

Permanent Markers Implementation Plan



August 19, 2004

**United States Department of Energy
Waste Isolation Pilot Plant**

**Carlsbad Field Office
Carlsbad, New Mexico**

Permanent Markers Implementation Plan

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Carlsbad, New Mexico**

August 19, 2004

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Abbreviations and Acronyms

AIC	Active Institutional Controls
AT	Awareness Triggers
ATP	Awareness Triggers Package
CAG	Compliance Application Guidance (EPA, 1996)
CFR	Code of Federal Regulations
CCA	Compliance Certification Application (DOE, 1996)
CRA	Compliance recertification Application (DOE, 2004)
D&D	Decontamination & Decommissioning
DOE	U.S. Department of Energy
DOE-CBFO	Carlsbad Field Office
EPA	U. S. Environmental Protection Agency
FEIS	Final Environmental Impact Statement
LWA	Land Withdrawal Act
M&OC	Management and Operating Contractor
MTT	Message Translation and Testing
PICs	Passive Institutional Controls
PMT	Permanent Markers Testing
QA	Quality Assurance
RM	Records Management
WIPP	Waste Isolation Pilot Plant

Definitions

Controlled Area - This area is the same as the Land Withdrawal Area.

Land Withdrawal Area - This area is defined in the WIPP Land Withdrawal Act. It is a geographic area of 16 sections surrounding the surface facilities (16 square miles; 10, 240 acres).

Conceptual Design - The design of the Passive Institutional Control (PIC) System proposed in the DOE's Compliance Certification Application (CCA) (DOE, 1996), Appendix PIC

Repository Footprint/Waste Disposal Footprint - The "footprint" consists of a line on the ground surface that reflects the perimeter of the Waste Disposal Area as it will exist at 2150 feet below the surface. The area it encloses, thus, is the same as Waste Disposal Area.

1.0 Introduction

The U.S. Department of Energy (DOE) is initiating a program of passive institutional controls (PICs) for the Waste Isolation Pilot Plant (WIPP). This program is required by U. S. Environmental Protection Agency (EPA) 40 CFR 191.14(c) (EPA, 1993) and 40 CFR 194.43 (EPA, 1996). The primary purpose of the PICs program is to provide a permanent record which identifies the location of the repository and its dangers, thus reducing the likelihood of inadvertent human intrusion into the repository. The EPA regulations specify that radioactive waste disposal systems must be designated by multiple PICs including permanent markers, long-term records and “other PICs” which DOE is calling “awareness triggers.”

The PICs proposed by the DOE Carlsbad Field Office (DOE-CBFO) are described in the Compliance Certification Application (CCA) (DOE, 1996) and the Compliance Recertification Application (CRA) (DOE, 2004); the descriptions included in these applications are called the “conceptual design.” This design meets the intent of the regulations, is feasible using current technology, and provides a basis for the EPA’s certification and recertification of the WIPP. The conceptual design, however, does not necessarily represent an optimum design. For example, the design may be optimized by selecting alternative technologies, materials, configurations, messages, or construction practices. The DOE has committed in the previous referenced application to review the conceptual design, conduct testing and evaluations, and recommend a final design prior to the end of the disposal operations period.

DOE has issued the PICs Implementation Plan as the top tier document to describe the overall Passive Institutional Controls Program. This plan is one of the three supporting documents and provides additional detail for the Permanent Markers. It presents DOE plans for the design and implementation of the Permanent Markers Program including the:

- Establishment of performance specifications;
- Determination of testing needs;
- Definition of a strategy for making design decisions; and
- Reassessment of the conceptual design.

The conceptual design for permanent markers at the WIPP includes six markers components. These are:

1. Large Surface Markers;
2. Small Subsurface Markers;
3. Berm;
4. Buried Storage Rooms;
5. Hot Cell; and
6. Information Center.

All of these components require some form of testing during the WIPP operating period. The testing program for these components is described in an additional document, the Permanent Markers Testing Program Plan, DOE/WIPP 00-3175, (DOE, 2000). The

general purpose of the permanent markers implementation program, including the testing program, is to develop information useful in optimizing the design by evaluating alternative configurations, alternative materials, and assistance in the development of final designs and the specification of permanent markers construction methods. Testing will help to determine the durability of alternative materials and design configurations and the effectiveness of the designs in conveying intended messages. In addition, testing will be useful in establishing standards for construction. The practicability of the construction of alternative designs will also be evaluated.

The permanent markers implementation program consists of three main parts:

- **Design Criteria** - The development of criteria for the selection of permanent markers components materials, designs, and methods of construction will provide a basis for the identification of appropriate testing methods;
- **Strategy** - Planning which includes decision making steps for arriving at a final design incorporating quality assurance and quality control methods; and
- **Testing** - Testing the suitability and effectiveness of the materials, designs, and construction methods and the translation and testing of the messages to be engraved on the large surface markers, small subsurface markers, buried storage rooms, and the information center.

This document defines activities to be performed to complete the first two portions of the overall permanent markers program. Specific plans for completing the third part (i.e., testing) are described in the Permanent Markers Testing Program Plan (DOE, 2000).

Information provided in this plan includes:

1. A description of regulatory requirements that must be met in implementing the permanent markers program and the sources of these requirements. This is provided in Section 2.0.
2. A description of the design bases for the permanent markers including performance objectives, performance criteria, and design criteria and the general process that will be implemented to ensure that the final designs of the permanent markers components meet these objectives and criteria. This is provided in Section 3.0.
3. A general description of the conceptual design for each marker component within the permanent marker system. This is provided in Section 4.0.
4. A discussion of each component within the conceptual design for each of the permanent markers components and descriptions of open design considerations related to each marker component. Alternative materials that have been proposed are also identified. These details are discussed in Section 5.0.
5. Summarized plans for the translation and testing of messages to be inscribed on the various markers components. This is provided in Section 6.0.

6. A description of the strategy necessary to fully develop permanent markers components designs and the general schedule for implementation of the program. This is provided in Section 7.0.
7. The quality assurance provisions, found in Section 8.0, that apply to work performed under the permanent markers implementation program.

2.0 Permanent Markers Requirements and Commitments

General requirements and commitments impacting the Permanent Markers System are detailed in the *Passive Institutional Controls Implementation Plan, DOE/WIP 04-2301*.

2.1 DOE Commitments in the CCA and CRA

Commitments made on the part of the DOE that relate to this implementation plan have been categorized in one of three ways. The first is general commitments, those related to topics such as quality assurance, general regulatory matters, and schedule. The second is design and construction. This category involves commitments related to topics such as the design of particular markers, materials, and the manner in which markers will be built. The third is permanent markers testing. This category involves commitments to test materials, configurations, and the feasibility of particular markers. The commitments made by the DOE in each of these categories are discussed in greater detail below.

2.1.1 General Commitments

The general commitments, to a large extent, are related to quality assurance and regulatory requirements. These are detailed in the *Passive Institutional Controls Implementation Plan, DOE/WIPP 04-2301*.

2.1.2 Design and Construction Commitments

Design and construction commitments are those that have a direct impact upon implementation of the permanent markers program. These include commitments to use certain materials for specific markers, to implement certain configurations, and to include warning messages. Examples of the types of design and construction commitments made by the DOE include a commitment to leave the hot cell as part of the permanent marker system, a commitment to construct the Buried Storage Rooms of granite slabs fitted into cut slots with specific dimensions, a commitment to construct small markers of three different materials to be buried throughout the repository footprint, and inscription of level II and III messages in seven languages on each of the repository footprint Large Surface Markers.

2.1.3 Permanent Markers Testing

The final category of commitments having an impact upon the permanent markers program is related to permanent markers testing. Generally, these commitments focus upon the testing of materials for building the permanent markers components; however, some commitments address other aspects of the permanent markers system. Examples of these include a commitment to test various materials and berm configurations, a commitment to implement the testing program during the disposal phase, a commitment to evaluate the system for unloading and moving large objects from the railroad spur to the permanent marker sites, a commitment to test materials for

the Small Subsurface Markers, and a commitment to test concrete for its potential use as a component in the permanent markers system.

2.2 EPA's Certification of Compliance

The EPA promulgated one primary condition related to implementation of the PICs program in its certification of compliance (EPA, 1998). This condition requires the DOE to submit a revised schedule and additional documentation illustrating the feasibility of implementing the PICs program described in the application. This must be submitted prior to the final five-year operational period.

2.3 DOE Commitments in the Docket

In Docket A-93-02, II-I-07 Enclosure 2-e, DOE committed to a number of activities. See the Passive Institutional Controls Implementation Plan (DOE/WIPP 04-2301), items 102-125 in Attachment 2. Among these commitments is a schedule of activities that will be addressed in the first five years of WIPP operation. In May, 2002, DOE requested a schedule change which was approved by EPA in November, 2002 (EPA Docket A-98-49, II-B-3, Item 41). The new approved schedule is shown in Table 1 below:

Table 1. Approved Schedule Changes for PICs Testing

Activity	Original Time Frame	New Time Frame
Identification of suitable source material	1999-2004	2007
Submit plans for test marker system to EPA	2003	2007
Construct and test berm and test markers	2004-2009	2008
Monitor performance of test berm and markers	2007-2083	2009-closure
Develop final design of markers	2083-2090	2033 (anticipated)
Finalize messages	n/a	2033 (anticipated)

3.0 Permanent Markers Design Process

The implementation of the permanent markers final design process requires the definition of performance objectives, performance criteria, and design criteria for each of the permanent markers components. These are derived from the requirements and commitments described in the previous section. They provide a basis for evaluating the acceptability of current and alternative designs. These objectives and criteria are identified below.

In addition, a decision logic is applied to the process of determining the final designs, including materials selection, for each of the permanent markers components. This decision-making process is also described in this section.

3.1 Design Bases

The design bases for the permanent markers components include performance objectives, performance criteria, and design criteria, as identified below.

3.1.1 Performance Objectives

Performance objectives for the permanent markers are listed below.

Permanent Markers shall:

1. Reduce the likelihood of inadvertent, intermittent human intrusion.
2. Deter systematic or persistent exploitation of the WIPP site.

3.1.2 Performance Criteria

Performance criteria for the permanent markers, derived from the performance objectives, are listed below. Permanent Markers shall:

1. Alert an intruder to the existence of the site.
2. Convey a warning of danger to an intruder.
3. Inform an intruder about the nature and degree of danger.
4. Endure in form and function for the longest time possible.

3.1.3 Design Criteria

Design criteria describe the standards that the design must achieve to satisfy the performance criteria. Viewed from a designer's perspective, design criteria set the scales of measurement by which the design will be evaluated in terms of the design's

implementation and performance. Design criteria may, but need not necessarily, include constructibility and cost considerations. For the WIPP permanent markers, constructibility is included because: (1) constructibility issues may be important, especially on first-of-the-kind marker designs having no precedent; and (2) the extreme time requirements (i.e. 10,000 years) embodied in the performance criteria may necessitate consideration of alternative design options.

The design criteria identified as necessary for the permanent markers to satisfy the performance criteria are listed below under the several performance criteria headings (the performance criteria are underlined):

1. To alert the intruder to the existence of the site, permanent markers must be:
 - a. readily detected from all directions and means of intrusion,
 - b. detectable directly by human senses and by indirect remote sensing methods, and
 - c. obviously anomalous with respect to the natural features of the site.
2. To convey a warning of the danger to an intruder, permanent markers must be:
 - a. identifiable as conveying a warning, and
 - b. able to convey danger independent of the language of the intruder.
3. To inform an intruder about the degree and nature of the danger, permanent markers must be:
 - a. able to be inscribed with symbols and letters,
 - b. contain sufficient information about the site and its dangers to dissuade intrusion and should be identifiable within the first four levels of understanding (as discussed in the CCA, Appendix PIC),
 - c. state the information in enough different languages that at least one of them will likely be familiar to the intruder, and
 - d. display the information so that it is readily discovered without the need for more than surficial intrusion into the site.
4. To endure in form and function for the longest time possible, permanent markers must be:
 - a. as resistant as possible to chemical and physical weathering, dissolution, and erosion,
 - b. able to withstand all foreseeable extreme natural conditions including earthquake, wind, flood, and fire,

- c. able to remain stable in form, location and position,
- d. able to resist vandalism,
- e. able to minimize risk of casual removal,
- f. lacking in economic value to be of no interest for scavenging and salvage, and
- g. sufficiently redundant to meet performance criteria despite some loss in numbers or form.

No one type of permanent marker can satisfy all of these criteria. Instead, a series of permanent markers components is needed, in which each marker is a component, capable of satisfying some of the criteria. The entire permanent marker system must be designed to satisfy all of the design criteria. The permanent marker system components included in the DOE conceptual designs for the various permanent marker components were selected to satisfy these design and performance criteria. These conceptual designs are described in later sections of this plan.

3.1.4 Design Criteria Applicable to Permanent Markers Components

The design criteria that apply to each of the five markers components yet to be designed and constructed are identified in Table 2.

3.2 Permanent Markers Design Decision Logic

The progression of activities necessary to determine the final designs of the permanent markers components is diagrammed in Figure 1. The diagram shows the progression of activities, beginning with each component in the conceptual design and design criteria. The conceptual design for each component is then subject to testing in two phases, a screening phase and a long-term testing phase. As results of the testing program are developed, the extent to which each component of the conceptual design meets the applicable design criteria will be assessed. When appropriate, changes to the conceptual design will be recommended and the designs will be modified. Testing can be iterative. The screening phase addresses both the constructability and the feasibility of the conceptual designs. Long-term testing will include cost versus benefits evaluations. National standards (such as ASTM, ASME, and NIST) will be used for the testing and construction of the permanent markers. When needed, non-standardized testing will be developed and performed according to the QA procedures discussed in Section 8.

Table 2. Design Criteria Applicable to Permanent Marker Components

Permanent Marker Components Criteria	Large Surface Markers	Inscriptions on Large Surface Markers	Small Subsurface Markers	Inscriptions on Small Subsurface Markers	Berm	Berm Magnets and Radar Reflectors	Buried Storage Rooms	Information Center	Inscriptions on Buried Storage Rooms and Information Center
1.a - readily detectable	●				●	●	●	●	
1.b - humanly detectable	●		●		●			●	
1.c - obviously anomalous	●		●		●	●	●	●	
2.a - conveys a warning		●		●					●
2.b - non-text danger indicator		●		●					●
3.a - inscribable	●		●				●	●	
3.b - sufficient information		●							●
3.c - contains different languages		●		●					●
3.d - open display of information	●							●	
4.a - resistant to degradation	●		●		●	●	●	●	
4.b - weather resistant	●		●		●	●	●	●	

Permanent Marker Components Criteria	Large Surface Markers	Inscriptions on Large Surface Markers	Small Subsurface Markers	Inscriptions on Small Subsurface Markers	Berm	Berm Magnets and Radar Reflectors	Buried Storage Rooms	Information Center	Inscriptions on Buried Storage Rooms and Information Center
4.c - retains composition	●		●		●	●	●	●	
4.d - vandalism resistance	●		●		●	●	●	●	
4.e - difficult to remove	●				●	●	●	●	
4.f - little or no economic value	●				●		●	●	
4.g - maintains longevity due to redundancy	●		●			●	●		

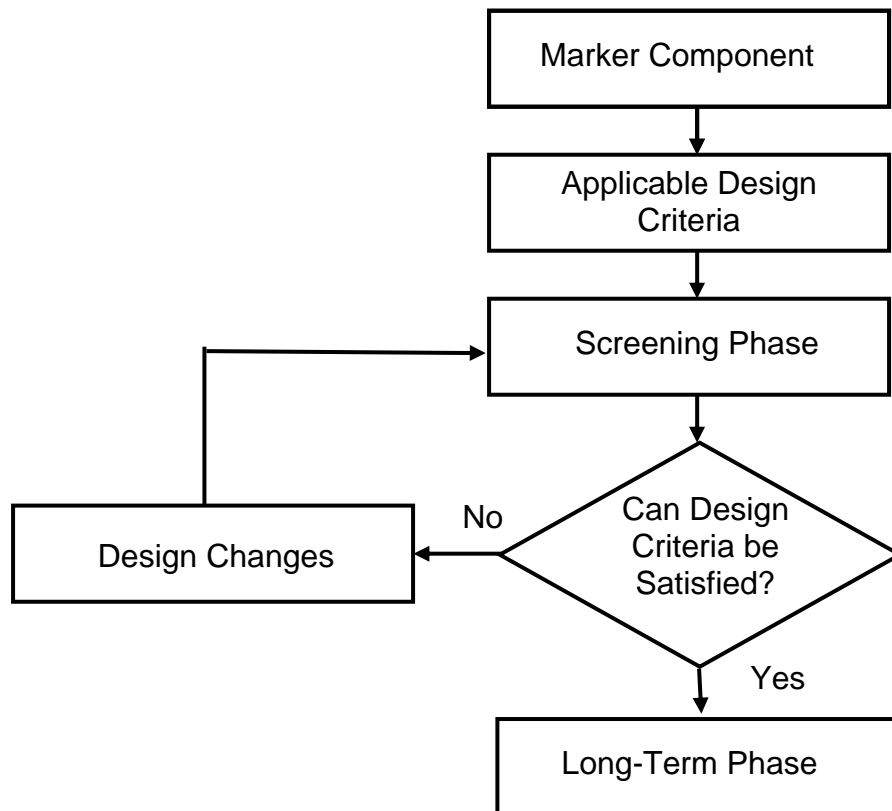


Figure 1. General Process for Finalizing Permanent Markers System Designs

4.0 General Description of the Permanent Marker Components

The following components comprise the WIPP permanent markers system: the Large Surface Markers, the Small Subsurface Markers, the Berm, the Buried Storage Rooms, the Hot Cell, and the Information Center. The types of messages conveyed by each component are described below, followed by a general description of the conceptual design for each component.

4.1 Messages Conveyed by the Permanent Markers

There are five levels of warning messages used in the passive institutional controls system for the WIPP. Higher levels convey increasingly complex messages. Level I through Level IV messages will be present at the WIPP site and will be incorporated into the permanent markers components. The Level V message will be communicated as stored archival records retained in local, state, federal, and international repositories and will not be directly associated with the permanent markers.

The Level I message will be communicated by four of the permanent markers components: the Large Surface Markers, the Berm, the Hot Cell, and the Information Center. These components communicate that the permanent markers are manmade and that their construction required considerable effort.

The Level II message will be engraved on the Large Surface Markers that are located on the perimeter of the repository footprint and on the perimeter of the controlled area. It will also be inscribed on the Small Subsurface Markers. The message is a warning of danger and cautions against drilling or digging.

The Level III message will be also engraved on the Large Surface Markers located on the perimeter of the repository footprint. It provides greater detail regarding what is buried, the area for which drilling and digging is prohibited, and indicates the depth of the radioactive waste.

The Level IV message, the most comprehensive and complex information located at the WIPP site, will be conveyed by the presence of the Buried Storage Rooms and by their contents. The primary purpose of providing this information is to prepare for the possibility that the Information Center or other permanent marker components cease to exist.

The Level IV message will be also communicated in the more easily accessible above ground Information Center. The Information Center contains an additional message regarding the location of the Buried Storage Rooms. The intent of the additional message is the preservation of the Buried Storage Rooms and their messages for future generations.

4.2 Descriptions of the Permanent Marker Components

General descriptions of the conceptual design for the permanent marker components contained in the CCA are provided below; Figure 2 illustrates their locations. Additional detail is provided in Section 5.0.

1. **Large Surface Markers** - The conceptual design calls for 32 Large Surface Markers erected on the perimeter of the controlled area, and 16 markers erected on the perimeter of the repository footprint, within the Berm. Each marker will consist of two separate stone monoliths joined by a mortise-and-tenon joint; the lower member will be a truncated pyramid and the upper member will be a right prism.
2. **Small Subsurface Markers** - The Small Subsurface Markers will be small buried disks warning of the presence of the repository. They will be buried throughout the repository footprint, within the Berm, and within the shaft seals. They will be randomly spaced and buried at depths ranging from two to six feet below the surface.
3. **Berm** - The Berm will enclose an area that is 110 percent of the repository footprint. As currently planned, it will have a core base material of salt; the core will be protected by at least two other types of materials. Magnets and Radar Reflectors will be buried in the Berm. These will be buried at specified intervals in the Berm, producing distinctive anomalous magnetic and radar-reflective signatures. A Buried Storage Room will also be constructed at grade inside the Berm on its south side.
4. **Buried Storage Rooms** - One Buried Storage Room will be buried within the Berm. This room will be constructed at grade level at the center of the southern section of the Berm. It will be completely covered by Berm material. A second Buried Storage Room will be buried in the controlled area outside of the Berm and the repository footprint. This room will be buried approximately 20 feet below the surface, north of the Berm on a line passing through the Information Center, the center of the northern and southern sections of the Berm and the Hot Cell.
5. **Hot Cell** - This is an existing reinforced concrete 40-by-70 foot structure with walls 4.5 feet thick. Its foundation extends 30 feet below grade, and the roof is 60 feet above grade. The Hot Cell will remain after closure as an "archeological remnant," effectively serving the function of an additional permanent marker.
6. **Information Center** - The Information Center will be an open structure having a rectangular design. It will be located on the land surface at the center of the repository footprint.

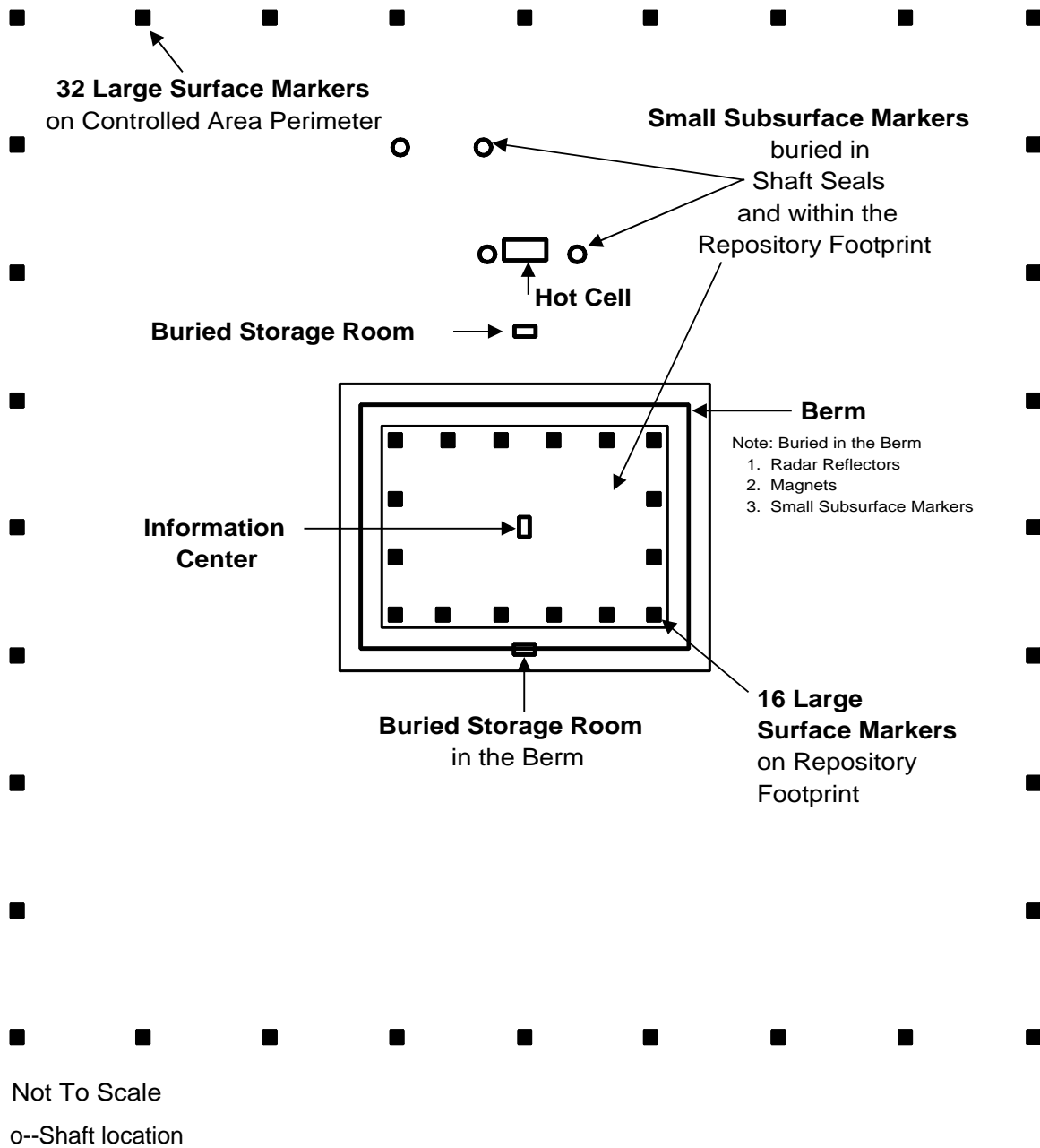


Figure 2. Permanent Markers Components

5.0 Permanent Markers Components Design Considerations

The conceptual designs of the permanent markers components are generally described in Chapter 7 of the CCA (DOE, 1996) and Chapter 7 of the CRA (DOE, 2004). Additional detail on the planned designs is provided in Appendix PIC of the CCA.

This section describes the conceptual design for each of the five permanent markers components yet to be constructed (the Hot Cell already exists). These designs represent currently anticipated design configurations and materials selections. Although multiple alternative designs and materials have been proposed for all of the components, it is necessary to use the conceptual design for each to provide a basis for the identification and implementation of appropriate tests. The conceptual design is believed to be achievable using existing technology. The conceptual design is the baseline against which alternatives will be evaluated. Testing is planned to occur over a period of many years; as test results are generated and evaluated, the conceptual design will evolve into the final design best meeting the performance objectives for the permanent markers components.

The designs described in this section are conceptual design B described in Appendix PIC of the CCA. Additional detail has been added where appropriate.

For each of the permanent markers components, some materials selection and design configuration considerations remain. Each conceptual design description is accompanied by a list of these open considerations. This helps to define testing parameters. This section also identifies alternative materials that warrant consideration in the testing program. In addition, for the Large Surface Markers, plans for evaluating the constructability of the component are generally described.

5.1 Large Surface Markers

Information related to the Large Surface Markers is provided in this section.

5.1.1 Conceptual Design

The Large Surface Markers will be placed on the perimeter of the controlled area and on the perimeter of the repository footprint. Thirty-two markers will be on the controlled area perimeter and sixteen will be on the repository footprint.

The markers will all be of the same design (Figure 3). They will consist of two separate stone monoliths (a lower member and an upper member) joined by a mortise-and-tenon joint. The lower member will be buried and will be in the

shape of a truncated pyramid. It will be 22 feet in height including the tenon. The base of the lower member will be 8 feet square; at the top of the truncated pyramid structure, it will measure 4 feet square. The tenon extending upward 5 feet from the truncated pyramid will be 2 feet square. All of the lower member will be below ground level except the tenon (17 feet of the lower member will be below grade). The upper member will be 25 feet in height and measure 4 feet by 4 feet; it will be entirely above ground level. A mortise will be cut in the lower portion of the upper member to match the tenon extending upward from the lower member.

Each Large Surface Marker will have warning messages engraved in the seven languages. The messages will be inscribed on all four sides of the upper member in the top 6-to-8 feet; this will result in messages placed 17-to-19 feet above ground level. Three of these messages will be primarily written text and one, the one facing towards the repository, will be an illustration with limited text. In addition, messages consisting primarily of written text will be inscribed on all four sides of the lower member below ground level. These messages will be located about 5-to-12 feet above the bottom of the lower member. The messages on the controlled area perimeter markers will differ from those on the repository footprint. The messages that will be engraved on the markers on the controlled area perimeter are shown in Figure 4, and those that will be on the markers placed on the repository footprint are shown in Figure 5. Additional detail regarding these messages is provided in Section 6.0.

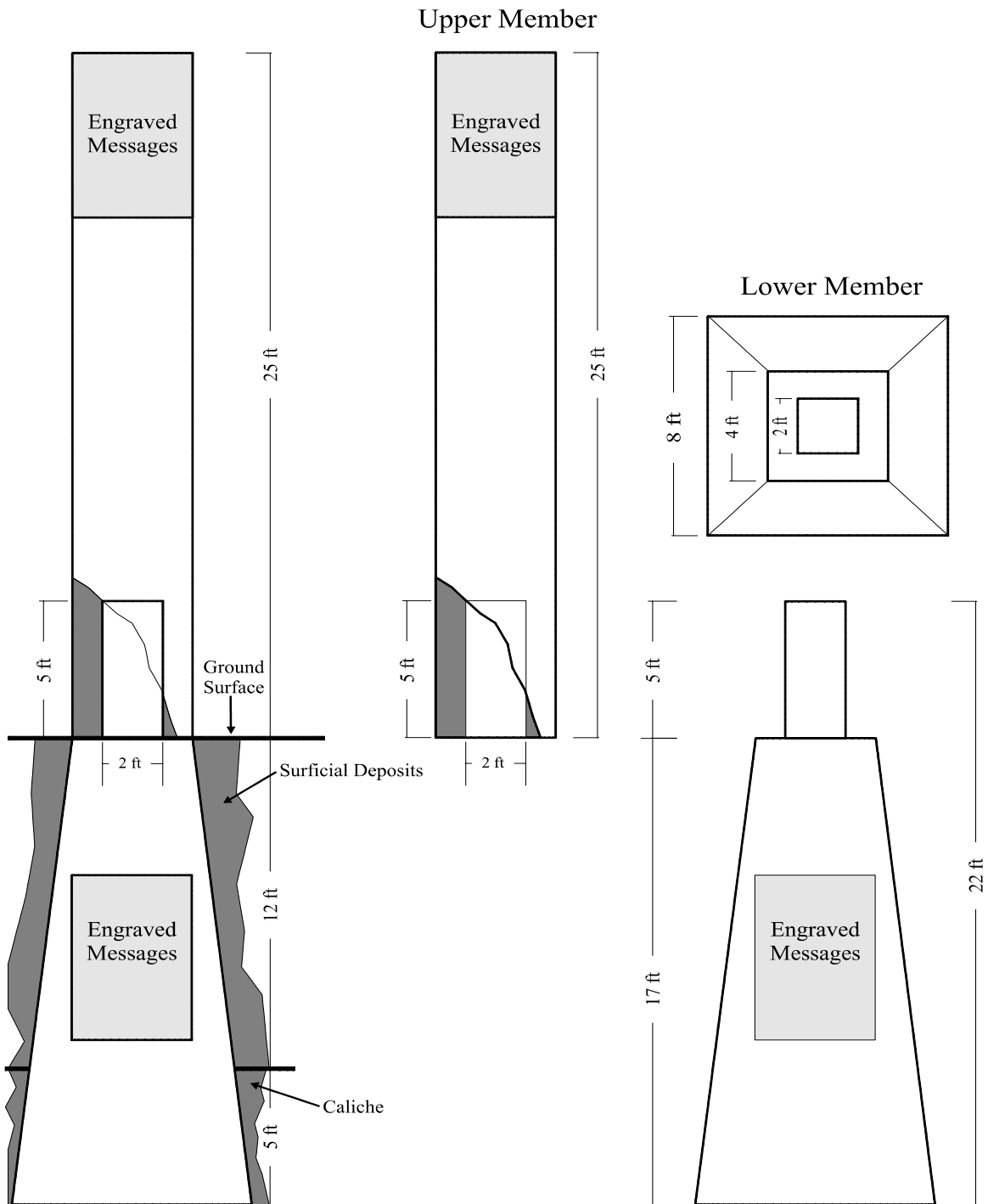


Figure 3. Large Surface Markers

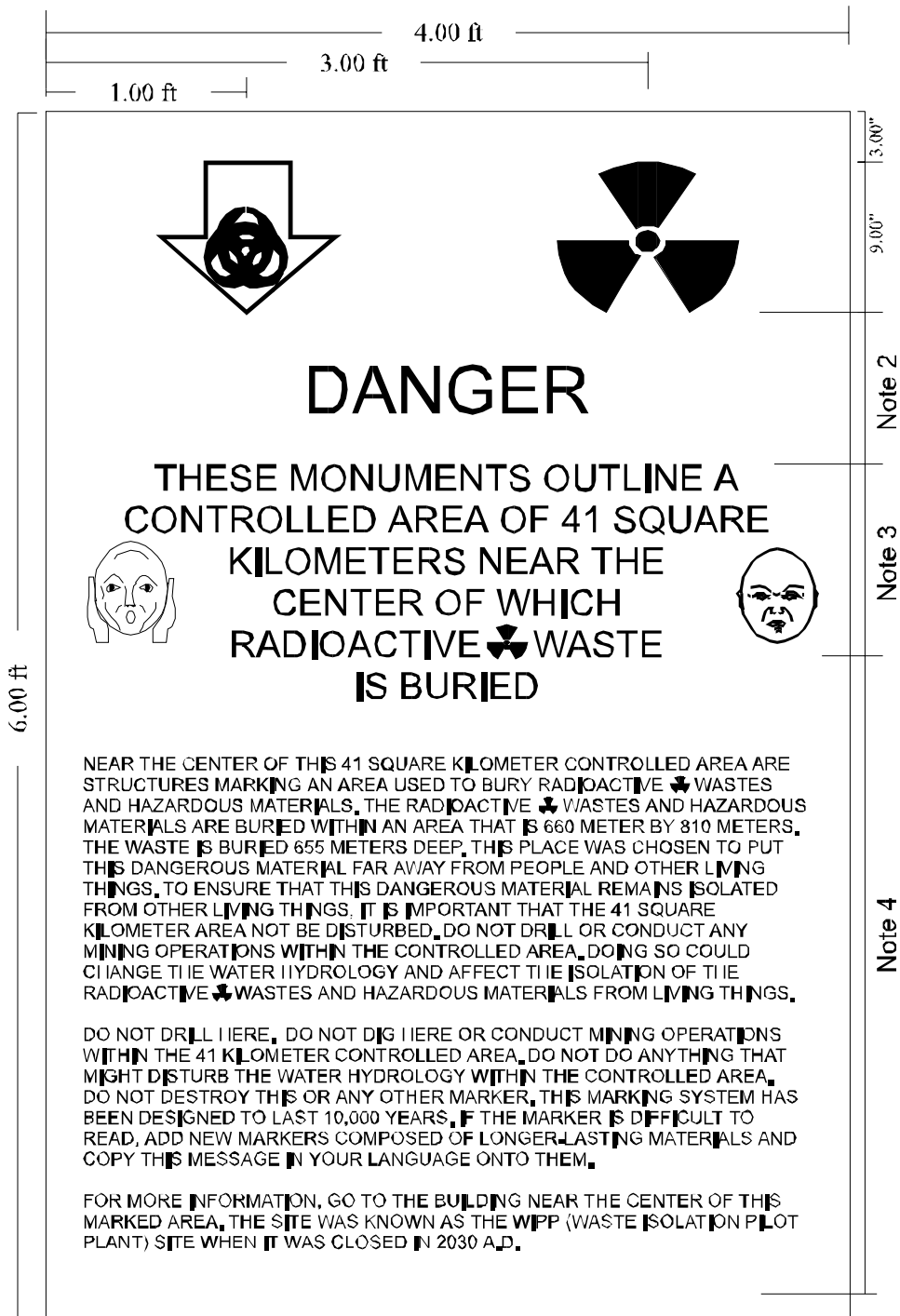
Additional details for the Large Surface Markers conceptual design are as follows.

1. The upper and lower members will be constructed of granite.
2. The surfaces of the markers will be polished to remove all loose material and indentations.
3. The lower member will weigh 65 tons.
4. The upper member will weigh 40 tons.
5. The calculated center of gravity of the two members will be 15.5 feet above the bottom of the lower member.

5.1.2 Open Design Considerations

Open design considerations related to the Large Surface Markers are listed below.

1. Although granite has been specified for the conceptual design, alternative materials will be evaluated. These may include basalt, sandstone, and quartzite, and man-made materials (e.g., concrete) identified during the research phases of the testing program. Characteristics of granite and other potential materials of construction are described in Permanent Markers Materials Analysis (John Hart and Associates, P.A., 2000).
2. Multiple grades and varieties of granite having differing characteristics are available from multiple sources. A specific granite has not been identified.
3. The number of Large Surface Markers and locations of these markers will also be finalized. This may result in fewer markers.
4. Various alternative markers materials may exhibit positive or negative characteristics with regard to the construction of the Large Surface Markers. For example, some materials may be susceptible to cracking during quarrying and transporting of the large members planned for the markers.
5. The inscription of messages may be easier on some markers materials than others. Potential problems with chipping and cracking during the inscription process must be assessed. Also, inscriptions may be more durable on some alternative materials. Granite surfaces may be subject to exfoliation.

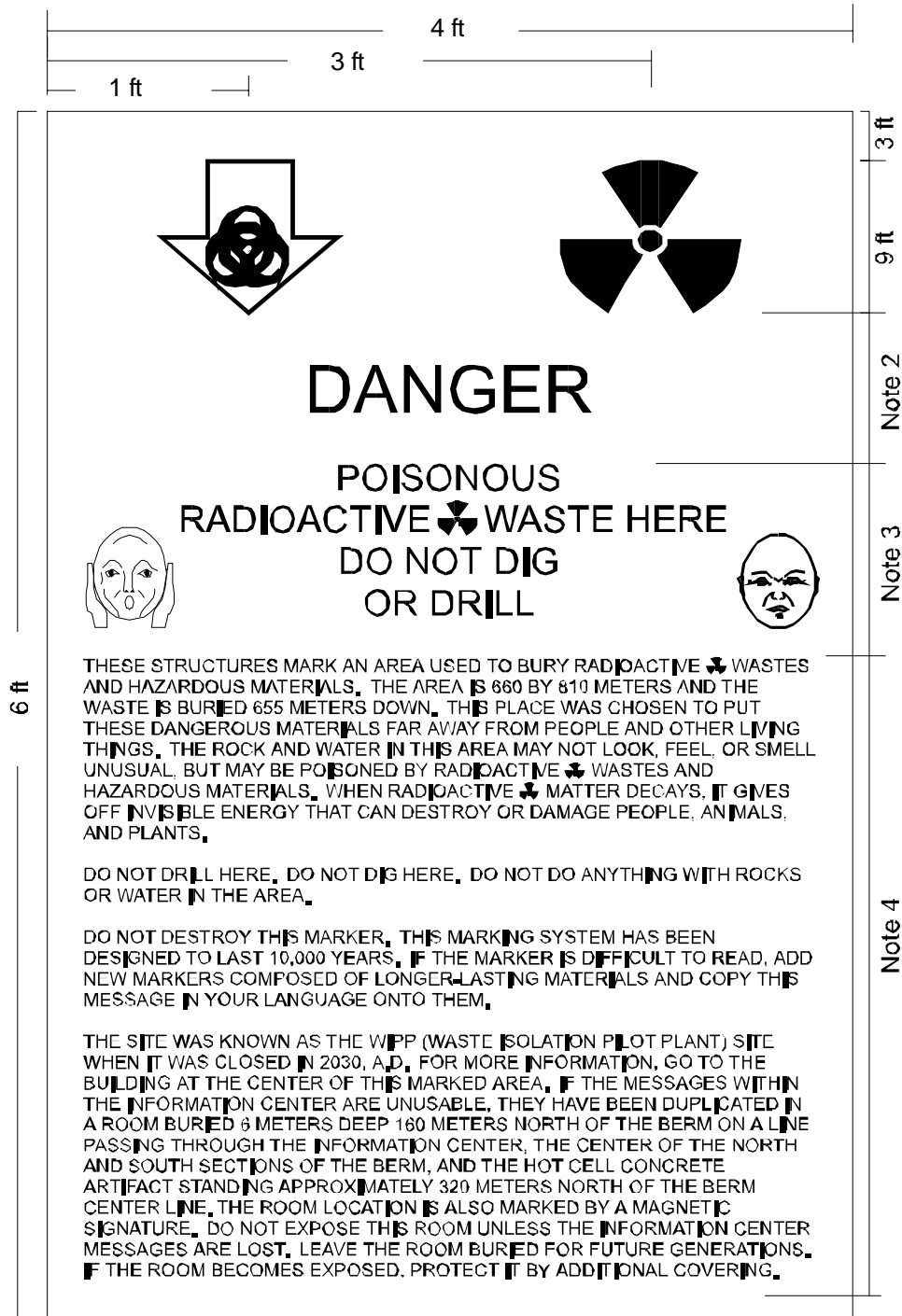


NOTES

- These messages will be carved into the stone faces as shown on the drawing. Each message will appear seven times on the marker, once in each language listed below. The message will appear at the top of the marker on three faces, leaving one blank face. It will appear on four surfaces at the bottom.
- The word "DANGER" will be in 3" high letters with a 3" space above and a 3" space below.
- The Level II message will be in 1 1/2" high letters with a 1" space between lines and a 2" space below the bottom line of the Message.
- The Level III message will be in 1" high letters with a 5/8" space between the lines. There will be a 1 1/2" space between the paragraphs of the message.

English Spanish Russian French Chinese Arabic Navajo

Figure 4. Text Appearing on the Large Surface Markers on the Controlled Area Boundary



NOTES

- These messages will be carved into the stone faces as shown on the drawing. Each message will appear seven times on the marker, once in each language listed below. The message will appear at the top of the marker on three faces, leaving one blank face. It will appear on four surfaces at the bottom.
English Spanish Russian French Chinese Arabic Navajo
- The word "DANGER" will be in 3" high letters with a 3" space above and a 3" space below.
- The Level II message will be in 1 1/2" high letters with a 1" space between lines and a 2" space below the bottom line of the Message.
- The Level III message will be in 1" high letters with a 5/8" space between the lines. There will be a 1 1/2" space between the paragraphs of the message.

Figure 5. Text Appearing on the Large Surface Markers on the Repository Footprint

6. Although the conceptual design anticipates the inscription of messages on the markers, the use of alternative materials such as ceramic message plaques imbedded in the markers may make inscription unnecessary. Ceramic plaques may be made with messages appearing in contrasting colors instead of inscriptions. With this concept, messages may endure for longer periods because the message will exist through the entire thickness of the ceramic plaque; the messages will not exist on only the surface, as would be the case with inscriptions.
7. It is anticipated that the very large granite monolithic members proposed under the conceptual design will be exceptionally difficult to quarry, load, transport, unload, and position without fracturing.
8. The use of alternative materials may require design change for maximum durability.

5.1.3 Alternative Materials

Alternative materials that have been suggested for the construction of the Large Surface Markers include basalt, sandstone, concrete, and others. Plans for evaluating alternative markers materials, including alternative sources of individual types of stone, are presented in the Permanent Markers Testing Program Plan (DOE, 2000).

5.1.4 Constructability Assessment

Condition 4 of the EPA certification of compliance for the WIPP addresses the PICs program. This condition requires, among other things, that the DOE provide "...documentation showing that the granite pieces for the proposed monuments and information rooms described in..." the CCA "...and supplementary information may be: quarried (cut and removed from the ground) without cracking due to tensile stresses from handling or isostatic rebound; engraved on the scale required by the design; transported to the site, given the weight and dimensions of the granite pieces and the capacity of existing rail cars and rail lines; loaded, unloaded, and erected without cracking based on the capacity of available equipment; and successfully joined." This must be provided "...not later than the final re-certification application submitted prior to closure of the disposal system..." (EPA, 1998).

The DOE will perform a "constructability" assessment to address these questions posed by the EPA. Testing will evaluate the feasibility positioning the various alternatives for the large stone members planned for the Large Surface Markers. Constructability may also be proven through the use of field scale trails. Details of this assessment are described in the Permanent Markers Testing Program Plan (DOE, 2000).

5.2 Small Subsurface Markers

Information related to the Small Subsurface Markers is provided in this section.

5.2.1 Conceptual Design

Small Subsurface Markers will be buried throughout the repository footprint, within the Berm, and in the four shaft seals. Spacing between these Small Subsurface Markers will be between 15 to 40 feet and random within that range, resulting in the emplacement of several thousand markers. Random spacing will preclude souvenir hunters from identifying a burial pattern, making it difficult to intentionally excavate and retrieve a large number of the markers.

The markers will be buried at selected depths between 2 and 6 feet and random depths within this range. This range of depths was selected for two reasons:

1. Soil covering the caliche in the local WIPP area ranges to a depth of 10 feet.
2. In preparing for drilling, local service companies typically excavate an area of about 260 feet by 300 feet. In addition, an area of approximately 150 by 150 feet is excavated to a depth of 4 to 6 feet to create a drilling mud pit. Also, a cellar is excavated to about 6 feet to accommodate the drill rig.

Thus, by burying the Small Subsurface Markers above the caliche and below the surface at random intervals over a range of shallow depths, a large number of the markers will be available for discovery during the process of excavating and preparing the drill site. This provides a reasonable likelihood that at least some of the markers will be discovered by the site-preparation crew.

The proposed design for the Small Subsurface Markers is a disk with a 9-inch diameter. The conceptual design is to fabricate the disks using a variety of different materials (CCA suggests 3) to lend redundancy to the system. Each marker will have a warning message in one of the seven languages used on the Large Surface Markers, the Buried Storage Rooms, and the Information Center. Equal numbers of markers in individual languages will be distributed. The Level II Message to be engraved on the markers is shown in Figure 6.



Figure 6. Text and Pictographs on Small Subsurface Markers

5.2.2 Open Design Considerations

Open design considerations related to the Small Subsurface Markers are listed below.

1. The material to be used to construct the Small Subsurface Markers has not been selected; testing a variety of materials is planned. Appendix PIC of the CCA proposes in-situ testing of markers materials at depths of 1 to 10 feet below the surface for a period of 40 to 60 years. It is intended that these tests will determine whether the materials are suitable for the subsurface environment at the site.
2. The exact number of Small Subsurface Markers to be buried at the site is undetermined at this time. Locations for small subsurface markers and spacing of them will be revisited to ensure maximum benefit from their emplacement.
3. The optimum burial depth must be determined. The burial depth should be greater than that reached by deep plowing and tilling or that expected to be dug by amateur archeologists. It also should be sufficiently shallow so that at least some of the markers will be discovered when drill sites are prepared for drilling.
4. Although the conceptual design anticipates the inscription of messages on the markers, the use of alternative materials such as ceramics may make inscription unnecessary. Similar to a suggestion for the Large Surface Markers, ceramic disks may be made with messages appearing in contrasting colors instead of inscriptions. With this concept, messages on a marker that has been damaged and split may still be legible because the message will exist through the entire disk structure; the messages will not exist on only the surface.
5. Glazes or coatings may be used to encapsulate the Small Subsurface Markers to prevent absorption of water and/or other chemicals that initiate corrosion. Candidate coatings include vitreous enamel for metal markers and ceramic glaze for ceramic markers. These coatings have an abrasion resistance better than metals or polymers and can be made with a specific composition resistant to any particular corrosive environment present at the site. Glazes are strong in compression and weak in tension. Therefore, the coating must have a lower thermal expansion than that of the marker material so that the glaze is in compression and the marker surface is in tension. This is easily achieved in the fabrication process by proper material selection and by controlling the cooling rate after the coating has been applied to the substrate (John Hart and Associates, P.A., 2000).

6. Small subsurface markers will be evaluated as part of the overall permanent markers component design for their unique contribution and for their contribution to the whole design.

5.2.3 Alternative Materials

Several alternative materials have been suggested for use as Small Subsurface Markers including granite, quartz, aluminum, titanium, stainless steel, hastelloy, inconel, ceramics, glass (lanthanum borate made by the Corning Glass Company), and highly durable plastics (polyethylene).

Any of the materials mentioned above would provide adequate durability, strength, and inscribability for the small subsurface markers. However, due to the number of markers that will be fabricated, it is likely that rock and metal can be eliminated from the candidate list due to cost. Polymers are especially attractive for this application because of the ability to stamp or otherwise rapidly produce the markers at a low unit cost. However, mass production at relatively low cost might also be achieved for some ceramics.

5.3 Berm

As noted previously, the Berm's presence inherently conveys a Level I message that something manmade is present. No higher level messages are communicated by the Berm. The Buried Storage Room that will be constructed inside the Berm (along with another Buried Storage Room located to the north of the Berm) will, however, contain messages of greater complexity (i.e., Levels II, III, and IV messages). The Buried Storage Rooms are discussed in subsection 5.4. Magnets and radar reflectors will also be buried in the Berm.

5.3.1 Constructed Berm

The conceptual design of the constructed Berm, open design considerations and alternative materials are described in this section.

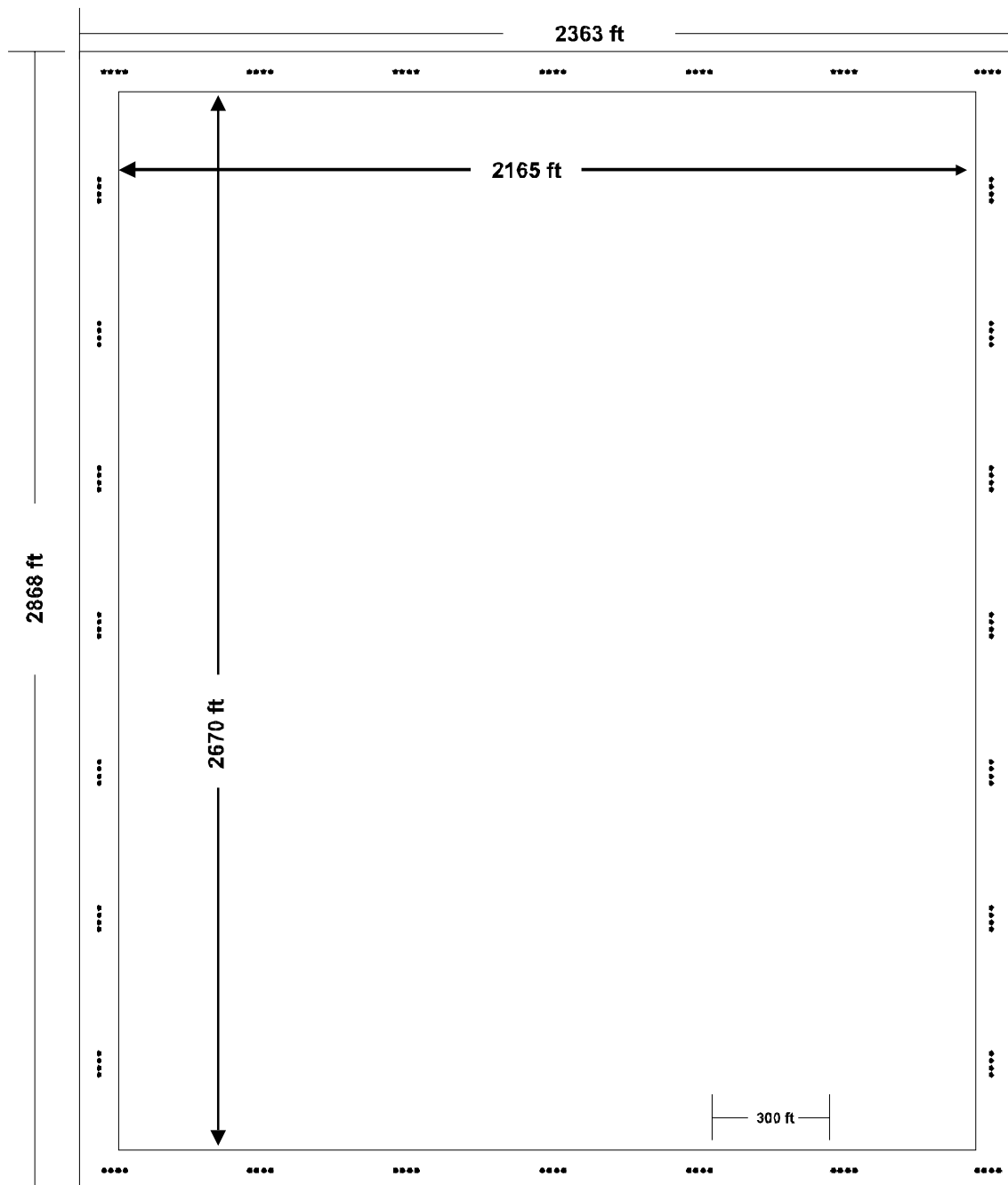
5.3.1.1 Conceptual Design

The Berm will be rectangular in plan, covering the footprint of the waste disposal area of the repository on the ground surface plus a small margin; it is not to exceed the area of the repository footprint by more than 10 percent. As planned in the conceptual design, the rectangular footprint of the disposal area measures 2063 by 2545 feet; the inner perimeter of the Berm measures 2165 by 2670 feet, so this plan incorporates a 51 foot margin between the repository outline and the Berm on the shorter (north and south) sides and a 62 foot margin on the longer

(east and west) sides. Since the Berm is 98 feet wide, the outer perimeter of the Berm measures 2363 feet by 2868 feet (see Figure 6).

The cross-sectional dimensions of the Berm conceptual design is shown in Figure 10. As currently specified, the Berm's minimum base is 98 feet, with a minimum height above ground of 33 feet. It will extend 10 feet below ground. The salt core is pyramidal in shape, and approximately 30 feet in height. The caliche layer covering the salt core is approximately 5-7 feet thick; the rip-rap covering the caliche is approximately 3-5 feet thick. The slope will be at least 1.3 horizontal to 1.0 vertical.

The design of the Berm will incorporate drainage outlets at intervals of approximately 328 feet to prevent ponding. These outlets will consist of rip-rap filled trenches 10 feet deep and 6.5 feet wide, extending through the Berm base below the surface. The Berm will have a concrete or granite stairway to the top and down the opposite side, centered on the west side of the Berm.



**** Set of 4 Trihedrals

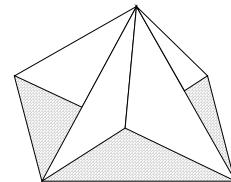


Figure 7. Berm Showing Locations of Radar Reflectors

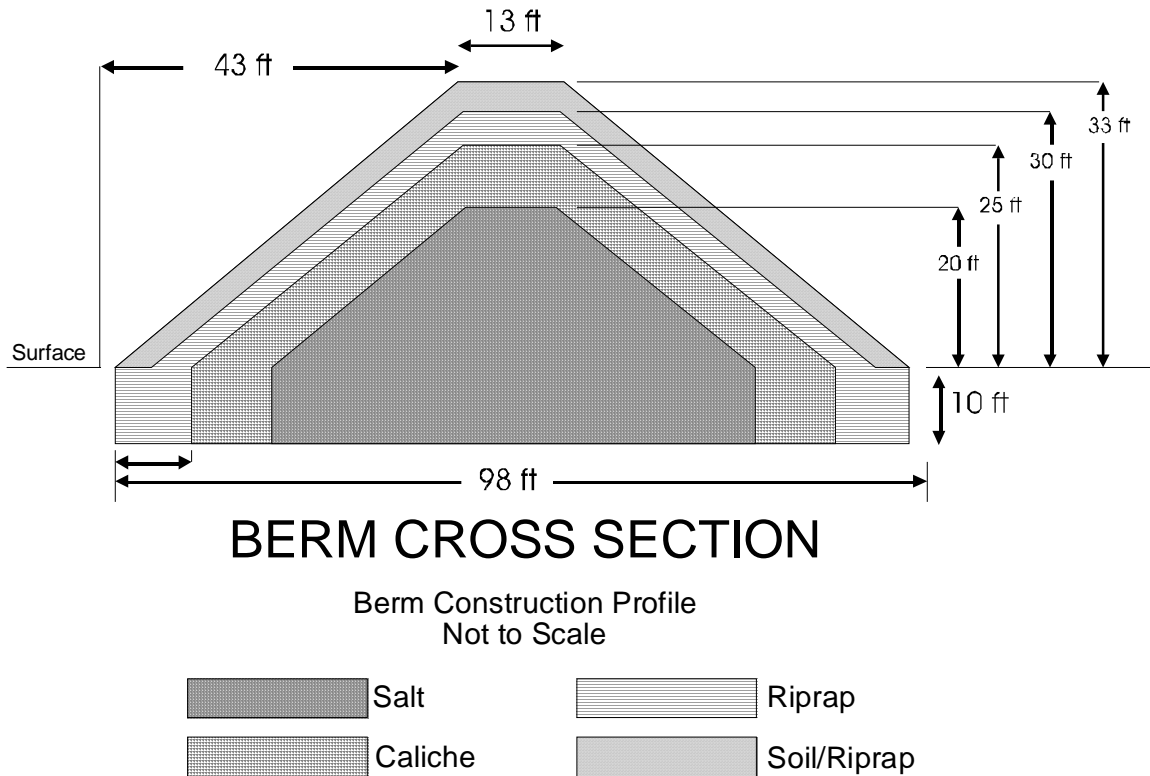


Figure 8. Berm Cross Section

5.3.1.2 Open Design Considerations

Open design considerations related to the Berm are listed below.

1. Although specific materials are part of the conceptual design (compacted salt, caliche, rip-rap), these will be tested and the recommended design may be modified to include more or less of some materials or to add or eliminate one or more from the design.
2. Alternative materials for construction of the Berm may be identified.
3. The availability of sufficient quantities of selected materials must be assessed.
4. The ability of rip-rap to protect a caliche layer in the Berm from erosion and animal burrowing will be tested.
5. Testing will be performed to determine whether soil/rip-rap is the best material for stabilizing the top of the Berm, as the conceptual design indicates.
6. The use of concrete versus granite blocks for the stairs will be evaluated.

7. To predict the structural performance of compacted crushed salt in the core of the berm, as proposed in the conceptual design, stability analyses were performed using the computer code SB Slope (Geosystems, 1994); the results of this work are reported in Permanent Markers Materials Analysis by John Hart and Associates, P.A. (2000). The stability analyses predict that the conceptual-design berm with its salt core would be unstable (factor of safety of less than 1.0 against slope failure by rotational displacement) under both static and pseudostatic (earthquake of 0.1g peak ground acceleration) load conditions. The calculated minimum factor of safety for a failure surface through the salt core is 0.88 for static load conditions and would be even lower with earthquake loading. The likely failure surface passes partly through the salt core. If the side slopes of the berm are reduced to a 0.33 grade (3H: 1V), the pseudostatic factor of safety is still too low, 0.92. In the design configuration where soil is used in place of salt, factors of safety are substantially higher, 1.27 for soil core versus 0.88 for salt core, clearly indicating that salt lacks the strength needed in the core of the berm. The safety factor with a soil core and 0.33 grade is 1.54 under static load conditions.
8. Another factor that influences the structural performance of the berm is settlement. All non-indurated earth materials are subject to settlement, generally resulting from densification of material. In typical earthfill construction practice, earth materials are mechanically compacted to increase the fill density, increasing its strength and minimizing its settlement potential. If a fill material is soluble, dissolution can create voids that not only reduce the material mass strength but also make the material susceptible to additional settlement. Such settlement can be non-uniform and large enough to increase the fill's susceptibility to erosion, intrusion by burrowing animals, and structural failure.
9. Design of the Berm may also be adjusted to ensure durability (i.e. design berm in such a way that water may easily flow out of the repository footprint area within the berm).

5.3.1.3 Alternative Materials

An alternative material for the core of the Berm is native soil. The DOE has committed to evaluate alternative materials available in the region.

5.3.2 Magnets

The purpose of the magnets to be placed inside the Berm is to alert future populations that something out of the ordinary is present at this site when aerial or other surveys are performed. The design of the magnets is intended to

accomplish two goals: (1) that the magnetic anomaly can be easily detected; and (2) if detected, that it effectively conveys a “not normal” or “anomaly present” message.

5.3.2.1 Conceptual Design

There is no conceptual design in the CCA Appendix PIC for the magnets. There is a discussion concerning large strontium ferrite magnets of approximately 3 feet in length and 1.64 by 1.64 feet in cross-section, buried within the Berm at intervals of 250 to 330 feet. These would present a magnetic signature at 300 feet above the magnets. Since aerial magnetic surveys are typically conducted at higher altitudes, the discussion in Appendix PIC is considered to be preliminary and does not represent a conceptual design. More research is needed on how to provide a magnetic signature that would serve the intended purpose of alerting future populations that something anomalous is present. The Permanent Markers Materials Analysis (John Hart and Associates, P.A., 2000) describes potential materials for use as magnets; details on how these will be tested are provided in the Permanent Markers Testing Program Plan (DOE, 2000).

5.3.2.2 Open Design Considerations

Since there is currently no conceptual design for the magnets, all design considerations remain open. This effort will require research into material properties and longevity of magnetic materials or materials that can be detected by magnetic surveys.

In addition, testing will be needed to verify that the pattern shown by the magnets will indicate something anomalous is present (i.e., that the magnetic pattern does not resemble a common feature such as an abandoned metal-containing building). Also, the question of placement of magnets either around the sides or on top of the Buried Storage Room in the Berm remains to be answered.

Finally, the intent of this marker is to provide a “signature” that will be identifiable at a distance. Other materials may provide a similar signature (i.e. magnetic ore) or another anomalous signature (i.e. one found by a proton magnetometer). These alternatives will be also be evaluated.

5.3.2.3 Alternative Materials

Although not specifically identified as such in the conceptual design, the particular material that would most likely be used for magnets is strontium hexaferrite ($\text{SrO} \cdot 6\text{Fe}_2\text{O}_3$). Alternative materials have not been identified. This material makes a hard permanent magnet that has high resistance to demagnetization, high remanence, coercivity, and saturation flux density, as well as low initial permeability. The most important properties of strontium hexaferrite

are cohesivity and “energy product.” The energy product is representative of the energy required to demagnetize the permanent magnet. A large external field is required to demagnetize strontium hexaferrite. Strontium hexaferrite exhibits a strong magnetization after a magnetic field has been applied and removed and is stable even if a certain strength of demagnetizing field is reapplied. The advantages of strontium hexaferrite over other magnetic counterparts include high coercivity and low permeability, low specific gravity, multipolarity on one surface, and the ability to be mixed with plastic and rubber to form magnets (Collins and Hirschfeld, 2000).

5.3.3 Radar Reflectors

The purpose of the radar reflectors to be emplaced inside the Berm is to provide another mechanism for alerting individuals in the future that something out of the ordinary is present at this site. They may be detected during aerial or other surveys. Thus, their design should be sufficient to accomplish two goals: (1) that the radar anomaly be easily detected; and (2) if detected, that the reflectors effectively convey the “not normal” or “anomaly present” message.

5.3.3.1 Conceptual Design

The radar reflectors proposed in CCA Appendix PIC consist of trihedrals (three adjacent plates set at right angles; see Figure 7) manufactured from stainless steel or inconel. Each facet of the trihedrals is proposed to measure 3 feet on a side, to optimize the interception of radar waves. The trihedrals will be grouped in sets of four spaced approximately every 300 feet in the Berm. In addition, four trihedrals will be placed around the Buried Storage Room, adjacent to and centered on each exterior wall.

5.3.3.2 Open Design Considerations

Open design considerations for the radar reflectors are as follows.

1. Two materials have been proposed for the trihedrals: stainless steel, and inconel. Additional materials will be evaluated to identify any others that might better satisfy the applicable design criteria.
2. The possibility of encasing the trihedrals in concrete is an open design question. Concrete may enhance corrosion resistance, but testing under WIPP-specific conditions, such as burial in halite, is needed.
3. The dimensions proposed for the trihedrals need to be tested to verify that, in fact, the 3-foot size is best for reflecting radar.
4. Verification of the message conveyed by the pattern of radar reflectors will be required to optimize the placement locations.

5. The intent of this marker is to provide a “signature” that will be identifiable at a distance. Other materials or designs may provide a similar signature or another anomalous signature (i.e. one found by a proton magnetometer). These alternatives will be also be evaluated.

5.3.3.3 Alternative Materials

Two materials have been proposed for testing: stainless steel, with or without protective casing in concrete; and inconel. In addition, it has been suggested that a glaze or coating applied to the radar reflectors may prolong their life.

5.4 Buried Storage Rooms

Information regarding the Buried Storage Rooms is provided in this section.

5.4.1 Conceptual Design

There will be two Buried Storage Rooms: one buried at grade level inside the Berm; and the second buried 20 feet below the surface, 525 feet north of the Berm on a line passing through the Information Center, the center of the northern and southern sections of the Berm, and the Hot Cell.

The room dimensions are the same for the two rooms: 39 feet long, by 22 feet wide, by 16 feet high (Figure 9). The walls of the rooms will consist of granite slabs joined only at the perimeter locations. Seven interior granite panels will be contained in each room. The walls and interior panels will be inscribed with Level IV messages (Figure 10). The text of the messages in English is in CCA Appendix PIC, Appendix C. Pictographs to be engraved in the panels will also include those used on the Small Subsurface Markers (Figure 6) and the Large Surface Markers (Figures 4 and 5). The conceptual design includes two optional materials for the floor and ceiling of the rooms: granite or concrete.

The only entrance to each room will consist of a single tapered hole in one wall measuring 2 feet at the inner minimum diameter (Figure 9). A plug will be inserted into the hole. The plug will weigh approximately 1600 pounds, so that its removal will require more than one individual or the use of machinery or explosives. The relatively small size of the opening will inhibit the removal of anything from the room.

The combined weight of the walls, panels, floor and ceiling of the rooms will be approximately 600 tons.

5.4.2 Open Design Considerations

Open design considerations regarding the Buried Storage Rooms include:

1. The final selection of materials of construction has not been made.
2. The placement of magnets on or around the room that will be inside the Berm has not been determined. Various configurations will be evaluated to establish which creates the more anomalous signature.
3. If concrete is used, a specific formulation has not been identified.
4. The potential for chemical interactions at points where different materials come into contact must be assessed if more than one type of material is used.
5. The number and location of the buried storage rooms will be evaluated.

5.4.3 Alternative Materials

The only alternative materials yet proposed for the two Buried Storage Rooms are concrete and granite.

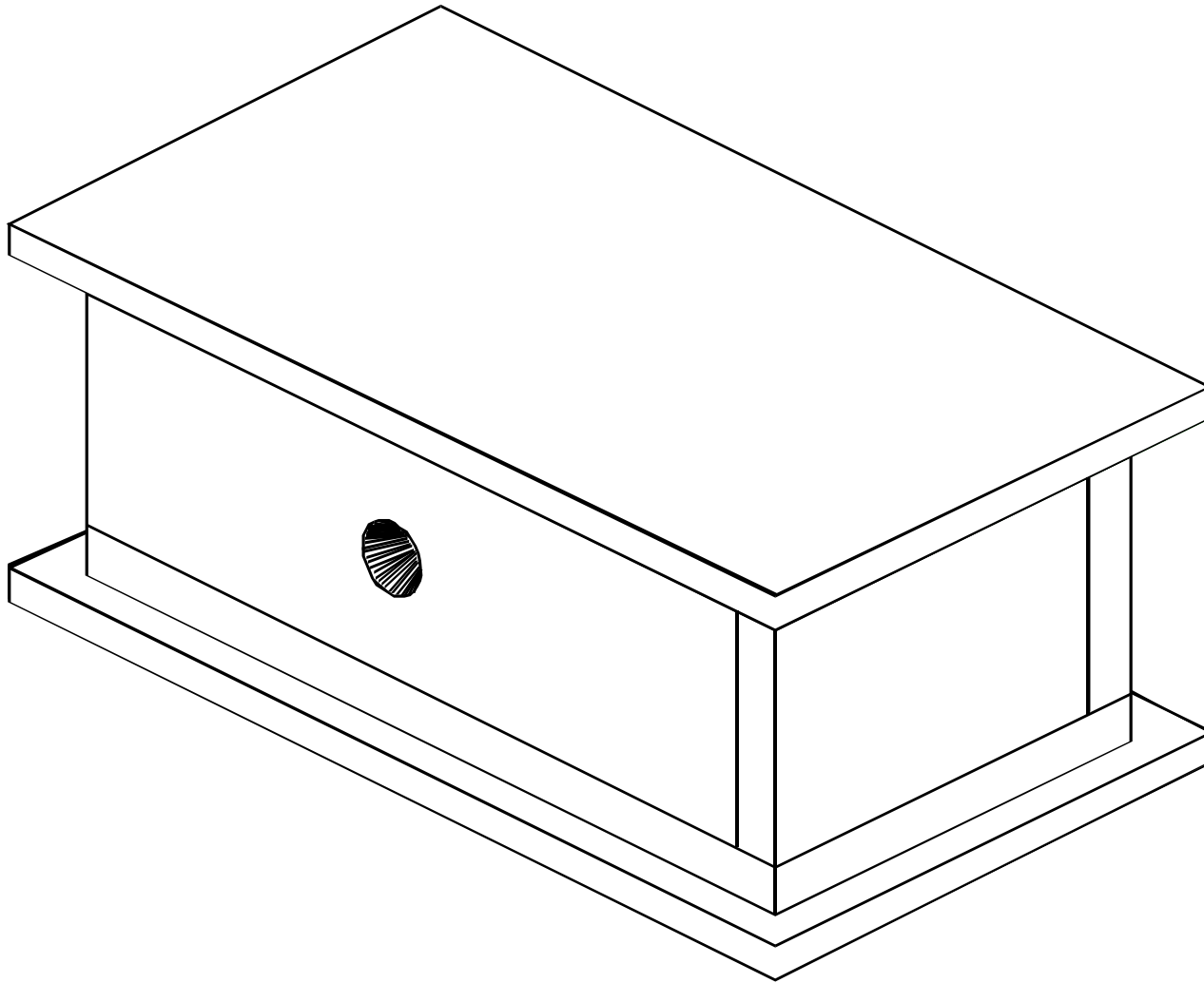


Figure 9. Buried Storage Room Showing Conical Opening

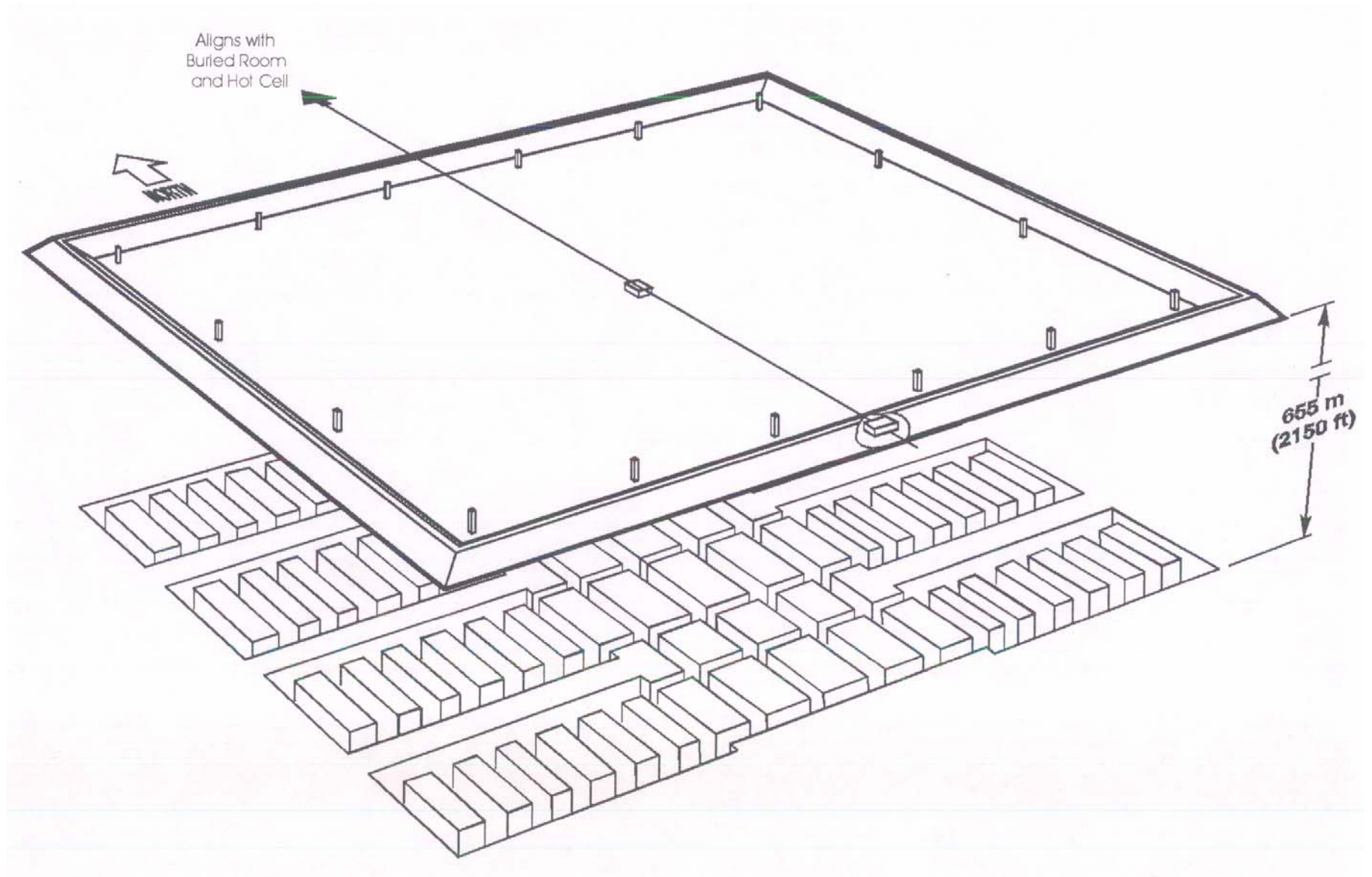


Figure 10. Pictographs Appearing in the Buried Storage Rooms and the Information Center

5.5 Hot Cell

The Hot Cell has already been constructed; it is intended to remain on site as an “archeological remnant,” thus serving as a “de facto” permanent marker.

Current plans are to use the below-grade portion of the building for cask-to-cask transfer of RH waste from “road” casks to “facility” casks. It is not currently known whether the building will be radioactively contaminated. If it is, it will be decontaminated during closure to the same standards as other WIPP facilities.

5.5.1 Conceptual Design

The Hot Cell is a reinforced concrete structure measuring 70 by 40 feet, with walls 4.5 feet thick. The Hot Cell foundation extends approximately 30 feet below grade, and the roof is 60 feet above grade. A floor separates the below-grade section from the above-grade section.

5.5.2 Open Design Considerations

There are currently no open design considerations regarding the Hot Cell. During the testing program, however, the concrete surfaces will be monitored to provide information regarding their resistance to weathering. Thus, the results of the monitoring of the Hot Cell concrete may be used in designing other permanent markers that may potentially contain concrete.

A study will be done, prior to finalizing the Permanent Markers design to compare the costs of tearing down the Waste Handling Building without damaging the Hot Cell versus the costs of demolishing the entire building including the Hot Cell.

5.5.3 Alternative Materials

Since the Hot Cell has already been constructed, no alternative materials are presently at issue.

5.6 Information Center

Information related to the Information Center is provided in this section.

5.6.1 Conceptual Design

The Information Center will be located above ground at the geometric center of the repository footprint. The site will be graded for drainage away from the Information Center. Overall dimensions of the structure will be 40 by 32 by 10 feet (Figure 11). The conceptual design is an open structure, allowing observation of the contents of the building with natural light. It will consist of walls, floor, and panels made of granite. The walls will be buried to five feet in compacted caliche to provide support for the building.

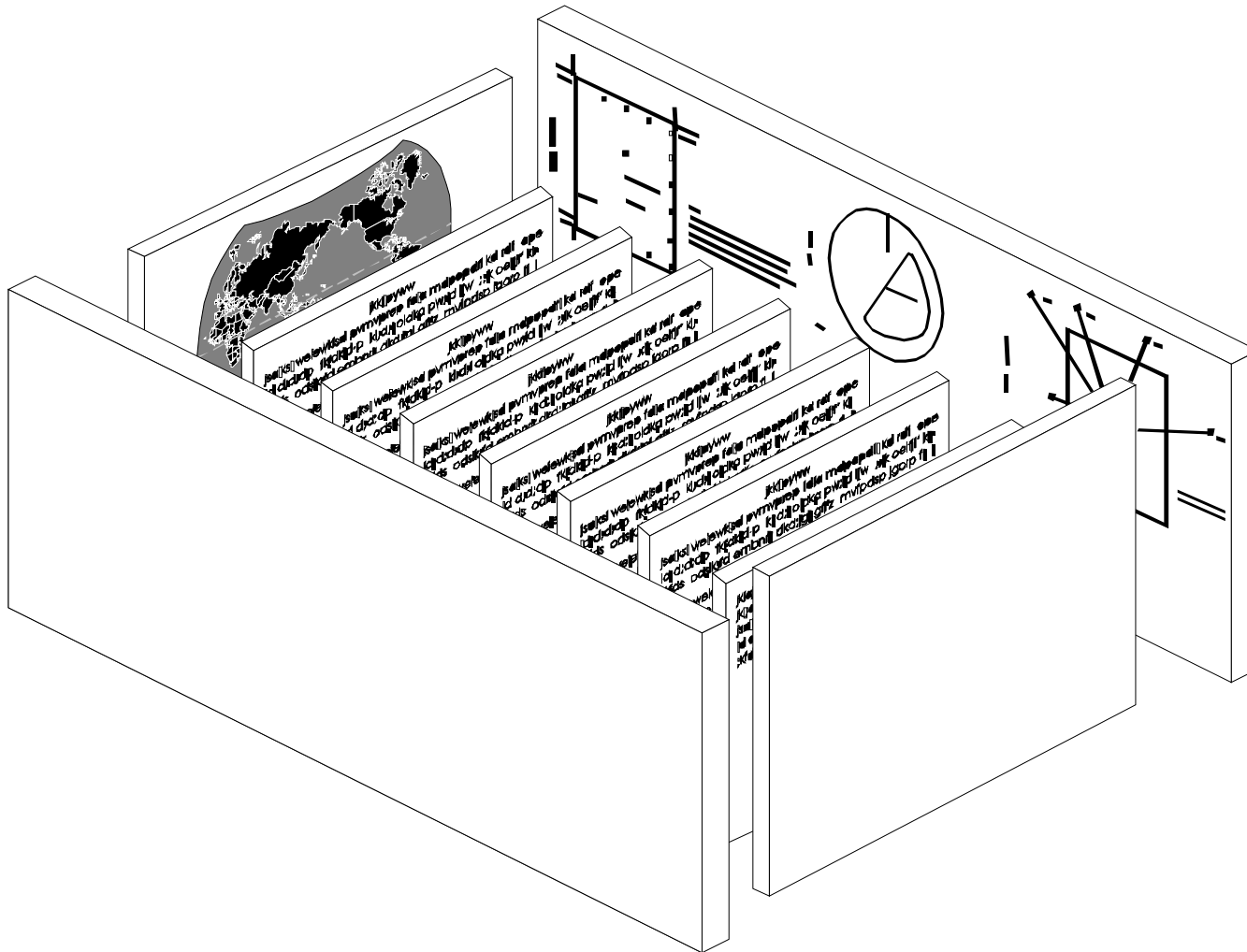


Figure 11. Information Center

The same Level IV messages that appear in the Buried Storage Rooms will appear on the Information Center. It will also contain information regarding the location of the Buried Storage Room in the Controlled Area. The primary function of this additional message is to caution humans not to excavate this Buried Storage Room but to leave it untouched for future generations in the event that the information in the Information Center is no longer readable.

5.6.2 Open Design Considerations

Open design considerations related to the Information Center are listed below.

1. Although granite has been specified for the conceptual design, alternative materials will be evaluated. These may include basalt, sandstone, and quartzite, and possibly man-made materials identified during the research phases of the testing program (e.g., concrete).
2. Multiple grades and varieties of granite having differing characteristics are available from multiple sources. A specific granite has not been identified.
3. Various alternative markers materials may exhibit positive or negative characteristics in regard to the construction of the Information Center. For example, some materials may be susceptible to cracking during quarrying and transporting of the large members planned for the markers.
4. The inscription of messages may be easier on some markers materials than others. Potential problems with chipping and cracking during the inscription process must be assessed. Also, inscriptions may be more durable on some alternative materials.
5. It has been suggested that the Information Center be designed so as to create a distinctive whistle sound when wind blows through the open structure, to help draw attention to the building. The desirability of this warrants investigation and, if determined to be desirable, provisions for this need to be incorporated into the design.
6. Because of its location on the surface and exposure to elements, additional designs may be evaluated to determine the design with the highest long term durability. A central large marker may be incorporated into the information center design to make it more visible.

5.6.3 Alternative Materials

Potential alternative materials for the construction of the Information Center include granite, basalt, sandstone, concrete, and others. At this time, concrete appears to be the most likely candidate material.

6.0 Messages Translation and Testing

The purpose of the messages translation and testing activity is to develop the final version of the text and pictographs to be engraved on the permanent markers at the WIPP. The messages will incorporate increasing degrees of complexity, ranging from Level I to Level IV. The message translation and testing program addresses only message Levels II, III, and IV, since Level I does not use language; it conveys only that something man-made is present. Level V messages consist of the more detailed records placed in archives and records centers; more information is available in the *Passive Institutional Controls Implementation Plan*.

As presently planned, the Level II messages will state through text and pictographs that there is danger present, and the danger is below the land surface. Level III messages tell that radioactive and hazardous waste is buried, instruct persons not to dig or drill, indicate the depth of burial, when WIPP was closed, that the repository is intended to last at least 10,000 years, that there is a decreasing danger over time, and requesting that the messages be updated to the current language or languages in use (space will be left on the markers for this purpose). Level IV messages expand on the above topics, and also address the potential for releases through ground water, identify cancer as the primary risk, provide detailed information on radioactive and chemical constituents of the waste, provide a geologic cross-section with reasons for choosing the Salado Formation for the WIPP, describe the locations world-wide where other nuclear waste sites are located, and urge readers to seek out those other sites and ensure consistency of messages.

To enhance the potential for comprehension of the messages, it is planned that they will be inscribed in seven languages: English, French, Spanish, Arabic, Russian, Chinese, and Navajo. This spread of languages representing different cultures and geographical regions will, it is hoped, potentially allow the markers to serve as "Rosetta Stones" for future populations, and thus increase the chance that they will be understood. Other means of improving possibilities for comprehension include the use of complementary diagrams and pictographs, use of simple words and short sentences, and through the testing of message comprehension with populations indigenous to areas speaking each language, as described in this plan.

The proposed text of the Level II, III, and IV messages are included in Appendix PIC of the CCA. Pictographs proposed in Appendix PIC include the following.

Level II Message:

- Graphic symbols of the human face expressing horror and terror;

- Graphic symbols of the human face expressing something nauseating or poisonous; and
- Trefoil and biohazard symbols.

Level III Message:

The pictographs described above, plus:

- Diagram conveying the danger of digging or drilling;
- Spatial perspective of the marking system to the underground repository; and
- Time elapse diagram from WIPP closure via north celestial pole migration, including faces showing disgust at closure to neutral at 10,000 years, to contentment well beyond 10,000 years, and decreasing size radioactive symbol.

Level IV Message:

The pictographs described above, plus:

- Detailed spatial perspective of the repository;
- Geologic cross section of the WIPP site and relative position of the repository within the formations;
- Periodic chart of the elements, identifying the major radioactive and non-radioactive elements present in waste buried at the WIPP site;
- Azimuths of the bright stars Vega, Arcturus, Sirius, and Canopus as they rise above the horizon at the time of WIPP closure, allowing calculation of the time of closure; and
- World map showing the locations where other radioactive wastes are buried.

Drawings of these pictographs are shown in CCA Appendix PIC.

The message translation and testing program will include a series of activities. These are generally described below. First, the current version of the messages in English will be checked for accuracy, and the assumptions on which the initial planning for the messages was based will be reviewed for continuing relevance and applicability, given the period that will have elapsed since their

establishment. As a part of this initial task, performance criteria will be defined for the messages translation effort.

Messages and Translation Testing will include:

- Evaluation of current messages
- Testing and evaluation of English messages
- Translation of messages
- Testing of translated messages
- Final messages selection

The English version of the messages (and accompanying pictographs) will be revised (if necessary) and tested on English-speaking populations. Revising and re-testing will be performed until performance criteria are met. Next, existing translations of the messages will be reviewed, and revised and updated as needed. The translated messages will then be tested with indigenous populations; the iterative process of revising and re-testing will be performed until defined performance criteria are met.

When finalized, all messages will be formally placed into the WIPP records system for eventual inscription on the permanent markers. The following sections describe these activities in greater detail.

6.1 Evaluate Existing Draft English Messages and Program Assumptions

As noted above, CCA Appendix PIC contains draft English versions of the Levels II, III, and IV messages to be placed on the permanent markers. As the first step in implementing the message testing program, these draft messages will be reviewed for accuracy of content. Factual information related to the WIPP may have changed since the messages were originally drafted.

After this initial step, further work on the message translation and testing program requires personnel with specialized knowledge in a branch of anthropology related to social and cultural anthropology, known as ethnography. Ethnography is “the study of human belief, custom and communication (1) through direct observation (both as a participant “insider” and as a cultural “outsider”), and (2) through personal, face-to-face interviews (structured as well as open-ended, in the native tongue)” (personal communication, D. Givens, June 7, 1999).

An organization experienced in ethnographic research, with particular expertise in communication, language and linguistic studies, will be contracted to perform the message testing. Although the message testing will be performed by the ethnographers, careful oversight by the DOE will be essential to ensure that the intent of the program is accomplished.

The first step for the contracted ethnographic research organization to perform will be to ensure that the overall process proposed for communication through messages and pictographs reflects state-of-the-art knowledge and practice in anthropology. New developments that might have occurred in communication theory since the Markers Panel convened in the early 1990s will be considered for possible incorporation into the program. This research may also result in changes to implementation plans for the program.

Several other issues will be re-visited by the DOE and the ethnographic specialists, working in coordination, to ensure that all regulatory requirements and commitments made to the EPA are met. These issues will include the choice of languages for the messages, design of the pictographs, and the possibility of the use of other designs or structures to communicate the message of danger at the site. Other issues or potential ways to improve the project will undoubtedly arise during the course of the on-going work.

Based on all of the above, the ethnographic research organization will prepare a work plan for the project. This plan will be reviewed, comments incorporated, and approved by the DOE prior to start of work.

In addition, all entities will be involved in preparing a quality assurance plan for the entire message testing and translation program, ensuring that the methods used incorporate proper formal documentation and meet all applicable DOE quality standards.

6.2 Revise, Test, and Finalize English Messages

Based on the research described above, new drafts of the English messages (text and pictographs) will be prepared. The ethnographic research organization will then initiate the testing phase for the English version.

Appropriate cultural groups will be identified for the English language tests. These will include different ethnic and racial groups, as well as groups with differing genders, education levels, incomes, and from varying regions of the United States, as well as Great Britain and other English-speaking countries. Representatives of the groups will be contacted and arrangements will be made to conduct testing.

Testing will then be performed, employing appropriate ethnographic research methods and experienced practitioners. Results will be compiled into a report that provides recommendations both for potential modifications in the messages and pictographs, and for possible changes to elements of the overall message translation and testing program. The English messages will be revised, as needed. If necessary, re-testing will be performed, and the messages finalized.

The ethnographic research organization will prepare a report on this first part of the program. The report will include issues, problems, and a discussion of results and will also include recommendations for later phases of the project.

6.3 Prepare Translations of Text in Designated Languages

In 1994, Level II, III, and IV messages in English were translated into French, Spanish, Chinese, Arabic, Russian, and Navajo (see CCA Appendix PIC). Following the modification of the English messages, a more complete translation into the other six languages will be performed. If the list of languages for final consideration, has been modified, new translations will be prepared.

The updating process will take into account all the information learned in the work described above, including new technical information about the WIPP as well as results of testing of the English version and pictographs and coordination with materials testing. The ethnographic research organization will participate in the consultations with the translators. The potential for the translators to be involved in the testing will be explored, to determine whether this would result in increased efficiency.

6.4 Test Translated Messages

Working with their counterparts in other countries, the ethnographic research organization under contract with the DOE will establish testing programs in appropriate countries around the world. As with testing of the English messages, various cultural groups within indigenous populations speaking each of the designated languages will be identified. Testing will be performed on these groups. Based on the results of the first round of tests, the message texts and pictographs will be revised, as appropriate. Final testing will confirm the content of the messages.

6.5 Finalize Translated Messages

After all testing is complete, the ethnographic research organization will prepare a final report on the entire project. This report will cover all testing, including a discussion of all problems, results of the tests, and recommendations. It will also include the organization's recommended text and pictographs for the messages in each language. The final report, including final text of messages, will be entered into the WIPP records management system for eventual inscription onto the permanent monuments.

7.0 Program Management

Implementation activities and the schedule of these activities are described in this section.

7.1 Implementation Activities

General activities necessary to implement the permanent markers program during the testing phase are identified in Figures 13 and 14. These figures identify activities related to the Large Surface Markers, the Small Subsurface Markers, and the Berm. For each element of the program, it is necessary to develop more detailed work-breakdown plans and detailed schedules.

7.2 Program Schedule

Because of the long term nature of the Permanent Markers planning, only a very general schedule of activities related to the implementation of the permanent markers program has been developed to date. See Figure 15 below. Current planning calls for the definition of testing goals and requirements in a revised Permanent Markers Testing Program Plan expected in 2004. Individual test plans are to be developed and finalized in test plan documents developed under QA guidance from both WTS and Sandia National Laboratories QA programs. Test markers, including a test berm, are scheduled to be constructed beginning in 2008.

Testing analysis and status reports will be prepared at five year intervals to be incorporated in the recertification process. These reports will summarize the related activities and any data that are generated during the testing phase. Additional reports will be developed as requested by EPA or directed by DOE.

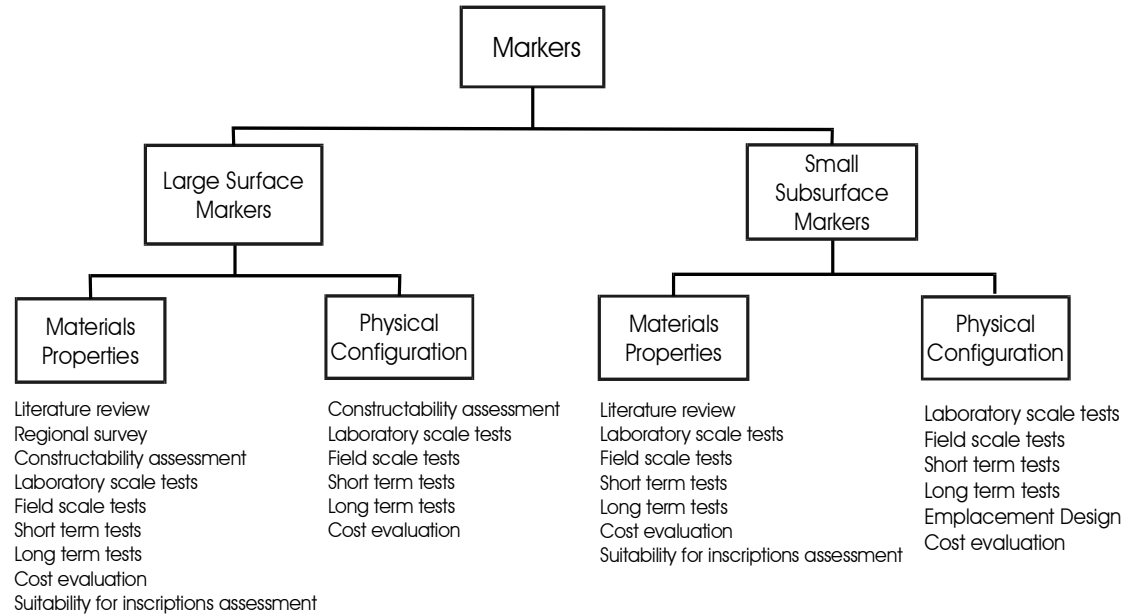


Figure 12. Implementation Activities for Large Surface Markers and Small Subsurface Markers

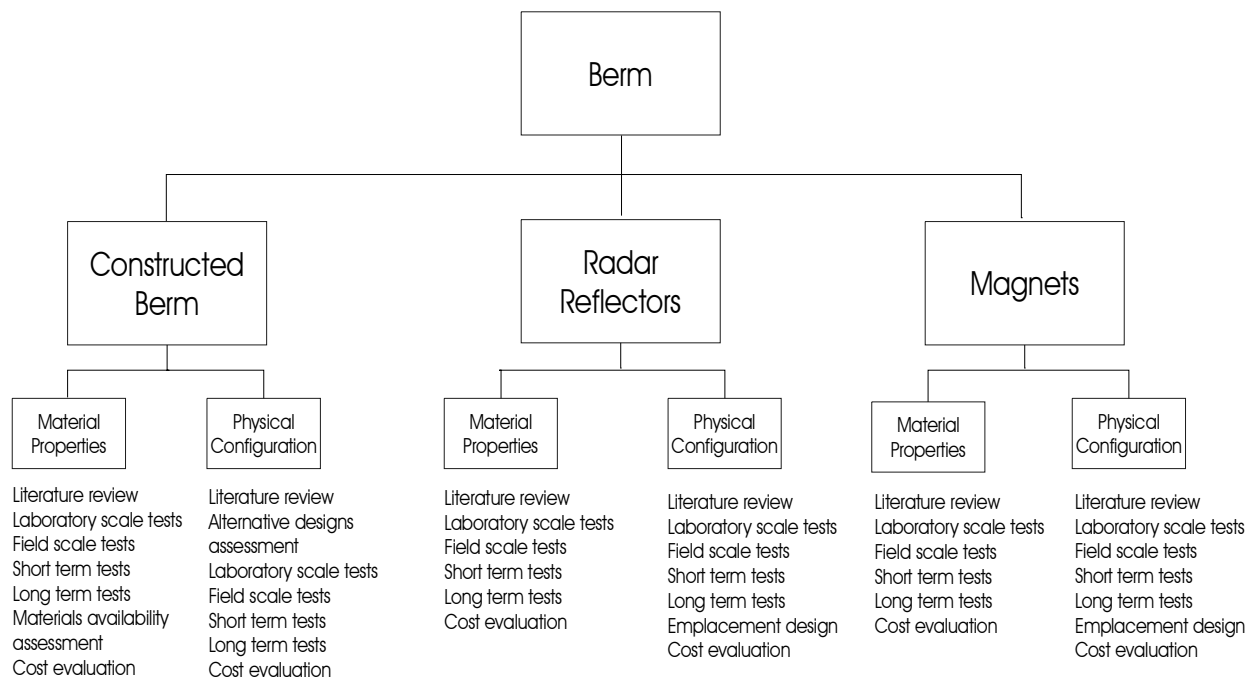
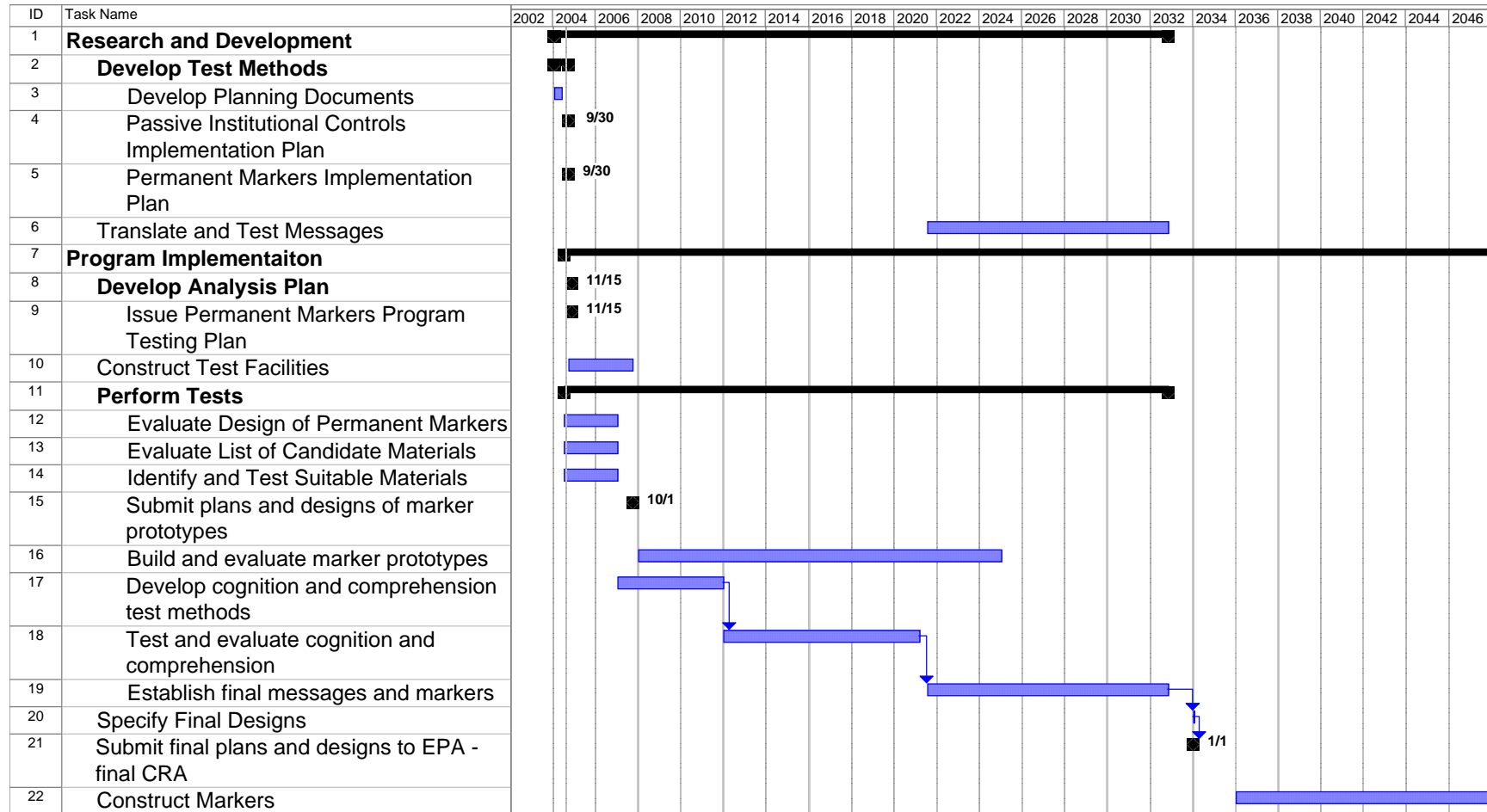


Figure 13. Implementation Activities for the Berm

Figure 14. Permanent Markers Implementation Schedule



8.0 Quality Assurance

The work performed in implementing the permanent markers program shall be developed under the requirements delineated with the CBFO Quality Assurance Program Description (QAPD) (DOE/CBFO 94-1012), applicable implementing documents, and guidance from DOE. The QAPD contains requirements applicable to all work, items, and activities conducted in support of the DOE; applicability of requirements for implementation of the permanent markers program will be determined using a graded approach. Organizations supporting the DOE are required to use the QAPD in the performance of work that is important to safety and waste isolation. The DOE permanent markers program management is responsible for ensuring that the applicable QAPD requirements are contractually imposed on subcontractors doing work in support of the permanent markers program. The provisions of the QAPD are consistent with established national standards such as 10 CFR Part 830, Nuclear Safety Management, American Society of Mechanical Engineers NQA-1, Quality Assurance Program Requirements for Nuclear Facilities, DOE Order 414.1, Quality Assurance, and the DOE Organization EM-1 Quality Assurance Requirements and Description.

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