MOLOKAI INTEGRATED SOLID WASTE MANAGEMENT FACILITY

CLOSURE AND POST-CLOSURE PLAN

Prepared for

COUNTY OF MAUI
Department of Environmental Management
Solid Waste Division
1 Main Plaza
2200 Main Street, Suite 225
Wailuku, Hawaii 96793

Prepared by

A-MEHR, INC
23016 Mill Creek Drive
Laguna Hills, CA 92653

October 2007
Revised January 2014
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This work was prepared by me or under my supervision

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Principal Engineer

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1. INTRODUCTION

This Closure and Post-Closure Plan has been prepared for the Molokai Integrated Solid Waste Management Facility (MISWMF) in accordance with requirements of Hawaii Administrative Rules (HAR) Title 11, Chapter 58, Sections 1-17 and 1-18. It describes the activities that will be taken to close and maintain the site at the end of its active life, in conformance with state and federal requirements including the following:

- Estimate the largest area of the site ever requiring closure at one time during the life of the site.
- Estimate the maximum inventory of wastes ever on site.
- Identify activities necessary to close the site.
- Describe the final cover design.
- Provide a schedule for conducting closure activities.
- Describe post-closure care and maintenance activities including a scheduled frequency for them.
- Provide contact information for the person or office responsible for post-closure care.
- Provide an estimate of the costs for a third party to close and provide post-closure care for the facility.
- Describe the funding mechanism to be used to meet the financial assurance requirements for closure and post-closure costs.

Sections 2, 3 and 4 of this Plan document provide background information on the MISWMF site, landfill design and environmental monitoring systems. Section 5 describes the facilities, activities and schedule for closure. Section 6 provides the required information on post-closure. Section 7 contains the cost estimates and financial assurance information.

2. FACILITY DESCRIPTION

2.1 Site Description

The MISWMF is a municipal solid waste (MSW) disposal facility owned by the County of Maui (County) and operated by the Department of Environmental Management, Solid Waste Division (SWD). The facility provides the following services to residents and businesses of Molokai:

- Solid waste disposal;
- Recycling of green waste;
- Recycling of HI-5 beverage containers and other designated materials;
- Recycling of major appliances (white goods); and
- Recycling of scrap metal, automobiles and related materials including tires, batteries, and motor oil.

Solid waste disposal is provided for public and commercial customers, subject to acceptance screening upon delivery, weighing of each load, and payment of the posted gate fees. The disposal fees are set by the County to support operation of the landfill and associated waste management programs.

MISWMF is located near the southern coast of the island of Molokai, on the dry leeward side of the island, approximately three miles northwest of Kaunakakai and approximately 1.25 miles inland with elevations spanning between approximately 200 to 250 feet mean sea level (MSL), and the topography gently slopes toward the south-southwest.

The project area is bounded to the north-northwest by Manawainui Gulch and to the south-southeast by a smaller unnamed gulch. The Tax Key Map identification for the site is TMK (2) 5-2-11:27 (portion). Figure 1 is a vicinity map showing the site location.

Figure 2 presents the existing site plan indicating the major functional areas of the site:

- The currently permitted solid waste landfill area (Phases 1-4) consisting of approximately 11.6 acres;
- The entrance area consisting of the scalehouse / landfill office building, and maintenance facility;
- Recycle Molokai facility;
- Green waste recycling drop-off and processing areas; and
- Receiving, storage, and processing area for Molokai Metals.

Figure 3 shows the proposed site plan with the following changes and additions:

- Proposed Phases 5 and 6 disposal areas measuring approximately 6.6 acres;
- Relocated green waste receiving and process area; and
- Final surface water management system with an expanded sedimentation basin.

2.2 Characteristics, Quantity and Source of Waste

MISWMF is permitted to receive all types of non-hazardous municipal solid waste from residential, commercial and industrial sources. The following waste types are not accepted:

- Regulated hazardous waste
- Radioactive waste
- PCB waste
- Untreated medical / infectious wastes
- Liquids in bulk or containers
- Commercial loads containing greater than 25% green waste, or household loads containing more than 50% green waste
- Scrap automobiles
- White goods
- Whole motor vehicle tires
- Lead acid batteries
- Compressed gas tanks

Of the above wastes prohibited from disposal, the site accepts scrap automobiles, white goods, compressed gas tanks, and lead acid batteries for recycling at the Molokai Metals Facility. All such wastes collected are shipped to off-site recyclers or end-users..

Asbestos may be accepted at the MISWMF if it has been delivered wet, double-bagged in minimum 6 mil plastic bags, and in compliance with 40 CFR Part 61, National Emission Standards for Hazardous Air Pollutants (NESHAP) Regulations. MISWMF personnel will consult with designated SWD engineering or compliance before accepting asbestos wastes for disposal. If accepted, properly packaged asbestos wastes will be deposited in a pit excavated apart from the daily working face of the landfill, and will be covered immediately with a minimum of four (4) feet of solid waste and cover soil. All asbestos deposits will be surveyed. A permanent record shall be maintained of all asbestos deposits including the date received, type and quantity of material, and survey coordinates including elevation.

Inspection and acceptance or rejection of unacceptable waste is the responsibility of the Scale Attendant, Landfill Attendant, and the Equipment Operator. Random checks of loads for unacceptable hazardous waste are part of the waste screening process.

Disposal records for the period from April 16, 2013 and April 17, 2019, the period spanned by the 6 most recent topographical surveys performed for the site, indicate the MISWMF received 30,853 tons for disposal during this period. The nominal average daily disposal tonnage for this period was 14 tons. The nominal average daily disposal tonnage for the most recent period of study of May 31, 2018 through April 17, 2019 was 16 tons.

The green waste processing area is located south of Molokai Metals and features receiving, mulching, and storage areas. Processed mulch is utilized on-site and is provided free of charge for off-site use by Molokai residents.

The Recycle Molokai facility is located south of the facility entrance area is a HI-5 redemption center. It also provides bins for depositing source-separated recyclables consisting of corrugated cardboard, paper bags, newspaper, plastic containers, aluminum cans, bi-metal cans, glass, paint, and electronic waste. Recyclable materials are sorted, processed, stored, and loaded into shipping containers for transport to end users or off-island processors.

The Molokai Metals facility processes scrap vehicles, white goods, used propane tanks, other scrap metal, lead-acid batteries and tires. Materials are received and stored, and are periodically transported to end users or off-island processors.

Over the period of Fiscal Year 2017 through Fiscal Year 2019, the MISWMF recycling operations have annually diverted from landfill disposal an average of 626 tons of scrap metal, 1,115 tons of green waste, and 46 tons of other recyclable materials.

2.3 Method of Operation

Disposal operations use the area fill method of disposal, whereby waste is discharged to a limited area each day and covered prior to the following day's operation. MISWMF is compacted using landfill track loaders or bulldozers prior to covering.

2.4 Landfill Containment Systems

Phases 1 and 2 were constructed without full composite liner systems complying with federal Subtitle D and Hawaii criteria for solid waste landfills, based on the exemption provided for facilities accepting less than 20 tons per day of solid waste.

Phase 1 was constructed with a 30-mil Polyvinylchloride (PVC) geomembrane liner above a compacted soil base, as a "pilot" test to determine whether subsequent cells would require liner systems for collection of leachate. Phase 2 was constructed with a compacted soil liner and a geomembrane lined 20' X 40' lysimeter constructed at the cells low point.

Phase 3 and 4 was constructed with a composite liner system compliant to Subtitle D standards. The liner system consists of the following elements, listed from bottom to top:

- A prepared subgrade of native soil consisting of a minimum 12 inches of soil compacted to 90 percent of maximum dry density;
- A low-permeability soil liner with a minimum thickness of 12 inches and a maximum permeability of 1.0×10^{-6} cm/sec;
- Geomembrane consisting of 80-mil high density polyethylene (HDPE);
- 16-ounce per square yard cushion geotextile;
- Leachate collection drainage layer consisting of 12 inches of sand or gravel with a permeability capable of maintaining less than 30 cm (12 inches) of hydraulic head above the geomembrane;
- 16-ounce per square yard filter geotextile; and
- 24-inch thick protective soil layer.

Figure 4 illustrates the liner systems for each phase of development. Phase 5 and 6 liner systems will be the same as that used in Phase 3 and 4.

New cell construction and final cover installation will generally be done by third party contractors having special qualifications for the work.

2.5 Landfill Development Sequence

Figure 2 presents the existing conditions of the Phases 1, 2, 3, and 4 disposal areas measuring approximately 11.6 acres, and the proposed Phases 5 and 6 disposal areas measuring approximately 6.6 acres. Figure 3 presents the constructed bottom grades/liner grades in Phases 1, 2, 3, and 4 and the liner grades of proposed Phases 5 and 6.

Figure 6 illustrates the final grading plan for Phases 1 through 6.

The incremental and cumulative design capacities for each phase of development, in cubic yards, are:

Phase	Size (acre)	Phase Capacity (cy)	Cumulative Capacity (cy)
1 and 2	6.8	263,200	263,200
3	2.2	87,200	350,400
4	2.6	113,200	463,600
5	3.2	111,700	575,300
6	3.4	261,900	837,200
Total	18.2	837,200	837,200

The design capacities are based on gross volume adjusted for volume occupied by 3 feet of leachate collection gravel and protective cover soil in Phases 3 through 6, and by 3 feet of final cover soil in all phases.

As of the date of the most recent topographic survey, April 17, 2019, the remaining net disposal capacity, less the space to be occupied by final cover, within the currently developed Phases 1 through 4 is approximately 53,987 cy. Additional net disposal capacity of approximately 373,600 cy is to be provided by the planned Phases 5 and 6, resulting in a total remaining site disposal capacity of approximately 427,600 cy. Based on the above outlined projected annualized rate of disposal capacity utilization of 17,617 cy and the total remaining site disposal capacity of 427,600 cy, the remaining site operational life is projected to be through the middle of the year 2043.

Appendix C contains a summary of the current remaining constructed capacity and an estimate of its projected operational life.

The following table provides the disposal capacity utilization projection and the anticipated development schedule for the planned Phases 5 and 6:

Fiscal Year	Beginning Capacity (cy)	Cell Constructed	Additional Capacity (cy)	Projected Annual Airspace Consumption (cy)	Ending Capacity (cy)
2019	53,987			12,453	41,534
2020	41,534	Phase 5	111,698	17,617	135,615
2021	135,615			17,617	117,998
2022	117,998			17,617	100,381
2023	100,381			17,617	82,764
2024	82,764			17,617	65,148
2025	65,148			17,617	47,531
2026	47,531	Phase 6	261,898	17,617	291,811
2027	291,811			17,617	274,195
2028	274,195			17,617	256,578
2029	256,578			17,617	238,961
2030	238,961			17,617	221,344
2031	221,344			17,617	203,727
2032	203,727			17,617	186,110
2033	186,110			17,617	168,493
2034	168,493			17,617	150,876
2035	150,876			17,617	133,259
2036	133,259			17,617	115,642
2037	115,642			17,617	98,025
2038	98,025			17,617	80,409
2039	80,409			17,617	62,792
2040	62,792			17,617	45,175
2041	45,175			17,617	27,558
2042	27,558			17,617	9,941
2043	9,941			9,941	0

<u>Notes:</u>
1. Beginning capacity based on aerial topographic survey dated 4-17-2019.
2. Average Annualized Capacity Consumption: 17,617 cy/year
3. 2019 airspace consumption prorated for the period from 4-17-2019 through 12-31-2019.
4. Total Remaining Capacity projected to be exhausted approximately mid-2043.

2.6 Leachate Management System

Phase 1, which was lined with a 30-mil PVC geomembrane, was constructed with leachate collection trenches and pipes along the west and south perimeters to collect leachate and convey it to the southeast corner of the cell. A solid header pipe continues outside the cell, sloping to a 6 foot diameter leachate collection sump (wet well) located approximately 40 feet from the southeast corner of the cell. A riser pipe (for leachate head monitoring) followed by a plug valve lies between the containment area and wet well. Though information about Phase 1 cell construction is limited, it is believed that the elevation of the low point of the cell is 204’ amsl;

therefore, leachate level must be maintained at a level below 205' for Hawaii Department of Health (HDOH) compliance.

The planned Phase 5 liner will tie into the Phase 1 liner/base grades, and leachate from Phase 1 will drain into the Phase 5 leachate collection system and be managed in the Phase 5 sump which is sized to manage leachate from Phases, 1, 2, 5, and 6. The Phase 1 leachate wet well will be abandoned and removed upon completion of the construction of the Phase 5 area.

Phase 2 was constructed with a compacted soil liner and a geomembrane-lined 20' X 40' lysimeter at the low point of the cell. A perforated pipe located at the bottom of the lysimeter connects to a solid pipe, which penetrates the liner on the west side through an anti-seepage boot. The LCRS pipe slopes downward to a collection point outside the west cell perimeter between Phases 1 and 2. Leachate can be pumped from the vertical sampling port if any is present.

In order to develop the liner grades for Phase 6, the current Phase 2 lysimeter sampling port will be removed and the lysimeter pipe projecting from Phase 2 will be converted to drain into the adjacent Phase 6 leachate collection system. Drainage from the Phase 2 lysimeter will be collected in the Phase 5 sump.

The Phase 3 disposal area is built with a lined internal LCRS sump constructed in the southwest corner of the cell. The leachate collection drainage layer in Phase 3 is 12-inch thick layer of gravel, placed above a geotextile cushion layer, which is immediately above the geomembrane liner. The LCRS gravel layer is covered with a geotextile filter layer. The cell floors for Phases 3 and 4 are graded with a minimum slope of 2 percent to drain to gravel-filled trenches in which 6-inch perforated HDPE pipes are placed. The cell floors and trenches are sloped toward the collection sump. The sump is located entirely within the lined area, with a bottom depth four feet below the adjacent floor liner area. It is lined with two feet of low-permeability soil and two layers of 80-mil HDPE geomembrane, and filled with gravel to the level of the adjacent drainage layer on the floor. The Phase 3 sump riser pipe is provided for sampling and withdrawing leachate from the sump. By regulation, the leachate head over the liner (saturated depth of water in the drainage layer) within the landfill cannot exceed 12 inches deep, except within the LCRS. The lowest elevation of liner at the edge of the Phase 3 sump is 221.5 feet; therefore the compliance level is 221.5 feet amsl in the Phase 3 sump.

The Phase 4 liner is hydraulically connected to the Phase 3 liner and is designed and constructed with a liner consistent with the Phase 3 liner. The Phase 4 liner is sloped from the north/northwest side to the south/southeast side. A lined leachate collection trench, consisting of a perforated pipe surrounded by gravel, runs along the south/southeast side of the Phase 4 liner, roughly parallel with the edge of the Phase 2 area and ties into the leachate collection trench in Phase 3. The trench runs to the southeast through Phase 3, roughly parallel with the edge of the Phase 1 and 2 areas and terminates in the Phase 3 LCRS sump. The Phase 3 sump was sized to serve both Phases 3 and 4.

The Phases 5 and 6 LCRS systems will have designs based on that of Phases 3 and 4, where the liners slope to leachate collection trenches. Phases 5 and 6 will be constructed with an LCRS trench and perforated collection pipe, sloped to drain to a new sump to be located in south corner of Phase 5.

As discussed previously, in regards to the Phase 3 LCRS sump, the Phase 5 LCRS sump must be monitored and pumped out in order to maintain leachate levels below the compliance level elevation (maximum 12 inches over liner outside the limits of the LCRS sump). The compliance elevation for the Phase 5 sump will be determined after completion of construction and be based on as-built liner and sump floor elevations. The compliance elevation will be properly documented and communicated to site operations personnel to ensure proper monitoring and disposal of leachate.

2.7 Proposed Ultimate Use of Land

Upon completion of its useful life as a landfill, the area of the MISWMF used for waste disposal will be returned to its original use as open space. The landfill office and recycling operations may be retained in support of other County recycling and waste-related activities, including management of MISWMF post-closure activities.

3. PHYSICAL SETTING

3.1 Climate

The climate at the landfill is characterized by an average temperature range from 67°F to 82°F and annual precipitation of approximately 15 inches. The design rainfall event at the site for a 24-hour, 25-year storm is 7.5 inches, and the 1-hour, 50-year storm is 2.5 inches (U.S. Weather Bureau, 1962).

Prevailing winds at MISWMF are generally from the northeast. Winds average approximately 13 miles per hour (mph) throughout the year and reach speeds of 25 mph or more with some frequency.

3.2 Seismic Environment

The United States Geological Survey (USGS) has classified the island of Molokai in UBC Seismic Zone 2B, defined as having a 10% probability of exceeding a peak ground acceleration of 0.15g in 50 years. According to USGS seismic hazard maps and data, the peak horizontal ground acceleration expected to occur with a probability of ten percent is 0.16g in 50 years, and 0.30 g in 250 years. Therefore, Molokai is located within a seismic impact zone and a seismic impact study must be conducted to demonstrate the landfill is designed to withstand the maximum horizontal acceleration.

The MISWMF landfill slopes and containment system design have been analyzed to demonstrate they will resist the maximum horizontal acceleration anticipated at the site. Using the final refuse grades, the stability of the final landfill slopes were evaluated using PCSTABL5M, a computer-based analytical program that computes static and pseudo-static factors of safety for the selected critical slope cross-sections. The set of critical slope cross-sections selected and analyzed passes through the unlined disposal cells of Phases 1 and 2 and the lined disposal cells of Phases 3, 4, 5 and 6. The analysis found for all of the cross-sections the static factor of safety exceeds 1.5 and the pseudo-static factor of safety exceeds 1.0, the generally accepted critical values for static and pseudo-static slope stability. Also, there will be no permanent deformation of the liner system during the design seismic event. Appendix B contains the slope stability report.

3.3 Site Access Control

The site is accessed from Maunaloa Highway by approximately 2,300 feet of asphalt-paved road leading to the entrance facility (scalehouse, landfill office, maintenance shop and Recycle Molokai facility). The road consists of two 12-foot lanes with three-foot shoulders and open channel drainages. It is designed for travel at speeds not to exceed 25 mph, with grades not exceeding seven percent. The gate near the Maunaloa Highway entrance is to be locked at all times when the site is unattended or otherwise not open to the public. Keys to the gate are limited to contractors and SWD staff. Distribution of additional keys must be authorized by appropriate County supervisors.

3.4 Surface Water Run-on and Run-off Control

A stormwater "Notice of General Permit Coverage" File No. R50A626, issued by the HDOH, governs the management and discharge of stormwater from MISWMF operations.

Surface water incident on the landfill is directed to perimeter drainage channels by maintaining minimum slopes of 2% to 3% toward side slopes. The perimeter channels are asphalt paved, and drain to the sedimention basin located south of Phase 5.

Stormwater facilities shown on Figure 3 are designed to serve both active and closed landfill conditions. Critical elements of the stormwater management system include the following:

- Perimeter channels and perimeter road drainage around the disposal area to convey stormwater to the sedimentation basin. Including channels along the north and east sides of Phases 3 and 4, and along the west side of proposed Phases 5 and 6. These channels also provide collection of stormwater runoff from the metals recycling and green waste processing areas.

- The primary sedimentation basin includes an overflow spillway to permit water discharge in a controlled manner. During construction of Phase 5, the basin will be enlarged by approximately 200%, to increase retention capacity, improve sediment removal, and minimize discharge events.

- A proposed channel that will convey runoff from the entrance facility area to the sedimentation basin via the existing channel bordering the Phase 3 disposal area.

Based on a hydrologic analysis, the current and proposed features of the surface water management system are designed to manage the 24-hour, 25-year storm as required by HAR 11-58.1-15(g).

4. ENVIRONMENTAL MONITORING SYSTEMS

4.1 Groundwater Monitoring

In 2008, the County conducted a study to determine if groundwater monitoring was necessary. It determined that groundwater monitoring was not necessary under both the "small landfill" and "no-migration" exemptions set forth in HAR 11-58.1-11(f) and HAR 11-58.1-16(a)(2) respectively. The study was conducted in 2008 by A-Mehr, Inc. confirming the findings of the original Dames & Moore study done in 1998 and states:

> *Maui County currently estimates that the total volume disposed during the 2006 calendar year was 6,421 tons or 17.6 tons per day on a 365 day per year basis (A-Mehr, Inc., 2007)*
>
> *A no-migration demonstration (Dames & Moore, 1998) was previously submitted by Maui County to the State of Hawaii Department of Health, pursuant to HAR 58.1-16(a)(2). Updated information related to that demonstration included in Section 7 of this monitoring plan (Site-Specific Groundwater and Leachate Monitoring Plan for the Molokai Integrated Solid Waste Facility; A-Mehr, Inc., April 2008). The analysis concludes, like the 1998 study, that although migration of leachate constituents is theoretically possible, the character of the underlying groundwater is such that hazards to human health and environment are highly unlikely.*

In the event the HDOH requires a groundwater monitoring program in the future, monitoring wells would be installed up-gradient and down-gradient of the landfill. The wells would be completed to the depth of sea level, with screened intervals established to monitor groundwater located at a maximum elevation of 0 to 5 feet above sea level. The wells would be capped with 12-inch diameter locking well monuments and protected by steel post bollards set in concrete.

4.2 Landfill Gas Monitoring and Control

Monitoring of a network of 5 gas probes is conducted on a quarterly basis to comply with HAR 11-58.1-15(d)(2). Figures 2 illustrates the locations of probes in the gas monitoring network. Gas monitoring results will be placed in the operating record.

The MISWMF will comply with the Clean Air Act. On March 12, 1996, the United States Environmental Protection Agency (USEPA) released its final rule that modifies the Clean Air Act to limit the ambient emissions of non-methane volatile organic compounds (NMOCs) from solid waste landfills (40 CFR Parts 51, 52, and 60, Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills). Under this rule, landfills having a design capacity in excess of 2.5 million megagrams (2.76 million tons) and 2.5 million cubic meters (3.27 million cubic yards) are required to establish control programs for landfill gas.

With a design capacity of 837,200 cubic yards, MISWMF Landfill is substantially below the regulatory threshold for requiring gas emission controls. Therefore, a landfill gas collection and control system will not be required at MISWMF.

5. CLOSURE PLAN

5.1 Estimated Closure Date

As indicated in Section 2.5, the estimated closure date, based on completion of filling in Phases 1 through 6, is approximately mid-2043. Although incremental closure is not currently planned, the County may propose one or more partial final closure projects in the future for areas that are at final grades with no additional waste fill anticipated.

5.2 Final Cover

Final cover for MISWMF will be designed and constructed in conformance with the requirements of HAR 11-58.1-17, which contains the following prescriptive elements:

a) an infiltration layer consisting of a minimum of 18 inches of earthen material having a permeability no greater than that of any bottom liner system or natural soils below the liner; or a permeability of 1×10^{-5} cm/sec, whichever is less, and

b) an erosion layer above the infiltration layer, containing a minimum of six inches of soil capable of sustaining native plant growth.

HAR 11-58.1-17 allows for approval of an alternative to the prescriptive design if it can be shown that the alternative design achieves infiltration and erosion control equivalent to the prescriptive design.

The County proposes to close MISWMF using an alternative design employing a soil monocover demonstrated to achieve infiltration and erosion control equivalent to the prescriptive design. A demonstration of equivalency will be provided in a future revision of this Closure Plan. For purposes of estimating closure cost for financial assurance, it is assumed the cover will consist of two (2) feet of compacted soil (one foot of additional compacted soil placed over the one foot of intermediate cover applied prior to closure) and one (1) foot of vegetative soil. The conceptual final cover cross-section is shown on Figure 4.

5.3 Leachate and Gas Management Facilities

5.3.1 Leachate Management Facilities

Leachate from MISWMF will be either be transported to a wastewater treatment plant or returned to the landfill as provided in HAR 11-58.1-15(i). Systems for reintroducing leachate to the landfill will be designed and incorporated in the final Closure Plan prior to closure.

All leachate monitoring shall be conducted as described in Section 2.6.

5.3.2 Phase 1 Leachate Collection System

As noted previously, after construction of the Phase 5 liner and LCRS sump the Phase 1 wet well will be removed, and leachate generated in Phase 1 will flow into collection trenches along the south and west sides of the cell which will drain onto the Phase 5 liner and into the Phase 5 LCRS sump. The leachate collection trenches within Phase 1 feature perforated pipes imbedded in gravel which will be connected to the Phase 5 leachate collection pipes/gravel filled trench.

5.3.3 Phase 2 Leachate Collection System

Phase 2 was constructed with a geomembrane lined 20' x 40' lysimeter at the cell low point. A perforated pipe is located at the bottom of the lysimeter and connects to a solid pipe which projects to the west edge of the Phase 2 area. As noted previously, after construction of the Phase 6 liner the Phase 2 leachate monitoring vertical riser pipe will be removed and the horizontal section will be extended to connect with the Phase 6 leachate collection pipes/gravel filled trench which will drain to the Phase 5 sump.

5.3.4 Phases 3 and 4 Leachate Collection System

The Phase 3 disposal area was built with a lined internal leachate collection sump constructed in the southwest corner of the cell. The leachate collection drainage layer is a 12-inch thick layer of gravel placed above a cushion geotextile above the geomembrane and covered with a filter geotextile. The cell floor is graded with a minimum slope of 2 percent to drain to a gravel-filled trench in which a 6-inch perforated HDPE pipe is placed. The cell floor and trench are sloped toward the collection sump. The sump is totally within the lined area, with a bottom depth four feet below the adjacent floor area. It is lined with two feet of low-permeability soil and two layers of 80-mil HDPE geomembrane, and filled with gravel to the level of the adjacent drainage layer on the floor. The Phase 3 sump riser pipe is provided for sampling and withdrawing leachate from the sump. By regulation, the leachate head over the liner (saturated depth of water in the drainage layer) within the landfill cannot exceed 12 inches deep. The elevation of the sump bottom is 216 feet above sea level, and the elevation of liner at the south edge of the sump and adjacent lined area is approximately 221.5 feet. The compliance level has been established at 221.5 feet above sea level. Accordingly, the sump must be monitored and pumped out in order to maintain leachate levels in the sump below elevation 221.5 feet.

The Phase 4 liner and leachate collection system design is identical to that of Phase 3, where the liner slopes to a leachate collection trench. The Phase 4 leachate collection pipe/gravel filled trench is connected to the piping in Phase 3 draining leachate into the Phase 3 sump.

5.3.5 Phases 5 and 6 Leachate Collection System

The Phases 5 and 6 LCRS systems will have designs consistent with Phases 3 and 4, where the liners slope to leachate collection trenches. Phases 5 and 6 will be constructed with an LCRS gravel filled trench and perforated collection pipe, sloped to drain to a new sump to be located in south corner of Phase 5.

As discussed previously, in regards to the Phase 3 LCRS sump, the Phase 5 LCRS sump must be monitored and pumped out in order to maintain leachate levels below the compliance level elevation. The compliance elevation for the Phase 5 sump will be determined after completion of construction and be based on as-built liner and sump floor elevations. The compliance elevation will be properly documented and communicated to site operations personnel to ensure proper monitoring and disposal of leachate.

5.3.6 Landfill Gas Management Facilities

As documented in Section 4.2, the design capacity of MISWMF, in terms of volume available for refuse disposal is 837,200 cubic yards including Phases 5 and 6. The total design capacity of the landfill is less than the 3.27 million cubic yards regulatory threshold for an active collection and control system and therefore, a landfill gas collection and control system is not be required at MISWMF.

5.4 Largest Area Requiring Closure

Final cover will be installed over the entire 18.2 acre waste footprint of MISWMF at the time of closure, estimated to occur in mid-2043.

5.5 Maximum Waste Inventory

At closure, when the landfill has been filled to the final grades, it is estimated there will be approximately 837,200 cubic yards of refuse and cover soil in place. Using an average in-place airspace utilization factor of 500 pounds of solid waste per cubic yard of airspace occupied by waste and cover soil, the landfill capacity of 837,200 cubic yards will contain approximately 209,000 tons of solid waste at closure.

5.6 Closure Activities

Closure of MISWMF will be implemented by the following sequence of activities:

- <u>Final design and construction procurement.</u> Detailed plans and specifications will be prepared by a Hawaii Registered Civil Engineer (RCE). Plans will include the final cover, storm water management system, demolition or removal of structures, any necessary revisions to site security or related systems, and modifications to environmental controls or monitoring systems. The plans and specifications will be used to secure one or more construction contracts to implement the closure.

- <u>Closure cap construction.</u> Construction of the final closure cap over the landfill surface will involve placing and grading soil and rock products, installation or modification of leachate management systems, and revisions to the surface water management and landfill gas monitoring systems. Construction activities will be carried out by one or more contractors, under the supervision of a RCE and qualified construction quality assurance personnel to ensure conformance to project plans and specifications.

- <u>Removal of structures.</u> Structures not required for support of post-closure maintenance activities will be demolished or removed from the site during the closure construction period. Some structures may be kept in use to support the County's solid waste management and recycling activities as well as to provide a base of operations for the post-closure program at MISWMF.

- <u>Closure documentation.</u> Following completion of all closure construction activities, the RCE will prepare a final construction quality assurance report certifying that closure has been completed in accordance with the Closure Plan and applicable plans and specifications. The County will submit the report to the HDOH in accordance with HAR 11-58.1-17(a)(8). In addition, the County, owner of the property, will record on the deed to the landfill property a notation that the site has been used as a landfill facility and that its use is restricted, as required under HAR 11.58.1-17(a)(9).

5.7 Closure Schedules

Closure activities will be implemented according to the following schedule, which will be refined as final closure plans are developed.

- Six months prior to final waste placement - Begin preparation of detailed plans and specifications.

- Six months following receipt of final waste – Complete all closure construction activities including removal of structures.

- Nine months following receipt of final waste – Complete documentation and notification requirements.

6. POST-CLOSURE PLAN

6.1 Post-Closure Responsibility

The County will provide 30 years of post-closure care and maintenance, unless a demonstration is made to the satisfaction of the HDOH that the site poses no further risk to the public of the environment. During the post-closure period, the County will inspect, maintain and monitor the site in conformance with HAR 11-58.1-17(b) by implementing the activities described in the following sections.

6.2 Monitoring and Maintenance Activities

This section describes the specific activities to be conducted during the post-closure period in conformance with HAR 11-58.1-17(b)(1), including:

- Maintenance of the final cover
- Operation and maintenance of leachate collection and removal systems
- Landfill gas monitoring

6.2.1 Final Cover Maintenance

The following scheduled activities will be conducted throughout the post-closure period to ensure the integrity of final cover systems.

- <u>Semi-annual inspection and maintenance.</u> Inspections during fall (September-October) and spring (March-April) will identify any areas of eroded cover or other damage, and repairs will be made by adding soil or rock, grading or other activities as required. All storm water conveyances and structures will be inspected, cleaned of sediment and repaired as needed. Areas of cover with vegetation will be inspected to ensure that any plants with rooting systems deeper than the top vegetative cover are removed, in order to prevent root damage to underlying closure cap.

- <u>As-needed inspections and repairs.</u> Unscheduled inspections will be made following any unusual events with potential to cause excessive erosion or damage to the closure cap. Such events would include extreme rainstorms or earthquakes. Any damage discovered during the inspection will be repaired on a timely basis.

- <u>Five-year settlement surveys.</u> Within one year after completion of final closure construction and at five-year intervals thereafter, the site will be surveyed and mapped using aerial topography. The maps will be reviewed to identify any areas where differential settlement may create flat spots that could cause surface water to pond or otherwise collect on the surface. Any areas so identified will be repaired at the next semi-annual inspection and maintenance event.

6.2.2 Leachate Collection and Removal System

Sumps in the leachate collection and removal system (LCRS) will be monitored on a regularly scheduled basis, at a frequency depending on the rate of leachate production at the site during the post-closure period. Leachate will be pumped at frequency necessary to maintain leachate head levels below the compliance elevations described in Section 2.6

Leachate disposal will be managed as described in Section 5.3.1 above. The volume of leachate collected is expected to decrease significantly after construction of the closure cap. It will continue to decrease during the post-closure period as organic matter in the MSW degrades.

6.2.3 Ground Water and Gas Monitoring

Current programs for monitoring of groundwater and landfill gas migration, as described in Section 4 above, will be continued throughout the post-closure period.

6.3 Contact Personnel

The title, address and telephone number of the person responsible for MISWMF post-closure activities is:

Chief, Solid Waste Division
Department of Environmental Management
County of Maui
2200 Main Street, Suite 225
Wailuku, Hawaii 96793
Telephone (808) 270-7875

6.4 Post-Closure Land Uses

The closed landfill area of the MISWMF site will be maintained as open space or for non-disposal solid waste management activities during the post-closure period. Other areas of the site may continue to be used for permissible activities associated with the County's solid waste management program, including recycling and equipment storage.

Prior to establishment of any occupied structures or intensive use activities in closed areas, appropriate amendments will be made to this Post-Closure Plan and submitted to DOH for approval. Amendments will describe precautions and programs to prevent damage to closure construction and the protection of health and safety relative to landfill gas.

7. FINANCIAL ASSURANCE

7.1 Applicable Requirements

This section responds to the requirements of HAR 11-58.1-18 for a financial assurance plan estimating the cost of closure and post-closure care for the largest site area ever requiring closure, and establishing financial assurance funding using financial assurance mechanisms approved by HAR 11-58.1-18(e).

7.2 Closure Cost Estimate

The estimated total cost for closure of MISWMF, including a 20% contingency factor, is $5,354,697. The cost estimate is summarized in Table 7-1.

Appendix A contains the detailed assumptions and computations. The estimated costs are in 2019 dollars and will be adjusted annually for inflation as provided in HAR 11-58.1-18(b)(1)(B).

7.3 Post-Closure Care Cost Estimate

The current estimated annual cost for post-closure care and maintenance of MISWMF is $78,940 per year, or $2,368,200 for 30 years. Table 7-1 presents a summary of post-closure costs. Appendix A contains the detailed assumptions and computations. The estimated costs are in 2019 dollars and will be adjusted annually for inflation as provided in HAR 11-58.1-18(c)(1)(B).

7.4 Financial Assurance Mechanism

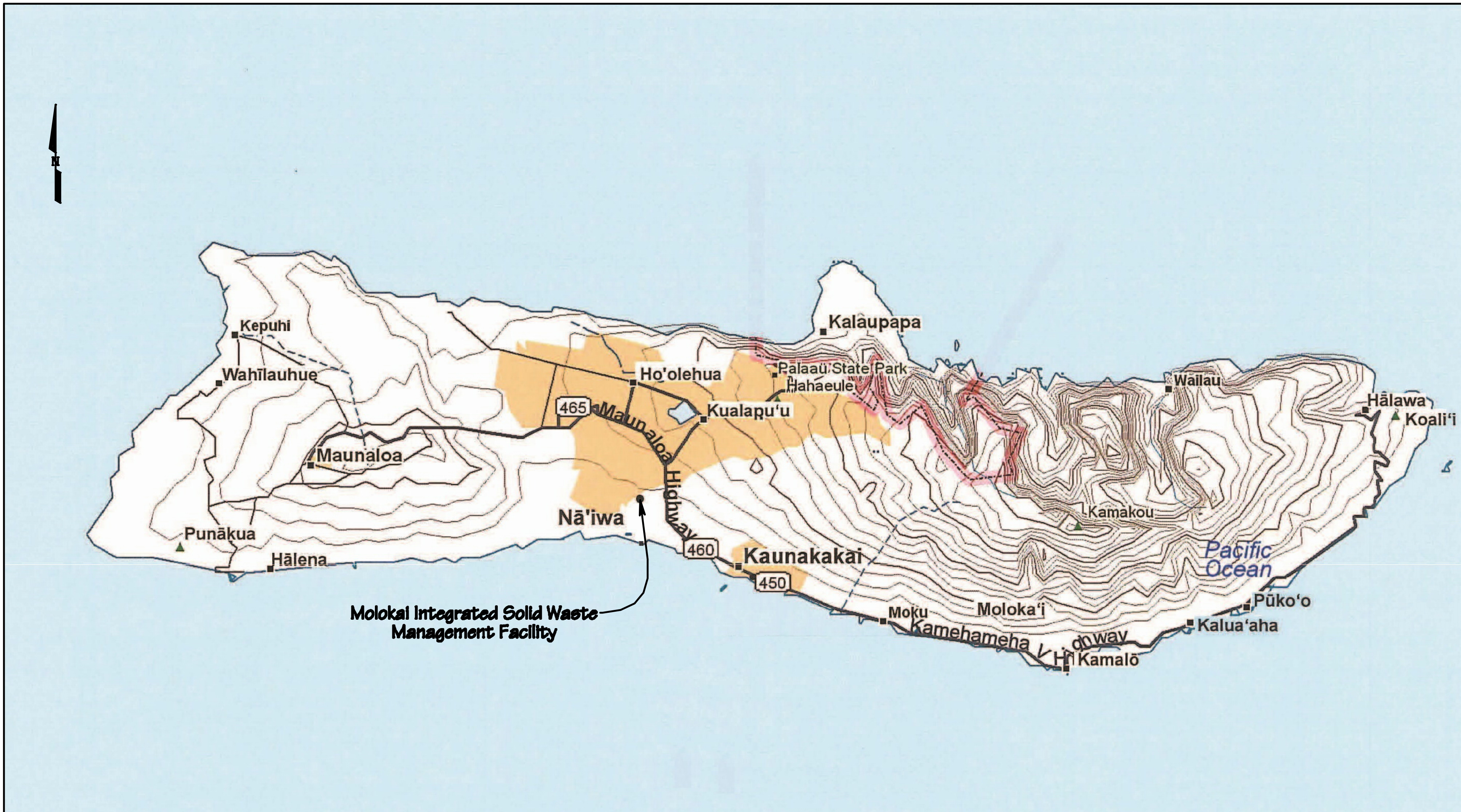
As a local government, the County provides financial assurance based on the local government financial test mechanism of federal 40 CFR Part 258, Section 258.74(f).

Financial assurance amounts will also be adjusted in the future for any partial final closure projects that may be completed before the entire site is fully closed.

TABLE 7-1
CENTRAL MAUI LANDFILL
CLOSURE / POST-CLOSURE COSTS

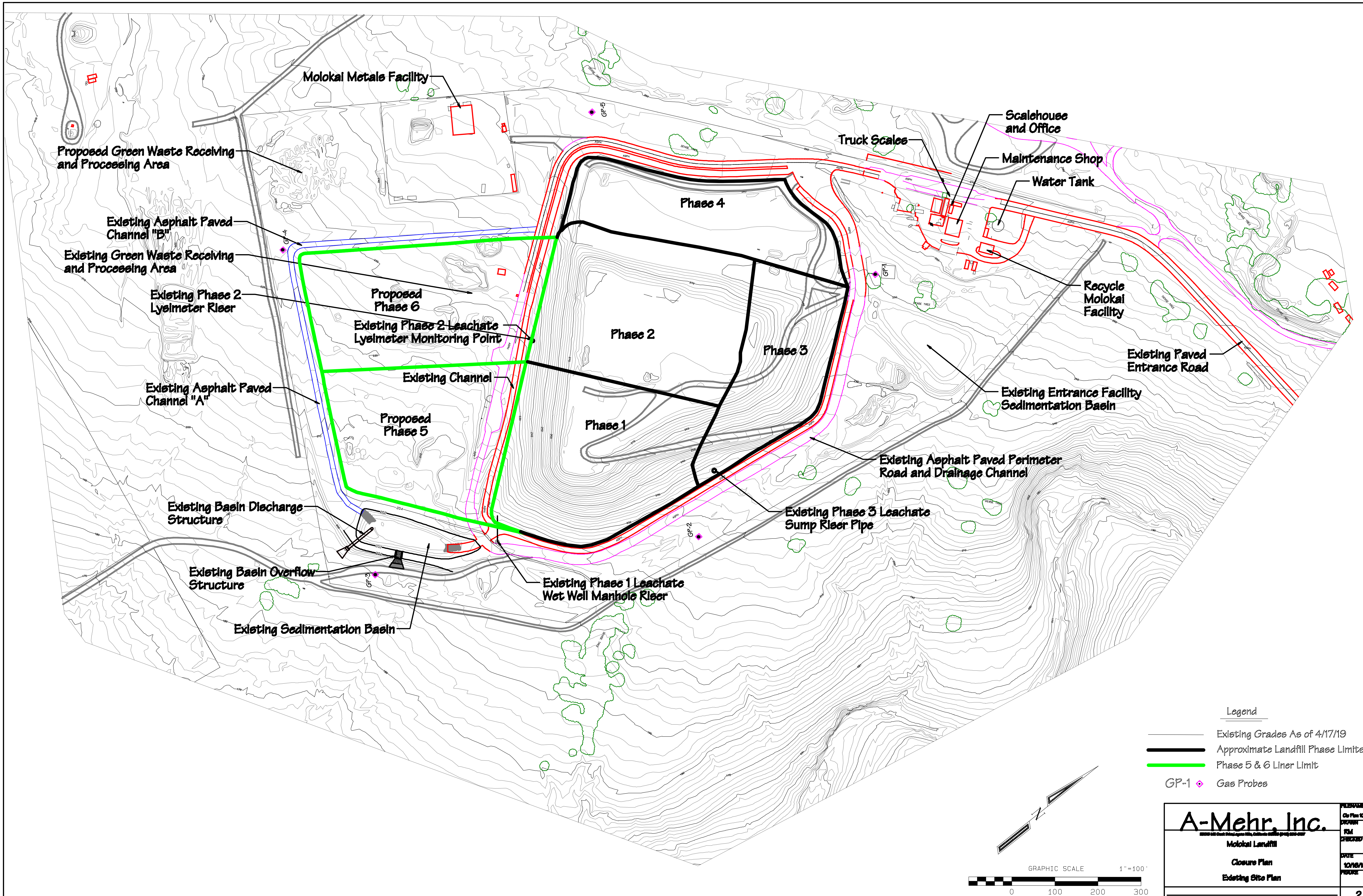
Closure				
Final Cover			$	3,841,212
Revegetation			$	236,169
Leachate Management			$	-
Landfill Gas Monitoring & Control			$	-
Groundwater Monitoring Installation			$	-
Drainage Installation			$	713,253
Security Installation			$	-
Removal of Structures			$	61,104
Subtotal Closure			$	4,851,738
Contingency			$	970,350
Total Closure Cost			**$**	**5,822,088**
Closure Cost per Acre	18.2	acres	$	319,895
Post-Closure Monitoring and Maintenance - Annual Cost				
Final Cover Maintenance			$	41,933
Leachate Management			$	18,126
Monitoring			$	16,020
Drainage			$	6,410
Security			$	1,278
Inspection			$	6,410
Subtotal - Annual Monitoring and Maintenance			$	90,178
Subtotal x 30 years			**$**	**2,705,339**
Total Closure and 30 Years Post-Closure Cost			**$**	**8,527,428**

FIGURES



Source: Delorme Topo Quads and Munekiyo Hiraga

A-Mehr, Inc. 23016 Mill Creek Drive, Laguna Hills, California 92653 (949) 206-0157	FILENAME Clo Plan 101619
	DRAWN
Molokai Landfill	CHECKED
Closure Plan	DATE 10/16/19
Location Drawing	FIGURE 1



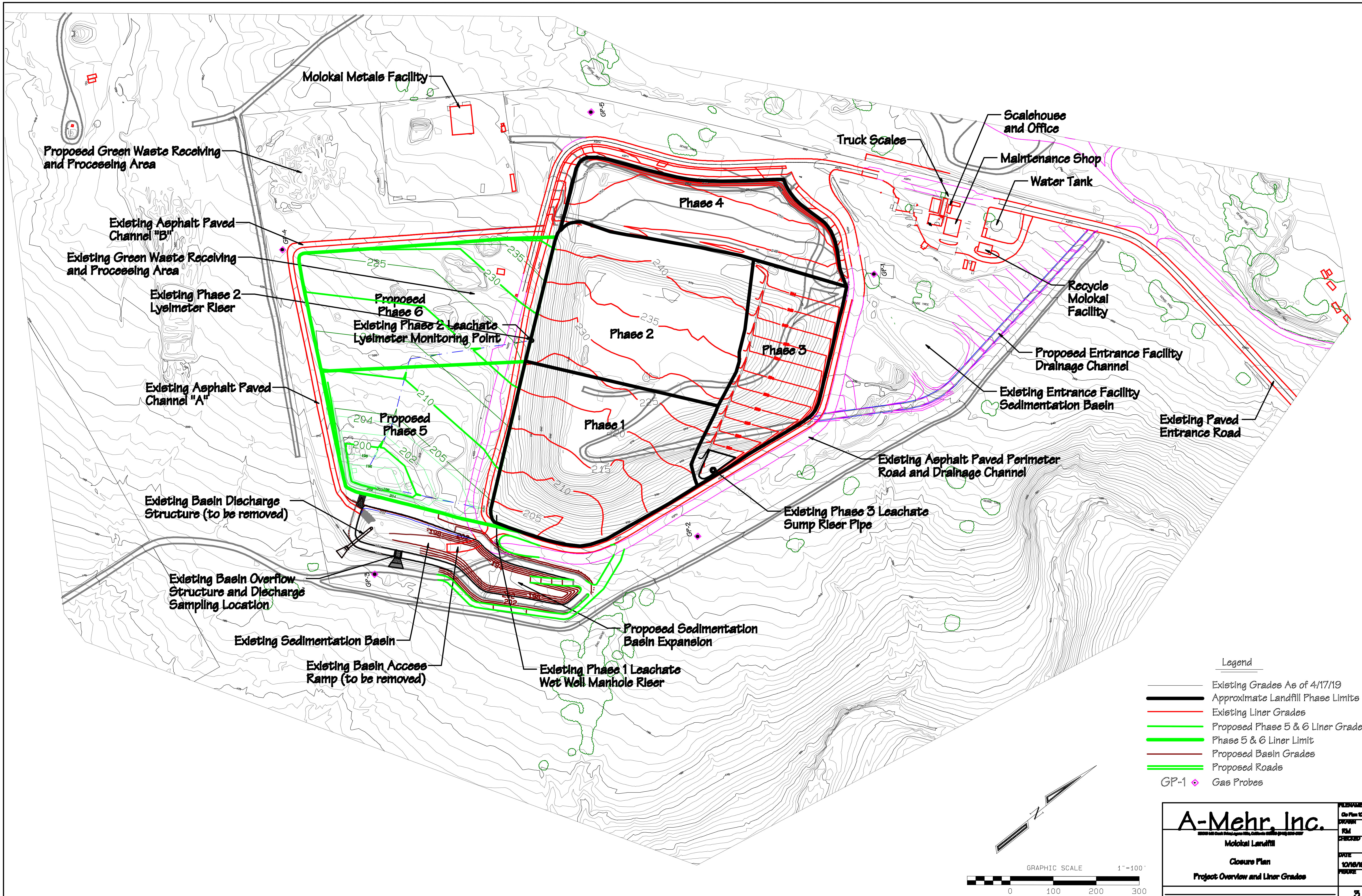
A-Mehr, Inc.

Molokai Landfill

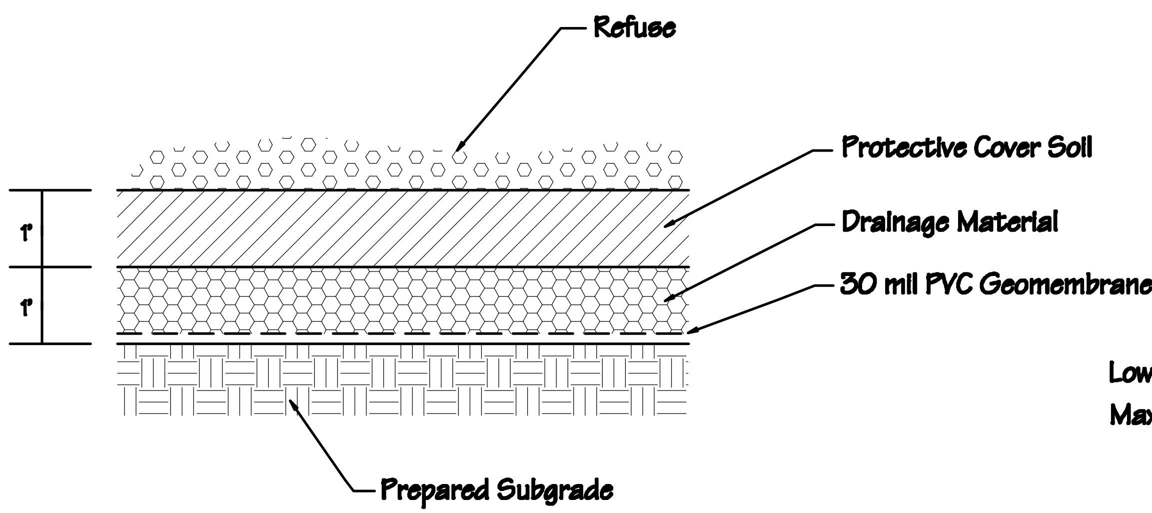
Closure Plan

Existing Site Plan

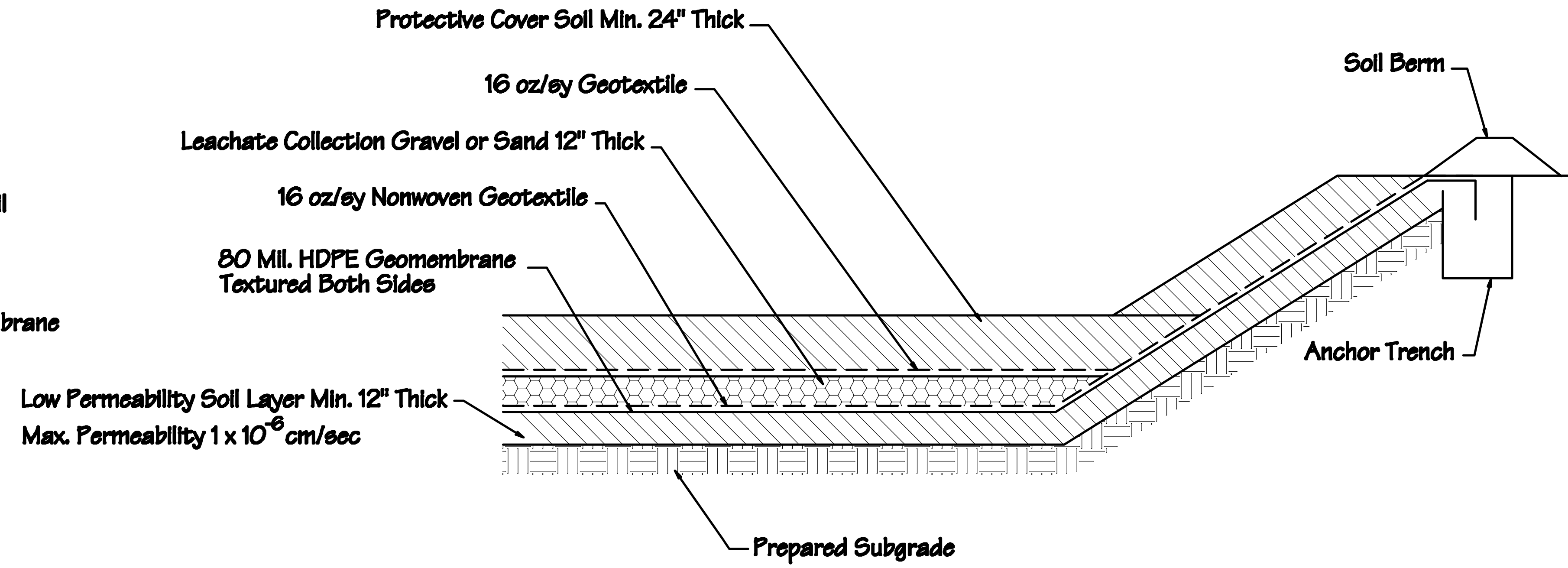
FILENAME	Clo Plan 101619
DRAWN	RM
CHECKED	
DATE	10/16/19
FIGURE	2



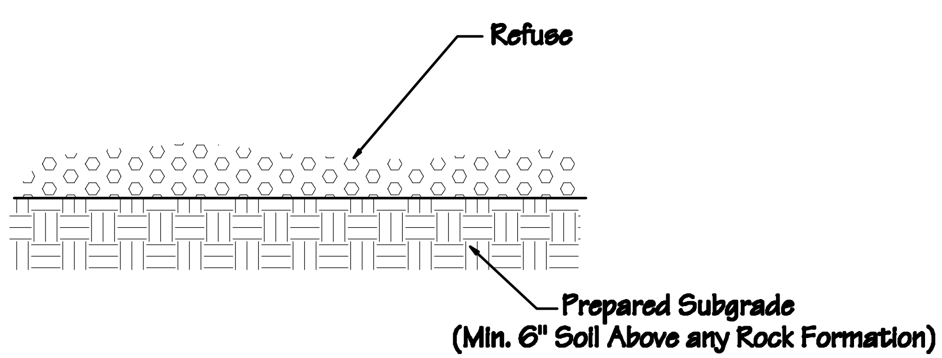
Molokai Metals Facility
Proposed Green Waste Receiving and Processing Area
Existing Asphalt Paved Channel "B"
Existing Green Waste Receiving and Processing Area
Existing Phase 2 Lysimeter Riser
Proposed Phase 6
Existing Phase 2 Leachate Lysimeter Monitoring Point
Existing Asphalt Paved Channel "A"
Proposed Phase 5
Existing Basin Discharge Structure (to be removed)
Existing Basin Overflow Structure and Discharge Sampling Location
Existing Sedimentation Basin
Existing Basin Access Ramp (to be removed)
Existing Phase 1 Leachate Wet Well Manhole Riser
Proposed Sedimentation Basin Expansion
Phase 4
Phase 2
Phase 3
Phase 1
Truck Scales
Scalehouse and Office
Maintenance Shop
Water Tank
Recycle Molokai Facility
Proposed Entrance Facility Drainage Channel
Existing Entrance Facility Sedimentation Basin
Existing Paved Entrance Road
Existing Asphalt Paved Perimeter Road and Drainage Channel
Existing Phase 3 Leachate Sump Riser Pipe
GP-1
GP-2
GP-3
GP-4
GP-5
Legend
Existing Grades As of 4/17/19
Approximate Landfill Phase Limits
Existing Liner Grades
Proposed Phase 5 & 6 Liner Grades
Phase 5 & 6 Liner Limit
Proposed Basin Grades
Proposed Roads
GP-1 Gas Probes
GRAPHIC SCALE 1"=100'
0 100 200 300
A-Mehr, Inc.
Molokai Landfill
Closure Plan
Project Overview and Liner Grades
FILENAME
DRAWN
RM
CHECKED
DATE
10/16/19
FIGURE
3



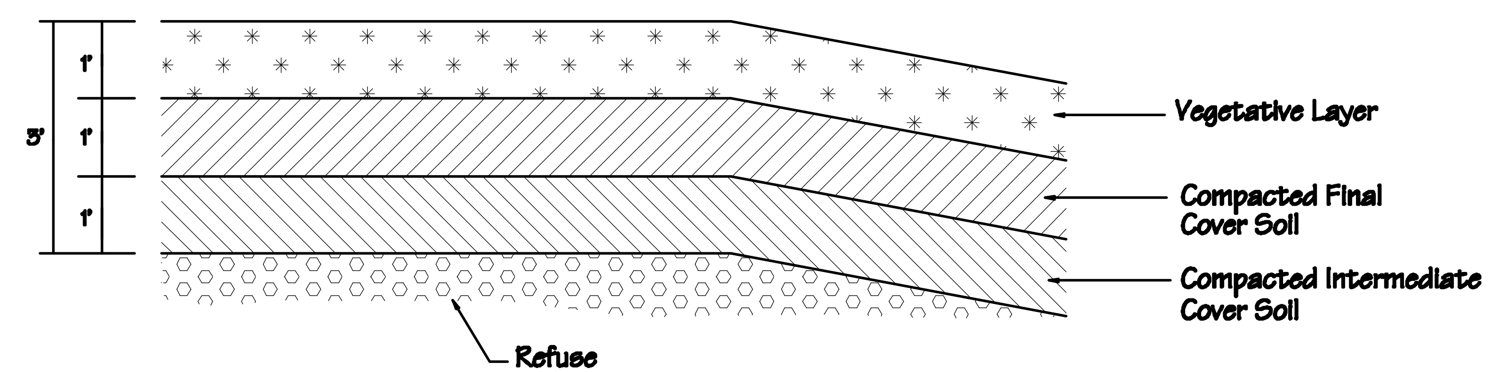
Phase 1 Liner System



Phase 3 Through 6 Liner System

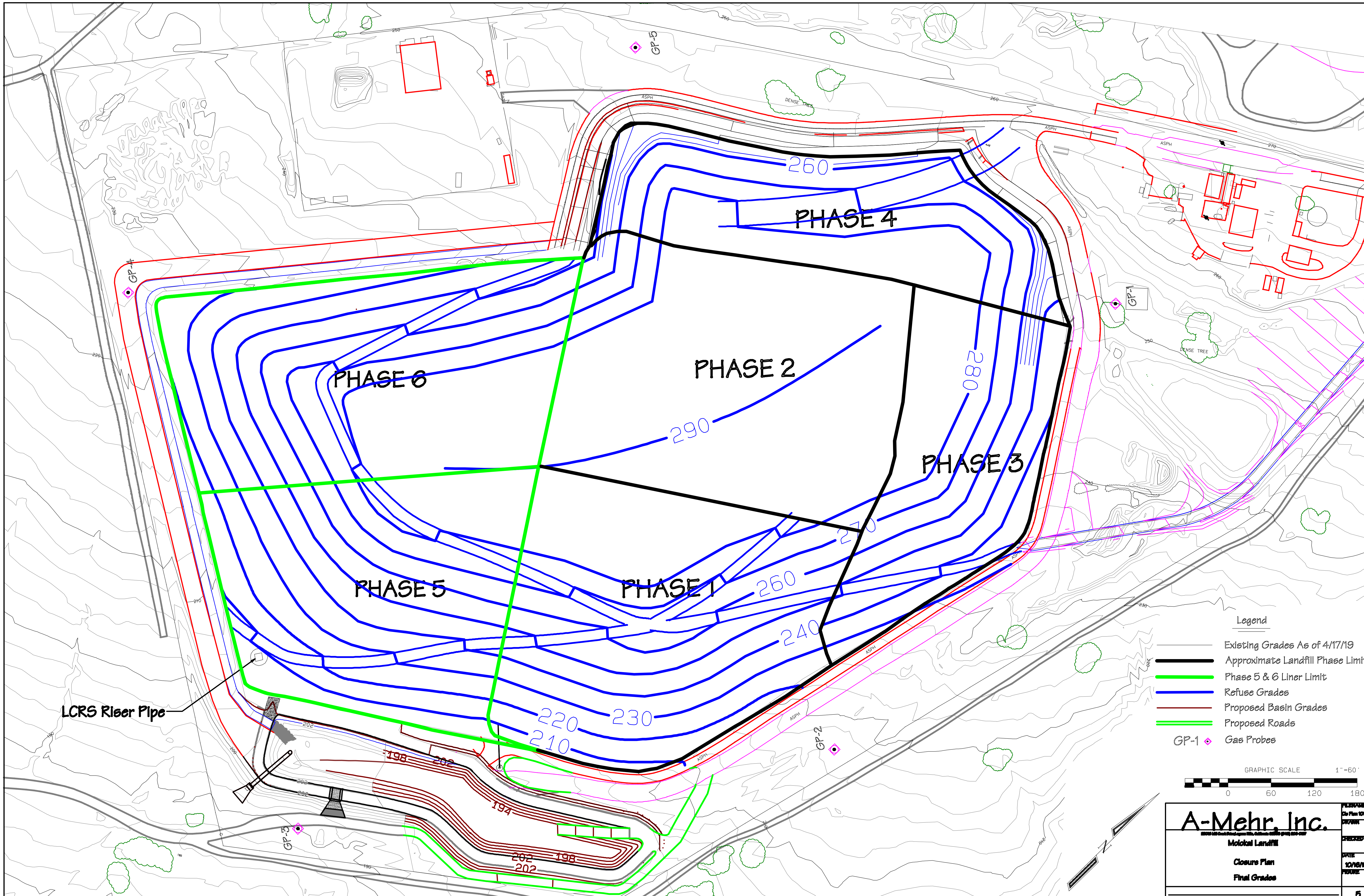


Phase 2 Liner System



Proposed Final Cover System - All Phases

A-Mehr, Inc.	FILENAME Clo Plan 101619
Molokai Landfill	DRAWN
Closure Plan	CHECKED
Bottom Liner and Final Cover Sections	DATE 10/16/19
	FIGURE 4


PHASE 4
PHASE 2
PHASE 6
PHASE 3
PHASE 5
PHASE 1
260
280
290
270
260
240
230
220
210
LCRS Riser Pipe
GP-1
GP-2
GP-4
GP-5
Legend
Existing Grades As of 4/17/19
Approximate Landfill Phase Limits
Phase 5 & 6 Liner Limit
Refuse Grades
Proposed Basin Grades
Proposed Roads
GP-1 Gas Probes
GRAPHIC SCALE 1"=60'
0 60 120 180
A-Mehr, Inc.
Molokai Landfill
Closure Plan
Final Grades
FILENAME
DRAWN
CHECKED
DATE
10/16/19
FIGURE
5

APPENDIX A

COST ESTIMATES

MOLOKAI INTEGRATED SOLID WASTE FACILITY
CLOSURE / POST-CLOSURE PLAN
COST ESTIMATE

SITE DESCRIPTION

General Site Information

Name of Facility	Molokai Landifll
Solid Waste Facility Permit No.	LF0076-93
Facility Operator	County of Maui
Site Owner	County of Maui
Site Address	Naiwa, Molokai, Hawaii
Assessors Parcel No.	TMK (2) 5-2-11:27 (portion)
Anticipated Closure Date	2040

Site Characteristics

Total Site Area		37 acres
Permitted Waste Footprint		18.79 acres
Actual Footprint to be Developed		18.2 acres
Type of Fill		Area
Underlying Geology		Igneous rock
Nearest Major Fault		N/A
On-Site Faults		No known faults
Depth to Groundwater	Minimum	200 to 250 feet

Waste Types and Volumes

Waste Type	MSW	
Estimated Waste in Place @ 4/17/19	409,613	cubic yards
Design Capacity Including Phases 5 & 6	837,200	cubic yards
Thickness of Waste at Closure	Minimum	20

	Average	35
	Maximum	50

Average Height Above Surrounding Terrain 40

Typical Grades of Side Slopes 3:1 horizontal:vertical

Quantity of Waste Received Typical 16 tons/day

Landfill Design Characteristics

Unlined Waste Area 6.8 acres (Phase 1 & 2)

Existing Lined Area 4.8 acres (Phase 3 & 4)

Lined Area at Closure 11.4 acres (Phases 3 through 6))

Base Liner Design Section

Foundation layer	recompacted native soil
Clay liner	1 ft compacted low permeability soil
Geomembrane	80 mil HDPE
Drainage layer	1 ft. gravel, geotextile above and below
Operations layer	2 ft. native soil

Side Slope Liner Design Section

Subgrade	Native soil/cushion layer graded and recompacted
Primary liner	1 foot compacted low permeability soil
Geomembrane	80 mil HDPE, smooth top and textured bottom
Drainage layer	Geotextile
Geotextile	16 oz. nonwoven
Operations layer	2 ft. native soil

Leachate Collection and Treatment

Primary Collectors	Perforated pipes & gravel in trenches
Sumps	Phases 1 and 2 - sump & wet well
	Phase 3: sump serving Phases 3 and 4
	Phase 5: sump serving Phases 5 and 6
Treatment	Reintroduce to landfill in Phases 3 - 6, or off-site disposal

Landfill Gas Management

Collection None required - small site below requirement threshold

MOLOKAI LANDFILL
CLOSURE PLAN

CLOSURE COST ESTIMATE

1. Final Cover
   a. Area to be covered — 18.2 acres
   Computed surface area — 792,792 sq. ft.

   b. Grading

	Quantity	Unit Cost	Amount
Grading preparation for Monolithic Final Cover, s.y.	88,088	$ 5.33	$ 469,750
Total			$ 469,750

   c. Cover Soil

Foundation layer	Compacted existing 1 ft. intermediate cover	
Monolithic final cover	1.0 ft.	
Total soil thickness	1 ft. in addition to existing 1 ft. intermediate cover	
Soil volume placed under final cover contract	29,360 cu. yd.	
Percent native soil	100%	
Unit cost to supply, place & compact	$ 55.55 per cu. yd.	
Cover soil cost		$ 1,630,927

   d. Vegetative Layer

Thickness	1 ft.	
Volume	29,360 cu. yd	
Unit cost to supply and place	$ 42.22 per cu. yd.	
		$ 1,239,505

   e. Geosynthetics

	Unit Cost	Quantity	Cost
None			$ -

   f. Engineering & Construction Quality Assurance

Total cover construction value	$ 3,340,182	
Engrg. & CQA as percent of construction	15%	
CQA cost		$ 501,030

   Final Cover Subtotal — $ 3,841,212

2. Revegetation

a. Area to be revegetated by hydroseeding	18.2 acres	
b. Unit costs	$ 12,976 per acre	
c. Revegetation subtotal		$ 236,169

3. Leachate Management
   No modifications required — $ -

4. Landfill Gas Monitoring & Control

a. Monitoring System

2-probe nested wells at 1000-foot spacing.
Depths of probes 10 & 40 ft.

No. of Wells to be added	0 (Installed in 2011)		
Cost per well	$ 5,000		
Cost for monitoring wells		$ -	
b. Collection System Not required		$ -	
c. Subtotal Landfill Gas			$ -

5. Groundwater Monitoring Installation

Additional wells to install	0 well	
Depth	ft.	
Unit cost of drilling & installation		
Cost of groundwater monitoring system additions		$ -

6. Drainage & Roads Item & Units	Quantity	Unit Cost	Amount	
30' Paved drainage road (top deck),l.f.	400	$ 378	$ 151,094	
15' paved and curbed drainage bench, l.f.	2,400	$ 211	$ 506,610	
Misc. Improvements, l.s.	1	$ 55,549	$ 55,549	
Total drainage cost				$ 713,253
7. Security - no modifications required				$ -
8. Removal of structures				$ 61,104
TOTAL CLOSURE COST				$ 4,851,738
Contingency	20%			$ 970,350
TOTAL INCLUDING CONTINGENCY				**$ 5,822,088**

MOLOKAI LANDFILL
POST-CLOSURE MAINTENANCE PLAN

ANNUAL POST-CLOSURE COST ESTIMATE

1. Final Cover Maintenance			
a. Earthwork Repair			
Area assumed for repair	0.5 acre		
Unit cost for repair incl. CQA and Engr.	$ 1.33 per sq. ft.		
Annual cost of repairs		$ 29,037	
b. Revegetation			
Area assumed for repair	1 acre		
Unit cost for repair	$ 12,896 per acre		
Annual cost of repairs		$ 12,896	
c. Subtotal for Final Cover Maintenance			$ 41,933
2. Leachate Management (Monitoring)			
a. Labor	2 hr/week		
b. Labor unit cost	$ 51.11 per hour		
c. Annual labor cost		$ 5,315	
d. Annual allowance for repairs & materials		$ 6,410	
e. Leachate sampling costs			
Number of samples per round	2		
Frequency of sampling per year	2		
Sampling cost per round	$ 644		
Testing cost per sample	$ 1,278		
Annual sampling and testing costs		$ 6,401	
g. Subtotal Leachate Management			$ 18,126
4. Monitoring			
a. Gas Monitoring			

Quarterly sampling - methane & trace gases
All points tested for TOC using FID/OVA
1 Bag sample collected for trace gas analysis using GC

Sampling cost per event	$ 2,566

Trace gas testing cost per event	$ 1,278			
Annual cost for sampling & testing		$ 15,376		
Annual cost for probe replacement		$ 644		
Gas Monitoring Subtotal			$ 16,020	
b. Groundwater Monitoring				
Number of wells	0			
Sample events per year	0			
Sampling cost per event	$ -			
Testing costs per sample	$ -			
Annual sampling and testing costs		$ -		
Annual maintenance & replacement of wells		$ -		
Groundwater Monitoring Subtotal			$ -	
d. Total Monitoring Costs				$ 16,020
5. Drainage and Roads - Annual maintenance cost				$ 6,410
6. Security - Annual maintenance cost				$ 1,278
7. Inspection - Semi-annual Inspections - annual cost				$ 6,410
TOTAL ANNUAL COST				**$ 90,178**
TOTAL COST FOR THIRTY (30) YEARS OF POST-CLOSURE CARE				**$ 2,705,339**

TABLE 7-1
MOLOKAI LANDFILL
CLOSURE / POST-CLOSURE COSTS

Closure			
Final Cover		$	3,841,212
Revegetation		$	236,169
Leachate Management		$	-
Landfill Gas Monitoring & Control		$	-
Groundwater Monitoring Installation		$	-
Drainage Installation		$	713,253
Security Installation		$	-
Removal of Structures		$	61,104
Subtotal Closure		$	4,851,738
Contingency		$	970,350
Total Closure Cost		**$**	**5,822,088**
Closure Cost per Acre	18.2 acres	$	319,895
Post-Closure Monitoring and Maintenance - Annual Cost			
Final Cover Maintenance		$	41,933
Leachate Management		$	18,126
Monitoring		$	16,020
Drainage		$	6,410
Security		$	1,278
Inspection		$	6,410
Subtotal - Annual Monitoring and Maintenance		$	90,178
Subtotal x 30 years		**$**	**2,705,339**
Total Closure and 30 Years Post-Closure Cost		**$**	**8,527,428**

APPENDIX B

SEISMIC STABILITY ANALYSIS

Seismic Stability Analysis
Molokai Integrated Solid Waste Facility
May 2019

Introduction

Molokai Integrated Solid Waste Facility (MISWF) is located within a "seismic impact zone", defined by Hawaii Administrative Rules (HAR) Section 11-58.1-13(e), as an area with a ten percent or greater probability of experiencing a horizontal acceleration, due to seismic shaking, of more than 0.10 g in a 250 year period. The United States Geological Survey (USGS) has classified the island of Molokai in UBC Seismic Zone 2B, defined as having a ten percent probability of exceeding a peak ground acceleration of 0.15 g in 50 years. (USGS, 2004a) USGS earthquake hazard maps estimate the peak horizontal ground acceleration in central Molokai to be 0.31 g with a 2% probability of occurrence in 50 years (See Figure 1). A probability of exceedance of 2% in 50 years is approximately equivalent to a probability of 10% in 250 years (USGS, 2004b), and represents an event expected to occur one time in approximately 2,400 years. (USGS, 1996)

HAR 1.58.1-13(e) prohibits municipal solid waste landfills to be constructed or expanded in a seismic impact zone unless the landfill operator or owner demonstrates that the containment structures of the landfill are designed to withstand the maximum horizontal acceleration due to an earthquake. A-Mehr, Inc. has prepared the following analysis to make the required demonstration.

Methodology

The analysis is based on a slope stability analysis of the landfill at the time when the landfill has reached its maximum permitted elevation, with design final grades at no steeper than 3:1 (horizontal: vertical) slope ratio as shown on Figure 1. A-Mehr, Inc. used the slope stability analysis computer program STABL6H to compute the static factor of safety and yield acceleration for three critical cross-sections, as shown on Figures 1 - 6. The program uses the Modified Bishop and Modified Janbu methods, to determine the location of the lowest factor of safety for failure planes through the liner system for static and pseudostatic conditions. The location with the lowest factor of safety was then analyzed using the more rigorous Spencer's Method of Slices, which produces more realistic results than the Modified Bishop and Janbu screening procedures.

The analysis was conducted according to procedures specified in the document "RCRA Subtitle D (248) Seismic Design Guidance for Municipal Solid Waste Facilities (U.S. Environmental Protection Agency, April 1995). The document provides a straightforward procedure for evaluating the seismic stability[1] of refuse slopes, as follows:

- Establish cross-sections and assign appropriate shear strength parameters.
- Conduct static stability analyses, using appropriate programs to search for the most critical locations in the cross-section to determine the lowest static factor of safety.
- Determine the seismic coefficient, k_s. The recommended value for k_s is 50% of the peak horizontal acceleration during the design earthquake.

[1] Seismic stability as evaluated in this report refers to stability against potential movements of significant volumes of refuse or soil, as distinguished from minor slippage of surface materials.

- Conduct pseudo-static stability analyses of the most critical locations for each cross-section, applying a horizontal load equivalent to the selected seismic coefficient $k_{s.}$.
- If the resulting pseudo-static factor of safety is greater than 1.0, the seismic stability analysis is complete.

Input Data

The analysis requires shear strength properties to be assigned to each material in the system. Table 1 lists the components form the liner – waste system. Due to the shallow excavation of the landfill base grades (approximately 5 feet), liner components are the same on the floor and side slopes, except for the presence of leachate collection gravel on the floor. Table 2 lists the properties for each component and interface.

The seismic coefficient used in the pseudo-static stability analysis is 50% of the peak horizontal acceleration as recommended by USEPA (1995), and the design earthquake is 0.5 x 0.31 = 0.155g.

Table 1
System Components – From Bottom to Top

Prepared subgrade
One (1) foot of low permeability soil liner
80 mil HDPE textured (both sides) geomembrane
16 ounce/square yard nonwoven geotextile
12 inches leachate collection sand or gravel
16 ounce/square yard nonwoven geotextile
2 ft. sandy clay soil (operations layer)
Solid waste

The analysis were conducted for the most critical conditions, assuming a maximum slope ratio of 3:1 (horizontal: vertical). The analysis evaluated the cross-sections illustrated on Figure 1, with shear strength properties typical of solid waste and the soil and liner materials present at the landfill, including a refuse mass unit weight of 85 pounds per cubic foot (pcf) based on site-specific waste compaction and soil use data for MISWF, which is a conservatively high maximum weight typically used in the industry.

Appendix A presents the data and calculations used to estimate the site-specific refuse mass unit weight of 85 pcf. Table 2 summarizes the input values for the stability analyses.

Table 2
Shear Strength Properties for Gross Slope Stability Analysis

Material	Friction angle (degrees)	Cohesion (lb./sq. ft.)	Unit Weight (lb./cu. ft.)
Low permeability soil liner	25	250	126
Solid Waste	33	0	85
Liner System Low permeability soil liner vs. textured HDPE liner interface	18		63

Results

The computer output sheets for the STABL6H stability analyses are presented in Appendix B. The results are summarized in the following discussion.

Static Factor of Safety:

Each of the three cross-sections was evaluated for the analytical case using the material properties listed in Table 2. The liner system was assigned the properties of the most critical interface, the low permeability soil liner / textured HDPE interface.

All cross-sections were determined to have static factors of safety (FS) equal to or greater than 1.5 for all cases. As shown in Table 3, the lowest FS determined by Spencer's Method of analysis for each was:

Cross-section 1-1 2.39
Cross-section 2-2 2.06
Cross-section 3-3 1.80

Pseudostatic Analysis:

All cross-sections were determined to have pseudo-static factors of safety (FS) in excess of 1.0 when analyzed using the seismic coefficient k_s = 0.16g. As shown in Table 3, the lowest seismic FS values for each cross-section are:

Cross-section 1-1 1.35
Cross-section 2-2 1.34
Cross-section 3-3 1.06

Table 3
Stability Analysis Results
Static and Pseudo-static Factors of Safety

Refuse Unit Weight (pcf)	Minimum Static Factor of Safety			Minimum Pseudo-static Factor of Safety		
	Cross-Section 1	Cross-Section 2	Cross-Section 3	Cross-Section 1	Cross-Section 2	Cross-Section 3
85	2.39	2.06	1.80	1.35	1.34	1.06

It should be noted that the analysis of gross slope stability was conducted using the interface shear strength of the textured HDPE against low-permeability soil liner, with a friction angle of 18 degrees for the lined areas of Phases 3, 4, 5 and 6. The unlined areas of Phases 1 and 2 were evaluated using parameters for low permeability soil, with a friction angle of 25 degrees and cohesion of 250 psf as indicated in Table 2. With seismic factors of safety greater than 1.0, it can be concluded there will be no permanent deformation of the liner system during the design seismic event.

Based on this analysis, we conclude that the containment system for the landfill is designed to resist the maximum horizontal acceleration from the design earthquake, and therefore meets the requirements of HAR 11-58.1-13(e).

Respectfully Submitted,

M. Ali Mehr

A-MEHR, INC.
M. Ali Mehrazarin, P.E.
Principal Engineer

References

EPA, 1995. RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities. EPA/600/R/95/051. U.S. Environmental Protection Agency, April 1995.

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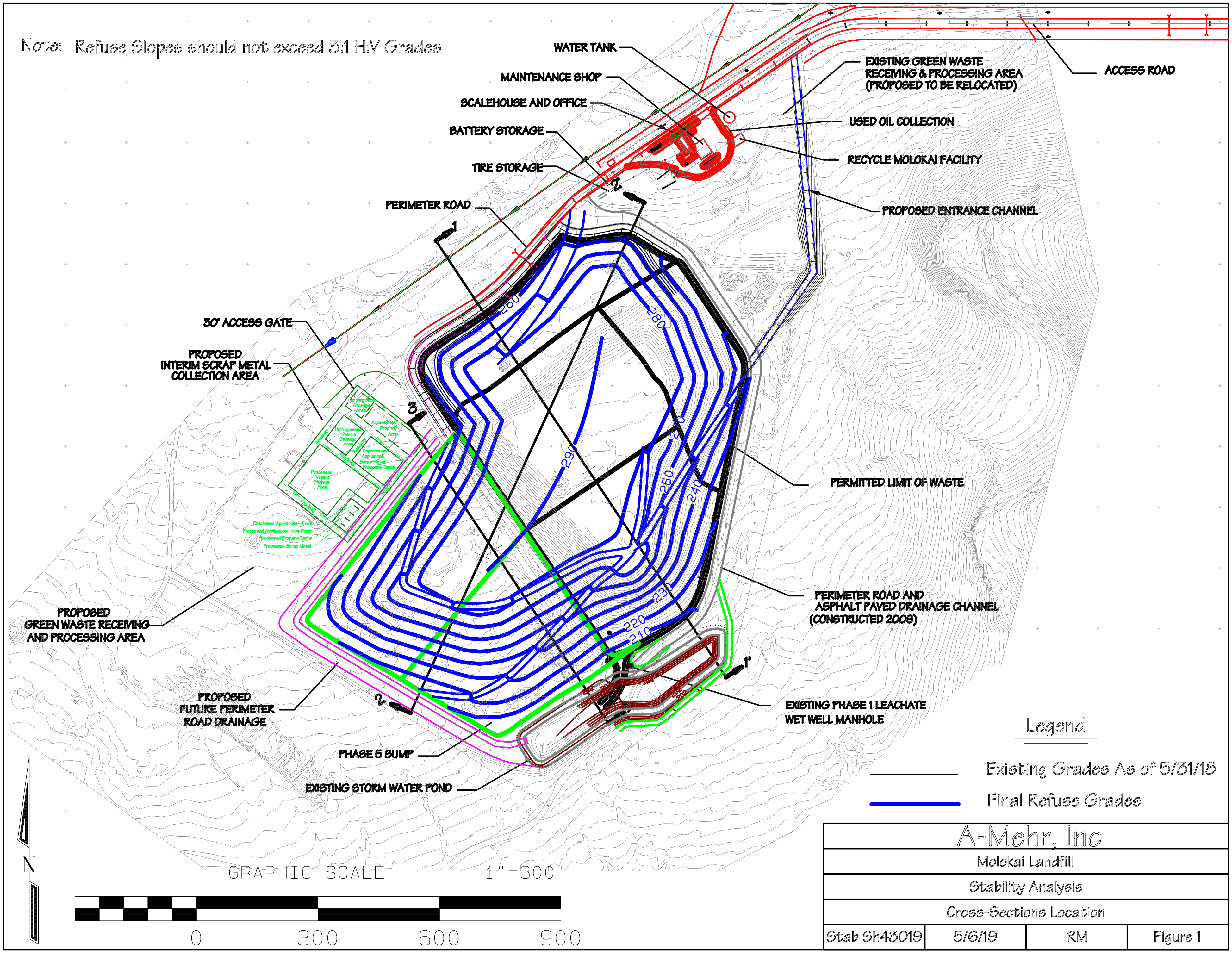
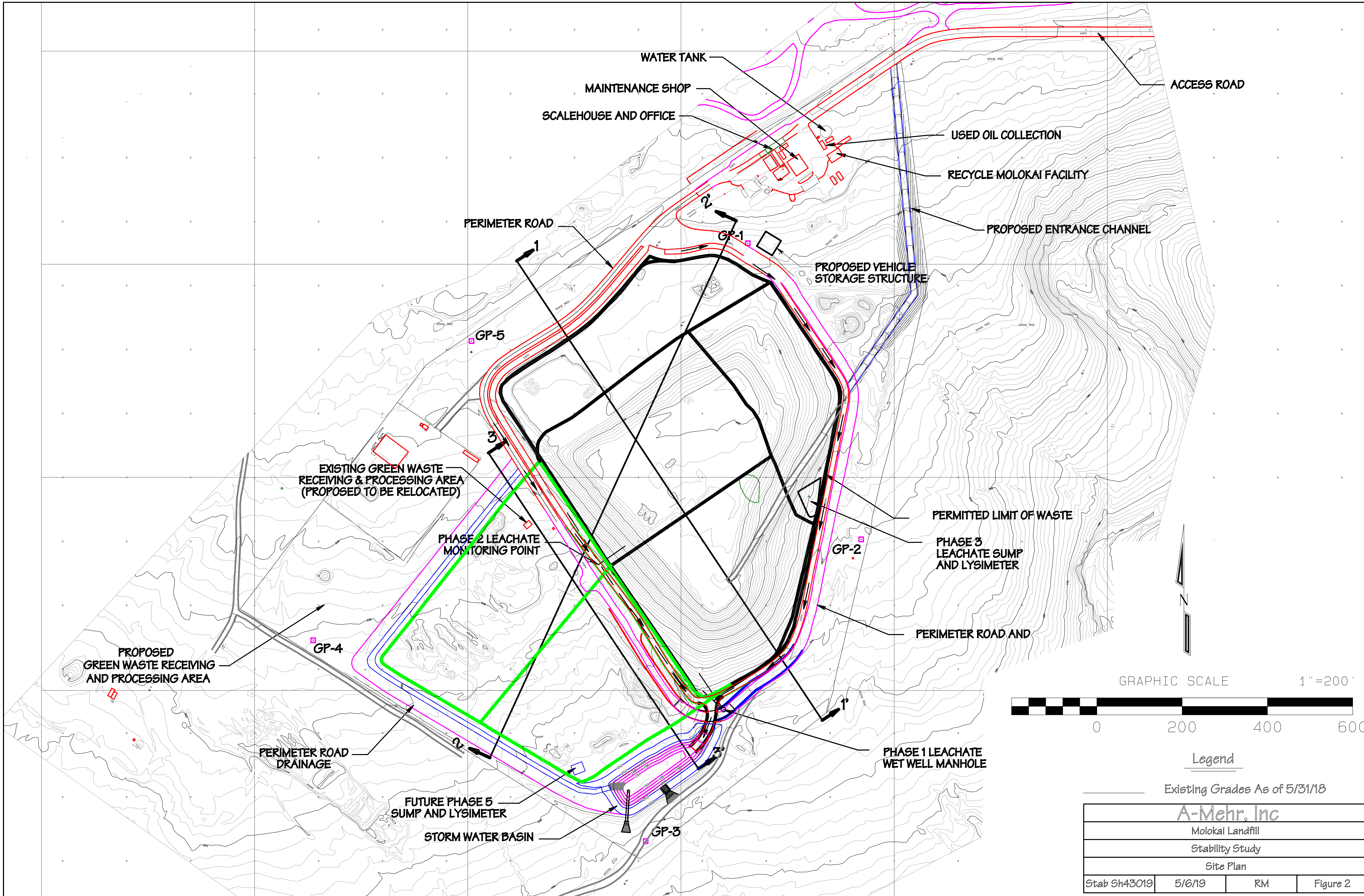
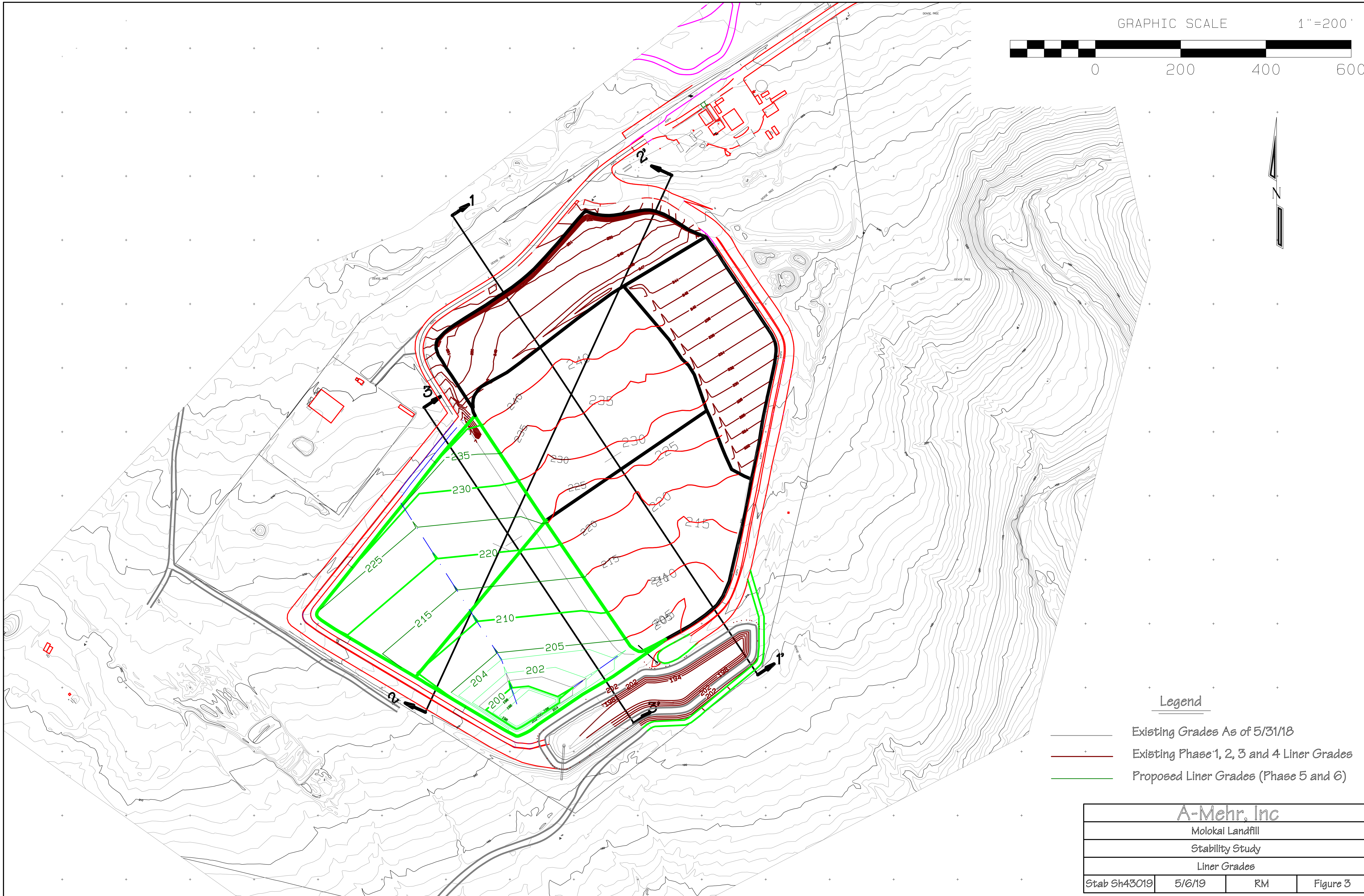
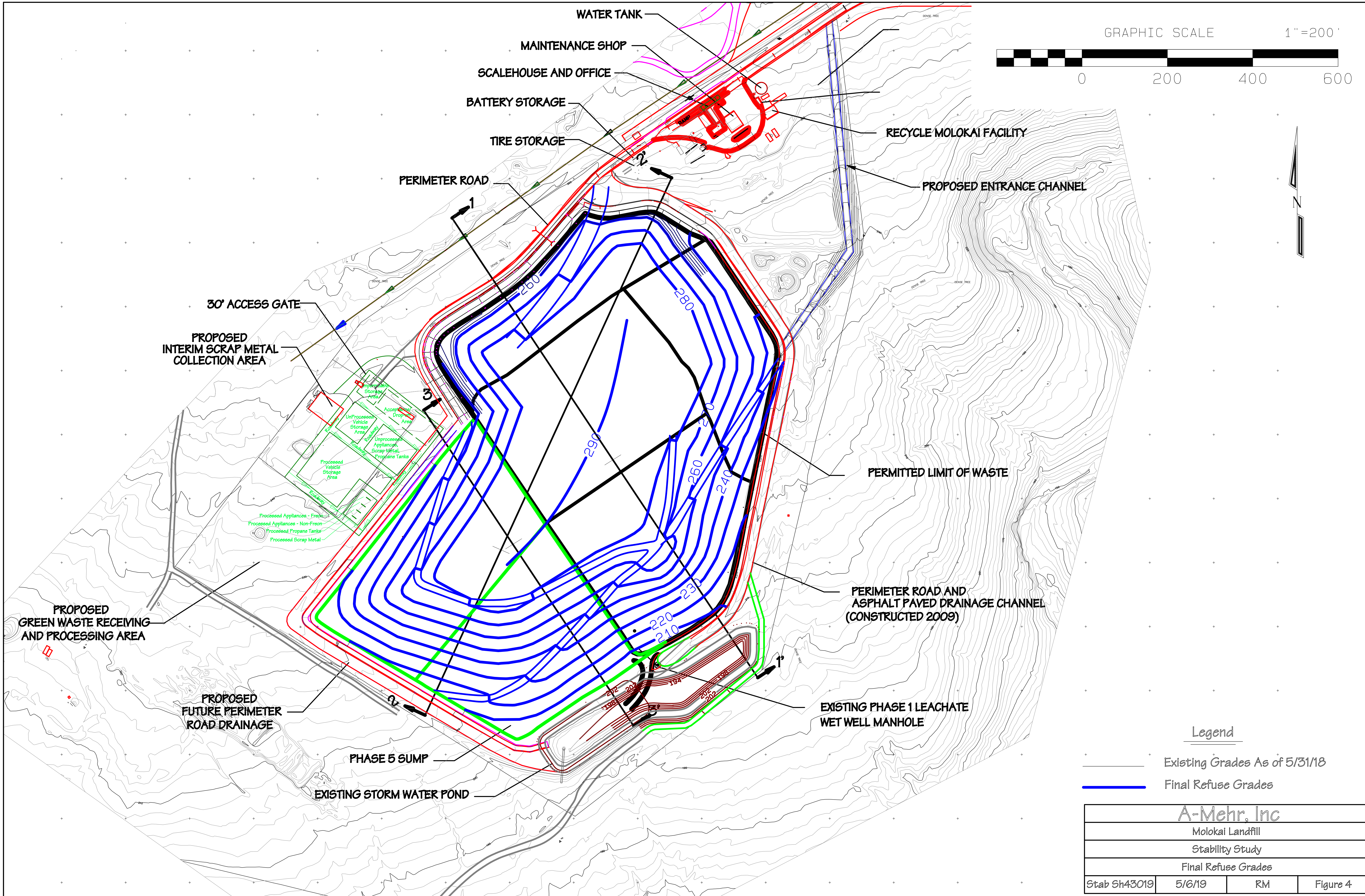
FIGURES


Note: Refuse Slopes should not exceed 3:1 H:V Grades
WATER TANK
MAINTENANCE SHOP
SCALEHOUSE AND OFFICE
BATTERY STORAGE
TIRE STORAGE
PERIMETER ROAD
EXISTING GREEN WASTE RECEIVING & PROCESSING AREA (PROPOSED TO BE RELOCATED)
ACCESS ROAD
USED OIL COLLECTION
RECYCLE MOLOKAI FACILITY
PROPOSED ENTRANCE CHANNEL
30' ACCESS GATE
PROPOSED INTERIM SCRAP METAL COLLECTION AREA
PERMITTED LIMIT OF WASTE
PERIMETER ROAD AND ASPHALT PAVED DRAINAGE CHANNEL (CONSTRUCTED 2009)
PROPOSED GREEN WASTE RECEIVING AND PROCESSING AREA
PROPOSED FUTURE PERIMETER ROAD DRAINAGE
EXISTING PHASE 1 LEACHATE WET WELL MANHOLE
PHASE 5 SUMP
EXISTING STORM WATER POND
1
1'
2
2'
3
210
220
230
240
250
260
280
290
Legend
Existing Grades As of 5/31/18
Final Refuse Grades
N
GRAPHIC SCALE 1"=300'
0
300
600
900
A-Mehr, Inc
Molokai Landfill
Stability Analysis
Cross-Sections Location
Stab Sh43019
5/6/19
RM
Figure 1

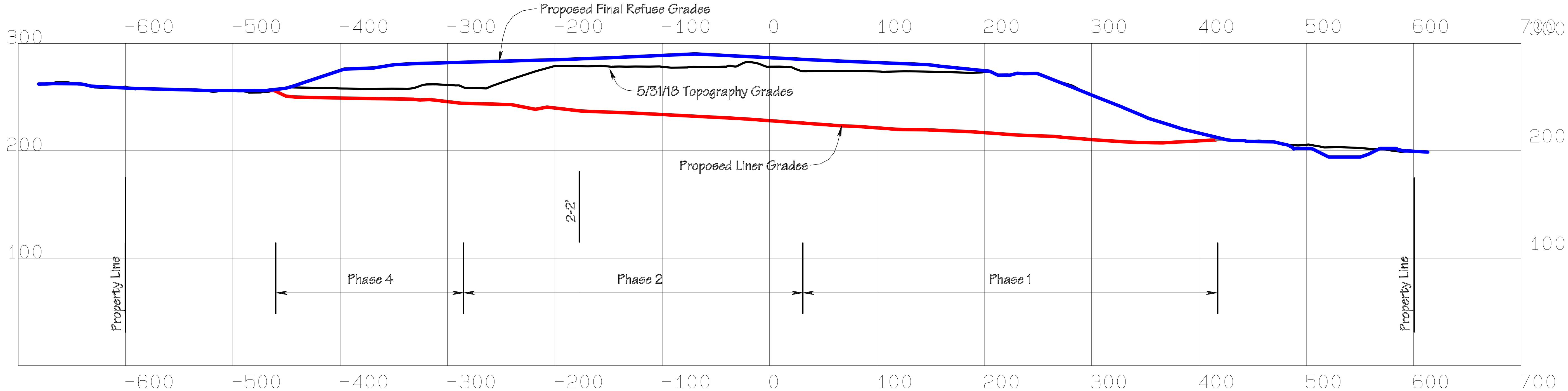

WATER TANK
MAINTENANCE SHOP
SCALEHOUSE AND OFFICE
ACCESS ROAD
USED OIL COLLECTION
RECYCLE MOLOKAI FACILITY
PROPOSED ENTRANCE CHANNEL
PERIMETER ROAD
PROPOSED VEHICLE STORAGE STRUCTURE
GP-1
GP-2
GP-3
GP-4
GP-5
EXISTING GREEN WASTE RECEIVING & PROCESSING AREA (PROPOSED TO BE RELOCATED)
PHASE 2 LEACHATE MONITORING POINT
PERMITTED LIMIT OF WASTE
PHASE 3 LEACHATE SUMP AND LYSIMETER
PERIMETER ROAD AND
PROPOSED GREEN WASTE RECEIVING AND PROCESSING AREA
PERIMETER ROAD DRAINAGE
FUTURE PHASE 5 SUMP AND LYSIMETER
STORM WATER BASIN
PHASE 1 LEACHATE WET WELL MANHOLE
N
GRAPHIC SCALE 1"=200'
0 200 400 600
Legend
Existing Grades As of 5/31/18
A-Mehr, Inc
Molokai Landfill
Stability Study
Site Plan
Stab Sh43019
5/6/19
RM
Figure 2



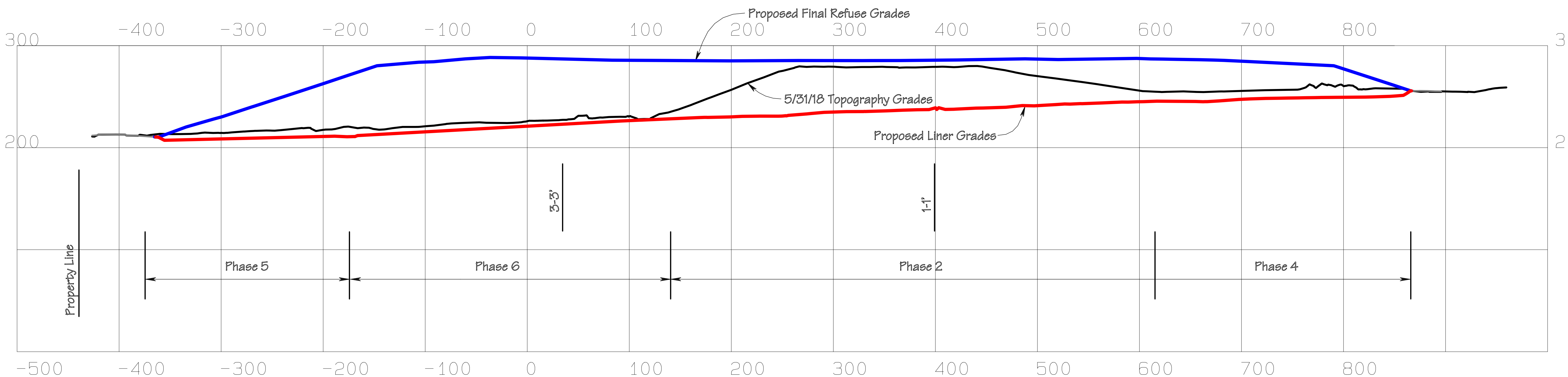
GRAPHIC SCALE 1"=200'
0
200
400
600
N
1
1'
2
2'
3
3'
245
240
235
230
225
220
215
210
205
202
204
200
Legend
Existing Grades As of 5/31/18
Existing Phase 1, 2, 3 and 4 Liner Grades
Proposed Liner Grades (Phase 5 and 6)
A-Mehr, Inc
Molokai Landfill
Stability Study
Liner Grades
Stab Sh43019
5/6/19
RM
Figure 3



WATER TANK
MAINTENANCE SHOP
SCALEHOUSE AND OFFICE
BATTERY STORAGE
TIRE STORAGE
PERIMETER ROAD
RECYCLE MOLOKAI FACILITY
PROPOSED ENTRANCE CHANNEL
30' ACCESS GATE
PROPOSED INTERIM SCRAP METAL COLLECTION AREA
PERMITTED LIMIT OF WASTE
PERIMETER ROAD AND ASPHALT PAVED DRAINAGE CHANNEL (CONSTRUCTED 2009)
PROPOSED GREEN WASTE RECEIVING AND PROCESSING AREA
PROPOSED FUTURE PERIMETER ROAD DRAINAGE
EXISTING PHASE 1 LEACHATE WET WELL MANHOLE
PHASE 5 SUMP
EXISTING STORM WATER POND
GRAPHIC SCALE 1"=200'
0 200 400 600
N
280
290
260
270
250
240
230
220
210
1
2
3
Legend
Existing Grades As of 5/31/18
Final Refuse Grades
A-Mehr, Inc
Molokai Landfill
Stability Study
Final Refuse Grades
Stab Sh43019
5/6/19
RM
Figure 4

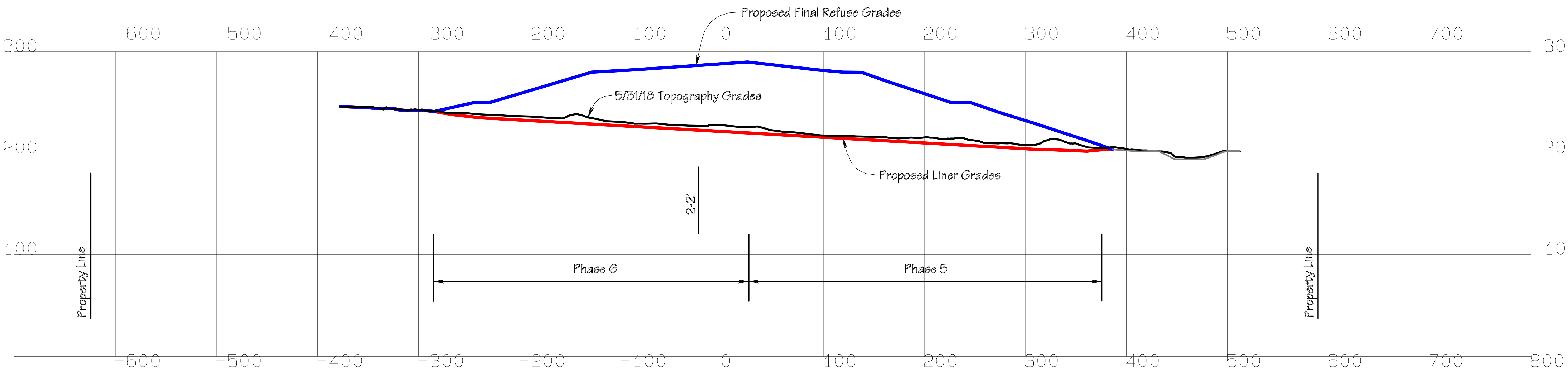


Cross-Section 1-1



Cross-Section 2-2

A-Mehr, Inc			
Molokai Landfill			
Stability Study			
Cross-Section 1-1' & 2-2'			
Stab Sh43019	5/6/19	RM	Figure 5



Cross-Section 3-3

A-Mehr, Inc			
Molokai Landfill			
Stability Study			
Cross-Section 3-3'			
Stab Sh43019	5/6/19	RM	Figure 6

APPENDIX A

SITE-SPECIFIC REFUSE MASS UNIT WEIGHT

MOLOKAI LANDFILL
SITE-SPECIFIC REFUSE MASS UNIT WEIGHT

Field Variables

AUF = Airspace Utilization Factor, pounds solid waste placed per cubic yard of landfill volume used (lb/cy)

Rs = Refuse:Soil Ratio, cubic yards of refuse placed per cubic yard of soil placed in the landfill

Ds = Density (unit weight) of soil, pounds/cubic foot (pcf)

Working Equations

Ww = pounds of waste per cubic foot of landfill volume used

Ww = AUF/27, pcf

Vs = volume fraction of soil in landfill refuse mass

Vs = (1/RS/[(1+RS)/RS] = 1/(1+RS) cf/cf

Ws = weight of soil per cubic foot of landfill refuse mass

Ws = Ds x Vs, pcf

Wr = total unit weight of waste and soil per cubic foot of landfill refuse mass

Wr = Ww + Ws

Therefore: **Wr = AUF/27 + Ds[1/(1+RS)]**

Data and Results

Data for AUF and SR is presented for three representative time periods in the Molokai Landfill Master Plan (A- Mehr, Inc., November 2009). The calculate refused mass unit weight (Wr) is calculated for each period as follows:

Period	AUF (lb/cy)	Rs	Ws (pcf)	Wr (pcf)
7/23/06 – 5/14/09	577	0.99:1	126	85
5/14/09 – 4/2/09	294	1.51:1	126	61
7/23/06 – 4/2/09	450	1.2:1	126	74

The calculated unit weight of 85 pcf for the combined three-year time period from July 2006 to May 2009 is a reasonable and conservative value for the site.

APPENDIX B

STABILITY ANALYSIS COMPUTER RESULTS

MOLOKAI INTEGRATED WASTE MANAGEMENT FACILITY
SLOPE STABILITY ANALYSIS RESULTS
PHASES 1-6 – MAY 2019

SCREENING ANALYSIS – MODIFIED BISHOP AND JANBU METHODS

REFUSE UNIT WEIGHT (PCF)	RUN NO.	CROSS-SECTION	STATIC ANALYSIS MINIMUM STATIC FACTOR OF SAFETY
			FS
85	Molf11-1cs	1-1’	3.53
85	Molf11-1	1-1’	>10
85	Molf11-2	1-1’	>10
85	Molf11-3s	1-1’	9.35
85	Molf11-4	1-1’	6.83
85	Molf11-5	1-1’	6.66
85	Molf11-6	1-1’	6.17
85	Molf11-7	1-1’	4.52
85	Molf11-8s	1-1’	3.11
85	Molf11-9	1-1’	5.54
85	Molf11r-1c	1’-1	2.39
85	Molf11r-1s	1’-1	8.95
85	Molf11r-2	1’-1	7.18
85	Molf11r-3	1’-1	6.68
85	Molf11r-4	1’-1	6.49
85	Molf11r-5s	1’-1	6.42
85	Molf11r-6s	1’-1	6.10
85	Molf11r-7s	1’-1	2.43
85	Molf11r-8s	1’-1	2.62
85	Molf11r-9	1’-1	2.81
85	Molf11r-10	1’-1	2.81
85	Molf22-1c	2-2’	2.17
85	Molf22-1	2-2’	8.48
85	Molf22-2	2-2’	7.97
85	Molf22-3	2-2’	7.62
85	Molf22-4s	2-2’	3.65
85	Molf22-5s	2-2’	2.16
85	Molf22-6s	2-2’	2.06
85	Molf22-7	2-2’	4.58
85	Molf22r-1c	2’-2	5.71
85	Molf22r-1	2’-2	>10
85	Molf22r-2	2’-2	>10
85	Molf22r-3	2’-2	>10
85	Molf22r-4s	2’-2	5.86
85	Molf22r-5s	2’-2	5.64
85	Molf22r-6s	2’-2	2.83
85	Molf22r-7	2’-2	6.23
85	Molf33-1c	3-3’	2.38
85	Molf33-1	3-3’	>10
85	Molf33-2	3-3’	>10
85	Molf33-3s	3-3’	2.71
85	Molf33-4	3-3’	3.42
85	Molf33r-1c	3’-3	1.95
85	Molf33r-1	3’-3	6.07
85	Molf33r-2s	3’-3	5.95
85	Molf33r-3s	3’-3	1.80
85	Molf33r-4s	3’-3	1.87
85	Molf33r-5s	3’-3	2.83

FINAL ANALYSIS – SPENCER'S METHOD OF SLICES

REFUSE UNIT WEIGHT (PCF)	RUN NO.	CROSS-SECTION	STATIC ANALYSIS	PSEUDO-STATIC ANALYSIS	
			MINIMUM STATIC FACTOR OF SAFETY	MINIMUM FACTOR OF SAFETY	YIELD ACCELERATION (G)
85	Molf11-1cs	1-1'	3.53	-	-
85	Molf11-1ce	1-1'	-	1.83	0.16
85	Molf11-1	1-1'	>10	-	-
85	Molf11-1e	1-1'	-	3.29	0.16
85	Molf11-2	1-1'	>10	-	-
85	Molf11-2e	1-1'	-	3.25	0.16
85	Molf11-3s	1-1'	9.35	-	-
85	Molf11-3e	1-1'	-	2.02	0.16
85	Molf11-4	1-1'	6.83	-	-
85	Molf11-4e	1-1'	-	2.77	0.16
85	Molf11-5	1-1'	6.66	-	-
85	Molf11-5e	1-1'	-	2.18	0.16
85	Molf11-6	1-1'	6.17	-	-
85	Molf11-6e	1-1'	-	1.90	0.16
85	Molf11-7	1-1'	4.52	-	-
85	Molf11-7e	1-1'	-	1.75	0.16
85	Molf11-8s	1-1'	3.11	-	-
85	Molf11-8e	1-1'	-	2.55	0.16
85	Molf11-9	1-1'	5.54	-	-
85	Molf11-9e	1-1'	-	3.60	0.16
85	Molf11r-1c	1'-1	2.39	-	-
85	Molf11r-1ce	1'-1	-	1.35	0.16
85	Molf11r-1s	1'-1	8.95	-	-
85	Molf11r-1e	1'-1	-	2.29	0.16
85	Molf11r-2	1'-1	7.18	-	-
85	Molf11r-2e	1'-1	-	2.22	0.16
85	Molf11r-3	1'-1	6.68	-	-
85	Molf11r-3e	1'-1	-	2.22	0.16
85	Molf11r-4	1'-1	6.49	-	-
85	Molf11r-4e	1'-1	-	2.30	0.16
85	Molf11r-5s	1'-1	6.42	-	-
85	Molf11r-5e	1'-1	-	2.18	0.16
85	Molf11r-6s	1'-1	6.10	-	-
85	Molf11r-6e	1'-1	-	2.15	0.16
85	Molf11r-7s	1'-1	2.43	-	-
85	Molf11r-7e	1'-1	-	1.40	0.16
85	Molf11r-8s	1'-1	2.62	-	-
85	Molf11r-8e	1'-1	-	1.91	0.16
85	Molf11r-9	1'-1	2.81	-	-
85	Molf11r-9e	1'-1	-	1.76	0.16
85	Molf11r-10	1'-1	2.81	-	-
85	Molf11r-10e	1'-1	-	1.76	0.16
85	Molf22-1c	2-2'	2.17	-	-
85	Molf22-1ce	2-2'	-	1.29	0.16
85	Molf22-1	2-2'	8.48	-	-
85	Molf22-1e	2-2'	-	1.71	0.16
85	Molf22-2	2-2'	7.97	-	-
85	Molf22-2e	2-2'	-	2.02	0.16
85	Molf22-3	2-2'	7.62	-	-
85	Molf22-3e	2-2'	-	2.15	0.16
85	Molf22-4s	2-2'	3.65	-	-
85	Molf22-4e	2-2'	-	1.41	0.16

85	Molf22-5s	2-2’	2.16	-	-
85	Molf22-5e	2-2’	-	1.37	0.16
85	Molf22-6s	2-2’	2.06	-	-
85	Molf22-6e	2-2’	-	1.34	0.16
85	Molf22-7	2-2’	4.58	-	-
85	Molf22-7e	2-2’	-	4.67	0.16
85	Molf22r-1c	2’-2	5.71	-	-
85	Molf22r-1ce	2-2’	-	1.95	0.16
85	Molf22r-1	2’-2	>10	-	-
85	Molf22r- 1e	2’-2	-	2.90	0.16
85	Molf22r-2	2’-2	>10	-	-
85	Molf22r-2e	2’-2	-	2.61	0.16
85	Molf22r-3	2’-2	>10	-	-
85	Molf22r-3e	2’-2	-	2.11	0.16
85	Molf22r-4s	2’-2	5.86	-	-
85	Molf22r-4e	2’-2	-	1.83	0.16
85	Molf22r-5s	2’-2	5.64	-	-
85	Molf22r-5e	2’-2	-	1.79	0.16
85	Molf22r-6s	2’-2	2.83	-	-
85	Molf22r-6e	2’-2	-	1.66	0.16
85	Molf22r-7	2’-2	6.23	-	-
85	Molf22r-7e	2’-2	-	4.12	0.16
85	Molf33-1c	3-3’	2.38	-	-
85	Molf33-1ce	3-3’	-	1.44	0.16
85	Molf33-1	3-3’	>10	-	-
85	Molf33-1e	3-3’	-	3.53	0.16
85	Molf33-2	3-3’	>10	-	-
85	Molf33-2e	3-3’	-	3.22	0.16
85	Molf33-3s	3-3’	2.71	-	-
85	Molf33-3e	3-3’	-	1.58	0.16
85	Molf33-4	3-3’	3.42	-	-
85	Molf33-4e	3-3’	-	2.08	0.16
85	Molf33r-1c	3’-3	1.95	-	-
85	Molf33r-1ce	3’-3	-	1.15	0.16
85	Molf33r-1	3’-3	6.07	-	-
85	Molf33r-1e	3’-3	-	1.56	0.16
85	Molf33r-2s	3’-3	5.95	-	-
85	Molf33r-2e	3’-3	-	1.54	0.16
85	Molf33r-3s	3’-3	1.80	-	-
85	Molf33r-3e	3’-3	-	1.06	0.16
85	Molf33r-4s	3’-3	1.87	-	-
85	Molf33r-4e	3’-3	-	1.10	0.16
85	Molf33r-5s	3’-3	2.83	-	-
85	Molf33r-5e	3’-3	-	1.57	0.16