for independent LLW disposal facilities, which has been the standard practice for the LLBGs at Hanford where the annual precipitation is low. To ensure that analyses are conservative when evaluating the potential releases from LLW disposal, even in lined facilities, no credit is taken for the liner. Due to long time period of analysis and the relative short expected life of liners (30-100 years) it was conservative to model transport to ground water as if the liner did not exist. Liners effectively minimize transport of contaminants from the disposal facility during operations. However, there is no scientific consensus regarding the lifetime of liners.

The mixed waste trenches, ERDF, and all of the lined disposal facilities evaluated in the HSW EIS alternatives are designed with liners that meet applicable technical standards. The liners are a combination of clay, drainable layers, and thick polymeric liners, as discussed in Section 2.2.3.5.

Some disposal facilities use only a clay liner with its natural ability to retard water flows. Smectite or bentonite-type clays are suitable for this function because they have very low permeability to water and are less subject to geologic modification with time than polymeric liners. However, they can be subject to shrinkage and cracking as the water environment changes.

Another option for minimizing contaminant migration could be the use of a permeable reactive barrier in-lieu of the traditional double-lined system. Disposal facility trench design could optimize the physical and chemical characteristics in a trench bottom in order to maximize artificially created attenuation of radionuclides and hazardous waste components. Disposal site design could optimize the soil adsorption capacity by artificially creating a permeable reactive barrier in the trench bottom by adding such materials as flyash, zeolite clays, various oxides, zero valence metals (e.g., metallic iron), granulated activated carbon, phosphates, lime, and peat. Manipulating trench-bottom material pH could also assist in enhancing specific contaminants' retardation. The type and amount of additives, method of additive installation (e.g., layered adsorbents vs. a homogenous blend of adsorbents), and physical/ chemical manipulations deployed to create an artificial reactive barrier would depend primarily on such factors as waste composition (types and volumes) and climate. Field and laboratory tests have demonstrated that flyash and zeolite clays alone greatly improve the retention of most radionuclides (except the actinides) and hazardous contaminants. Installing such a reactive permeable liner system under a mixed waste trench could provide a long-term solution to waste isolation as opposed to the uncertainty associated with long-term performance of landfill barriers, performance monitoring, and landfill liner systems. A permeable reactive barrier could be substantially lower in cost than a traditional double-lined system due to such factors as lower construction costs and elimination of the need to collect and treat leachate during the operating life cycle of the facility and would provide, with a high level of certainty, the ability to isolate waste for thousands of years.

D.5 Barrier Options

The modified RCRA Subtitle C Barrier was selected for use in this EIS as the reference design barrier for LLW and MLLW disposal facilities and is discussed in Section 2.2.3.6. A focused feasibility study (DOE 1996) was performed to examine engineered barrier options that have broad application and are considered viable from the standpoint of effectiveness, implementability, and cost. The feasibility study evaluated a total of four conceptual barrier designs for different types of waste sites. The Hanford

Barrier, the modified RCRA Subtitle C Barrier, and the modified RCRA Subtitle D Barrier were considered as the baseline designs for the purpose of the evaluation. A fourth barrier design, the standard RCRA Subtitle C Barrier, was also evaluated; it is commonly applied at other waste sites across the country. These four designs provide a range of barrier options to minimize health and environmental risks associated with a site and specific waste categories for design life periods of 1000, 500, 100, or 30 years, respectively. Design criteria for the 500- and 1000-year design life barriers include performance to extend beyond active institutional control and monitoring periods. An alternative approach, which is being considered for commercial radioactive waste disposal, is also discussed below.

D.5.1 Hanford Barrier

The Hanford Barrier was designed for disposal facilities with Greater than Category C (GTCC) LLW, GTCC MLLW, and/or wastes with significant inventories of TRU constituents. This barrier is designed to remain functional for a performance period of 1000 years and to provide the maximum practicable degree of containment and hydrologic protection of the evaluated designs. The Hanford Barrier is composed of nine layers of durable material (excluding the grading fill layer) with a combined thickness of 4.5 m (14.7 ft) (see Figure D.12). The barrier layers are designed to maximize evapotranspiration, and to minimize moisture infiltration and bio-intrusion, considering long-term variations in Hanford Site climate.

The primary structural differences between the Hanford Barrier and other barriers discussed in this report are increased thicknesses of the individual layers within the barrier and the inclusion of a coarse-fractured basalt layer to control bio-intrusion and to limit inadvertent human intrusion.

D.5.2 Standard RCRA Subtitle C Barrier

This barrier design can be used at disposal facilities containing hazardous constituents. This barrier is designed to provide containment and hydrologic protection for a period of 30 years, to include institutional control consisting of monitoring and necessary maintenance. The Standard RCRA Subtitle C Barrier is composed of five primary layers (not counting the grading fill layer) with a combined minimum thickness of 1.65 m (65 in.) (see Figure D.13). The barrier layers are designed to shed surface waters, and only minimally account for moisture retention and evapotranspiration capabilities. Bio-intrusion is mitigated primarily by institutional control, monitoring, and maintenance. However, EPA guidelines suggest using optional surface layer treatments for bio-intrusion considerations.

The Standard RCRA Subtitle C Barrier technology meets EPA's minimum technology guidance (EPA 1989). The Standard RCRA Subtitle C Barrier has limited applications and use at the Hanford Site. Limitations include a design life that may be inadequate for the radioactive waste categories; an anticipated high surveillance and maintenance and operations cost caused by implementation of the low permeability layer design features in an arid climate condition; and maintenance and operations cost caused by surface water runon and runoff control, collection, and discharge facilities.

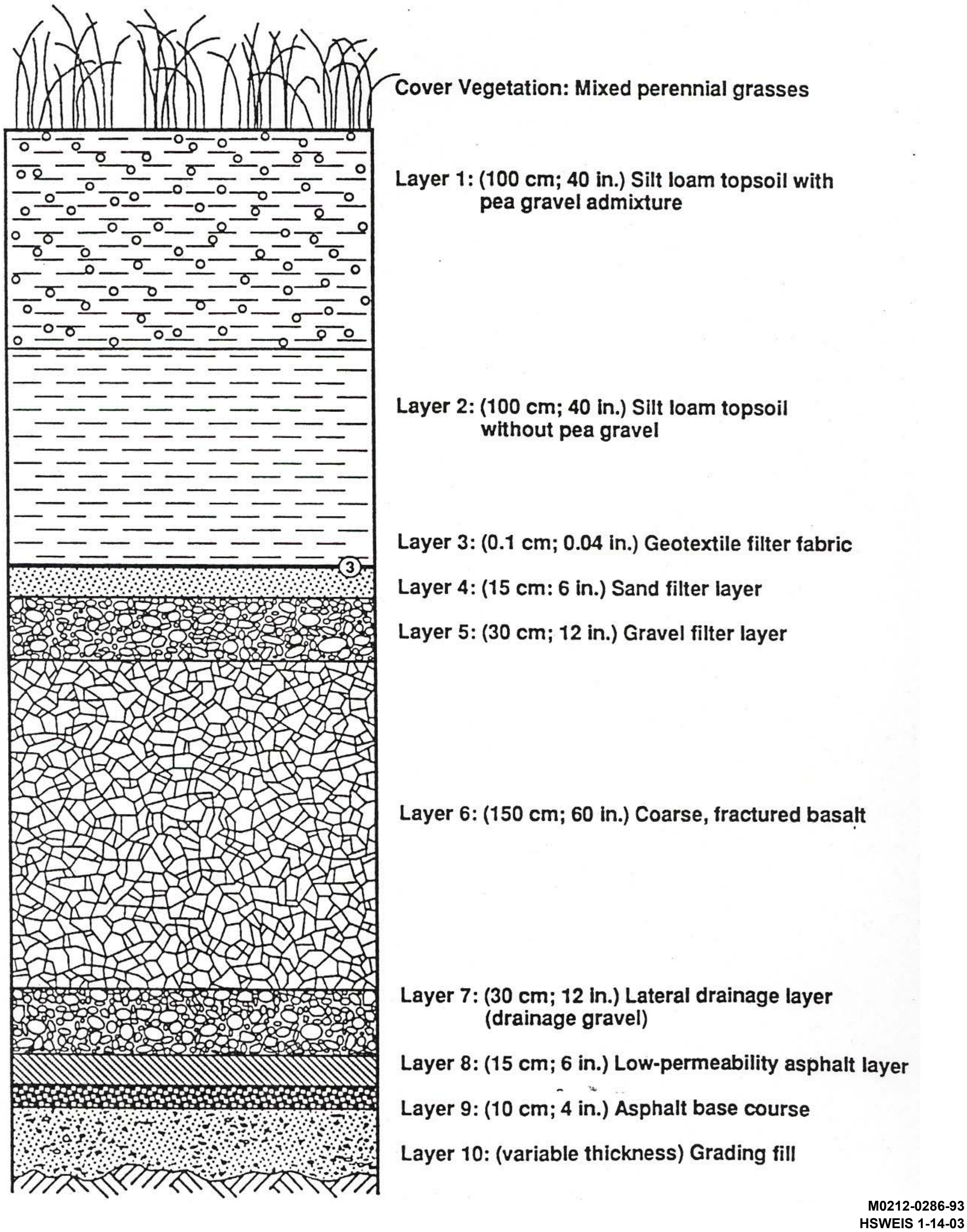

Figure D.12. Hanford Barrier

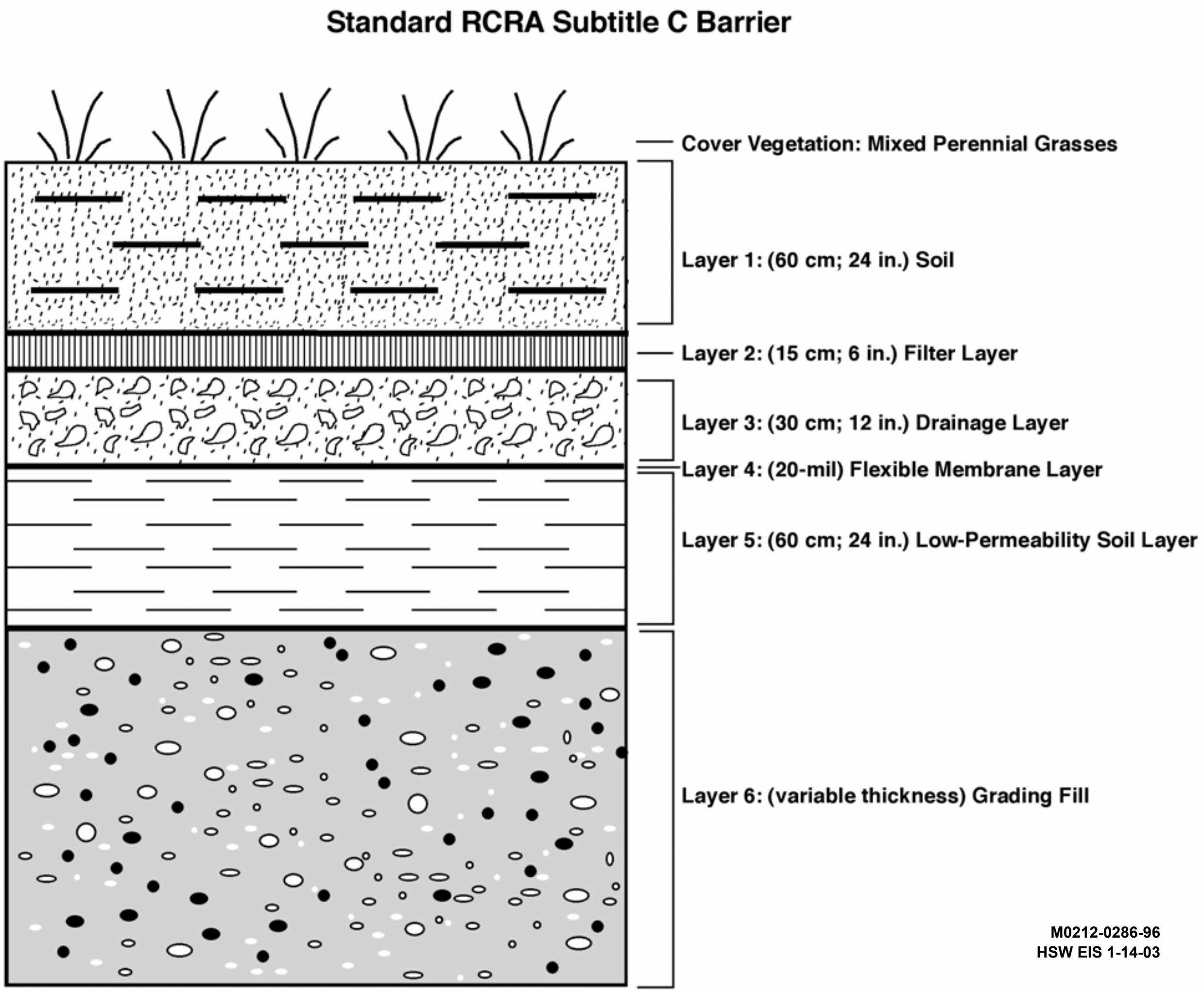

Figure D.13. Standard RCRA Subtitle C Barrier

D.5.3 Modified RCRA Subtitle D Barrier

This barrier is designed for non-radiological and non-hazardous solid waste disposal facilities, as well as Category 1 LLW sites where hazardous constituents are not present. The modified RCRA Subtitle D Barrier as shown in Figure D.14 is composed of four layers of durable material with a combined minimum thickness of 0.90 m (2.9 ft) excluding the grading fill layer. It is designed to provide limited bio-intrusion and limited hydrologic protection (relative to the Hanford and Modified RCRA Subtitle C barrier designs) for a performance period of 100 years. The performance period is consistent with the radionuclide concentrations and activity limits specified for Cat 1 LLW. The 100-year design life is also consistent with the minimum expected duration of active institutional control.

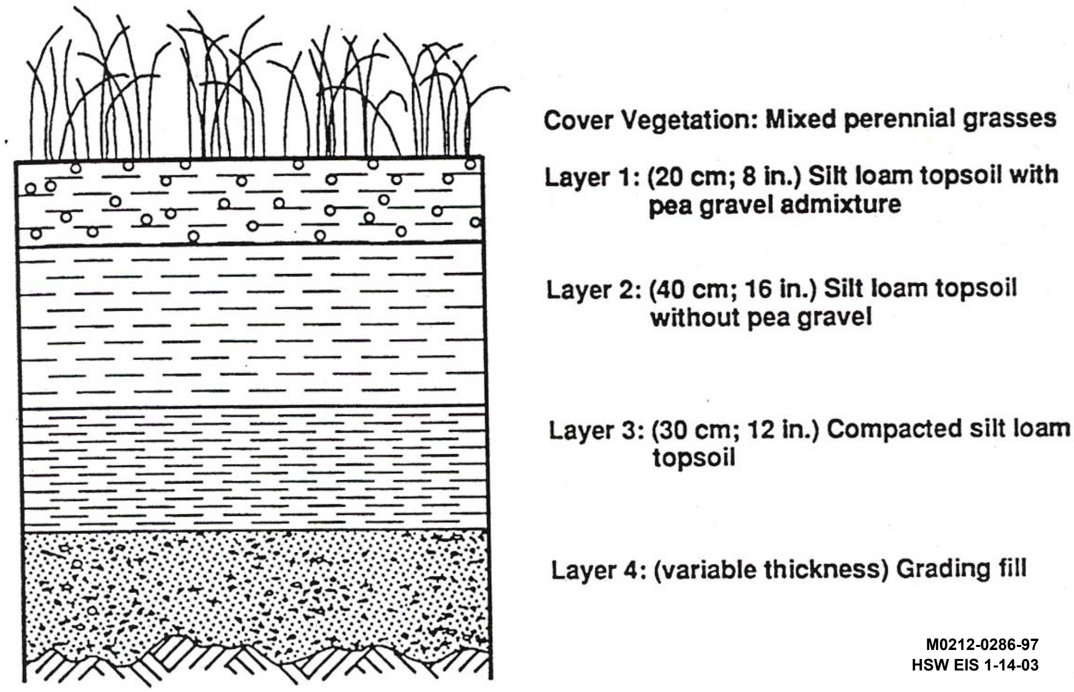

Figure D.14. Modified RCRA Subtitle D Barrier with Bentonite Mix

D.5.4 Conceptual Cover Barrier with Bentonite Mix

This barrier has been evaluated by WDOH (WDOH 1999) for use at the leased commercial disposal facility adjacent to the 200 Areas (the US Ecology Site). The conceptual cover barrier is shown in Figure D.15. Some of the key characteristics of the barrier design are a 4-inch surface layer with 50 percent gravel, 36-inch silt loam layer, and a 12-inch bentonite clay (12 percent) low-permeability barrier.

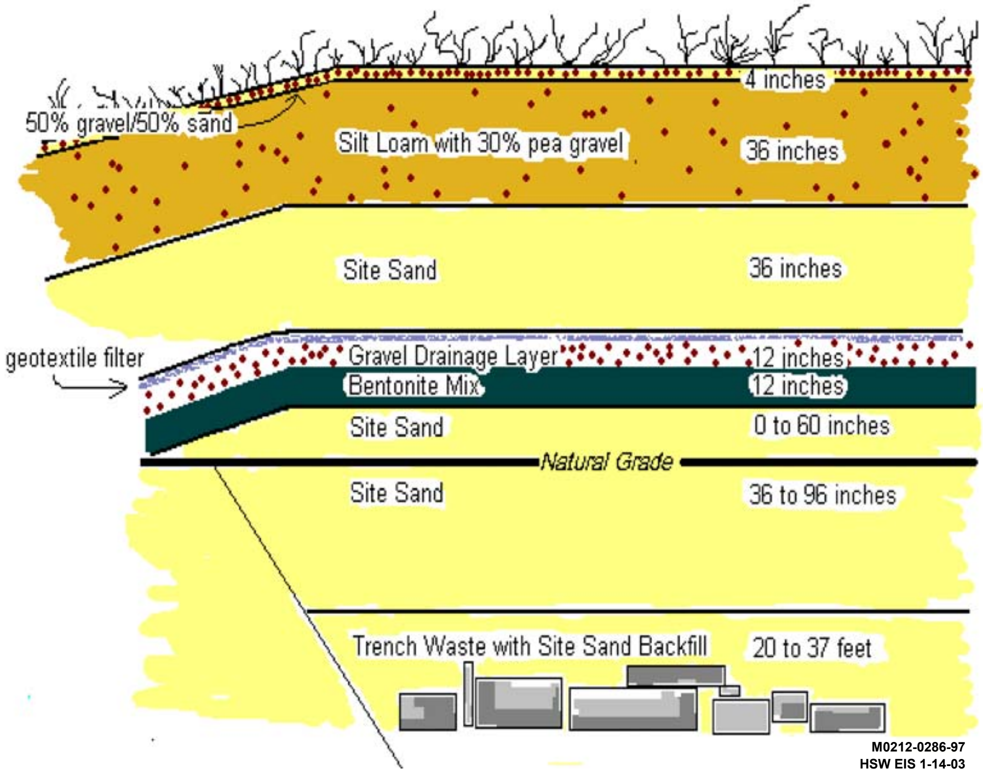

Figure D.15. US Ecology Conceptual Cover Barrier

D.6 References

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