The alternative stratigraphy options for the prototype were tabled.

G. Gee contacted Mary Peterson. The work she is involved with includes:

1) in situ bioremediation - mixed waste remediation
2) electro-kinetic remediation
3) non-biological in situ treatment
4) subsidence control

There is nothing about characterizing wastes. D. Wing will contact Jim Anderson about waste forms on site.

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ER2502 Prototype Barrier for the Hanford Site

References

Attendees
L.L. Cadwell
J.W. Cammann
S.D. Consort
M.J. Fayer
D.L. Fort
G.W. Gee
M.W. Ligotke
D.R. Myers
K.L. Petersen
J.C. Sonnichsen
W.H. Walters
R.I. Watkins
N.R. Wing

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H.D. Freeman
S.O. Link
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D. Wing briefly reviewed the pinch theory.

S. Consort reviewed the minutes from the April 7th meeting with comments by D. Wing.

The new schedule for the project was explained by R. Watkins. Revising the conceptual design is assumed to be our present work. The schedule still needs a few adjustments.

D. Wing and K. Petersen spoke to Don Wood about guidance on human intrusion. DOE/RL 91-45, rev. 1, is the document of risk assessment complying with the Tri-Party Agreement. DOE's plans to maintain control after 100 years, but not at the same level (i.e. fences and guards) as the present. According to the document, barriers with markers and warnings are to deter the inadvertent intruder. Sideslopes should not be dangerous. Protection of the deliberate intruder is not a concern. People must be made aware of the hazard. Riprap is to prevent animal burrowing, not human access. D. Myers asked about blending the barrier into the topography. D. Wood had said that DOE preferred the structure to be obvious. The Washington Administrative Code allows blending the structure into the terrain. D.

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Myers also asked about bikers and 4-wheel drive vehicles ruining the barrier's performance. According to D. Wood you can only deter the public, not prevent. We are not responsible for the performance of the design if humans interfere. D. Myers would prefer to make it difficult for anyone to disturb the barrier.

J. Cammann presented the goal and the programmatic objectives, the update of the 1990 objectives.

The goal is to provide defensible evidence that the design(s) of the final barrier will adequately control water infiltration; plant, animal, and human intrusion; and erosion by wind and water for a minimum of 1,000 years and isolate wastes from the accessible environment. (See handout.) There was a discussion about the wording concerning human intrusion. The second paragraph mentioned the changes expected over the next 10,000 years being considered in the studies and tests used to establish confidence that the final barrier will be able to meet a 1,000 year design life. The BDT basically agreed to accept the goal, but with some editing.

J. Cammann explained the eight objectives and listed measures of success for each (see handouts).

There are multiple barrier designs being tested at Hill Air Force Base, Ogden, Utah. The area receives approximately 18 inches of precipitation annually (about 3 times Hanford's annual amount). J. Cammann suggested encouraging the construction of a Hanford design barrier with the other designs at the base for comparison testing.

Also, J. Cammann reviewed the issues affecting the design (see handout). The design team is providing options for the regulators to decide upon. Note: D. Wood did not see any need to eliminate the subsurface markers from the design.

D. Wing, L. Cadwell, and J. Cammann designed a new variation of the barrier surface (see handout) using the comments from the peer review. The drawing does not show transition zones between the surface treatments. The design of the sideslopes includes a blended slope on the southwest side, rip rap on the northeast side, and retaining walls on the ends with platforms for access to monitoring equipment. Plexiglass windows could be placed in the retaining walls for viewing the barrier's stratigraphy. There was a discussion of whether the prototype should resemble a final barrier or contain things like viewing windows for exhibit. The prototype will not look like the real version because of access ramps for probes, etc. It may be easier to demonstrate the functions of the barrier to those without a background in this subject using this version of the prototype. The prototype should be designed for relative ease of monitoring. D. Fort was concerned that we need to develop or incorporate methods of monitoring the performance of a final barrier in the prototype. J. Cammann noted that some of this technology is in the process of being developed and is not available yet. D. Fort was also concerned about the interface between the retaining wall and the

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layers of the barrier. He suggested moving the crest to one side, but then one sideslope treatment would not be tested.

M. Fayer presented a synopsis of monitoring needs and possible objectives by task groups (see handout). He had not received anything from the groups involved with animal and plant studies.

W. Walters noted that we will need extra meetings to decide on the design within the proposed schedule. J. Cammann proposed that the BTAB and BDT spend an entire day together until we decides on a design. Everyone agreed to meet Thursday, April 16th.

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ER2502 Prototype Barrier for the Hanford Site

References

Attendees

T. Ambalam
L.L. Cadwell
J.W. Cammann
S.D. Consort
M.J. Fayer
D.L. Fort
G.W. Gee
B.G. Gilmore
M.W. Ligotke
D.R. Myers
K.L. Petersen
J.C. Sonnichsen
W.H. Walters
R.I. Watkins
N.R. Wing

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H.D. Freeman
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D. Wing reminded the Barrier Design Team and the Barrier Technical Advisory Board that the prototype does not have to be the final design. There is no right or wrong prototype.

J. Cammann presented a rewritten version of the goal presented Tuesday. The second paragraph was expanded (see handout). There was discussion about adding a statement explaining what is meant by human intrusion or just adding the word "inadvertent" to describe the type of human intrusion. J. Cammann reviewed the objectives including two new ones that had been added to the list.

L. Cadwell reviewed the issues submitted by the peer review group (see handout).

D. Fort asked if monitoring for the final barrier was going to be validated in the prototype. D. Wing said it would be a separate issue for the future in the program.

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BARRIER STRATIGRAPHY

Concerns of the peer review group:

1) The silt and asphalt are insufficient as primary and secondary barriers to intrusion. Burial by a dune would prevent the silt from functioning as designed.
2) The water control system needs protection from human and other biointrusion.
3) The barrier must show RCRA equivalency.
4) Admix should be included in the entire two meters of silt.

The design team decided to change the stratigraphy from the 1990 design.

Design Criteria:

Redundancy of low permeability layers was discussed. High density polyethylene (HDPE) and asphalt were preferred over bentonite mix and Claymax. W. Walters asked for a reference for the lifespan of geosynthetics. Testing of the asphalt is of major importance, but water will reach the asphalt only if the silt is tested to failure. The failure test could be performed at the end of the three year study period. The design team discussed whether the asphalt should be above or below the HDPE geomembrane with an filter layer between. If the geomembrane was above the asphalt layer, the geomembrane could be punched through at the end of the study period to flood the asphalt. A suggestion was made to place moisture sensors or a lysimeter under the asphalt, or test the asphalt in a separate plot. A salt tracer could be added to the water to detect leaks.

J. Cammann drew a cross-section of the barrier from the input of the discussion (see handout). With more input from D. Fort, L. Cadwell, and G. Gee, another variation was added. A major discussion of the stratigraphy of the barrier followed. Is five meters of thickness necessary? The lower portion of the silt does not need to be compacted. Because of the silt's thickness, cobbles not needed in the lower portion to protect the capillary break from burrowing animals. Is the basalt only to deter humans from reaching the waste or to protect the impermeable layers as well? Should there be basalt in two places to perform both functions (but use fill for the bottom layer in the prototype for cost savings)? G. Gee asked why use basalt instead of another material such as Pasco gravels. D. Fort said that these gravels were unstable because they do not interlock unless they are crushed. D. Myers and D. Fort stated that the basalt would not be as expensive for production as for the prototype. Was basalt needed to vent the site? The 5/8 inch road top course will vent any gas. Basalt is politically beneficial. It can serve as a biobarrier to large animals and plants.

The discussion of HDPE versus asphalt as the primary low permeability layer began again. The HDPE geomembrane would be useful in determining if water leaks through the capillary break. After the three years of testing, a trench could

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be dug through the prototype to inspect the layers and look for moisture. The prototype could be dissected and samples of the asphalt taken into the lab to test hydraulic conductivity, etc. If the asphalt were placed on top, the silt could be removed at the end of the test period and the asphalt could be flooded. Also, one less layer of cushioning material would be required for this design.

Design C was chosen by the team for the stratigraphy (see handout). The sequence from top to bottom of this design is as follows:

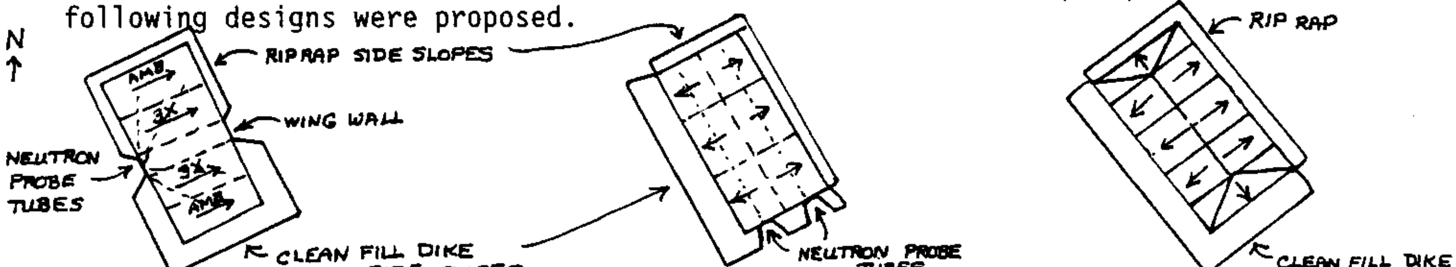
1) 2 meters of silt; the top 1 meter admixed with pea gravel
2) 0.25 meter of fine to medium sand
3) 0.25 meter of crushed rock
4) 0.5 meter basalt
5) foundation
6) asphalt
7) drainage gravel
8) geotextile
9) HDPE geomembrane
10) sand foundation

Meeting adjourned for lunch and reconvened in another conference room.

According to the EPA document on cover design, only one low permeability layer is required for RCRA covers for Class C wastes.

BARRIER SIDE SLOPES

L. Cadwell reviewed previous ideas for multiple edge treatments. He suggested the identification of a working group to resolve specific design issues. A discussion followed about whether side slopes would be blended into the landscape, actual slope of edges, and whether retaining walls would be at one or both ends of the prototype. The discussion then moved to what slope, if any, was required on the surface. The original design had used a 2% slope. The EPA document states 3-5% for surface and drainage layers. But drainage layers are not required for arid climates. A 2% slope will flatten over time. If the design followed the natural grade, a constant thickness could be maintained in the layers. The prototype could be sloped in one direction with sideslopes tested only on the downhill side. Half could be a clean fill dike and the other half would be rip rap. The following designs were proposed.



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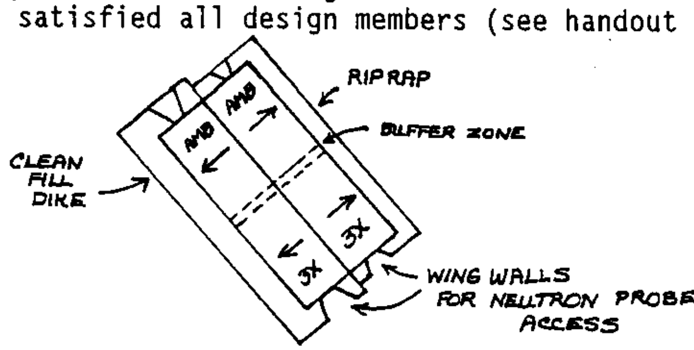
The team decided on three surface treatments: ambient, three times average annual precipitation, and the 1000 year storm. After much discussion, the team decided that the 1000 year storm would be tested only at the end of the study period on two of the plots originally devoted to other tests.

Instead of retaining walls at the ends, the side slope treatments would be extended around the ends with wing walls placed in them for probe access, etc.

G. Gee noted that it would be difficult to establish vegetation in the first year. A number of special treatments will be required including adding water to the silt. D. Fort noted that moisture will have to be added to the silt just to handle it.

The design team agreed to a 50-50 split between the rip rap and the clean fill dike treatments. Also, the prototype will be crowned in the middle. The test areas will be roughly square to minimize edge effects. A version suggested by M. Ligotke with wing walls satisfied all design members (see handout and below).



W. Walters, D. Fort , and T. Ambalam will design the surface and layer interface to the slopes. D. Fort presented a cross-section of the prototype and described construction. The following discussion brought some alterations so that drainage through the side slopes would not intercept the asphalt layer.

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ER2502 Prototype Barrier for the Hanford Site

References

Attendees
L.L. Cadwell
J.W. Cammann
J.C. Chatters
S.D. Consort
M.J. Fayer
D.L. Fort
G.W. Gee
M.W. Ligotke
D.R. Myers
K.L. Petersen
J.C. Sonnichsen
W.H. Walters
R.I. Watkins
N.R. Wing

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B.G. Gilmore
Attenders
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S. Consort reviewed the minutes from the last meeting.

D. Wing reviewed the agenda and the status of old action items. A statement is being developed about human intrusion.

D. Myers presented the letter that requests an estimate of the costs to build the ~~prototype~~ barrier by May 15th. There was a discussion of a post mortem study of desiccation of the clay liner at the LERF site when it is reclaimed in three to five years.

D. Fort provided sketches of the stratigraphy and sideslope interfaces. the following items were discussed.

? The BDT/BTAB needs to decide about having a road on the perimeter.

J. Chatters recommended rounding off the corners.

The team had another discussion about the positions of the asphalt and the HDPE liner. The need for the HDPE was questioned.

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A long discussion took place about the design of the structure of the clean fill dike sideslope. The team had to decide whether the basalt rip rap on the clean fill dike side should be constructed like the rip rap sideslope with the clean fill just to conceal the structure, or use the clean fill to support the silt and test for erosion. The peer review group had suggested that distinct alternatives be tested.

G. Gee suggested that a minimum of 8 drains were needed to collect water from the different surface and sideslope treatments. D. Fort suggested 12 drains - in each of the four test areas include one drain from the asphalt, one from the HDPE geomembrane, and one from the sideslope. D. Fort asked about using gypsum blocks to detect water. G. Gee explained that the gypsum blocks are calibrated to determine capillary pressures, but this can be difficult to correlate to the water content of the soils.

Two plan views were presented, one with retaining walls and one without. The walls would sharply distinguish between test areas for demonstration purposes. Wind tests might be impacted by walls. Construction without walls may be less expensive. The vote kept becoming tied. Cost will be the driver on the choice.

The team finally decided that the clean fill would support the silt on the clean fill dike sideslope treatment instead of building up the basalt as on the rip rap side. (New sketches will be presented at the next meeting.)

Comment by J. Cammann: Does the name of the project need to be changed (from prototype to test facility) to eliminate confusion as to the purpose of this design?

The percentage and thickness of admix was addressed by G. Gee. There is no information on the performance of one meter of admixed silt with triple the average annual precipitation. The lysimeters contain silt admixed with gravel only in the top 8 inches. The amount of gravel in the admixture is 30 percent. In the lysimeters, which have a flat surface, water ponds in the winter and the soil freezes. The 2 percent slope of the barrier surface will produce runoff in winter. To simulate winter conditions during testing, M. Ligotke suggested that a snow machine should be used. G. Gee had thought of using crushed ice. If the barrier's performance is dependent upon surface evaporation (as in winter), is there too much admixed soil in the design? G. Gee would prefer a thinner layer of admixed soil. Others would prefer to keep the one meter thickness, but lessen the concentration of gravel. The present design proposal was for 20 percent gravel in the admixture.

G. Gee explained his barrier design variation that was mentioned at the last meeting. This idea consists of adding boulders to the surface that would be difficult for humans to move.

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Task group presentations:

L. Cadwell explained the impact of monitoring biointrusion on the barrier design. Most of the information on animal intrusion will be acquired from a post mortem of the barrier, so will not impact design. Reference locations will be required (EDM) for animal intrusion data and subsidence studies. Plant intrusion studies will require sampling ports. Lexan pipe (2.5 inch) was suggested as the material to be used for the access pipe. Destructive sampling may be performed on the prototype at the end of the design life. Different tracers could be used above and below the asphalt. Plants for the prototype could be collected from disturbed sites. The team had a discussion about vegetated versus bare surface.

Due to lack of time, continuation of presentations by the task groups were postponed until the next meeting.

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Project or Work Order No. and Title
ER2502 Prototype Barrier for the Hanford Site

References

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H.D. Freeman
Attenders
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Attendees
L.L. Cadwell
J.W. Cammann
J.C. Chatters
S.D. Consort
M.J. Fayer
D.L. Fort
G.W. Gee
B.G. Gilmore
M.W. Ligotke
D.R. Myers
K.L. Petersen
J.C. Sonnichsen
W.H. Walters
R.I. Watkins
J. Waugh
N.R. Wing

R. Watkins stated that all components of the design must be agreed upon by next week.

D. Wing mentioned the preliminary results from the lab tests on construction materials for the prototype. The tests were producing incorrect data such as a hydraulic conductivity of 10^{-4} cm/sec for the gravel and a hydraulic conductivity for the silt that was greater than that of the gravel. G. Gee and M. Fayer are investigating the problems.

S. Consort reviewed the minutes from the last meeting. A correction was required to the statement about the requested estimate.

K. Petersen presented a preliminary version of a statement on preventing human intrusion. The objective is to warn the inadvertent intruder. The design team discussed some minor revisions which will be included and presented at the next meeting. The statement is based on defining the limits of DOE's responsibility to control the site.

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J. Waugh commented on the barrier program. He is organizing a technical exchange between the government contractors working on barrier designs and the EPA and state regulators. The exchange is tentatively scheduled for late summer.

D. Myers handed out information on the cost estimate.

L. Cadwell reviewed the information on bio-intrusion testing that he had presented at the last meeting. The prototype will not be an efficient place to test methods of preventing animal burrowing. Information can be obtained at the end of the prototype testing period. He asked how plant intrusion could be sampled with horizontal access tubes. Would tracers be viable or would there be contamination problems? Clear tube lysimeters with the same stratigraphy as the barrier could be built off to the side for demonstration purposes.

G. Gee presented information on the water storage capability of different percentages of gravel per volume of silt. He suggested an admixture of 10% gravel in the top one meter of silt. L. Cadwell suggested using 20% gravel in only one half meter of silt. M. Ligotke suggested this also, but with 10% gravel in the next half meter down.

G. Gee explained the objectives and techniques to test the control of water infiltration. These include the following:

1) water content of soil - horizontal access tubes for neutron probes
2) drainage measurements - collection system for soil
3) drainage measurements - collection system for side slopes
4) air pressure measurements - pressure sensors in basalt rip rap
5) temperature measurements - sensors along horizontal access tubes
6) water potential measurements - moisture blocks or thermal conductivity sensors at base of silt layer and perhaps in sand filter and base of rip rap
7) precipitation measurements - tipping bucket rain gauges and manual units
8) root observations - rhizotron tubes

D. Fort presented the results of his calculations on the quantities of water that will be produced from applying three times the annual average precipitation to the prototype barrier. Using sketches, he described the proposed sequence of construction and the drainage collection systems. He explained how a dose system (used in sanitary sewers) would collect the drainage. Twenty collection systems would be needed - four systems from the asphalt and sixteen systems to collect from each treatment and side slope.

D. Fort described the use of crushed road top course along the perimeter of the barrier's surface. This layer of rock will be approximately three inches deep and five meters wide. It will serve as an access road and as protection against erosion. J. Chatters suggested scattering some of this rock down the slope on the

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S.D. CONSORT	
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clean fill dike side of the barrier. L. Cadwell noted that vegetation could grow through a this thin armor of rock.

M. Ligotke described the objectives and techniques to test and monitor wind erosion. These included the following:

1) documenting the uniformity of the admixture of gravel and silt
2) installing erosion pins to measure inflation/deflation rates (erosion pins could affect the local environment - electronic surveying techniques may be preferred)
3) installing three masts (two on and one near the barrier) to measure the vertical profile of the wind
4) measuring saltation using two momentum profiling devices and /or four to six saltating sand traps

Also, at the end of the scheduled testing period, stress the prototype by adding a sand dune to one area and burning the vegetation on another.
The design team had a discussion on deflation and armoring of the barrier surface.

As part of the water erosion testing, W. Walters suggested monitoring a strip ten feet in width for soil loss and sediment yield. This would be a controlled area that could be bordered by wood framing. If this strip is located in the buffer zone between the different precipatation treatment zones, it could be reached without disturbing these other test zones. The test strip would be set up after construction of the prototype is completed. Subsidence as well as soil properties would be measured on this strip. J. Waugh noted that there exists the potential for flow concentration over long surfaces producing gully erosion. Can this be tested with a strip ten feet in width?

M. Fayer suggested taking samples of each layer of the prototype as it is placed. D. Fort said that the quality control people will take these samples. A discussion of the requirements for modelling the barrier stratigraphy was postponed.

K. Petersen explained how some rainfall studies of California were performed and the data presented. This was to show how the climatic data could be used to calculate how much water would be needed to stress the prototype.

D. Wing reviewed the action items to be performed. G. Gee, M. Ligotke, and W. Walters will meet to decide on the admixture of gravel and silt that will be used.

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KAISER ENGINEERS HANFORD

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Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	17	May 12, 1992

Project or Work Order No. and Title
ER2502 Prototype Barrier for the Hanford Site

References

Attendees
L.L. Cadwell
J.C. Chatters
S.D. Consort
M.J. Fayer
D.L. Fort
H.D. Freeman
G.W. Gee
B.G. Gilmore
M.W. Ligotke
K.L. Petersen
R.A. Romine
J.C. Sonnichsen
W.H. Walters
N.R. Wing

Distribution
J.W. Cammann
D.R. Myers
R.I. Watkins
Attenders
Eng.Doc. Control

S. Consort reviewed the minutes from the last meeting.

D. Wing noted that Paul Crane would arrive later to present preliminary data from testing the construction materials for the prototype. The odd results from the earlier tests were from problems with the equipment fittings. The problems have been corrected.

K. Petersen presented a revised version of the statement on preventing human intrusion. After minor revisions, the design team voted to accept the statement.

D. Wing reviewed the status of old action items.

J. Chatters suggested objectives for testing analogues. Settling and surface erosion should be tracked. The layers of the prototype will be documented as they are built. D. Fort stated that the site will be surveyed and benchmarks will be installed before the barrier is built.

The amount of gravel to be admixed was decided at 15% in the top 1 meter of silt and none in the deeper meter of silt.

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MINUTES OF MEETING - CONTINUED

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G. Gee had some questions on the construction of the collecting systems from HDPE. D. Fort described the construction of the collecting systems. The scuppers of HDPE will be fabricated in the shop. J. Chatters questioned whether the four corner collecting systems were necessary. G. Gee asked if asphalt should be added under the HDPE. H. Freeman suggested spraying on rubberized asphalt coating instead of HDPE. This material is already used in reservoirs. HDPE would not be required to protect the asphalt from the gravel because the asphalt is self-healing. Scuppers will be tested for leaks in the shop. The leaks in the membrane above the scuppers are less important. The leakage rate allowed for HDPE assumes a head of water, as in a surface impoundment, not just drainage. Installation costs could be higher for the HDPE than the asphalt because of the number of seams required. The design team voted in favor of using the asphalt coating. The scuppers would still be fabricated from HDPE. The thickness of the asphalt could be determined by spraying it onto a geogrid until the grid is no longer visible. The slope of the sides in the collecting basins will be from 3% to 6% so water should not be trapped in depressions on the slope. D. Wing suggested notifying the peer review group of the asphalt coating idea.

D. Fort described the barrier stratigraphy and construction sequence. The BDT/BTAB voted to omit the 8 outside collecting basins on the ends. The side slopes on the ends of the barrier will not be irrigated. The total number of collecting systems planned is now 12 instead of 20.

H. Freeman asked if there was any interest in a rubberized asphalt coating over the asphalt aggregate layer. D. Fort said that the asphalt will be placed in two lifts which should negate any need for the coating.

The BDT/BTAB voted to accept the stratigraphic design for the prototype. It was noted that permeameter tests should be performed during construction.

P. Crane presented the preliminary information from testing the construction materials for the prototype.

D. Fort proposed using the drainage material being used in the LERF Project. This gravel has a hydraulic conductivity of 0.1 to 1.0 cm/sec when compacted.

The next workshop is tentatively scheduled for mid-June. W. Riggsbee, member of the peer review group, has been invited to the next weekly meeting. The report from the peer review group has not been received yet.

A draft plan for testing and monitoring of the prototype will be finished in two weeks.

D. Wing reviewed the action items to be performed.

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S.D. CONSORT	
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KAISER ENGINEERS HANFORD

MINUTES OF MEETING

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Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	18	May 19, 1992

Project or Work Order No. and Title

ER2502 Prototype Barrier for the Hanford Site

References

Attendees

L.L. Cadwell
S.D. Consort
M.J. Fayer
H.D. Freeman
M.W. Ligotke
K.L. Petersen
W.H. Walters

Distribution

J.W. Cammann
J.C. Chatters
D.L. Fort
G.W. Gee
B.G. Gilmore
D.R. Myers
R.A. Romine
J.C. Sonnichsen
R.I. Watkins
N.R. Wing
Attenders
Eng.Doc. Control

S. Consort reviewed the minutes from the last meeting.

W. Riggsbee had given another preliminary draft of the report to D. Wing last week. The report has been delayed by problems with contracts. A discussion followed on the scheduling of the June workshop. The members of the peer review group are all free in the latter part of June (22nd to 26th). Information on the latest design will be sent to the peer review group at least one week in advance of the workshop (proposed date of mailing - June 10th). A conference call will be held with the peer review group a couple of days after they receive the information.

W. Riggsbee will send information to H. Freeman on work he was involved with about the asphalt used in the Grout Project.

H. Lachmann requested a briefing on construction requirements for a final barrier for those who are involved with the macro-engineering project. The shape of the area in which waste will be buried when it is moved to the 200 Area plateau can be arranged to facilitate the construction of barriers.

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K. Petersen presented the latest revised version of the statement on preventing human intrusion. The revisions were from the last meeting plus a couple of minor changes suggested at this meeting.

H. Freeman investigated the cost of the asphalt coating for the collecting systems. The cost to install a coating up to ½" thick is less than $1.00/ft².

The format for the draft plan for testing and monitoring of the prototype was distributed with the agenda.

L. Cadwell reviewed the action items to be performed.

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MINUTES OF MEETING

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Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	19	June 2, 1992

Project or Work Order No. and Title
ER2502 Prototype Barrier for the Hanford Site

References

Attendees

L.L. Cadwell
S.D. Consort
D.L. Fort
H.D. Freeman
B.G. Gilmore
M.W. Ligotke
D.R. Myers
K.L. Petersen
J.C. Sonnichsen
W.H. Walters
R.I. Watkins

Distribution

J.W. Cammann
J.C. Chatters
M.J. Fayer
G.W. Gee
R.A. Romine
N.R. Wing
Attenders
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L. Cadwell reviewed the pinch theory. The peer review report was received, but page 15 was missing. L. Cadwell will investigate.

S. Consort reviewed the minutes from the last meeting. H. Freeman has not received any information from W. Riggsbee about his work with the asphalt used in the Grout Project.

H. Freeman and D. Fort discussed the styrene butadiene asphalt coating. D. Fort had spoken to the vendor who installs this coating. He related the information about the tests that have been performed on this asphalt by PNL and Bechtel.

The task group leaders are to send their input for the draft plan for testing and monitoring of the prototype to D. Wing by Thursday. There was some discussion of the requirements to monitor vegetation growth. Horizontal pipe through the sand or gravel filter will provide access to monitor root growth. The task group for water erosion studies had decided to perform the high stress tests at the McGee Ranch site instead of on the prototype.

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Type	Meeting No.	Date
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Most of the BDT/BTAB had just received the report from the peer review group, so there were few comments at this time.

L. Cadwell reviewed the action items to be performed. The package of information for the peer review group must be ready by June 10th.

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Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	20	June 30, 1992

Project or Work Order No. and Title
ER2502 Prototype Barrier for the Hanford Site

References

Attendees

L.L. Cadwell
S.D. Consort
H.D. Freeman
G.W. Gee
B.G. Gilmore
M.W. Ligotke
D.R. Myers
K.L. Petersen
R.A. Romine
N.R. Wing

Distribution

J.W. Cammann
J.C. Chatters
M.J. Fayer
D.L. Fort
J.C. Sonnichsen
W.H. Walters
R.I. Watkins
Attenders
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D. Wing handed out page 15 of the peer review report which had been missing. Also, he handed out copies of J. Cammann's work on the goal, objectives, and strategy for interfacing with regulators for the barrier program.

D. Wing reviewed some of the comments from the peer review group and the BDT/BTAB response at the meeting on June 23rd. He listed the following comments from the peer review group that came from the close-out session.

1) General concurrence with the design -- questions about sideslopes being undercut by water and destruction caused by humans with off-road vehicles.
2) The peer review group supports the need for a prototype.
3) There is a need for studies of gas generation characteristics and subsidence. Also, the group was concerned about possible reactions between gases and asphalt.
4) Barrier objectives -- 0.05 cm/yr - what does this mean?
5) Need detailed testing and monitoring plan. The peer review group would like to review this plan.
6) How will we prove the asphalt is equivalent in performance to clay of RCRA design?

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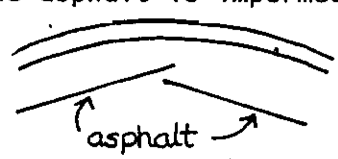
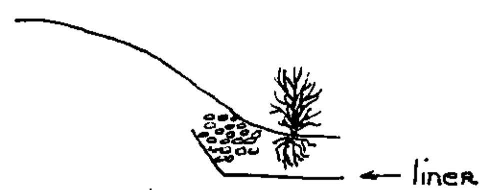
7) Must understand physical properties of asphalt.
8) Post mortem testing.
9) Evaluate water balance using UNSAT H and HELP.
10) Minimum of three years of monitoring.
11) Suggest a vertical vapor barrier (would not penetrate silts). But will vapor phase transport be masked by other things?
12) Use prototype to test other equipment.

The design team discussed the above comments. Also discussed were what physical tests should be performed and whether these tests should be conducted on the prototype or separately. A separate test was suggested for testing the compatibility of carbon tetrachloride and asphalt.

G. Gee asked how to design for gas problems if the asphalt is impermeable. He suggested designing the asphalt layer as two sections that met with an overhang at the ridge down the center. H. Freeman noted that this design could have subsidence problems.

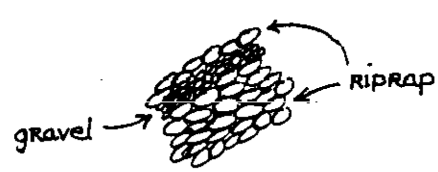


Concerns from one reviewer about vegetation -- plant roots have reached the clay layer at UMTRA sites. The rock on the side slopes fills with silt. On some sites, trees have been introduced. Should there be a catch basin with vegetation at the base of the slopes to harvest water? This condition will occur naturally, so why not exploit it? Liner to provide catch basin will also prevent backflow.



Another concern is whether rhizotron tubes will provide preferential pathways for water infiltration.

Suggestion to add gravel layer near surface of riprap to prevent deeper penetration of windblown sand and silt thus deterring deep root penetration. D. Myers suggested that one section of riprap be tested by adding sand -- test on prototype or separate plot?



One comment from the peer review group was the importance of testing whether the capillary break will function over a large area?

K. Petersen answered how the 1000 year storm could be applied. Begin with one inch in the first hour and taper down during the next 23 hours.

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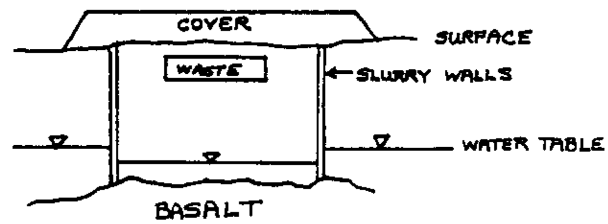
B. Gilmore noted that if a barrier is as large as three square miles, it could cut off local recharge (if any) to the water table.

D. Myers presented the idea being studied recently of walling off the entire section beneath the 200 Areas from the surface down to the basalt. Since there exists a plume of carbon tetrachloride beneath 200 West and a plume of cyanide beneath 200 East, building a slurry wall around the perimeter of both areas could seal off the contamination (assuming that the slurry wall could be sealed against the basalt). The seal required to contain the contaminants may not be feasible and costs may be prohibitive.



D. Wing asked the task group leaders to review the testing and monitoring plan.

B. Gilmore suggested creating a standardized way of handling data from all of the different task groups. This item was tabled for the next meeting.

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S.D. CONSORT	
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KAISER ENGINEERS HANFORD	MINUTES OF MEETING	BHI-00007 Rev. 00

Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	21	July ~~7~~ 14, 1992

Project or Work Order No. and Title

ER2502 Prototype Barrier for the Hanford Site

References

Attendees

L.L. Cadwell
J.W. Cammann
S.D. Consort
J.L. Downs
D.A. Duranceau
M.J. Fayer
H.D. Freeman
D.L. Fort
G.W. Gee
B.G. Gilmore
A.C. Harris
M.W. Ligotke
K.L. Petersen
W.H. Riggsbee
J.C. Sonnichsen
W.H. Walters
R.I. Watkins
N.R. Wing

Distribution

J.C. Chatters
D.R. Myers
R.A. Romine
Attenders
Eng.Doc. Control

D. Wing welcomed everyone and began introductions since more members of the task groups were present.

W. Riggsbee presented the twelve comments of the second peer review which were mentioned at the meeting of June 30th. The BDT/BTAB discussed these comments. The draft document from the peer review group is in the process of being signed off.

D. Wing explained the history behind the program goal, the statement on human intrusion, and the objectives.

D. Fort presented the latest status of the barrier design including modifications recommended by the peer review group. He explained where the materials for construction would be obtained. He is working on the design for the vapor barrier. The design team was asked to decide whether to keep ½m as the thickness of the basalt riprap. This thickness was based on economy. The decision was to retain ½m as the design thickness. Also, D. Fort requested information from the task groups on placement of testing equipment in the barrier. He recommended

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coating the asphaltic concrete with the rubberized asphalt coating that will be used on the collecting basins so that this layer is a composite.

A. Harris asked about the cost of the barrier compared to other barrier designs. D. Wing said that there is no comparable design because the RCRA barrier is only designed for a 30 year lifespan while Hanford's design is for 1000 years. Also, costs will be higher for building a small prototype with all the testing and monitoring equipment compared with mass producing materials on site for the larger final barriers that will not contain all of the special testing features.

G. Gee presented the testing and monitoring plan explaining the layout of treatments and equipment. He also invited design team members to join him on a tour of cover designs at Hill Air Force Base in Ogden, Utah on July 23rd.

D. Wing said that the barrier development program document was being revised again. This time it was being made into a Barrier Design Team document.

L. Cadwell asked for the task groups to each submit a one to two page document on their work which will be compiled into a highlights document. He needs this input by the middle of August.

J. Cammann presented his work on the summary of end use and regulatory interfacing. The RCRA covers have been failing at a rate of approximately one per month across the nation. The regulators are in favor of the barrier project. Appointing a special topics group was suggested. Also, building a Hanford barrier beside a RCRA barrier at Hill Air Force Base for a direct comparison of performance was suggested again.

D. Wing met with sponsors last Thursday. Funding is still meager. More work has to be done to obtain funding. The sponsors are pleased with the technical aspects.

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KAISER ENGINEERS HANFORD

MINUTES OF MEETING

Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	22	August 18, 1992

Project or Work Order No. and Title
ER2502 Prototype Barrier for the Hanford Site

References

Attendees
L.L. Cadwell
S.D. Consort
D.L. Fort
G.W. Gee
F.H. Lee
D.R. Myers
K.L. Petersen
J.C. Sonnichsen
W.H. Walters
R.I. Watkins
N.R. Wing

Distribution
J.W. Cammann
J.C. Chatters
J.L. Downs
M.J. Fayer
H.D. Freeman
B.G. Gilmore
A.C. Harris
M.W. Ligotke
R.A. Romine
Attenders
Eng.Doc. Control

D. Wing opened the meeting with information on the following items:
He answered questions about the projected budget after October 1st.
The document from the peer review workshop has been submitted for clearance and editing.
He reviewed last week's meeting with the WDOE and EPA.
He introduced Fred Lee from project management in Westinghouse and reviewed the background on applying DOE Order 4700 to this project. R. Gilchrist has said that DOE 4700 does not apply. F. Lee was part of a meeting last week between the DOE and the project management of Westinghouse. The project plan for the barrier is being converted into a project management plan to fall in line with 4700. This project is special and will be isolated from the rest of the ER program.

D. Wing suggested updating the design basis document to create a better document trail for this project.

D. Fort reported on the status of the specification and drawings for the barrier design. He explained the problem with tying into the water supply. The system has been due for upgrade for years.

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S.D. CONSORT	
Title	Title

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D. Wing reported on the status of the Barrier Development Plan and other documents.

G. Gee reported on the status of the testing and monitoring plan. The peer review group has read and commented on the draft version.

L. Cadwell had received most of the input from the task groups for the highlights document.

K. Petersen described the status of the project on coring lake sediments to analyze past climates.

D. Wing explained the memorandum of understanding between the OTD and the ER on funding for the barrier prototype.

W. Walters described the erosion studies on the plots that were built in 1990. One had native soil and the other was admixed with pea gravel. The simulated rainfall was applied at a rate of 60 mm/hr (simulator's limit is about 80 mm/hr) for a ½ hour test. This produced a great deal of runoff. The second test produced less sediment. A greater amount of vegetation grew on the admixed plot. Vegetation was established by the second year. This year, the test with simulated rainfall (60mm/hr) did not produce runoff for the first 8 minutes. The test was extended from ½ hour to 1 hour. The runoff contained very little sediment, insufficient for hydrometer analysis.

G. Gee spoke about funding for 1993.

R. Watkins outlined the action items for D. Wing (questions on the technical data checklist and safety classification).

D. Wing noted that the specification and drawings will be reviewed by the peer review panel. RCR's will be requested from all who review the specification and drawings.

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S.D. CONSORT	
Title	Title

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Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	23	August 25, 1992

Project or Work Order No. and Title

ER2502 Prototype Barrier for the Hanford Site

References

Attendees

J.W. Cammann
S.D. Consort
D.L. Fort
G.W. Gee
F.H. Lee
W.W. Pickett
J.C. Sonnichsen
W.H. Walters
R.I. Watkins
N.R. Wing

Distribution

L.L. Cadwell
J.C. Chatters
J.L. Downs
M.J. Fayer
H.D. Freeman
B.G. Gilmore
A.C. Harris
M.W. Ligotke
D.R. Myers
K.L. Petersen
R.A. Romine
Attenders
Eng.Doc. Control

D. Wing told the team about the meeting with the EPA and the DOE last week on August 20th. The EPA proposed to move the location for construction of the prototype barrier from the Hanford Meteorological Station to the 200-BP-1 Operable Unit. The proposed sites are 1) over the clean 216-B-61 crib or 2) over the 216-B-57 crib which contains waste. The cover over 216-B-57 would be a hybrid of a final cover over the waste and the prototype with its additions for testing and monitoring as an extension. D. Wing asked the task groups to discuss the impacts of changing the location of the prototype. The operable unit has a continuing problem with wind blown contamination. Also, there is subsurface contamination in some areas. The 216-B-61 crib does not require a cover because it has never been used.

J. Cammann noted that technology and RCRA equivalency must be proven before a ROD can be obtained.

D. Fort said that a ROD would not be required if the prototype was built over a contaminated site as a treatability study. But we must know the extent of the contamination at the 216-B-57 crib to redesign the cover.

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S.D. CONSORT	
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J. Cammann said that the wind erosion tests would be affected by the change in barrier orientation required to place the prototype over 216-B-61. Also, visitors to the prototype might need protective clothing if they will be downwind of waste sites. The interface between future barriers over the adjacent waste sites could be a problem.

R. Watkins noted that the monitoring wells near the cribs would have to be abandoned and replaced.

W. Walters asked about samples being contaminated and the difficulty of releasing them from the site. All samples would require surveying for radioactivity.

D. Wing noted that building over 216-B-61 (a clean site) would require redesign of the barrier without gaining anything. Potential contamination on the surface at 216-B-61 could cause problems.

The barrier must be built by the end of 1993 to comply with the milestone for DOE headquarters.

The construction of the prototype at 216-B-61 would have unnecessary costs and delays unless this area was removed from within the boundary of the operable unit.

The BDT listed the pro's and con's of the choice between the two sites within the 200-BP-1 operable unit in the following tables.

216-B-57

PRO's	CON's
potentially completes site closure	proximity to tank farms (potential surface contamination)
shows progress in Hanford plan for clean-up	extent of contamination unknown
could save money on operable unit if prototype design does not require modification	difficulty obtaining release of samples from 200 Area (contaminated samples)
assume treatability study	interface with future covers over waste sites both within and outside of operable unit
technology transfer from OTD to ER	functions and requirements of this site unknown

Prepared By	Approved By
S.D. CONSORT	
Title	Title

HPM_614.KEH 9/1/90

Type	Meeting No.	Date
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Minutes Continued

	impact to cost and schedule (design alterations and construction delays)
	revision of testing and monitoring plan (no 3X precipitation, etc.)
	restricted access (OSHA and radiation training required)

<u>216-B-61</u>

PRO's	CON's
clean site	orientation to wind will be different
same size barrier as present design for prototype (no major redesign required)	proximity to other contamination
compromise between 216-B-57 and not moving prototype	existing wells must be abandoned and replaced
located in an operable unit and over a waste disposal structure	impact to cost and schedule
	delay in removing samples from 200 Area
	monitoring more expensive
	restricted access (OSHA and radiation training may be required)
	no long term benefit (no risk-based requirements)

D. Fort suggested a statement of how we can support EPA, a counter proposal after looking at the pro's and con's. The bottom half of the prototype design could be constructed over 216-B-57 (an interim cover of asphalt) while the location for the prototype remains near the meteorological station. The operable unit could provide funding for the cover for 216-B-57. It would be better to have the "flag ship" barrier at the meteorological station than within the operable unit.

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S.D. CONSORT	
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Minutes Continued

Constructing the prototype over a contaminated crib would require higher QA and maybe a different safety classification. SAR required or would a PA be sufficient?

The choice of sideslope treatment is being tested by the prototype. Which would be used over 216-B-57? An interim asphalt cover would not require this decision and could provide a test for the asphalt's performance. The asphalt could be protected from sunlight by drainage gravel covered by a geotextile and an overburden of sand. The geotextile and sand would be removed when the cover was completed. In the interim, the overburden would be vegetated.

Eventually, the EPA would have everything in the operable unit covered. The BDT would provide design input for what they need as a separate design activity. The design input would address problems with interfacing covers especially with the problem of the waste sites being at different elevations. Intermediate covers could be used for different operable units with completion over all adjacent units later. G. Gee proposed deep fill with vegetation over potential water collection points in adjoining covers with different elevations.

COUNTER PROPOSAL

1) Leave the prototype barrier located at the Hanford Meteorological Station.

2) The BDT will design and construct a cover at the 200-BP-1 operable unit using "state-of-the-art" technology and expertise in barrier design.

3) Continue support to close out technical issues for ongoing studies (erosion studies, biointrusion studies, etc.) and short-term studies (building Hanford cover at Hill AFB to demonstrate RCRA equivalency).

COUNTER PROPOSAL

PRO's	CON's
no cost and schedule impacts to prototype	
satisfies both technical and political needs	
BDT believes Hanford cover design better than RCRA version	

Prepared By	Approved By
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systems approach to barrier design at 200-BP-1 (could eliminate barrier interface problems)	
meets requirements of EPA's draft accelerated ROD/remediation	
allows systematic completion of barrier development plan	
eliminates restrictions on access, testing, and monitoring	
likely no cost and schedule impact to final closure of inactive crib sites	

R. Watkins will write the proposal.

Prepared By	Approved By
S.D. CONSORT	
Title	Title

KAISER ENGINEERS HANFORD

MINUTES OF MEETING

BHI-00007
Rev. 00

Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	24	Sept. 11, 1992

Project or Work Order No. and Title

ER2502 Prototype Barrier for the Hanford Site

References

Attendees

J.W. Cammann
S.D. Consort
D.L. Fort
G.W. Gee
F.H. Lee
D.R. Myers
W.W. Pickett
W.H. Walters
N.R. Wing

Distribution

L.L. Cadwell
J.C. Chatters
J.L. Downs
M.J. Fayer
H.D. Freeman
B.G. Gilmore
A.C. Harris
M.W. Ligotke
K.L. Petersen
R.A. Romine
J.C. Sonnichsen
R.I. Watkins
Attenders
Eng.Doc. Control

The design team met to review comments on the preliminary version of the specification.

W. Walters had some questions whether there was sufficient information about obtaining the desired gradation for the basalt (to see if average size is 4 inches). How should samples be taken? Visually inspect or run sample over a "grizzly"? There was a suggestion to dictate particle size of fine materials to control blasting. The team decided to change the maximum particle size from 12 to 10 inches. Particles larger in one dimension could still come through, but the smaller maximum size would provide greater control. The design team decided to have no more than 5% passing a 5/8 inch sieve to control the fine materials.

J. Cammann suggested that the WHC mobile laboratory would be present at the borrow sites to test the gradation of materials. We will add the statement to the specification that the operator will verify screening of materials. Also, J. Cammann suggested changing references to KEH to onsite architect/engineer.

Prepared By	Approved By
S.D. CONSORT	
Title	Title

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MINUTES OF MEETING - CONTINUED

Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	24	Sept. 11, 1992

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Minutes Continued

D. Myers comments were reviewed and changes decided for the following.

- ASTM A 778 & A 312 will be checked to determine if they should be added for well screens and stainless steel pipe.
- ASTM A 240 will be checked to see if it should be removed.
- Instructions for the compaction of some materials will be added.
- There was a question about problems with the aluminum pipe in contact with a galvanized steel encasement. The section of pipe in the encasement must be wrapped or the encasement material changed to PVC.
- A hold point is needed after the neutron probe access tubes are in place, but before they are covered. At this time, a dummy probe would be pulled through to ensure correct installation of the pipe.
- 50% passing a #230 sieve was deemed too fine for the specification of the silt. The team decided to change to 30% passing a #230 sieve. Also, instructions for adding water to the silt (to assist in handling it) will be added.
- The reference to the "Hoosier" method of placing the silt will be removed and silt placement will be redefined.

M. Fayer asked for a greater tolerance in placing the access tubes for the neutron probes and the comment was accepted.

D. Wing suggested placing a sign on the access road to the site that would identify the project. This could be ordered through the sign shop later and not added to the specification.

G. Gee suggested adding plot details to final treatment drawing.

D. Myers suggested changing the wording on signs restricting access. The signs could be lettered with something similar to "unauthorized entry may damage the validity of environmental testing". The team agreed to this change.

Both members of the design team and the peer review group asked that the overlap between the geomembrane and the geotextile in the collection basins be reversed.

Details on the utility vault drawings required minor changes.

There was a discussion of placing ball valves in transparent tubes on the siphons in low flow areas. Also, a siphon should be tested.

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Title	Title

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MINUTES OF MEETING

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Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	25	Sept. 14, 1992

Project or Work Order No. and Title

ER2502 Prototype Barrier for the Hanford Site

References

Attendees

L.L. Cadwell
S.D. Consort
M.J. Fayer
D.L. Fort
M.W. Ligotke
D.R. Myers
K.L. Petersen
W.W. Pickett
W.H. Riggsbee
R.I. Watkins
N.R. Wing

Distribution

J.W. Cammann
J.C. Chatters
J.L. Downs
H.D. Freeman
G.W. Gee
B.G. Gilmore
A.C. Harris
F.H. Lee
R.A. Romine
J.C. Sonnichsen
W.H. Walters
Attenders
Eng.Doc. Control

The design team met to review comments on the preliminary version of the specification.

L. Cadwell asked about controlling wind blown sand and dust during barrier construction. These details are included in a section of Division 1 which had not yet been available for review.

D. Fort responded to the action items from the meeting of September 11th.
The ASTM for the pipe is 312, not 240.
There will be a problem with aluminum pipe in contact with a carbon steel encasement. The section of pipe in the encasement must be wrapped or the encasement material changed to PVC. It was decided to change the encasement material to PVC.

M. Ligotke asked about moving the location of the parking lot to the north side of the access road to minimize its effects on the wind erosion studies. Also, this would provide the contractor with a better location for a trailer during

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S.D. CONSORT

Title

Approved By

Title

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HANFORD

MINUTES OF MEETING - CONTINUED

Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	25	Sept. 14, 1992

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Minutes Continued

construction. M. Ligotke corrected the sieve sizes for the pea gravel. There was a discussion of obtaining an electrical power source or running equipment from batteries or a solar supply. The three towers for measuring the vertical profile of the wind will be connected to a data logger located beside the tower which is off the barrier. Cables connecting the data logger to the towers can be buried in conduit and will be documented on as-built drawings.

D. Wing proposed documenting all testing and monitoring equipment on as-built drawings.

D. Fort asked the team to designate the hold points needed in the specification for the contractor. The information in the testing and monitoring plan will control the hold points and answer many of the questions submitted by the peer review group. Since the plan is not available yet, estimated hold points will be added to the specification. ECNs may be used later to accommodate unforseen hold points.

Limits must be specified for the construction zone. Only five acres or less may be disturbed during construction to comply with the NEPA documentation. Area outside of the boundary of influence noted on the drawings may not be disturbed without prior written permission.

M. Fayer quickly went over his comments with D. Fort.

There were some questions about tolerances of materials. D. Fort pointed out where these were stated and some changes were made.

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S.D. CONSORT	
Title	Title

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KAISER ENGINEERS HANFORD	**MINUTES OF MEETING** BHI-00007 Rev. 00	
Type: BDT/BTAB WEEKLY MEETING	Meeting No.: 26	Date: Sept. 22, 1992

Project or Work Order No. and Title
ER2502 Prototype Barrier for the Hanford Site

References

Attendees
M.R. Adams
J.W. Cammann
J.C. Chatters
S.D. Consort
H.D. Downey
M.J. Fayer
D.L. Fort
H.D. Freeman
G.W. Gee
B.G. Gilmore
M.W. Ligotke
D.R. Myers
K.L. Petersen
W.W. Pickett
R.A. Romine
M.R. Sackschewsky
W.H. Walters
R.I. Watkins
N.R. Wing

Distribution
L.L. Cadwell
J.L. Downs
A.C. Harris
F.H. Lee
J.C. Sonnichsen
Attenders
Eng.Doc. Control

The BDT/BTAB began the meeting with lunch. D. Wing thanked everyone for their work on the barrier project.

J. Cammann talked about the program and the development of barrier technology. The regulators already have favorable opinions about the technology. They are supportive of disposal in situ of wastes in the cribs of the 200-BP-1 Operable Unit. The waste could be grouted to prevent subsidence. There is a letter from the EPA to WHC about constructing the prototype barrier over 216-B-57 crib as a treatability study. DOE-RL is in favor of this plan. The size of the barrier would not have the acreage restriction required by the permit on the original proposed site. EPA is apparently not concerned with the quantities of water proposed for testing the prototype. Mobile laboratories could be provided on site to deal with the difficulty of removing samples from a zone with potential contamination. Surfactants could be applied on the tank farm to minimize wind blown contamination.

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S.D. CONSORT	
Title	Title

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Type	Meeting No.	Date
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D. Myers presented slides on the construction of the 216-B-57 crib and a profile of the radioactive contaminant distribution from the three boreholes drilled through this crib.

J. Cammann noted that the barrier over 216-B-57 must be constructed to interface with the future barrier over all the used cribs of the 200-BP-1 Operable Unit.

The southern half of the 216-B-57 crib is at grade and the northern half is a few feet above grade. The barrier would be built against the steep slope of the tank farm. Also, there could be radioactive surface contamination from the tank farm.

M. Adams explained the circumstances and reasons for building over 216-B-57 crib. DOE wishes to meet some RODs before the deadlines. Approximately the northern third of 216-B-57 crib is clean because it was not used.

D. Fort asked about the lateral extent of the contamination plume. This information is needed for design. This cover would have to interface with the future cover over the rest of the 200-BP-1 contaminated cribs. The design constraints of this site must be determined before redesign can proceed.

G. Gee explained the testing of the sideslopes planned for the prototype which includes application of water with infiltration expected. An extension of the barrier would be required to keep this portion of the testing off of the waste site.

The BDT asked questions about the budget. $2.2 million is the amount of the present budget. The extenuating circumstances for relocating the barrier from a clean site to 216-B-57 (including controlled access, training for hazardous sites, surveys by health physics technicians, increased size of barrier to cover waste site as well as provide testing area, etc.) will increase the expense of construction. What budget will provide the support staff? Also, design costs increase. The design of the prototype for the clean site is complete. Except for the stratigraphy, most of the design will have to be changed to accommodate the new location including a new shape, orientation, and access on the steeper site, altered layout of the drainage and collection systems, and redesign of the sideslope configuration.

G. Gee noted that NEPA documentation took 1½ years to obtain for a clean site. M. Adams said that being a treatability study will exclude the prototype from NEPA permits, but these will be required for the closure of the entire 200-BP-1 site.

M. Adams wants to show that we can construct the barrier on a "hot" site. He said to contact M.A. Buckmaster for information on the extent and characteristics of contaminants.

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J. Cammann asked if barriers were truly needed at this site since the radionuclides are do not appear to be migrating after the years of exposure to infiltration of precipitation and water pored into the cribs. Also, is the ER program willing to support continuation of testing to demonstrate the probability that this design will last 1000 years? H. Downey could not guarantee such support.

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Title	Title

KAISER ENGINEERS HANFORD

MINUTES OF MEETING

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Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	28	October 13, 1992

Project or Work Order No. and Title
ER2502 Prototype Barrier for the Hanford Site

References

Attendees

M.R. Adams
L.L. Cadwell
J.W. Cammann
R.A. Carlson
S.D. Consort
D.L. Fort
G.W. Gee
B.G. Gilmore
M.W. Ligotke
D.R. Myers
K.L. Petersen
J.C. Sonnichsen
R.I. Watkins
N.R. Wing

Distribution

J.C. Chatters
J.L. Downs
M.J. Fayer
H.D. Freeman
A.C. Harris
F.H. Lee
R.A. Romine
W.H. Walters
Attenders
Eng.Doc. Control

J. Cammann presented the agenda for the meeting.
1) Site specific considerations (i.e. cover entire crib?)
2) Short-term considerations
3) Long-term considerations
4) Barrier redesign (cost, schedule, design)
5) Other concerns

R. Watkins distributed a DSI identifying specific requirements that KEH needs from WHC and DOE for redesign. Points noted were a five-week engineering study with no CDR before definitive design begins.

L. Cadwell asked if the redesign was still for a prototype, a hybrid, or what? J. Cammann said that the design is still for a prototype because the technology must still be demonstrated. We must minimize the impact on the prototype that the move to 216-B-57 may cause.

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S.D. CONSORT	
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Minutes Continued

The design team discussed the following questions.

Who will perform the treatability study and establish objectives for data quality, the ER or the BDT/BTAB? The BDT/BTAB. The design objectives will drive the data quality objectives.

How do we design the prototype so that it does not impact future plans for the 200-BP-1? Side slope treatment must be decided because it will affect orientation and the interface with future barriers.

Will part of the barrier for 216-B-57 remain as a final barrier?

Who is responsible for negotiating ARARs with the regulators since specific requirements and codes are not defined in the regulations? The feasibility study by Golder Associates should determine regulatory requirements. The operable units are not under the jurisdiction of the NRC, but under CERCLA.

L. Cadwell asked if we could use tracers (i.e. lithium chloride) to monitor plant intrusion on the 216-B-57 site because the site is already contaminated. ER recommended against this.

D. Fort, G. Gee, and B. Gilmore calculated the approximate quantities of water that would be applied and collected. Approximately 40,500 gallons of water would be applied to about 2/3 acre of the prototype to simulate a 1000 year storm (about 73,000 gal/acre). About ½ million gal/acre/year would be applied to that portion of the prototype being tested with three times the average annual precipitation. The runoff will have to be tested for radionuclide content. Will containment be required for the runoff? Could the runoff be trucked to modutanks or sent to the clean crib, 216-B-61?

Are there other tests and monitoring that should be added to a prototype on a contaminated site that were not included for the clean site.

D. Wing asked about schedule requirements. Prototype must be constructed within FY'93. If constructed with onsite forces, the 90-day bid cycle will be eliminated.

D. Myers noted that the site near the Meteorological Station would be leveled by cut and fill work. Borrow materials will be necessary at the crib site. Vegetation at 216-B-57 that must be cleared may be "hot". Some wells (ground water monitoring and vadose zone) must be abandoned.

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If a portion of the prototype is to remain as part of the permanent barrier on 200-BP-1, will warning markers be installed? This will limit tilling to reduce compaction in the silt.

ER confirmed that the prototype (at least the portion over the crib) should be designed to remain as a piece of the permanent surface barrier. This means including all components. The prototype should be left over 216-B-57 and not disturbed when the remaining cribs are covered.

The lateral extent of the waste must be determined before the barrier is constructed. Otherwise, the side slopes would have to be disturbed later to investigate.

The portion of the barrier over the crib needs to be designed with the best choices. The extension that will be tested for validation of design can be built with the options.

The thickness of the basalt was reduced for the design at the Meteorological Station because it was unnecessary to test it at full thickness.

Answers are still needed about safety class and QA requirements.

A corner of the extension could be destructively tested.

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MINUTES OF MEETING

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Type	Meeting No.	Date
BDT/BTAB WEEKLY MEETING	29	October 16, 1992

Project or Work Order No. and Title
ER2502 Prototype Barrier for the Hanford Site

References

Attendees

L.L. Cadwell
J.W. Cammann
S.D. Consort
D.L. Fort
G.W. Gee
D.R. Myers
J.C. Sonnichsen
R.I. Watkins
N.R. Wing

Distribution

J.C. Chatters
J.L. Downs
M.J. Fayer
H.D. Freeman
B.G. Gilmore
A.C. Harris
F.H. Lee
M.W. Ligotke
K.L. Petersen
R.A. Romine
W.H. Walters
Attenders
Eng.Doc. Control

J. Cammann presented slides of the 200-BP-1 Operable Unit.

ER has agreed to fund an additional investigation of the lateral extent of the contaminant plume. Are we to cover the crib or the contaminant plume with the prototype? If we do not cover the contamination, why build over the crib?

J. Cammann presented slides of the possible extent and orientation of the prototype.

There might be a meeting scheduled with R.D. Izatt of DOE next week.

The team discussed the possibility of spreading contamination with the testing planned.

D. Fort presented his design ideas for the extent of the prototype when allowing for a 5° and 15° angle of lateral dispersion of contaminants from the 216-B-57 crib.

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S.D. CONSORT	
Title	Title

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HANFORD

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G. Gee suggested that collection systems could be placed under all side slopes to protect against water infiltrating contaminated areas. Asphalt could be extended to provide an area to harvest water from the side slopes. Otherwise, the introduction of water on the side slopes will spread laterally and could interact with the plume of contaminant. Working on a clean site allows more freedom of testing and manipulation.

The meeting closed with an action item to compile information for a meeting with R. Izatt. Prepare sketches with different footprints over the crib.

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S.D. CONSORT	
Title	Title

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Appendix B

Construction Drawings

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PROJECT TITLE:

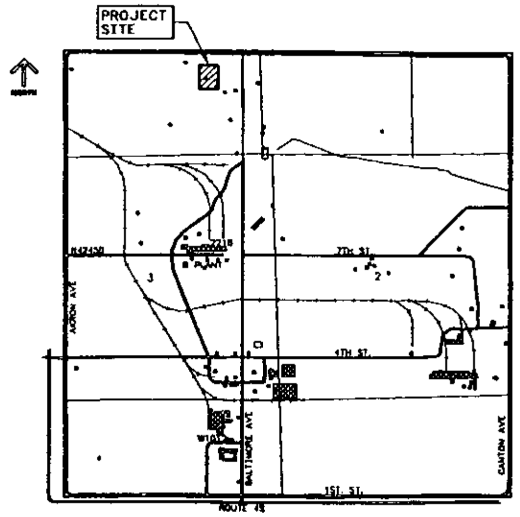
W-263 PROTOTYPE SURFACE BARRIER

FOR:

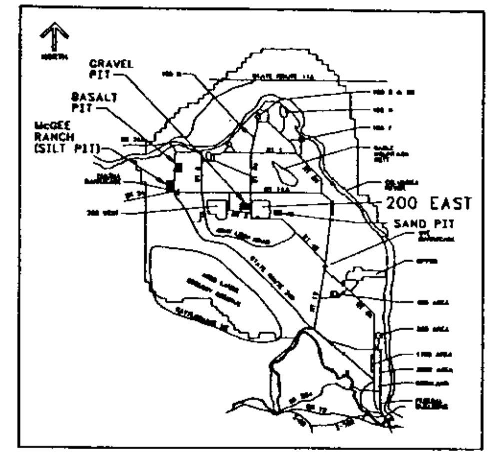
WESTINGHOUSE HANFORD COMPANY

BY:

KAISER ENGINEERS HANFORD



200 EAST AREA MAP



KEY MAP

DRAWING LIST

DWG. NO.	INDEX	BLDG. NO.	TITLE
H-2-817484	0110	216-B-57	DRAWING LIST
H-2-817485	0110	216-B-57	CIVIL - SITE PREP PLAN
H-2-817486	0110	216-B-57	CIVIL - PROFILE - RAW WATER
H-2-817487 SH 1 & 2	0110	216-B-57	CIVIL - PROFILE & DETAILS - RAW WATER
H-2-817488 SH 1	0110	216-B-57	CIVIL - PLAN, SECTION & DETAIL - WATER COLLECTION SYSTEM
H-2-817488 SH 2	0110	216-B-57	CIVIL - PLAN, SECTION & DETAIL - WATER VOLUME SYSTEM
H-2-817489 SH 1	0110	216-B-57	CIVIL - PLAN, SECTION & DETAIL - ASPHALTIC LAYER
H-2-817489 SH 2	0110	216-B-57	CIVIL - PLAN, SECTION & DETAIL - ASPHALT LAYER DRAINAGE
H-2-817490	0110	216-B-57	CIVIL - PLANS - DRAINAGE & BASALT LAYERS
H-2-817491	0110	216-B-57	CIVIL - PLAN - FILTER & CLEAN FILL LAYERS
H-2-817492	0110	216-B-57	CIVIL - PLAN - LOWER & UPPER SILT LAYERS
H-2-817493 SH 1 & 2	0110	216-B-57	CIVIL - FINAL PLAN - ROADS, BARRICADES, SIGNS
H-2-817494	0110	216-B-57	CIVIL - SECTIONS & DETAILS -BARRIER CROSS SECTION
H-2-817495	0110	216-B-57	CIVIL - PLAN & DETAILS - ASPHALT TEST PAD, LYSIMETER
H-2-817496	0110	216-B-57	CIVIL - DETAILS - ROAD, SIGNS & ACCESS TUBES
H-2-817497 SH 1	8001	216-B-57 & 2503-E	ELECTRICAL - SITE PLAN & DETAILS
H-2-817497 SH 2	8002/8003	216-B-57 & 2503-E	ELECTRICAL - DETAILS
H-2-817497 SH 3	8003	216-B-57 & 2503-E	ELECTRICAL - DETAILS

SPECIFICATIONS

ER3412-C1	CONSTRUCTION SPECIFICATION (CPAF)
ER3412-C2	CONSTRUCTION SPECIFICATION

LEGEND

HANFORD COORDINATES (IN FEET)	*N46000* (ITALICS)
LAMBERT GRID COORDINATE (IN METERS)	N137500 (BLOCK)
PERMANENT MONUMENT	
EXISTING CONTOUR (0.5 METER INTERVALS)	
FINISH CONTOUR (0.5 METER INTERVALS)	219.5
SPOT ELEVATION (FNSH)	220.50
LEVEL RIDGE OR VALLEY ELEVATION	195.88
SLOPE DIRECTION	
EXISTING FEATURE	
EXST UNDERGROUND PIPELINE	
POST BARRICADE	
SECURITY FENCE	
BOUNDARY OF CLEARING OR GRUBBING	
COLLECTION ZONE	6E

GENERAL NOTES

1. CODES AND STANDARDS

   A.) BASED ON THE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS OR STANDARDS (ARARS) REQUIREMENT OF SECTION 121 OF THE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA), THE DESIGN IS BASED ON CONFORMANCE TO THE TECHNICAL REQUIREMENTS OF 40 CFR 191 AND 10 CFR 61, THOUGH THESE REGULATIONS ARE NOT DIRECTLY APPLICABLE.

   B.) THE PROTOTYPE SURFACE BARRIER CONTAINS ELEMENTS FOR THE TESTING OF A LONG TERM SURFACE BARRIER CONCEPT PROPOSED FOR THE HANFORD SITE. SUBSTANTIATION OF SUCH ISSUES AS EQUIVALENCY TO REGULATORY STANDARDS, LIFE EXPECTANCY, AND MINIMAL MAINTENANCE ARE SOME OF THE OBJECTIVES.

2. THE BREADTH OF COVERAGE PROVIDED BY THE PROTOTYPE SURFACE BARRIER AT THE 216-B-57 CRIB WAS ESTABLISHED TO COVER THE INFILTRATIVE SURFACE OF THE CRIB PLUS THE NEAR SURFACE PLUME EXTENSION AT THE SOUTH END OF THE CRIB. IN SITU CHARACTERIZATION PROBES OF APPROXIMATELY 15 METERS (50 FEET) IN DEPTH HAVE VERIFIED INCLUSION OF THE NEAR SURFACE PLUME WITHIN THE FULLY FUNCTIONING PORTION OF THE BARRIER. (32 M x 69 M)

3. ELEVATIONS SHOWN ARE METERS ABOVE MEAN SEA LEVEL
   CONTOUR INTERVALS = 0.5 METER (UNLESS NOTED)

4. DIMENSIONAL TOLERANCES ARE AS FOLLOWS (UNLESS NOTED):

EXAMPLE	ACCURACY
WITHOUT DECIMAL - 25 M	± 0.5 M
75 mm	± 5 mm
SINGLE DECIMAL PLACE - 5.0 M	± 0.1 M
TWO DECIMAL PLACES - 1.00 M	± 0.05 M
THREE DECIMAL PLACES - 1.020 M	± 0.005 M

5. PIPE SIZES SHOWN ARE NOMINAL. CONVERSION FROM METRIC TO ENGLISH IS AS FOLLOWS: 12mm = ½ INCH; 65mm = 2½ INCHES; 75mm = 3 INCHES; 100mm = 4 INCHES; 150mm = 6 INCHES; 300mm = 12 INCHES.

6. NOMINAL DIMENSIONS FOR WIDTH OF ASPHALT LIFTS:
   3.7 M = 12 ft
   4.1 M = 13.5 ft
   5.7 M = 18.7 ft or 19 ft
   FOR LENGTHS OF PIPE OFFSETS: 150mm = 6 INCHES

7. BOLD CONTOUR LINES INDICATE THE EXTENT OF THE MATERIAL LAYER NOTED IN THE PLAN TITLE. PLANS ARE ORIENTED ON THE DRAWINGS IN AN ANTICIPATED CONSTRUCTION SEQUENCE.

H-2-817484

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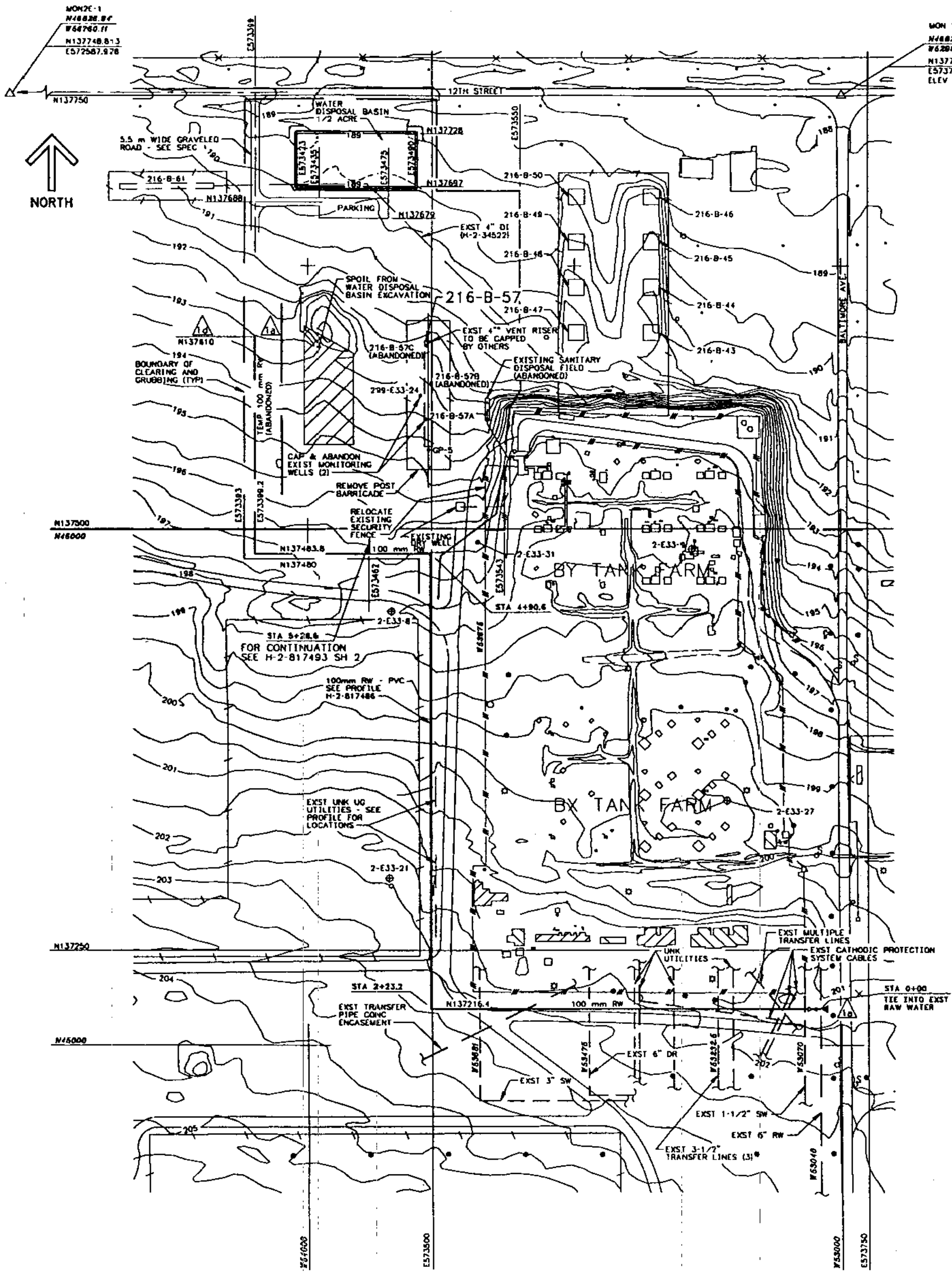
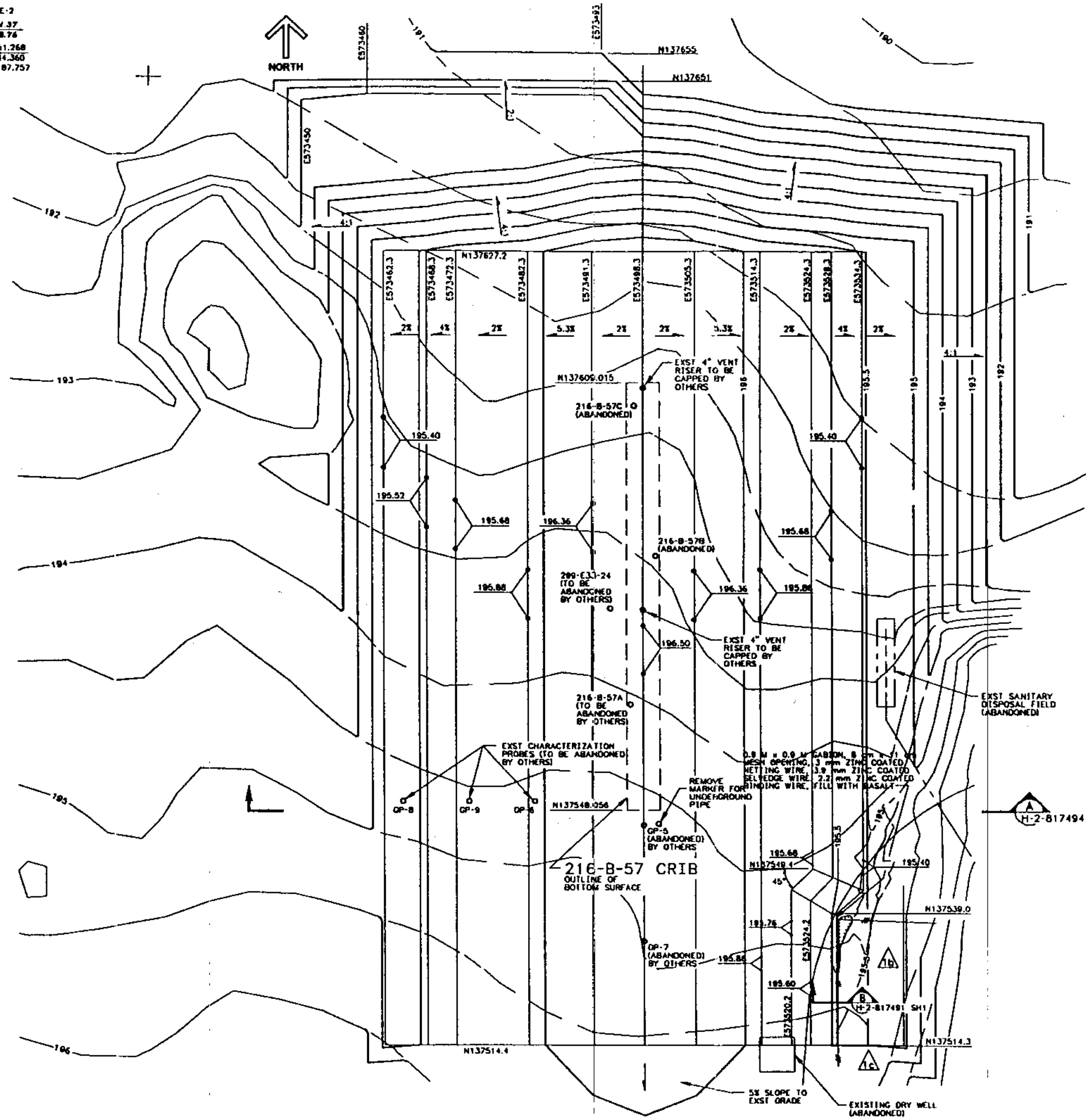


SITE PLAN
SCALE = 1:1200



ENLARGED PLAN 216-B-57 CRIB - SITE PREP/SUBGRADE FILL
SCALE = 1:300

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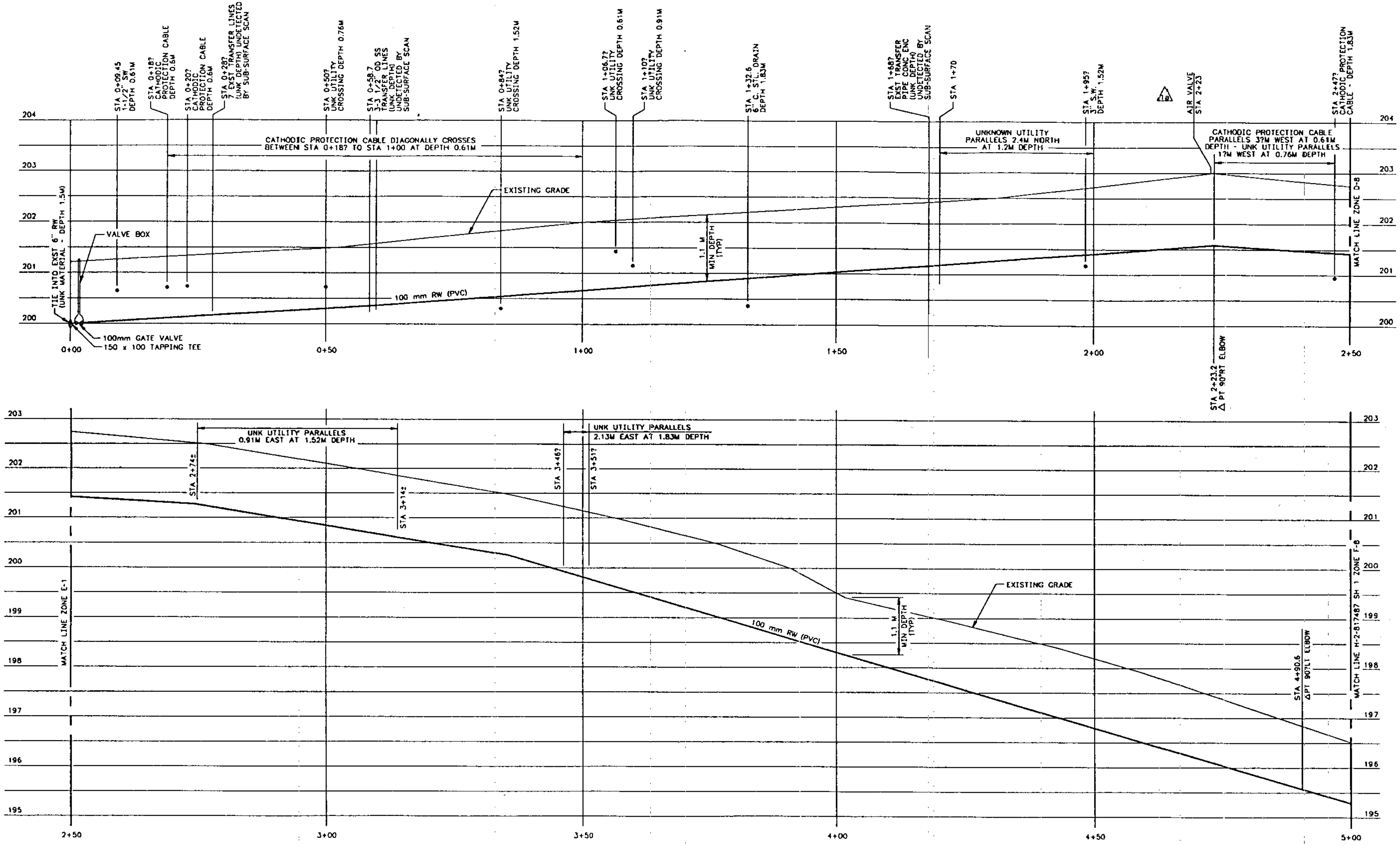

RAW WATER PROFILE

SCALE = 1:300 HORIZONTAL
1:30 VERTICAL

(STATIONING AND ELEVATIONS IN METERS)

H-2-817486

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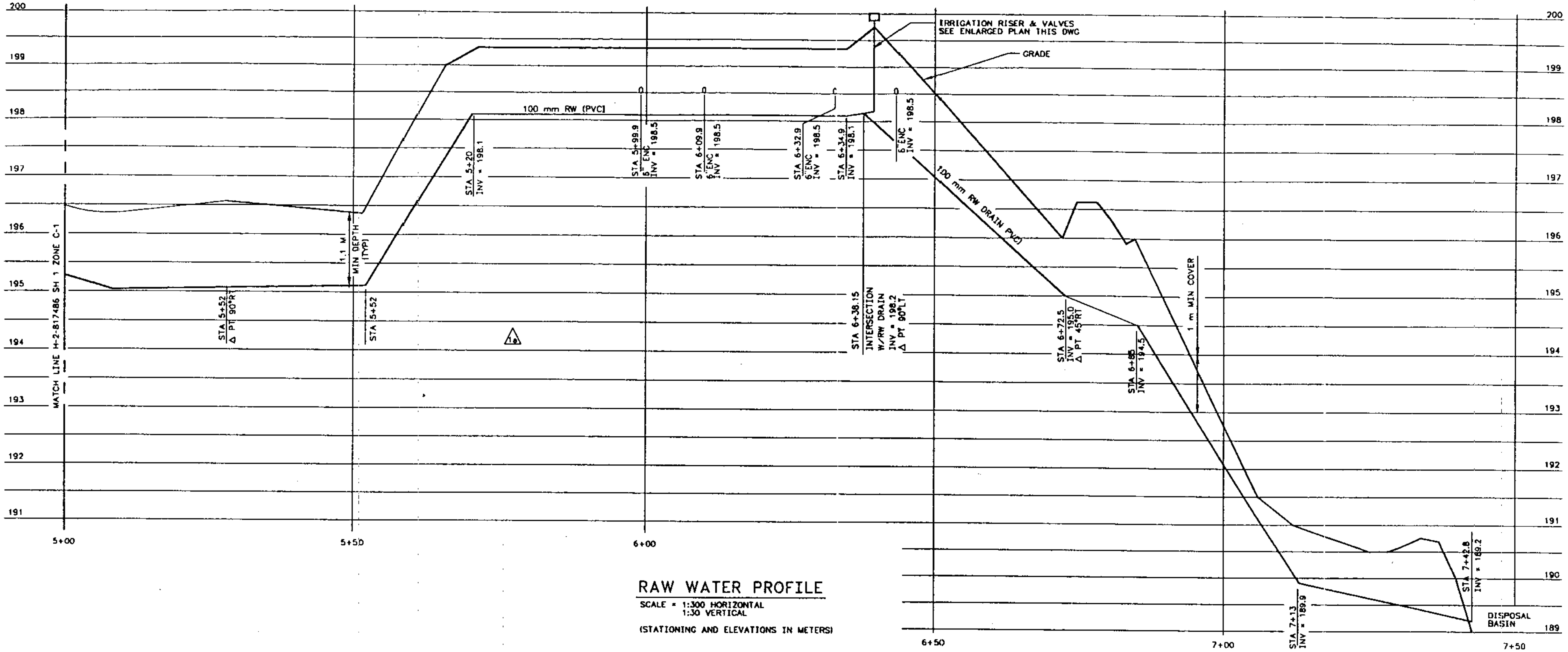
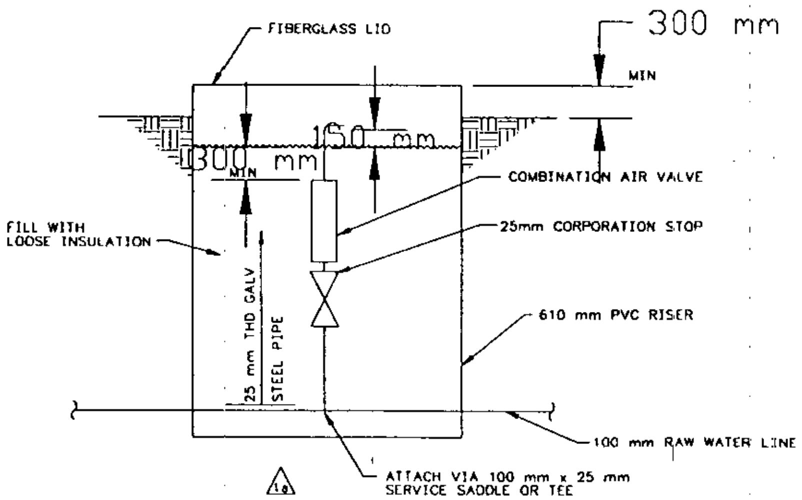


RAW WATER PROFILE

SCALE = 1:300 HORIZONTAL
1:30 VERTICAL
(STATIONING AND ELEVATIONS IN METERS)



DETAIL - AIR RELIEF VALVES

SCALE: NONE

H-2-817487 SH 1

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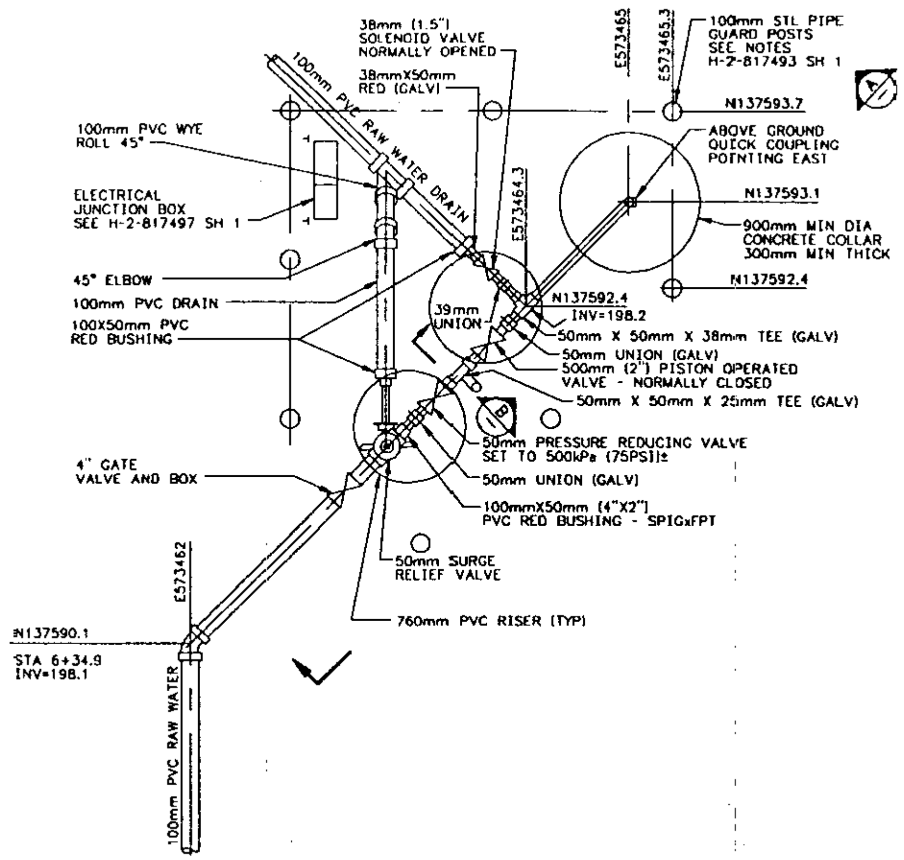
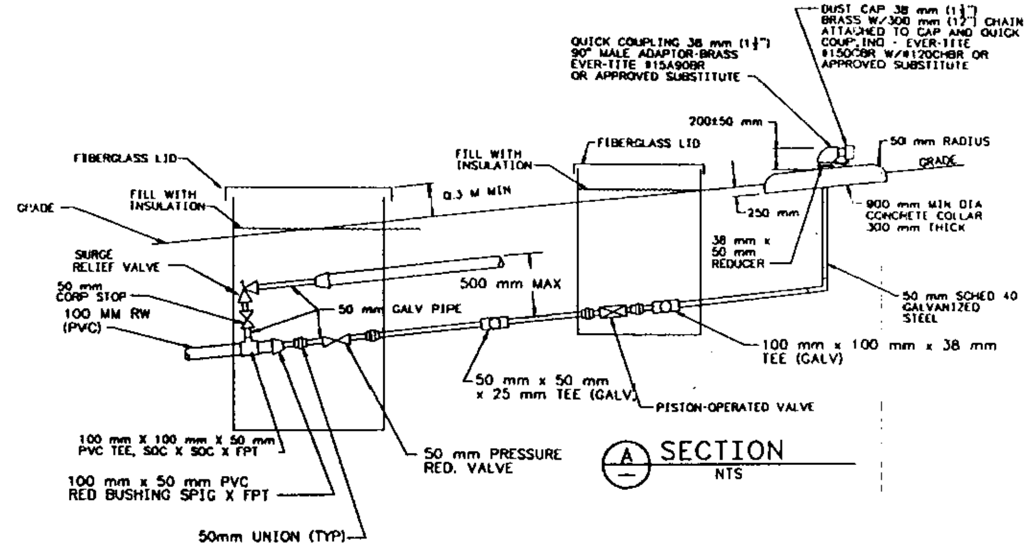
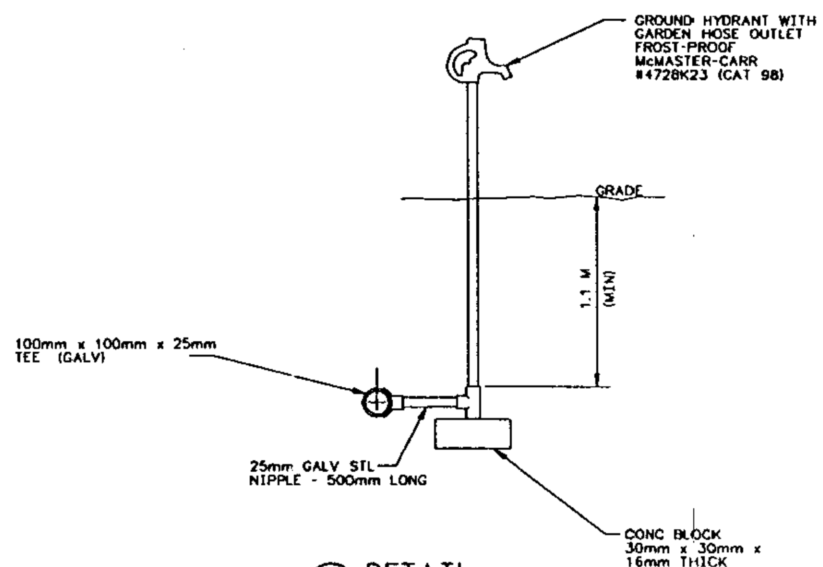




A SECTION
NTS



B DETAIL
SCALE: NONE

H-2-817487 SH 2

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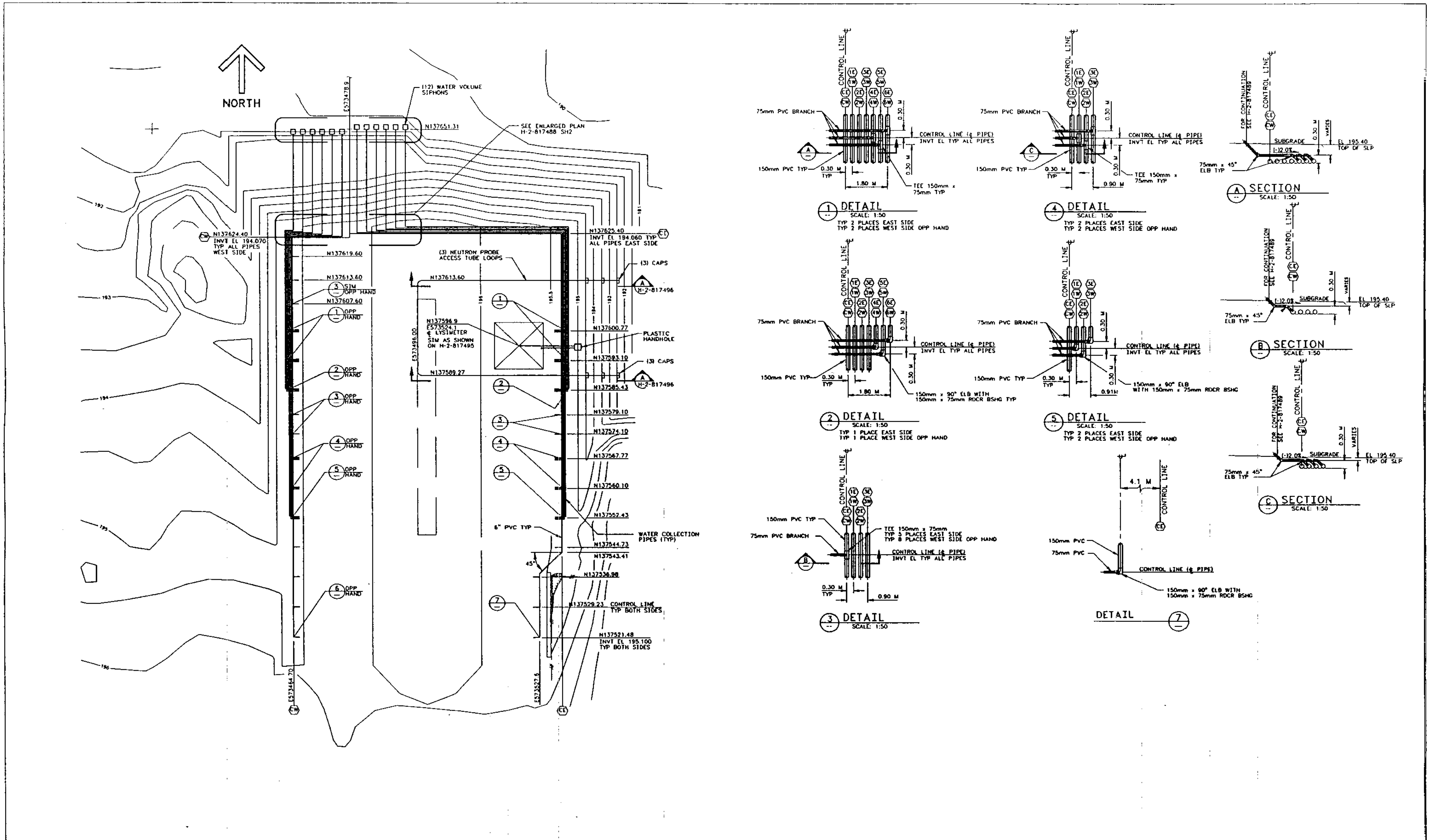

H-2-817488 SH 1

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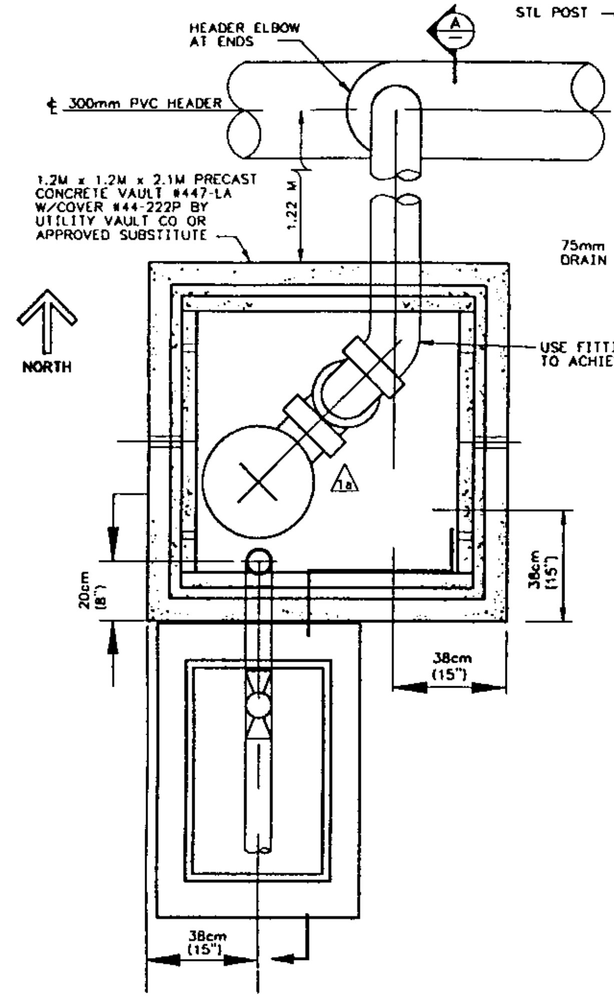
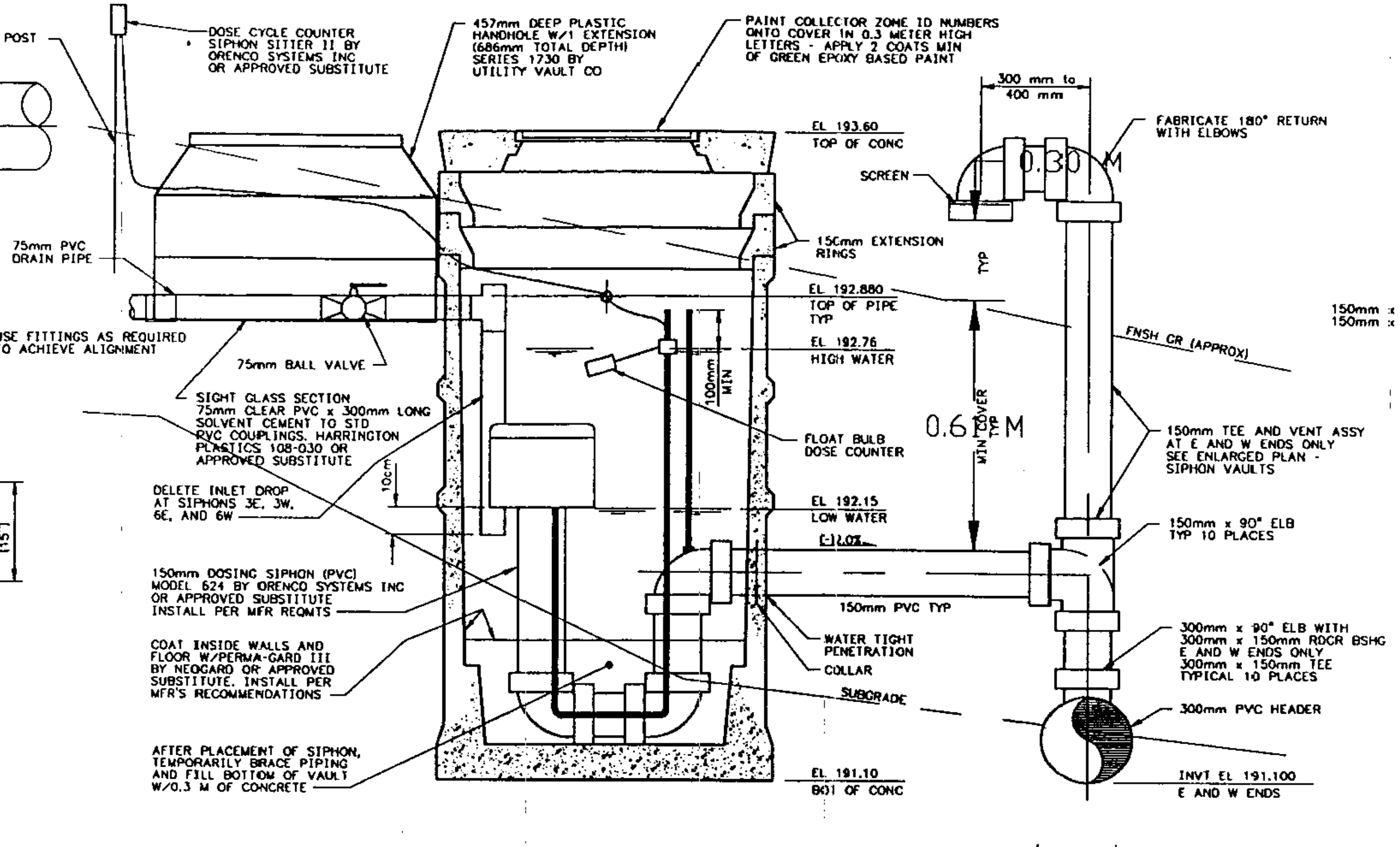
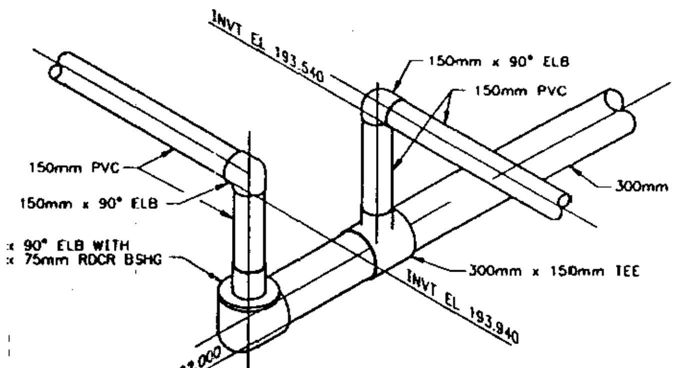


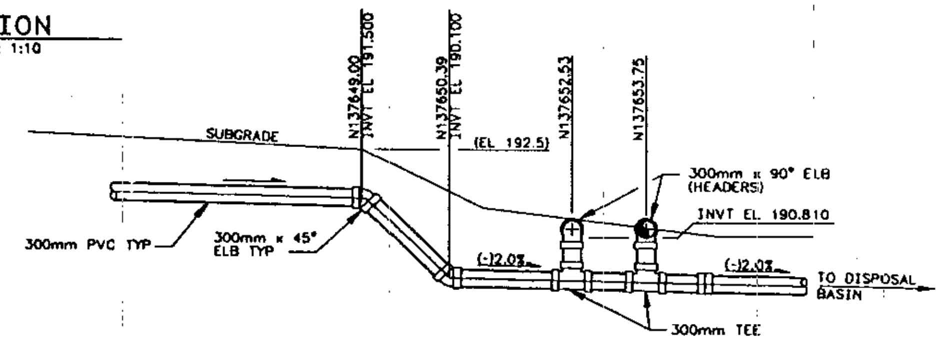
1 WATER VOLUME SIPHON
SCALE: NONE
TYPICAL 12 PLACES



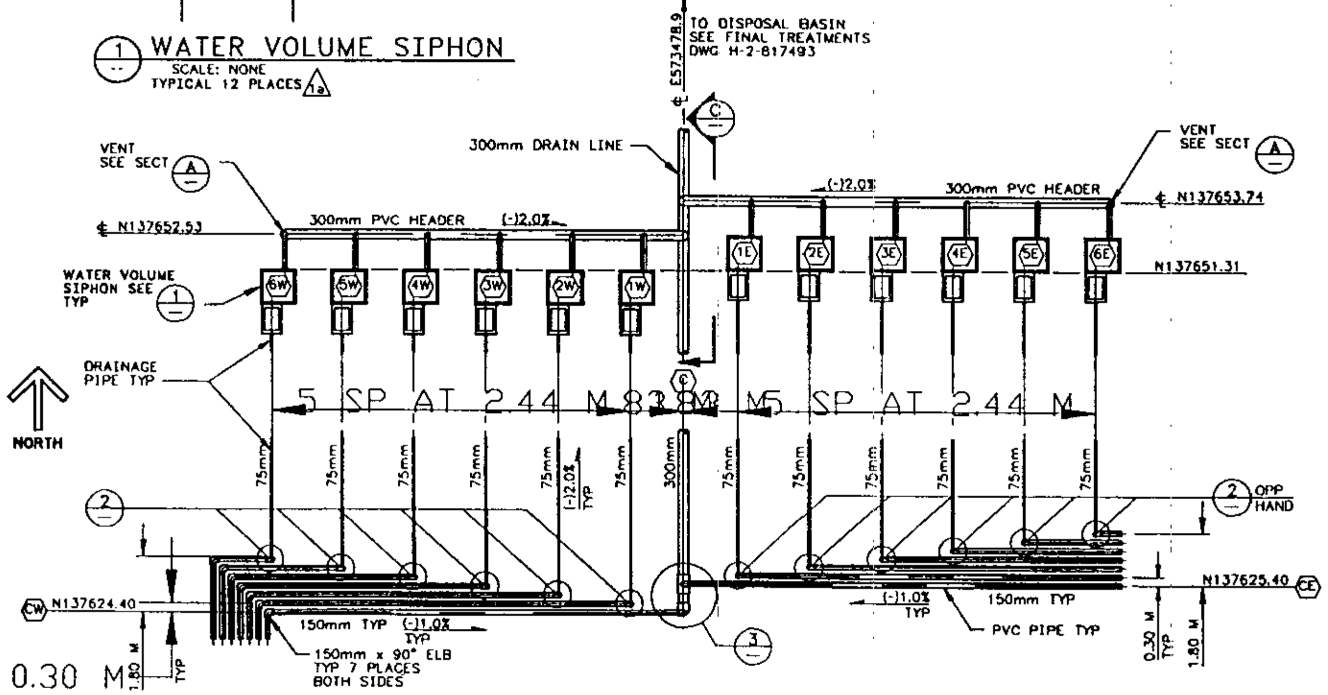
A SECTION
SCALE: 1:10



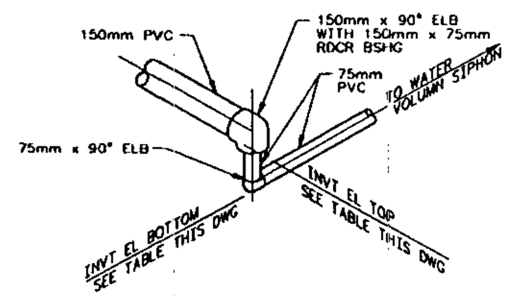
3 DETAIL
SCALE: NONE



C DRAIN LINE PROFILE
SCALE: 1:50



ENLARGED PLAN - SIPHON VAULTS
SCALE: 1:100



2 DETAIL
SCALE: NONE
TYPICAL 12 PLACES
(6 PLACES OPP HAND)

DETAIL 2 INVERT ELEVATIONS

PIPE	6W	5W	4W	3W	2W	1W	1E	2E	3E	4E	5E	6E
INVT EL TOP	194.030	194.010	193.990	193.980	193.960	193.940	193.540	193.560	193.580	193.590	193.610	193.630
INVT EL BOTTOM	193.270	193.280	193.280	193.290	193.300	193.300	193.300	193.300	193.290	193.280	193.280	193.270

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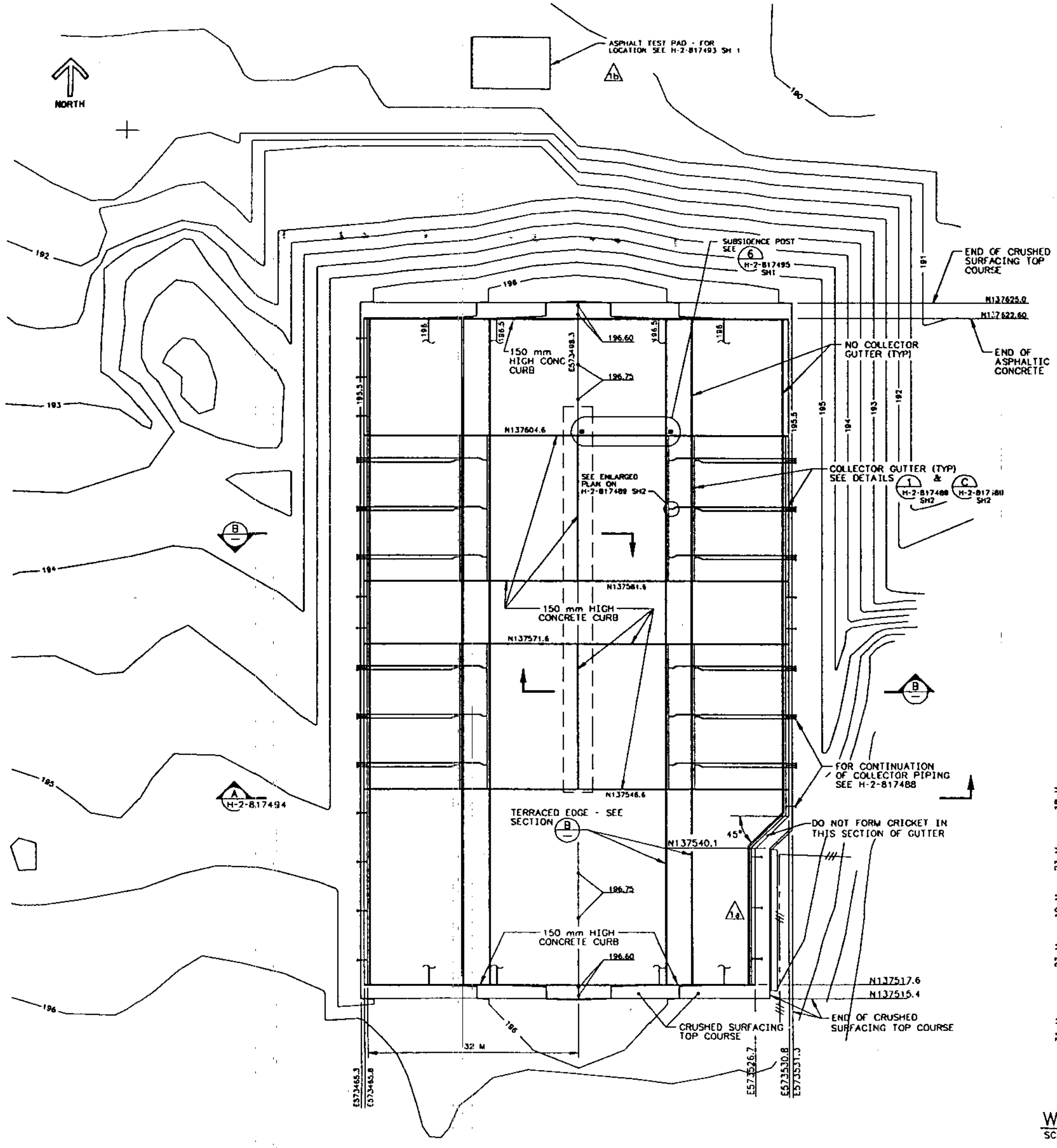
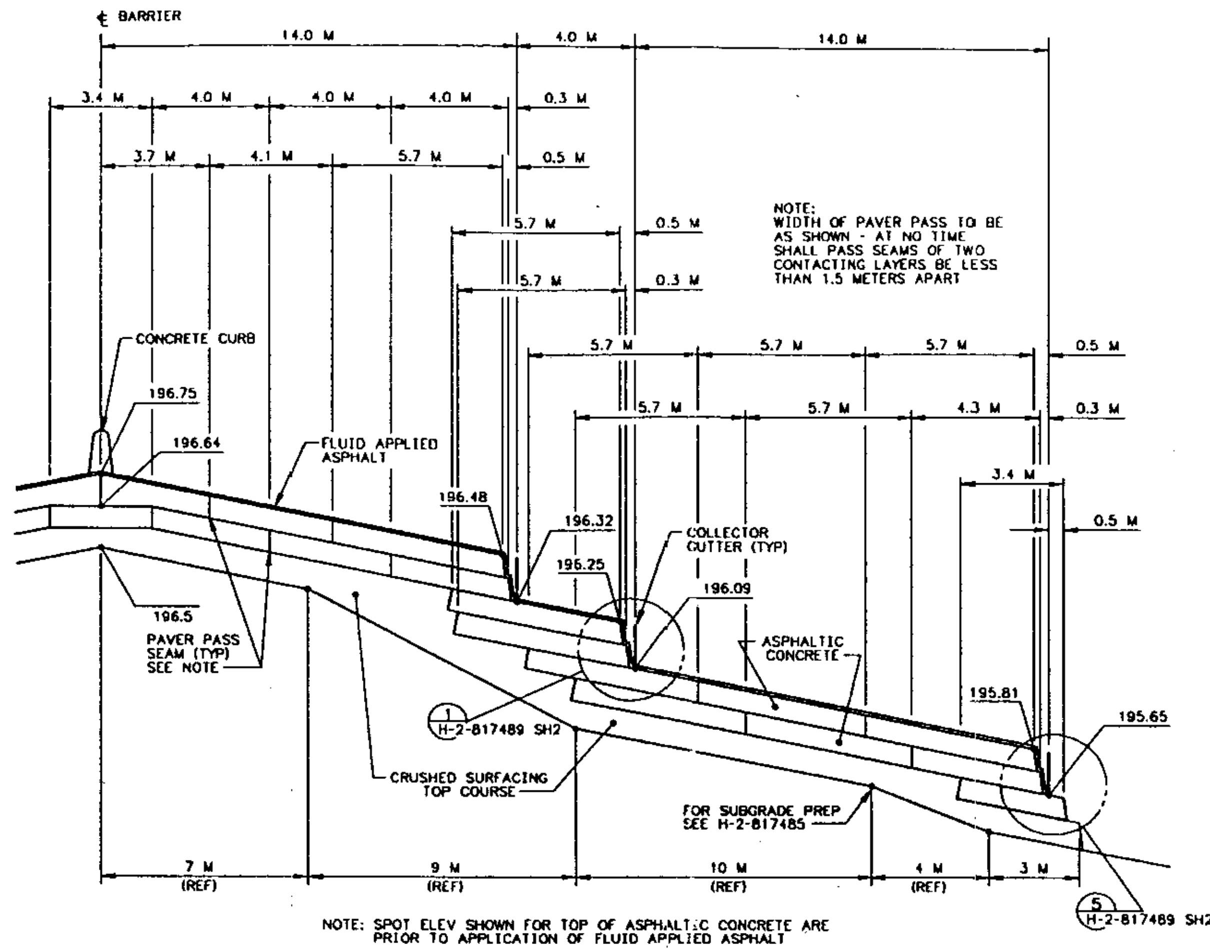
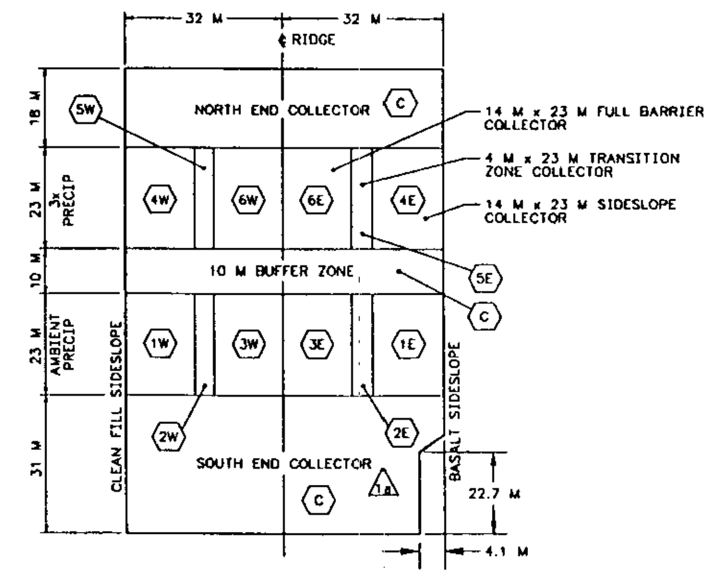


ASPHALTIC CONCRETE COMPOSITE LAYER
SCALE = 1:300



SECTION B
SCALE: HORIZ 1:100
VERT 1:10



WATER COLLECTION SYSTEM ZONES
SCALE = 1:600

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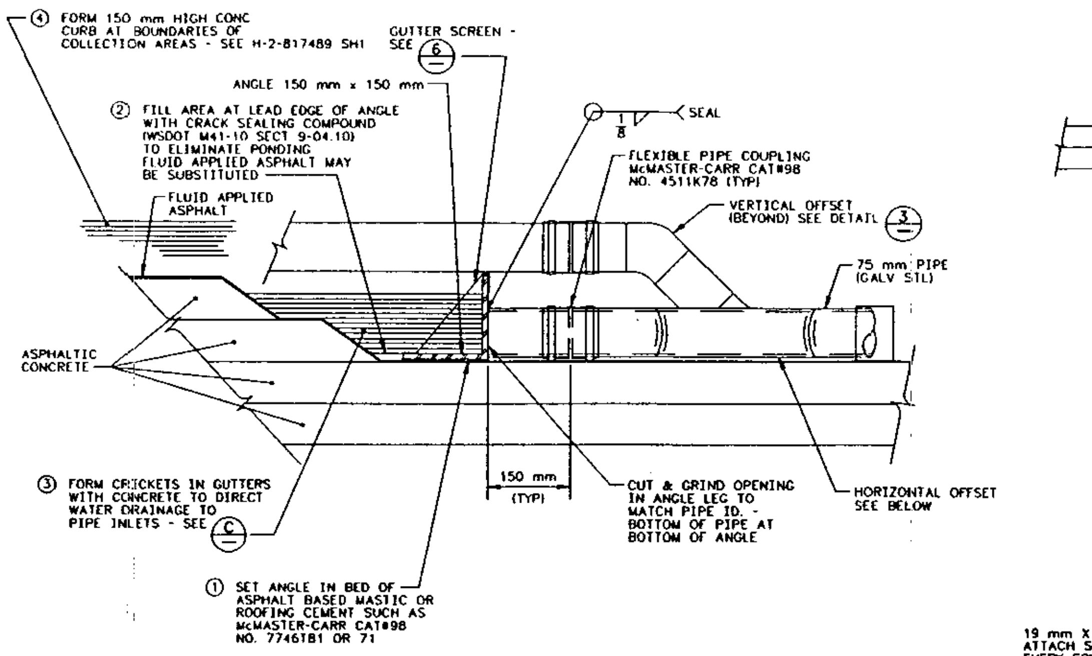
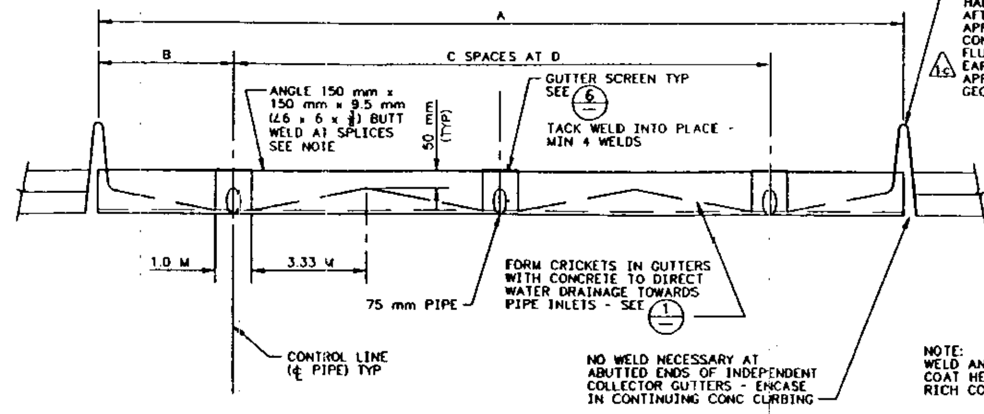


NOTE:
NUMBERS IN CIRCLES ① DENOTE SEQUENCE OF CONSTRUCTION BEGINNING AFTER APPLICATION OF FLUID APPLIED ASPHALT AND 24 HOUR CURE

DETAIL - WATER COLLECTION SECTION (1 / H-2-817489 SH1)
SCALE = 1:5

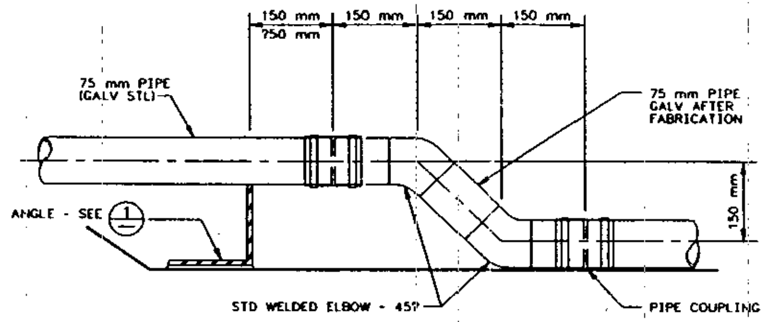


COLLECTOR ZONE (SEE H-2-817489 SH 1)	DIMENSION				QUANTITY
	A	B	C	D	
SOUTH END COLLECTOR	31.00 M	3.875 M	3	7.75 M	2
BUFFER ZONE COLLECTOR	10.00 M	2.50 M	1	5.00 M	2
NORTHWEST END COLLECTOR	18.00 M	3.00 M	2	6.00 M	1*
COLLECTORS 1 THRU 6 (E & W)	23.00 M	3.83 M	2	7.67 M	12

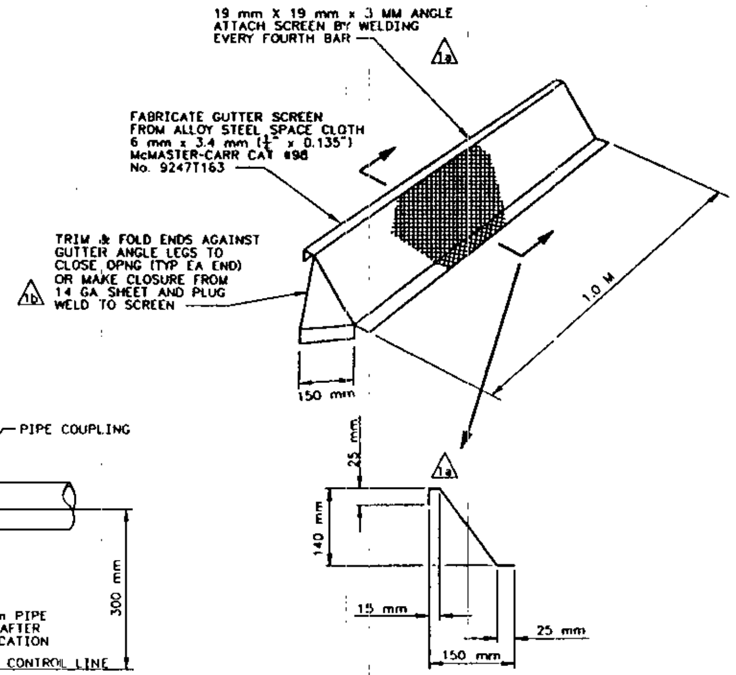
* NO COLLECTOR REQUIRED AT EAST SIDE OF NORTH COLLECTOR ZONE

NOTE:
WELD ANGLE AT SPLICES USING 1/8" BUTT WELD. COAT HEAT AFFECTED AREA WITH 2 COATS ZINC RICH COMPOUND.

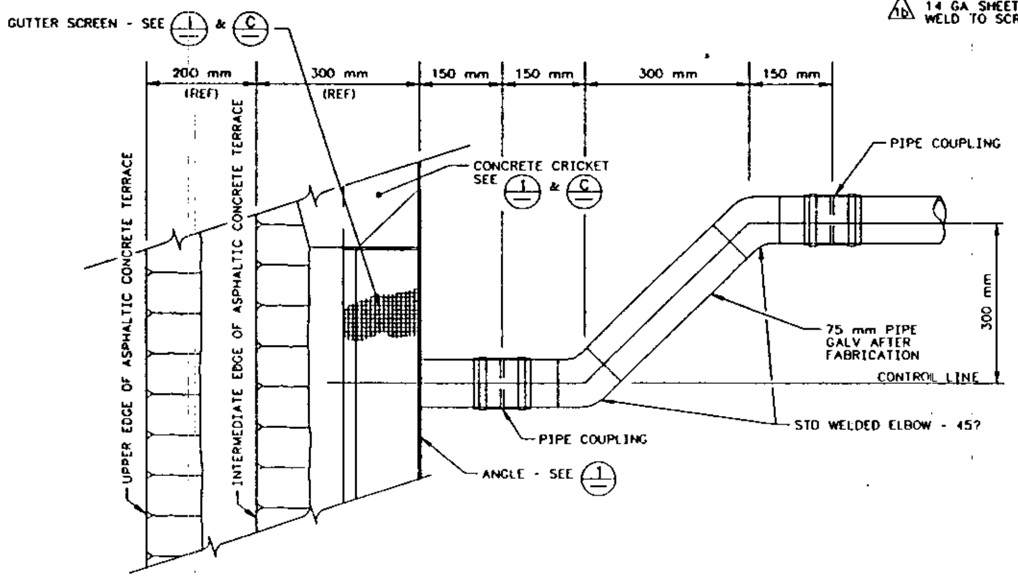
SECTION - WATER COLLECTOR ELEVATION (C / H-2-817489 SH 1)
SCALE: HORIZ = 1:50
VERT = 1:5



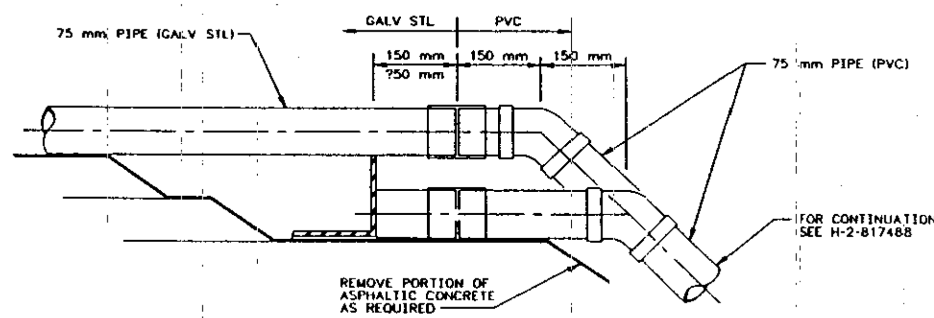
DETAIL - COLLECTOR PIPE VERTICAL OFFSET (3)
SCALE = 1:5



DETAIL - GUTTER SCREEN (6)
NTS



ENLARGED PLAN - COLLECTOR PIPE HORIZONTAL OFFSET
SCALE = 1:5



DETAIL - COLLECTOR PIPE MATERIAL TRANSITION (5 / H-2-817489 SH1)
SCALE = 1:5

H-2-817489 SH 2

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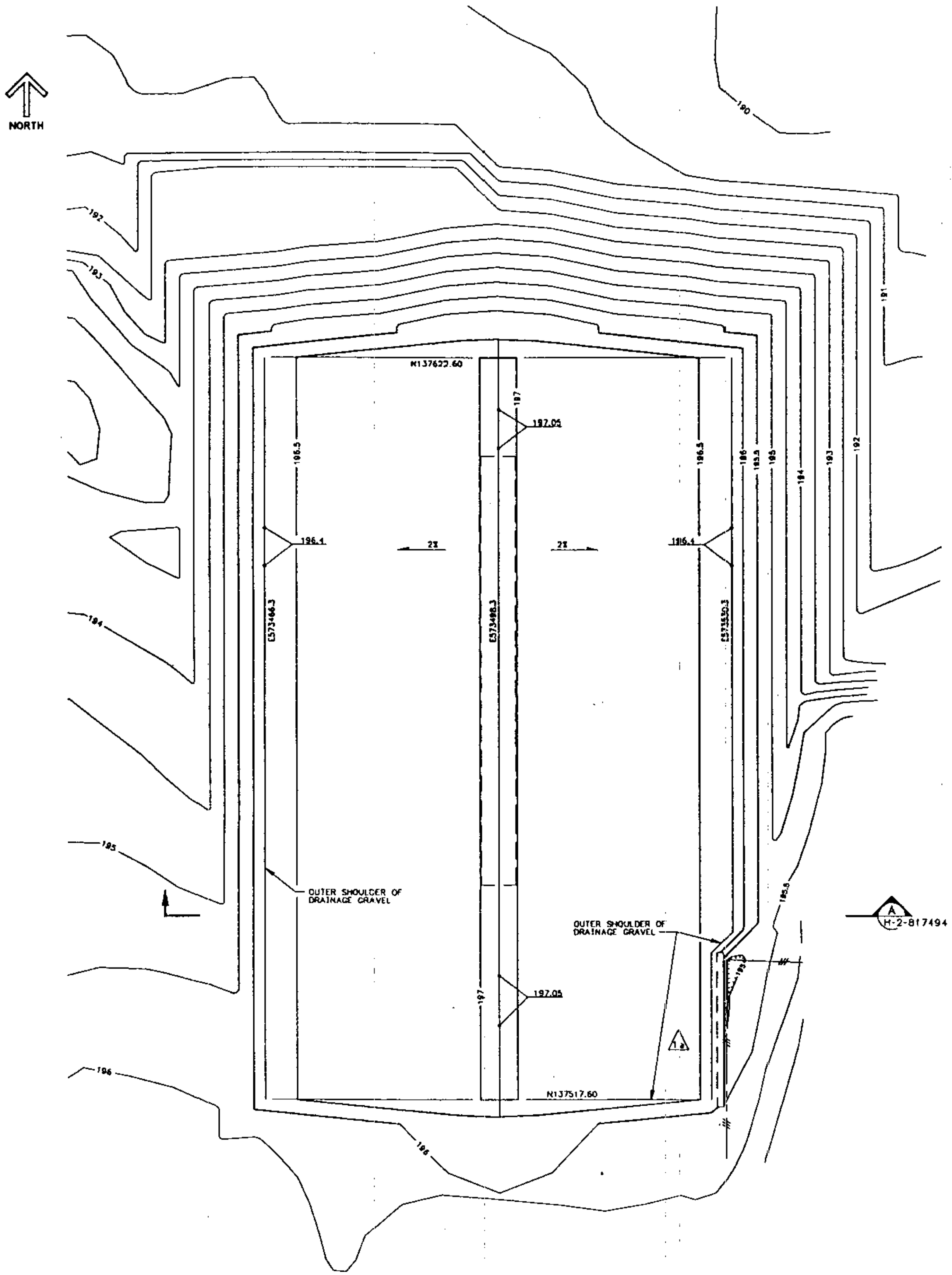
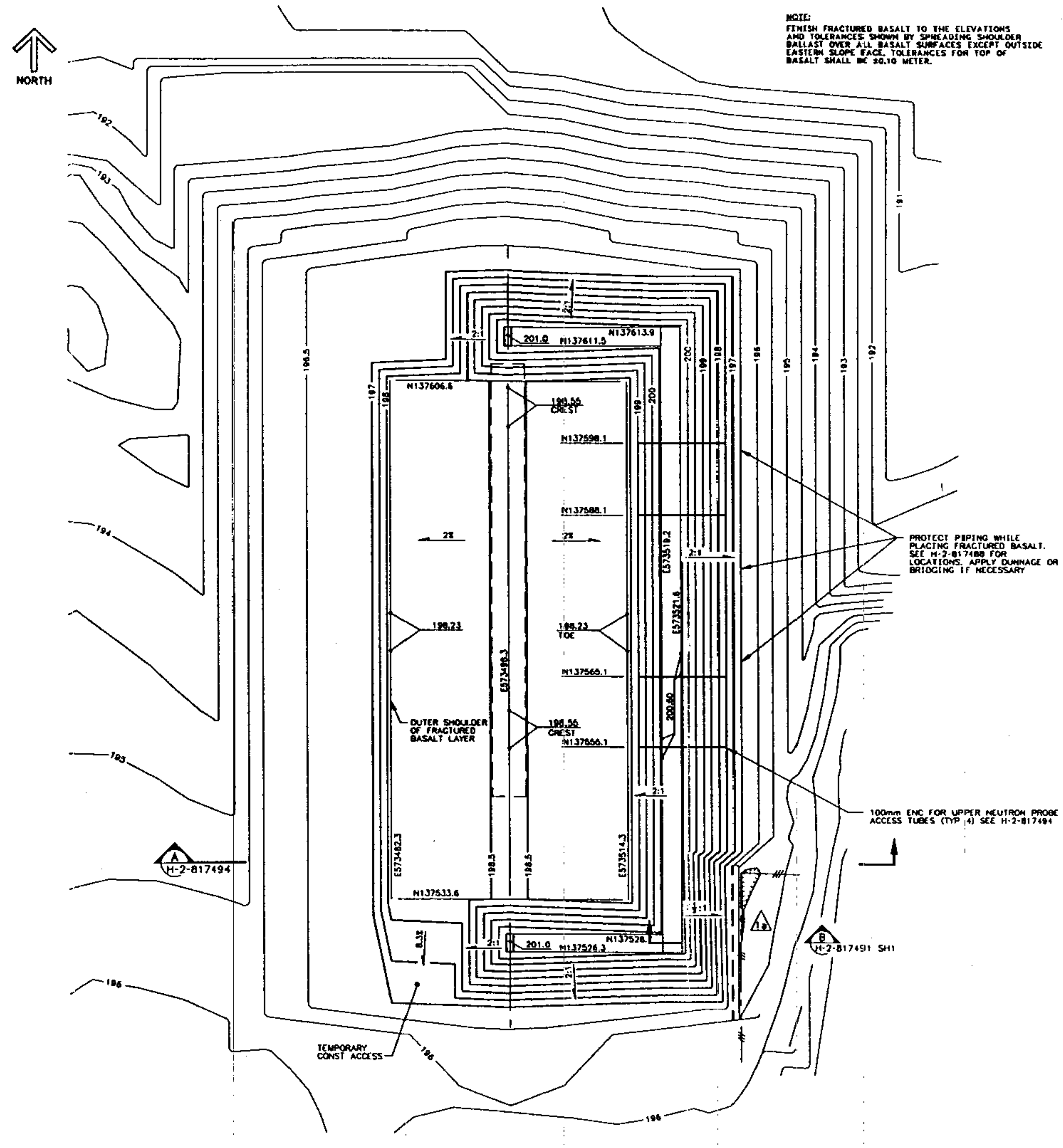


DRAINAGE GRAVEL LAYER
SCALE = 1:300

NOTE:
FINISH FRACTURED BASALT TO THE ELEVATIONS AND TOLERANCES SHOWN BY SPREADING SHOULDER BALLAST OVER ALL BASALT SURFACES EXCEPT OUTSIDE EASTERN SLOPE FACE. TOLERANCES FOR TOP OF BASALT SHALL BE ±0.10 METER.



FRACTURED BASALT PLACEMENT
SCALE = 1:300

H-2-817490

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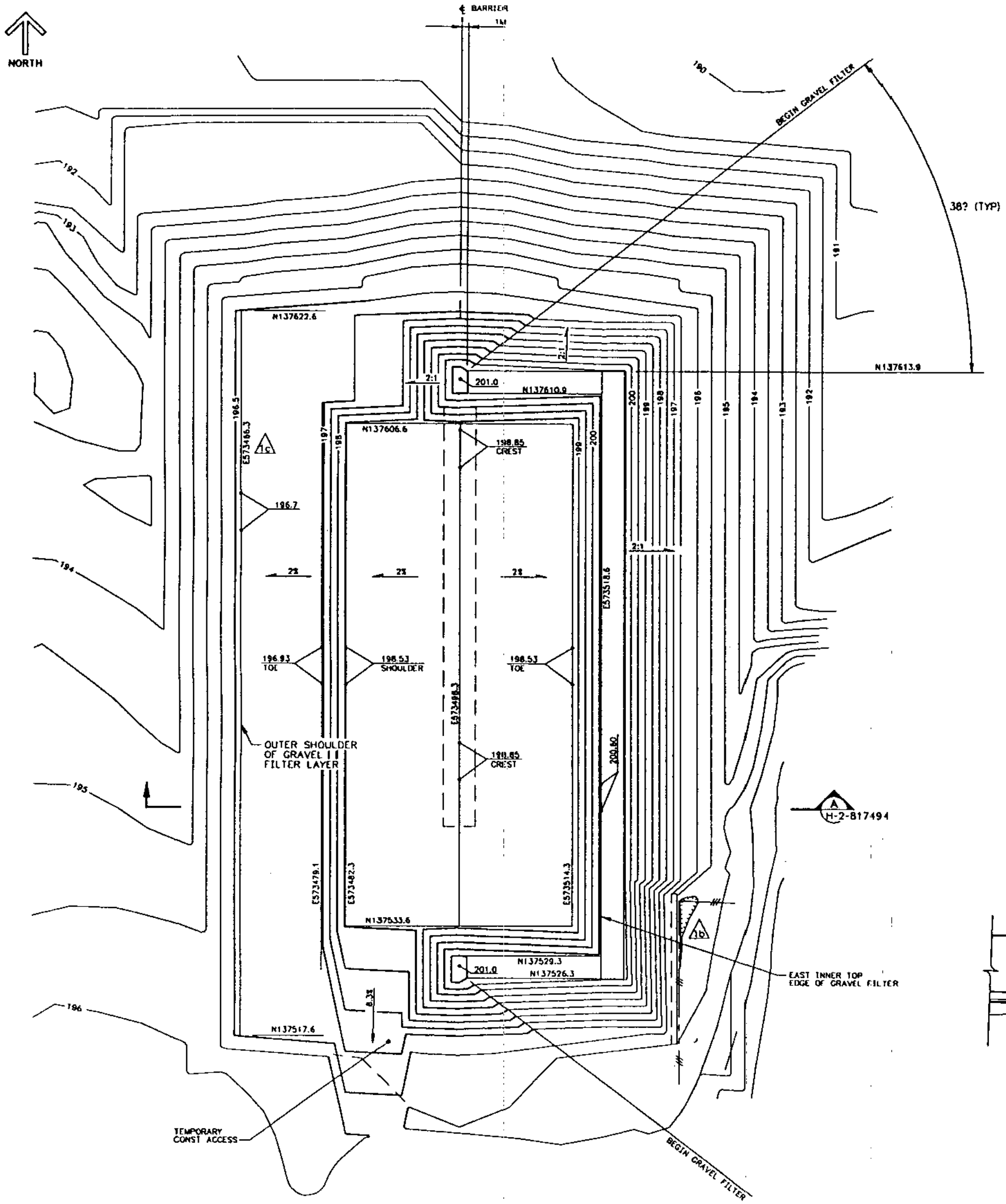
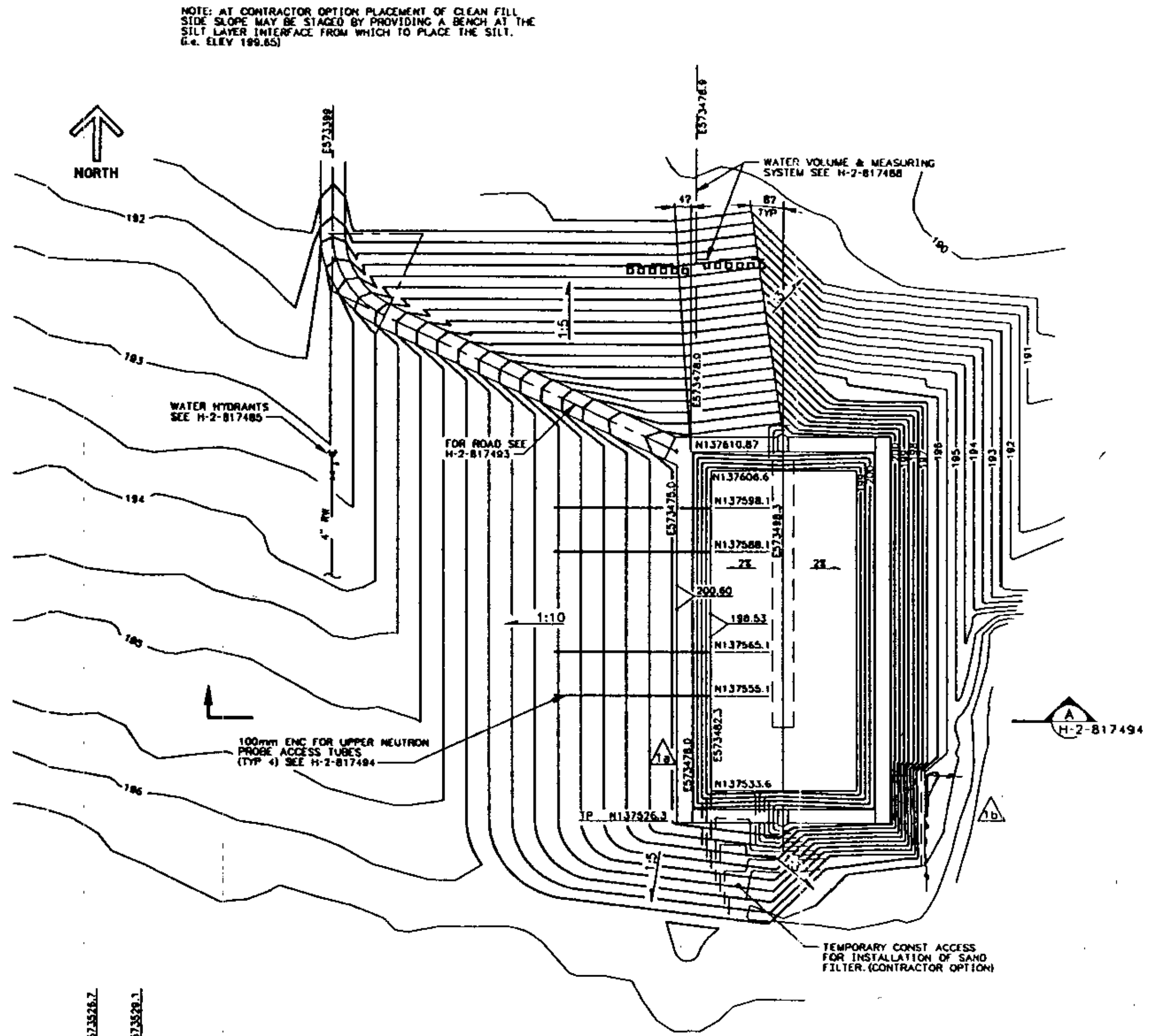
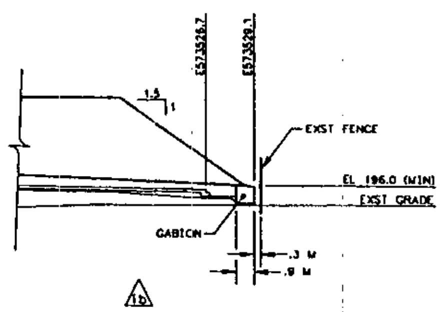


GRAVEL FILTER LAYER
SCALE = 1:300



CLEAN FILL SIDE SLOPE
SCALE = 1:600



B SECTION
H-2-817485 SH1 SCALE = 1:150

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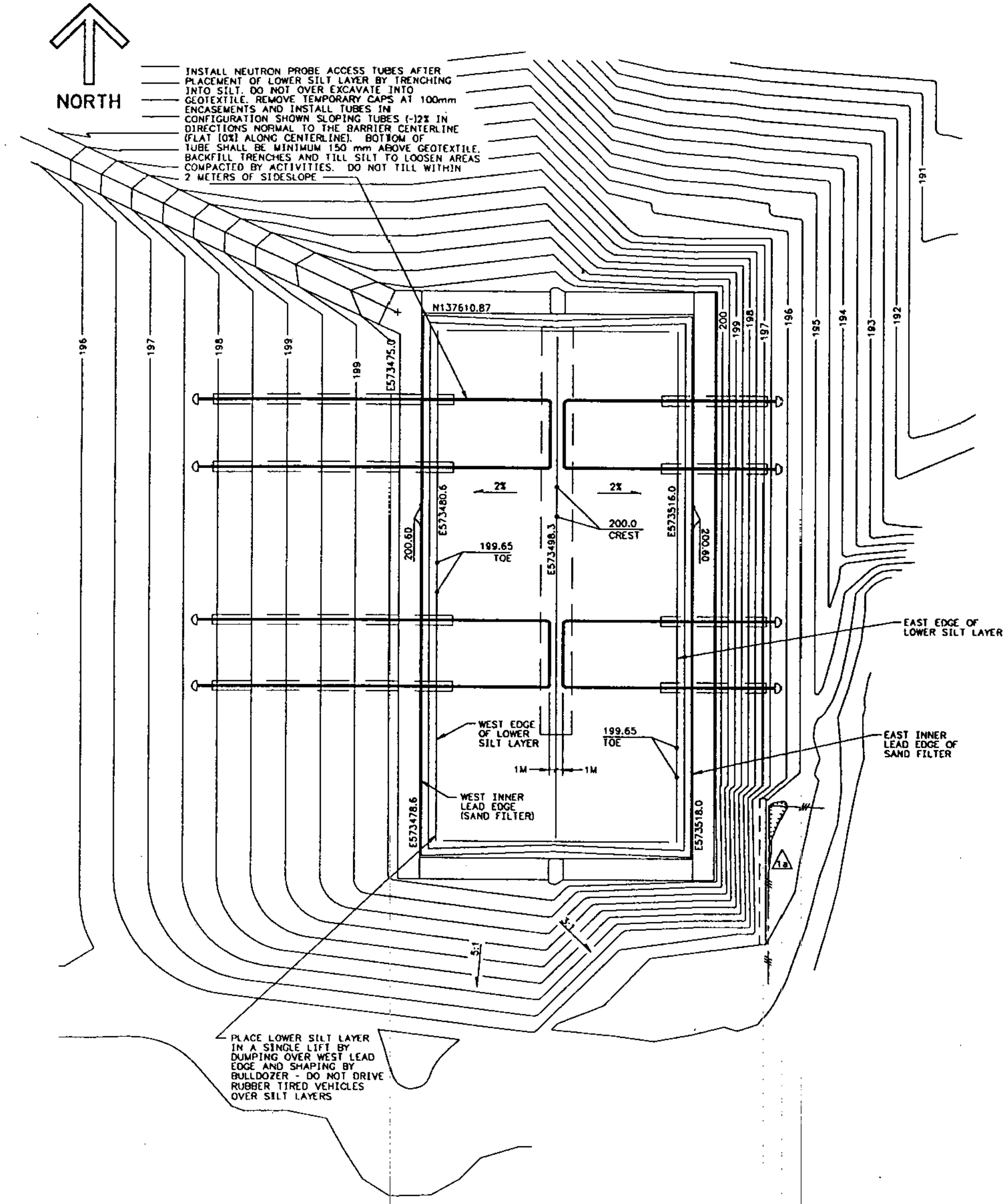
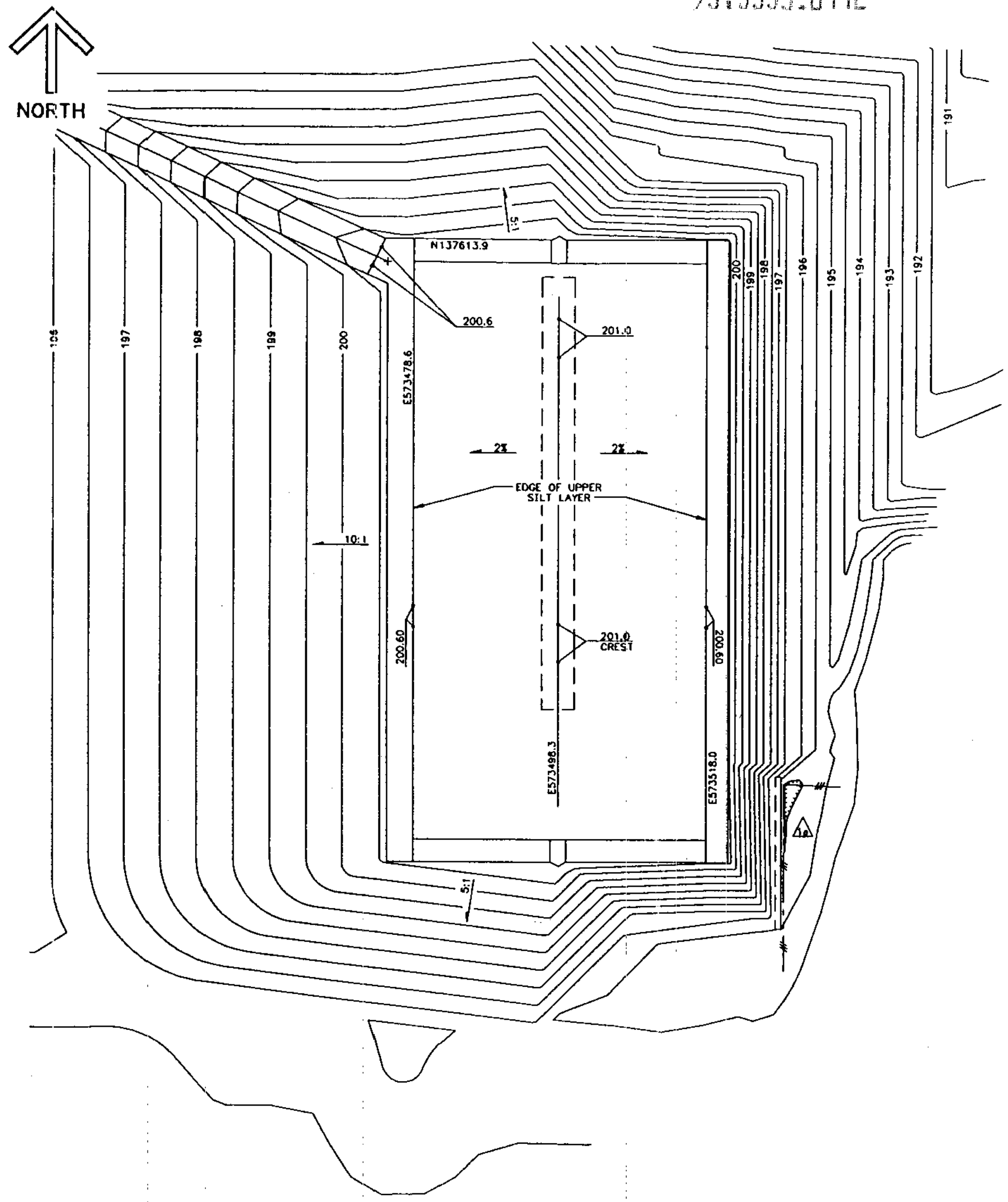


LOWER SILT LAYER
SCALE = 1:300



UPPER SILT (ADMIX) LAYER
SCALE = 1:300

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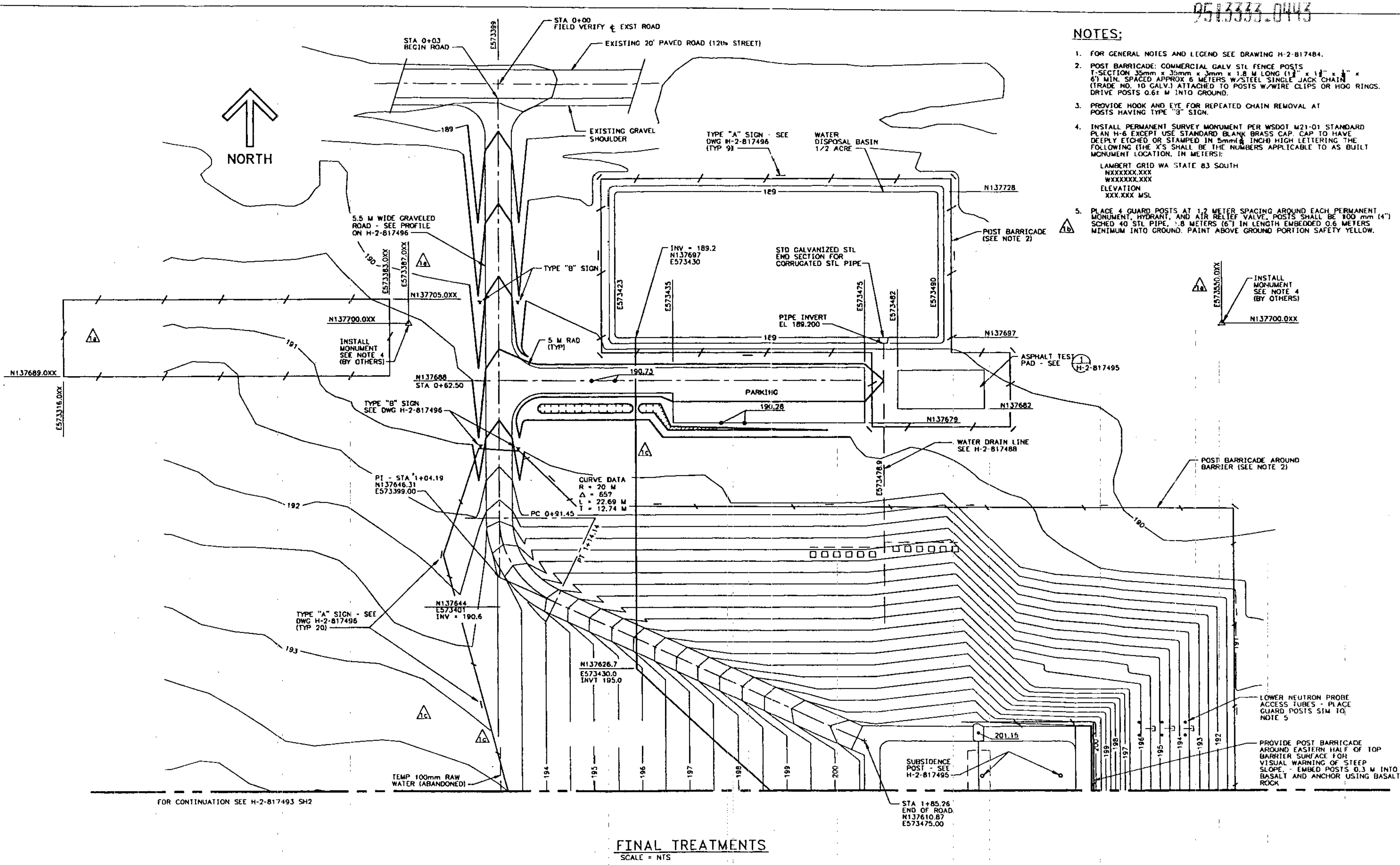
NOTES:

1. FOR GENERAL NOTES AND LEGEND SEE DRAWING H-2-817484.
2. POST BARRICADE: COMMERCIAL GALV STL FENCE POSTS T-SECTION 35mm x 35mm x 3mm x 1.8 M LONG (1[illegible]" x 1[illegible]" x [illegible]" x 6') MIN. SPACED APPROX 6 METERS W/STEEL SINGLE JACK CHAIN (TRADE NO. 10 GALV.) ATTACHED TO POSTS W/WIRE CLIPS OR HOG RINGS. DRIVE POSTS 0.6± M INTO GROUND.
3. PROVIDE HOOK AND EYE FOR REPEATED CHAIN REMOVAL AT POSTS HAVING TYPE "3" SIGN.
4. INSTALL PERMANENT SURVEY MONUMENT PER WSDOT M21-01 STANDARD PLAN H-6 EXCEPT USE STANDARD BLANK BRASS CAP. CAP TO HAVE DEEPLY ETCHED OR STAMPED IN 5mm([illegible] INCH) HIGH LETTERING THE FOLLOWING (THE X'S SHALL BE THE NUMBERS APPLICABLE TO AS BUILT MONUMENT LOCATION, IN METERS):

   LAMBERT GRID WA STATE 83 SOUTH
   NXXXXXX.XXX
   WXXXXXX.XXX
   ELEVATION
   XXX.XXX MSL

5. PLACE 4 GUARD POSTS AT 1.2 METER SPACING AROUND EACH PERMANENT MONUMENT, HYDRANT, AND AIR RELIEF VALVE. POSTS SHALL BE 100 mm (4") SCHED 40 STL PIPE, 1.8 METERS (6") IN LENGTH EMBEDDED 0.6 METERS MINIMUM INTO GROUND. PAINT ABOVE GROUND PORTION SAFETY YELLOW.



FINAL TREATMENTS

SCALE = NTS

H-2-817493 SH 1

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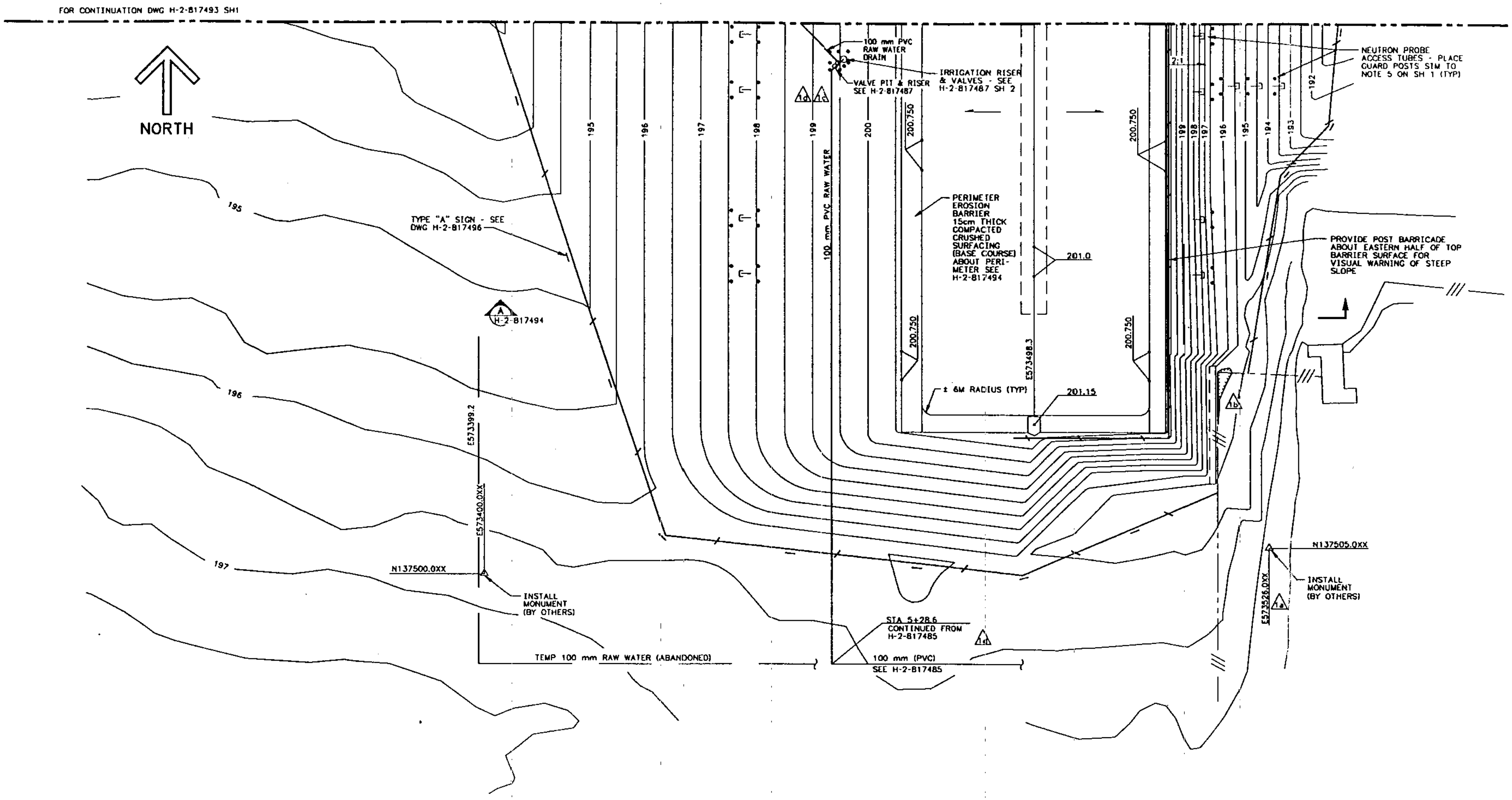

FINAL TREATMENTS
SCALE = 1:300

H-2-817493 SH 2

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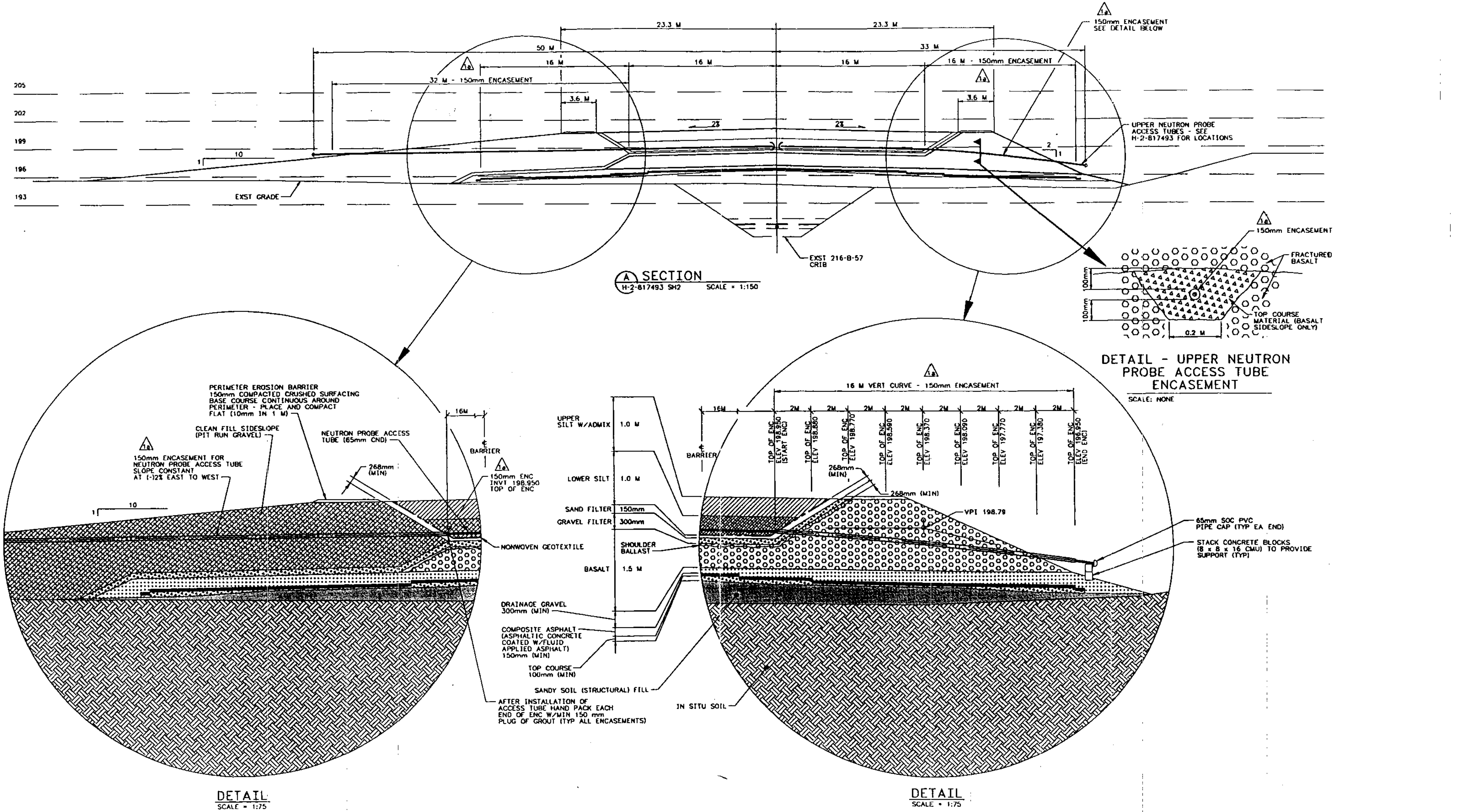
23.3 M
23.3 M
50 M
33 M
16 M
16 M
16 M
16 M - 150mm ENCASEMENT
32 M - 150mm ENCASEMENT
150mm ENCASEMENT SEE DETAIL BELOW
3.6 M
3.6 M
2%
2%
10
1
2
1
205
202
199
196
193
EXST GRADE
UPPER NEUTRON PROBE ACCESS TUBES - SEE H-2-817493 FOR LOCATIONS
EXST 216-B-57 CRIB
A SECTION
H-2-817493 SH2
SCALE = 1:150
150mm ENCASEMENT
FRACTURED BASALT
100mm
100mm
0.2 M
TOP COURSE MATERIAL (BASALT SIDESLOPE ONLY)
DETAIL - UPPER NEUTRON PROBE ACCESS TUBE ENCASEMENT
SCALE: NONE
PERIMETER EROSION BARRIER 150mm COMPACTED CRUSHED SURFACING BASE COURSE CONTINUOUS AROUND PERIMETER - PLACE AND COMPACT FLAT (10mm IN 1 M)
CLEAN FILL SIDESLOPE (PIT RUN GRAVEL)
NEUTRON PROBE ACCESS TUBE (65mm CND)
150mm ENCASEMENT FOR NEUTRON PROBE ACCESS TUBE SLOPE CONSTANT AT (-12% EAST TO WEST
16M
BARRIER
268mm (MIN)
150mm ENC INVT 198.950 TOP OF ENC
10
1
NONWOVEN GEOTEXTILE
UPPER SILT W/ADMIX 1.0 M
LOWER SILT 1.0 M
SAND FILTER 150mm
GRAVEL FILTER 300mm
SHOULDER BALLAST
BASALT 1.5 M
DRAINAGE GRAVEL 300mm (MIN)
COMPOSITE ASPHALT (ASPHALTIC CONCRETE COATED W/FLUID APPLIED ASPHALT) 150mm (MIN)
TOP COURSE 100mm (MIN)
SANDY SOIL (STRUCTURAL) FILL
AFTER INSTALLATION OF ACCESS TUBE HAND PACK EACH END OF ENC W/MIN 150 mm PLUG OF GROUT (TYP ALL ENCASEMENTS)
IN SITU SOIL
16 M VERT CURVE - 150mm ENCASEMENT
16M
2M
BARRIER
TOP OF ENC ELEV 198.950 (START ENC)
TOP OF ENC ELEV 198.860
TOP OF ENC ELEV 198.770
TOP OF ENC ELEV 198.580
TOP OF ENC ELEV 198.370
TOP OF ENC ELEV 198.090
TOP OF ENC ELEV 197.770
TOP OF ENC ELEV 197.380
TOP OF ENC ELEV 196.950 (END ENC)
268mm (MIN)
268mm (MIN)
VPI 198.79
65mm SOC PVC PIPE CAP (TYP EA END)
STACK CONCRETE BLOCKS (8 x 8 x 16 CMU) TO PROVIDE SUPPORT (TYP)
DETAIL
SCALE = 1:75
DETAIL
SCALE = 1:75

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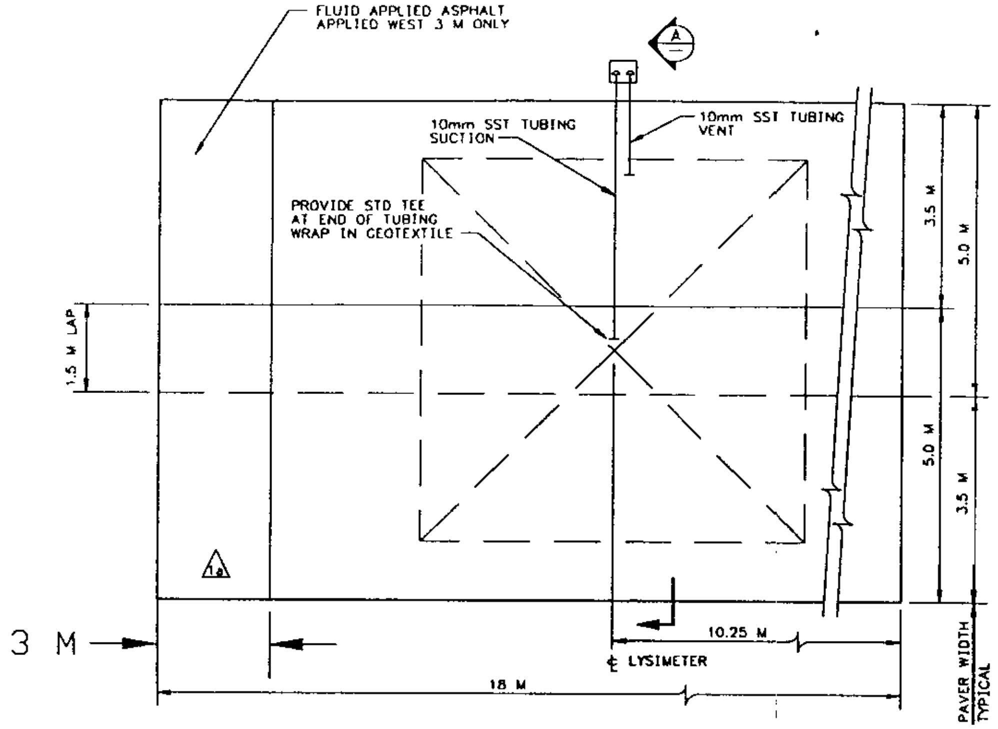
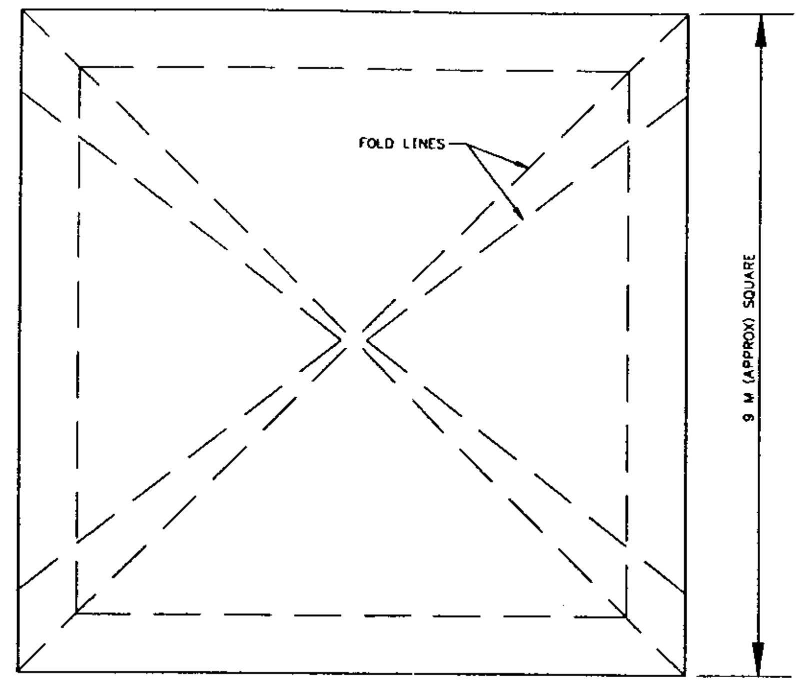
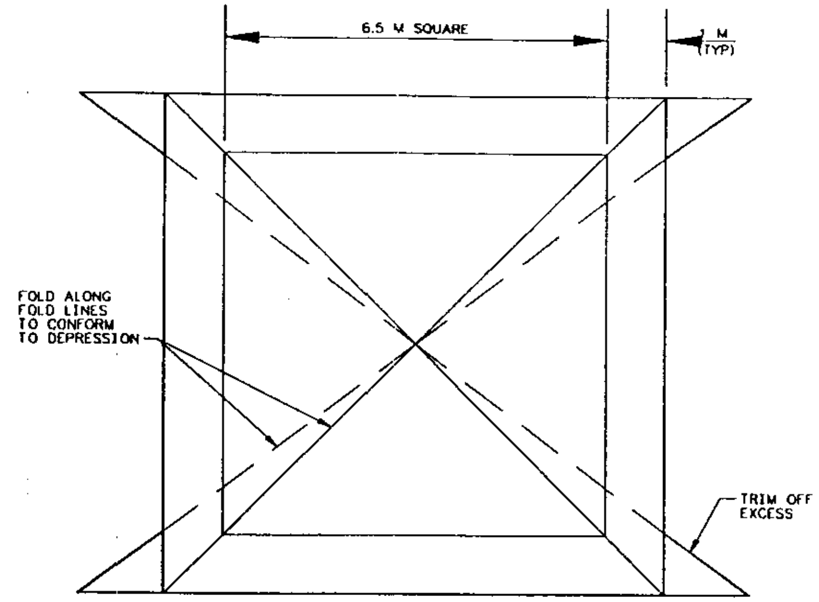


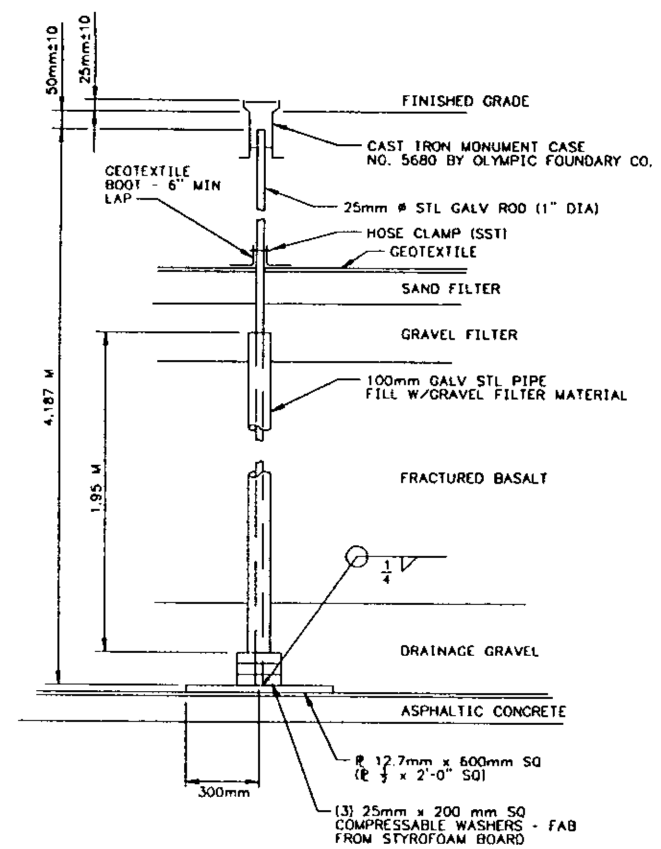
ENLARGED PLAN - ASPHALT TEST PAD (1 / H-2-817493 SH1)
SCALE: 1:50



PLAN - GEOMEMBRANE PAN LYSIMETER (UNFOLDED)
SCALE: 1:50

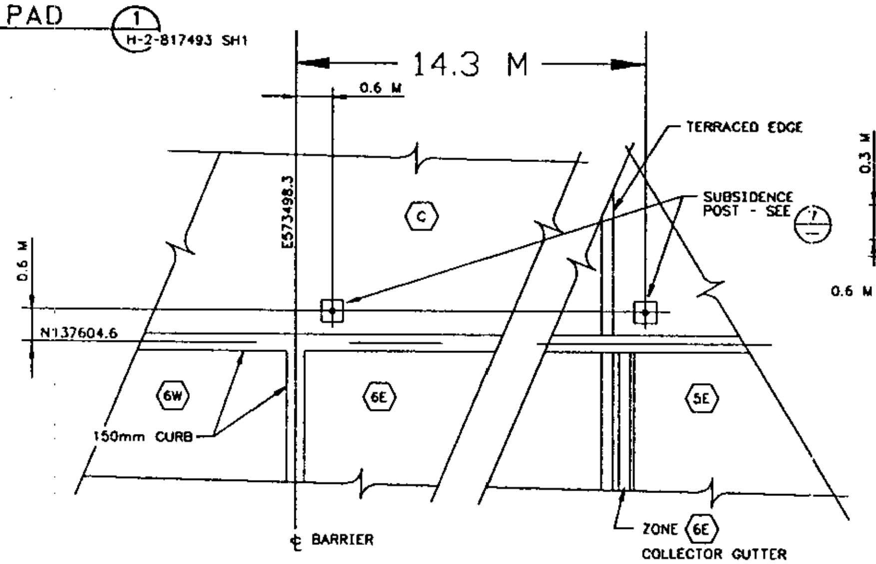


PLAN - GEOMEMBRANE PAN LYSIMETER (FOLDED)
SCALE: 1:50

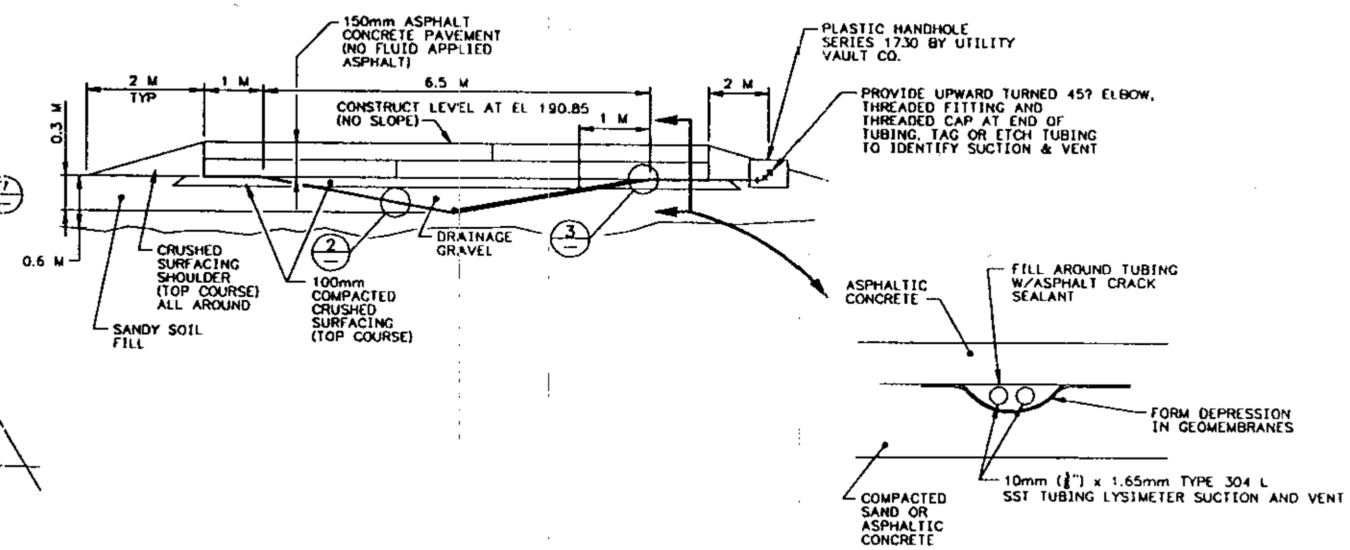


NOTE: MAINTAIN POST PLUMB WITHIN 1 CM/METER DURING ALL CONSTRUCTION ACTIVITIES

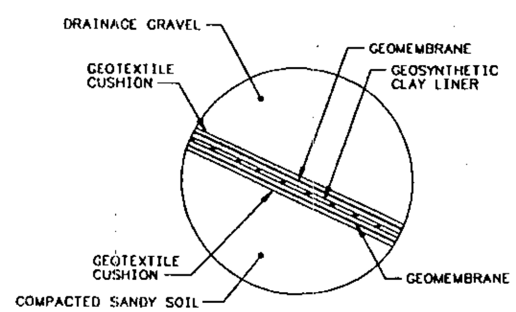
SUBSIDENCE POST (7)
SCALE: NONE



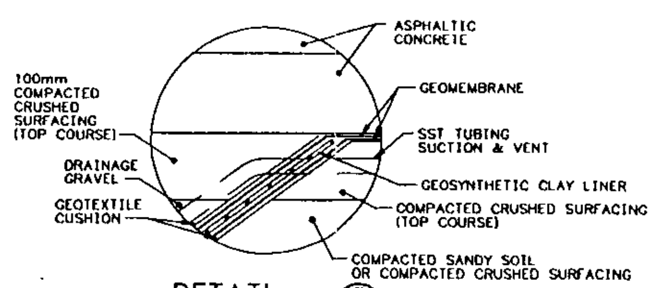
ENLARGED PLAN - SUBSIDENCE POSTS (6 / H-2-817189 SH1)
SCALE: NONE



SECTION - LYSIMETER (A)
SCALE: HORIZ 1:50
VERT 1:25



DETAIL (2)
SCALE: NONE



DETAIL (3)
SCALE: NONE

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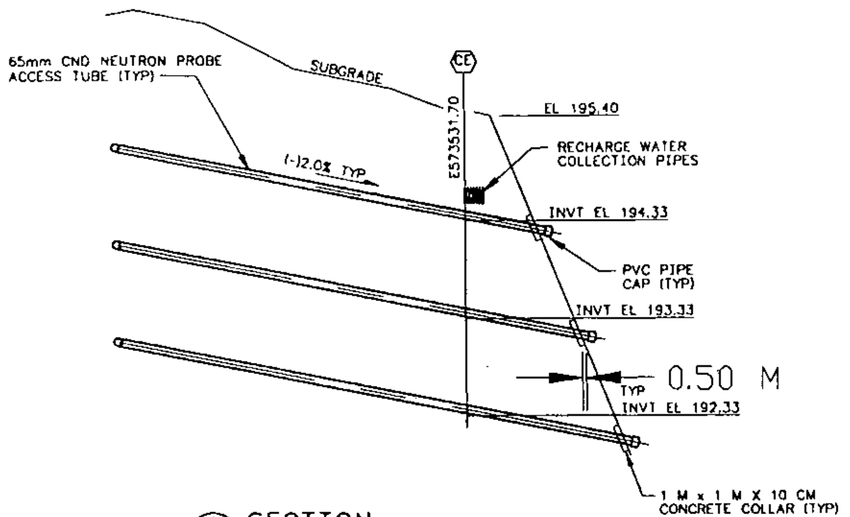
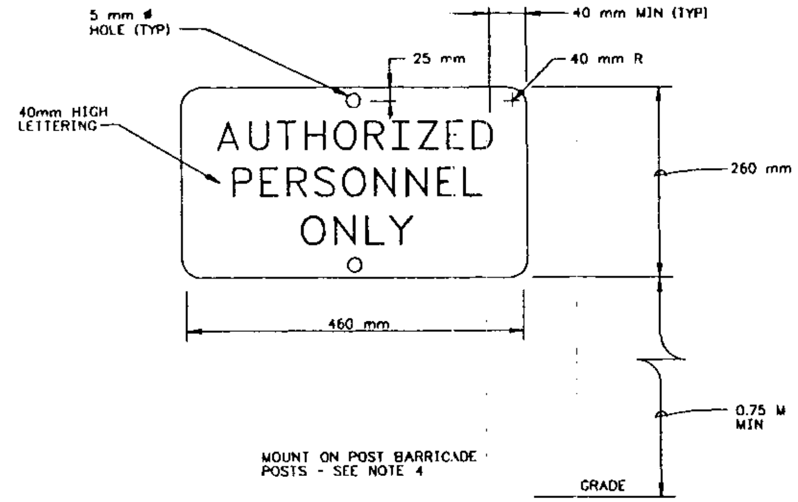
NOTES:

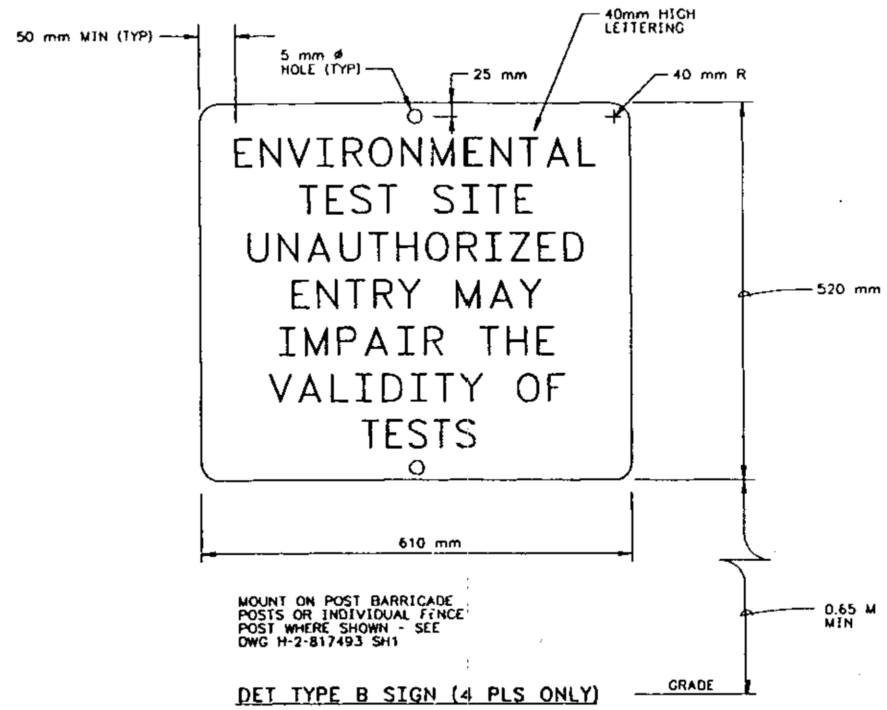
1. FABRICATE SIGN PER WSDOT M41-10 SECTION 9-28.2.
2. LETTERS IN ACCORDANCE WITH USDOT STANDARD HIGHWAY SIGNS MANUAL, STANDARD ALPHABET, ALL CAPS.
3. ATTACH TO FENCE POSTS WITH NO. 8-32 ZINC-PLATED STEEL THREAD CUTTING SCREWS (OR BOLTS) AND WASHER.
4. PLACE ONE TYPE A SIGN ON EVERY 5TH FENCE POST ABOUT BARRICADE.



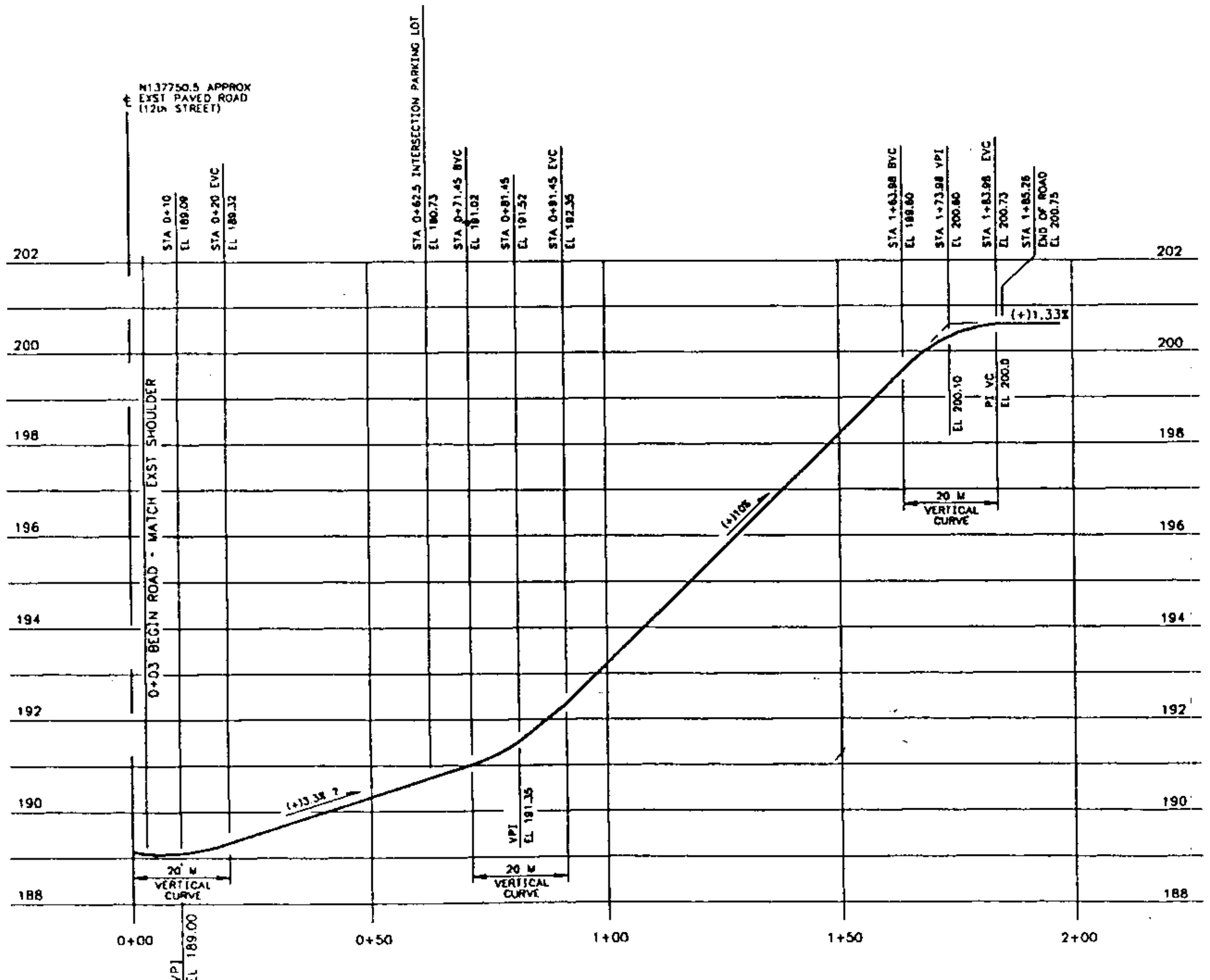
B SECTION
H-2-817488 SH1 SCALE: HORIZ 1:300 VERT 1:30



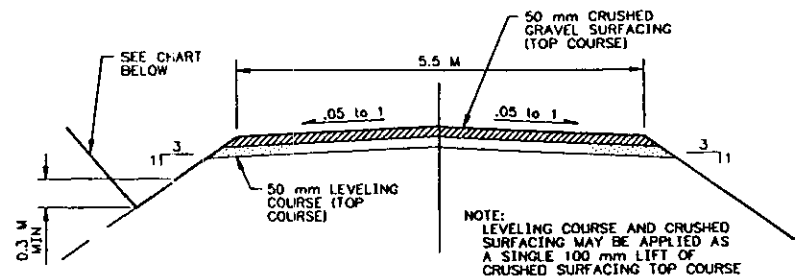
DET TYPE A SIGN
SCALE = 1:4
NOTE:
LETTERS - BLACK (NON-REFL)
BACKGROUND - WHITE (REFL)



DET TYPE B SIGN (4 PLS ONLY)
SCALE = 1:4
NOTE:
LETTERS - BLACK (NON-REFL)
BACKGROUND - WHITE (REFL)
TYP 2 EACH



GRAVEL SINGLE LANE ROAD PROFILE
SCALE - 1:600 HORIZONTAL
1:60 VERTICAL
(STATIONING AND ELEVATIONS IN METERS)



GRAVEL SURFACED SINGLE LANE
PATROL OR SERVICE ROAD
SCALE: NONE

HEIGHT OF CUT	SLOPE	HEIGHT OF CUT
0 TO 1.5 M	4 : 1	0 TO 3 M
	3 : 1	3 M TO 6 M
OVER 1.5 M	2 : 1	OVER 6 M

SLOPE CHART

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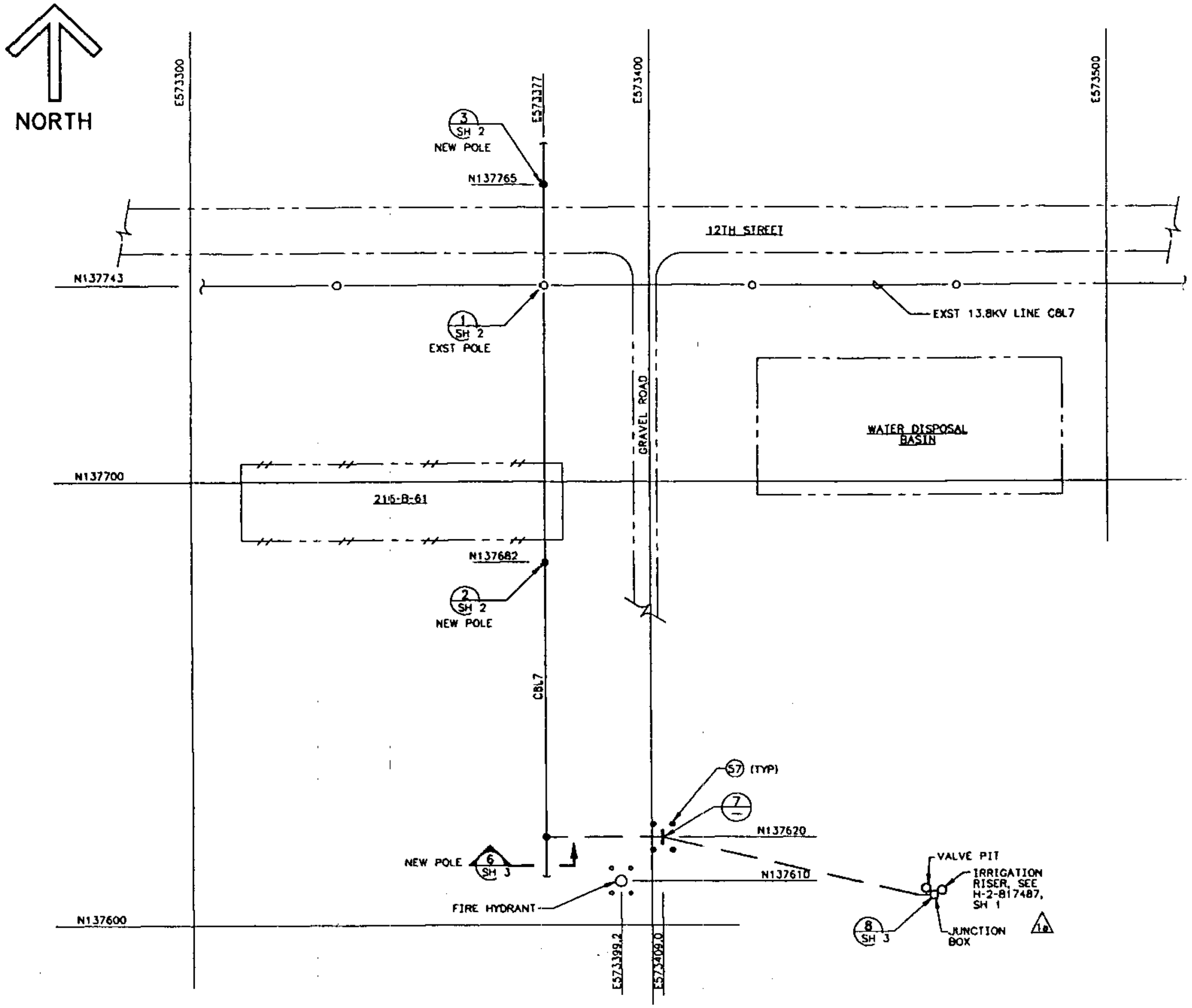
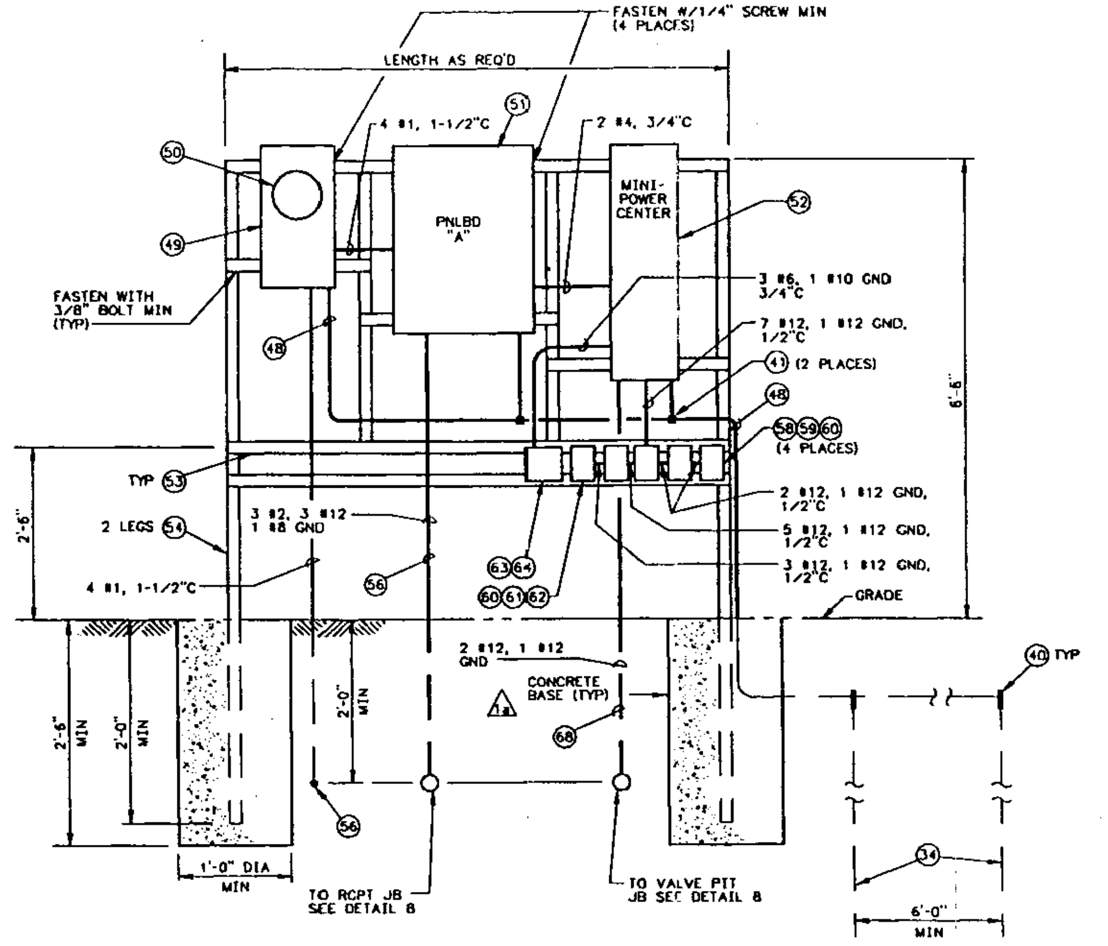


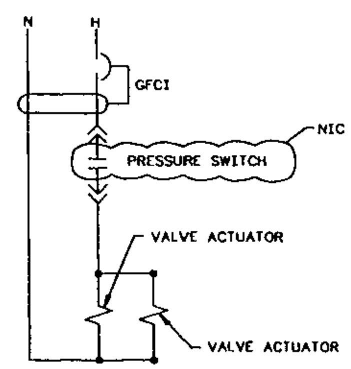
SITE PLAN
SCALE: 1=500 (METRIC)

STRINGING SAG & TENSION CHART
RULING SPAN LENGTH = 203 FEET

	AMBIENT TEMPERATURE °F								
	0°	15°	30°	45°	60°	75°	90°	105°	120°
SAG(FT)	3.1	3.4	3.6	3.9	4.1	4.3	4.5	4.8	5.0
TENSION (LB)	133	123	115	108	101	96	92	88	84



DETAIL 7
NTS
(LOOKING WEST)



ELEMENTARY DIAGRAM
IRRIGATION CONTROL

NOTES:

1. SEE SHEET 3 FOR PARTS LIST.
2. SEE CONSTRUCTION SPECIFICATION W-263-C2 FOR MATERIAL DESCRIPTION AND INSTALLATION INSTRUCTIONS.
3. ABBREVIATIONS ARE PER ASME Y1.1-1989.
4. THE LISTING OF MATERIALS ON THIS DRAWING DOES NOT RELIEVE THE CONTRACTOR FROM PROVIDING ALL MATERIALS NECESSARY FOR A COMPLETE AND ACCEPTABLE INSTALLATION.

H-2-817497 SH 1

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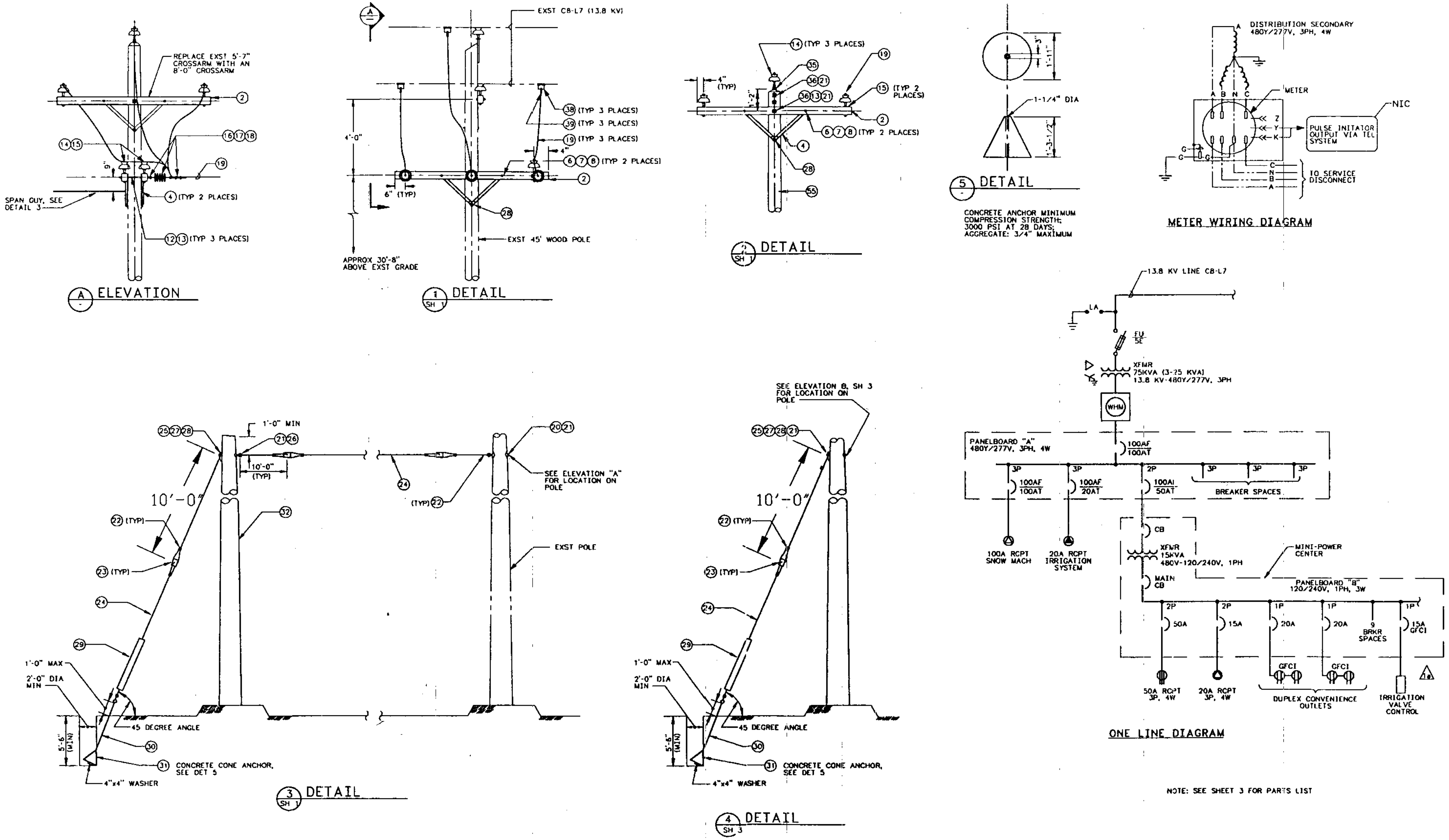
REPLACE EXST 5'-7" CROSSARM WITH AN 8'-0" CROSSARM
(4) (TYP 2 PLACES)
(12)(13) (TYP 3 PLACES)
SPAN GUY, SEE DETAIL 3
A ELEVATION
EXST CB-L7 (13.8 KV)
(38) (TYP 3 PLACES)
(39) (TYP 3 PLACES)
(19) (TYP 3 PLACES)
(6)(7)(8) (TYP 2 PLACES)
6" (TYP)
4'-0"
EXST 45' WOOD POLE
APPROX 30'-8" ABOVE EXST GRADE
1 DETAIL
(14) (TYP 3 PLACES)
(15) (TYP 2 PLACES)
(6)(7)(8) (TYP 2 PLACES)
2 DETAIL
1-1/4" DIA
5 DETAIL
CONCRETE ANCHOR MINIMUM COMPRESSION STRENGTH: 3000 PSI AT 28 DAYS; AGGREGATE: 3/4" MAXIMUM
DISTRIBUTION SECONDARY 480Y/277V, 3PH, 4W
METER
NIC
PULSE INITIATOR OUTPUT VIA TEL SYSTEM
TO SERVICE DISCONNECT
METER WIRING DIAGRAM
13.8 KV LINE CB-L7
LA
FU 5E
XFMR 75KVA (3-25 KVA) 13.8 KV-480Y/277V, 3PH
WHM
PANELBOARD "A" 480Y/277V, 3PH, 4W
100AF 100AT
BREAKER SPACES
100A RCPT SNOW MACH
20A RCPT IRRIGATION SYSTEM
CB
XFMR 15KVA 480V-120/240V, 1PH
MAIN CB
MINI-POWER CENTER
PANELBOARD "B" 120/240V, 1PH, 3W
9 BRKR SPACES
15A GFCI
50A RCPT 3P, 4W
20A RCPT 3P, 4W
DUPLEX CONVENIENCE OUTLETS
IRRIGATION VALVE CONTROL
ONE LINE DIAGRAM
1'-0" MIN
10'-0" (TYP)
10'-0"
SEE ELEVATION "A" FOR LOCATION ON POLE
EXST POLE
1'-0" MAX
2'-0" DIA MIN
45 DEGREE ANGLE
5'-6" (MIN)
CONCRETE CONE ANCHOR, SEE DET 5
4"x4" WASHER
3 DETAIL
SEE ELEVATION B, SH 3 FOR LOCATION ON POLE
4 DETAIL
NOTE: SEE SHEET 3 FOR PARTS LIST

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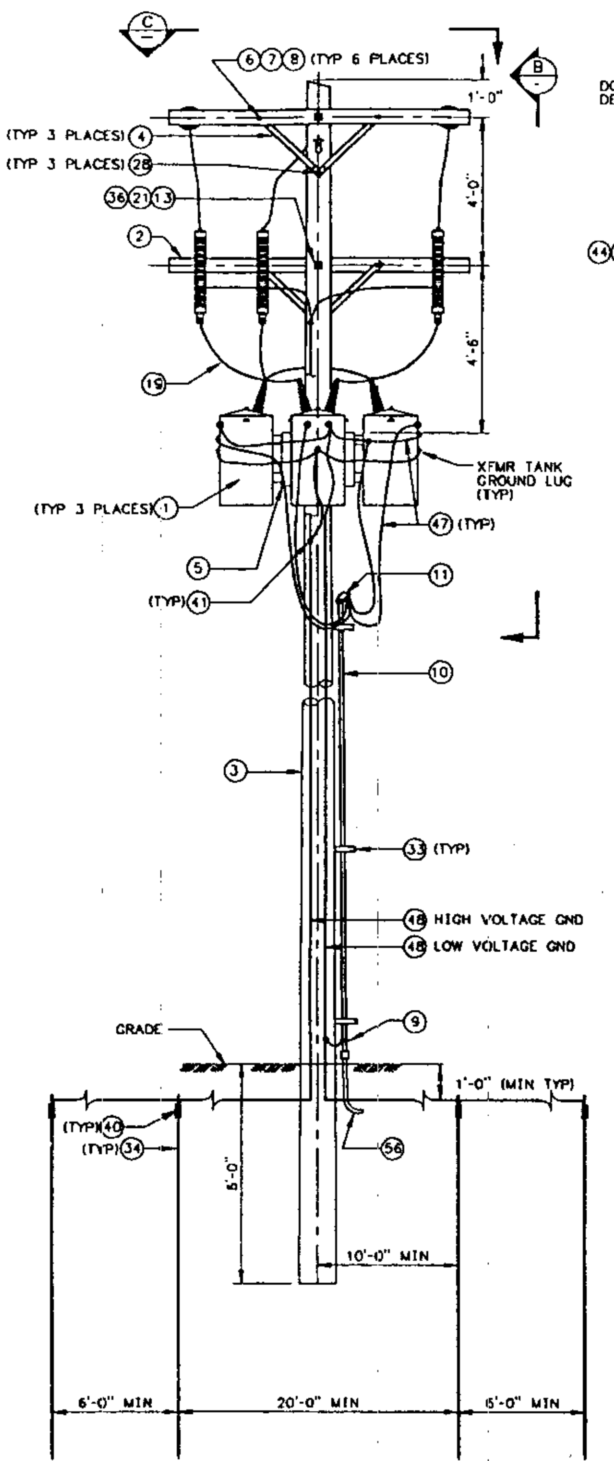
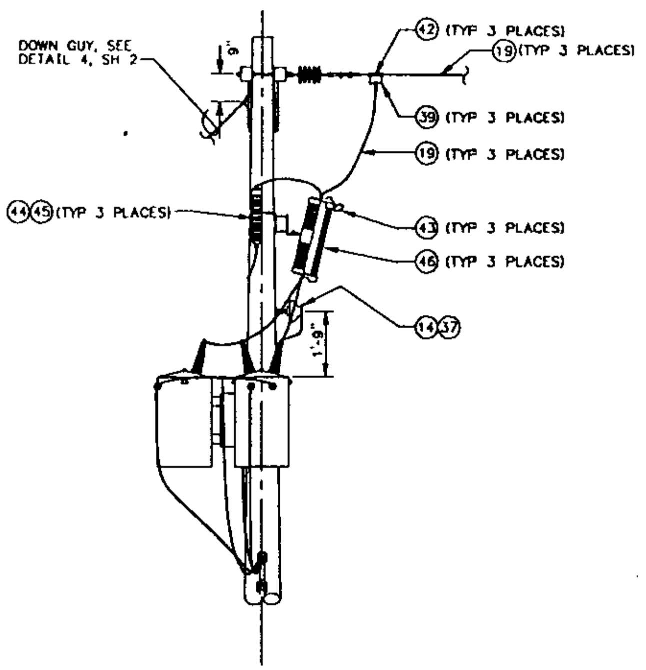
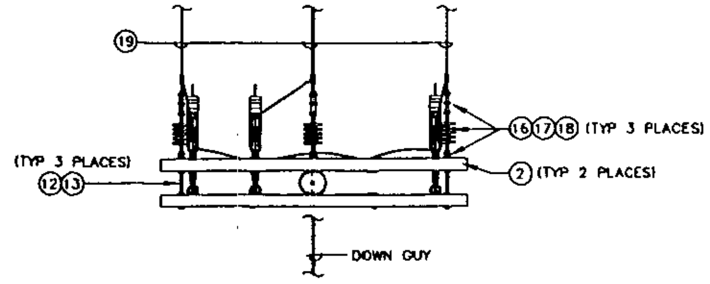


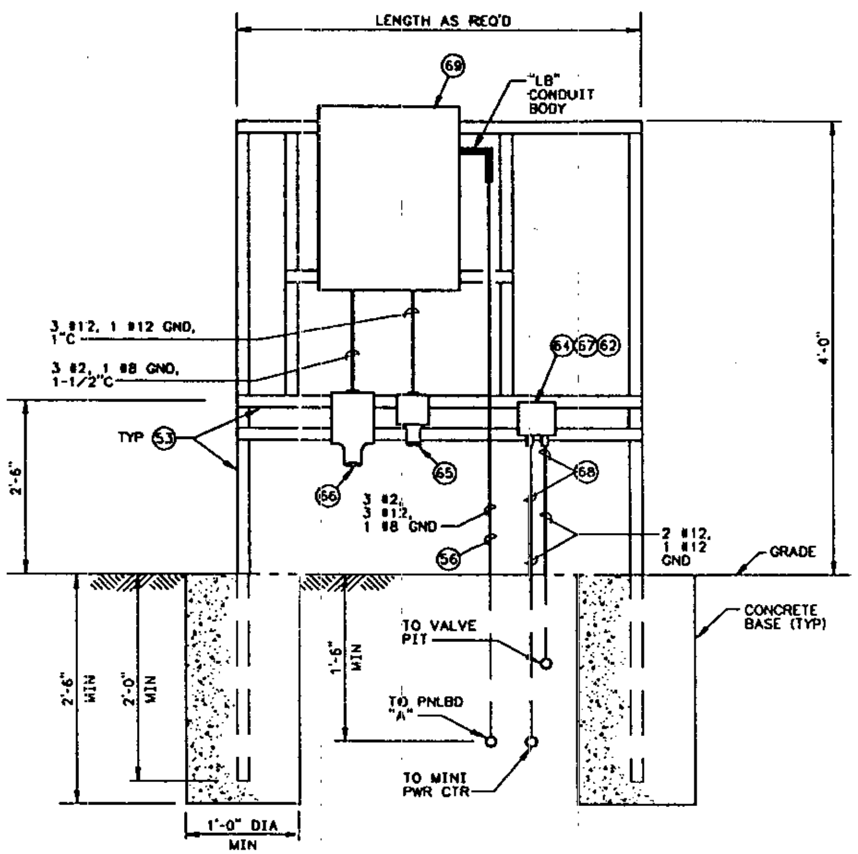
6 ELEVATION



B ELEVATION



C PLAN



8 DETAIL
SH 1 NTS

MATERIALS

PT #	DESCRIPTION
1	TRANSFORMER, 25 KVA, 13.8KV - 277V
2	CROSSARM, WOOD(SOLID). 8'-0" x 4-5/8" x 3-5/8" W/4-11/16" PIN HOLES. REA M19, TYPE 03.
3	WOOD POLE, CLASS 2, 40 FT. LENGTH
4	BRACE, CROSSARM, FLAT, GALVANIZED STEEL 30" x 1/4" x 1-1/4" W/7/16" & 9/16 MOUNTING HOLES (PAIR)
5	TRIPLE HANGER BRACKET, 12" AND 24" SPACING
6	BOLT, CARRIAGE, 3/8"-16UNC-2A x 5" W/NUT
7	WASHER, ROUND, 1" O.D. x 14 GA x 7/16" DIA HOLE
8	NUT, MF LOCK, SQUARE 3/8"-16UNC-2B
9	CONDUIT GROUND CLAMP
10	RIGID STEEL CONDUIT, 1-1/2"
11	WEATHERHEAD FOR 1-1/2" CONDUIT
12	BOLT, DOUBLE-ARMING, 5/8" DIA, W/4 NUTS, LENGTH TO SUIT
13	WASHER, SQUARE, 2-1/4" x 3/16" THK x 11/16" DIA HOLE
14	INSULATOR, PIN TYPE 'F' NECK, 15 KV PORCELAIN, 1" THREAD PER ANSI 55-5, W/RADIO NOISE FREE GLAZE
15	PIN FOR INSULATOR, FORGED STEEL, 1" LEAD THREAD WITH 5/8" SHANK x 12-1/2" LG
16	STANDARD EYE NUT, 5/8"
17	INSULATOR, DEADEND TYPE, 15KV, EPOXY STEEL COMPOSITE, LEAKAGE DISTANCE 16 IN., 15,000 LB. TENSILE STRENGTH
18	STRAIN CLAMP, FORGED STEEL, GALVANIZED
19	CONDUCTOR, BARE 7 STRAND #6 AWG MEDIUM HARD DRAWN COPPER
20	STRAIGHT THIMBLE EYE BOLT, 5/8" x LENGTH AS REQUIRED W/NUT
21	CURVED WASHER 3" x 3" x 1/4", 11/16" DIA HOLE
22	PREFORMED GUY GRIP OR 3 INCH, 3 BOLT GUY CLAMP
23	INSULATOR, GUY STRAIN, PORCELAIN, 20,000 LB. TENSILE STRENGTH PER ANSI 54-4
24	GUY CABLE, 7 STRAND 7/16" SEIMENS-MARTIN
25	ANGLE THIMBLE EYE BOLT, 5/8" x LENGTH AS REQUIRED
26	THIMBLE EYE NUT, 5/8"
27	LOAD PLATE, CURVED, 2-1/2" x 7" x 3/16" W/ 9/16" & 11/16" HOLES
28	LAG SCREW, 1/2" x 5" LONG
29	PLASTIC GUY GUARD, YELLOW, 8' x 1-1/2" FULL ROUND
30	ANCHOR ROD, DOUBLE THIMBLE EYE, 3/4" x 9'-0" LONG
31	GUY ANCHOR, CONCRETE CONE, SEE DETAIL 5
32	GUYING STUB POLE, 35 FOOT, CLASS 3
33	PIPE STRAP, ONE HOLE MALLEABLE IRON WITH BACK SPACER
34	GROUND ROD, COPPERCLAD STEEL, 5/8" DIA x 8'-0" LONG
35	POLE TOP PIN, PRESSED STEEL, 1" DIA LEAD, 20" LENGTH
36	MACHINE BOLT, 5/8", LENGTH AS REQD (WITH NUT)
37	STANDOFF PIN, LAG SCREW TYPE, FORGED STEEL, HOT DIP GALVANIZED, 5/8" DIA SHANK, 1" DIA LEAD
38	HOTLINE BAIL CLAMP, FOR 2/0 ACSR
39	HOTLINE CLAMP, BRONZE, FOR #6 AWG COPPER
40	GROUND ROD TO CABLE CLAMP, COPPER, COMPRESSION TYPE or EXOTHERMIC WELD
41	SPLIT BOLT CONNECTOR FOR COPPER GROUND WIRES
42	HOTLINE BAIL CLAMP, FOR #6 AWG COPPER
43	DISTRIBUTION POWER FUSEHOLDER 14.4 KVA
44	LIGHTNING ARRESTOR, 15 KV
45	CUTOUT/ARRESTOR BRACKET
46	FUSE, UNIT CURRENT RATING 5E, 14.4 KV
47	POWER CONDUCTOR, 600 VOLT, #1 AWG COPPER, TYPE THWN INSUL
48	GROUND WIRE, #4 AWG INSULATED COPPER CONDUCTOR
49	METER ENCLOSURE, 600 VOLT, OUTDOOR
50	KW HOUR METER
51	PANELBOARD, 480/277 VOLT, 100 AMP, 18 CIRCUIT, WITH 100 A MAIN CIRCUIT BREAKER, NEMA 3R
52	MINI-POWER CENTER, OUTDOOR PACKAGED POWER SUPPLY, 15 KVA, 120/240 VOLTS AC
53	FRAMING CHANNEL, 1-5/8" x 1-5/8" GALVANIZED STEEL
54	DOUBLE FRAMING CHANNEL, 3-1/4" x 1-5/8" GALVANIZED STEEL
55	WOOD POLE, CLASS 3, 40 FT. LENGTH
56	PVC COATED RIGID STEEL CONDUIT, 1-1/2"
57	TRAFFIC GUARD POST, (MATCH EXISTING POSTS AT FIRE HYDRANT)
58	DUPLEX RECEPTACLE, SPECIFICATION GRADE, 20 AMP, 125V, 2 POLE, 3 WIRE GROUNDING, NEMA CONFIG 5-20R, GFCI
59	RAINTITE OUTLET ENCLOSURE, INDUSTRIAL GRADE, TAYMAC CORP CAT NO. 20310 OR EQUAL
60	SINGLE GANG TYPE FS OUTLET BOX
61	SINGLE RECEPTACLE, 20 AMP, 125/250V, 3 POLE, 4 WIRE GROUNDING, NEMA CONFIG 14-20R
62	RAINTITE OUTLET ENCLOSURE, INDUSTRIAL GRADE, TAYMAC CORP CAT NO. 30310 OR EQUAL
63	SINGLE RECEPTACLE, 50 AMP, 125/250V, 3 POLE, 4 WIRE GROUNDING, NEMA CONFIG 14-50R WITH WEATHERPROOF BOX AND LIFT LID COVER
64	TWO GANG TYPE FS OUTLET BOX
65	RECEPTACLE, WATERTIGHT, 20 AMP, 480V, 3 POLE, 4 WIRE WITH 15° ANGLE BACK BOX. HUBBELL CAT NO. 420R7W OR EQUAL. FURNISH WITH MATING PLUG, KELLEMS STRAIN RELIEF GRIP, AND 300 FEET OF 4 CONDUCTOR #12 AWG, 600V, TYPE SO POWER CORD.
66	RECEPTACLE, 100 AMP, 600V, 3 WIRE, 4 POLE WITH BACK BOX, ANGLE ADAPTER AND SPRING DOOR, WP, CROUSE-HINDS CAT NO. AREA 10425 OR EQUAL.
67	SINGLE RECEPTACLE, 20 AMP, 125V, 2 POLE, 3 WIRE GROUNDING, NEMA CONFIG L5-20R. FURNISH WITH MATING PLUG
68	PVC COATED RIGID STEEL CONDUIT, 3/4"
69	JUNCTION BOX 12" X 12" 6" GALVANIZED STEEL W/SCREW GASKETED COVER, NEMA 3

H-2-817497 SH 3

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Appendix C

Filter Calculations

KAISER ENGINEERS HANFORD	**CALCULATION IDENTIFICATION AND INDEX**	Page 1 of 9 Date 4/21/93

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline ENVIRONMENTAL ENG. WO/Job No. ER3412/W-263 Calculation No. ER3412-03

Project No. & Name W-263 PROTOTYPE SURFACE BARRIER

Calculation Item DETERMINING GRADATION RANGES FOR FILTER MEDIA

These calculations apply to:

Dwg. No. ______ Rev. No. ______

Dwg. No. ______ Rev. No. ______

Other (Study, CDR) SPECIFICATION W263-C2

Rev. No. 0

The status of these calculations is:

- ☐ Preliminary Calculations
- ☒ Final Calculations
- ☐ Check Calculations (On Calculation Dated ______)
- ☐ Void Calculation (Reason Voided ______)

Incorporated in Final Drawings? ☐ Yes ☐ No

This calculation verified by independent "check" calculations? ☐ Yes ☐ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	[signature] 4/21/93		
Checked by	[signature] 4/23/93		
Approved by	[signature] 4/23/93		
Checked Against Approved Vendor Data			

INDEX

KEH 0378.00 (06/92)

CALCULATION CROSS INDEX (Typical)

Subject Calculation No. ER3412-03

Subject Calculation Revision No.	Superceded by Calculation No.	These interfacing calculation/documents provide input to the subject calculation, and if revised may require revision of the subject calculation.		Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calculation/ documents require revision?		Has the output interface calculation/ documents been revised?		Discipline manager's signature and date indicating evaluation complete.
		Calculation/Document No.	Revision No.	Calculation/Document No.	Revision No.	Yes	No	Yes	No	
0				SPEC ER3412-C2	0		X		X	D.L. Fort 7/6/93

C-3

9613323.0462

Client WHC		WO/Job No. ER3412/W-263	
Subject PROTOTYPE SURFACE BARRIER		Date 4/21/93	By S.D. CONSORT
DETERMINING GRADATION RANGES FOR FILTER MEDIA		Checked 4-23-93	By RG Hollenbeck
Location 216-B-57 CRIB, 200E		Revised	By

OBJECTIVE:

Determine the allowable gradation ranges for a filter media between the McGee silts and the drainage gravel in the Prototype Surface Barrier. The filter media must be sufficiently fine grained to limit the downward movement of overlying McGee silts, but coarse enough not to migrate into the underlying drainage gravel. The drainage gravel will also serve as a filter between the overlying filter media and the underlying basalt.

DESIGN INPUTS:

Criteria and Source:

A prototype design of a cover (surface barrier) will be constructed over the 216-B-57 crib in the 200-BP-1 Operable Unit on the Hanford Site as part of a demonstration of in situ disposal of contaminated soils. The design of the surface barrier requires a fine grained soil to support vegetation as the surface layer with an underlying drainage layer. Beneath the drainage layer, the prototype will contain a layer of basalt to inhibit deep animal burrowing and root penetration. McGee silts will be used as the fine grained soil. A filter media is needed between the silts and the drainage layer (a gravel) to limit the movement (piping) of silt into the coarser grained materials. The filter media must not clog the pore space of the gravel. The drainage gravel will be commercially available road base, either Crushed Surfacing Base Course (CSBC, 1¼ inch minus) or Crushed Surfacing Top Course (CSTC, $^5/_8$ inch minus). Criteria for the filter media is given in the book by H.R. Cedergren (page 156) as follows:

1) The 15% size (D_{15}) of a filter material must be not more than four or five times the 85% size (D_{85}) of the protected soil. This criteria limits piping.

2) The 15% size of a filter material should be at least four or five times the 15% size of a protected soil. This criteria guarantees sufficient permeability, which is not a factor in this design.

3) The 50% (D_{50}) size of a filter material must be not more than 25 times that of a protected soil. This criteria is applied to filter media with gradation curves approximately parallel to the protected soil. Filtration tests are unnecessary when this criteria is applied.

Client WHC | WO/Job No. ER3412/W-263
Subject PROTOTYPE SURFACE BARRIER | Date 4/21/93 | By S.D. CONSORT
DETERMINING GRADATION RANGES FOR FILTER MEDIA | Checked 4-23-93 | By R G Hollenbeck
Location 216-B-57 CRIB, 200E | Revised | By

Given or Known Data:

The gradation curves for the finest grained silts and the coarsest gravel road base were used in the calculations to obtain a range of conservative values for the filter media. The silts are from Test Pit 6 (TP-6) at the McGee Ranch site and are described in a geotechnical report by Chen-Northern, Inc. The road base is defined in the Washington State Department of Transportation Standard Specifications, 9-03.9(1-3). This data has been plotted on Graph 1.

Methods to be Used:

The criteria given above will be used to calculate by hand the range of values for the filter media with respect to the overlying silts and the underlying drainage gravel. Filter design methods from "Seepage, Drainage, and Flownets" by H.R. Cedergren will be used.

References:

Cedergren, H.R., Seepage, Drainage, and Flow Nets, John Wiley & Sons, Inc., 3rd Edition, 1989.

Chen-Northern, Inc., "Report of Geotechnical Investigation", W-105, 242-A, Evaporation and PUREX Interim Retention Basins, Hanford Federal Reservation, Project No. 90-1901, August 1990.

CALCULATIONS:

The McGee silts are defined as Layer 1, the filter media is Layer 2, and the drainage gravel is defined as Layer 3. When calculating the potential for piping of the filter media into the gravel, Layer 3 is considered a filter that protects Layer 2.

D_{15F} = grain diameter (size) at 15% finer by weight of the Filter media
D_{85F} = size at 85% finer by weight of the Filter media

'c' and 'f' indicate coarse and fine ranges allowed by Cedergren (e.g. D_{15Fc}).

D_{15s} = size at 15% finer by weight of the McGee silts
D_{85s} = size at 85% finer by weight of the McGee silts
D_{15g} = size at 15% finer by weight of the drainage gravel
D_{85g} = size at 85% finer by weight of the drainage gravel

Client WHC		WO/Job No. ER3412/W-263	
Subject PROTOTYPE SURFACE BARRIER		Date 4/21/93	By S.D. CONSORT
DETERMINING GRADATION RANGES FOR FILTER MEDIA		Checked 4-23-93	By RG Hollenbeck
Location 216-B-57 CRIB, 200E		Revised	By

D_{85s} = 0.086 mm (Graph 1, TP-6 curve)

D_{15g} = 2.2 mm (Graph 1, CSBC-CRS curve)

Defining the limit of the coarser range of Layer 2:

$D_{15F}/D_{85s} \leq 5$ implies that $D_{15Fc} = D_{85s} \cdot 5$

D_{15Fc} = 0.43 mm

This point is used to develop curve 'A' on Graph 1. Curve 'A' parallels the TP-6 curve.

Defining the limit of the finer range of Layer 2:

$D_{15g}/D_{85F} \leq 5$ implies that $D_{85Ff} = D_{15g}/5$

D_{85Ff} = 0.44 mm

This value was used to develop curve 'B' on Graph 1. Curve 'B' parallels the CSBC-CRS curve.

Checking Layers 1 and 2 with respect to the third criteria:

$D_{50F}/D_{50s} \leq 25$ implies that

D_{50Ff} = 0.205 mm (Graph 1, curve 'B')

D_{50s} = 0.052 mm (Graph 1, TP-6)

$$\frac{D_{50Ff}}{D_{50s}} = 3.9 \quad << 25 \text{ OK}$$

D_{50Fc} = 3.3 mm (Graph 1, curve 'A')

$$\frac{D_{50Fc}}{D_{50s}} = 63.5 \quad > 25 \text{ too high}$$

Since the D_{50Fc} is too coarse for the silt, the third criteria was used to calculate the coarsest grain size allowed for the filter.

D_{50Fct} = coarsest grain size of filter at 50% finer by weight

Client WHC | WO/Job No. ER3412/W-263
Subject PROTOTYPE SURFACE BARRIER | Date 4/21/93 | By S.D. CONSORT
DETERMINING GRADATION RANGES FOR FILTER MEDIA | Checked 4-23-93 | By RG Hollenbeck
Location 216-B-57 CRIB, 200E | Revised | By

$$D_{50Fct} = D_{50s} \cdot 25$$

$$D_{50Fct} = 1.3 \text{ mm}$$

This value of the coarsest grain size was used to modify curve 'A'.

Checking Layers 2 and 3 with respect to the third criteria:

$D_{50g}/D_{50F} \leq 25$ implies that

$D_{50g} = 16$ mm (Graph 1, CSBC-CRS)

$$\frac{D_{50g}}{D_{50Fc}} = 5.0 \quad << 25 \quad \text{OK}$$

$D_{50Ff} = 0.205$ mm (Graph 1, curve 'B')

$$\frac{D_{50g}}{D_{50Ff}} = 78.1 \quad >> 25 \quad \text{too high}$$

D_{50Fft} = finest grain size of filter at 50% finer by weight

$$D_{50Fft} = \frac{D_{50g}}{25}$$

$$D_{50Fft} = 0.64 \text{ mm}$$

The above value was used to develop the dashed curve, parallel to curve 'B' on Graph 1, which defines the finest grain sizes for the filter. The range between curve 'A' and the dashed curve restricts the filter material to a range of values difficult to find. Choosing a finer grained drainage gravel will extend the limits of the filter to finer grain sizes. The gravel chosen is the coarsest range of Crushed Surfacing Top Course (CSTC). The coarse range of the filter was based on the TP-6 gradation curve and is not affected by the change in drainage media.

$D_{15g} = 0.84$ mm (Graph 2, CSTC-CRS)

$$D_{85Ff} = \frac{D_{15g}}{5} \qquad D_{85Ff} = 0.17 \text{ mm}$$

Client WHC | WO/Job No. ER3412 /W-263
Subject PROTOTYPE SURFACE BARRIER | Date 4/21/93 | By S.D. CONSORT
DETERMINING GRADATION RANGES FOR FILTER MEDIA | Checked 4-23-93 | By RG Hollenbeck
Location 216-B-57 CRIB, 200E | Revised | By

The D_{85Ff} calculated from the coarse fraction of the drainage gravel can be used to produce a range limit curve parallel with the CSTC-CRS (dashed curve on Graph 2).

Checking Layers 1 and 2 with respect to the third criteria:

D_{50gc} = 5.2 mm (Graph 2, CSTC-CRS)

$D_{50Fft} = \frac{D_{50gc}}{25}$ D_{50Fft} = 0.208 mm

The D_{50Ff} on the curve produced from the calculated D_{85Ff} was too fine grained to satisfy the third criteria. The D_{50Fft} was used to develop the final limits for the range of finest grain sizes allowable for the filter media. The curve is drawn parallel to the CSTC-CRS curve and is defined as curve 'C' on Graph 2.

Checking the fine fraction of Layer 3 and the basalt with respect to the first criteria:

D_{15B} = 25 mm (Graph 1 or 2, Basalt)

D_{85gf} = 9.2 mm (Graph 2, CSTC-FINE)

$\frac{D_{15B}}{D_{85gf}}$ = 2.7 mm < 5 for CSTC-FINE OK

Checking the coarse fraction of Layer 3 and the basalt with respect to the third criteria:

D_{50B} = 101.6 mm (Graph 1 or 2, Basalt)

$\frac{D_{50B}}{D_{50gc}}$ = 19.2 mm < 25 for CSTC-CRS OK

Checking the fine fraction of Layer 3 and the basalt with respect to the third criteria:

D_{50gf} = 2.4 mm

$\frac{D_{50B}}{D_{50gf}}$ = 42.3 mm > 25 too high

Client WHC | WO/Job No. ER3412 / W-263
Subject PROTOTYPE SURFACE BARRIER | Date 4/21/93 | By S.D. CONSORT
DETERMINING GRADATION RANGES FOR FILTER MEDIA | Checked 4-23-93 | By RG Hollenbeck
Location 216-B-57 CRIB, 200E | Revised | By

The fine fraction of Layer 3 does not fit the third criteria. Also, if the finer fraction of the basalt moves to the lower portion of the basalt layer during construction, the D_{50} of the basalt in contact with Layer 3 may be too coarse for even the coarse fraction of the drainage gravel. Another filter layer between the drainage gravel and the basalt is required.

FINDINGS & CONCLUSIONS:

Using Crushed Surfacing Base Course as a drainage media was found to be too restricting to the gradation range of a filter. Crushed Surfacing Top Course was substituted as the drainage gravel which allowed a broader, more obtainable range. This range is bound by curves 'A' and 'C' on Graph 2 and the yields the following range of values:

D_{85} = 2.4 to 0.41

D_{50} = 1.3 to 0.205

D_{15} = 0.42 to 0.03

The D_{85} and D_{15} values resulted from applying the first criteria. The D_{50} values are a result from applying the third criteria. A filter media conforming to these criteria will limit the piping of McGee silts into the filter, and limit the filter from piping into the drainage gravel. A filter whose gradation is closer to the coarse side of the allowable range is preferred because it would provide a better capillary break at the interface between the silts and the filter.

The fine fraction of the Crushed Surfacing Top Course did not meet the third criteria when evaluated with respect to the basalt layer. Another filter media is required between the basalt and the overlying drainage gravel of Top Course. Leveling the surface of the basalt with shoulder ballast is required.

C-10

▽ TP-6

◇ CSBC-CRS

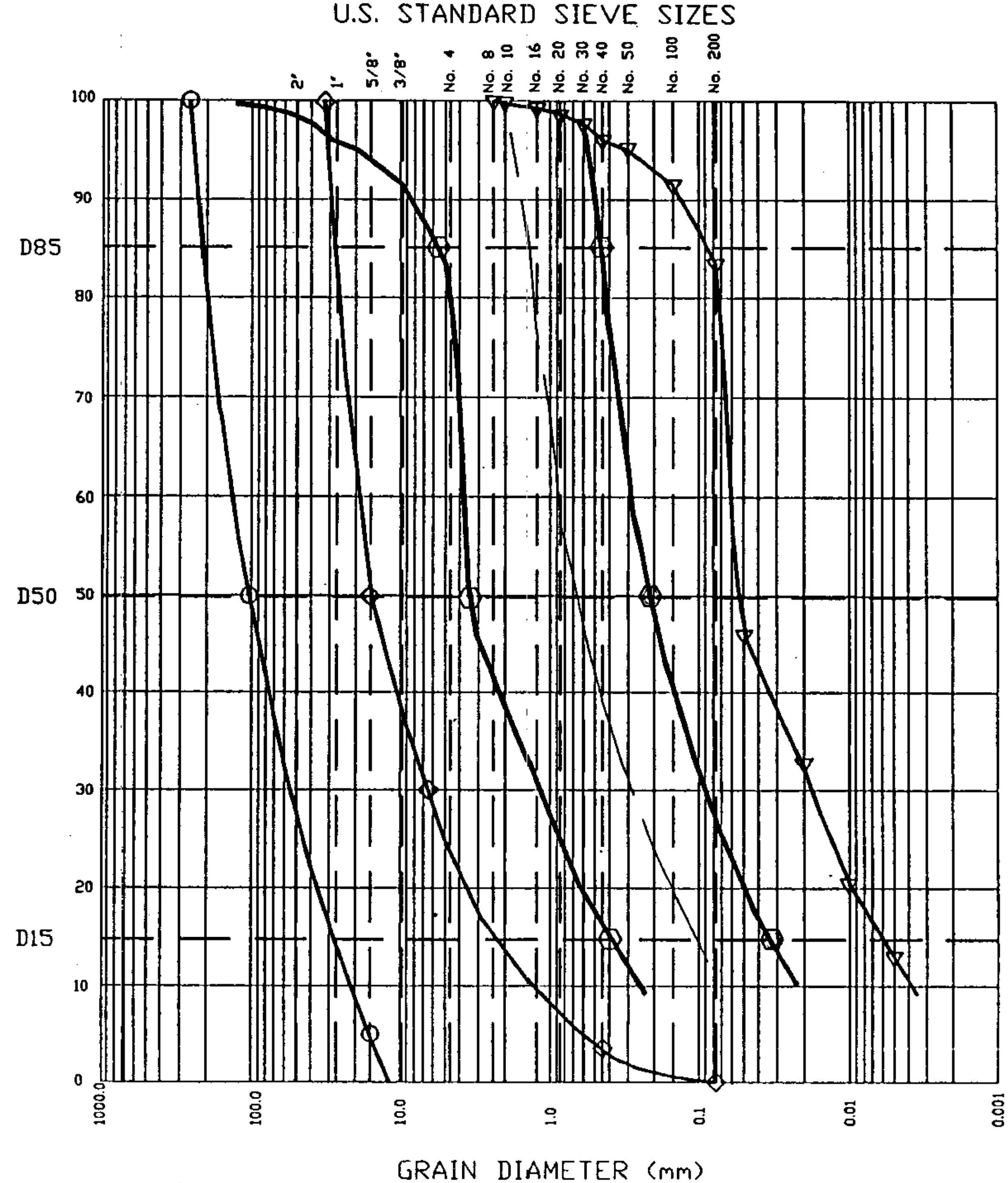
○ BASALT

○ FILTER (UNMODIFIED CURVE 'A')

⬡ FILTER (CURVE 'B')

SIEVE SIZE INCHES or MESH #	SIEVE SIZE MM	MCGEE SILT TP-6	CSBC CRS
2.5	63		
2	50		
1.25	31.7		100
1	25		
0.625	16		50
0.375	9.5		
0.25	6.3		30
# 4	4.76		
# 8	2.36	100	
# 10	2.0	99.8	
# 16	1.19	99	
# 20	0.84	98	
# 30	0.59	97.5	
# 40	0.425	96.2	3
# 50	0.3	95.5	
# 100	0.15	92	
# 200	0.074	84.1	0
	0.05	46	
	0.02	33	
	0.01	21	
	0.005	13	

GRAPH 1



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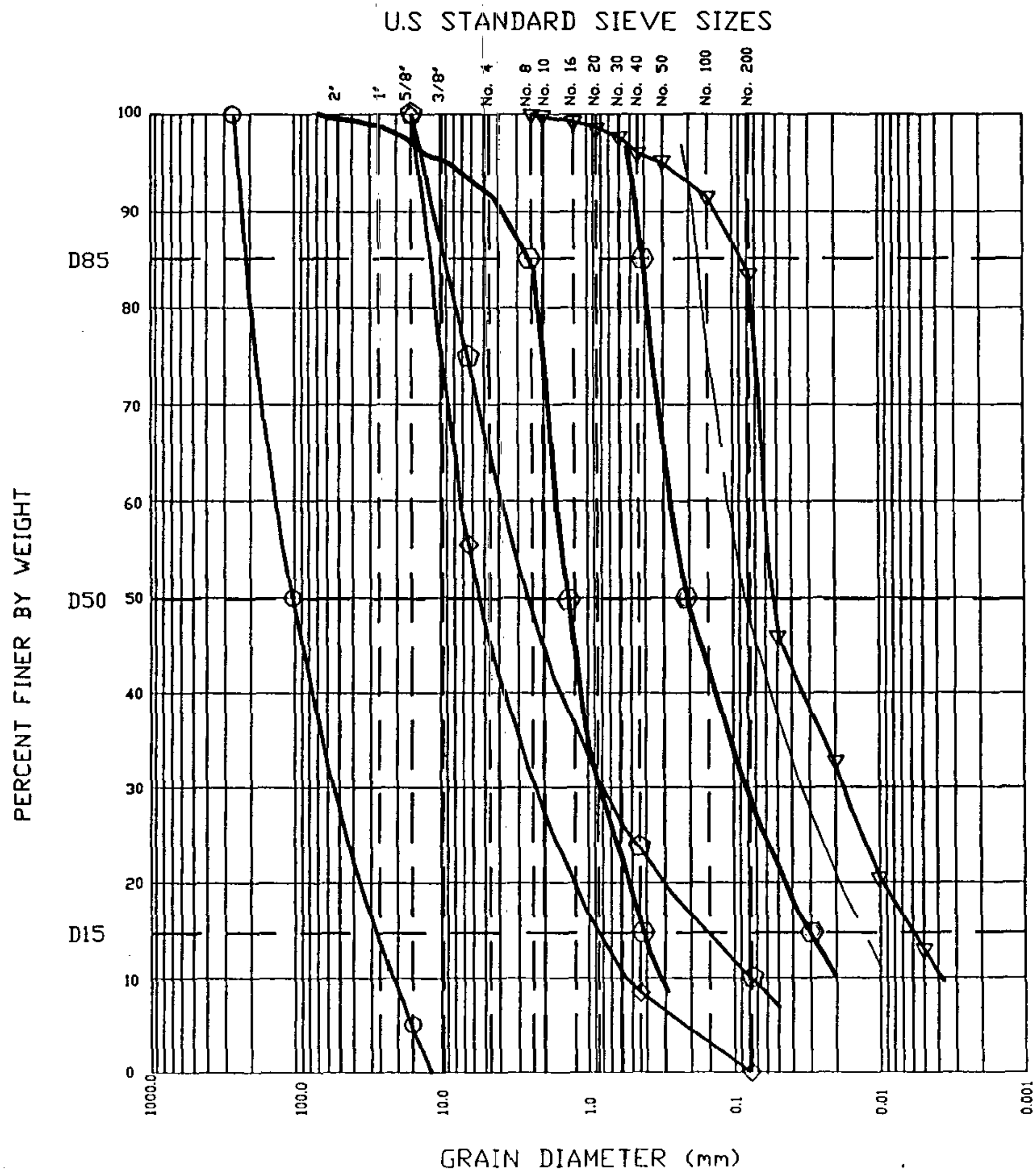
GRAPH 2



▽ TP-6

◇ CSTC-CRS

⬠ CSTC-FINE

○ BASALT

○ FILTER (MODIFIED CURVE 'A')

⬡ FILTER (CURVE 'C')

C-11

SIEVE SIZE INCHES or MESH #	MM	MCGEE SILT TP-6	CSTC CRS
2.5	63		
2	50		
1.25	31.7		
1	25		
0.625	16		100
0.375	9.5		
0.25	6.3		55
# 4	4.76		
# 8	2.36	100	
# 10	2.0	99.8	
# 16	1.19	99	
# 20	0.84	98	
# 30	0.59	97.5	
# 40	0.425	96.2	8
# 50	0.3	95.5	
# 100	0.15	92	
# 200	0.074	84.1	0
	0.05	46	
	0.02	33	
	0.01	21	
	0.005	13	

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Appendix D

Kaiser Interoffice Memorandum

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Rev. 00

INTEROFFICE MEMORANDUM

TO D. L. Fort

DATE March 17, 1993

FROM Ed Becker*
ICF -KE Oakland

COPIES TO

JOB NO. ER3412

SUBJECT PROTOTYPE SURFACE BARRIER AT 200-BP-1 OPERABLE UNIT: SOILS SPECIALIST LETTER REPORT PER STATEMENT OF WORK-PROJECT W-236

1. Evaluation of range of settlements to be anticipated at the surface of the asphaltic concrete liner and effect on drainage potential.

The barrier as presently conceived will have an asphaltic concrete liner which will be covered by a number of soil and rock layers as shown on Drawing Number ES-3412-E3, Rev. 0; Civil Section and Details. The area of the full depth barrier will be approximately 46.6M x 87.6M (153.8 x 287.3 feet). The total depth of soil/rock layers to be placed on top of the asphaltic concrete liner is 4.50M (14.76 ft.). The evaluation of the anticipated settlements was made on the basis of elastic theory for a loaded area on a semi-infinite media. This is considered to be valid in as much as the site of the proposed barrier is underlain by granular materials consisting mostly of sands and gravel. Settlements due to loads applied to these materials will take place essentially immediately upon application of the load and are not time dependant as is, for instance, the consolidation process for saturated clays. The results of the analysis indicate that a slight "dishing" effect of the asphaltic concrete layer can be anticipated due to settlements resulting from the weight of the overlying soil/rock layers. The maximum amount of this "dishing" effect is approximately 1 inch (2.54 cm) of differential settlement from the mid-point along the long edge of the asphaltic concrete area to the

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INTEROFFICE MEMORANDUM

middle of the asphaltic concrete area. This will be a reverse slope superimposed on the 18 inch (46.6 cm) slope provided during construction for drainage. It is thus evident that settlements will have an essentially negligible effect on the proper drainage functioning of the proposed barrier.

2. Evaluation of subgrade materials.

The site for the proposed prototype surface barrier in underlain to a considerable depth (300 to 400 ft.) by granular materials consisting of sands and gravel. Basalt rock several thousand feet thick underlies the soil/rock material. Groundwater is reportedly at a depth of approximately 230 ft. The sands and gravels are made up of rounded particles and the formations tend to be in a medium dense to dense state in the natural deposits. These materials are an excellent construction material on which to place the barrier. The 4.5M barrier will load the area to approximately 8t/M2 (0.8 kg/cm2; 1.6ksf). This is a very moderate loading condition for the site subsoils. Similarly, the proposed use of a locally available sandy soil for fill to bring the site to a uniform grade will result in a fill of similar properties as the underlying materials. After clearing and grubbing it is recommended that the existing site surface be compacted with a vibrating roller and the sandy soil fill place in layers 30 cm or less in thickness and each layer be similarly compacted.

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3. Stability of side slopes for filter media.

Slopes in granular material such as crushed basalt or sands and gravel fail by surface sloughing or ravelling when the slopes exceed the angle of repose of the materials. It is estimated that the angle of repose for the crushed basalt is of the order of 45° which is equivalent to a 1:1 slope. The basalt placed at a slope of 2:1 (which is equivalent to 26.6°) is therefore in a very stable configuration.

Similarly, the filter material (30cm of gravel overlain by 15cm of sand) will be stable at a 2:1 slope. It is estimated that the angle of repose for these materials will be on the order of 35° (equivalent to a 1.42:1 slope) and should exhibit no stability problems when placed at a slope of 2:1. The material will not be compacted when placed on the 2:1 slope. The 45cm thickness measured normal to the slope is 50.3 cm deep when measured vertically. It is estimated that placing the silty soils against the filter soil will result in a densification of no more that 5% or 2.5cm when measured vertically.

4. It would seem to be prudent to measure the subsidence that takes place from the placement of the barrier material above the asphaltic concrete liner and the possible small long term movements that may take place over time. Such a measuring system should be in place before placement of materials onto

INTEROFFICE MEMORANDUM

the asphaltic concrete liner commences so as to measure the total subsidence that occurs during placement. An effective and simple system would be a rod 3/4 inches in diameter and 4.5 meters long attached to a 1 meter square plate placed on the completed asphaltic concrete liner. This rod should be sleeved off where it passed through the fractured basalt. Using bench marks located at least 30 to 40 meters away from the barrier, the initial elevation of the top end of the in place rod should be established. Readings could then be continued on a scheduled basis during and after the construction of the barrier. It is suggested at least 2 settlement markers be used; one located somewhere in the central portion of the barrier area and a second near the edge of the barrier in order to establish the order of magnitude of both the total and differential settlements that take place. The data obtained should be plotted on a regular basis.

5. In some areas, where the surface barrier may ultimately be used, the waste material was disposed of within wood cribbing structure, in drums with voids remaining between the drums etc. It is anticipated that over the long term the wood, drums etc. will decompose, rust out etc. which will cause in-filling of the voids resulting in long term gradual settlements of the surface barrier. Performing a field testing program to simulate these type of settlements and barrier deflection is desirable. A suggested scheme for accomplishing such a program is described below, making use of device similar to a flat-jack used for testing in-situ rock formations for dam foundations.

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The idea is to place lens like cells below the barrier and then collapse these cells resulting in barrier settlement to simulate actual future field performance. It is anticipated these cells could be made from sheet metal and are herein given the name of plate-cells. It is suggested the plate-cells be circular shaped of the order of 10 ft. in diameter. Plate-cell would consist of a top and bottom 10ft diameter circular plate welded to a 10 ft. diameter circular half-round edge element. The diameter of the half-round edge element would be the thickness (or depth in a vertical sense) of the plate cell. Plate-cells could be built having thickness say in the range of 3 to 12 inches. During placement of these plate-cells, below the barrier prior to barrier construction, they would be filled with water and have a piping or tubing arrangement such that the water could be bled off to allow plate-cell collapse after barrier construction was completed. If a typical 15 ft. barrier is used with 110#/ft3 material the pressure in the plate-cell would be 1650 psf or 11.5 psi. If these plate-cells were placed totally encapsulated in clean sand the plate-cell top and bottom would have the same pressure and no deflection would take place as long as the water was not bled off. The circular half-round plate-cell edges should be designed for the bursting pressures with an adequate factor of safety. These pressures would be modest. For instance, assuming an internal design pressure of 40 psi (including factor of safety) the bursting pressures would range from 120 to 480#/in of circumference of the plate cell. Designing for such pressures for sheet metal plate construction would be a simple matter. By placing a number

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of these plate-cells one above the other with say 6 inches of sand between them, any desired amount of induced settlement/deflection could be achieved by simply placing an appropriate number of plate-cells one above the other. The rate of settlement could also be controlled by the rate at which water was allowed to bleed off.

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