2 OF 3

APPENDICES FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT NEW KAUAʻI LANDFILL

MAʻALO, KAUAʻI, HAWAIʻI

County of Kauaʻi
Department of Public Works
Solid Waste Division
4444 Rice Street, Room 275
Līhuʻe, Kauaʻi, Hawaiʻi

July 2018

APPENDICES

Appendix D Conceptual Design Report Municipal Solid Waste Landfill and Resource Recovery Park at Ma‘alo, Kaua‘i, Hawai‘i (AECOM 2017)

Appendix E Acoustic Study for the Municpal Solid Waste Landfill, Ma‘alo, Kaua‘i, Hawai‘i (Y. Ebisu & Associates 2018)

Appendix F New Kaua‘i Landfill Traffic and Roadways Engineering Feasibility Study (AECOM 2016)

Appendix G Wildlife Hazard Assessment (SWCA 2016)

Appendix D
Conceptual Design Report
Municipal Solid Waste Landfill
and Resource Recovery Park
at Ma‘alo, Kaua‘i, Hawai‘i
(AECOM 2017)

CONCEPTUAL DESIGN REPORT MUNICIPAL SOLID WASTE LANDFILL AND RESOURCE RECOVERY PARK AT MAʻALO KAUAʻI, HAWAIʻI

County of Kauaʻi
Department of Public Works
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August 2017

CONCEPTUAL DESIGN REPORT MUNICIPAL SOLID WASTE LANDFILL AND RESOURCE RECOVERY PARK AT MAʻALO KAUAʻI, HAWAIʻI

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August 2017

EXECUTIVE SUMMARY

With the island’s only permitted landfill facility expected to reach capacity and require closure in the coming years, the County of Kaua‘i (County) proposes to develop a new municipal solid waste landfill (MSWLF) at the Ma‘alo site near Hanamā‘ulu in order to comply with its mandate to provide for safe disposal of the island’s municipal solid waste. In line with its waste diversion goals, the County also proposes to develop a Resource Recovery Park (RRP) at or near the new MSWLF to assist in maximizing diversion of material from the landfill.

The County is currently conducting an Environmental Impact Statement (EIS) for its proposal to site, permit, construct, and operate a new MSWLF at Ma‘alo. To complement the EIS process, this *Conceptual Design Report* presents two alternative conceptual designs for the proposed MSWLF and RRP facilities, evaluates the technical feasibility of the proposed facilities, evaluates potential design alternatives (where applicable), and helps identify potential environmental impacts of the facilities.

PROJECT AND SITE BACKGROUND

After it became clear by early 2000 that the Kekaha MSWLF was approaching the end of its useful life, several siting studies were undertaken to identify a solution for the County’s waste disposal needs. The most recent of these studies (AECOM 2012) evaluated such factors as site life, costs, landowner willingness, sustainability, agricultural value, and the results of a Community Criteria Evaluation and identified the Ma‘alo site as the preferred and longest-term solution. The County initiated the EIS process to develop and operate a new landfill and RRP at Ma‘alo with publication of a public notice in February 2013. Upon completion of the public review process and approval of the EIS, the land would need to be acquired or land use rights secured, and detailed site investigation, engineering design, permitting, and other approvals obtained and completed before construction could begin.

The proposed MSWLF site at Ma‘alo is located approximately 4 miles north of Līhu‘e, east of Ma‘alo Road, mauka (west) of and across Kālepa Ridge from Kūhiō Highway, and more than 1 mile inland from the Pacific Ocean. Although bounded by mountains and ridges, site topography is relatively flat, and the site is presently used as pasture. The 270-acre Ma‘alo parcel is owned by the State of Hawai‘i. The proposed RRP is under consideration for development either at the proposed MSWLF site or at a nearby 80-acre parcel owned by Grove Farms, Inc. located approximately one-half mile west of the Ma‘alo parcel; it is currently used for agriculture.

LANDFILL DESIGN FEATURES

Two alternative conceptual designs are presented in this report:

- Alternative 1 sites the MSWLF on the Ma‘alo parcel and the RRP on the separate nearby parcel.
- Alternative 2 sites the MSWLF and the RRP together on the Ma‘alo parcel.

Basic landfill components incorporated in this design as stipulated in Federal and State regulations include an impermeable base liner to impede landfill leachate from impacting the groundwater aquifer beneath the landfill, development of the landfill in sequential phases, daily soil cover and final cover when the landfill reaches final capacity, estimation of landfill capacity, and determination of soil balance. Other components in this design include geotechnical design, landfill gas extraction system, leachate management system, surface water management system, building infrastructure, access roads and utilities, and permitting, monitoring, and oversight.

ALTERNATIVE 1 CONCEPTUAL DESIGN

Proposed Landfill

Base Liner: The design includes a nine-layer base liner system consisting of (from bottom to top): (1) prepared compacted-soil subbase grade covered with a 6-inch granular foundation lift; (2) secondary geosynthetic clay liner (GCL); (3) secondary 60-mil high-density polyethylene (HDPE) geomembrane; (4) primary GCL; (5) primary 60-mil HDPE geomembrane; (6) nonwoven cushion geotextile; (7) 12-inch granular drainage layer; (8) nonwoven separator geotextile; and (9) 24-inch operations layer (to protect the liner from penetrations).

Landfill Phasing: The proposed MSWLF would be constructed in five phases, with Phases 1–4 physically defined by their base liner systems' lateral limits, and Phase 5 a vertical phase that directly overlays the completed Phases 1–4. The phasing would be further subdivided into cells, which could be constructed on an as-needed basis. The total footprint of the Alternative 1 proposed MSWLF limit of waste (LOW) is 170.7 acres. Subbase liner elevations would be a minimum of 10 ft above groundwater elevations, and subbase sideslopes would have a maximum slope gradient of 3 horizontal (H) to 1 vertical (V).

Final Cover: The proposed final cover system would consist of (top-to-bottom): (1) 18-inch topsoil/root zone soil layer, (2) geocomposite drainage layer; (3) 40-mil linear low-density polyethylene liner (double-sided textured); (4) GCL; and (5) 12-inch intermediate cover over the top of waste.

Landfill Capacity: Projected total capacity for the five phases is 33.4 million cubic yards of waste mass volume, for an expected site life of 265 years (at the current rate of landfilling).

Soil Balance: Granular material for the drainage and operations layers does not appear to be available on site and would be obtained from offsite sources. Significant quantities of cover soil could need to be identified in later years of site operations.

Geotechnical Design: Preliminary geotechnical investigation indicates that the project site is suitable for construction of the proposed landfill. Excavated site soils would likely be suitable for use as daily/intermediate cover, topsoil, a rooting-zone layer, and sideslope diversion berms and may also be suitable for use as a low-permeability compacted soil layer. Top slopes are designed to be sloped at 5% (20:1 H:V); sideslopes of both final and intermediate covers (e.g., for each phase) are designed to be sloped at a ratio of 3.5:1 (H:V). The final cover system, waste mass, and base liner system of the proposed Ma'alo MSWLF are expected to remain stable under a seismic event of 0.10g. Based on in situ soil material properties at the site, including the lack of sandy soil, liquefaction is not expected.

Gas Extraction System: The gas extraction system would include extraction wells, extraction piping, and a control device. The design includes vertical landfill gas (LFG) wells and open flares, installation of well boreholes no closer than 10 ft to the liner material, use of corrosion-resistant materials such as polyvinyl chloride (PVC) or HDPE and extraction well connector assemblies, allowance for expandability and accessibility, and sufficient flexibility and modulus of elasticity of the header pipe material. The control systems are not being selected at this time because the County's need and the system sizing requirements may change over time.

Leachate Management System: The design calls for leachate to be removed passively by gravity-fed leachate collection and transmission pipes located in the granular drainage layer. Phase 1 would be divided into seven areas with one leachate collection and transmission pipe each, with a minimum 2.0% slope toward the perimeter. At the perimeter, the perforated leachate collection pipe would transition to a non-perforated pipe that drains to a dual-contained leachate transfer pipe located within the perimeter berm. The dual-contained leachate transfer pipe would gravity-drain to a wet

well located near the southwest corner of Phase 1. The leachate would then be pumped through a force main to a proposed leachate evaporation pond.

MSWLF Surface Water Management System: Run-on to the property would be routed around the landfill facilities by channels, culverts, and berms and discharge from the site at locations similar to pre-development flows. Surface water flow on the landfill itself would be controlled using diversion berms located on the landfill sideslopes approximately 10–30 ft below the perimeter of the Phase 1 landfill top deck that would direct surface water to rock-lined downslope channels; each downslope channel would have a trapezoidal cross-section and convey water to a surface water basin via a perimeter channel or a culvert in some locations. The proposed system was designed and analyzed to confirm capability of handling design flow rates and ensure that Phase 1 post-development peak flow rates to offsite areas during design storms would not exceed pre-development peak flow rates. The Phase 1 surface water basin would accommodate surface water runoff from the landfill for both the 100-year 1-hour, 25-year 24-hour, and 100-year 24-hour storm events and would discharge all collected water within 48 hours after the conclusion of a storm event.

Initial Site Development Activities: Initial development of the proposed MSWLF includes Cell 1.1 (i.e., the first portion of Phase 1), leachate evaporation pond, surface water management system, shop, scale house, drop-off area, parking lots, and internal roadways. Construction activities required prior to beginning landfilling operations at the site include construction of temporary erosion control, dust control, and best management practices; construction of offsite access roads and utility lines; site clearing and grubbing; construction of onsite access roads; excavation and mass-grading; subgrade preparation; installation of the Cell 1.1 landfill liner; installation of the leachate management system; construction of the leachate evaporation pond; construction of the surface water management system, including the infiltration basin; and construction of the septic system, office building, shop, scale and scale house, and public drop-off facility.

Alternative 1 Proposed Resource Recovery Park

RRP Facilities: The design includes the following key elements recommended in the RRP *Feasibility Study* (FS) (AECOM 2013; EIS Appendix C) and provides the basis of design for their capacities and sizing: integrated public drop-off and reuse facility, materials recovery facility (MRF), composting facility, and LFG-to-energy facility (reserved area for potential future implementation). The design may be implemented in phases and modified in the future. Because the Alternative 1 RRP site is much larger than the Alternative 2 RRP site, it offers more flexibility for the County to change facilities and processes in response to changing conditions over time.

RRP Surface Water Management System: Stormwater run-on and runoff at the site would be managed through a network of channels, culverts, and basins. Two open-air surface water management basins are designed to accommodate surface runoff for 100-year 1-hour, 25-year 24-hour, and 100-year 24-hour storm events and to discharge all surface water within 48 hours after a storm event.

Alternative 1 Access Roads and Utilities

The proposed access route connects the proposed MSWLF site to the public road network and Kūhiō Highway near Kaua’i Beach Drive via existing cane haul roads. One of two driveways would connect the MSWLF site to the Alternative 1 RRP site (AECOM 2016; EIS Appendix E). Recommended improvements to render the existing roads capable of sustaining 20-ton multi-axle vehicles include widening and paving roads, establishing utility corridors, and providing drainage improvements. Electricity and telephone service would be connected at the intersection of Laulima Street and Kūhiō Highway. A 12-inch waterline would be connected to the County water system at the intersection of Laulima Street and Kūhiō Highway. Wastewater from both the Alternative 1 MSWLF and the RRP sites would be managed on each site with installation of an individual wastewater system septic tank and absorption bed.

ALTERNATIVE 2 CONCEPTUAL DESIGN

Alternative 2 sites the RRP on the Ma‘alo MSWLF parcel. The landfill’s slightly smaller footprint (160.5 acres) than that for Alternative 1 results in a slight decrease in anticipated capacity (29,893,000 cy, or 237 years; a decrease of 28 years or 10.6% compared to Alternative 1). Base liner, landfill phasing, soil balance, gas extraction and leachate management systems, and building infrastructure design elements are nearly identical to those for Alternative 1. Increased capacity would be provided in the surface water management system with additional and larger basins than those for the Alternative 1 MSWLF site to account for increased stormwater runoff due to the addition of the RRP facilities to the site. Initial site development activities include the same tasks identified for Alternative 1 along with whichever RRP facilities are initially implemented. The proposed RRP facilities are the same as for Alternative 1 except that insufficient space may be available for a potential future waste to energy plant. Consolidation of the RRP and MSWLF sites under Alternative 2 would result in increased infrastructure efficiencies and potential operational savings, but provides less space and capacity to respond to potential future resource recovery needs.

DESIGN ALTERNATIVES

The design evaluates multiple alternatives for base liners, gas extraction control systems, leachate management systems, surface water retention basins, and wastewater; the recommended alternative for each component is incorporated into the conceptual design. The design also incorporates the results of alternatives analyses conducted for access roads presented in the *Traffic and Roadways Engineering Feasibility Study* (AECOM 2016; EIS Appendix E) and for RRP components presented in the RRP FS (AECOM 2013; EIS Appendix C).

ENVIRONMENTAL PERMITS, CONSULTATIONS, APPROVALS, AND MONITORING

The design identifies landfill and RRP requirements including permits and regulatory approvals, and outlines monitoring, inspection, and sampling programs, including LFG, groundwater, and leachate monitoring.

The proposed MSWLF would be subject to the design, operational, financial, and other requirements set forth in RCRA Subtitle D and in the Hawai‘i Administrative Rules Chapter 11-58.1. Prior to development of the MSWLF, a Solid Waste Management Permit Application would require preparation and submittal to the State of Hawai‘i Department of Health (DOH) Solid & Hazardous Waste Branch for review and approval. The landfill owner and operator would conduct all required monitoring and reporting before, during, and after the useful life of the facility, in accordance with the solid waste management permit, subject to oversight by DOH.

The parcels containing the proposed access route are zoned as Residential and Industrial; estimated time for rezoning and requisite right-of-way acquisitions is 12 months. Estimated time for approval of a National Pollutant Discharge Elimination System (NPDES) Form C permit from the State DOH for access road and related construction is 6 months. One of the two potential driveways connecting the MSWLF and RRP sites under Alternative 1 crosses a wetlands area that would likely be impacted if that route is developed. This would require a Clean Water Act Section 404 permit from the U.S. Army Corps of Engineers, and the process could require mitigation measures that are expected to take approximately 1 year to negotiate.

COST ESTIMATES

Detailed cost estimates are provided for developing Phase 1A of the MSWLF and the proposed RRP under both alternatives. Estimated construction costs are summarized in Table ES-1.

Table ES-1: Summary of Estimated Initial Construction Costs for Proposed MSWLF Phase 1A and RRP

Alternative	MSWLF	RRP	Access Roads and Utilities [a]	Total
1	$41,372,000	$30,512,000	$18,738,000 to $19,793,000	$90,622,000 to $91,677,000
2	$40,951,000	$26,480,000	$11,692,000	$79,123,000

Note: Estimated costs exclude contingency or discount rates.

[a] Access roads and utilities costs are from the *Traffic and Roadways Engineering Feasibility Study* (AECOM 2016; EIS Appendix E): Project Access Route E3 (Kaua'i Beach Drive), and for Alternative 1 include costs for developing one of two driveways connecting the MSWLF and RRP sites.

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ACRONYMS AND ABBREVIATIONS

§	Section
°	degree
ADA	American Disabilities Act
bgs	below ground surface
BMP	best management practice
C&D	construction and demolition
CAB	Clean Air Branch, State of Hawai‘i Department of Health
CFR	Code of Federal Regulations
CHARM	center-for-hard-recycle materials
CM	construction management
cm/sec	centimeters per second
County	County of Kaua‘i
CQA	construction quality assurance
CWA	Clean Water Act
CWB	Clean Water Branch, State of Hawai‘i Department of Health
cy	cubic yard
DLNR	Department of Land and Natural Resources, State of Hawai‘i
DOH	Department of Health, State of Hawai‘i
DOT	Department of Transportation, State of Hawai‘i
DPW	Department of Public Works, County of Kaua‘i
EA/EISPN	environmental assessment/environmental impact study public notice
EIS	environmental impact statement
EPA	Environmental Protection Agency, United States
FS	feasibility study
ft	foot/feet
ft^2	square foot
g	gravitational pull
GCL	geosynthetic clay liner
gpd	gallons per day
H	horizontal
HAR	Hawai‘i Administrative Rules
HDPE	high-density polyethylene
HELP	Hydraulic Evaluation of Landfill Performance
HHW	household hazardous waste
HRS	Hawai‘i Revised Statutes
ISWMP	Integrated Solid Waste Management Plan
kPa	kilopascal
LandGEM	Landfill Gas Emissions Model
LFG	landfill gas
LOW	limit of waste
MACT	Maximum Achievable Control Technology
MACLS	Mayor’s Advisory Committee on Landfill Site Selection
MFA	Masa Fujioka & Associates
MSWLF	municipal solid waste landfill
Mg	megagram
Mg/yr	megagrams per year
MRF	materials recovery facility
msl	mean sea level
MSW	municipal solid waste
MSWLF	municipal solid waste landfill

NESHAPS	National Emissions Standards for Hazardous Air Pollutants
NMOC	nonmethane organic compound
NPDES	National Pollutant Discharge Elimination System
NSPS	New Source Performance Standards
NWI	National Wetlands Inventory
O&M	operations and maintenance
OCC	old corrugated containers
PET	polyethylene terephthalate
PGA	peak ground acceleration
psf	pounds per square foot
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
ROW	right-of way
RRP	resource recovery park
SCS	Soil Conservation Service
SHPD	State Historic Preservation Division, State of Hawai‘i Department of Land and Natural Resources
SHWB	Solid & Hazardous Waste Branch, State of Hawai‘i Department of Health
SLUDBA	State Land Use District Boundary Amendment
TMK	Tax Map Key
TPY	tons per year
TREFS	traffic and roadways engineering feasibility study
UIC	Underground Injection Control
USACE	United States Army Corps of Engineers
V	vertical
WWTP	wastewater treatment plant
ZOI	zone of influence

1.0 INTRODUCTION AND PURPOSE

The County of Kaua‘i (County) currently operates the Kekaha Municipal Solid Waste Landfill (MSWLF) for disposal of the island's municipal solid waste (MSW). The Kekaha MSWLF, which is the only permitted landfill facility on the island of Kaua‘i, is expected to reach capacity in the coming years. To continue to fulfill the County's mandate to provide for the safe disposal of the island's MSW, a new MSWLF must be operational by the time the Kekaha MSWLF is closed.

The County is currently conducting an Environmental Impact Statement (EIS) for its proposal to site, permit, construct, and operate a new MSWLF. As a result of previous studies that culminated in the 2012 *Siting Study Report* (AECOM 2012), the new MSWLF is proposed to be located at the Ma‘alo site near Hanamā‘ulu, pending completion of the EIS. The County also proposes to develop a Resource Recovery Park (RRP) to assist in maximizing diversion of material from the landfill. To complement the EIS process, this *Conceptual Design Report* has been prepared to present two alternative conceptual designs of the proposed Ma‘alo MSWLF and RRP facilities, evaluate the technical feasibility of the proposed facilities, evaluate potential design alternatives (where applicable), and help identify and quantify potential environmental impacts of the facilities. Because the proposed site is large, the MSWLF would be constructed incrementally, in phases and one cell at a time. Similarly, the RRP may be implemented over time, such that all capital investments for both facilities need not be made at one time. This report describes the alternative landfill and RRP designs, and also details the initial designs for the initial phases of landfill operations. The Phase 1 landfill designs present the engineering design details that would eventually be applied to the entire MSWLF.

This *Conceptual Design Report* is structured as follows:

1. **Introduction and Purpose**
2. **Project and Site Background:** background on the selection of the proposed site, the Ma‘alo site's physical and socio-cultural characteristics, and the RRP concept.
3. **Landfill Design Features:** introduction of key landfill components evaluated in subsequent sections of the report.
4. **Proposed Alternative 1 MSWLF and RRP Conceptual Design:** overall landfill designs for constructing the proposed Alternative 1 MSWLF, including geotechnical design, gas extraction system, leachate management system, surface water management design, and other required features; and the various potential RRP facilities at the Alternative 1 site (on a parcel near but separate from the MSWLF site).
5. **Proposed Alternative 2 MSWLF and RRP Conceptual Design:** overall landfill designs for constructing the proposed Alternative 2 MSWLF, including geotechnical design, gas extraction system, leachate management system, surface water management design, and other required features; and the various potential RRP facilities at the Alternative 2 site (on the same parcel as the MSWLF site).
6. **Design Alternatives:** potential alternatives for various design components, for consideration in the EIS.
7. **Environmental Permits, Consultations, Approvals, and Monitoring:** Federal, State, and County requirements and monitoring activities.
8. **Cost Estimates:** planning-level cost estimates for the various landfill and RRP components for Alternative 1 and Alternative 2.
9. **References:** bibliographic details for publications cited in the report.

2.0 PROJECT AND SITE BACKGROUND

The following subsections include a summary of the new landfill siting process conducted since the year 2000 (Section 2.1), the RRP concept (Section 2.2), and the physical and other characteristics of the proposed Ma‘alo site (Section 2.3).

2.1 NEW LANDFILL SITING PROCESS

The search for a new County MSWLF was initiated when it became clear by early 2000 that the Kekaha MSWLF was approaching the end of its useful life. Several studies were completed including 2001/2002 siting studies, a 2007–2009 Mayor’s advisory committee study, and the most recent July 2012 siting study.

- The initial 2001/2002 siting studies (Earth Tech 2001, 2002) used a geographic information system to aid in applying several exclusionary criteria (State landfill siting rules and environmental, technical, and social/cultural criteria) to identify recommended locations for a new MSWLF on the island of Kaua‘i. Eight sites located throughout Kaua‘i were identified as having suitable characteristics, and each was scored for its ability to meet each criterion.
- In 2007, Mayor Bryan Baptiste convened the County of Kaua‘i Mayor’s Advisory Committee on Landfill Site Selection (MACLS) as a citizens’ advisory committee tasked with developing community-based criteria to aid in selecting a new MSWLF site for Kaua‘i. In its report published in 2009, the committee expanded the list of criteria used in the 2001/2002 siting studies to 26 community criteria, and weighted each criterion according to perceived importance (R. M. Towill 2009). Also in 2009, consultant R. W. Beck updated the County of Kaua‘i *Integrated Solid Waste Management Plan* (ISWMP), which identified general processes for developing a MSWLF siting strategy (Beck 2009).
- The County hired consultant AECOM Technical Services, Inc. (formerly doing business as Earth Tech, Inc.) in 2011 to conduct an updated siting study aligned with the 2009 ISWMP strategy. In the study, the primary factors used in identifying an optimal landfill site included the results of a Community Criteria Evaluation (based on a refinement of the MACLS criteria), site life, costs, landowner willingness, sustainability, and agricultural value, among others. Of the eight sites evaluated, all of which were confirmed to be technically feasible, the *New Kaua‘i Landfill Siting Study Report* (AECOM 2012) identified the Ma‘alo site as the preferred and longest-term solution for the County’s waste disposal problem.

With the proposed site identified at Ma‘alo, the next major step involves conducting a detailed EIS in accordance with Hawai‘i Revised Statutes (HRS) Chapter 343. In preparation for the EIS, an Environmental Assessment/Environmental Impact Study Public Notice (EA/EISPN) was published on February 8, 2013 (AECOM and R. M. Towill 2013) to inform interested parties of the project, outline categories of potential environmental impacts of the proposed Project, and seek public comment on subjects that should be addressed in the EIS. To support the EIS, site-specific analyses and designs, including this *Conceptual Design Report*, are being performed.

Once the public review process is complete and the EIS is approved, the land would need to be acquired or land use rights secured, and detailed site investigation, engineering design, permitting, and other approvals obtained and completed before construction could begin. That process could take an additional 8 years after completion of the EIS.

2.2 RESOURCE RECOVERY PARK CONCEPT

In 2009, the County published its ISWMP, which identified and recommended a range of programs, activities, and facilities to be implemented in order to maximize waste diversion. The ISWMP projected a diversion rate of 35% by 2013, a goal adopted by the County in 2009–2010. A longer-term and higher waste diversion goal of 70% by 2023 has since been adopted by the County. Currently, the County estimates its diversion rate is approximately 31%.

To achieve greater waste diversion, the County has identified the concept of co-locating a range of resource recovery facilities at a convenient and central location on the island. For economy of cost and integration of operations, the RRP is proposed to be located either within the 270-acre MSWLF parcel (“Alternative 2 proposed RRP site”) or at a nearby 83-acre parcel (the “Alternative 1 proposed RRP site”); see Figure 1. The RRP is also being analyzed during the environmental review (EIS) process.

A RRP is a facility where:

- Larger quantities of wastes that are managed by curbside collection can be received and processed for reuse, recycling, or recovery.
- Wastes that are not collected curbside can be received directly from residents or businesses to provide an outlet for the public to dispose of large-volume or bulky non-hazardous waste materials, and small-volume difficult-to-manage or household hazardous waste (HHW) materials.
- Alternatives are provided to support the reuse and recovery of a broader range of valuable materials.
- Facilities and services are made available to commercial establishments or private waste haulers that collect their waste with the means to achieve their own diversion goals or meet current or future County policies/regulations such as disposal bans. These County-provided facilities are generally intended to supplement and complement, not compete with, existing private-sector facilities.

The proposed RRP is intended to be a comprehensive and integrated set of waste management programs and facilities that support maximization of waste reuse, recycling, and recovery. A Feasibility Study (FS) was conducted to analyze and recommend potential facilities that could be included in the RRP (AECOM 2013; EIS Appendix C). It is anticipated that the RRP would offer a number of additional benefits to the County, possibly including energy production and job creation. The success of the proposed RRP would ultimately be measured by the quantity of waste that is efficiently diverted from disposal, extending the life of the municipal landfill site.

2.3 MA‘ALO SITE SETTING

The proposed MSWLF and RRP site(s) are located approximately 4 miles north of Līhu‘e, east of Ma‘alo Road, mauka (west) of and across Kālepa Ridge from Kūhiō Highway, and more than 1 mile inland from the Pacific Ocean (Figure 1).

2.3.1 Natural Environment

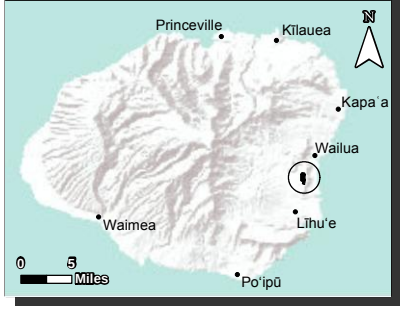
The following sections summarize the natural environment of the site; each aspect will be covered in more detail in the forthcoming EIS.

2.3.1.1 CLIMATE AND RAINFALL

The climate in the project area is characterized as semitropical and is influenced by Hawai‘i’s geographic location within the tropics, southwest of the Pacific High or anticyclone region. The principle features of the climate are equable daily and seasonal temperatures, predominant northeasterly trade winds, and a marked variation in rainfall, from the wet to the dry season and from place to place. The average annual temperature recorded at the Līhu‘e International Airport, the nearest National Weather Service weather station to the proposed site, ranges from 71.3 degrees (°) Fahrenheit during the coolest month to 79.1° Fahrenheit during the warmest month. Average annual rainfall in the Ma‘alo area is 60–80 inches per year (Izuka and Gingerich 1998; Giambelluca et al. 1986); most rainfall occurs during the winter months. On average, three-fourths of this total falls during the 7-month wet season (October–April); the dry season occurs during May–September.

S:\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\09_GIS\02_Maps\12_CDR MSWLF and RRP\01_MXD\Figure 1 - Site Location Map_rev3.mxd 8/28/2017

LOCATION MAP



LEGEND

- Access Road
- Driveway Alternative
- Street/Road

NOTES

1. Base Map: Google Earth 2013
2. Map Projection: State Plane Zone 4 Feet

N

0 1,500 3,000 Feet

Figure 1
Site Location Map
Conceptual Design Report
MSWLF and RRP at Ma'alo
Ma'alo, Kaua'i, Hawai'i

Winds at the Līhu‘e Airport are predominantly from the northeast at speeds of 10–13 knots. Relative humidity, moderate to high in all seasons, is slightly higher in the wet season than in the dry. The average relative humidity recorded at Līhu‘e Airport is 67% in mid-afternoon and 83% in the early morning hours. Completely cloudless skies are rare. On average, clouds cover 60–70% of the sky during the daylight hours. The Ma‘alo site is somewhat sheltered from the island's dominant northeast trade winds by the 3-mile-long, north-south-oriented Kālepa Ridge, which rises sharply to 300 feet (ft) above the eastern border of the site.

2.3.1.2 Geologic Setting

The Ma‘alo site (this term refers to the proposed MSWLF site, the Alternative 2 RRP site, and the Alternative 1 RRP site, collectively) is located more than 1 mile west of the central east coast of the island of Kaua‘i. It lies within the Līhu‘e Basin, a large depression bounded by the high, steep slopes of the Wai‘ale‘ale massif on the west, the Makaleha mountains on the north, Hā‘upu Ridge on the south, and Kālepa Ridge on the east. These bounding ridges and mountains are remnants of the lava flows that formed the original volcanic dome (Waimea Canyon Volcanic Series). The floor of the Līhu‘e depression is covered by late lava flows of the Kōloa Volcanic Series (Macdonald et al. 1960). The Ma‘alo site is located at an elevation of approximately 300 ft above sea level (msl), along the northeast margin of the Līhu‘e depression immediately west of Kālepa Ridge, which reaches a peak elevation over 700 ft msl and forms a natural barrier between the site and the shoreline to the east. The Kōloa Volcanic rocks that underlie the site typically weather to stiff saprolitic soils near the ground surface.

2.3.1.3 Topography

The Ma‘alo site is located in an undeveloped rural area at a minimum elevation of approximately 280 ft msl in the central-east portion of Līhu‘e Basin. Overall topography slopes gently to the south, with a low saddle running north and south through the approximate middle of the proposed MSWLF site. To the east of the site is Kālepa Ridge, while the north, south, and west boundaries of the MSWLF site are relatively flat terrain presently used as pasture. The Alternative 1 RRP site, which is currently used for agriculture, is generally flat, with topography sloping gently to the south. Active and inactive irrigation ditches are present throughout the general project area. In support of this Project, precision aerial mapping was conducted and photogrammetric mapping services were provided to produce topographic mapping for the proposed site vicinity; the aerial photograph is reproduced in Appendix H. Some modification of the site topography would be required for construction of the proposed facilities and surface water management systems.

2.3.1.4 Soils

Soil information for the project site was obtained from the U.S. Department of Agriculture Natural Resources Conservation Service (USDA NRCS 2011). Generally, two soil associations are predominant at the proposed MSWLF site:

- The Līhu‘e-Puhi association consists of deep, nearly level to steep, well-drained soils that have a fine textured or moderately fine textured subsoil on uplands.
- The Rough Mountainous Land-Rough Broken Land-Rock Outcrop association consists of well-drained to excessively drained, very steep to precipitous lands of mountains and gulches.

As shown on Figure 2 and detailed in the EA-EISPN (AECOM and R. M. Towill 2013), five types of soil are found at the Ma‘alo site, with Līhu‘e silty clays and Nonopahu clay the dominant types. Permeability, runoff, and erosion hazard ratings vary among them.

To aid in site design, a preliminary geotechnical site exploration and laboratory testing program was performed (Section 4.1.6.1) to investigate the site stratigraphy and the soil's structural

characteristics, such as classification, compaction, and permeability parameters. The Preliminary Geotechnical Investigation Data Report is included in Appendix B.

2.3.1.5 Surface Water Resources

As shown on Figure 3**,** surface water resources in the vicinity of the Ma‘alo site include Ai‘i Reservoir to the west, Okinawa Reservoir to the southwest, an unnamed reservoir to the north, the South Fork of the Wailua River approximately 3,000–3,500 ft to the north (running roughly parallel to the north and northwest boundary of the site), and Hanamā‘ulu Stream to the southwest. Because the U.S. Fish & Wildlife Service’s National Wetlands Inventory (NWI) had mapped several former and current irrigation ditches on the proposed Ma‘alo site as potential wetlands, the U.S. Army Corps of Engineers (USACE) was consulted; they concluded that there are no jurisdictional wetlands within the site borders (USACE 2013). A wetland labeled by the NWI as a “Freshwater Emergent Wetland” is located southwest of the proposed MSWLF site border (USFWS 2011).

The proposed MSWLF site is located within a topographical saddle region. A surface water management system would be necessary to control run-on from areas upslope of the site, as well as runoff from areas within the project site. This could include the use of soil stabilization berms, drainage channels, detention and infiltration basins, and other features as described herein, to prevent run-on, runoff, and erosion and to promote drainage while maintaining site stability.

2.3.1.6 Groundwater and Hydrology

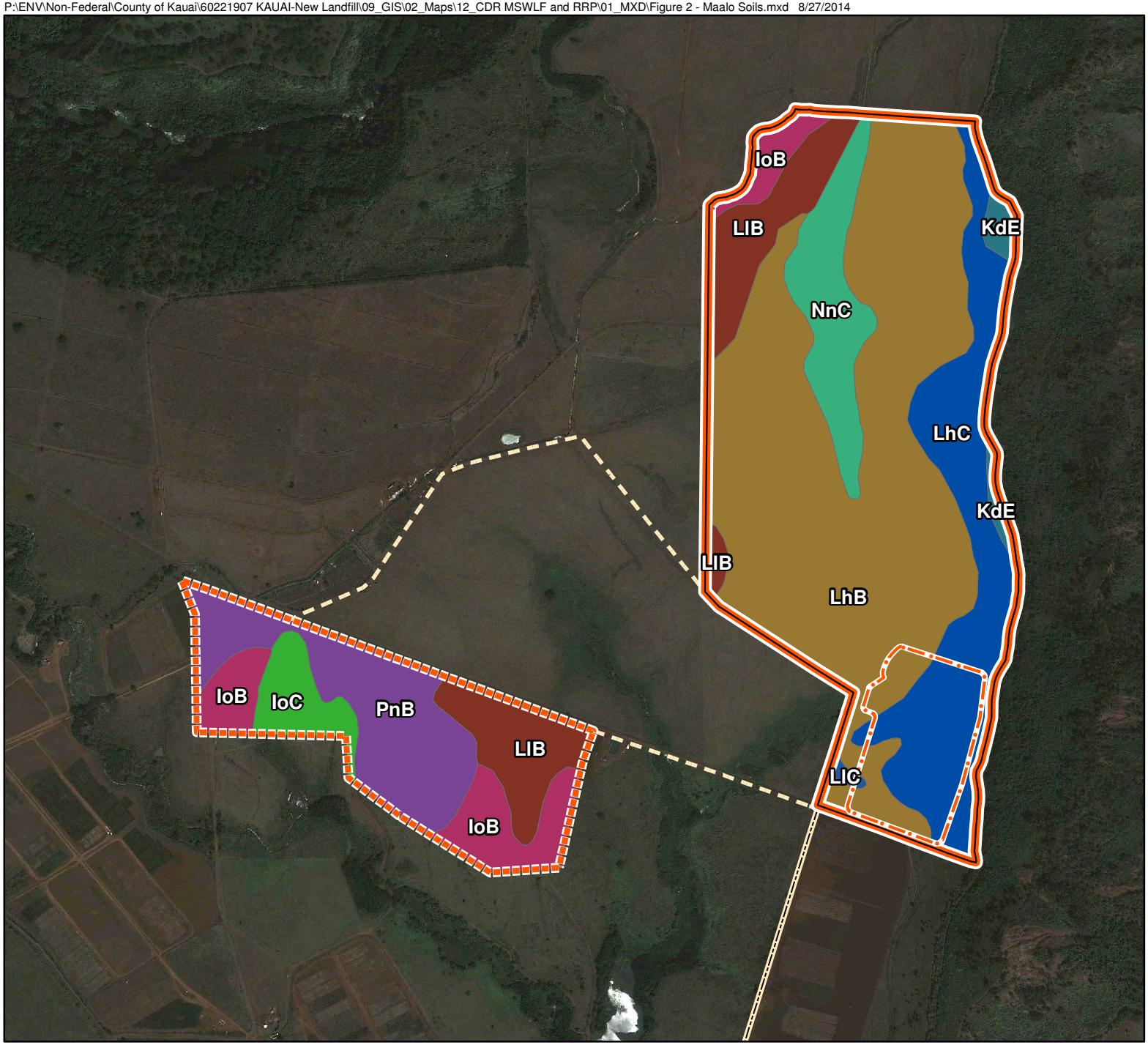
The proposed MSWLF site is within the geologic/hydrogeologic region known as the Līhu‘e District (Macdonald et al. 1960) and is a part of the Wailua River watershed. Basal groundwater occurs in the lava flows of the Nāpali formation in Kālepa Ridge, in most of Hā‘upu Ridge, and is also likely in Nonou Ridge. Wells investigated before 1960 near the Kālepa Ridge had basal heads produced by the impounding effect of lava flows of the Kōloa volcanic series surrounding the ridge, with thicknesses of approximately 10–16 ft. Dikes in the ridge likely divide the basal aquifer into compartments, but wells are too few to estimate the size of the compartments and their water-bearing capacities. Shallow groundwater may discharge into streams from the lava flows of the Nāpali formation that compose the high west wall of the Līhu‘e depression, but its occurrence does not appear favorable for easy development of the groundwater. Shallow water issues from small perched bodies and dike reservoirs, but can be seen only in seeps and small springs distributed along the stream channels and valley walls. No flow from dike reservoirs occurs at large springs that would encourage development of high-level groundwater in tunnels.

Because the proposed Project site lies above (mauka of) the State of Hawai‘i Underground Injection Control (UIC) Line, the groundwater below the site is designated as a potential groundwater drinking water source by the State of Hawai‘i Department of Health (DOH). Although the DOH Safe Drinking Water Branch is prohibited from revealing locations of drinking water sources, its representatives have confirmed that the Ma‘alo site is more than 1,000 ft from known or planned drinking water sources (AECOM and R. M. Towill 2013). In addition, the County of Kaua‘i Department of Public Works has reported that there are no active wells and no current plans for the County Department of Water to develop any wells within 1,000 ft of the proposed site (Eddy 2011).

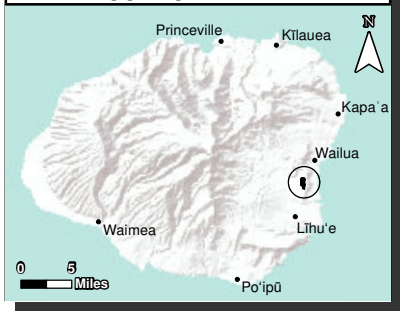
2.3.1.7 Air Quality

An air quality monitoring station was established in 1972 by the DOH Clean Air Branch (CAB) at the District Health Office on ‘Umi Street in downtown Līhu‘e. In 2005, particulate matter were measured at the station well below the Hawai‘i State Standard and the Federal Primary and Secondary Standards. Although information on other pollution sources was not generally available from the DOH for the proposed Ma‘alo site, the DOH in its assessment of Statewide air quality noted that air “quality in the State of Hawai‘i continues to be one of the best in the nation, and criteria pollutant levels remain well below state and federal ambient air quality standards” (DOH 2006).

P:\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\09_GIS\02_Maps\12_CDR MSWLF and RRP\01_MXD\Figure 2 - Maalo Soils.mxd 8/27/2014



LOCATION MAP



LEGEND

- Proposed Ma'alo Landfill Site
- Alternative 1 RRP Site
- Alternative 2 RRP Site
- Access Road
- Driveway Alternative

Lithology

- IoB: Ioleau silty clay loam, 2-6%
- IoC: Ioleau silty clay loam, 6-12%
- KdE: Kalapa silty clay, 20-40%
- LhB: Lihue silty clay, 0-8%
- LhC: Lihue silty clay, 8-15%
- LIB: Lihue gravelly silty clay, 0-8%
- LIC: Lihue gravelly silty clay, 8-15%
- NnC: Nonopahu clay, 2-10%
- PnB: Puhi silty clay loam, 3-8%

NOTES

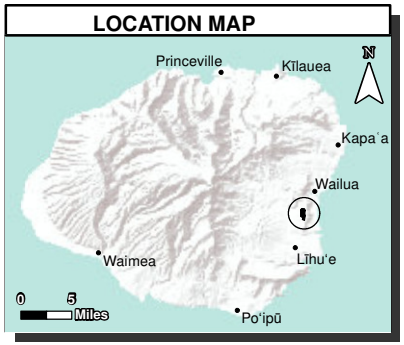
1. Base Map: Google Earth Pro 2013
2. Map Projection: State Plane Zone 4 Feet

N

0 750 1,500 Feet

Figure 2
Ma'alo Soils
Conceptual Design Report
MSWLF and RRP at Ma'alo
Ma'alo, Kaua'i, Hawai'i

P:\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\09_GIS\02_Maps\12_CDR MSWLF and RRP\01_MXD\Figure 3 - Maalo Surface Water.mxd 8/27/2014



LEGEND

- Surface Water Body
- Stream
- Street/Road
- Access Road
- Driveway Alternative

NOTES

1. Base Map: Google Earth 2013
2. Map Projection: State Plane Zone 4 Feet

N

0 1,500 3,000 Feet

Figure 3
Surface Water in
the Project Vicinity
Conceptual Design Report
MSWLF and RRP at Ma'alo
Ma'alo, Kaua'i, Hawai'i

2.3.1.8 Flora and Fauna

Plant species found within and surrounding the proposed Project location consists primarily of fallow agricultural species, with some scattered introduced, non-native trees and shrub species. Due to past agricultural practices at the site involving extensive clearing and planting, discovering the presence of rare, threatened, or endangered species is not anticipated. The entire Kālepa Ridge, paralleling the eastern boundary of the site, is designated the Kālepa Forest Reserve by the State of Hawaiʻi Department of Land and Natural Resources (DLNR).

A study of the floral and faunal resources within and surrounding the project site was conducted as part of the EIS process to assess the potential for adverse effects by the project to rare, threatened, and endangered species and habitat (EIS Appendix L). Although protected bird species were observed flying above the site during the study, the study concluded that no plant species of particular interest or concern with respect to resource value are present on the site, no nesting colonies or appropriate nesting habitat for protected avian species were observed, all observed mammalian species were non-native and unprotected, and no federally designated Critical Habitat is present on site.

2.3.2 Human Environment

The following sections summarize the human environment of the site; further detail is provided in the Socioeconomic Assessment conducted for the EIS (EIS Appendix K).

2.3.2.1 Demographic Characteristics

The population of the island of Kauaʻi was 67,091 as of April 1, 2010, representing an increase of approximately 8,628 from 2000, when the population was 58,463. The proposed site is located within the Līhuʻe District, but close to the boundary of the Kawaihau District. Together the two districts have a population of 35,675, approximately one-half of Kauaʻi's total population. The communities located closest to the Maʻalo site are Hanamāʻulu (2 miles south) and Līhuʻe (3.5 miles south). The 2012 State of Hawaiʻi Data Book (DBEDT 2012) identifies the 2010 resident population of Hanamāʻulu at 3,835 and Līhuʻe at 6,455.

2.3.2.2 Historical and Archaeological Resources

The conditions of the existing area immediately surrounding the proposed Project site are rural, with the majority of the land being used primarily for agriculture. Development in this area is focused on the south side of the Kālepa Ridge near the coastline. Maʻalo Road and Wailua Falls lie to the west and northwest, respectively. In pre-contact times, the Wailua River, along both shores, was the most important high-status area on Kauaʻi. No visible surface remnants exist today of the chiefly homes or the supporting loʻi and kula lands. Western accounts of the area following the arrival of Captain Cook are rare, because most voyagers stopped instead at Waimea on the southwestern side of the island, which eventually overshadowed Wailua in importance. Historic and modern agricultural activity has drastically impacted the landscape in the vicinity of the project area. It is likely that pre-contact agricultural and habitation activity areas were located near the project area, especially along the Wailua River and its tributaries, but disturbance from rice and sugarcane farming has probably destroyed any remains of pre-contact archaeology within the project area (CSH 2008). A detailed Archaeological Inventory Survey (AIS) and Cultural Impact Assessment (CIA) were conducted for the Project EIS (EIS Appendices I and J). The AIS identified and catalogued a historic property (remnants of a plantation-era complex) for which no further historic preservation is recommended; the AIS findings are subject to review by the State Historic Preservation Division. The CIA recommended community involvement and precautions to prevent uncontrolled runoff from the proposed Project site.

2.3.2.3 Existing Land Use and Ownership

As shown on Figure 4, the proposed MSWLF site lies within one large parcel designated as Tax Map Key (TMK): (4) 3-9-002: 020, owned by the State of Hawaiʻi and comprising 2,162.78 acres, and the

Alternative 1 RRP site lies within one large parcel designated as TMK: (4) 3-8-002: 001, owned by Grove Farm Company, Inc. and comprising 1,114.9 acres. The County is currently in active discussions with the owners for the use of the sites. Both the State and Grove Farm, Inc. have agreed in principal for the potential use of the respective sites, contingent on the outcome of the EIS, further discussion, and agreement on details.

2.3.2.4 Traffic and Circulation

The proposed Project sites are located approximately 2 miles from the urbanized areas of Hanamā‘ulu and Līhu‘e. The sites themselves are not located near residential or developed areas, but potential access routes that may connect the proposed MSWLF site to Kūhiō Highway are located near residences and businesses. Kūhiō Highway in this section of the island has a significant amount of traffic because it provides a link between Līhu‘e and the Kapa‘a-Wailua area to the north.

A Traffic and Roadways Engineering Feasibility Study (TREFS) was conducted to study existing traffic patterns and analyze potential traffic impacts associated with several potential access road alternatives from the landfill and RRP site(s) to Kūhiō Highway (AECOM 2016; EIS Appendix E). The TREFS provided a traffic impact assessment, an engineering feasibility study and cost estimate, and a social impact assessment to assist the County in choosing the proposed access route. Based on the analyses performed and the public feedback generated, the County has chosen the access route shown on Figure 1 (from the intersection of Kaua‘i Beach Drive and Kūhiō Highway).

Additionally, the State Department of Transportation is considering a possible highway bypass project to provide relief to Kūhiō Highway in the vicinity of Hanamā‘ulu and Līhu‘e. If this State project is pursued and completed in a timely fashion, then an alternate access road may be proposed and developed for the landfill.

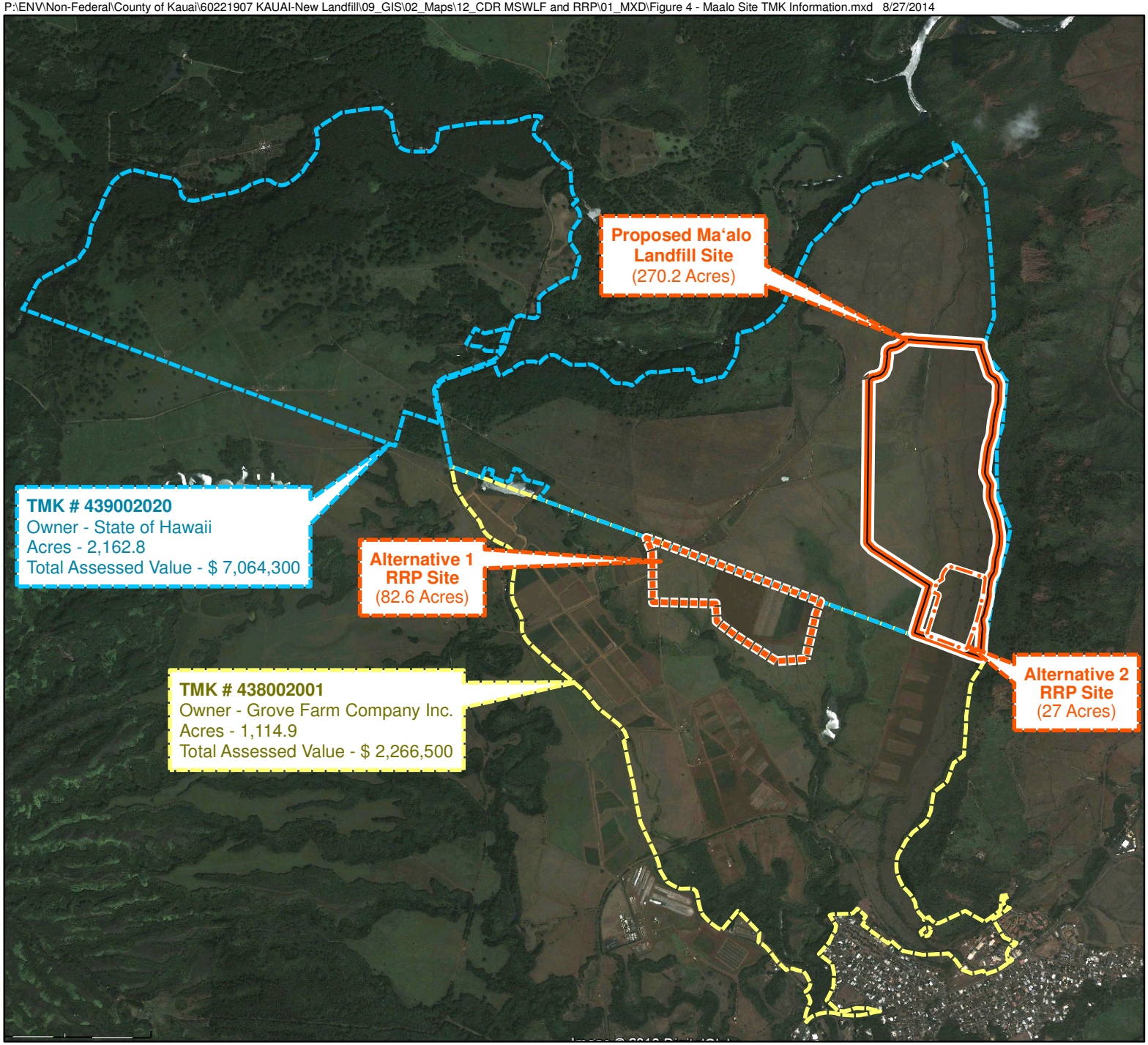
2.3.2.5 Utilities and Wastewater

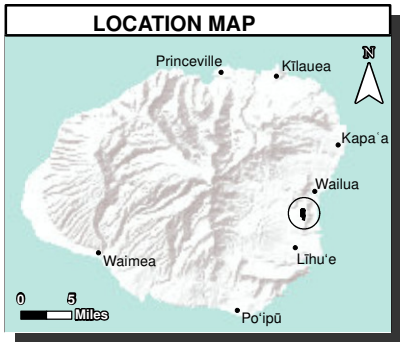
Currently, no electrical, telephone, water supply, or wastewater connections serve the site.

2.3.2.6 Drainage

The existing site is used for agriculture and grazing and is relatively undeveloped. Mitigation measures in compliance with State and County regulations and guidance would be implemented to prevent run-on from offsite sources and runoff from onsite sources during construction and operation of the facilities. Engineered drainage control systems for the sites have been designed and are presented in this *Conceptual Design Report* in accordance with the requirements of the County drainage and erosion control standards and the DOH Solid & Hazardous Waste Branch (SHWB), and in preparation for the County’s application for the Solid Waste Permit.

P:\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\09_GIS\02_Maps\12_CDR MSWLF and RRP\01_MXD\Figure 4 - Maalo Site TMK Information.mxd 8/27/2014





LEGEND

- Proposed Ma'alo Landfill Site
- Alternative 1 RRP Site
- Alternative 2 RRP site
- TMK 439002020 Boundary
- TMK 438002001 Boundary
- Access Road
- Driveway Alternative

NOTES

1. Base Map: Google Earth 2013
2. Map Projection: State Plane Zone 4 Feet

N

0 1,500 3,000 Feet

Figure 4
Proposed Project Site's
Tax Map Key Information
Conceptual Design Report
MSWLF and RRP at Ma'alo
Ma'alo, Kaua'i, Hawai'i

3.0 LANDFILL DESIGN FEATURES

Design of a new MSWLF involves many components and considerations to protect the environment, including groundwater resources and air quality, and to guard against damage occurring due to natural hazards such as earthquakes and floods. Furthermore, a functioning MSWLF must contain basic infrastructure needed for operations, staff, and equipment. A brief overview of MSWLF design is presented in this section to provide the reader with a general background for understanding subsequent sections of this report, which discuss conceptual design features specific to the proposed MSWLF. A conceptual schematic of the general layout of the proposed Ma‘alo MSWLF is presented on Drawing 2 for Alternative 1 (proposed MSWLF and RRP on separate parcels) and on Drawing 19 for Alternative 2 (proposed MSWLF and RRP on the same parcel). The ultimate details of landfill construction would be determined during facility permitting, subject to DOH review and approval.

3.1 BASIC DESIGN COMPONENTS

Several basic landfill components are required for compliance with the Resource Conservation and Recovery Act (RCRA) Subtitle D and associated State of Hawai‘i rules and statutes:

- **Base Liner Design.** A new MSWLF requires placement of a layer of low-permeability soils at the bottom (base) of the site, overlaid with an impervious geomembrane liner. Together, these layers impede landfill leachate (liquid that contacts and is released by waste), which can contain environmental contaminants, from impacting the groundwater aquifer beneath the landfill. The geomembrane liner is manufactured to provide a specified degree of resistance to tensile strain, tears, impacts, punctures, environmental stress cracking, and chemicals. Typically, a berm (a mound of soil compacted and shaped by heavy equipment to a defined shape) is constructed around the perimeter of the placement area prior to installing the liner to prevent leachate from draining horizontally beyond the edge of the liner. Typically, at least one side (the inside) of the berm is also lined. A leachate collection system is installed above the liner to prevent excessive buildup of leachate on the liner that could otherwise result in leachate migrating through the liner.
- **Phases and Cells.** MSWLFs are generally developed in phases. Each phase of the landfill is developed sequentially; within each phase operation is further divided into individual fill areas that are referred to as “cells.” As each cell reaches capacity, an adjacent cell is constructed and then filled, with partial overlay on the preceding cell for stability and maximizing operational airspace for the constructed base liner area. Approximate capacities, grades, and elevations of the proposed phases and the initial cell have been calculated as part of this design.
- **Final Cover Design.** Daily soil cover (which is typically locally available soils or other approved material) is placed over the waste mass at the end of each day’s operation to deter wildlife from scavenging, prevent wind transport of waste, and promote surface water drainage. Additionally, a final landfill cover must be installed when the landfill reaches final capacity, prior to site closure. Typically, the permit describes daily cover requirements and the regulations specify infiltration and permeability requirements for the final cover. A final cover system typically includes a compacted soil layer overlain by a geomembrane liner. Various soil and geosynthetic materials are placed over the geomembrane liner for surface water management, protection of the geomembrane liner, and establishment of vegetation to prevent erosion of the final cover. The slope angles and cover design must be designed and evaluated to ensure that the sideslopes are not subject to failure due to gravity, seismic activity, or heavy rainfall events.
- **Landfill Capacity.** Landfill capacity can be described based on the available volume at a disposal facility dedicated to disposal of waste mass (e.g., cubic yards [cy]), or based on the anticipated site life, i.e., the duration that the facility is able to accept waste (e.g., years). Landfill volumetric capacity depends on the properties of the MSW, daily soil cover types and amounts, moisture content, and the degree of compaction of the MSW and soil cover.

The anticipated facility site life is estimated based on the anticipated amount of incoming MSW (commonly expressed as annual volumes or “tonnages”), potential fluctuations due to population growth or changes in the MSW source (such as the influence of recycling), compaction efficiency, and the landfill volumetric capacity.

- **Soil Balance.** A soil balance consists of determining the amount of soil available from excavating for base liner construction, and comparing this to the amount of soil required for base liner construction, daily and intermediate cover, and the final cover. Soil sources beyond those obtained during site excavation, both on and off site, are often required if the soil balance (i.e., soil available minus soil required) is negative.

3.2 GEOTECHNICAL DESIGN

Structural criteria must be evaluated when designing a new landfill to ensure its long-term stability. The compaction and drainage characteristics of underlying soil must be measured to ensure that the ground on which the landfill is constructed is capable of supporting it. The permeability of the soil must be ascertained to determine drainage characteristics. Safe sideslope angles at which to stack the waste material and provide for safe operation of equipment must be calculated to ensure against movement of the sideslopes as the height of the landfill grows, which increases pressure on the material underneath. In addition, the degree of horizontal movement that the ground could potentially experience in the MSWLF area during an earthquake must be determined to enable adequate design to prevent failure of the landfill’s base liner, sideslopes, or gas extraction and leachate collection systems during foreseeable earthquake events.

3.3 LANDFILL GAS EXTRACTION SYSTEM

A MSW contains organic waste; as microbes digest the organics, gas is produced, primarily methane and carbon dioxide. With the quantities of organic matter found in a typical MSW, flammable methane can build up to dangerous levels if left uncontrolled. Landfill gas (LFG) extraction wells, piping, and control devices must be installed so that the gas can be extracted and then vented, burned off through a flare system, or conditioned for use as a fuel. Sufficient quantities of methane for the cost-effective generation of electricity or use as a fuel would not be expected until the site has been operational for several years. Therefore, plans for such a system at Ma‘alo would likely be phased in after several years of operation. The initial design presented in this report calls for flaring off (i.e., burning) the gas.

3.4 LEACHATE MANAGEMENT SYSTEM

Landfill leachate is generated from both rainwater coming in contact with the waste mass and liquids present in the MSW at the time of placement in the landfill; this liquid accumulates at the base of the landfill and inevitably contains environmental contaminants. Leachate drains vertically downward by gravity through the MSW. The base liner over the subgrade is designed to prevent further downward migration of leachate into the subsurface; however, the leachate must be routinely collected and removed to prevent it from building up on the base liner. Regulations limit how much leachate may collect over a liner at any time. Leachate compliance elevations are calculated during design to ensure appropriate leachate removal.

In a typical leachate management system, a uniform layer of sand or gravel, optionally in conjunction with geosynthetic materials such as geotextiles and geocomposite drainage media, is placed above the base liner and under the MSW. Leachate percolates downward through the waste into this highly permeable layer, where it is collected in a system of perforated pipes and transported to a series of low points or sumps. The accumulated leachate is then typically pumped out of the sumps and collected in a wet well (typically a concrete or synthetic structure for the collection and containment of leachate to be pumped). Ultimately, the leachate is pumped either to collection tanks for offsite treatment, to an onsite lined evaporation/treatment pond, to a municipal sewer system, or (if approved by for leachate recirculation) back into the waste mass. In Hawai‘i, landfill leachate is

typically allowed to evaporate completely in an evaporation pond or trucked off site for treatment (e.g., at wastewater treatment plants).

3.5 SURFACE WATER MANAGEMENT

Surface water at the site must be managed to ensure that rainfall does not affect the stability of the landfill, cause excessive erosion, or transport any contaminants off site. Additionally, stormwater management systems are typically designed to minimize the amount of rain that contacts waste, thus creating leachate. Stormwater management systems typically divert stormwater from landfill sites into stormwater detention basins, where sediment is removed. Detention basins can either discharge the stormwater offsite as surface water flow, or operate as infiltration basins, storing the water until it evaporates or infiltrates into the subsurface.

3.6 BUILDING INFRASTRUCTURE

Infrastructure such as an office building, maintenance building, scale house, and parking areas are required for operating a MSWLF. These facilities are typically located near the site entrance.

3.7 ROADS AND UTILITIES

Currently, the proposed MSWLF site is not connected by paved roads to the island’s public road network. Construction of access roads would be required to connect the site to the County road system. Kūhiō Highway (State Highway 56), one of Kaua‘i’s main thoroughfares, passes approximately 1 mile south of the site on its transit through Hanamā‘ulu. Farther north, the highway passes slightly closer to and directly east of the site, but the two are separated by Kālepa Ridge. The proposed access route (Figure 1) is primarily situated upon existing cane-haul (“dirt”) roads. Construction of the access roads would also include construction of utility corridors to bring electric and potable water to the proposed facilities. Wastewater would be managed using an onsite septic system at the MSWLF site (and at the Alternative 2 RRP site, if implemented). Site stormwater and leachate would not be allowed to enter the septic systems.

3.8 PERMITTING, MONITORING, AND OVERSIGHT

Landfills in the United States are regulated by the U.S. Environmental Protection Agency (EPA). Landfills in Hawai‘i are also regulated by the State DOH SHWB. The proposed MSWLF would be subject to the design, operational, financial, and other requirements set forth in RCRA Subtitle D and in the Hawai‘i Administrative Rules (HAR) Chapter 11-58.1. Prior to development of the MSWLF, a Solid Waste Management Permit Application (which includes a detailed engineering report, financial assurances, and several monitoring and management plans) would require preparation and submittal to the DOH SHWB for review and approval. Technical documentation included in the Solid Waste Management Permit Application would include detailed landfill design features and supporting calculations; proposed site operation plans, including environmental monitoring plans; and closure/post-closure plans. The landfill owner and operator would conduct all required monitoring and reporting before, during, and after the useful life of the facility, in accordance with the solid waste management permit, subject to oversight by the State DOH.

4.0 ALTERNATIVE 1 CONCEPTUAL DESIGN

This section provides engineering analyses and design parameters for the Alternative 1 proposed MSWLF and RRP. Under Alternative 1, the landfill would be sited on the Ma‘alo parcel and the RRP would be sited on a separate nearby parcel (Figure 1). Alternative 1 has a somewhat larger landfill footprint and longer site life than Alternative 2, which has the RRP sited within the Ma‘alo (MSWLF) parcel (the Alternative 2 conceptual design is presented in Section 5.0).

The analyses and design parameters presented below are likely to be refined and implemented should the proposed Project be constructed. Accompanying this report are drawings titled Draft *Conceptual Designs, Ma‘alo Municipal Solid Waste (MSW) Landfill and Resource Recovery Park at Ma‘alo, Kaua‘i, Hawai‘i*, prepared by AECOM, dated August 2014. These drawings are referenced in the following sections describing the design elements of the proposed MSWLF and RRP.

4.1 ALTERNATIVE 1 PROPOSED LANDFILL

The proposed landfill would be designed to accept non-hazardous MSW and comply with the design requirements of RCRA Subtitle D, and HAR Chapter 11-58.1. The Alternative 1 design maximizes the use of the 264-acre MSWLF parcel, resulting in a very long anticipated lifetime, as described below.

4.1.1 Base Liner

The system of layers that compose a landfill base liner is designed to impede landfill leachate from impacting the groundwater aquifer beneath the landfill. The landfill base liner system for the Alternative 1 proposed MSWLF is, from bottom to top:

1. Prepared subbase grade (existing, in-situ soil below the liner system, compacted and covered with 6-inch granular foundation lift, compacted, and prepared for liner installation).
2. Secondary geosynthetic clay liner (GCL) (to provide secondary inhibition of flow of leachate and to enhance the liner’s ability to withstand deformation); the secondary GCL is not required by the regulations, but is a design alternative that has been adopted as part of the proposed landfill design (as described in Section 6.1.1).
3. Secondary 60-mil high-density polyethylene (HDPE) geomembrane (to inhibit secondary flow of leachate); the secondary GCL is not required by the regulations, but is an design alternative that has been adopted as part of the proposed landfill design (as described in Section 6.1.1).
4. Primary GCL (to provide primary inhibition of flow of leachate and to enhance the liner’s ability to withstand deformation).
5. Primary 60-mil HDPE geomembrane (to inhibit primary flow of leachate).
6. Nonwoven cushion geotextile (to protect the primary geomembrane).
7. 12-inch granular drainage layer (to collect leachate and transport it from the liner, preventing excessive leachate build-up).
8. Nonwoven separator geotextile (to maintain composition of the drainage layer).
9. 24-inch operations layer (to protect the liner from penetrations).

The base liner design is graphically presented as Detail 1 on Drawing 31. The proposed base liner exceeds the requirements of RCRA Subtitle D and HAR Chapter 11-58.1. The minimum design requirements include a base liner with a geomembrane liner overlaying 2 ft of recompacted soils with a maximum permeability 1×10^{-7} centimeter per second (cm/sec). If a HDPE geomembrane liner is to be part of the base liner system, then it must have a minimum thickness of 60 mils. The proposed Ma‘alo MSWLF base liner incorporates two liners, designated as primary and secondary, with each

liner composed of a 60-mil HDPE geomembrane and a GCL. The multiple-liner system is proposed for further protection of the underlying groundwater aquifer of the site, as described in Section 6.1.1.

The expected effectiveness of the GCL in containing leachate has been analyzed using the EPA's Hydraulic Evaluation of Landfill Performance (HELP) model (Schroeder et al. 1994), using standard industry design and modeling assumptions representing potential geomembrane defects during the manufacturing process and potential installation damage. The analysis is done for Phase 1 when it is filled to approximate maximum waste depths. Conservatively assuming that all rainfall becomes leachate and that no intermediate cover is in place to buffer or divert the rain, the leachate generation analysis estimates an average annual exfiltration through the base liner system of 0.105 cubic foot per acre per year, or 0.8 gallon per acre per year (see HELP Model output in Appendix D).

Assuming that the regulation liner soils are not available and that the proposed base liner system consists of a GCL rather than the prescriptive 2-ft compacted soil layer, a point of compliance assessment would be required as part of the Solid Waste Management Permit Application. The assessment would be based on detailed geotechnical investigations and groundwater monitoring that would be conducted in the future. Such an assessment is not unusual, has been successfully conducted for the existing Kekaha MSWLF, and is expected to confirm that the GCL would perform at least as well as the prescriptive 2-ft compacted soil layer.

4.1.2 Landfill Phasing

MSWLFs are generally developed in phases, with each phase further divided into cells that are sequentially constructed and filled. The Alternative 1 proposed MSWLF would be constructed in five phases. Drawing 2 and Drawing 3 show the overall layout, proposed phases, and initial development areas of the Alternative 1 MSWLF, and Drawing 12 and Drawing 13 show the cross-section views, including a projection on the nearby Kālepa Ridge. Phases 1–4 would be physically defined by their base liner systems' lateral limits (Drawing 2), and Phase 5 would be a vertical phase that directly overlays the completed Phases 1–4. The total footprint of the Alternative 1 proposed MSWLF limit of waste (LOW) is 170.7 acres. To maximize available airspace for disposal, each phase would be overlain onto the previous phase, as shown in the cross-sections on Drawing 12 and Drawing 13. Overlaying of one phase onto another is accomplished by connecting the base liners of each phase over the perimeter berm, creating one continuous base liner system, as shown in Detail 4 on Drawing 31. The resulting lined area allows for waste disposal in the "valley" created from the operation of adjacent phases. The filling sequence of the proposed landfill is anticipated to be as follows (for either alternative):

- **Phase 1:** Filling would commence in the southeastern portion of the site. The initial site development would include the infrastructure required to be in place at the beginning of landfill operations, including that portion designated Cell 1.1 (Drawing 11), the entrance area, and initial phases of control systems, as described below.
- **Phase 2:** Once the last cell of Phase 1 has been completed, operation would commence in a second plot located directly north of Phase 1. Phase 2 would overlay onto the north sideslope of Phase 1.
- **Phase 3:** Once the last cell of Phase 2 has been completed, operation would commence in a third plot, west and adjacent to Phase 2. Similar to the Phase 2 overlay onto the north sideslope of Phase 1, Phase 3 would overlay onto the west sideslope of Phase 2.
- **Phase 4:** The final lateral phase would be located directly adjacent to the west side of Phase 1 and the south side of Phase 3. Phase 4 would overlay waste mass onto the west sideslope of Phase 1 (and a portion of Phase 2), as well as the south sideslope of Phase 3.
- **Phase 5:** would not add any new horizontal area to the LOW, but would overlay Phases 1–4 and increases the facility's overall final waste mass height.

Each landfill phase would consist of a series of cells, which would be constructed as needed to maintain operational airspace and can vary in size and shape based on this need. A cell is a smaller portion of the overall phase that allows for smaller work areas and controlled site operations, requires less capital expenses for construction and operations, and facilitates limiting and managing leachate and LFG production and extraction. Cell designations for Ma‘alo MSWLF are based on the phase in which the cell is being constructed and the order in which the cells are constructed. The designation is *Cell (phase number).(cell order)*; e.g., the first cell constructed as part of Phase 1 would be Cell 1.1, the second Phase 1 cell would be Cell 1.2, and the first Phase 2 cell would be Cell 2.1. Alternative 1, Cell 1.1 is shown on Drawing 11. The date of construction of each subsequent cell would depend on the rate of incoming waste, compaction efficiency, daily cover soil needs, and the required construction time, tempered by the need to control the amount of time that liner systems are exposed to the elements.

The subbase grades for the Alternative 1 proposed MSWLF are proposed to be 10 ft below and roughly parallel to the current topography and drainage features of the property: base grades for Phases 1 and 2 slope from a high point on the east to a low point on the west, and Phases 3 and 4 slope from a high point on the west to a low point on the east. This orientation of subbase grades was chosen to minimize land disturbance during each phase’s operation and to provide groundwater separation based on current (limited) groundwater information. Actual subbase grade elevations and orientation could change with the additional knowledge gained from completion of a formal geotechnical investigation and groundwater monitoring program that would be conducted for preparation of the detailed design and solid waste management permit application. The leachate transfer pipe would lie at the low points of the leachate collection pipes in the berm constructed between Phases 1–2 and Phases 3–4. All subbase slopes along and perpendicular to the leachate collection lines are 2%. Alternative 1 subbase grades, which represent the surface at which the base liner is constructed, are shown for the entire landfill on Drawing 3, and for Phase 1 on Drawing 5.

Subbase liner elevations would range from approximately 270 to 307 ft msl, a minimum of 10 ft above groundwater elevations reported in the borings advanced at the site (which probably only encountered perched groundwater lenses, rather than an actual aquifer). The sideslopes of the proposed Ma‘alo MSWLF subbase would have a maximum slope gradient of 3 horizontal (H) to 1 vertical (V). Leachate from the leachate collection piping located within each cell would be transferred to a dual-containment HDPE pipe system located in the separation berm between Phases 1 and 4 and between Phases 2 and 3 (dual-containment piping involves placing one smaller-diameter pipe inside a larger-diameter pipe). The smaller-diameter pipe is the transmission pipe of the liquids; the larger-diameter pipe provides additional protection to the smaller-diameter pipe and protects against a release should a leak in the transmission pipe occur. The leachate collection piping would be allowed to pass through the base liner system at an engineered pipe penetration that allows for gravity leachate collection (no pumping required) (Drawing 32). The dual-containment leachate piping for Phases 1 and 4 would slope to the south to a wet well (Drawing 33). This wet well in turn connects to the proposed leachate evaporation pond south of Phase 4 (Drawing 6). When the leachate level in the wet well reaches a set point, a pump in the wet well is activated to pump out the leachate to the leachate evaporation pond. Details of the proposed leachate management system as presented in Section 4.1.8 and potential design alternatives are summarized in Section 6.1.3.

The proposed landfill phasing, base liner geometry, and gravity leachate management system would meet regulatory requirements for leachate head levels in the landfill to minimize the potential for release of leachate.

4.1.3 Final Cover

In addition to the daily soil cover applied to a landfill’s waste mass to deter scavenging wildlife, prevent wind transport of waste, and promote surface water drainage, a final landfill cover must be installed when a MSWLF reaches final capacity, prior to site closure. Regulations specify infiltration and permeability requirements for the final cover: HAR Section (§) 11-58.1-17(a) requires that landfill

covers have an 18-inch infiltration layer with a permeability less than or equal to the permeability of any bottom (base) liner system or 1×10^{-5} cm/sec, whichever is less, and a minimum 6-inch erosion layer that can sustain plant growth and inhibit erosion, or approved equivalent. The Alternative 1 proposed MSWLF base liner system consists of a prepared subgrade, a secondary GCL and 60-mil HDPE geomembrane liner, and a primary GCL and 60-mil HDPE geomembrane liner. Upon demonstration that less surface water infiltration is allowed through the proposed final cover than exfiltration through the primary bottom liner, the requirements of HAR § 11-58.1-17(a) would have been met. Supporting calculations and a design discussion of the proposed final cover cross-section and the permitted bottom liner are presented in Appendix D.6.

The following top-to-bottom cover system, as shown in Detail 5 on Drawing 31, is expected to be proposed in the permit application to the DOH:

1. 18-inch topsoil/root zone soil layer
2. Geocomposite drainage layer
3. 40-mil linear low-density polyethylene liner (double-sided textured)
4. GCL
5. 12 inches of intermediate cover material
6. Top of waste

The proposed final cover design would meet the requirements of HAR § 11-58.1-17(a). Alternative 1 final cover grades are shown for the entire landfill on Drawing 4, and for Phase 1 on Drawing 7. Drawing 12 and Drawing 13 superimpose these final cover grades on the nearby Kālepa Ridge.

4.1.4 Landfill Capacity

The anticipated useful site life is directly related to the landfill volumetric capacity (i.e., the "airspace") to accept waste mass and cover soil, the incoming waste stream composition and rate, the overall compaction efficiency, type and amount of cover, and other site operational factors. Because the proposed landfill would be a new facility, the estimate of available airspace is controlled by the overall footprint of the facility, final cover design grades, height constraints, if any, and other practical or operational considerations.

The estimate of site life depends primarily upon the available airspace, the rate of waste disposal, and the efficiency of compaction efforts. The existing Kekaha MSWLF landfills waste at a rate of approximately 82,000 tons per year (TPY), and operates with an in-place compacted waste mass density of approximately 1,300 pounds per cubic yard (cy) (0.65 ton of MSW per cy of airspace). For this conceptual design, the waste stream and compaction rates are assumed to remain the same. Although the population is expected to increase over time, the County expects to establish the RRP for recycling and waste diversion, and also expects to implement other waste diversion initiatives, including curbside collection of recyclables. Therefore, use of current rates is expected to provide conservative estimates of site life and associated costs.

Table 1 lists the projected capacities of the first Cell, the remainder of Phase 1, and the remaining four phases of the Alternative 1 proposed MSWLF.

Table 1: Alternative 1 Proposed MSWLF Projected Capacity

Phase	Design Waste Mass Volume (cy)	Annual Waste Tonnage (tons)	Compaction Factor (tons of waste/ in-place cy)	Annual Airspace Consumed (cy)	Expected Site Life (years, rounded)
1A (initial development)	1,099,000	82,000	0.65	126,154	9
1 (remainder)	3,432,000	82,000	0.65	126,154	27
2	4,399,000	82,000	0.65	126,154	35
3	5,149,000	82,000	0.65	126,154	41
4	9,973,000	82,000	0.65	126,154	79
5	9,316,000	82,000	0.65	126,154	74
Total	33,368,000				265

Notes: Expected site life does not account for waste mass settlement over time (consolidation), which is expected to add to the site life.

4.1.5 Soil Balance

Construction and operation of the Alternative 1 proposed MSWLF would require acquisition of soil from on- and offsite sources. Onsite sources of soil include those areas planned for excavation (e.g., areas within the proposed LOW, portions of the surface water management system, and areas proposed for mass grading for infrastructure development). Offsite sources of suitable soil may need to be identified by the County.

Based on the Preliminary Geotechnical Investigation, granular material for the drainage and operations layers does not appear to be available on site and would be obtained from local aggregate suppliers. Concurrent with Phase 1 development, soil could be stockpiled within the facility based on construction and operational needs. Soil material quantities available within the facility and the quantity required for construction and operation of the Alternative 1 proposed MSWLF are summarized in Table 2. Significant quantities of cover soil would need to be identified in later years of site operations. Detailed soil quantity calculations for Alternative 1 are presented for Phase 1 in Appendix A.1, and for Phases 2–5 in Appendix A.2.

Table 2: Alternative 1 Available and Required Soil Material Quantities

Phase	Topsoil		Miscellaneous Soil		Granular Material	
	Available within Ma‘alo MSWLF (cy)	Required (cy)	Available within Ma‘alo MSWLF (cy)	Required (cy)	Available within Ma‘alo MSWLF (cy)	Required (cy)
1	49,000	37,300	851,000	1,307,000	0	221,000
2–5	154,800	124,600	312,600	7,222,700	0	612,300

Note: All quantities are presented in cubic yards (cy).

4.1.6 Geotechnical Design

Geotechnical design includes evaluation of structural criteria to ensure the landfill’s long-term stability and protect against failure of the landfill’s base liner, sideslopes, or gas extraction and leachate collection systems.

4.1.6.1 Site Exploration

In May 2012, AECOM subcontracted Masa Fujioka & Associates (MFA) to complete a limited preliminary investigation to investigate the geotechnical and groundwater conditions of the proposed MSWLF site. The site exploration included advancing and logging six soil borings selectively located throughout the 270-acre site, and collection and geotechnical analysis of soil samples. Boring

locations are shown on Drawing 1, and the Preliminary Geotechnical Investigation Data Report is presented in Appendix B.1.

Laboratory testing included soil classification tests, compaction tests, and moisture-density relationships. Based on the borings and laboratory results, the predominant foundation soils on site are residual silts and clays. The Geotechnical Investigation Data Report summarizes the subsurface conditions at the Ma‘alo site as follows:

> *Site topography, geology, and soils generally conform to the published information, except that MFA did not encounter any granular soils.*
>
> *All 6 borings encountered residual soil overlying saprolite. In most borings, saprolite was encountered at depths of approximately 4-5 feet bgs, except B2, in which the residual soil persisted to about 7.5 feet bgs. Topsoil was encountered only in boings B1 (approx. 6 inches thick) and B2 (approx. 2 feet thick). Soils were mostly stiff or hard, but much of the saprolite encountered was brittle (broke apart easily with pressure). Basalt rock was encountered in the western three borings: hard basalt at 39 feet bgs in B1; hard basalt at 40 feet bgs in B3, and weathered basalt at 50.5 feet bgs in B4.*
>
> *Perched groundwater was encountered in all borings at depths between 14 and 38 feet bgs. Boring B3* [total depth 41.5 ft] *was left open for 24 hours to allow the water level to stabilize. The water level in B3 was measured at a depth of 15.7 feet bgs on May 16, 2012.*

From a geotechnical standpoint, the project site was considered suitable for construction of the proposed landfill. Existing site soils that would be excavated would likely be suitable for use as daily/intermediate cover, topsoil, a rooting-zone layer, and sideslope diversion berms and may also be suitable for use as a low-permeability compacted soil layer, pending further analysis during design.

4.1.6.2 Slope Stability Evaluation

The slope stability of the proposed Alternative 1 landfill geometry was analyzed based on the facility’s anticipated final shape after completion of waste placement and installation of final cover. The landfill permit application would contain complete geotechnical evaluations for the final design of the landfill. Top slopes are designed to be sloped at 5% (20:1 H:V); sideslopes of both final and intermediate covers (e.g., for each phase) are designed to be sloped at a ratio of 3.5:1 (H:V).

Summary of Slope Stability Calculation Assumptions

The waste mass properties were defined based on discussions with operators of the existing Kekaha MSWLF and published articles on waste mass properties. Waste mass properties are dependent on the degree of compaction, lift thickness, composition of the waste stream, moisture, and the amount of daily cover soil or alternate daily cover used.

A paper entitled *Shear Strength of Municipal Solid Waste: A Laboratory Study* (Motan et al. 1997) proposed waste mass strength values of 35° and cohesion of 20 kilopascals (kPa) (418 pounds per square ft [psf]) for MSW. Those waste mass strength values are considered representative for Kaua‘i’s waste stream and the proposed MSWLF. Consistent with previous (approved) stability analyses performed for the Kekaha MSWLF, stability analyses used waste mass properties of 33° and 200 psf cohesion, which are conservative compared to the values suggested by Motan et al. (1997).

In addition to the waste mass properties, the critical interface of the proposed base liner system governs overall site stability and requires additional consideration. Based on the proposed base liner system design and friction angles, the critical interface is the contact surface between textured

geomembrane to nonwoven geotextile. This interface exists in the base liner system at the following locations:

1. Between the cushion geotextile and the top of the primary textured HDPE geomembrane
2. Between the bottom of the of the primary textured HDPE geomembrane to the top nonwoven geotextile of the primary GCL
3. Between the bottom nonwoven geotextile of the primary GCL to the top of the secondary geomembrane liner
4. Between the bottom of the secondary textured HDPE geomembrane to the top nonwoven geotextile of the secondary GCL

Detail 1 on Drawing 31 depicts the base liner system and denotes the critical interfaces.

Based on typical published and expected literature values for this interface, an interface friction angle of 23° and 8 kPa (167 psf) of adhesion are expected. To provide more conservative design, the calculations were run using a lower critical interface friction angle of 15°. Use of textured geomembrane throughout the facility on the sideslopes and base would further assist in overall stability.

Summary of Slope Stability Calculations

The slope stability analysis included two types of failure scenarios based on the geometry of the facility and the geotechnical properties of foundation soils and waste mass:

- A block type failure along the base liner critical interface
- A circular failure that passes through the foundation soils or support structures (e.g., perimeter berms) as well as through the waste mass

Based on the assumptions detailed in Appendix B.2, factors of safety under various scenarios were calculated using Slope/W, an industry-recognized slope stability software program included as part of the GeoStudio 2007 software suite. For slope stability, the factor of safety is a defined as a minimum ratio of maximum available resisting forces divided by actual driving forces under various scenarios. The scenarios were evaluated in the "worst-case" cross-sections presented in Appendix B.2, and the worst-case (minimum) factors of safety were reported for each scenario. Consistent with current industry practice, the U.S. Army Corps of Engineers *Slope Stability Engineer Manual* (USACE 2003) recommends a minimum factor of safety of 1.5 for long-term static conditions. The calculated factor of safety was compared to the minimum allowable factor of safety for static (non-seismic) conditions of 1.5 for each scenario. The calculated factor of safety was significantly higher than 1.5 in all static cases, suggesting stable conditions and acceptable design. Slope stability analysis for Phase 1 is summarized in Table 3.

Slope stability was also analyzed under seismic conditions, to evaluate the stability of the facility during a seismic event. The analysis was performed to evaluate whether the waste mass and liner system would be able to withstand the design seismic event, based on a horizontal peak ground acceleration (PGA) of 0.1g, as defined in Section 4.1.6.4. The *RCRA Subtitle D Seismic Design Guidance for Municipal Solid Waste Landfill Facilities* (EPA 1995) states that a factor of safety of 1.0 has been shown to be conservative in assessments of slope performance in earthquakes. A factor of safety of 1.0 (when the maximum available resisting forces are equal to the driving forces) or greater demonstrates overall stability for a seismic event, whereas a factor of safety of less than 1.0 suggests that slope failure would be expected to occur. For conservative design, a minimum allowable factor of safety (for seismic conditions) of 1.20 was chosen for this analysis. As shown in the grey rows of Table 3, all sections and scenarios evaluated met or exceeded this criterion.

Table 3: Alternative 1 Phase 1 Summary of Buildout Slope Stability Factors of Safety

‘Worst-Case’ Cross-Section	Condition	Failure Condition	Static/Seismic	Factor of Safety	Minimum Factor of Safety
A–A′ East	Base Liner	Block	Static	3.85	1.50
	Waste Mass/Foundation	Circular	Static	2.82	1.50
	Base Liner	Block	Seismic	2.36	1.20
	Waste Mass/Foundation	Circular	Seismic	2.04	1.20
A–A′ West	Base Liner	Block	Static	1.92	1.50
	Waste Mass/Foundation	Circular	Static	2.08	1.50
	Base Liner	Block	Seismic	1.29	1.20
	Waste Mass/Foundation	Circular	Seismic	1.36	1.20
B–B′ East	Base Liner	Block	Static	3.84	1.50
	Waste Mass/Foundation	Circular	Static	2.91	1.50
	Base Liner	Block	Seismic	1.26	1.20
	Waste Mass/Foundation	Circular	Seismic	2.07	1.20
B–B′ West	Base Liner	Block	Static	1.94	1.50
	Waste Mass/Foundation	Circular	Static	2.23	1.50
	Base Liner	Block	Seismic	1.30	1.20
	Waste Mass/Foundation	Circular	Seismic	1.37	1.20

For additional conservative design, the geomembrane would be textured on both sides to promote stability. Texturing of geomembrane can be of different forms in which the surface of the geomembrane contains various thickness and heights or structures (such as small HDPE spikes) creating an uneven surface and more contact surface area thus making the surface more resistant to slope failure. Even though a textured geomembrane can provide higher friction angles (critical design angle required for a contact surface between dissimilar materials) of 20° or more, the stability for Phase 1 was conservatively analyzed with an assumed minimum interface friction angle of only 15°. The use of a textured geomembrane would therefore provide an overall of factor safety even better than that shown in Table 3, and would also assist with placement of the granular drainage layer and operations layers on the sideslopes.

Verification of assumed interface friction angles would be required via laboratory testing of all soil and geosynthetic materials under design parameters prior to use in construction. Minimum required interface friction angles are defined in Appendix B.2, and would become part of the construction requirements.

Based on the analysis and material properties presented in Appendix B.2, Phase 1 is expected to remain stable. Other phases are governed by similar properties and dimensions, and are therefore also expected to remain stable (this would be confirmed with additional detailed calculations during permitting of those Phases).

4.1.6.3 Final Cover Stability Evaluation

The stability of the proposed Ma‘alo MSWLF final cover was evaluated to determine the maximum slope lengths over which a continuous layer of geocomposite can be installed; this maximum length is a function of final cover soil permeability. This analysis evaluated stability of the proposed final cover under static, seismic, and seepage conditions. Using the Infinite Slope Stability equation, under static conditions the minimum interface friction angle of the final cover must be at least 23.1° to provide a factor of safety of 1.5. This equation provides a conservative analysis, as the equation is not dependent on further protection provided by buttressing at the toe of slope, soil thickness, slope length, and cover soil permeability. The final cover proposed for the proposed MSWLF would be

similar to the approved alternate final cover for the Kekaha MSWLF. Supporting calculations are presented in Appendix B.3.

Slope stability of the final cover under seismic conditions was also analyzed using the Infinite Slope Stability equation. Based on a horizontal PGA of 0.1g, as defined in Section 4.1.6.4, the critical interface friction angle for the final cover system must be at least 25.5° to provide a factor of safety of 1.20. Supporting calculations are presented in Appendix B.3.

Seepage stability accounts for the actual performance of the geocomposite drainage layer under the influence of the estimated runoff quantities and infiltration through the cover soils, based on the design storm event. Using a design 25-year 24-hour storm event of 13.4 inches and final cover soil permeabilities ranging from 1×10^{-3} cm/sec to 1×10^{-5} cm/sec, the maximum slope length for acceptable performance of the geocomposite while maintaining stability of the final cover system ranges from 27 ft to 934 ft (approximately 7–257 ft in vertical elevation difference, for a 3.5:1 H:V sideslope), to provide a factor of safety of 1.2. The final cover soil permeability was varied to account for potential differences in soil materials available at the time of final cover construction. As determined by the analysis, the more permeable the final cover soils are the more rainwater infiltration is required to be handled by the geocomposite, resulting in shorter slope lengths for the geocomposite to maintain stability. As the final cover surface water management system is designed, geocomposite outlets would be provided at berms and perimeter channels as necessary based on cover soil and geocomposite parameters to maintain the maximum allowable slope lengths for the chosen cover soils. For Phase 1, the maximum slope length has been calculated to be approximately 140 ft. Supporting calculations are presented in Appendix B.3.

The proposed final cover system is expected to be stable under static conditions, in a seismic event of 0.10g, and during design rain events, as long as the specified material properties are met or exceeded.

4.1.6.4 Seismicity and Liquefaction Evaluation

Seismicity Evaluation

HAR § 11-58.1-13(e) and the Code of Federal Regulations (CFR), Section (§)40 (Subtitle D), Part 258.14 require that “new MSWLF units… shall not be located in seismic impact zones, unless the owner or operator demonstrates… that all containment structures… are designed to resist the maximum horizontal acceleration in lithified earth material for the site.” HAR § 11-58.1-3 defines a “seismic impact zone” as an area with a 10% or greater probability that the maximum horizontal acceleration in lithified earth material (rock) would exceed the earth’s gravitational pull (g) by 10% (i.e., 0.1g) in 250 years.

According to the U.S. Geological Survey’s Seismic Deaggregation website (URL: http://geohazards.usgs.gov), the seismic hazard, magnitude, and the horizontal PGA can be determined for a set latitude and longitude. Using the Ma‘alo site latitude and longitude of 159.3579W, 22.0166N, a horizontal PGA of 0.10g was obtained (USGS 2014), noting the containment structure must be designed to resist maximum horizontal acceleration. Both the build-out stability analysis and final cover stability analysis have been evaluated for these seismic conditions.

The final cover system, waste mass, and base liner system of the proposed Ma‘alo MSWLF are expected to remain stable under a seismic event of 0.10g.

Liquefaction Evaluation

Liquefaction can occur in a saturated, cohesionless, medium-dense to loose sand layer, due to an earthquake that creates sudden high pore pressures, resulting in decreased shear strength. Liquefaction may cause ground failures such as settlement or lateral spreading.

Given the in situ soil material properties at the proposed site, including the lack of sandy soil (Section 4.1.6.1), liquefaction is not expected. While not expected to be an issue, liquefaction would be evaluated as part of the overall site geotechnical program during detailed design and permitting if sandy soils are encountered for any individual phase of the proposed landfill.

4.1.6.5 Geomembrane Compatibility

The geomembrane proposed for Ma'alo MSWLF is manufactured from HDPE, which has a high ultraviolet ray and chemical resistance while providing flexibility. These features make an HDPE geomembrane ideal for leachate retention at the proposed MSWLF. HDPE geomembranes are the predominant means of liner systems for all modern landfills.

HDPE geomembrane for the Ma'alo MSWLF base liner is the appropriate application, required by regulation, and would perform well in retaining collected leachate and overall site stability.

4.1.7 Gas Extraction System

A MSWLF requires a LFG extraction system to prevent buildup of dangerous levels of flammable gas (principally methane) that is produced by the microbial digestion of organic waste over time. Such a system includes wells, piping, and control devices to extract the gas for flaring off or collection and treatment as a fuel. This subsection discusses the requirements and emissions estimates for the LFG extraction system for the conceptual design of the facility. Projected waste receipts are based on 2012 actual waste receipts at the existing Kekaha MSWLF.

4.1.7.1 Applicable Requirements

Under the Clean Air Act, landfills may be subject to both New Source Performance Standards (NSPS) and National Emissions Standards for Hazardous Air Pollutants (NESHAPS).

New Source Performance Standards

The Clean Air Act contains, among other things, NSPS for stationary sources of air pollutants (40 CFR §60) that are intended to reduce the emissions of landfill gas, which is composed of both nonmethane organic compounds (NMOC) and methane. Once the permitted capacity of a landfill exceeds a threshold size, i.e., greater than 2.5 million megagrams (Mg) (i.e., 2.5 million cubic meters), the facility must conform to the NSPS requirements, beginning with submittal of both a design capacity report [40 CFR §60.757(a)(1)(ii)] and an initial NMOC report (CFR §60.754) to the EPA and DOH within 90 days of beginning construction. EPA has indicated that "beginning construction" means the letting of substantial contracts for construction. Phase 1 of the proposed MSWLF would have a design capacity greater than the threshold, but Cell 1.1 would not. Therefore, the time for compliance with the NSPS would depend on whether the County first permits Cell 1.1, or the entire Phase 1 landfill. The information included in this *Conceptual Design Report* is preliminary and is included for information and planning purposes. Specific requirements would be further refined during air permitting, subject to DOH CAB approval.

A preliminary analysis of the NMOC emission rate using the Tier 1 default inputs, the average waste acceptance rate, and the following equation indicates that NMOC emissions for Phase 1 may exceed 50 Mg per year (Mg/yr) during the 4th year of waste acceptance. The rate of NMOC emissions in any year (M_{NMOC}) is given by:

$$M_{NMOC} = 2L_o R (e^{-kc} - e^{-kt}) C_{NMOC} (3.6 \times 10^{-9})$$

Where:

L_o = methane generation potential (170 cubic meters per Mg solid waste)

R = average annual acceptance rate (74,389 Mg/yr)

k	= methane generation rate constant, 0.050 $year^{-1}$
t	= age of landfill (predicted Alternative 1-Phase 1 site life is 36 years)
C_{NMOC}	= concentration of NMOC (4,000 parts per million by volume as hexane)
c	= time since closure, years; for active landfill c=0 and $e^{-kc} = 1$
3.6×10^{-9}	= unit conversion factor

Therefore:

$M_{NMOC, max}$	= Peak mass emission rate of NMOC for the Alternative 1, Phase 1 landfill: 304 Mg in year 36 (the final year of Alternative 1, Phase 1 operations)

Based on the above preliminary results, the facility would be required to either install an active gas extraction system within 30 months after the NMOC Report that specifies NMOC emissions ≥ 50 Mg/yr, or recalculate NMOC based on either a Tier 2 or Tier 3 analysis. Tier 2 and Tier 3 analyses use onsite monitoring results to refine the estimated rate of NMOC emissions. Thus, the gas extraction system could be installed and operational 6 years after opening of the facility (within 30 months of submittal of the Tier 1 report demonstrating that the facility exceeds 50 Mg/yr), unless a Tier 2 or Tier 3 analysis is completed demonstrating that the facility emits less than this threshold, which would be more likely the more organics are diverted from landfilling (e.g., at the RRP).

If the Tier 2 analysis is conducted and results demonstrate that the NMOC emissions do not exceed 50 Mg/yr, or if the rate of landfilling decreases, then the requirement to install a gas extraction system may be deferred. An annual recalculation may be required (5-year forecasting is sometimes acceptable). Once the recalculation of NMOC emissions demonstrates that the 50-Mg/year threshold is exceeded, installation of a gas extraction system would be required within 30 months of the date on which the facility exceeds 50 Mg/yr, and the design would be a gas extraction system complying with the provisions of EPA's NSPS.

If the optional Tier 2 evaluation suggests a NMOC emission rate above 50 Mg/yr as hexane, then the facility would either conduct a Tier 3 test or install a gas extraction system in conformance with the requirements of the NSPS. If the optional Tier 3 evaluation suggests a NMOC emission rate above 50 Mg/yr as hexane, then the facility would need to install a gas extraction system in conformance with the requirements of the NSPS.

The County may elect to install a gas extraction system for the purpose of energy recovery even if the Tier 1 or Tier 2 calculations demonstrate that a system is not required. In this situation, the monitoring, reporting, or recordkeeping provisions of the landfill NSPS would not be applicable.

National Emissions Standards for Hazardous Air Pollutants

Landfills are also subject to NESHAPS in accordance with Sections 111 and 112 of the Clean Air Act (42 U.S.C. 1963). These standards require application of technology based emissions standards referred to as Maximum Achievable Control Technology (MACT). In accordance with HAR, landfills are covered sources. Landfills with a design capacity greater than 2.5 million Mg (or cubic meters) are required to submit a timely application for an operating permit under Part 70 or 71 ("covered source permit"). Thus, for the proposed MSWLF, an initial covered source operating permit would be submitted within 12 months plus 90 days from commencement of construction of the landfill, once it reaches 2.5 Mg permitted capacity. As noted above, EPA has indicated that construction means the letting of substantial contracts for the work.

4.1.7.2 Gas Extraction System Conceptual Design

A conceptual gas extraction system was developed for Phase 1 of the Alternative 1 proposed MSWLF for information and planning purposes. Detailed design, which would include component

sizing calculations and equipment selection, is not provided this report because the concepts could change in the future, which might necessitate new calculations. The conceptual design includes vertical gas extraction wells, associated header piping, a condensate management system, and a blower flare facility. The conceptual design also includes the capability to add an energy recovery system, if and when the County decides to do so.

Although the Phase 1 design capacity would trigger the landfill NSPS requirements, installation of the gas extraction system would probably not be required until approximately 6 years after initial waste acceptance. The gas extraction system conceptual design would nevertheless be applicable, unless modifications are made to the landfill design.

The gas extraction system is expected to include gas extraction wells, gas extraction piping, and a control device. The system components, which meet the requirements listed in 40 CFR §60.759, would be as follows:

- Air intrusion would be minimized by ensuring that the well screen is no closer than 15 ft to the finished ground surface and by using only the minimal required vacuum pressure to extract LFG.
- Damage to underlying liners would be avoided by ensuring that the well borehole does not extend closer than 10 ft to the liner material.
- Corrosion-resistant materials such as polyvinyl chloride (PVC) or HDPE would be used.
- Extraction wells would have connector assemblies (e.g., closing valves, sampling ports) suitable for NSPS monitoring.
- Extraction devices would be installed at appropriate spacing intervals to ensure that gas is extracted from all areas warranting control, as detailed in Appendix E.2.
- The gas system would allow for expandability and accessibility: blind flanges would be included at strategic locations in the system layout to allow for future gas system expansions. In addition, HDPE pipe could be cut and new components fused in place to expand the system easily, if needed.
- The flexibility and the modulus of elasticity of the header pipe material would be verified to be sufficient to prevent collapse due to settlement and to withstand planned overburden and traffic loads. Well pipes would not be PVC because PVC is more susceptible to bending when heated.
- The active gas extraction system would be designed to handle the maximum expected gas flow rate from the entire area of the landfill that warrants control, over the intended use period of the gas extraction system equipment.
- Open flares used for control would be designed and operated in accordance with 40 CFR §60.18.

Drawing 9 shows the conceptual gas extraction system layout for Phase 1, and Drawing 36 and Drawing 37 include conceptual details for the gas extraction system components. These drawings are conceptual, and the actual, detailed gas extraction system layout and components, including header pipe sizing, pressure loss calculations, and gas mover equipment, would be specified during final design and permitting, subject to regulatory approval.

Gas Extraction Rates

To ensure future compliance with landfill NSPS, specifically, 40 CFR §60.752(b)(2)(ii)(A)(3) and (4), should the facility become subject to those provisions, the gas extraction system would be designed to extract LFG at a sufficient rate to minimize the subsurface lateral migration and surface emissions of LFG. Anticipated gas generation rates are calculated in Appendix E.1. The required rate of

extraction would be achieved by sizing and installing sufficient extraction elements, transmission piping, blower(s), and control device(s) for the estimated maximum flow rate of LFG.

The gas extraction system would be designed to extract LFG at a sufficient rate to maintain a negative gauge pressure at all wellheads, per 40 CFR §60.751. Application of a negative gauge pressure and minimization of air infiltration would be verified by regular monitoring of each LFG wellhead.

Per the definition stated in 40 CFR §60.751, “sufficient density” (i.e., the spacing intervals between the LFG extraction wells) means “any number, spacing, and combination of extraction system components necessary to maintain emission and migration control ….” Preliminary well spacing, as shown (Drawing 9), was established based on expected site-specific conditions (e.g., waste age, waste density, moisture content), zone of influence (ZOI) estimates, past experience, and engineering judgment. This is consistent with spacing criteria used at other Hawai‘i landfills, and should effectively control surface emissions and subsurface migration of LFG in accordance with NSPS requirements.

LFG Generation Rates and Flow Characteristics

In compliance with 40 CFR §60.752(b)(2)(ii)(A), the maximum expected LFG flow rate for the site, including Phase 1, would be used for sizing the gas extraction system. The preliminary peak Phase 1 LFG generation rate is estimated to be 1,418 cubic ft per minute, based on the Landfill Gas Emissions Model (LandGEM) (Alexander et al. 2005) presented in Appendix E.1.

Depths of Extraction Wells

The depths of the extraction wells would be limited to prevent physical contact with the underlying liner system, which could compromise the liner, and to prevent intake of perched liquids, which could inhibit gas extraction. The vertical wells would be installed at the appropriate depths as designed by a professional engineer in a manner to maximize capture of LFG without compromising the landfill liner system.

LFG Extraction System Components

The gas extraction system is designed to maximize extraction of landfill gas while minimizing induced air infiltration through the cover into the landfill. Both vertical and horizontal gas extraction wells are typically used to extract LFG from landfills. This subsection describes the preliminary LFG extraction system design.

Vertical LFG Wells

Detail 2 on Drawing 36 shows a typical vertical well configuration. The lower portion of the well casing is slotted and surrounded by a clean gravel pack to enhance transport of gas into the well while inhibiting waste from entering the well. The upper portion of the well is not slotted and is surrounded by bentonite seals and a well boot to prevent ambient outside air from “short-circuiting” the well, which would reduce the ZOI and effectiveness of the extraction wells. LFG enters the well pipe through slots in the well pipe extending through the portion of the well backfilled with clean gravel. Typically, the minimum open area of the slots is 12 square inches per foot to provide sufficient open area for free flow of gases while minimizing the compressive stress on the well screen.

A well’s zone of influence is the area from which the well effectively draws LFG, and is primarily limited by the amount of vacuum that can be applied without causing an excessive amount of air intrusion into the landfill. Typically, to reduce air intrusion and short-circuiting and thereby increase the ZOI, the upper 1/3 of the final well depth (with a minimum of 10 ft and a maximum of 25 ft) is not slotted or backfilled with gravel. Experience has shown that this ratio provides a good balance between air intrusion control and LFG extraction efficiency. Air intrusion is also minimized by using

soil backfill in the upper zone of the vertical wells and hydrated bentonite seals both above the lower clean gravel pack and where the pipe penetrates the landfill soil cover. The final cap design would also likely include a "boot" around the well in the vicinity of the anticipated geosynthetic cap material, to further minimize air intrusion and short-circuiting. Air intrusion and LFG emissions would be controlled through periodic monitoring and adjustment of the gas extraction system in coordination with appropriate maintenance of the landfill cover system.

Details of the conceptual design for gas extraction wells are provided on Drawing 36 and Drawing 37. The ZOI for each well is based on the Darcy equation calculation shown in Appendix E.2.

Extraction Well Perforation and Backfill

Extraction wells must be perforated to allow LFG entry without excessive head loss, and the surrounding gravel pack must be sized to prevent blocking of perforations. Many site-specific factors would be examined to determine the length of the slotted portion of the gas well. Due to the costs associated with new well installation, it is in the best interest of the landfill to choose the optimal slot depth to extract as much gas as possible from the well, yet maintain compliance with NSPS well parameters. For example, slots/perforations may be extended if odors are a problem).

The well detail and pipe perforation detail provided on Drawing 36 are expected to meet the requirements for the system, but may be modified during final design.

Well/Extraction Device Backfill

Gravel, washed aggregate, or other acceptable crushed stone (with low carbonate content) of sufficient size and/or inert non-calcareous material would be used for extraction device backfill to prevent penetration or blockages of the LFG extractor pipe perforations/slots. An acceptable substitute may be used if it prevents blockage/penetration of the extractor pipe perforations/slots, subject to DOH approval.

Accessibility

The system would be designed to provide accessibility to the gas extraction system components by persons on foot. Wellheads would extend above grade for ease of access and would be surrounded by bollards, where required, for protection.

Condensate Management

Condensate that forms in the transmission piping would be managed by sloping the LFG transmission piping to low points in the gas extraction system, where sumps and drains would be located to collect and remove the condensate from the transmission piping. Removed condensate would be managed by the site leachate management system (Section 4.1.8).

Control Systems

The Clean Air Act NSPS require that LFG extracted by a NSPS-compliant gas extraction system be sent to NSPS-compliant control system device(s), such as an open flare, an enclosed NMOC-reduction combustion device, or a treatment system that processes the gas for subsequent sale or use (see Section 6.1.2) [40 CFR §60.752(b)(2)(iii)]. A LFG control device, devices, and/or treatment system would be chosen to adequately comply with the NSPS requirements. Control device(s) at the landfill would be adequately sized to handle all the gas extracted by the gas extraction system. NSPS-compliant control devices to address the LFG produced by the site would be installed as needed to combust or condition the extracted LFG.

The control systems are not being selected at this time because the County's need and the system sizing requirements may change over time. Any control device employed would be designed, chosen, installed, and operated in compliance with applicable regulations. The capacity of the control system may increase and decrease over time in response to changing waste streams and changing

amount and quality of LFG produced by the landfill. Therefore, the control device, devices, or system chosen for any interim or future timeframes may vary depending on the site-specific LFG characteristics including the quantities produced. All designs or design changes to the LFG control system would be subject to regulatory review and would be reviewed by a professional engineer to determine if an air permit is necessary.

4.1.8 Leachate Management System

Leachate is any liquid that contacts and is then released by waste materials. Leachate must be properly collected and managed due to its potential for containing environmental contaminants. Water entering the MSWLF from rain events or arriving at the site within the waste percolates through the MSW and collects in the granular drainage layer overlying the liner system. This leachate is removed by leachate collection and transmission pipes located in the granular drainage layer. Drawing 6 displays a schematic of the overall leachate management system proposed for Alternative 1 Phase 1. Details are shown on Drawing 31, Drawing 32, and Drawing 33, and would be further refined during the design phase, subject to regulatory review.

Phase 1 would be divided into seven areas that each drain to the west. Each area would have one leachate collection and transmission pipe. The pipes would have a minimum 2.0% slope toward the perimeter. At the perimeter, the perforated leachate collection pipe would transition to a non-perforated pipe that would drain to a dual-contained leachate transfer pipe located within the perimeter berm. The dual-contained leachate transfer pipe would gravity-drain to a wet well located near the southwest corner of Phase 1. The leachate would then be pumped through a force main to the proposed Leachate Evaporation Pond (but see potential design alternatives in Section 6.1.3). Details of the wet well and leachate load out pad are presented on Drawing 33.

The leachate collection pipes would be constructed of 8-inch-diameter perforated HDPE with a standard dimension ratio of 9 to protect against crushing. A leachate collection pipe strength analysis was performed considering future conditions. The analysis assumed a maximum waste depth overlying the leachate collection pipe on the landfill floor of 252.5 ft, and a maximum cover depth over the dual-contained leachate transfer pipe of 234.5 ft. The pipe strength calculations have determined that the proposed pipe sizes, perforations, and wall thickness would have suitable factors of safety.

Appendix D presents supporting calculations for the leachate management system, including estimated leachate generation rates, pipe capacity requirements, pipe strength analysis, perforation sizing, and leachate evaporation pond sizing.

4.1.8.1 Leachate Generation

The amount of leachate expected to enter the leachate collection and transmission pipes was estimated for Phase 1 using the EPA HELP Model Version 3.07 computer modeling program (Schroeder et al. 1994) under two conditions: active and intermediate. Active conditions represent areas of active waste filling when 6 inches of daily cover is in place. Intermediate conditions represent areas with 12 inches of intermediate cover soil in place. Conservatively, the calculations consider all areas prior to placement of final cover.

The HELP Model was used to estimate the daily leachate generation value on a per-acre basis. The total amount of leachate generated at the facility is largely based on the total area of the site that is open at any given time for waste disposal. The leachate generation rate depends ultimately on coordination of intermediate cover placement, closure of portions of the facility at final grade, and the promotion of surface water drainage and management during interim active conditions.

The HELP Model was used to estimate maximum peak daily, average monthly, and average annual leachate generation rates for Phase 1 when all the base area draining to the southernmost two leachate collection pipes of Phase 1 is active and the rest of Phase 1 is under intermediate

conditions (i.e., a conservative representation of conditions during operation of the last cell in Phase 1). The HELP Model uses the following assumptions:

- Modern construction practices and construction quality assurance (CQA) practices ensure proper geomembrane placement and minimize damage to the liner. For modeling purposes, good installation placement of the geomembrane base liner is assumed in the HELP model. To consider potential damage that may occur to the geomembrane during landfill construction, two installation defects per acre are assumed. An installation defect is assumed to be a round hole with an area of 1 square centimeter. The model also considers the potential for defects resulting from the manufacturing process. Modern manufacturing and factory quality control minimizes the potential for pinholes in the geomembrane caused by the manufacturing of the geomembrane. The model assumes manufacturing defects to consist of one pinhole per acre, with a diameter of 1 millimeter.
- The waste mass is assumed to be at field capacity, and therefore not absorbing water (this is a conservative assumption).

Temperature, precipitation, and average wind speed data from the nearby Līhu‘e Airport for January 2003 through December 2012 were used. The HELP Model inputs and output are detailed in Appendix D.1. The following approximate design leachate generation rates were calculated for Phase 1:

- Peak Daily Value: 174,000 gal/day
- Average Monthly Value: 44,000 gal/day
- Average Annual Value: 23,000 gal/day

4.1.8.2 Leachate Collection Pipe Dimensions

As shown in shown in Appendix D.2, the required leachate collection pipe spacing was determined by first calculating the maximum pipe flow capacity using Manning’s equation for the 8-inch collection pipe, and conservatively assuming full flow within the pipe. Using a minimum slope of 2%, the pipes can transmit 801,400 gallons per day. The peak daily leachate generation rate is approximately 5,240 gallons/acre/day for open conditions. Therefore, one single pipe at a slope of 2% can accommodate leachate flows from nearly 153 acres. The entire Alternative 1 Phase 1 encompasses 44.9 acres and includes multiple leachate collection pipes. Therefore, the leachate collection piping capacity is more than adequate to convey the leachate generated in Phase 1.

Perforation sizing of the leachate collection pipe was also analyzed to ensure proper flow into the pipe and removal of the leachate from the base liner. Perforations of 0.5 inch spaced 5 inches on center are adequate for leachate pipe flow. Calculations are provided in Appendix D.4.

The proposed leachate collection pipe dimensions would adequately collect leachate and minimize head on the base liner system.

4.1.8.3 Leachate Transfer System

Leachate flows to the leachate collection pipes located along the base liner low points and gravity-drains within the pipes along the 2% base grade until it reaches the perimeter dual-contained leachate transfer pipe. The dual-contained leachate transfer pipe is an 8-inch-diameter pipe sloped at 0.5% to a wet well near the southwest corner of the landfill. Maximum daily flow from Phase 1 is estimated to be approximately 174,000 gallons/day (121 gallons/minute). Leachate would be pumped from the wet well to the leachate evaporation pond through dual-contained HDPE forcemain piping. A 4-inch forcemain pipe is sufficient to handle anticipated leachate flows from the entire Phase 1. The forcemain sizing would be reviewed during detailed design of future landfill phases, at which time actual leachate flow data would be available from Phase 1. Transfer pipe and wet well details are shown on Drawing 33.

Leachate levels in the wet well are controlled by the use of pressure transducers set for specific elevations to trigger pump on, pump off, and high-level alarm. The controls for the leachate pumps would be housed in a control panel near the wet well. Calculations for pipe strength of the leachate collection pipes are included in Appendix D.3.

The proposed leachate transfer system would meet the leachate extraction requirements and would ensure that the maximum allowable leachate head on the base liner system is not exceeded.

4.1.8.4 Leachate Evaporation Pond Sizing

Leachate is proposed to be treated on site using a lined leachate evaporation pond with aerators, as is currently done at the County's existing Kekaha landfill. Use of an evaporation pond to treat the leachate eliminates (or at least reduces) the need to transport leachate off site for treatment at a wastewater treatment plant (see potential design alternatives in Section 6.1.3). The leachate evaporation pond has been designed based on the anticipated average monthly leachate generation rates estimated using the HELP Model (Section 4.1.8.1). The recommended size of the pond has been calculated for the Alternative 1 layout, based on conservative assumptions when all of Phase 1 has been constructed, including 10 acres with a 6-inch daily cover, and 34.9 acres with 12 inches of intermediate cover. The design provides sufficient evaporative area so that pond storage and pan evaporation would meet or exceed the leachate inflow to the pond. Evaporation and treatment would likely be supplemented with the use of powered aerators. The leachate evaporation pond sizing calculations show that the proposed 5.4-acre pond will work for the entire Alternative 1 Phase 1 area, as detailed in Appendix D.5. The recommended holding capacity is dependent on assumed leachate generation rates and landfill conditions, which would vary during the life of the landfill. The evaluation of leachate pond size requirements may change over the life of the proposed landfill. The complete Phase 1 holding capacity would be further evaluated during the detailed design phase, subject to DOH review prior to site development.

A leachate load-out facility would also be included at the west end of the leachate evaporation pond. Should the pond approach capacity due to greater than average rainfall and/or leachate generation, or other temporary needs dictate, the leachate could be pumped into tanker trucks and transported to a wastewater treatment plant (WWTP).

During later Phases of development (Phases 2-4), it is expected that Phase I would be covered, minimizing rainfall infiltration, and that the liquids would eventually stabilize and stop contributing to leachate. This would be offset by the generation of leachate in the subsequent Phases, such that the proposed leachate evaporation pond sized for Phase 1 should also be able to handle leachate from later phases. If not, the potential design alternatives in Section 6.1.3 could be implemented, or additional on-site areas could be devoted to leachate treatment (Drawing 2).

4.1.9 MSWLF Surface Water Management System

A surface water management system must be established to maintain the stability of the landfill, minimize erosion and generation of leachate, and prevent transport of contaminants to offsite areas. Typically, this is accomplished by controlling surface water run-on to the site from offsite areas and stormwater runoff from the site, through a network of berms, channels, and other structures.

Drawing 8 shows the overall proposed Alternative 1 Phase 1 surface water management system, Drawing 34 and Drawing 35 show design details, and Appendix C presents design details and detailed supporting calculations. It is anticipated that the system would be expanded as needed to cover each phase as the phase comes online. The surface water management system was designed and analyzed to confirm that the proposed system would be capable of handling the design flow rates and to ensure that Phase 1 post-development peak flow rates to offsite areas would not exceed pre-development peak flow rates during the design storms, in accordance with the County of Kaua'i Department of Public Works (DPW) *Storm Water Runoff System Manual* (DPW 2001), while ensuring that surface water basins discharge all collected water within 48 hours after the conclusion

of a storm event. As an incorporated design alternative (see Section 6.1.4), the surface water basins are designed to remain dry between storm events.

The analyses were completed using SEDCAD+, a state of the art computer program developed by the University of Kentucky to assist in the design and evaluation of surface water management system components. The program is capable of computing peak flows and runoff volume, sizing channels and culverts, and calculating the hydraulic performance of sedimentation and infiltration basins. Methods utilized in SEDCAD+ include the Soil Conservation Service (SCS) Upland Curve Method for calculating time of concentration, Muskinghum's Method for routing between structures, and SCS Technical Release - 55 (TR-55) parameters for runoff volumes.

In accordance with County DPW guidelines (DPW 2001), the stormwater analysis evaluated pre- and post-development site conditions under two different storm events:

- 100-year 1-hour storm event of 4.9 inches of rainfall
- 25-year 24-hour storm event of 13.4 inches of rainfall

To further assess the performance of the surface water basin, the Phase 1 post-development conditions were also evaluated for the 100-year 24-hour storm event of 17.5 inches of rainfall. The peak rainfall values are based on the design plates in the County DPW *Storm Water Runoff System Manual* (DPW 2001). Appendix C.1 presents the design storm data and other site-specific design parameters.

As detailed in Appendix C.6 and Appendix C.7, run-on to the property would be routed around the landfill facilities by channels, culverts, and berms. Generally, run-on routed around the facility would discharge from the site at locations similar to pre-development flows (e.g., in the north and south troughs of the saddle areas). As detailed in Appendix C.2, the stormwater analysis confirms that the peak flow rates exiting the site to the north and the south would be reduced from the existing conditions during the design storms as a result of site development. Therefore, no negative impacts to downstream features or structures should occur.

Surface water flow on the landfill itself would be controlled to prevent contact with waste and minimize the potential for erosion of the landfill cover. Diversion berms would be located on the landfill sideslopes, approximately 10–30 ft below the perimeter of the Phase 1 landfill top deck. These berms would direct surface water to rock-lined downslope channels. Each downslope channel would have a trapezoidal cross-section and convey water to a surface water basin via a perimeter channel or a culvert in some locations. During operation of each phase, temporary sideslope berms and surface water control features would be maintained to prevent contact with waste and minimize potential for erosion of the landfill intermediate cover. Operationally, this may require construction of temporary sumps to collect surface water adjacent to developed liner areas.

As detailed in Appendix C.2, the Phase 1 surface water basin has been designed to accommodate surface water runoff from the landfill for both the 100-year 1-hour and 25-year 24-hour storm events. The basin would also safely pass the 100-year 24-hour storm event. Because the surface water basin is open-air, it is designed to discharge all water within 48 hours of the storm conclusion in order to minimize standing water, which could attract wildlife. As detailed in Appendix C.3, the diversion berms, consisting of low-profile compacted soil mounds, are designed to convey runoff from a 100-year 1-hour storm event and the 25-year 24-hour storm event, with minimal freeboard in place.

As detailed in Appendix C.4, each of the downslope channels would have sideslopes of 2:1 and a width of 4 ft, would be lined with riprap for erosion protection, and would be capable of managing the 100-year 1-hour and 25-year 24-hour storm events.

4.1.10 Initial Site Development Activities

The initial development of the Alternative 1 proposed MSWLF is summarized on Drawing 10 and Drawing 11 and includes Cell 1.1, the leachate evaporation pond, the surface water management system, the shop, scale house, drop-off area, parking lots, and internal roadways. Construction activities that would be required prior to beginning landfilling operations at the site include the following tasks:

- Construction of temporary erosion control, dust control, and best management practices (BMPs)
- Construction of offsite access roads and utility lines
- Site clearing and grubbing
- Construction of onsite access roads
- Excavation and mass-grading
- Subgrade preparation
- Installation of the Cell 1.1 landfill liner
- Installation of the leachate management system
- Construction of the leachate evaporation pond
- Construction of the surface water management system, including the infiltration basin
- Construction of the septic system, office building, shop, scale and scale house, and public drop-off facility

To ensure protection of the site from erosion during storm conditions that occur during excavation and grading work, ground disturbance would be held to the minimum area necessary to accommodate movement of heavy equipment and materials required for construction. To ensure proper construction and environmental controls during site work, BMPs would be in place, and an independent construction management (CM)/CQA firm would monitor construction. Staging and stockpile areas would be prepared as necessary with appropriate surface water discharge pollution prevention features. Additional measures would be employed for fugitive dust containment, parking areas for workers, water, and the establishment of access roads and utilities.

Upon completion of site preparation activities, site restoration activities would include repairing inadvertent damage or other impacts to roadways or other offsite features, if any. Construction staging areas would be cleaned and re-graded. All areas impacted by construction would be properly cleaned, graded, and restored via seeding, hydro-mulching, or revegetation, as appropriate.

4.1.11 Building Infrastructure

Infrastructure such as office and maintenance buildings, scale house, and parking areas are required for operating a MSWLF. Drawing 10 shows the infrastructure facilities for the Alternative 1 proposed MSWLF, including the shop area, scale house, drop-off area, and internal roadways. Buildings and scales are expected to be similar to those facilities at the existing Kekaha MSWLF, with the exception of the office building, which is expected to be one-half the size of the existing office at the Kekaha MSWLF. Site utilities and wastewater design are presented in Section 4.3.

4.2 ALTERNATIVE 1 PROPOSED RESOURCE RECOVERY PARK

As part of this project, the County is considering establishing a RRP that includes a range of co-located resource recovery facilities near the proposed MSWLF to achieve greater waste diversion. Potential waste diversion activities that could be co-located at a RRP were studied in the *Kaua'i Resource Recovery Park Feasibility Study* (RRP FS) (AECOM 2013; EIS Appendix C), which evaluated various components and technologies based on the potential for diversion of wastes from

the municipal landfill, capital and operations and maintenance (O&M) costs, space requirements, anticipated benefits, and potential impacts to the community. The RRP FS and facility design are based on data collected in various studies and analyses previously conducted, including:

- *Integrated Solid Waste Management Plan,* County of Kaua‘i (Beck 2009)
- *Centralized Composting Facility Master Plan,* County of Kaua‘i (Beck 2008)
- *Pilot Curbside Recycling Report,* County of Kaua‘i (SAIC 2011)

The RRP FS (AECOM 2013; EIS Appendix C) recommended the following facilities for inclusion at the proposed RRP, and provided the basis of design for the facility capacities and sizing:

- Integrated public drop-off and reuse facility
  - Recyclables and waste drop-off
  - HHW depot
  - Electronic waste depot
  - Metals recycling facility
  - C&D debris material processing and recycling facility
  - Used tire processing facility
  - Center-for-hard-recycle materials (CHARM)
  - Reuse center
  - Educational center
- Materials recovery facility (MRF)
- Composting facility
- LFG-to-energy facility (reserved area for potential future implementation)

This list of recommended RRP facilities has been carried forward for inclusion as key design elements in this *Conceptual Design Report*. While the County is committed to maximizing waste diversion activities, it may not be able to provide all of these RRP facilities at the beginning of operations. This design should therefore be considered a master plan, which may be implemented in phases, and may be modified in the future should conditions or technologies change, presenting additional opportunities.

Alternative 1 sites the proposed RRP at an 83-acre parcel near the proposed Ma‘alo MSWLF parcel (Figure 1 and Drawing 14). Because the Alternative 1 RRP site is much larger than the Alternative 2 RRP site, the Alternative 1 RRP site offers more flexibility for the County to change in response to changing conditions over time. The facility layout for the Alternative 1 proposed RRP is illustrated on Drawing 15 through Drawing 18.

4.2.1 Facilities

The RRP facilities described herein may potentially be implemented in phases over time. Initially, the RRP would likely include, at a minimum, the Integrated Public Drop-Off and Reuse Facility.

4.2.1.1 Integrated Public Drop-Off and Residual Waste Tipping Area

The RRP FS (AECOM 2013; EIS Appendix C) recommended several critical facilities for inclusion in the RRP integrated public drop-off area. Integrating or centralizing drop-offs at a single location can enhance the experience of a RRP user, decrease the transportation and time that may otherwise be required to take materials to multiple locations, and promote increased diversion. This subsection

discusses each component and specifies the quantities of materials that formed the basis for the design of each.

By the end of the 20-year planning period, 9,900 TPY of materials may potentially be diverted through this public drop-off facility and reuse center (AECOM 2013; EIS Appendix C). These materials include recyclables, green waste, C&D material, used tires, scrap metals, and residential waste. The integrated public drop-off facility includes three separate drop-off locations in the RRP:

- Public drop-off
- White goods drop-off
- Residual waste tipping area

The integrated public drop-off and residual waste tipping area would require an area of approximately 5–10 acres, based on the design of similar facilities developed by AECOM on the mainland. The combined area required for all the drop-off components is a function of the site area available, anticipated number of vehicles to be accommodated during peak periods, parking requirements, and access for service vehicles (see Drawing 15 and Drawing 16).

The proposed integrated public drop-off facility includes the following features:

- Up to four bins (two active and two on standby) for the receipt/temporary storage of single-stream or commingled recyclable materials, plus one bin for oversized cardboard and six to eight bins for residential waste drop-off
- A HI-5 (State Deposit Beverage Container program) redemption center
- A specially designed building for the receipt, consolidation, lab-packing, and storage of HHW and consolidation of electronic waste
- One duty bin and one standby bin for each of the following, plus associated processing areas:
  - Greenwaste
  - Scrap metals including white goods and propane tanks
  - C&D waste
  - Used tires
- An enclosed storage area for hard-to-recycle materials (CHARM) not already addressed through the other proposed facilities and programs
- A reuse center
- An educational center
- Drop-off covered areas for waste motor oil and filters and for used cooking oil (space to accommodate four to six 55-gallon drums

The quantity of bins proposed for each waste type is based on standard practices and similar facilities developed by AECOM.

Public Drop-Off

The public drop-off facility would be the main collection point for most materials processed at the RRP, and would therefore be located near the RRP entrance to accommodate higher traffic and promote increased diversion through ease of access, visibility, and awareness. Bins would be provided for the public to self-sort materials into separate containers for recyclables, green waste, oversized cardboard, residential C&D debris, and scrap metals.

Upon entering, the public would drive their vehicles up a ramp onto an elevated platform. Collection bins would be placed at a lower grade to allow residents to drop the materials into the bins and avoid potential injuries from lifting. Several bins would be available to allow the public to self-sort recyclable materials into different bins. The drop-off area would be covered by a canopy to prevent stormwater from coming into contact with dropped-off materials. After materials are deposited by the public, the RRP operator would transfer the materials to appropriate areas of the RRP for further processing.

Residual Waste Tipping Area

A drop-off area for residual MSW would be located near the recyclable drop-off area, as a final option to manage any residual waste that cannot be reused, recovered, or recycled. Co-locating an MSW drop-off area near the recyclable drop-off area promotes the integrity of the recycling material streams, which directly affects marketability. Open-top bins under a canopy-covered area would be provided to collect the residual wastes. The public would drive to this area and deposit the residual waste into the storage bins. The bins would be placed at ground level. Once the waste bin reaches capacity, or daily, whichever occurs first, the waste bin would be transported to the MSW landfill, and a standby bin put into active duty at the drop-off area.

White Goods Drop-Off

The white goods drop-off area would include a 3,500-ft^2 compacted clay pad where white goods can be left by the public. The size of the white goods drop-off area is based on best practices of similarly sized facilities that have been developed by AECOM. The white goods would then be moved by the RRP operator to the white goods storage area proposed to be located in the eastern part of the RRP. White goods would be moved to the storage area at the RRP operator's discretion, e.g., when white goods are accumulating in the drop-off area, or to prevent them from being left for extended periods.

Additional Information

It is expected that the facility would be staffed by approximately 12 personnel at a given time. A large variety of materials can be managed in one location, thus providing additional efficiencies and cost savings for operation equipment and staff requirements.

The proposed capital cost requirement is based on paved roadways and other areas. The capital cost estimate(see Section 8.1.2) includes: site clearing and grubbing, excavation, paved roadways, other paved areas, scale and scale house, residual drop-off area canopy, HHW and electronics building, HI-5 building, reuse center, utilities, permits and engineering, and a contingency.

The RRP is expected to receive approximately 26 inbound/outbound vehicles per day from the public, as well as 4 small trucks operated by facility employees (inbound/outbound), and 12 employee personal vehicles (inbound/outbound) per day. The facility is expected to expel approximately 100 roll-off trucks inbound/outbound per year; integrated drop-off material leaves the facility in roll-off trucks.

4.2.1.2 Reuse and CHARM

Direct local reuse of items can be considered the highest-value waste diversion process, as it is the least resource- and energy-intensive option, encourages local direct reuse, and displaces the purchase of new items. A reuse center typically provides an opportunity for the exchange of second-hand or gently used items, such as clothing, furniture, computers, sporting equipment, housewares, and building materials. Generally, the items must be clean and in good working condition. These materials are received from the public and then resold as-is for a fee. Some higher-value items may be repaired or refurbished by staff in order to enhance the potential reuse of the item.

Hard-to-recycle materials are typically generated in small quantities, and include materials for which there are very limited markets and secondary uses. These materials may include but are not limited

to certain types of plastics (e.g., large durable #2 and polystyrene), foam blocks, plus various household items (e.g., textiles, hardcover books, and mattresses). These materials would be collected, segregated, and stored within an enclosed building co-located with the reuse center.

The CHARM component would be an enclosed facility located near the entrance as it would likely be the first stop of many RRP visitors (see Drawing 16). An 11,000-ft^2 pre-engineered building along with an area for outside storage of materials is proposed for the reuse and hard-to-recycle center at the RRP. The building size is based on the projected quantity of materials that would be managed and the estimated period that materials would be held.

It is expected that three to four full-time staff members would be employed at the CHARM to supervise the facility and market any collected hard-to-recycle materials. Adequate parking space would be provided for visitors and working staff. The reuse and hard-to-recycle materials center is suggested as an inclusion to the RRP, and traffic estimates associated with the integrated public drop-off facility include the CHARM.

4.2.1.3 HHW and Electronic Waste Depot

A stand-alone depot for the collection and storage of domestically generated hazardous wastes (limited to household quantities) and electrical waste is proposed to be included at the RRP. The County may also consider accepting small quantities of hazardous waste from small businesses and farmers, as appropriate, and subject to permitting requirements. Typical HHWs include aerosols, batteries, oil, paint, cleaning products, pesticides, and propane cylinders. Electronic wastes include computers, monitors, televisions, and stereo equipment. The inclusion of the HHW and electronic waste depot as a stand-alone facility would enable the RRP to better manage and store these types of materials separate from other recyclables and MSW, thereby preventing commingling and cross-contamination. The HHW and electronic material would be sheltered in order to prevent exposure to climatic conditions that may affect the accumulated materials, preserve the value of the material, and prevent contact with rainwater.

The HHW and electronic depot would be a pre-engineered building with an area of approximately 5,000 ft^2 (Drawing 16). Of the total building area, 3,000 ft^2 would be for HHW materials and 2,000 ft^2 would be for electronic waste material. Sufficient space is required inside the building to provide a receiving area to allow the materials to be inspected and a determination made on how they are to be managed prior to accepting the material. Space is required for bulking of materials including paints and flammable liquids, and additional space is required for the wastes once they are properly packed in drums or containers, prior to shipment offsite. One or two 20- or 40-foot shipping containers may be required for the receipt and temporary storage of electronic waste. Approximately 370 TPY of residential HHW is currently generated in the County, and it is expected that 300 TPY of electronic waste would be diverted to the facility (AECOM 2013; EIS Appendix C).

The facility would be constructed with non-combustible materials, properly ventilated, and provide spill containment and fire safety features. Enhanced safety features included in construction can result in increased construction costs, but are required to maintain the usability of the facility and provide a safe human environment.

Adjacent to the HHW and electronic waste depot building, a 500-ft^2 concrete pad would be situated for drum storage of waste cooking oil, waste motor oil, filters, and a secure fenced area for propane tanks. The concrete pad is sized to enable sufficient drum storage and provide secondary containment.

The facility would be staffed by two trained personnel to manage electronic wastes received and coordinate and supervise HHW drop-off.

4.2.1.4 HI-5 REDEMPTION CENTER

The RRP provides an ideal location for a HI-5 redemption center, maximizing diversion of these materials and the return of deposit fees to residents. The redemption center would be staffed on a full-time basis and would be located adjacent to the reuse center/CHARM (see Drawing 16). The HI-5 center would require a minimum of three full-time staff, based on existing redemption center requirements.

A 3,000-ft^2 pre-engineered building is proposed for the HI-5 redemption center, based on the quantity of material the RRP is anticipated to receive. It is estimated that approximately 2,730 tons of HI-5 containers were dropped off at private depots throughout Kaua'i in FY2011. For sizing of the facility, it is assumed that 30% of the current quantity may be processed at the County's facility, with the potential to increase to 70% by the end of the 20-year planning period (AECOM 2013; EIS Appendix C).

4.2.1.5 MATERIALS RECOVERY FACILITY

A MRF is a processing facility that receives recyclable materials, sorts the materials based on type, removes any contaminants, compacts the materials, and bales them into a form suitable for transport and sale to markets. Although the County may implement a MRF at another site prior to the opening of this facility, the RRP master plan includes a MRF, which is an essential component of the County's waste diversion strategy. Should a MRF be sited elsewhere prior to opening of the RRP, the County has the option to relocate it at the RRP for cost savings.

The proposed MRF building dimensions are 225 ft × 150 ft × 28 ft height. The building includes:

- Two overhead doors to receive materials
- Two depressed loading docks to load recovered materials
- Two overhead doors to facilitate the removal of roll-off bins

Included in the interior of the process building is a combined elevated glass-enclosed walkway and classroom to facilitate educational tours, as well as a single-story office area (3,000 ft^2) constructed of architectural block (see Drawing 17).

The proposed design of the MRF considered the following design parameters:

- Lower bound: Estimate for curbside-collected residential materials with no recovery from the commercial sector, at the end of the 20-year planning period, is 7,682 TPY (AECOM 2013; EIS Appendix C).
- Projected upper bound: Estimated recovery from the commercial sector at the end of the planning period is 14,265 TPY. Adding this to the upper limit of the residential figure of 12,417 TPY results in a total expected capacity of 26,683 TPY at the end of the planning period.

The proposed MRF consists of a single-stream sorting system with a capacity of 10 tons/hr capacity. The MRF sorting process includes the following major steps:

- Potentially recyclable materials are loaded into an in-feed conveyor (either an in-floor conveyor or a conveyor and storage hopper arrangement mounted on a concrete slab).
- The materials are moved by conveyor belt to three pre-sort stations for the removal of old corrugated containers (OCC), film, large rigid plastics, and non-recyclable MSW.
- A glass breaker screen is used to separate glass fractions less than 2 inches. Glass falls into a bunker or roll-off bin below the pre-sort station.

- Materials are then moved by conveyor to a disc screen to separate fibers from containers. Based on a difference in dimensions, large fiber materials rise over the top of the disc screen onto a fiber quality post-sort line, while small OCC, film, and containers are removed to a mixed paper stream. Two bunkers are dedicated to the interim storage of the mixed paper fraction prior to baling.
- Containers fall through the screen onto a transfer conveyor to a "container-line." The transfer conveyor passes a fiber post-sort station to allow for manual fiber removal prior to the container sort line. The container sort line includes the following components:
  - Magnetic separator to remove ferrous materials
  - Eddy current separator to remove aluminum
  - Six push-through-style manual sort bunkers for steel, polyethylene terephthalate (PET), and HDPE. Two spare bunkers are also included to provide the future option to sort HDPE by color and expand the program to include #3–#7 plastics, should a market develop
  - Push-through bunkers onto baler feed conveyor
  - Compactor for residual material
- A two-ram baler to bale both the fibers and containers
- Manually diversion of OCC from the waste stream, where it is either floor-sorted or removed off the pre-sort station

The MRF is expected to have 15 full-time staff:

- 1 – facility manager
- 1 – receptionist/materials sales
- 1 – supervisor/mechanic
- 1 – scale house operator
- 1 – equipment operator
- 10 – sorters (2 on pre-sort, 2 on the fiber line, 2 on the container line)

4.2.1.6 Education Center

An education center would be included in the MRF building to support large group presentations and interactive discussions, and serve as a staging area for groups before receiving a tour of the RRP (see Drawing 17). To support such functions, the education center is designed as a boardroom style meeting room. Workstations can also be provided to support research that may be ongoing at the RRP, such as composting, energy production, technology evaluation, and monitoring.

The educational center would be an elevated glassed-in viewing area, to facilitate educational functions and tours. The educational center is sized to accommodate approximately 60 students, in the event that it is to support school tours. The educational center is recommended to be located in the structural footprint of the MRF building within the proposed elevated glassed-in viewing area.

4.2.1.7 Composting Facility

Approximately 33,800 TPY of organic material, including greenwastes, biosolids, and food wastes, could potentially be captured and diverted at the RRP by the end of the 20-year planning period, representing approximately 21% of the total waste stream on Kaua'i (AECOM 2013; EIS Appendix C). A windrow facility design was recommended in the *Centralized Composting Facility Master Plan* (Beck 2008), with transition to an aerated static pile once biosolids and food wastes are introduced.

The size of the windrow facility, including windrow composting, storage of composted material, and buffer areas for the projected quantities, is estimated at 9 acres (see Drawing 15 and Drawing 17). A chipper and grinder at the facility and windrow covers would be required.

The proposed composting facility would require 5 full-time staff:

- 2 – site personnel
- 2 – equipment operators
- 1 – weighbridge operator

The windrow composting facility proposed for the RRP promotes aerobic processes to break down the greenwaste and provide useful composting product. After the windrow facility has been operational for some time and the facility operates predictably, the County may consider transitioning to aerated static piles to allow for the inclusion of biosolids and food wastes in the composting process.

Greenwaste includes lawn trimmings, tree trimmings, and other organic yard and garden wastes. Residents would be able to dispose of green wastes in collection bins at the public drop-off location, or on a drop-off pad located at the windrow composting facility area. The drop-off pad would consist of a compacted clay surface necessary for a loader to operate, and would be large enough to accommodate larger vehicles and trailers. When a bin at the public drop-off becomes full, a standby bin must also be available for use when the active bin reaches capacity.

4.2.1.8 Tire Baling Facility

The proposed RRP includes a processing area with the capacity to manage all residential and commercial used tires generated in the County, which is estimated to be approximately 70,000-80,000 tires per year by the end of the 20-year planning period (AECOM 2013; EIS Appendix C). The County received approximately 13,700 used tires in 2011.

One 40-cy bin would be required for the receipt and temporary storage of used tires in the public drop-off area. Loose tires would be stored on site for up to 1 week in a covered area to prevent accumulation of rainwater in tires (which can provide mosquito-breeding habitat). The tires would then be transported to a used-tire processing area (0.4 acre) on the east part of the RRP to consolidate and process the tires for shipment to market (see Drawing 18). The processing area would include a vertical-downstroke baler located on a concrete slab in a 625-ft^2 sprung-steel fabric-covered building.

It is estimated that the tire baling facility would require one to two full-time staff to supervise the facility, if it is co-located with other drop-off facilities.

4.2.1.9 Metals Recycling Facility

A metals recycling facility would accept a range of scrap metals including, automobiles, white goods, propane tanks, and other metal scraps. Household scrap metal is typically generated in small quantities, either during renovation projects or via disposal of appliances and propane tanks. Several collection points would be available at the RRP for the drop-off of various types of metals:

- Smaller pieces of scrap metal: collected at the public drop-off in an open-top 40-cy bin.
- Propane tanks: collected and stored within a secured area near the HHW facility.
- Appliances or white goods: accepted at the hard-surface drop-off area or at the metal processing area. Appliances containing refrigerants would be segregated from those appliances that do not contain refrigerants. As required by law, the refrigerants would be properly removed before processing.

- Scrap vehicles: deposited at an automobile processing area.

County data indicate that approximately 4,669 tons of all metal types were processed in FY2011; this is expected to increase over the study period, as described in the RRP FS (AECOM 2013; EIS Appendix C).

The proposed metals recycling facility would require an area of approximately 5.5 acres (see Drawing 18). One 40-cy bin would be required for the receipt/temporary storage of small-to-mid-size scrap metal items in the integrated public drop off-area. A larger laydown area of approximately 5,000–10,000 ft^2 would be provided for collection of heavier materials, such as automobiles and appliances. This laydown area would be located adjacent to the onsite scrap metal processing area. An area of 0.15 acre would be required for the scrap metal processing line. When sufficient quantities of metals or propane tanks are collected at the public drop-off, they would be moved to the processing area for proper management.

Scrap vehicles would be sent directly to the automobile processing area. At the processing area, any liquids would be drained, and the scrap metal, white goods, and vehicles would be compacted and baled for shipment to market.

Capital costs associated with the scrap metal drop-off are limited to the required bin, a secure area adjacent to the HHW depot for propane tanks, and a small paved drop-off area for white goods. The required processing facilities include a 5.5-acre hard-surface area plus the scrap metal processing equipment.

The scrap metal drop-off would require an estimated one to two full-time staff to supervise the facility, if it is co-located with other drop-off facilities. The processing of collected scrap metal would be undertaken by a contractor, similar to the existing Puhi Metals Recycling Center (equipment would include a dual-shaft shredder, baler feed conveyor, and two-ram baler).

4.2.1.10 C&D PROCESSING

C&D materials commonly include concrete, brick, block, asphalt, treated or untreated lumber, plasterboard or drywall, cabinets, doors, windows, roofing, and soil. A series of open-top bins could be provided to collect small quantities of these source-separated materials. Up to three 40-cy bins would be required for the receipt and temporary storage of residential C&D material in the integrated public drop-off area. When sufficient quantities of C&D materials are collected, the bins would be moved to the C&D processing area.

Available data indicate that over 5,000 TPY of C&D material is generated on Kaua'i; not all material would be suitable for recovery at the facility. An area of approximately 0.84 acre would be provided for stockpiling/temporary storage of concrete, brick, block, and asphalt (see Drawing 18). This material would be received mainly from commercial sources. An estimated site area of 1 acre would be required to receive, consolidate, and process construction waste materials. The strategy to divert C&D materials from disposal consists of a combination of programs/policies, services contracts, and infrastructure. These would likely be developed in two phases:

- **Phase 1 C&D Processing Facility:** It is recommended that the County enact a waste ordinance that dictates C&D waste materials be source-separated at construction/demolition sites as clean loads of mixed rigid film plastics, clean drywall, mixed scrap metal, uncontaminated wood, pallets, OCC, and small quantities of concrete brick and block. These clean loads would be delivered to a concrete slab at the C&D processing area. Dedicated storage bunkers constructed of stacked concrete blocks would be constructed to segregate different C&D materials. Once a sufficient quantity of any material has accumulated to justify shipping, the material would be top-loaded into roll-offs or trailers and shipped to market.

- **Phase 2 C&D Sorting Facility:** If the waste ordinance regarding source separation does not yield the desired result, the County may implement the second phase of this facility, which would consist of a C&D sorting line to process mixed C&D materials. Twelve sorting staff would be required at the sorting facility.

4.2.1.11 Concrete, Brick, Block, and Asphalt Processing and Storage Area

Large quantities of unprocessed concrete and asphalt would be stored at the designated storage bunkers. The total proposed storage area is approximately 12,500 ft^2 (see Drawing 18). Processed concrete and asphalt would be stored at adjacent designated storage bunkers and shipped to market.

4.2.2 RRP Surface Water Management System

The proposed RRP surface water management system manages stormwater run-on and runoff at the site through a network of channels, culverts, and basins. The proposed system was designed and analyzed to confirm that it would be capable of handling the design flow rates, and to ensure that post-development peak flow rates to offsite areas would not exceed pre-development peak flow rates during the design storms, while ensuring that surface water basins would discharge within 48 hours.

Analyses of channels, culverts, and basins are based on the conceptual grading plan and existing site conditions. Upon finalization of the detailed layout and site grading plan, calculations would be reviewed and revised as necessary to accommodate actual, planned site conditions. For the purposes of analyzing the surface water management system, the RRP was assumed to be graded at a 0.5% slope to the east and south. The stormwater analyses are included in Appendix C. The analyses for the RRP surface water management system design were completed using SEDCAD+.

The stormwater analysis evaluated pre- and post-development site conditions under two different design storm events:

- 100-year 1-hour storm event of 4.9 inches of rainfall
- 25-year 24-hour storm event of 13.4 inches of rainfall

To further assess the performance of the surface water basins, the post-development site conditions were also evaluated for a 100-year 24-hour storm event of 17.5 inches of rainfall. The peak rainfall values are based on the design plates associated with the County DPW's *Storm Water Runoff System Manual* (DPW 2001).

4.2.2.1 Surface Water Run-on and Runoff

Based on the general topography of the area, surface water currently flows onto the site from areas to the north. Prior to reaching the RRP site, surface water would be collected in a channel along the road adjoining the RRP to the north and routed around the RRP to the east. No surface water run-on from areas other than the north is expected.

Under existing pre-development conditions, surface water runoff exits the site from the east, southeast, south, and west of the RRP site. The runoff flow to the east is generally overland flow, which is expected to combine with the more channelized flow from the southeast, approximately 400 ft east of the site. The runoff flow to the west drains to the south, where it combines with runoff exiting the site from the south. When comparing to post-development conditions, the east/southeast and south/west runoff flows have been combined.

The stormwater analysis confirms that the peak flows rates exiting the site would be reduced from the existing conditions during the design storms as a result of site development. Therefore, no negative impacts to downstream features or structures should occur.

4.2.2.2 Surface Water Channels

The primary conveyance of surface water within the RRP would be through grass-lined channels located adjacent to site access roads. As shown in Appendix C, these channels have been conservatively designed to convey runoff from a 100-year 1-hour storm event and a 25-year 24-hour storm event with a minimum of 0.5 foot of freeboard in place. Typical diversion channel, culvert, and spillway details for a RRP are presented on Drawing 38. In general, the channels would have a trapezoidal cross-section and would be 3.0 ft deep with a bottom width of 2 ft, or 3.5 ft deep with a bottom width of 6 ft. It is anticipated that the channels would be constructed with 3:1 (H:V) sideslopes. Where the channels intercept site roads and driveways, 18- or 24-inch diameter culverts would be used to maintain flow and vehicle access. Multiple culvert pipes may be used at each culvert location.

4.2.2.3 Retention Basins

Two surface water management basins (the “East” and “South” basins) have been designed for the Alternative 1 RRP site (see Drawing 15) to accommodate surface runoff from the RRP for 100-year 1-hour, 25-year 24-hour, and 100-year 24-hour storm events. The open-air surface water basins are designed to discharge all surface water within 48 hours after a storm event (see Design Alternatives presented in Section 6.3). Gravel spreader berms would be used at each basin outlet to distribute the flow over a wider area.

Surface water runoff from the compost area is assumed to be impacted by composting activities. The compost area basin is designed to capture runoff from the compost area and hold it until it is pumped out. The water from the Compost Area Pond is intended to be pumped to the surface water basin, pending approval of the Regulators. If the water from the Compost Area Pond is not approved to go to the surface water basin, it would be trucked to the Leachate Evaporation Pond at the MSW Landfill. If biosolids are accepted at the compost facility, then the runoff would be pumped from the compost area pond and hauled off site for treatment. The compost area basin is sized to completely contain the 100-year 1-hour and 25-year 24-hour storm events, in accordance with County DPW guidance (DPW 2001). A portion of the 100-year 24-hour storm event would be allowed to discharge through an emergency spillway without damaging the basin. It is anticipated that the compost area basin would be emptied between storm events. The compost area basin would use steep, riprap-lined basin sideslopes to minimize potential habitat for waterfowl and birds.

4.3 Alternative 1 Access Roads and Utilities

Both Alternative 1 sites (proposed MSWLF and RRP) require paved-road connection to the island’s public road network and connection to utilities, including electricity, telephone service, and supply water. A detailed TREFS (AECOM 2016; EIS Appendix E) was conducted to determine the proposed access route and utility corridor, as presented in this section.

4.3.1 Access Route

As shown on Figure 1, the proposed access route connects the southern corner of the proposed MSWLF site to the public road network and Kūhiō Highway near Kaua’i Beach Drive via existing cane haul roads. The offsite access route starts at the Kaua’i Beach Drive / Kūhiō Highway intersection and intersects with Laulima Street, at which point the route follows the Laulima Street access to the MSWLF site. A portion of either Driveway 1 or Driveway 2 would also be used to connect the MSWLF site to the Alternative 1 RRP site.

4.3.1.1 Kaua’i Beach Drive / Kūhiō Highway Intersection

The existing Kaua’i Beach Drive / Kūhiō Highway intersection is a 3-way, unsignalized intersection. The State Department of Transportation (DOT) right-of way (ROW) is 60 ft wide. The existing intersection can accommodate WB-40 truck-turning movements. The existing pavement sections could not be found from as-built records. Based on discussions with the State DOT regarding this access route to the landfill, coordination with the Līhu‘e bypass project would be required. Turn lanes

from both the northbound and southbound directions on Kūhiō Highway would be required. The intersection layout is shown on Figure 5. Proposed improvements to the Kauai Beach Drive / Kūhiō Highway intersection are:

- Signalize the intersection
- Widen roads and pave: 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase
  - Left-turn lane in northbound direction on Kūhiō Highway:
    11-ft lane, 200-ft storage length, 100-ft taper length
  - Right-turn lane in southbound direction on Kūhiō Highway:
    11-ft lane, 200-ft storage length, 100-ft taper length
- Construct American Disabilities Act (ADA)-accessible pedestrian ramps on two corners of the intersection
- Acquire additional ROW land (including survey maps)

Upon implementation of the proposed improvements, all turning movements at the proposed intersection would accommodate the WB-40 design vehicle.

4.3.1.2 Access Roadway

The proposed access roadway, shown on Figure 1, is owned by Visionary LLC and Grove Farm Co., Inc. A portion of the route (the Roberts Hawai'i Driveway) is an 18-ft-wide paved road with no defined lane widths or shoulder widths. The remainder of the access roadway consists of cane haul ("dirt") roads. Recommended improvements to the proposed access roadway, which must conform to County of Kaua‘i requirements, are:

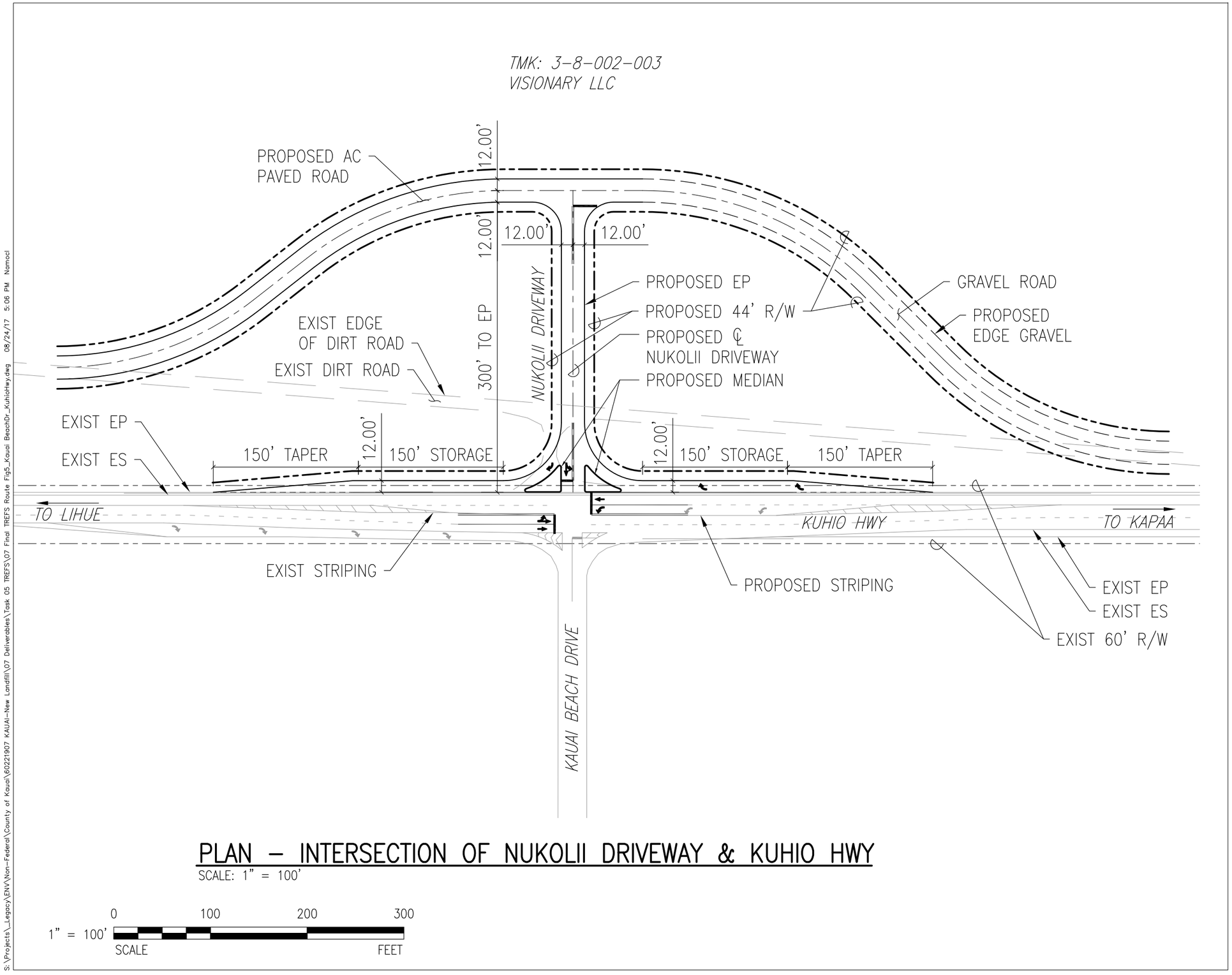
- Acquire additional ROW (including survey maps)
- Stabilize shoulders and provide erosion control
- Provide drainage improvements (potentially including shoulder swales, culverts, and drainage outfalls)
- Establish utility corridors to bring water, electricity, and phones to the proposed Project site
- Widen roads and pave: 12-ft lanes with 4-ft shoulders; 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase
- Provide chain-link fence on both sides of the access roadway
- Provide noise barrier on side fronting residential housing

The access road would be paved to be capable of sustaining heavy traffic consisting of 20-ton multi-axle vehicles. The road design provides adequate turning room for trucks up to 48 ft in length.

4.3.1.3 RRP Access: Driveway 1 or 2

One of two Driveway routes shown on Figure 1 would be used to connect the Alternative 1 MSWLF site to the RRP site. Both routes are currently cane haul roads:

- **Driveway 1** (approximately 1,913 linear feet). Driveway 1 is a direct route to the RRP site that crosses two offsite wetlands. The wetlands currently run under the existing cane haul roads using two culverts; however, the road would need to be expanded into the wetlands, and the culverts redesigned. This impact to the offsite wetlands would require consultation with and a permit from the USACE. Driveway 1 runs from the southwest corner of the proposed MSWLF west along most of the northern border of the Alternative 1 proposed RRP site.



KEY MAP

NOTES

SOURCE: GOOGLE EARTH
DATE: 10-10-2013

Figure 5
Plan of Kaua'i Beach Drive/ Kuhio Highway Intersection
Conceptual Design Report
MSWLF and RRP at Ma'alo
Ma'alo, Kaua'i, Hawai'i

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- **Driveway 2** (approximately 4,965 linear feet). Driveway 2 is an alternate, longer route that bypasses the culverts and offsite wetlands, but may have more impact on land use in the host parcel. From the southwest border of the Alternative 1 proposed MSWLF site, it arcs northwest and then southwest to the north border of the Alternative 1 proposed RRP site, where it intersects with the existing Driveway 1.

Proposed improvements to Driveway 1 or 2 include:

- Provide chain-link fence on both sides of the driveway
- Establish utility corridors to bring water, electricity, and phones to the RRP site
- Provide new pavement (including road widening): 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase
- Widen/relocate gate
- For Driveway 1 only: Reconstruct culverts connecting portions of the offsite wetlands, widen the road into the wetlands, and provide wetland consultation, permitting, and mitigation
- Acquire additional ROW (including survey maps)

4.3.1.4 RRP Internal Road

Drawing 14 depicts existing conditions at the Alternative 1 proposed RRP site, and Drawing 15 depicts the proposed site facility layout, including access roads. Although it is expected that only one or two entrances/exits would be regularly used, four entrance/exit points for residential and commercial vehicles may be provided from the main access road.

An existing single-lane gravel road curves within the site from west to east with a radius of approximately 1,060 ft (Drawing 14); this road would be used as an internal road within the RRP (Drawing 15). The internal road would be paved to be capable of sustaining heavy traffic consisting of 20-ton multi-axle vehicles. This road design provides adequate turning room for trucks up to 48 ft in length.

4.3.2 Electrical Supply and Telephone and Internet Service

Electricity and telephone service would be connected at the intersection of Laulima Street and Kūhiō Highway. Utility poles carrying services would be constructed along Laulima Street and the site access road to the site entrance. All electrical systems would comply with applicable codes. All buildings would be provided with electrical service panels complete with circuit breakers. Building electrical service would be sufficient for the proposed building’s use and electrical equipment requirements.

Shielded mast lighting compatible with Kaua‘i guidelines would be provided for emergency use on all roadways and parking areas, but would not be turned on at night on a regular basis. Interior lighting would be provided to suit ceiling height and work space with adequate illumination levels for space usage.

An uninterruptable power supply system would be provided as an emergency power supply with batteries for 30 minutes’ operation of essential-scale data management systems and other essential computer servers where required. An emergency generator would be provided with sufficient capacity for operation of main buildings and scale house interior lighting, computers and communication systems, and pumping systems during a power failure.

Onsite telephone lines and internet access would be provided to scale houses, offices, and buildings. The fire detection, alarm, and firefighting systems would be provided in accordance with local fire code requirements.

4.3.3 Water Supply

The nearest connection to the County water system is the 12-inch main along Kūhiō Highway at the intersection of Laulima Street. A 12-inch waterline would be connected there and installed parallel to the access road to the MSWLF and RRP sites. Potable water would be provided to all buildings where staff work during operating hours.

4.3.4 Wastewater

Wastewater from both the Alternative 1 MSWLF and the RRP sites would be managed on each site with installation of an individual wastewater system septic tank and absorption bed. The wastewater system is designed to accommodate a maximum wastewater flow rate of 11,000 gallons per day (gpd) (based on DWM 1993), which equates to 2,200 gpd / 200 gpd per equivalent bedroom, or 55 equivalent bedrooms. Since flow would be more than 800 gpd, the required septic tank volume is:

$$1{,}000 + (Q - 800) \times 1.25 = 13{,}750 \text{ gallons}$$

Therefore, each system would include three 5,000-gallon concrete septic tanks in parallel. Assuming a low soil percolation rate of 60 minutes per inch, an absorption area of 330 square ft^2 per equivalent bedroom would be required. Thus, the required absorption area is 18,150 ft^2. The allowable credit for leaching chambers (DOH offers absorption area credit for storage) is excluded for conservative design. Each system could consist of two roughly 70-ft × 130-ft beds in parallel, split by a distribution box.

4.3.5 Landscaping

4.3.5.1 MSWLF Site

Grass would be established in open areas for dust control, to improve aesthetics, and to reduce erosion. Additionally, while not required, additional (e.g., perimeter) landscaping may be proposed during the EIS process to mitigate visual impacts.

4.3.5.2 RRP Site

Landscaping is proposed to improve the aesthetics of the site and mitigate visual impacts. A landscaped berm with trees and hedges is proposed along the north border of the site, adjacent to the main access road. To improve aesthetics for residential visitors, an area with trees and hedges is proposed between the residential and commercial drop-off areas. Planting of trees is proposed around the surface water management ponds. All open space would be grassed to improve aesthetics and reduce erosion.

4.3.6 Security

4.3.6.1 MSWLF Site

Security at the MSWLF site would include gated access roads, perimeter fencing, and other natural barriers to deter unauthorized access. Fencing would limit access to the site from adjacent roadways and neighboring properties, and gates would be kept locked at night and when the facility is closed. Appropriate lighting would also be provided at the office/administration building. During working hours, the attendant at the scale house would provide security to prevent unauthorized access or illegal dumping. Security would meet the criteria set forth by 40 CFR 112.7.g.1 and would be adjusted as necessary to deter vandals and unwanted entry into the site.

4.3.6.2 RRP Site

A chain-link fence would be constructed around the entire site for security purposes. Access gates are proposed at the four entrances/exits along the main access road. The gates would be capable of being locked during non-operating hours and other times to control access to and egress from the proposed RRP.

5.0 ALTERNATIVE 2 CONCEPTUAL DESIGN

This section provides engineering analyses and design parameters for the Alternative 2 proposed MSWLF and RRP. Alternative 2 has the landfill and RRP sited together on the 270-acre Ma‘alo (MSWLF) parcel, and does not require the use of the Alternative 1 RRP site, or the connecting Driveways 1 or 2. Alternative 2 has a somewhat smaller landfill footprint and shorter anticipated MSWLF site life than Alternative 1, which has the RRP sited on a separate nearby parcel (the Alternative 1 conceptual design is presented in Section 4.0). The Alternative 2 RRP offers less area for future expansion or other operations.

The analyses and design parameters presented below are likely to be refined and implemented should the proposed Project be constructed. Accompanying this report are drawings titled Draft *Conceptual Designs, Ma‘alo Municipal Solid Waste (MSW) Landfill and Resource Recovery Park at Ma‘alo, Kaua‘i, Hawai‘i*, prepared by AECOM, dated August 2014. These drawings are referenced in the following sections describing the design elements of the proposed MSWLF and RRP.

5.1 ALTERNATIVE 2 PROPOSED LANDFILL

5.1.1 Base Liner

The Base Liner for the Alternative 2 landfill would be identical to that for the Alternative 1 landfill, with a reduced area of coverage corresponding to the slightly smaller landfill footprint for Alternative 2. The base liner is described in detail in Section 4.1.1.

5.1.2 Landfill Phasing

The Alternative 2 proposed MSWLF would be constructed in five phases, similar to Alternative 1. Drawing 19 and Drawing 20 show the overall layout, proposed phases, and initial development areas of the Alternative 2 MSWLF, and Drawing 28 and Drawing 29 show the cross-section views, including a projection on the nearby Kālepa Ridge. Phases 1–4 would be physically defined by their base liner systems’ lateral limits, and Phase 5 would be a vertical phase that directly overlays completed Phases 1–4. The total footprint of the proposed Alternative 2 LOW is 152.7 acres (i.e., approximately 18 acres, or 10.5%, smaller than Alternative 1). The phases would be sequenced and developed, and one continuous base liner system created, in the same manner as in Alternative 1 (Detail 4 on Drawing 31). The initial landfill cell, Alternative 2 Cell 1.1, is shown on Drawing 27.

The subbase grades for the Alternative 2 proposed MSWLF are proposed to be 10 ft below and roughly parallel to the current topography and drainage features of the property, with similar orientation and sloping as under Alternative 1. Subbase liner elevations would range from approximately 270 to 307 ft msl, a minimum of 10 ft above groundwater elevations reported in the perched water encountered in borings advanced at the site (MFA 2012). Subbase slopes and other dimensions would be similar to those in Alternative 1. Alternative 2 subbase grades, which represent the surface at which the base liner is constructed, are shown for the entire landfill on Drawing 20, and for Phase 1 on Drawing 22.

The proposed landfill phasing, base liner geometry, and gravity leachate management system would meet regulatory requirements for leachate head levels in the landfill to minimize the potential for release of leachate.

5.1.3 Final Cover

The proposed final cover design for the Alternative 2 MSWLF is identical to that presented for Alternative 1, occupies less area, and would meet the requirements of HAR § 11-58.1-17(a). Alternative 2 final cover grades are shown for the entire landfill on Drawing 21, and for Phase 1 on Drawing 24.

5.1.4 Landfill Capacity

Table 4 summarizes the projected capacities of the five phases of the Alternative 2 proposed MSWLF, using the same assumptions discussed in Section 4.1.4 for Alternative 1. The anticipated capacity of the Alternative 2 landfill is 29,893,000 cy, or 237 years. These numbers represent a decrease of 28 years (or 10.6%) compared to Alternative 1.

Table 4: Alternative 2 Proposed MSWLF Projected Capacity

Phase	Design Waste Mass Volume (cy)	Annual Waste Tonnage (tons)	Compaction Factor (tons of waste/ in-place cy)	Annual Airspace Consumed (cy)	Expected Site Life (years)
1A (initial development)	1,099,000	82,000	0.65	126,154	8.7
1 (remainder)	1,180,000	82,000	0.65	126,154	9.4
2	4,399,000	82,000	0.65	126,154	34.9
3	5,149,000	82,000	0.65	126,154	40.8
4	8,950,000	82,000	0.65	126,154	70.9
5	9,116,000	82,000	0.65	126,154	72.3
Total	29,893,000				237

Notes: Expected site life does not account for waste mass settlement over time (consolidation), which is expected to add to the site life.

5.1.5 Soil Balance

Table 5 summarizes the Alternative 2 soil balance calculations, using the same assumptions discussed in Section 4.1.5 for Alternative 1. Offsite sources of suitable soil may need to be identified by the County. Detailed soil material quantity calculations for Alternative 2 are presented for Phase 1 in Appendix A.2, and for Phases 2–5 in Appendix A.3.

Table 5: Alternative 2 Available and Required Soil Material Quantities

	Topsoil		Miscellaneous Soil		Granular Material
Phase	Available within Ma‘alo MSWLF (cy)	Required (cy)	Available within Ma‘alo MSWLF (cy)	Required (cy)	Required (cy)
1	37,300	28,300	749,700	1,171,000	167,700
2–5	154,800	124,600	312,600	7,222,700	612,300

Note: All quantities are presented in cubic yards (cy).

5.1.6 Geotechnical Design

The geotechnical parameters that influence the stability, seismicity, and geomembrane analyses for Alternative 2 are identical to Alternative 1. As described in Section 4.1.6, the landfill design meets all applicable geotechnical criteria.

5.1.7 Gas Extraction System

The Alternative 2 gas extraction system design would be nearly identical to the design for Alternative 1, as presented in Section 4.1.7, but with fewer extraction wells and less transmission piping, as shown on Drawing 26.

5.1.8 Leachate Management System

The Alternative 2 leachate management system design would be nearly identical to the design for Alternative 1, as presented in Section 4.1.8, but with less collection piping, as shown on Drawing 23.

5.1.9 MSWLF Surface Water Management System

The Alternative 2 surface water management system design (Drawing 25) would be very similar to the design for the Alternative 1 MSWLF, as presented in Section 4.1.9, but with additional detention capacity in the proposed south surface water basin (see Drawing 21) and a new entrance area surface water detention basin (see Drawing 30). These basins account for the increased stormwater runoff due to the addition of the RRP facilities to the MSWLF site. Additionally, the shape of the basin in Alternative 2 has been modified to optimize available space for the RRP. Housing the proposed RRP at the landfill site increases the runoff from the design storm due to increased paved areas and roofs. The basin areas shown on the drawings are expected to be conservative. The RRP adds approximately 30 acres of development. The Alternative 2 MSWLF is approximately 10 acres smaller than the Alternative 1 MSWLF. The two basins combined are approximately 60% larger than the Alternative 1 basin.

5.1.10 Initial Site Development Activities

The initial site development plan for the proposed Alternative 2 MSWLF is shown on Drawing 27, and includes Cell 1.1, the leachate evaporation pond, the surface water management system, the shop, scale house, drop-off area, internal roadways, and whichever RRP facilities are initially implemented. Construction activities that would be required prior to beginning operations at the site include the same tasks listed for Alternative 1 in Section 4.1.10, plus construction of the initial RRP facilities (Section 5.2.1).

5.1.11 Building Infrastructure

Drawing 19 and Drawing 27 show the infrastructure facilities for Alternative 2, including the shop area, scale house, drop-off area, parking lots, internal roadways, and RRP facilities (see Section 5.2.1).

5.2 ALTERNATIVE 2 PROPOSED RESOURCE RECOVERY PARK

The County is considering the design alternative of establishing the RRP on the proposed MSWLF site. The facilities proposed at the Alternative 2 RRP site are the same as for the Alternative 1 RRP site, except that insufficient space may be available to set aside for a potential future waste to energy plant (it is possible that certain operations could be relocated in the future to accommodate waste to energy, if required; e.g., relocating composting operations above a completed or not-yet-begun landfill phase). Alternative 2 consolidates the RRP and MSWLF sites, resulting in increased infrastructure efficiencies (e.g., shared stormwater facilities, access roads, and office space), as well as potential operational savings (e.g., shared staff and maintenance). However, the Alternative 2 RRP provides less space and capacity to respond to potential future resource recovery needs.

5.2.1 Facilities

The RRP facilities described herein and in the RRP FS (AECOM 2013; EIS Appendix C) may potentially be implemented in phases over time. Initially, the RRP would likely include, at a minimum, the Integrated Public Drop-Off and Reuse Facility. The facilities are identical to those described in Section 4.2.1, except no set-aside is provided for a potential future waste to energy facility. Drawing 30 shows the Alternative 2 RRP facility layout.

5.2.2 RRP Surface Water Management System

The Alternative 2 RRP surface water management system was planned and laid out using the same general assumptions described for Alternative 1 in Section 4.2.2 and Appendix C. One additional surface water detention basin was added. The south surface water basin was expanded and the shape was modified to optimize available space (Drawing 30). Aside from that, modifications include relocation of channels and culverts. The final size requirements for each surface water feature would be determined during final design for the final selected alternative.

Surface water runoff from the compost area is assumed to be impacted by composting activities. The compost facility surface water detention pond (Drawing 30) is designed to capture runoff from the compost area and hold it until it is pumped out. The water from the compost facility surface water detention pond is intended to be pumped to the south surface water basin, pending approval of the Regulators. If the water from the compost facility surface water detention pond is not approved to go to the south surface water basin, it would be pumped to the leachate evaporation pond. If biosolids are accepted at the compost facility, then the runoff would be pumped from the detention pond and hauled off site for treatment. The compost facility surface water detention pond is sized to completely contain the 100-year 1-hour and 25-year 24-hour storm events, in accordance with County DPW guidance (DPW 2001). A portion of the 100-year 24-hour storm event would be allowed to discharge through an emergency spillway without damaging the detention pond. It is anticipated that the compost facility surface water detention pond would be emptied between storm events. The compost facility surface water detention pond would use steep, riprap-lined basin sideslopes to minimize potential habitat for waterfowl and birds.

5.3 ALTERNATIVE 2 ACCESS ROAD AND UTILITIES

The Alternative 2 access roads and utility requirements are identical to those for Alternative 1 (Section 4.3) except that Driveways 1 or 2 and their associated utility corridors are not required.

5.3.1 Landscaping

Grass would be established in open areas for dust control, to improve aesthetics, and to reduce erosion. Additionally, while not required, additional (e.g., perimeter) landscaping may be proposed during the EIS process to mitigate visual impacts.

5.3.2 Security

As in Alternative 1, a chain-link fence would be constructed around the entire site for security purposes. Access gates would be established at the entrance along the main access road. The gates would be capable of being locked during non-operating hours and other times to control access to and egress from the proposed MSWLF and RRP.

6.0 DESIGN ALTERNATIVES

In addition to the overall Alternative 1 and 2 MSWLF and RRP Conceptual Designs described in Sections 4.0 and 5.0, potential design alternatives to various components of the proposed facilities were also considered. These are presented below, along with an assessment of their feasibility, impacts, and recommendations.

6.1 ALTERNATIVE DESIGNS FOR MSWLF COMPONENTS

6.1.1 Base Liner Alternatives

Several base liner alternatives are feasible:

A. **Single layer (prescriptive design).** RCRA Subtitle D and HAR Chapter 11-58.1 prescribe use of a compacted soil layer with a minimum thickness of 2 ft, overlain by a single liner composed of a 60-mil HDPE geomembrane. The soil must have a permeability of no more than 1×10^{-7} cm/sec. Compacted soils needed for this layer typically include clays, silts, and possibly sandy clay/silts. The subsurface of the proposed Ma'alo MSWLF site appears to contain soil suitable for use in the base liner, pending further analysis. Future subsurface investigations would be conducted at the site during the design phase to further determine the properties of existing site soils.

B. **Geosynthetic clay liner.** A GCL is an alternative to the prescriptive compacted soil layer. A GCL is partially composed of sodium bentonite and expands when it comes into in contact with liquids, forming a barrier to liquid movement. A GCL provides several advantages over a compacted soil layer, including homogeneity (which increases effectiveness), enhanced ability of the liner to withstand deformation, and reduced construction and material costs.

C. **Double liner.** Two liners (primary and secondary) can be installed to provide further protection of the underlying groundwater aquifer of the site, beyond the requirements of the regulations. Each liner could be either a prescriptive soil liner or a GCL liner.

Recommended Base Liner Alternative (Sections 4.1.1, 5.1.1). Although the vicinity of the proposed Project is not currently used as a groundwater supply, it is located mauka of (above) the UIC line, and is therefore a potential source of groundwater supply. In order to provide additional protection to safeguard the underlying aquifer, the County has chosen to incorporate a double liner (Alternative C). The proposed design also incorporates Alternative B, i.e., the proposed primary and secondary liners are both composed of a 60-mil HDPE geomembrane and a GCL. The implementation of both base liners, Alternatives B and C, would provide a workable and protective liner system.

6.1.2 Gas Extraction Control System

The Clean Air Act regulations provide three alternative NSPS-compliant gas extraction systems, 40 CFR §60.752(b)(2)(iii):

A. **§60.752(b)(2)(iii)(A).** An open flare designed and operated in accordance with §60.18.

B. **§60.752(b)(2)(iii)(B).** A control system designed and operated to reduce NMOC by 98 weight-percent, or, when an enclosed combustion device is used for control, to either reduce NMOC by 98 weight percent or reduce the outlet NMOC concentration to less than 20 parts per million by volume, dry basis as hexane at 3 percent oxygen. The reduction efficiency or parts per million by volume shall be established by an initial performance test, required under §60.8 using the test methods specified in §60.754(d).

C. **§60.752(b)(2)(iii)(C).** Route all collected gas to a treatment system that processes the collected gas for subsequent sale or use. All emissions from any atmospheric vent from the gas treatment system shall be subject to the requirements of paragraph (b)(2)(iii)(A) or (B) of this section.

Recommended Gas Extraction Control System (Sections 4.1.7, 5.1.7). The control system is not being selected at this time because the County's future needs and related system sizing requirements may change. The capacity of the control system may increase and decrease over time in response to changing waste streams and changing amount and quality of LFG produced by the landfill. Therefore, the control device, devices, or system chosen for any interim or future timeframes may vary depending on the site-specific LFG characteristics including the quantities produced. Site facility layouts allow for the incorporation of both flares and a LFG to energy facility (Drawing 9 and Drawing 26).

The RRP FS (AECOM 2013 and EIS Appendix C: Section 4.15) presents a detailed analysis of the potential for LFG to energy production. Such a facility is recommended to be installed and permitted by the time sufficient LFG is being generated at the MSWLF to make a LFG to energy feasible. This time frame, however, is highly dependent on the amount of organic waste diverted from the landfill (e.g., via the composting facility and other County initiatives). A flare may be employed until such date as sufficient gas is being produced to make a LFG to energy facility feasible and economical.

6.1.3 Leachate Management System

Multiple feasible leachate management systems were considered:

A. **Leachate evaporation pond.** Leachate could be treated on site using a lined leachate evaporation pond with aerators, as is currently done at the County's existing Kekaha landfill. Sufficient evaporative area would be provided so that pan evaporation meets or exceeds the projected leachate inflow to the pond (plus stormwater loading). Pond size requirements may change over the life of the proposed landfill, and additional areas can be reserved for future evaporation pond expansion (Drawing 2 and Drawing 19). A leachate loadout facility would be established next to the leachate evaporation pond; should the pond approach capacity, or other temporary needs dictate, the leachate could be pumped into tanker trucks and transported to a WWTP. This is a proven alternative that has operated successfully at Kekaha for many years without incident. This alternative requires strict controls on the design and construction of the pond, but eliminates the risk of accidents or releases during transport. Operation of a leachate evaporation pond is relatively effective, simple, and inexpensive. Calculations are presented in Appendix D.5.

B. **Double-walled leachate holding tanks.** Leachate holding tanks could be used to provide temporary leachate holding capacity to facilitate hauling of leachate off site for treatment via tanker trucks. The leachate holding tanks would be double-walled tanks so that potential leaks would be detected and contained. Additionally, a concrete-lined leachate loadout area would be designed to capture any leachate spilled during the loading of the hauling trucks. This is also a proven technology, which is successfully employed at facilities such as Waimanalo Gulch Landfill on O'ahu. This alternative lessens the risk of release from the evaporation pond compared to Alternative A, but introduces the risk of release during transport. This alternative has significant operational costs. Calculations are presented in Appendix D.6.

C. **Single-walled leachate holding tanks with a lined secondary containment pond for potential leakage.** This alternative is similar to but less expensive on a per-tank basis than Alternative B (although these lower expenses would be somewhat offset by the inclusion of a secondary containment system, and additional containment system construction could be required if more tanks are brought online after initial construction). Similar to Alternative B, this alternative lessens the risk of release from the evaporation pond compared to Alternative A, but introduces the risk of release during transport. This alternative has significant operational costs.

D. **Leachate recirculation.** Leachate recirculation is a technique where collected leachate is reintroduced or recirculated into the waste mass. This is completed by pumping the leachate into the waste mass through pipes such as dedicated force-mains and

perforated distribution piping, or by surface application in the active waste area. The technique is a common practice in the industry outside of Hawai‘i, and has several benefits, including the reduction of leachate disposal costs, improved waste mass consolidation, accelerated recoverable LFG generation, and faster decomposition of wastes (and thus enhanced landfill airspace and site life). While this alternative is an excellent option from a technical standpoint, leachate recirculation is not currently implemented in the State of Hawai‘i because current State regulations do not allow for research, development, and demonstration applications.

E. **Pumping leachate directly to the WWTP.** This alternative consists of constructing a series of double-containment force-mains and lift stations to pump leachate from the site to the nearest WWTP or adequately sized existing sewer. This construction would require right-of-away access involving multiple agencies and utilities as well as regulatory approval. Long-term maintenance for pumps, piping, and facilities for the life of the Ma‘alo MSWLF could involve significant costs. This type of system does not afford much flexibility for varying leachate generation quantities during operation, whereas holding tanks and evaporation ponds can be added and removed as needed over the life of the landfill. Due to the size and complexity of the system, this option also may be considered to entail higher risk of a release of leachate. This option is not included in the current design.

Recommended Leachate Management Alternative (Sections 4.1.8, 5.1.8). Alternative D, leachate recirculation, provides multiple benefits, and it is recommended that this option, which is now well established on the U.S. mainland, be pursued with the DOH. However, because this is not currently allowed, Alternative A has been selected as part of the proposed facility design. This option is well established and eliminates the need to transport leachate off site for treatment at a WWTP. Details of the leachate evaporation pond are presented on Drawing 39.

6.1.4 Leachate Transfer System

Two feasible leachate transfer system alternatives were considered:

A. **Gravity (passive) leachate collection.** Leachate collection pipes would be located along the base liner low points. Leachate would drain via gravity flow within the pipes along a 2% base grade until it reaches a perimeter dual-contained leachate transfer pipe sloped at 0.5% to a wet well near the southwest corner of the landfill. Leachate levels in the wet well would be controlled by the use of pressure transducers set for specific elevations to trigger pump on, pump off, and high-level alarm. Leachate would then be pumped to the leachate evaporation pond (Section 6.1.3) through dual-contained HDPE forcemain piping.

B. **Active extraction system.** An active extraction system would use a sump (a depression) in the lowest points of the landfill cells to collect leachate, which would be pumped up the landfill sideslope. With the leachate pumped under pressure, the leachate would be conveyed by a dual-contained forcemain pipe either directly to the proposed evaporation pond or to a wet well and subsequently pumped to the proposed evaporation pond. This alternative is dependent on electrical access for running the pumps, pump controls, and associated level systems. This system would be more complex and require additional power, equipment, and backup systems; and would therefore have opportunities for system down time or failure. On the other hand, this alternative has the advantage of not penetrating the liner system, thereby eliminating potential release points. Future expansion to Phases 2–5 would also require the piping for each sump to be extended vertically and potentially protected by a vertical manhole.

Recommended Leachate Transfer System Alternative (Sections 4.1.8.3, 5.1.8). Alternative A is recommended. This alternative would require less power and costs, and is relatively simple, which provides less opportunity for system downtime or failures. The proposed leachate transfer system

would meet the leachate extraction requirements and would ensure that the maximum allowable leachate head on the base liner system is not exceeded. If future design refinements due to additional investigation should reconfigure the base grades, then implementing an active system may be reconsidered.

6.2 ALTERNATIVES FOR RESOURCE RECOVERY PARK COMPONENTS

The RRP FS (AECOM 2013; EIS Appendix C) contains detailed analysis of various potential RRP facilities. This conceptual design incorporates the result of that alternative analysis.

6.3 SURFACE WATER MANAGEMENT SYSTEM – SURFACE WATER BASIN

Four feasible surface water retention basin alternatives were considered:

A. **Open infiltration basin.** Surface water runoff could be channeled and conveyed to an open basin designed to accommodate runoff for the 100-year 1-hour and the 100-year 24-hour storm events. The collected water could be allowed to infiltrate into the subsurface over time, as is currently done at the Kekaha MSWLF. However, unlike Kekaha, silty-clayey soils at the proposed site would probably result in slow infiltration, which may require supplementation via underground injection. This alternative would reduce the surface water supply currently flowing to offsite, down-gradient wetlands, rivers, etc. This alternative might eliminate the need for a commercial NPDES permit, saving effort and costs over the lifetime of the project; however, a large basin may be required.

B. **Open detention basin.** Surface water runoff would be conveyed similarly to Alternative A, but instead delivered to a detention basin. The detention basin would allow particulates to settle out, and would release the water to down-gradient offsite drainage areas over time.

C. **Open detention basin with 48-hour discharge.** This alternative is similar to Alternative B, but the surface water basin size would be increased and the design modified to discharge all water within 48 hours of the storm conclusion. This alternative would minimize standing water in accordance with FAA guidance for managing wildlife attractants (FAA 2005).

D. **Covered basin with a floating geomembrane cover.** A covered basin with a floating geomembrane cover would allow the retention of water for use in dust control, vegetation watering, and emergency response. This alternative would eliminate standing water that could attract wildlife.

Recommended Surface Water Management System Alternative (Sections 4.1.9, 5.1.9). Alternative C is recommended. This alternative would comply with FAA guidance for wildlife attractants, continue to provide water to downstream, offsite features, and would not require the size and associated expense of Alternative D (which would increase in later phases of landfill development).

6.4 ALTERNATIVES FOR ROADS AND UTILITIES

6.4.1 Access Road Alternatives

The TREFS (AECOM 2016; EIS Appendix E) contains detailed analysis of various potential access routes. This conceptual design incorporates the results of that alternative analysis.

6.4.2 Wastewater Alternatives

Two feasible alternatives for managing wastewater from the MSWLF and RRP were considered:

A. **Onsite septic system.** Wastewater can be managed on site with installation of an individual wastewater system septic tank and absorption bed. The tanks would be designed and constructed in accordance with applicable regulations, and would periodically be pumped out.

B. **Connection to County sewer system.** A sewer line could be installed from the nearest connection at Kūhiō Highway to the site. This alternative would involve significant construction and costs, for marginal benefits.

Recommended Wastewater Alternative (Sections 4.3.4, 5.3). Alternative A, installation of onsite septic systems, is recommended due to the cost and energy consumption involved with installing a sewer line from Kūhiō Highway to the site. Under the Alternative 1 proposed MSWLF and RRP, two septic systems would be installed, one at the MSWLF and one at the RRP; under the Alternative 2 proposed MSWLF and RRP, two septic systems would be installed at the site.

7.0 ENVIRONMENTAL PERMITS, CONSULTATIONS, APPROVALS, AND MONITORING

Permitting, consultation, approval, and monitoring requirements for the proposed MSWLF and RRP facilities would be the same under Alternative 1 (RRP sited on a nearby parcel) and Alternative 2 (RRP sited on the MSWLF parcel).

7.1 LANDFILL REQUIREMENTS

Implementation of the proposed action requires coordination and consultation with the Federal, State, and County agencies for the following permits, clearances, or approvals summarized in Table 6.

Table 6: Landfill Permits, Regulatory Approvals, and Related Requirements

Permit or Approval	Description	Regulation(s)	Administrative Authority
EIS	The site of the proposed Ma‘alo MSWLF is located on State of Hawai‘i land, and the proposed Project would use County of Kaua‘i funds; therefore, the proposed Project would trigger the State environmental review process. As part of the environmental review process, an EIS is currently being prepared for the proposed Project, and this conceptual design informs that analysis.	HRS Chapter 343	DOH Office of Environmental Quality Control
Solid Waste Management Permit	A MSWLF must be authorized under a Solid Waste Management Permit.	HAR § 11-58.1-04	DOH SHWB
Historic Preservation Review	State and county projects that may affect a historic property must obtain a concurrence of “no historic properties affected” from the State of Hawai‘i DLNR, State Historic Preservation Division (SHPD) prior to commencement.	HRS Chapter 6E-8; HAR 13-275	SHPD
Clean Water Act (CWA) § 402 National Pollutant Discharge Elimination System (NPDES) Permit(s)	Section 402 of the federal CWA establishes the NPDES program regulating the discharge of pollutants to waters of the United States. NPDES permits would be required to authorize discharges of surface water associated with construction activities that result in disturbance of 1 acre or more of total land area, and also for the facilities’ operational surface water management system discharges.	CWA (33 U.S.C. Section 1251 et seq.); HRS 342D; HAR § 11-55, Appendix C	DOH Clean Water Branch (CWB)
Grading Permit, Grubbing Permit	Per County of Kaua‘i Ordinance 808, §22-7.6(b), a grading permit is not required for a sanitary landfill, subject to applicable County, State, or Federal government regulations or laws.	Ordinance No. 808	N/A
Building Permit	A building permit would be required for MSWLF facility buildings.	Ordinance No. 929	County of Kaua‘i DPW, Engineering Division
State Special Use Permit	The proposed Ma‘alo site is in a State Agricultural District and therefore may require a State Special Use Permit.	HRS 205	County of Kaua‘i Planning Department and State Land Use Commission
State Land Use District Boundary Amendment (SLUDBA)	An alternative to the State Special Use Permit that is under consideration involves filing a SLUDBA petition for a change in the State Land Use District designation from Agricultural to Urban. If selected, the State Special Use Permit would not be required.	HRS 205	State Land Use Commission
County Change of Zone Application	The requirement for a Change of Zone from Agriculture (A) to the General Industrial (IG) zone would be required following the filing and approval of the SLUDBA in accordance with Article 6 of the Comprehensive Zoning Ordinance.	Comprehensive Zoning Ordinance	County of Kaua‘i Planning Department

N/A not applicable

7.1.1 Monitoring

Environmental monitoring of the proposed Project would be conducted throughout the life of the landfill and after final closure to ensure any unintended environmental effects are detected and mitigated before developing into larger problems. The monitoring program would consist of inspections and samplings conducted pursuant to State and Federal regulations and guidance. A summary of the environmental monitoring for the proposed MSWLF is presented below.

7.1.2 Inspection Program

The detailed landfill inspection and monitoring program would be included in the site Operations Plan, which forms part of the solid waste management permit application, and is subject to review by the DOH. A qualified individual would inspect the landfill and surrounding areas on a routine basis. The inspections would include, at a minimum, the following areas:

- **Surface water control features.** The system would be inspected for erosion, scouring, clogging, excess vegetation, and differential settlement. Surface water control features would be repaired and kept free of debris and sediment that could prevent the system from operating correctly. Diversion berms, any perimeter ditches, and other engineered channels on site would be re-graded when necessary to provide continued drainage of surface water runoff.
- **LFG control and monitoring system.** The system would be inspected to ensure that the gas extraction and monitoring system remains operational. The inspection would look for damage to valves, emergency switches, wellheads, water submersion, and other defects that may prevent LFG monitoring.
- **Leachate management system.** The system would be inspected for proper operation of level switches, aerators, pumps, the flow meter, and any other components that control the flow of leachate. Secondary containment around any leachate holding tanks would be inspected for liquid. Furthermore, sediment accumulation within any system components would be monitored to maintain flow rates. Maintenance and operation of the leachate management system would be in accordance with the requirements of HAR §11-58.1-14, as applicable.
- **Groundwater monitoring wells.** Monitoring wells would be inspected to ensure that they are functional, intact, accessible, and visible.
- **Spill prevention.** A Spill Prevention Countermeasures Control Plan would be developed to ensure that petroleum products and other hazardous materials used for landfill operations are stored in areas that are protected against larger releases to the environment (e.g., berms, sumps, BMPs). Spill prevention structures would be regularly inspected to ensure their effectiveness.

Any deficiencies noted during regular inspection activities would be repaired in a timely manner to prevent environmental impacts from occurring.

7.1.3 Sampling Program

In conjunction with the inspection program, the LFG and groundwater sampling program would help to ensure that any potential environmental impacts are detected and remediated before more extensive environmental impacts occur.

7.1.3.1 LFG Monitoring

A quarterly LFG monitoring program would be implemented to ensure that the concentration of methane gas does not exceed the lower explosive limit for methane at the property boundary or 25% of the lower explosive limit for methane in facility structures. All occupied MSWLF buildings, such as the scale house and office and maintenance buildings, would be continuously monitored for the

presence of methane using permanently installed continuous gas monitors. As continuous monitoring devices, these detectors have a built-in alarm system that is activated and sounds if gas concentrations are detected. As part of the program, gas probes would be installed around the landfill perimeter and regularly sampled for methane and oxygen. The monitoring program would comply with HAR §11-58.1-15(d) and 40 CFR 258 Subpart C. LFG monitoring results would be submitted to the DOH.

7.1.3.2 Groundwater and Leachate Monitoring

A Groundwater Monitoring Plan would be developed for the proposed Project in accordance with HAR §11-58.1-16, 40 CFR 258 Subpart E, and the State of Hawai'i *Landfill Groundwater Monitoring Guidance Document* (DOH 2002). The monitoring plan would be submitted and approved by the DOH prior to site operation.

In general, groundwater monitoring wells would be initially installed around the landfill perimeter in upgradient, crossgradient, and downgradient locations. New groundwater wells may need to be constructed over the landfill life as new cells are brought into operation. Prior to opening of the landfill for acceptance of MSW, a 2-year quarterly background monitoring program would be conducted to establish background groundwater conditions. A statistical evaluation approach would then be used to detect for the presence of volatile organic compounds and statistically significant increases in concentrations of leachate indicator parameters. Groundwater monitoring during landfill operation would likely be conducted at least semi-annually. Each monitoring event would consist of the sampling of each well and measuring groundwater levels to determine groundwater flow direction and hydraulic gradient.

Leachate monitoring during landfill operation would likely be conducted on at least an annual basis to develop a database of potential source information and to evaluate the suitability of site monitoring parameters.

Groundwater and leachate analytical results would be summarized in reports that would regularly be submitted to the DOH for their review.

7.2 RRP Requirements

Table 7 summarizes the permits and approvals that may be required to implement the proposed RRP. Also provided are citations of applicable regulations and the administrative authority responsible for implementing those regulations.

Table 7: RRP Permits, Regulatory Approvals, and Related Requirements

Permit or Approval	Description	Regulation(s)	Administrative Authority
Recycling and Auto Salvage Facility Application	Required for construction and operation of recycling facilities that process more than one type of recyclable material, and for auto salvage facilities.	HAR § 11-58.1-33	DOH SHWB
Composting/Co-Composting Facility Application	Construction and operation of composting facilities (greenwaste greater than 3,000 TPY).	HAR § 11-58.1-41	DOH SHWB
Used Oil Permit Application	For facilities that operate as a transporter, recycler, or marketer of used oil.	HAR § 11-58.1-54	DOH SHWB
Transfer Station Application	Construction and operation of transfer stations (i.e., residual waste tipping area).	HAR § 11-58.1-31	DOH SHWB
Solid Waste Disclosure Form	Required for construction activities that generate C&D waste and site clearing debris.	HAR § 11-58.1	DOH SHWB
Chapter 6E Historic Preservation Review	State and county projects that may affect a historic property must obtain a concurrence of "no affect" to historic properties from SHPD, prior to commencement.	HRS Chapter 6E-8; HAR 13-275	DLNR SHPD

Permit or Approval	Description	Regulation(s)	Administrative Authority
CWA Section 402 NPDES Permits	Section 402 of the CWA establishes the NPDES program regulating the discharge of pollutants to water of the United States. NPDES permits under Appendix B cover stormwater and non-stormwater runoff from industrial activities. NPDES permits under Appendix C are required to authorize discharges of stormwater associated with construction activities that result in disturbance of 1 acre or more of total land area.	CWA (33 U.S.C. Section 1251 et seq.); HRS 342D; HAR § 11-55, Appendix B and C	DOH CWB
Non-Covered Source Air Permit	May be required for processing activities at the compost and C&D facilities that generate airborne particulates. Large industrial equipment may also require an air permit.	HAR § 11-60.1	DOH CAB
Grading Permit	Required for grading that exceeds 100 cy of cut or fill or exceeds 5 ft in vertical height at its deepest point.	Ordinance No. 808	County of Kaua'i DPW, Engineering Division
Grubbing Permit	Required to dislodge or uproot any vegetation, including tree, timber, shrubbery, and plants, from the surface of the ground.	Ordinance No. 808	County of Kaua'i DPW, Engineering Division
Building Permit	A building permit would be required for RRP facility buildings.	Ordinance No. 929	County of Kaua'i DPW, Engineering Division
Stockpiling Permit	Required to temporarily open-store earth materials in excess of 100 cy on any premise except the premises upon which a grading permit has been issued for the purpose of using the material as fill material at some other premises at a future time.	Ordinance No. 808	County of Kaua'i DPW, Engineering Division
State Special Use Permit	The proposed site is in a State Agricultural District and therefore may require a State Special Use Permit.	HRS 205	County of Kaua'i Planning Department and State Land Use Commission
State Land Use District Boundary Amendment (SLUDBA)	An alternative to the State Special Use Permit that is under consideration involves filing a SLUDBA petition for a change in the State Land Use District designation from Agricultural to Urban. If selected, the State Special Use Permit would not be required.	HRS 205	State Land Use Commission
County Change of Zone Application	The requirement for a Change of Zone from Agriculture (A) to the General Industrial (IG) zone would be required following the filing and approval of the SLUDBA in accordance with Article 6 of the Comprehensive Zoning Ordinance.	Comprehensive Zoning Ordinance	County of Kaua'i Planning Department

This list is preliminary; additional permits may be required once design and construction plans are finalized. Because the RRP would involve various components potentially operated by individual operators, separate permits may need to be obtained for each facility. The DOH and other regulators should be consulted prior to beginning the actual permitting process to determine specific requirements and any additional required documentation.

7.3 ACCESS ROUTE PERMITTING, LAND USE, AND LAND ACQUISITIONS

The parcels containing the proposed access route are zoned as Residential and Industrial. ROW acquisitions, described in Section 4.3.1 (Alternative 1), would need to be secured. The property owners of the ROW acquisition areas are Visionary LLC and Grove Farm Co., Inc. Estimated time for rezoning and ROW acquisition is 12 months. Access road and related construction (Section 4.3.1) would require an NPDES Form C permit from the State DOH. Estimated time for approval from DOH is 6 months.

If Alternative 1 is implemented and Driveway 1 is chosen to connect the sites, then a small portion of the offsite wetlands would likely be impacted; this would require a Clean Water Act Section 404 permit from the USACE. This process could require mitigation measures, and would be expected to take approximately 1 year to negotiate.

8.0 COST ESTIMATES

8.1 ALTERNATIVE 1 COST ESTIMATES

8.1.1 Alternative 1 Proposed MSWLF Costs

This section summarizes the anticipated capital costs to construct Alternative 1 Cell 1.1 and all required supporting infrastructure for site access and operation of the MSWLF. The cost components are:

- **Earthwork.** Development of Cell 1.1 and the supporting infrastructure would require excavation and segregation of existing soils, clearing and grubbing of surface vegetation (e.g., trees, shrubs, organic debris), and erosion control (such as silt fencing) around disturbed areas. Segregated soils such as topsoil, structural fill, low-permeability soil, and daily cover soils could be stockpiled or directly used for specific engineered requirements. For example, structural fill is soils placed and compacted to define the geometric shape in areas in addition to existing soils. These structures include berms, roads, surface water retention basins, and fill around retaining walls. Topsoil would be used to assist in revegetating disturbed areas and soil structures to promote vegetation and minimize erosion. Mobilization and demobilization of equipment and personnel (contractor's operators, supervisors, and miscellaneous items) to and from the facility to complete this work would be an upfront cost and is accounted for in the estimate. Costs are based on RS Means (2013) Heavy Construction Cost Data and experience on similar projects.
- **Facility entrance.** The main artery for landfill activities is the facility entrance. Associated operational support structures include a septic system to process wastewater from the onsite personnel and visitors and an office building to house County and site operator personnel associated with the MSWLF, a maintenance building for onsite servicing of landfill heavy equipment, a scale/ticket house for documentation of actual incoming MSW tonnage (public and private hauler use), and a public drop-off facility. The rough cost for the septic system would be $200,000 (assumed $220,000 escalated to future year). Permitting would be a one-time $100 filing-fee Individual Wastewater System registration with the State DOH Wastewater Branch with no recurring permitting or reporting requirements. Semiannual pumping of each septic tank would be approximately $1,200 per occurrence ($2,400 per annum). For the septic systems, costs are based on RS Means (2013) Heavy Construction Cost Data, experience on similar projects, and supplier correspondence.
- **Cell 1.1 base liner construction.** The base liner of Cell 1.1 is the actual component of the MSWLF that would be prepared and house MSW. The base liner, which retains and collects the leachate, would be engineered to meet required regulations for Subtitle D landfills at the time of construction. The base liner system includes a foundation soil layer, which is a graded supporting layer for placement of the base liner. The base liner itself would be constructed of geosynthetics including two layers of GCL, two layers of 60-mil textured HDPE geomembrane, and a nonwoven cushion geotextile. Costs are based RS Means (2013) Heavy Construction Cost Data and supplier correspondence.
- **Leachate management system.** Leachate collected from the in-place MSW along the base liner is removed from the base liner by slope of the base liner, perforated piping on the base liner, and dual-contained piping outside the cell; it is then pumped to a leachate aeration/ evaporation pond from a wet well. This estimate also accounts for pumping systems for leachate management and construction and operation of the aeration pond. Costs are based RS Means (2013) Heavy Construction Cost Data, experiences on similar projects, and supplier correspondence.
- **Surface water management.** Surface water management consists of physical features of the facility used to control, store, and discharge surface water. This would be completed by managing run-on water from outside the MSWLF boundaries with designed control berms and channels and various sized culverts, and using riprap and erosion control matting to

deter soil erosion. Costs are based RS Means (2013) Heavy Construction Cost Data and supplier correspondence.

- **Access roads.** Access roads are the primary designated and controlled routes for vehicle traffic into, on, and off the MSWLF. Access roads for the proposed facility include asphalt-paved roads and areas for the main gated entrance, public drop-off facility, site office, ticket/scale house, and maintenance building, and an aggregate (gravel) road from the asphalt-paved areas to the operational area of Cell 1.1. Asphalt roads assist in surface water control and aid in maintaining clean traffic patterns for the general public. Gravel roads provide operation ease in maintaining for heavy equipment use as well as drainage. Costs are based RS Means (2013) Heavy Construction Cost Data and supplier correspondence.
- **Miscellaneous features and programs.** Miscellaneous features for the MSWLF include security, safety, communication, and office supplies/hardware features such as security fencing and access gates around the perimeter of the developed facility for controlled access, bollards around the public drop off area, and special communication hardware for the wet well. Part of the permitting process consists of two substantial programs that would support the final engineered design of Ma‘alo MSWLF:
  - A geotechnical and groundwater investigation program would drill borings to multiple depths to determine groundwater elevations and continuity, and along with specific laboratory testing of collected samples, the physical properties and application of in-place soils.
  - A groundwater monitoring program would include installation of groundwater monitoring wells to ensure relation of historical groundwater depths to base liner elevation. Costs are based on RS Means (2013) Heavy Construction Cost Data and experiences on similar projects.
- **CM and CQA.** CM and CQA are services provided by a qualified engineering consulting firm or similar that operates as the onsite representative of the County to direct and document construction of the facility. The CM/CQA firm(s) would be responsible for submitting completed documentation to the DOH for final approval to operate the facility. The estimated cost for this effort is assumed to be a percentage of the overall construction costs for Cell 1.1.
- **Engineering and permitting.** Engineering for development of the MSWLF includes submittal of all required permit submittals, such as the solid waste permit application for example, prior to the construction of the MSWLF. These costs can vary depending on County requests and needs at time of completion. This estimated cost is assumed to be a percentage of the overall subtotal of the cost estimate.
- **Contingency.** A contingency is a designated amount of funds that are allocated and maintained to offset unforeseen or uncontrollable situations. These situations may include, but are not limited to, weather delays during construction, permit delays, new regulations, changes in subsurface features, changes in costs over time, or requested design changes. This cost item is estimated to be a percentage of the overall subtotal of the cost estimate.

The total preliminary estimated cost for supporting infrastructure and Cell 1.1 of the Ma‘alo MSWLF Alternative 1 (without contingencies) is $41.4 million. (For planning purposes, an additional contingency of $6.2 million is recommended.) Table 8 presents details of the cost estimates for the Alternative 1 proposed landfill. Initial development of the Alternative 1 MSWLF is estimated to include 70.4 acres of the property.

Table 8: Alternative 1 Proposed MSWLF Phase 1A Initial Development Construction Cost Estimate

Item		Unit	Quantity	Rate	Amount	Comments	Source
1	Mobilization/Demobilization	LS	1	$300,000	$300,000	Based on bid from Kekaha Cell 1 construction.	Experience
2	Erosion Control BMPs	LS	1	$10,000	$10,000		
3	Clearing/Grubbing	acre	70.4	$3,688	$259,662	All disturbed areas (includes Phase 1A, surface water basin, leachate pond, and entrance area)	RS Means: cut and chip light trees and grub stumps and remove; 31 11 10.10 0020 and 0150. Assume 50% cost reduction due to limited woody vegetation on site.
4	Topsoil Removal & Stockpiling	CY	56,789	$10.63	$603,526	All disturbed areas (includes Phase 1A, basin, leachate pond, and entrance area). Assumes 6" of topsoil.	RS Means: topsoil stripping and stockpiling; 31 14 13.23 1440
5	Excavation	CY	273,488	$8.78	$2,400,426	All disturbed areas (includes Phase 1A, surface water basin, leachae pond, and entrance area)	RS Means, excavate common earth, 3/4 cy backhoe, 3 dump trucks 1 mile round trip; G1030 120 1600
6	Topsoil Placement	CY	33,000	$6.25	$206,299	Haul from stockpile & spread. Total disturbed areas minus gravel areas, paved areas, and Phase 1A.	RS Means, equipment and labor only: borrow loading and spreading; 31 23 23.15 7000
7	Structural Fill	CY	272,178	$23.07	$6,278,592	All areas (includes Phase 1A, surface water basin, leachate pond, and entrance area). Material available from on-site excavation.	RS Means: structural backfill, 105 HP dozer, 300' haul, 4 passes, common earth; G1030 115 2050.
Facility Entrance Area							
8	Scale	EA	2	$97,780	$195,560	Includes concrete foundation, new Fairbanks scale and freight.	Experience/Recent Projects & Centerscal Automation Hawaii, Inc.
9	Ticket House	SF	846	$264.00	$223,344	Assume brick building on concrete slab.	RS Means, assume 10% OH & P
10	Office Building	SF	1,978	$264.00	$522,192	Assume brick building on concrete slab.	RS Means, assume 10% OH & P
11	Maintenance Building	SF	3,150	$92.40	$291,060	Assume metal building on concrete slab.	Recent Projects, assume 10% OH & P
12	Retaining Walls	LF	550	$320.08	$176,042	In public drop-off area.	RS Means, cast-in-place retaining wall, 6' high; 32 32 13 10 1900
13	Seeding	SF	1,782,000	$0.06	$99,147	Total disturbed areas minus gravel areas, paved areas, and Phase 1A.	RS Means: seeding athletic field, slope mix with mulch and fertilizer; 32 92 19.14 4600
Phase 1A Liner							
14	6-inch granular foundation lift	CY	12,070	$23.07	$278,428		RS Means: Same as structural fill, above.
15	60-mil textured HDPE geomembrane	SF	666,174	$0.85	$564,916	Includes extra layer under 1,200 ft of perforated leachate pipe. Includes material, freight, labor, and mark-up.	GSE
16	GCL	SF	651,774	$0.63	$409,575	Assume Bentoliner NSL by GSE. Includes material, freight, labor, and mark-up.	GSE
17	16-oz/sy non-woven Cushion Geotextile	SF	666,174	$0.38	$254,212	1- layer (above geomembrane) Includes extra layer under 1,200 ft of perforated leachate pipe. Assumes GSE NW16. Includes material, freight, labor, and mark-up.	GSE
Leachate Management							
18	12-inch Drainage Layer	CY	24,140	$101.26	$2,444,308		RS Means: 80 HP 300' haul, sand & gravel, also material and hauling; 31 23 23.14 2400, see notes 3 and 4
19	6-oz/sy non-woven Separator Geotextile	SF	651,774	$0.27	$175,718	Assumes GSE NW6. Includes material, freight, labor, and mark-up.	GSE
20	24-inch operations layer	CY	48,280	$101.26	$4,888,616		RS Means, same as drainage layer above.
21	8-inch SDR 9 HDPE Pipe	LF	1,510	$31.63	$47,765	Includes perforated and solid (cleanout riser) pipes.	RS Means: 8" SDR 21 HDPE, butt fusion joints; 33 11 13.35 0300. Assume 10% increase in cost for material and shipping of SDR 9
22	Liner penetration	EA	2	$5,250	$10,500	Flatstock/pipe boot prefabricated structure.	Forrer Supply, assume 50% of material cost for shipping and installation.
23	8" inside 12" dual containted gravity pipe	LF	2,750	$97.99	$269,478	Includes 50 ft stub at each current and future liner penetration.	RS Means: 8" and 12" SDR 21 HDPE, butt fusion joints and 3' excavation; 33 11 13.35 0300 and 0500, 31 23 16.13 0060. Assume 10% increase in cost for material and shipping of SDR 11
24	80-mil HDPE Geomembrane (in liner penetration area)	SF	4,000	$1.52	$6,067	Assume a 40'x50' area for each liner penetration	Assume double cost of 40-mil (as provided by GSE).
25	Wetwell #1	EA	1	$28,680	$28,680	Includes 48" inside 63" prefabricated wetwell and shipping.	Forrer Supply, assume installation is 20% of material cost.
26	Wetwell Pumps & controls	LS	1	$40,000	$40,000	Includes 2 pumps (Flygt submersible), pump guide rails, disconnects, discharge hose, etc.	Flygt, assume 20% of material cost for shipping and installation charges.
27	4" inside 8" dual contained forcemain	LF	750	$57.01	$42,755	Assumes trenching for entire pipe length.	RS Means: 4" and 8" SDR 21, butt fusion joints, and 3' excavation; 33 11 13.35 0100 and 0300, 31 23 16.13 0060. Assume 10% increase in cost for material and shipping of SDR 11
28	Leachate Loadout	LS	1	$19,748	$19,748	Includes concrete slab, piping and misc. appurtenances.	Experience, RS Means: 6" heavy industrial reinforced slab on grade; A1030 120 4560
29	40,000 gal. double-wall leachate tank	EA	0	$81,599	$0	Assume 10% contractor mark-up on tank. Includes freight. [No tanks]	Modern Welding
30	EPG VSD 2-2 Pump and appurtenances	EA	0	$5,828	$0	Assume pump in each tank, and two extra pumps. Includes pump rails and controls in each tank. [No tanks]	Assume 20% of material cost for shipping and installation charges.
31	Pump control panel	LS	1	$18,057	$18,057	Includes radio transmission of alarms and status.	Assume 20% of material cost for shipping and installation charges
32	Pumps, pipes to leach. evap. pond	LS	1	$39,200	$39,200	Includes wetwell, pumps, and piping.	Assume 20% of material cost for shipping and installation charges
33	Leachate Pond Liner Construction	LS	1	$450,000	$450,000	Includes 6 Ac. Geomembrane Liner, Geoweb, and aeration system.	Assume 20% of material cost for shipping and installation charges

Item		Unit	Quantity	Rate	Amount	Comments	Source
Surface Water Management							
34	Surface water run-on channels	LF	4,940	$52.97	$261,676	Berms/channels to route run-on through site. Assume channels/berms will be excavated into the existing topography and constructed with a net soil balance. Assume 62 sf of cut and fill per linear foot of channel.	RS Means, same as structural fill above.
35	Surface water culvert (24" CMP)	LF	2,720	$54.28	$147,635	Under access road in entrance area, pond discharge structures, and temporary culvert under access road draining Phase 1 area.	RS Means, bituminous coated CMP and end sections; 33 41 13.40 2140 and 2275
36	Surface water culvert (36" CMP)	LF	1,150	$87.36	$100,461	Under access road in entrance area.	RS Means, bituminous coated CMP and end sections; 33 41 13.40 2180 and 2285
37	Riprap	CY	3,218	$111.64	$359,271	At culvert inlet/outlet, surface water basin spillways, gravel spreader berm, and run-on channel RO-1 (950 linear feet).	RS Means: Dumped riprap, 50 lb average, also hauling; 31 37 13.10 0300, see note 3; Assume 175 lbs/cf
38	Erosion Control Mat	Roll	56	$250.49	$14,027	Assume P5000 permanent erosion control blanket is used (roll size: 7.5 ft x 90 ft.). 4 rolls required for RO-2 cross section, 1,200 feet long.	Granite Environmental, includes shipping, assume 10% of material cost for installation.
Access Road							
39	Paved Road / Parking Areas	SY	17,733	$41.77	$740,755	Only considers road within site boundary.	RS Means, 9" crushed stone base, 2" asphalt binder course and 2"wearing course and hauling; 32 1123.23 0200, 32 12 16.13 0120 & 0380, see Note 3
40	Crushed Aggregate Road (9-inches) (all-weather)	SY	19,573	$18.33	$358,764	Includes gravel roads	RS Means: Base course drainage layers, 3/4" stone, 9" deep, also hauling; 32 11 23.23 0200, see note 3
41	Geotextile	SF	335,757	$0.29	$98,041	Assume non-woven NW8 by GSE under paved and gravel areas. Includes material, freight, labor, and mark-up.	GSE
Utilities							
42	Electrical	LF	57,780	$48.94	$2,827,900	Three utility costs were considered: KIUC ($100/LF), HTCO ($35/LF), and OTWC ($10/LF). Based on the conservative estimate using the Access Road B and Driveway 1 access route.	Based on experience and recent past projects.
43	Water	LF	20,140	$239.37	$4,821,000	Two access routes had the same cost: Access Road A and Driveway 1, and Access Road B and Driveway 1. Estimate includes excavation, backfill, 12-in pipe, and booster pump station	Based on experience and recent past projects.
44	Wastewater	LS	1	$514,000	$514,000	Estimate includes septic system and on-site piping to it, excavation, backfill, 8-in pipe, and sewer manholes.	Based on experience and recent past projects.
Miscellaneous							
45	Groundwater Monitoring Wells	LS	1	$140,948	$140,948	8 new wells, assumed 60 feet deep, 20 ft. screen with 2" casing, 3 concrete bollards per well. Includes field oversight, well development, documentation & reporting and PM oversight of work.	Based on Experience and information from Geotek Hawaii, Inc.
46	Guard Post	EA	16	$987.73	$15,804	Assumed 8 in the public drop off area and 8 around the maintenance building corners and doors.	RS Means: 32 17 13.13 1300
47	Security Fence	LF	17,000	$47.51	$807,691	Assumed around entire perimeter of Phase 1 and entrance area.	RS Means, 8' high chain link fence with 3 strands of barb wire, posts 10' O.C. set in concrete; 32 31 13.20 0920
48	Fence Gate	LF	24	$325.08	$7,802	Cantilever sliding gate, assume 24' opening	RS Means, cantilever slide gate, 10' high; 32 31 13.20 3120
49	Pump and radio panel setup	LS	1	$27,992	$27,992	Includes master radio pannel, programing and testing, computer and software.	Flygt, assume 20% of material cost for shipping and installation charges.
50	Site geotechnical and groundwater investigation	LS	1	$200,000	$200,000		Experience
51	Misc. Site Setup	LS	1	$100,000	$100,000	Office computers, printers, copiers, etc.	Assumed
				Subtotal	*$33,097,639*		
				Engineering and permitting -- 12%	$3,971,717		
				CM/CQA -- 8%	$2,647,811		
				Subtotal	$39,717,167		
				Hawaii General Excise Tax -- 4.166%	$1,654,617		
				Total	**$41,371,784**		
				Contingency -- 15%	$6,205,768		

Notes:

1. RS Means data based on RS Means Heavy Construction Cost Data, 2011 and adjusted for 2013 dollars based on values in the 2013 RS Means Square Foot Costs.
2. The RS Means city cost index for Honolulu Hawaii is: 117.5
3. Hauling costs added for soil materials is based on RS Means values for an 18 cy truck, 35 MPH average speed, and a 10 mile cycle; RS Means 31 23 23.20 9066.
4. A cost of materials for drainage layer, and operations layer is added based on contractor bids from 2010 for the construction Cell 1 at Kekaha. These costs have been increased by contractor overhead and the same adjustment as the 2011 RS Means costs to be in 2013 dollars. The cost per cubic yard of the materials only, in 2013 dollars, is: $91.88
5. KIUC (Kauai Island Utility Cooperative), HTCO (Hawaiian Telcom Inc.), OTWC (Oceanic Time Warner Cable).
6. Booster pump station for water utility was estimated to be $750,000 LS.

8.1.2 Alternative 1 Proposed RRP Costs

Table 9 summarizes the overall Alternative 1 proposed RRP estimated construction cost. The corresponding construction cost details are presented in Appendix G.1. The RRP may be developed in phases such that all of these costs are not incurred by the first day of operation (i.e., when the initial landfill costs, Section 8.1.1, *would* be incurred). Development of the Alternative 1 RRP is estimated to include 55 acres of the (noncontiguous) RRP property.

Table 9: Alternative 1 Proposed RRP Construction Cost Estimate Summary

Item	Cost
1. Pre-Development Requirements (Investigation, Survey, and Design)	$155,000
2. Site Preparation (Exclude Future Waste-to-Energy Facility)	$168,500
3. Roads (Exclude Future Waste-to-Energy Facility)	$1,991,600
4. Integrated Residential Drop-Off Facilities	$6,190,700
5. Integrated Processing Facilities	$12,675,600
6. Surface Water Management System	$1,335,500
7. Landscaping, Erosion Control, and Fencing	$293,000
8. Utilities	$1,160,000
9. Miscellaneous Items	$440,000
Subtotal	*$24,410,000*
Engineering and Permitting: 12%	$2,929,000
CM/CQA: 8%	$1,953,000
Subtotal	*$29,292,000*
Hawaii General Excise Tax: 4.166%	*$1,220,000*
Total	**$30,512,000**
Contingency: 15%	**4,577,000**
Possible Future Waste-to-Energy Facility	$150,068,000

8.1.3 Access Route Costs

As detailed in the TREFS (AECOM 2016; EIS Appendix E), the cost to establish the access route and utility lines from Kūhiō Highway to the MSWLF site is estimated to be $17.3 million.

If Driveway 1 is selected to connect the MSWLF and RRP sites, an additional $6.8 million may be required. If Driveway 2 is selected to connect the MSWLF and RRP sites, an additional $5.4 million may be required.

8.2 ALTERNATIVE 2 COST ESTIMATES

8.2.1 Alternative 2 Proposed MSWLF Costs

This section summarizes the anticipated capital costs to construct Alternative 2 Cell 1.1 and all required supporting infrastructure for site access and operation of the MSWLF. Most of the costs are identical to those described above for Alternative 1 (Section 8.1.1), with the following exceptions:

- **Earthwork.** Earthwork for development of Alternative 2 MSWLF encompasses 57.7 acres (18% less than the 70.4 acres proposed to be developed under Alternative 1).
- **Facility entrance.** The Alternative 2 facility entrance is similar to the Alternative 1 facility entrance, as described in Section 8.1.1. For Alternative 2, the construction of retaining walls for the public drop-off facility has been deleted because the facility would be built as part of the RRP. Less seeding is required for the Alternative 2 facility entrance area because some of the grading and seeding would be done with the RRP.

- **Cell 1.1 base liner construction.** Alternative 2, Cell 1.1 base liner construction is identical to Alternative 1, Cell 1.1 base liner construction.
- **Leachate management system.** The Alternative 2 Cell 1.1 leachate management system is nearly identical to Alternative 1. Perforated piping is identical. Gravity piping to the wetwell is 685 feet shorter for Alternative 2. The wetwell design is expected to be identical for both alternatives. The forcemain is approximately 30 feet longer. The proposed leachate evaporation pond is planned to be the same.
- **Surface water management system.** The Alternative 2 surface water management system is similar to Alternative 1. It would cover less area and thus be somewhat less extensive and expensive.
- **Access roads.** Alternative 2 contains 13,500 cy of paved internal access roads (compare to Alternative 1; 17,700 cy). Alternative 2 contains 14,900 cy of aggregate internal access roads (compare to Alternative 1; 19,600 cy).
- **Miscellaneous features and programs.** Miscellaneous features for Alternative 2 are nearly identical to those for Alternative 1. Eight fewer guardposts are included because they would be installed in the public drop-off facility as part of the RRP.
- **Engineering and permitting.** As under Alternative 1, engineering and permitting costs are assumed to be a percentage of the overall construction costs.
- **CM and CQA.** As under Alternative 1, CM and CQA costs are assumed to be a percentage of the overall construction costs.
- **Contingency.** As under Alternative 1, contingency costs are assumed to be a percentage of the overall construction costs.

The total preliminary estimated cost for supporting infrastructure and Cell 1.1 of the Alternative 2 proposed MSWLF is $41.0 million. Table 10 presents details of the cost estimates for the Alternative 2 proposed landfill. Initial development of the Alternative 2 MSWLF is estimated to include 57.7 acres of the property.

Table 10: Alternative 2 Proposed MSWLF Phase 1A Initial Development Construction Cost Estimate

Item		Unit	Quantity	Rate	Amount	Comments	Source
1	Mobilization/Demobilization	LS	1	$300,000	$300,000	Based on bid from Kekaha Cell 1 construction.	Experience
2	Erosion Control BMPs	LS	1	$10,000	$10,000		
3	Clearing/Grubbing	acre	57.7	$3,688	$212,819	All disturbed areas (includes Phase 1A, surface water basin, leachate pond, and entrance area)	RS Means: cut and chip light trees and grub stumps and remove; 31 11 10.10 0020 and 0150. Assume 50% cost reduction due to limited woody vegetation on site.
4	Topsoil Removal & Stockpiling	CY	46,545	$10.63	$494,654	All disturbed areas (includes Phase 1A, basin, leachate pond, and entrance area). Assumes 6" of topsoil.	RS Means: topsoil stripping and stockpiling; 31 14 13.23 1440
5	Excavation	CY	258,204	$8.78	$2,266,277	All disturbed areas (includes Phase 1A, surface water basin, leachae pond, and entrance area)	RS Means, excavate common earth, 3/4 cy backhoe, 3 dump trucks 1 mile round trip; G1030 120 1600
6	Topsoil Placement	CY	27,047	$6.25	$169,084	Haul from stockpile & spread. Total disturbed areas minus gravel areas, paved areas, and Phase 1A.	RS Means, equipment and labor only: borrow loading and spreading; 31 23 23.15 7000
7	Structural Fill	CY	293,192	$23.07	$6,763,343	All areas (includes Phase 1A, surface water basin, leachate pond, and entrance area). Material available from on-site excavation.	RS Means: structural backfill, 105 HP dozer, 300' haul, 4 passes, common earth; G1030 115 2050.
Facility Entrance Area							
8	Scale	EA	2	$97,780	$195,560	Includes concrete foundation, new Fairbanks scale and freight.	Experience/Recent Projects & Centerscal Automation Hawaii, Inc.
9	Ticket House	SF	846	$264.00	$223,344	Assume brick building on concrete slab.	RS Means, assume 10% OH & P
10	Office Building	SF	1,978	$264.00	$522,192	Assume brick building on concrete slab.	RS Means, assume 10% OH & P
11	Maintenance Building	SF	3,150	$92.40	$291,060	Assume metal building on concrete slab.	Recent Projects, assume 10% OH & P
12	Retaining Walls	LF	0	$320.08	$0	In public drop-off area. (Zero because Alternative 2 Public Drop-off is in RFP)	RS Means, cast-in-place retaining wall, 6' high; 32 32 13 10 1900
13	Seeding	SF	1,160,000	$0.06	$64,540	Total disturbed areas minus gravel areas, paved areas, and Phase 1A.	RS Means: seeding athletic field, slope mix with mulch and fertilizer; 32 92 19.14 4600
Phase 1A Liner							
14	6-inch granular foundation lift	CY	12,070	$23.07	$278,428		RS Means: Same as structural fill, above.
15	60-mil textured HDPE geomembrane	SF	666,174	$0.85	$564,916	Includes extra layer under 1,200 ft of perforated leachate pipe. Includes material, freight, labor, and mark-up.	GSE
16	GCL	SF	651,774	$0.63	$409,575	Assume Bentoliner NSL by GSE. Includes material, freight, labor, and mark-up.	GSE
17	16-oz/sy non-woven Cushion Geotextile	SF	666,174	$0.38	$254,212	1- layer (above geomembrane) Includes extra layer under 1,200 ft of perforated leachate pipe. Assumes GSE NW16. Includes material, freight, labor, and mark-up.	GSE
Leachate Management							
18	12-inch Drainage Layer	CY	24,140	$101.26	$2,444,308		RS Means: 80 HP 300' haul, sand & gravel, also material and hauling; 31 23 23.14 2400, see notes 3 and 4
19	6-oz/sy non-woven Separator Geotextile	SF	651,774	$0.27	$175,718	Assumes GSE NW6. Includes material, freight, labor, and mark-up.	GSE
20	24-inch operations layer	CY	48,280	$101.26	$4,888,616		RS Means, same as drainage layer above.
21	8-inch SDR 9 HDPE Pipe	LF	1,510	$31.63	$47,765	Includes perforated and solid (cleanout riser) pipes.	RS Means: 8" SDR 21 HDPE, butt fusion joints; 33 11 13.35 0300. Assume 10% increase in cost for material and shipping of SDR 9
22	Liner penetration	EA	2	$5,250	$10,500	Flatstock/pipe boot prefabricated structure.	Forrer Supply, assume 50% of material cost for shipping and installation.
23	8" inside 12" dual containted gravity pipe	LF	2,750	$97.99	$269,478	Includes 50 ft stub at each current and future liner penetration.	RS Means: 8" and 12" SDR 21 HDPE, butt fusion joints and 3' excavation; 33 11 13.35 0300 and 0500, 31 23 16.13 0060. Assume 10% increase in cost for material and shipping of SDR 11
24	80-mil HDPE Geomembrane (in liner penetration area)	SF	4,000	$1.52	$6,067	Assume a 40'x50' area for each liner penetration	Assume double cost of 40-mil (as provided by GSE).
25	Wetwell #1	EA	1	$28,680	$28,680	Includes 48" inside 63" prefabricated wetwell and shipping.	Forrer Supply, assume installation is 20% of material cost.
26	Wetwell Pumps & controls	LS	1	$40,000	$40,000	Includes 2 pumps (Flygt submersible), pump guide rails, disconnects, discharge hose, etc.	Flygt, assume 20% of material cost for shipping and installation charges.
27	4" inside 8" dual contained forcemain	LF	750	$57.01	$42,755	Assumes trenching for entire pipe length.	RS Means: 4" and 8" SDR 21, butt fusion joints, and 3' excavation; 33 11 13.35 0100 and 0300, 31 23 16.13 0060. Assume 10% increase in cost for material and shipping of SDR 11
28	Leachate Loadout	LS	1	$19,748	$19,748	Includes concrete slab, piping and misc. appurtenances.	Experience, RS Means: 6" heavy industrial reinforced slab on grade; A1030 120 4560
29	40,000 gal. double-wall leachate tank	EA	0	$81,599	$0	Assume 10% contractor mark-up on tank. Includes freight. [No tanks]	Modern Welding
30	EPG VSD 2-2 Pump and appurtenances	EA	0	$5,828	$0	Assume pump in each tank, and two extra pumps. Includes pump rails and controls in each tank. [No tanks]	Assume 20% of material cost for shipping and installation charges.
31	Pump control panel	LS	1	$18,057	$18,057	Includes radio transmission of alarms and status.	Assume 20% of material cost for shipping and installation charges
32	Pumps, pipes to leach. evap. Pond	LS	1	$49,200	$49,200	Includes wetwell, pumps, and piping.	Assume 20% of material cost for shipping and installation charges
33	Leachate Pond Liner Construction	LS	1	$450,000	$450,000	Includes 6 Ac. Geomembrane Liner, Geoweb, and aeration system.	Assume 20% of material cost for shipping and installation charges

Item		Unit	Quantity	Rate	Amount	Comments	Source
Surface Water Management							
34	Surface water run-on channels	LF	4,940	$52.97	$261,676	Berms/channels to route run-on through site. Assume channels/berms will be excavated into the existing topography and constructed with a net soil balance. Assume 62 sf of cut and fill per linear foot of channel.	RS Means, same as structural fill above.
35	Surface water culvert (24" CMP)	LF	2,720	$54.28	$147,635	Under access road in entrance area, pond discharge structures, and temporary culvert under access road draining Phase 1 area.	RS Means, bituminous coated CMP and end sections; 33 41 13.40 2140 and 2275
36	Surface water culvert (36" CMP)	LF	1,150	$87.36	$100,461	Under access road in entrance area.	RS Means, bituminous coated CMP and end sections; 33 41 13.40 2180 and 2285
37	Riprap	CY	3,218	$111.64	$359,271	At culvert inlet/outlet, surface water basin spillways, gravel spreader berm, and run-on channel RO-1 (950 linear feet).	RS Means: Dumped riprap, 50 lb average, also hauling; 31 37 13.10 0300, see note 3; Assume 175 lbs/cf
38	Erosion Control Mat	Roll	56	$250.49	$14,027	Assume P5000 permanent erosion control blanket is used (roll size: 7.5 ft x 90 ft.). 4 rolls required for RO-2 cross section, 1,200 feet long.	Granite Environmental, includes shipping, assume 10% of material cost for installation.
Access Road							
39	Paved Road / Parking Areas	SY	13,500	$41.77	$563,927	Only considers road within site boundary.	RS Means, 9" crushed stone base, 2" asphalt binder course and 2"wearing course and hauling; 32 1123.23 0200, 32 12 16.13 0120 & 0380, see Note 3
40	Crushed Aggregate Road (9-inches) (all-weather)	SY	14,900	$18.33	$273,107	Includes gravel roads	RS Means: Base course drainage layers, 3/4" stone, 9" deep, also hauling; 32 11 23.23 0200, see note 3
41	Geotextile	SF	255,600	$0.29	$74,635	Assume non-woven NW8 by GSE under paved and gravel areas. Includes material, freight, labor, and mark-up.	GSE
Utilities							
42	Electrical	LF	57,780	$48.94	$2,827,900	Three utility costs were considered: KIUC ($100/LF), HTCO ($35/LF), and OTWC ($10/LF). Based on the conservative estimate using the Access Road B and Driveway 1 access route.	Based on experience and recent past projects.
43	Water	LF	20,140	$239.37	$4,821,000	Two access routes had the same cost: Access Road A and Driveway 1, and Access Road B and Driveway 1. Estimate includes excavation, backfill, 12-in pipe, and booster pump station	Based on experience and recent past projects.
44	Wastewater	LS	1	$514,000	$514,000	Estimate includes septic system and on-site piping to it, excavation, backfill, 8-in pipe, and sewer manholes.	Based on experience and recent past projects.
Miscellaneous							
45	Groundwater Monitoring Wells	LS	1	$140,948	$140,948	8 new wells, assumed 60 feet deep, 20 ft. screen with 2" casing, 3 concrete bollards per well. Includes field oversight, well development, documentation & reporting and PM oversight of work.	Based on Experience and information from Geotek Hawaii, Inc.
46	Guard Post	EA	8	$987.73	$7,902	Assumed 0 in public drop off area and 8 around the maintenance building corners and doors. [Public drop-off is in RRP]	RS Means: 32 17 13.13 1300
47	Security Fence	LF	17,000	$47.51	$807,691	Assumed around entire perimeter of Phase 1 and entrance area.	RS Means, 8' high chain link fence with 3 strands of barb wire, posts 10' O.C. set in concrete; 32 31 13.20 0920
48	Fence Gate	LF	24	$325.08	$7,802	Cantilever sliding gate, assume 24' opening	RS Means, cantilever slide gate, 10' high; 32 31 13.20 3120
49	Pump and radio panel setup	LS	1	$27,992	$27,992	Includes master radio pannel, programing and testing, computer and software.	Flygt, assume 20% of material cost for shipping and installation charges.
50	Site geotechnical and groundwater investigation	LS	1	$200,000	$200,000		Experience
51	Misc. Site Setup	LS	1	$100,000	$100,000	Office computers, printers, copiers, etc.	Assumed
				Subtotal	*$32,760,871*		
				Engineering and Permitting -- 12%	$3,931,304		
				CM/CQA -- 8%	$2,620,870		
				Subtotal	$39,313,045		
				Hawaii General Excise Tax -- 4.166%	$1,637,781		
				Total	**$40,950,826**		
				Contingency -- 15%	$6,142,624		

Notes:

1. RS Means data based on RS Means Heavy Construction Cost Data, 2011 and adjusted for 2013 dollars based on values in the 2013 RS Means Square Foot Costs.
2. The RS Means city cost index for Honolulu Hawaii is: 117.5
3. Hauling costs added for soil materials is based on RS Means values for an 18 cy truck, 35 MPH average speed, and a 10 mile cycle; RS Means 31 23 23.20 9066.
4. A cost of materials for drainage layer, and operations layer is added based on contractor bids from 2010 for the construction Cell 1 at Kekaha. These costs have been increased by contractor overhead and the same adjustment as the 2011 RS Means costs to be in 2013 dollars. The cost per cubic yard of the materials only, in 2013 dollars, is: $91.88
5. KIUC (Kauai Island Utility Cooperative), HTCO (Hawaiian Telcom Inc.), OTWC (Oceanic Time Warner Cable).
6. Booster pump station for water utility was estimated to be $750,000 LS.

8.2.2 Alternative 2 Proposed RRP Costs

Table 11 summarizes the overall Alternative 2 proposed RRP estimated construction cost. The corresponding construction cost details are presented in Appendix G.2. Some of the cost items for the Alternative 1 RRP (e.g., wastewater, stormwater, internal roadways.) are consolidated in the Alternative 2 MSWLF cost (Section 8.2.1), resulting in overall project savings.

The RRP may be developed in phases such that all of these costs are not incurred by the first day of operation (i.e., when the initial landfill costs, Section 8.2.1, *would* be incurred). Development of the Alternative 2 RRP is estimated to include 30.9 acres of the property.

Table 11: Alternative 2 Proposed RRP Construction Cost Estimate Summary

Item	Cost
1. Pre-Development Requirements (Investigation, Survey, and Design)	$0
2. Site Preparation (Exclude Waste-to-Energy Facility)	$83,500
3. Roads (Exclude Waste-to-Energy Facility)	$858,000
4. Integrated Residential Drop-Off Facilities	$6,028,478
5. Integrated Processing Facilities	$12,475,582
6. Surface Water Management System	$400,000
7. Landscaping, Erosion Control, and Fencing	$90,000
8. Utilities	$970,000
9. Miscellaneous Items	$275,000
Subtotal	*$21,180,560*
Permits and Engineering - 12%	*$2,541,667*
CM/CQA - 8%	*$1,694,445*
Subtotal	*$25,416,672*
Hawaii General Excise Tax - 4.166%	*$1,058,859*
Total	**$26,480,000**
Contingency - 15%	*$3,970,000*
Possible Future Waste-to-Energy Facility	$150,070,000

8.2.3 Access Route Costs

As detailed in the TREFS (AECOM 2016; EIS Appendix E), the cost to establish the access route and utility lines from Kūhiō Highway to the MSWLF site is estimated to be $17.3 million.

8.3 COST SUMMARY

The summary costs presented in Table 12 do not include a contingency to cover future changes, scope clarifications, or cost escalations. Alternative 2 construction would cost approximately 10-11 percent less than Alternative 1 for the items included in this cost estimate.

Table 12: Summary of Estimated Initial Construction Costs for Proposed MSWLF Phase 1A and RRP

Alternative	MSWLF	RRP	Access Roads and Utilities [a]	Total
1	$41,372,000	$30,512,000	$18,738,000 to $19,793,000	$90,622,000 to $91,677,000
2	$40,951,000	$26,480,000	$11,692,000	$79,123,000
Future Waste-To-Energy	—	$150,070,000	—	$150,070,000

Note: Estimated costs exclude contingency or discount rates.

[a] Access roads and utilities costs are from the *Traffic and Roadways Engineering Feasibility Study* (AECOM 2016; EIS Appendix E): Project Access Route E3 (Kaua'i Beach Drive), and for Alternative 1 include costs for developing one of two driveways connecting the MSWLF and RRP sites.

9.0 REFERENCES

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40 Code of Federal Regulations (CFR) 70. 1992. *State Operating Permit Programs.*

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40 Code of Federal Regulations (CFR) 258. 2006. *Criteria for Municipal Solid Waste Landfills*.

42 United States Code (U.S.C.) 1963. *Clean Air Act,* as amended. Chapter 85, §§7401-7671.

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———. 2013. *Resource Recovery Park Feasibility Study*. Prepared for County of Kaua‘i, Department of Public Works. Honolulu. April.

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DRAWINGS

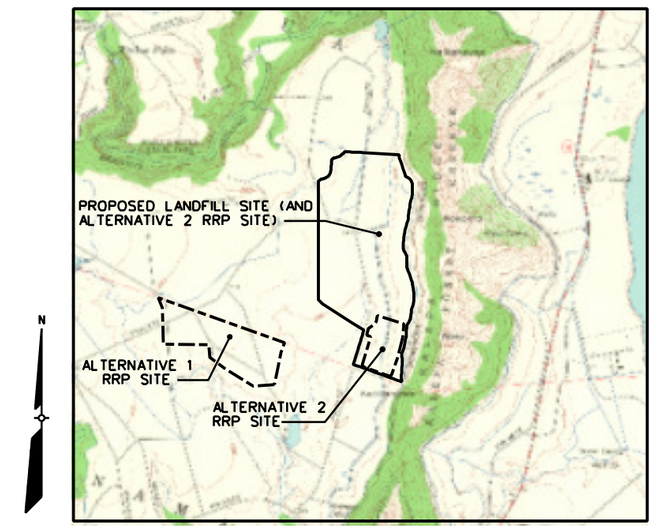
CONCEPTUAL DESIGNS
MA'ALO MUNICIPAL SOLID WASTE (MSW) LANDFILL AND RESOURCE RECOVERY PARK AT MA'ALO

KAUA'I, HAWAI'I

AUGUST 2014

VICINITY MAP

INDEX	
DRAWING NO.	TITLE
-	TITLE AND INDEX
1	PROPOSED MSWLF SITE EXISTING CONDITIONS
2	ALTERNATIVE 1 - LANDFILL FACILITY LAYOUT
3	ALTERNATIVE 1 - SUBBASE GRADING PLAN
4	ALTERNATIVE 1 - FINAL COVER GRADING PLAN
5	ALTERNATIVE 1 - PHASE 1 SUBBASE GRADING PLAN
6	ALTERNATIVE 1 - PHASE 1 LEACHATE MANAGEMENT SYSTEM
7	ALTERNATIVE 1 - PHASE 1 FINAL COVER GRADING PLAN
8	ALTERNATIVE 1 - PHASE 1 SURFACE WATER MANAGEMENT PLAN
9	ALTERNATIVE 1 - PHASE 1 LANDFILL GAS COLLECTION SYSTEM
10	ALTERNATIVE 1 - LANDFILL ENTRANCE AREA LAYOUT
11	ALTERNATIVE 1 - INITIAL LANDFILL SITE DEVELOPMENT PLAN
12	ALTERNATIVE 1 - LANDFILL CROSS SECTIONS A-A', B-B'
13	ALTERNATIVE 1 - LANDFILL CROSS SECTIONS C-C', D-D'
14	ALTERNATIVE 1 - RRP SITE EXISTING CONDITIONS
15	ALTERNATIVE 1 - RRP SITE FACILITY LAYOUT
16	ALTERNATIVE 1 - RRP SITE AREA 1
17	ALTERNATIVE 1 - RRP SITE AREA 2
18	ALTERNATIVE 1 - RRP SITE AREA 3
19	ALTERNATIVE 2 - LANDFILL FACILITY LAYOUT
20	ALTERNATIVE 2 - SUBBASE GRADING PLAN
21	ALTERNATIVE 2 - FINAL COVER GRADING PLAN
22	ALTERNATIVE 2 - PHASE 1 SUBBASE GRADING PLAN
23	ALTERNATIVE 2 - PHASE 1 LEACHATE MANAGEMENT SYSTEM
24	ALTERNATIVE 2 - PHASE 1 FINAL COVER GRADING PLAN
25	ALTERNATIVE 2 - PHASE 1 SURFACE WATER MANAGEMENT PLAN
26	ALTERNATIVE 2 - PHASE 1 LANDFILL GAS COLLECTION SYSTEM
27	ALTERNATIVE 2 - INITIAL LANDFILL SITE DEVELOPMENT PLAN
28	ALTERNATIVE 2 - LANDFILL CROSS SECTIONS A-A', B-B'
29	ALTERNATIVE 2 - LANDFILL CROSS SECTIONS C-C', D-D'
30	ALTERNATIVE 2 - ENTRANCE AREA AND RRP SITE FACILITY LAYOUT
31	DETAILS: BASE LINER AND LEACHATE COLLECTION SYSTEM
32	DETAILS: PIPE PENETRATION AND GRADING PLAN
33	DETAILS: LEACHATE WET WELL AND LOADOUT STATION
34	DETAILS: DIVERSION BERM AND CULVERT
35	DETAILS: SEDIMENTATION BASIN AND SPILLWAYS
36	DETAILS: GAS EXTRACTION SYSTEM
37	DETAILS: BLOWER AND FLARE STATION
38	TYPICAL RRP DETAILS: DIVERSION CHANNEL, CULVERT, AND SPILLWAYS
39	DETAILS: LEACHATE EVAPORATION POND



SOURCE:
BASE MAP TAKEN FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE: KAPAA QUADRANGLE, HAWAII

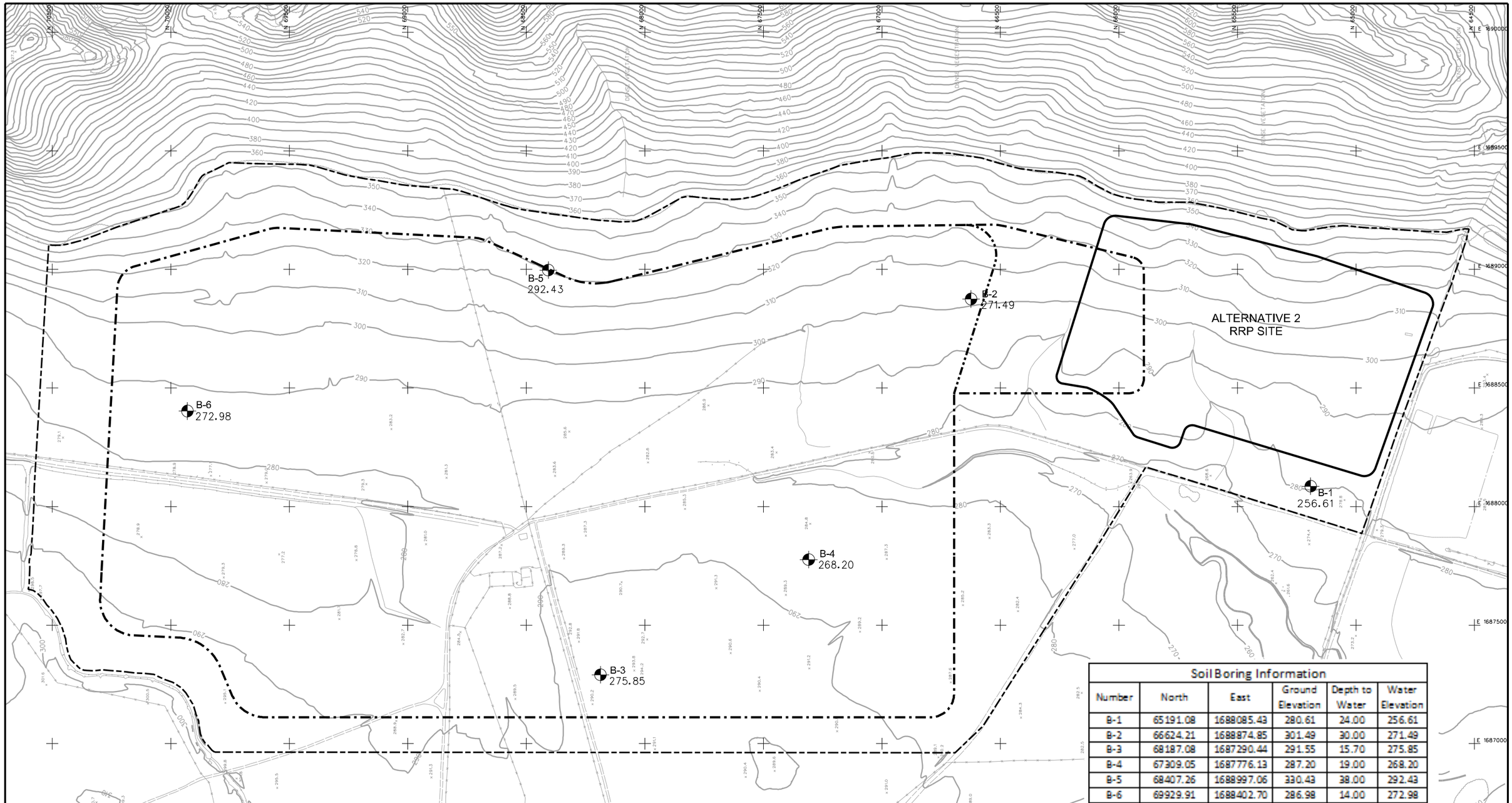
LOCATION MAP

PREPARED FOR

COUNTY OF KAUA'I, DEPARTMENT OF PUBLIC WORKS
4444 RICE STREET
LIHUE, KAUA'I, 96766

PREPARED BY AECOM

1001 BISHOP STREET
SUITE 1600
HONOLULU, HAWAII 96813
808-523-8874



Soil Boring Information					
Number	North	East	Ground Elevation	Depth to Water	Water Elevation
B-1	65191.08	1688085.43	280.61	24.00	256.61
B-2	66624.21	1688874.85	301.49	30.00	271.49
B-3	68187.08	1687290.44	291.55	15.70	275.85
B-4	67309.05	1687776.13	287.20	19.00	268.20
B-5	68407.26	1688997.06	330.43	38.00	292.43
B-6	69929.91	1688402.70	286.98	14.00	272.98

LEGEND

- 680 — EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- APPRXIMATE LIMITS OF ALTERNATIVE 2 RRP SITE
- PROPOSED LIMITS OF WASTE - ALTENATIVE 1
- PROPOSED LIMITS OF WASTE - ALTERNATIVE 2
- B-1 256.61 — SOIL BORING LOCATION AND APPROXIMATE GROUNDWATER ELEVATION

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. SOIL BORINGS ADVANCED BY MASA FUJIOKA & ASSOCIATES ON MAY 14-16, 2012.

N

SCALE 0' 200' 400'

AECOM

DRAWING 1
PROPOSED MSWLF SITE
EXISTING CONDITIONS

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

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POTENTIAL FUTURE SURFACE WATER BASIN

POTENTIAL FUTURE LEACHATE EVAPORATION POND

PHASE 2

CELL 1.1
(INITIAL DEVELOPMENT)

PHASE 1

PHASE 3

PHASE 4

SOUTH SURFACE WATER BASIN

LEACHATE EVAPORATION POND

REFER TO DRAWING 10 FOR ENTRANCE AREA LAYOUT

SITE ACCESS ROAD

DRIVEWAY #1

DRIVEWAY #2

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- ACCESS ROAD

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

N

SCALE 0' 200' 400'

AECOM

DRAWING 2
ALTERNATIVE 1
LANDFILL FACILITY LAYOUT

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO

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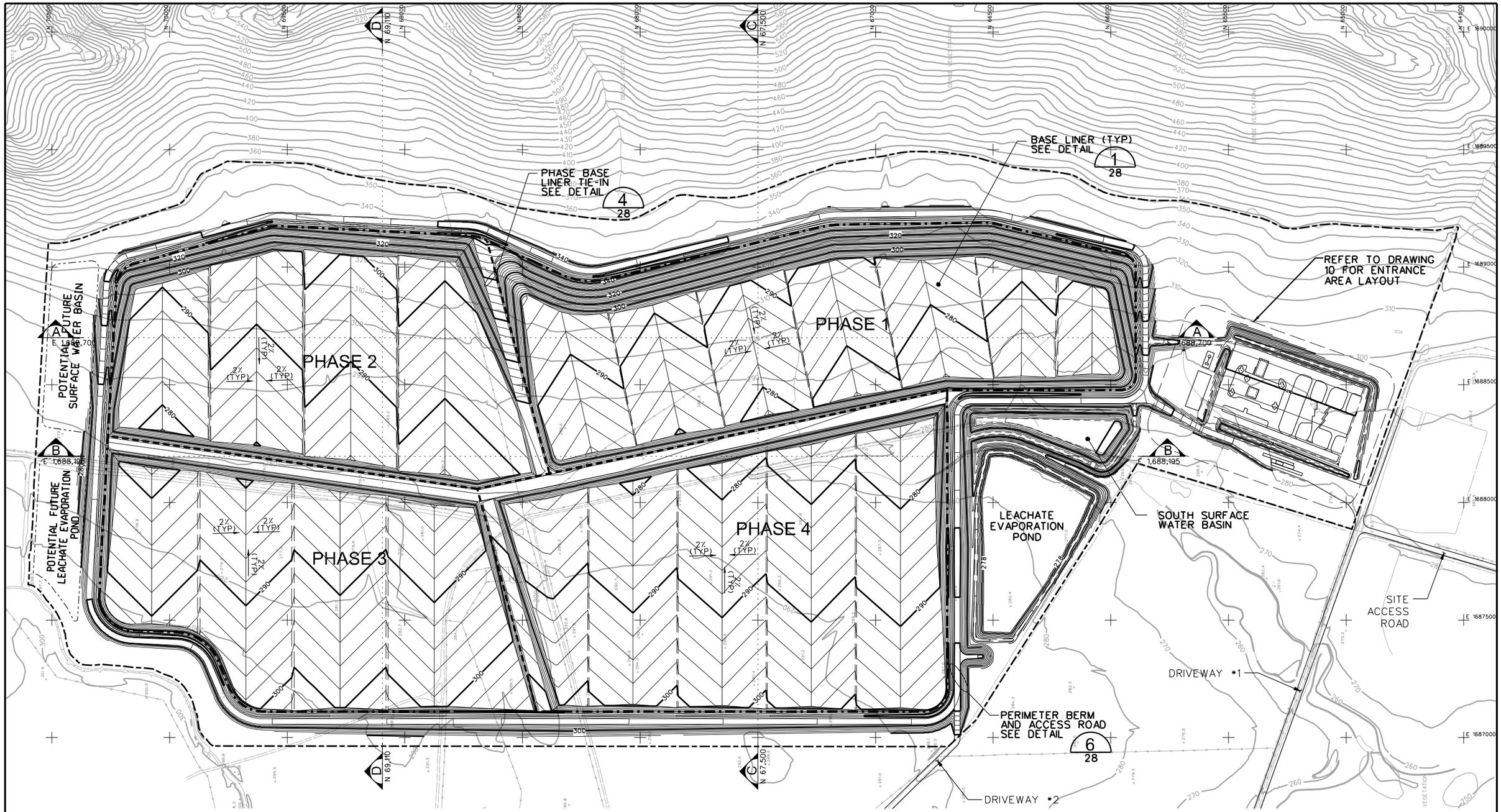

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- ACCESS ROAD
- POTENTIAL FUTURE SURFACE WATER BASIN

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT SUBBASE AND SURFACE FOR INSTALLATION OF APPROVED GEOSYNTHETIC BASE LINER.
4. PHASE 5 IS A VERTICAL PHASE OVERLYING PHASES 1 THROUGH 4.

AECOM

DRAWING 3
ALTERNATIVE 1
SUBBASE GRADING PLAN
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

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FINAL COVER SYSTEM
SEE DETAIL 5/31

REFER TO DRAWING 10 FOR ENTRANCE AREA LAYOUT

POTENTIAL FUTURE SURFACE WATER BASIN

POTENTIAL FUTURE LEACHATE EVAPORATION POND

SOUTH SURFACE WATER BASIN

LEACHATE EVAPORATION POND (SEE DETAIL SHEET 39)

SITE ACCESS ROAD

PERIMETER BERM AND ACCESS ROAD SEE DETAIL 6/28

DRIVEWAY #1

DRIVEWAY #2

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- ACCESS ROAD
- POTENTIAL FUTURE SURFACE WATER BASIN

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT TOP OF FINAL COVER SYSTEM.

SCALE 0' 200' 400'

AECOM

DRAWING 4
ALTERNATIVE 1
FINAL COVER GRADING PLAN

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

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BASE LINER SEE DETAIL 1/31

PROPOSED LOCATION OF SEPTIC FIELD

REFER TO DRAWING 10 FOR ENTRANCE AREA LAYOUT

CELL 1.1

PHASE 1

FUTURE PHASE 2

FUTURE PHASE BASE LINER TIE-IN SEE DETAIL 4/31

SOUTH SURFACE WATER BASIN

LEACHATE EVAPORATION POND

PERIMETER BERM AND ACCESS ROAD SEE DETAIL 6/31

FUTURE PHASE 3

FUTURE PHASE 4

SITE ACCESS ROAD

DRIVEWAY #2

DRIVEWAY #1

E 1689500

E 1689000

E 1688500

E 1688000

E 1687500

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- ACCESS ROAD
- SECURITY FENCE

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT SUBBASE AND SURFACE FOR INSTALLATION OF PROPOSED GEOSYNTHETIC BASE LINER.

N

SCALE 0' 150' 300'

AECOM

DRAWING 5
ALTERNATIVE 1
PHASE 1 SUBBASE GRADING PLAN

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

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LEACHATE COLLECTION SYSTEM SEE DETAILS 2/31 AND 3/31

LEACHATE CLEANOUT RISER PIPE

CONDENSATE DRAIN PIPE ON SIDESLOPE FOR FUTURE CONNECTION TO LFG CONDENSATE KNOCKOUT DRAIN SEE DETAILS 4/35 AND 5/35

CELL 1.1

PHASE 1

FUTURE PHASE 2

WET WELL #1 SEE DETAIL 1/33

CONDENSATE DRAIN PIPE ON SIDESLOPE FOR FUTURE CONNECTION TO LFG CONDENSATE KNOCKOUT DRAIN (DRAINS TO AREA OF LOW POINT) SEE DETAILS 4/35 AND 5/35

SOUTH SURFACE WATER BASIN

DUAL-CONTAINMENT GRAVITY LEACHATE TRANSFER PIPE SEE TRENCH DETAIL 2/33

LEACHATE EVAPORATION POND (SEE DETAIL DRAWING 39)

FUTURE PHASE 3

LEACHATE COLLECTION PIPE LINE PENETRATION SEE DETAILS 1/32 AND 2/32

FUTURE PHASE 4

FORCEMAIN LEACHATE TRANSFER PIPE TO LEACHATE EVAPORATION POND SEE DETAIL 3/33

SITE ACCESS ROAD

DRIVEWAY #2

DRIVEWAY #1

LEACHATE LOADOUT STATION SEE DETAIL 4/33

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- GRADE BREAK
- LEACHATE COLLECTION PIPE
- LEACHATE CLEANOUT RISER
- SECURITY FENCE

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT SUBBASE AND SURFACE FOR INSTALLATION OF PROPOSED GEOSYNTHETIC BASE LINER.

SCALE 0' 150' 300'

AECOM

DRAWING 6
ALTERNATIVE 1 - PHASE 1
LEACHATE MANAGEMENT SYSTEM
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

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FINAL COVER SYSTEM SEE DETAIL 5/31

PERIMETER BERM AND ACCESS ROAD SEE DETAIL 6/31

PROPOSED LOCATION OF SEPTIC FIELD

REFER TO DRAWING 10 FOR ENTRANCE AREA LAYOUT

PHASE 1

FUTURE PHASE 2

FUTURE PHASE BASE LINER TIE-IN SEE DETAIL 4/31

SOUTH SURFACE WATER BASIN

LEACHATE EVAPORATION POND

FUTURE PHASE 3

FUTURE PHASE 4

DRIVEWAY #2

SITE ACCESS ROAD

DRIVEWAY #1

LEGEND

- EXISTING TOPOGRAPHY (680)
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- SECURITY FENCE

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT TOP OF FINAL COVER SYSTEM.

N

SCALE 0' 150' 300'

AECOM

DRAWING 7
ALTERNATIVE 1
PHASE 1 FINAL COVER GRADING PLAN

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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RUN-ON CHANNEL (TYP) SEE DETAIL 5/34

ROAD CHANNEL SEE DETAIL 5/34

SURFACE WATER DIVERSION BERM (TYP.) SEE DETAIL 5/34

BENCH SEE DETAIL 2/34

PHASE 1

FUTURE PHASE 2

PERIMETER CHANNEL (TYP.) SEE DETAILS 6/31 AND 5/34

DOWNSLOPE CHANNEL (TYP.) SEE DETAIL 3/34

MAINTAIN EXISTING DRAINAGE FEATURES TO MANAGE RUN-ON AND SITE DRAINAGE

FUTURE PHASE 3

FUTURE PHASE 4

SOUTH SURFACE WATER BASIN SEE DETAILS 1/35 2/35

DRIVEWAY #2

EMERGENCY SPILLWAY

SECONDARY SPILLWAY

PRIMARY SPILLWAY

CULVERT (TYP) SEE DETAIL 6/34

PROPOSED LOCATION OF SEPTIC FIELD

MAINTAIN EXISTING DRAINAGE FEATURES TO MANAGE RUN-ON AND SITE DRAINAGE

GRAVEL SPREADER BERM SEE DETAIL 3/35

SITE ACCESS ROAD

DRIVEWAY #1

E 1689500
E 1689000
E 1688500
E 1688000
E 1687500

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- SECURITY FENCE
- SURFACE WATER FLOW
- RUN-ON CHANNEL
- CULVERT
- RIP RAP

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT TOP OF FINAL COVER SYSTEM. SEE FINAL COVER DETAIL 5/31

N

SCALE 0' 150' 300'

AECOM

DRAWING 8
ALTERNATIVE 1 - PHASE 1
SURFACE WATER MANAGEMENT PLAN

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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HEADER ACCESS RISER (TYP) SEE DETAIL 9/36

BLIND FLANGE CONNECTION (TYP) SEE DETAIL 5/36

CONTROL VALVE (TYP) SEE DETAIL 8/36

GAS EXTRACTION WELL (TYP) SEE DETAIL 1/36 2/36

BLOWER AND FLARE STATION SEE DETAIL 1/37

POTENTIAL FUTURE LANDFILL GAS-TO-ENERGY PLANT

PHASE 1

FUTURE PHASE 2

FUTURE PHASE 3

FUTURE PHASE 4

GW-1 GW-2 GW-3 GW-4 GW-5 GW-6 GW-7 GW-8 GW-9 GW-10 GW-11 GW-12 GW-13 GW-14 GW-15 GW-16

H.P.

DRAIN CONDENSATE TO SIDESLOPE DRAIN PIPE TO LEACHATE SYSTEM

CONDENSATE KNOCKOUT (TYP) SEE DETAIL 4/35

CONDENSATE DRAIN TO LEACHATE WET WELL #1

SITE ACCESS ROAD

DRIVEWAY #2

DRIVEWAY #1

E 1689500 E 1689000 E 1688500 E 1688000 E 1687500

LEGEND

- EXISTING TOPOGRAPHY
- PROPERTY LINE
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- SECURITY FENCE
- GAS COLLECTION HEADER PIPE
- GAS COLLECTION WELL
- CONDENSATE KNOCKOUT
- CONTROL VALVE
- HEADER ACCESS RISER

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT TOP OF FINAL COVER SYSTEM. SEE FINAL COVER DETAIL 5/31

N

SCALE 0' 150' 300'

AECOM

DRAWING 9
ALTERNATIVE 1 - PHASE 1
LANDFILL GAS COLLECTION SYSTEM

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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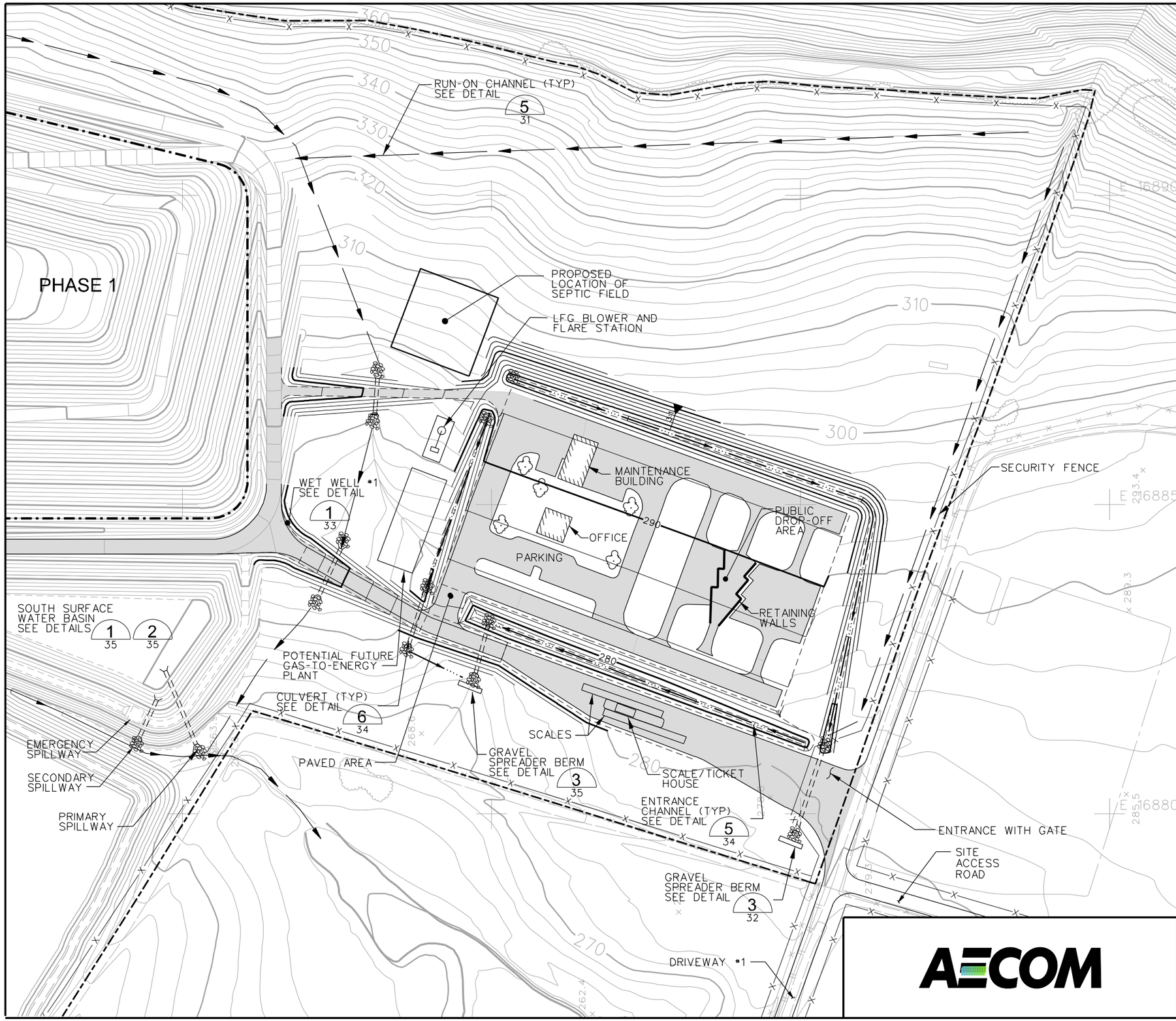

LEGEND

- EXISTING TOPOGRAPHY
- PROPERTY LINE
- PROPOSED LIMITS OF WASTE
- SECURITY FENCE
- ASPHALT PAVED AREA
- CULVERT
- SURFACE WATER FLOW
- RUN-ON CHANNEL
- RIP RAP

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

N

SCALE 0' 80' 160'

AECOM

DRAWING 10
ALTERNATIVE 1
LANDFILL ENTRANCE AREA LAYOUT

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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AREA NOT DISTURBED BY CONSTRUCTION

RUN-ON CHANNEL (TYP) SEE DETAIL 5/34

AREA NOT DISTURBED BY CONSTRUCTION

PROPOSED LOCATION OF SEPTIC FIELD

TEMPORARY SURFACE WATER DIVERSION BERM

PHASE 1

CELL 1.1

FUTURE PHASE 2

TEMPORARY SURFACE WATER DIVERSION BERM (TYP) SEE DETAIL 5/34

TEMPORARY CULVERT

36" CULVERTS SEE NOTE 5

WET WELL #1 SEE DETAIL

SOUTH SURFACE WATER BASIN SEE NOTE 4

TEMPORARY CULVERT

SILT FENCE

DUAL-CONTAINMENT GRAVITY LEACHATE TRANSFER PIPE SEE DETAIL 2/33

LEACHATE EVAPORATION POND

FORCEMAIN LEACHATE TRANSFER PIPE TO LEACHATE EVAPORATION POND SEE DETAIL 3/33

FUTURE PHASE 3

LEACHATE COLLECTION PIPE LINE PENETRATION SEE DETAILS 1/32 AND 2/32

FUTURE PHASE 4

OPERATIONS TO MANAGE CELL 1.1 SURFACE WATER RUNOFF DURING FILLING

RIPRAP (TYP)

E 1689500

E 1689000

E 1688500

E 1688000

E 1687500

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- GRADE BREAK
- LEACHATE COLLECTION PIPE
- SECURITY FENCE
- SILT FENCE
- RIPRAP
- LEACHATE CLEANOUT RISER
- AREA DISTURBED BY CONSTRUCTION

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN IN CELL 1.1 DEPICT TOP OF INTERMEDIATE COVER.
4. SURFACE WATER BASINS AND DITCHES WILL EMPTY WITHIN 48 HOURS AFTER THE CONCLUSION OF A STORM EVENT.
5. ALL CULVERTS AND TEMPORARY CULVERTS ARE 24" UNLESS OTHERWISE NOTED.

N

SCALE 0' 150' 300'

AECOM

DRAWING 11
ALTERNATIVE 1 - INITIAL LANDFILL SITE DEVELOPMENT PLAN
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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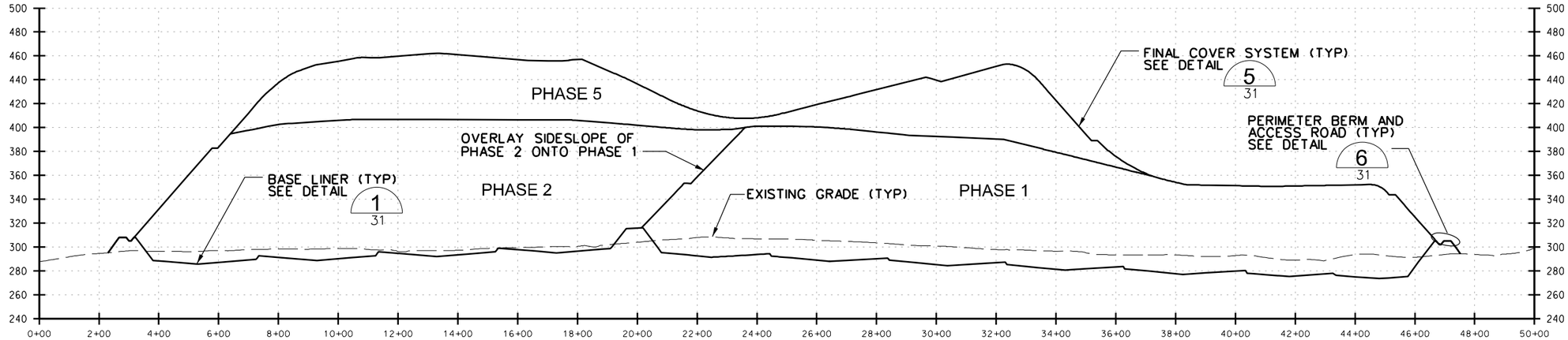
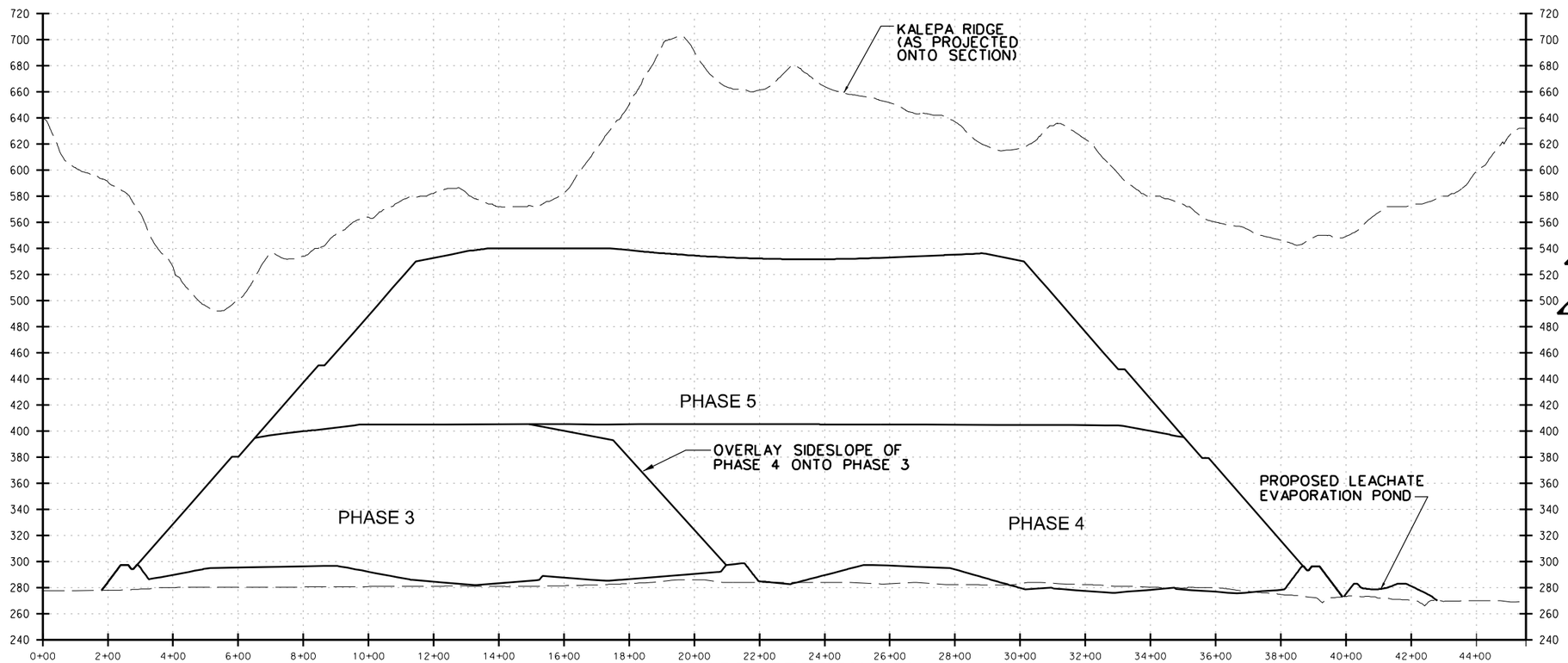


CROSS SECTION A-A'
E 1,688,700



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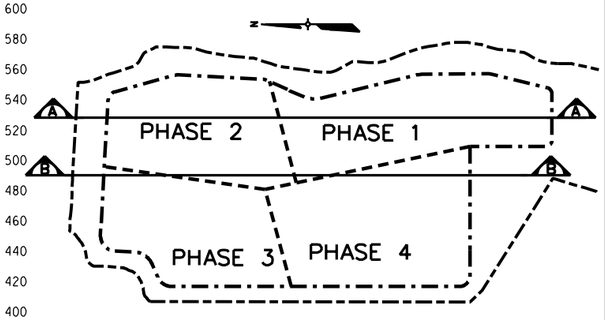

CROSS SECTION LOCATION MAP

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

HORIZ. SCALE 0' 200' 400'
VERT. SCALE 0' 50' 100'

AECOM

DRAWING 12
ALTERNATIVE 1
LANDFILL CROSS SECTIONS A-A', B-B'
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
AUGUST 2014 KAUA'I, HAWAII 60221907

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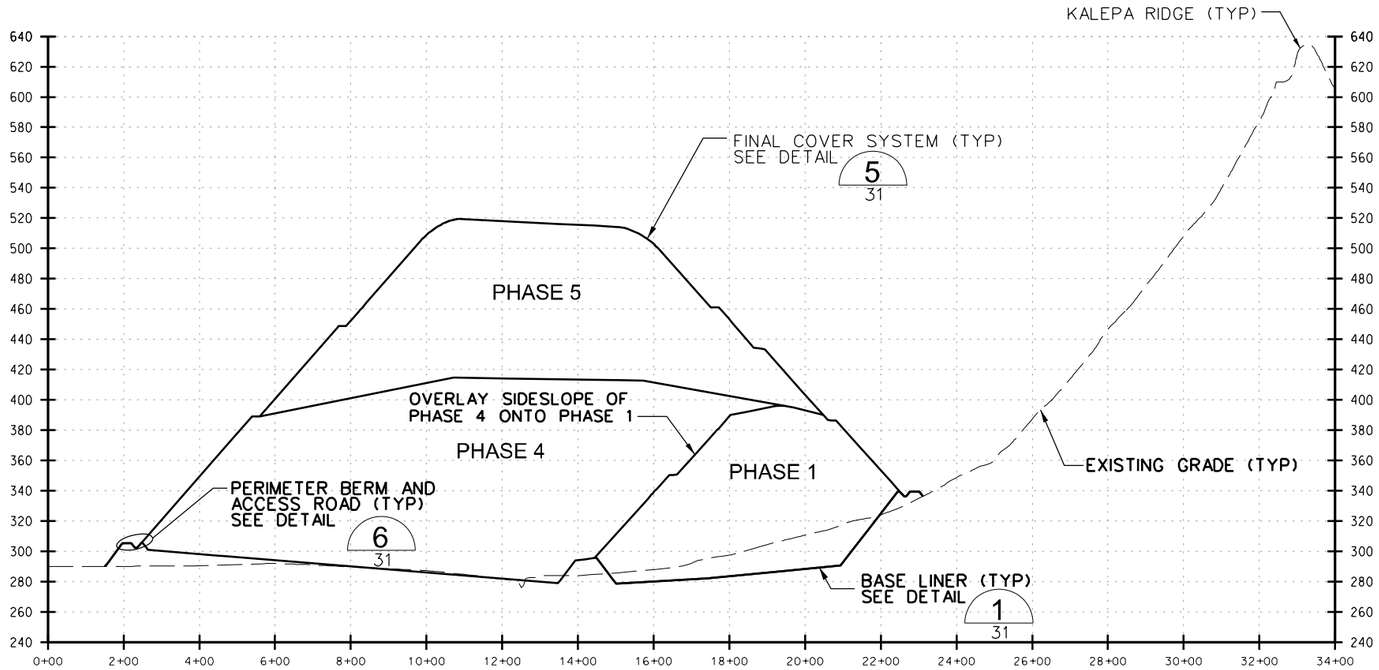
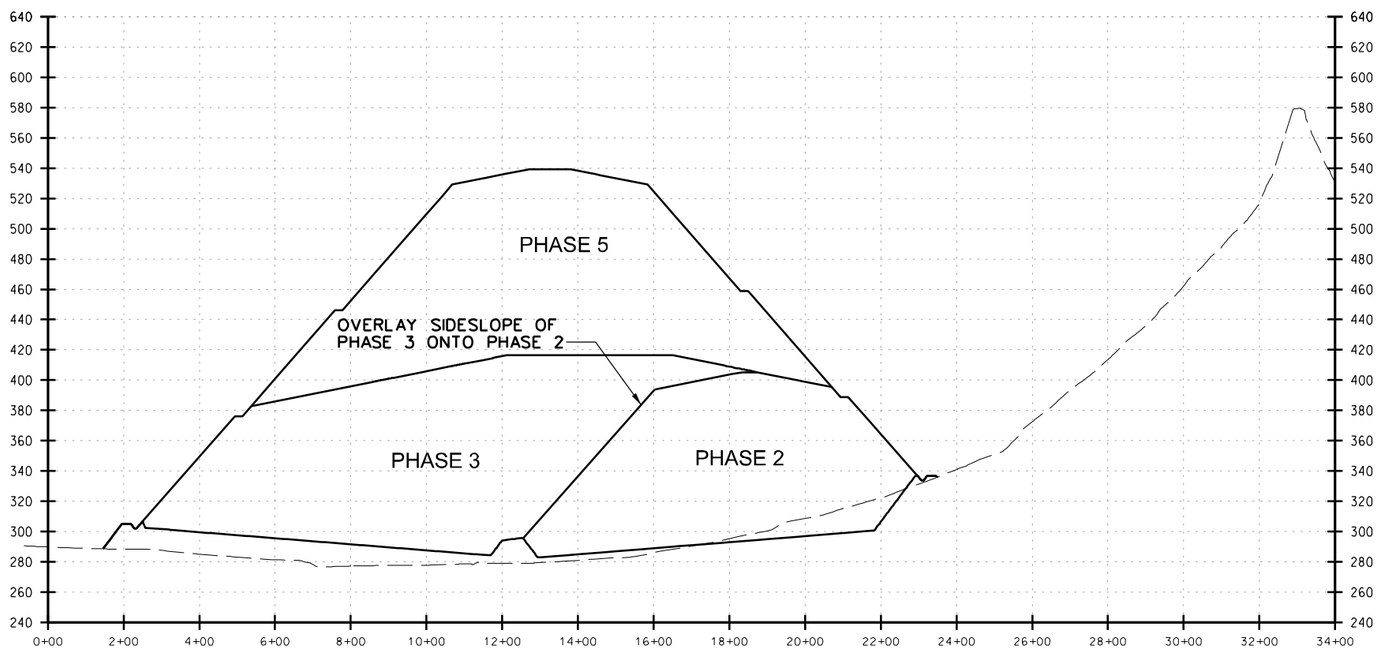


CROSS SECTION C-C'
N 67,500



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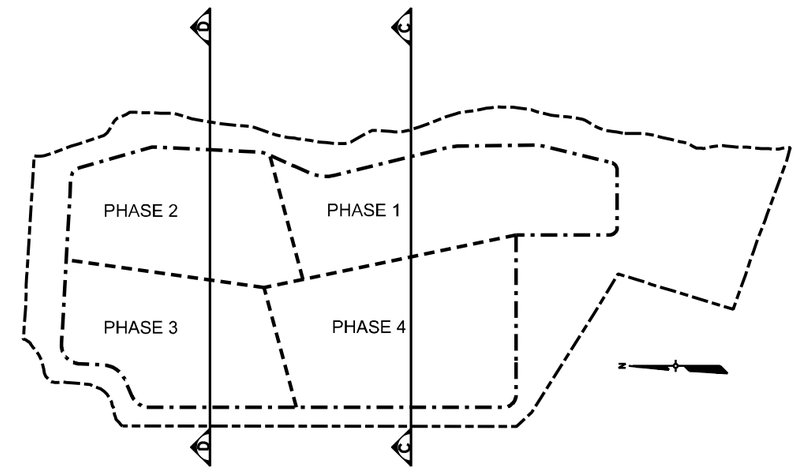
N 69,110



CROSS SECTION LOCATION MAP

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

HORIZ. SCALE 0' 200' 400'
VERT. SCALE 0' 50' 100'

AECOM

DRAWING 13
ALTERNATIVE 1
LANDFILL CROSS SECTIONS C-C', D-D'
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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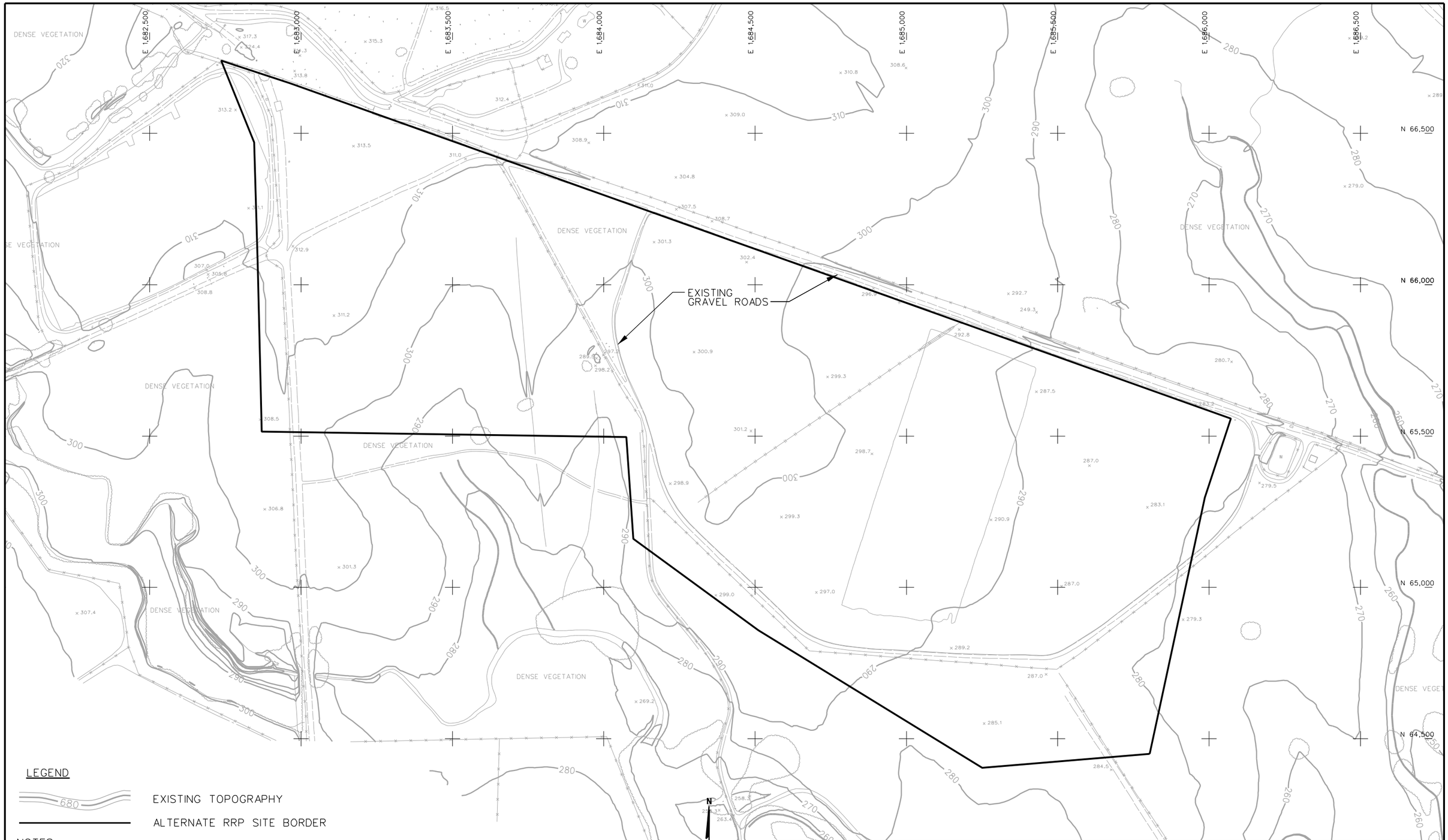

LEGEND

680 EXISTING TOPOGRAPHY

ALTERNATE RRP SITE BORDER

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

AECOM

DRAWING 14
ALTERNATIVE 1
RRP SITE EXISTING CONDITIONS

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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RRP AREA 1
SEE DRAWING 16

RRP AREA 2
SEE DRAWING 17

RRP AREA 3
SEE DRAWING 18

DRIVEWAY #2

MATERIAL PROCESSING CENTER

PROPOSED LOCATION OF SEPTIC FIELD

MAIN ENTRANCE

SINGLE-STREAM MATERIAL RECOVERY FACILITY

DRIVEWAY #1

SCRAP AUTOMOBILE PROCESSING AREA

POTENTIAL FUTURE WASTE TO ENERGY FACILITY

SITE (INTERNAL) ACCESS ROAD

PUBLIC DROP-OFF AREA

RESIDUAL WASTE TIPPING AREA

WINDROW COMPOST FACILITY

TIRE BALING AREA

EAST SURFACE WATER MANAGEMENT BASIN

WHITEGOODS AND MISCELLANEOUS METALS SHREDDING BALING AND STORAGE AREA

C&D PROCESSING AREA

CONCRETE, BRICK, BLOCK, ASPHALT PROCESSING AND STORAGE AREA

SOUTH SURFACE WATER MANAGEMENT BASIN

DENSE VEGETATION

LEGEND

EXISTING TOPOGRAPHY

ALTERNATE RRP SITE FOOTPRINT BORDER

CULVERT

SURFACE WATER FLOW

PAVED ROADS

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.

2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

N

SCALE 0' 150' 300'

AECOM

DRAWING 15
ALTERNATIVE 1
RRP SITE FACILITY LAYOUT
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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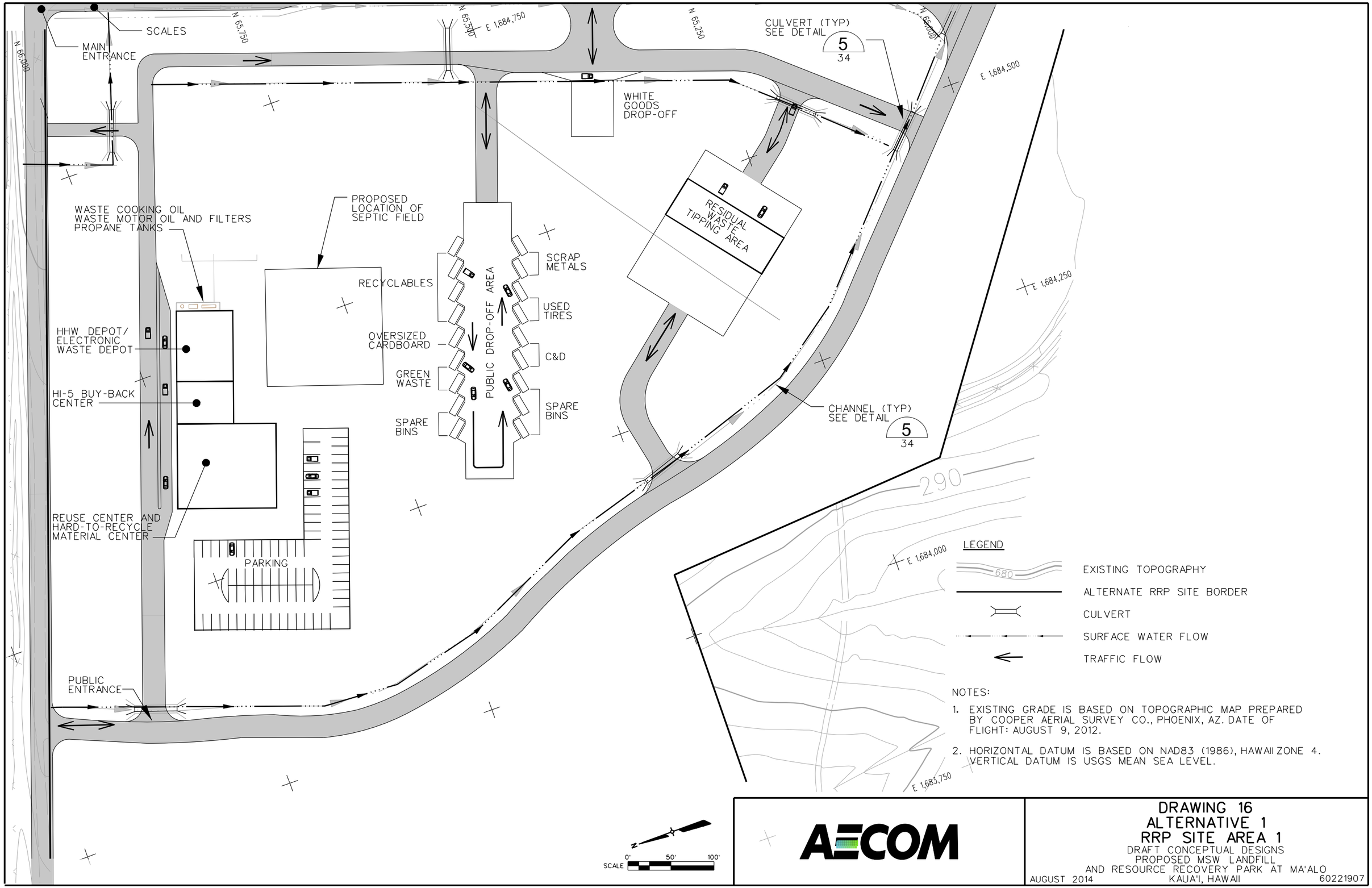

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

DRAWING 16
ALTERNATIVE 1
RRP SITE AREA 1
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014

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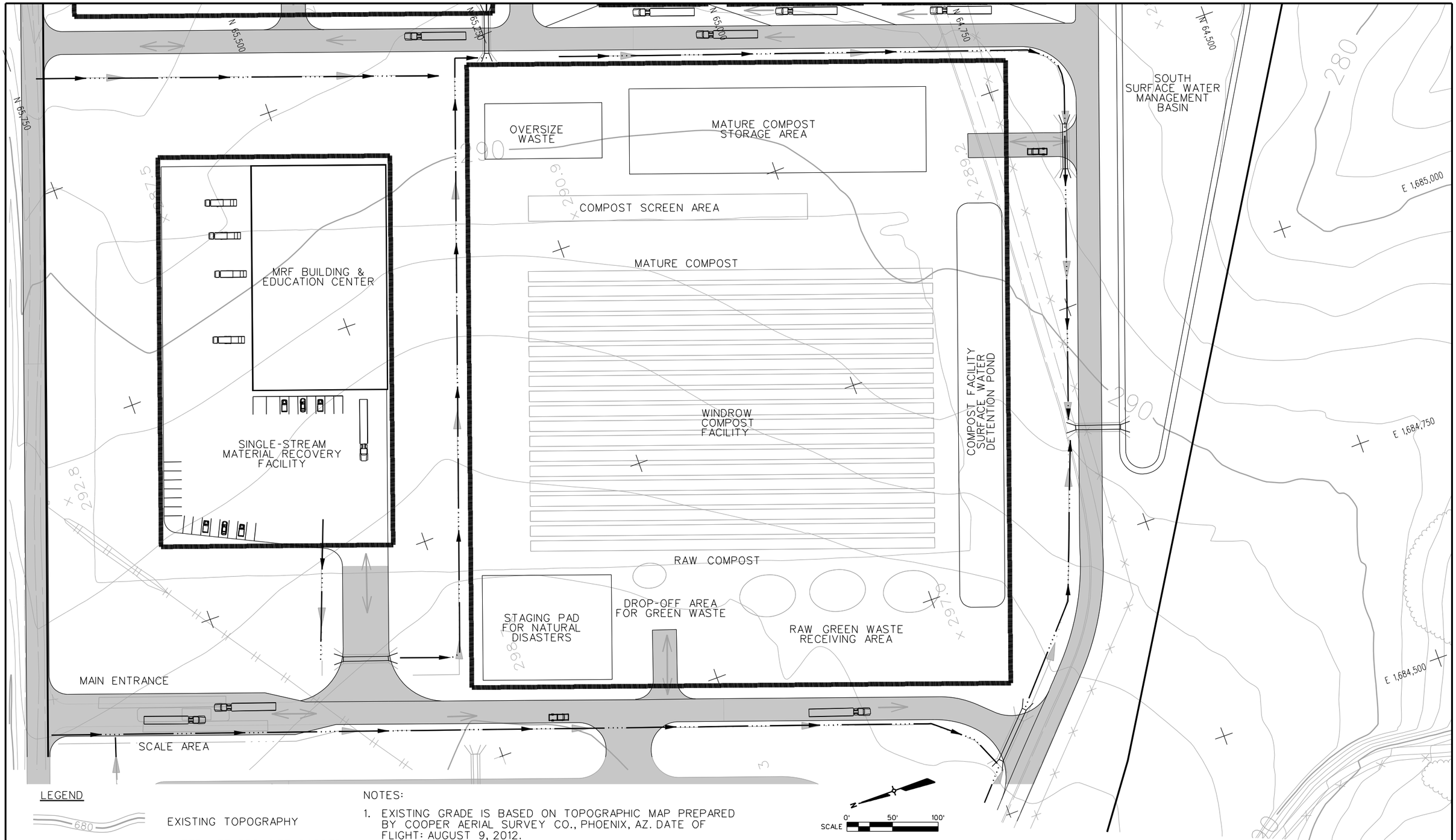

LEGEND

- EXISTING TOPOGRAPHY (680)
- ALTERNATE RRP SITE BORDER
- CULVERT
- SURFACE WATER FLOW
- TRAFFIC FLOW

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

AECOM

DRAWING 17
ALTERNATIVE 1
RRP SITE AREA 2
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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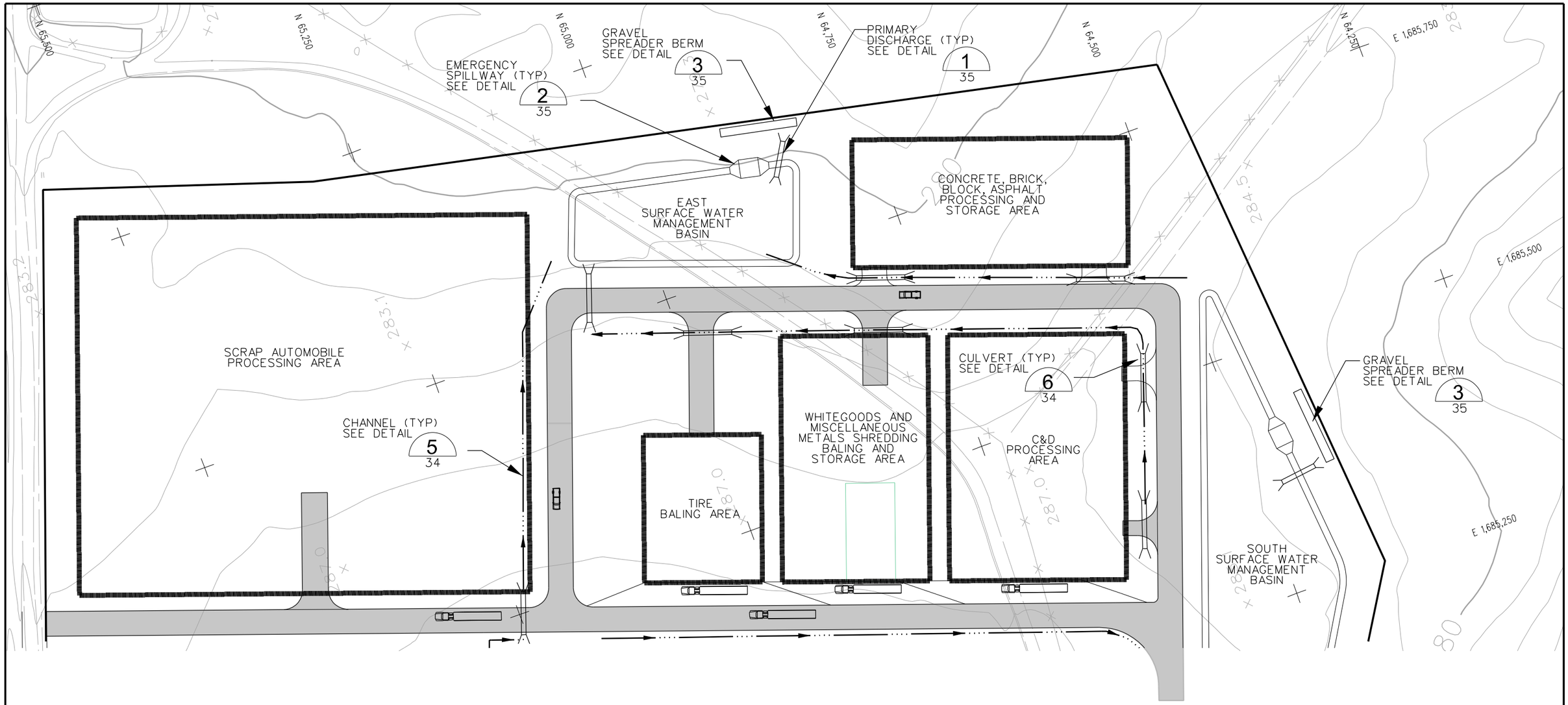

LEGEND

- EXISTING TOPOGRAPHY (680)
- ALTERNATE RRP SITE BORDER
- CULVERT
- SURFACE WATER FLOW
- TRAFFIC FLOW

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

N

SCALE 0' 50' 100'

AECOM

DRAWING 18
ALTERNATIVE 1
RRP SITE AREA 3
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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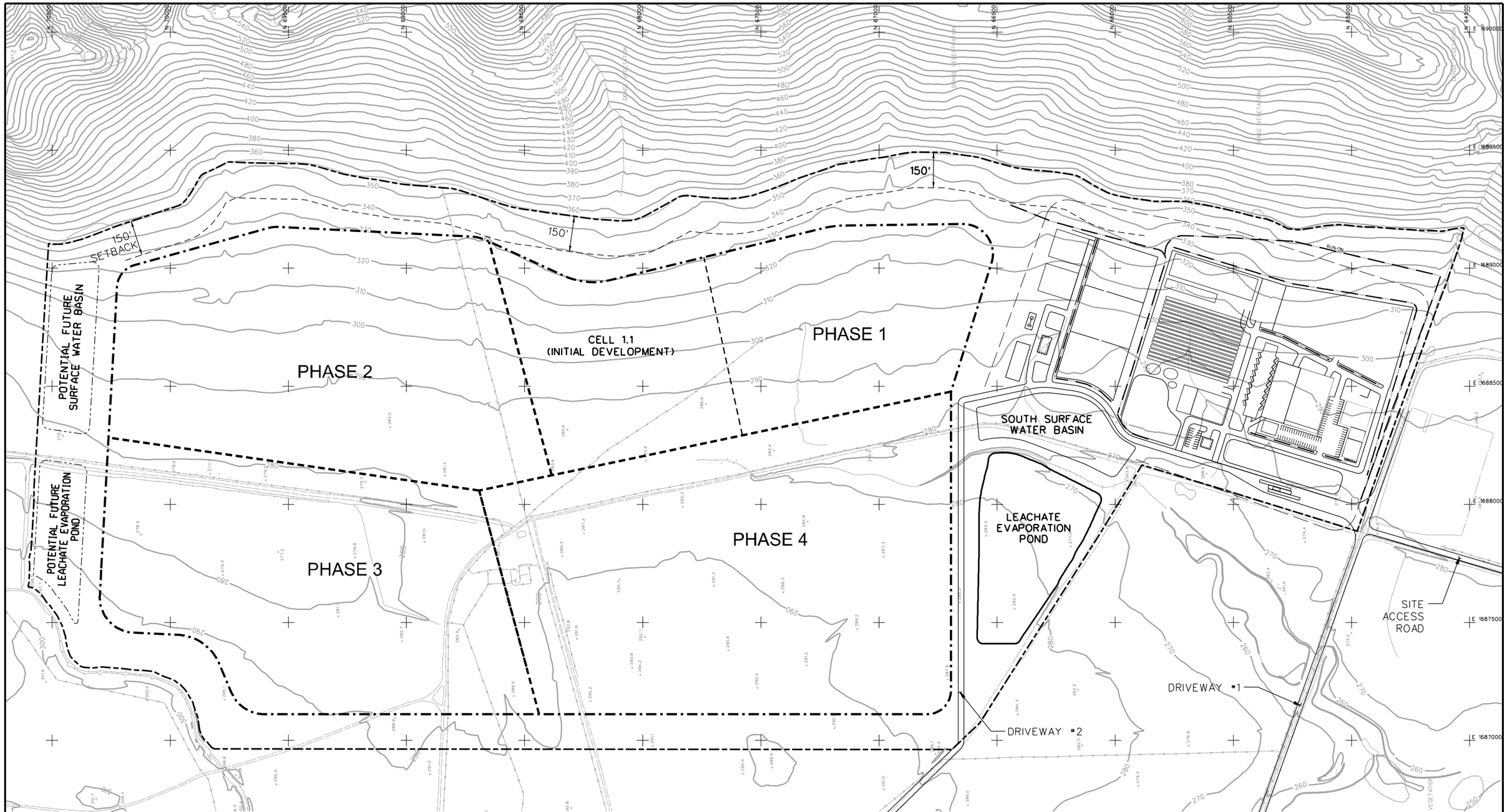

LEGEND

- EXISTING TOPOGRAPHY (680)
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- ACCESS ROAD

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

AECOM

DRAWING 19
ALTERNATIVE 2
LANDFILL FACILITY LAYOUT

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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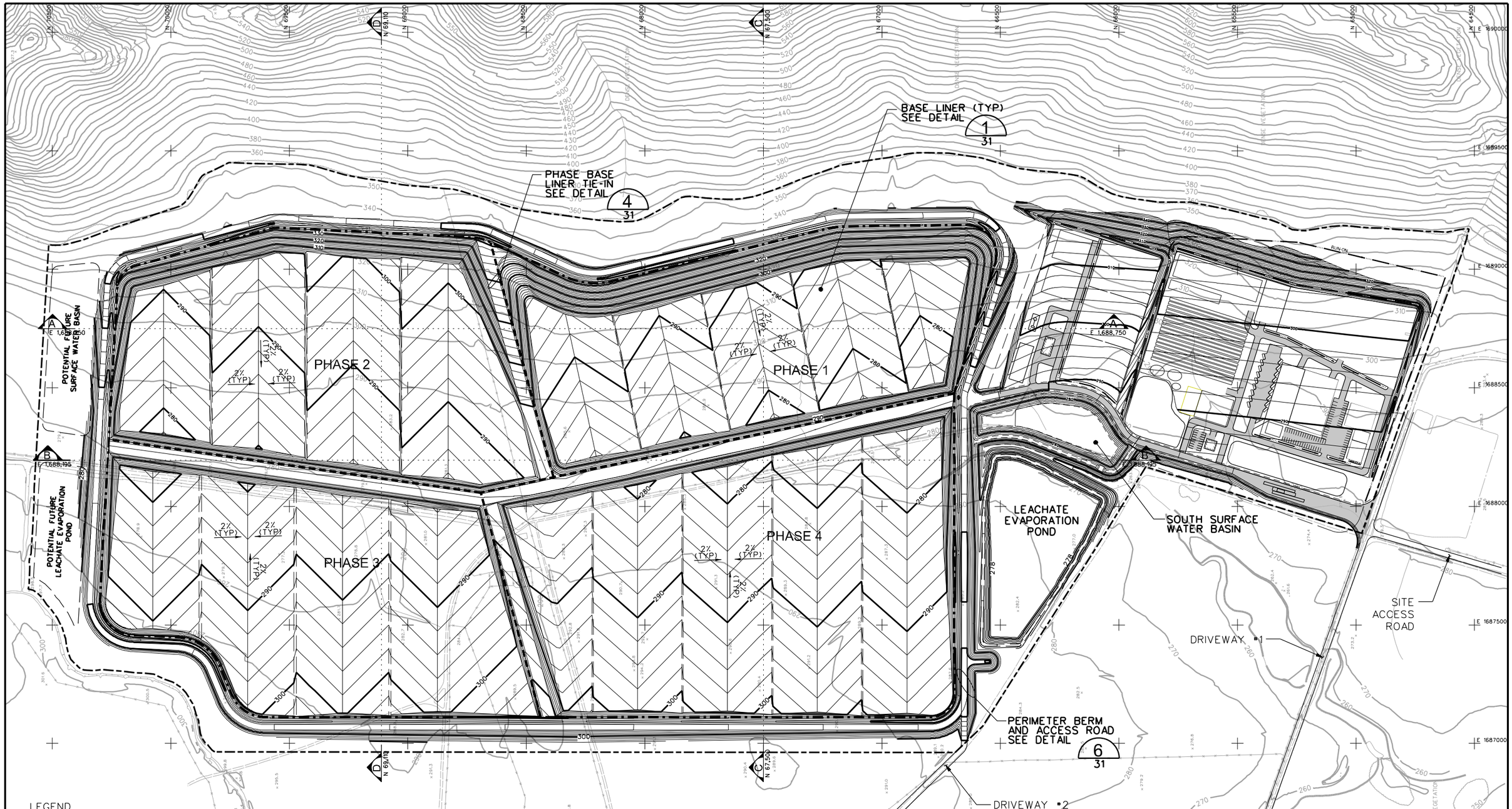

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- ACCESS ROAD
- POTENTIAL FUTURE SURFACE WATER BASIN
- PAVED ROAD

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT SUBBASE AND SURFACE FOR INSTALLATION OF PROPOSED GEOSYNTHETIC BASE LINER.
4. ALL SITE ROADS TO BE ALL-WEATHER GRAVEL ROADS UNLESS SHOWN AS PAVED ROADS.

AECOM

DRAWING 20
ALTERNATIVE 2
SUBBASE GRADING PLAN

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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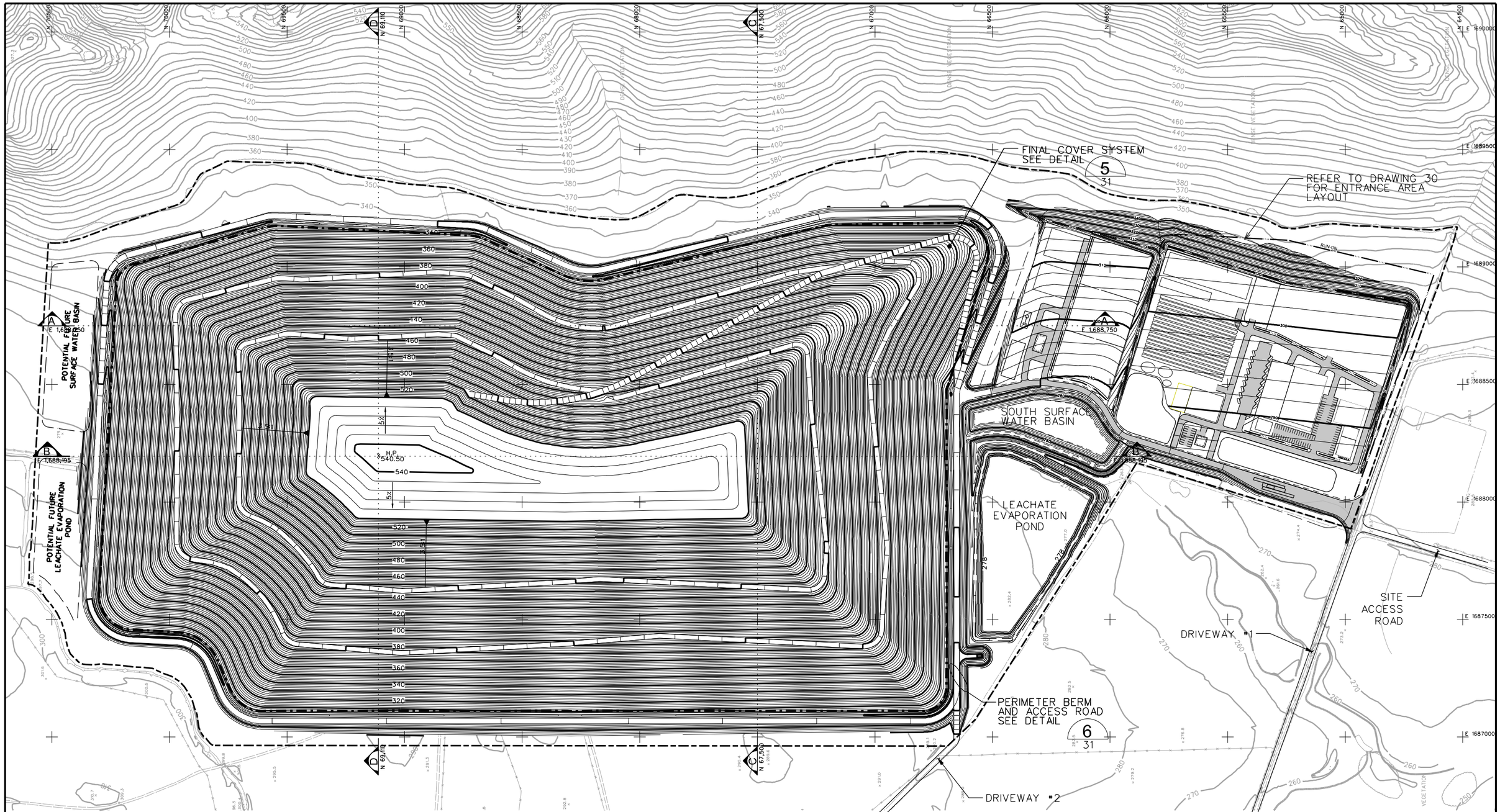

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- ACCESS ROAD

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT TOP OF FINAL COVER SYSTEM.

AECOM

DRAWING 21
ALTERNATIVE 2
FINAL COVER GRADING PLAN
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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SECURITY FENCE

BASE LINER SEE DETAIL 1/31

REFER TO DRAWING 30 FOR ENTRANCE AREA LAYOUT

RUN-ON

CELL 1.1

PHASE 1

FUTURE PHASE 2

FUTURE PHASE BASE LINER TIE-IN SEE DETAIL 4/31

SOUTH SURFACE WATER BASIN

PERIMETER BERM AND ACCESS ROAD SEE DETAIL 6/31

LEACHATE EVAPORATION POND

ENTRANCE GATE

FUTURE PHASE 3

FUTURE PHASE 4

SITE ACCESS ROAD

DRIVEWAY #1

DRIVEWAY #2

E 1689500

E 1689000

E 1688500

E 1688000

E 1687500

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- ACCESS ROAD
- POTENTIAL FUTURE SURFACE WATER BASIN
- SECURITY FENCE

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT SUBBASE AND SURFACE FOR INSTALLATION OF APPROVED GEOSYNTHETIC BASE LINER.

N

SCALE 0' 150' 300'

AECOM

DRAWING 22
ALTERNATIVE 2
PHASE 1 SUBBASE GRADING PLAN
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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LEACHATE COLLECTION SYSTEM SEE DETAILS 2/31 AND 3/31

LEACHATE CLEANOUT RISER PIPE

SECURITY FENCE

CONDENSATE DRAIN PIPE ON SIDESLOPE FOR FUTURE CONNECTION TO LFG CONDENSATE KNOCKOUT DRAIN SEE DETAILS 4/35 AND 5/35

WET WELL #1 SEE DETAIL 1/33

CELL 1.1

PHASE 1

FUTURE PHASE 2

CONDENSATE DRAIN PIPE ON SIDESLOPE FOR FUTURE CONNECTION TO LFG CONDENSATE KNOCKOUT DRAIN (DRAINS TO AREA OF LOW POINT) SEE DETAILS 4/35 AND 5/35

SOUTH SURFACE WATER BASIN

FORCEMAIN LEACHATE TRANSFER PIPE TO LEACHATE EVAPORATION POND SEE DETAIL 3/33

LEACHATE EVAPORATION POND

FUTURE PHASE 3

LEACHATE COLLECTION PIPE LINE PENETRATION SEE DETAILS 1/32 AND 2/32

FUTURE PHASE 4

DUAL-CONTAINMENT GRAVITY LEACHATE TRANSFER PIPE SEE DETAIL 2/33

SITE ACCESS ROAD

DRIVEWAY #1

DRIVEWAY #2

LEACHATE LOADOUT STATION SEE DETAIL 4/33

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- GRADE BREAK
- LEACHATE COLLECTION PIPE
- LEACHATE CLEANOUT RISER
- SECURITY FENCE

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT SUBBASE AND SURFACE FOR INSTALLATION OF PROPOSED GEOSYNTHETIC BASE LINER.

SCALE 0' 150' 300'

AECOM

DRAWING 23
ALTERNATIVE 2 - PHASE 1
LEACHATE MANAGEMENT SYSTEM

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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PERIMETER BERM AND ACCESS ROAD SEE DETAIL 6/31

FINAL COVER SYSTEM SEE DETAIL 5/31

SECURITY FENCE

REFER TO DRAWING 30 FOR ENTRANCE AREA LAYOUT

RUN-ON

PHASE 1

FUTURE PHASE 2

FUTURE PHASE BASE LINER TIE-IN SEE DETAIL 4/31

SOUTH SURFACE WATER BASIN

LEACHATE EVAPORATION POND

ENTRANCE GATE

FUTURE PHASE 3

FUTURE PHASE 4

SITE ACCESS ROAD

DRIVEWAY #2

DRIVEWAY #1

E 1689500

E 1689000

E 1688500

E 1688000

E 1687500

LEGEND

- EXISTING TOPOGRAPHY (680)
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- SECURITY FENCE

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT TOP OF FINAL COVER SYSTEM.

N

SCALE 0' 150' 300'

AECOM

DRAWING 24
ALTERNATIVE 2
PHASE 1 FINAL COVER GRADING PLAN

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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RUN-ON CHANNEL (TYP) SEE DETAIL 5/34

SECURITY FENCE

ROAD CHANNEL SEE DETAIL 5/34

SURFACE WATER DIVERSION BERM (TYP.) SEE DETAIL 5/34

BENCH SEE DETAIL 2/34

PHASE 1

FUTURE PHASE 2

PERIMETER CHANNEL (TYP.) SEE DETAILS 6/31 AND 5/34

DOWNSLOPE CHANNEL (TYP.) SEE DETAIL 3/34

MAINTAIN EXISTING DRAINAGE FEATURES TO MANAGE RUN-ON AND SITE DRAINAGE

FUTURE PHASE 3

FUTURE PHASE 4

SOUTH SURFACE WATER BASIN SEE DETAILS 1/35 2/35

EMERGENCY SPILLWAY

SECONDARY SPILLWAY

PRIMARY SPILLWAY

SPILLWAY W/ VALVE

COMPOST AREA POND

MAINTAIN EXISTING DRAINAGE FEATURES TO MANAGE RUN-ON AND SITE DRAINAGE

GRAVEL SPREADER BERM SEE DETAIL 3/35

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- SECURITY FENCE
- SURFACE WATER FLOW
- RUN-ON CHANNEL
- CULVERT
- RIP RAP

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT TOP OF FINAL COVER SYSTEM. SEE FINAL COVER DETAIL 5/31

N

SCALE 0' 150' 300'

AECOM

DRAWING 25
ALTERNATIVE 2 - PHASE 1
SURFACE WATER MANAGEMENT PLAN

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO

AUGUST 2014 KAUA'I, HAWAII 60221907

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SECURITY FENCE

BLOWER AND FLARE STATION SEE DETAIL 1/37

GAS EXTRACTION WELL (TYP) SEE DETAIL 1/36 2/36

HEADER ACCESS RISER (TYP) SEE DETAIL 9/36

BLIND FLANGE CONNECTION (TYP) SEE DETAIL 5/36

CONTROL VALVE (TYP) SEE DETAIL 8/36

GW-1 GW-2 GW-3 GW-4 GW-5 GW-6 GW-7 GW-8 GW-9 GW-10 GW-11 GW-12 GW-13

H.P.

PHASE 1

FUTURE PHASE 2

FUTURE PHASE 3

FUTURE PHASE 4

DRAIN CONDENSATE TO SIDESLOPE DRAIN PIPE TO LEACHATE SYSTEM

CONDENSATE KNOCKOUT (TYP) SEE DETAIL 4/35

POTENTIAL FUTURE LANDFILL GAS-TO-ENERGY PLANT

CONDENSATE DRAIN TO LEACHATE WET WELL #1

RUN-ON

E 1689500 E 1689000 E 1688500 E 1688000 E 1687500

LEGEND

- EXISTING TOPOGRAPHY
- PROPERTY LINE
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- SECURITY FENCE
- GAS COLLECTION HEADER PIPE
- GAS COLLECTION WELL
- CONDENSATE KNOCKOUT
- CONTROL VALVE
- HEADER ACCESS RISER

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN DEPICT TOP OF FINAL COVER SYSTEM. SEE FINAL COVER DETAIL 5/31

N

SCALE 0' 150' 300'

AECOM

DRAWING 26
ALTERNATIVE 2 - PHASE 1
LANDFILL GAS COLLECTION SYSTEM

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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AREA NOT DISTURBED BY CONSTRUCTION

RUN-ON CHANNEL (TYP) SEE DETAIL 5/34

SECURITY FENCE

APPROX. LOCATION OF SEPTIC FIELD

AREA NOT DISTURBED BY CONSTRUCTION

TEMPORARY SURFACE WATER DIVERSION BERM

TEMPORARY SURFACE WATER DIVERSION BERM (TYP) SEE DETAIL 5/34

TEMPORARY CULVERT

SOUTH SURFACE WATER BASIN SEE NOTE 4

SILT FENCE

OPERATIONS TO MANAGE CELL 1.1 SURFACE WATER RUNOFF DURING FILLING

LEACHATE EVAPORATION POND

RIPRAP (TYP)

SITE ENTRANCE

SITE ACCESS ROAD

DRIVEWAY #1

DRIVEWAY #2

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- GRADE BREAK
- LEACHATE COLLECTION PIPE
- SECURITY FENCE
- SILT FENCE
- RIPRAP
- LEACHATE CLEANOUT RISER
- AREA DISTURBED BY CONSTRUCTION

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. GRADES SHOWN IN CELL 1.1 DEPICT TOP OF INTERMEDIATE COVER.
4. SURFACE WATER BASINS AND DITCHES WILL EMPTY WITHIN 48 HOURS AFTER THE CONCLUSION OF A STORM EVENT.
5. ALL CULVERTS AND TEMPORARY CULVERTS ARE 24" UNLESS OTHERWISE NOTED.

N

SCALE 0' 150' 300'

AECOM

DRAWING 27
ALTERNATIVE 2 - INITIAL LANDFILL SITE DEVELOPMENT PLAN

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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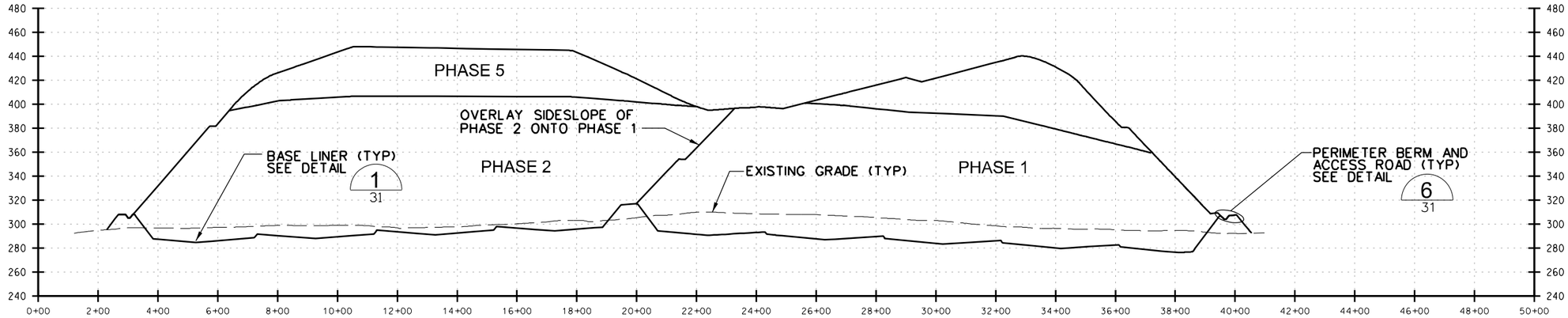
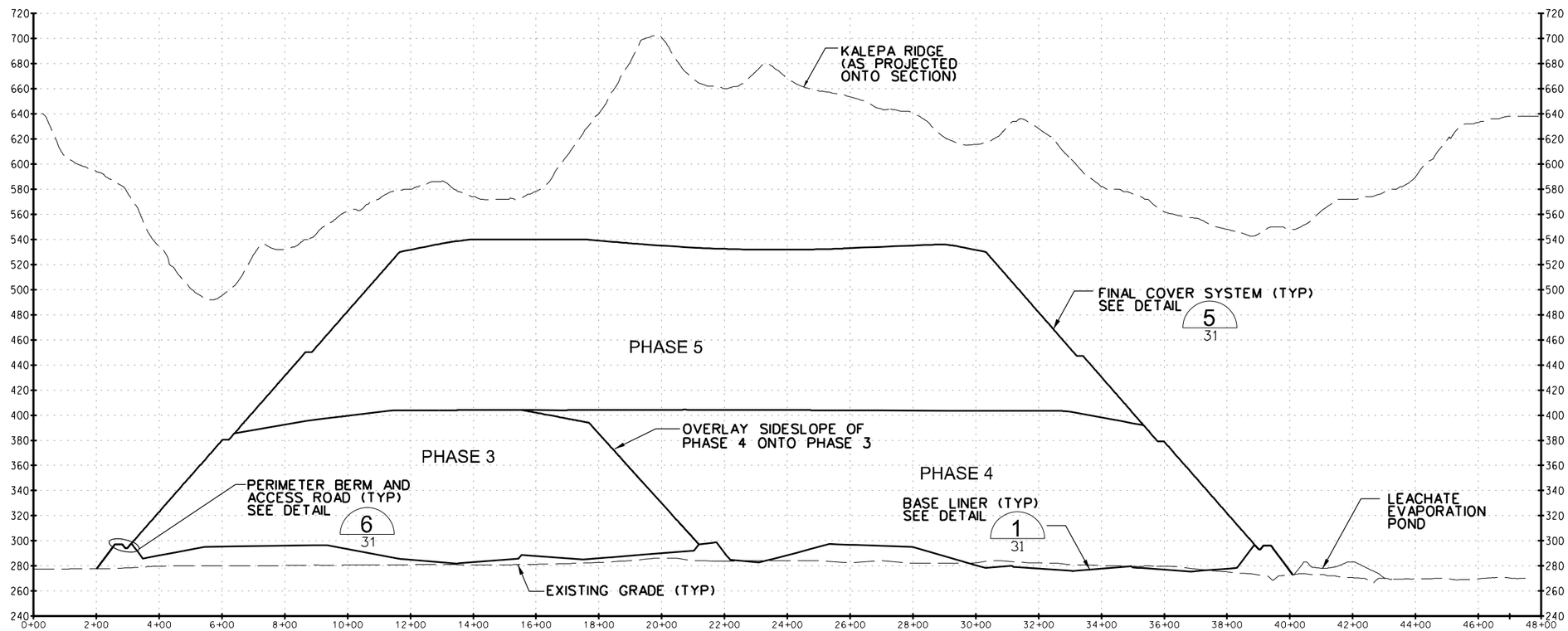


CROSS SECTION A-A'
E 1,688,700



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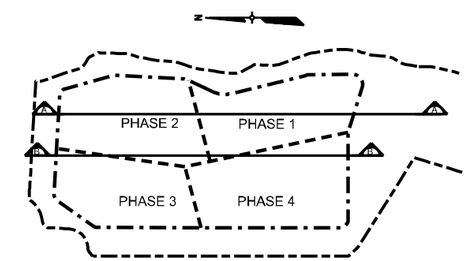

CROSS SECTION LOCATION MAP

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

HORIZ. SCALE 0' 200' 400'
VERT. SCALE 0' 50' 100'

AECOM

DRAWING 28
ALTERNATIVE 2
LANDFILL CROSS SECTIONS A-A', B-B'
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
AUGUST 2014 KAUA'I, HAWAII 60221907

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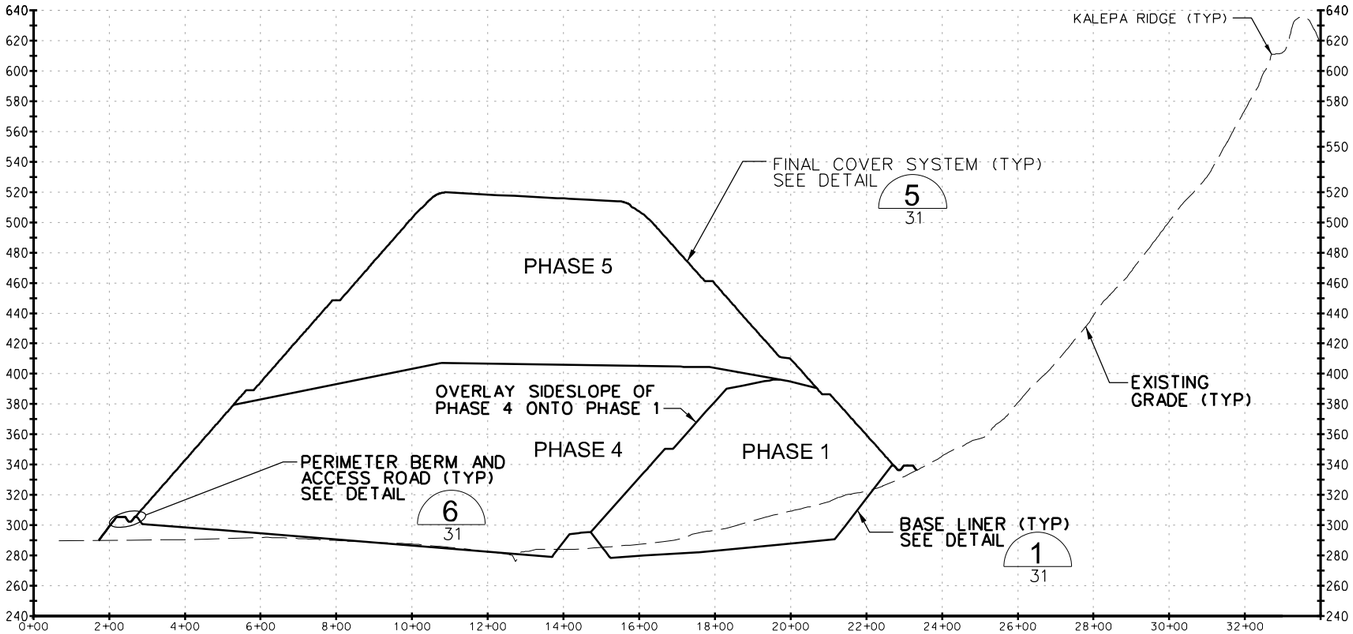
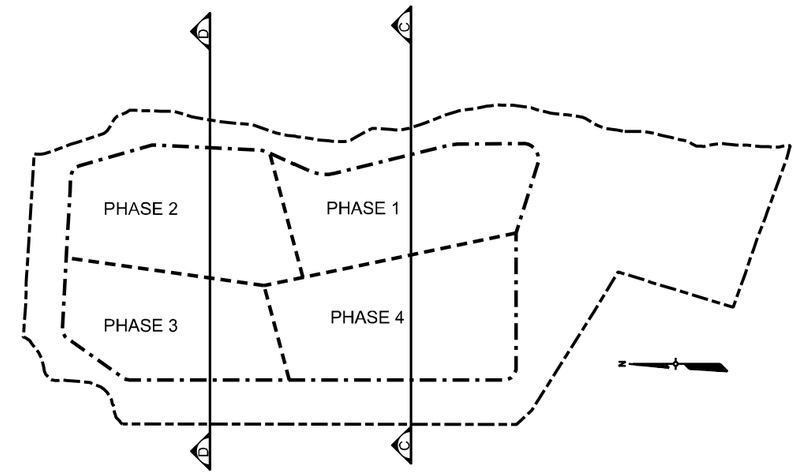
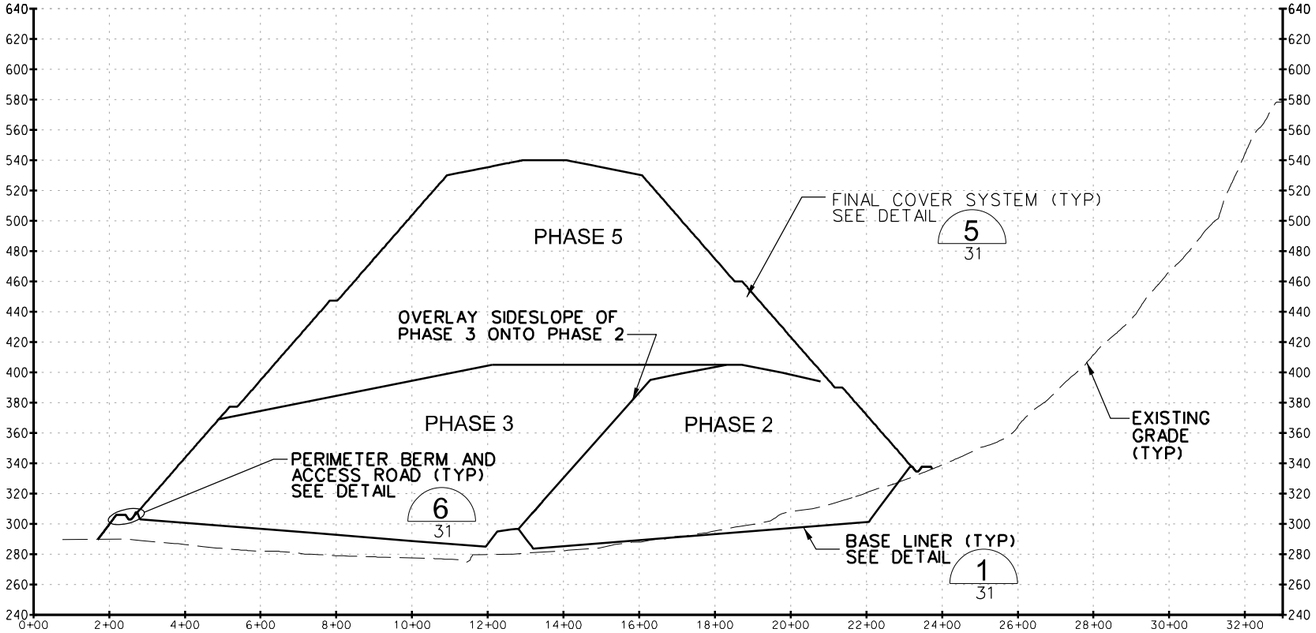


CROSS SECTION C-C'
N 67,500



CROSS SECTION LOCATION MAP



CROSS SECTION D-D'
N 69,110

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

HORIZ. SCALE 0' 200' 400'
VERT. SCALE 0' 50' 100'

AECOM

DRAWING 29
ALTERNATIVE 1
LANDFILL CROSS SECTIONS C-C', D-D'
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
AUGUST 2014 KAUA'I, HAWAII 60221907

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PHASE 1

RUN-ON

RUN-ON

PROPOSED LOCATION OF SEPTIC FIELD

PROPOSED LOCATION OF SEPTIC FIELD

C&D PROCESSING (1.2 ACRES)

CONCRETE, BRICK, BLOCKS, ASPHALT PROCESSING AND STORAGE AREA (1.2 ACRES)

WHITE GOODS AND MISCELLANEOUS METALS SHREDDING, BALING, AND STORAGE AREA (1.2 ACRES)

FLARE

MAINTENANCE

POTENTIAL FUTURE GAS-TO-ENERGY PLANT

SOUTH SURFACE WATER BASIN

LEACHATE EVAPORATION POND

COMPOST FACILITY SURFACE WATER DETENTION POND

DISCHARGE STRUCTURE TO SPILLWAY W/ VAVLE

MATURE COMPOST STORAGE AREA (35,000 ft)

COMPOST SCREEN AREA

WINDROW COMPOST FACILITY (2.25 ACRES)

RAW COMPOST DROP-OFF AREA FOR GREEN WASTE

OVERSIZED WASTE

STAGING PAD FOR NATURAL DISASTERS (16,000 ft)

TIRE BALING AREA

SCRAP AUTOMOBILE PROCESSING AREA (3.0 ACRES)

PUBLIC DROP-OFF (FREE)

RESIDUAL WASTE TIPPING AREA (25,000ft²)

MRF BUILDING & EDUCATION CENTER (35,000ft²)

WHTE GOODS DROP OFF

ENTRANCE AREA SURFACE WATER DETENTION BASIN

LANDFILL OFFICE

SCALES

RE-USE CENTER AND HARD TO RECYCLE MATERIAL CENTER

HI-5 BUYBACK CENTER

HHW AND ELECTRONIC WASTE DEPOT

WASTE COOKING OIL
WASTE MOTOR OIL AND FILTERS
PROPANE TANKS

ENTRANCE GATE

SITE ACCESS ROAD

E 16890

E 16885

E 16880

LEGEND

- EXISTING TOPOGRAPHY
- PROPERTY LINE
- PROPOSED LIMITS OF WASTE
- SECURITY FENCE
- ASPHALT PAVED AREA
- CULVERT
- SURFACE WATER FLOW
- RUN-ON CHANNEL
- RIP RAP

SCALE 0' 80' 160'

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

AECOM

DRAWING 30
ALTERNATIVE 2 LANDFILL ENTRANCE AREA AND RRP SITE FACILITY LAYOUT

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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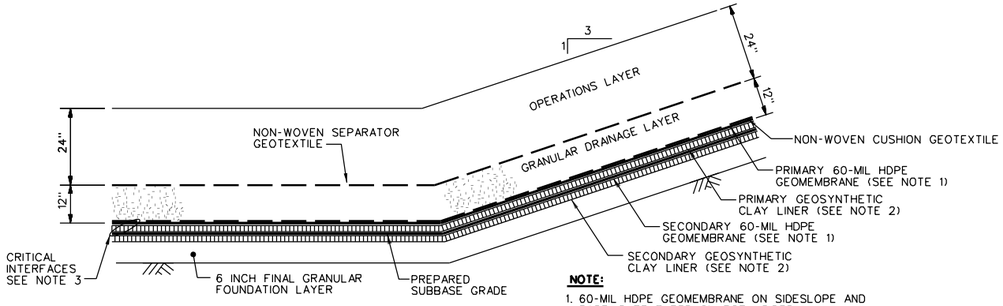


NOTE:

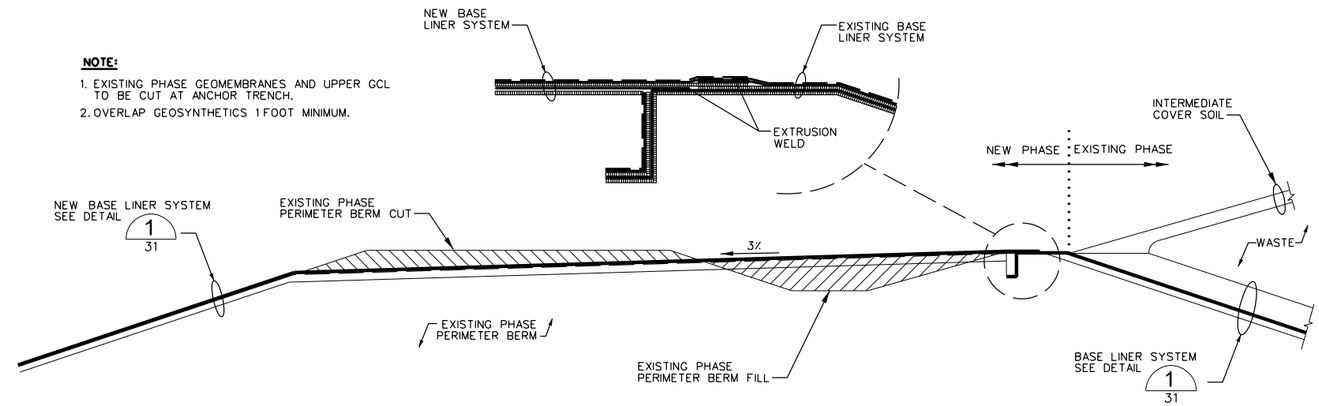
1. 60-MIL HDPE GEOMEMBRANE ON SIDESLOPE AND BASE IS TEXTURED ON BOTH SIDES.
2. GCL SHALL HAVE NON-WOVEN GEOTEXTILE ON BOTH SIDES.
3. CRITICAL INTERFACES FOR THE BASE LINER OCCUR BETWEEN THE NON-WOVEN GEOTEXTILE (CUSHION AND FOR GCL) TO TEXTURED HDPE GEOMEMBRANE. THESE INTERFACES EXIST ON BOTH THE TOP AND BOTTOM OF BOTH THE PRIMARY AND SECONDARY TEXTURED GEOMEMBRANES AS SHOWN.

BASE LINER DETAIL 1

NTS

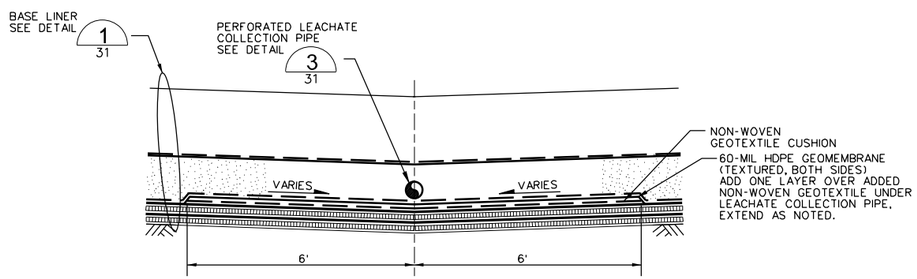
NOTE:

1. EXISTING PHASE GEOMEMBRANES AND UPPER GCL TO BE CUT AT ANCHOR TRENCH.
2. OVERLAP GEOSYNTHETICS 1 FOOT MINIMUM.



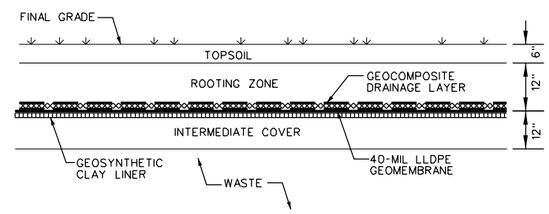
PHASE BASE LINER TIE-IN 4

NTS



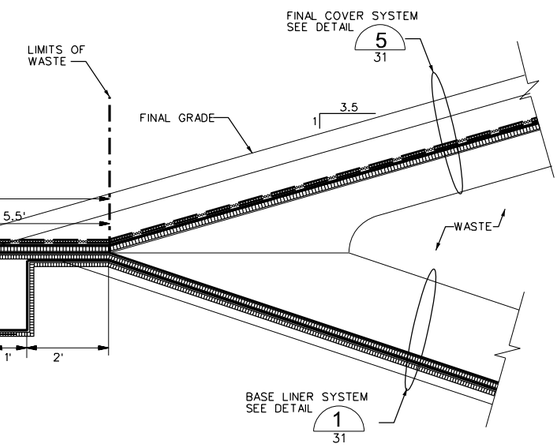
LEACHATE COLLECTION SYSTEM 2

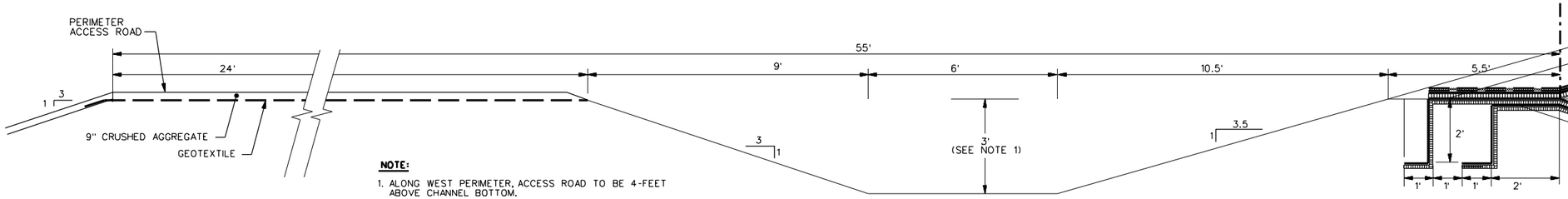
NTS



FINAL COVER SYSTEM 5

NTS



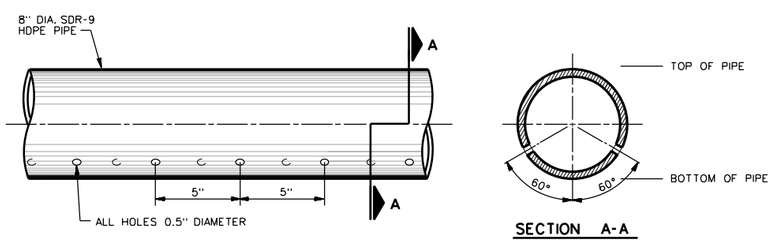


NOTE:

1. ALONG WEST PERIMETER, ACCESS ROAD TO BE 4-FEET ABOVE CHANNEL BOTTOM.
2. UPON BASE LINER ANCHOR TRENCH CONSTRUCTION, MINIMUM 1-FOOT OF SOIL TO BE PLACED OVER ANCHOR TRENCH TO PROTECT GEOSYNTHETICS AND PROVIDE SURFACE WATER SEPARATION BETWEEN PERIMETER CHANNEL AND WASTE.

PERIMETER BERM/ACCESS ROAD 6

NTS



SECTION A-A

NOTE:

1. ALL HOLES TO BE ALTERNATELY STAGGERED.

PERFORATED LEACHATE COLLECTION PIPE 3

NTS

AECOM

DRAWING 31
DETAILS: BASELINER AND LEACHATE COLLECTION SYSTEM

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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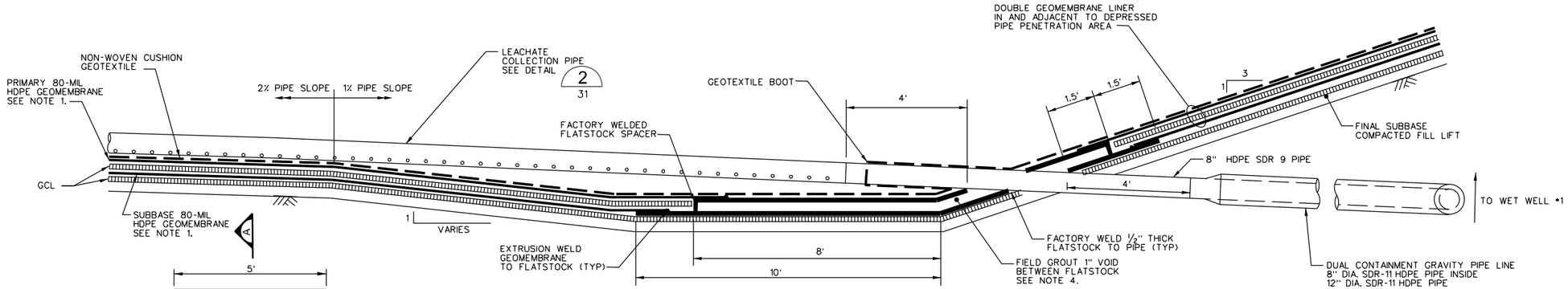
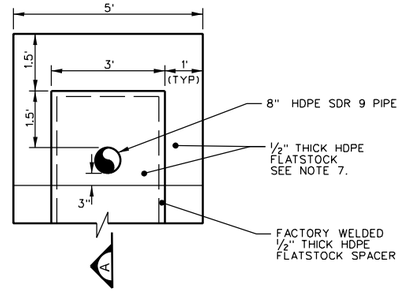


SECTION A-A



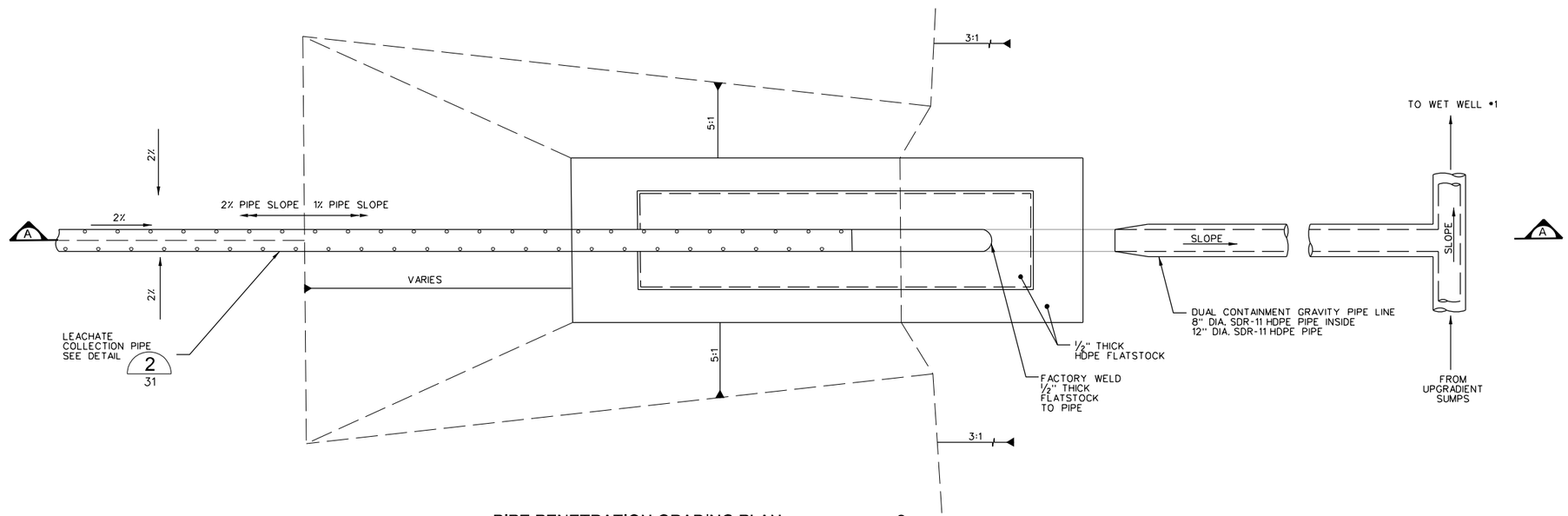
PLAN

PIPE PENETRATION DETAIL 1

NTS

NOTES:

1. GEOMEMBRANE PANELS IMMEDIATELY ADJACENT TO PIPE PENETRATION TO BE 80-MIL HDPE GEOMEMBRANE. SUBBASE GEOMEMBRANE IN SUMP ONLY
2. EXTRUSION WELD GEOMEMBRANE TO HDPE FLATSTOCK WITH A MINIMUM 6 INCHES OF OVERLAP.
3. ALL GEOMEMBRANE IS TEXTURED ON BOTH SIDES.
4. PIPE PENETRATION ASSEMBLY TO BE FACTORY AND FIELD AIR TESTED FOR WATER TIGHTNESS. FIELD GROUT VOID AFTER SATISFACTORY FIELD AIR TESTING AND EXTRUSION WELD TEST/GROUT OPENINGS.
5. PLACE MULTIPLE LAYER OF GCL FOR EACH TRANSITION AND THICKNESS ALONG TOP FLATSTOCK.
6. PIPE CONNECTIONS TO BE FIELD CONNECTIONS USING ELECTRO-FUSION COUPLINGS.
7. ROUND ALL CORNERS AND EDGES OF FLATSTOCK.



PIPE PENETRATION GRADING PLAN 2

NTS

AECOM

DRAWING 32
DETAILS: PIPE PENETRATION AND GRADING PLAN

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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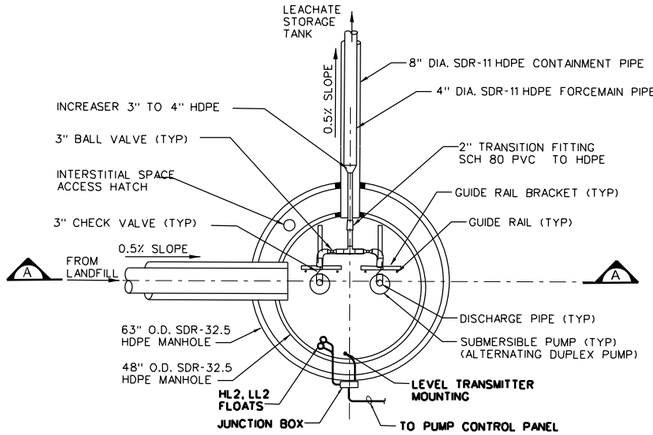

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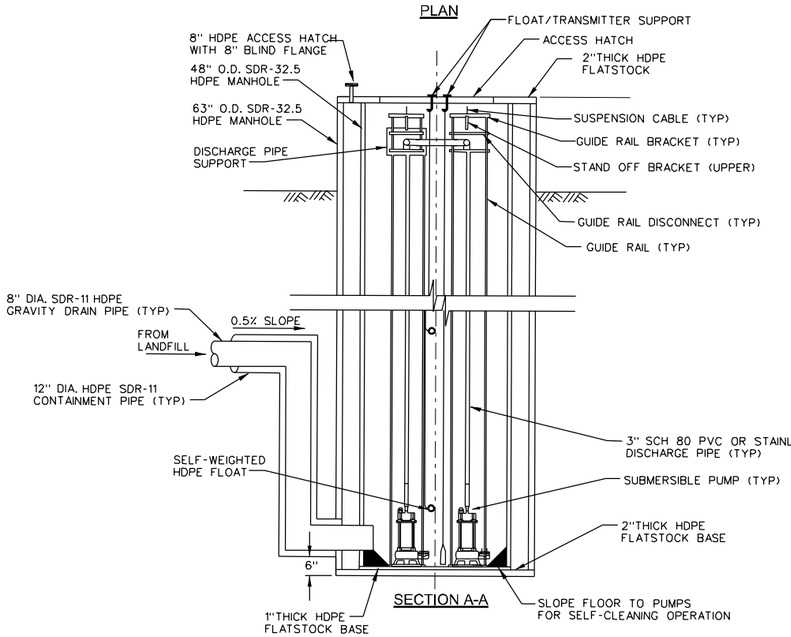
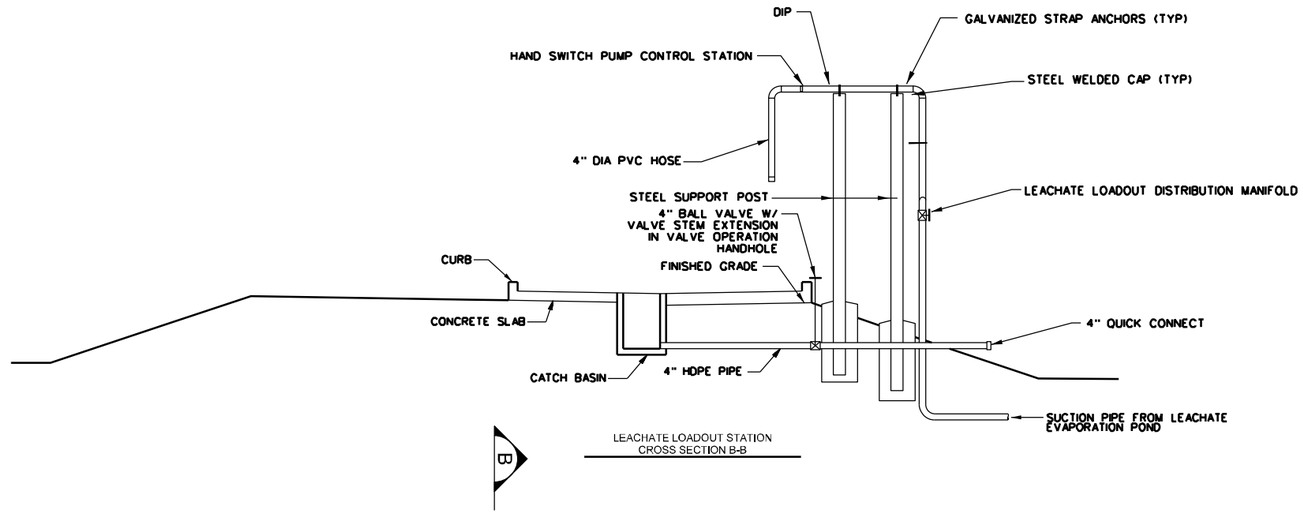
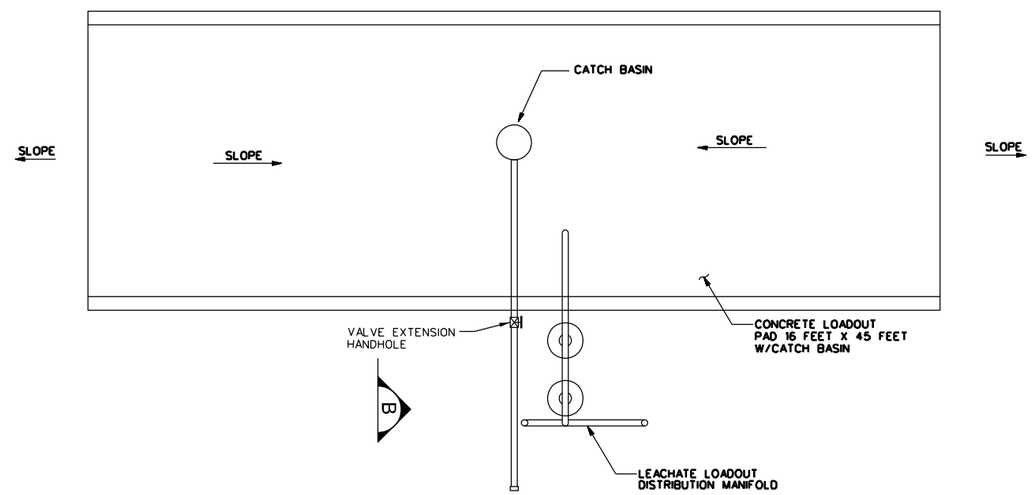


LEACHATE FORCEMAIN WET WELL #1 1
NTS



LEACHATE LOADOUT STATION
CROSS SECTION B-B



PLAN VIEW

LEACHATE LOADOUT STATION 4
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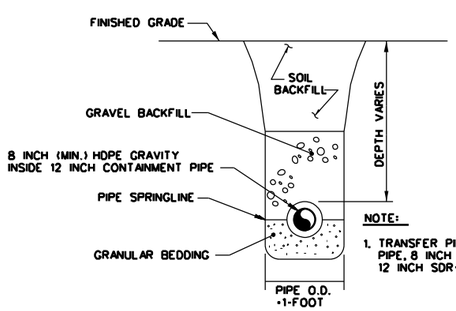
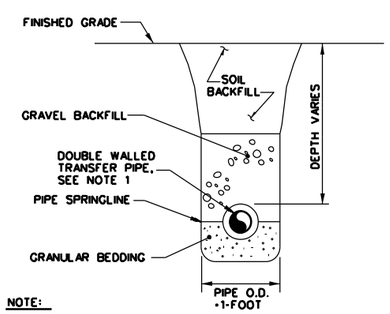


NOTE:
1. TRANSFER PIPE TO BE DOUBLE-WALLED PIPE, 8 INCH SDR-11 HDPE PIPE INSIDE 12 INCH SDR-11 HDPE CONTAINMENT PIPE.

GRAVITY LEACHATE TRANSFER PIPE (TYP) 2
NTS



NOTE:
1. TRANSFER PIPE TO BE DOUBLE-WALLED PIPE, PIPE FROM WET WELL #1 TO LEACHATE EVAPORATION POND TO BE 4 INCH SDR-11 HDPE CARRIER PIPE INSIDE 8-INCH SDR-11 HDPE CONTAINMENT PIPE.

FORCEMAIN LEACHATE TRANSFER PIPE (TYP) 3
NTS

AECOM

DRAWING 33
DETAILS: LEACHATE WET WELL AND LOADOUT STATION

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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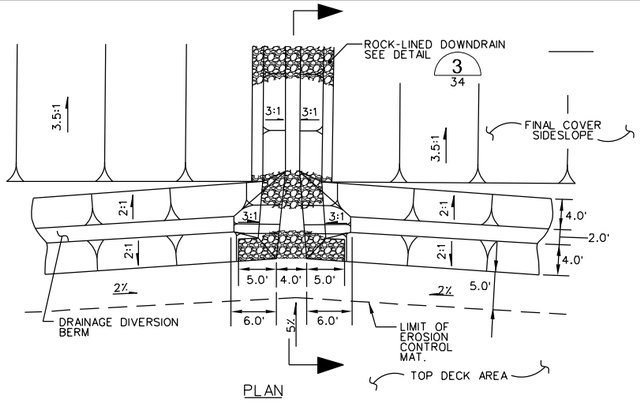
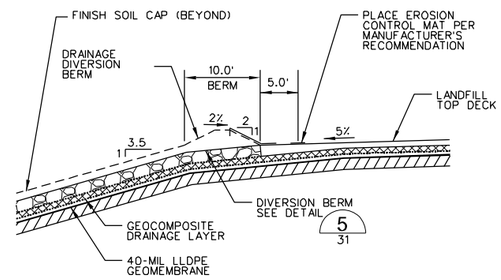


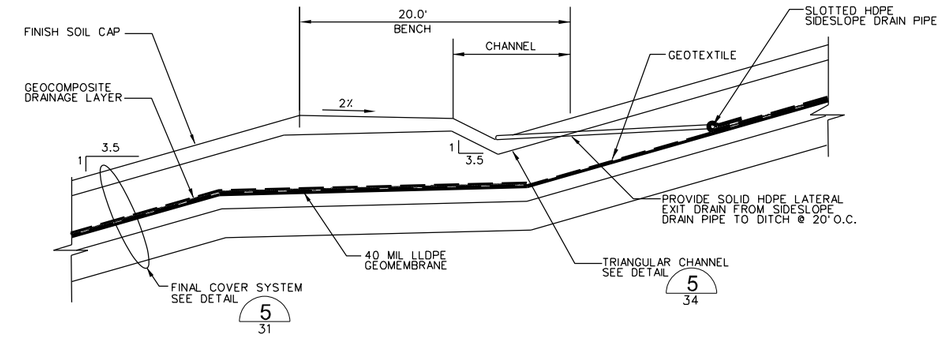
PLAN



PROFILE

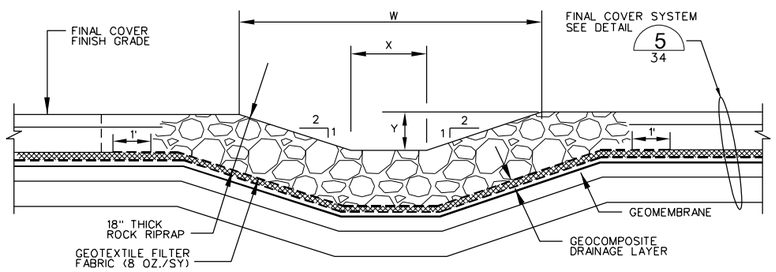
DIVERSION BERM/DOWNDRAIN TRANSITION 1

NTS



FINAL COVER BENCH PROFILE DETAIL 2

NTS

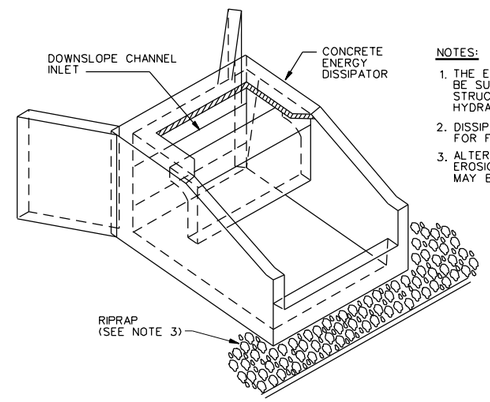


NOTE:

1. DOWNSLOPE CHANNEL DIMENSIONS VARY WITH LOCATION AND ESTIMATED FLOW. DOWNSLOPE CHANNEL DIMENSIONS ARE PROVIDED IN APPENDIX C-4.

ROCK-LINED DOWNSLOPE CHANNEL DETAIL 3

NTS

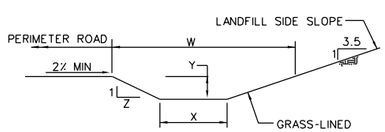


NOTES:

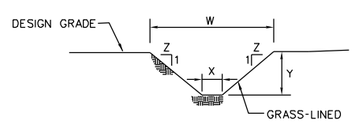
1. THE ENERGY DISSIPATOR SHOWN MAY BE SUBSTITUTED WITH AN EQUIVALENT STRUCTURE THAT ACHIEVES THE SAME HYDRAULIC PERFORMANCE.
2. DISSIPATOR DIMENSIONS WILL BE DETERMINED FOR FINAL DESIGN
3. ALTERNATIVE MATERIALS, SUCH AS EROSION CONTROL BLANKET, MAY BE SUBSTITUTED FOR THE RIPRAP.

ENERGY DISSIPATOR 4

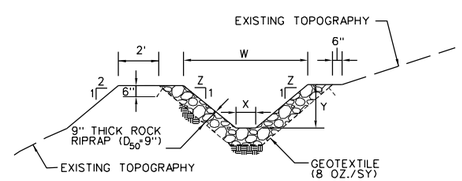
NTS



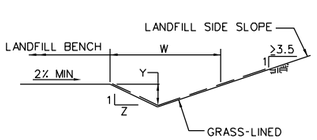
TYPE D DITCH, PERIMETER ROAD



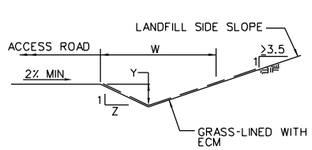
TYPE E RUN-ON/ENTRANCE AREA CHANNEL



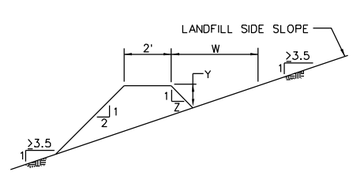
TYPE F RUN-ON CHANNEL



TYPE A DITCH, BENCH



TYPE B DITCH, ACCESS ROAD



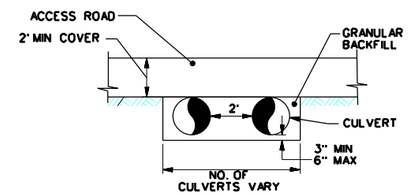
TYPE C DITCH, SIDESLOPE DIVERSION BERM

NOTE:

1. PLACE HAY BALES OR SILT FENCE ADJACENT TO ALL DITCHES TO PREVENT SILT AND SEDIMENT FROM WASHING INTO DITCH UNTIL VEGETATION IS ESTABLISHED.
2. DIVERSION BERM AND CHANNEL DIMENSIONS VARY. BERM DIMENSIONS AND CHANNEL DIMENSIONS WILL BE DETERMINED FOR FINAL DESIGN.

DIVERSION BERM/CHANNEL DETAIL 5

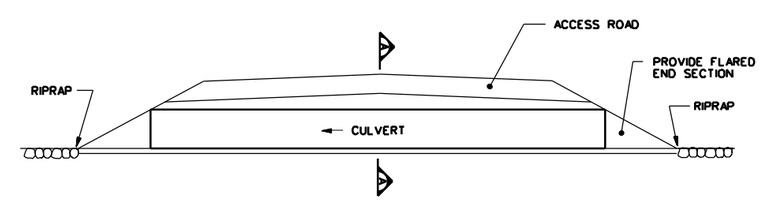
NTS



SECTION A-A

NOTES:

1. CULVERT DIMENSIONS WILL VARY AND WILL BE PROVIDED FOR FINAL DESIGN.
2. PLACE RIPRAP AT CULVERT INLET AND OUTLET LOCATIONS.
3. INSTALL FLARED END SECTIONS AT BOTH INLET AND OUTLET ENDS.
4. PROVIDE MINIMUM 2.0' COVER OVER CULVERT AT ROAD EDGE.
5. MULTIPLE CULVERTS WILL BE INSTALLED PARALLEL TO ONE ANOTHER WITH 2.0' MINIMUM SEPARATION.
6. A STRUCTURE HAVING EQUIVALENT HYDRAULIC PERFORMANCE MAY BE SUBSTITUTED SUBJECT TO REVIEW AND APPROVAL.



CULVERT PROFILE

CULVERT INSTALLATION DETAIL 6

NTS

AECOM

DRAWING 34
DETAILS: DIVERSION BERM AND CULVERT
DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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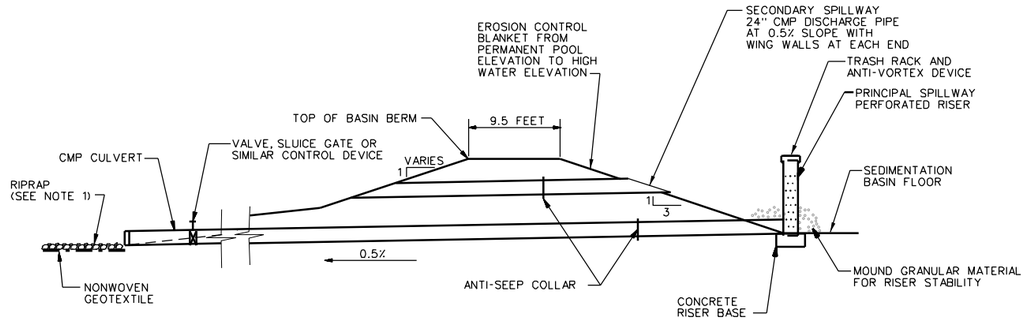
Table 1

SEDIMENTATION BASIN AND SPILLWAY DATA

	ALTERNATIVE 1 PRELIMINARY South Basin
Bottom of Basin Elevation (Average MSL)	270.0
100-year, 24-hour Critical Storm High Water Elevation (MSL)	254.4
Principal Spillway Discharge Culvert Inlet Invert Elevation (MSL)	270.0
Secondary Spillway Invert Elevation (MSL)	274.5
Emergency Spillway Invert Elevation (MSL)	283.0
Top of Emergency Spillway Berm Elev. (MSL)	285.5
Principal Spillway Diameter of Perforated Riser Pipe(s) (in.)	15-inch
Secondary Spillway Diameter	24-inch
Width of Emergency Spillway at Invert Elevation (ft)	20.0
Diameter Of Perforated Holes at Elevation in Riser (in.)	2-inch
Total Number of Perforated Holes at Elevation in Riser	4 at 270.0 and every 0.5ft to Elev. 274.0

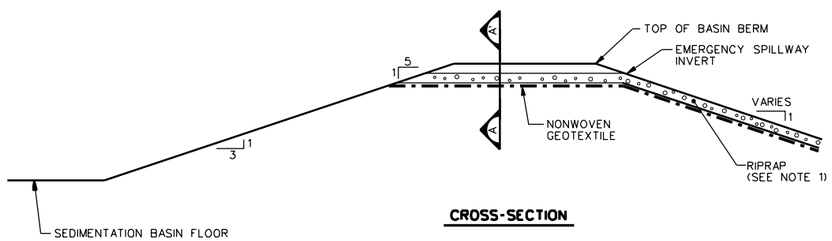


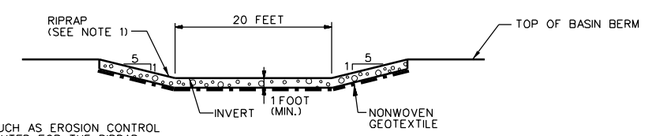
NOTE:

1. ALTERNATIVE MATERIALS, SUCH AS EROSION CONTROL BLANKET, MAY BE SUBSTITUTED FOR THE RIPRAP.
2. SEDIMENTATION BASIN AND SPILLWAY DATA IS SUMMARIZED IN TABLE 1.

TYPICAL SPILLWAY PROFILE 1

NTS



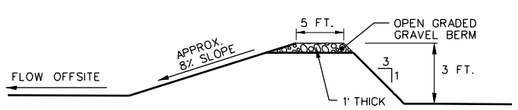


NOTE:

1. ALTERNATIVE MATERIALS, SUCH AS EROSION CONTROL BLANKET, MAY BE SUBSTITUTED FOR THE RIPRAP.

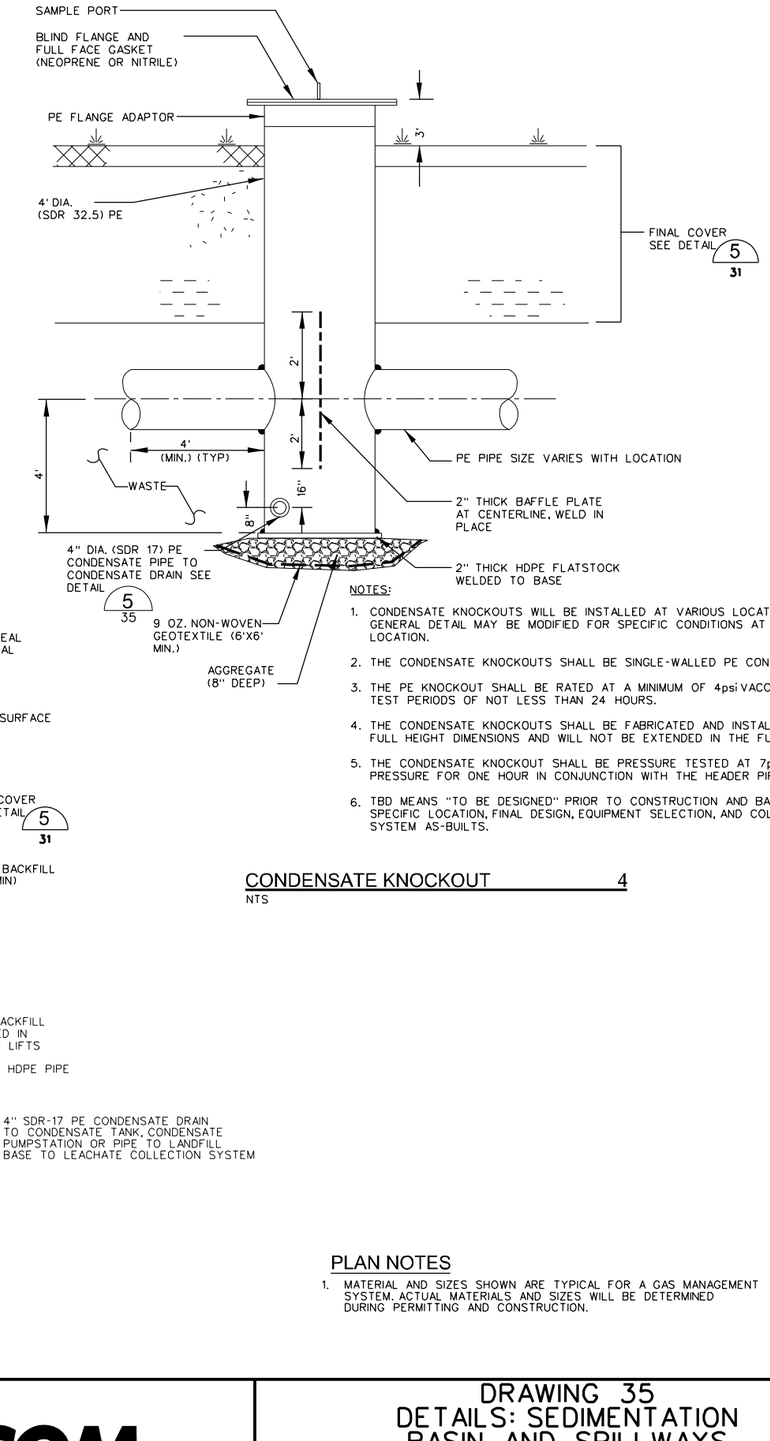
EMERGENCY SPILLWAY FOR SEDIMENTATION BASINS 2

NTS



GRAVEL SPREADER BERM 3

NTS

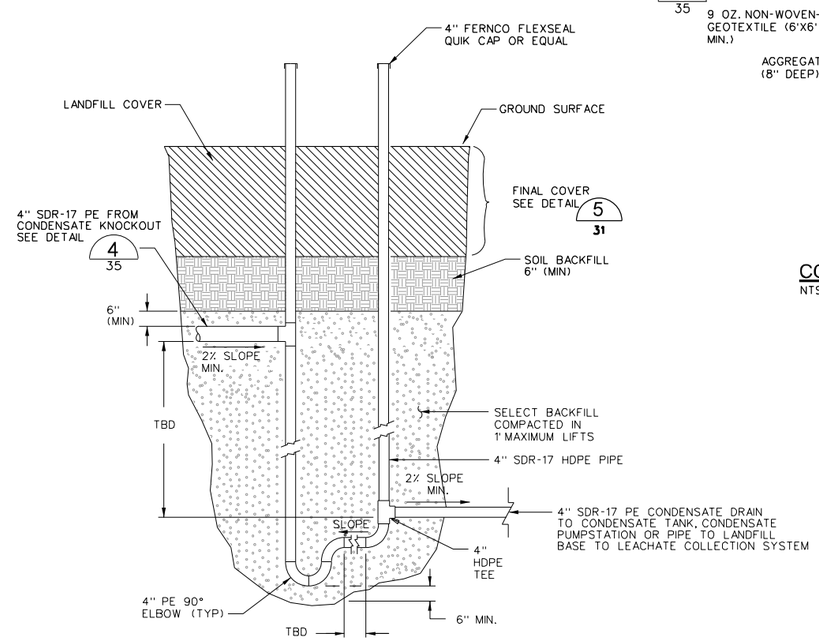


NOTES:

1. CONDENSATE KNOCKOUTS WILL BE INSTALLED AT VARIOUS LOCATIONS. THIS GENERAL DETAIL MAY BE MODIFIED FOR SPECIFIC CONDITIONS AT EACH LOCATION.
2. THE CONDENSATE KNOCKOUTS SHALL BE SINGLE-WALLED PE CONSTRUCTION.
3. THE PE KNOCKOUT SHALL BE RATED AT A MINIMUM OF 4psi VACCUM FOR TEST PERIODS OF NOT LESS THAN 24 HOURS.
4. THE CONDENSATE KNOCKOUTS SHALL BE FABRICATED AND INSTALLED TO FULL HEIGHT DIMENSIONS AND WILL NOT BE EXTENDED IN THE FUTURE.
5. THE CONDENSATE KNOCKOUT SHALL BE PRESSURE TESTED AT 7psi PRESSURE FOR ONE HOUR IN CONJUNCTION WITH THE HEADER PIPE.
6. TBD MEANS "TO BE DESIGNED" PRIOR TO CONSTRUCTION AND BASED ON SPECIFIC LOCATION, FINAL DESIGN, EQUIPMENT SELECTION, AND COLLECTION SYSTEM AS-BUILTS.

CONDENSATE KNOCKOUT 4

NTS



CONDENSATE DRAIN 5

NTS

PLAN NOTES

1. MATERIAL AND SIZES SHOWN ARE TYPICAL FOR A GAS MANAGEMENT SYSTEM. ACTUAL MATERIALS AND SIZES WILL BE DETERMINED DURING PERMITTING AND CONSTRUCTION.

AECOM

DRAWING 35
DETAILS: SEDIMENTATION BASIN AND SPILLWAYS

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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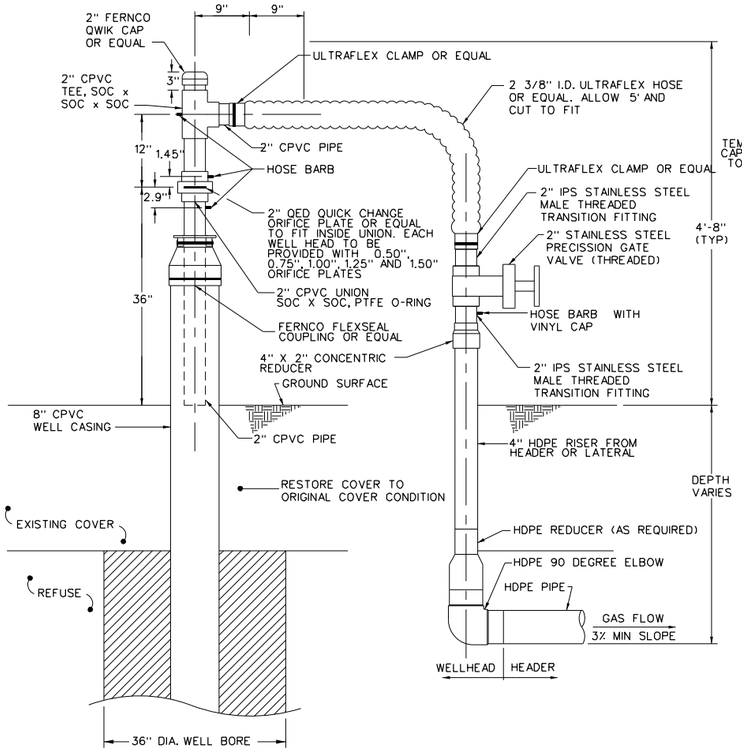
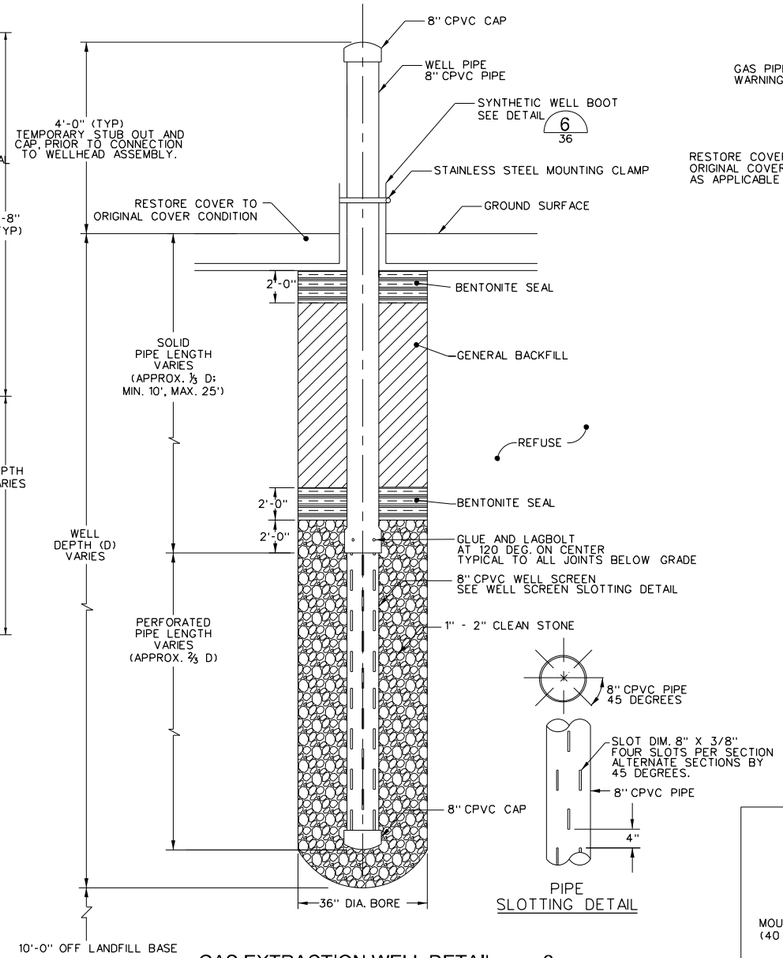


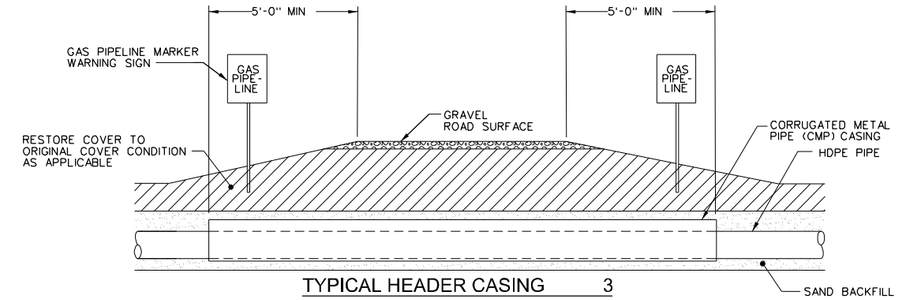
GAS EXTRACTION WELLHEAD DETAIL 1

NTS



GAS EXTRACTION WELL DETAIL 2

NTS

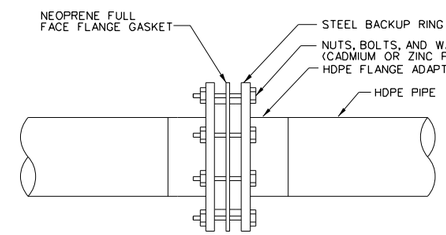


TYPICAL HEADER CASING 3

NTS

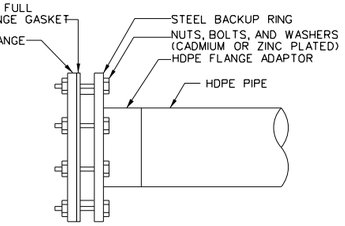
NOTES:

1. CONTRACTOR IS RESPONSIBLE FOR ROADWAY REPAIR TO ORIGINAL CONDITION AFTER CONSTRUCTION.
2. IN AREAS WHERE ROAD CASING IS REQUIRED, USE GALVANIZED CMP CASING TWO PIPE SIZES LARGER THAN HEADER PIPE.
3. LOCATION OF ALL ROAD CASINGS TO BE FIELD DETERMINED BY OWNER.



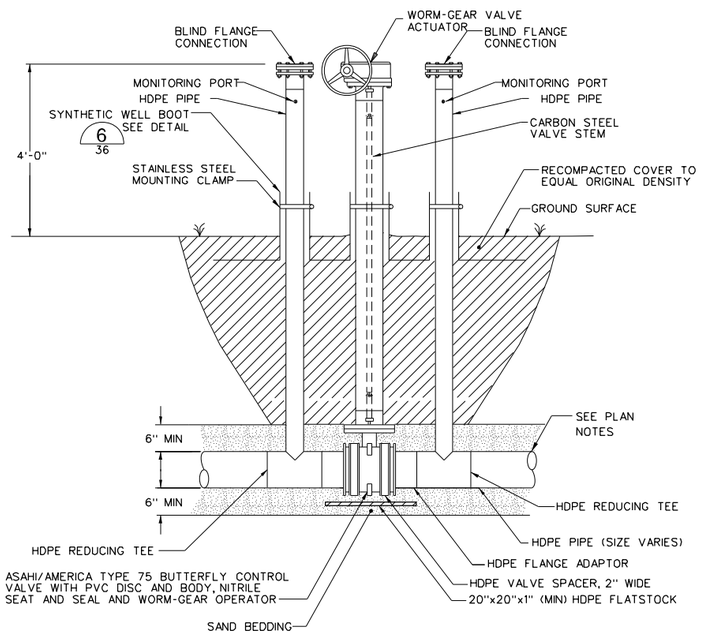
FLANGE CONNECTION (TYP) 4

NTS



BLIND FLANGE (TYP) 5

NTS

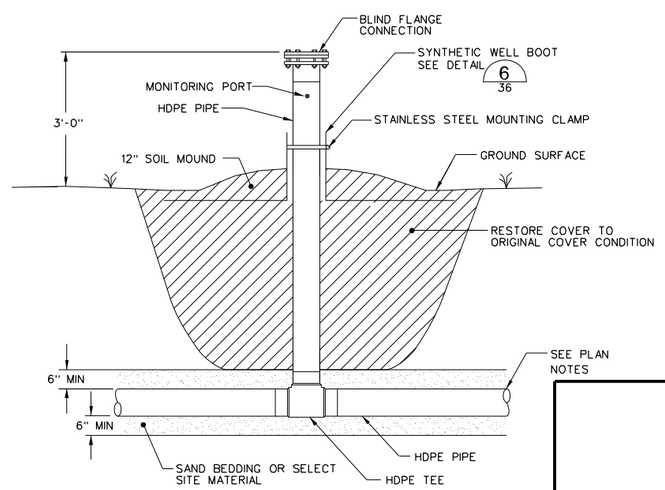


UNDERGROUND CONTROL VALVE 8

NTS

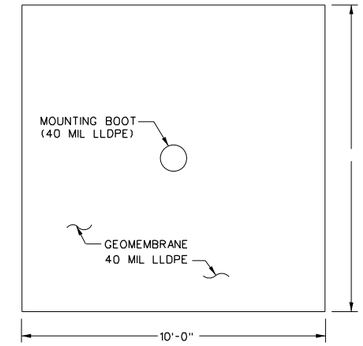
NOTE:

1. VALVE TO BE CYCLED BEFORE BACKFILLING AND INSTALLED CLOSED.



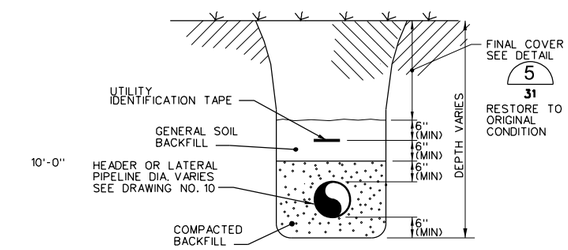
HEADER ACCESS RISER 9

NTS



SYNTHETIC WELL BOOT 6

NTS



LFG PIPE (HEADER AND LATERAL)(TYP) 7

NTS

PLAN NOTES

1. MATERIAL AND SIZES SHOWN ARE TYPICAL FOR A GAS MANAGEMENT SYSTEM. ACTUAL MATERIALS AND SIZES WILL BE DETERMINED DURING PERMITTING AND CONSTRUCTION.
2. ALL HDPE PIPE IS SDR-17 AND ALL FITTINGS ARE SDR-11 UNLESS OTHERWISE NOTED.
3. ALL CPVC PIPE AND FITTINGS ARE SCH 80 UNLESS OTHERWISE NOTED. PIPE SHALL BE CLASS 23457-B PER ASTM D-1784 UNLESS ALTERNATIVE IS APPROVED.
4. CLEAN SAND OR SELECT SITE MATERIAL BEDDING AND BACKFILL COMPACTED IN MAXIMUM LIFTS OF 9".
5. ALL NUTS, BOLTS AND WASHERS ARE CADMIUM OR ZINC PLATED UNLESS OTHERWISE STATED.
6. DIMENSIONS, LOCATION & SIZE OF SYSTEM COMPONENTS ARE SUBJECT TO CHANGE IN THE FIELD DURING CONSTRUCTION.
7. SYSTEM COMPONENTS MAY HAVE SUBSTITUTE COMPONENTS INSTALLED OF EQUAL VALUE & CAPABILITY.
8. NO PIPE PENETRATIONS WILL OCCUR THROUGH BASE LINER.

AECOM

DRAWING 36
DETAILS: GAS EXTRACTION SYSTEM

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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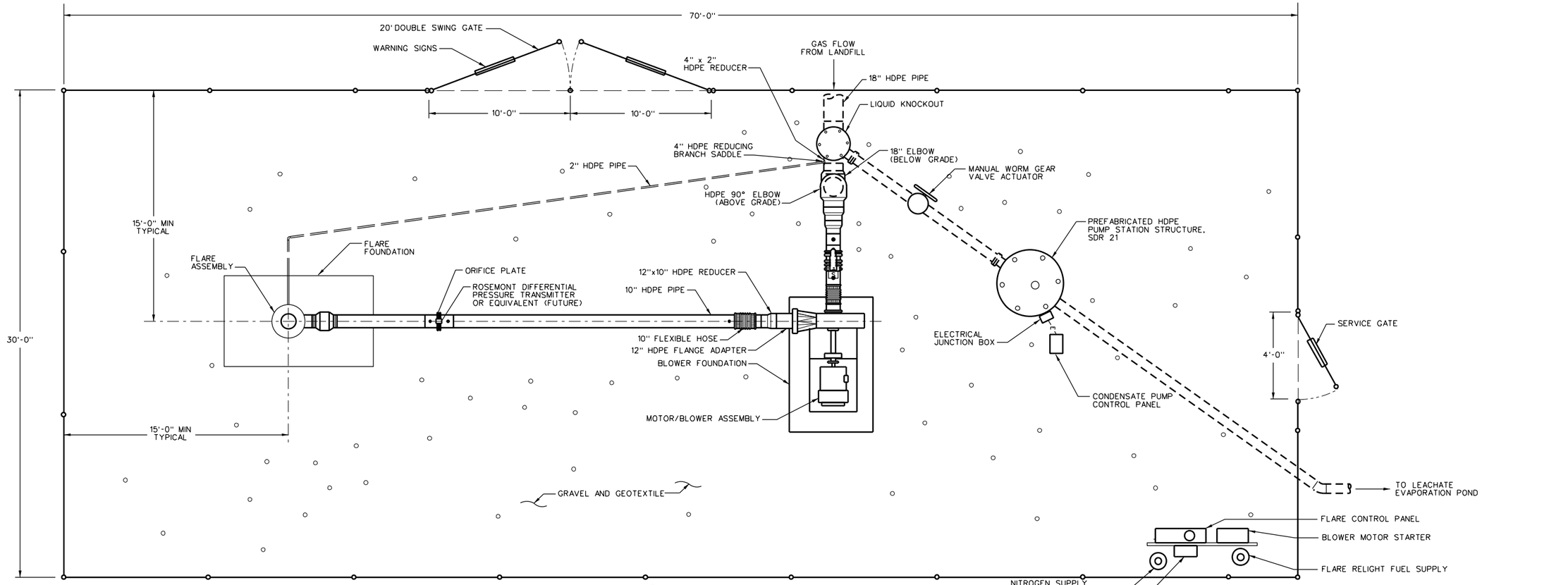
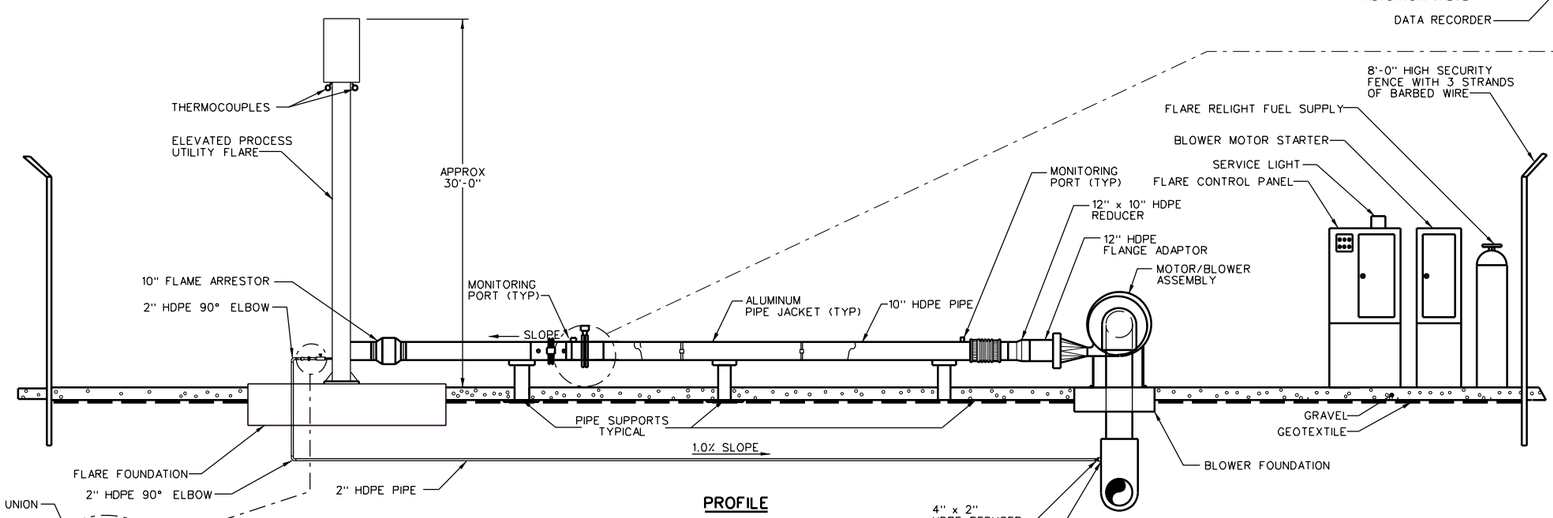
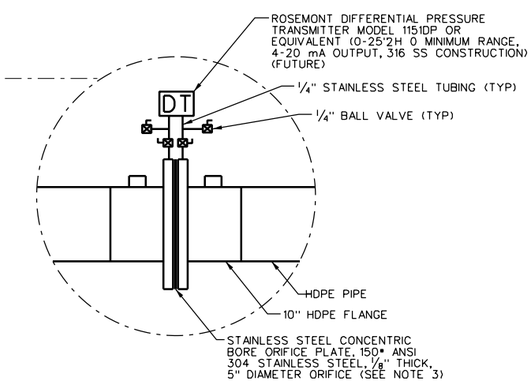


PLAN

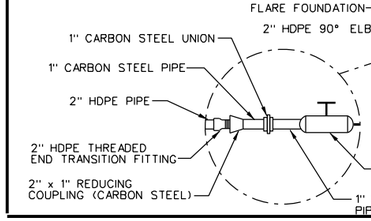


PROFILE



PLAN NOTES

1. MATERIAL AND SIZES SHOWN ARE TYPICAL FOR A GAS MANAGEMENT SYSTEM. ACTUAL MATERIALS AND SIZES WILL BE DETERMINED DURING PERMITTING AND CONSTRUCTION.



NOTE:

1. BLOWER FLARE STATION DESIGN IS PRELIMINARY. DESIGN SIZES, DIMENSIONS, AND LAYOUT MAY CHANGE DURING FINAL DESIGN AND PREPARATION OF CONSTRUCTION DRAWINGS.

BLOWER / FLARE STATION 1

NTS

AECOM

DRAWING 37
DETAILS: BLOWER AND FLARE STATION

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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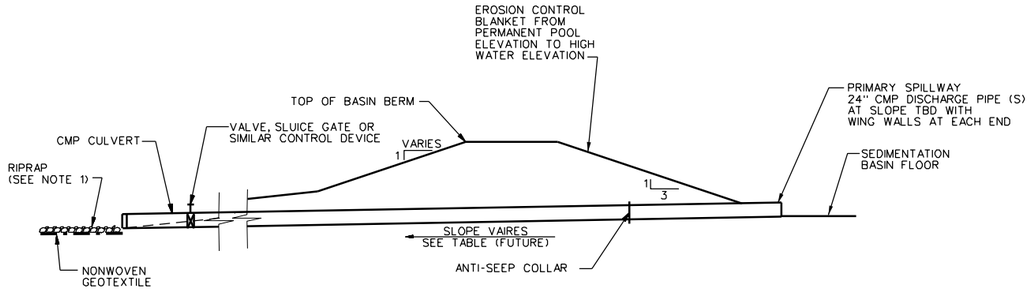
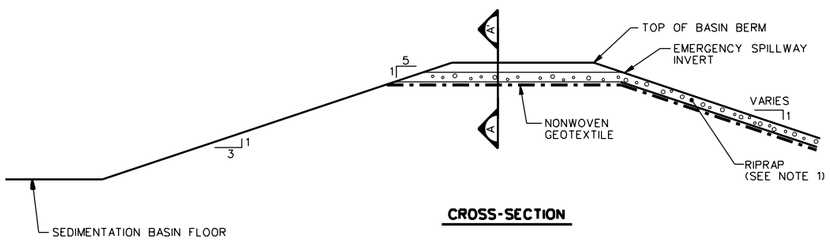


NOTE:

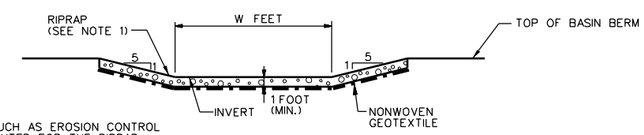
1. ALTERNATIVE MATERIALS, SUCH AS EROSION CONTROL BLANKET, MAY BE SUBSTITUTED FOR THE RIPRAP.

TYPICAL SPILLWAY PROFILE 1

NTS



CROSS-SECTION



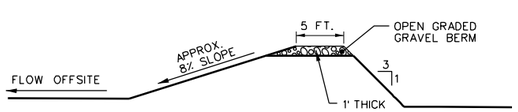
NOTE:

1. ALTERNATIVE MATERIALS, SUCH AS EROSION CONTROL BLANKET, MAY BE SUBSTITUTED FOR THE RIPRAP.

CROSS-SECTION A-A'

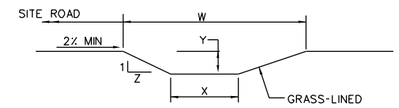
EMERGENCY SPILLWAY FOR SEDIMENTATION BASINS 2

NTS



GRAVEL SPREADER BERM 3

NTS



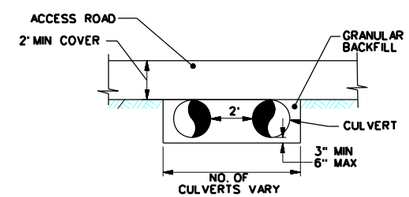
TYPE A CHANNEL, PERIMETER ROAD

NOTE:

1. PLACE HAY BALES OR SILT FENCE ADJACENT TO ALL DITCHES TO PREVENT SILT AND SEDIMENT FROM WASHING INTO DITCH UNTIL VEGETATION IS ESTABLISHED.
2. DIVERSION BERM AND CHANNEL DIMENSIONS VARY, SEE TABLE (FUTURE) FOR BERM DIMENSIONS AND CHANNEL DIMENSIONS.

DIVERSION CHANNEL DETAIL 4

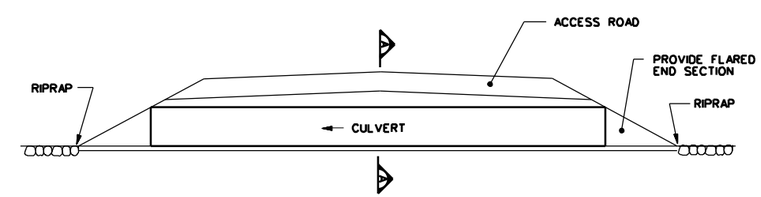
NTS



NOTES:

1. CULVERT DIMENSIONS VARY.
2. PLACE RIPRAP AT CULVERT INLET AND OUTLET LOCATIONS.
3. INSTALL FLARED END SECTIONS AT BOTH INLET AND OUTLET ENDS.
4. PROVIDE MINIMUM 2.0' COVER OVER CULVERT AT ROAD EDGE.
5. MULTIPLE CULVERTS WILL BE INSTALLED PARALLEL TO ONE ANOTHER WITH 2.0' MINIMUM SEPARATION.
6. A STRUCTURE HAVING EQUIVALENT HYDRAULIC PERFORMANCE MAY BE SUBSTITUTED SUBJECT TO REVIEW AND APPROVAL.

SECTION A-A



CULVERT PROFILE

CULVERT INSTALLATION DETAIL 5

NTS

AECOM

DRAWING 38
TYPICAL RRP DETAILS: DIVERSION CHANNEL, CULVERT, AND SPILLWAYS

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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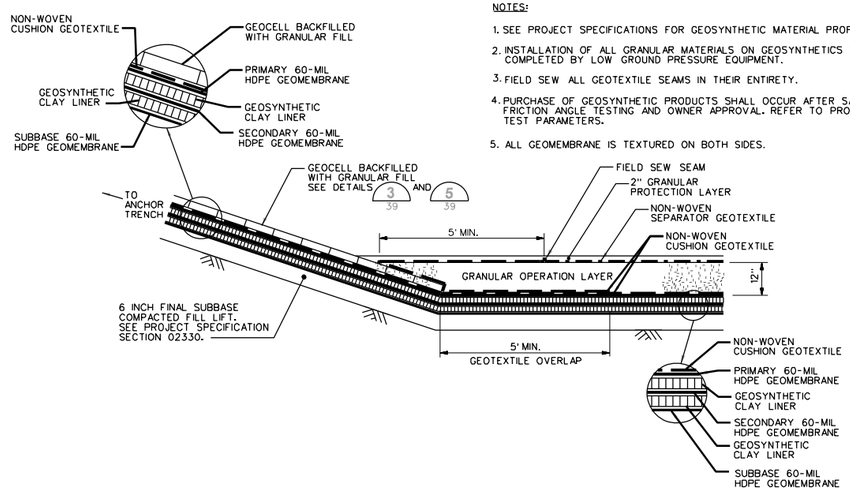
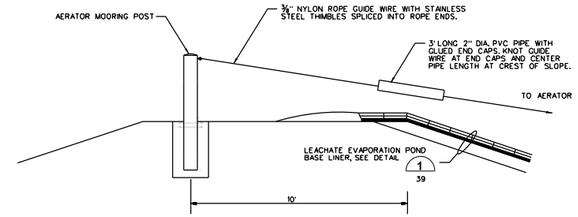
NOTES:

1. SEE PROJECT SPECIFICATIONS FOR GEOSYNTHETIC MATERIAL PROPERTIES.
2. INSTALLATION OF ALL GRANULAR MATERIALS ON GEOSYNTHETICS TO BE COMPLETED BY LOW GROUND PRESSURE EQUIPMENT.
3. FIELD SEW ALL GEOTEXTILE SEAMS IN THEIR ENTIRETY.
4. PURCHASE OF GEOSYNTHETIC PRODUCTS SHALL OCCUR AFTER SATISFACTORY INTERFACE FRICTION ANGLE TESTING AND OWNER APPROVAL. REFER TO PROJECT SPECIFICATIONS FOR TEST PARAMETERS.
5. ALL GEOMEMBRANE IS TEXTURED ON BOTH SIDES.



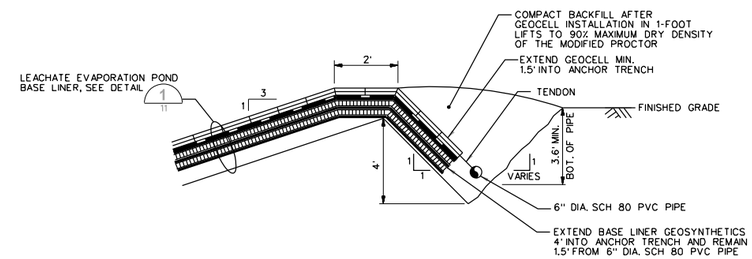
LEACHATE EVAPORATION POND BASE LINER DETAIL 1

NTS



AERATOR MOORING POST LOCATION AND GUIDE WIRE DETAIL 2

NTS

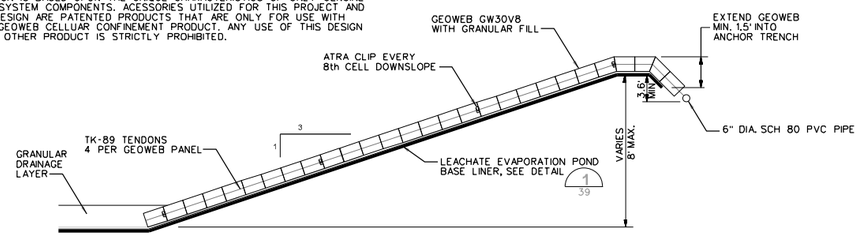


LEACHATE EVAPORATION POND BASE LINER ANCHOR TRENCH DETAIL 4

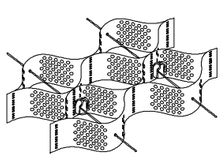
NTS

NOTES:

1. GEOCELL SYSTEM DESIGN AND DETAILS PROVIDED BY PRESTO.
2. THIS DESIGN IS BASED UPON THE UNIQUE CHARACTERISTICS OF ONLY GENUINE GEOWEB SYSTEM COMPONENTS. ACESSORIES UTILIZED FOR THIS PROJECT AND IN THIS DESIGN ARE PATENTED PRODUCTS THAT ARE ONLY FOR USE WITH GENUINE GEOWEB CELLUAR CONFINEMENT PRODUCT. ANY USE OF THIS DESIGN FOR ANY OTHER PRODUCT IS STRICTLY PROHIBITED.



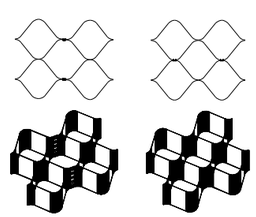
GEOWEB ANCHORAGE AND TERMINATION DETAIL



TENDON DETAIL

NOTES FOR STANDARD CONNECTIONS BETWEEN GEOWEB® SECTIONS:

1. ADJACENT GEOWEB SECTIONS ARE STAPLED TOGETHER USING MANUFACTURER APPROVED STAPLERS AND STAPLES
2. THE TOP EDGES OF ADJACENT CELL WALLS SHOULD BE HELD FLUSH WHEN STAPLING.
3. SIDE CONNECTIONS BETWEEN EXPANDED GEOWEB SECTIONS SHOULD BE INTERLEAFED AS SHOWN IN FIGURE A. WELDED EDGE SEAMS SHOULD BE ALIGNED WHEN STAPLING.
4. END CONNECTIONS BETWEEN GEOWEB SECTIONS SHOULD BE BUTTED AS SHOWN IN FIGURE B. THE LONGITUDINAL CENTER-LINES OF ABUTTING EXTERNAL CELLS SHOULD BE ALIGNED AND STAPLED AT THE CELL WALL CONTACT POINT.



INTERLEAFED ABUTTED

SIDE AND END CONNECTION DETAIL

STEP 1 - PLACE THE TENDON UNDER ONE ARM OF THE ATRA® CLIP.

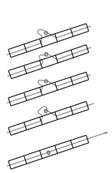
STEP 2 - DIAGONALLY CROSS THE TENDON OVER THE TOP OF THE ATRA® CLIP.

STEP 3 - PLACE THE TENDON UNDER THE OTHER ARM AND PULL TAUGHT TO REMOVE ANY SLACK.

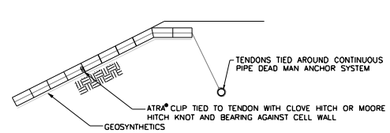
STEP 4 - DIAGONALLY CROSS THE TENDON BACK OVER THE TOP OF THE ATRA® CLIP AND PLACE THE TENDON UNDER THE FIRST ARM.

STEP 5 - PULL THE TENDON TAUGHT TO REMOVE ANY SLACK. REPEAT THIS PROCESS IF THE TENDON SLIPS AROUND THE ATRA® CLIP.

STEP 6 - PULL THE TENDON TAUGHT AT THE LOCATION OF THE NEXT ATRA® CLIP



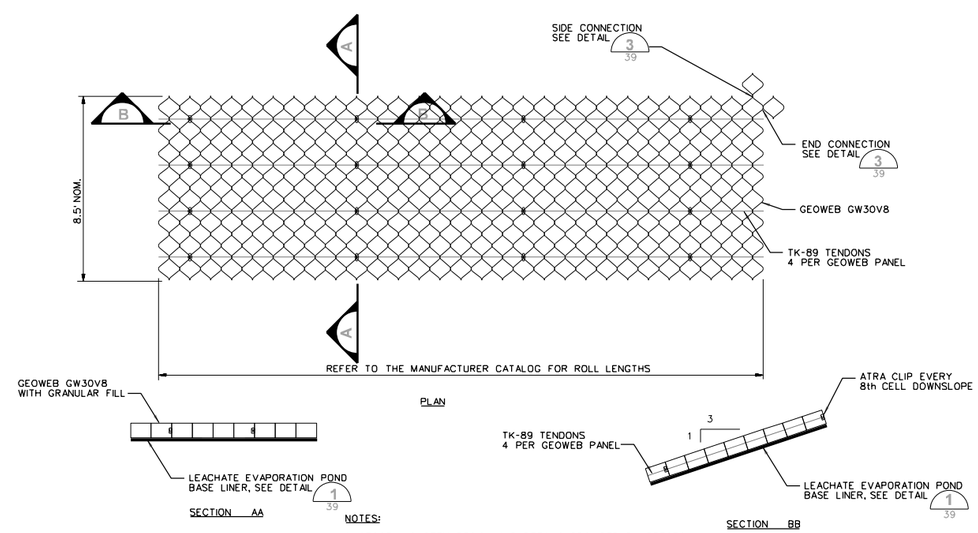
ALTRA CLIP INSTALLATION DETAIL



TYPICAL TENDON CREST ANCHOR SYSTEM DETAIL

GEOCELL INSTALLATION AND ANCHORING DETAIL 3

NTS



NOTES:

1. GEOCELL SYSTEM DESIGN AND DETAILS PROVIDED BY PRESTO.
2. THIS DESIGN IS BASED UPON THE UNIQUE CHARACTERISTICS OF ONLY GENUINE GEOWEB SYSTEM COMPONENTS. ACESSORIES UTILIZED FOR THIS PROJECT AND IN THIS DESIGN ARE PATENTED PRODUCTS THAT ARE ONLY FOR USE WITH GENUINE GEOWEB CELLUAR CONFINEMENT PRODUCT. ANY USE OF THIS DESIGN FOR ANY OTHER PRODUCT IS STRICTLY PROHIBITED.

GEOCELL PANEL CONNECTIONS DETAIL 5

NTS

AECOM

DRAWING 39
DETAILS: LEACHATE EVAPORATION POND

DRAFT CONCEPTUAL DESIGNS
PROPOSED MSW LANDFILL
AND RESOURCE RECOVERY PARK AT MA'ALO
KAUA'I, HAWAII

AUGUST 2014 60221907

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Appendix A:
Soil Balance Calculations

Appendix A.1
Soil Material Requirements
– Alternative 1, Phase 1

Client	County of Kaua'i	**Subject**	Soil Material	**Prepared By** NKW	**Date** 8/12/14
Project	Ma'alo Landfill		Requirements – Alternative 1	**Reviewed By**	Date
Conceptual Design			Phase 1	**Approved By**	Date

SOIL MATERIAL REQUIREMENTS – ALTERNATIVE 1 PHASE 1

Objective

Calculate the miscellaneous soil, rooting zone, topsoil, granular drainage layer, and operations layer material available and required for development of Phase 1 of the Alternative 1 landfill.

Design Criteria and Assumptions

1. Initial development will progress from construction of support facilities and Phase 1, to construction of subsequent phases, waste filling, and final cover construction. Materials required for development and operation obtained from on-site sources will include landfill excavation, surface water management system excavation and construction, leachate evaporation pond excavation and construction, and grading activities. Material will also be obtained from off-site sources and trucked to the facility. All granular material is assumed to be obtained off-site. Volumes required for each material type and the material available of each material type (miscellaneous soil, topsoil, and granular material) are summarized in Table 1 and Table 2.

2. Limited site geologic data is available. Based on the "Preliminary Geotechnical Investigation, Kauai Landfill Siting EIS, Ma'alo Site" prepared by Masa Fujioka and Associates, June 11, 2013, it is assumed that the top 8 inches is topsoil, all other soil excavated is assumed to be miscellaneous soil.

3. The waste to daily/intermediate cover ratio may range from 3:1 to 5:1. A waste to daily/intermediate cover ratio of 4:1 is assumed for this calculation. Therefore, 20 percent of the waste volume is daily/intermediate cover.

4. The following layers and features are considered in this calculation:

    a. Daily/intermediate cover.
    b. 6-inch topsoil layer.
    c. 12-inch rooting zone layer.
    d. Facility construction, including:
        i. perimeter berms;
        ii. perimeter roads;
        iii. run-on channels;
        iv. structural fill;

    e. Surface water diversion berms.
    f. Entrance area including the maintenance area and main access road.
    g. South surface water basin.
    h. Leachate evaporation pond.
    i. 12-inch granular drainage layer, including sideslopes and 6-inch granular foundation layer.

5. The net airspace is the volume from the bottom of final cover to the top of the granular drainage layer. The net airspace of Alternative 1 Phase 1, as discussed in Section 4.1.4, is approximately 4,530,000 cy.

6. Grading for run-on channels RO-1, RO-2, and RO-3 is not shown on the drawings. The run-on channels generally flow cross-slope. The run-on channels will be constructed so that a portion of the channel width is cut into the existing topography with a constructed berm making up the remainder of the width of the channel. It is assumed that the excavated soils from the cut into the existing slope will be used to construct the berm so that the construction of the run-on channels will result in no net

cut or fill of soil. The topsoil needed for the construction of the run-on channels will be available from the excavation of the channels.

7. Grading for sideslope diversion berms is not shown on the drawings. The additional miscellaneous soil needed to construct the berms is calculated based on the drawings and details.

8. The items listed below were computed and calculated using the In-Roads computer program or scaled from the drawing set. In-Roads computer program results are provided in Attachment 1.

   a. The area, accounting for surface slopes, of both the final cover and the top of liner is as follows.

Item	Area
Phase 1 Final Cover (sf)	2,012,100
Phase 1 Base Liner (sf)	1,988,900

   b. The cuts and fills for the subgrade preparation.

   c. The sideslope surface water diversion berm volumes.

   d. The cuts and fills for the South Surface Water Basin.

   e. The cuts and fills for the Leachate Evaporation Pond.

   f. The cuts and fills for the entrance area grading and main access road grading.

Calculations

Sideslope diversion berm volume required:
From the drawings and details, there are approximately 7,630 linear feet of sideslope diversion berms and the cross sectional area is approximately 62 sf.
Therefore,
sideslope diversion berm volume = 62 sf x 7,630 linear ft x 1 cy / 27 cf = 17,520 cy

Daily/intermediate cover volume required: 4,530,000 cy x 0.20 = 906,000 cy

6-inch topsoil layer soil volume required: (0.5 ft x 2,012,100 sf) x 1 cy/27 cf = 37,261 cy

12-inch rooting zone layer volume required: (1 ft x 2,012,100 sf) x 1 cy/27 cf = 74,522 cy

12-inch granular drainage layer volume required: (1 ft x 1,988,900 sf) x 1 cy/27 cf = 73,663 cy

24-inch operations layer volume required: (2 ft x 1,988,900 sf) x 1 cy/27 cf = 147,326 cy

Topsoil Available (Phase 1 area): (8 in x 1 ft/12 in) x 1,988,900 sf) x 1 cy/27 cf = 49,108 cy

Misc. Soils Available (Phase 1 area): Misc soils available are the excavation volume minus the topsoil. 810,750 cy – 49,108 cy = 761,642 cy

Volume summaries based on the calculations above and In-Roads output are provided in Table 1 and Table 2.

Client	County of Kaua'i	**Subject**	Soil Material	**Prepared By**	NKW	**Date** 8/12/14
Project	Ma'alo Landfill		Requirements – Alternative 1	**Reviewed By**		Date
Conceptual Design			Phase 1	**Approved By**		Date

Table 1: Granular Material

	Required
12-inch granular drainage layer (cy)	73,663
24-inch operations layer (cy)	147,326
Total Granular Material	**220,989**

Table 2: Topsoil and Miscellaneous Soil

	Topsoil		Miscellaneous Soil	
	Available (cy)	Required (cy)	Available (cy)	Required (cy)
6-inch topsoil layer	----	37,261	----	----
12-inch rooting zone layer	----	----	----	74,522
Daily/intermediate cover required- 20% of net airspace	----	----	----	906,000
Sideslope surface water diversion berms	----	----	----	17,520
Subgrade preparation	49,108	----	761,642	239,792
Entrance area grading	See Note 1		55,284	18,986
South Surface Water Basin	See Note 1		9,868	21,965
Leachate Evaporation Pond	See Note 1		23,952	27,968
Run-on channels	See Note 2		See Note 2	
Subtotal	**49,108**	**37,261**	**850,748**	**1,306,753**

Notes:

1. Topsoil required for construction of the entrance area channels, South Surface Water Basin, and Leachate Evaporation Pond is available from the excavation of each feature.
2. Soils excavated for run-on channel construction will be used for construction of the channels resulting in no net cut or fill of soils. Topsoil required for construction of the run-on channels is available from excavation of the channels.

Conclusions

The available and required miscellaneous soils, topsoil, and granular drainage layer material quantities are summarized in Table 1 and Table 2. Total soil quantities for Alternative 1 Phase 1 are summarized in Table 1.

Table 3: Soil Quantities Summary

	Material Available	Material Required
Miscellaneous Soils	851,000	1,307,000
Topsoil	49,000	37,300
Granular Material	0	221,000

ATTACHMENT 1

IN-ROADS OUTPUT

Item 1: Phase 1 cut/fill
Grid Volume Report

Original Surface: Maalo 2012 topo
Design Surface: BG P1 r5

Grid Interval: 5.0

Cut: 810,750.0 cu yd
Fill: 239,792.2 cu yd
Net: 570,957.8 cu yd

Item 2: Entrance area cut/fill
Grid Volume Report

Original Surface: Phase 1 topo
Design Surface: Entrance Grading

Grid Interval: 5.0

Cut: 55,284.3 cu yd
Fill: 18,986.3 cu yd
Net: 36,298.1 cu yd

Item 3: Sed basin cut/fill
Grid Volume Report

Original Surface: Phase 1 topo
Design Surface: Sed basin

Grid Interval: 5.0

Cut: 9,868.3 cu yd
Fill: 21,964.9 cu yd
Net: -12,096.5 cu yd

Item 4: cover area
Surface Area Report

Surface: FG p1 rev
Fence Mode: Inside

True Area: 2,012,087.6 sq ft
Planar Area: 1,954,745.0 sq ft

Item 5: Liner area
Surface Area Report

Surface: BG P1 r5
Fence Mode: Inside

True Area: 1,988,936.9 sq ft
Planar Area: 1,954,749.4 sq ft

Triangle Volume Report

Report Created: 7/28/2014
Time: 4:07pm

Mode: Entire Surface
Input Grid Factor: 1.000000

Original Surface: **Maalo 2012 topo**
Description:
Preference: Default
Type: Existing
Design Surface: **Revised Alternate Base Grades**
Description:
Preference: Default
Type: Existing
Cut Factor: 1.00
Fill Factor: 1.00

Cut:	26355406.3 cu ft
Fill:	35599018.2 cu ft
Net:	-9243611.8 cu ft

Cut:	976126.2 cu yd
Fill:	1318482.2 cu yd
Net:	-342356.0 cu yd

Alternative 2
- Overall
- Material Balance

Original Surface: **Maalo 2012 topo**
Description:
Preference: Default
Type: Existing
Design Surface: **Leachate Pond**
Description:
Preference: Default
Type: Existing
Cut Factor: 1.00
Fill Factor: 1.00

Cut:	646707.9 cu ft
Fill:	755126.7 cu ft
Net:	-108418.8 cu ft

Cut:	23952.1 cu yd

Leachate Pond
- Material Balance

Leachate Pond
Fill for Berms

Fill:	27967.7 cu yd
Net:	-4015.5 cu yd

Original Surface: **Revised Alternate Base Grades**
Description:
Preference: Default
Type: Existing
Design Surface: **Revised Alternate Final Cover**
Description:
Preference: Default
Type: Existing

Cut Factor:	1.00
Fill Factor:	1.00

Cut:	7253.5 cu ft
Fill:	902815236.7 cu ft
Net:	-902807983.2 cu ft

Cut:	268.6 cu yd
Fill:	33437601.4 cu yd
Net:	-33437332.7 cu yd

Alternative 2
~~[illegible]~~
overall Airspace

Surface Area Report

Surface: Revised Alternate Base Grades
Fence Mode: Inside

True Area: 7053373.6 sq ft
Planar Area: 6986491.2 sq ft

Surface Area Report

Surface: Revised Alternate Final Cover
Fence Mode: Inside

True Area: 7216200.3 sq ft
Planar Area: 6986688.1 sq ft

Appendix A.2
Soil Material Requirements
– Alternative 2, Phase 1

Client	County of Kaua'i	**Subject**	Soil Material	**Prepared By** NKW	**Date** 8/12/14
Project	Ma'alo Landfill		Requirements – Alternative 2	**Reviewed By**	Date
Conceptual Design			Phase 1	**Approved By**	Date

SOIL MATERIAL REQUIREMENTS – ALTERNATIVE 2 PHASE 1

Objective

Calculate the miscellaneous soil, rooting zone, topsoil, granular drainage layer, and operations layer material available and required for development of Phase 1 of the Alternative 2 landfill.

Design Criteria and Assumptions

1. Initial development will progress from construction of support facilities and Phase 1, to construction of subsequent phases, waste filling, and final cover construction. Materials required for development and operation obtained from on-site sources will include landfill excavation, surface water management system excavation and construction, leachate evaporation pond excavation and construction, and grading activities. Material will also be obtained from off-site sources and trucked to the facility. All granular material is assumed to be obtained off-site. Volumes required for each material type and the material available of each material type (miscellaneous soil, topsoil, and granular material) are summarized in Table 1 and Table 2.

2. Limited site geologic data is available. Based on the "Preliminary Geotechnical Investigation, Kauai Landfill Siting EIS, Ma'alo Site" prepared by Masa Fujioka and Associates, June 11, 2013, it is assumed that the top 8 inches is topsoil, all other soil excavated is assumed to be miscellaneous soil.

3. The waste to daily/intermediate cover ratio may range from 3:1 to 5:1. A waste to daily/intermediate cover ratio of 4:1 is assumed for this calculation. Therefore, 20 percent of the waste volume is daily/intermediate cover.

4. The following layers and features are considered in this calculation:

    a. Daily/intermediate cover.
    b. 6-inch topsoil layer.
    c. 12-inch rooting zone layer.
    d. Facility construction, including:
        i. perimeter berms;
        ii. perimeter roads;
        iii. run-on channels;
        iv. structural fill;

    e. Surface water diversion berms.
    f. Entrance area including the maintenance area and main access road.
    g. South surface water basin.
    h. Leachate evaporation pond.
    i. 12-inch granular drainage layer, including sideslopes and 6-inch granular foundation layer.

5. The net airspace is the volume from the bottom of final cover to the top of the granular drainage layer. The net airspace of Alternative 2 Phase 1, as discussed in Section 5.1.4, is approximately 3,520,000 cy.

6. Grading for run-on channels RO-1, RO-2, and RO-3 is not shown on the drawings. The run-on channels generally flow cross-slope. The run-on channels will be constructed so that a portion of the channel width is cut into the existing topography with a constructed berm making up the remainder of the width of the channel. It is assumed that the excavated soils from the cut into the existing slope will be used to construct the berm so that the construction of the run-on channels will result in no net

cut or fill of soil. The topsoil needed for the construction of the run-on channels will be available from the excavation of the channels.

7. Grading for sideslope diversion berms is not shown on the drawings. The additional miscellaneous soil needed to construct the berms is calculated based on the drawings and details.

8. The items listed below were computed and calculated using the In-Roads computer program or scaled from the drawing set. In-Roads computer program results are provided in Attachment 1.

   a. The area, accounting for surface slopes, of both the final cover and the top of liner is as follows.

Item	Area
Phase 1 Final Cover (sf)	1,526,517
Phase 1 Base Liner (sf)	1,508,892

   b. The cuts and fills for the subgrade preparation.

   c. The sideslope surface water diversion berm volumes.

   d. The cuts and fills for the South Surface Water Basin.

   e. The cuts and fills for the Leachate Evaporation Pond.

   f. The cuts and fills for the entrance area grading and main access road grading.

Calculations

Sideslope diversion berm volume required:
From the drawings and details, there are approximately 6,080 linear feet of sideslope diversion berms and the cross sectional area is approximately 62 sf.
Therefore,
sideslope diversion berm volume = 62 sf x 6,080 linear ft x 1 cy / 27 cf = 13,961 cy

Daily/intermediate cover volume required: 3,520,000 cy x 0.20 = 704,000 cy

6-inch topsoil layer soil volume required: (0.5 ft x 1,526,517 sf) x 1 cy/27 cf = 28,269 cy

12-inch rooting zone layer volume required: (1 ft x 1,526,517 sf) x 1 cy/27 cf = 56,538 cy

12-inch granular drainage layer volume required: (1 ft x 1,508,892 sf) x 1 cy/27 cf = 55,880 cy

24-inch operations layer volume required: (2 ft x 1,508,892 sf) x 1 cy/27 cf = 111,770 cy

Topsoil Available (Phase 1 area): (8 in x 1 ft/12 in) x 1,508,892 sf) x 1 cy/27 cf = 37,257 cy

Misc. Soils Available (Phase 1 area): Misc soils available are the excavation volume minus the topsoil. 566,877 cy – 37,257 cy = 529,620 cy

Volume summaries based on the calculations above and In-Roads output are provided in Table 1 and Table 2.

Client	County of Kaua'i	**Subject**	Soil Material	**Prepared By**	NKW	**Date** 8/12/14
Project	Ma'alo Landfill		Requirements – Alternative 2	**Reviewed By**		Date
Conceptual Design			Phase 1	**Approved** By		Date

Table 1: Granular Material

	Required
12-inch granular drainage layer (cy)	55,880
24-inch operations layer (cy)	111,770
Total Granular Material	**167,650**

Table 2: Topsoil and Miscellaneous Soil

	Topsoil		Miscellaneous Soil	
	Available (cy)	Required (cy)	Available (cy)	Required (cy)
6-inch topsoil layer	----	28,269	----	----
12-inch rooting zone layer	----	----	----	56,538
Daily/intermediate cover required- 20% of net airspace	----	----	----	704,000
Sideslope surface water diversion berms	----	----	----	13,961
Subgrade preparation	37,257	----	529,620	213,821
Entrance area grading	See Note 1		210,208	160,637
South Surface Water Basin	See Note 1		9,868	21,965
Leachate Evaporation Pond	See Note 1		23,952	27,968
Run-on channels	See Note 2		See Note 2	
Subtotal	**37,257**	**28,269**	**749,696**	**1,170,922**

Notes:

1. Topsoil required for construction of the entrance area channels, South Surface Water Basin, and Leachate Evaporation Pond is available from the excavation of each feature.
2. Soils excavated for run-on channel construction will be used for construction of the channels resulting in no net cut or fill of soils. Topsoil required for construction of the run-on channels is available from excavation of the channels.

Conclusions

The available and required miscellaneous soils, topsoil, and granular drainage layer material quantities are summarized in Table 1 and Table 2. Total soil quantities for Alternative 2 Phase 1 are summarized in Table 1.

Table 3: Soil Quantities Summary

	Material Available	Material Required
Miscellaneous Soils	749,700	1,171,000
Topsoil	37,300	28,300
Granular Material	0	167,700

ATTACHMENT 1

IN-ROADS OUTPUT

Triangle Volume Report

Report Created: 7/28/2014
Time: 4:07pm

Mode: Entire Surface
Input Grid Factor: 1.000000

Original Surface: **Maalo 2012 topo**
Description:
Preference: Default
Type: Existing
Design Surface: **Revised Alternate Base Grades –**
Description: Alternative 2 - Entire Site
Preference: Default
Type: Existing
Cut Factor: 1.00
Fill Factor: 1.00

Cut:	26355406.3 cu ft
Fill:	35599018.2 cu ft
Net:	-9243611.8 cu ft

Cut:	976126.2 cu yd
Fill:	1318482.2 cu yd
Net:	-342356.0 cu yd

Original Surface: **Maalo 2012 topo**
Description:
Preference: Default
Type: Existing
Design Surface: **Leachate Pond**
Description:
Preference: Default
Type: Existing
Cut Factor: 1.00
Fill Factor: 1.00

Cut:	646707.9 cu ft
Fill:	755126.7 cu ft
Net:	-108418.8 cu ft

Cut:	23952.1 cu yd

Fill:	27967.7 cu yd
Net:	-4015.5 cu yd

Original Surface: Revised Alternate Base Grades

Description:

Preference: Default

Type: Existing

Design Surface: Revised Alternate Final Cover

Description:

Preference: Default

Type: Existing

Cut Factor:	1.00
Fill Factor:	1.00

Cut:	7253.5 cu ft
Fill:	902815236.7 cu ft
Net:	-902807983.2 cu ft

Cut:	268.6 cu yd
Fill:	33437601.4 cu yd
Net:	-33437332.7 cu yd

Original Surf. MAALO 2012 TOPO

Description:
Preference: Default
Type: Existing

Design Surface: Alternate 2 Phase 1 Base Grades

Description:
Preference: Default
Type: Existing

Cut Factor:	1.00
Fill Factor:	1.00

Cut:	15305668.8 cu ft
Fill:	5773174.5 cu ft
Net:	9532494.3 cu ft

Cut:	566876.6 cu yd
Fill:	213821.3 cu yd
Net:	353055.3 cu yd

Alternative 2
- Phase 1
- Material Balance

Original Surface: Alternate 2 Phase 1 Base Grades

Description:
Preference: Default
Type: Existing

Design Surface: Alternate 2 Phase 1 Final Cover

Description:
Preference: Default
Type: Existing

Cut Factor:	1.00
Fill Factor:	1.00

Cut:	751.8 cu ft
Fill:	98837723.8 cu ft
Net:	-98836972.0 cu ft

Cut:	27.8 cu yd
Fill:	3660656.4 cu yd
Net:	-3660628.6 cu yd

Alternative 2
- Phase 1
- Airspace

Appendix A.3
Soil Material Requirements
– Alternatives 1 and 2, Phases 2 through 5

Client	County of Kaua'i	**Subject**	Soil Material	**Prepared By**	TCR	**Date**	6/27/13
Project	Ma'alo Landfill		Requirements Alternatives 1	**Reviewed By**	MJV	**Date**	6/27/13
Conceptual Design			and 2, Phases 2 Through 5	**Approved By**	KJB	**Date**	6/27/13

SOIL MATERIAL REQUIREMENTS ALTERNATIVES 1 AND 2, PHASES 2 THROUGH 5

Objective

Calculate the miscellaneous soil, rooting zone, topsoil, granular drainage layer, and operations layer material available and required for development of Phases 2 through 5 of the landfill. Note that Phases 2 through 5 are virtually the same for both Alternative 1 and Alternative 2.

Design Criteria and Assumptions

1. The soils required and available as calculated in this calculation assume that Phase 1 and the entrance area are constructed and covered as discussed in the "Soil Material Requirements – Phase 1" calculation. A portion of the soils for the Phase 1 cover will be available due to the overlay of Phases 2 through 5 onto Phase 1.

2. Materials required for development and operation obtained from on-site sources will include landfill excavation, surface water management system excavation and construction, and grading activities. Material will also be obtained from off-site sources and trucked to the facility. All granular material is assumed to be obtained off-site. Volumes required for each material type and the material available of each material type (miscellaneous soil, topsoil, and granular material) are summarized in Table 1, and Table 2.

3. Limited site geologic data is available. Based on the "Preliminary Geotechnical Investigation, Kauai Landfill Siting EIS, Ma'alo Site" prepared by Masa Fujioka and Associates, June 11, 2013, it is assumed that the top 8 inches is topsoil, all other soil excavated is assumed to be miscellaneous soil.

4. The waste to daily/intermediate cover ratio may range from 3:1 to 5:1. A waste to daily/intermediate cover ratio of 4:1 is assumed for this calculation. Therefore, 20 percent of the waste volume is daily/intermediate cover.

5. The following layers and features are considered in this calculation:

    a. Daily/intermediate cover.
    b. 6-inch topsoil layer.
    c. 12-inch rooting zone layer.
    d. Facility construction, including:
        i. perimeter berms;
        ii. perimeter roads;
        iii. run-on channels;
        iv. structural fill;
        v. surface water basins

    e. Surface water diversion berms.
    f. 12-inch granular drainage layer, including sideslopes and 6-inch granular foundation layer.

6. The net airspace is the volume from the bottom of final cover to the top of the granular drainage layer. The net airspace of Phases 2, 3, 4, and 5 is approximately 28,726,000 cy.

7. Grading for run-on channels is not shown on the drawings. The run-on channels generally flow cross-slope. The run-on channels will be constructed so that a portion of the channel width is cut into the existing topography with a constructed berm making up the remainder of the width of the channel. It is assumed that the excavated soils from the cut into the existing slope will be used to construct the

berm so that the construction of the run-on channels will result in no net cut or fill of soil. The topsoil needed for the construction of the run-on channels will be available from the excavation of the channels.

8. Grading for sideslope diversion berms is not shown on the drawings. Based the soil volumes required for Phase 1, the additional miscellaneous soil needed to construct the berms for Phases 2 through 5 is assumed to be equal to 50% of the topsoil required.

9. Surface water basins for Phases 2 through 4 will be designed in the future. Assume that the net balance for Phases 2 through 5 surface water basins is three times the net soil balance for the Phase 1 South Sedimentation Basin. From the "Soil Material Requirements – Phase 1" calculation, the net soil balance for the South Sedimentation Basin is a fill of approximately 12,100 cy.

10. The items listed below were computed and calculated using the In-Roads computer program or scaled from the drawing set. In-Roads computer program results are provided in Attachment 1.

    a. The area, accounting for surface slopes, of both the final cover and the top of liner is as follows.

Item	Area
Phases 2 through 5 Final Cover (sf)	6,728,579
Phases 2 through 5 Base Liner (sf)	5,511,059
Area of Phases 2 through 5 overlying Phase 1 (sf)	1,062,383

    b. The cuts and fills for the subgrade preparation.

Calculations

Daily/intermediate cover volume required: 28,862,000 cy x 0.20 = 5,772,400 cy

6-inch topsoil layer soil volume required: (0.5 ft x 6,728,579 sf) x 1 cy/27 cf = 124,600 cy

Sideslope diversion berm volume required (assume 50% of topsoil volume):
sideslope diversion berm volume = 0.50 x 124,600 cy = 62,300 cy

12-inch rooting zone layer volume required: (1 ft x 6,728,579 sf) x 1 cy/27 cf = 249,200 cy

12-inch granular drainage layer volume required: (1 ft x 5,511,059 sf) x 1 cy/27 cf = 204,100 cy

24-inch operations layer volume required: (2 ft x 5,511,059 sf) x 1 cy/27 cf = 408,200 cy

Topsoil Available (Phases 2 through 5): (8 in x 1 ft/12 in) x 5,471,257 sf x 1 cy/27 cf = 135,093 cy

Misc. Soil Available (Phases 2 through 5): Misc soils available are the excavation volume minus the topsoil. 408,378 cy – 135,093 cy = 273,285 cy

Topsoil Available (Phase 1 overlay area): (6 in x 1 ft/12 in) x 1,062,383 sf x 1 cy/27 cf = 19,700 cy

Misc.Soil Available (Phase 1 overlay area): (1 ft x 1,062,383 sf) x 1 cy/27 cf = 39,300 cy

Volume summaries based on the calculations above and In-Roads output are provided in Table 1 and Table 2.

Client	County of Kaua'i	**Subject**	Soil Material	**Prepared By** TCR	**Date** 6/27/13
Project	Ma'alo Landfill		Requirements Alternatives 1	**Reviewed By** MJV	**Date** 6/27/13
Conceptual Design			and 2, Phases 2 Through 5	**Approved By** KJB	**Date** 6/27/13

Table 1: Granular Material

	Required
12-inch granular drainage layer (cy)	204,100
24-inch operations layer (cy)	408,200
Total Granular Material	**612,300**

Table 2: Topsoil and Miscellaneous Soil

	Topsoil		Miscellaneous Soil	
	Available (cy)	Required (cy)	Available (cy)	Required (cy)
6-inch topsoil layer	----	124,600	----	----
12-inch rooting zone layer	----	----	----	249,200
Daily/intermediate cover required- 20% of net airspace	----	----	----	5,772,400
Sideslope surface water diversion berms	----	----	----	62,300
Subgrade preparation	135,100	----	273,300	1,109,400
Phase 1 Cover Overlay	19,700	----	39,300	---
Surface Water Basins (assumed)	See Note 1		---	29,400
Run-on channels	See Note 2		See Note 2	
Subtotal	**154,800**	**124,600**	**312,600**	**7,222,700**

Notes:

1. Topsoil required for construction of the surface water basins is available from the excavation of the basins.
2. Soils excavated for run-on channel construction will be used for construction of the channels resulting in no net cut or fill of soils. Topsoil required for construction of the run-on channels is available from excavation of the channels.

Conclusions

The available and required miscellaneous soils, topsoil, and granular drainage layer material quantities are summarized in Table 1 and Table 2. Total soil quantities for Phase 1 are summarized in Table 1.

Table 3: Soil Quantities Summary

	Material Available	Material Required
Miscellaneous Soils	312,600	7,222,700
Topsoil	154,800	124,600
Granular Material	0	612,300

ATTACHMENT 1

IN-ROADS OUTPUT

Item 1: Cut/fill for base grades (Phases 2, 3, and 4 combined)

Grid Volume Report

Original Surface: Maalo 2012 topo
Design Surface: Overall BG R

Inside

Grid Interval: 2.0

Cut: 408,378.1 cu yd
Fill: 1,109,387.7 cu yd
Net: -701,009.6 cu yd

Item 2: Area of limits of waste (Phases 2, 3, and 4 combined)

Surface Area Report

Surface: Overall BG R
Fence Mode: Inside

True Area: 5,511,058.5 sq ft
Planar Area: 5,471,256.6 sq ft

Item 3: Area of final cover Phases 2, 3, and 4 (includes Phase 1 "Overlay")

Surface Area Report

Surface: Overall FG R2
Fence Mode: Inside

True Area: 6,728,579.4 sq ft
Planar Area: 6,515,628.4 sq ft

Item 4. Area of Phase 1 cover "overlaid" by filling from Phases 2, 3, and 4

Surface Area Report

Surface: FG p1 rev
Fence Mode: Inside

True Area: 1,062,383.1 sq ft
Planar Area: 1,033,924.4 sq ft

Appendix B:
Preliminary Geotechnical Investigation Data Report

Appendix B.1
Preliminary Geotechnical Investigation Data Report

MASA FUJIOKA & ASSOCIATES
Environmental • Geotechnical • Hydrogeological Consultants
98-021 Kamehameha Highway, Suite 337 • Aiea, Hawaii 96701-4914
Telephone: (808) 484-5366 • Facsimile: (808) 484-0007

June 11, 2012

AECOM Technical Services, Inc.
1001 Bishop Street, Suite 1600
Honolulu, Hawai‘i 96813

Attention. Mr. Frank Cioffi

Subject: **Data Report**
Preliminary Geotechnical Investigation
Kauai Landfill Siting EIS
Ma‘alo Site
Island of Kaua‘i, Hawai‘i

Dear Mr. Cioffi,

Masa Fujioka and Associates (MFA) is pleased to submit this geotechnical data report to AECOM Technical Services, Inc. (AECOM) for the subject project.

PROJECT CONSIDERATIONS

Based on the Statement of Work provided, we understand that the geotechnical investigation is in support of the conceptual design of a potential future landfill site, and the data will be used to assist the County of Kaua‘i’s decision-making process and Environmental Impact Statement (EIS).

SCOPE OF WORK

The following Scope of Work was performed:

1. *Site reconnaissance and kick-off meeting:* An MFA Engineering Geologist conducted a site reconnaissance and kick-off meeting with AECOM’s project engineer to agree on drilling access and boring locations, as well as to review the geotechnical investigation work plan.

2. *Field Investigation:* We conducted a field investigation consisting of 6 borings drilled to depths between 30 to 50 feet below ground surface

(bgs). Boring locations were determined by AECOM. The decision to terminate borings at depths shallower than 50 feet was made according to criteria provided in the field by AECOM. These criteria included depth at which groundwater was encountered and consistency of the soil.

3. *Obtain samples and conduct lab testing:* Recovered bulk soil samples and Standard Penetration Test (SPT) samples were taken to MFA's lab for testing. Initial testing requirements were for compaction, gradation, Atterberg Limits, remolded permeability, and Moisture-Density testing. We were unable to collect samples in Shelby tubes for permeability testing because we did not encounter soft material. Further, we did not encounter any granular material for gradation testing. Therefore, tests conducted by MFA consisted of: Atterberg Limits, proctors, moisture tests (on bagged samples), and moisture-density tests (on sleeved samples). We prepared remolded samples for AECOM to run permeability tests.

4. *Provide a data report:* MFA prepared this letter report summarizing our findings and laboratory test results.

SITE SETTING

The Project Site ("Site") is approximately 4 miles north of Lihu'e, makai (seaward) of Ma'alo Road. The general location of the project is depicted on *Figure 1, Project Location Map*. The Site is currently used as ranch land, primarily for cattle. We understand that the land is owned by the State of Hawai'i and leased to Amfac Land Company. We further understand that the Site is currently zoned as agriculture and in the recent past was planted with sugarcane.

GEOLOGIC SETTING

Regional Geology

Kauai is one of the most structurally complex islands in Hawaii. It is generally believed to be a single-volcano island, although some isotopic data challenge that interpretation. The strata forming the main mass of the Kauai volcanic complex are assigned to the Waimea Canyon Basalt[1]. A large caldera (15-20 km across) was at the top

[1] Sherrod, D.R., Sinton, J.M., Watkins, S.E., and Brunt, K.M. 2007. *Geologic Map of the State of Hawai'i.* Open-File Report 2007-1089. United States Geological Survey.

of the shield, and a smaller one (about 3 km long) on the southeastern flank. Both filled with lava flows[2].

A subcircular graben 6-7 miles across, called the Lihue basin, ranges from the Waialeale massif on the west to the Kalepa and Nonou ridges on the east. The Site is situated in the eastern portion of the Lihue basin. The walls of this basin have been greatly eroded, and the basin largely filled at a much later date with rejuvenated period volcanics of the Koloa volcanic series[3].

The predominant theory had been that the Lihue basin was the result of the collapse of a caldera near the eastern flank of the shield. However, the hypothesis of a landslide-based origin for the Lihue basin has been suggested based on structure contours (i.e. elevation of the base of Koloa Volcanics in the Lihue basin), coupled with adjacent bathymetry. The hypothesis is further supported by the abrupt thickening of the Koloa Volcanics at the foot of the Kalepa Ridge, and the existence of fossiliferous marine mudstone encountered in borings at depths below modern sea level (-125 to -175m). This hypothesis requires that there is a fault boundary along the east side of the basin[4], which more or less coincides with the eastern boundary of the Site.

Site Geology

Just east of the Site is the Kalepa Ridge, consisting of Waimea Canyon Basalt from the shield-building stage of the island. The western portion of the Site is mapped as lava flows of the Koloa Volcanics (geologic map symbol Qtkol), rock type ‘a‘ā and lesser pāhoehoe, with an age range of 0.15-3.85 million years ago (Ma)[5]; this was part of the rejuvenated period volcanics that filled much of the Lihue basin. The eastern portion of the Site is mapped as Older alluvium (geologic map symbol Qtao), consisting of consolidated sand and gravel.

The standard error for the source map is 100 m (±50 m): limited field testing on the Island of Kauai indicated that the accuracy of the geologic units is generally well within that limit, “commonly better than 50 m.” Geologic units are presented on Figure 2, Project Geologic Map.

---

[2] Macdonald, G. A., Abbott, A.T., & Peterson, F.L. (1983). *Volcanoes in the Sea: The Geology of Hawaii* (2nd Ed.). Honolulu: University of Hawaii Press.
[3] Macdonald, G.A., Davis, D.A., & Cox, D.C. 1960. *Geology and Ground-water Resources of the Island of Kauai, Hawaii*. [Bulletin 13.] Hawaii Division of Hydrography. Published in Cooperation with the Geological Survey, United States Department of the Interior.
[4] Sherrod, et. al. *Op. Cit.* pp. 17-18.
[5] Ibid.

Borings B1, B3, and B4 are within the area mapped as Koloa Volcanics. Borings B2 and B5 are within the area mapped as Older alluvium. Boring B6 is near the unit boundary and may fall within either. However, MFA borings did not encounter granular soils in any of the borings.

MAPPED SOILS

Soils at the Site were mapped by the United States Department of Agriculture (USDA) Soil Conservation Service[6]. Most of the Site is mapped as soils of the Lihue Series, with a small portion in the northwest mapped as part of the Ioleau Series, and a larger swath in the north central portion of the Site mapped as Nonopahu Series soils. Two small areas at the easternmost edge of the site are mapped as soils of the Kalapa Series. All 6 borings were drilled in areas mapped as soils of the Lihue Series. A soils map is presented as Figure 3, Project Soils Map.

The Soil Survey describes the Lihue Series as consisting of "well-drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock." The majority of the Site, including borings B2, B3, B4, and B6, is mapped as *Lihue silty clay, 0 to 8 percent slopes (LhB)*, which is described as follows: "This soil is on the tops of broad interfluves in the uplands. Included in mapping were small areas of a soil that has a very dark grayish-brown surface layer and a mottled subsoil. In a representative profile the surface layer is dusky-red silty clay about 12 inches thick. The subsoil, more than 48 inches thick, is dark-red and dark reddish-brown, compact silty clay that has subangular blocky structure. The substratum is soft, weathered rock…. Permeability is moderately rapid, runoff is slow, and the erosion hazard is no more than slight.

Boring B5 is mapped as within *Lihue silty clay, 8 to 15 percent slopes (LhC)*, which is described as soils on which runoff is slow, and the erosion hazard is slight.

An area in the northwest of the Site, in which there were no borings, is mapped as *Lihue gravelly silty clay, 0 to 8 percent slopes (LIB)*, which is described as "similar to *Lihue silty clay, 0 to 8 percent slopes*, except that it contains ironstone-gibbsite pebbles and has brighter colors in the B horizon."

[6] United States Department of Agriculture Soil Conservation Service [in cooperation with The University of Hawaii Agricultural Experiment Station]. 1972. *Soil Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii*. Washington, DC: U.S. Government Printing Office.

Boring B1 is near the map unit boundary between *Lihue silty clay, 0 to 8 percent slopes* and *Lihue gravelly silty clay, 0 to 8 percent slopes (LIC)*, the latter of which is described having slow runoff and slight erosion hazard.[7]

The Nonopahu Series is described as consisting of "moderately well drained soils on uplands on the island of Kauai. These soils developed in material weathered from basic igneous rock high in olivine." The swath in the north central portion of the Site is mapped as *Nonopahu clay, 2 to 10 percent slopes (NnC)*, which is described as follows: "This soil is on low ridges in the uplands. Included in mapping were small areas where the slope is less than 2 percent. In a representative profile the surface layer is dark grayish-brown clay about 17 inches thick. The next layer, about 48 inches thick, is brown or grayish-brown clay and silty clay that has angular blocky and subangular blocky structure. This soil is underlain by soft, weathered rock…. Permeability is moderately slow, runoff is medium, and the erosion hazard is moderate."[8]

The Ioleau Series, mapped in the northwestern most corner of the Site, is described as consisting of "well-drained soils on uplands on the island of Kauai. These oils developed in material weathered from basic igneous rock, probably mixed with volcanic ash."[9]

The Kalapa Series (adjacent to the Site to the east and including two small ears at the edge of the Site) "consists of well-drained soils at the base of slopes on the island of Kauai. These soils developed in material weathered from basic igneous rock and in colluvium. They are moderately sloping to very steep."[10]

SITE CONDITIONS

Site Geomorphology

Site topography ranges from approximately 280 to 360 feet above sea level. Figure 4 depicts contours from USGS topographic mapping. The site is generally hummocky, covered with clumps of tall grasses such as California grass, with few trees.

Figure 4 additionally includes mapped hydrography, which depicts irrigation ditches. MFA found that the irrigation ditch that is mapped as existing between the borings are no longer active; and the former ditch, along with what appears to be a

[7] Ibid. pp. 82-83.
[8] Ibid. p. 100.
[9] Ibid. p. 47.
[10] Ibid. p. 55.

second, unmapped ditch, are mostly characterized by an increase in the vegetation / amount of trees. One irrigation pond was noted, which was overflowing, creating a marshy area northwest of boring B2. A deep ditch was noted in the southern half of the site beginning roughly east of B4.

Site topography, geology and soils generally conform to the published information, except that MFA did not encounter granular soils.

All 6 borings encountered residual soil overlying saprolite. In most borings, saprolite was encountered at depths of approximately 4-5 feet bgs, except B2, in which the residual soil persisted to about 7.5 feet bgs. Topsoil was encountered only in borings B1 (approx. 6 inches thick) and B2 (approx. 2 feet thick). Soils were mostly stiff or hard, but much of the saprolite encountered was brittle (broke apart easily with pressure). Basalt rock was encountered in the western three borings: hard basalt at 39 feet bgs in B1; hard basalt at 40 feet bgs in B3, and weathered basalt at 50.5 feet bgs in B4.

FIELD INVESTIGATION AND LABORATORY TESTING

MFA conducted our field investigation from May 14-16, 2012. Weather was generally dry (very light showers on one afternoon), ranging from sunny to overcast, with little breeze. Ground surface was dry except in an area downgradient of an overflowing irrigation pond, and vegetation was dry, indicating no significant recent rains. All borings were drilled by a truck-mounted drill rig using 6-inch OD (3¼-inch ID) hollow-stem augers.

Shallow bulk samples were collected from each boring, and additional bulk samples consisting of selected cuttings were collected from 3 of the borings. SPT samples were collected at depths of 1, 5, 10, 15, 20, 30, 40, and 50 feet. Selected samples (minimum 2 per boring) were collected in 6-inch sleeves (1½-inch diameter). Logs of borings are presented as Figure 5. Soils encountered within the borings were classified in accordance with the Unified Soil Classification System, Exhibit 1. A legend for the boring logs is presented as Exhibit 2.

Perched groundwater was encountered in all borings at depths between 14 and 38 feet bgs. Boring B3 was left open for 24 hours to allow the water level to stabilize. The water level in B3 was measured at a depth of 15.7' bgs on May 16, 2012, at 1756 hours.

Recovered samples were taken to MFA’s lab for testing. Laboratory testing was assigned by AECOM. Laboratory testing consisted of identification tests (Atterberg Limits), compaction (Proctor) tests, moisture tests (for bagged samples) and moisture-

density tests (for sleeved samples). Pocket penetrometer readings were taken on sleeved samples to check unconfined compressive strength.

Laboratory test results are presented on the boring logs and in Appendix A. Pocket penetrometer (Qp) readings, moisture content, and dry density are presented on the logs of borings. Appendix A contains the lab test sheets for Atterberg Limits and compaction tests.

LIMITATIONS

This report was prepared for the use of AECOM Technical Services, Inc., in accordance with generally accepted geotechnical engineering principles and practices, and may not be suitable for the use of other parties.

Our services were provided consistent with normal standard of practice. No other representation is intended or implied.

- o 0 o -

It has been our pleasure to prepare this geotechnical letter report for you. Please contact the undersigned if there are any questions regarding this letter report.

Respectfully submitted,

MASA FUJIOKA & ASSOCIATES
A Professional Partnership

Masanobu R. Fujioka, P.E.

Managing Partner

MRF/ecl

Attachments:

Figure 1. Project Location Map
Figure 2. Project Geologic Map
Figure 3. Project Soils Map
Figure 4. Project Contour Map
Figure 5. Logs of Borings

Exhibit 1. Unified Soil Classification System
Exhibit 2. Boring Legend

Appendix A. Lab Test Data

FIGURES

FIGURE 1. PROJECT LOCATION MAP

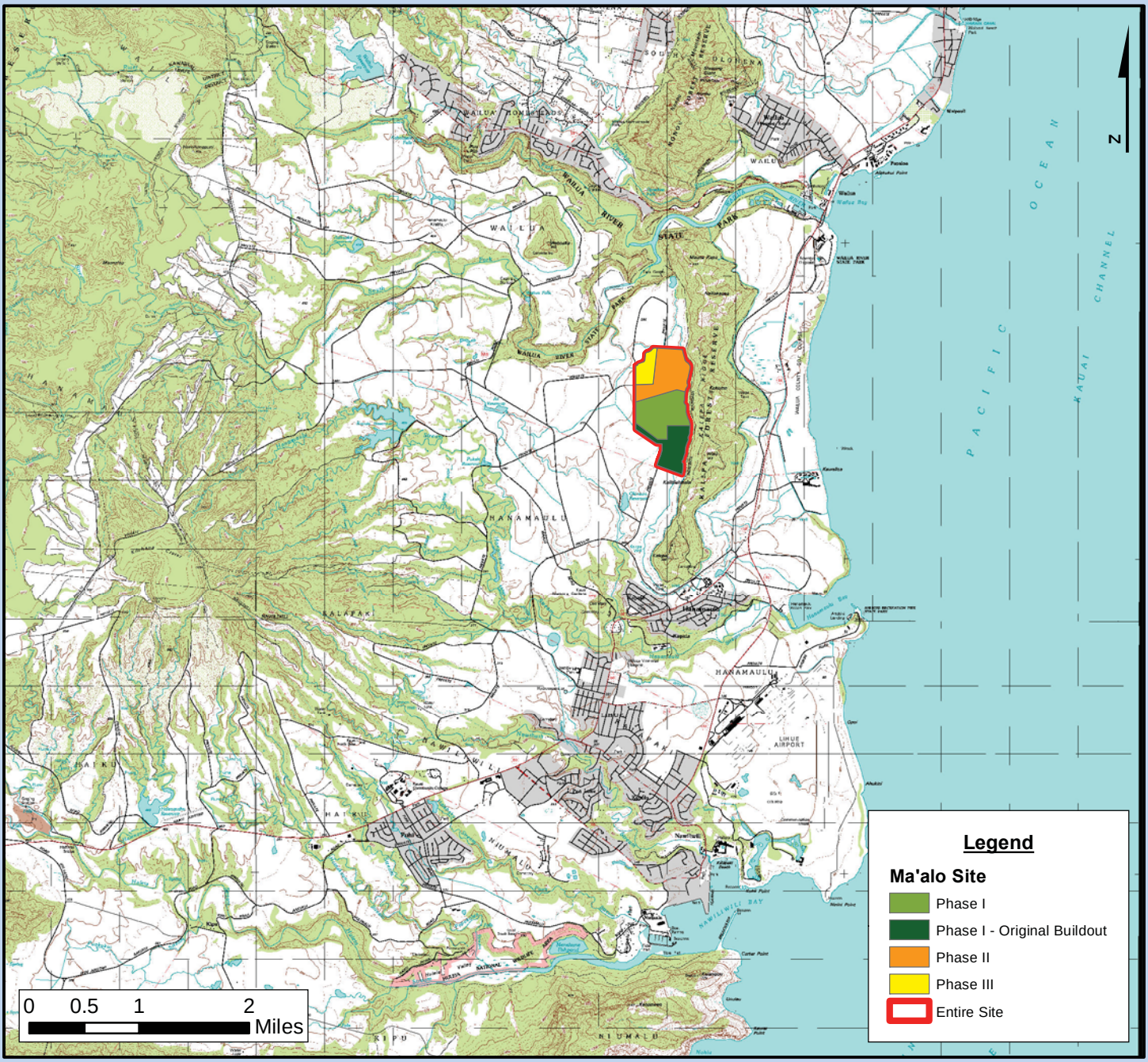
FIGURE 2. PROJECT GEOLOGIC MAP

FIGURE 3. PROJECT SOILS MAP

FIGURE 4. PROJECT CONTOUR MAP

FIGURE 5. LOGS OF BORINGS

Ma‘alo Site



Project Location

Project: 12239-012
Approved: DRD
Drawn: ECL
Date: June 2012

Notes:
1. Site boundaries and proposed boring locations from map provided by AECOM. Georeferenced by MFA.
2. Basemap from U.S. Geological Survey, Western Geographic Science Center. August 2004. Kauai Digital Raster Graphic. Derived from the 7.5-minute, 1:24,000-scale raster image of a scanned USGS topographic or planimetric map. Retrieved from Hawaii Data Clearinghouse, http://hawaii.wr.usgs.gov/

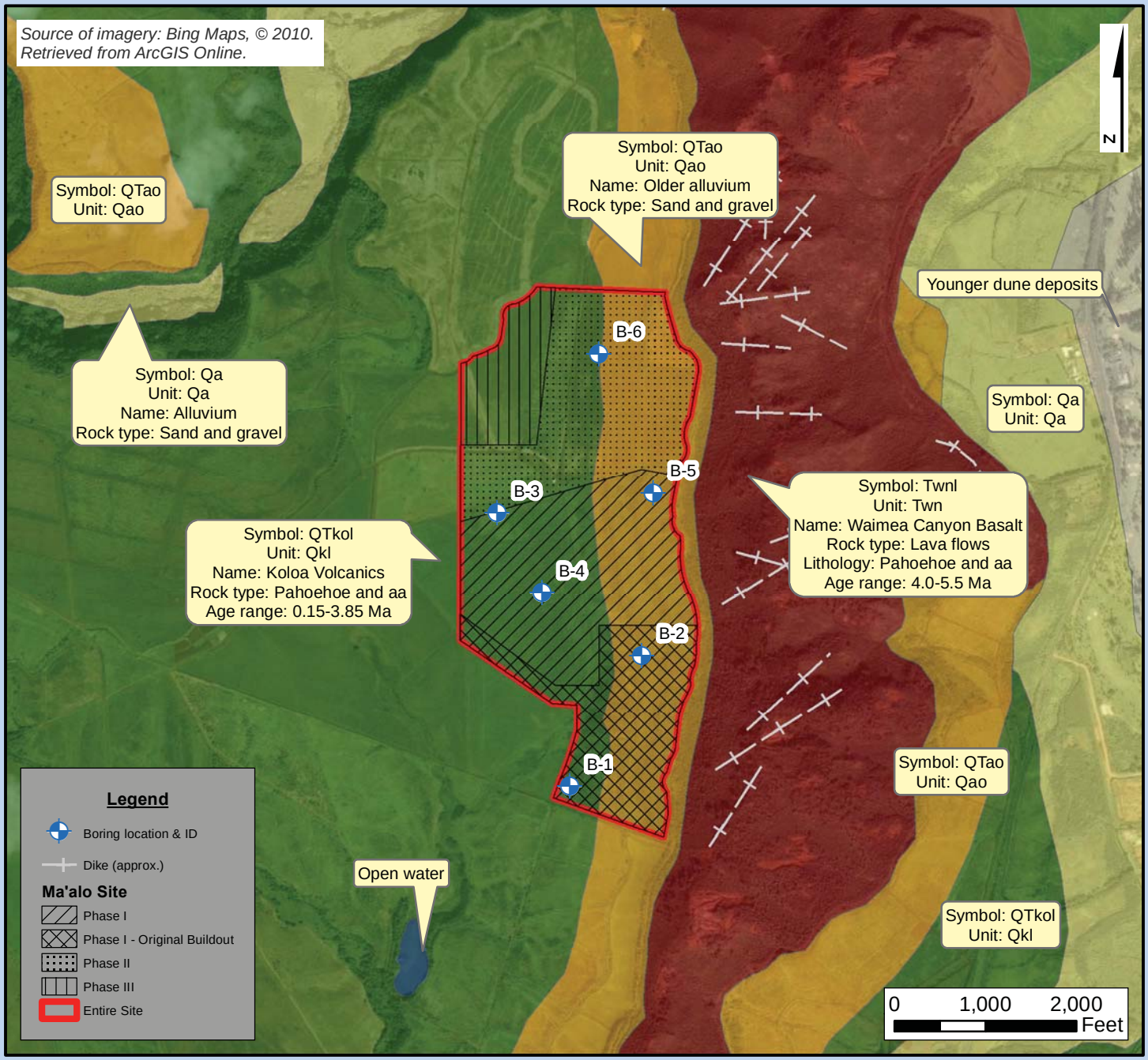
Figure 1

Project Location Map

Preliminary Geotechnical Investigation
Kaua‘i Landfill Siting EIS
Ma‘alo Site
Island of Kaua‘i Hawai'i

MASA FUJIOKA & ASSOCIATES
ENVIRONMENTAL • GEOTECHNICAL • HYDROGEOLOGICAL CONSULTANTS

Ma‘alo Site



Project Location

Project: 12239-012
Approved: DRD
Drawn: ECL
Date: June 2012

1. Boring locations identified by hand-held GPS. No survey was conducted.
2. Site boundaries from map provided by AECOM. Georeferenced by MFA.
3. Geology data source: Sherrod, David R., J.M. Sinton, S.E. Watkins, and K.M. Brunt. 2007. Geologic map of the State of Hawai`i: U.S. Geological Survey Open-File Report 2007-1089 [http://pubs.usgs.gov/of/2007/1089/]. Map unit boundaries are only as accurate as the source data; contacts should be considered approximate. Standard error is 100 m (±50 m). Dike coverage should be considered schematic only.

Figure 2

Project Geologic Map

Preliminary Geotechnical Investigation
Kaua‘i Landfill Siting EIS
Ma‘alo Site
Island of Kaua‘i Hawai'i

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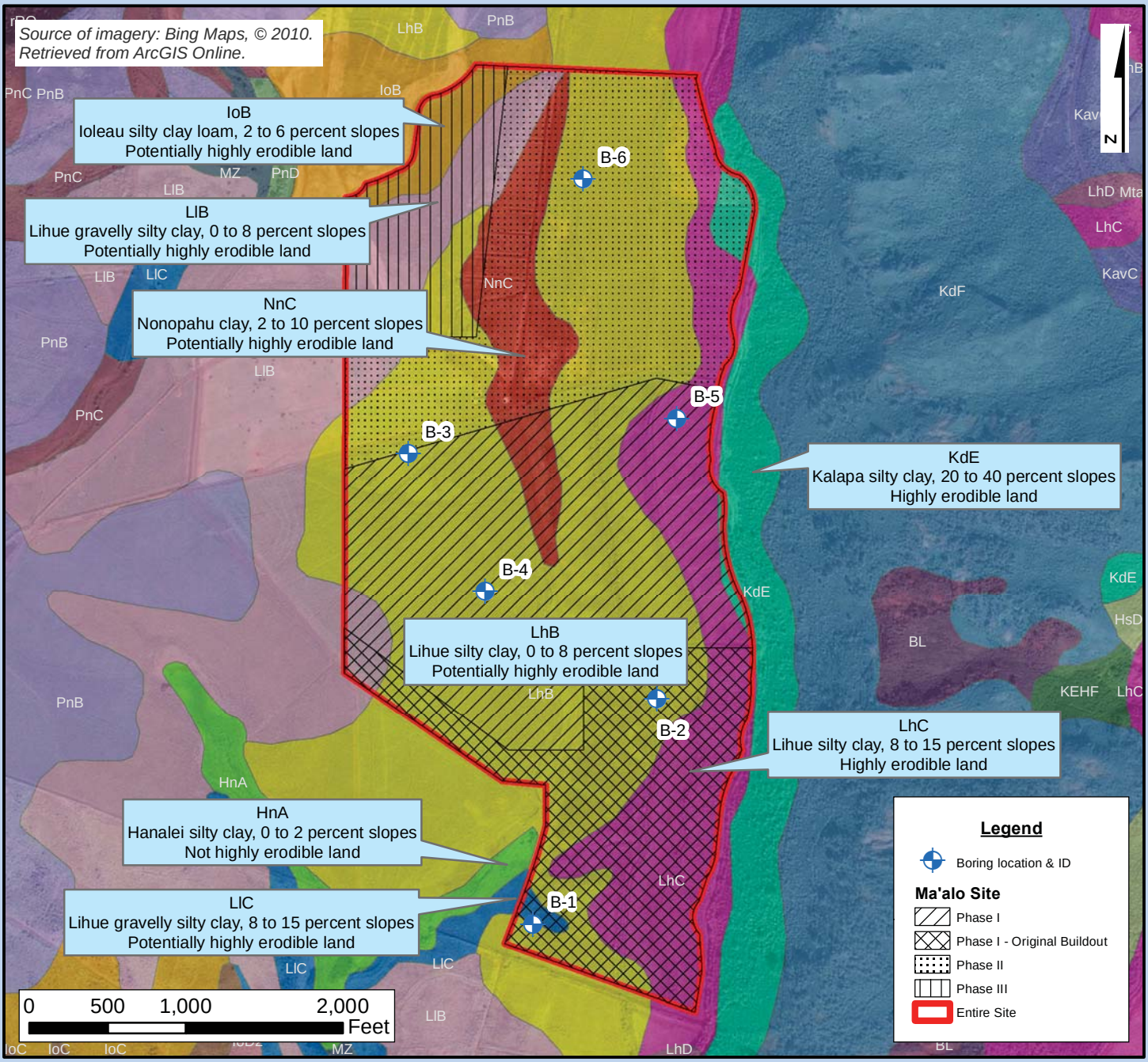
Ma‘alo Site



Project Location

Project: 12239-012
Approved: DRD
Drawn: ECL
Date: June 2012

1. Boring locations identified by hand-held GPS. No survey was conducted.
2. Site boundaries from map provided by AECOM. Georeferenced by MFA.
3. Soils data source: USDA Natural Resources Conservation Service. 1972. Soils [State GIS layer], with associated SSURGO data. Retrieved May 2009 from Hawaii Statewide GIS Program website, http://hawaii.gov/dbedt/gis/download.htm. Map unit boundaries are only as accurate as the source data; contacts should be considered approximate.

Figure 3

Project Soils Map

Preliminary Geotechnical Investigation
Kaua‘i Landfill Siting EIS
Ma‘alo Site
Island of Kaua‘i Hawai'i

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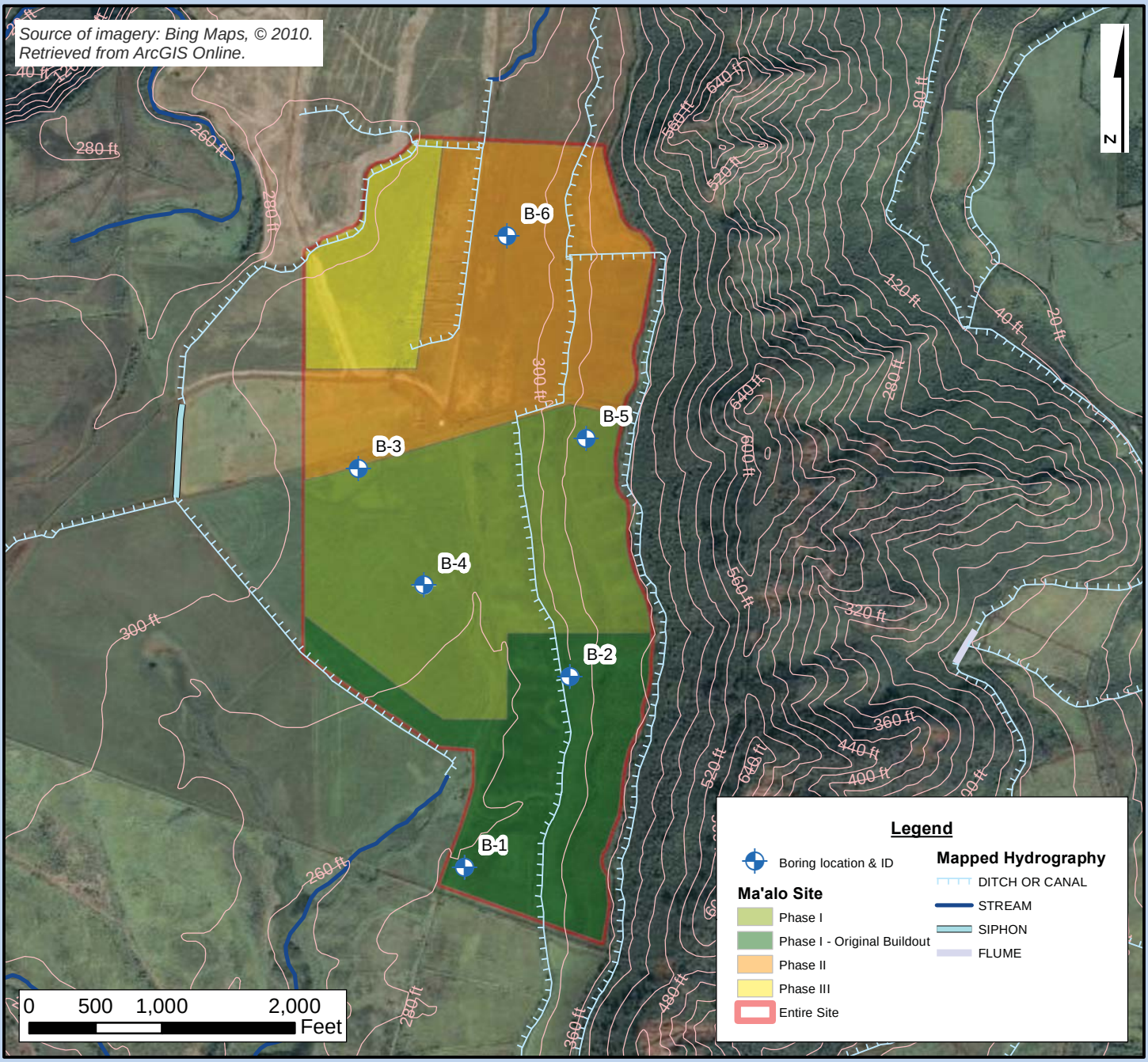
Ma‘alo Site



Project Location

Project: 12239-012
Approved: DRD
Drawn: ECL
Date: June 2012

1. Boring locations identified by hand-held GPS. No survey was conducted.
2. Site boundaries from map provided by AECOM. Georeferenced by MFA.
3. Contours from U.S. Geological Survey, Western Geographic Science Center. August 2004. Kauai Hypsography - 40 ft Contour Interval. Digitized from USGS maps. Retrieved from Hawaii Data Clearinghouse, http://hawaii.wr.usgs.gov/
4. Hydrography source: U.SGS, Western Geographic Science Center. August 2004. Kauai Digital Raster Graphic. Derived from the 7.5-minute, 1:24,000-scale raster image of a scanned USGS topographic or planimetric map. Retrieved from Hawaii Data Clearinghouse, http://hawaii.wr.usgs.gov/

Figure 4

Project Contour Map

Preliminary Geotechnical Investigation
Kaua‘i Landfill Siting EIS
Ma‘alo Site
Island of Kaua‘i Hawai'i

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Masa Fujioka & Associates 98-021 Kamehameha Highway #337 Aiea, Hawaii 96701 (808) 484-5366	**Boring: B-1** **Kauai Landfill Siting, Ma'alo Site** **County of Kauai** **Ma'alo, Kauai**	**Figure: 5.1** **Job Number: 12239-012** **Elevation: 280' approx. (not surveyed)**

Driller: Valley Well Drilling		**Drilling**	**Date: May 16, 2012**
Drill Method: Hollow-stem auger		**Started: 1340**	
Sample Method: 1.5-inch SPT		**Finished: 1640**	
Borehole Diameter: 6 inches	**Water Level : 24-25 feet bgs**	**Logged By: ECL**	**Checked By: MRF**

Sample #	Moisture Content	Dry Density	Blows / Foot	Depth (Ft)	USCS	Material Description	Test Results
				0	CH MH	Surface: hummocky grass 2-3' tall, and barren soil, dry (cattle ranch land)	
B1-1	32	71	89			Dk brn silty clay w/ few grass roots, v. stiff to hard, dry (topsoil)	Qp>4.5 TSF
B1-BULK						Med brn clayey silt (residual soil), hard, dry	
						Colors red	
B1-2	46	64	52	5		Red clayey silt w/ med grey & little yellow mottling (saprolite), hard, dry	Qp>4.5 TSF
B1-3	48		34	10	CH	Medium yellowish orange silty clay w/ light tan & dk red mottling (saprolite), hard, dry, brittle (breaks apart easily)	
B1-4	56	57	34	15	MH	Red, orange, yellow & brown mottled clayey silt (saprolite), hard, dry, brittle (breaks apart easily)	Qp=2.5 TSF
B1-5	59		53	20		Yellow & reddish orange mottled clayey silt (saprolite), hard, moist	Qp=4.5 TSF
				25		Groundwater encountered approx. 24-25' bgs @ 1455 hours	
B1-6			22	30		Dk reddish brn clayey silt w/ black & red mottling (saprolite), v. stiff, wet, brittle (breaks apart easily). (Drilling eases from hard to medium.)	
				35			

Masa Fujioka & Associates 98-021 Kamehameha Highway #337 Aiea, Hawaii 96701 (808) 484-5366	**Boring: B-1** **Kauai Landfill Siting, Ma'alo Site** **County of Kauai** **Ma'alo, Kauai**	**Figure: 5.1** **Job Number: 12239-012** **Elevation: 280' approx. (not surveyed)**

Driller: Valley Well Drilling		**Drilling**	**Date: May 16, 2012**
Drill Method: Hollow-stem auger		**Started: 1340**	
Sample Method: 1.5-inch SPT		**Finished: 1640**	
Borehole Diameter: 6 inches	**Water Level : 24-25 feet bgs**	**Logged By: ECL**	**Checked By: MRF**

Sample #	Moisture Content	Dry Density	Blows / Foot	Depth (Ft)	USCS	Material Description	Test Results
				35	MH		
					Rx	Med to dk grey basalt, hard (very hard drilling)	
B1-7	23		refusal	40			
						Boring terminated 40.5' bgs. Groundwater encountered approx. 24-25' bgs.	
				45			
				50			
				55			
				60			
				65			
				70			

Masa Fujioka & Associates 98-021 Kamehameha Highway #337 Aiea, Hawaii 96701 (808) 484-5366	**Boring: B-2** **Kauai Landfill Siting, Ma'alo Site** **County of Kauai** **Ma'alo, Kauai**	**Figure: 5.2** **Job Number: 12239-012** **Elevation: 300' approx. (not surveyed)**

Driller: Valley Well Drilling		**Drilling**	**Date: May 16, 2012**
Drill Method: Hollow-stem auger		**Started: 0935**	
Sample Method: 1.5-inch SPT		**Finished: 1300**	
Borehole Diameter: 6 inches	**Water Level : 30-35 feet bgs**	**Logged By: ECL**	**Checked By: MRF**

Sample #	Moisture Content	Dry Density	Blows / Foot	Depth (Ft)	USCS	Material Description	Test Results
				0		Surface: moderately tall (2-3') grassy hummocks, somewhat rough terrain (cattle ranch land)	
B2-1	35	64	57		CH		Qp>4.5 TSF
					MH	Dk brn silty clay, plastic, hard, dry, w/ some organics (topsoil)	
B2-BULK 1						Dk brn clayey silt (residual soil), hard, dry	LL=59%, PI=20%, compaction
B2-2	43	70	refusal	5			Qp>4.5 TSF
						Colors w/ some dk grey	
B2-3	45	65	85	10		Dk grey & red mottled clayey silt (saprolite), hard, dry	Qp>4.5 TSF
						Colors more red	
						Hard drilling	
B2-4	39		97	15		Red & med grey clayey silt w/ some yellow (saprolite), hard, dry	Qp=4.5 TSF
B2-5	41	71	97	20			Qp>4.5 TSF
				25		Colors med reddish brn; drilling becomes easier	
B2-BULK 2							LL=81%, PI=29%, compaction
B2-6	46		80	30		Red, dk grey & yellow mottled clayey silt (saprolite), hard, dry	
						Groundwater encountered between 30-35' bgs	
				35			

Masa Fujioka & Associates 98-021 Kamehameha Highway #337 Aiea, Hawaii 96701 (808) 484-5366	**Boring: B-2** **Kauai Landfill Siting, Ma'alo Site** **County of Kauai** **Ma'alo, Kauai**	**Figure: 5.2** **Job Number: 12239-012** **Elevation: 300' approx. (not surveyed)**

Driller: Valley Well Drilling		**Drilling**	**Date: May 16, 2012**
Drill Method: Hollow-stem auger		**Started: 0935**	
Sample Method: 1.5-inch SPT		**Finished: 1300**	
Borehole Diameter: 6 inches	**Water Level : 30-35 feet bgs**	**Logged By: ECL**	**Checked By: MRF**

Sample #	Moisture Content	Dry Density	Blows / Foot	Depth (Ft)	USCS	Material Description	Test Results
				35	MH	Drilling becomes hard	
B2-7	61		78	40		Dk grey & red clayey silt w/ some yellow (saprolite), hard, dry	
				45			
B2-8	62		refusal	50		Mostly dk red clayey silt w/ some dk grey & little yellow (saprolite), hard, moist, brittle (breaks apart easily) Boring terminated 51.5' bgs. Groundwater encountered approx. 30-35' bgs.	
				55			
				60			
				65			
				70			

Masa Fujioka & Associates 98-021 Kamehameha Highway #337 Aiea, Hawaii 96701 (808) 484-5366	**Boring: B-3** **Kauai Landfill Siting, Ma'alo Site** **County of Kauai** **Ma'alo, Kauai**	**Figure: 5.3** **Job Number: 12239-012** **Elevation: Btwn 280-300' est.**

Driller: Valley Well Drilling		**Drilling**	**Date: May 15, 2012**
Drill Method: Hollow-stem auger		**Started: 1100**	
Sample Method: 1.5-inch SPT		**Finished: 1530**	
Borehole Diameter: 6 inches	**Water Level : 15.7 feet bgs**	**Logged By: ECL**	**Checked By: MRF**

Sample #	Moisture Content	Dry Density	Blows / Foot	Depth (Ft)	USCS	Material Description	Test Results
				0	CH	Surface: hummocky grass, dry (cattle ranch land)	
B3-1	38		29			Lt yellowish brn silty clay w/ little red mottling (residual soil), v. stiff, dry	
B3-BULK						(Bulk sample collected from 0-5' depth)	
B3-2	51	63	67	5	ML	Red & lt grey clayey silt or silt w/ little yellow, w/ little plasticity (saprolite), hard, dry	Qp>4.5 TSF
B3-3	64	55	28	10		Lt grey, red, yellow & lt brn silt (saprolite), v. stiff, dry	Qp=3.0 TSF
B3-4	72	49	15	15		Reddish silt w/ some yellow & lt grey (saprolite), stiff, moist	Qp=1.5 TSF
						Groundwater measured @15.7' bgs @1756 on 5/16/12	
						Groundwater encountered approx. 19' bgs during drilling, @1150 on 5/15/12	
B3-5	68		29	20		Lt orangish brn silt, v. stiff, wet	
				25			
B3-6			refusal	30	CL	Med brn silty clay w/ dk grey basalt gravel, hard, wet	
				35			

Masa Fujioka & Associates 98-021 Kamehameha Highway #337 Aiea, Hawaii 96701 (808) 484-5366	**Boring: B-3** **Kauai Landfill Siting, Ma'alo Site** **County of Kauai** **Ma'alo, Kauai**	**Figure: 5.3** **Job Number: 12239-012** **Elevation: Btwn 280-300' est.**

Driller: Valley Well Drilling		**Drilling**	**Date: May 15, 2012**
Drill Method: Hollow-stem auger		**Started: 1100**	
Sample Method: 1.5-inch SPT		**Finished: 1530**	
Borehole Diameter: 6 inches	**Water Level : 15.7 feet bgs**	**Logged By: ECL**	**Checked By: MRF**

Sample #	Moisture Content	Dry Density	Blows / Foot	Depth (Ft)	USCS	Material Description	Test Results
				35	CL	Hard drilling	
B3-7	60		94	40	GM	Dk grey basalt gravel, hard, wet.	
						Boring terminated 41.5' bgs. Groundwater measured @15.7' bgs.	
				45			
				50			
				55			
				60			
				65			
				70			

Masa Fujioka & Associates 98-021 Kamehameha Highway #337 Aiea, Hawaii 96701 (808) 484-5366	**Boring: B-4** **Kauai Landfill Siting, Ma'alo Site** **County of Kauai** **Ma'alo, Kauai**	**Figure: 5.4** **Job Number: 12239-012** **Elevation: Btwn 280-300' est.**

Driller: Valley Well Drilling		**Drilling**	**Date: May 15-16, 2012**
Drill Method: Hollow-stem auger		**Started: 1615 on 5/15/12**	
Sample Method: 1.5-inch SPT		**Finished: 0857 on 5/16/12**	
Borehole Diameter: 6 inches	**Water Level : 19 feet bgs**	**Logged By: ECL**	**Checked By: MRF**

Sample #	Moisture Content	Dry Density	Blows / Foot	Depth (Ft)	USCS	Material Description	Test Results
				0	CH	Surface: short hummocky grass, dry (cattle ranch land)	
B4-1			78			Med brownish red silty clay / some lt brn & yellow mottling (residual soil), hard, dry	
B4-BULK						(Bulk sample collected from 0-5' depth)	
				5	MH	Red, lt grey & yellow mottled clayey silt (saprolite), hard, dry	
B4-2	42		62				
B4-3	49	63	37			Very lt grey & red mottled clayey silt (saprolite) w/ some yellow, hard, dry	Qp=4.0 TSF
				10		Colors more reddish	
B4-4	52		23			Becomes v. stiff	
B4-5			32			Beomes hard	
				15	ML	Med brn silt w/ yellow streaks (saprolite), m. stiff, moist	
B4-6	71	52	6				Qp=1.75 TSF
				20		Groundwater encountered @0700 hours on 5/16/12	
B4-7			31			Red silt w/ dk grey basalt gravel, w/ black and yellow possibly organic material (saprolite), hard, moist	
				25			
				30	MH	Dk grey sandy clayey silt (saprolite) w/ red & yellow, hard, moist	
B4-8	78		58				
				35			

Masa Fujioka & Associates 98-021 Kamehameha Highway #337 Aiea, Hawaii 96701 (808) 484-5366	**Boring: B-4** **Kauai Landfill Siting, Ma'alo Site** **County of Kauai** **Ma'alo, Kauai**	**Figure: 5.4** **Job Number: 12239-012** **Elevation: Btwn 280-300' est.**

Driller: Valley Well Drilling		**Drilling**	**Date: May 15-16, 2012**
Drill Method: Hollow-stem auger		**Started: 1615 on 5/15/12**	
Sample Method: 1.5-inch SPT		**Finished: 0857 on 5/16/12**	
Borehole Diameter: 6 inches	**Water Level : 19 feet bgs**	**Logged By: ECL**	**Checked By: MRF**

Sample #	Moisture Content	Dry Density	Blows / Foot	Depth (Ft)	USCS	Material Description	Test Results
				35	MH	Dk grey sandy clayey silt (saprolite) w/ red & yellow, hard, moist	
B4-9			refusal	40	ML Rx	Med reddish brn sandy silt (saprolite), hard, moist, brittle (breaks apart easily) Dk grey basalt, weathered, hard Very hard drilling	
				45			
B4-10	33		refusal	50		Boring terminated 50.5' bgs. Groundwater encountered approx. 19' bgs.	
				55			
				60			
				65			
				70			

Masa Fujioka & Associates 98-021 Kamehameha Highway #337 Aiea, Hawaii 96701 (808) 484-5366	**Boring: B-5** **Kauai Landfill Siting, Ma'alo Site** **County of Kauai** **Ma'alo, Kauai**	**Figure: 5.5** **Job Number: 12239-012** **Elevation: 330' approx. (not surveyed)**

Driller: Valley Well Drilling		**Drilling**	**Date: May 14-15, 2012**
Drill Method: Hollow-stem auger		**Started: 1426 on 5/14/12**	
Sample Method: 1.5-inch SPT		**Finished: 1000 on 5/15/12**	
Borehole Diameter: 6 inches	**Water Level : 38 feet bgs**	**Logged By: ECL**	**Checked By: MRF**

Sample #	Moisture Content	Dry Density	Blows / Foot	Depth (Ft)	USCS	Material Description	Test Results
				0	CH	Surface: sparse hummocky grass, dry (cattle ranch land)	
						Med to dk brn silty clay, plastic, v. stiff to hard, dry	
B5-BULK							
B5-1			75			Colors dk brn	
						Dk brn silty clay (residual soil), hard, dry	
				5			
B5-2	42		refusal			Med brn clay w/ lt grey & red mottles (saprolite), hard, dry	
				10	MH		
B5-3	49	64	83			Lt grey & red mottled clayey silt w/ some med brn (saprolite), hard, dry	Qp>4.5 TSF
						Colors reddish brn	
				15			
B5-4	41		refusal			Reddish brn clayey silt (saprolite) w/ grey & yellow mottles, hard, dry	
						Drilling eases to medium	
				20			
B5-5	48	65	38			Lt grey & reddish brn clayey silt w/ yellow mottling (saprolite), hard, dry	Qp>4.5 TSF
				25			
				30			
B5-6	65	56	45			Red & lt grey mottled clayey silt (saprolite) w/ little white & yellow, hard, dry	Qp=2.5 TSF
				35			

Masa Fujioka & Associates 98-021 Kamehameha Highway #337 Aiea, Hawaii 96701 (808) 484-5366	**Boring: B-5** **Kauai Landfill Siting, Ma'alo Site** **County of Kauai** **Ma'alo, Kauai**	**Figure: 5.5** **Job Number: 12239-012** **Elevation: 330' approx. (not surveyed)**

Driller: Valley Well Drilling		**Drilling**	**Date: May 14-15, 2012**
Drill Method: Hollow-stem auger		**Started: 1426 on 5/14/12**	
Sample Method: 1.5-inch SPT		**Finished: 1000 on 5/15/12**	
Borehole Diameter: 6 inches	**Water Level : 38 feet bgs**	**Logged By: ECL**	**Checked By: MRF**

Sample #	Moisture Content	Dry Density	Blows / Foot	Depth (Ft)	USCS	Material Description	Test Results
				35	MH		
						Groundwater encountered approx. 38' bgs	
B5-7	64		29	40		Lt greyish red clayey silt w/ lt grey & red brittle gravel that breaks up easily by hand (saprolite), v. stiff, wet	
				45			
B5-8	66		54	50		Red, lt & dk grey & brn mottled clayey silt w/ little white & yellow, w/ dk grey basalt gravel (saprolite), hard, wet	
						Boring terminated 51.5' bgs. Groundwater encountered approx. 38' bgs.	
				55			
				60			
				65			
				70			

Masa Fujioka & Associates 98-021 Kamehameha Highway #337 Aiea, Hawaii 96701 (808) 484-5366	**Boring: B-6** **Kauai Landfill Siting, Ma'alo Site** **County of Kauai** **Ma'alo, Kauai**	**Figure: 5.6** **Job Number: 12239-012** **Elevation: 300' approx. (not surveyed)**

Driller: Valley Well Drilling		**Drilling**	**Date: May 14, 2012**
Drill Method: Hollow-stem auger		**Started: 1010**	
Sample Method: 1.5-inch SPT		**Finished: 1225**	
Borehole Diameter: 6 inches	**Water Level : 14 feet bgs**	**Logged By: ECL**	**Checked By: MRF**

Sample #	Moisture Content	Dry Density	Blows / Foot	Depth (Ft)	USCS	Material Description	Test Results
				0		Surface: grassy hummocks (cattle ranch land)	
					CH	Med brn clay, hard, dry	
B6-1			46			Colors dk brn (residual soil)	
B6-BULK 1						(Bulk sample collected from 0-5' depth)	
				5	MH		
B6-2	45	64	82			Dk brn clayey silt w/ yellow & red mottling (saprolite), hard, dry	Qp>4.5 TSF
				10			
B6-3	56	58	21			Med brn clayey silt w/ yellow & red mottling (saprolite), v. stiff, moist	Qp=4.25 TSF
						Colors lt brn	
B6-BULK 2							LL=64%, PI=21%, compaction
						Groundwater encountered approx. 14' bgs	
				15			
B6-4	51		33			Med brn clayey silt w/ yellow, red & white mottling, w/ little gravel (saprolite), hard, wet	
B6-5			18	20		Lt yellowish brn clayey silt w/ gravel (saprolite), v. stiff, wet	
				25			
				30			
B6-6	47		84			Reddish clayey silt w/ brn, lt grey & yellow mottling, w/ gravel (saprolite), hard, wet	
						Boring terminated 31.5' bgs. Groundwater encountered approx. 14' bgs.	
				35			

EXHIBITS

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			SYMBOLS GRAPHIC	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
Coarse grained soils More than 50% of material is larger than No. 200 sieve size	Gravel and gravelly soils More than 50% of coarse fraction retained on No. 4 sieve	Clean gravels (little or no fines)		GW	Well-graded gravels, Gravel, Sand mixtures, Little or no fines
				GP	Poorly-graded gravels, Gravel-sand mixtures, Little or no fines
		Gravel with fines (appreciable amount of fines)		GM	Silty gravels, Gravel-sand-silt mixtures
				GC	Clayey gravels, Gravel-sand-clay mixtures
	Sand and sandy soils More than 50% of coarse fraction passing on No. 4 sieve	Clean sands (little or no fines)		SW	Well-graded sands, Gravelly sands, Little or no fines
				SP	Poorly-graded sands, Gravelly sands, Little or no fines
		Sands with fines (appreciable amount of fines)		SM	Silty sands, Sand-silt mixtures
				SC	Clayey sands, Sand-clay mixtures
Fine grained soils More than 50% of material is smaller than No. 200 sieve size	Silts and clays	Liquid limit less than 50		ML	Inorganic silts and very fine sands, Rock flour, Silty or clayey fine sands or clayey silts with slight plasticity
				CL	Inorganic clays of low to medium plasticity, Gravelly clays, Sandy clays, Silty clays, Lean clays
				OL	Organic silts and organic silty clays of low plasticity
	Silts and clays	Liquid limit greater than 50		MH	Inorganic silts, Micaceous or diatomaceous fine sand or silty soils
				CH	Inorganic clays of high plasticity, Fat clays
				OH	Organic clays of medium to high plasticity, Organic silts
Highly organic soils				PT	Peat, Humus, Swamp soils with high organic contents

Note: Dual symbols are used to indicate borderline soil classifications

EXHIBIT 1

Boring Legend

Sample Type

Split Spoon Sample

Split Spoon No Sample Recovered

Disturbed Sample

Standard Penetration Test Sample

Standard Penetration Test No Sample Recovered

Core

Field Tests

Qp = Pocket Penetrometer
TV = Torvane

Lab Tests

LL = Liquid Limit (ASTM D-4318)
PI = Plasticity Index (ASTM D-4318)
CBR = California Bearing Ratio (ASTM D-1883)
MC = Moisture Content (ASTM D-2216)
DD = Density (ASTM D-2937)
Gradation (Particle Size Analysis) (ASTM D-422)
Consolidation (ASTM D-2435)
Direct Shear (ASTM D-3080)

APPENDIX A

LAB TEST DATA

ATTERBERG LIMITS

PROJECT:	AE Com	Figure:	A.1
JOB NO:	12239-012	Air Dried:	Before
SAMPLE NO:	B2- Bulk1	Preperation:	Dry
LOCATION:	Ma'alo	Date Received:	5/20/12
DEPTH:	1'	Date Tested:	6/6/12
DISCRIPTION OF SOIL:	MH	Date Reported:	6/7/12
CLIENT:	AE Com		

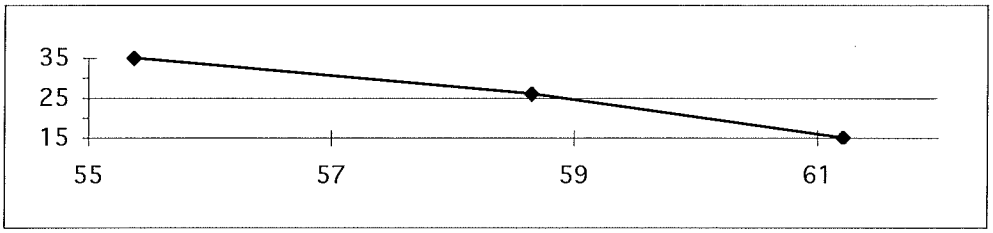
PLASTIC LIMIT DETERMINATION

SAMPLE OR TRIAL NO.	1	2
MOISTURE TIN NO.	a	b
WT WET SOIL +TARE (g)	20.34	20.14
WT. DRY SOIL + TARE (g)	19.01	18.92
WT. MOISTURE TIN	15.66	15.77
WT. WATER (g)	1.33	1.22
WT. DRY SOIL (g)	3.35	3.15
MOISTURE CONTENT (%)	39.70	38.73

Plastic Limit = 39 %

LIQUID LIMIT

SAMPLE OR TRIAL NO.	1	2	3
MOISTURE TIN NO.	a	b	c
WT WET SOIL +TARE (g)	14.97	14.28	13.08
WT. DRY SOIL + TARE (g)	10.28	9.67	8.82
Wt. Tare (g)	1.81	1.81	1.86
wT. WATER (g)	4.69	4.61	4.26
WT. DRY SOIL (g)	8.47	7.86	6.96
MOISTURE CONTENT (%)	55.37	58.65	61.21
No. of Blows	35	26	15
	35-25	30-20	25-15



Liquid Limit = 59 % at N = 25 blows
Plasticity Index = 20 %

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98-021 Kamehameha Hwy. #337
Aiea, HI 96701

ATTERBERG LIMITS

PROJECT:	AE Com	Figure:	A.2
JOB NO:	12239-012	Air Dried:	Before
SAMPLE NO:	B2- Bulk2	Preperation:	Dry
LOCATION:	Ma'alo	Date Received:	5/20/12
DEPTH:	26'	Date Tested:	6/6/12
DISCRIPTION OF SOIL:	MH	Date Reported:	6/7/12
CLIENT:	AE Com		

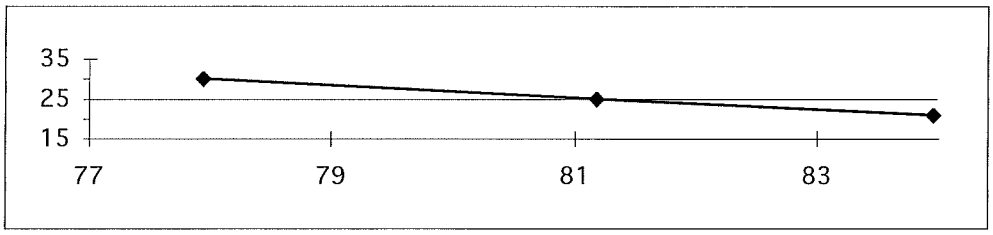
PLASTIC LIMIT DETERMINATION

SAMPLE OR TRIAL NO.	1	2
MOISTURE TIN NO.	a	b
WT WET SOIL +TARE (g)	20.25	20.56
WT. DRY SOIL + TARE (g)	18.70	18.95
WT. MOISTURE TIN	15.75	15.80
WT. WATER (g)	1.55	1.61
WT. DRY SOIL (g)	2.95	3.15
MOISTURE CONTENT (%)	52.54	51.11

Plastic Limit = 52 %

LIQUID LIMIT

SAMPLE OR TRIAL NO.	1	2	3
MOISTURE TIN NO.	a	b	c
WT WET SOIL +TARE (g)	15.02	12.90	11.70
WT. DRY SOIL + TARE (g)	9.26	7.94	7.20
Wt. Tare (g)	1.87	1.83	1.84
wT. WATER (g)	5.76	4.96	4.50
WT. DRY SOIL (g)	7.39	6.11	5.36
MOISTURE CONTENT (%)	77.94	81.18	83.96
No. of Blows	30	25	21
	35-25	30-20	25-15



Liquid Limit = 81 % at N = 25 blows
Plasticity Index = 29 %

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ATTERBERG LIMITS

PROJECT:	AE Com	Figure:	A.3
JOB NO:	12239-012	Air Dried:	Before
SAMPLE NO:	B6- Bulk2	Preperation:	Dry
LOCATION:	Ma'alo	Date Received:	5/20/12
DEPTH:	13'	Date Tested:	6/6/12
DISCRIPTION OF SOIL:	MH	Date Reported:	6/7/12
CLIENT:	AE Com		

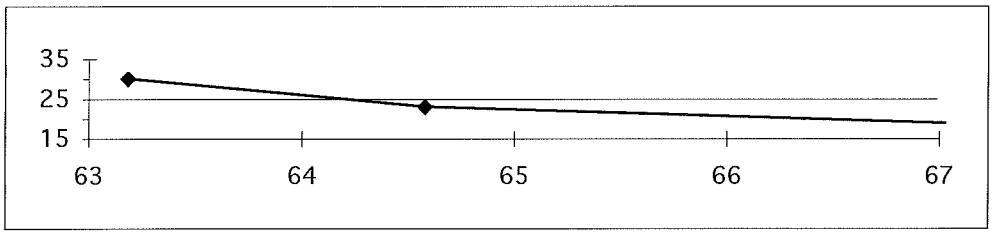
PLASTIC LIMIT DETERMINATION

SAMPLE OR TRIAL NO.	1	2
MOISTURE TIN NO.	a	b
WT WET SOIL +TARE (g)	20.08	19.87
WT. DRY SOIL + TARE (g)	18.73	18.54
WT. MOISTURE TIN	15.58	15.47
WT. WATER (g)	1.35	1.33
WT. DRY SOIL (g)	3.15	3.07
MOISTURE CONTENT (%)	42.86	43.32

Plastic Limit = 43 %

LIQUID LIMIT

SAMPLE OR TRIAL NO.	1	2	3
MOISTURE TIN NO.	a	b	c
WT WET SOIL +TARE (g)	15.87	13.92	12.05
WT. DRY SOIL + TARE (g)	10.43	9.18	7.93
Wt. Tare (g)	1.82	1.84	1.83
wT. WATER (g)	5.44	4.74	4.12
WT. DRY SOIL (g)	8.61	7.34	6.10
MOISTURE CONTENT (%)	63.18	64.58	67.54
No. of Blows	30	23	18
	35-25	30-20	25-15



Liquid Limit = 64 % at N = 25 blows
Plasticity Index = 21 %

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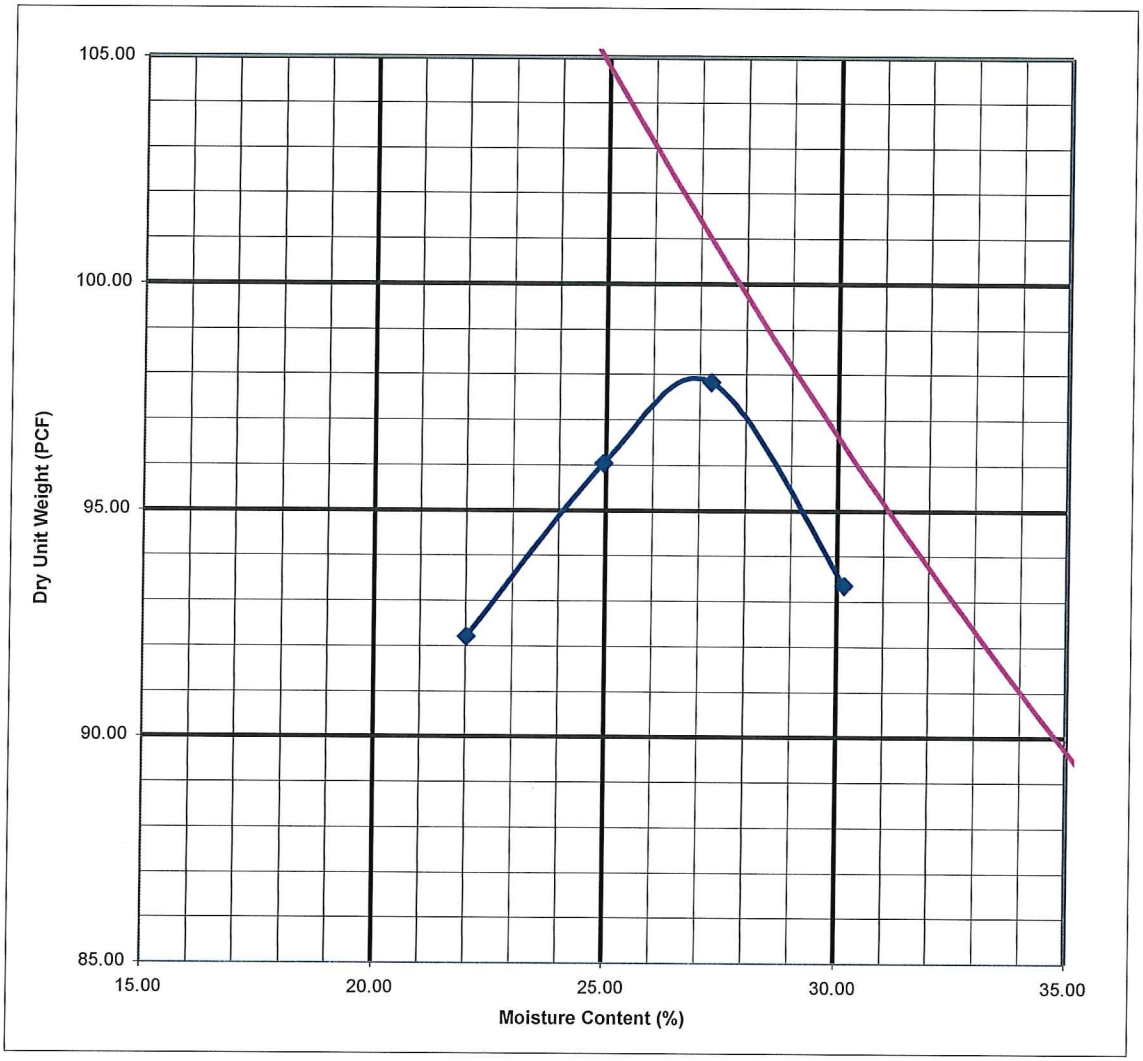
Project: AE Com
Location: Ma'alo
Soil: Brn silty clay
Sample: B2- Bulk 1
Depth: 2.5'
Job No.: 12239-012
Client: AE Com

Figure: A.4
Method Used: A
Preparation Method: Dry
Rammer: Mechanical
Date Received: 5/20/12
Date Tested: 6/5/12
Date Reported: 6/6/12



Specific Gravity:

Method of Compaction: Modified (ASTM D1557)

Test Results:

Optimum Moisture Content = 27 %

Maximum Dry Density = 98 PCF

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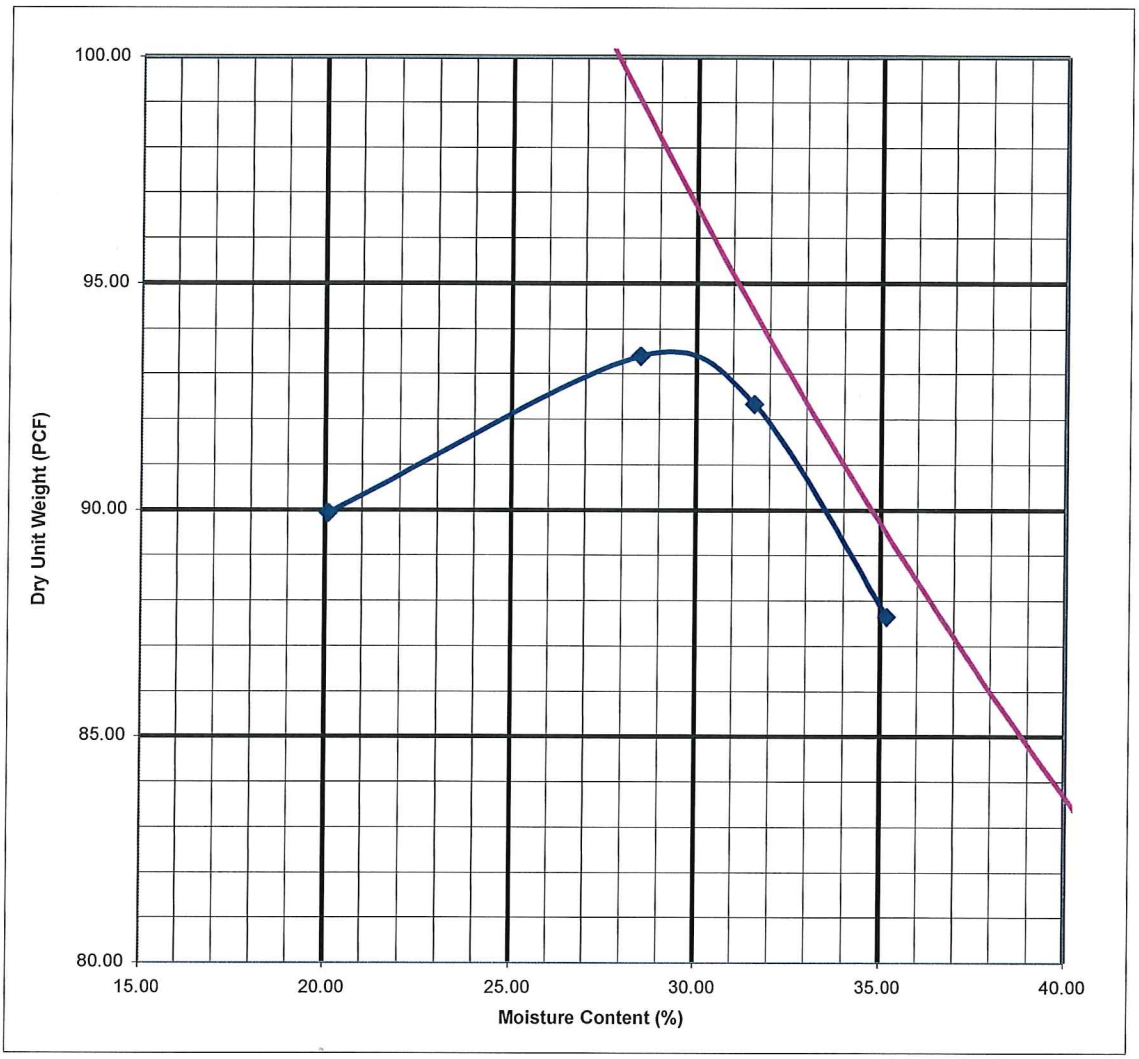
Project:	AE Com	Figure:	A.5
Location:	Ma'alo	Method Used:	A
Soil:	Brn/orange silty clay	Preparation Method:	Dry
Sample:	B2- Bulk 2	Rammer:	Mechanical
Depth:	26'	Date Received:	5/20/12
Job No.:	12239-012	Date Tested:	6/5/12
Client:	AE Com	Date Reported:	6/6/12



Specific Gravity:

Method of Compaction: Modified (ASTM D1557)

Test Results:

Optimum Moisture Content = 29 %

Maximum Dry Density = 93.5 PCF

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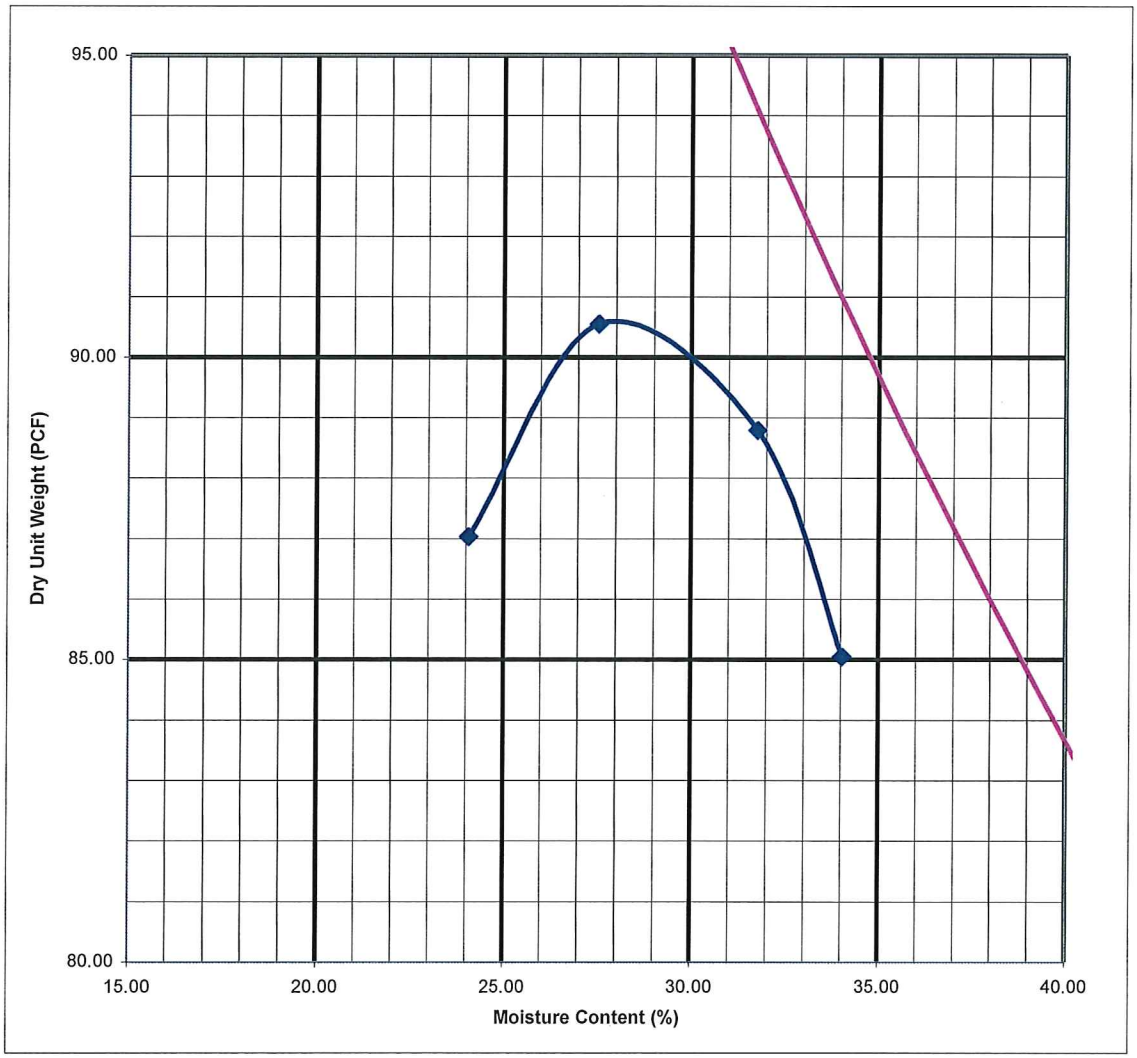
Project:	AE Com	Figure:	A.6
Location:	Ma'alo	Method Used:	A
Soil:	Brn/orange silty clay	Preparation Method:	Dry
Sample:	B6- Bulk 2	Rammer:	Mechanical
Depth:	13'	Date Received:	5/20/12
Job No.:	12239-012	Date Tested:	6/5/12
Client:	AE Com	Date Reported:	6/6/12



Specific Gravity:

Method of Compaction: Modified (ASTM D1557)

Test Results:

Optimum Moisture Content = 28 %

Maximum Dry Density = 90.5 PCF

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98-021 Kamehameha Hwy. #337
Aiea, HI 96701

Appendix B.2
Buildout Stability Analysis

FINAL BUILDOUT STABILITY

Objective

Determine the stability at final buildout of Phase 1 for the proposed Ma'alo Landfill.

Design Criteria and Assumptions

1. The stability analysis was conducted using computer slope stability software named "Slope/W" and is part of the GeoStudio 2012 software suite. This program allows the use of several different methods for determining slope stability of circular and non-circular failure surfaces. The computer program performs an automatic search to identify potential slip surface that has the least factor of safety. The method utilized for completion of this analysis was the Morgenstern-Price Method which solves for both force and moment equilibrium.
2. Two representative cross sections were modeled for the analysis, Sections A-A and B-B. These cross section locations are presented as Figure 1 in Attachment 1.
3. The proposed final cover slope will be a maximum 3.5:1 (H:V) with a minimum 5% slope on the cover crown.
4. Leachate recirculation will not be performed.
5. Modes of Failure: The following modes of failure are considered (see Attachment 2):

    a. Circular Failure: A circular failure surface that lies entirely within the waste mass or passes through the waste mass, perimeter berm, and foundation soils.
    b. Base Liner Non-circular Failure: A non-circular failure surface originating along the base liner then up through the waste mass.

6. Factor of safety of 1.5 will be employed for determining acceptance of proposed final landfill geometry during static conditions.
7. Seismic analysis will be completed as the site specific horizontal peak ground acceleration is 0.10g which and is equal to minimum required by Subtitle D for analysis. Based upon the USGS Seismic Deaggregation website, the peak horizontal ground acceleration can be determined by entering the site latitude and longitude. Site latitude and longitude used for seismic evaluation of 159.3591W, 22.0213N. Output from the website provided as Attachment 3. A Factor of Safety of 1.2 will used as this event is short term).
8. All references to elevations correlate to the site specific vertical datum.

Material Properties

Waste Mass

Waste mass properties are dependant the amount of compaction, lift thickness, composition and waste stream, moisture, and the amount of daily cover soil or alternate daily cover used. Conversations with Kekaha Sanitary Landfill staff indicate a typical waste unit weight of approximately 62 pcf. For purpose of this analysis, the waste mass density is assumed to be similar.

Reference 1 completed a literature review and determined resulting in internal friction angles of 25 to 51 degrees with cohesion varying from 0 to 42 kPa (0 to 877 psf) can be expected for MSW landfills. The reference concluded municipal solid waste strength properties can be

considered as reasonable at friction angle of 35 degrees and cohesion 20kPa (418 psf). To provide consistency with the previous permitted documents the waste friction angle value of 33 degrees was maintained.

Waste Mass: $\gamma_{buildout}$ = 62 pcf
$\phi_{buildout}$ = 33 degrees
$c_{buildout}$ = varies <= 418 psf

By observation the critical failure surface will be a block type failure and reside along the critical base liner interfaces. Cohesion of the waste mass was assumed to be only 200 psf for conservative analysis.

Base Liner - Critical Interface Friction Angle (Geosynthetics)
The proposed base liner system is expected to consist of (top to bottom):

- 2-foot granular operations layer
- Separation geotextile, nonwoven
- 1-foot granular drainage layer
- Nonwoven cushion geotextile
- Primary 60-mil HDPE textured (both sides) geomembrane
- Primary Geosynthetic clay liner (GCL)
- Secondary 60-mil HDPE textured (both sides) geomembrane
- Secondary Geosynthetic clay liner (GCL)
- Prepared granular foundation

Interfaces exist when dissimilar materials come in contact. The frictional properties of these interfaces depend on test conditions, which include normal loading, rate of shearing, degree of submergence, size of apparatus, manufacturer, etc. The following table shows typical interface friction values that are achievable with the proposed base liner system components. Typical interface friction angles for other materials can also be found in Reference 2:

Critical Base Liner Interfaces and Friction Angles

Interface	Typical Interface Friction Test Results	
	Friction Angle (degrees)	Adhesion (kPa)
Nonwoven geotextile (separator, cushion, or of GCL) / to granular layers	33	0
Nonwoven geotextile (cushion) / textured HDPE geomembrane	25	8
Nonwoven geotextile (GCL) / textured HDPE geomembrane	23	8
Needle-punched GCL (internal friction angle)	39.7	19.9

Upon review of the above table, the critical interface of the base liner for the landfill is 23 degrees. For conservative analysis, this interface is assumed to be 15 degrees. The critical

interface was modeled as a 4-foot thick layer under the waste mass.

The following material properties are applied:

Base Liner: γ = 130 pcf
ϕ = 15 degrees
c = 0 psf

Final Cover

The final cover system may also consist of intermediate cover soil, a grading layer, a geomembrane, a geocomposite, rooting soils, and topsoil. A separate calculation discusses the stability of the final cover system in greater detail.

The following material properties are applied:

Final Cover: γ = 130 pcf
ϕ = 30 degrees
c = 100 psf

Compacted Fill

Areas of the facility that will require berming or fill soils to meet subbase grades are expected to be constructed of on-site silty clay or silt soils. The following material properties are applied:

Compacted Fill: γ = 130 pcf
ϕ = 28 degrees
c = 0 psf

Insitu Soils – Foundation Soils

Review of Borings 1 through 6 determined the foundation soils consist primarily of residual silts and clays. The majority of the soil, including the silt, exhibited some degree of plasticity. In general, the consistency of the clay was stiff to hard based on penetrometer tests. The silt was medium dense to extremely dense based on SPT data.

The following material properties are applied:

Insitu Soils: γ = 115 pcf
ϕ' = 28 degrees
c' = 0 psf

Bedrock

Basalt bedrock was encountered in several borings approximately 40 feet below ground surface. Some borings did not encounter bedrock before termination at 50 feet below ground surface. For the analysis, bedrock was assumed to be impenetrable and lie approximately 50 feet below ground surface at elevation 240.

The following material properties are applied:

Bedrock: γ = 140 pcf
High Strength

Groundwater Elevation

Groundwater was encountered in the borings between 14 and 38 feet below ground surface. For this analysis, the groundwater elevation was assumed to be at elevation 270.

Conclusions

The results of the computer modeling are:

Section	Failure Mode	Factor of Safety	Figure
AA East	Base Liner	3.85	1
	Circular	2.82	2
	Base Liner - Seismic	2.36	3
	Circular - Seismic	2.04	4
AA West	Base Liner	1.92	5
	Circular	2.08	6
	Base Liner - Seismic	1.29	7
	Circular - Seismic	1.36	8
BB East	Base Liner	3.84	9
	Circular	2.91	10
	Base Liner - Seismic	1.26	11
	Circular - Seismic	2.07	12
BB West	Base Liner	1.94	13
	Circular	2.23	14
	Base Liner - Seismic	1.30	15
	Seismic 0.10g	1.37	16

The proposed geometry of the facility is expected to remain stable for static conditions, and under a seismic load of 0.10 g, based upon the presented interface friction angles, soil properties, and waste mass properties.

Additional geotechnical exploration and laboratory testing will be completed to confirm the assumed soil properties prior to construction of the landfill. Interface friction angle testing will also be completed prior to construction and after changes in manufacturer or significant material property changes, if possible. This analysis should be repeated if geotechnical exploration or interface friction angle testing is completed and prior to construction show a significant change in the assumed properties, to ensure that the factor of safety is adequate.

A small amount of apparent cohesion has been assumed in the cover soils to prevent infinite slope type failures from being shown as critical. The cover stability is provided under separate cover.

References

1. Motan, E. Sabri; Benson, Craig H.; Tuncer, B. Edil, "Shear Strength of Municipal Solid Waste: A Laboratory Study".
2. Koerner, George R. and Najero, Dhani, "Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces", Geosynthetic Research Institute, GRI Report #30, June 14, 2005.
3. "Data Report, Preliminary Geotechnical Investigation, Kauai Landfill Siting EIS, Ma'alo Site, Island of Kauai, Hawaii", prepared by Masa Fujioka & Associates, dated June 11, 2012.
4. Drawings titled, "Draft Conceptual Design, Ma'alo Sanitary Landfill and Resource Recovery Park", prepared by AECOM, dated November 2013.

ATTACHMENT 1

CROSS SECTION LOCATIONS FOR FINAL BUILDOUT STABILITY ANALYSIS

SECURITY FENCE

REFER TO DRAWING 10 FOR CONCEPTUAL ENTRANCE AREA LAYOUT

CELL 1.1

PHASE 1

FUTURE PHASE 2

FUTURE PHASE 3

FUTURE PHASE 4

FUTURE PHASE BASE LINER TIE-IN SEE DETAIL 4/14

SOUTH SURFACE WATER BASIN

ENTRANCE GATE

B-1 256.61

B-3 275.85

B-4 268.20

B-4 271.49

A

B

C

SECTION A

SECTION B

SECTION C

LEGEND

- EXISTING TOPOGRAPHY
- LANDFILL SITE FOOTPRINT
- PROPOSED LIMITS OF WASTE
- PROPOSED LIMIT OF PHASE
- ACCESS ROAD
- B-1 256.61 SOIL BORING LOCATION AND APPROXIMATE GROUNDWATER ELEVATION
- SECURITY FENCE

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.
3. SOIL BORINGS ADVANCED BY MASA FUJIOKA & ASSOCIATES ON MAY 14-16, 2012.

N

SCALE 0' 150' 300'

AECOM

ATTACHMENT 1
GEOTECHNICAL ANALYSIS
CROSS SECTION LOCATIONS

DRAFT CONCEPTUAL DESIGN
PROPOSED MA'ALO SANITARY LANDFILL
AND RESOURCE RECOVERY PARK
KAUAI, HAWAII

NOVEMBER 2013 60221907

11/21/2013 10:20:58 AM
Pentable = VA.tbl
Server = USCH6501
L:\work\60221907\000_CADD\Maalo\CS\GEOTECH FIGURE.dgn

ATTACHMENT 2

OUPUT FIGURES 1 THROUGH 12

Ma'alo Section A-A' East

Block Failure Along Base Liner

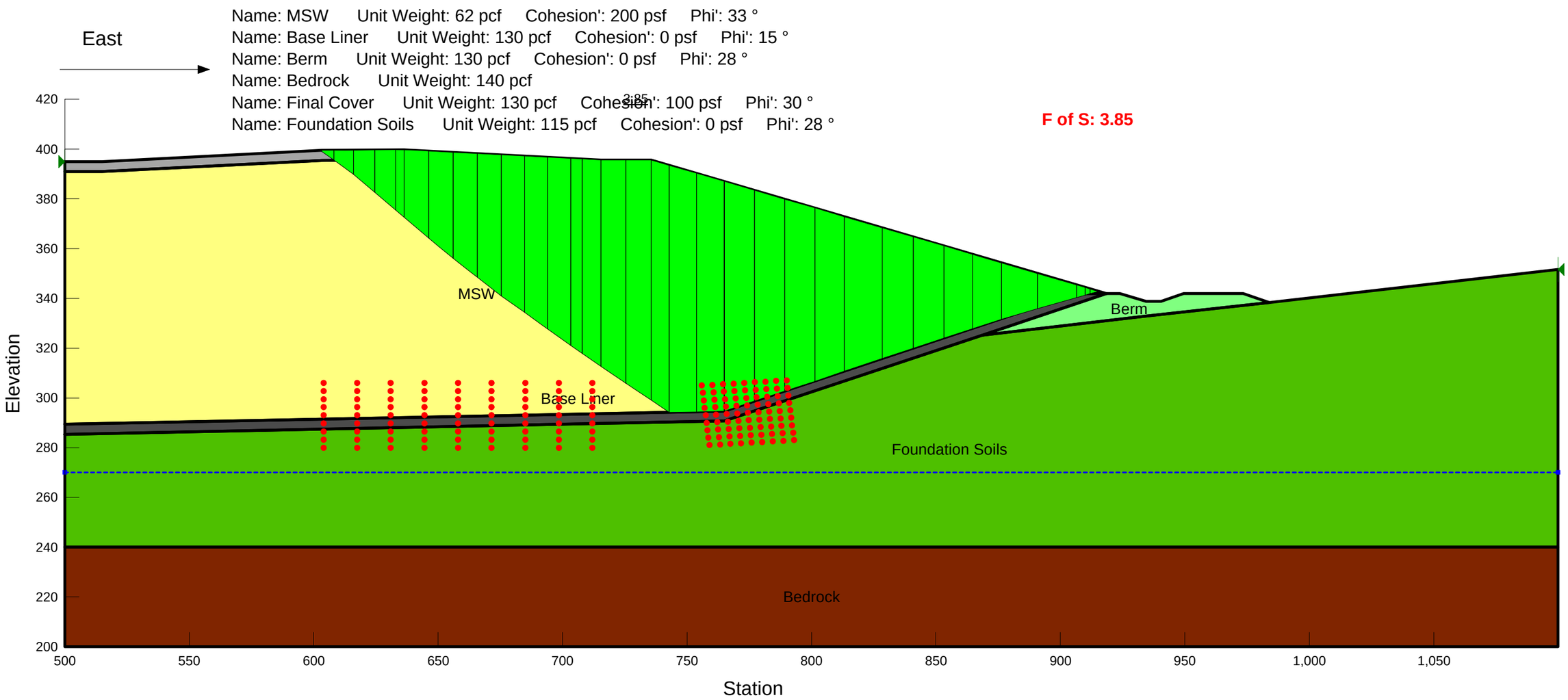


Figure 1

Ma'alo Section A-A' East

Global Failure Through Berm

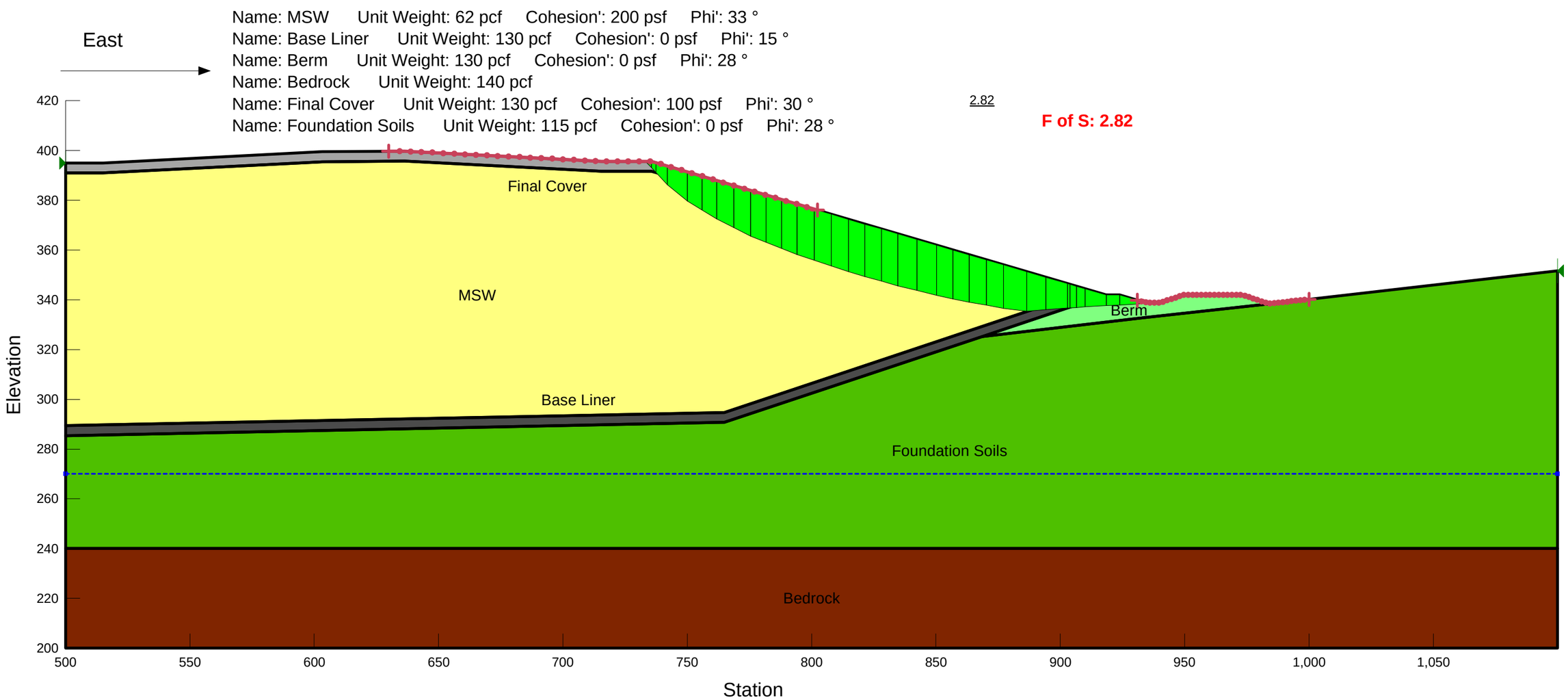


Figure 2

Ma'alo Section A-A' East

Base Lliner with Seismic

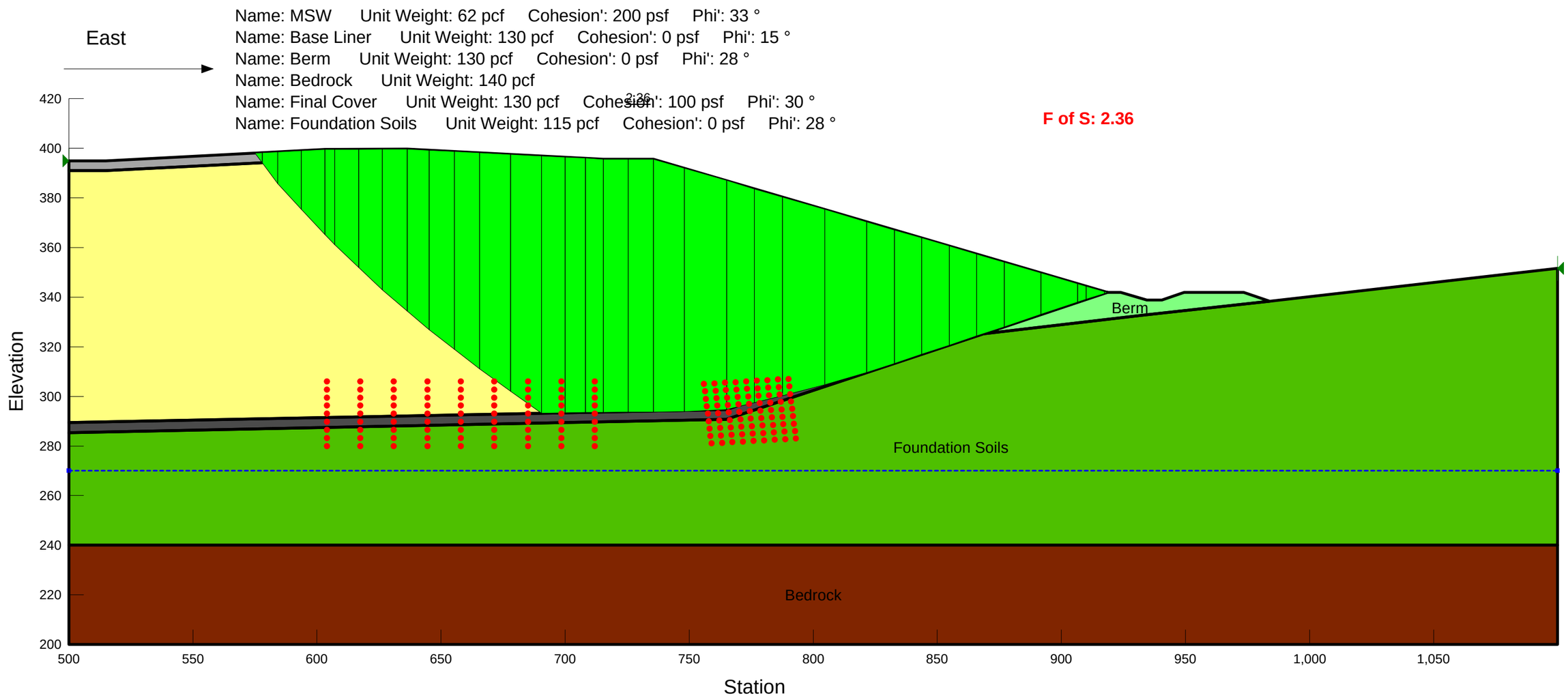


Figure 3

Ma'alo Section A-A' East

Seismic

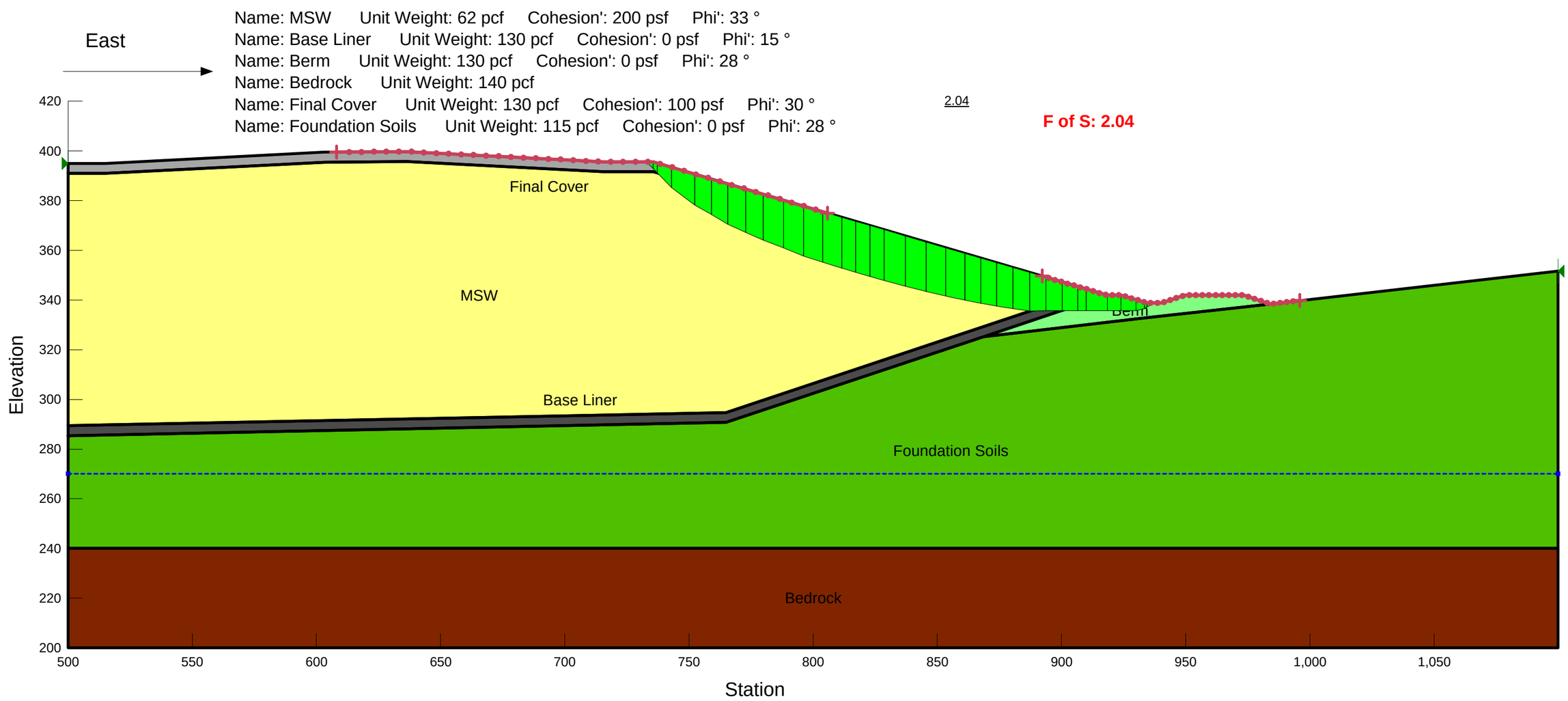


Figure 4

Ma'alo Section A-A' West

Block Failure Along Base Liner

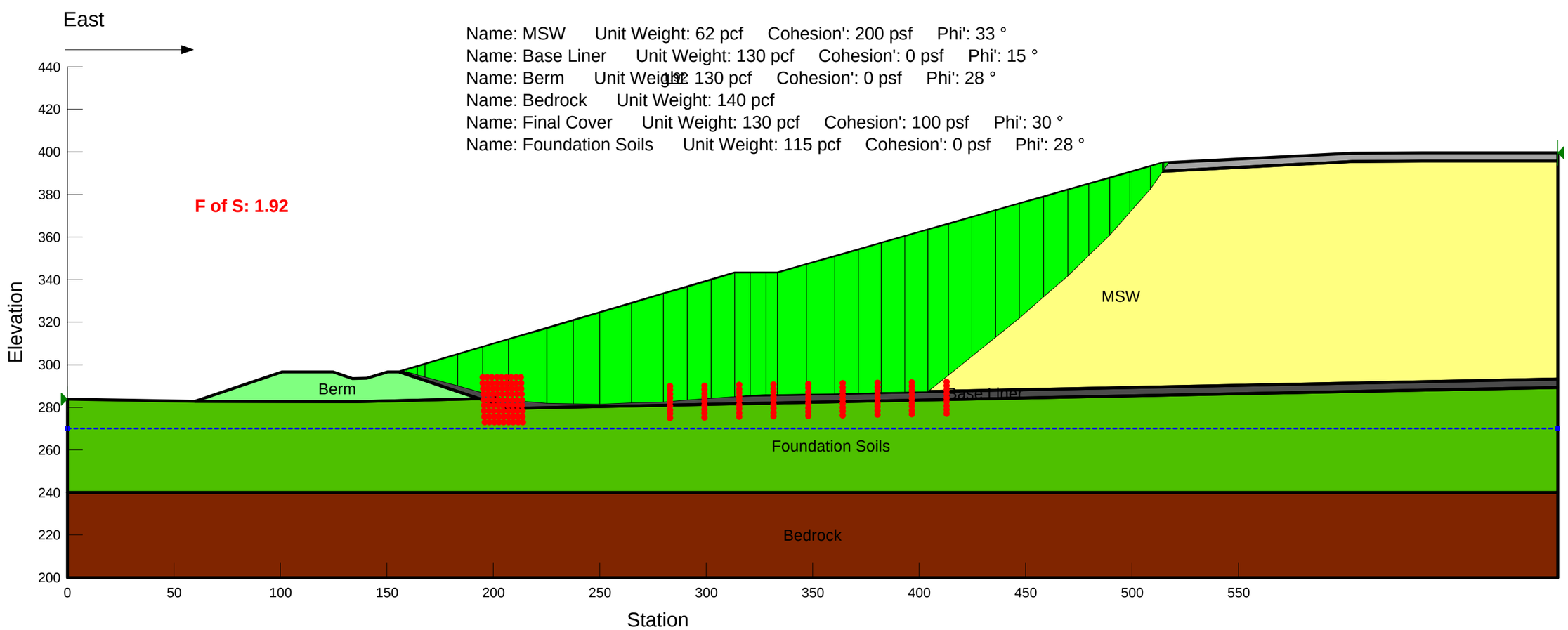


Figure 5

Ma'alo Section A-A' West

Global Failure Through Berm

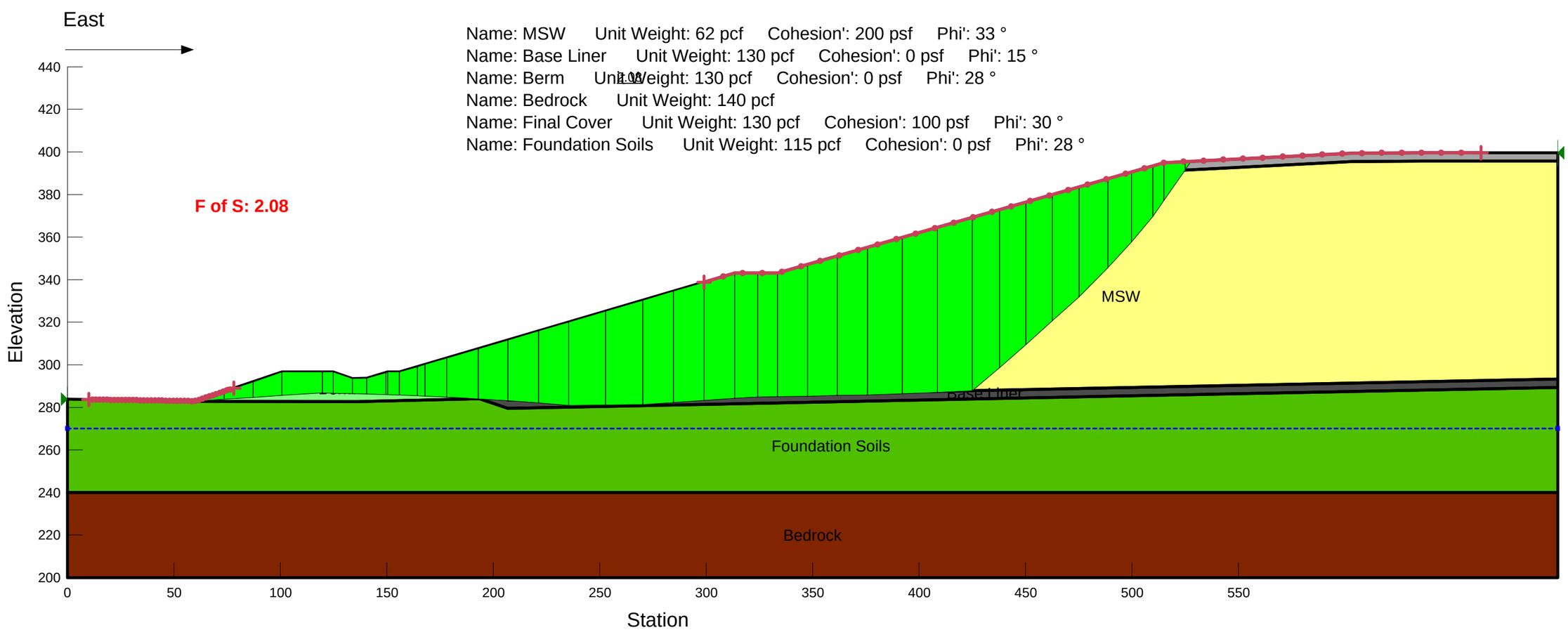


Figure 6

Ma'alo Section A-A' West

Block with Seismic

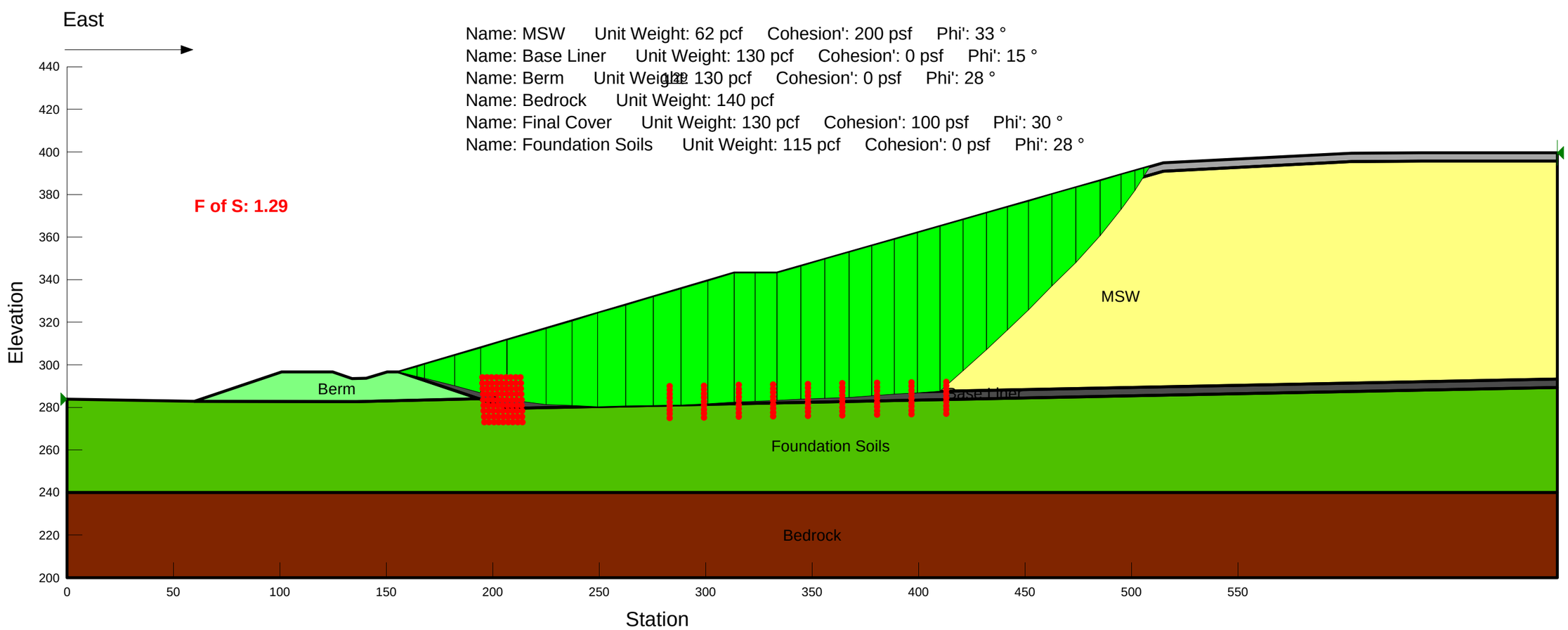


Figure 7

Ma'alo Section A-A' West

Seismic 0.10g

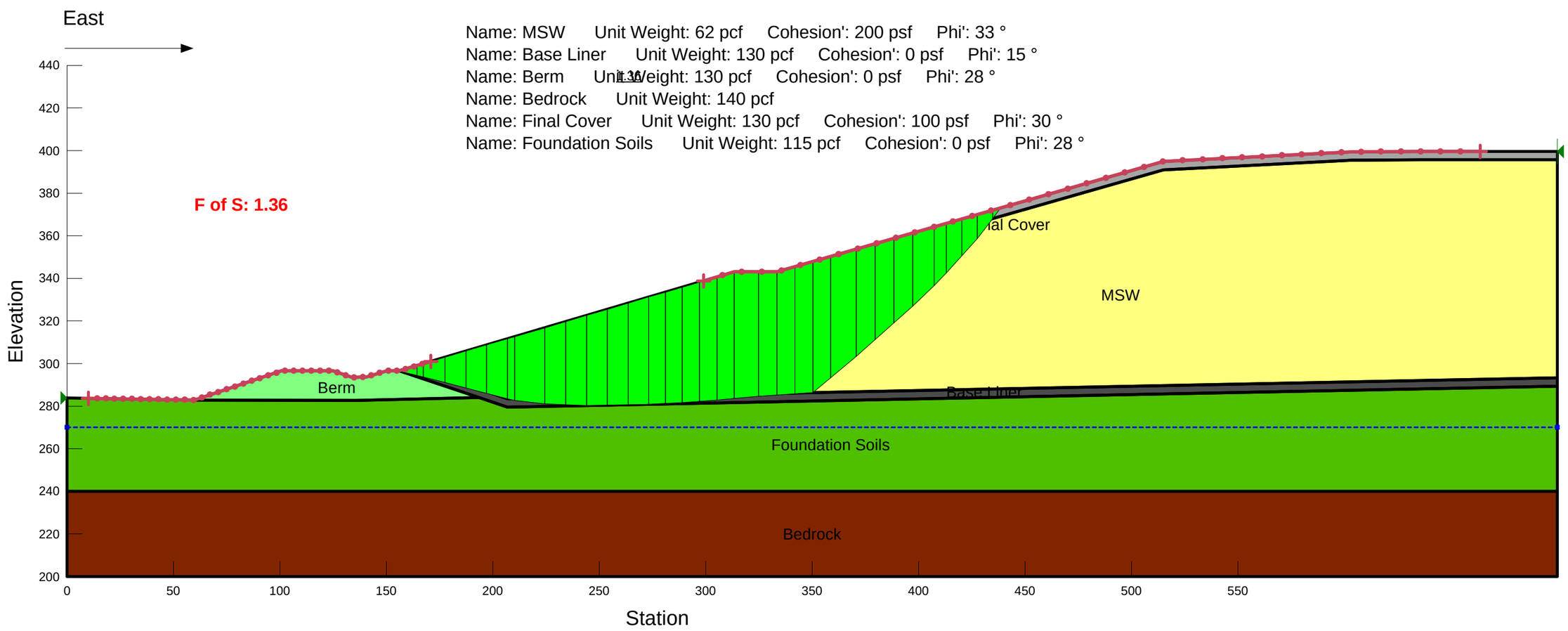


Figure 8

Ma'alo Section B-B' East

Block Failure Along Base Liner

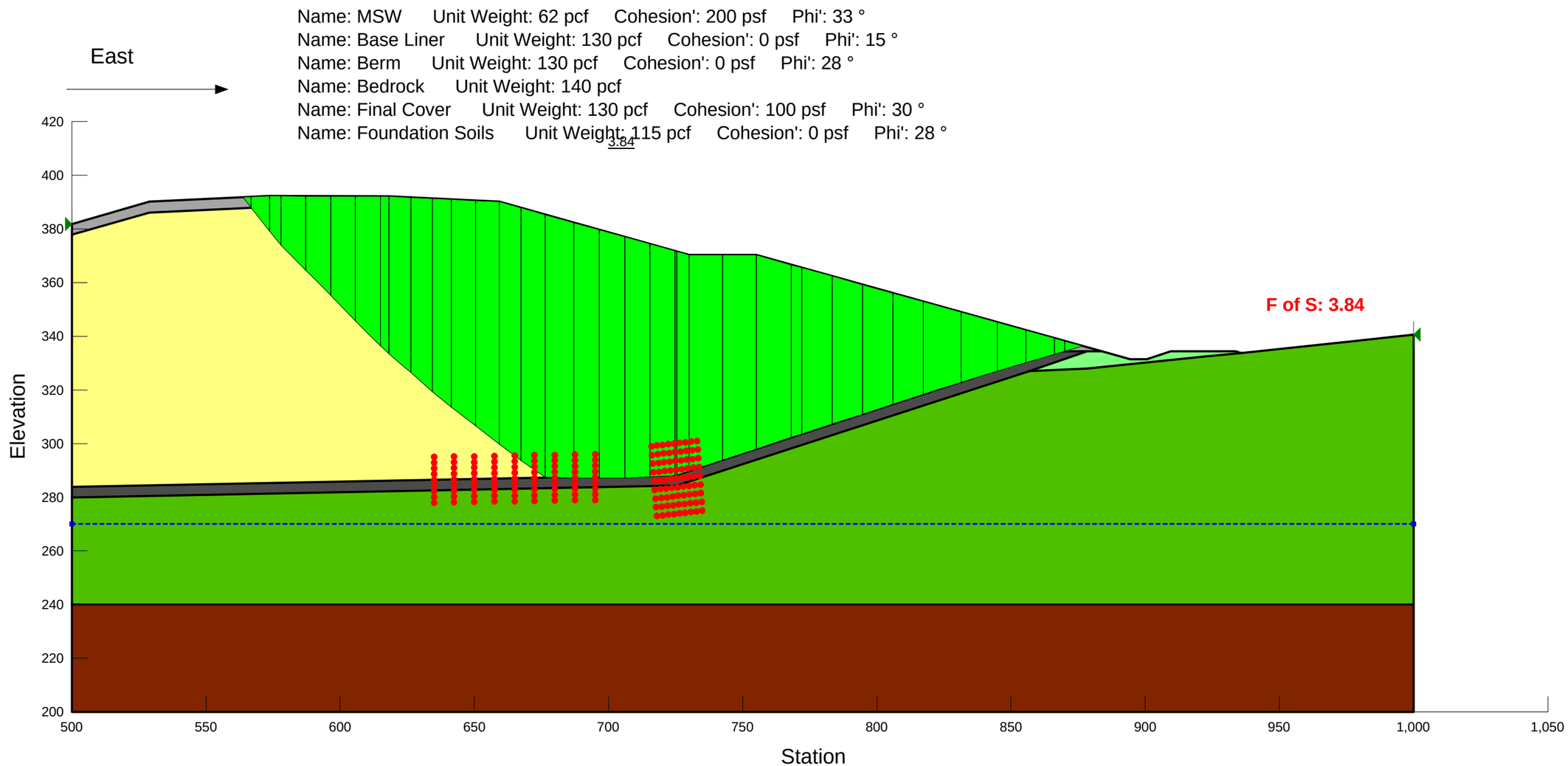


Figure 9

Ma'alo Section B-B' East

Global Failure Through Berm

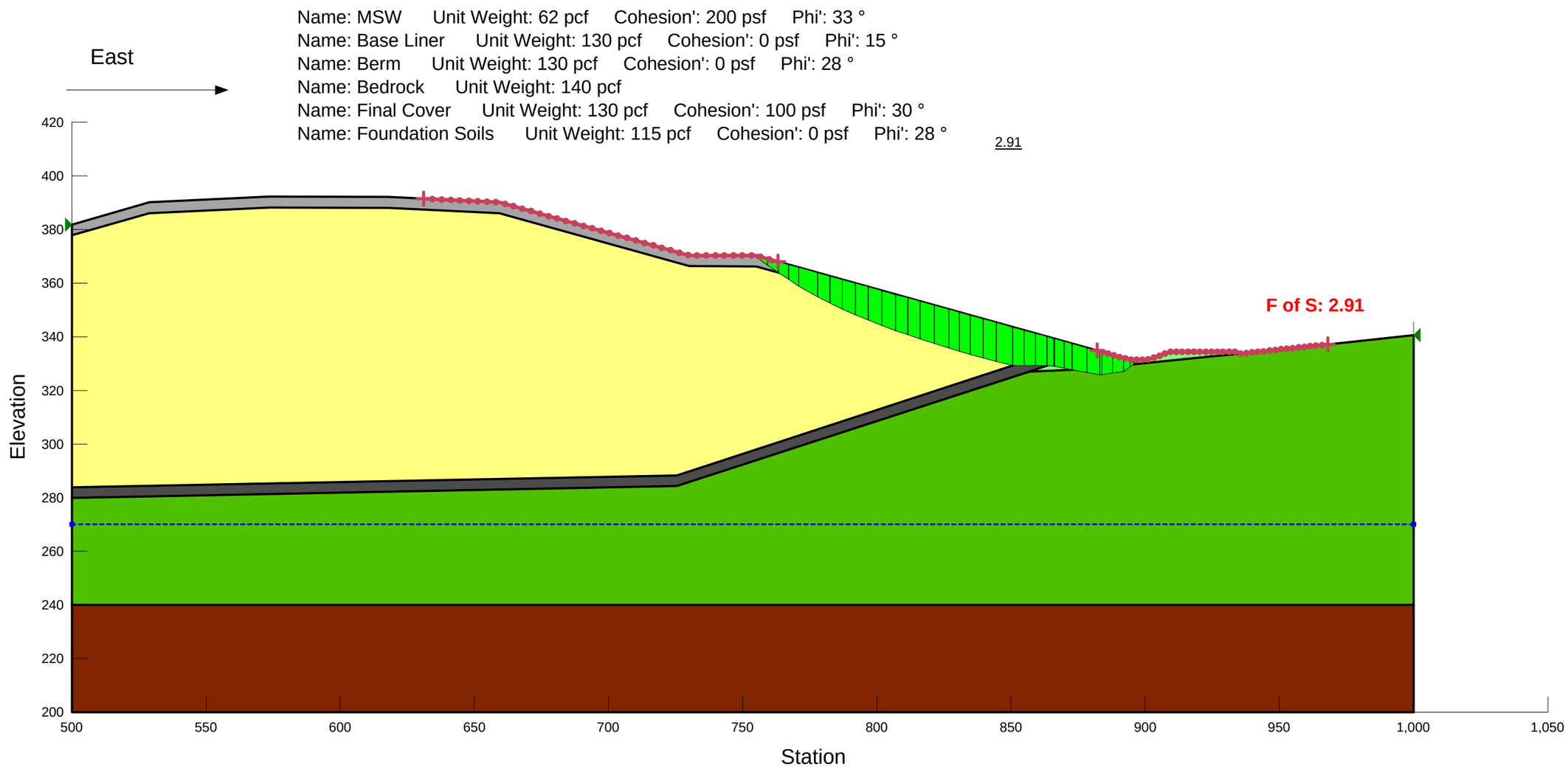


Figure 10

Ma'alo Section B-B' East

Block with Seismic

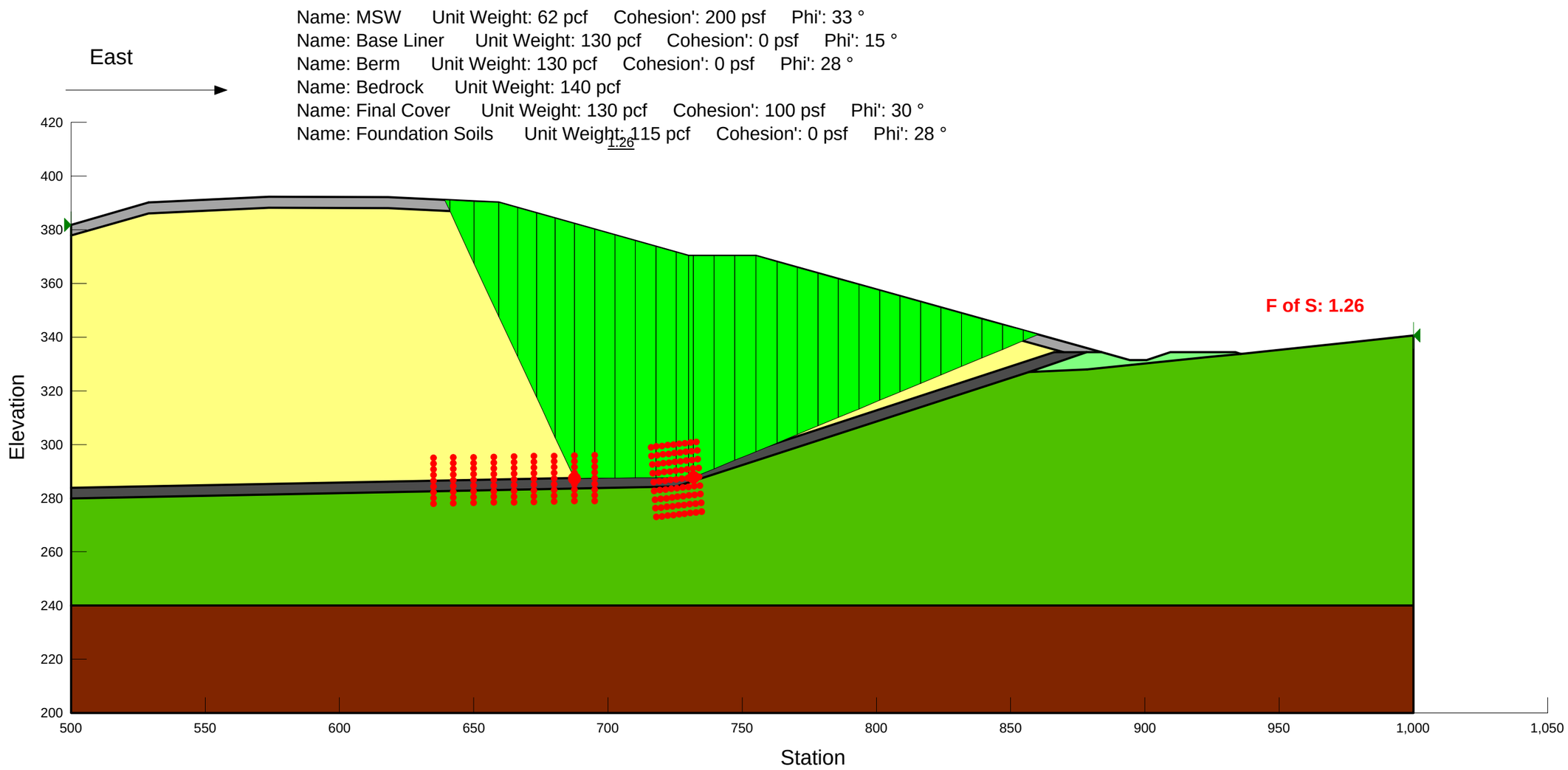


Figure 11

Ma'alo Section B-B' East

Seismic 0.10 g

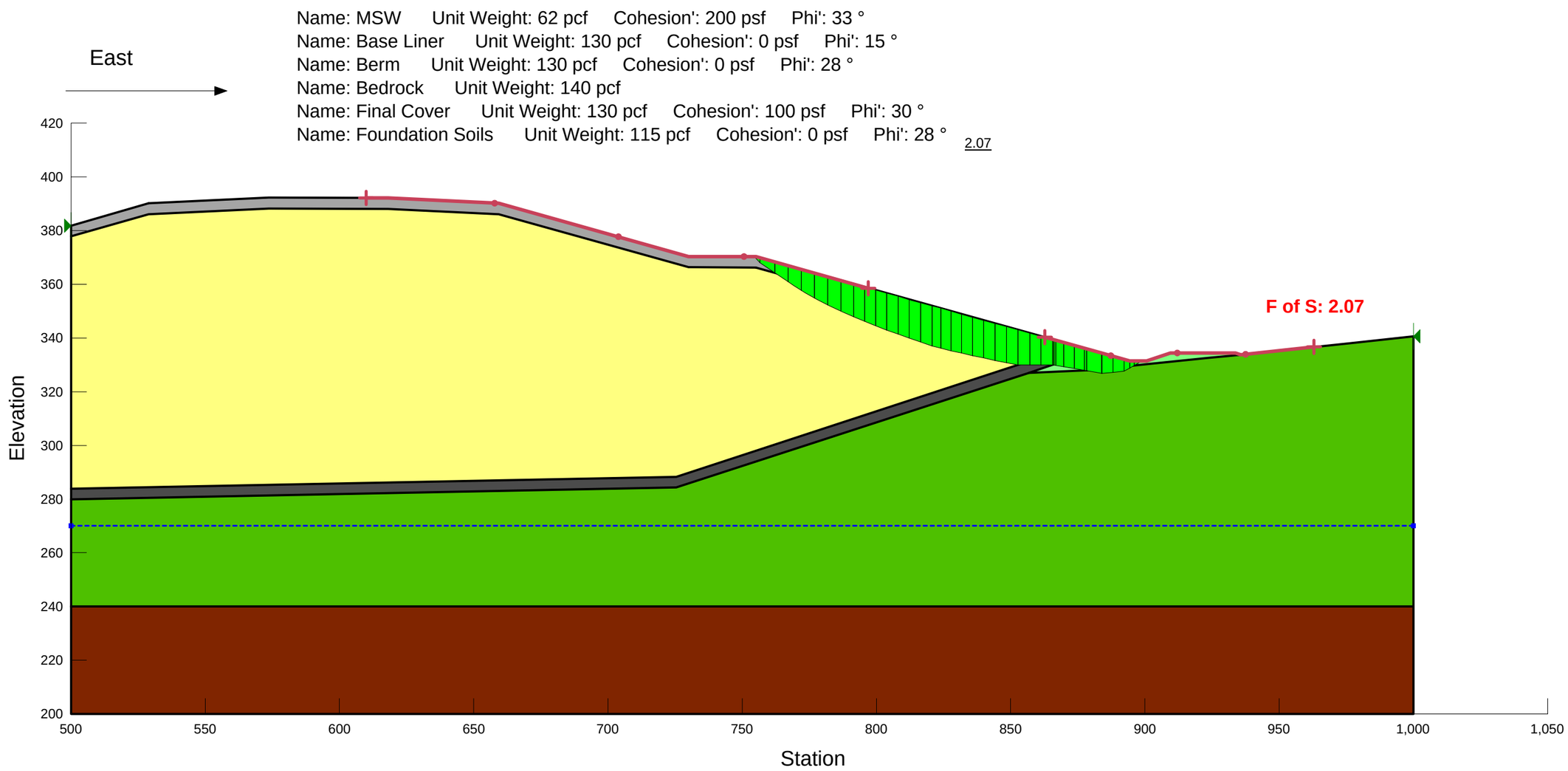


Figure 12

Ma'alo Section B-B' West

Block Failure Along Base Liner

Name: MSW Unit Weight: 62 pcf Cohesion': 200 psf Phi': 33 °
Name: Base Liner Unit Weight: 130 pcf Cohesion': 0 psf Phi': 15 °
Name: Berm Unit Weight: 130 pcf Cohesion': 0 psf Phi': 28 °
Name: Bedrock Unit Weight: 140 pcf
Name: Final Cover Unit Weight: 130 pcf Cohesion': 100 psf Phi': 30 °
Name: Foundation Soils Unit Weight: 115 pcf Cohesion': 0 psf Phi': 28 °

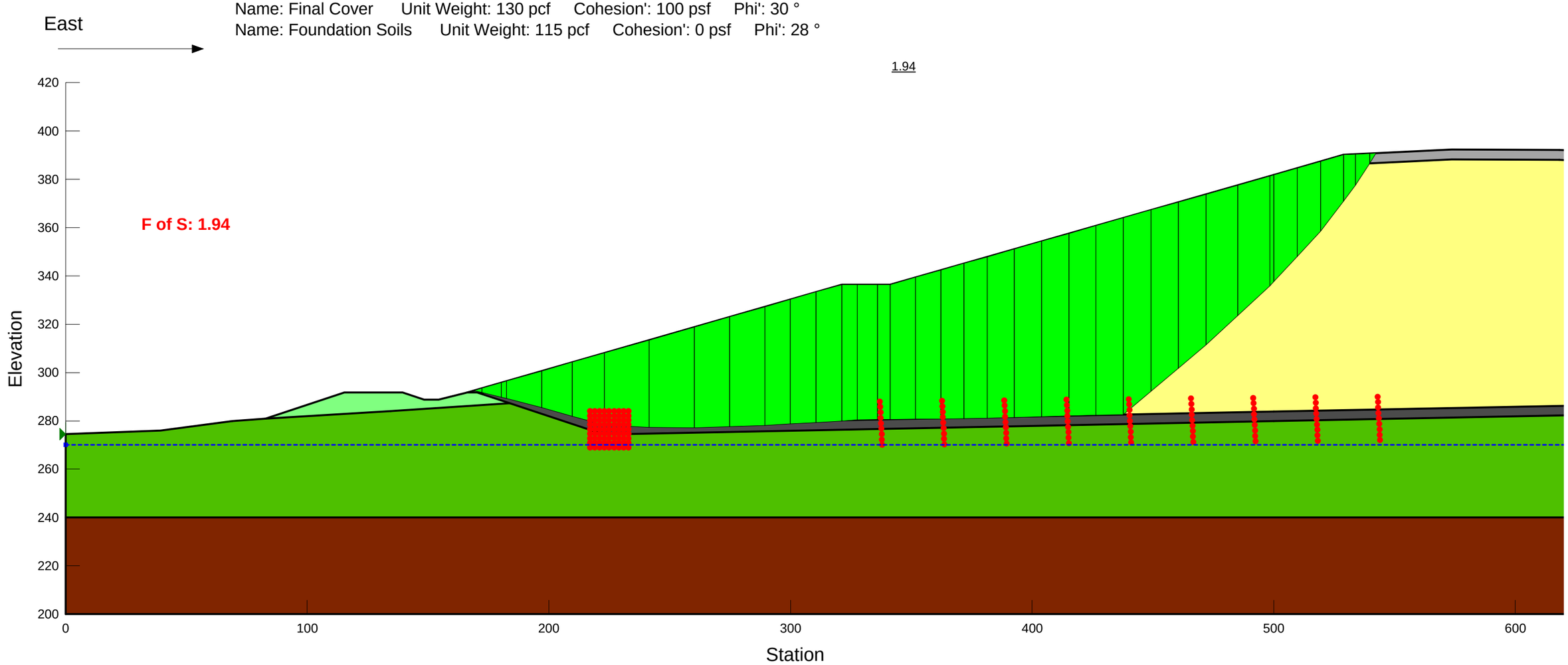


Figure 13

Ma'alo Section B-B' West

Global Failure Through Berm

Name: MSW Unit Weight: 62 pcf Cohesion': 200 psf Phi': 33 °
Name: Base Liner Unit Weight: 130 pcf Cohesion': 0 psf Phi': 15 °
Name: Berm Unit Weight: 130 pcf Cohesion': 0 psf Phi': 28 °
Name: Bedrock Unit Weight: 140 pcf
Name: Final Cover Unit Weight: 130 pcf Cohesion': 100 psf Phi': 30 °
Name: Foundation Soils Unit Weight: 115 pcf Cohesion': 0 psf Phi': 28 °

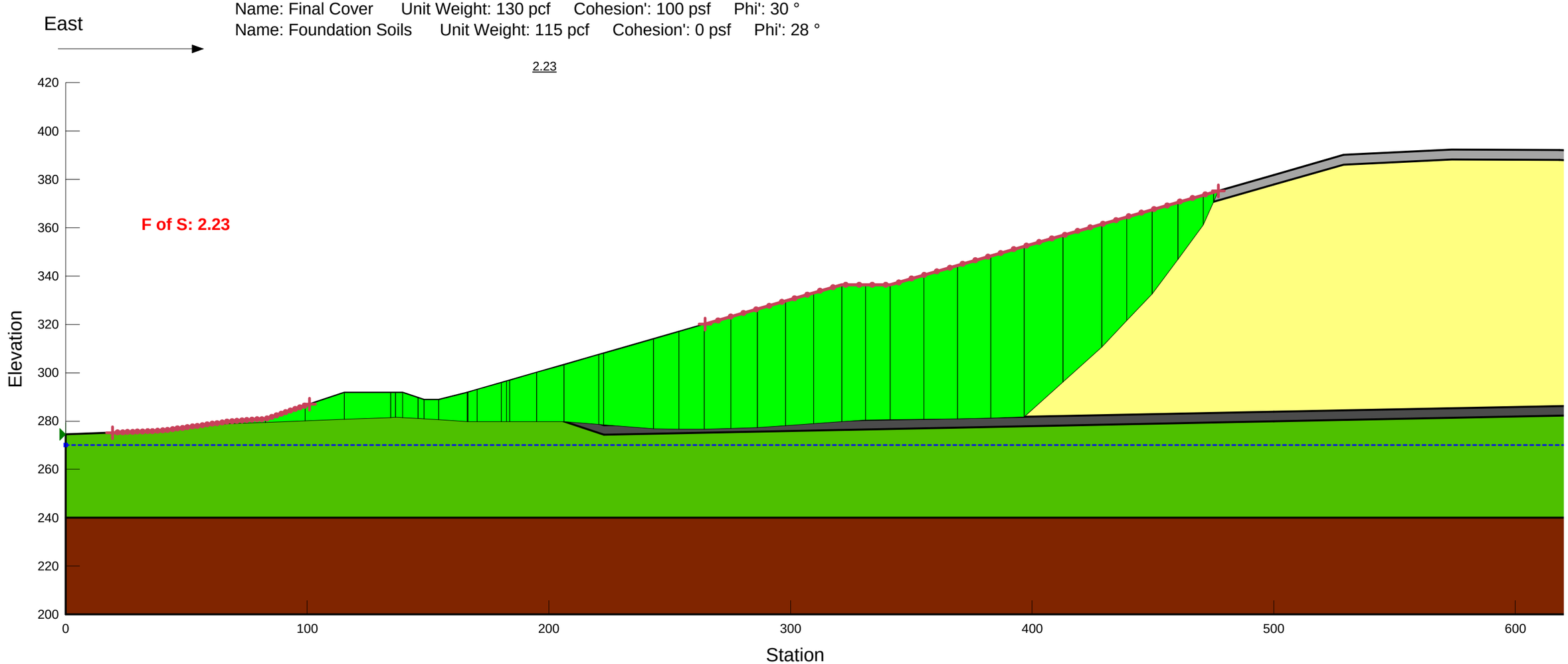


Figure 14

Ma'alo Section B-B' West

Block with Seismic

Name: MSW Unit Weight: 62 pcf Cohesion': 200 psf Phi': 33 °
Name: Base Liner Unit Weight: 130 pcf Cohesion': 0 psf Phi': 15 °
Name: Berm Unit Weight: 130 pcf Cohesion': 0 psf Phi': 28 °
Name: Bedrock Unit Weight: 140 pcf
Name: Final Cover Unit Weight: 130 pcf Cohesion': 100 psf Phi': 30 °
Name: Foundation Soils Unit Weight: 115 pcf Cohesion': 0 psf Phi': 28 °

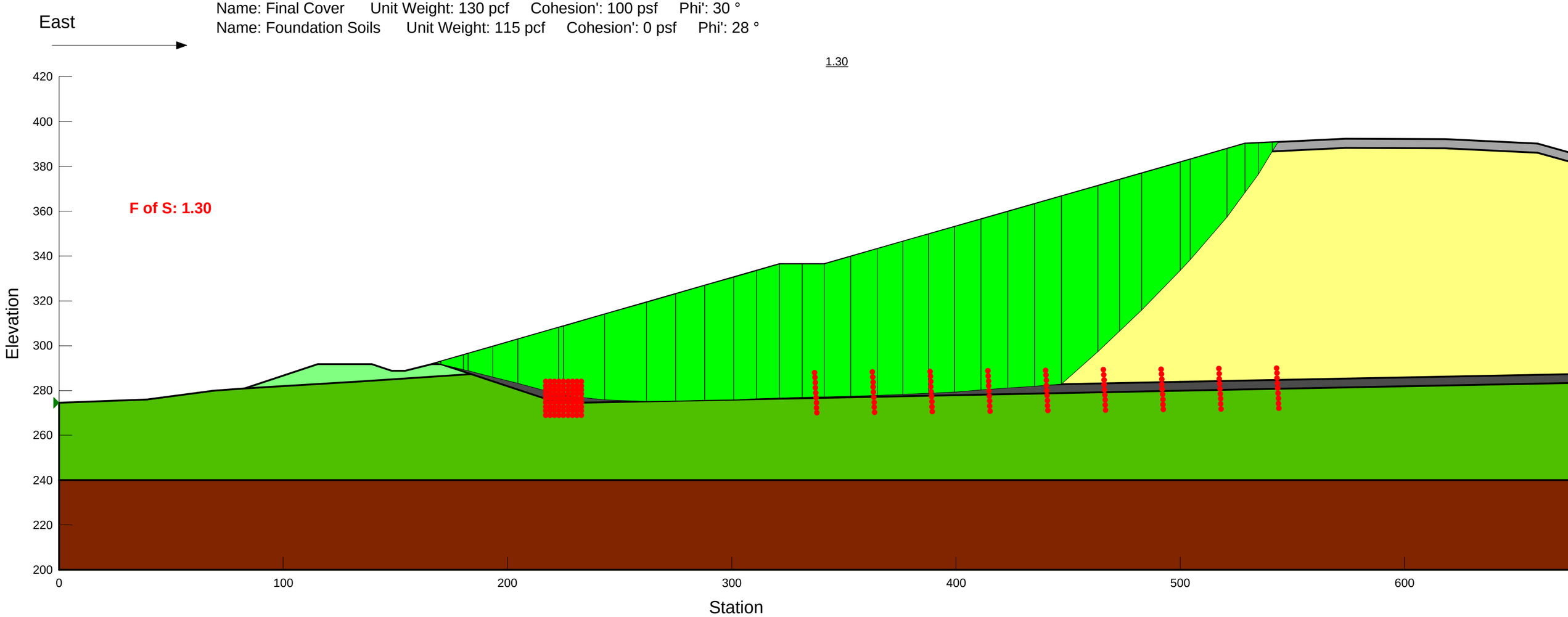


Figure 15

Ma'alo Section B-B' West

Seismic 0.10 g

Name: MSW Unit Weight: 62 pcf Cohesion': 200 psf Phi': 33 °
Name: Base Liner Unit Weight: 130 pcf Cohesion': 0 psf Phi': 15 °
Name: Berm Unit Weight: 130 pcf Cohesion': 0 psf Phi': 28 °
Name: Bedrock Unit Weight: 140 pcf
Name: Final Cover Unit Weight: 130 pcf Cohesion': 100 psf Phi': 30 °
Name: Foundation Soils Unit Weight: 115 pcf Cohesion': 0 psf Phi': 28 °

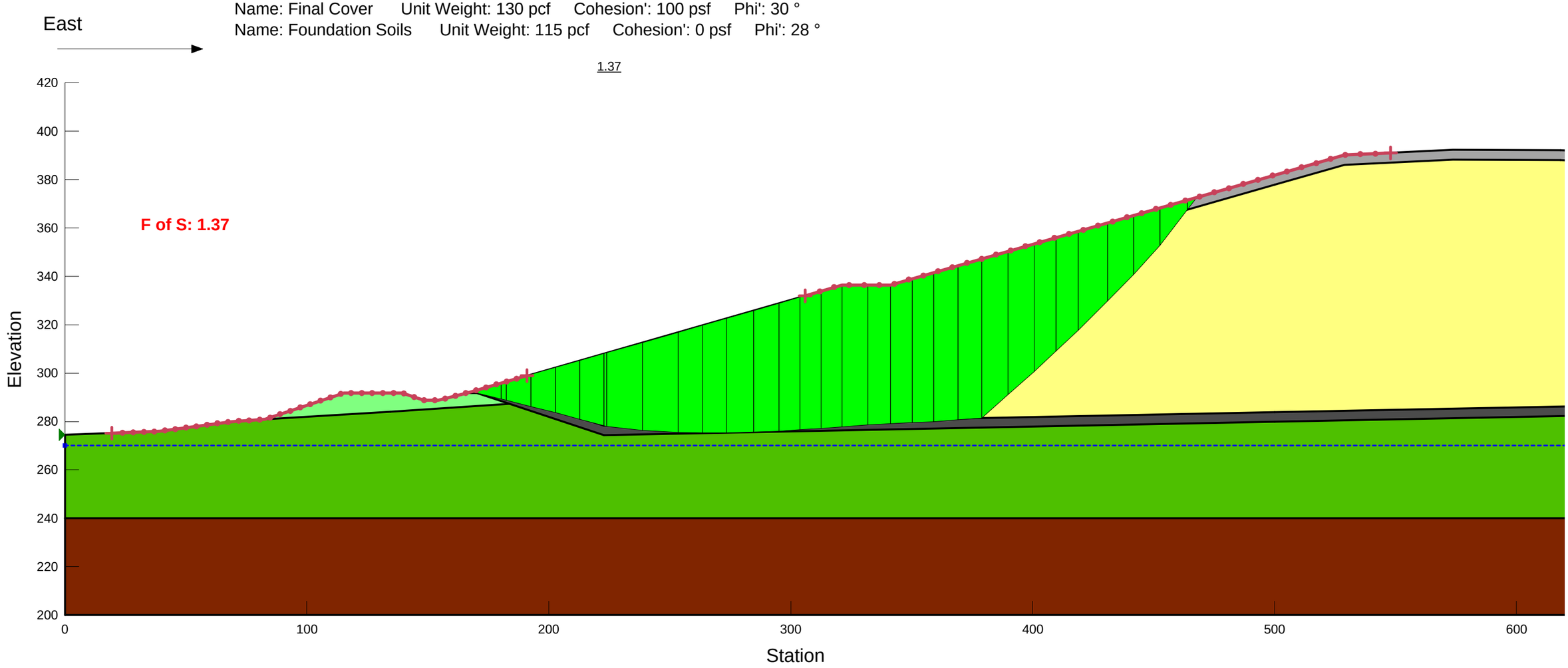
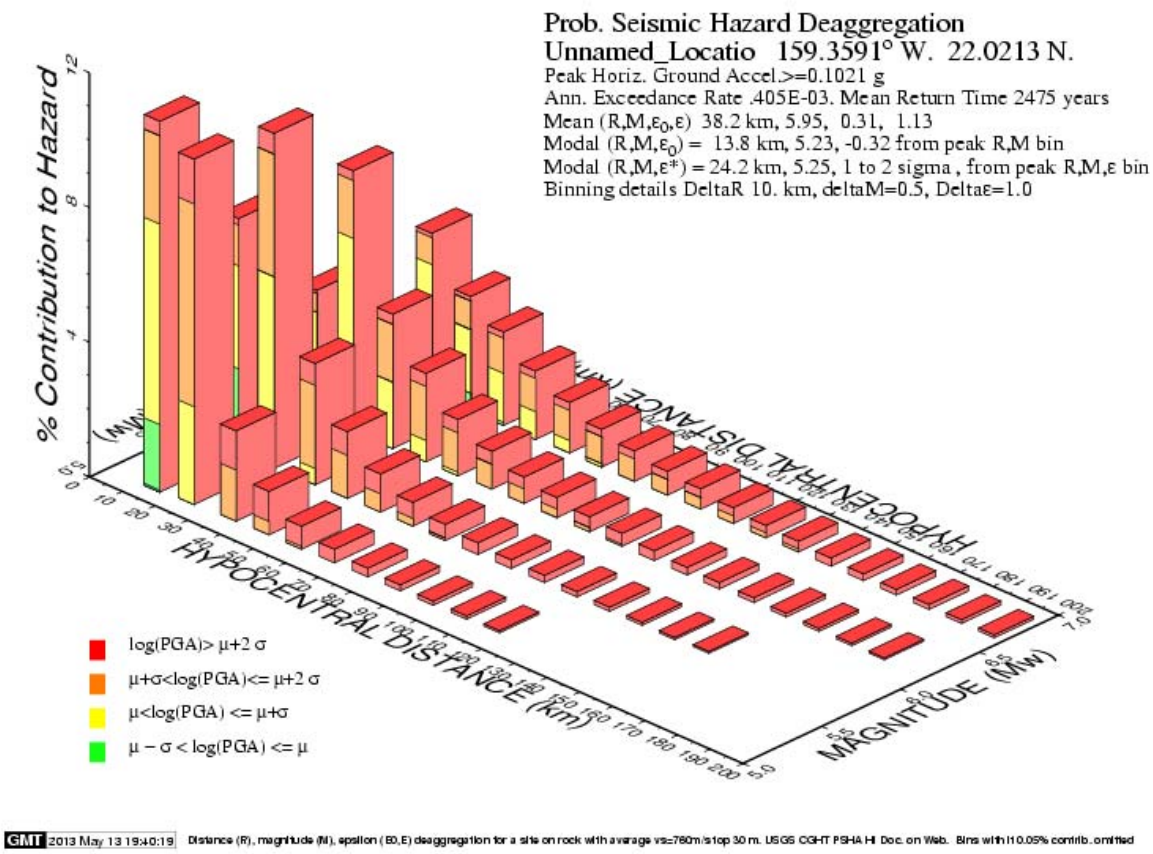


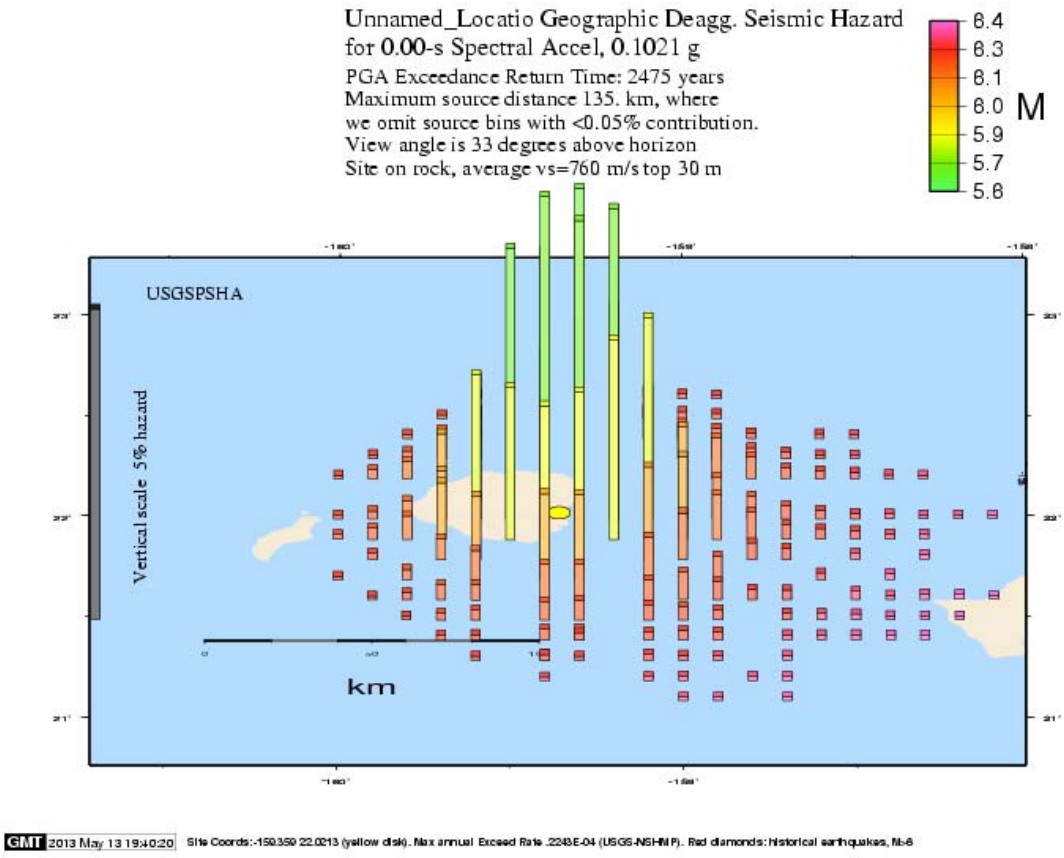
Figure 16

ATTACHMENT 3

SEISMIC HAZARD DEAGGREGATION FIGURES



Source: USGS Seismic Deaggregation website
(http://eqint.cr.usgs.gov/deaggint/1996/index.php?PHPSESSID=c352aa4d77s5kn25jmtrpbu0l7)



Source: USGS Seismic Deaggregation website (http://eqint.cr.usgs.gov/deaggint/1996/index.php?PHPSESSID=c352aa4d77s5kn25jmtrpbu0l7)

Appendix B.3
Final Cover Stability Analysis

Client	County of Kaua'i	**Subject**	Final Cover	**Prepared By**	KJB	**Date**	11/21/13
Project	Ma'alo Landfill		Drainage Layer Capacity	**Reviewed By**	JMT	**Date**	11/21/13
Conceptual Design			And Slope Stability	**Approved By**	KJB	**Date**	11/21/13

FINAL COVER DRAINAGE LAYER CAPACITY AND SLOPE STABILITY

Objective

Evaluate the final cover slope stability under static and seepage conditions for the proposed Ma'alo Sanitary Landfill that incorporates the use of geosynthetics and soil materials.

Design Criteria & Assumptions

1. The attached final cover cross section is applicable (Figure 1).
2. A 100-year 24-hour rain event is 4.9 inches and 25-year 24-hour rain event is 13.4 inches per Reference 1. The 25-year 24-hour storm event is the assumed rain event for the seepage condition given the amount of rainfall.
3. Interface friction angle testing as well as transmissivity testing should be completed prior to construction and use of the proposed materials. This calculation is completed to evaluate the acceptability of the proposed drainage materials under expected normal loadings and minimum interface friction angles.
4. The geocomposite drainage layer will consist of a HDPE geonet with a nonwoven geotextile heat-bonded to both sides.
5. A factor of safety of 1.5 will be used to determine slope stability under static conditions (consistent with past permitted approvals). A factor of safety of 1.2 and a drainage layer capacity greater than one (DLC >=1) for seepage conditions (short-term condition) in defining minimum material requirements. By defining a DLC >=1 all infiltration through the protective cover soil will be managed in the thickness of the geocomposite drainage layer. Under short-term conditions, the final cover protective cover soil layer above the geocomposite drainage layer is assumed to be at field capacity, a temporary condition.
6. Seismic analysis will be completed as the site specific horizontal peak ground acceleration is 0.10g which and is equal to minimum required by Subtitle D for analysis. Based upon the USGS Seismic Deaggregation website, the peak horizontal ground acceleration can be determined by entering the site latitude and longitude. Site latitude and longitude used for seismic evaluation of 159.3591W, 22.0213N. Output from the website provided as Attachment 3. A Factor of Safety of 1.2 will used as this event is short term.

Calculations

The stability of the final cover is primarily dependent upon the shear resistance of the weakest interface, slope length, slope inclination, and the seepage condition. The following information was collected/selected before conducting the actual stability analysis.

Material/Design Properties

Protective Cover Soil (well graded sand):

Unit weight, moist	γ_{moist} = 110 pcf = 17.3 kN/m^3
Unit weight, saturated (assumed)	$\gamma_{saturated}$ = 120 pcf = 18.9 kN/m^3
Permeability	$k_{c.s.}$ = varies
Thickness (permitted)	$h_{c.s.}$ = 18 inches = 457.2 mm
Internal friction angle	$\phi_{c.s.}$ = 30 degrees (conservative)

Runoff Coefficient:

Runoff coefficient is an estimated percentage of precipitation allowed to runoff the final cover. The runoff coefficient is dependant upon the type of soils and slope steepness. The proposed protective cover soil will consist of on-site well graded sands. The runoff coefficient based upon Reference 5 (Attachment 1) is estimated at:

Clayey soils, slopes greater than 7% RC = 0.25 to 0.35
Sandy soils, slopes greater than 7% RC = 0.15 to 0.20

For conservative design (i.e. less runoff, more infiltration), a runoff coefficient of RC = 0.15 has been used.

Slope Inclination:

Slope inclination: β = 3.5H:1V = $\tan^{-1}$ (1/3.5) = 15.9 degrees

Design rainfall intensity (Reference 1):

25-year, 24-hour storm event I = 13.4 inches/24 hours
I = (13.4/24) inches/hour = 0.56 inches/hr
I = 14.2 mm/hr

Geocomposite Drainage Layer Properties (Attachment 2):

Geocomposite thickness (geonet only): $t_{composite}$ = 200 mil or 5 mm (per GSE)

Transmissivity (design) $\theta = 1\text{x}10^{-4}$ m^2/sec

Permeability:

$$k_d = \left(\frac{1\text{x}10^{-4}\ \text{m}^2/\text{sec}}{5\ \text{mm}}\right)\left(\frac{100\ \text{cm}}{1\ \text{m}}\right)^2\left(\frac{10\ \text{mm}}{1\ \text{cm}}\right) = 2\ \text{cm/sec}$$

Infinite Slope Stability (Static and Seismic)

The infinite slope stability is determined by force summation along the sideslope angle resulting in a factor of safety (Reference 6) without a buttress effect at the toe of slope under static conditions or:

$$FS = \frac{\text{resisting forces}}{\text{driving forces}} = \frac{F}{W \sin\beta} = \frac{N \tan\delta}{W \sin\beta} = \frac{W \cos\beta \tan\delta}{W \sin\beta}$$

$$FS = \frac{\tan\delta}{\tan\beta}$$

where:

FS = Factor of Safety
W = Weight of soil overlying geomembrane
N = Normal force
δ = critical interface friction angle
β = sideslope angle

Solving for 3.5:1 slope (15.9 degrees) and Factor of Safety of 1.5, the minimum critical interface friction angle is:

$$FS = \frac{\tan\delta}{\tan\beta} \Rightarrow 1.5 = \frac{\tan\delta_{3.5:1}}{\tan 15.9} \Rightarrow \delta_{3.5:1} = \tan^{-1}(1.5 * \tan 15.9)$$

$$\delta_{3.5:1} = 23.1 \text{ degrees}$$

The infinite slope stability is not dependent upon cover soil thickness, slope length, or cover soil permeability.

The infinite stability analysis can be modified to incorporate the seismic component. The seismic component is a horizontal force that is equal to the seismic coefficient times the weight of the soil or $C_S W$. The added seismic driving force along the geomembrane is determined to be equal to $\cos\beta(C_S W)$. In addition the normal force, N is reduced by the seismic force by an opposing force of $\sin\beta(C_S W)$. Applying these to the infinite stability analysis equation above, we obtain:

$$FS = \frac{\text{resisting forces}}{\text{driving forces}} = \frac{(N - \sin\beta C_S W)\tan\delta}{W \sin\beta + \cos\beta(C_S W)}$$

$$FS = \frac{(W \cos\beta - \sin\beta CsW)\tan\delta}{W \sin\beta + \cos\beta(C_S W)} = \frac{(\cos\beta - \sin\beta Cs)\tan\delta}{\sin\beta + \cos\beta(C_S)}$$

where:

C_S = Seismic coefficient
δ = critical interface friction angle
β = sideslope angle

Solving for 3.5:1 slope (15.9 degrees) and Factor of Safety of 1.2 (short term) and the minimum critical interface friction angle for static conditions of δ =23.1 degrees:

$$FS = \frac{(\cos\beta - \sin\beta Cs)\tan\delta}{\sin\beta + \cos\beta(C_S)} = \frac{(\cos 15.9 - \sin 15.9(0.1))\tan 23.1}{\sin 15.9 + \cos 15.9(0.1)} = 1.07 < 1.2$$

The resulting Factor of Safety for the static critical interface friction angle is 1.07 which is less than the design Factor of Safety of 1.20. This means the critical interface friction angle needs to be increased, assuming an increased critical interface friction angle of δ =25.5 degrees, we obtain:

$$FS = \frac{(\cos\beta - \sin\beta Cs)\tan\delta}{\sin\beta + \cos\beta(C_S)} = \frac{(\cos 15.9 - \sin 15.9(0.1))\tan 25.5}{\sin 15.9 + \cos 15.9(0.1)} = 1.20 = 1.2$$

The resulting critical minimum critical interface for seismic conditions is 25.5 degrees for a Factor of Safety of 1.20.

Methodology for Drainage Layer Capacity Analysis

The degree of submergence of the final cover under the design precipitation should be determined prior to conducting the final cover stability analysis. In order to quantify the degree of submergence, the drainage layer capacity (DLC) of the design option will be determined first. The procedure is based upon those presented by Soong and Koerner, 1997 (Reference 3).

The procedure is:

$$DLC = \frac{FLUX_{allow}}{FLUX_{req'd}}$$

For geocomposite drainage layer:

$FLUX_{allow}$ = Allowable flux (flow rate per unit width of final cover)
= $k_d iA$
= $k_d \sin\beta(t*1)$
= $(k_d*t)\sin\beta$
= $\theta\sin\beta$

where:

k_d = permeability of drainage material
i = hydraulic gradient = sinβ
β= slope angle
A = cross-sectional area of the drainage layer per unit width of final cover
t = thickness of drainage layer
θ = transmissivity of geocomposite

$FLUX_{req'd}$ = Required flux per unit width of sideslope
= (PERC)L*cosβ(1.0)

where:

$$\text{PERC = percolation} = \begin{cases} I & (k_{\text{cover soil}} \geq I) \\ k_{\text{cover soils.}} & (k_{\text{cover soils}} < I) \end{cases}$$

I = design rainfall intensity
$k_{\text{cover soils}}$ = permeability of vegetative/protective cover
L = slope length
β = slope angle

Methodology for Seepage Slope Stability Analysis

The final cover stability analysis is conducted using procedures developed specifically for veneer cover situations; see Koerner and Soong, 1998 (Reference 4). Spreadsheet program, based on the procedures recommended in the above referenced literature for seepage conditions was constructed, calibrated, and used in this analysis. Note that the input values were previously converted as needed into SI units for ease of spreadsheet input and analysis.

Conclusions

The following conditions are considered in the final cover stability analyses. These consisted of:

1. Static condition: Determine the minimum interface friction angle based upon infinite slope stability analysis (see section above), and
2. Seepage condition: Determine the correlations between the maximum length of continuous geocomposite drainage layer, permeability of protective soils and the critical interface friction angle.

The results of the final cover stability have been completed in previous section and on spreadsheets with the results attached and summarized below in Table 1.

Client	County of Kaua'i	**Subject**	Final Cover	**Prepared By**	KJB	**Date**	11/21/13
Project	Ma'alo Landfill		Drainage Layer Capacity	**Reviewed By**	JMT	**Date**	11/21/13
	Conceptual Design		And Slope Stability	**Approved By**	KJB	**Date**	11/21/13

Table 1
Summary of Slope Stability Results For Static and Seepage Conditions

Condition	Slope (H:V)	Rain Event	Maximum Protective Cover Permeability (cm/sec)	Slope Length Feet, (meters)	Cover Soil Thickness Feet, (mm)	Critical Friction Angle	Factor of Safety	DLC	Figure
Static	3.5:1	Infinite slope stability analysis, these parameters are not applied.				23.1	1.50 = 1.50	NA	NA
Seismic, C_S = 0.1	3.5:1	Infinite slope stability analysis, these parameters are not applied.				25.5	1.20 = 1.20	NA	NA
Seepage	3.5:1	25-year	$1x10^{-3}$	27.8 (8.5)	1.5 (457.2)	23.1*	1.69 > 1.20	1.0 = 1.0	2
			$5x10^{-4}$	27.9 (8.5)			1.69 > 1.20	1.0 = 1.0	3
			$1x10^{-4}$	93.4 (28.5)			1.54 > 1.20	1.0 = 1.0	4
			$5x10^{-5}$	186.9 (57.0)			1.51 > 1.20	1.0 = 1.0	5
			$1x10^{-5}$	934.1 (284.7)			1.49 > 1.20	1.0 = 1.0	6

* Conservative analysis using lowest critical interface friction angle.

Based upon the above results, the friction angle for the final cover system should be a minimum of 25.5 degrees. Depending upon the final cover soil permeability the geocomposite may need to be daylighted if the final cover slope lengths are longer than the correlating maximum geocomposite length for a given soil permeability.

If the transmissivity and correlating permeability of a site specific geocomposite is greater than the design requirement, this calculation should be revisited and slope lengths may increase for a continuous layer of geocomposite with higher permeability protective cover soils.

Please note continuous geocomposite slope lengths can not be increased by increasing the critical friction angle since the DLC factor governs the suitability of the geocomposite. The overall factor of safety would increase, but the performance of the geocomposite still governs maximum continuous geocomposite slope length.

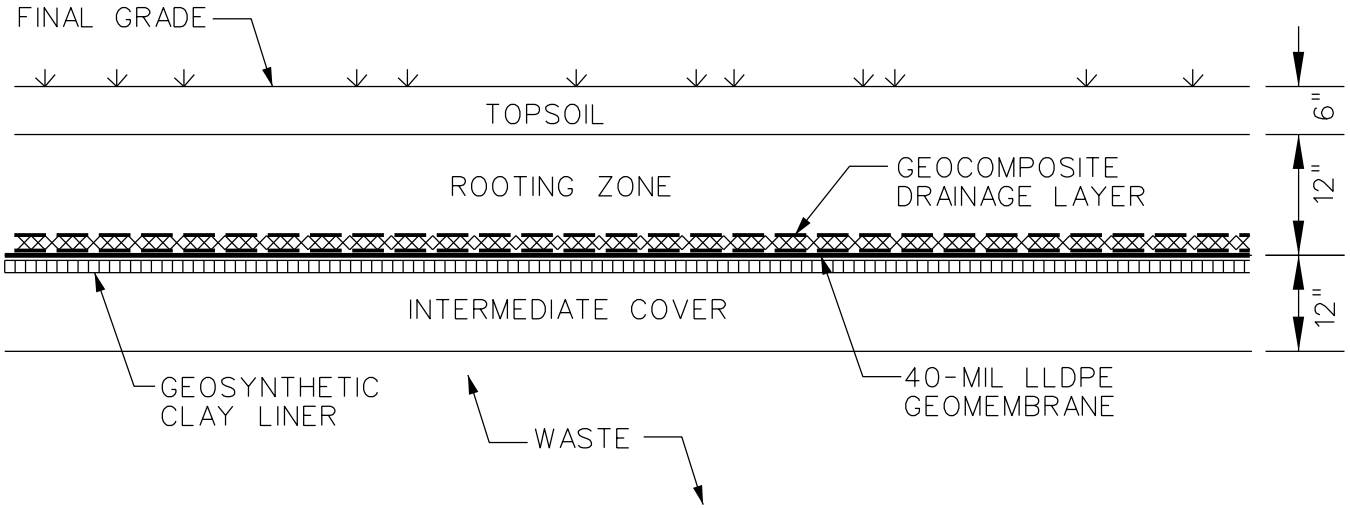
The above calculation also assumes that the drainage from the proposed crown of the facility is daylighted or drained prior to the 3.5:1 slopes.

References

1. Department of Engineering, County of Kauai. 2001. "Stormwater Runoff System Manual." Lihue, Kauai, Hawaii
2. Drawings titled, "Draft Conceptual Design, Ma'alo Sanitary Landfill and Resource Recovery Park", prepared by AECOM, dated November 2013
3. Soong, T.-Y. and Koerner, R.M. (1997) "The Design of Drainage Systems Over Geosynthetically Lined Slopes", Report #19, Geosynthetic Research Institute, Philadelphia, PA 19104, 88 pgs.
4. Koerner, R. M. and Soong, T.-Y. (1998), "Analysis and Design of Veneer Cover Soils" *Proc. 6th Int. Conf. on Geosynthetics, Atlanta*, USA, IFAI, pp. 1-23.
5. Daniel, David E., "Geotechnical Practice for Waste Disposal", page 216.
6. Koerner, R. M., "Designing with Geosynthetics," Fourth Edition, pps. 478 and 480.

FIGURE 1

TYPICAL FINAL COVER LINER CROSS SECTION



FINAL COVER SYSTEM **5**

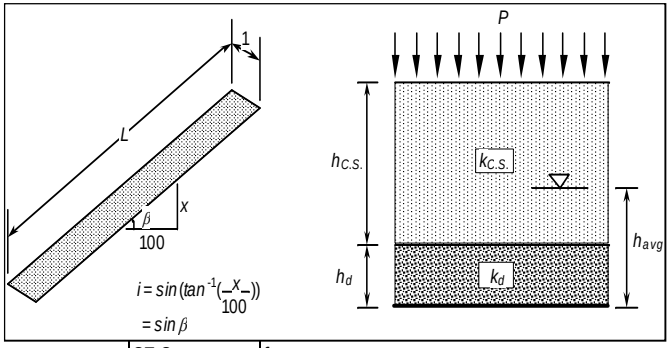
NTS

FIGURES 2 THROUGH 6

SLOPE STABILITY UNDER SEEPAGE CONDITIONS FIGURES
3.5:1 SLOPE, VARIOUS SLOPE LENGTHS, 18-INCH PROTECTIVE COVER THICKNESS

Calculation of stability under seepage condition

Calculation of DLC and PSR



	27.8	ft			
L =	8.5	m	i =	0.2740	
β =	15.9	°	$L(\cos\beta)$ =	8.15	m
			x =	2.32	m
$h_{C.S.}$ =	457.2	mm	$h_{C.S.}$ =	0.5	m
h_d or t_{GS} =	5.0	mm	h_d or t_{GS} =	0.01	m
			$h_{C.S.} + h_d$ =	0.46	m
$k_{C.S.}$ =	1.00E-03	cm/s	$k_{C.S.}$ =	1.0E-05	m/s
k_d or k_{GS} =	2.00E+00	cm/s	k_d or k_{GS} =	2.0E-02	m/s
P =	14.20	mm/hr	P (RC) =	2.1	mm/hr
RC =	0.15		Actual runoff =	2.13	mm/hr
			PERC =	12.07	mm/h
			$FLUX_{actual}$ =	0.098	m^3/hr
			$FLUX_{allow}$ =	0.099	m^3/hr

Results:

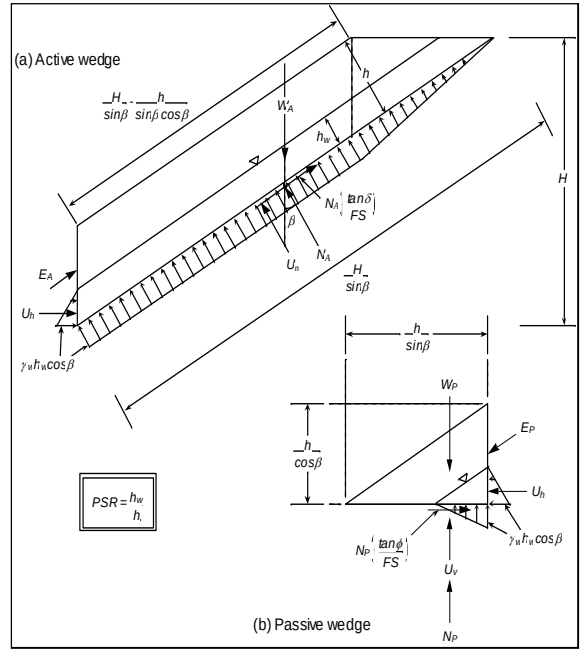
DLC	***1.003***
PSR	***0.011***
FS	***1.694***

DLC = 1.0027

q = 2.7E-05 m^3/sec

h_{avg} = 0.00 m

PSR = 0.011



Calculation of FS

Active Wedge:

W_A =	60.8082	kN
U_n =	0.39821	kN
U_h =	0.00012	kN
N_A =	58.0835	kN

Passive Wedge:

W_P =	7.01353	kN
U_V =	0.00043	kN

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

where a = 16.0

b = -29.5

c = 3.9

FS= 1.694

thickness of cover soil = h = 0.46 m

length of slope measured along the top of clay layer = L = 8 m

soil slope angle along top of clay = β = 15.9 ° = 0.28 (rad.)

vertical height of the slope measured from the toe = H = 2.3 m

parallel submergence ratio = PSR = 0.01

depth of the water surface measured from the top of clay layer = h_w = 0.00 m

dry unit weight of the cover soil = γ_{moist} =	17.3	kN/m^3
saturated unit weight of the cover soil = $\gamma_{sat'd}$ =	18.9	kN/m^3
unit weight of water = γ_w =	9.81	kN/m^3
friction angle of the cover soil = ϕ =	30.0	° = 0.52 (rad.)
critical interface = δ =	23.1	° = 0.40 (rad.)

Note: numbers in boxes are input values

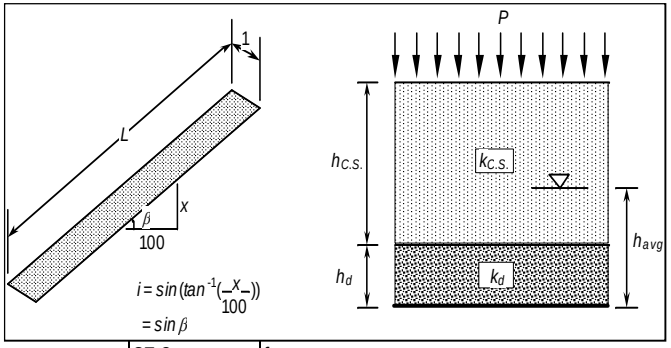
numbers in Italics are calculated values

Constructed by Te-Yang Soong

Figure 2

Calculation of stability under seepage condition

Calculation of DLC and PSR



	27.9	ft			
L =	8.5	m	i =	0.2740	
β =	15.9	°	$L(\cos\beta)$ =	8.17	m
			x =	2.33	m
$h_{C.S.}$ =	457.2	mm	$h_{C.S.}$ =	0.5	m
h_d or t_{GS} =	5.0	mm	h_d or t_{GS} =	0.01	m
			$h_{C.S.} + h_d$ =	0.46	m
$k_{C.S.}$ =	5.00E-04	cm/s	$k_{C.S.}$ =	5.0E-06	m/s
k_d or k_{GS} =	2.00E+00	cm/s	k_d or k_{GS} =	2.0E-02	m/s
P =	14.20	mm/hr	P (RC) =	2.1	mm/hr
RC =	0.15		Actual runoff =	2.13	mm/hr
			PERC =	12.07	mm/h
			$FLUX_{actual}$ =	0.099	m^3/hr
			$FLUX_{allow}$ =	0.099	m^3/hr

Results:

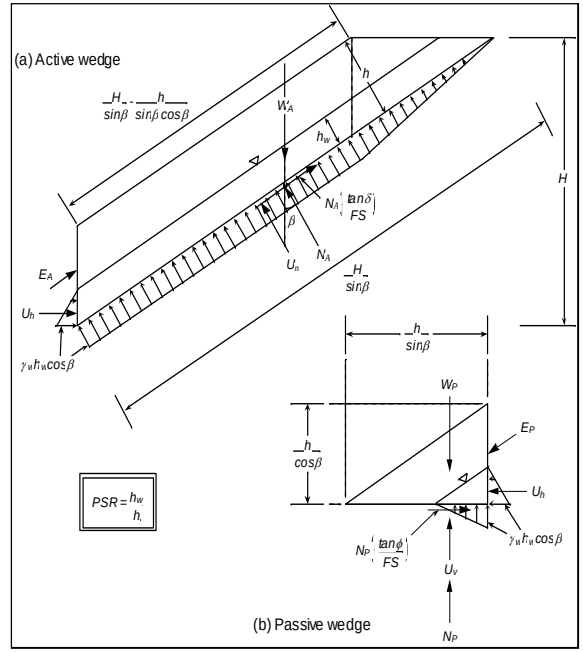
DLC	1.000
PSR	0.012
FS	1.693

DLC = 1.0000

q = 2.7E-05 m^3/sec

h_{avg} = 0.01 m

PSR = 0.012



Calculation of FS

Active Wedge:

W_A =	60.9968	kN
U_n =	0.43157	kN
U_h =	0.00014	kN
N_A =	58.2316	kN

Passive Wedge:

W_P =	7.01355	kN
U_V =	0.0005	kN

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

where a = 16.1
b = -29.5
c = 3.9

FS= 1.693

thickness of cover soil = h =	0.46	m		
length of slope measured along the top of clay layer = L =	8	m		
soil slope angle along top of clay = β =	15.9	°	= 0.28	(rad.)
vertical height of the slope measured from the toe = H =	2.3	m		
parallel submergence ratio = PSR =	0.01			
depth of the water surface measured from the top of clay layer = h_w =	0.01	m		
dry unit weight of the cover soil = γ_{moist} =	17.3	kN/m^3		
saturated unit weight of the cover soil = $\gamma_{sat'd}$ =	18.9	kN/m^3		
unit weight of water = γ_w =	9.81	kN/m^3		
friction angle of the cover soil = ϕ =	30.0	°	= 0.52	(rad.)
critical interface = δ =	23.1	°	= 0.40	(rad.)

Note: numbers in boxes are input values

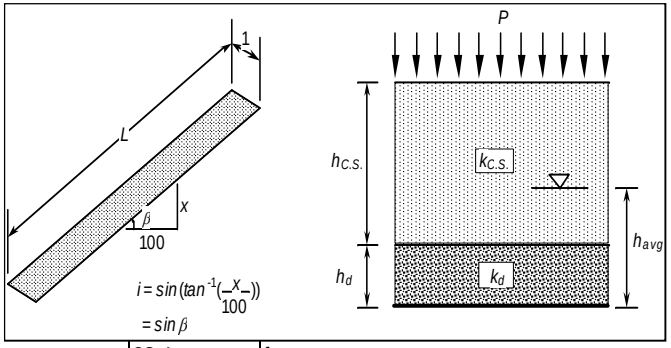
numbers in Italics are calculated values

Constructed by Te-Yang Soong

Figure 3

Calculation of stability under seepage condition

Calculation of DLC and PSR



	93.4	ft			
L =	28.5	m	i =	0.2740	
β =	15.9	°	$L(\cos\beta)$ =	27.39	m
			x =	7.80	m
$h_{C.S.}$ =	457.2	mm	$h_{C.S.}$ =	0.5	m
h_d or t_{GS} =	5.0	mm	h_d or t_{GS} =	0.01	m
			$h_{C.S.} + h_d$ =	0.46	m
$k_{C.S.}$ =	1.00E-04	cm/s	$k_{C.S.}$ =	1.0E-06	m/s
k_d or k_{GS} =	2.00E+00	cm/s	k_d or k_{GS} =	2.0E-02	m/s
P =	14.20	mm/hr	P (RC) =	2.1	mm/hr
RC =	0.15		Actual runoff =	10.60	mm/hr
			PERC =	3.60	mm/h
			$FLUX_{actual}$ =	0.099	m^3/hr
			$FLUX_{allow}$ =	0.099	m^3/hr

Results:

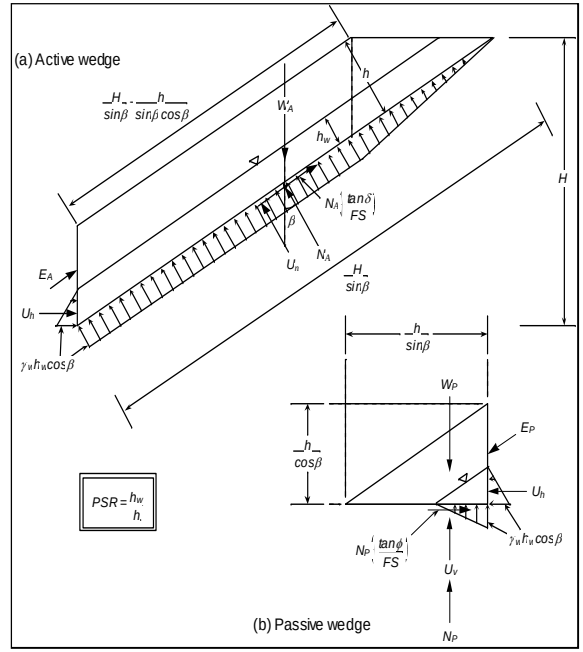
DLC	1.000
PSR	0.011
FS	1.545

DLC = 1.0003

q = 2.7E-05 m^3/sec

h_{avg} = 0.00 m

PSR = 0.011



Calculation of FS

Active Wedge:

W_A =	220.924	kN
U_n =	1.34257	kN
U_h =	0.00012	kN
N_A =	211.129	kN

Passive Wedge:

W_P =	7.01353	kN
U_V =	0.00043	kN

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

where a = 58.2
b = -99.2
c = 14.2

FS= 1.545

thickness of cover soil = h = 0.46 m
length of slope measured along the top of clay layer = L = 28 m
soil slope angle along top of clay = β = 15.9 ° = 0.28 (rad.)
vertical height of the slope measured from the toe = H = 7.8 m
parallel submergence ratio = PSR = 0.01
depth of the water surface measured from the top of clay layer = h_w = 0.00 m

dry unit weight of the cover soil = γ_{moist} =	17.3	kN/m^3
saturated unit weight of the cover soil = $\gamma_{sat'd}$ =	18.9	kN/m^3
unit weight of water = γ_w =	9.81	kN/m^3
friction angle of the cover soil = ϕ =	30.0	° = 0.52 (rad.)
critical interface = δ =	23.1	° = 0.40 (rad.)

Note: numbers in boxes are input values

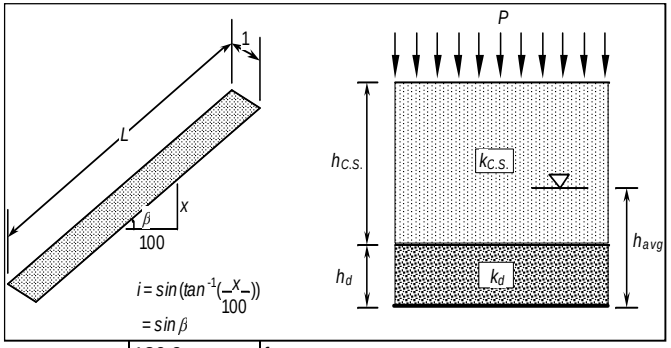
numbers in Italics are calculated values

Constructed by Te-Yang Soong

Figure 4

Calculation of stability under seepage condition

Calculation of DLC and PSR



	186.9	ft			
L =	57.0	m	i =	0.2740	
β =	15.9	°	$L(\cos\beta)$ =	54.79	m
			x =	15.61	m
$h_{C.S.}$ =	457.2	mm	$h_{C.S.}$ =	0.5	m
h_d or t_{GS} =	5.0	mm	h_d or t_{GS} =	0.01	m
			$h_{C.S.} + h_d$ =	0.46	m
$k_{C.S.}$ =	5.00E-05	cm/s	$k_{C.S.}$ =	5.0E-07	m/s
k_d or k_{GS} =	2.00E+00	cm/s	k_d or k_{GS} =	2.0E-02	m/s
P =	14.20	mm/hr	P (RC) =	2.1	mm/hr
RC =	0.15		Actual runoff =	12.40	mm/hr
			PERC =	1.80	mm/h
			$FLUX_{actual}$ =	0.099	m^3/hr
			$FLUX_{allow}$ =	0.099	m^3/hr

Results:

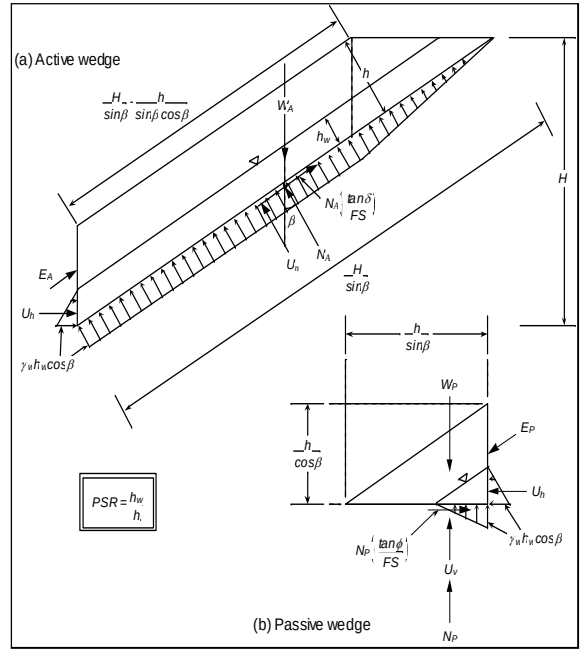
DLC	1.000
PSR	0.011
FS	1.516

DLC = 1.0000

q = 2.7E-05 m^3/sec

h_{avg} = 0.00 m

PSR = 0.011



Calculation of FS

Active Wedge:

W_A =	448.984	kN
U_n =	2.68703	kN
U_h =	0.00012	kN
N_A =	429.12	kN

Passive Wedge:

W_P =	7.01353	kN
U_V =	0.00043	kN

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

where a = 118.3
b = -198.5
c = 29.0

FS= 1.516

thickness of cover soil = h =	0.46	m			
length of slope measured along the top of clay layer = L =	57	m			
soil slope angle along top of clay = β =	15.9	°	= 0.28	(rad.)	
vertical height of the slope measured from the toe = H =	15.6	m			
parallel submergence ratio = PSR =	0.01				
depth of the water surface measured from the top of clay layer = h_w =	0.00	m			
dry unit weight of the cover soil = γ_{moist} =	17.3	kN/m^3			
saturated unit weight of the cover soil = $\gamma_{sat'd}$ =	18.9	kN/m^3			
unit weight of water = γ_w =	9.81	kN/m^3			
friction angle of the cover soil = ϕ =	30.0	°	= 0.52	(rad.)	
critical interface = δ =	23.1	°	= 0.40	(rad.)	

Note: numbers in boxes are input values

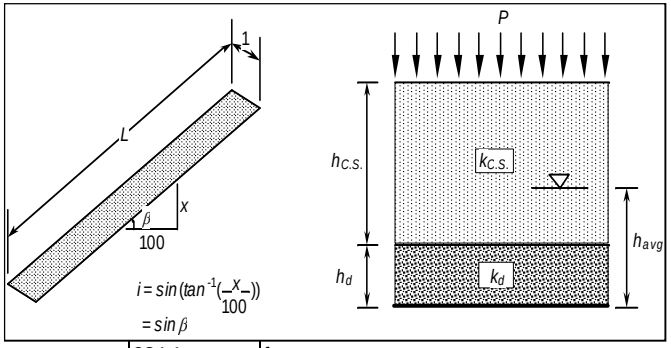
numbers in Italics are calculated values

Constructed by Te-Yang Soong

Figure 5

Calculation of stability under seepage condition

Calculation of DLC and PSR



	934.1	ft			
L =	284.7	m	i =	0.2740	
β =	15.9	°	$L(\cos\beta)$ =	273.83	m
			x =	78.00	m
$h_{C.S.}$ =	457.2	mm	$h_{C.S.}$ =	0.5	m
h_d or t_{GS} =	5.0	mm	h_d or t_{GS} =	0.01	m
			$h_{C.S.} + h_d$ =	0.46	m
$k_{C.S.}$ =	1.00E-05	cm/s	$k_{C.S.}$ =	1.0E-07	m/s
k_d or k_{GS} =	2.00E+00	cm/s	k_d or k_{GS} =	2.0E-02	m/s
P =	14.20	mm/hr	P (RC) =	2.1	mm/hr
RC =	0.15		Actual runoff =	13.84	mm/hr
			PERC =	0.36	mm/h
			$FLUX_{actual}$ =	0.099	m^3/hr
			$FLUX_{allow}$ =	0.099	m^3/hr

Results:

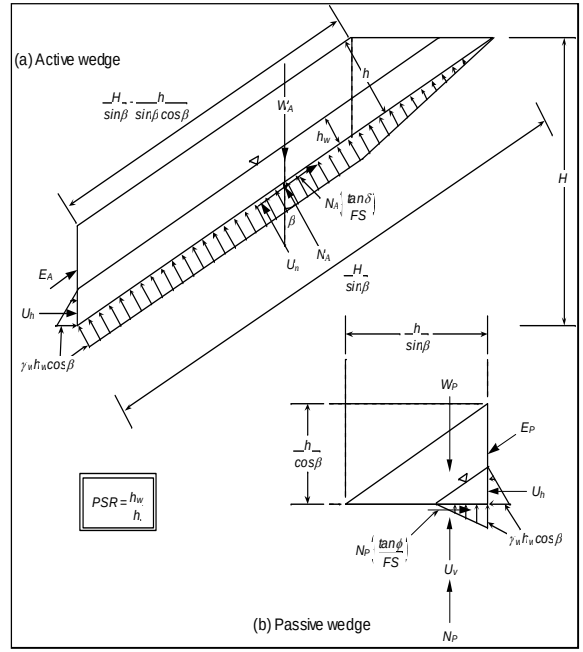
DLC	1.000
PSR	0.011
FS	1.494

DLC = 1.0005

q = 2.7E-05 m^3/sec

h_{avg} = 0.00 m

PSR = 0.011



thickness of cover soil = h = 0.46 m

length of slope measured along the top of clay layer = L = 285 m

soil slope angle along top of clay = β = 15.9 ° = 0.28 (rad.)

vertical height of the slope measured from the toe = H = 78.0 m

parallel submergence ratio = PSR = 0.01

depth of the water surface measured from the top of clay layer = h_w = 0.00 m

dry unit weight of the cover soil = γ_{moist} =	17.3	kN/m^3		
saturated unit weight of the cover soil = $\gamma_{sat'd}$ =	18.9	kN/m^3		
unit weight of water = γ_w =	9.81	kN/m^3		
friction angle of the cover soil = ϕ =	30.0	°	= 0.52	(rad.)
critical interface = δ =	23.1	°	= 0.40	(rad.)

Calculation of FS

Active Wedge:

W_A = 2271.94 kN
U_n = 13.4247 kN
U_h = 0.00012 kN
N_A = 2171.59 kN

Passive Wedge:

W_P = 7.01353 kN
U_V = 0.00043 kN

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

where a = 598.6
b = -992.3
c = 146.5

FS= 1.494

Note: numbers in boxes are input values

numbers in Italics are calculated values

Constructed by Te-Yang Soong

Figure 6

ATTACHMENT 1

RUNOFF COEFFICIENT REFERENCE

10.2.1 Thornthwaite method

The earliest, comprehensive method for water balance analysis was developed by Thornthwaite and Mather (1957). Fenn *et al.* (1975) developed for the US Environmental Protection Agency (EPA) a water balance method for predicting leachate generation for solid waste disposal sites based on the Thornthwaite method, proposing runoff coefficients for landfills and moisture storage values for municipal waste. The water balance method employs average monthly values of precipitation and other climatic parameters. To determine monthly infiltration (*IN*) into the cover, one subtracts monthly runoff (*R*) from monthly precipitation (*P*).

$$IN = P - R \tag{10.1}$$

Runoff can be calculated from precipitation, as follows

$$R = CP \tag{10.2}$$

where C is a runoff coefficient that can be estimated from the guidance provided by Fenn *et al.* (1975):

description of the grass-covered soil	slope of ground surface	runoff coefficient (C)
sandy soil	flat (<2%)	0.05–0.10
	mild (2 – 7%)	0.10–0.15
	steep (>7%)	0.15–0.20
clayey soil	flat (<2%)	0.13–0.17
	mild (2 – 7%)	0.18–0.22
	steep (>7%)	0.25–0.35

Potential evapotranspiration (*PET*), which depends on mean temperature, heat index, and hours of sunlight, can be calculated from tables provided by Thornthwaite and Mather (1957). The cumulative monthly infiltration minus potential evapotranspiration (*IN* – *PET*) is calculated. A negative number for *IN* – *PET* indicates that the cover has a tendency to dry out; a positive value indicates that there is a tendency for the cover soil to become wetter. If *IN* – *PET* is negative, water may evapotranspire from the cover soil, but if the soil is already dry, no further drying will occur. The amount of drying depends not only on *IN* – *PET* but also on the water content of the soil.

If *IN* – *PET* is positive, water may be stored in the cover soil (which would produce an increase in water content). However, if the water content is already very high, the soil can store no additional water and water will percolate downward through the cover soil. The field capacity of the soil is the maximum water content that a soil can attain without draining water by gravity. Field capacity can be determined by

REFERENCE: "GEOTECHNICAL PRACTICE FOR WASTE DISPOSAL", DANIEL, DAVID E., PG 216.

ATTACHMENT 2

TYPICAL GEOCOMPOSITE PROPERTIES

PRODUCT DATA SHEET

GSE FabriNet Geocomposite

GSE FabriNet geocomposite consists of a 200 mil thick GSE HyperNet geonet heat-laminated on one or both sides with a GSE nonwoven needle-punched geotextile. The geotextile is available in mass per unit area range of 6 oz/yd^2 to 16 oz/yd^2. The geocomposite is designed and formulated to perform drainage function under a range of anticipated site loads, gradients and boundary conditions.

AT THE CORE:
A 200 mil thick HyperNet geonet heat-laminated on one or both sides with a nonwoven needlepunched geotextile.

Product Specifications

Tested Property	Test Method	Frequency	Minimum Average Roll Value		
Geocomposite			6 oz/yd^2	8 oz/yd^2	10 oz/yd^2
Transmissivity[2], gal/min/ft, (m^2/sec) Double-Sided Composite Single-Sided Composite	ASTM D 4716	1/540,000 ft^2	 0.5 (1x10^{-4}) 4.8 (1x10^{-3})	 0.5 (1x10^{-4}) 4.8 (1x10^{-3})	 0.4 (9x10^{-5}) 4.3 (9x10^{-4})
Ply Adhesion, lb/in	ASTM D 7005	1/50,000 ft^2	1.0	1.0	1.0
Geonet Core[3] – GSE HyperNet					
Transmissivity[2], gal/min/ft (m^2/sec)	ASTM D 4716		9.6 (2 x 10^{-3})	9.6 (2 x 10^{-3})	9.6 (2 x 10^{-3})
Density, g/cm^3	ASTM D 1505	1/50,000 ft^2	0.94	0.94	0.94
Tensile Strength (MD), lb/in	ASTM D 5035/7179	1/50,000 ft^2	45	45	45
Carbon Black Content, %	ASTM D 1603[6]/4218	1/50,000 ft^2	2.0	2.0	2.0
Geotextile[3,4]					
Mass per Unit Area, oz/yd^2	ASTM D 5261	1/90,000 ft^2	6	8	10
Grab Tensile, lb	ASTM D 4632	1/90,000 ft^2	160	220	260
Puncture Strength, lb	ASTM D 4833	1/90,000 ft^2	90	120	165
AOS, US sieve[1], (mm)	ASTM D 4751	1/540,000 ft^2	70 (0.212)	80 (0.180)	100 (0.150)
Permittivity, sec^{-1}	ASTM D 4491	1/540,000 ft^2	1.5	1.3	1.0
Flow Rate, gpm/ft^2	ASTM D 4491	1/540,000 ft^2	110	95	75
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	per formulation	70	70	70
NOMINAL ROLL DIMENSIONS					
Geonet Core Thickness, mil	ASTM D 5199	1/50,000 ft^2	200	200	200
Roll Width[5], ft			14.5	14.5	14.5
Roll Length[5], ft	Double-Sided Composite Single-Sided Composite		270 300	260 300	230 290
Roll Area, ft^2	Double-Sided Composite Single-Sided Composite		3,915 4,350	3,770 4,350	3,335 4,205

[Product specifications continued on back]

[*]

AT THE CORE:

A 200 mil thick GSE HyperNet geonet heat-laminated on one or both sides with a nonwoven needlepunched geotextile.

Product Specifications [continued]

NOTES:

- (1)AOS in mm is a maximum average roll value.
- (2)Gradient of 0.1, normal load of 10,000 psf, water at 70˚F between steel plates for 15 minutes. Contact GSE for performance transmissivity value for use in design.
- (3)Component properties prior to lamination.
- (4)Refer to geotextile product data sheet for additional specifications.
- (5)Roll widths and lengths have a tolerance of ±1%.
- (6)Modified.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL™

[DURABILITY RUNS DEEP] For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

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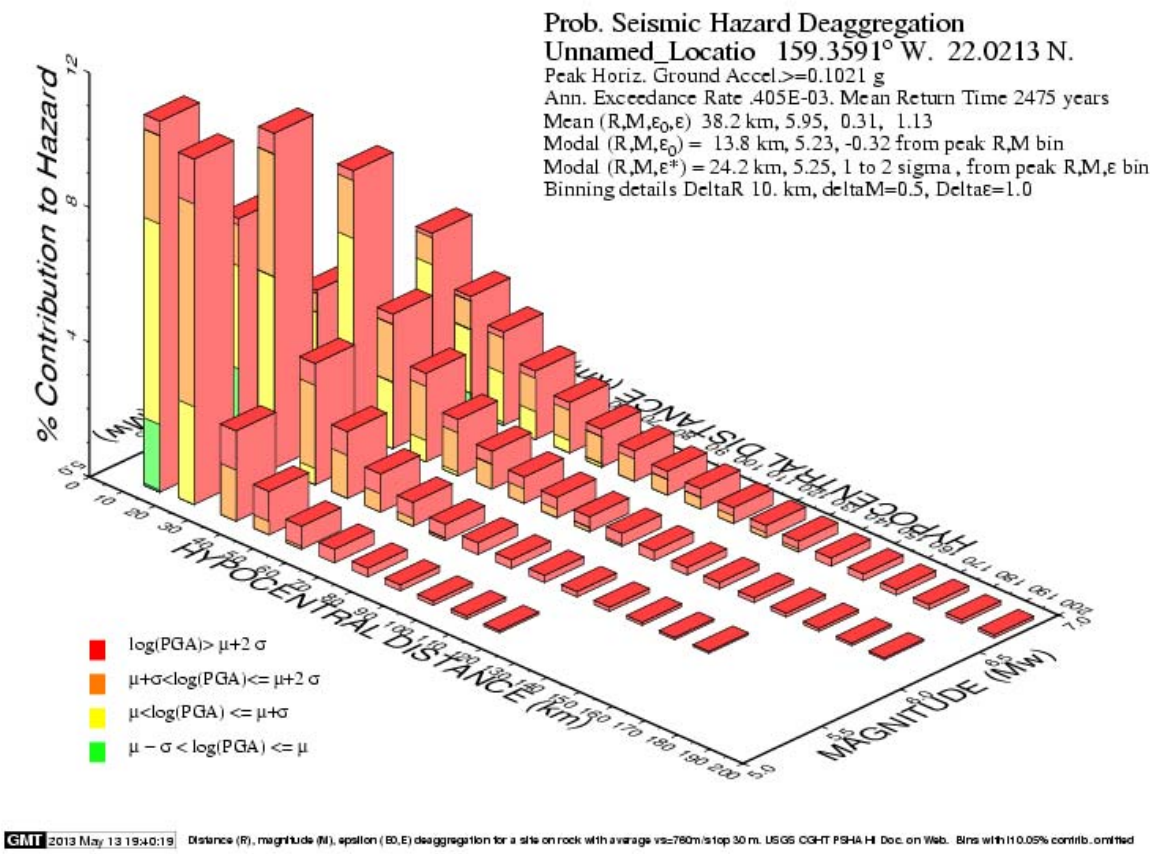
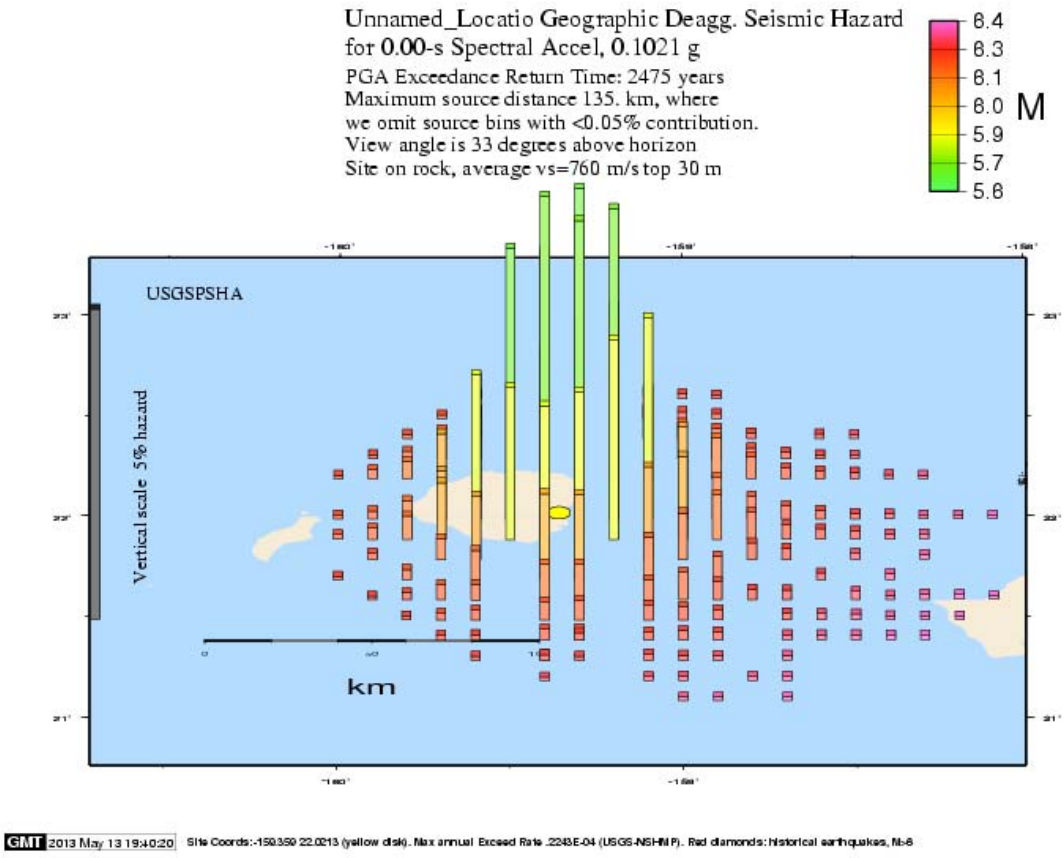
ATTACHMENT 3

SEISMIC HAZARD DEAGGREGATION FIGURES



Source: USGS Seismic Deaggregation website
(http://eqint.cr.usgs.gov/deaggint/1996/index.php?PHPSESSID=c352aa4d77s5kn25jmtrpbu0l7)



Source: USGS Seismic Deaggregation website (http://eqint.cr.usgs.gov/deaggint/1996/index.php?PHPSESSID=c352aa4d77s5kn25jmtrpbu0l7)

Appendix C:
Surface Water Management Calculations

Appendix C.1
Surface Water Runoff Parameters and Design Storm Requirements

SURFACE WATER RUNOFF PARAMETERS AND DESIGN STORM REQUIREMENTS

Objective

Determine rainfall value and curve number to be used as input in SEDCAD+. The curve number is used to determine how much precipitation becomes runoff. The curve number is primarily a function of soil type, cover type and treatment, and hydrologic condition. SEDCAD+ uses SCS methods to compute runoff volume.

Design Criteria and Assumptions

1. SEDCAD+, a computer program, was used to design and evaluate the surface water management system for the Ma'alo Landfill. SEDCAD+ is a program developed at the University of Kentucky to assist in the design and evaluation of surface water management system components.

   The program is capable of computing peak flow, calculating runoff volume, sizing channels and culverts, and computing the hydraulic performance of sedimentation basins. SEDCAD+ utilizes the following methods within the program:
   - SCS Upland Curve Method for calculating time of concentration.
   - Muskingum's Method for routing between structures.
   - SCS Technical Release - 55 (TR-55) parameter for runoff volume.

   Within this appendix are calculations for each element of the surface water management system along with SEDCAD+ program input/output.

2. Surface water run-on from nearby areas will be routed around the site and kept separate from surface water run-off from landfill areas. Surface water run-off from landfill areas will be managed in a surface water sedimentation basin.

3. Evaluate the following storm events for surface water management structures and sedimentation basin:
   a. 100-year, 1-hour storm event.
   b. 25-year, 24-hour storm event.
   c. 100-year, 24-hour storm event.

4. Determine peak rainfall values as recommended in the Storm Water Runoff System Manual, July 2001, Department of Public Works, County of Kauai. Peak rainfall values are based on the attached data from Technical Paper No. 43, Rainfall-Frequency Atlas of the Hawaiian Islands.

5. Use SCS storm distribution Type I, per attached page.

6. Determine curve number, assuming final cover conditions are pasture, grassland, or range, poor condition, and hydrologic soil group B. Assume impervious areas, paved and open ditches, represents the leachate holding tank and entrance areas. Determine curve number from tables provided in SCS TR-55. See attached table for curve number determination.

Conclusions

1. A 100-year, 1-hour storm event yields 4.9 inches of rainfall.
2. A 25-year, 24-hour storm event yields 13.4 inches of rainfall.
3. A 100-year, 24-hour storm event yields 17.5 inches of rainfall.
4. The curve number is 79 for the landfill final cover condition.
5. The curve number is 89 for the leachate holding tank and entrance areas.

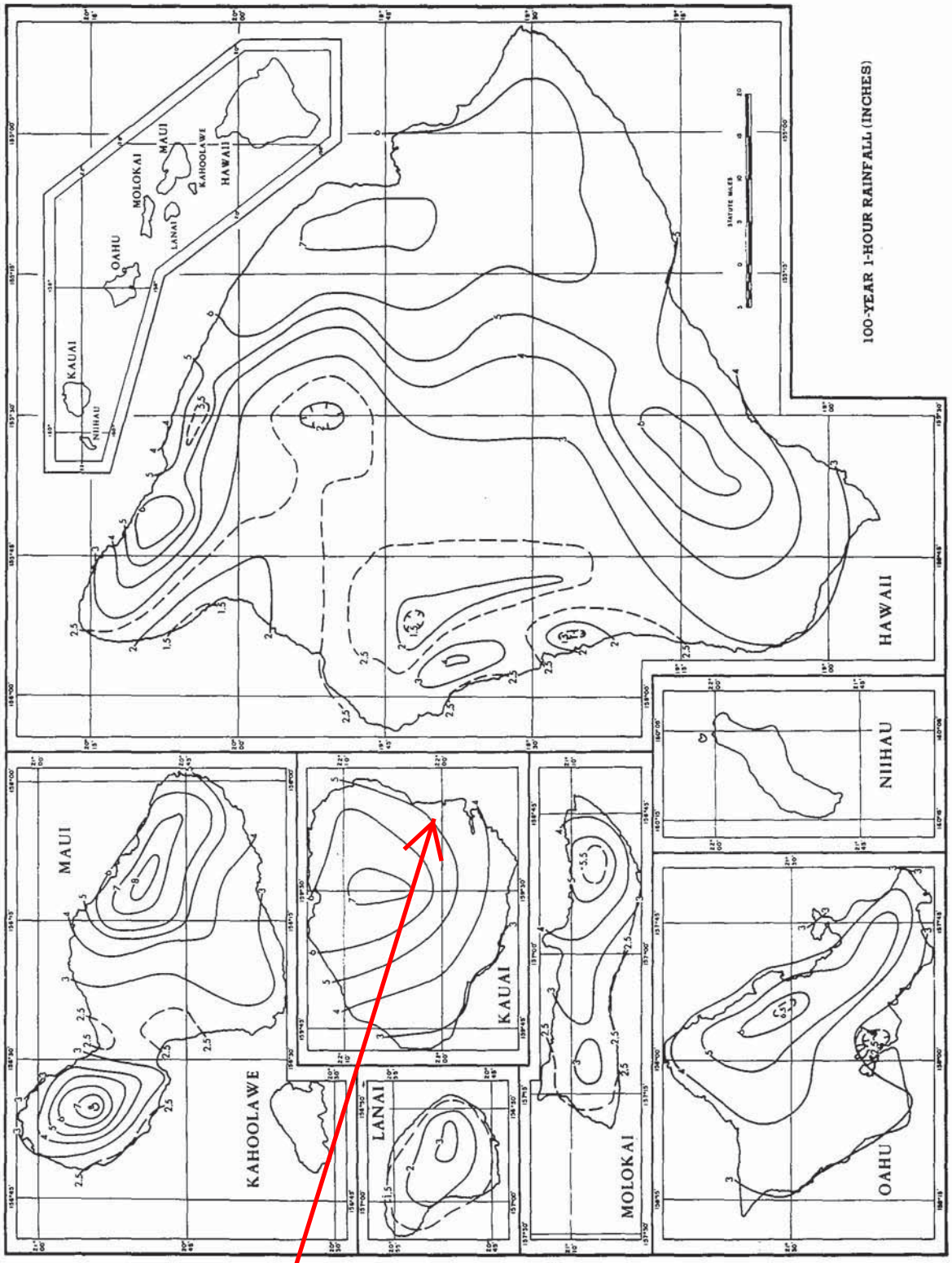


FIGURE 21.—100-yr. 1-hr. rainfall (in.)

Approximate Site Location
(4.9 inches)

Source: Technical Paper No. 43, Rainfall-Frequency Atlas of the Hawaiian Islands, 1963

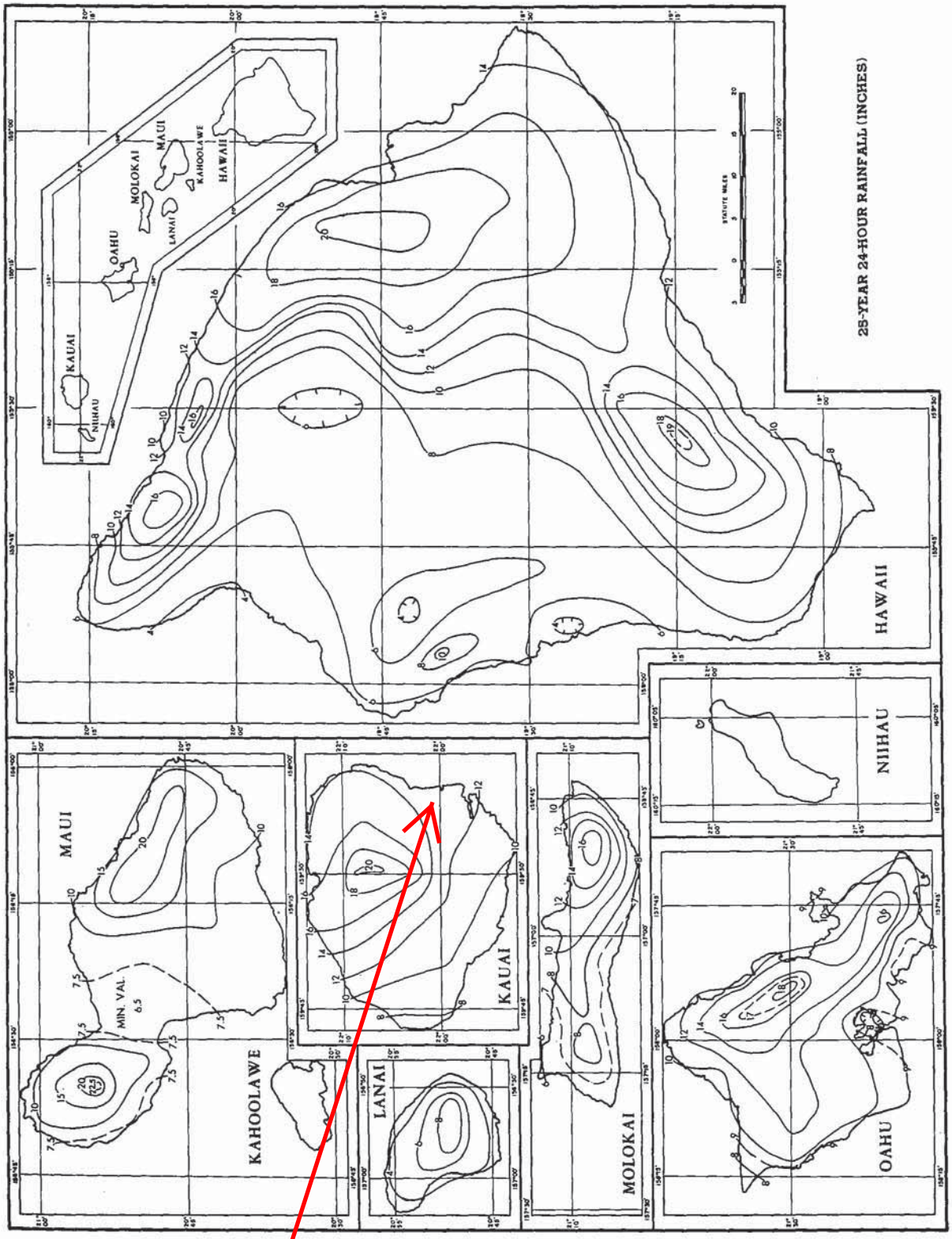
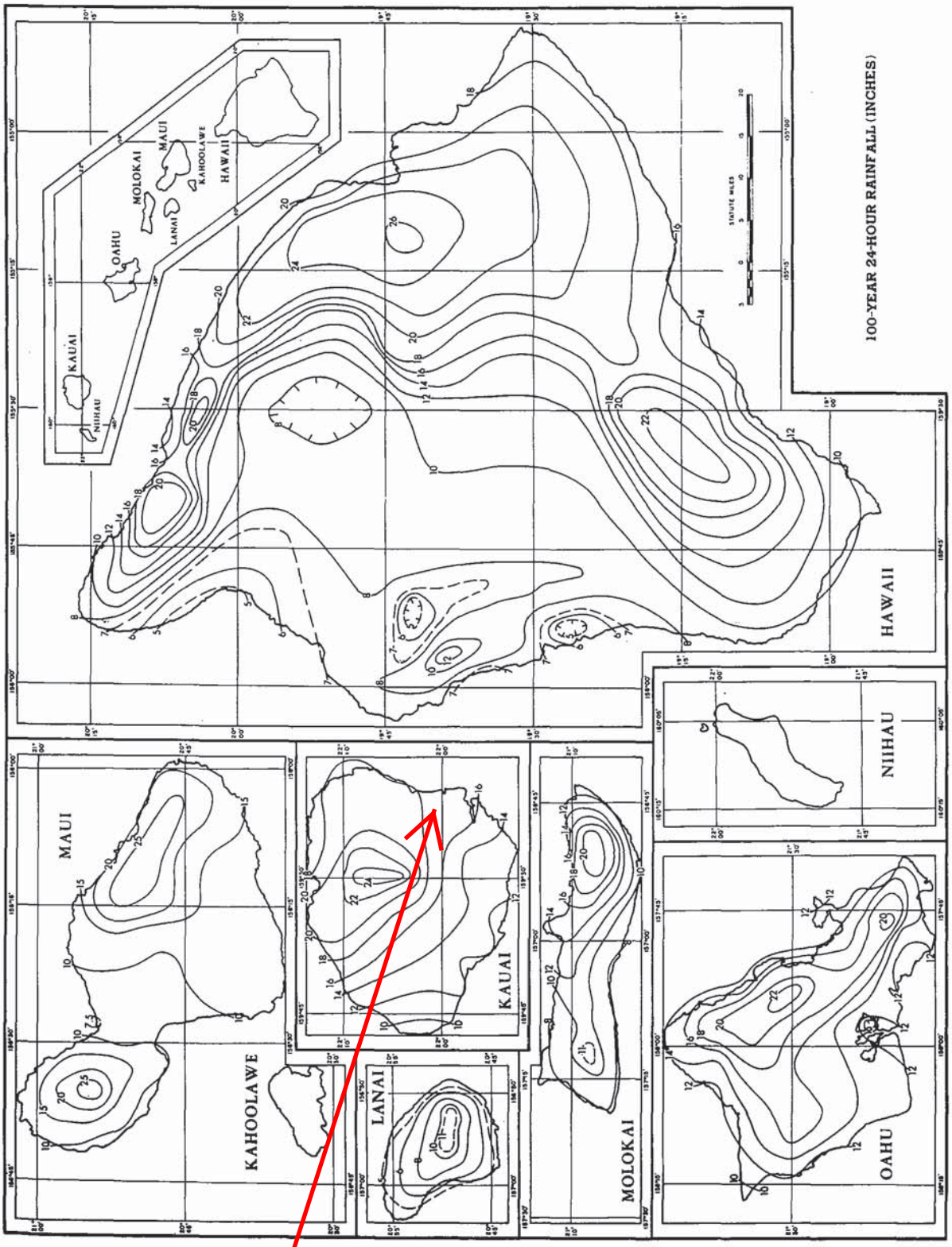


FIGURE 54.—25-yr. 24-hr. rainfall (in.)

Source: Technical Paper No. 43, Rainfall-Frequency Atlas of the Hawaiian Islands, 1963

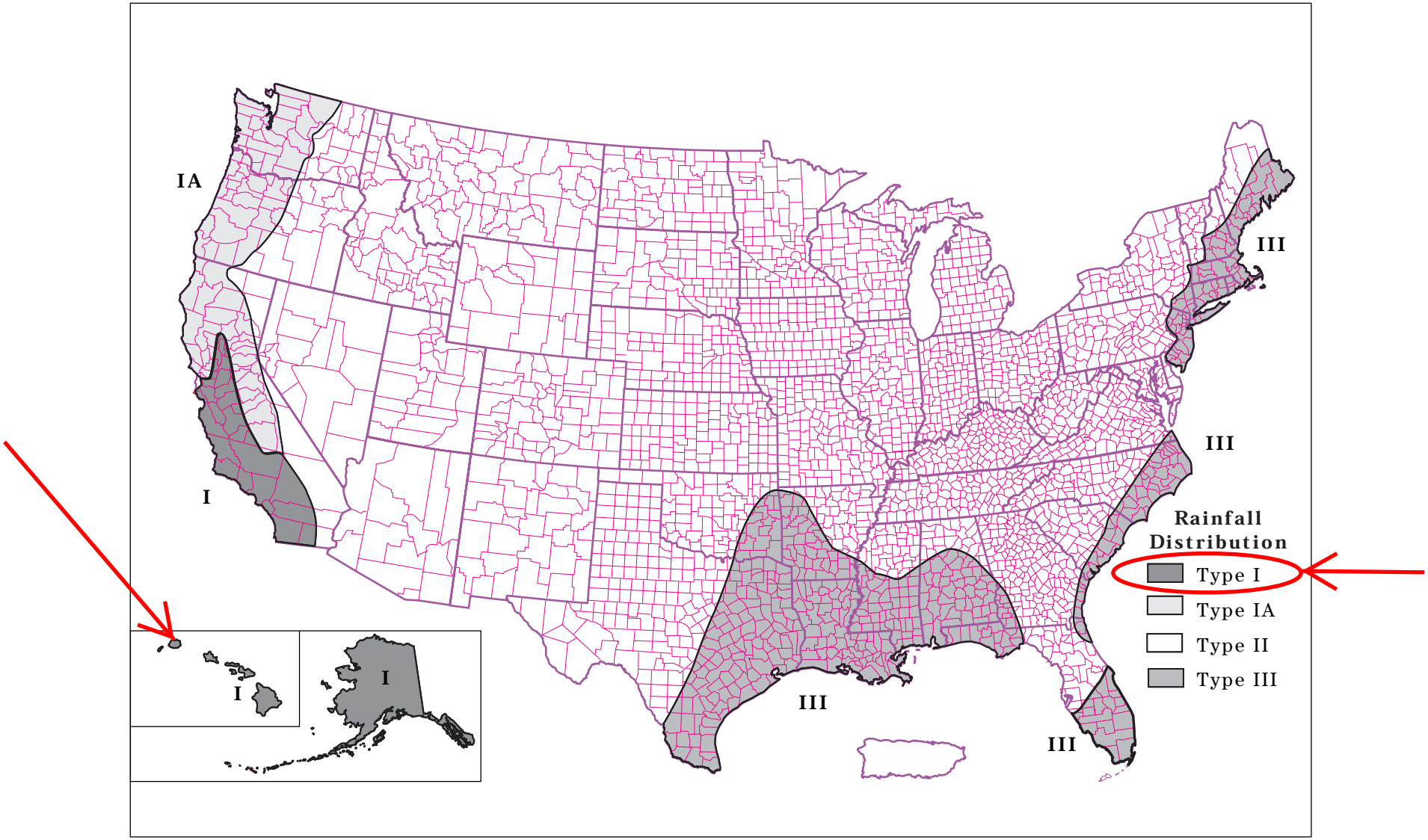
Approximate Site Location
(13.4 inches)



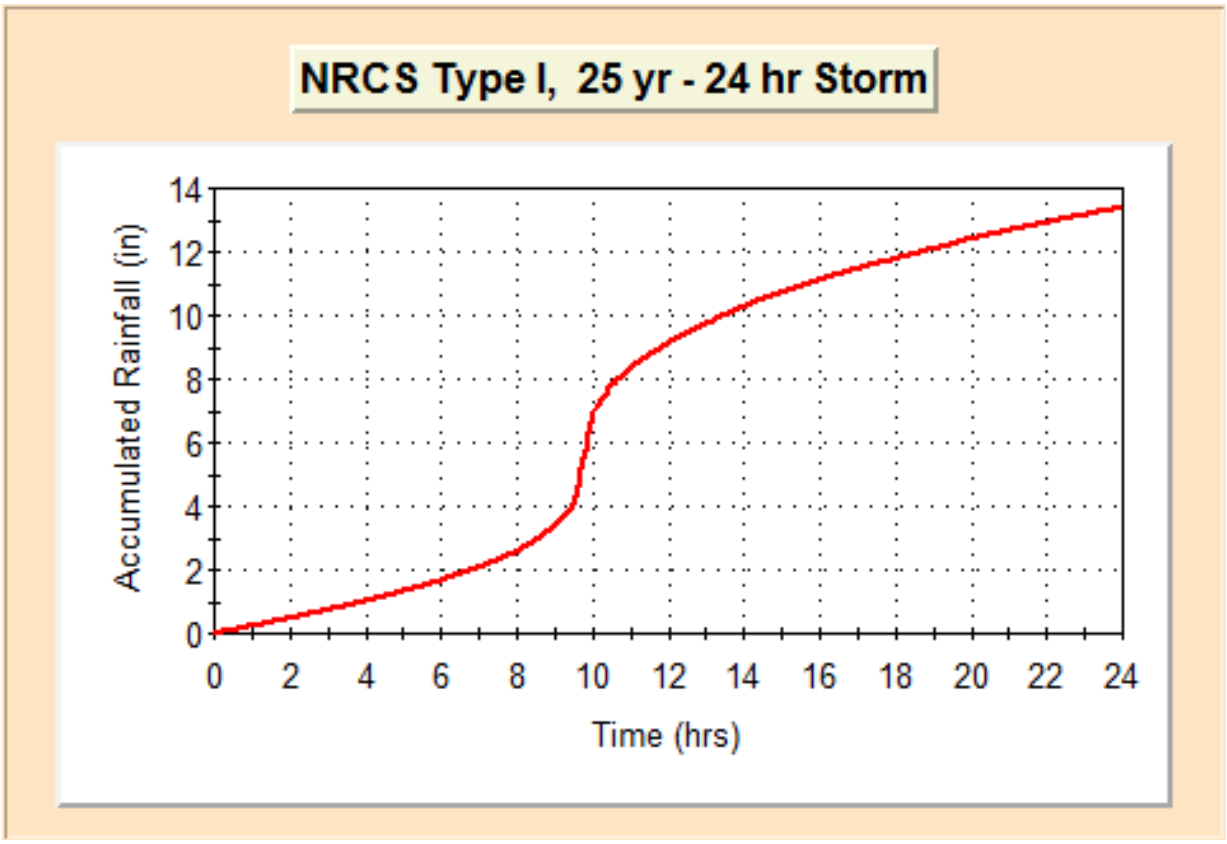
Approximate Site Location
(17.5 inches)

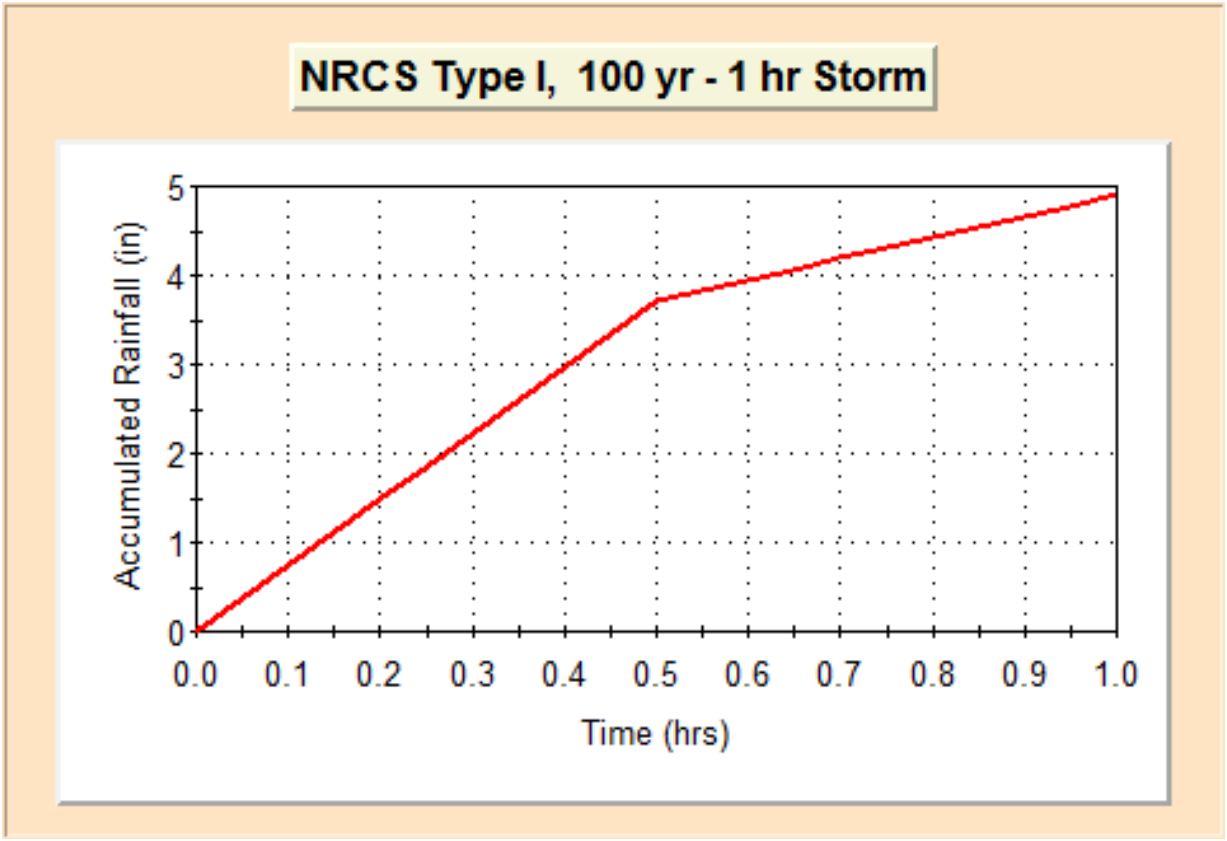
FIGURE 56.—100-yr. 24-hr. rainfall (in.)

Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions

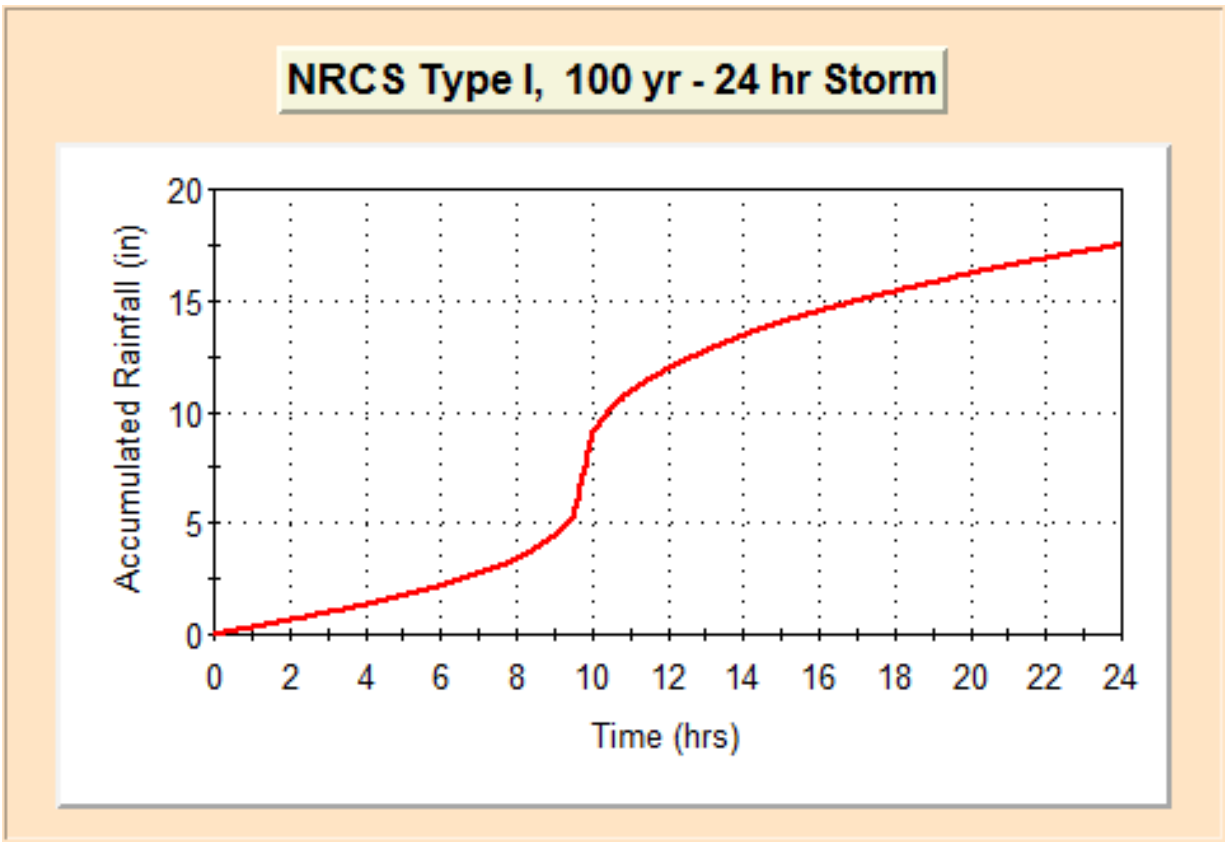


Source: "PPI Handbook of Polyethylene Pipe", downloaded May, 2006
www.plasticpipe.org/general/ppi_handbook.php



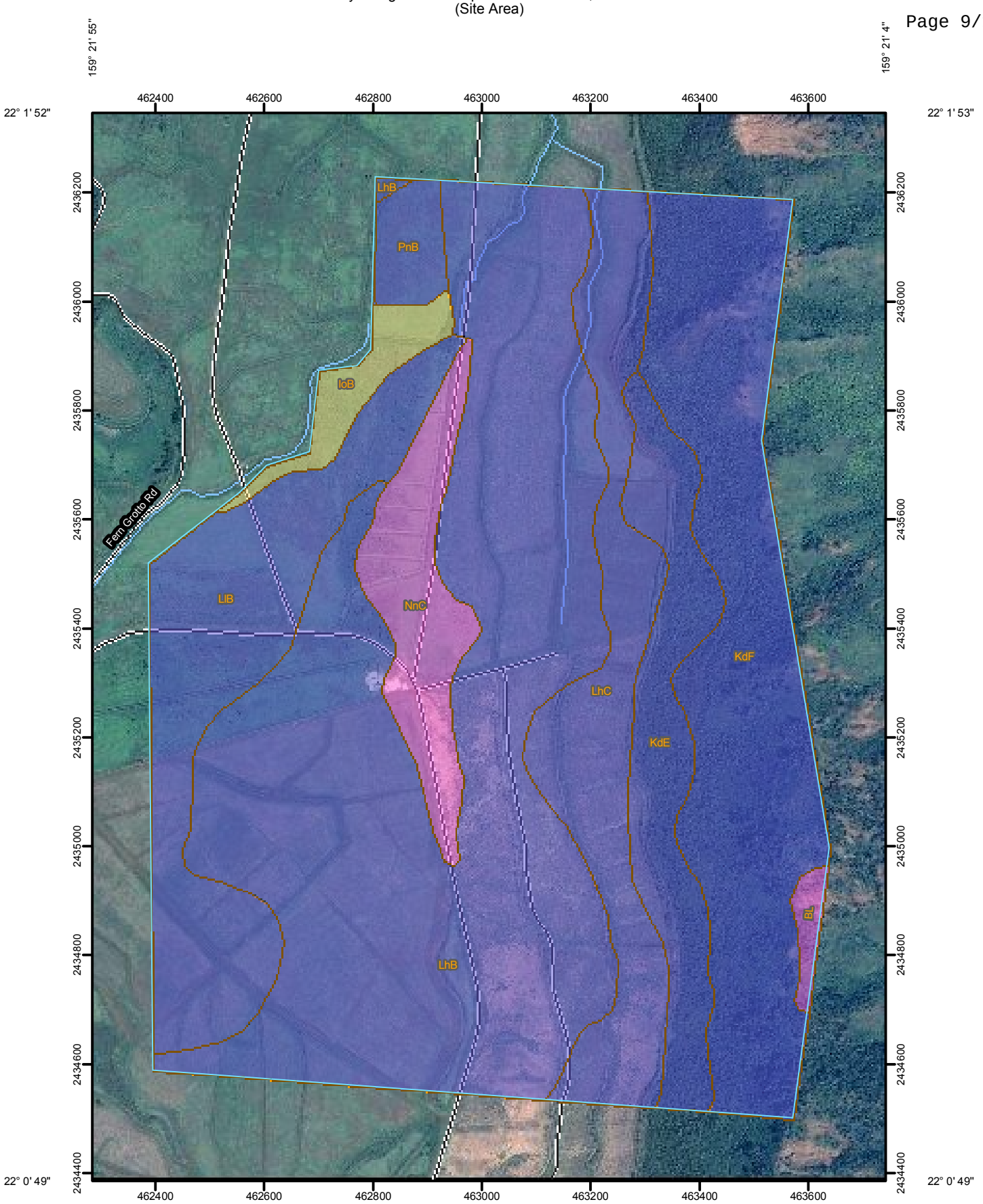


Source: SEDCAD+ 4 for Windows.



Source: SEDCAD+ 4 for Windows.

Hydrologic Soil Group—Island of Kauai, Hawaii
(Site Area)



Map Scale: 1:9,360 if printed on A size (8.5" x 11") sheet.

N

Meters
0 50 100 200 300

Feet
0 350 700 1,400 2,100

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Political Features

Cities

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

MAP INFORMATION

Map Scale: 1:9,360 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 4N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Island of Kauai, Hawaii
Survey Area Data: Version 7, Sep 27, 2012

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Island of Kauai, Hawaii (HI960)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BL	Badland	D	2.6	0.6%
IoB	Ioleau silty clay loam, 2 to 6 percent slopes	C	8.3	1.9%
KdE	Kalapa silty clay, 20 to 40 percent slopes	B	31.7	7.3%
KdF	Kalapa silty clay, 40 to 70 percent slopes	B	82.0	18.8%
LhB	Lihue silty clay, 0 to 8 percent slopes	B	180.5	41.4%
LhC	Lihue silty clay, 8 to 15 percent slopes	B	46.2	10.6%
LlB	Lihue gravelly silty clay, 0 to 8 percent slopes	B	55.1	12.6%
NnC	Nonopahu clay, 2 to 10 percent slopes	D	23.1	5.3%
PnB	Puhi silty clay loam, 3 to 8 percent slopes	B	6.8	1.6%
Totals for Area of Interest			**436.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Table 2-2c Runoff curve numbers for other agricultural lands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.
2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.
3 *Poor*: <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
4 Actual curve number is less than 30; use CN = 30 for runoff computations.
5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.
6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Source: Urban Hydrology for Small Watersheds, Technical Release 55, June 1986, United States Department of Agriculture.

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]	77	86	91	94	
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Source: Urban Hydrology for Small Watersheds, Technical Release 55, June 1986, United States Department of Agriculture.

Appendix C.2
Surface Water Sedimentation Basin Analysis

SURFACE WATER SEDIMENTATION BASIN ANALYSIS

Objective

Evaluate the post-development surface water flow conditions, and design the surface water sedimentation basins and determine the design flows for each surface water management structure.

Design Criteria and Assumptions

1. Surface water sedimentation basins will be used to detain and discharge surface water run-off from the landfill footprint.

2. Assume entire landfill has final cover. The basin and ditch system is designed to comply with the requirements of the Hawaii Administrative Rules and Federal Regulations. The County of Kauai Department of Public Works Stormwater Runoff System Manual is utilized in the design as appropriate.

3. The basin is designed to manage the design storm events. The basin and ditch will empty through a discharge structure in less than 48 hours after the conclusion of the storm event.

4. Figure 1 shows the post-development surface water management system network with subbasin drainage areas and structure labels for final elevations.

5. The results from the 100-year, 1-hour and 25-year, 24-hour storms are used in the design of the surface water management structures. The 100-year, 24-hour storm is used only to evaluate the performance of the South Sedimentation Basin emergency spillway.

Calculations

1. SEDCAD+ was used to determine the surface water flows and the stage-storage-discharge relationships for the basin. SEDCAD+ output for pre-development flows are provided herein in Attachments 1A and 1B, the output for the post-development flows are provided herein in Attachments 2A, 2B, and 2C. The basin was analyzed for the 100-year, 1-hour, the 25-year, 24-hour storm, and the 100-yr, 24-hr storm events. Tables 2 and 3 summarize the results from the SEDCAD+ analyses.

Conclusions

1. The proposed Phase 1 development, when compared to pre-development surface water flows for the design storm events, will not increase the peak run-on to downstream properties.

2. The proposed South Sedimentation Basin will perform as designed. The 25-year, 24-hour storm event is handled through the principal spillways. The 100-year, 24-hour storm event is managed through the emergency spillway and maintains more than 1 foot of freeboard.

3. The South South Sedimentation Basin outlet structures are detailed in the drawings.

4. The following Tables 1 through 4 summarize the results from the SEDCAD+ analyses and compare the results.

TABLE 1 – PRE-DEVELOPMENT SURFACE WATER FLOWS

Pre-Development SEDCAD Structure No.	Description	Pre-Development Surface Water Flow (cfs)	
		100-yr, 1-hr Storm	25-yr, 24-hr Storm
(Structure 2 flow – Structure 3 flow)	Flow To South (not passing through Existing Culvert A)	192.65	242.06
3	Existing Culvert A	328.70	559.19
4	Existing Culvert B	157.00	188.75
5	Flow To North	60.79	60.36

TABLE 2 – PRE to POST-DEVELOPMENT FLOW COMPARISON

Description	Pre-Development Surface Water Flow (cfs)		Post-Development Surface Water Flow (cfs)	
	100-yr, 1-hr Storm	25-yr, 24-hr Storm	100-yr, 1-hr Storm	25-yr, 24-hr Storm
Flow To South (not passing through Existing Culvert A)	192.65	242.06	130.90 (55.87 + 75.03)	176.39 (51.11 + 78.26)
Existing Culvert A	328.70	559.19	298.38	411.33
Existing Culvert B	157.00	188.75	14.65	16.84
Flow To North	60.79	60.36	53.04	52.66

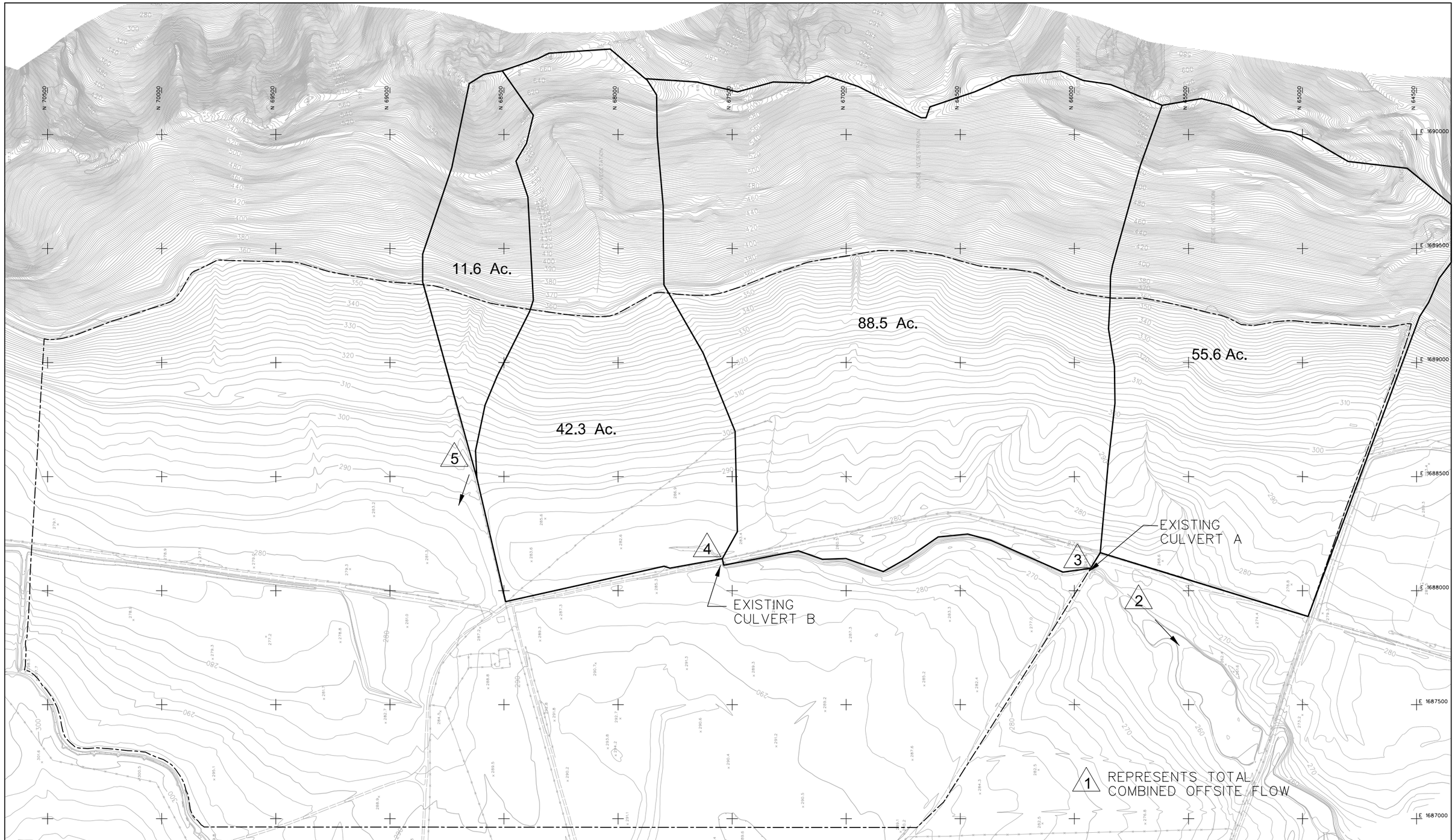
TABLE 3 – SUMMARY OF SEDIMENTATION BASIN ANALYSES

Parameter	South Sedimentation Basin		
	100-Year, 1-Hour Storm	100-Year, 24-Hour Storm	25-Year, 24-Hour Storm
Total Drainage Area (ac)	53.69		
Peak Flow In (cfs)	163.18	260.95	190.61
Peak Flow Out (cfs)	33.25	153.16	48.99
Peak Water Elevation (ft.)	278.47	284.40	282.81
Dewatering Time (days)	1.21	1.34	1.28
Volume of Permanent Pool (ac-ft)	0.0		
Permanent Pool Elev. (ft.)	--		
Top of Berm Elevation	285.5		
Bottom of Basin Elevation	270.0		

TABLE 4 – POST-DEVELOPMENT PEAK FLOWS FOR DESIGN OF STRUCTURES

Structure No.	Type/ Name of Structure	Peak Storm Flows (cfs)	
		100-Year, 1-Hour	25-Year, 24-Hour
1	South Sedimentation Basin	163.18	190.61
2	Culvert C-8	163.18	190.61
3	Perimeter Channel PC-1	64.45	74.95
4	Perimeter Channel PC-4	71.42	86.29
5	Downslope Channel DS-1S	71.30	74.41
6	Diversion Berm DB-1S	6.93	6.21
7	Diversion Berm DB-2S	13.31	13.22
8	Downslope Channel DS-2S / Culvert C-9	52.42	55.10
9	Bench B-1S	18.70	19.40
10	Bench B-2S	12.94	12.85
11	Downslope Channel DS-3S	22.11	22.96
12	Diversion Berm DB-3S	6.41	5.74
13	Diversion Berm DB-4S	17.50	17.38
14	Road Channel RC-2	5.53	4.95
15	Road Channel RC-1	3.73	3.34
16	Perimeter Channel PC-2 / Culvert C-7	59.11	69.97
17	Perimeter Channel PC-3	18.09	19.79
18	Downslope Channel DS-1E	40.89	36.61
19	Diversion Berm DB-1E	11.36	10.17
20	Diversion Berm DB-2E	9.61	8.60
21	Perimeter Channel PC-5	20.41	21.43
22	Downslope Channel DS-1N	61.79	57.00
23	Diversion Berm DB-1N	6.23	5.58
24	Diversion Berm DB-2N	9.28	9.21
25	Downslope Channel DS-2N / Culvert C-10	47.24	42.29
26	Bench B-1N	11.01	9.86
27	Bench B-2N	12.29	11.00
28	Downslope Channel DS-3N	23.94	21.43
29	Diversion Berm DB-3N	17.71	15.85
30	Diversion Berm DB-4N	6.23	5.58
31	Downslope Channel DS-2E / Culvert C-11	19.92	17.83
32	Bench B-1E	5.42	4.85
33	Bench B-2E	14.50	12.98
34	Entrance Area North Spreader Berm	55.87	51.11
35	Entrance Channel EC-2 / Culvert C-3	19.83	17.54
36	EC-3 / Culvert C-4	12.79	10.84
37	Entrance Channel EC-1 / Culvert C-2	39.72	33.71
38	Entrance Area South Spreader Berm / Culvert C-1	75.03	78.26
39	Run-on Channel RO-4 Lower Reach	26.52	28.64
40	RO-4 Upper Reach	26.88	26.69
41	Total Flow Offsite (input to satisfy model requirements)	--	--
42	Flow Offsite to the South	386.54	519.55
43	Existing Culvert A	297.61	411.33
44	RO-1 Middle and Lower Reaches / Culvert C-6	254.64	337.52
45	RO-1 Upper Reach / Culvert C-5	252.69	336.24
46	Run-on Channel RO-2	116.29	122.20
47	Run-on Channel RO-3	200.32	249.22
48	Existing Culvert B	14.65	16.84
49	Flow Offsite to the North	53.04	52.66

Note: The purpose of this table is to identify the worst-case flow condition for each structure.



4 = SEDCAD STRUCTURE NUMBER

N

SCALE 0' 200' 400'

AECOM

FIGURE 1
PRE-DEVLOPMENT SEDCAD
SUB-WATERSHED

CONCEPTUAL DESIGN
MA'ALO SANITARY LANDFILL
KAUAI, HAWAII

MAY 2013

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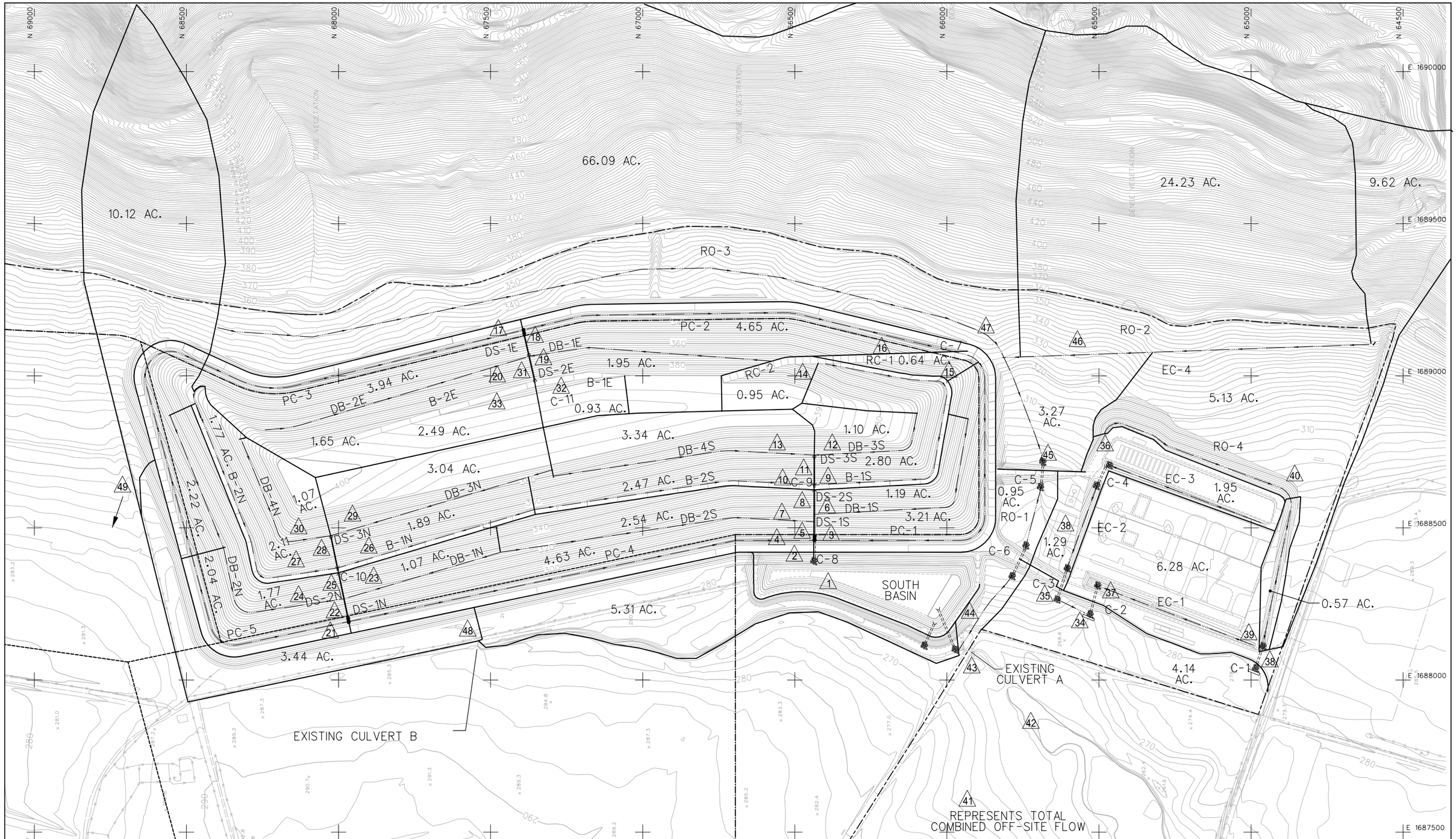

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FIGURE 2
POST-DEVLOPMENT SEDCAD
SUB-WATERSHED
CONCEPTUAL DESIGN
MA'ALO SANITARY LANDFILL
KAUAI, HAWAII

MAY 2013

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ATTACHMENT 1A

PRE-DEVELOPMENT FLOW EVALUATION
SEDCAD+ OUTPUT
100-YEAR, 1-HOUR STORM EVENT

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Ma'alo Phase 1 Conceptual Design

Pre-Development

100-yr, 1-hr Storm

AECOM

Copyright 1998 -2010 Pamela J. Schwab

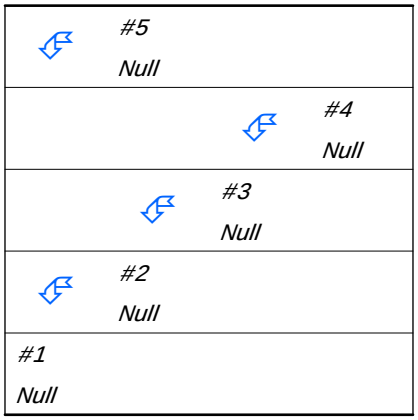
General Information

Storm Information:

Storm Type:	NRCS Type I
Design Storm:	100 yr - 1 hr
Rainfall Depth:	4.900 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	Off Site
Null	#2	==>	#1	0.000	0.000	Flow to South
Null	#3	==>	#2	0.000	0.000	Existing Culvert A
Null	#4	==>	#3	0.593	0.160	Existing Culvert B
Null	#5	==>	#1	0.000	0.000	Flow to North



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#4	3. Short grass pasture	1.00	17.10	1,710.00	0.80	0.593
#4	**Muskingum K:**					**0.593**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#5	11.600	11.600	60.79	2.67
#4	42.300	42.300	157.00	9.53
#3	88.500	130.800	328.70	29.42
#2	55.600	186.400	521.35	41.95
#1	0.000	198.000	547.11	44.61

Structure Detail:

Structure #5 (Null)

Flow to North

Structure #4 (Null)

Existing Culvert B

Structure #3 (Null)

Existing Culvert A

Structure #2 (Null)

Flow to South

Structure #1 (Null)

Off Site

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#5	1	11.600	0.150	0.000	0.000	79.000	TR55	60.79	2.666
	Σ	**11.600**						**60.79**	**2.666**
#4	1	42.300	0.500	0.000	0.000	79.000	TR55	157.00	9.528
	Σ	**42.300**						**157.00**	**9.528**
#3	1	88.500	0.569	0.000	0.000	79.000	TR55	307.64	19.897
	Σ	**130.800**						**328.70**	**29.424**
#2	1	55.600	0.443	0.000	0.000	79.000	TR55	218.42	12.521
	Σ	**186.400**						**521.35**	**41.945**
#1	Σ	**198.000**						**547.11**	**44.611**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#2	1	3. Short grass pasture	0.00	0.00	0.00	0.000	0.000
		6. Grassed waterway	20.00	32.00	160.00	6.700	0.006
		6. Grassed waterway	22.50	90.00	400.00	7.110	0.015
		3. Short grass pasture	28.00	145.60	520.00	4.230	0.034
		6. Grassed waterway	10.00	60.00	600.00	4.740	0.035
		3. Short grass pasture	2.60	19.75	760.00	1.280	0.164
		3. Short grass pasture	1.50	9.89	660.00	0.970	0.189
#2	**1**	**Time of Concentration:**					**0.443**
#3	1	3. Short grass pasture	30.00	282.00	940.00	4.380	0.059
		3. Short grass pasture	7.60	67.64	890.00	2.200	0.112
		3. Short grass pasture	2.60	9.87	380.00	1.280	0.082
		6. Grassed waterway	1.00	17.10	1,710.00	1.500	0.316
#3	**1**	**Time of Concentration:**					**0.569**
#4	1	3. Short grass pasture	28.00	308.00	1,100.00	4.230	0.072
		3. Short grass pasture	6.70	74.37	1,110.00	2.070	0.148
		6. Grassed waterway	0.40	3.80	950.00	0.940	0.280
#4	**1**	**Time of Concentration:**					**0.500**
#5	1	3. Short grass pasture	34.00	346.80	1,020.00	4.660	0.060
		3. Short grass pasture	8.30	62.25	750.00	2.300	0.090
#5	**1**	**Time of Concentration:**					**0.150**

ATTACHMENT 1B

PRE-DEVELOPMENT FLOW EVALUATION
SEDCAD+ OUTPUT
25-YEAR, 24-HOUR STORM EVENT

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Ma'alo Phase 1
Conceptual Design

Pre-Development

25-yr, 24-hr Storm

AECOM

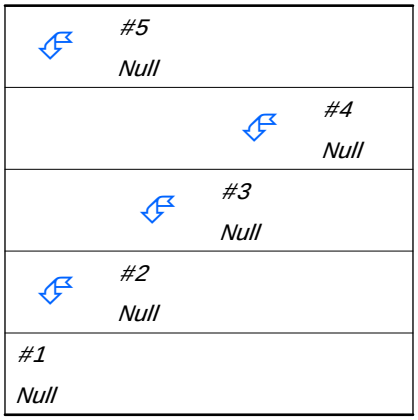
General Information

Storm Information:

Storm Type:	NRCS Type I
Design Storm:	25 yr - 24 hr
Rainfall Depth:	13.400 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	Off Site
Null	#2	==>	#1	0.000	0.000	Flow to South
Null	#3	==>	#2	0.000	0.000	Existing Culvert A
Null	#4	==>	#3	0.593	0.160	Existing Culvert B
Null	#5	==>	#1	0.000	0.000	Flow to North



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#4	3. Short grass pasture	1.00	17.10	1,710.00	0.80	0.593
#4	**Muskingum K:**					**0.593**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#5	11.600	11.600	60.36	10.47
#4	42.300	42.300	188.75	37.42
#3	88.500	130.800	440.21	115.55
#2	55.600	186.400	676.78	164.72
#1	0.000	198.000	715.15	175.19

Structure Detail:

Structure #5 (Null)

Flow to North

Structure #4 (Null)

Existing Culvert B

Structure #3 (Null)

Existing Culvert A

Structure #2 (Null)

Flow to South

Structure #1 (Null)

Off Site

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#5	1	11.600	0.150	0.000	0.000	79.000	TR55	60.36	10.470
	Σ	**11.600**						**60.36**	**10.470**
#4	1	42.300	0.500	0.000	0.000	79.000	TR55	188.75	37.417
	Σ	**42.300**						**188.75**	**37.417**
#3	1	88.500	0.569	0.000	0.000	79.000	TR55	375.47	78.137
	Σ	**130.800**						**440.21**	**115.554**
#2	1	55.600	0.443	0.000	0.000	79.000	TR55	258.54	49.171
	Σ	**186.400**						**676.78**	**164.725**
#1	Σ	**198.000**						**715.15**	**175.195**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#2	1	3. Short grass pasture	0.00	0.00	0.00	0.000	0.000
		6. Grassed waterway	20.00	32.00	160.00	6.700	0.006
		6. Grassed waterway	22.50	90.00	400.00	7.110	0.015
		3. Short grass pasture	28.00	145.60	520.00	4.230	0.034
		6. Grassed waterway	10.00	60.00	600.00	4.740	0.035
		3. Short grass pasture	2.60	19.75	760.00	1.280	0.164
		3. Short grass pasture	1.50	9.89	660.00	0.970	0.189
#2	**1**	**Time of Concentration:**					**0.443**
#3	1	3. Short grass pasture	30.00	282.00	940.00	4.380	0.059
		3. Short grass pasture	7.60	67.64	890.00	2.200	0.112
		3. Short grass pasture	2.60	9.87	380.00	1.280	0.082
		6. Grassed waterway	1.00	17.10	1,710.00	1.500	0.316
#3	**1**	**Time of Concentration:**					**0.569**
#4	1	3. Short grass pasture	28.00	308.00	1,100.00	4.230	0.072
		3. Short grass pasture	6.70	74.37	1,110.00	2.070	0.148
		6. Grassed waterway	0.40	3.80	950.00	0.940	0.280
#4	**1**	**Time of Concentration:**					**0.500**
#5	1	3. Short grass pasture	34.00	346.80	1,020.00	4.660	0.060
		3. Short grass pasture	8.30	62.25	750.00	2.300	0.090
#5	**1**	**Time of Concentration:**					**0.150**

ATTACHMENT 2A

SEDIMENTATION BASIN DESIGN FINAL ELEVATION
SEDCAD+ OUTPUT
100-YEAR, 1-HOUR STORM EVENT

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Ma'alo Phase 1
Conceptual Design

Post Development

100-yr, 1-hr Storm

AECOM

General Information

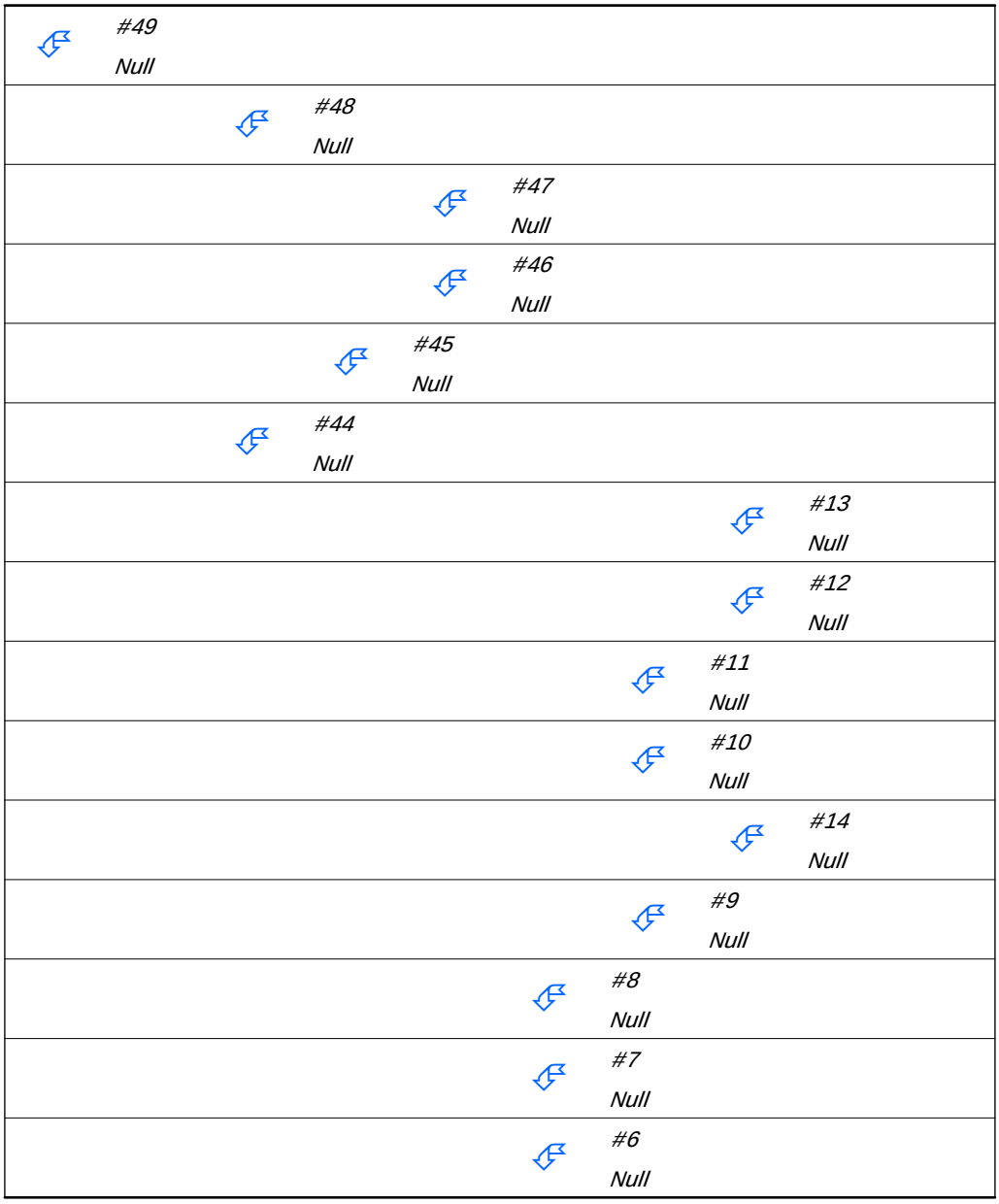
Storm Information:

Storm Type:	NRCS Type I
Design Storm:	100 yr - 1 hr
Rainfall Depth:	4.900 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Pond	#1	==>	#43	0.000	0.000	South Surface Water Sedimentation Basin
Null	#2	==>	#1	0.000	0.000	Culvert C-8
Null	#3	==>	#2	0.000	0.000	Perimeter Channel PC-1
Null	#4	==>	#2	0.000	0.000	PC-4
Null	#5	==>	#2	0.000	0.000	Downslope Channel DS-1S
Null	#6	==>	#5	0.000	0.000	Diversion Berm DB-1S
Null	#7	==>	#5	0.000	0.000	DB-2S
Null	#8	==>	#5	0.000	0.000	DS-2S / Culvert C-9
Null	#9	==>	#8	0.000	0.000	Bench B-1S
Null	#10	==>	#8	0.000	0.000	B-2S
Null	#11	==>	#8	0.000	0.000	DS-3S
Null	#12	==>	#11	0.000	0.000	DB-3S
Null	#13	==>	#11	0.000	0.000	DB-4S
Null	#14	==>	#9	0.026	0.357	Road Channel RC-2
Null	#15	==>	#3	0.200	0.290	RC-1
Null	#16	==>	#3	0.200	0.290	PC-2 / Culvert C-7
Null	#17	==>	#16	0.395	0.192	PC-3
Null	#18	==>	#16	0.395	0.192	DS-1E
Null	#19	==>	#18	0.000	0.000	DB-1E
Null	#20	==>	#18	0.000	0.000	DB-2E
Null	#21	==>	#4	0.502	0.168	PC-5
Null	#22	==>	#4	0.502	0.168	DS-1N
Null	#23	==>	#22	0.000	0.000	DB-1N
Null	#24	==>	#22	0.000	0.000	DB-2N
Null	#25	==>	#22	0.000	0.000	DS-2N / Culvert C-10
Null	#26	==>	#25	0.000	0.000	B-1N
Null	#27	==>	#25	0.000	0.000	B-2N
Null	#28	==>	#25	0.000	0.000	DS-3N
Null	#29	==>	#28	0.000	0.000	DB-3N
Null	#30	==>	#28	0.000	0.000	DB-4N
Null	#31	==>	#18	0.000	0.000	DS-2E / Culvert C-11
Null	#32	==>	#31	0.000	0.000	B-1E
Null	#33	==>	#31	0.000	0.000	B-2E
Null	#34	==>	#42	0.000	0.000	Entrance Area North Spreader Berm
Null	#35	==>	#34	0.000	0.000	Culvert C-3 / Entrance Channel EC-2
Null	#36	==>	#35	0.039	0.286	Culvert C-4 / EC-3
Null	#37	==>	#34	0.000	0.000	Culvert C-2 / EC-1
Null	#38	==>	#42	0.000	0.000	Culvert C-1 / South Spreader Berm
Null	#39	==>	#38	0.000	0.000	Run-on Channel RO-4 Lower Reach

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#40	==>	#39	0.102	0.216	RO-4 Upper Reach
Null	#41	==>	End	0.000	0.000	Flow Offsite
Null	#42	==>	#41	0.000	0.000	Flow To South
Null	#43	==>	#42	0.000	0.000	Existing Culvert A
Null	#44	==>	#43	0.000	0.000	RO-1 Lower & Middle Reaches / C-6
Null	#45	==>	#44	0.051	0.322	RO-1 Upper / C-5
Null	#46	==>	#45	0.023	0.362	RO-2
Null	#47	==>	#45	0.023	0.362	RO-3
Null	#48	==>	#43	0.218	0.280	Existing Culvert B
Null	#49	==>	#41	0.000	0.000	Flow to North



#5 *Null*				
				#30 *Null*
				#29 *Null*
			#28 *Null*	
			#27 *Null*	
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		#24 *Null*		
		#23 *Null*		
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#4 *Null*				
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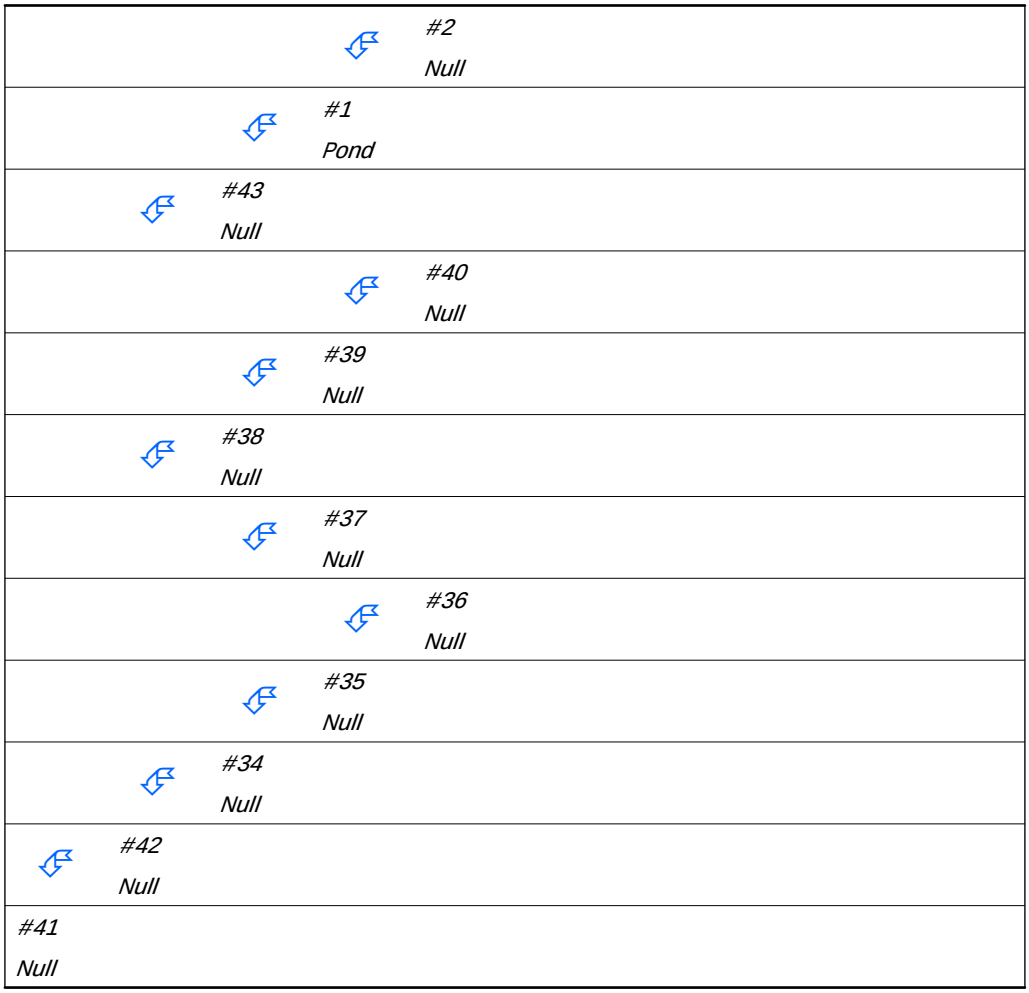
#3 *Null*				



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#14	6. Grassed waterway	8.00	32.39	405.00	4.24	0.026
#14	**Muskingum K:**					**0.026**
#15	6. Grassed waterway	7.00	35.00	500.00	3.96	0.035
	6. Grassed waterway	0.50	3.15	630.00	1.06	0.165
#15	**Muskingum K:**					**0.200**
#16	6. Grassed waterway	7.00	35.00	500.00	3.96	0.035
	6. Grassed waterway	0.50	3.15	630.00	1.06	0.165
#16	**Muskingum K:**					**0.200**
#17	6. Grassed waterway	0.50	7.55	1,510.00	1.06	0.395
#17	**Muskingum K:**					**0.395**
#18	6. Grassed waterway	0.50	7.55	1,510.00	1.06	0.395
#18	**Muskingum K:**					**0.395**
#21	6. Grassed waterway	0.33	5.13	1,555.00	0.86	0.502

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#21	**Muskingum K:**					**0.502**
#22	6. Grassed waterway	0.33	5.13	1,555.00	0.86	0.502
#22	**Muskingum K:**					**0.502**
#36	6. Grassed waterway	2.30	7.36	320.00	2.27	0.039
#36	**Muskingum K:**					**0.039**
#40	6. Grassed waterway	0.75	3.56	475.00	1.29	0.102
#40	**Muskingum K:**					**0.102**
#45	6. Grassed waterway	2.20	5.06	230.00	2.22	0.028
	6. Grassed waterway	6.20	19.21	310.00	3.73	0.023
#45	**Muskingum K:**					**0.051**
#46	6. Grassed waterway	8.90	33.81	380.00	4.47	0.023
#46	**Muskingum K:**					**0.023**
#47	6. Grassed waterway	8.90	33.81	380.00	4.47	0.023
#47	**Muskingum K:**					**0.023**
#48	6. Grassed waterway	2.10	35.91	1,710.00	2.17	0.218
#48	**Muskingum K:**					**0.218**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#49	10.120	10.120	53.04	2.33
#48	3.440	3.440	14.65	0.78
#47	66.090	66.090	200.32	14.84
#46	24.230	24.230	116.29	5.46
#45	3.270	93.590	252.69	21.01
#44	1.730	95.320	254.64	21.38
#13	3.340	3.340	17.50	0.77
#12	1.100	1.100	6.41	0.24
#11	0.000	4.440	22.11	1.01
#10	2.470	2.470	12.94	0.57
#14	0.950	0.950	5.53	0.21
#9	2.800	3.750	18.70	0.85
#8	0.000	10.660	52.42	2.43
#7	2.540	2.540	13.31	0.58
#6	1.190	1.190	6.93	0.26
#5	0.000	14.390	71.30	3.27
#30	1.070	1.070	6.23	0.23
#29	3.040	3.040	17.71	0.66
#28	0.000	4.110	23.94	0.90
#27	2.110	2.110	12.29	0.46
#26	1.890	1.890	11.01	0.41
#25	0.000	8.110	47.24	1.77
#24	1.770	1.770	9.28	0.41
#23	1.070	1.070	6.23	0.23
#22	0.000	10.950	61.79	2.41
#21	4.260	4.260	20.41	0.94
#4	4.630	19.840	71.42	4.39
#33	2.490	2.490	14.50	0.54
#32	0.930	0.930	5.42	0.20
#31	0.000	3.420	19.92	0.75
#20	1.650	1.650	9.61	0.36
#19	1.950	1.950	11.36	0.42
#18	0.000	7.020	40.89	1.53
#17	3.940	3.940	18.09	0.89
#16	4.650	15.610	59.11	3.46
#15	0.640	0.640	3.73	0.14
#3	3.210	19.460	64.45	4.33

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#2		0.000	53.690	163.18	11.99
#1	In	0.000	53.690	163.18	11.99
	Out			33.25	0.00
#43		5.310	157.760	297.61	35.34
#40		5.130	5.130	26.88	1.18
#39		0.570	5.700	26.52	1.30
#38		9.620	15.320	75.03	3.51
#37		6.280	6.280	39.72	1.86
#36		1.950	1.950	12.79	0.60
#35		1.290	3.240	19.83	0.88
#34		0.000	9.520	55.87	2.74
#42		3.090	185.690	386.54	42.27
#41		0.000	195.810	430.09	44.60

Structure Detail:

Structure #49 (Null)

Flow to North

Structure #48 (Null)

Existing Culvert B

Structure #47 (Null)

RO-3

Structure #46 (Null)

RO-2

Structure #45 (Null)

RO-1 Upper / C-5

Structure #44 (Null)

RO-1 Lower & Middle Reaches / C-6

Structure #13 (Null)

DB-4S

Structure #12 (Null)

DB-3S

Structure #11 (Null)

DS-3S

Structure #10 (Null)

B-2S

Structure #14 (Null)

Road Channel RC-2

Structure #9 (Null)

Bench B-1S

Structure #8 (Null)

DS-2S / Culvert C-9

Structure #7 (Null)

DB-2S

Structure #6 (Null)

Diversion Berm DB-1S

Structure #5 (Null)

Downslope Channel DS-1S

Structure #30 (Null)

DB-4N

Structure #29 (Null)

DB-3N

Structure #28 (Null)

DS-3N

Structure #27 (Null)

B-2N

Structure #26 (Null)

B-1N

Structure #25 (Null)

DS-2N / Culvert C-10

Structure #24 (Null)

DB-2N

Structure #23 (Null)

DB-1N

Structure #22 (Null)

DS-1N

Structure #21 (Null)

PC-5

Structure #4 (Null)

PC-4

Structure #33 (Null)

B-2E

Structure #32 (Null)

B-1E

Structure #31 (Null)

DS-2E / Culvert C-11

Structure #20 (Null)

DB-2E

Structure #19 (Null)

DB-1E

Structure #18 (Null)

DS-1E

Structure #17 (Null)

PC-3

Structure #16 (Null)

PC-2 / Culvert C-7

Structure #15 (Null)

RC-1

Structure #3 (Null)

Perimeter Channel PC-1

Structure #2 (Null)

Culvert C-8

Structure #1 (Pond)

South Surface Water Sedimentation Basin

Pond Inputs:

Initial Pool Elev:	270.00 ft
Initial Pool:	0.00 ac-ft

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
283.00	10.00	5.00:1	5.00:1	20.00

Perforated Riser

Riser Diameter (in)	Riser Height (ft)	Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Number of Holes per Elev
18.00	5.00	18.00	150.00	0.50	0.0240	274.50	6

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	80.00	0.50	0.0240	274.50	0.50	1.00

Pond Results:

Peak Elevation:	278.47 ft
Dewater Time:	1.21 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
269.99	0.010	0.000	0.000		
270.00	0.130	0.001	0.000		Low hole SPW #2
270.49	0.263	0.095	0.441	11.60	
270.99	0.447	0.271	1.073	3.00	
271.49	0.680	0.551	1.845	2.35	
271.99	0.961	0.959	2.737	2.20	
272.00	0.967	0.968	2.812	0.05	
272.49	1.028	1.457	4.175	1.70	
272.99	1.092	1.987	5.453	1.35	
273.49	1.158	2.549	6.774	1.10	
273.99	1.226	3.145	8.155	0.95	
274.00	1.227	3.157	8.176	0.05	
274.49	1.271	3.769	9.152	0.85	
274.50	1.272	3.782	9.170		Spillway #2 Spillway #3

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
274.99	1.316	4.416	10.026	0.80	
275.49	1.363	5.086	14.385	0.70	
275.99	1.410	5.779	18.221	0.50	
276.49	1.458	6.495	22.655	0.45	
276.99	1.506	7.236	25.403	0.35	
277.49	1.556	8.002	28.316	0.35	
277.99	1.606	8.792	30.954	0.30	
278.47	1.655	9.573	33.251	0.45	Peak Stage
278.49	1.657	9.608	33.354		
278.99	1.709	10.449	35.554		
279.49	1.762	11.317	37.605		
279.99	1.815	12.211	39.549		
280.49	1.869	13.132	41.409		
280.99	1.924	14.080	43.155		
281.49	1.980	15.056	44.842		
281.99	2.037	16.060	46.471		
282.49	2.094	17.093	48.025		
282.99	2.152	18.155	49.553		
283.00	2.154	18.176	49.584		Spillway #1
283.49	2.212	19.246	75.353		
283.99	2.271	20.367	101.637		
284.49	2.332	21.517	165.191		
284.99	2.393	22.699	250.703		
285.49	2.456	23.911	358.019		
285.50	2.457	23.936	382.019		

Detailed Discharge Table

Elevation (ft)	Emergency Spillway (cfs)	Perf. Riser (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
269.99	0.000	0.000	0.000	0.000
270.00	0.000	2.00>0.000	0.000	0.000
270.49	0.000	2.00>0.441	0.000	0.441
270.99	0.000	2.00>1.073	0.000	1.073
271.49	0.000	2.00>1.845	0.000	1.845
271.99	0.000	2.00>2.737	0.000	2.737
272.00	0.000	2.00>2.812	0.000	2.812
272.49	0.000	2.00>4.175	0.000	4.175
272.99	0.000	2.00>5.453	0.000	5.453

Elevation (ft)	Emergency Spillway (cfs)	Perf. Riser (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
273.49	0.000	2.00>6.774	0.000	6.774
273.99	0.000	8.155	0.000	8.155
274.00	0.000	8.176	0.000	8.176
274.49	0.000	9.152	0.000	9.152
274.50	0.000	9.170	0.000	9.170
274.99	0.000	10.026	0.000	10.026
275.49	0.000	10.820	(2)>3.566	14.385
275.99	0.000	11.554	(2)>6.667	18.221
276.49	0.000	12.241	(1)>10.414	22.655
276.99	0.000	12.889	(6)>12.514	25.403
277.49	0.000	13.505	(6)>14.811	28.316
277.99	0.000	14.093	(6)>16.861	30.954
278.49	0.000	14.657	(6)>18.697	33.354
278.99	0.000	15.199	(6)>20.355	35.554
279.49	0.000	15.722	(6)>21.883	37.605
279.99	0.000	16.228	(6)>23.321	39.549
280.49	0.000	16.718	(6)>24.691	41.409
280.99	0.000	17.195	(6)>25.960	43.155
281.49	0.000	17.658	(6)>27.185	44.842
281.99	0.000	18.109	(6)>28.362	46.471
282.49	0.000	18.549	(6)>29.476	48.025
282.99	0.000	18.979	(6)>30.575	49.553
283.00	0.000	18.987	(6)>30.597	49.584
283.49	24.349	19.399	(6)>31.605	75.353
283.99	49.195	19.810	(6)>32.632	101.637
284.49	111.380	20.213	(6)>33.599	165.191
284.99	195.529	20.608	(6)>34.566	250.703
285.49	301.543	20.995	(6)>35.481	358.019
285.50	325.517	21.003	(6)>35.500	382.019

Structure #43 (Null)

Existing Culvert A

Structure #40 (Null)

RO-4 Upper Reach

Structure #39 (Null)

Run-on Channel RO-4 Lower Reach

Structure #38 (Null)

Culvert C-1 / South Spreader Berm

Structure #37 (Null)

Culvert C-2 / EC-1

Structure #36 (Null)

Culvert C-4 / EC-3

Structure #35 (Null)

Culvert C-3 / Entrance Channel EC-2

Structure #34 (Null)

Entrance Area North Spreader Berm

Structure #42 (Null)

Flow To South

Structure #41 (Null)

Flow Offsite

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#49	1	10.120	0.133	0.000	0.000	79.000	TR55	53.04	2.326
	Σ	**10.120**						**53.04**	**2.326**
#48	1	3.440	0.365	0.000	0.000	79.000	TR55	14.65	0.775
	Σ	**3.440**						**14.65**	**0.775**
#47	1	66.090	0.746	0.000	0.000	79.000	TR55	200.32	14.841
	Σ	**66.090**						**200.32**	**14.841**
#46	1	24.230	0.247	0.000	0.000	79.000	TR55	116.29	5.455
	Σ	**24.230**						**116.29**	**5.455**
#45	1	3.270	0.065	0.000	0.000	79.000	TR55	19.05	0.712
	Σ	**93.590**						**252.69**	**21.008**
#44	1	0.780	0.031	0.000	0.000	79.000	TR55	4.54	0.170
	2	0.950	0.028	0.023	0.343	79.000	TR55	5.53	0.207
	Σ	**95.320**						**254.64**	**21.385**
#13	1	3.340	0.134	0.000	0.000	79.000	TR55	17.50	0.768
	Σ	**3.340**						**17.50**	**0.768**
#12	1	1.100	0.118	0.000	0.000	79.000	TR55	6.41	0.240
	Σ	**1.100**						**6.41**	**0.240**
#11	Σ	**4.440**						**22.11**	**1.007**
#10	1	2.470	0.127	0.000	0.000	79.000	TR55	12.94	0.568
	Σ	**2.470**						**12.94**	**0.568**
#14	1	0.950	0.031	0.000	0.000	79.000	TR55	5.53	0.207
	Σ	**0.950**						**5.53**	**0.207**
#9	1	2.800	0.157	0.000	0.000	79.000	TR55	14.67	0.644
	Σ	**3.750**						**18.70**	**0.850**
#8	Σ	**10.660**						**52.42**	**2.425**
#7	1	2.540	0.141	0.000	0.000	79.000	TR55	13.31	0.584
	Σ	**2.540**						**13.31**	**0.584**
#6	1	1.190	0.100	0.000	0.000	79.000	TR55	6.93	0.259
	Σ	**1.190**						**6.93**	**0.259**
#5	Σ	**14.390**						**71.30**	**3.268**

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#30	1	1.070	0.000	0.000	0.000	79.000	TR55	6.23	0.233
	Σ	**1.070**						**6.23**	**0.233**
#29	1	3.040	0.119	0.000	0.000	79.000	TR55	17.71	0.662
	Σ	**3.040**						**17.71**	**0.662**
#28	Σ	**4.110**						**23.94**	**0.895**
#27	1	2.110	0.119	0.000	0.000	79.000	TR55	12.29	0.460
	Σ	**2.110**						**12.29**	**0.460**
#26	1	1.890	0.095	0.000	0.000	79.000	TR55	11.01	0.412
	Σ	**1.890**						**11.01**	**0.412**
#25	Σ	**8.110**						**47.24**	**1.767**
#24	1	1.770	0.138	0.000	0.000	79.000	TR55	9.28	0.407
	Σ	**1.770**						**9.28**	**0.407**
#23	1	1.070	0.075	0.000	0.000	79.000	TR55	6.23	0.233
	Σ	**1.070**						**6.23**	**0.233**
#22	Σ	**10.950**						**61.79**	**2.407**
#21	1	2.040	0.246	0.000	0.000	79.000	TR55	9.80	0.460
	2	2.220	0.072	0.239	0.168	79.000	TR55	12.93	0.484
	Σ	**4.260**						**20.41**	**0.943**
#4	1	4.630	0.506	0.000	0.000	79.000	TR55	17.08	1.042
	Σ	**19.840**						**71.42**	**4.392**
#33	1	2.490	0.118	0.000	0.000	79.000	TR55	14.50	0.542
	Σ	**2.490**						**14.50**	**0.542**
#32	1	0.930	0.081	0.000	0.000	79.000	TR55	5.42	0.203
	Σ	**0.930**						**5.42**	**0.203**
#31	Σ	**3.420**						**19.92**	**0.745**
#20	1	1.650	0.120	0.000	0.000	79.000	TR55	9.61	0.359
	Σ	**1.650**						**9.61**	**0.359**
#19	1	1.950	0.100	0.000	0.000	79.000	TR55	11.36	0.425
	Σ	**1.950**						**11.36**	**0.425**
#18	Σ	**7.020**						**40.89**	**1.529**
#17	1	3.940	0.290	0.000	0.000	79.000	TR55	18.09	0.885
	Σ	**3.940**						**18.09**	**0.885**

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#16	1	4.650	0.401	0.000	0.000	79.000	TR55	19.09	1.047
	Σ	**15.610**						**59.11**	**3.462**
#15	1	0.640	0.026	0.000	0.000	79.000	TR55	3.73	0.139
	Σ	**0.640**						**3.73**	**0.139**
#3	1	3.210	0.205	0.000	0.000	79.000	TR55	16.06	0.727
	Σ	**19.460**						**64.45**	**4.328**
#2	Σ	**53.690**						**163.18**	**11.989**
#1	Σ	**53.690**						**163.18**	**11.989**
#43	1	5.310	0.251	0.000	0.000	79.000	TR55	25.36	1.193
	Σ	**157.760**						**297.61**	**35.341**
#40	1	5.130	0.157	0.000	0.000	79.000	TR55	26.88	1.179
	Σ	**5.130**						**26.88**	**1.179**
#39	1	0.570	0.102	0.000	0.000	79.000	TR55	3.32	0.124
	Σ	**5.700**						**26.52**	**1.303**
#38	1	9.620	0.161	0.000	0.000	79.000	TR55	50.42	2.211
	Σ	**15.320**						**75.03**	**3.514**
#37	1	6.280	0.211	0.000	0.000	89.000	TR55	39.72	1.864
	Σ	**6.280**						**39.72**	**1.864**
#36	1	1.950	0.183	0.000	0.000	89.000	TR55	12.79	0.598
	Σ	**1.950**						**12.79**	**0.598**
#35	1	1.290	0.073	0.000	0.000	79.000	TR55	7.51	0.281
	Σ	**3.240**						**19.83**	**0.879**
#34	Σ	**9.520**						**55.87**	**2.743**
#42	1	3.090	0.025	0.000	0.000	79.000	TR55	18.00	0.673
	Σ	**185.690**						**386.54**	**42.272**
#41	Σ	**195.810**						**430.09**	**44.598**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#3	1	3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	7.00	35.00	500.00	3.960	0.035

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		6. Grassed waterway	0.50	3.15	630.00	1.060	0.165
#3	**1**	**Time of Concentration:**					**0.205**
#4	1	3. Short grass pasture	28.60	21.45	75.00	4.270	0.004
		6. Grassed waterway	0.33	5.13	1,555.00	0.860	0.502
#4	**1**	**Time of Concentration:**					**0.506**
#6	1	3. Short grass pasture	28.60	21.45	75.00	4.270	0.004
		6. Grassed waterway	2.00	14.79	740.00	2.120	0.096
#6	**1**	**Time of Concentration:**					**0.100**
#7	1	3. Short grass pasture	28.60	22.88	80.00	4.270	0.005
		6. Grassed waterway	2.00	20.80	1,040.00	2.120	0.136
#7	**1**	**Time of Concentration:**					**0.141**
#9	1	3. Short grass pasture	5.00	3.25	65.00	1.780	0.010
		3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	2.00	21.80	1,090.00	2.120	0.142
#9	**1**	**Time of Concentration:**					**0.157**
#10	1	3. Short grass pasture	28.50	27.07	95.00	4.270	0.006
		6. Grassed waterway	2.00	18.60	930.00	2.120	0.121
#10	**1**	**Time of Concentration:**					**0.127**
#12	1	3. Short grass pasture	5.00	20.25	405.00	1.780	0.063
		6. Grassed waterway	2.00	8.39	420.00	2.120	0.055
#12	**1**	**Time of Concentration:**					**0.118**
#13	1	3. Short grass pasture	5.00	6.50	130.00	1.780	0.020
		3. Short grass pasture	28.60	10.01	35.00	4.270	0.002
		6. Grassed waterway	2.00	17.19	860.00	2.120	0.112
#13	**1**	**Time of Concentration:**					**0.134**
#14	1	3. Short grass pasture	5.00	3.50	70.00	1.780	0.010
		6. Grassed waterway	8.00	26.40	330.00	4.240	0.021
#14	**1**	**Time of Concentration:**					**0.031**
#15	1	6. Grassed waterway	8.00	32.39	405.00	4.240	0.026
#15	**1**	**Time of Concentration:**					**0.026**
#16	1	3. Short grass pasture	28.60	27.17	95.00	4.270	0.006
		6. Grassed waterway	0.50	7.55	1,510.00	1.060	0.395
#16	**1**	**Time of Concentration:**					**0.401**
#17	1	3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	0.50	5.45	1,090.00	1.060	0.285
#17	**1**	**Time of Concentration:**					**0.290**
#19	1	3. Short grass pasture	5.00	5.00	100.00	1.780	0.015
		3. Short grass pasture	28.60	17.16	59.99	4.270	0.003
		6. Grassed waterway	2.00	12.60	630.00	2.120	0.082
#19	**1**	**Time of Concentration:**					**0.100**
#20	1	3. Short grass pasture	28.60	17.16	60.00	4.270	0.003
		6. Grassed waterway	2.00	18.00	900.00	2.120	0.117

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#20	**1**	**Time of Concentration:**					**0.120**
#21	1	3. Short grass pasture	28.60	31.46	110.00	4.270	0.007
		6. Grassed waterway	0.33	2.44	740.00	0.860	0.239
#21	**1**	**Time of Concentration:**					**0.246**
#21	2	3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	5.50	46.75	850.00	3.510	0.067
#21	**2**	**Time of Concentration:**					**0.072**
#23	1	3. Short grass pasture	28.60	22.88	80.00	4.270	0.005
		6. Grassed waterway	2.00	10.80	540.00	2.120	0.070
#23	**1**	**Time of Concentration:**					**0.075**
#24	1	3. Short grass pasture	28.60	21.45	75.00	4.270	0.004
		6. Grassed waterway	2.00	20.50	1,025.00	2.120	0.134
#24	**1**	**Time of Concentration:**					**0.138**
#26	1	3. Short grass pasture	28.60	27.17	95.00	4.270	0.006
		6. Grassed waterway	2.00	13.60	680.00	2.120	0.089
#26	**1**	**Time of Concentration:**					**0.095**
#27	1	6. Grassed waterway	2.00	18.19	910.00	2.120	0.119
#27	**1**	**Time of Concentration:**					**0.119**
#29	1	3. Short grass pasture	5.00	6.50	130.00	1.780	0.020
		3. Short grass pasture	28.60	4.29	15.00	4.270	0.000
		6. Grassed waterway	2.00	15.20	760.00	2.120	0.099
#29	**1**	**Time of Concentration:**					**0.119**
#30	1	6. Grassed waterway	2.00	10.00	500.00	2.120	0.065
#30	**1**	**Time of Concentration:**					**0.000**
#32	1	3. Short grass pasture	5.00	5.30	106.00	1.780	0.016
		6. Grassed waterway	2.00	10.00	500.00	2.120	0.065
#32	**1**	**Time of Concentration:**					**0.081**
#33	1	3. Short grass pasture	5.00	3.50	70.00	1.780	0.010
		6. Grassed waterway	2.00	16.60	830.00	2.120	0.108
#33	**1**	**Time of Concentration:**					**0.118**
#35	1	3. Short grass pasture	2.30	7.36	320.00	1.210	0.073
#35	**1**	**Time of Concentration:**					**0.073**
#36	1	5. Nearly bare and untilled, and alluvial valley fans	0.50	0.50	100.00	0.700	0.039
		6. Grassed waterway	0.50	2.75	550.00	1.060	0.144
#36	**1**	**Time of Concentration:**					**0.183**
#37	1	3. Short grass pasture	2.30	8.62	375.00	1.210	0.086
		6. Grassed waterway	0.50	2.39	480.00	1.060	0.125
#37	**1**	**Time of Concentration:**					**0.211**
#38	1	3. Short grass pasture	20.00	106.00	530.00	3.570	0.041
		6. Grassed waterway	22.00	198.00	900.00	7.030	0.035
		6. Grassed waterway	5.70	17.95	315.00	3.580	0.024
		6. Grassed waterway	2.60	13.78	530.00	2.410	0.061

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#38	**1**	**Time of Concentration:**					**0.161**
#39	1	6. Grassed waterway	0.75	3.56	474.66	1.290	0.102
#39	**1**	**Time of Concentration:**					**0.102**
#40	1	3. Short grass pasture	12.00	19.79	164.91	2.770	0.016
		3. Short grass pasture	33.30	31.63	94.98	4.610	0.005
		6. Grassed waterway	0.75	4.76	635.00	1.290	0.136
#40	**1**	**Time of Concentration:**					**0.157**
#42	1	3. Short grass pasture	7.50	15.00	199.99	2.190	0.025
#42	**1**	**Time of Concentration:**					**0.025**
#43	1	3. Short grass pasture	33.30	11.65	35.00	4.610	0.002
		3. Short grass pasture	1.00	0.90	90.00	0.800	0.031
		6. Grassed waterway	2.10	35.91	1,710.00	2.170	0.218
#43	**1**	**Time of Concentration:**					**0.251**
#44	1	3. Short grass pasture	33.30	8.32	25.00	4.610	0.001
		3. Short grass pasture	7.30	9.85	135.00	2.160	0.017
		6. Grassed waterway	6.20	11.16	180.00	3.730	0.013
#44	**1**	**Time of Concentration:**					**0.031**
#44	2	6. Grassed waterway	2.20	5.06	230.00	2.220	0.028
#44	**2**	**Time of Concentration:**					**0.028**
#45	1	3. Short grass pasture	10.00	47.50	475.00	2.520	0.052
		3. Short grass pasture	3.00	1.95	65.00	1.380	0.013
#45	**1**	**Time of Concentration:**					**0.065**
#46	1	3. Short grass pasture	27.00	264.60	980.00	4.150	0.065
		6. Grassed waterway	1.50	18.00	1,200.00	1.830	0.182
#46	**1**	**Time of Concentration:**					**0.247**
#47	1	3. Short grass pasture	32.30	347.22	1,075.00	4.540	0.065
		6. Grassed waterway	0.50	13.00	2,600.00	1.060	0.681
#47	**1**	**Time of Concentration:**					**0.746**
#48	1	3. Short grass pasture	33.30	13.32	40.00	4.610	0.002
		6. Grassed waterway	3.40	11.90	350.00	2.760	0.035
		6. Grassed waterway	0.40	4.44	1,110.00	0.940	0.328
#48	**1**	**Time of Concentration:**					**0.365**
#49	1	3. Short grass pasture	32.30	347.22	1,075.00	4.540	0.065
		6. Grassed waterway	12.90	18.06	140.00	5.380	0.007
		6. Grassed waterway	5.75	46.00	800.00	3.590	0.061
#49	**1**	**Time of Concentration:**					**0.133**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#21	2	6. Grassed waterway	0.33	2.44	740.00	0.860	0.239
#21	**2**	**Muskingum K:**					**0.239**
#44	2	6. Grassed waterway	6.20	19.21	310.00	3.730	0.023
#44	**2**	**Muskingum K:**					**0.023**

ATTACHMENT 2B

SEDIMENTATION BASIN DESIGN FINAL ELEVATION
SEDCAD+ OUTPUT
25-YEAR, 24-HOUR STORM EVENT

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Ma'alo Phase 1
Conceptual Design

Post Development

25-yr, 24-hr Storm

AECOM

General Information

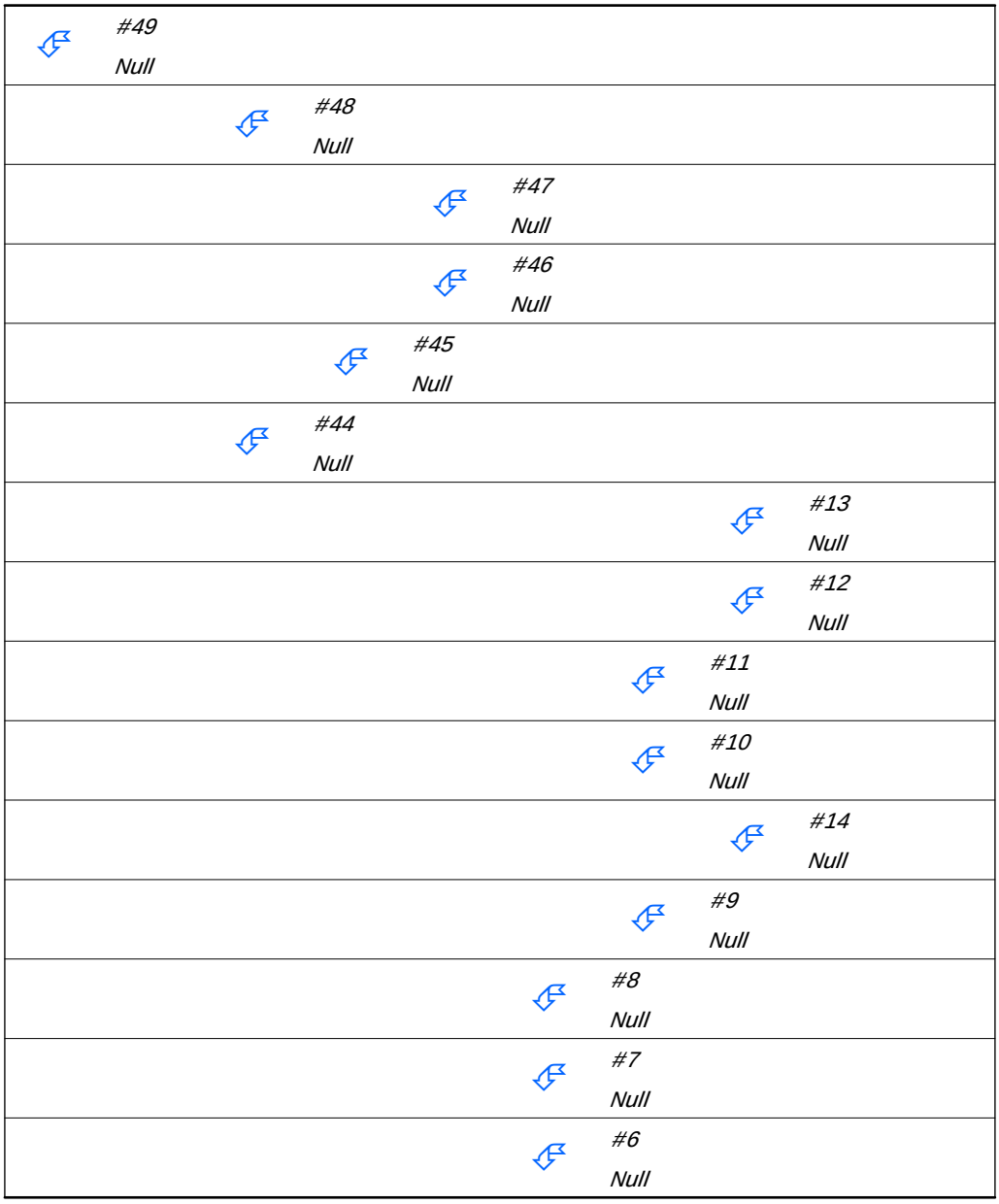
Storm Information:

Storm Type:	NRCS Type I
Design Storm:	25 yr - 24 hr
Rainfall Depth:	13.400 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Pond	#1	==>	#43	0.000	0.000	South Surface Water Sedimentation Basin
Null	#2	==>	#1	0.000	0.000	Culvert C-8
Null	#3	==>	#2	0.000	0.000	Perimeter Channel PC-1
Null	#4	==>	#2	0.000	0.000	PC-4
Null	#5	==>	#2	0.000	0.000	Downslope Channel DS-1S
Null	#6	==>	#5	0.000	0.000	Diversion Berm DB-1S
Null	#7	==>	#5	0.000	0.000	DB-2S
Null	#8	==>	#5	0.000	0.000	DS-2S / Culvert C-9
Null	#9	==>	#8	0.000	0.000	Bench B-1S
Null	#10	==>	#8	0.000	0.000	B-2S
Null	#11	==>	#8	0.000	0.000	DS-3S
Null	#12	==>	#11	0.000	0.000	DB-3S
Null	#13	==>	#11	0.000	0.000	DB-4S
Null	#14	==>	#9	0.026	0.357	Road Channel RC-2
Null	#15	==>	#3	0.200	0.290	RC-1
Null	#16	==>	#3	0.200	0.290	PC-2 / Culvert C-7
Null	#17	==>	#16	0.395	0.192	PC-3
Null	#18	==>	#16	0.395	0.192	DS-1E
Null	#19	==>	#18	0.000	0.000	DB-1E
Null	#20	==>	#18	0.000	0.000	DB-2E
Null	#21	==>	#4	0.502	0.168	PC-5
Null	#22	==>	#4	0.502	0.168	DS-1N
Null	#23	==>	#22	0.000	0.000	DB-1N
Null	#24	==>	#22	0.000	0.000	DB-2N
Null	#25	==>	#22	0.000	0.000	DS-2N / Culvert C-10
Null	#26	==>	#25	0.000	0.000	B-1N
Null	#27	==>	#25	0.000	0.000	B-2N
Null	#28	==>	#25	0.000	0.000	DS-3N
Null	#29	==>	#28	0.000	0.000	DB-3N
Null	#30	==>	#28	0.000	0.000	DB-4N
Null	#31	==>	#18	0.000	0.000	DS-2E / Culvert C-11
Null	#32	==>	#31	0.000	0.000	B-1E
Null	#33	==>	#31	0.000	0.000	B-2E
Null	#34	==>	#42	0.000	0.000	Entrance Area North Spreader Berm
Null	#35	==>	#34	0.000	0.000	Culvert C-3 / Entrance Channel EC-2
Null	#36	==>	#35	0.039	0.286	Culvert C-4 / EC-3
Null	#37	==>	#34	0.000	0.000	Culvert C-2 / EC-1
Null	#38	==>	#42	0.000	0.000	Culvert C-1 / South Spreader Berm
Null	#39	==>	#38	0.000	0.000	Run-on Channel RO-4 Lower Reach

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#40	==>	#39	0.102	0.216	RO-4 Upper Reach
Null	#41	==>	End	0.000	0.000	Flow Offsite
Null	#42	==>	#41	0.000	0.000	Flow To South
Null	#43	==>	#42	0.000	0.000	Existing Culvert A
Null	#44	==>	#43	0.000	0.000	RO-1 Lower & Middle Reaches / C-6
Null	#45	==>	#44	0.051	0.322	RO-1 Upper / C-5
Null	#46	==>	#45	0.023	0.362	RO-2
Null	#47	==>	#45	0.023	0.362	RO-3
Null	#48	==>	#43	0.218	0.280	Existing Culvert B
Null	#49	==>	#41	0.000	0.000	Flow to North



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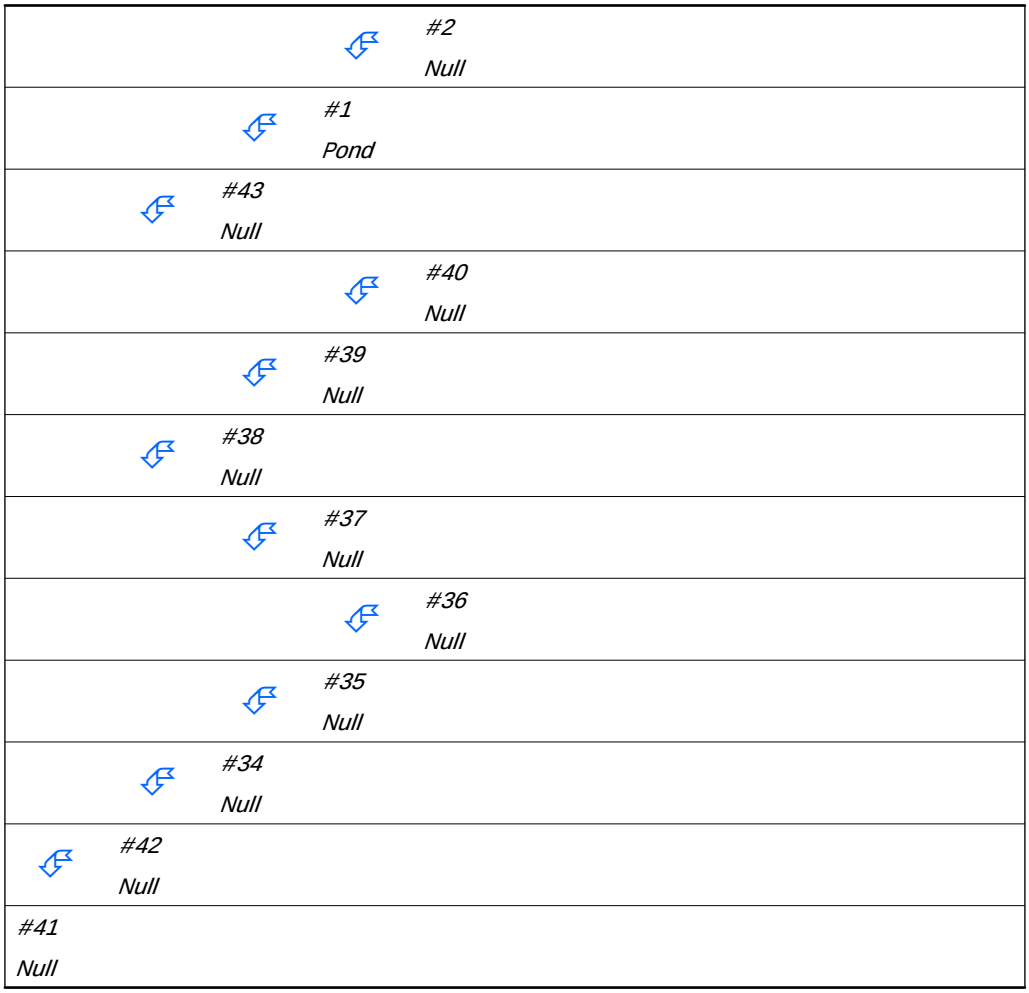

Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#14	6. Grassed waterway	8.00	32.39	405.00	4.24	0.026
#14	**Muskingum K:**					**0.026**
#15	6. Grassed waterway	7.00	35.00	500.00	3.96	0.035
	6. Grassed waterway	0.50	3.15	630.00	1.06	0.165
#15	**Muskingum K:**					**0.200**
#16	6. Grassed waterway	7.00	35.00	500.00	3.96	0.035
	6. Grassed waterway	0.50	3.15	630.00	1.06	0.165
#16	**Muskingum K:**					**0.200**
#17	6. Grassed waterway	0.50	7.55	1,510.00	1.06	0.395
#17	**Muskingum K:**					**0.395**
#18	6. Grassed waterway	0.50	7.55	1,510.00	1.06	0.395
#18	**Muskingum K:**					**0.395**
#21	6. Grassed waterway	0.33	5.13	1,555.00	0.86	0.502

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#21	**Muskingum K:**					**0.502**
#22	6. Grassed waterway	0.33	5.13	1,555.00	0.86	0.502
#22	**Muskingum K:**					**0.502**
#36	6. Grassed waterway	2.30	7.36	320.00	2.27	0.039
#36	**Muskingum K:**					**0.039**
#40	6. Grassed waterway	0.75	3.56	475.00	1.29	0.102
#40	**Muskingum K:**					**0.102**
#45	6. Grassed waterway	2.20	5.06	230.00	2.22	0.028
	6. Grassed waterway	6.20	19.21	310.00	3.73	0.023
#45	**Muskingum K:**					**0.051**
#46	6. Grassed waterway	8.90	33.81	380.00	4.47	0.023
#46	**Muskingum K:**					**0.023**
#47	6. Grassed waterway	8.90	33.81	380.00	4.47	0.023
#47	**Muskingum K:**					**0.023**
#48	6. Grassed waterway	2.10	35.91	1,710.00	2.17	0.218
#48	**Muskingum K:**					**0.218**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#49	10.120	10.120	52.66	9.13
#48	3.440	3.440	16.84	3.04
#47	66.090	66.090	249.22	58.28
#46	24.230	24.230	122.20	21.42
#45	3.270	93.590	336.24	82.61
#44	1.730	95.320	337.52	84.14
#13	3.340	3.340	17.38	3.01
#12	1.100	1.100	5.74	0.98
#11	0.000	4.440	22.96	3.99
#10	2.470	2.470	12.85	2.23
#14	0.950	0.950	4.95	0.84
#9	2.800	3.750	19.40	3.37
#8	0.000	10.660	55.10	9.59
#7	2.540	2.540	13.22	2.29
#6	1.190	1.190	6.21	1.06
#5	0.000	14.390	74.41	12.94
#30	1.070	1.070	5.58	0.95
#29	3.040	3.040	15.85	2.70
#28	0.000	4.110	21.43	3.65
#27	2.110	2.110	11.00	1.87
#26	1.890	1.890	9.86	1.68
#25	0.000	8.110	42.29	7.20
#24	1.770	1.770	9.21	1.60
#23	1.070	1.070	5.58	0.95
#22	0.000	10.950	57.00	9.75
#21	4.260	4.260	21.43	3.78
#4	4.630	19.840	86.29	17.62
#33	2.490	2.490	12.98	2.21
#32	0.930	0.930	4.85	0.83
#31	0.000	3.420	17.83	3.04
#20	1.650	1.650	8.60	1.46
#19	1.950	1.950	10.17	1.73
#18	0.000	7.020	36.61	6.23
#17	3.940	3.940	19.79	3.48
#16	4.650	15.610	69.97	13.82
#15	0.640	0.640	3.34	0.57
#3	3.210	19.460	74.95	17.24

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#2		0.000	53.690	190.61	47.80
#1	In	0.000	53.690	190.61	47.80
	Out			48.99	0.00
#43		5.310	157.760	411.33	139.67
#40		5.130	5.130	26.69	4.63
#39		0.570	5.700	28.64	5.14
#38		9.620	15.320	78.26	13.82
#37		6.280	6.280	33.71	6.09
#36		1.950	1.950	10.84	1.96
#35		1.290	3.240	17.54	3.10
#34		0.000	9.520	51.11	9.20
#42		3.090	185.690	519.55	165.43
#41		0.000	195.810	563.81	174.56

Structure Detail:

Structure #49 (Null)

Flow to North

Structure #48 (Null)

Existing Culvert B

Structure #47 (Null)

RO-3

Structure #46 (Null)

RO-2

Structure #45 (Null)

RO-1 Upper / C-5

Structure #44 (Null)

RO-1 Lower & Middle Reaches / C-6

Structure #13 (Null)

DB-4S

Structure #12 (Null)

DB-3S

Structure #11 (Null)

DS-3S

Structure #10 (Null)

B-2S

Structure #14 (Null)

Road Channel RC-2

Structure #9 (Null)

Bench B-1S

Structure #8 (Null)

DS-2S / Culvert C-9

Structure #7 (Null)

DB-2S

Structure #6 (Null)

Diversion Berm DB-1S

Structure #5 (Null)

Downslope Channel DS-1S

Structure #30 (Null)

DB-4N

Structure #29 (Null)

DB-3N

Structure #28 (Null)

DS-3N

Structure #27 (Null)

B-2N

Structure #26 (Null)

B-1N

Structure #25 (Null)

DS-2N / Culvert C-10

Structure #24 (Null)

DB-2N

Structure #23 (Null)

DB-1N

Structure #22 (Null)

DS-1N

Structure #21 (Null)

PC-5

Structure #4 (Null)

PC-4

Structure #33 (Null)

B-2E

Structure #32 (Null)

B-1E

Structure #31 (Null)

DS-2E / Culvert C-11

Structure #20 (Null)

DB-2E

Structure #19 (Null)

DB-1E

Structure #18 (Null)

DS-1E

Structure #17 (Null)

PC-3

Structure #16 (Null)

PC-2 / Culvert C-7

Structure #15 (Null)

RC-1

Structure #3 (Null)

Perimeter Channel PC-1

Structure #2 (Null)

Culvert C-8

Structure #1 (Pond)

South Surface Water Sedimentation Basin

Pond Inputs:

Initial Pool Elev:	270.00 ft
Initial Pool:	0.00 ac-ft

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
283.00	10.00	5.00:1	5.00:1	20.00

Perforated Riser

Riser Diameter (in)	Riser Height (ft)	Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Number of Holes per Elev
18.00	5.00	18.00	150.00	0.50	0.0240	274.50	6

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	80.00	0.50	0.0240	274.50	0.50	1.00

Pond Results:

Peak Elevation:	282.81 ft
Dewater Time:	1.28 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
269.99	0.010	0.000	0.000		
270.00	0.130	0.001	0.000		Low hole SPW #2
270.49	0.263	0.095	0.441	2.59*	
270.99	0.447	0.271	1.073	3.00	
271.49	0.680	0.551	1.845	2.35	
271.99	0.961	0.959	2.737	2.20	
272.00	0.967	0.968	2.812	0.05	
272.49	1.028	1.457	4.175	1.70	
272.99	1.092	1.987	5.453	1.35	
273.49	1.158	2.549	6.774	1.10	
273.99	1.226	3.145	8.155	1.00	
274.00	1.227	3.157	8.176		
274.49	1.271	3.769	9.152	0.85	
274.50	1.272	3.782	9.170		Spillway #2 Spillway #3

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
274.99	1.316	4.416	10.026	0.80	
275.49	1.363	5.086	14.385	0.85	
275.99	1.410	5.779	18.221	2.20	
276.49	1.458	6.495	22.655	1.20	
276.99	1.506	7.236	25.403	1.10	
277.49	1.556	8.002	28.316	0.85	
277.99	1.606	8.792	30.954	0.75	
278.49	1.657	9.608	33.354	0.60	
278.99	1.709	10.449	35.554	0.60	
279.49	1.762	11.317	37.605	0.60	
279.99	1.815	12.211	39.549	0.55	
280.49	1.869	13.132	41.409	0.60	
280.99	1.924	14.080	43.155	0.60	
281.49	1.980	15.056	44.842	0.65	
281.99	2.037	16.060	46.471	0.75	
282.49	2.094	17.093	48.025	0.80	
282.81	2.131	17.763	48.989	0.95	Peak Stage
282.99	2.152	18.155	49.553		
283.00	2.154	18.176	49.584		Spillway #1
283.49	2.212	19.246	75.353		
283.99	2.271	20.367	101.637		
284.49	2.332	21.517	165.191		
284.99	2.393	22.699	250.703		
285.49	2.456	23.911	358.019		
285.50	2.457	23.936	382.019		

**Designates time(s) to dewater have been extrapolated beyond the 50 hour hydrograph limit.*

Detailed Discharge Table

Elevation (ft)	Emergency Spillway (cfs)	Perf. Riser (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
269.99	0.000	0.000	0.000	0.000
270.00	0.000	2.00>0.000	0.000	0.000
270.49	0.000	2.00>0.441	0.000	0.441
270.99	0.000	2.00>1.073	0.000	1.073
271.49	0.000	2.00>1.845	0.000	1.845
271.99	0.000	2.00>2.737	0.000	2.737
272.00	0.000	2.00>2.812	0.000	2.812
272.49	0.000	2.00>4.175	0.000	4.175

Elevation (ft)	Emergency Spillway (cfs)	Perf. Riser (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
272.99	0.000	2.00>5.453	0.000	5.453
273.49	0.000	2.00>6.774	0.000	6.774
273.99	0.000	8.155	0.000	8.155
274.00	0.000	8.176	0.000	8.176
274.49	0.000	9.152	0.000	9.152
274.50	0.000	9.170	0.000	9.170
274.99	0.000	10.026	0.000	10.026
275.49	0.000	10.820	(2)>3.566	14.385
275.99	0.000	11.554	(2)>6.667	18.221
276.49	0.000	12.241	(1)>10.414	22.655
276.99	0.000	12.889	(6)>12.514	25.403
277.49	0.000	13.505	(6)>14.811	28.316
277.99	0.000	14.093	(6)>16.861	30.954
278.49	0.000	14.657	(6)>18.697	33.354
278.99	0.000	15.199	(6)>20.355	35.554
279.49	0.000	15.722	(6)>21.883	37.605
279.99	0.000	16.228	(6)>23.321	39.549
280.49	0.000	16.718	(6)>24.691	41.409
280.99	0.000	17.195	(6)>25.960	43.155
281.49	0.000	17.658	(6)>27.185	44.842
281.99	0.000	18.109	(6)>28.362	46.471
282.49	0.000	18.549	(6)>29.476	48.025
282.99	0.000	18.979	(6)>30.575	49.553
283.00	0.000	18.987	(6)>30.597	49.584
283.49	24.349	19.399	(6)>31.605	75.353
283.99	49.195	19.810	(6)>32.632	101.637
284.49	111.380	20.213	(6)>33.599	165.191
284.99	195.529	20.608	(6)>34.566	250.703
285.49	301.543	20.995	(6)>35.481	358.019
285.50	325.517	21.003	(6)>35.500	382.019

Structure #43 (Null)

Existing Culvert A

Structure #40 (Null)

RO-4 Upper Reach

Structure #39 (Null)

Run-on Channel RO-4 Lower Reach

Structure #38 (Null)

Culvert C-1 / South Spreader Berm

Structure #37 (Null)

Culvert C-2 / EC-1

Structure #36 (Null)

Culvert C-4 / EC-3

Structure #35 (Null)

Culvert C-3 / Entrance Channel EC-2

Structure #34 (Null)

Entrance Area North Spreader Berm

Structure #42 (Null)

Flow To South

Structure #41 (Null)

Flow Offsite

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#49	1	10.120	0.133	0.000	0.000	79.000	TR55	52.66	9.134
	Σ	**10.120**						**52.66**	**9.134**
#48	1	3.440	0.365	0.000	0.000	79.000	TR55	16.84	3.045
	Σ	**3.440**						**16.84**	**3.045**
#47	1	66.090	0.746	0.000	0.000	79.000	TR55	249.22	58.281
	Σ	**66.090**						**249.22**	**58.281**
#46	1	24.230	0.247	0.000	0.000	79.000	TR55	122.20	21.423
	Σ	**24.230**						**122.20**	**21.423**
#45	1	3.270	0.065	0.000	0.000	79.000	TR55	17.05	2.903
	Σ	**93.590**						**336.24**	**82.607**
#44	1	0.780	0.031	0.000	0.000	79.000	TR55	4.07	0.692
	2	0.950	0.028	0.023	0.343	79.000	TR55	4.95	0.843
	Σ	**95.320**						**337.52**	**84.143**
#13	1	3.340	0.134	0.000	0.000	79.000	TR55	17.38	3.015
	Σ	**3.340**						**17.38**	**3.015**
#12	1	1.100	0.118	0.000	0.000	79.000	TR55	5.74	0.977
	Σ	**1.100**						**5.74**	**0.977**
#11	Σ	**4.440**						**22.96**	**3.991**
#10	1	2.470	0.127	0.000	0.000	79.000	TR55	12.85	2.229
	Σ	**2.470**						**12.85**	**2.229**
#14	1	0.950	0.031	0.000	0.000	79.000	TR55	4.95	0.843
	Σ	**0.950**						**4.95**	**0.843**
#9	1	2.800	0.157	0.000	0.000	79.000	TR55	14.57	2.527
	Σ	**3.750**						**19.40**	**3.370**
#8	Σ	**10.660**						**55.10**	**9.591**
#7	1	2.540	0.141	0.000	0.000	79.000	TR55	13.22	2.293
	Σ	**2.540**						**13.22**	**2.293**
#6	1	1.190	0.100	0.000	0.000	79.000	TR55	6.21	1.056
	Σ	**1.190**						**6.21**	**1.056**
#5	Σ	**14.390**						**74.41**	**12.940**

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#30	1	1.070	0.000	0.000	0.000	79.000	TR55	5.58	0.950
	Σ	**1.070**						**5.58**	**0.950**
#29	1	3.040	0.119	0.000	0.000	79.000	TR55	15.85	2.699
	Σ	**3.040**						**15.85**	**2.699**
#28	Σ	**4.110**						**21.43**	**3.649**
#27	1	2.110	0.119	0.000	0.000	79.000	TR55	11.00	1.873
	Σ	**2.110**						**11.00**	**1.873**
#26	1	1.890	0.095	0.000	0.000	79.000	TR55	9.86	1.678
	Σ	**1.890**						**9.86**	**1.678**
#25	Σ	**8.110**						**42.29**	**7.200**
#24	1	1.770	0.138	0.000	0.000	79.000	TR55	9.21	1.598
	Σ	**1.770**						**9.21**	**1.598**
#23	1	1.070	0.075	0.000	0.000	79.000	TR55	5.58	0.950
	Σ	**1.070**						**5.58**	**0.950**
#22	Σ	**10.950**						**57.00**	**9.747**
#21	1	2.040	0.246	0.000	0.000	79.000	TR55	10.29	1.805
	2	2.220	0.072	0.239	0.168	79.000	TR55	11.58	1.971
	Σ	**4.260**						**21.43**	**3.775**
#4	1	4.630	0.506	0.000	0.000	79.000	TR55	20.57	4.093
	Σ	**19.840**						**86.29**	**17.616**
#33	1	2.490	0.118	0.000	0.000	79.000	TR55	12.98	2.211
	Σ	**2.490**						**12.98**	**2.211**
#32	1	0.930	0.081	0.000	0.000	79.000	TR55	4.85	0.826
	Σ	**0.930**						**4.85**	**0.826**
#31	Σ	**3.420**						**17.83**	**3.036**
#20	1	1.650	0.120	0.000	0.000	79.000	TR55	8.60	1.465
	Σ	**1.650**						**8.60**	**1.465**
#19	1	1.950	0.100	0.000	0.000	79.000	TR55	10.17	1.731
	Σ	**1.950**						**10.17**	**1.731**
#18	Σ	**7.020**						**36.61**	**6.232**
#17	1	3.940	0.290	0.000	0.000	79.000	TR55	19.79	3.476
	Σ	**3.940**						**19.79**	**3.476**

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#16	1	4.650	0.401	0.000	0.000	79.000	TR55	22.26	4.112
	Σ	**15.610**						**69.97**	**13.820**
#15	1	0.640	0.026	0.000	0.000	79.000	TR55	3.34	0.568
	Σ	**0.640**						**3.34**	**0.568**
#3	1	3.210	0.205	0.000	0.000	79.000	TR55	16.44	2.856
	Σ	**19.460**						**74.95**	**17.244**
#2	Σ	**53.690**						**190.61**	**47.800**
#1	Σ	**53.690**						**190.61**	**47.800**
#43	1	5.310	0.251	0.000	0.000	79.000	TR55	26.72	4.684
	Σ	**157.760**						**411.33**	**139.669**
#40	1	5.130	0.157	0.000	0.000	79.000	TR55	26.69	4.630
	Σ	**5.130**						**26.69**	**4.630**
#39	1	0.570	0.102	0.000	0.000	79.000	TR55	2.97	0.506
	Σ	**5.700**						**28.64**	**5.136**
#38	1	9.620	0.161	0.000	0.000	79.000	TR55	50.06	8.683
	Σ	**15.320**						**78.26**	**13.819**
#37	1	6.280	0.211	0.000	0.000	89.000	TR55	33.71	6.095
	Σ	**6.280**						**33.71**	**6.095**
#36	1	1.950	0.183	0.000	0.000	89.000	TR55	10.84	1.957
	Σ	**1.950**						**10.84**	**1.957**
#35	1	1.290	0.073	0.000	0.000	79.000	TR55	6.73	1.145
	Σ	**3.240**						**17.54**	**3.102**
#34	Σ	**9.520**						**51.11**	**9.197**
#42	1	3.090	0.025	0.000	0.000	79.000	TR55	16.11	2.743
	Σ	**185.690**						**519.55**	**165.428**
#41	Σ	**195.810**						**563.81**	**174.562**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#3	1	3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	7.00	35.00	500.00	3.960	0.035

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		6. Grassed waterway	0.50	3.15	630.00	1.060	0.165
#3	**1**	**Time of Concentration:**					**0.205**
#4	1	3. Short grass pasture	28.60	21.45	75.00	4.270	0.004
		6. Grassed waterway	0.33	5.13	1,555.00	0.860	0.502
#4	**1**	**Time of Concentration:**					**0.506**
#6	1	3. Short grass pasture	28.60	21.45	75.00	4.270	0.004
		6. Grassed waterway	2.00	14.79	740.00	2.120	0.096
#6	**1**	**Time of Concentration:**					**0.100**
#7	1	3. Short grass pasture	28.60	22.88	80.00	4.270	0.005
		6. Grassed waterway	2.00	20.80	1,040.00	2.120	0.136
#7	**1**	**Time of Concentration:**					**0.141**
#9	1	3. Short grass pasture	5.00	3.25	65.00	1.780	0.010
		3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	2.00	21.80	1,090.00	2.120	0.142
#9	**1**	**Time of Concentration:**					**0.157**
#10	1	3. Short grass pasture	28.50	27.07	95.00	4.270	0.006
		6. Grassed waterway	2.00	18.60	930.00	2.120	0.121
#10	**1**	**Time of Concentration:**					**0.127**
#12	1	3. Short grass pasture	5.00	20.25	405.00	1.780	0.063
		6. Grassed waterway	2.00	8.39	420.00	2.120	0.055
#12	**1**	**Time of Concentration:**					**0.118**
#13	1	3. Short grass pasture	5.00	6.50	130.00	1.780	0.020
		3. Short grass pasture	28.60	10.01	35.00	4.270	0.002
		6. Grassed waterway	2.00	17.19	860.00	2.120	0.112
#13	**1**	**Time of Concentration:**					**0.134**
#14	1	3. Short grass pasture	5.00	3.50	70.00	1.780	0.010
		6. Grassed waterway	8.00	26.40	330.00	4.240	0.021
#14	**1**	**Time of Concentration:**					**0.031**
#15	1	6. Grassed waterway	8.00	32.39	405.00	4.240	0.026
#15	**1**	**Time of Concentration:**					**0.026**
#16	1	3. Short grass pasture	28.60	27.17	95.00	4.270	0.006
		6. Grassed waterway	0.50	7.55	1,510.00	1.060	0.395
#16	**1**	**Time of Concentration:**					**0.401**
#17	1	3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	0.50	5.45	1,090.00	1.060	0.285
#17	**1**	**Time of Concentration:**					**0.290**
#19	1	3. Short grass pasture	5.00	5.00	100.00	1.780	0.015
		3. Short grass pasture	28.60	17.16	59.99	4.270	0.003
		6. Grassed waterway	2.00	12.60	630.00	2.120	0.082
#19	**1**	**Time of Concentration:**					**0.100**
#20	1	3. Short grass pasture	28.60	17.16	60.00	4.270	0.003
		6. Grassed waterway	2.00	18.00	900.00	2.120	0.117

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#20	**1**	**Time of Concentration:**					**0.120**
#21	1	3. Short grass pasture	28.60	31.46	110.00	4.270	0.007
		6. Grassed waterway	0.33	2.44	740.00	0.860	0.239
#21	**1**	**Time of Concentration:**					**0.246**
#21	2	3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	5.50	46.75	850.00	3.510	0.067
#21	**2**	**Time of Concentration:**					**0.072**
#23	1	3. Short grass pasture	28.60	22.88	80.00	4.270	0.005
		6. Grassed waterway	2.00	10.80	540.00	2.120	0.070
#23	**1**	**Time of Concentration:**					**0.075**
#24	1	3. Short grass pasture	28.60	21.45	75.00	4.270	0.004
		6. Grassed waterway	2.00	20.50	1,025.00	2.120	0.134
#24	**1**	**Time of Concentration:**					**0.138**
#26	1	3. Short grass pasture	28.60	27.17	95.00	4.270	0.006
		6. Grassed waterway	2.00	13.60	680.00	2.120	0.089
#26	**1**	**Time of Concentration:**					**0.095**
#27	1	6. Grassed waterway	2.00	18.19	910.00	2.120	0.119
#27	**1**	**Time of Concentration:**					**0.119**
#29	1	3. Short grass pasture	5.00	6.50	130.00	1.780	0.020
		3. Short grass pasture	28.60	4.29	15.00	4.270	0.000
		6. Grassed waterway	2.00	15.20	760.00	2.120	0.099
#29	**1**	**Time of Concentration:**					**0.119**
#30	1	6. Grassed waterway	2.00	10.00	500.00	2.120	0.065
#30	**1**	**Time of Concentration:**					**0.000**
#32	1	3. Short grass pasture	5.00	5.30	106.00	1.780	0.016
		6. Grassed waterway	2.00	10.00	500.00	2.120	0.065
#32	**1**	**Time of Concentration:**					**0.081**
#33	1	3. Short grass pasture	5.00	3.50	70.00	1.780	0.010
		6. Grassed waterway	2.00	16.60	830.00	2.120	0.108
#33	**1**	**Time of Concentration:**					**0.118**
#35	1	3. Short grass pasture	2.30	7.36	320.00	1.210	0.073
#35	**1**	**Time of Concentration:**					**0.073**
#36	1	5. Nearly bare and untilled, and alluvial valley fans	0.50	0.50	100.00	0.700	0.039
		6. Grassed waterway	0.50	2.75	550.00	1.060	0.144
#36	**1**	**Time of Concentration:**					**0.183**
#37	1	3. Short grass pasture	2.30	8.62	375.00	1.210	0.086
		6. Grassed waterway	0.50	2.39	480.00	1.060	0.125
#37	**1**	**Time of Concentration:**					**0.211**
#38	1	3. Short grass pasture	20.00	106.00	530.00	3.570	0.041
		6. Grassed waterway	22.00	198.00	900.00	7.030	0.035
		6. Grassed waterway	5.70	17.95	315.00	3.580	0.024
		6. Grassed waterway	2.60	13.78	530.00	2.410	0.061

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#38	**1**	**Time of Concentration:**					**0.161**
#39	1	6. Grassed waterway	0.75	3.56	474.66	1.290	0.102
#39	**1**	**Time of Concentration:**					**0.102**
#40	1	3. Short grass pasture	12.00	19.79	164.91	2.770	0.016
		3. Short grass pasture	33.30	31.63	94.98	4.610	0.005
		6. Grassed waterway	0.75	4.76	635.00	1.290	0.136
#40	**1**	**Time of Concentration:**					**0.157**
#42	1	3. Short grass pasture	7.50	15.00	199.99	2.190	0.025
#42	**1**	**Time of Concentration:**					**0.025**
#43	1	3. Short grass pasture	33.30	11.65	35.00	4.610	0.002
		3. Short grass pasture	1.00	0.90	90.00	0.800	0.031
		6. Grassed waterway	2.10	35.91	1,710.00	2.170	0.218
#43	**1**	**Time of Concentration:**					**0.251**
#44	1	3. Short grass pasture	33.30	8.32	25.00	4.610	0.001
		3. Short grass pasture	7.30	9.85	135.00	2.160	0.017
		6. Grassed waterway	6.20	11.16	180.00	3.730	0.013
#44	**1**	**Time of Concentration:**					**0.031**
#44	2	6. Grassed waterway	2.20	5.06	230.00	2.220	0.028
#44	**2**	**Time of Concentration:**					**0.028**
#45	1	3. Short grass pasture	10.00	47.50	475.00	2.520	0.052
		3. Short grass pasture	3.00	1.95	65.00	1.380	0.013
#45	**1**	**Time of Concentration:**					**0.065**
#46	1	3. Short grass pasture	27.00	264.60	980.00	4.150	0.065
		6. Grassed waterway	1.50	18.00	1,200.00	1.830	0.182
#46	**1**	**Time of Concentration:**					**0.247**
#47	1	3. Short grass pasture	32.30	347.22	1,075.00	4.540	0.065
		6. Grassed waterway	0.50	13.00	2,600.00	1.060	0.681
#47	**1**	**Time of Concentration:**					**0.746**
#48	1	3. Short grass pasture	33.30	13.32	40.00	4.610	0.002
		6. Grassed waterway	3.40	11.90	350.00	2.760	0.035
		6. Grassed waterway	0.40	4.44	1,110.00	0.940	0.328
#48	**1**	**Time of Concentration:**					**0.365**
#49	1	3. Short grass pasture	32.30	347.22	1,075.00	4.540	0.065
		6. Grassed waterway	12.90	18.06	140.00	5.380	0.007
		6. Grassed waterway	5.75	46.00	800.00	3.590	0.061
#49	**1**	**Time of Concentration:**					**0.133**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#21	2	6. Grassed waterway	0.33	2.44	740.00	0.860	0.239
#21	**2**	**Muskingum K:**					**0.239**
#44	2	6. Grassed waterway	6.20	19.21	310.00	3.730	0.023
#44	**2**	**Muskingum K:**					**0.023**

ATTACHMENT 2C

SEDIMENTATION BASIN DESIGN FINAL ELEVATION
SEDCAD+ OUTPUT
100-YEAR, 24-HOUR STORM EVENT

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Ma'alo Phase 1 Conceptual Design

Post Development

100-yr, 24-hr Storm

AECOM

General Information

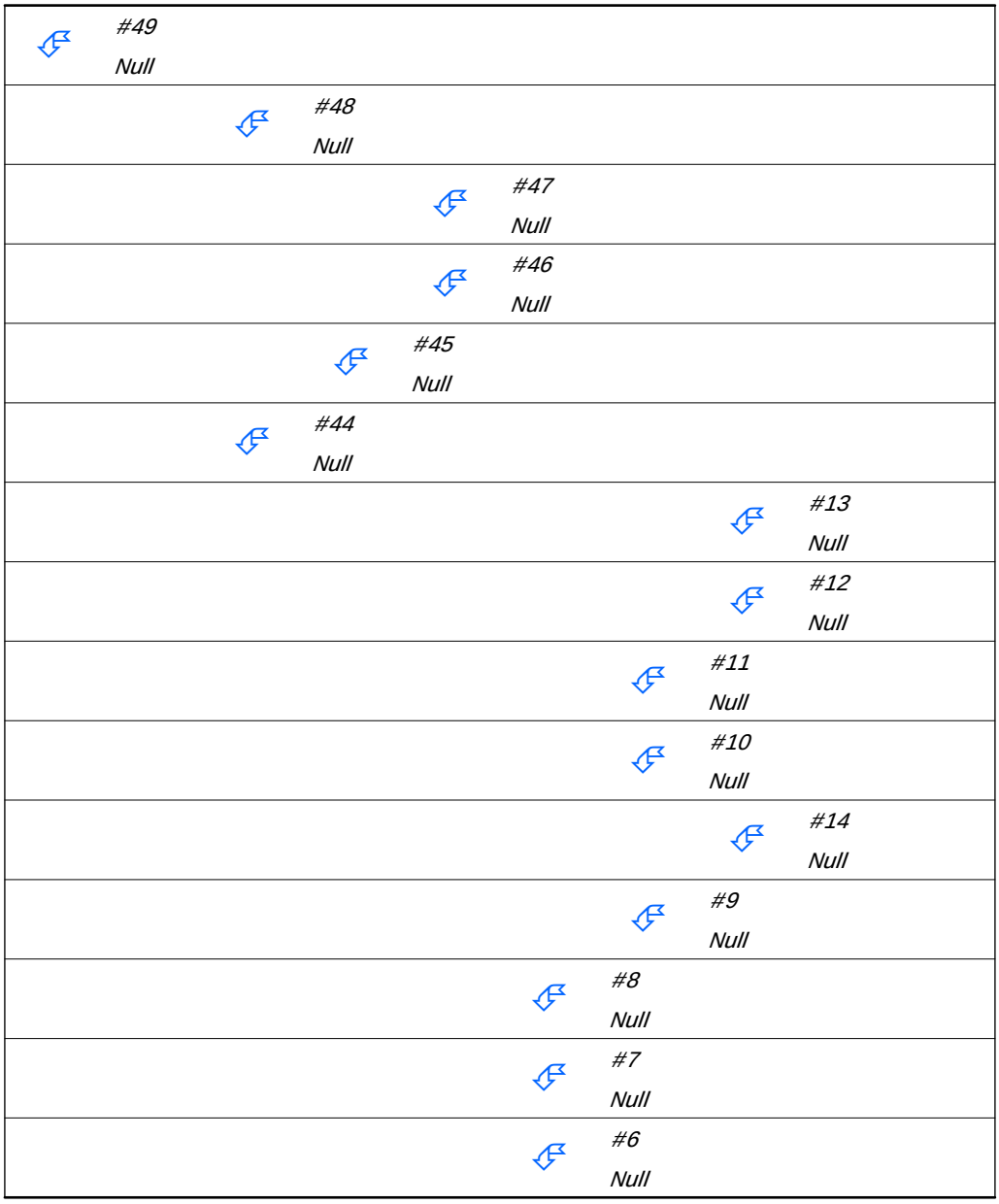
Storm Information:

Storm Type:	NRCS Type I
Design Storm:	100 yr - 24 hr
Rainfall Depth:	17.500 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Pond	#1	==>	#43	0.000	0.000	South Surface Water Sedimentation Basin
Null	#2	==>	#1	0.000	0.000	Culvert C-8
Null	#3	==>	#2	0.000	0.000	Perimeter Channel PC-1
Null	#4	==>	#2	0.000	0.000	PC-4
Null	#5	==>	#2	0.000	0.000	Downslope Channel DS-1S
Null	#6	==>	#5	0.000	0.000	Diversion Berm DB-1S
Null	#7	==>	#5	0.000	0.000	DB-2S
Null	#8	==>	#5	0.000	0.000	DS-2S / Culvert C-9
Null	#9	==>	#8	0.000	0.000	Bench B-1S
Null	#10	==>	#8	0.000	0.000	B-2S
Null	#11	==>	#8	0.000	0.000	DS-3S
Null	#12	==>	#11	0.000	0.000	DB-3S
Null	#13	==>	#11	0.000	0.000	DB-4S
Null	#14	==>	#9	0.026	0.357	Road Channel RC-2
Null	#15	==>	#3	0.200	0.290	RC-1
Null	#16	==>	#3	0.200	0.290	PC-2 / Culvert C-7
Null	#17	==>	#16	0.395	0.192	PC-3
Null	#18	==>	#16	0.395	0.192	DS-1E
Null	#19	==>	#18	0.000	0.000	DB-1E
Null	#20	==>	#18	0.000	0.000	DB-2E
Null	#21	==>	#4	0.502	0.168	PC-5
Null	#22	==>	#4	0.502	0.168	DS-1N
Null	#23	==>	#22	0.000	0.000	DB-1N
Null	#24	==>	#22	0.000	0.000	DB-2N
Null	#25	==>	#22	0.000	0.000	DS-2N / Culvert C-10
Null	#26	==>	#25	0.000	0.000	B-1N
Null	#27	==>	#25	0.000	0.000	B-2N
Null	#28	==>	#25	0.000	0.000	DS-3N
Null	#29	==>	#28	0.000	0.000	DB-3N
Null	#30	==>	#28	0.000	0.000	DB-4N
Null	#31	==>	#18	0.000	0.000	DS-2E / Culvert C-11
Null	#32	==>	#31	0.000	0.000	B-1E
Null	#33	==>	#31	0.000	0.000	B-2E
Null	#34	==>	#42	0.000	0.000	Entrance Area North Spreader Berm
Null	#35	==>	#34	0.000	0.000	Culvert C-3 / Entrance Channel EC-2
Null	#36	==>	#35	0.039	0.286	Culvert C-4 / EC-3
Null	#37	==>	#34	0.000	0.000	Culvert C-2 / EC-1
Null	#38	==>	#42	0.000	0.000	Culvert C-1 / South Spreader Berm
Null	#39	==>	#38	0.000	0.000	Run-on Channel RO-4 Lower Reach

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#40	==>	#39	0.102	0.216	RO-4 Upper Reach
Null	#41	==>	End	0.000	0.000	Flow Offsite
Null	#42	==>	#41	0.000	0.000	Flow To South
Null	#43	==>	#42	0.000	0.000	Existing Culvert A
Null	#44	==>	#43	0.000	0.000	RO-1 Lower & Middle Reaches / C-6
Null	#45	==>	#44	0.051	0.322	RO-1 Upper / C-5
Null	#46	==>	#45	0.023	0.362	RO-2
Null	#47	==>	#45	0.023	0.362	RO-3
Null	#48	==>	#43	0.218	0.280	Existing Culvert B
Null	#49	==>	#41	0.000	0.000	Flow to North



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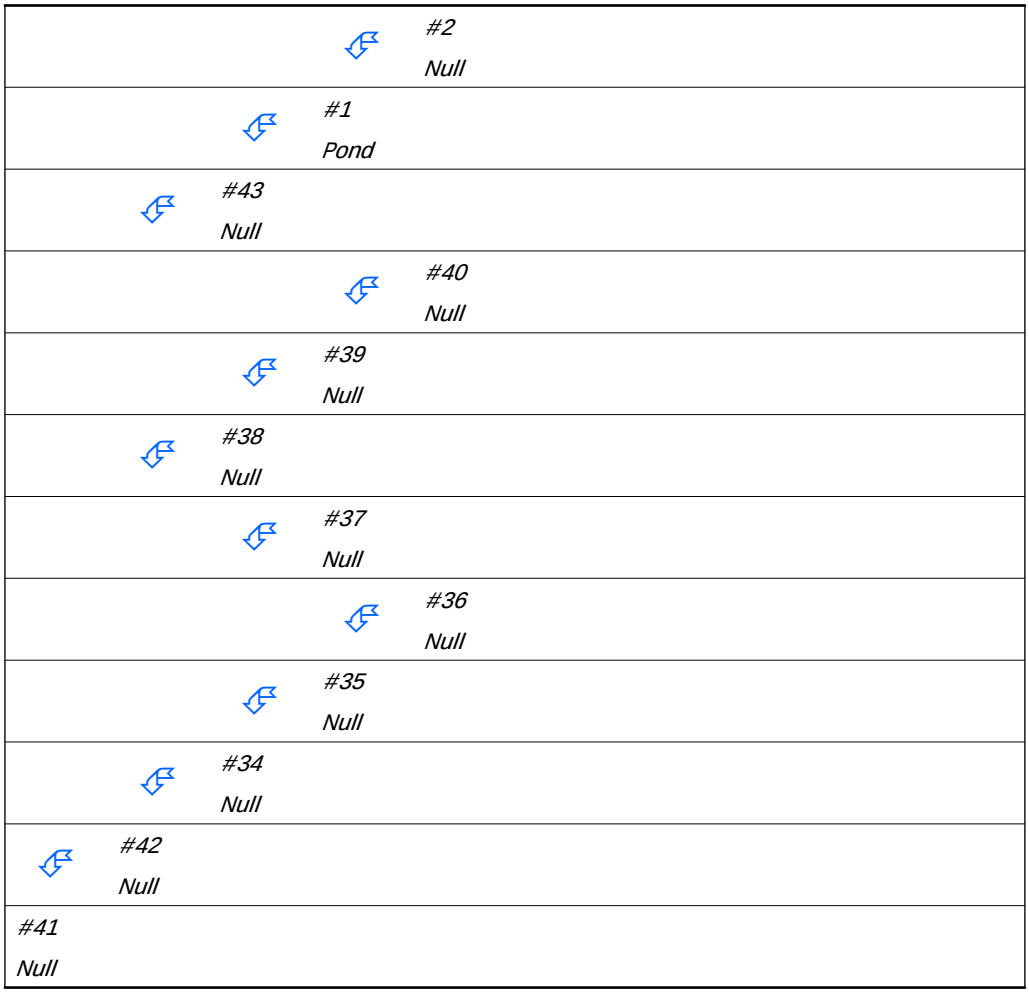


Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#14	6. Grassed waterway	8.00	32.39	405.00	4.24	0.026
#14	**Muskingum K:**					**0.026**
#15	6. Grassed waterway	7.00	35.00	500.00	3.96	0.035
	6. Grassed waterway	0.50	3.15	630.00	1.06	0.165
#15	**Muskingum K:**					**0.200**
#16	6. Grassed waterway	7.00	35.00	500.00	3.96	0.035
	6. Grassed waterway	0.50	3.15	630.00	1.06	0.165
#16	**Muskingum K:**					**0.200**
#17	6. Grassed waterway	0.50	7.55	1,510.00	1.06	0.395
#17	**Muskingum K:**					**0.395**
#18	6. Grassed waterway	0.50	7.55	1,510.00	1.06	0.395
#18	**Muskingum K:**					**0.395**
#21	6. Grassed waterway	0.33	5.13	1,555.00	0.86	0.502

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#21	**Muskingum K:**					**0.502**
#22	6. Grassed waterway	0.33	5.13	1,555.00	0.86	0.502
#22	**Muskingum K:**					**0.502**
#36	6. Grassed waterway	2.30	7.36	320.00	2.27	0.039
#36	**Muskingum K:**					**0.039**
#40	6. Grassed waterway	0.75	3.56	475.00	1.29	0.102
#40	**Muskingum K:**					**0.102**
#45	6. Grassed waterway	2.20	5.06	230.00	2.22	0.028
	6. Grassed waterway	6.20	19.21	310.00	3.73	0.023
#45	**Muskingum K:**					**0.051**
#46	6. Grassed waterway	8.90	33.81	380.00	4.47	0.023
#46	**Muskingum K:**					**0.023**
#47	6. Grassed waterway	8.90	33.81	380.00	4.47	0.023
#47	**Muskingum K:**					**0.023**
#48	6. Grassed waterway	2.10	35.91	1,710.00	2.17	0.218
#48	**Muskingum K:**					**0.218**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#49	10.120	10.120	71.49	12.56
#48	3.440	3.440	22.97	4.19
#47	66.090	66.090	340.60	80.17
#46	24.230	24.230	166.45	29.47
#45	3.270	93.590	460.16	113.63
#44	1.730	95.320	461.73	115.74
#13	3.340	3.340	23.59	4.15
#12	1.100	1.100	7.74	1.34
#11	0.000	4.440	31.20	5.49
#10	2.470	2.470	17.45	3.07
#14	0.950	0.950	6.69	1.16
#9	2.800	3.750	26.35	4.64
#8	0.000	10.660	74.89	13.19
#7	2.540	2.540	17.94	3.15
#6	1.190	1.190	8.38	1.45
#5	0.000	14.390	101.11	17.80
#30	1.070	1.070	7.53	1.31
#29	3.040	3.040	21.40	3.71
#28	0.000	4.110	28.93	5.02
#27	2.110	2.110	14.85	2.58
#26	1.890	1.890	13.30	2.31
#25	0.000	8.110	57.09	9.90
#24	1.770	1.770	12.50	2.20
#23	1.070	1.070	7.53	1.31
#22	0.000	10.950	77.05	13.41
#21	4.260	4.260	29.20	5.19
#4	4.630	19.840	117.77	24.23
#33	2.490	2.490	17.53	3.04
#32	0.930	0.930	6.55	1.14
#31	0.000	3.420	24.07	4.18
#20	1.650	1.650	11.61	2.01
#19	1.950	1.950	13.73	2.38
#18	0.000	7.020	49.42	8.57
#17	3.940	3.940	26.97	4.78
#16	4.650	15.610	95.60	19.01
#15	0.640	0.640	4.51	0.78
#3	3.210	19.460	102.28	23.72

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#2		0.000	53.690	260.95	65.75
#1	In	0.000	53.690	260.95	65.75
	Out			153.16	0.00
#43		5.310	157.760	557.79	192.12
#40		5.130	5.130	36.24	6.37
#39		0.570	5.700	39.19	7.06
#38		9.620	15.320	106.74	19.01
#37		6.280	6.280	44.55	8.16
#36		1.950	1.950	14.33	2.62
#35		1.290	3.240	23.39	4.20
#34		0.000	9.520	67.85	12.36
#42		3.090	185.690	704.12	227.26
#41		0.000	195.810	763.97	239.82

Structure Detail:

Structure #49 (Null)

Flow to North

Structure #48 (Null)

Existing Culvert B

Structure #47 (Null)

RO-3

Structure #46 (Null)

RO-2

Structure #45 (Null)

RO-1 Upper / C-5

Structure #44 (Null)

RO-1 Lower & Middle Reaches / C-6

Structure #13 (Null)

DB-4S

Structure #12 (Null)

DB-3S

Structure #11 (Null)

DS-3S

Structure #10 (Null)

B-2S

Structure #14 (Null)

Road Channel RC-2

Structure #9 (Null)

Bench B-1S

Structure #8 (Null)

DS-2S / Culvert C-9

Structure #7 (Null)

DB-2S

Structure #6 (Null)

Diversion Berm DB-1S

Structure #5 (Null)

Downslope Channel DS-1S

Structure #30 (Null)

DB-4N

Structure #29 (Null)

DB-3N

Structure #28 (Null)

DS-3N

Structure #27 (Null)

B-2N

Structure #26 (Null)

B-1N

Structure #25 (Null)

DS-2N / Culvert C-10

Structure #24 (Null)

DB-2N

Structure #23 (Null)

DB-1N

Structure #22 (Null)

DS-1N

Structure #21 (Null)

PC-5

Structure #4 (Null)

PC-4

Structure #33 (Null)

B-2E

Structure #32 (Null)

B-1E

Structure #31 (Null)

DS-2E / Culvert C-11

Structure #20 (Null)

DB-2E

Structure #19 (Null)

DB-1E

Structure #18 (Null)

DS-1E

Structure #17 (Null)

PC-3

Structure #16 (Null)

PC-2 / Culvert C-7

Structure #15 (Null)

RC-1

Structure #3 (Null)

Perimeter Channel PC-1

Structure #2 (Null)

Culvert C-8

Structure #1 (Pond)

South Surface Water Sedimentation Basin

Pond Inputs:

Initial Pool Elev:	270.00 ft
Initial Pool:	0.00 ac-ft

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
283.00	10.00	5.00:1	5.00:1	20.00

Perforated Riser

Riser Diameter (in)	Riser Height (ft)	Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Number of Holes per Elev
18.00	5.00	18.00	150.00	0.50	0.0240	274.50	6

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	80.00	0.50	0.0240	274.50	0.50	1.00

Pond Results:

Peak Elevation:	284.40 ft
Dewater Time:	1.34 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
269.99	0.010	0.000	0.000		
270.00	0.130	0.001	0.000		Low hole SPW #2
270.49	0.263	0.095	0.441	2.59*	
270.99	0.447	0.271	1.073	3.00	
271.49	0.680	0.551	1.845	2.35	
271.99	0.961	0.959	2.737	2.20	
272.00	0.967	0.968	2.812	0.05	
272.49	1.028	1.457	4.175	1.70	
272.99	1.092	1.987	5.453	1.35	
273.49	1.158	2.549	6.774	1.10	
273.99	1.226	3.145	8.155	1.00	
274.00	1.227	3.157	8.176		
274.49	1.271	3.769	9.152	0.85	
274.50	1.272	3.782	9.170		Spillway #2 Spillway #3

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
274.99	1.316	4.416	10.026	0.80	
275.49	1.363	5.086	14.385	0.70	
275.99	1.410	5.779	18.221	0.55	
276.49	1.458	6.495	22.655	0.95	
276.99	1.506	7.236	25.403	1.20	
277.49	1.556	8.002	28.316	0.95	
277.99	1.606	8.792	30.954	0.85	
278.49	1.657	9.608	33.354	0.90	
278.99	1.709	10.449	35.554	0.75	
279.49	1.762	11.317	37.605	0.70	
279.99	1.815	12.211	39.549	0.65	
280.49	1.869	13.132	41.409	0.65	
280.99	1.924	14.080	43.155	0.60	
281.49	1.980	15.056	44.842	0.70	
281.99	2.037	16.060	46.471	0.70	
282.49	2.094	17.093	48.025	0.90	
282.99	2.152	18.155	49.553	1.25	
283.00	2.154	18.176	49.584		Spillway #1
283.49	2.212	19.246	75.353	1.10	
283.99	2.271	20.367	101.637	0.60	
284.40	2.321	21.299	153.159	0.50	Peak Stage
284.49	2.332	21.517	165.191		
284.99	2.393	22.699	250.703		
285.49	2.456	23.911	358.019		
285.50	2.457	23.936	382.019		

**Designates time(s) to dewater have been extrapolated beyond the 50 hour hydrograph limit.*

Detailed Discharge Table

Elevation (ft)	Emergency Spillway (cfs)	Perf. Riser (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
269.99	0.000	0.000	0.000	0.000
270.00	0.000	2.00>0.000	0.000	0.000
270.49	0.000	2.00>0.441	0.000	0.441
270.99	0.000	2.00>1.073	0.000	1.073
271.49	0.000	2.00>1.845	0.000	1.845
271.99	0.000	2.00>2.737	0.000	2.737
272.00	0.000	2.00>2.812	0.000	2.812
272.49	0.000	2.00>4.175	0.000	4.175

Elevation (ft)	Emergency Spillway (cfs)	Perf. Riser (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
272.99	0.000	2.00>5.453	0.000	5.453
273.49	0.000	2.00>6.774	0.000	6.774
273.99	0.000	8.155	0.000	8.155
274.00	0.000	8.176	0.000	8.176
274.49	0.000	9.152	0.000	9.152
274.50	0.000	9.170	0.000	9.170
274.99	0.000	10.026	0.000	10.026
275.49	0.000	10.820	(2)>3.566	14.385
275.99	0.000	11.554	(2)>6.667	18.221
276.49	0.000	12.241	(1)>10.414	22.655
276.99	0.000	12.889	(6)>12.514	25.403
277.49	0.000	13.505	(6)>14.811	28.316
277.99	0.000	14.093	(6)>16.861	30.954
278.49	0.000	14.657	(6)>18.697	33.354
278.99	0.000	15.199	(6)>20.355	35.554
279.49	0.000	15.722	(6)>21.883	37.605
279.99	0.000	16.228	(6)>23.321	39.549
280.49	0.000	16.718	(6)>24.691	41.409
280.99	0.000	17.195	(6)>25.960	43.155
281.49	0.000	17.658	(6)>27.185	44.842
281.99	0.000	18.109	(6)>28.362	46.471
282.49	0.000	18.549	(6)>29.476	48.025
282.99	0.000	18.979	(6)>30.575	49.553
283.00	0.000	18.987	(6)>30.597	49.584
283.49	24.349	19.399	(6)>31.605	75.353
283.99	49.195	19.810	(6)>32.632	101.637
284.49	111.380	20.213	(6)>33.599	165.191
284.99	195.529	20.608	(6)>34.566	250.703
285.49	301.543	20.995	(6)>35.481	358.019
285.50	325.517	21.003	(6)>35.500	382.019

Structure #43 (Null)

Existing Culvert A

Structure #40 (Null)

RO-4 Upper Reach

Structure #39 (Null)

Run-on Channel RO-4 Lower Reach

Structure #38 (Null)

Culvert C-1 / South Spreader Berm

Structure #37 (Null)

Culvert C-2 / EC-1

Structure #36 (Null)

Culvert C-4 / EC-3

Structure #35 (Null)

Culvert C-3 / Entrance Channel EC-2

Structure #34 (Null)

Entrance Area North Spreader Berm

Structure #42 (Null)

Flow To South

Structure #41 (Null)

Flow Offsite

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#49	1	10.120	0.133	0.000	0.000	79.000	TR55	71.49	12.564
	Σ	**10.120**						**71.49**	**12.564**
#48	1	3.440	0.365	0.000	0.000	79.000	TR55	22.97	4.188
	Σ	**3.440**						**22.97**	**4.188**
#47	1	66.090	0.746	0.000	0.000	79.000	TR55	340.60	80.167
	Σ	**66.090**						**340.60**	**80.167**
#46	1	24.230	0.247	0.000	0.000	79.000	TR55	166.45	29.467
	Σ	**24.230**						**166.45**	**29.467**
#45	1	3.270	0.065	0.000	0.000	79.000	TR55	23.02	3.993
	Σ	**93.590**						**460.16**	**113.627**
#44	1	0.780	0.031	0.000	0.000	79.000	TR55	5.49	0.952
	2	0.950	0.028	0.023	0.343	79.000	TR55	6.69	1.160
	Σ	**95.320**						**461.73**	**115.740**
#13	1	3.340	0.134	0.000	0.000	79.000	TR55	23.59	4.147
	Σ	**3.340**						**23.59**	**4.147**
#12	1	1.100	0.118	0.000	0.000	79.000	TR55	7.74	1.343
	Σ	**1.100**						**7.74**	**1.343**
#11	Σ	**4.440**						**31.20**	**5.490**
#10	1	2.470	0.127	0.000	0.000	79.000	TR55	17.45	3.066
	Σ	**2.470**						**17.45**	**3.066**
#14	1	0.950	0.031	0.000	0.000	79.000	TR55	6.69	1.160
	Σ	**0.950**						**6.69**	**1.160**
#9	1	2.800	0.157	0.000	0.000	79.000	TR55	19.78	3.476
	Σ	**3.750**						**26.35**	**4.636**
#8	Σ	**10.660**						**74.89**	**13.193**
#7	1	2.540	0.141	0.000	0.000	79.000	TR55	17.94	3.153
	Σ	**2.540**						**17.94**	**3.153**
#6	1	1.190	0.100	0.000	0.000	79.000	TR55	8.38	1.453
	Σ	**1.190**						**8.38**	**1.453**
#5	Σ	**14.390**						**101.11**	**17.799**

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#30	1	1.070	0.000	0.000	0.000	79.000	TR55	7.53	1.307
	Σ	**1.070**						**7.53**	**1.307**
#29	1	3.040	0.119	0.000	0.000	79.000	TR55	21.40	3.712
	Σ	**3.040**						**21.40**	**3.712**
#28	Σ	**4.110**						**28.93**	**5.019**
#27	1	2.110	0.119	0.000	0.000	79.000	TR55	14.85	2.577
	Σ	**2.110**						**14.85**	**2.577**
#26	1	1.890	0.095	0.000	0.000	79.000	TR55	13.30	2.308
	Σ	**1.890**						**13.30**	**2.308**
#25	Σ	**8.110**						**57.09**	**9.904**
#24	1	1.770	0.138	0.000	0.000	79.000	TR55	12.50	2.197
	Σ	**1.770**						**12.50**	**2.197**
#23	1	1.070	0.075	0.000	0.000	79.000	TR55	7.53	1.307
	Σ	**1.070**						**7.53**	**1.307**
#22	Σ	**10.950**						**77.05**	**13.408**
#21	1	2.040	0.246	0.000	0.000	79.000	TR55	14.02	2.482
	2	2.220	0.072	0.239	0.168	79.000	TR55	15.63	2.711
	Σ	**4.260**						**29.20**	**5.193**
#4	1	4.630	0.506	0.000	0.000	79.000	TR55	28.08	5.630
	Σ	**19.840**						**117.77**	**24.232**
#33	1	2.490	0.118	0.000	0.000	79.000	TR55	17.53	3.041
	Σ	**2.490**						**17.53**	**3.041**
#32	1	0.930	0.081	0.000	0.000	79.000	TR55	6.55	1.136
	Σ	**0.930**						**6.55**	**1.136**
#31	Σ	**3.420**						**24.07**	**4.176**
#20	1	1.650	0.120	0.000	0.000	79.000	TR55	11.61	2.015
	Σ	**1.650**						**11.61**	**2.015**
#19	1	1.950	0.100	0.000	0.000	79.000	TR55	13.73	2.381
	Σ	**1.950**						**13.73**	**2.381**
#18	Σ	**7.020**						**49.42**	**8.573**
#17	1	3.940	0.290	0.000	0.000	79.000	TR55	26.97	4.782
	Σ	**3.940**						**26.97**	**4.782**

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#16	1	4.650	0.401	0.000	0.000	79.000	TR55	30.38	5.656
	Σ	**15.610**						**95.60**	**19.011**
#15	1	0.640	0.026	0.000	0.000	79.000	TR55	4.51	0.781
	Σ	**0.640**						**4.51**	**0.781**
#3	1	3.210	0.205	0.000	0.000	79.000	TR55	22.33	3.928
	Σ	**19.460**						**102.28**	**23.720**
#2	Σ	**53.690**						**260.95**	**65.751**
#1	Σ	**53.690**						**260.95**	**65.751**
#43	1	5.310	0.251	0.000	0.000	79.000	TR55	36.39	6.443
	Σ	**157.760**						**557.79**	**192.120**
#40	1	5.130	0.157	0.000	0.000	79.000	TR55	36.24	6.369
	Σ	**5.130**						**36.24**	**6.369**
#39	1	0.570	0.102	0.000	0.000	79.000	TR55	4.01	0.696
	Σ	**5.700**						**39.19**	**7.065**
#38	1	9.620	0.161	0.000	0.000	79.000	TR55	67.96	11.943
	Σ	**15.320**						**106.74**	**19.008**
#37	1	6.280	0.211	0.000	0.000	89.000	TR55	44.55	8.161
	Σ	**6.280**						**44.55**	**8.161**
#36	1	1.950	0.183	0.000	0.000	89.000	TR55	14.33	2.620
	Σ	**1.950**						**14.33**	**2.620**
#35	1	1.290	0.073	0.000	0.000	79.000	TR55	9.08	1.575
	Σ	**3.240**						**23.39**	**4.196**
#34	Σ	**9.520**						**67.85**	**12.357**
#42	1	3.090	0.025	0.000	0.000	79.000	TR55	21.75	3.774
	Σ	**185.690**						**704.12**	**227.259**
#41	Σ	**195.810**						**763.97**	**239.823**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#3	1	3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	7.00	35.00	500.00	3.960	0.035

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		6. Grassed waterway	0.50	3.15	630.00	1.060	0.165
#3	**1**	**Time of Concentration:**					**0.205**
#4	1	3. Short grass pasture	28.60	21.45	75.00	4.270	0.004
		6. Grassed waterway	0.33	5.13	1,555.00	0.860	0.502
#4	**1**	**Time of Concentration:**					**0.506**
#6	1	3. Short grass pasture	28.60	21.45	75.00	4.270	0.004
		6. Grassed waterway	2.00	14.79	740.00	2.120	0.096
#6	**1**	**Time of Concentration:**					**0.100**
#7	1	3. Short grass pasture	28.60	22.88	80.00	4.270	0.005
		6. Grassed waterway	2.00	20.80	1,040.00	2.120	0.136
#7	**1**	**Time of Concentration:**					**0.141**
#9	1	3. Short grass pasture	5.00	3.25	65.00	1.780	0.010
		3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	2.00	21.80	1,090.00	2.120	0.142
#9	**1**	**Time of Concentration:**					**0.157**
#10	1	3. Short grass pasture	28.50	27.07	95.00	4.270	0.006
		6. Grassed waterway	2.00	18.60	930.00	2.120	0.121
#10	**1**	**Time of Concentration:**					**0.127**
#12	1	3. Short grass pasture	5.00	20.25	405.00	1.780	0.063
		6. Grassed waterway	2.00	8.39	420.00	2.120	0.055
#12	**1**	**Time of Concentration:**					**0.118**
#13	1	3. Short grass pasture	5.00	6.50	130.00	1.780	0.020
		3. Short grass pasture	28.60	10.01	35.00	4.270	0.002
		6. Grassed waterway	2.00	17.19	860.00	2.120	0.112
#13	**1**	**Time of Concentration:**					**0.134**
#14	1	3. Short grass pasture	5.00	3.50	70.00	1.780	0.010
		6. Grassed waterway	8.00	26.40	330.00	4.240	0.021
#14	**1**	**Time of Concentration:**					**0.031**
#15	1	6. Grassed waterway	8.00	32.39	405.00	4.240	0.026
#15	**1**	**Time of Concentration:**					**0.026**
#16	1	3. Short grass pasture	28.60	27.17	95.00	4.270	0.006
		6. Grassed waterway	0.50	7.55	1,510.00	1.060	0.395
#16	**1**	**Time of Concentration:**					**0.401**
#17	1	3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	0.50	5.45	1,090.00	1.060	0.285
#17	**1**	**Time of Concentration:**					**0.290**
#19	1	3. Short grass pasture	5.00	5.00	100.00	1.780	0.015
		3. Short grass pasture	28.60	17.16	59.99	4.270	0.003
		6. Grassed waterway	2.00	12.60	630.00	2.120	0.082
#19	**1**	**Time of Concentration:**					**0.100**
#20	1	3. Short grass pasture	28.60	17.16	60.00	4.270	0.003
		6. Grassed waterway	2.00	18.00	900.00	2.120	0.117

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#20	**1**	**Time of Concentration:**					**0.120**
#21	1	3. Short grass pasture	28.60	31.46	110.00	4.270	0.007
		6. Grassed waterway	0.33	2.44	740.00	0.860	0.239
#21	**1**	**Time of Concentration:**					**0.246**
#21	2	3. Short grass pasture	28.60	25.74	90.00	4.270	0.005
		6. Grassed waterway	5.50	46.75	850.00	3.510	0.067
#21	**2**	**Time of Concentration:**					**0.072**
#23	1	3. Short grass pasture	28.60	22.88	80.00	4.270	0.005
		6. Grassed waterway	2.00	10.80	540.00	2.120	0.070
#23	**1**	**Time of Concentration:**					**0.075**
#24	1	3. Short grass pasture	28.60	21.45	75.00	4.270	0.004
		6. Grassed waterway	2.00	20.50	1,025.00	2.120	0.134
#24	**1**	**Time of Concentration:**					**0.138**
#26	1	3. Short grass pasture	28.60	27.17	95.00	4.270	0.006
		6. Grassed waterway	2.00	13.60	680.00	2.120	0.089
#26	**1**	**Time of Concentration:**					**0.095**
#27	1	6. Grassed waterway	2.00	18.19	910.00	2.120	0.119
#27	**1**	**Time of Concentration:**					**0.119**
#29	1	3. Short grass pasture	5.00	6.50	130.00	1.780	0.020
		3. Short grass pasture	28.60	4.29	15.00	4.270	0.000
		6. Grassed waterway	2.00	15.20	760.00	2.120	0.099
#29	**1**	**Time of Concentration:**					**0.119**
#30	1	6. Grassed waterway	2.00	10.00	500.00	2.120	0.065
#30	**1**	**Time of Concentration:**					**0.000**
#32	1	3. Short grass pasture	5.00	5.30	106.00	1.780	0.016
		6. Grassed waterway	2.00	10.00	500.00	2.120	0.065
#32	**1**	**Time of Concentration:**					**0.081**
#33	1	3. Short grass pasture	5.00	3.50	70.00	1.780	0.010
		6. Grassed waterway	2.00	16.60	830.00	2.120	0.108
#33	**1**	**Time of Concentration:**					**0.118**
#35	1	3. Short grass pasture	2.30	7.36	320.00	1.210	0.073
#35	**1**	**Time of Concentration:**					**0.073**
#36	1	5. Nearly bare and untilled, and alluvial valley fans	0.50	0.50	100.00	0.700	0.039
		6. Grassed waterway	0.50	2.75	550.00	1.060	0.144
#36	**1**	**Time of Concentration:**					**0.183**
#37	1	3. Short grass pasture	2.30	8.62	375.00	1.210	0.086
		6. Grassed waterway	0.50	2.39	480.00	1.060	0.125
#37	**1**	**Time of Concentration:**					**0.211**
#38	1	3. Short grass pasture	20.00	106.00	530.00	3.570	0.041
		6. Grassed waterway	22.00	198.00	900.00	7.030	0.035
		6. Grassed waterway	5.70	17.95	315.00	3.580	0.024
		6. Grassed waterway	2.60	13.78	530.00	2.410	0.061

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#38	**1**	**Time of Concentration:**					**0.161**
#39	1	6. Grassed waterway	0.75	3.56	474.66	1.290	0.102
#39	**1**	**Time of Concentration:**					**0.102**
#40	1	3. Short grass pasture	12.00	19.79	164.91	2.770	0.016
		3. Short grass pasture	33.30	31.63	94.98	4.610	0.005
		6. Grassed waterway	0.75	4.76	635.00	1.290	0.136
#40	**1**	**Time of Concentration:**					**0.157**
#42	1	3. Short grass pasture	7.50	15.00	199.99	2.190	0.025
#42	**1**	**Time of Concentration:**					**0.025**
#43	1	3. Short grass pasture	33.30	11.65	35.00	4.610	0.002
		3. Short grass pasture	1.00	0.90	90.00	0.800	0.031
		6. Grassed waterway	2.10	35.91	1,710.00	2.170	0.218
#43	**1**	**Time of Concentration:**					**0.251**
#44	1	3. Short grass pasture	33.30	8.32	25.00	4.610	0.001
		3. Short grass pasture	7.30	9.85	135.00	2.160	0.017
		6. Grassed waterway	6.20	11.16	180.00	3.730	0.013
#44	**1**	**Time of Concentration:**					**0.031**
#44	2	6. Grassed waterway	2.20	5.06	230.00	2.220	0.028
#44	**2**	**Time of Concentration:**					**0.028**
#45	1	3. Short grass pasture	10.00	47.50	475.00	2.520	0.052
		3. Short grass pasture	3.00	1.95	65.00	1.380	0.013
#45	**1**	**Time of Concentration:**					**0.065**
#46	1	3. Short grass pasture	27.00	264.60	980.00	4.150	0.065
		6. Grassed waterway	1.50	18.00	1,200.00	1.830	0.182
#46	**1**	**Time of Concentration:**					**0.247**
#47	1	3. Short grass pasture	32.30	347.22	1,075.00	4.540	0.065
		6. Grassed waterway	0.50	13.00	2,600.00	1.060	0.681
#47	**1**	**Time of Concentration:**					**0.746**
#48	1	3. Short grass pasture	33.30	13.32	40.00	4.610	0.002
		6. Grassed waterway	3.40	11.90	350.00	2.760	0.035
		6. Grassed waterway	0.40	4.44	1,110.00	0.940	0.328
#48	**1**	**Time of Concentration:**					**0.365**
#49	1	3. Short grass pasture	32.30	347.22	1,075.00	4.540	0.065
		6. Grassed waterway	12.90	18.06	140.00	5.380	0.007
		6. Grassed waterway	5.75	46.00	800.00	3.590	0.061
#49	**1**	**Time of Concentration:**					**0.133**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#21	2	6. Grassed waterway	0.33	2.44	740.00	0.860	0.239
#21	**2**	**Muskingum K:**					**0.239**
#44	2	6. Grassed waterway	6.20	19.21	310.00	3.730	0.023
#44	**2**	**Muskingum K:**					**0.023**

Appendix C.3
Surface Water Diversion Berm Analysis

SURFACE WATER DIVERSION BERM ANALYSIS

Objective

Design a diversion berm to intercept surface water runoff from the final cover and divert surface water runoff to the downslope channels or perimeter channels.

Design Criteria and Assumptions

1. Two types of diversion berms designed for Ma'alo Landfill are:
   a. Sideslope drainage diversion berm.
   b. Bench diversion berm.
   c. Road diversion berm (channel formed by access road within the limits of waste).

2. Diversion berms will be conservatively designed to convey the maximum runoff from either a 100-year, 1-hour storm event or runoff from a 25-year, 24-hour storm event with 0.1 foot of freeboard. The maximum runoff occurs with the 25-year, 24-hour storm. Therefore, 25-year, 24-hour storm design flows are used in this analysis.

3. Diversion berm designs will be based on worst case flow conditions. Peak flows are derived from SEDCAD+ output included in attachments of Appendix C-2.

Calculations

One analysis was performed to design each type of diversion berm. The design was performed using the peak flow rates obtained from both the 100-year, 1-hour storm event and the 25-year, 24-hour storm event. SEDCAD+ results are contained in Appendix C-2. Diversion berms are labeled as shown on Figure No. 1 in Appendix C-2.

1. Sideslope Drainage Diversion Berm

The largest flow is estimated to occur in the sideslope drainage diversion berm designated as DB-3N. The flow in this drainage diversion berm is estimated to be 17.71 cfs for the 100-year, 1-hour storm. Flows are shown in the SEDCAD+ output included in Appendix C-2. The SEDCAD+ channel design utility was used to evaluate the sideslope diversion berms for the highest estimated flow. The results of this analysis are presented herein on Page 3.

2. Bench Diversion Berm

The largest flow is estimated to occur in the bench/terrace diversion berm designated as B-1S. The flow in this diversion berm is estimated to be 19.40 cfs for the 25-year, 24-hour storm, as shown on the SEDCAD+ output files presented in Appendix C-2. The SEDCAD+ Channel Design Utility was used to evaluate the diversion berm for the highest estimated flow. The results of this analysis are presented herein on page 4.

3. Road Diversion Berm (Road Channel)

The largest flow is estimated to occur in the road channel designated as RC-2. The flow in this diversion berm is estimated to be 5.53 cfs for the 100-year, 1-hour storm, as shown on the SEDCAD+ output files presented in Appendix C-2. The SEDCAD+ Channel Design Utility was used to evaluate the diversion berm for the highest estimated flow. The results of this analysis are presented herein on page 5.

Conclusions

Berm details resulting from this calculation are included on the design detail drawing in the plan set. Following are descriptions of the channel designs:

1. The sideslope drainage diversion berm forms a 2-foot deep, v-notch, grass channel with a 3.5:1 (H:V) sideslope on one side and a 3:1 (H:V) sideslope on the other side. The channel slopes at 2 percent toward the downslope channels.

2. The bench/terrace diversion berm forms a 2-foot deep, v-notch, grass channel with a 3.5:1 (H:V) sideslope on one side and a maximum 3.5:1 (H:V) sideslope on the other side. The channel slopes at 2 percent toward the downslope channel.

3. The road channel diversion berm forms a 1.5-foot deep, v-notch, grass channel. The channel sidelope is 3.5:1 (H:V) on one side and 2:1 (H:V) on the other side. The channel slopes at 8 percent.

Sideslope Drainage Diversion Berm

Material: Grass mixture

Triangular Channel

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.5:1	3.0:1	2.0	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	17.71 cfs		17.71 cfs	
Depth:	1.30 ft	1.40 ft	1.88 ft	1.98 ft
Top Width:	8.42 ft	9.07 ft	12.23 ft	12.88 ft
Velocity:	3.24 fps		1.54 fps	
X-Section Area:	5.46 sq ft		11.50 sq ft	
Hydraulic Radius:	0.619 ft		0.899 ft	
Froude Number:	0.71		0.28	
Roughness Coefficient:	0.0471		0.1274	

Bench/Terrace Diversion Berm

Material: Grass mixture

Triangular Channel

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.5:1	3.5:1	2.0	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	19.40 cfs		19.40 cfs	
Depth:	1.30 ft	1.40 ft	1.88 ft	1.98 ft
Top Width:	9.09 ft	9.79 ft	13.17 ft	13.87 ft
Velocity:	3.28 fps		1.56 fps	
X-Section Area:	5.91 sq ft		12.40 sq ft	
Hydraulic Radius:	0.625 ft		0.905 ft	
Froude Number:	0.72		0.28	
Roughness Coefficient:	0.0468		0.1259	

Road Channel Diversion Berm

Material: Grass mixture

Triangular Channel

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.5:1	2.0:1	8.0	D, B	0.10			4.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	5.53 cfs		5.53 cfs	
Depth:	0.73 ft	0.83 ft	1.10 ft	1.20 ft
Top Width:	3.99 ft	4.54 ft	6.06 ft	6.61 ft
Velocity:	3.82 fps		1.66 fps	
X-Section Area:	1.45 sq ft		3.34 sq ft	
Hydraulic Radius:	0.341 ft		0.518 ft	
Froude Number:	1.12		0.39	
Roughness Coefficient:	0.0538		0.1639	

Appendix C.4
Surface Water Downslope Channel Analysis

SURFACE WATER DOWNSLOPE CHANNEL ANALYSIS

Objective

Design a downslope channel to convey surface water runoff from the diversion berms and benches/terraces to the perimeter channels, culverts, and sedimentation basins.

Design Criteria and Assumptions

1. Downslope channels will be able to convey runoff from the highest peak flow storm; either a 100-year, 1-hour storm event or a 25-year, 24-hour storm event, without overflow.

2. Each downslope channel will be designed based on actual estimated flow condition and slope.

3. Downslope channel sideslopes will be 2:1 (horizontal:vertical). Downslope channels will slope at approximately 3.5H:1V (28.6%) and will be lined with riprap for erosion protection.

4. Downslope channels will be trapezoidal in shape. The channels will cut into the landfill, final cover installed, then riprap installed.

Calculations

Each of the downslope channels are considered. The peak design flow rate associated with each downslope channel is shown on the SEDCAD+ output files presented in Appendix C-2. Downslope channel locations are shown on Figure No. 1, provided in Appendix C-2.

To simplify construction and design, two downslope channel design cross sections are considered. The SEDCAD+ Channel Design Utility was used to evaluate the downslope channels. The results of these analyses are presented on pages 3 and 4 and summarized in Table 1.

Table 1: Design Downslope Channel Cross Sections

Design Option	Peak Allowable Flow (cfs)	Slope (%)	Bottom Width (ft)	Sideslopes (H:V)	Depth (ft)		Minimum Design Freeboard[1] (ft)	Rip-Rap Size (in)		
					Flow Depth SEDCAD^{+1}	Design Depth		D_{min}	D_{50}	D_{max}
A	32.0	28.6	4	2:1	0.67	1.0	0.33	3	6	9
B	79.0	28.6	4	2:1	1.11	1.5	0.39	5	9	12

Note:
1. SEDCAD^{+} depth does not include freeboard.

Client	County of Kaua'i	**Subject**	Surface Water	**Prepared By**	TCR	**Date**	5/28/13
Project	Ma'alo Landfill		Downslope Channel Analysis	**Reviewed By**	NKW	**Date**	5/28/13
Conceptual Design				**Approved By**	KJB	**Date**	5/29/13

Conclusions

The two typical cross-section of the downslope channels were developed as shown in the drawing set to meet the requirements of the SEDCAD+ analyses. The depths of the channels vary according to the location and peak flow. Dimensions identified by the SEDCAD+ analyses were rounded up to the nearest 0.5 foot to obtain the typical cross-section. Each peak flow rate and specific slope was input into the SEDCAD+ Channel Design Utility. The results are presented on pages 2 through 5. The following schedule was developed to summarize the downslope channel designs.

SEDCAD Structure Number	Down-slope Channel	Peak Design Flow (cfs)	Peak Allowable Flow for Design Option (cfs)	Design Option (A or B)
5	DS-1S	74.41	79.0	B
8	DS-2S	55.10	79.0	B
11	DS-3S	22.96	32.0	A
18	DS-1E	40.89	79.0	B
31	DS-2E	19.92	32.0	A
22	DS-1N	61.79	79.0	B
25	DS-2N	47.24	79.0	B
28	DS-3N	23.94	32.0	A

Downslope Channel - Design A (max. flow = 32 cfs)

Material: Riprap

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
4.00	2.0:1	2.0:1	28.6			

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	32.00 cfs	
Depth:	0.67 ft	
Top Width:	6.68 ft	
Velocity:	8.94 fps	
X-Section Area:	3.58 sq ft	
Hydraulic Radius:	0.511 ft	
Froude Number:	2.15	
Manning's n:	0.0570	
Dmin:	3.00 in	
D50:	6.00 in	
Dmax:	9.00 in	

Downslope Channel - Design B (max. flow = 79 cfs)

Material: Riprap

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
4.00	2.0:1	2.0:1	28.5			

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	79.00 cfs	
Depth:	1.11 ft	
Top Width:	8.42 ft	
Velocity:	11.50 fps	
X-Section Area:	6.87 sq ft	
Hydraulic Radius:	0.768 ft	
Froude Number:	2.24	
Manning's n:	0.0580	
Dmin:	5.00 in	
D50:	9.00 in	
Dmax:	12.00 in	

Appendix C.5
Energy Dissipator Design

ENERGY DISSIPATOR DESIGN

Objective

Design the energy dissipator structures to limit erosion at the point where the downslope channels discharge into the perimeter channels.

Design Criteria and Assumptions

1. Use impact-type energy dissipator, U.S. Bureau of Reclamation (USBR) Type VI Baffle Wall Energy Dissipator. Use design procedure presented in Section VIII-C of "Hydraulic Design of Energy Dissipators for Culverts and Channels," (HEC-14), U.S. Federal Highway Administration, Washington, D.C., September 1983.

2. Size energy dissipators to convey runoff from the highest peak flow storm; either a 100-year, 1-hour storm event or a 25-year, 24-hour storm event, without overflow.

3. Size energy dissipators using data from downslope channel analysis in Appendix C-4. Use Froude number obtained from downslope channel analysis in Appendix C-4.

4. Two downslope channel designs, A and B, are discussed in Appendix C-4. Only channel Design B discharges to a perimeter channel and is applicable for the design of energy dissipaters.

Calculations

The energy dissipator calculations are shown in the attached pages. The attached pages present Figure VIII-C-2: Design Curve – Baffle Wall Dissipator and Table VIII-C-1: Baffle Wall Dissipator from HEC-14.

For Downslope Channel Design B:

From Appendix C-4: Fruede number, Fr = 2.24; H_o = 1.11 ft.
From Figure 9.14 (HEC-14), H_o / W_B = 0.6 Therefore, W_B = 0.6 / H_o = 0.6 / 1.11 ft. = 0.54 ft.
Use Table 9.2 (HEC 14), to determine Energy Dissipator dimensions (see Table 1 below).

Conclusions

Attachment 1 includes the typical detail for the energy dissipators. The minimum energy dissipator size is utilized. The following table summarizes the design parameters and dimensions from the typical detail:

Table 1: Energy Dissipator Dimensions (in feet-inches)

ID	W	h_1	H_2	L	H_3	L_1	L_2	H_4	W_1	W_2	t_3	t_2	t_1	t_4	t_5
Designs B	4-0	3-1	1.5	5-6	0-8	2-4	3-1	1-8	0-4	1-1	0-6	0-6	0-6	0-6	0-3

Other erosion control measures with equivalent hydraulic performance may also be used.

9.4 USBR TYPE VI IMPACT BASIN

The U.S. Bureau of Reclamation (USBR) Type VI impact basin was developed at the USBR Laboratory (ASCE, 1957). The dissipator is contained in a relatively small box-like structure that requires no tailwater for successful performance. Although the emphasis in this manual is on its use at culvert outlets, the structure may also be used in open channels.

The shape of the basin has evolved from extensive tests, but these were limited in range by the practical size of field structures required. With the many combinations of discharge, velocity, and depth possible for the incoming flow, it became apparent that some device was needed which would be equally effective over the entire range. The vertical hanging baffle, shown in Figure 9.13, proved to be this device. Energy dissipation is initiated by flow striking the vertical hanging baffle and being deflected upstream by the horizontal portion of the baffle and by the floor, creating horizontal eddies.

Notches in the baffle are provided to aid in cleaning the basin after prolonged periods of low or no flow. If the basin is full of sediment, the notches provide concentrated jets of water for cleaning. The basin is designed to carry the full discharge over the top of the baffle if the space beneath the baffle becomes completely clogged. Although this performance is not good, it is acceptable for short periods of time.

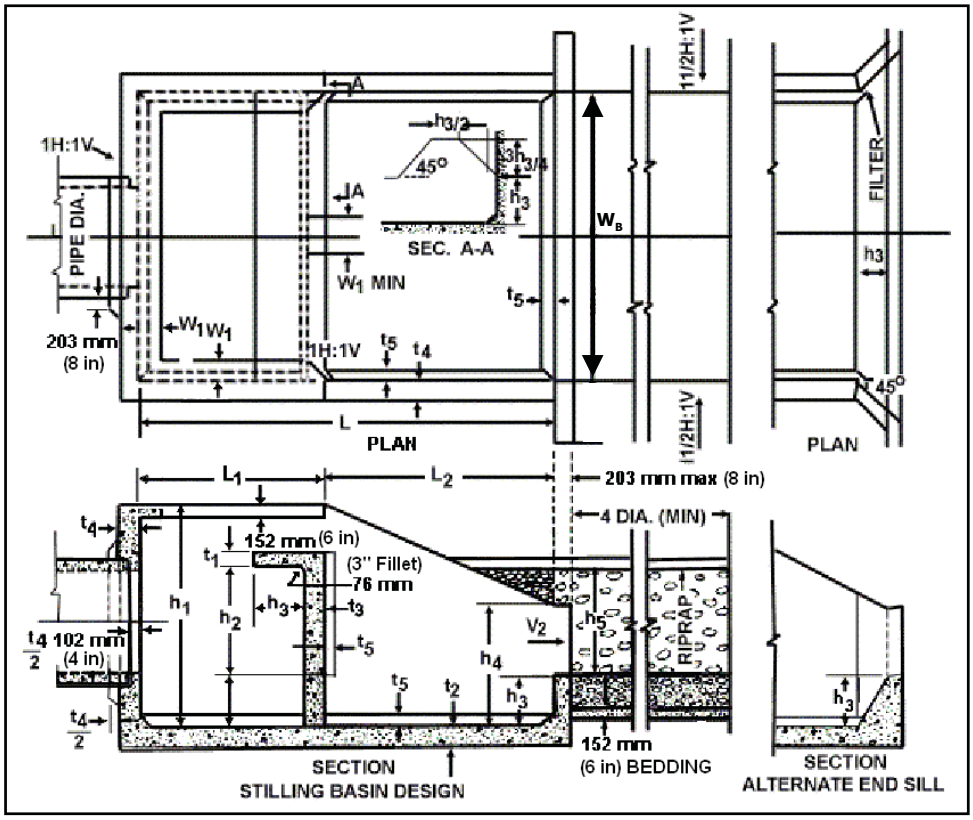


Figure 9.13. USBR Type VI Impact Basin

The design information is presented as a dimensionless curve in Figure 9.14. This curve incorporates the original information contained in ASCE (1957) and the results of additional experimentation performed by the Department of Public Works, City of Los Angeles. The curve

shows the relationship of the Froude number to the ratio of the energy entering the dissipator to the width of dissipator required. The Los Angeles tests indicate that limited extrapolation of this curve is permissible.

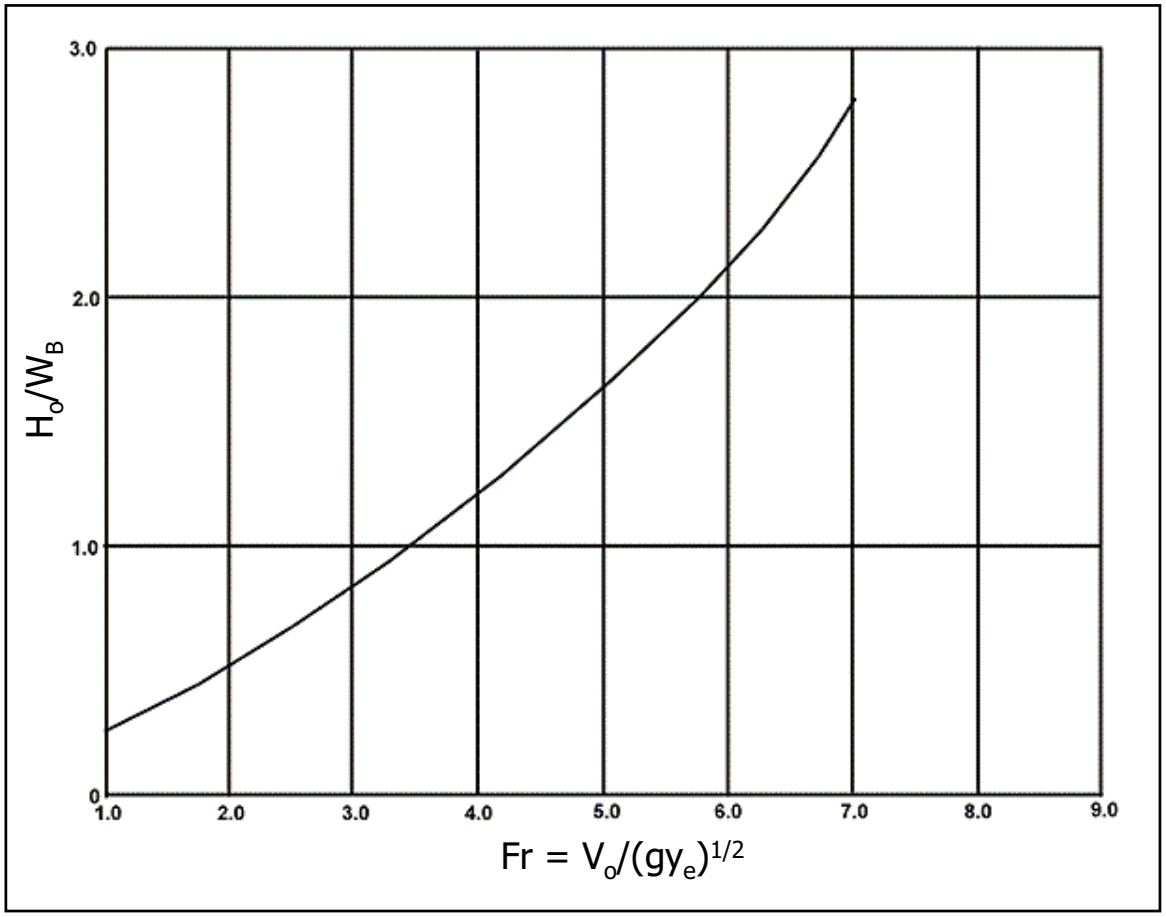


Figure 9.14. Design Curve for USBR Type VI Impact Basin

Once the basin width, W_B, has been determined, many of the other dimensions shown in Figure 9.13 follow according to Table 9.2. To use Table 9.2, round the value of W_B to the nearest entry in the table to determine the other dimensions. Interpolation is not necessary.

In calculating the energy and the Froude number, the equivalent depth of flow, $y_e = (A/2)^{1/2}$, entering the dissipator from a pipe or irregular-shaped conduit must be computed. In other words, the cross section flow area in the pipe is converted into an equivalent rectangular cross section in which the width is twice the depth of flow. The conduit preceding the dissipator can be open, closed, or of any cross section.

The effectiveness of the basin is best illustrated by comparing the energy losses within the structure to those in a natural hydraulic jump, Figure 9.15. The energy loss was computed based on depth and velocity measurements made in the approach pipe and also in the downstream channel with no tailwater. Compared with the natural hydraulic jump, the USBR Type VI impact basin shows a greater capacity for dissipating energy.

Although tailwater is not necessary for successful operation, a moderate depth of tailwater will improve the performance. For best performance set the basin so that maximum tailwater does not exceed $h_3 + (h_2/2)$ which is half of the baffle.

The basin floor should be constructed horizontally and will operate effectively with entrance conduits on slopes up to 15° (27%). For entrance conduits with slopes greater than 15°, a horizontal conduit section of at least four conduit widths long should be provided immediately upstream of the dissipator. Experience has shown that, even for conduits with slopes less than 15 degrees, it is more efficient when the horizontal section of pipe recommended for steeper slopes is used. In every case, the proper position of the entrance invert, as shown in Figure 9.13, should be maintained.

If a horizontal section of pipe is provided before the dissipator, the conduit should be analyzed to determine if a hydraulic jump would form in the conduit. When a hydraulic jump is expected and the pipe outlet is flowing full, a vent about one-sixth the pipe diameter should be installed at a convenient location upstream from the jump.

To provide structural support to the hanging baffle, a short support should be placed under the center of the baffle wall. This support will also provide an additional energy dissipating barrier to the flow.

Table 9.2 (SI). USBR Type VI Impact Basin Dimensions (m) (AASHTO, 1999)

W_B	h_1	h_2	h_3	H_4	L	L_1	L_2
1.0	0.79	0.38	0.17	0.43	1.40	0.59	0.79
1.5	1.16	0.57	0.25	0.62	2.00	0.88	1.16
2.0	1.54	0.75	0.33	0.83	2.68	1.14	1.54
2.5	1.93	0.94	0.42	1.04	3.33	1.43	1.93
3.0	2.30	1.12	0.50	1.25	4.02	1.72	2.30
3.5	2.68	1.32	0.58	1.46	4.65	2.00	2.68
4.0	3.12	1.51	0.67	1.67	5.33	2.28	3.08
4.5	3.46	1.68	0.75	1.88	6.00	2.56	3.46
5.0	3.82	1.87	0.83	2.08	6.52	2.84	3.82
5.5	4.19	2.03	0.91	2.29	7.29	3.12	4.19
6.0	4.60	2.25	1.00	2.50	7.98	3.42	4.60

W_B	W_1	W_2	t_1	t_2	t_3	t_4	t_5
1.0	0.08	0.26	0.15	0.15	0.15	0.15	0.08
1.5	0.13	0.42	0.15	0.15	0.15	0.15	0.08
2.0	0.15	0.55	0.15	0.15	0.15	0.15	0.08
2.5	0.18	0.68	0.16	0.18	0.18	0.16	0.08
3.0	0.22	0.83	0.20	0.20	0.22	0.20	0.08
3.5	0.26	0.91	0.20	0.23	0.23	0.21	0.10
4.0	0.30	0.91	0.20	0.28	0.25	0.25	0.10
4.5	0.36	0.91	0.20	0.30	0.30	0.30	0.13
5.0	0.39	0.91	0.22	0.31	0.30	0.30	0.15
5.5	0.41	0.91	0.22	0.33	0.33	0.33	0.18
6.0	0.45	0.91	0.25	0.36	0.35	0.35	0.19

Table 9.2 (CU). USBR Type VI Impact Basin Dimensions (ft) (AASHTO, 2005)

W_B	h_1	h_2	h_3	h_4	L	L_1	L_2
4.	3.08	1.50	0.67	1.67	5.42	2.33	3.08
5.	3.83	1.92	0.83	2.08	6.67	2.92	3.83
6.	4.58	2.25	1.00	2.50	8.00	3.42	4.58
7.	5.42	2.58	1.17	2.92	9.42	4.00	5.42
8.	6.17	3.00	1.33	3.33	10.67	4.58	6.17
9.	6.92	3.42	1.50	3.75	12.00	5.17	6.92
10.	7.58	3.75	1.67	4.17	13.42	5.75	7.67
11.	8.42	4.17	1.83	4.58	14.58	6.33	8.42
12.	9.17	4.50	2.00	5.00	16.00	6.83	9.17
13.	10.17	4.92	2.17	5.42	17.33	7.42	10.00
14.	10.75	5.25	2.33	5.83	18.67	8.00	10.75
15.	11.50	5.58	2.50	6.25	20.00	8.50	11.50
16.	12.25	6.00	2.67	6.67	21.33	9.08	12.25
17.	13.00	6.33	2.83	7.08	21.50	9.67	13.00
18.	13.75	6.67	3.00	7.50	23.92	10.25	13.75
19.	14.58	7.08	3.17	7.92	25.33	10.83	14.58
20.	15.33	7.50	3.33	8.33	26.58	11.42	15.33

W_B	W_1	W_2	t_1	t_2	t_3	t_4	t_5
4.	0.33	1.08	0.50	0.50	0.50	0.50	0.25
5.	0.42	1.42	0.50	0.50	0.50	0.50	0.25
6.	0.50	1.67	0.50	0.50	0.50	0.50	0.25
7.	0.50	1.92	0.50	0.50	0.50	0.50	0.25
8.	0.58	2.17	0.50	0.58	0.58	0.50	0.25
9.	0.67	2.50	0.58	0.58	0.67	0.58	0.25
10.	0.75	2.75	0.67	0.67	0.75	0.67	0.25
11.	0.83	3.00	0.67	0.75	0.75	0.67	0.33
12.	0.92	3.00	0.67	0.83	0.83	0.75	0.33
13.	1.00	3.00	0.67	0.92	0.83	0.83	0.33
14.	1.08	3.00	0.67	1.00	0.92	0.92	0.42
15.	1.17	3.00	0.67	1.00	1.00	1.00	0.42
16.	1.25	3.00	0.75	1.00	1.00	1.00	0.50
17.	1.33	3.00	0.75	1.08	1.00	1.00	0.50
18.	1.33	3.00	0.75	1.08	1.08	1.08	0.58
19.	1.42	3.00	0.83	1.17	1.08	1.08	0.58
20.	1.50	3.00	0.83	1.17	1.17	1.17	0.67

Source: HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channels, Third Edition, July 2006

Appendix C.6
Culvert Analysis

CULVERT ANALYSIS

Objective

Design culverts under the final cover access road and under the perimeter access road. These culverts will convey surface water runoff from the downslope channels and perimeter channels to the infiltration channels and basin system. Also culverts under entrance area roads and site access roads.

Design Criteria and Assumptions

1. Culverts will be sized to convey the greater of the peak flow from the 100-year, 1-hour storm event or the 25-year, 24-hour storm event.

2. Assume corrugated metal pipe (CMP) will be used for the culverts. Use a Manning's Roughness Coefficient "n" of 0.024 for corrugated metal pipe.

3. Assume flared end sections will be attached at both inlet and outlet ends of the culverts to provide a smooth transition of flow.

4. Assume rip rap will be used for erosion protection at the culvert inlet and outlet. Alternative materials to riprap, such as a geotextile erosion control mat, may be used to provide erosion protection.

5. Assume a minimum culvert diameter of 18-inches. Culverts recommended in these calculations may be substituted with a structure that provides equal hydraulic performance (i.e., box culvert, pipe arches, etc.)

6. Culverts will be sized using the SEDCAD+ utilities culvert design program. Output is attached. For simplicity culverts with a similar flow are analyzed together.

7. For culverts that will be subjected to vehicular traffic it is assumed that 2 feet of cover soils will be placed over the pipe. Due to upstream geometry the cover over the pipe is not always representative of upstream surface water containment conditions. Headwater depths are assumed based on anticipated conditions at each culvert. Headwater depths assume 0.1 foot of freeboard upstream of the culvert inlet.

8. For culverts that discharge to a channel, a tailwater depth is assumed based on the flow in the downstream channel. Culvert C-8 discharges to the basin above the highwater line, the tailwater depth is therefore assumed to be 0.

Calculations

The expected flow rate to each culvert is presented within the SEDCAD+ output for the sedimentation basin system analyses included in Appendix C-2. The SEDCAD+ Culvert Design Utility was used to evaluate the culverts. The results of these analyses are presented in Attachment 1. Actual culverts will be field fit according to location.

Conclusions

Design culvert requirements are summarized in Table 1 below. The peak flow rate and design assumptions for each culvert were input into the SEDCAD+ Culvert Design Utility.

Table 1: Culvert Analysis Results

Culvert ID Label	Peak Design Flow (cfs)	Total Max. Allowable Flow (cfs)	SEDCAD+ Output	Culvert Information (SEDCAD+ Input)					
			Max. Allowable Flow per pipe (cfs)	Dia. (in.)	No. of Pipes	Max. Length (ft.)	Min. Slope (%)	Head-water (ft)	Tail-water (ft)
C-1	78.26	86.8	12.4	24	7	100	0.5	2.9	2.0
C-2	39.72	43.5	14.5	24	3	100	0.5	3.9	2.5
C-3	19.83	29.0	14.5	24	2	100	0.5	3.9	2.5
C-4	12.79	14.5	14.5	24	1	100	0.5	3.9	2.5
C-5	336.24	352.8	39.2	24	9	100	0.5	3.9	3.0
C-6	337.52	348.8	43.6	36	8	100	3	3.9	2.5
C-7	69.97	84.6	28.2	36	3	120	0.5	2.9	2.0
C-8	190.61	226.0	45.2	36	5	70	1	3.9	0
C-9	55.10	72.4	18.1	24	4	25	0.5	2.9	1.2
C-10	47.24	54.3	18.1	24	3	25	0.5	2.9	1.2
C-11	19.92	36.2	18.1	24	2	25	0.5	2.9	1.2

Notes:

1. Place riprap at culvert inlet and outlet locations.
2. Install flared end sections at both inlet and outlet ends.
3. Culverts recommended in these calculations may be substituted with an equivalent structure that provides equal hydraulic performance (i.e., box culvert, pipe arch, etc.).
4. Culvert slope is approximate. Actual slopes at final design will need to verify adequacy of pipe sizes.
5. Headwater is assumed. Actual headwater will need to verified at final design to verify adequacy of pipe sizes.

ATTACHMENT 1

SEDCAD+ CULVERT DESIGN UTILITY OUTPUT

Culvert C-1

Culvert Inputs:

Length (ft)	Slope (%)	Manning's n	Max. Headwater (ft)	Tailwater (ft)	Entrance Loss Coef. (Ke)
100.00	0.50	0.0240	2.90	2.00	0.50

Culvert Results:

Minimum pipe diameter: 1 - 24 inch pipe(s) required

Detailed Performance Curves

Design Discharge = 12.40 cfs

Maximum Headwater = 2.90 ft

(BOLD indicates design pipe size)

Headwater (ft)	Discharge (cfs) (21 in)	**Discharge (cfs) (24 in)**	Discharge (cfs) (30 in)
0.29	0.00	**0.00**	0.00
0.58	0.00	**0.00**	0.00
0.87	0.00	**0.00**	0.00
1.16	0.00	**0.00**	0.00
1.45	0.00	**0.00**	0.00
1.74	3.69	**5.15**	7.20
2.03	5.48	**7.66**	11.61
2.32	6.82	**9.53**	15.51
2.61	7.94	**11.09**	19.07
2.90	8.91	**12.45**	21.26
3.19	9.80	**13.68**	22.86
3.48	10.60	**14.81**	24.89
3.77	11.35	**15.86**	26.77
4.06	12.06	**16.84**	28.52
4.35	12.72	**17.77**	30.17

Culverts C-2, C-3, and C-4

Culvert Inputs:

Length (ft)	Slope (%)	Manning's n	Max. Headwater (ft)	Tailwater (ft)	Entrance Loss Coef. (Ke)
100.00	0.50	0.0240	3.90	2.50	0.50

Culvert Results:

Minimum pipe diameter: 1 - 24 inch pipe(s) required

Detailed Performance Curves

Design Discharge = 14.50 cfs

Maximum Headwater = 3.90 ft

(BOLD indicates design pipe size)

Headwater (ft)	Discharge (cfs) (21 in)	**Discharge (cfs) (24 in)**	Discharge (cfs) (30 in)
0.39	0.00	**0.00**	0.00
0.78	0.00	**0.00**	0.00
1.17	0.00	**0.00**	0.00
1.56	0.00	**0.00**	0.00
1.95	0.00	**0.00**	0.00
2.34	4.39	**6.14**	10.66
2.73	6.43	**8.99**	15.61
3.12	7.97	**11.14**	19.34
3.51	9.26	**12.93**	22.45
3.90	10.39	**14.51**	25.19
4.29	11.40	**15.93**	27.66
4.68	12.33	**17.23**	29.92
5.07	13.20	**18.44**	32.02
5.46	14.01	**19.58**	33.99
5.85	14.78	**20.66**	35.86

Culvert C-5

Culvert Inputs:

Length (ft)	Slope (%)	Manning's n	Max. Headwater (ft)	Tailwater (ft)	Entrance Loss Coef. (Ke)
100.00	1.00	0.0240	3.90	3.00	0.50

Culvert Results:

Minimum pipe diameter: 1 - 36 inch pipe(s) required

Detailed Performance Curves

Design Discharge = 39.20 cfs

Maximum Headwater = 3.90 ft

(BOLD indicates design pipe size)

Headwater (ft)	Discharge (cfs) (30 in)	**Discharge (cfs) (36 in)**	Discharge (cfs) (42 in)
0.39	0.00	**0.00**	0.00
0.78	0.00	**0.00**	0.00
1.17	0.00	**0.00**	0.00
1.56	0.00	**0.00**	0.00
1.95	0.00	**0.00**	0.00
2.34	10.66	**16.60**	18.43
2.73	15.61	**24.33**	29.46
3.12	19.34	**30.14**	38.57
3.51	22.45	**34.99**	46.59
3.90	25.19	**39.25**	55.16
4.29	27.66	**43.09**	62.70
4.68	29.92	**46.61**	67.79
5.07	32.02	**49.90**	72.50
5.46	33.99	**52.97**	76.94
5.85	35.86	**55.88**	81.13

Culvert C-6

Culvert Inputs:

Length (ft)	Slope (%)	Manning's n	Max. Headwater (ft)	Tailwater (ft)	Entrance Loss Coef. (Ke)
100.00	1.00	0.0240	3.90	2.50	0.50

Culvert Results:

Minimum pipe diameter: 1 - 36 inch pipe(s) required

Detailed Performance Curves

Design Discharge = 43.60 cfs

Maximum Headwater = 3.90 ft

(BOLD indicates design pipe size)

Headwater (ft)	Discharge (cfs) (30 in)	**Discharge (cfs) (36 in)**	Discharge (cfs) (42 in)
0.39	0.00	**0.00**	0.00
0.78	0.00	**0.00**	0.00
1.17	0.00	**0.00**	0.00
1.56	4.47	**4.40**	5.67
1.95	12.25	**14.01**	16.90
2.34	16.75	**20.99**	24.09
2.73	20.26	**27.41**	31.78
3.12	23.26	**33.85**	39.81
3.51	25.91	**40.00**	48.28
3.90	28.31	**43.66**	56.52
4.29	30.53	**47.13**	62.70
4.68	32.59	**50.38**	67.79
5.07	34.53	**53.43**	72.50
5.46	36.37	**56.31**	76.94
5.85	38.11	**59.05**	81.13

Culvert C-7

Culvert Inputs:

Length (ft)	Slope (%)	Manning's n	Max. Headwater (ft)	Tailwater (ft)	Entrance Loss Coef. (Ke)
120.00	0.50	0.0240	2.90	2.00	0.50

Culvert Results:

Minimum pipe diameter: 1 - 36 inch pipe(s) required

Detailed Performance Curves

Design Discharge = 28.20 cfs

Maximum Headwater = 2.90 ft

(BOLD indicates design pipe size)

Headwater (ft)	Discharge (cfs) (30 in)	**Discharge (cfs) (36 in)**	Discharge (cfs) (42 in)
0.29	0.00	**0.00**	0.00
0.58	0.00	**0.00**	0.00
0.87	0.00	**0.00**	0.00
1.16	0.00	**0.00**	0.00
1.45	2.77	**3.42**	4.51
1.74	7.99	**9.61**	11.89
2.03	11.89	**14.47**	16.62
2.32	15.50	**19.19**	22.16
2.61	18.83	**23.91**	27.87
2.90	21.05	**28.25**	33.41
3.19	22.13	**32.21**	38.83
3.48	23.98	**34.32**	44.12
3.77	25.70	**36.23**	49.16
4.06	27.30	**39.01**	52.54
4.35	28.83	**41.61**	54.86

Culvert C-8

Culvert Inputs:

Length (ft)	Slope (%)	Manning's n	Max. Headwater (ft)	Tailwater (ft)	Entrance Loss Coef. (Ke)
70.00	1.00	0.0240	3.90	0.00	0.50

Culvert Results:

Minimum pipe diameter: 1 - 36 inch pipe(s) required

Detailed Performance Curves

Design Discharge = 45.20 cfs

Maximum Headwater = 3.90 ft

(BOLD indicates design pipe size)

Headwater (ft)	Discharge (cfs) (30 in)	**Discharge (cfs) (36 in)**	Discharge (cfs) (42 in)
0.39	5.66	**7.52**	9.30
0.78	7.67	**10.60**	13.59
1.17	9.43	**13.31**	17.47
1.56	11.00	**15.76**	20.98
1.95	13.74	**17.98**	24.19
2.34	18.60	**21.69**	27.16
2.73	23.42	**28.14**	31.84
3.12	26.65	**34.74**	40.02
3.51	29.56	**40.95**	48.47
3.90	32.20	**45.20**	56.79
4.29	34.65	**49.31**	63.69
4.68	36.93	**53.11**	70.22
5.07	39.07	**56.65**	75.71
5.46	41.11	**59.99**	80.81
5.85	43.05	**63.14**	85.62

Culverts C-9, C-10, and C-11

Culvert Inputs:

Length (ft)	Slope (%)	Manning's n	Max. Headwater (ft)	Tailwater (ft)	Entrance Loss Coef. (Ke)
25.00	0.50	0.0240	2.90	1.20	0.50

Culvert Results:

Minimum pipe diameter: 1 - 24 inch pipe(s) required

Detailed Performance Curves

Design Discharge = 18.10 cfs

Maximum Headwater = 2.90 ft

(BOLD indicates design pipe size)

Headwater (ft)	Discharge (cfs) (21 in)	**Discharge (cfs) (24 in)**	Discharge (cfs) (30 in)
0.29	0.00	**0.00**	0.00
0.58	0.00	**0.00**	0.00
0.87	0.00	**0.00**	0.00
1.16	2.40	**2.72**	3.80
1.45	5.56	**6.32**	7.98
1.74	8.05	**9.22**	11.18
2.03	9.93	**11.81**	14.54
2.32	11.35	**14.30**	18.16
2.61	12.96	**16.02**	21.84
2.90	14.39	**18.13**	25.41
3.19	15.69	**20.02**	28.41
3.48	16.89	**21.75**	31.64
3.77	18.00	**23.34**	34.28
4.06	19.06	**24.84**	36.72
4.35	20.05	**26.24**	39.00

Appendix C.7
Surface Water Perimeter Channel Analysis

SURFACE WATER PERIMETER CHANNEL ANALYSIS

Objective

Design run-on channels to divert surface water run-on around the landfill and design perimeter channels adjacent to the perimeter road and the channel along the site access road to transmit surface water runoff to culverts.

Design Criteria and Assumptions

1. Channels will be able to convey runoff from the highest peak flow storm; either a 100-year, 1-hour storm event or a 25-year, 24-hour storm event, without overflow.

2. Perimeter channel sideslopes will be 3:1 (horizontal:vertical) on the road side and 3.5:1 on the landfill side.

3. Run-on and entrance channel sideslopes will be 3:1 on both sides.

5. Channel slopes vary. Each channel will be designed based on actual anticipated flows and slopes. Note that the slope in the SEDCAD output is rounded to the nearest tenth.

Calculations

The channel locations and peak flow rate associated with each perimeter channel is shown on the SEDCAD+ output files presented in Appendix C-2 of the engineering report. The SEDCAD+ Channel Design Utility was used to evaluate the channels. The results of these analyses are presented in Attachment 1.

Conclusions

Design channel requirements are summarized in Table 1 below. Dimensions identified by the SEDCAD+ analyses were rounded up to obtain the typical cross-section. The peak flow rate and shallowest slope for each channel was input into the SEDCAD+ Channel Design Utility.

CALCULATION SHEET

AECOM

Project No. 60221907

Client	County of Kaua'i	**Subject**	Surface Water	**Prepared By**	TCR	**Date**	5/28/13
Project	Ma'alo Landfill		Perimeter and Run-on	**Reviewed By**	NKW	**Date**	5/28/13
Conceptual Design			Channel Analysis	**Approved By**	KJB	**Date**	5/29/13

Table 1: Phase 1 Channel Schedule

SEDCAD+ Structure No.	Channel	Channel Slope (%)	Peak Design Flow (cfs)	SEDCAD+[1] Depth (ft)	Design Scenario[1]			
					Channel Bottom Width (ft)	Channel Lining	Channel Side-slopes	Min. Design Depth (ft)
3	PC-1 Upper Reach	7.0	74.95	1.40	6	Grass / Erosion Mat	3.5, 3:1	1.5 (use 3.0)
	PC-1 Lower Reach	0.5		2.91	6	Grass	3.5, 3:1	3.0
16	PC-2	0.5	69.97	2.86	6	Grass	3.5, 3:1	3.0
17	PC-3	0.5	19.79	2.05	6	Grass	3.5, 3:1	2.5 (use 3.0)
4	PC-4	0.33	86.29	3.38	6	Grass	3.5, 3:1	3.5 (use 4.0)
21	PC-5 Upper Reach	5.5	21.43	1.07	6	Grass / Erosion Mat	3.5, 3:1	1.5 (use3.0)
	PC-5 Lower Reach	0.33		2.36	6	Grass	3.5, 3:1	2.5 (use 3.0)
45	RO-1 Upper Reach	8.9	336.24	2.18	8	Riprap	3:1	2.5
44	RO-1 Mid Reach	2.2	337.52	2.80	8	Riprap	3:1	3.0
	RO-1 Lower Reach	6.2	337.52	2.36	8	Riprap	3:1	2.5
46	RO-2	1.5	122.20	2.14	10	Grass / Erosion Mat	3:1	2.5
47	RO-3	0.5	249.22	3.2	15	Grass	3:1	3.5
39	RO-4 Upper Reach	0.75	26.88	2.0	6	Grass	3:1	2.0 (use 3.0)
40	RO-4 Lower Reach	2.5	26.84	1.42	6	Grass	3:1	1.5 (use 3.0)
37	EC-1	0.5	39.72	2.48	6	Grass	3:1	2.5 (use 3.0)
35	EC-2	2.3	11.69	1.30	4	Grass	3:1	1.5 (use 2.5)
36	EC-3	0.5	10.53	1.92	4	Grass	3:1	2.0 (use 2.5)

Notes:

1. SEDCAD depth includes 0.1 ft freeboard.
2. The perimeter channels will be 3.0 feet in depth except along the west perimeter of Phase 1, where the depth will be 4.0 feet.
3. The ability of grass channel lining to resist scour and erosion is dependent on many factors. Permanent erosion control mat or other channel stabilization erosion control measures are recommended for some channels as indicated in the design. Additional channels may need erosion control measures depending on actual site conditions.
4. For run-on channel RO-1, a riprap with the following characteristics is recommended:
   a. Minimum thickness = 18.0 inches
   b. D_{min} = 5.0 inches
   c. D_{50} = 9.0 inches
   d. D_{max} = 12 inches

ATTACHMENT 1

SEDCAD+ CHANNEL DESIGN UTILITY OUTPUT

Perimeter Channel PC-1 Upper Reach

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	3.5:1	3.0:1	7.0	D, B	0.10			4.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	74.95 cfs		74.95 cfs	
Depth:	0.92 ft	1.02 ft	1.30 ft	1.40 ft
Top Width:	11.99 ft	12.64 ft	14.42 ft	15.07 ft
Velocity:	9.04 fps		5.67 fps	
X-Section Area:	8.29 sq ft		13.22 sq ft	
Hydraulic Radius:	0.676 ft		0.893 ft	
Froude Number:	1.91		1.04	
Roughness Coefficient:	0.0335		0.0644	

Perimeter Channel PC-1 Lower Reach

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	3.5:1	3.0:1	0.5	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	74.95 cfs		74.95 cfs	
Depth:	1.93 ft	2.03 ft	2.81 ft	2.91 ft
Top Width:	18.55 ft	19.20 ft	24.28 ft	24.93 ft
Velocity:	3.16 fps		1.76 fps	
X-Section Area:	23.71 sq ft		42.59 sq ft	
Hydraulic Radius:	1.239 ft		1.695 ft	
Froude Number:	0.49		0.23	
Roughness Coefficient:	0.0384		0.0851	

Perimeter Channel PC-2

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	3.5:1	3.0:1	0.5	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	69.97 cfs		69.97 cfs	
Depth:	1.88 ft	1.98 ft	2.76 ft	2.86 ft
Top Width:	18.23 ft	18.88 ft	23.95 ft	24.60 ft
Velocity:	3.07 fps		1.69 fps	
X-Section Area:	22.80 sq ft		41.34 sq ft	
Hydraulic Radius:	1.213 ft		1.669 ft	
Froude Number:	0.48		0.23	
Roughness Coefficient:	0.0390		0.0875	

Perimeter Channel PC-3

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	3.5:1	3.0:1	0.5	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	19.79 cfs		19.79 cfs	
Depth:	1.16 ft	1.26 ft	1.95 ft	2.05 ft
Top Width:	13.51 ft	14.16 ft	18.70 ft	19.35 ft
Velocity:	1.75 fps		0.82 fps	
X-Section Area:	11.28 sq ft		24.13 sq ft	
Hydraulic Radius:	0.814 ft		1.251 ft	
Froude Number:	0.34		0.13	
Roughness Coefficient:	0.0523		0.1492	

Perimeter Channel PC-4

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	3.5:1	3.0:1	0.3	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	86.29 cfs		86.29 cfs	
Depth:	2.27 ft	2.37 ft	3.28 ft	3.38 ft
Top Width:	20.78 ft	21.43 ft	27.33 ft	27.98 ft
Velocity:	2.83 fps		1.58 fps	
X-Section Area:	30.45 sq ft		54.70 sq ft	
Hydraulic Radius:	1.419 ft		1.931 ft	
Froude Number:	0.41		0.20	
Roughness Coefficient:	0.0381		0.0841	

Perimeter Channel PC-5 Upper Reach

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	3.5:1	3.0:1	5.5	D, B	0.10			4.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	21.43 cfs		21.43 cfs	
Depth:	0.59 ft	0.69 ft	0.97 ft	1.07 ft
Top Width:	9.86 ft	10.51 ft	12.30 ft	12.95 ft
Velocity:	4.55 fps		2.42 fps	
X-Section Area:	4.71 sq ft		8.87 sq ft	
Hydraulic Radius:	0.469 ft		0.704 ft	
Froude Number:	1.16		0.50	
Roughness Coefficient:	0.0463		0.1143	

Perimeter Channel PC-5 Lower Reach

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	3.5:1	3.0:1	0.3	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	21.43 cfs		21.43 cfs	
Depth:	1.34 ft	1.44 ft	2.26 ft	2.36 ft
Top Width:	14.72 ft	15.37 ft	20.66 ft	21.31 ft
Velocity:	1.54 fps		0.71 fps	
X-Section Area:	13.89 sq ft		30.06 sq ft	
Hydraulic Radius:	0.919 ft		1.409 ft	
Froude Number:	0.28		0.10	
Roughness Coefficient:	0.0524		0.1508	

Run-on Channel RO-1 Upper Reach

Material: Riprap

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
8.00	3.0:1	3.0:1	8.9	0.10		

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	336.24 cfs	
Depth:	2.08 ft	2.18 ft
Top Width:	20.48 ft	21.08 ft
Velocity:	11.35 fps	
X-Section Area:	29.62 sq ft	
Hydraulic Radius:	1.400 ft	
Froude Number:	1.66	
Manning's n:	0.0490	
Dmin:	5.00 in	
D50:	9.00 in	
Dmax:	12.00 in	

Run-on Channel RO-1 Middle Reach

Material: Riprap

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
8.00	3.0:1	3.0:1	2.2	0.10		

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	337.52 cfs	
Depth:	2.70 ft	2.80 ft
Top Width:	24.19 ft	24.79 ft
Velocity:	7.77 fps	
X-Section Area:	43.41 sq ft	
Hydraulic Radius:	1.732 ft	
Froude Number:	1.02	
Manning's n:	0.0410	
Dmin:	3.00 in	
D50:	6.00 in	
Dmax:	9.00 in	

Run-on Channel RO-1 Lower Reach

Material: Riprap

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
8.00	3.0:1	3.0:1	6.2	0.10		

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	337.52 cfs	
Depth:	2.26 ft	2.36 ft
Top Width:	21.55 ft	22.15 ft
Velocity:	10.12 fps	
X-Section Area:	33.36 sq ft	
Hydraulic Radius:	1.497 ft	
Froude Number:	1.43	
Manning's n:	0.0480	
Dmin:	5.00 in	
D50:	9.00 in	
Dmax:	12.00 in	

Run-on Channel RO-2

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
10.00	3.0:1	3.0:1	1.5	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	122.20 cfs		122.20 cfs	
Depth:	1.46 ft	1.56 ft	2.04 ft	2.14 ft
Top Width:	18.75 ft	19.35 ft	22.26 ft	22.86 ft
Velocity:	5.83 fps		3.71 fps	
X-Section Area:	20.96 sq ft		32.95 sq ft	
Hydraulic Radius:	1.090 ft		1.438 ft	
Froude Number:	0.97		0.54	
Roughness Coefficient:	0.0331		0.0627	

Run-on Channel RO-3

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
15.00	3.0:1	3.0:1	0.5	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	249.22 cfs		249.22 cfs	
Depth:	2.30 ft	2.40 ft	3.10 ft	3.20 ft
Top Width:	28.81 ft	29.41 ft	33.61 ft	34.21 ft
Velocity:	4.94 fps		3.31 fps	
X-Section Area:	50.40 sq ft		75.36 sq ft	
Hydraulic Radius:	1.705 ft		2.177 ft	
Froude Number:	0.66		0.39	
Roughness Coefficient:	0.0304		0.0535	

Run-on Channel RO-4 Upper Reach

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	3.0:1	3.0:1	0.8	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	26.88 cfs		26.88 cfs	
Depth:	1.17 ft	1.27 ft	1.90 ft	2.00 ft
Top Width:	13.02 ft	13.62 ft	17.39 ft	17.99 ft
Velocity:	2.42 fps		1.21 fps	
X-Section Area:	11.13 sq ft		22.20 sq ft	
Hydraulic Radius:	0.830 ft		1.233 ft	
Froude Number:	0.46		0.19	
Roughness Coefficient:	0.0471		0.1224	

Run-on Channel RO-4 Lower Reach

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	3.0:1	3.0:1	2.5	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	26.84 cfs		26.84 cfs	
Depth:	0.82 ft	0.92 ft	1.32 ft	1.42 ft
Top Width:	10.94 ft	11.54 ft	13.92 ft	14.52 ft
Velocity:	3.84 fps		2.04 fps	
X-Section Area:	6.98 sq ft		13.15 sq ft	
Hydraulic Radius:	0.623 ft		0.916 ft	
Froude Number:	0.85		0.37	
Roughness Coefficient:	0.0447		0.1087	

Entrance Channel EC-1

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	3.0:1	3.0:1	0.5	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	39.72 cfs		39.72 cfs	
Depth:	1.53 ft	1.63 ft	2.38 ft	2.48 ft
Top Width:	15.18 ft	15.78 ft	20.30 ft	20.90 ft
Velocity:	2.45 fps		1.27 fps	
X-Section Area:	16.20 sq ft		31.35 sq ft	
Hydraulic Radius:	1.034 ft		1.488 ft	
Froude Number:	0.42		0.18	
Roughness Coefficient:	0.0439		0.1083	

Entrance Channel EC-2

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
4.00	3.0:1	3.0:1	2.3	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	11.69 cfs		11.69 cfs	
Depth:	0.70 ft	0.80 ft	1.20 ft	1.30 ft
Top Width:	8.22 ft	8.82 ft	11.21 ft	11.81 ft
Velocity:	2.72 fps		1.28 fps	
X-Section Area:	4.29 sq ft		9.14 sq ft	
Hydraulic Radius:	0.508 ft		0.788 ft	
Froude Number:	0.66		0.25	
Roughness Coefficient:	0.0528		0.1506	

Entrance Channel EC-3

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
4.00	3.0:1	3.0:1	0.5	D, B	0.10			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	10.53 cfs		10.53 cfs	
Depth:	1.04 ft	1.14 ft	1.82 ft	1.92 ft
Top Width:	10.24 ft	10.84 ft	14.94 ft	15.54 ft
Velocity:	1.42 fps		0.61 fps	
X-Section Area:	7.40 sq ft		17.28 sq ft	
Hydraulic Radius:	0.700 ft		1.112 ft	
Froude Number:	0.29		0.10	
Roughness Coefficient:	0.0584		0.1855	

Appendix C.8
RRP Surface Water Runoff Parameters and Design Storm Requirements

RRP SURFACE WATER RUNOFF PARAMETERS AND DESIGN STORM REQUIREMENTS

Objective

Determine rainfall value and curve number to be used as input in SEDCAD+. The curve number is used to determine how much precipitation becomes runoff. The curve number is primarily a function of soil type, cover type and treatment, and hydrologic condition. SEDCAD+ uses SCS methods to compute runoff volume.

Design Criteria and Assumptions

1. SEDCAD+, a computer program, was used to design and evaluate the surface water management system for the Ma'alo Resource Recovery Park (RRP). SEDCAD+ is a program developed at the University of Kentucky to assist in the design and evaluation of surface water management system components.

   The program is capable of computing peak flow, calculating runoff volume, sizing channels and culverts, and computing the hydraulic performance of sedimentation basins. SEDCAD+ utilizes the following methods within the program:
   - SCS Upland Curve Method for calculating time of concentration.
   - Muskingum's Method for routing between structures.
   - SCS Technical Release - 55 (TR-55) parameter for runoff volume.

   Within this appendix are calculations for each element of the surface water management system along with SEDCAD+ program input/output.

2. Surface water run-on from nearby areas will be routed around the site and kept separate from surface water runoff from RRP areas. Surface water runoff from the RRP areas will be managed in a surface water sedimentation basin.

3. Evaluate the following storm events for surface water management structures and sedimentation basin:
   a. 100-year, 1-hour storm event.
   b. 25-year, 24-hour storm event.
   c. 100-year, 24-hour storm event.

4. Determine peak rainfall values as recommended in the Storm Water Runoff System Manual, July 2001, Department of Public Works, County of Kauai. Peak rainfall values are based on the attached data from Technical Paper No. 43, Rainfall-Frequency Atlas of the Hawaiian Islands.

5. Use SCS storm distribution Type I, per attached page.

6. Determine curve number, assuming final cover conditions are pasture, grassland, or range, poor condition, and hydrologic soil group B. Assume impervious areas, paved and open ditches, represents the leachate holding tank and entrance areas. Determine curve number from tables provided in SCS TR-55. See attached table for curve number determination.

Client	County of Kaua'i	**Subject**	RRP Surface Water	**Prepared By**	TCR	**Date**	11/22/13
Project	Resource Recovery	Runoff Parameters and		**Reviewed By**	NKW	**Date**	11/22/13
Conceptual Design		Design Storm Requirements		**Approved By**		**Date**	

Conclusions

1. A 100-year, 1-hour storm event yields 4.9 inches of rainfall.
2. A 25-year, 24-hour storm event yields 13.4 inches of rainfall.
3. A 100-year, 24-hour storm event yields 17.5 inches of rainfall.
4. The curve number is 79 for the existing conditions.
5. The curve number is 98 for paved and building areas of the RRP.
6. The curve number is 85 for developed RRP areas.

Appendix C.9
RRP Surface Water Basin Analysis

RRP SURFACE WATER BASIN ANALYSIS

Objective

Evaluate the post-development surface water flow conditions, and design the surface water basins and determine the design flows for each surface water management structure for the Resource Recovery Park (RRP).

Design Criteria and Assumptions

1. Surface water basins will be used to detain and discharge surface water runoff from the RRP. The compost area basin will hold liquids to be hauled off and treated while the other basins will allow discharge of surface water.

2. The County of Kauai Department of Public Works Stormwater Runoff System Manual is utilized in the design as appropriate.

3. The basins are designed to manage the design storm events. The basins and channels will empty through discharge structures in less than 48 hours after the conclusion of the storm event.

4. Figures 1 and 2 show the pre- and post-development surface water management system networks with subbasin drainage areas and structure labels.

5. The results from the 100-year, 1-hour and 25-year, 24-hour storms are used in the design of the surface water management structures. The 100-year, 24-hour storm is used only to evaluate the performance of the Surface Water Basin emergency spillways.

6. The design is conceptual and should be re-evaluated when final RRP design conditions are established.

7. Note that the slope in the SEDCAD output is rounded to the nearest tenth.

Calculations

1. SEDCAD+ was used to determine the surface water flows and the stage-storage-discharge relationships for each basin. SEDCAD+ output for pre-development flows are provided herein in Attachments 1A and 1B. The output for the post-development flows are provided herein in Attachments 2A, 2B, and 2C. The basins were analyzed for the 100-year, 1-hour storm, the 25-year, 24-hour storm, and the 100-yr, 24-hr storm events. Tables 2 and 3 summarize the results from the SEDCAD+ analyses.

TABLE 1 – PRE-DEVELOPMENT SURFACE WATER FLOWS

Pre-Development SEDCAD Structure No.	Description	Pre-Development Surface Water Flow (cfs)	
		100-yr, 1-hr Storm	25-yr, 24-hr Storm
2, 3	Flow to East and Southeast	114.91 (63.67 + 51.24)	137.51 (77.34 + 60.17)
4, 5	Flow to South and West	85.19 (29.40 +_55.79)	96.98 (67.79 + 29.19)

Note: Flow to east and southeast combine just off site and flow to same waterway. Flow to South and West cobine just south of the site and flow to the same waterway.

Conclusions

1. The proposed RRP development, when compared to pre-development surface water flows for the design storm events, will not increase the peak run-on to downstream properties.

2. The proposed Surface Water Basins will perform as designed. The 25-year, 24-hour storm event is handled through the principal spillways. The 100-year, 24-hour storm event is managed through the emergency spillway and maintains more than 1 foot of freeboard.

3. The Compost Area Basin is designed to hold storm water runoff for hauling off-site for treatment. The 100-yr, 24-hr storm causes the Compost Area Basin to discharge through the emergency spillway preventing treatment of a portion of the storm runoff.

4. The following Tables 1 through 4 summarize the results from the SEDCAD+ analyses and compare the results.

TABLE 2 – PRE to POST-DEVELOPMENT FLOW COMPARISON

Description	Pre-Development Surface Water Flow (cfs)		Post-Development Surface Water Flow (cfs)	
	100-yr, 1-hr Storm	25-yr, 24-hr Storm	100-yr, 1-hr Storm	25-yr, 24-hr Storm
Flow to East and Southeast	114.91	137.51	47.41	56.05
Flow to South and West	85.19	96.98	34.06	43.61

Note: Flow to east and southeast combine just of site and flow to same waterway. Flow to South and West cobine just south of the site and flow to the same waterway.

TABLE 3 – SUMMARY OF SEDIMENTATION BASIN ANALYSES

Parameter	South Surface Water Basin			East Surface Water Basin		
	100-Year, 1-Hour Storm	100-Year, 24-Hour Storm	25-Year, 24-Hour Storm	100-Year, 1-Hour Storm	100-Year, 24-Hour Storm	25-Year, 24-Hour Storm
Total Drainage Area (ac)	21.88			20.93		
Peak Flow In (cfs)	90.13	125.93	94.35	104.56	137.52	103.12
Peak Flow Out (cfs)	34.06	58.46	43.61	47.41	80.30	56.05
Peak Water Elevation (ft.)	285.63	287.47	286.38	283.01	284.57	283.58
Dewatering Time (days)	0.46	0.92	0.91	0.33	0.83	0.82
Volume of Permanent Pool (ac-ft)	Dry Basin			Dry Basin		
Permanent Pool Elev. (ft.)	Dry Basin			Dry Basin		
Top of Berm Elevation	289.0			286.0		
Bottom of Basin Elevation	283.0			280.0		
Emergency Spillway Invert Elev.	287.0			284.0		

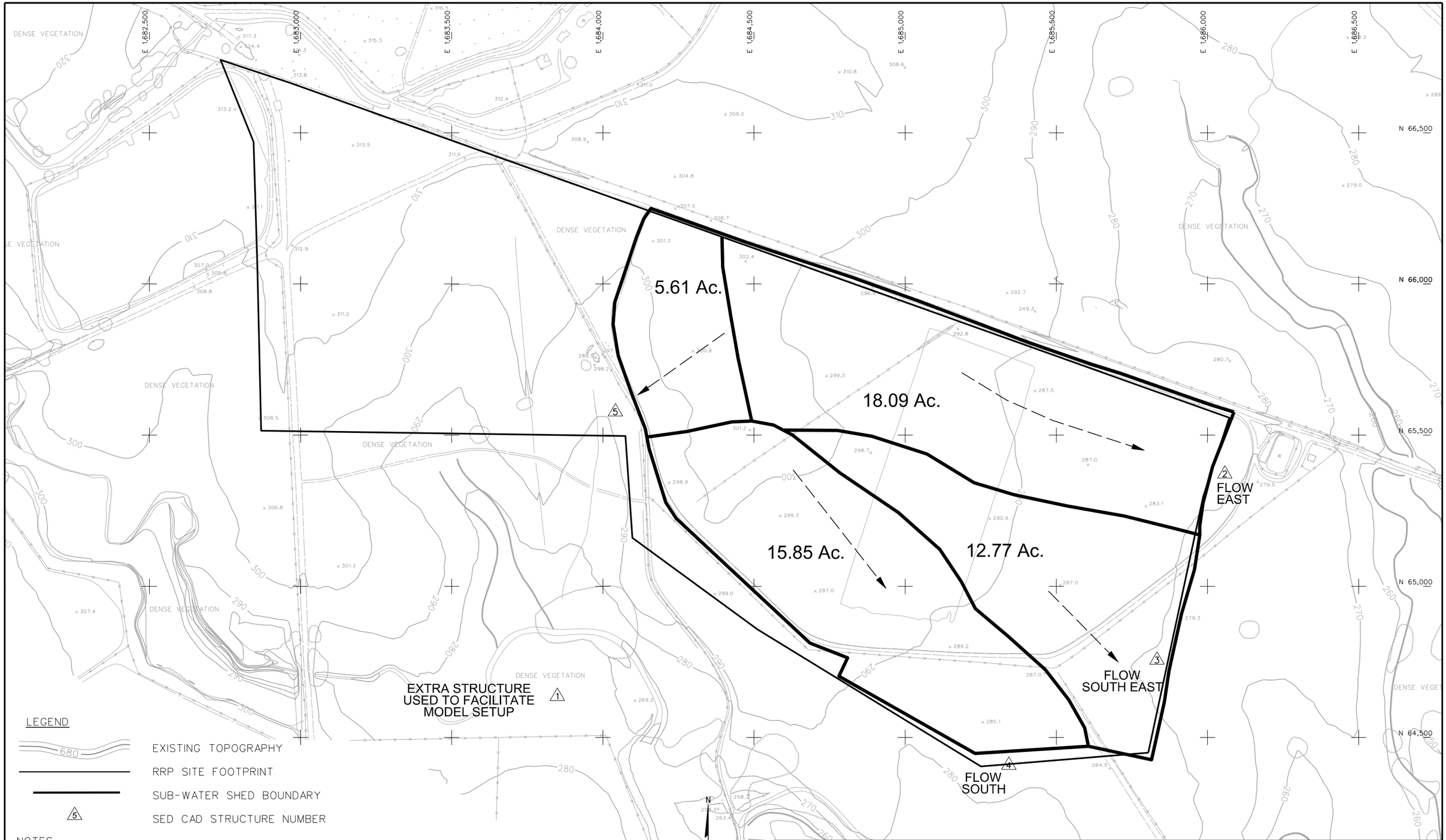
TABLE 3 CONTINUED– SUMMARY OF SEDIMENTATION BASIN ANALYSES

Parameter	Compost Area Basin		
	100-Year, 1-Hour Storm	100-Year, 24-Hour Storm	25-Year, 24-Hour Storm
Total Drainage Area (ac)			
Peak Flow In (cfs)	50.29	65.81	49.14
Peak Flow Out (cfs)	0.07	2.83	0.09
Peak Water Elevation (ft.)	286.61	292.84	291.81
Dewatering Time (days)	--	--	--
Volume of Permanent Pool (ac-ft)	Dry Basin		
Permanent Pool Elev. (ft.)	Dry Basin		
Top of Berm Elevation	294.0		
Bottom of Basin Elevation	279.0		
Emergency Spillway Invert Elev.	292.5		

Note: 1. Compost Area Basin will be pumped and hauled off-site for treatment after storm events. It is assumed that the basin is emptied between storm events.
2. Under normal conditions there will be no discharge from the Compost Area Basin. A small discharge is assumed for modeling purposes so that the basin is empty at the beginning of the modeled storm event.

TABLE 4 – POST-DEVELOPMENT PEAK FLOWS FOR DESIGN OF STRUCTURES

Structure No.	Type/ Name of Structure	Peak Storm Flows (cfs)	
		100-Year, 1-Hour	25-Year, 24-Hour
1	Flow Off-Site to South	34.06	44.04
2	Gravel Spreader Berm	34.06	44.04
3	South Surface Water Basin (Discharge)	34.06	43.61
4	Culverts C1 and C2	9.94	9.71
5	Culverts C3, C4, and C5	11.20	10.77
6	Culvert C10	85.56	90.65
7	Culvert C7	6.20	5.61
8	Culvert C9	8.92	8.06
9	Culvert C11	83.42	86.69
10	Culvert C12	21.51	20.31
11	Culvert C13	6.76	6.16
12	Culvert C14	47.96	47.50
13	Culvert C15	9.92	8.96
14	Culverts C16, and C17	28.68	29.78
15	Compost Area Basin (Discharge)	0.07	0.09
16	East Surface Water Basin (Flow Off-Site to East) (Discharge)	47.41	56.05
17	Culvert C6	23.47	21.95
18		70.80	69.84
19	Culvert C8	44.88	42.94
20	Flow Off-site	80.19	98.71
Note: The purpose of this table is to identify the worst-case flow condition for each structure.			



LEGEND

- EXISTING TOPOGRAPHY
- RRP SITE FOOTPRINT
- SUB-WATER SHED BOUNDARY
- SED CAD STRUCTURE NUMBER

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

AECOM

FIGURE 1
CONCEPTUAL SITE PRE-DEVELOPMENT
SEDCAD SUBWATERSHED
DRAFT CONCEPTUAL DESIGN
PROPOSED MA'ALO SANITARY LANDFILL
AND RESOURCE RECOVERY PARK
KAUAI, HAWAII

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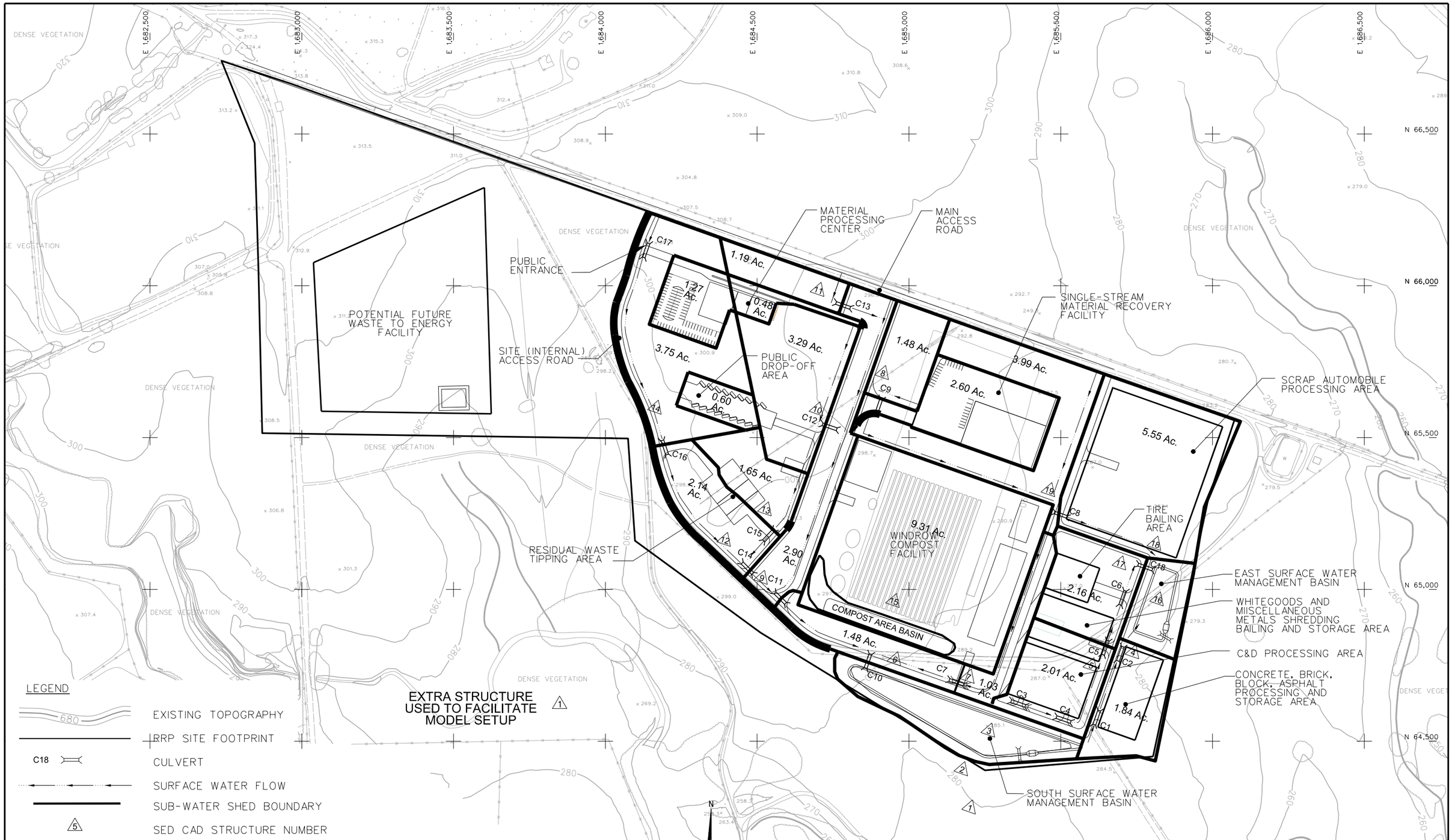

LEGEND

- EXISTING TOPOGRAPHY (680)
- RRP SITE FOOTPRINT
- C18 CULVERT
- SURFACE WATER FLOW
- SUB-WATER SHED BOUNDARY
- 5 SED CAD STRUCTURE NUMBER

NOTES:

1. EXISTING GRADE IS BASED ON TOPOGRAPHIC MAP PREPARED BY COOPER AERIAL SURVEY CO., PHOENIX, AZ. DATE OF FLIGHT: AUGUST 9, 2012.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4. VERTICAL DATUM IS USGS MEAN SEA LEVEL.

AECOM

FIGURE 2
CONCEPTUAL SITE POST-DEVELOPMENT SEDCAD SUBWATERSHED

DRAFT CONCEPTUAL DESIGN
PROPOSED MA'ALO SANITARY LANDFILL AND RESOURCE RECOVERY PARK
KAUAI, HAWAII

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ATTACHMENT 1A

PRE-DEVELOPMENT FLOW EVALUATION
SEDCAD+ OUTPUT
100-YEAR, 1-HOUR STORM EVENT

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Pre-Development Surface Water 100-yr, 1-hr Storm

Resource Recovery Park

Feasibility Study

County of Kaua'i

AECOM

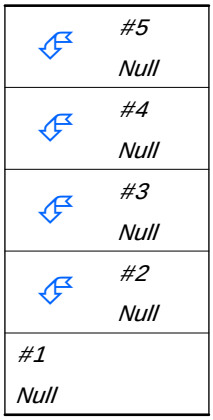
General Information

Storm Information:

Storm Type:	NRCS Type I
Design Storm:	100 yr - 1 hr
Rainfall Depth:	4.900 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	Total flow from site
Null	#2	==>	#1	0.000	0.000	Flow to East
Null	#3	==>	#1	0.000	0.000	Flow to Southeast
Null	#4	==>	#1	0.000	0.000	Flow to South
Null	#5	==>	#1	0.000	0.000	Flow to West



Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#5	5.610	5.610	29.40	1.29
#4	15.850	15.850	55.79	3.54
#3	12.770	12.770	51.24	2.86
#2	18.090	18.090	63.67	4.04
#1	0.000	52.320	178.57	11.73

Structure Detail:

Structure #5 (Null)

Flow to West

Structure #4 (Null)

Flow to South

Structure #3 (Null)

Flow to Southeast

Structure #2 (Null)

Flow to East

Structure #1 (Null)

Total flow from site

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#5	1	5.610	0.152	0.000	0.000	79.000	TR55	29.40	1.289
	Σ	**5.610**						**29.40**	**1.289**
#4	1	15.850	0.555	0.000	0.000	79.000	TR55	55.79	3.537
	Σ	**15.850**						**55.79**	**3.537**
#3	1	12.770	0.423	0.000	0.000	79.000	TR55	51.24	2.863
	Σ	**12.770**						**51.24**	**2.863**
#2	1	18.090	0.555	0.000	0.000	79.000	TR55	63.67	4.037
	Σ	**18.090**						**63.67**	**4.037**
#1	Σ	**52.320**						**178.57**	**11.727**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#2	1	3. Short grass pasture	1.30	23.65	1,820.00	0.910	0.555
#2	**1**	**Time of Concentration:**					**0.555**
#3	1	3. Short grass pasture	1.60	24.64	1,540.00	1.010	0.423
#3	**1**	**Time of Concentration:**					**0.423**
#4	1	3. Short grass pasture	1.10	18.26	1,660.00	0.830	0.555
#4	**1**	**Time of Concentration:**					**0.555**
#5	1	3. Short grass pasture	1.00	3.12	312.00	0.800	0.108
		6. Grassed waterway	1.40	3.93	281.00	1.770	0.044
#5	**1**	**Time of Concentration:**					**0.152**

ATTACHMENT 1B

PRE-DEVELOPMENT FLOW EVALUATION
SEDCAD+ OUTPUT
25-YEAR, 24-HOUR STORM EVENT

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Pre-Development Surface Water 25-yr, 24-hr Storm

Resource Recovery Park

Feasibility Study

County of Kaua'i

AECOM

General Information

Storm Information:

Storm Type:	NRCS Type I
Design Storm:	25 yr - 24 hr
Rainfall Depth:	13.400 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	Total flow from site
Null	#2	==>	#1	0.000	0.000	Flow to East
Null	#3	==>	#1	0.000	0.000	Flow to Southeast
Null	#4	==>	#1	0.000	0.000	Flow to South
Null	#5	==>	#1	0.000	0.000	Flow to West

	#5 *Null*
	#4 *Null*
	#3 *Null*
	#2 *Null*
#1 *Null*	

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#5	5.610	5.610	29.19	5.06
#4	15.850	15.850	67.79	13.89
#3	12.770	12.770	60.17	11.24
#2	18.090	18.090	77.37	15.85
#1	0.000	52.320	223.56	46.05

Structure Detail:

Structure #5 (Null)

Flow to West

Structure #4 (Null)

Flow to South

Structure #3 (Null)

Flow to Southeast

Structure #2 (Null)

Flow to East

Structure #1 (Null)

Total flow from site

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#5	1	5.610	0.152	0.000	0.000	79.000	TR55	29.19	5.063
	Σ	**5.610**						**29.19**	**5.063**
#4	1	15.850	0.555	0.000	0.000	79.000	TR55	67.79	13.892
	Σ	**15.850**						**67.79**	**13.892**
#3	1	12.770	0.423	0.000	0.000	79.000	TR55	60.17	11.243
	Σ	**12.770**						**60.17**	**11.243**
#2	1	18.090	0.555	0.000	0.000	79.000	TR55	77.37	15.855
	Σ	**18.090**						**77.37**	**15.855**
#1	Σ	**52.320**						**223.56**	**46.053**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#2	1	3. Short grass pasture	1.30	23.65	1,820.00	0.910	0.555
#2	**1**	**Time of Concentration:**					**0.555**
#3	1	3. Short grass pasture	1.60	24.64	1,540.00	1.010	0.423
#3	**1**	**Time of Concentration:**					**0.423**
#4	1	3. Short grass pasture	1.10	18.26	1,660.00	0.830	0.555
#4	**1**	**Time of Concentration:**					**0.555**
#5	1	3. Short grass pasture	1.00	3.12	312.00	0.800	0.108
		6. Grassed waterway	1.40	3.93	281.00	1.770	0.044
#5	**1**	**Time of Concentration:**					**0.152**

ATTACHMENT 2A

POST-DEVELOPMENT SEDIMENTATION BASIN DESIGN
SEDCAD+ OUTPUT
100-YEAR, 1-HOUR STORM EVENT

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Post-Development Surface Water 100-yr, 1-hr Storm

Resource Recovery Park

Feasibility Study

County of Kaua'i

AECOM

General Information

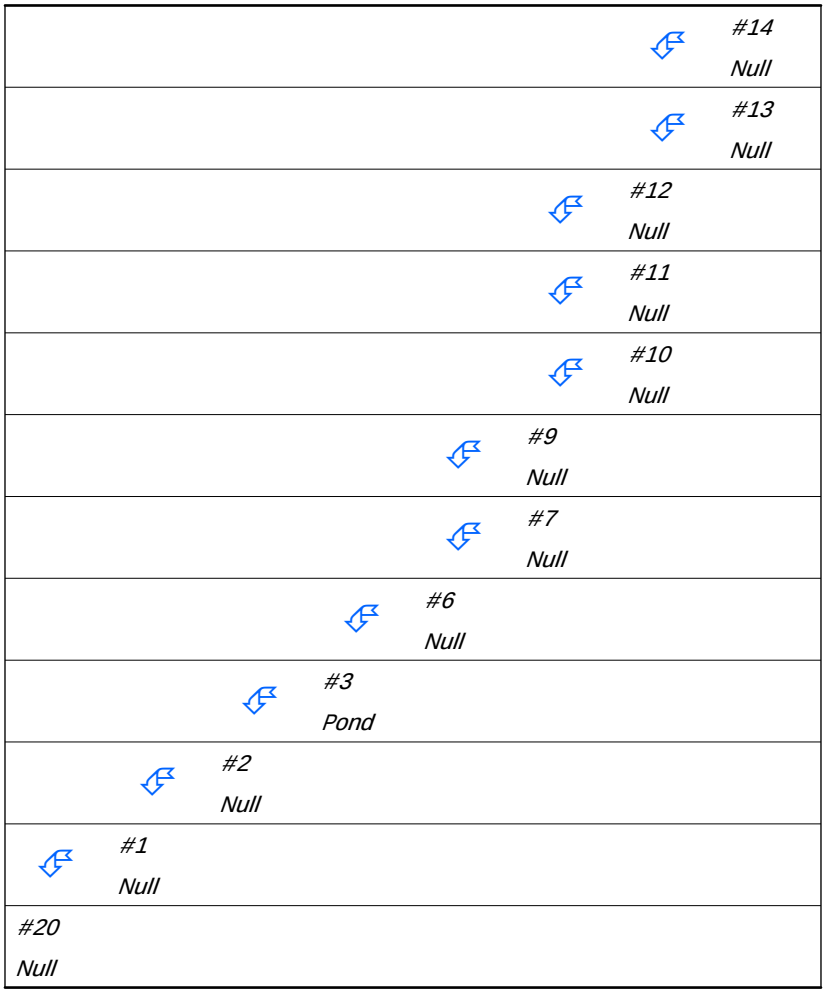
Storm Information:

Storm Type:	NRCS Type I
Design Storm:	100 yr - 1 hr
Rainfall Depth:	4.900 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#20	0.000	0.000	Flow from site to South
Null	#2	==>	#1	0.000	0.000	Spreader Berm
Pond	#3	==>	#2	0.000	0.000	South Surface Water Basin
Null	#4	==>	#16	0.075	0.192	SWS 4-1, Culverts C1 and C2
Null	#5	==>	#17	0.000	0.000	SWS 5-1, Culverts C3, C4, and C5
Null	#6	==>	#3	0.000	0.000	SWS 6-1, Culvert C10
Null	#7	==>	#6	0.023	0.192	SWS 7-1, Culvert C7
Null	#8	==>	#19	0.183	0.192	SWS 8-1, Culvert C9
Null	#9	==>	#6	0.157	0.192	SWS 9-1, Culvert C11
Null	#10	==>	#9	0.151	0.192	SWS 10-1, Culvert C12
Null	#11	==>	#9	0.309	0.192	SWS 11-1, Culvert C13
Null	#12	==>	#9	0.026	0.192	SWS 12-1, Culvert C14
Null	#13	==>	#12	0.044	0.192	SWS 13-1, Culvert C15
Null	#14	==>	#12	0.140	0.192	SWS 14-1, Culverts C16 and C17
Pond	#15	==>	#20	0.000	0.000	Compost Area Basin
Pond	#16	==>	#20	0.000	0.000	East Surface Water Basin
Null	#17	==>	#16	0.000	0.000	SWS 17-1, Culvert C6
Null	#18	==>	#16	0.000	0.000	SWS 18-1
Null	#19	==>	#18	0.096	0.192	SWS 19-1, Culvert C8
Null	#20	==>	End	0.000	0.000	Extra structure to facilitate model setup -Entire Flow Off-Site

#8 *Null*
#19 *Null*
#18 *Null*
#5 *Null*
#17 *Null*
#4 *Null*
#16 *Pond*
#15 *Pond*



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#4	6. Grassed waterway	0.50	1.45	290.00	1.06	0.075
#4	**Muskingum K:**					**0.075**
#7	6. Grassed waterway	0.50	0.45	90.00	1.06	0.023
#7	**Muskingum K:**					**0.023**
#8	6. Grassed waterway	0.50	3.50	700.00	1.06	0.183
#8	**Muskingum K:**					**0.183**
#9	6. Grassed waterway	0.50	3.00	600.00	1.06	0.157
#9	**Muskingum K:**					**0.157**
#10	6. Grassed waterway	0.50	2.90	580.00	1.06	0.151
#10	**Muskingum K:**					**0.151**
#11	6. Grassed waterway	0.50	5.90	1,180.00	1.06	0.309
#11	**Muskingum K:**					**0.309**
#12	6. Grassed waterway	0.50	0.50	100.00	1.06	0.026

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#12	**Muskingum K:**					**0.026**
#13	6. Grassed waterway	0.50	0.85	170.00	1.06	0.044
#13	**Muskingum K:**					**0.044**
#14	6. Grassed waterway	0.50	2.67	535.00	1.06	0.140
#14	**Muskingum K:**					**0.140**
#19	6. Grassed waterway	0.50	1.84	370.00	1.06	0.096
#19	**Muskingum K:**					**0.096**

Structure Summary:

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#8		1.480	1.480	8.92	0.41
#19		6.590	8.070	44.88	2.48
#18		5.550	13.620	70.80	3.99
#5		2.010	2.010	11.20	0.55
#17		2.160	4.170	23.47	1.11
#4		1.840	1.840	9.94	0.50
#16	In	1.300	20.930	104.56	5.94
	Out			47.41	5.94
#15	In	9.310	9.310	50.29	2.51
	Out			0.07	0.29
#14		5.620	5.620	28.68	1.72
#13		1.650	1.650	9.92	0.45
#12		2.140	9.410	47.96	2.76
#11		1.190	1.190	6.76	0.31
#10		3.770	3.770	21.51	1.08
#9		2.900	17.270	83.42	4.94
#7		1.030	1.030	6.20	0.28
#6		1.480	19.780	85.56	5.63
#3	In	2.100	21.880	90.13	6.19
	Out			34.06	6.19
#2		0.400	22.280	34.06	6.29
#1		0.000	22.280	34.06	6.29
#20		0.000	52.520	80.19	12.52

Structure Detail:

Structure #8 (Null)

SWS 8-1, Culvert C9

Structure #19 (Null)

SWS 19-1, Culvert C8

Structure #18 (Null)

SWS 18-1

Structure #5 (Null)

SWS 5-1, Culverts C3, C4, and C5

Structure #17 (Null)

SWS 17-1, Culvert C6

Structure #4 (Null)

SWS 4-1, Culverts C1 and C2

Structure #16 (Pond)

East Surface Water Basin

Pond Inputs:

Initial Pool Elev:	280.01 ft
Initial Pool:	0.01 ac-ft

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
284.00	15.00	5.00:1	5.00:1	20.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	50.00	0.25	0.0240	280.01	0.50	0.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	50.00	0.25	0.0240	280.01	0.50	0.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	50.00	0.25	0.0240	280.01	0.50	0.00

Pond Results:

Peak Elevation:	283.01 ft
Dewater Time:	0.33 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
280.00	0.900	0.000	0.000		
280.01	0.900	0.009	0.000		Spillway #2 Spillway #3 Spillway #4
280.50	0.944	0.461	6.460	6.05	
281.00	0.991	0.945	12.544	0.65	
281.50	1.038	1.452	19.694	0.35	
282.00	1.087	1.983	30.915	0.30	
282.50	1.136	2.538	38.025	0.20	
283.00	1.187	3.119	47.203	0.35	
283.01	1.189	3.136	47.414	0.05	Peak Stage
283.50	1.238	3.725	54.984		
283.75	1.265	4.038	58.428		
284.00	1.291	4.358	61.788		Spillway #1
284.50	1.345	5.017	71.812		
285.00	1.400	5.703	128.869		
285.50	1.450	6.415	197.964		
286.00	1.500	7.153	288.600		

Detailed Discharge Table

Elevation (ft)	Emergency Spillway (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
280.00	0.000	0.000	0.000	0.000	0.000
280.01	0.000	0.000	0.000	0.000	0.000
280.50	0.000	(1)>2.153	(1)>2.153	(1)>2.153	6.460
281.00	0.000	(1)>4.181	(1)>4.181	(1)>4.181	12.544
281.50	0.000	(1)>6.565	(1)>6.565	(1)>6.565	19.694
282.00	0.000	(1)>10.305	(1)>10.305	(1)>10.305	30.915
282.50	0.000	(6)>12.675	(6)>12.675	(6)>12.675	38.025
283.00	0.000	(6)>15.734	(6)>15.734	(6)>15.734	47.203
283.50	0.000	(6)>18.328	(6)>18.328	(6)>18.328	54.984
283.75	0.000	(6)>19.476	(6)>19.476	(6)>19.476	58.428
284.00	0.000	(6)>20.596	(6)>20.596	(6)>20.596	61.788
284.50	3.931	(6)>22.627	(6)>22.627	(6)>22.627	71.812
285.00	55.406	(6)>24.488	(6)>24.488	(6)>24.488	128.869
285.50	119.328	(6)>26.212	(6)>26.212	(6)>26.212	197.964
286.00	205.107	(6)>27.831	(6)>27.831	(6)>27.831	288.600

Structure #15 (Pond)

Compost Area Basin

Pond Inputs:

Initial Pool Elev:	279.01 ft
Initial Pool:	0.00 ac-ft

Perforated Riser

Riser Diameter (in)	Riser Height (ft)	Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Number of Holes per Elev
12.00	15.00	12.00	100.00	0.50	0.0240	294.00	1

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
292.50	14.00	5.00:1	5.00:1	20.00

Pond Results:

Peak Elevation:	286.61 ft
Dewater Time:	22.58 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
279.00	0.050	0.000	0.000		
279.01	0.050	0.001	0.000		Low hole SPW #1
279.50	0.070	0.030	0.018	19.38*	
280.00	0.095	0.071	0.026	19.04*	
280.50	0.122	0.125	0.032	20.41*	
281.00	0.153	0.194	0.037	22.46*	
281.50	0.188	0.279	0.041	24.89*	
282.00	0.226	0.383	0.045	27.57*	
282.50	0.268	0.506	0.049	30.44*	
283.00	0.313	0.651	0.052	33.48*	
283.50	0.362	0.820	0.056	36.67*	
284.00	0.414	1.014	0.059	39.99*	
284.50	0.470	1.235	0.062	43.44*	
285.00	0.529	1.484	0.064	47.00*	
285.50	0.592	1.764	0.067	50.67*	
286.00	0.658	2.077	0.069	54.45*	
286.50	0.728	2.423	0.072	58.33*	
286.61	0.745	2.505	0.072	13.65	Peak Stage
287.00	0.802	2.806	0.074		
287.50	0.879	3.226	0.077		
288.00	0.959	3.685	0.079		
288.50	1.043	4.185	0.081		
289.00	1.131	4.729	0.083		
289.50	1.222	5.317	0.085		
290.00	1.317	5.951	0.087		
290.50	1.415	6.634	0.089		
291.00	1.516	7.367	0.091		
291.50	1.622	8.151	0.093		
292.00	1.730	8.989	0.095		
292.50	1.842	9.882	0.096		Spillway #2
293.00	1.958	10.832	4.081		
293.50	2.077	11.841	56.144		
294.00	2.200	12.910	120.930		Spillway #1

**Designates time(s) to dewater have been extrapolated beyond the 50 hour hydrograph limit.*

Detailed Discharge Table

Elevation (ft)	Perf. Riser (cfs)	Emergency Spillway (cfs)	Combined Total Discharge (cfs)
279.00	0.000	0.000	0.000
279.01	1.00>0.000	0.000	0.000
279.50	0.018	0.000	0.018
280.00	0.026	0.000	0.026
280.50	0.032	0.000	0.032
281.00	0.037	0.000	0.037
281.50	0.041	0.000	0.041
282.00	0.045	0.000	0.045
282.50	0.049	0.000	0.049
283.00	0.052	0.000	0.052
283.50	0.056	0.000	0.056
284.00	0.059	0.000	0.059
284.50	0.062	0.000	0.062
285.00	0.064	0.000	0.064
285.50	0.067	0.000	0.067
286.00	0.069	0.000	0.069
286.50	0.072	0.000	0.072
287.00	0.074	0.000	0.074
287.50	0.077	0.000	0.077
288.00	0.079	0.000	0.079
288.50	0.081	0.000	0.081
289.00	0.083	0.000	0.083
289.50	0.085	0.000	0.085
290.00	0.087	0.000	0.087
290.50	0.089	0.000	0.089
291.00	0.091	0.000	0.091
291.50	0.093	0.000	0.093
292.00	0.095	0.000	0.095
292.50	0.096	0.000	0.096
293.00	0.098	3.982	4.081
293.50	0.100	56.044	56.144
294.00	0.102	120.828	120.930

Structure #14 (Null)

SWS 14-1, Culverts C16 and C17

Structure #13 (Null)

SWS 13-1, Culvert C15

Structure #12 (Null)

SWS 12-1, Culvert C14

Structure #11 (Null)

SWS 11-1, Culvert C13

Structure #10 (Null)

SWS 10-1, Culvert C12

Structure #9 (Null)

SWS 9-1, Culvert C11

Structure #7 (Null)

SWS 7-1, Culvert C7

Structure #6 (Null)

SWS 6-1, Culvert C10

Structure #3 (Pond)

South Surface Water Basin

Pond Inputs:

Initial Pool Elev:	283.01 ft
Initial Pool:	0.01 ac-ft

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	100.00	0.25	0.0240	283.01	0.50	0.00

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
287.00	14.00	5.00:1	5.00:1	20.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	100.00	0.25	0.0240	283.01	0.50	0.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	100.00	0.25	0.0240	283.01	0.50	0.00

Pond Results:

Peak Elevation:	285.63 ft
Dewater Time:	0.46 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
283.00	1.200	0.000	0.000		
283.01	1.381	0.013	0.000		Spillway #1 Spillway #3 Spillway #4
283.50	1.415	0.698	7.124	8.45	
284.00	1.451	1.414	11.695	0.95	
284.50	1.486	2.149	18.105	0.60	
285.00	1.523	2.901	27.723	0.40	
285.50	1.560	3.671	32.192	0.35	
285.63	1.570	3.883	34.060	0.25	Peak Stage
286.00	1.597	4.460	39.164		
286.50	1.634	5.268	45.043		
287.00	1.673	6.095	50.306		Spillway #2
287.50	1.711	6.941	59.012		
288.00	1.750	7.806	115.393		
288.50	1.873	8.712	184.252		
289.00	2.000	9.680	274.321		

Detailed Discharge Table

Elevation (ft)	Straight Pipe (cfs)	Emergency Spillway (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
283.00	0.000	0.000	0.000	0.000	0.000
283.01	0.000	0.000	0.000	0.000	0.000
283.50	(1)>2.375	0.000	(1)>2.375	(1)>2.375	7.124
284.00	(1)>3.898	0.000	(1)>3.898	(1)>3.898	11.695
284.50	(1)>6.035	0.000	(1)>6.035	(1)>6.035	18.105
285.00	(1)>9.241	0.000	(1)>9.241	(1)>9.241	27.723
285.50	(6)>10.731	0.000	(6)>10.731	(6)>10.731	32.192
286.00	(6)>13.055	0.000	(6)>13.055	(6)>13.055	39.164
286.50	(6)>15.014	0.000	(6)>15.014	(6)>15.014	45.043
287.00	(6)>16.769	0.000	(6)>16.769	(6)>16.769	50.306
287.50	(6)>18.343	3.982	(6)>18.343	(6)>18.343	59.012
288.00	(6)>19.783	56.044	(6)>19.783	(6)>19.783	115.393
288.50	(6)>21.141	120.828	(6)>21.141	(6)>21.141	184.252
289.00	(6)>22.424	207.049	(6)>22.424	(6)>22.424	274.321

Structure #2 (Null)

Spreader Berm

Structure #1 (Null)

Flow from site to South

Structure #20 (Null)

Extra structure to facilitate model setup -Entire Flow Off-Site

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#8	1	1.480	0.177	0.000	0.000	85.000	TR55	8.92	0.407
	Σ	**1.480**						**8.92**	**0.407**
#19	1	3.990	0.366	0.000	0.000	85.000	TR55	20.43	1.085
	2	2.600	0.039	0.183	0.192	98.000	TR55	19.39	0.985
	Σ	**8.070**						**44.88**	**2.476**
#18	1	5.550	0.361	0.000	0.000	85.000	TR55	28.58	1.509
	Σ	**13.620**						**70.80**	**3.986**
#5	1	2.010	0.281	0.000	0.000	85.000	TR55	11.20	0.547
	Σ	**2.010**						**11.20**	**0.547**
#17	1	2.160	0.224	0.000	0.000	85.000	TR55	12.26	0.567
	Σ	**4.170**						**23.47**	**1.114**
#4	1	1.840	0.312	0.000	0.000	85.000	TR55	9.94	0.496
	Σ	**1.840**						**9.94**	**0.496**
#16	1	1.300	0.000	0.000	0.000	85.000	TR55	8.48	0.343
	Σ	**20.930**						**104.56**	**5.939**
#15	1	9.310	0.312	0.000	0.000	85.000	TR55	50.29	2.512
	Σ	**9.310**						**50.29**	**2.512**
#14	1	3.750	0.310	0.000	0.000	85.000	TR55	20.30	1.012
	2	0.600	0.078	0.028	0.192	98.000	TR55	4.48	0.227
	3	1.270	0.022	0.099	0.192	98.000	TR55	9.47	0.481
	Σ	**5.620**						**28.68**	**1.721**
#13	1	1.650	0.180	0.000	0.000	85.000	TR55	9.92	0.453
	Σ	**1.650**						**9.92**	**0.453**
#12	1	2.140	0.180	0.000	0.000	85.000	TR55	12.86	0.587
	Σ	**9.410**						**47.96**	**2.760**
#11	1	1.190	0.224	0.000	0.000	85.000	TR55	6.76	0.312
	Σ	**1.190**						**6.76**	**0.312**
#10	1	3.290	0.239	0.000	0.000	85.000	TR55	18.99	0.897
	2	0.480	0.039	0.091	0.192	98.000	TR55	3.58	0.182
	Σ	**3.770**						**21.51**	**1.079**
#9	1	2.900	0.362	0.000	0.000	85.000	TR55	14.92	0.789

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	Σ	**17.270**						**83.42**	**4.940**
#7	1	1.030	0.178	0.000	0.000	85.000	TR55	6.20	0.283
	Σ	**1.030**						**6.20**	**0.283**
#6	1	1.480	0.131	0.000	0.000	85.000	TR55	9.00	0.410
	Σ	**19.780**						**85.56**	**5.633**
#3	1	2.100	0.000	0.000	0.000	85.000	TR55	13.70	0.554
	Σ	**21.880**						**90.13**	**6.187**
#2	1	0.400	0.080	0.000	0.000	85.000	TR55	2.61	0.106
	Σ	**22.280**						**34.06**	**6.293**
#1	Σ	**22.280**						**34.06**	**6.293**
#20	Σ	**52.520**						**80.19**	**12.524**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#2	1	3. Short grass pasture	0.75	1.50	200.00	0.690	0.080
#2	**1**	**Time of Concentration:**					**0.080**
#4	1	3. Short grass pasture	0.50	1.90	380.00	0.560	0.188
		3. Short grass pasture	0.50	1.25	250.00	0.560	0.124
#4	**1**	**Time of Concentration:**					**0.312**
#5	1	3. Short grass pasture	0.50	1.35	270.00	0.560	0.133
		3. Short grass pasture	0.50	1.50	300.00	0.560	0.148
#5	**1**	**Time of Concentration:**					**0.281**
#6	1	6. Grassed waterway	0.50	2.50	500.00	1.060	0.131
#6	**1**	**Time of Concentration:**					**0.131**
#7	1	6. Grassed waterway	0.50	3.40	680.00	1.060	0.178
#7	**1**	**Time of Concentration:**					**0.178**
#8	1	3. Short grass pasture	0.50	1.00	200.00	0.560	0.099
		6. Grassed waterway	0.50	1.50	300.00	1.060	0.078
#8	**1**	**Time of Concentration:**					**0.177**
#9	1	3. Short grass pasture	0.50	0.75	150.00	0.560	0.074
		6. Grassed waterway	0.50	5.50	1,100.00	1.060	0.288
#9	**1**	**Time of Concentration:**					**0.362**
#10	1	3. Short grass pasture	0.50	1.50	300.00	0.560	0.148
		6. Grassed waterway	0.50	1.75	350.00	1.060	0.091
#10	**1**	**Time of Concentration:**					**0.239**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#10	2	7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
#10	**2**	**Time of Concentration:**					**0.039**
#11	1	3. Short grass pasture	0.50	2.00	400.00	0.560	0.198
		6. Grassed waterway	0.50	0.50	100.00	1.060	0.026
#11	**1**	**Time of Concentration:**					**0.224**
#12	1	3. Short grass pasture	0.50	0.50	100.00	0.560	0.049
		6. Grassed waterway	0.50	2.50	500.00	1.060	0.131
#12	**1**	**Time of Concentration:**					**0.180**
#13	1	3. Short grass pasture	0.50	1.30	260.00	0.560	0.128
		6. Grassed waterway	0.50	1.00	200.00	1.060	0.052
#13	**1**	**Time of Concentration:**					**0.180**
#14	1	3. Short grass pasture	0.50	1.15	230.00	0.560	0.114
		6. Grassed waterway	0.50	3.75	750.00	1.060	0.196
#14	**1**	**Time of Concentration:**					**0.310**
#14	2	7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
		7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
#14	**2**	**Time of Concentration:**					**0.078**
#14	3	7. Paved area and small upland gullies	0.50	0.58	116.00	1.420	0.022
#14	**3**	**Time of Concentration:**					**0.022**
#15	1	3. Short grass pasture	0.50	2.75	550.00	0.560	0.272
		3. Short grass pasture	0.75	0.75	100.00	0.690	0.040
#15	**1**	**Time of Concentration:**					**0.312**
#17	1	3. Short grass pasture	0.50	1.45	290.00	0.560	0.143
		6. Grassed waterway	0.50	1.55	310.00	1.060	0.081
#17	**1**	**Time of Concentration:**					**0.224**
#18	1	3. Short grass pasture	0.50	2.65	530.00	0.560	0.262
		6. Grassed waterway	0.50	1.90	380.00	1.060	0.099
#18	**1**	**Time of Concentration:**					**0.361**
#19	1	3. Short grass pasture	0.50	2.60	520.00	0.560	0.257
		6. Grassed waterway	0.50	2.08	416.00	1.060	0.109
#19	**1**	**Time of Concentration:**					**0.366**
#19	2	7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
#19	**2**	**Time of Concentration:**					**0.039**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#10	2	6. Grassed waterway	0.50	1.75	350.00	1.060	0.091
#10	**2**	**Muskingum K:**					**0.091**
#14	2	6. Grassed waterway	0.50	0.55	110.00	1.060	0.028
#14	**2**	**Muskingum K:**					**0.028**
#14	3	6. Grassed waterway	0.50	1.90	380.00	1.060	0.099
#14	**3**	**Muskingum K:**					**0.099**
#19	2	6. Grassed waterway	0.50	3.50	700.00	1.060	0.183
#19	**2**	**Muskingum K:**					**0.183**

ATTACHMENT 2B

POST-DEVELOPMENT SEDIMENTATION BASIN DESIGN
SEDCAD+ OUTPUT
25-YEAR, 24-HOUR STORM EVENT

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Post-Development Surface Water 25-yr, 24-hr Storm

Resource Recovery Park

Feasibility Study

County of Kaua'i

AECOM

General Information

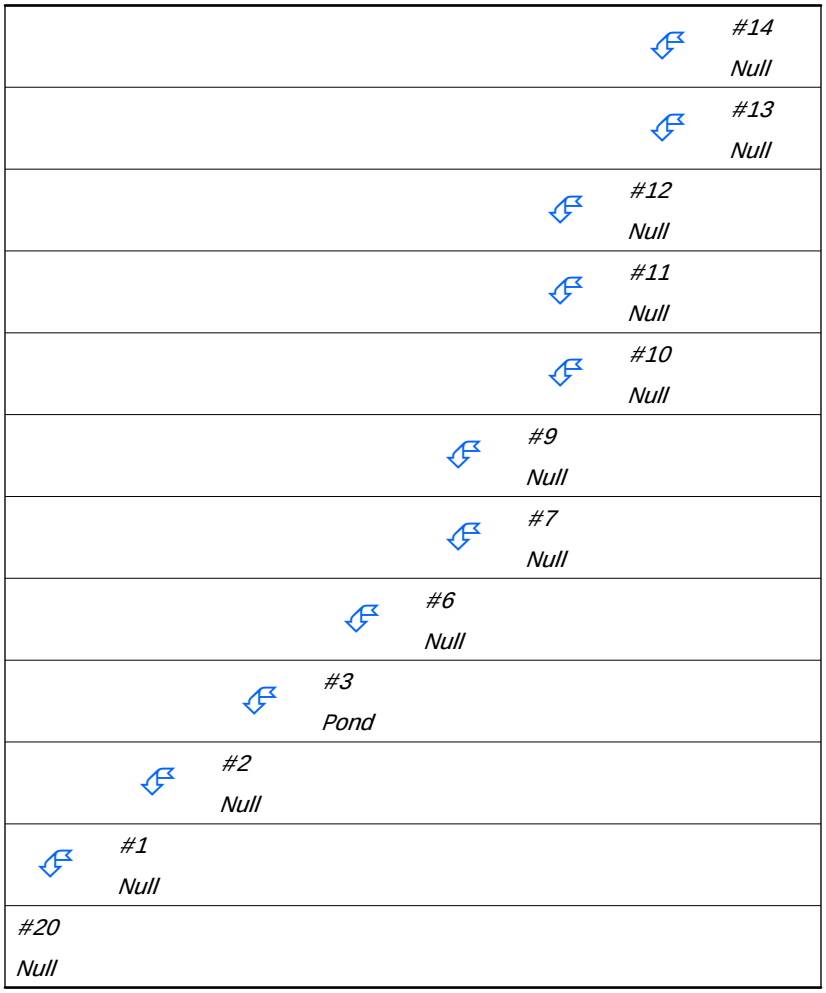
Storm Information:

Storm Type:	NRCS Type I
Design Storm:	25 yr - 24 hr
Rainfall Depth:	13.400 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#20	0.000	0.000	Flow from site to South
Null	#2	==>	#1	0.000	0.000	Spreader Berm
Pond	#3	==>	#2	0.000	0.000	South Surface Water Basin
Null	#4	==>	#16	0.075	0.192	SWS 4-1, Culverts C1 and C2
Null	#5	==>	#17	0.000	0.000	SWS 5-1, Culverts C3, C4, and C5
Null	#6	==>	#3	0.000	0.000	SWS 6-1, Culvert C10
Null	#7	==>	#6	0.023	0.192	SWS 7-1, Culvert C7
Null	#8	==>	#19	0.183	0.192	SWS 8-1, Culvert C9
Null	#9	==>	#6	0.157	0.192	SWS 9-1, Culvert C11
Null	#10	==>	#9	0.151	0.192	SWS 10-1, Culvert C12
Null	#11	==>	#9	0.309	0.192	SWS 11-1, Culvert C13
Null	#12	==>	#9	0.026	0.192	SWS 12-1, Culvert C14
Null	#13	==>	#12	0.044	0.192	SWS 13-1, Culvert C15
Null	#14	==>	#12	0.140	0.192	SWS 14-1, Culverts C16 and C17
Pond	#15	==>	#20	0.000	0.000	Compost Area Basin
Pond	#16	==>	#20	0.000	0.000	East Surface Water Basin
Null	#17	==>	#16	0.000	0.000	SWS 17-1, Culvert C6
Null	#18	==>	#16	0.000	0.000	SWS 18-1
Null	#19	==>	#18	0.096	0.192	SWS 19-1, Culvert C8
Null	#20	==>	End	0.000	0.000	Extra structure to facilitate model setup -Entire Flow Off-Site

#8 *Null*
#19 *Null*
#18 *Null*
#5 *Null*
#17 *Null*
#4 *Null*
#16 *Pond*
#15 *Pond*



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#4	6. Grassed waterway	0.50	1.45	290.00	1.06	0.075
#4	**Muskingum K:**					**0.075**
#7	6. Grassed waterway	0.50	0.45	90.00	1.06	0.023
#7	**Muskingum K:**					**0.023**
#8	6. Grassed waterway	0.50	3.50	700.00	1.06	0.183
#8	**Muskingum K:**					**0.183**
#9	6. Grassed waterway	0.50	3.00	600.00	1.06	0.157
#9	**Muskingum K:**					**0.157**
#10	6. Grassed waterway	0.50	2.90	580.00	1.06	0.151
#10	**Muskingum K:**					**0.151**
#11	6. Grassed waterway	0.50	5.90	1,180.00	1.06	0.309
#11	**Muskingum K:**					**0.309**
#12	6. Grassed waterway	0.50	0.50	100.00	1.06	0.026

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#12	**Muskingum K:**					**0.026**
#13	6. Grassed waterway	0.50	0.85	170.00	1.06	0.044
#13	**Muskingum K:**					**0.044**
#14	6. Grassed waterway	0.50	2.67	535.00	1.06	0.140
#14	**Muskingum K:**					**0.140**
#19	6. Grassed waterway	0.50	1.84	370.00	1.06	0.096
#19	**Muskingum K:**					**0.096**

Structure Summary:

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#8		1.480	1.480	8.06	1.43
#19		6.590	8.070	42.94	8.08
#18		5.550	13.620	69.84	13.38
#5		2.010	2.010	10.77	1.92
#17		2.160	4.170	21.95	3.91
#4		1.840	1.840	9.71	1.74
#16	In	1.300	20.930	103.12	20.27
	Out			56.05	20.27
#15	In	9.310	9.310	49.14	8.81
	Out			0.09	0.33
#14		5.620	5.620	29.78	5.60
#13		1.650	1.650	8.96	1.59
#12		2.140	9.410	47.50	9.25
#11		1.190	1.190	6.16	1.10
#10		3.770	3.770	20.31	3.67
#9		2.900	17.270	86.69	16.78
#7		1.030	1.030	5.61	0.99
#6		1.480	19.780	90.65	19.21
#3	In	2.100	21.880	94.35	21.22
	Out			43.61	21.22
#2		0.400	22.280	44.04	21.61
#1		0.000	22.280	44.04	21.61
#20		0.000	52.520	98.71	42.21

Structure Detail:

Structure #8 (Null)

SWS 8-1, Culvert C9

Structure #19 (Null)

SWS 19-1, Culvert C8

Structure #18 (Null)

SWS 18-1

Structure #5 (Null)

SWS 5-1, Culverts C3, C4, and C5

Structure #17 (Null)

SWS 17-1, Culvert C6

Structure #4 (Null)

SWS 4-1, Culverts C1 and C2

Structure #16 (Pond)

East Surface Water Basin

Pond Inputs:

Initial Pool Elev:	280.01 ft
Initial Pool:	0.01 ac-ft

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
284.00	15.00	5.00:1	5.00:1	20.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	50.00	0.25	0.0240	280.01	0.50	0.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	50.00	0.25	0.0240	280.01	0.50	0.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	50.00	0.25	0.0240	280.01	0.50	0.00

Pond Results:

Peak Elevation:	283.58 ft
Dewater Time:	0.82 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
280.00	0.900	0.000	0.000		
280.01	0.900	0.009	0.000		Spillway #2 Spillway #3 Spillway #4
280.50	0.944	0.461	6.460	9.75	
281.00	0.991	0.945	12.544	6.35	
281.50	1.038	1.452	19.694	1.70	
282.00	1.087	1.983	30.915	0.70	
282.50	1.136	2.538	38.025	0.40	
283.00	1.187	3.119	47.203	0.35	
283.50	1.238	3.725	54.984	0.35	
283.58	1.247	3.823	56.054	0.15	Peak Stage
283.75	1.265	4.038	58.428		
284.00	1.291	4.358	61.788		Spillway #1
284.50	1.345	5.017	71.812		
285.00	1.400	5.703	128.869		
285.50	1.450	6.415	197.964		
286.00	1.500	7.153	288.600		

Detailed Discharge Table

Elevation (ft)	Emergency Spillway (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
280.00	0.000	0.000	0.000	0.000	0.000
280.01	0.000	0.000	0.000	0.000	0.000
280.50	0.000	(1)>2.153	(1)>2.153	(1)>2.153	6.460
281.00	0.000	(1)>4.181	(1)>4.181	(1)>4.181	12.544
281.50	0.000	(1)>6.565	(1)>6.565	(1)>6.565	19.694
282.00	0.000	(1)>10.305	(1)>10.305	(1)>10.305	30.915
282.50	0.000	(6)>12.675	(6)>12.675	(6)>12.675	38.025
283.00	0.000	(6)>15.734	(6)>15.734	(6)>15.734	47.203
283.50	0.000	(6)>18.328	(6)>18.328	(6)>18.328	54.984
283.75	0.000	(6)>19.476	(6)>19.476	(6)>19.476	58.428
284.00	0.000	(6)>20.596	(6)>20.596	(6)>20.596	61.788
284.50	3.931	(6)>22.627	(6)>22.627	(6)>22.627	71.812
285.00	55.406	(6)>24.488	(6)>24.488	(6)>24.488	128.869
285.50	119.328	(6)>26.212	(6)>26.212	(6)>26.212	197.964
286.00	0.000	(6)>0.000	(6)>0.000	(6)>0.000	288.600

Structure #15 (Pond)

Compost Area Basin

Pond Inputs:

Initial Pool Elev:	279.01 ft
Initial Pool:	0.00 ac-ft

Perforated Riser

Riser Diameter (in)	Riser Height (ft)	Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Number of Holes per Elev
12.00	15.00	12.00	100.00	0.50	0.0240	294.00	1

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
292.50	14.00	5.00:1	5.00:1	20.00

Pond Results:

Peak Elevation:	291.81 ft
Dewater Time:	61.61 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
279.00	0.050	0.000	0.000		
279.01	0.050	0.001	0.000		Low hole SPW #1
279.50	0.070	0.030	0.018	19.38*	
280.00	0.095	0.071	0.026	19.04*	
280.50	0.122	0.125	0.032	20.41*	
281.00	0.153	0.194	0.037	22.46*	
281.50	0.188	0.279	0.041	24.89*	
282.00	0.226	0.383	0.045	27.57*	
282.50	0.268	0.506	0.049	30.44*	
283.00	0.313	0.651	0.052	33.48*	
283.50	0.362	0.820	0.056	36.67*	
284.00	0.414	1.014	0.059	39.99*	
284.50	0.470	1.235	0.062	43.44*	
285.00	0.529	1.484	0.064	47.00*	
285.50	0.592	1.764	0.067	50.67*	
286.00	0.658	2.077	0.069	54.45*	
286.50	0.728	2.423	0.072	58.33*	
287.00	0.802	2.806	0.074	62.31*	
287.50	0.879	3.226	0.077	66.40*	
288.00	0.959	3.685	0.079	70.58*	
288.50	1.043	4.185	0.081	74.86*	
289.00	1.131	4.729	0.083	79.21*	
289.50	1.222	5.317	0.085	83.66*	
290.00	1.317	5.951	0.087	88.19*	
290.50	1.415	6.634	0.089	92.80*	
291.00	1.516	7.367	0.091	97.49*	
291.50	1.622	8.151	0.093	102.25*	
291.81	1.690	8.674	0.094	25.45	Peak Stage
292.00	1.730	8.989	0.095		
292.50	1.842	9.882	0.096		Spillway #2
293.00	1.958	10.832	4.081		
293.50	2.077	11.841	56.144		
294.00	2.200	12.910	120.930		Spillway #1

Detailed Discharge Table

Elevation (ft)	Perf. Riser (cfs)	Emergency Spillway (cfs)	Combined Total Discharge (cfs)
279.00	0.000	0.000	0.000
279.01	1.00>0.000	0.000	0.000
279.50	0.018	0.000	0.018
280.00	0.026	0.000	0.026
280.50	0.032	0.000	0.032
281.00	0.037	0.000	0.037
281.50	0.041	0.000	0.041
282.00	0.045	0.000	0.045
282.50	0.049	0.000	0.049
283.00	0.052	0.000	0.052
283.50	0.056	0.000	0.056
284.00	0.059	0.000	0.059
284.50	0.062	0.000	0.062
285.00	0.064	0.000	0.064
285.50	0.000	0.000	0.067
286.00	0.000	0.000	0.069
286.50	0.000	0.000	0.072
287.00	0.000	0.000	0.074
287.50	0.000	0.000	0.077
288.00	0.000	0.000	0.079
288.50	0.000	0.000	0.081
289.00	0.000	0.000	0.083
289.50	0.000	0.000	0.085
290.00	0.000	0.000	0.087
290.50	0.000	0.000	0.089
291.00	0.000	0.000	0.091
291.50	0.000	0.000	0.093
292.00	0.000	0.000	0.095
292.50	0.000	0.000	0.096
293.00	0.000	0.000	4.081
293.50	0.000	0.000	56.144
294.00	0.000	0.000	120.930

Structure #14 (Null)

SWS 14-1, Culverts C16 and C17

Structure #13 (Null)

SWS 13-1, Culvert C15

Structure #12 (Null)

SWS 12-1, Culvert C14

Structure #11 (Null)

SWS 11-1, Culvert C13

Structure #10 (Null)

SWS 10-1, Culvert C12

Structure #9 (Null)

SWS 9-1, Culvert C11

Structure #7 (Null)

SWS 7-1, Culvert C7

Structure #6 (Null)

SWS 6-1, Culvert C10

Structure #3 (Pond)

South Surface Water Basin

Pond Inputs:

Initial Pool Elev:	283.01 ft
Initial Pool:	0.01 ac-ft

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	100.00	0.25	0.0240	283.01	0.50	0.00

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
287.00	14.00	5.00:1	5.00:1	20.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	100.00	0.25	0.0240	283.01	0.50	0.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	100.00	0.25	0.0240	283.01	0.50	0.00

Pond Results:

Peak Elevation:	286.38 ft
Dewater Time:	0.91 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
283.00	1.200	0.000	0.000		
283.01	1.381	0.013	0.000		Spillway #1 Spillway #3 Spillway #4
283.50	1.415	0.698	7.124	11.85	
284.00	1.451	1.414	11.695	5.05	
284.50	1.486	2.149	18.105	2.10	
285.00	1.523	2.901	27.723	1.00	
285.50	1.560	3.671	32.192	0.65	
286.00	1.597	4.460	39.164	0.55	
286.38	1.625	5.071	43.608	0.60	Peak Stage
286.50	1.634	5.268	45.043		
287.00	1.673	6.095	50.306		Spillway #2
287.50	1.711	6.941	59.012		
288.00	1.750	7.806	115.393		
288.50	1.873	8.712	184.252		
289.00	2.000	9.680	274.321		

Detailed Discharge Table

Elevation (ft)	Straight Pipe (cfs)	Emergency Spillway (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
283.00	0.000	0.000	0.000	0.000	0.000
283.01	0.000	0.000	0.000	0.000	0.000
283.50	(1)>2.375	0.000	(1)>2.375	(1)>2.375	7.124
284.00	(1)>3.898	0.000	(1)>3.898	(1)>3.898	11.695
284.50	(1)>6.035	0.000	(1)>6.035	(1)>6.035	18.105
285.00	(1)>9.241	0.000	(1)>9.241	(1)>9.241	27.723
285.50	(6)>10.731	0.000	(6)>10.731	(6)>10.731	32.192
286.00	(6)>13.055	0.000	(6)>13.055	(6)>13.055	39.164
286.50	(6)>15.014	0.000	(6)>15.014	(6)>15.014	45.043
287.00	(6)>16.769	0.000	(6)>16.769	(6)>16.769	50.306
287.50	(6)>18.343	3.982	(6)>18.343	(6)>18.343	59.012
288.00	(6)>19.783	56.044	(6)>19.783	(6)>19.783	115.393
288.50	(6)>21.141	120.828	(6)>21.141	(6)>21.141	184.252
289.00	(6)>22.424	207.049	(6)>22.424	(6)>22.424	274.321

Structure #2 (Null)

Spreader Berm

Structure #1 (Null)

Flow from site to South

Structure #20 (Null)

Extra structure to facilitate model setup -Entire Flow Off-Site

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#8	1	1.480	0.177	0.000	0.000	85.000	TR55	8.06	1.428
	Σ	**1.480**						**8.06**	**1.428**
#19	1	3.990	0.366	0.000	0.000	85.000	TR55	20.75	3.805
	2	2.600	0.039	0.183	0.192	98.000	TR55	14.88	2.848
	Σ	**8.070**						**42.94**	**8.082**
#18	1	5.550	0.361	0.000	0.000	85.000	TR55	28.94	5.295
	Σ	**13.620**						**69.84**	**13.377**
#5	1	2.010	0.281	0.000	0.000	85.000	TR55	10.77	1.920
	Σ	**2.010**						**10.77**	**1.920**
#17	1	2.160	0.224	0.000	0.000	85.000	TR55	11.18	1.989
	Σ	**4.170**						**21.95**	**3.909**
#4	1	1.840	0.312	0.000	0.000	85.000	TR55	9.71	1.742
	Σ	**1.840**						**9.71**	**1.742**
#16	1	1.300	0.000	0.000	0.000	85.000	TR55	7.10	1.244
	Σ	**20.930**						**103.12**	**20.271**
#15	1	9.310	0.312	0.000	0.000	85.000	TR55	49.14	8.813
	Σ	**9.310**						**49.14**	**8.813**
#14	1	3.750	0.310	0.000	0.000	85.000	TR55	19.80	3.552
	2	0.600	0.078	0.028	0.192	98.000	TR55	3.43	0.657
	3	1.270	0.022	0.099	0.192	98.000	TR55	7.27	1.391
	Σ	**5.620**						**29.78**	**5.601**
#13	1	1.650	0.180	0.000	0.000	85.000	TR55	8.96	1.588
	Σ	**1.650**						**8.96**	**1.588**
#12	1	2.140	0.180	0.000	0.000	85.000	TR55	11.63	2.059
	Σ	**9.410**						**47.50**	**9.247**
#11	1	1.190	0.224	0.000	0.000	85.000	TR55	6.16	1.096
	Σ	**1.190**						**6.16**	**1.096**
#10	1	3.290	0.239	0.000	0.000	85.000	TR55	17.66	3.146
	2	0.480	0.039	0.091	0.192	98.000	TR55	2.75	0.526
	Σ	**3.770**						**20.31**	**3.672**
#9	1	2.900	0.362	0.000	0.000	85.000	TR55	15.11	2.767

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	Σ	**17.270**						**86.69**	**16.782**
#7	1	1.030	0.178	0.000	0.000	85.000	TR55	5.61	0.993
	Σ	**1.030**						**5.61**	**0.993**
#6	1	1.480	0.131	0.000	0.000	85.000	TR55	8.13	1.439
	Σ	**19.780**						**90.65**	**19.214**
#3	1	2.100	0.000	0.000	0.000	85.000	TR55	11.47	2.009
	Σ	**21.880**						**94.35**	**21.223**
#2	1	0.400	0.080	0.000	0.000	85.000	TR55	2.18	0.382
	Σ	**22.280**						**44.04**	**21.606**
#1	Σ	**22.280**						**44.04**	**21.606**
#20	Σ	**52.520**						**98.71**	**42.209**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#2	1	3. Short grass pasture	0.75	1.50	200.00	0.690	0.080
#2	**1**	**Time of Concentration:**					**0.080**
#4	1	3. Short grass pasture	0.50	1.90	380.00	0.560	0.188
		3. Short grass pasture	0.50	1.25	250.00	0.560	0.124
#4	**1**	**Time of Concentration:**					**0.312**
#5	1	3. Short grass pasture	0.50	1.35	270.00	0.560	0.133
		3. Short grass pasture	0.50	1.50	300.00	0.560	0.148
#5	**1**	**Time of Concentration:**					**0.281**
#6	1	6. Grassed waterway	0.50	2.50	500.00	1.060	0.131
#6	**1**	**Time of Concentration:**					**0.131**
#7	1	6. Grassed waterway	0.50	3.40	680.00	1.060	0.178
#7	**1**	**Time of Concentration:**					**0.178**
#8	1	3. Short grass pasture	0.50	1.00	200.00	0.560	0.099
		6. Grassed waterway	0.50	1.50	300.00	1.060	0.078
#8	**1**	**Time of Concentration:**					**0.177**
#9	1	3. Short grass pasture	0.50	0.75	150.00	0.560	0.074
		6. Grassed waterway	0.50	5.50	1,100.00	1.060	0.288
#9	**1**	**Time of Concentration:**					**0.362**
#10	1	3. Short grass pasture	0.50	1.50	300.00	0.560	0.148
		6. Grassed waterway	0.50	1.75	350.00	1.060	0.091
#10	**1**	**Time of Concentration:**					**0.239**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#10	2	7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
#10	**2**	**Time of Concentration:**					**0.039**
#11	1	3. Short grass pasture	0.50	2.00	400.00	0.560	0.198
		6. Grassed waterway	0.50	0.50	100.00	1.060	0.026
#11	**1**	**Time of Concentration:**					**0.224**
#12	1	3. Short grass pasture	0.50	0.50	100.00	0.560	0.049
		6. Grassed waterway	0.50	2.50	500.00	1.060	0.131
#12	**1**	**Time of Concentration:**					**0.180**
#13	1	3. Short grass pasture	0.50	1.30	260.00	0.560	0.128
		6. Grassed waterway	0.50	1.00	200.00	1.060	0.052
#13	**1**	**Time of Concentration:**					**0.180**
#14	1	3. Short grass pasture	0.50	1.15	230.00	0.560	0.114
		6. Grassed waterway	0.50	3.75	750.00	1.060	0.196
#14	**1**	**Time of Concentration:**					**0.310**
#14	2	7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
		7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
#14	**2**	**Time of Concentration:**					**0.078**
#14	3	7. Paved area and small upland gullies	0.50	0.58	116.00	1.420	0.022
#14	**3**	**Time of Concentration:**					**0.022**
#15	1	3. Short grass pasture	0.50	2.75	550.00	0.560	0.272
		3. Short grass pasture	0.75	0.75	100.00	0.690	0.040
#15	**1**	**Time of Concentration:**					**0.312**
#17	1	3. Short grass pasture	0.50	1.45	290.00	0.560	0.143
		6. Grassed waterway	0.50	1.55	310.00	1.060	0.081
#17	**1**	**Time of Concentration:**					**0.224**
#18	1	3. Short grass pasture	0.50	2.65	530.00	0.560	0.262
		6. Grassed waterway	0.50	1.90	380.00	1.060	0.099
#18	**1**	**Time of Concentration:**					**0.361**
#19	1	3. Short grass pasture	0.50	2.60	520.00	0.560	0.257
		6. Grassed waterway	0.50	2.08	416.00	1.060	0.109
#19	**1**	**Time of Concentration:**					**0.366**
#19	2	7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
#19	**2**	**Time of Concentration:**					**0.039**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#10	2	6. Grassed waterway	0.50	1.75	350.00	1.060	0.091
#10	**2**	**Muskingum K:**					**0.091**
#14	2	6. Grassed waterway	0.50	0.55	110.00	1.060	0.028
#14	**2**	**Muskingum K:**					**0.028**
#14	3	6. Grassed waterway	0.50	1.90	380.00	1.060	0.099
#14	**3**	**Muskingum K:**					**0.099**
#19	2	6. Grassed waterway	0.50	3.50	700.00	1.060	0.183
#19	**2**	**Muskingum K:**					**0.183**

ATTACHMENT 2C

POST-DEVELOPMENT SEDIMENTATION BASIN DESIGN
SEDCAD+ OUTPUT
100-YEAR, 24-HOUR STORM EVENT

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Post-Development Surface Water 100-yr, 24-hr Storm

Resource Recovery Park

Feasibility Study

County of Kaua'i

AECOM

General Information

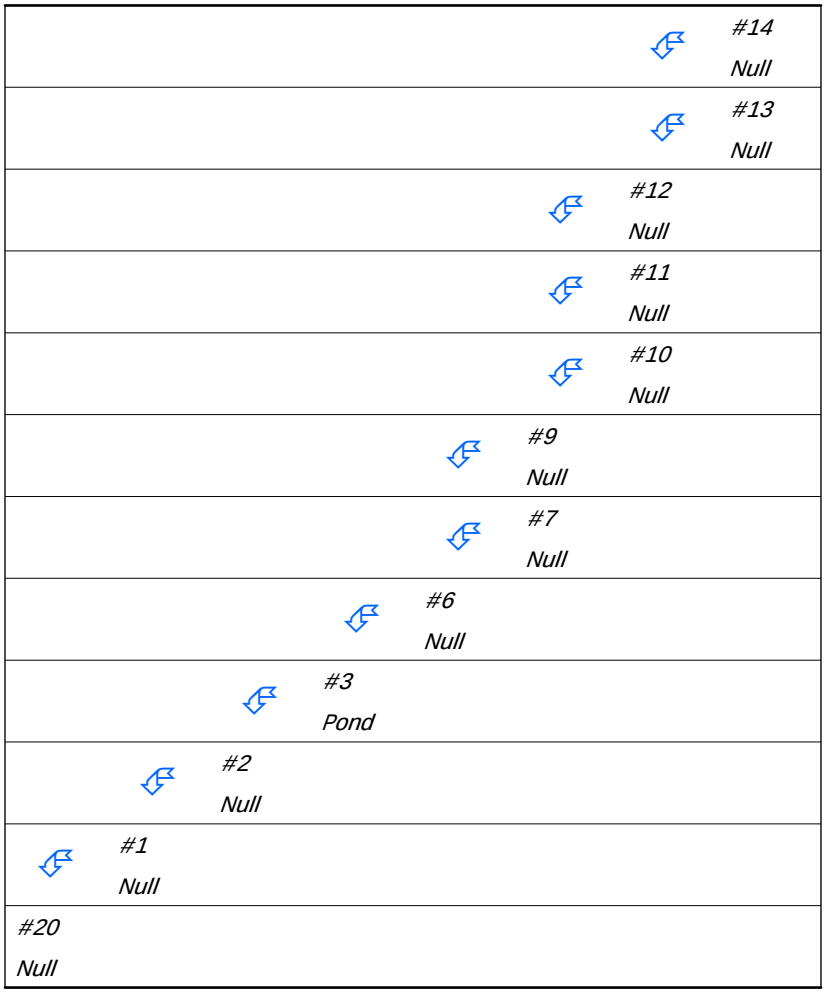
Storm Information:

Storm Type:	NRCS Type I
Design Storm:	100 yr - 24 hr
Rainfall Depth:	17.500 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#20	0.000	0.000	Flow from site to South
Null	#2	==>	#1	0.000	0.000	Spreader Berm
Pond	#3	==>	#2	0.000	0.000	South Surface Water Basin
Null	#4	==>	#16	0.075	0.192	SWS 4-1, Culverts C1 and C2
Null	#5	==>	#17	0.000	0.000	SWS 5-1, Culverts C3, C4, and C5
Null	#6	==>	#3	0.000	0.000	SWS 6-1, Culvert C10
Null	#7	==>	#6	0.023	0.192	SWS 7-1, Culvert C7
Null	#8	==>	#19	0.183	0.192	SWS 8-1, Culvert C9
Null	#9	==>	#6	0.157	0.192	SWS 9-1, Culvert C11
Null	#10	==>	#9	0.151	0.192	SWS 10-1, Culvert C12
Null	#11	==>	#9	0.309	0.192	SWS 11-1, Culvert C13
Null	#12	==>	#9	0.026	0.192	SWS 12-1, Culvert C14
Null	#13	==>	#12	0.044	0.192	SWS 13-1, Culvert C15
Null	#14	==>	#12	0.140	0.192	SWS 14-1, Culverts C16 and C17
Pond	#15	==>	#20	0.000	0.000	Compost Area Basin
Pond	#16	==>	#20	0.000	0.000	East Surface Water Basin
Null	#17	==>	#16	0.000	0.000	SWS 17-1, Culvert C6
Null	#18	==>	#16	0.000	0.000	SWS 18-1
Null	#19	==>	#18	0.096	0.192	SWS 19-1, Culvert C8
Null	#20	==>	End	0.000	0.000	Extra structure to facilitate model setup -Entire Flow Off-Site

#8 *Null*
#19 *Null*
#18 *Null*
#5 *Null*
#17 *Null*
#4 *Null*
#16 *Pond*
#15 *Pond*



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#4	6. Grassed waterway	0.50	1.45	290.00	1.06	0.075
#4	**Muskingum K:**					**0.075**
#7	6. Grassed waterway	0.50	0.45	90.00	1.06	0.023
#7	**Muskingum K:**					**0.023**
#8	6. Grassed waterway	0.50	3.50	700.00	1.06	0.183
#8	**Muskingum K:**					**0.183**
#9	6. Grassed waterway	0.50	3.00	600.00	1.06	0.157
#9	**Muskingum K:**					**0.157**
#10	6. Grassed waterway	0.50	2.90	580.00	1.06	0.151
#10	**Muskingum K:**					**0.151**
#11	6. Grassed waterway	0.50	5.90	1,180.00	1.06	0.309
#11	**Muskingum K:**					**0.309**
#12	6. Grassed waterway	0.50	0.50	100.00	1.06	0.026

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#12	**Muskingum K:**					**0.026**
#13	6. Grassed waterway	0.50	0.85	170.00	1.06	0.044
#13	**Muskingum K:**					**0.044**
#14	6. Grassed waterway	0.50	2.67	535.00	1.06	0.140
#14	**Muskingum K:**					**0.140**
#19	6. Grassed waterway	0.50	1.84	370.00	1.06	0.096
#19	**Muskingum K:**					**0.096**

Structure Summary:

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#8		1.480	1.480	10.76	1.93
#19		6.590	8.070	57.05	10.82
#18		5.550	13.620	93.09	17.98
#5		2.010	2.010	14.40	2.60
#17		2.160	4.170	29.33	5.29
#4		1.840	1.840	13.01	2.36
#16	In	1.300	20.930	137.52	27.31
	Out			80.30	27.31
#15	In	9.310	9.310	65.81	11.92
	Out			2.83	2.16
#14		5.620	5.620	39.58	7.49
#13		1.650	1.650	11.96	2.15
#12		2.140	9.410	63.21	12.43
#11		1.190	1.190	8.23	1.48
#10		3.770	3.770	27.10	4.95
#9		2.900	17.270	115.66	22.60
#7		1.030	1.030	7.48	1.34
#6		1.480	19.780	121.02	25.89
#3	In	2.100	21.880	125.93	28.60
	Out			58.46	28.60
#2		0.400	22.280	59.02	29.12
#1		0.000	22.280	59.02	29.12
#20		0.000	52.520	133.54	58.59

Structure Detail:

Structure #8 (Null)

SWS 8-1, Culvert C9

Structure #19 (Null)

SWS 19-1, Culvert C8

Structure #18 (Null)

SWS 18-1

Structure #5 (Null)

SWS 5-1, Culverts C3, C4, and C5

Structure #17 (Null)

SWS 17-1, Culvert C6

Structure #4 (Null)

SWS 4-1, Culverts C1 and C2

Structure #16 (Pond)

East Surface Water Basin

Pond Inputs:

Initial Pool Elev:	280.01 ft
Initial Pool:	0.01 ac-ft

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
284.00	15.00	5.00:1	5.00:1	20.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	50.00	0.25	0.0240	280.01	0.50	0.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	50.00	0.25	0.0240	280.01	0.50	0.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	50.00	0.25	0.0240	280.01	0.50	0.00

Pond Results:

Peak Elevation:	284.57 ft
Dewater Time:	0.83 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
280.00	0.900	0.000	0.000		
280.01	0.900	0.009	0.000		Spillway #2 Spillway #3 Spillway #4
280.50	0.944	0.461	6.460	6.25	
281.00	0.991	0.945	12.544	8.55	
281.50	1.038	1.452	19.694	2.50	
282.00	1.087	1.983	30.915	0.85	
282.50	1.136	2.538	38.025	0.45	
283.00	1.187	3.119	47.203	0.35	
283.50	1.238	3.725	54.984	0.30	
283.75	1.265	4.038	58.428	0.15	
284.00	1.291	4.358	61.788	0.15	Spillway #1
284.50	1.345	5.017	71.812	0.35	
284.57	1.354	5.119	80.304	0.10	Peak Stage
285.00	1.400	5.703	128.869		
285.50	1.450	6.415	197.964		
286.00	1.500	7.153	288.600		

Detailed Discharge Table

Elevation (ft)	Emergency Spillway (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
280.00	0.000	0.000	0.000	0.000	0.000
280.01	0.000	0.000	0.000	0.000	0.000
280.50	0.000	(1)>2.153	(1)>2.153	(1)>2.153	6.460
281.00	0.000	(1)>4.181	(1)>4.181	(1)>4.181	12.544
281.50	0.000	(1)>6.565	(1)>6.565	(1)>6.565	19.694
282.00	0.000	(1)>10.305	(1)>10.305	(1)>10.305	30.915
282.50	0.000	(6)>12.675	(6)>12.675	(6)>12.675	38.025
283.00	0.000	(6)>15.734	(6)>15.734	(6)>15.734	47.203
283.50	0.000	(6)>18.328	(6)>18.328	(6)>18.328	54.984
283.75	0.000	(6)>19.476	(6)>19.476	(6)>19.476	58.428
284.00	0.000	(6)>20.596	(6)>20.596	(6)>20.596	61.788
284.50	3.931	(6)>22.627	(6)>22.627	(6)>22.627	71.812
285.00	55.406	(6)>24.488	(6)>24.488	(6)>24.488	128.869
285.50	119.328	(6)>26.212	(6)>26.212	(6)>26.212	197.964
286.00	205.107	(6)>27.831	(6)>27.831	(6)>27.831	288.600

Structure #15 (Pond)

Compost Area Basin

Pond Inputs:

Initial Pool Elev:	279.01 ft
Initial Pool:	0.00 ac-ft

Perforated Riser

Riser Diameter (in)	Riser Height (ft)	Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Number of Holes per Elev
12.00	15.00	12.00	100.00	0.50	0.0240	294.00	1

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
292.50	14.00	5.00:1	5.00:1	20.00

Pond Results:

Peak Elevation:	292.84 ft
Dewater Time:	65.68 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
279.00	0.050	0.000	0.000		
279.01	0.050	0.001	0.000		Low hole SPW #1
279.50	0.070	0.030	0.018	19.38*	
280.00	0.095	0.071	0.026	19.04*	
280.50	0.122	0.125	0.032	20.41*	
281.00	0.153	0.194	0.037	22.46*	
281.50	0.188	0.279	0.041	24.89*	
282.00	0.226	0.383	0.045	27.57*	
282.50	0.268	0.506	0.049	30.44*	
283.00	0.313	0.651	0.052	33.48*	
283.50	0.362	0.820	0.056	36.67*	
284.00	0.414	1.014	0.059	39.99*	
284.50	0.470	1.235	0.062	43.44*	
285.00	0.529	1.484	0.064	47.00*	
285.50	0.592	1.764	0.067	50.67*	
286.00	0.658	2.077	0.069	54.45*	
286.50	0.728	2.423	0.072	58.33*	
287.00	0.802	2.806	0.074	62.31*	
287.50	0.879	3.226	0.077	66.40*	
288.00	0.959	3.685	0.079	70.58*	
288.50	1.043	4.185	0.081	74.86*	
289.00	1.131	4.729	0.083	79.21*	
289.50	1.222	5.317	0.085	83.66*	
290.00	1.317	5.951	0.087	88.19*	
290.50	1.415	6.634	0.089	92.80*	
291.00	1.516	7.367	0.091	97.49*	
291.50	1.622	8.151	0.093	102.25*	
292.00	1.730	8.989	0.095	107.10*	
292.50	1.842	9.882	0.096	112.02*	Spillway #2
292.84	1.922	10.534	2.832	11.20	Peak Stage
293.00	1.958	10.832	4.081		
293.50	2.077	11.841	56.144		
294.00	2.200	12.910	120.930		Spillway #1

**Designates time(s) to dewater have been extrapolated beyond the 50 hour hydrograph limit.*

Detailed Discharge Table

Elevation (ft)	Perf. Riser (cfs)	Emergency Spillway (cfs)	Combined Total Discharge (cfs)
279.00	0.000	0.000	0.000
279.01	1.00>0.000	0.000	0.000
279.50	0.018	0.000	0.018
280.00	0.026	0.000	0.026
280.50	0.032	0.000	0.032
281.00	0.037	0.000	0.037
281.50	0.041	0.000	0.041
282.00	0.045	0.000	0.045
282.50	0.049	0.000	0.049
283.00	0.052	0.000	0.052
283.50	0.056	0.000	0.056
284.00	0.059	0.000	0.059
284.50	0.062	0.000	0.062
285.00	0.064	0.000	0.064
285.50	0.067	0.000	0.067
286.00	0.069	0.000	0.069
286.50	0.072	0.000	0.072
287.00	0.074	0.000	0.074
287.50	0.077	0.000	0.077
288.00	0.079	0.000	0.079
288.50	0.081	0.000	0.081
289.00	0.083	0.000	0.083
289.50	0.085	0.000	0.085
290.00	0.087	0.000	0.087
290.50	0.089	0.000	0.089
291.00	0.091	0.000	0.091
291.50	0.093	0.000	0.093
292.00	0.095	0.000	0.095
292.50	0.096	0.000	0.096
293.00	0.098	3.982	4.081
293.50	0.100	56.044	56.144
294.00	0.102	120.828	120.930

Structure #14 (Null)

SWS 14-1, Culverts C16 and C17

Structure #13 (Null)

SWS 13-1, Culvert C15

Structure #12 (Null)

SWS 12-1, Culvert C14

Structure #11 (Null)

SWS 11-1, Culvert C13

Structure #10 (Null)

SWS 10-1, Culvert C12

Structure #9 (Null)

SWS 9-1, Culvert C11

Structure #7 (Null)

SWS 7-1, Culvert C7

Structure #6 (Null)

SWS 6-1, Culvert C10

Structure #3 (Pond)

South Surface Water Basin

Pond Inputs:

Initial Pool Elev:	283.01 ft
Initial Pool:	0.01 ac-ft

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	100.00	0.25	0.0240	283.01	0.50	0.00

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
287.00	14.00	5.00:1	5.00:1	20.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	100.00	0.25	0.0240	283.01	0.50	0.00

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev (ft)	Entrance Loss Coefficient	Tailwater Depth (ft)
24.00	100.00	0.25	0.0240	283.01	0.50	0.00

Pond Results:

Peak Elevation:	287.47 ft
Dewater Time:	0.92 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
283.00	1.200	0.000	0.000		
283.01	1.381	0.013	0.000		Spillway #1 Spillway #3 Spillway #4
283.50	1.415	0.698	7.124	8.65	
284.00	1.451	1.414	11.695	6.95	
284.50	1.486	2.149	18.105	2.60	
285.00	1.523	2.901	27.723	1.20	
285.50	1.560	3.671	32.192	0.70	
286.00	1.597	4.460	39.164	0.60	
286.50	1.634	5.268	45.043	0.45	
287.00	1.673	6.095	50.306	0.45	Spillway #2
287.47	1.709	6.887	58.455	0.60	Peak Stage
287.50	1.711	6.941	59.012		
288.00	1.750	7.806	115.393		
288.50	1.873	8.712	184.252		
289.00	2.000	9.680	274.321		

Detailed Discharge Table

Elevation (ft)	Straight Pipe (cfs)	Emergency Spillway (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
283.00	0.000	0.000	0.000	0.000	0.000
283.01	0.000	0.000	0.000	0.000	0.000
283.50	(1)>2.375	0.000	(1)>2.375	(1)>2.375	7.124
284.00	(1)>3.898	0.000	(1)>3.898	(1)>3.898	11.695
284.50	(1)>6.035	0.000	(1)>6.035	(1)>6.035	18.105
285.00	(1)>9.241	0.000	(1)>9.241	(1)>9.241	27.723
285.50	(6)>10.731	0.000	(6)>10.731	(6)>10.731	32.192
286.00	(6)>13.055	0.000	(6)>13.055	(6)>13.055	39.164
286.50	(6)>15.014	0.000	(6)>15.014	(6)>15.014	45.043
287.00	(6)>16.769	0.000	(6)>16.769	(6)>16.769	50.306
287.50	(6)>18.343	3.982	(6)>18.343	(6)>18.343	59.012
288.00	(6)>19.783	56.044	(6)>19.783	(6)>19.783	115.393
288.50	(6)>21.141	120.828	(6)>21.141	(6)>21.141	184.252
289.00	(6)>22.424	207.049	(6)>22.424	(6)>22.424	274.321

Structure #2 (Null)

Spreader Berm

Structure #1 (Null)

Flow from site to South

Structure #20 (Null)

Extra structure to facilitate model setup -Entire Flow Off-Site

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#8	1	1.480	0.177	0.000	0.000	85.000	TR55	10.76	1.932
	Σ	**1.480**						**10.76**	**1.932**
#19	1	3.990	0.366	0.000	0.000	85.000	TR55	27.75	5.148
	2	2.600	0.039	0.183	0.192	98.000	TR55	19.44	3.736
	Σ	**8.070**						**57.05**	**10.815**
#18	1	5.550	0.361	0.000	0.000	85.000	TR55	38.71	7.163
	Σ	**13.620**						**93.09**	**17.979**
#5	1	2.010	0.281	0.000	0.000	85.000	TR55	14.40	2.597
	Σ	**2.010**						**14.40**	**2.597**
#17	1	2.160	0.224	0.000	0.000	85.000	TR55	14.93	2.691
	Σ	**4.170**						**29.33**	**5.288**
#4	1	1.840	0.312	0.000	0.000	85.000	TR55	13.01	2.356
	Σ	**1.840**						**13.01**	**2.356**
#16	1	1.300	0.000	0.000	0.000	85.000	TR55	9.43	1.683
	Σ	**20.930**						**137.52**	**27.305**
#15	1	9.310	0.312	0.000	0.000	85.000	TR55	65.81	11.923
	Σ	**9.310**						**65.81**	**11.923**
#14	1	3.750	0.310	0.000	0.000	85.000	TR55	26.52	4.805
	2	0.600	0.078	0.028	0.192	98.000	TR55	4.49	0.862
	3	1.270	0.022	0.099	0.192	98.000	TR55	9.50	1.825
	Σ	**5.620**						**39.58**	**7.492**
#13	1	1.650	0.180	0.000	0.000	85.000	TR55	11.96	2.148
	Σ	**1.650**						**11.96**	**2.148**
#12	1	2.140	0.180	0.000	0.000	85.000	TR55	15.51	2.786
	Σ	**9.410**						**63.21**	**12.425**
#11	1	1.190	0.224	0.000	0.000	85.000	TR55	8.23	1.482
	Σ	**1.190**						**8.23**	**1.482**
#10	1	3.290	0.239	0.000	0.000	85.000	TR55	23.61	4.256
	2	0.480	0.039	0.091	0.192	98.000	TR55	3.59	0.690
	Σ	**3.770**						**27.10**	**4.946**
#9	1	2.900	0.362	0.000	0.000	85.000	TR55	20.22	3.743

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	Σ	**17.270**						**115.66**	**22.596**
#7	1	1.030	0.178	0.000	0.000	85.000	TR55	7.48	1.343
	Σ	**1.030**						**7.48**	**1.343**
#6	1	1.480	0.131	0.000	0.000	85.000	TR55	10.84	1.947
	Σ	**19.780**						**121.02**	**25.887**
#3	1	2.100	0.000	0.000	0.000	85.000	TR55	15.24	2.718
	Σ	**21.880**						**125.93**	**28.605**
#2	1	0.400	0.080	0.000	0.000	85.000	TR55	2.90	0.518
	Σ	**22.280**						**59.02**	**29.122**
#1	Σ	**22.280**						**59.02**	**29.122**
#20	Σ	**52.520**						**133.54**	**58.590**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#2	1	3. Short grass pasture	0.75	1.50	200.00	0.690	0.080
#2	**1**	**Time of Concentration:**					**0.080**
#4	1	3. Short grass pasture	0.50	1.90	380.00	0.560	0.188
		3. Short grass pasture	0.50	1.25	250.00	0.560	0.124
#4	**1**	**Time of Concentration:**					**0.312**
#5	1	3. Short grass pasture	0.50	1.35	270.00	0.560	0.133
		3. Short grass pasture	0.50	1.50	300.00	0.560	0.148
#5	**1**	**Time of Concentration:**					**0.281**
#6	1	6. Grassed waterway	0.50	2.50	500.00	1.060	0.131
#6	**1**	**Time of Concentration:**					**0.131**
#7	1	6. Grassed waterway	0.50	3.40	680.00	1.060	0.178
#7	**1**	**Time of Concentration:**					**0.178**
#8	1	3. Short grass pasture	0.50	1.00	200.00	0.560	0.099
		6. Grassed waterway	0.50	1.50	300.00	1.060	0.078
#8	**1**	**Time of Concentration:**					**0.177**
#9	1	3. Short grass pasture	0.50	0.75	150.00	0.560	0.074
		6. Grassed waterway	0.50	5.50	1,100.00	1.060	0.288
#9	**1**	**Time of Concentration:**					**0.362**
#10	1	3. Short grass pasture	0.50	1.50	300.00	0.560	0.148
		6. Grassed waterway	0.50	1.75	350.00	1.060	0.091
#10	**1**	**Time of Concentration:**					**0.239**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#10	2	7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
#10	**2**	**Time of Concentration:**					**0.039**
#11	1	3. Short grass pasture	0.50	2.00	400.00	0.560	0.198
		6. Grassed waterway	0.50	0.50	100.00	1.060	0.026
#11	**1**	**Time of Concentration:**					**0.224**
#12	1	3. Short grass pasture	0.50	0.50	100.00	0.560	0.049
		6. Grassed waterway	0.50	2.50	500.00	1.060	0.131
#12	**1**	**Time of Concentration:**					**0.180**
#13	1	3. Short grass pasture	0.50	1.30	260.00	0.560	0.128
		6. Grassed waterway	0.50	1.00	200.00	1.060	0.052
#13	**1**	**Time of Concentration:**					**0.180**
#14	1	3. Short grass pasture	0.50	1.15	230.00	0.560	0.114
		6. Grassed waterway	0.50	3.75	750.00	1.060	0.196
#14	**1**	**Time of Concentration:**					**0.310**
#14	2	7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
		7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
#14	**2**	**Time of Concentration:**					**0.078**
#14	3	7. Paved area and small upland gullies	0.50	0.58	116.00	1.420	0.022
#14	**3**	**Time of Concentration:**					**0.022**
#15	1	3. Short grass pasture	0.50	2.75	550.00	0.560	0.272
		3. Short grass pasture	0.75	0.75	100.00	0.690	0.040
#15	**1**	**Time of Concentration:**					**0.312**
#17	1	3. Short grass pasture	0.50	1.45	290.00	0.560	0.143
		6. Grassed waterway	0.50	1.55	310.00	1.060	0.081
#17	**1**	**Time of Concentration:**					**0.224**
#18	1	3. Short grass pasture	0.50	2.65	530.00	0.560	0.262
		6. Grassed waterway	0.50	1.90	380.00	1.060	0.099
#18	**1**	**Time of Concentration:**					**0.361**
#19	1	3. Short grass pasture	0.50	2.60	520.00	0.560	0.257
		6. Grassed waterway	0.50	2.08	416.00	1.060	0.109
#19	**1**	**Time of Concentration:**					**0.366**
#19	2	7. Paved area and small upland gullies	0.50	1.00	200.00	1.420	0.039
#19	**2**	**Time of Concentration:**					**0.039**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#10	2	6. Grassed waterway	0.50	1.75	350.00	1.060	0.091
#10	**2**	**Muskingum K:**					**0.091**
#14	2	6. Grassed waterway	0.50	0.55	110.00	1.060	0.028
#14	**2**	**Muskingum K:**					**0.028**
#14	3	6. Grassed waterway	0.50	1.90	380.00	1.060	0.099
#14	**3**	**Muskingum K:**					**0.099**
#19	2	6. Grassed waterway	0.50	3.50	700.00	1.060	0.183
#19	**2**	**Muskingum K:**					**0.183**

Appendix C.10
RRP Culvert Analysis

Client	County of Kaua'i	**Subject**	RRP Culvert	**Prepared By**	TCR	**Date**	11/22/13
Project	Resource Recovery	Analysis		**Reviewed By**	NKW	**Date**	11/22/13
Park Conceptual Design				**Approved By**		**Date**	

RRP CULVERT ANALYSIS

Objective

Design culverts under the Resource Recovery Park site roads. These culverts will convey surface water runoff to the surface water basins.

Design Criteria and Assumptions

1. Culverts will be sized to convey the greater of the peak flow from the 100-year, 1-hour storm event or the 25-year, 24-hour storm event.

2. Assume corrugated metal pipe (CMP) will be used for the culverts. Use a Manning's Roughness Coefficient "n" of 0.024 for corrugated metal pipe.

3. Assume flared end sections will be attached at both inlet and outlet ends of the culverts to provide a smooth transition of flow.

4. Assume rip rap will be used for erosion protection at the culvert inlet and outlet. Alternative materials to riprap, such as a geotextile erosion control mat, may be used to provide erosion protection.

5. Assume a minimum culvert diameter of 18-inches. Culverts recommended in these calculations may be substituted with a structure that provides equal hydraulic performance (i.e., box culvert, pipe arches, etc.)

6. Culverts will be sized using the SEDCAD+ utilities culvert design program. Output is attached. For simplicity culverts with a similar flow are analyzed together.

7. Culverts will be subjected to vehicular traffic, therefore, it is assumed that 2 feet of cover soils will be placed over the pipe. Due to upstream geometry the cover over the pipe is not always representative of upstream surface water containment conditions. Headwater depths are assumed to be 3 feet, while tailwater is assumed to be 2 feet. Headwater and tailwater depths are measured from pipe invert.

8. The culvert design is conceptual and should be re-evaluated when final design conditions are established. Note that the slope in the SEDCAD output is rounded to the nearest tenth.

Calculations

The expected flow rate to each culvert is presented within the SEDCAD+ output for the surface water basin analyses. The SEDCAD+ Culvert Design Utility was used to evaluate the culverts. The results of these analyses are presented in Attachment 1. Actual culverts will be field fit according to location. Length will vary from approximately 30 to 80 feet. The capacity of two different diameter culverts were analyzed using SEDCAD+, see Attachment 1. Table 1 lists the culvert capacities.

Table 1: Culvert Capacities			
18-inch CMP Culvert		24-inch CMP Culvert	
No. of Culverts	Maximum Allowable Flow (cfs)	No. of Culverts	Maximum Allowable Flow (cfs)
1	6.10	1	12.49
2	2 x 6.10 = 12.20	2	2 x 12.49 = 24.98
3	3 x 6.10 = 18.30	3	3 x 12.49 = 37.47
4	4 x 6.10 = 24.40	4	4 x 12.49 = 49.96
5	5 x 6.10 = 30.50	5	4 x 12.49 = 62.45
		8	8 x 12.49 = 99.92

Note: Culvert capacity will vary depending on the assumed input parameters.

Conclusions

Design culvert requirements are summarized in Table 2 below. The peak flow rate and design assumptions for each culvert were input into the SEDCAD+ Culvert Design Utility.

Table 2: Culvert Analysis Results

Culvert ID Label	Peak Design Flow (cfs)	Total Max. Allowable Flow (cfs)	SEDCAD+ Output	Culvert Information (SEDCAD+ Input)			
			Max. Allowable Flow per pipe (cfs)	Dia. (in.)	No. of Pipes	Max. Length (ft.)	Min. Slope (%)
C1, C2, C3, C4, C5, C7, C9, C13, and C15	11.20	12.20	6.10	18	2	80	0.25
C6, C12, and C18	23.47	24.98	12.49	24	2	80	0.25
C8, C14, C16, and C17	47.96	49.96	12.49	24	4	80	0.25
C10 and C11	90.65	99.92	12.49	24	8	80	0.25

Notes:

1. Headwater assumed to be 3.0 feet, tailwater assumed to be 2.0 ft. Actual headwater will need to be verified at final design to verify adequacy of pipe sizes.
2. Place riprap at culvert inlet and outlet locations.
3. Install flared end sections at both inlet and outlet ends.
4. Culverts recommended in these calculations may be substituted with an equivalent structure that provides equal hydraulic performance (i.e., box culvert, pipe arch, etc.).
5. Culvert slope is assumed. Actual slopes at final design will need to be used to verify adequacy of pipe sizes.

ATTACHMENT 1

SEDCAD+ CULVERT DESIGN UTILITY OUTPUT

18-inch Culvert

Culvert Inputs:

Length (ft)	Slope (%)	Manning's n	Max. Headwater (ft)	Tailwater (ft)	Entrance Loss Coef. (Ke)
80.00	0.25	0.0240	3.00	2.00	0.50

Culvert Results:

Minimum pipe diameter: 1 - 18 inch pipe(s) required

Detailed Performance Curves

Design Discharge = 6.10 cfs

Maximum Headwater = 3.00 ft

(BOLD indicates design pipe size)

Headwater (ft)	Discharge (cfs) (15 in)	**Discharge (cfs) (18 in)**	Discharge (cfs) (21 in)
0.30	0.00	**0.00**	0.00
0.60	0.00	**0.00**	0.00
0.90	0.00	**0.00**	0.00
1.20	0.00	**0.00**	0.00
1.50	0.00	**0.00**	0.00
1.80	0.00	**0.00**	0.00
2.10	1.91	**3.04**	4.48
2.40	2.72	**4.32**	6.35
2.70	3.33	**5.29**	7.77
3.00	3.85	**6.10**	8.97
3.30	4.31	**6.83**	10.03
3.60	4.72	**7.48**	10.99
3.90	5.09	**8.07**	11.87
4.20	5.44	**8.63**	12.69
4.50	5.78	**9.16**	13.46

24-inch Culvert

Culvert Inputs:

Length (ft)	Slope (%)	Manning's n	Max. Headwater (ft)	Tailwater (ft)	Entrance Loss Coef. (Ke)
80.00	0.25	0.0240	3.00	2.00	0.50

Culvert Results:

Minimum pipe diameter: 1 - 24 inch pipe(s) required

Detailed Performance Curves

Design Discharge = 12.49 cfs

Maximum Headwater = 3.00 ft

(BOLD indicates design pipe size)

Headwater (ft)	Discharge (cfs) (21 in)	**Discharge (cfs) (24 in)**	Discharge (cfs) (30 in)
0.30	0.00	**0.00**	0.00
0.60	0.00	**0.00**	0.00
0.90	0.00	**0.00**	0.00
1.20	0.00	**0.00**	0.00
1.50	0.00	**0.00**	0.00
1.80	0.00	**0.00**	0.00
2.10	4.48	**6.24**	9.89
2.40	6.35	**8.83**	14.78
2.70	7.77	**10.82**	18.77
3.00	8.97	**12.49**	20.90
3.30	10.03	**13.96**	23.04
3.60	10.99	**15.30**	25.44
3.90	11.87	**16.52**	27.62
4.20	12.69	**17.66**	29.64
4.50	13.46	**18.73**	31.54

Appendix C.11
RRP Surface Water Perimeter Channel Analysis

RRP SURFACE WATER PERIMETER CHANNEL ANALYSIS

Objective

Design conceptual channels to direct surface water run-off from the Resource Recovery Park (RRP) to surface water basins.

Design Criteria and Assumptions

1. The grading of the RRP, and channels within the RRP, are assumed to be 0.5%.

2. Channels will be able to convey runoff from the highest peak flow storm; either a 100-year, 1-hour storm event or a 25-year, 24-hour storm event, without overflow.

3. Perimeter channel sideslopes will be 3:1 (horizontal:vertical) on both sides.

4. From the Surface Water Basin Analysis the flow in the channels varies from approximately 7 cfs to less than 91 cfs. Two typcial channel cross sections are designed to cover all the channels.

5. The channel design is conceptual and should be re-evaluated when final design conditions are established. Each channel corresponds to a culvert labeled in the SEDCAD model. Note that the slope in the SEDCAD output is rounded to the nearest tenth.

Calculations

The SEDCAD+ Channel Design Utility was used to evaluate the channels. The results of these analyses are presented in Attachment 1.

Conclusions

Design channel requirements are summarized in Table 1 below. Dimensions identified by the SEDCAD+ analyses were rounded up to obtain the typical cross-section. The peak flow rate and shallowest slope for each channel was input into the SEDCAD+ Channel Design Utility.

Table 1: Conceptual Channel Design

Channel Slope (%)	Peak Design Flow (cfs)	SEDCAD+[1] Depth (ft)	Channel Bottom Width (ft)	Channel Lining	Channel Side-slopes	Min. Design Depth (ft)
0.5	23.0	3.0	2	Grass	3:1	3.0
0.5	91.0	3.5	6	Grass	3:1	3.5

Notes:
1. SEDCAD depth includes 0.5 ft freeboard.
2. The ability of grass channel lining to resist scour and erosion is dependent on many factors. Permanent erosion control mat or other channel stabilization erosion control measures may be needed depending on actual site conditions.

ATTACHMENT 1

SEDCAD+ CHANNEL DESIGN UTILITY OUTPUT

2-Foot Channel

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
2.00	3.0:1	3.0:1	0.5	D, B	0.50			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	23.00 cfs		23.00 cfs	
Depth:	1.63 ft	2.13 ft	2.50 ft	3.00 ft
Top Width:	11.76 ft	14.76 ft	17.02 ft	20.02 ft
Velocity:	2.05 fps		0.97 fps	
X-Section Area:	11.20 sq ft		23.82 sq ft	
Hydraulic Radius:	0.911 ft		1.335 ft	
Froude Number:	0.37		0.14	
Roughness Coefficient:	0.0481		0.1323	

6-foot Channel

Material: Grass mixture

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	3.0:1	3.0:1	0.5	D, B	0.50			5.0

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	93.00 cfs		93.00 cfs	
Depth:	2.12 ft	2.62 ft	3.00 ft	3.50 ft
Top Width:	18.70 ft	21.70 ft	24.03 ft	27.03 ft
Velocity:	3.56 fps		2.06 fps	
X-Section Area:	26.13 sq ft		45.12 sq ft	
Hydraulic Radius:	1.348 ft		1.804 ft	
Froude Number:	0.53		0.27	
Roughness Coefficient:	0.0361		0.0757	

Appendix D:
Leachate Management System Calculations

Appendix D.1
Leachate Generation Analysis

Client	County of Kaua'i	**Subject**	Leachate	**Prepared By** MJV	**Date** 6/25/13
Project	Ma'alo Landfill		Generation Analysis	**Reviewed By** TCR	**Date** 6/26/13
Conceptual Design				**Approved By** KJB	**Date** 6/27/13

LEACHATE GENERATION ANALYSIS

Objective

Estimate the quantity of leachate generated for the Ma'alo Landfill during filling, using the USEPA Hydraulic Evaluation of Landfill Performance Version 3.07 (HELP) computer modeling program and site data.

Design Criteria and Assumptions

1. This analysis was performed to estimate leachate generation rates in the proposed landfill on a per acre basis, based on conditions that yield the greatest leachate quantities.

2. This analysis estimates leachate generation rates when final grades are reached in Phase 1 prior to final cover placement. Additional waste will be placed as a layover onto Phase 1 as future phases are constructed; however, this will not increase leachate volumes collected over the condition assumed in this calculation.

3. Active conditions are to be modeled as a conservative analysis. Active conditions refer to the situation of active waste placement and 6 inches of soil cover in place. An intermediate condition was also modeled for areas which are not actively receiving waste and have 12 inches of soil cover in place. No final cover was modeled.

HELP Model Version 3.07 Input:

1. Solar radiation data can be default data, user input or synthetically generated by the HELP model. Synthetically generated solar radiation data for Honolulu, Hawaii was used to simulate site weather conditions.

2. Temperature, precipitation, and average wind speed data was obtained from site records at the Lihue Airport from January 2003 through December 2012.

3. Geomembrane liner pinhole density and size were assumed to account for possible manufacturing defects during geomembrane production. The HELP Model User's Guide for Version 3.07 states that the pinhole density for a typical geomembrane is 0.5 to 1 pinhole per acre. One pinhole per acre was assumed to be present.

4. The placement quality for the geomembrane liner was assumed to be "good". A placement quality of "good" according to the HELP Model User's Guide "assumes good field installation with well prepared, smooth soil surface and geomembrane wrinkle control". The HELP Model User's Guide suggests 1 to 4 installation defects for an installation quality of "good". To be conservative, 2 installation defects per acre were assumed for the geomembrane liner.

5. For active phase analysis, it is assumed that 0 percent of the area will allow rainwater runoff. For the intermediate phase, it is assumed that areas will be completely covered by intermediate soil cover that will route stormwater off the landfill, and runoff is possible for 100 percent of the area.

6. The HELP model was used to calculate the curve number for the cell based on the intermediate cover soil type, a slope of 5 percent (approximate slope at crest) and a typical intermediate slope length of 130 feet.

7. The initial moisture content of the waste layer was conservatively assumed to be at field capacity.

8. Soil layers were generally modeled using HELP model default soil characteristics (porosity, field capacity, wilting point, saturated hydraulic conductivity). The exceptions are the geosynthetic clay liner (bentonite mat) and the operations layer. The default saturated hydraulic conductivity of the bentonite mat is adjusted to reflect current manufacturer data. The operations layer is assumed to have a hydraulic conductivity of 6.0×10^{-3} cm/sec.

9. The longest flow path and shallowest slope along the base liner was input, resulting in the highest potential leachate head estimate. For the proposed base liner, the longest flow length is 280 feet and the slope is approximately 2.85 percent.

10. A 1-acre design area was used for modeling purposes to compute unit quantities.

11. The landfill is proposed to be constructed in phases to limit the size of the active area in each phase. The phasing has not been finalized yet.

12. Active/Intermediate Condition Inputs (see also Table 1):
    - 107 feet of waste (approximate maximum waste depth for Phase 1)
    - Bare ground conditions (no vegetation)
    - Evaporative zone depth = 10 in. (recommended by HELP Model for bare ground for Honolulu, Hawaii)
    - Maximum leaf area index = 0 (recommended by HELP Model for bare ground)
    - Fraction of area allowing runoff = 0 percent (active), 100 percent (intermediate)
    - Runoff curve number = 92.2 (calculated by HELP model)
    - Length of model run = 10 years

Client	County of Kaua'i	**Subject**	Leachate	**Prepared By** MJV	**Date** 6/25/13
Project	Ma'alo Landfill		Generation Analysis	**Reviewed By** TCR	**Date** 6/26/13
	Conceptual Design			**Approved By** KJB	**Date** 6/27/13

Help Model General Layout

Table 1: Active/Intermediate Condition – Model Layout

(Layer Number) Layer Description	Flow	Thickness	Saturated Hydraulic Conductivity	Soil Type/ Texture Number
(1)vertical percolation	↓	6 in. (active) 12 in. (int)	1.9×10^{-4} cm/sec	Daily or Intermediate cover/#9
(2)vertical percolation	↓	1,284 inches	1.0×10^{-3} cm/sec	waste/#18
(3)vertical percolation	↓	24 inches	6.0×10^{-3} cm/sec	operations layer/ #43
(4)lateral drainage	→	12 inches	3.0×10^{-1} cm/sec	gravel/ #21
(5)60-mil geomembrane Liner	↓	0.06 inch	2.0×10^{-13} cm/sec	geomembrane/#35
(6)Geosynthetic Clay Layer	↓	0.25 inches	5.0×10^{-9} cm/sec	GCL/#44

Table 2: Soil Texture Properties

Soil Texture	Soil Classification		Comments, Properties, and Uses
	USDA	USCS	
44	---	---	Based on HELP model default parameter for a bentonite mat (0.6 cm or 0.25 inches thick) with the hydraulic conductivity changed from 3×10^{-9} cm/sec to 5×10^{-9} cm/sec.
43	S	SW	Operations layer. Based on HELP model default soil parameter no. 2 with the hydraulic conductivity changed from 5.8×10^{-3} cm/sec to 6×10^{-3} cm/sec.
35	---	---	HELP model default parameters for High Density Polyethylene (HDPE) geomembrane.
21	---	---	Gravel drainage layer. HELP model default soil parameter for gravel, hydraulic conductivity of 3.0×10^{-1} cm/sec
18	---	---	HELP model default parameter for municipal solid waste.
9	SiL	ML	HELP model default soil used to model daily and intermediate cover.

Note: All soil properties are defaults of the HELP Model, Version 3.07 unless otherwise designated.

Client	County of Kaua'i	**Subject**	Leachate	**Prepared By** MJV	**Date** 6/25/13
Project	Ma'alo Landfill		Generation Analysis	**Reviewed By** TCR	**Date** 6/26/13
Conceptual Design				**Approved By** KJB	**Date** 6/27/13

Calculations

Calculations performed by the HELP Model are included in the output located in the following pages. See Tables 3 and 4 for the modeling results based on peak daily, peak average monthly, and peak average annual values. The HELP Model presents peak daily results in inches per day and cubic feet per day. Results for average monthly values are based on the average values for the month with the highest leachate quantity. The HELP Model presents the average annual results in inches per year and cubic feet per year. See the sample conversions below.

A. Active Condition:

Peak daily lateral drainage collected from layer 4 (leachate quantity) for the 1-acre design area:

$$\left(\frac{700.6\,\text{cf}}{\text{day x acre}}\right)\left(\frac{7.48\,\text{gallons}}{1\,\text{cf}}\right) = 5{,}240\ \text{gal/acre/day}$$

Maximum average monthly lateral drainage collected from layer 4 (leachate quantity) for the 1-acre design area:

$$\left(\frac{2.2125\,\text{inches}}{\text{month}}\right)\left(\frac{1\,\text{foot}}{12\,\text{inches}}\right)\left(\frac{43{,}560\,\text{sf}}{\text{acre}}\right)\left(\frac{7.48\,\text{gallons}}{1\,\text{cf}}\right)\left(\frac{\text{month}}{30\,\text{days (for April)}}\right) = 2{,}002\ \text{gal/acre/day}$$

Average annual lateral drainage collected from layer 4 (leachate quantity) for the 1-acre design area:

$$\left(\frac{53{,}492.4\,\text{cf}}{\text{year x acre}}\right)\left(\frac{7.48\,\text{gallons}}{1\,\text{cf}}\right)\left(\frac{\text{year}}{365\,\text{days}}\right) = 1{,}096\,\text{gal/acre/day}$$

Table 3: Active Condition Calculated Results from HELP Analysis Output

Parameter	Peak Daily Value	Average Monthly Value	Peak Average Annual Value
Leachate Head on Base (filling at final grade)	2.08 inches	0.43 inches	0.23 inches
Leachate Quantity (filling at final grade)	5,240 gallons/acre/day	2,002 gallons/acre/day	1,096 gallons/acre/day

NOTE: Refer to the attached HELP Model output (filename: ACTIVE.OUT).

B. Intermediate Condition:

Peak daily lateral drainage collected from layer 4 (leachate quantity) for the 1-acre design area:

$$\left(\frac{467.1\,\text{cf}}{\text{day x acre}}\right)\left(\frac{7.48\,\text{gallons}}{1\,\text{cf}}\right) = 3{,}494\ \text{gal/acre/day}$$

Maximum average monthly lateral drainage collected from layer 4 (leachate quantity) for the 1-acre design area:

$$\left(\frac{0.7294\,\text{inches}}{\text{month}}\right)\left(\frac{1\,\text{foot}}{12\,\text{inches}}\right)\left(\frac{43{,}560\,\text{sf}}{\text{acre}}\right)\left(\frac{7.48\,\text{gallons}}{1\,\text{cf}}\right)\left(\frac{\text{month}}{28\,\text{days (for February)}}\right) = 707\ \text{gal/acre/day}$$

Average annual lateral drainage collected from layer 4 (leachate quantity) for the 1-acre design area:

$$\left(\frac{16{,}989.7\,\text{cf}}{\text{year x acre}}\right)\left(\frac{7.48\,\text{gallons}}{1\,\text{cf}}\right)\left(\frac{\text{year}}{365\,\text{days}}\right) = 348\,\text{gal/acre/day}$$

Table 4: Intermediate Condition Calculated Results from HELP Analysis Output

Parameter	Peak Daily Value	Average Monthly Value	Peak Average Annual Value
Leachate Head on Base (filling at final grade)	1.41 inches	0.15 inches	0.075 inches
Leachate Quantity (filling at final grade)	3,494 gallons/acre/day	707 gallons/acre/day	348 gallons/acre/day

NOTE: Refer to the attached HELP Model output (filename: MAALOINT.OUT).

Daily Phase 1 Leachate Estimation:

The worst-case scenario that results in the greatest volume of leachate generated is anticipated to occur when the area draining to the southernmost leachate collection pipe (4.7 acres) and the adjacent area draining to the leachate collection pipe to the north (4.9 acres) are open, and the remainder of Phase 1 (35.2 acres) has intermediate cover. The resulting daily leachate volumes are calculated below:

Based on peak daily leachate generation:
(9.6 acres x 5,240 gal/acre/day) + (35.2 acres x 3,494 gal/acre/day) = **173,293 gal/day**

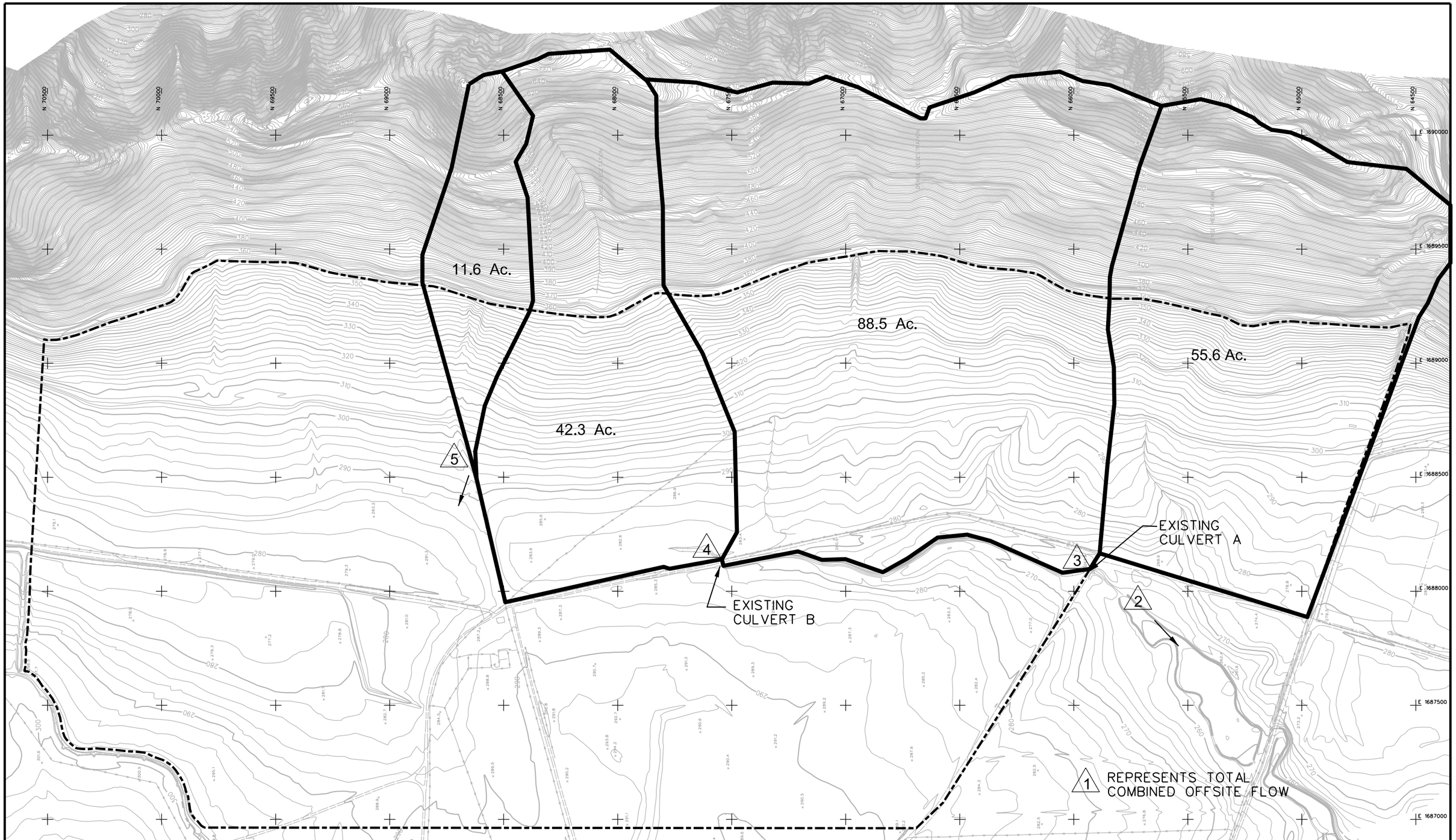
Based on average monthly leachate generation:
(9.6 acres x 2,002 gal/acre/day) + (35.2 acres x 707 gal/acre/day) = **44,106 gal/day**

Based on peak average annual leachate generation:
(9.6 acres x 1,096 gal/acre/day) + (35.2 acres x 348 gal/acre/day) = **22,771 gal/day**

Conclusions

Active conditions when the approximately northern 75% (35.2 acres) of Phase 1 are at final grade with intermediate cover in place and the areas draining to the two southernmost leachate collection pipes (9.6 acres) are actively receiving waste are summarized above. The estimated maximum daily total leachate generation for all of Phase 1 is approximately 173,300 gallons.

These values are estimated using a waste with an initial water content at field capacity. The HELP Model was used to calculate leachate volumes and should be considered only an estimate of potential field conditions.



4 = SEDCAD STRUCTURE NUMBER

N

SCALE 0' 200' 400'

AECOM

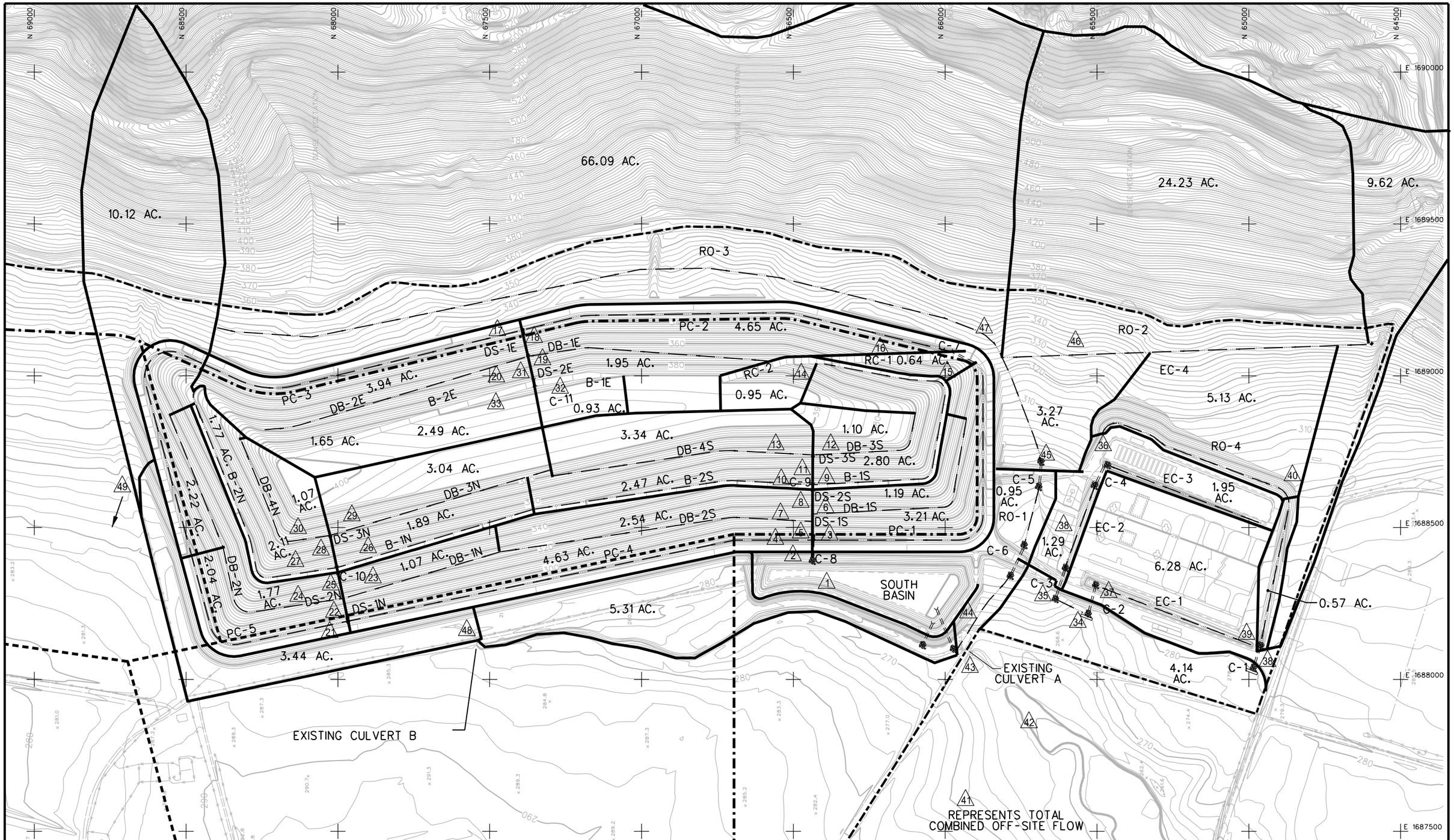
FIGURE 1
PRE-DEVLOPMENT SEDCAD SUB-WATERSHED

CONCEPTUAL DESIGN
MA'ALO SANITARY LANDFILL
KAUAI, HAWAII

JULY 2013

60221907

6/26/2013 9:04:22 PM
Pentaxia = ab-ttu
Server = USSHEIS01
L:\Work\60221907\000_CADD\Models\Conceptual Design Task\Pre-Dev SW.dgn



AECOM

FIGURE 2
POST-DEVLOPMENT SEDCAD SUB-WATERSHED

CONCEPTUAL DESIGN
MA'ALO SANITARY LANDFILL
KAUAI, HAWAII

JULY 2013

60221907

6/27/2013 5:20:57 PM
Plotted by: ALEX
Server = USSHE501
C:\Users\landdfl\Desktop\Conceptual Design Tank\Post-Dev SW.dgn

ATTACHMENT 1

HELP MODEL OUTPUT – ACTIVE CONDITION
(FILENAME: ACTIVE.OUT)

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    G:\04DEPT03\USERS\VANN\HELP30~1\MAALO.D4
TEMPERATURE DATA FILE:      G:\04DEPT03\USERS\VANN\HELP30~1\MAALO.D7
SOLAR RADIATION DATA FILE:  G:\04DEPT03\USERS\VANN\HELP30~1\MAALO.D13
EVAPOTRANSPIRATION DATA:    G:\04DEPT03\USERS\VANN\HELP30~1\MAALO.D11
SOIL AND DESIGN DATA FILE:  G:\04DEPT03\USERS\VANN\HELP30~1\ACTIVE.D10
OUTPUT DATA FILE:           G:\04DEPT03\USERS\VANN\HELP30~1\ACTIVE.OUT


TIME:   9:56     DATE:   4/12/2013


******************************************************************************

     TITLE:  Proposed Ma'alo Landfill - Active Phase Waste Filling

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   9
           THICKNESS                   =      6.00   INCHES
           POROSITY                    =      0.5010 VOL/VOL
           FIELD CAPACITY              =      0.2840 VOL/VOL
           WILTING POINT               =      0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2868 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC


                                  LAYER  2
```

```
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  18
THICKNESS                   =   1284.00   INCHES
POROSITY                    =      0.6710 VOL/VOL
FIELD CAPACITY              =      0.2920 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2927 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  43
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1464 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.600000005000E-02 CM/SEC


                        LAYER  4
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  21
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3970 VOL/VOL
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0459 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC
SLOPE                       =      2.85   PERCENT
DRAINAGE LENGTH             =    280.0    FEET


                        LAYER  5
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      2.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD
```

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 44

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999997000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 130. FEET.

SCS RUNOFF CURVE NUMBER	=	92.20	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.059	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	5.690	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.118	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	381.766	INCHES
TOTAL INITIAL WATER	=	381.766	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Lihue Hawaii

STATION LATITUDE	=	21.98	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	0	
END OF GROWING SEASON (JULIAN DATE)	=	367	
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	11.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00	%

NOTE: PRECIPITATION DATA FOR LIHUE HAWAII
WAS ENTERED FROM AN ASCII DATA FILE.

NOTE: TEMPERATURE DATA FOR LIHUE HAWAII
WAS ENTERED FROM AN ASCII DATA FILE.

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HONOLULU HAWAII
AND STATION LATITUDE = 21.98 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 2003 THROUGH 2012

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	4.61	8.32	1.53	2.15	1.29
	1.65	1.90	1.51	2.63	3.63	5.49
STD. DEVIATIONS	2.22	3.16	11.17	0.65	2.76	0.71
	1.14	1.96	0.82	2.03	2.11	6.01
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	2.602	2.075	2.817	1.844	1.469	1.117
	1.199	1.698	1.349	1.956	2.693	2.700
STD. DEVIATIONS	1.291	0.875	1.667	0.930	1.077	0.758
	0.721	1.374	0.790	1.188	1.375	1.409
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	1.6201	1.4182	1.3228	2.2125	1.8791	1.3282
	1.2025	1.0630	0.8147	0.4579	0.4095	1.0076
STD. DEVIATIONS	1.2608	1.1004	1.3182	1.3350	1.9048	1.8367
	1.7921	1.3502	1.3812	1.0771	1.0471	1.2251

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.3021	0.2898	0.2467	0.4264	0.3504	0.2560
	0.2242	0.1982	0.1570	0.0854	0.0789	0.1879
STD. DEVIATIONS	0.2351	0.2270	0.2458	0.2573	0.3552	0.3539
	0.3342	0.2518	0.2662	0.2009	0.2018	0.2285

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 2003 THROUGH 2012

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.05	(12.814)	138121.5	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	23.518	(5.7512)	85371.29	61.809
LATERAL DRAINAGE COLLECTED FROM LAYER 4	14.73620	(10.24032)	53492.398	38.72850
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00003	(0.00002)	0.105	0.00008
AVERAGE HEAD ON TOP OF LAYER 5	0.234	(0.162)		
CHANGE IN WATER STORAGE	-0.204	(8.1576)	-742.30	-0.537

```
*******************************************************************************

                PEAK DAILY VALUES FOR YEARS 2003 THROUGH 2012
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              8.86         32161.799

      RUNOFF                                     0.000            0.0000

      DRAINAGE COLLECTED FROM LAYER  4           0.19301        700.62781

      PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000         0.00139

      AVERAGE HEAD ON TOP OF LAYER  5            1.116

      MAXIMUM HEAD ON TOP OF LAYER  5            2.083

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)               18.4 FEET

      SNOW WATER                                 0.00             0.0000


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.5690

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1118

       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 2012

LAYER	(INCHES)	(VOL/VOL)
1	0.7910	0.1318
2	374.8229	0.2919
3	3.4787	0.1449
4	0.4406	0.0367
5	0.0000	0.0000
6	0.1875	0.7500
SNOW WATER	0.000	

****
****

ATTACHMENT 2

HELP MODEL OUTPUT – INTERMEDIATE CONDITION
(FILENAME: MAALOINT.OUT)

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    G:\04DEPT03\USERS\VANN\HELP30~1\MAALO.D4
TEMPERATURE DATA FILE:      G:\04DEPT03\USERS\VANN\HELP30~1\MAALO.D7
SOLAR RADIATION DATA FILE:  G:\04DEPT03\USERS\VANN\HELP30~1\MAALO.D13
EVAPOTRANSPIRATION DATA:    G:\04DEPT03\USERS\VANN\HELP30~1\MAALO.D11
SOIL AND DESIGN DATA FILE:  G:\04DEPT03\USERS\VANN\HELP30~1\MAALOINT.D10
OUTPUT DATA FILE:           G:\04DEPT03\USERS\VANN\HELP30~1\MAALOINT.OUT


TIME:   9:54     DATE:   4/12/2013


******************************************************************************

     TITLE:  Proposed Ma'alo Landfill - Active Phase Waste Filling

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   9
           THICKNESS                   =     12.00   INCHES
           POROSITY                    =      0.5010 VOL/VOL
           FIELD CAPACITY              =      0.2840 VOL/VOL
           WILTING POINT               =      0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2430 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC


                                   LAYER  2
```

```
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  18
THICKNESS                   =   1284.00   INCHES
POROSITY                    =      0.6710 VOL/VOL
FIELD CAPACITY              =      0.2920 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  43
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1287 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.600000005000E-02 CM/SEC


                        LAYER  4
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  21
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3970 VOL/VOL
FIELD CAPACITY              =      0.0320 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0403 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC
SLOPE                       =      2.85   PERCENT
DRAINAGE LENGTH             =    280.0    FEET


                        LAYER  5
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      2.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD
```

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 44

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999997000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 130. FEET.

SCS RUNOFF CURVE NUMBER	=	92.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.348	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	5.010	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.350	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	381.605	INCHES
TOTAL INITIAL WATER	=	381.605	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Lihue Hawaii

STATION LATITUDE	=	21.98	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	0	
END OF GROWING SEASON (JULIAN DATE)	=	367	
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	11.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	72.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00	%

NOTE: PRECIPITATION DATA FOR LIHUE HAWAII
WAS ENTERED FROM AN ASCII DATA FILE.

NOTE: TEMPERATURE DATA FOR LIHUE HAWAII
WAS ENTERED FROM AN ASCII DATA FILE.

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HONOLULU HAWAII
AND STATION LATITUDE = 21.98 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 2003 THROUGH 2012

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	4.61	8.32	1.53	2.15	1.29
	1.65	1.90	1.51	2.63	3.63	5.49
STD. DEVIATIONS	2.22	3.16	11.17	0.65	2.76	0.71
	1.14	1.96	0.82	2.03	2.11	6.01
RUNOFF						
TOTALS	0.794	1.810	4.032	0.035	0.511	0.026
	0.284	0.275	0.055	0.367	0.729	1.913
STD. DEVIATIONS	1.079	1.862	6.995	0.066	1.342	0.055
	0.642	0.746	0.128	0.535	0.875	3.293
EVAPOTRANSPIRATION						
TOTALS	2.551	1.954	2.788	1.757	1.403	1.056
	1.151	1.697	1.328	1.822	2.605	2.608
STD. DEVIATIONS	1.269	0.871	1.631	0.901	0.954	0.715
	0.574	1.259	0.767	0.965	1.315	1.419
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	0.6614	0.7294	0.4029	0.5941	0.6452	0.5587
	0.4097	0.1877	0.1111	0.0661	0.0468	0.2673
STD. DEVIATIONS	0.6408	0.9420	0.4518	0.7646	1.1291	1.0365
	0.9779	0.4066	0.1615	0.0481	0.0306	0.4092

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.1233	0.1500	0.0751	0.1145	0.1203	0.1077
	0.0764	0.0350	0.0214	0.0123	0.0090	0.0499
STD. DEVIATIONS	0.1195	0.1948	0.0842	0.1473	0.2106	0.1997
	0.1824	0.0758	0.0311	0.0090	0.0059	0.0763

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 2003 THROUGH 2012

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.05	(12.814)	138121.5	100.00
RUNOFF	10.832	(8.0146)	39321.49	28.469
EVAPOTRANSPIRATION	22.720	(5.4240)	82473.23	59.711
LATERAL DRAINAGE COLLECTED FROM LAYER 4	4.68037	(3.61148)	16989.738	12.30057
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001	(0.00001)	0.038	0.00003
AVERAGE HEAD ON TOP OF LAYER 5	0.075	(0.057)		
CHANGE IN WATER STORAGE	-0.183	(3.1524)	-663.01	-0.480

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                PEAK DAILY VALUES FOR YEARS 2003 THROUGH 2012
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              8.86         32161.799

      RUNOFF                                     7.812        28357.3594

      DRAINAGE COLLECTED FROM LAYER  4           0.12868        467.09976

      PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000         0.00089

      AVERAGE HEAD ON TOP OF LAYER  5            0.744

      MAXIMUM HEAD ON TOP OF LAYER  5            1.413

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)               13.8 FEET

      SNOW WATER                                 0.00             0.0000


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3949

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1350

       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 2012

LAYER	(INCHES)	(VOL/VOL)
1	1.9217	0.1601
2	374.9280	0.2920
3	2.3572	0.0982
4	0.3840	0.0320
5	0.0000	0.0000
6	0.1875	0.7500
SNOW WATER	0.000	

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Appendix D.2
Leachate Pipe Flow Capacity Analysis

Client	County of Kaua'i	**Subject**	Leachate Pipe	**Prepared By** MJV	**Date** 4/12/13
Project	Ma'alo Landfill		Flow Capacity Analysis	**Reviewed By** KMK	**Date** 4/12/13
	Conceptual Design			**Approved By** KJB	**Date** 5/29/13

LEACHATE PIPE FLOW CAPACITY ANALYSIS

Objective

To evaluate the leachate collection and transfer pipe flow capacity of the proposed Phase 1 leachate management system and determine the maximum allowable area draining to the leachate collection and transfer pipes based on pipe capacity.

Design Criteria and Assumptions

1. Use Manning's equation to calculate the allowable leachate collection pipe flow.

2. The leachate collection pipe is an 8-inch HDPE SDR 9 pipe. The outside diameter (OD) of the pipe is about 8.625 inches, and the inside diameter (ID) is about 6.59 inches. The leachate transfer pipe is an 8-inch HDPE SDR 11 pipe inside a 12-inch HDPE SDR 11 pipe. The OD of the 8-inch SDR 11 pipe is 8.625 inches, and the ID is 6.96 inches. See Attachment 1 for pipe dimensions.

3. The Manning's "n" for gravity open channel flow in HDPE pipe is approximately 0.011.

4. The 8-inch diameter pipes will be evaluated for a 2 percent slope for the leachate collection pipes and a minimum 0.5 percent slope for the transfer pipe.

5. The maximum leachate generation rate in Phase 1 is 5,240 gal/acre/day under active conditions based upon the peak daily leachate generation results provided in Appendix D-1.

6. The area of Phase 1 is 44.9 acres.

Calculations

Allowable Flow:

Determine the maximum allowable flow, assuming the pipe is flowing full. (Note: Gravity pipes carry more liquid when running 85 percent to 95 percent full than when 100 percent full):

Manning's Equation:

$$Q_{allow} = \frac{1.49}{n} A R_h^{2/3} S^{1/2}$$

Where Q_{allow} = allowable flow rate, ft^3/sec
n = Manning's roughness coefficient $\approx$ 0.011 for HDPE pipe
A = cross-sectional area of the pipe, ft^2
R_h = hydraulic radius, ft
= ID/4 for full flow
S = slope of pipe

For the collection pipe at a 2 Percent Slope:

Determine the values for each factor:

$$A = \frac{(6.59)^2 \pi}{4} = 34.1 \text{ in}^2 = 0.24 \text{ ft}^2$$

R_h = ID/4 = (6.59)/4 inches= 1.65 inches = 0.14 ft

S = 0.020

$$Q_{allow} = \frac{1.49}{n} A R_h^{2/3} S^{0.5}$$

$$Q_{allow} = \frac{1.49}{0.011}(0.24)(0.14)^{2/3}(0.020)^{0.5} = 1.24 \text{ cfs} = 557 \text{ gpm} = 801{,}400 \text{ gpd}$$

Allowable Drainage Area for One Leachate Collection Pipe at 2 Percent Slope:

$$= \frac{\text{Allowable Flow}}{\text{Leachate Generated per acre}} = \frac{801{,}400 \text{ gpd}}{5{,}240.0 \text{ gpad}} = 153 \text{ acres}$$

For the transfer pipe at a 0.50 Percent Slope:

Determine the values for each factor:

$$A = \frac{(6.96)^2 \pi}{4} = 38.05 \text{ in}^2 = 0.26 \text{ ft}^2$$

R_h = ID/4 = (6.96)/4 inches= 1.74 inches = 0.145 ft

S = 0.005

$$Q_{allow} = \frac{1.49}{n} A R_h^{2/3} S^{0.5}$$

$$Q_{allow} = \frac{1.49}{0.011}(0.26)(0.145)^{2/3}(0.005)^{0.5} = 0.69 \text{ cfs} = 308 \text{ gpm} = 443{,}952 \text{ gpd}$$

Allowable Drainage Area for Leachate Transfer Pipe at 0.5 Percent Slope:

$$= \frac{\text{Allowable Flow}}{\text{Leachate Generated per acre}} = \frac{443{,}952 \text{ gpd}}{5{,}240.0 \text{ gpad}} = 110 \text{ acres}$$

Client	County of Kaua'i	**Subject**	Leachate Pipe	**Prepared By** MJV	**Date** 4/12/13
Project	Ma'alo Landfill		Flow Capacity Analysis	**Reviewed By** KMK	**Date** 4/12/13
Conceptual Design				**Approved By** KJB	**Date** 5/29/13

Conclusion

Based on the above calculations, the 8-inch diameter HDPE SDR 9 leachate collection pipe will provide sufficient flow capacity to convey the anticipated amount of leachate generated under active conditions for approximately 153 acres for a pipe at a 2 percent slope. The 8-inch diameter HDPE SDR 11 leachate transfer pipe will provide sufficient flow capacity to convey the anticipated amount of leachate generated under active conditions for approximately 110 acres for a pipe at a 0.5 percent slope. Therefore, both the leachate collection and transfer pipes have sufficient capacity to collect and transmit leachate flows from the 44.9 acre Phase 1 at the Ma'alo Landfill.

Attachment 1

OD			Pipe inside diameter (d)	Minimum Wall Thickness (t)	Weight (w)
Nominal in.	Actual in.	SDR	in.	in.	lb. per foot
		7	3.88	0.795	5.172
		7.3	3.95	0.762	4.996
		9	4.25	0.618	4.182
		9.3	4.29	0.598	4.065
		11	4.49	0.506	3.505
5	5.563	11.5	4.54	0.484	3.368
		13.5	4.69	0.412	2.912
		15.5	4.80	0.359	2.564
		17	4.87	0.327	2.353
		21	5.00	0.265	1.929
		26	5.11	0.214	1.574
		32.5	5.20	0.171	1.270
		7	4.62	0.946	7.336
		7.3	4.70	0.908	7.086
		9	5.06	0.736	5.932
		9.3	5.11	0.712	5.765
		11	5.35	0.602	4.971
6	6.625	11.5	5.40	0.576	4.777
		13.5	5.58	0.491	4.130
		15.5	5.72	0.427	3.637
		17	5.80	0.390	3.338
		21	5.96	0.315	2.736
		26	6.08	0.255	2.233
		32.5	6.19	0.204	1.801
		7	6.01	1.232	12.433
		7.3	6.12	1.182	12.010
		9	6.59	0.958	10.054
		9.3	6.66	0.927	9.771
		11	6.96	0.784	8.425
8	8.625	11.5	7.04	0.750	8.096
		13.5	7.27	0.639	7.001
		15.5	7.45	0.556	6.164
		17	7.55	0.507	5.657
		21	7.75	0.411	4.637
		26	7.92	0.332	3.784

Appendix D.3
Pipe Strength Analysis

PIPE STRENGTH ANALYSIS

Objective

Leachate collection pipes will be located at the low points on the base liner of Phase 1. The pipes will be subjected to increased overburden pressures as waste filling progresses. The pipes will be evaluated for compressive ring thrust (wall crushing), ring deflection, and wall buckling. Leachate transfer pipes located within soil berms will be evaluated for the same criteria.

Design Criteria and Assumptions

1. Leachate collection pipe will be 8-inch diameter, SDR 9, HDPE pipe O.D. = 8.625 inches, minimum wall thickness, t = 0.958, from reference 1 (refer to page 9 in Attachment 1).

2. Largest waste height at closure over the leachate collection pipes in during Phase 1 development will be approximately 107 feet (difference between final grade and base grade less 2.5 feet of final cover soils and 3 feet of granular and operations layers above base grade). To be conservative and to consider potential future conditions, this analysis considers a maximum waste thickness of 252.5 feet. Note that the largest waste height over the leachate collection pipe is conservatively set equal to the maximum waste depth.

3. Leachate transfer pipe will be 8-inch diameter, SDR 11, HDPE pipe, encased in a 12-inch diameter, SDR 11, HDPE pipe. The 12-inch pipe has an O.D. = 12.75 inches, minimum wall thickness, t = 1.159, from reference 1 (refer to page 10 in Attachment 1).

4. Largest waste height at closure over the leachate transfer pipes will be approximately 234.5 feet (difference between final grade and base grade less 2.5 feet of final cover soils, 3 feet of granular and operations layers, and 20 feet of soil embankment above the pipe).

5. The unit weight of cover soil, granular layer, and operations layer material was assumed to be 130 lbs/ft^3. The unit weight of waste was assumed to be 62 lbs/ft^3.

6. The leachate collection pipes will be perforated in the lower quarters. Research (Reference 2) indicates that inclusion of perforations in the lower quarters of the pipe has no significant changes on pipe deflection versus load performance. Thus, the perforated pipe stiffness is assumed the same as that of the solid pipe.

7. An approximately 120,000-pound compactor as the live load (Caterpillar 836) for waste filling, and an approximately 60,000 pound compactor (Caterpillar CS56) will be used for the live load over the transfer pipe during construction.

8. To be conservative, calculate the live load as a concentrated load.

9. Conservatively assume the temperature of the leachate drainage layer is equal to the temperature of the pipes and is 100°F (37.8°C) (see Attachment 2). The apparent modulus of elasticity for HDPE pipe is 23,000 psi (see Table 3-1 in Attachment 1).

Methodology Reference:

1. Evaluation of buried pipes will follow procedure outlined in the "PPI Handbook of Polyethylene Pipe", downloaded May 2006 www.plasticpipe.org/general/ppihandbook.php.

2. Daniel P. Dietzler, "Structural Design of Landfill Leachate Collection System." Sixth Annual Madison Conference of Applied Research & Practice on Municipal & Industrial Waste, September 14-15, 1983.

Methodology

(1) Calculate the total external pressure, P_T, at the top of the pipe. P_T is composed of three components: pressure due to static loads, pressure due to live loads, and apparent pressure due to internal vacuum. The total external pressure is determined for two cases, one with shallow soil height over the pipe, one with maximum soil height over pipe:

$$P_T = P_s + P_L + P_i \qquad \text{< 1a >}$$

Where: P_s = total "static load" pressure, soil dead load
P_L = total "live load" pressure
P_i = total effective external pressure due to internal vacuum

The total "static load" pressure, soil dead load, P_s, at the top of the pipe for the two cases is conservatively calculated using a prism load.

$$P_s = \Sigma(w * H) \qquad \text{< 1b >}$$

Where: w = unit weight of waste or soil above the pipe
H = height of waste or soil above the pipe

The total "live load" pressure, vehicle traffic load, P_L, at the top of the pipe for the two cases is calculated using Boussinesq's Equation.

$$P_L = \frac{3 \times I_F \times W_L \times H^3}{2 \times \pi \times r^5} \qquad \text{< 2 >}$$

Where: P_L = live load, psf
I_F = impact factor
W_L = wheel load, lb
H = depth of cover, ft.

r = distance from the point of load application to pipe crown, ft.

(2) Examine compressive ring thrust (wall crushing) by calculating the compressive stress, S_A:

$$S_A = \frac{(P_{RD}) \times DR}{288} \qquad <3>$$

Where: S_A = compressive stress, psi
P_{RD} = radial directed earth pressure, psf
DR = dimension Ration, D_O/t
D_O = pipe outside diameter, in.
t = pipe wall thickness, in.

$$P_{RD} = (VAF) \times w \times H = (VAF) \times P_T \qquad <4>$$

Where: P_{RD} = radial directed earth pressure, psf
VAF = Vertical Arching Factor
w = unit weight of soil, pcf
H = depth of cover, ft.
P_T = total external pressure, psf

$$VAF = 0.88 - 0.71 \times \frac{S_R - 1}{S_R + 2.5} \qquad <5>$$

Where: VAF = Vertical Arching Factor
S_R = hoop thrust stiffness ratio

$$S_R = \frac{1.43 \times M_S \times r_{CENT}}{E \times t} \qquad <6>$$

Where: S_R = hoop thrust stiffness ratio
M_S = one-dimensional modulus of soil, psi
r_{CENT} = radius to centroidal axis of pipe, in.
E = apparent modulus of elasticity of pipe material, psi
t = pipe wall thickness

The recommended long-term compressive strength design value is 780 psi for PE 3408 pipe at 100° F (1,000 psi x 0.78, see Tables 1-3 and 2-12 in Attachment 1)

$S_A \leq 780$ psi

(3) Examine ring deflection of the pipe by calculating the deflection, $\Delta X/D_M$:

$$\Delta X/D_M = D_F \times \varepsilon \qquad <7>$$

Where: $\Delta X/D_M$ = deflection
D_F = deformation factor

ε = soil strain

$$\varepsilon = \frac{w \times H}{144 \times E_S} = \frac{P_T}{144 \times E_S} \qquad <8>$$

Where: P_T = total external pressure, psf
w = unit weight of soil, pcf
H = depth of soil cover, ft.
E_S = secant modulus of the soil, psi

D_F is determined from Figure 2-6 of Attachment 1 using the rigidity factor, R_F

$$R_F = \frac{12 \times E_S \times (DR - 1)^3}{E} \qquad <9>$$

Where: E_S = secant modulus of the soil (soil strain), psi
DR = dimension ratio
E = apparent modulus of elasticity of pipe material, psi

$$E_S = M_S \times \frac{(1 + \mu) \times (1 - 2 \times \mu)}{(1 - \mu)} \qquad <10>$$

Where: M_S = one-dimensional modulus
μ = poisson's ratio of soil

The recommended allowable ring deflection for non-pressure HDPE pipe and accounting for a large safety factor is 7.5% (see page 2 in Attachment 1).

(4) Calculate the allowable pipe wall buckling pressure, $P_{CR.}$

$$P_{CR} = \frac{2.4 \times \varphi \times R_H}{D_M} \times (E \times I)^{1/3} \times (E_S{}^*)^{2/3} \qquad < 11 >$$

Where:

- P_{CR} = allowable buckling pressure, psi
- φ = calibration factor, 0.55 for granular soils (see page 7 in Attachment 1)
- R_H = geometry factor, 1 (for deep burial, see page 7 in Attachment 1)
- D_M = mean diameter (D_O – t), in.
  - D_O = pipe outside diameter, in.
  - t = pipe wall thickness, in.
- E = apparent modulus of elasticity of pipe material, psi
- I = pipe wall moment of inertia, in^4/in ($t^3/12$, if solid wall construction)
- $E_S{}^*$ = $E_S/(1-\mu)$
  - E_S = secant modulus of the soil, psi
  - μ = poisson's ratio of soil

The allowable buckling pressure should be compared to the total "static load" pressure, P_T, on the pipe.

$$P_{CR} \geq P_T$$

Calculations

1. Calculate total external pressure on the leachate collection pipe.

$$P_T = P_s + P_L + P_i \qquad < 1a >$$

Where:

- P_T = total external pressure, psf
- P_s = total "static load" pressure, soil dead load
- P_L = total "live load" pressure
- P_i = total effective external pressure due to internal vacuum

The leachate collection pipe will have no internal pressure. Therefore, P_i = 0.0 psi for both shallow and largest soil height cases.

Total "static load" pressure on pipe, equation < 1b >

$$P_s = \Sigma(w * H) \qquad < 1b >$$

Where:

- w_{soil} = 130 pcf, unit weight of soil above pipe
- w_{waste} = 62 pcf, unit weight of waste

Shallow waste height (during waste filling):

H_{soil} = 3 ft (granular drainage and operation layers)
H_{waste} = 5 ft
P_s = [(130 pcf x 3 ft) + (62 pcf x 5 ft)] x 1 ft^2/144 in^2
P_s = 4.86 psi

Largest waste height:

H_{soil} = 2.5 ft cover + 3 ft granular drainage layer
H_{waste} = 252.5 ft, largest height of waste over pipe
P_s = [(130 pcf x 5.5 ft) + (62 pcf x 252.5 ft)] x 1 ft^2/144 in^2
P_s = 113.7 psi

The total "live load" pressure, vehicle traffic load, P_L, at the top of the pipe for the two cases is calculated using Boussinesq's Equation.

$$P_L = \frac{3 \times I_F \times W_L \times H^3}{2 \times \pi \times r^5} \qquad <2>$$

Where
- P_L = total "live load" pressure, psf
- I_F = impact factor = 1.5, assumed for slow vehicle velocity see Attachment 3
- W_L = wheel load = 60,000 lbs (approximately 120,000 lbs for Caterpillar 836 compactor divided by 2 drums)
- H = depth of cover, ft.
- r = distance from the point of load application to pipe crown (same as H), ft.

For the Shallow Waste Height Case:

Where H = r = depth of cover; 8 ft (5 ft of waste + 3 ft drainage and operational layers)

$$P_L = \frac{3 \times 1.5 \times 60{,}000 \times (8)^3}{2 \times \pi \times (8)^5} = 671.4 \text{ psf} \times 1\ ft^2/144\ in^2 = 4.66 \text{ psi}$$

For the Largest Waste Height Case:

The "live load" pressure, P_L, applied at the top of the final cover will be negligible due to the distance (approximately 250 feet) from the top of the pipe. Therefore, P_L = 0. At the burial depths greater than 5 feet, loads from an AASHTO Standard H-20 truck are "not usually significant because the load is attenuated significantly compared (with) loads under 1 or 2 feet of cover." The H-20 loading represents a 40,000-lb. dual axle truck (see Attachment 3).

Shallow waste height:

Total external pressure, $P_T = P_s + P_L + P_i$ = 4.86 psi + 4.66 psi + 0 = 9.52 psi

Largest waste height:

Total external pressure, $P_T = P_s + P_L + P_i$ = 113.7 psi + 0 + 0 psi = 113.7 psi

113.7 psi x 144 in^2/ft^2 = 16,370 psf

The worst case situation is the largest waste height case and will therefore be used in the leachate collection pipe analysis.

2. Calculate total external pressure on the leachate transfer pipe.

$$P_T = P_s + P_L + P_i \qquad < 2 >$$

Where: P_s = total "static load" pressure soil dead load
P_L = total "live load" pressure
P_i = total effective external pressure due to internal vacuum

The transfer pipe will have no internal pressure. Therefore, P_i = 0.0 psi for both shallow and largest waste height cases.

Total static load on pipe, equation < 1 >

$$P_s = \Sigma(r * H) \qquad < 1 >$$

Where: r_{soil} = 130 pcf, unit weight of soil above pipe
r_{waste} = 62 pcf, unit weight of waste

Shallow waste height (during construction):

H_{soil} = 3 ft (pipe bedding)
P_s = (130 pcf x 3 ft) x 1 $ft^2/144\ in^2$
P_s = 2.71 psi

Largest waste height:

H_{soil} = 2.5 ft cover + 3 ft operations and granular drainage layer + 20 ft perimeter berm = 25.5 ft
H_{waste} = 234.5 ft, largest height of waste
P_s = [(130 pcf x 25.5 ft) + (62 pcf x 234.5 ft)] x 1 $ft^2/144\ in^2$
P_s = 124.0 psi

The total "live load" pressure, vehicle traffic load, P_L, at the top of the pipe for the two cases is calculated using Boussinesq's Equation.

$$P_L = \frac{3 \times I_F \times W_L \times H^3}{2 \times \pi \times r^5} \qquad < 2 >$$

Where P_L = live load, psf

I_F = impact factor = 1.5, assumed for slow vehicle velocity (see Attachment 3)

W_L = wheel load = 60,000 lbs (approximately centrifugal force of a Caterpillar CS56 vibratory roller)

H = depth of cover, ft.

r = distance from the point of load application to pipe crown (same as H), ft.

For the Shallow Waste Height Case:

Where: H = r = depth of cover; 3 ft pipe bedding

$$P_L = \frac{3 \times 1.5 \times 60{,}000 \times (3)^3}{2 \times \pi \times (3)^5} = 4774.6 \text{ psf} \times 1 \text{ ft}^2/144 \text{ in}^2 = 33.16 \text{ psi}$$

For the Largest Waste Height Case:

The live load, P_L, applied at the top of the final cover will be negligible due to the distance (over 230 feet) from the top of the pipe. Therefore, $P_L = 0$. At the burial depths greater than 5 feet, loads from an AASHTO Standard H-20 truck are "not usually significant because the load is attenuated significantly compared (with) loads under 1 or 2 feet of cover." The H-20 loading represents a 40,000-lb. dual axle truck.

Shallow waste height:

Total external pressure, $P_T = P_s + P_L + P_i = 2.71 \text{ psi} + 33.16 \text{ psi} + 0 = 35.87 \text{ psi}$

Largest waste height:

Total external pressure, $P_T = P_s + P_L + P_i = 124.0 \text{ psi} + 0 + 0 \text{ psi} = 124.0 \text{ psi}$

$124.0 \text{ psi} \times 144 \text{ in}^2/\text{ft}^2 = 17{,}854 \text{ psf}$

The worst case situation is the largest waste height case and will therefore be used in the analysis of the leachate transfer pipe.

3. Evaluate the compressive ring thrust (wall crushing), ring deflection, and wall buckling for the leachate collection pipe and leachate transfer pipe.

An excel spreadsheet is used to evaluate the leachate collection pipe and leachate transfer pipe. The spreadsheet calculation inputs are summarized in Tables 1 and 2. The spreadsheet results are summarized in Table 3 and provided in detail in Attachment 4. Sample calculations for the leachate extraction pipe are provided below.

Table 1: General Calculation Inputs					
			8" Collection Pipe	12" Transfer Outer Pipe	
D_O =	pipe outside diameter, in.	=	8.625	12.75	in.
t =	pipe wall thickness, in.	=	0.958	1.159	in.
P_T =	total external pressure, psf	=	16,370	17,854	psf
		=	113.7	124.0	psi
E =	apparent modulus of elasticity of pipe material, psi	=	23,000		psi
M_S =	one-dimensional modulus, (for 90% standard proctor and vertical waste and soil stress (Table 2-14, Plastic Pipe Institute, 2006)	=	3,400	3,560	(for total pressure stated above)
μ =	Poisson's ratio of soil, to model granular drainage layer, (Table 2-15, Plastic Pipe Institute, 2006)	=	0.15		(value for coarse sand)
The recommended long-term compressive strength design value for HDPE pipe (psi) (Tables 1-3 & 2-12, Plastic Pipe Institute, 2006)		=	780		
D_F =	Deformation Factor, (Figure 2-6, Plastic Pipe Institute, 2006) for R_F as in ring deflection.	=	1.15	1.4	
φ =	Calibration Factor	=	0.55		(for granular soils)
R_H =	Geometry Factor, (page 7 of Attachment 1, Plastic Pipe Institute, 2006)	=	1		(for deep burial)

I. Sample Calculations 8-inch HDPE Leachate Collection Pipe

A. Compressive Ring Thrust (Wall Crushing) Analysis

The compressive stress, S_A, by equation 3:

$$S_A = \frac{(P_{RD}) \times DR}{288} \qquad <3>$$

Where: S_A = compressive stress, psi
P_{RD} = radial directed earth pressure, psf
DR = dimension Ratio, D_O/t
D_O = pipe outside diameter, in.

Calculate the hoop stiffness ratio, S_R, using equation 6 to determine the vertical arching

factor, VAF, using equation 5. The radial directed earth pressure, P_{RD}, can then be calculated using equation < 4 >:

$$S_R = \frac{1.43 \times M_S \times r_{CENT}}{E \times t} \qquad < 6 >$$

Where: S_R = hoop thrust stiffness ratio
M_S = one-dimensional modulus of soil, 3,290 psi (for 90% standard proctor and 113.7 psi vertical soil stress, see Table 2-14 included in Attachment 1)
r_{CENT} = radius to centroidal axis of pipe, 3.83 in. ($r_{cent} = r_{pipe} – t/2$ = 8.625/2 - 0.958/2)
E = apparent modulus of elasticity of pipe material, 23,000 psi
t = pipe wall thickness, 0.958 in.

$$S_R = \frac{1.43 \times M_S \times r_{CENT}}{E \times t} = \frac{1.43 \times 3{,}400 \text{ psi} \times 3.83 \text{ in}}{23{,}000 \text{ psi} \times 0.958 \text{ in}} = 0.845$$

$$VAF = 0.88 – 0.71 \times \frac{S_R - 1}{S_R + 2.5} = 0.88 – 0.71 \times \frac{0.845 – 1}{0.845 + 2.5} = 0.913$$

Where: VAF = Vertical Arching Factor
S_R = hoop thrust stiffness ratio

$$P_{RD} = (VAF) \times w \times H = (VAF) \times P_T = 0.913 \times 16{,}370 \text{ psf} = 14{,}946 \text{ psf}$$

Where: P_{RD} = radial directed earth pressure, psf
VAF = Vertical Arching Factor
w = unit weight of soil, pcf
H = depth of cover, ft.
P_T = total external pressure, psf

$$S_A = \frac{(P_{RD}) \times DR}{288} = \frac{14{,}946 \text{ psf} \times (8.625 \text{ in} / 0.958 \text{ in})}{288} = 467 \text{ psi}$$

The recommended long-term compressive strength design value is 780 psi at 100ºF for PE 3408 pipe, (see Tables 1-3 and 2-12 in Attachment 1).

P_{RD} = 467 psi ≤ 780 psi

The factor of safety for wall crushing is defined by:

F.S. = Allowable / Actual = 780 / 467 = 1.6

A factor of safety of 1.6 demonstrates that the pipe will perform without wall crushing.

B. Calculate the secant modulus of the soil, E_S, using equation 10, determine the rigidity factor, R_F, using equation 9 and the soil strain using equation 8. The rigidity factor is used to determine the deformation factor which is used to calculate the percent deflection, $\Delta X/D_M$ x 100, of the pipe using equation 7.

$$E_S = M_S \times \frac{(1 + \mu) \times (1 - 2 \times \mu)}{(1 - \mu)} \qquad <10>$$

Where: E_S = secant modulus of the soil, psi
M_S = one-dimensional modulus, 3,400 psi (for 90% standard Proctor and 113.7 psi vertical soil stress, see Table 2-14 included in Attachment 1)
μ = Poisson's ratio of soil, 0.15 (used to be conservative, value for coarse sand from Table 2-15 included in Attachment 1).

$$E_S = 3{,}400 \text{ psi} \times \frac{(1 + 0.15) \times (1 - 2 \times 0.15)}{(1 - 0.15)} = 3{,}220 \text{ psi}$$

$$R_F = \frac{12 \times E_S \times (DR - 1)^3}{E} \qquad <9>$$

Where: R_F =rigidity factor
E_S = secant modulus of the soil, psi (see calculated value above)
DR = dimension ratio, D_O/t, 9, (8.625/0.958)
E = apparent modulus of elasticity of pipe material, 23,000 psi

$$R_F = \frac{12 \times E_S \times (DR - 1)^3}{E} = \frac{12 \times 3{,}220 \text{ psi} \times (9 - 1)^3}{23{,}000 \text{ psi}} = 860$$

$$\varepsilon = \frac{P_T}{144 \times E_S} \qquad <8>$$

Where: P_T = total external pressure, 16,370 psf
E_S = secant modulus of the soil, psi (see calculated value above)

$$\varepsilon = \frac{P_T}{144 \times E_S} = \frac{16{,}370 \text{ psf}}{144 \times 3{,}220 \text{ psi}} = 0.0353$$

$$\Delta X/D_M = D_F \times \varepsilon \qquad <7>$$

Where: $\Delta X/D_M$ = deflection
D_F = deformation factor, 1.15 (from Figure 2-6 included in Attachment 1 for R_F as calculated above).
ε = soil strain

$\Delta X/D_M = D_F \times \varepsilon = 1.15 \times 0.0353 = 0.0406$

Percent Deflection = 0.0406 x 100 = 4.06%

The recommended allowable ring deflection for non-pressure pipe and accounting for a large safety factor is 7.5% (see page 2 in Attachment 1). Therefore, the pipe will not deflect beyond the allowable limit.

C. Calculate the allowable pipe wall buckling pressure, P_{CR}.

$$P_{CR} = \frac{2.4 \times \varphi \times R_H}{D_M} \times (E \times I)^{1/3} \times (E_S{}^*)^{2/3} \qquad < 11 >$$

Where: P_{CR} = allowable buckling pressure, psi

- φ = calibration factor, 0.55 for granular soils (see page 7 in Attachment 1)
- R_H = geometry factor, 1 (for deep burial, see page 7 in Attachment 1)
- D_M = mean diameter (D_O – t), 7.667 in. (8.625 – 0.958)
  - D_O = pipe outside diameter, 8.625 in.
  - t = pipe wall thickness, 0.958 in.
- E = Apparent modulus of elasticity of pipe material, 23,000 psi
- I = Pipe wall moment of inertia, 0.0733 in^4/in ($t^3/12 = 0.927^3/12$)
- $E_S{}^* = E_S/(1-\mu)$ = 3,220 psi/(1 – 0.15) = 3,788 psi
  - E_S = secant modulus of the soil, 3,220 psi (see calculation above)
  - μ = poisson's ratio of soil, 0.15 (used to be conservative, value for coarse sand from Table 2-15 included in Attachment 1).

$$P_{CR} = \frac{2.4 \times 0.55 \times 1}{7.667} \times (23{,}000 \times 0.0733)^{1/3} \times (3{,}788)^{2/3} = 498 \text{ psi}$$

The allowable buckling pressure should be compared to the total external pressure, P_T, on the pipe.

498 psi = $P_{CR} \geq$ 113.7 psi =P_T

Factor of safety for wall buckling is:

F.S. = P_{CR} / P_T = 498 psi / 113.7 psi = 4.4

A factor of safety of 4.4 demonstrates that the pipe will perform without wall buckling.

Conclusions

The results of the above calculations are summarized below. The proposed leachate collection pipes and leachate extraction pipes will perform as designed without strength failure.

Table 2: Results Summary

	8" SDR 9 HDPE Leachate Collection Pipe	12" SDR 11 HDPE Leachate Transfer Outer Pipe
Compressive Ring Thrust (Wall Crushing)	F.S. = 1.6	F.S. = 1.3
Ring Deflection (7.5% allowable)	4.06%	4.23%
Wall Buckling	F.S. = 4.4	F.S. = 3.3

Compressive Ring Thrust (Wall Crushing)

8" SDR 9 Leachate Collection Pipes

$$S_A = \frac{(P_{RD}) \times DR}{288}$$

Where:	S_A	= compressive stress, psi	=	467
	P_{RD}	= radial directed waste or soil pressure, psf	=	14,946
	DR	= Dimension Ratio, D_O/t	=	9.0
	D_O	= pipe outside diameter, in.	=	8.625
	t	= pipe wall thickness, in.	=	0.958

P_{RD} = (VAF) x γ x H = (VAF) x PT < 4 >

Where:	P_{RD}	= radial directed earth waste or soil pressure, psf	=	14,946
	VAF	= Vertical Arching Factor	=	0.913
	P_T	= total external pressure, psf	=	16,370

$$VAF = 0.88 - 0.71 \times \frac{S_R - 1}{S_R + 2.5}, \quad <5>$$

Where:	VAF	= Vertical Arching Factor	=	0.913
	S_R	= hoop thrust stiffness Ratio	=	0.845

$$S_R = \frac{1.43 \times M_S \times r_{cent}}{E \times t} \quad <6>$$

Where:	S_R	= hoop thrust stiffness Ratio	=	0.845
	M_S	= one-dimensional modulus of waste and soil, psi	=	3,400
	r_{cent}	= radius to centroidal axis of pipe, in.		
		$=r_{pipe}$ - t/2	=	3.83
	E	= apparent modulus of elasticity of pipe material, psi	=	23,000
	t	= pipe wall thickness	=	0.958

Allowable = Recommended long-term compressive strength design value for HDPE pipe from Plastic Pipe Institute, 2006

Allowable (psi), $S_A \leq$ 780

Actual (psi), S_A = 467

FS = Allowable/actual

FS = 1.6

Ring Deflection Analysis

8" SDR 9 Leachate Collection Pipes

Calculate the secant modulus of the soil, E_S, using equation 10; determine the rigidity factor, R_F, using equation 9 and the soil strain using equation 8. The rigidity factor is used to determine the deformation factor which is used to calculate the percent deflection, $\Delta X/D_M$ x 100, of the pipe using equation 7.

$$E_S = M_S \times \frac{(1 + \mu) \times (1 - 2 \times \mu)}{(1 - \mu)} \qquad <10>$$

Where:	E_S =	secant modulus of the granular drainage layer, psi	=	3,220
	M_S =	one-dimensional modulus, (for 90% standard proctor and vertical waste and soil stress (Table 2-14, Plastic Pipe Institute, 2006)	=	3,400
	μ =	Poisson's ratio of soil, used to represent the granular drainage layer material (Table 2-15, Plastic Pipe Institute, 2006)	=	0.15

$$R_F = \frac{12 \times E_S \times (DR - 1)^3}{E} \qquad <9>$$

Where:	R_F =	rigidity factor	=	860
	E_S =	Secant modulus of the soil, psi (see calculated value above)	=	3,220
	DR =	dimension ratio, (DR = D_o/t)	=	9.0
		D_o	=	8.625
		t	=	0.958
	E =	apparent modulus of elasticity of pipe material, psi	=	23,000

$$\varepsilon = \frac{P_T}{144 \times E_S} \qquad <8>$$

Where:	P_T =	total external pressure, psf	=	16,370.00
	E_S =	Secant modulus of the soil, psi (see calculated value above)	=	3,220
	ε	= soil strain	=	0.0353

$$\Delta X/D_M = D_F \times \varepsilon \qquad <7>$$

Where:	$\Delta X/D_M$	= deflection	=	0.0406
	D_F	= Deformation Factor, (Figure 2-6, Plastic Pipe Institute, 2006) for R_F as calculated above.	=	1.15
	ε	= soil strain	=	0.0353
		Percent Deflection = deflection x 100	=	4.0595

The recommended allowable ring deflection for non-pressure pipe is 7.5% which provides a large factor of safety against instability and strain (Plastic Pipe Institute, Chapter 6, 2006).

Is the ring deflection allowable? (actual < allowable)	**Yes**

Pipe Wall Buckling Analysis
8" SDR 9 Leachate Collection Pipes

Calculate the allowable pipe wall buckling pressure, $P_{CR.}$

$$P_{CR} = \frac{2.4 \times \varphi \times R_H}{D_M} \times (E \times I)^{1/3} \times (E_S{}^*)^{2/3} \qquad \text{< 11 >}$$

Where:	P_{CR}	= allowable buckling pressure, psi	=	498
	φ	= Calibration Factor	=	0.55
	R_H	= Geometry Factor, (equation 2-29, Plastic Pipe Institute, 2006)	=	1
	D_M	= mean diameter (D_O – t), in.	=	7.667
	D_O	= pipe outside diameter, in.	=	8.625
	t	= pipe wall thickness, in.	=	0.958
	E	= apparent modulus of elasticity of pipe material, psi	=	23,000
	I	= pipe wall moment of inertia, in^4/in ($t^3/12$)	=	0.0733
	$E_S{}^*$	= $E_S/(1-\mu)$, psi	=	3,788
	E_S	= Secant modulus of the soil, (see calculation in Ring Deflection)	=	3,220
	μ	= Poisson's ratio of soil, (from Table 2-15, used to represent the granular drainage layer material, Plastic Pipe Institute, 2006)	=	0.15

The allowable buckling pressure should be compared to the total "static load" pressure, P_T, on the pipe.

Actual, psi: P_T = 113.68

Allowable, psi: P_{CR} = 498

Factor of safety for wall buckling is:

F.S. = P_{CR} / P_T = 4.38

Compressive Ring Thrust (Wall Crushing)

12" SDR 11 Leachate Transfer Containment Pipe

$$S_A = \frac{(P_{RD}) \times DR}{288}$$

Where:	S_A	= compressive stress, psi	=	586
	P_{RD}	= radial directed waste or soil pressure, psf	=	15,337
	DR	= Dimension Ratio, D_O/t	=	11.0
	D_O	= pipe outside diameter, in.	=	12.75
	t	= pipe wall thickness, in.	=	1.159

P_{RD} = (VAF) x γ x H = (VAF) x PT < 4 >

Where:	P_{RD}	= radial directed earth waste or soil pressure, psf	=	15,337
	VAF	= Vertical Arching Factor	=	0.859
	P_T	= total external pressure, psf	=	17,854

$$VAF = 0.88 - 0.71 \times \frac{S_R - 1}{S_R + 2.5}, \quad <5>$$

Where:	VAF	= Vertical Arching Factor	=	0.859
	S_R	= hoop thrust stiffness Ratio	=	1.108

$$S_R = \frac{1.43 \times M_S \times r_{cent}}{E \times t} \quad <6>$$

Where:	S_R	= hoop thrust stiffness Ratio	=	1.108
	M_S	= one-dimensional modulus of waste and soil, psi	=	3,560
	r_{cent}	= radius to centroidal axis of pipe, in.		
		$=r_{pipe}$ - t/2	=	5.8
	E	= apparent modulus of elasticity of pipe material, psi	=	23,000
	t	= pipe wall thickness	=	1.159

Allowable = Recommended long-term compressive strength design value for HDPE pipe from Plastic Pipe Institute, 2006

Allowable (psi), $S_A \leq$ 780

Actual (psi), S_A = 586

FS = Allowable/actual

FS = 1.30

Ring Deflection Analysis

12" SDR 11 Leachate Transfer Containment Pipe

Calculate the secant modulus of the soil, E_S, using equation 10; determine the rigidity factor, R_F, using equation 9 and the soil strain using equation 8. The rigidity factor is used to determine the deformation factor which is used to calculate the percent deflection, $\Delta X/D_M$ x 100, of the pipe using equation 7.

$$E_S = M_S \times \frac{(1 + \mu) \times (1 - 2 \times \mu)}{(1 - \mu)} \qquad <10>$$

Where:	E_S =	secant modulus of the granular drainage layer, psi	=	3,372
	M_S =	one-dimensional modulus, (for 90% standard proctor and vertical waste and soil stress (Table 2-14, Plastic Pipe Institute, 2006)	=	3,560
	μ =	Poisson's ratio of soil, used to represent the granular drainage layer material (Table 2-15, Plastic Pipe Institute, 2006)	=	0.15

$$R_F = \frac{12 \times E_S \times (DR - 1)^3}{E} \qquad <9>$$

Where:	R_F =	rigidity factor	=	1,759
	E_S =	Secant modulus of the soil, psi (see calculated value above)	=	3,372
	DR =	dimension ratio, (DR = D_o/t)	=	11.0
		D_o	=	12.75
		t	=	1.159
	E =	apparent modulus of elasticity of pipe material, psi	=	23,000

$$\varepsilon = \frac{P_T}{144 \times E_S} \qquad <8>$$

Where:	P_T =	total external pressure, psf	=	17,854.00
	E_S =	Secant modulus of the soil, psi (see calculated value above)	=	3,372
	ε	= soil strain	=	0.0368

$$\Delta X/D_M = D_F \times \varepsilon \qquad <7>$$

Where:	$\Delta X/D_M$	= deflection	=	0.0423
	D_F	= Deformation Factor, (Figure 2-6, Plastic Pipe Institute, 2006) for R_F as calculated above.	=	1.15
	ε	= soil strain	=	0.0368
		Percent Deflection = deflection x 100	=	4.232

The recommended allowable ring deflection for non-pressure pipe is 7.5% which provides a large factor of safety against instability and strain (Plastic Pipe Institute, Chapter 6, 2006).

Is the ring deflection allowable? (actual < allowable)	**Yes**

Pipe Wall Buckling Analysis
12" SDR 11 Leachate Transfer Containment Pipe

Calculate the allowable pipe wall buckling pressure, $P_{CR.}$

$$P_{CR} = \frac{2.4 \times \varphi \times R_H}{D_M} \times (E \times I)^{1/3} \times (E_S{}^*)^{2/3} \qquad \langle 11 \rangle$$

Where:	P_{CR}	= allowable buckling pressure, psi	=	411
	φ	= Calibration Factor	=	0.55
	R_H	= Geometry Factor, (equation 2-29, Plastic Pipe Institute, 2006)	=	1
	D_M	= mean diameter (D_O – t), in.	=	11.591
	D_O	= pipe outside diameter, in.	=	12.75
	t	= pipe wall thickness, in.	=	1.159
	E	= apparent modulus of elasticity of pipe material, psi	=	23,000
	I	= pipe wall moment of inertia, in^4/in ($t^3/12$)	=	0.1297
	$E_S{}^*$	= $E_S/(1-\mu)$, psi	=	3,967
	E_S	= Secant modulus of the soil, (see calculation in Ring Deflection)	=	3,372
	μ	= Poisson's ratio of soil, (from Table 2-15, used to represent the granular drainage layer material, Plastic Pipe Institute, 2006)	=	0.15

The allowable buckling pressure should be compared to the total "static load" pressure, P_T, on the pipe.

Actual, psi: P_T = 123.99

Allowable, psi: P_{CR} = 411

Factor of safety for wall buckling is:

F.S. = P_{CR} / P_T = 3.3

Source: "PPI Handbook of Polyethylene Pipe", downloaded May, 2006 www.plasticpipe.org/general/ppi_handbook.php

As indicated in Table 1-2, polyethylene pipe which meets the requirements of ASTM D2513 may be used for the transport of liquefied petroleum gas (LPG). NFPA 58 recommends a maximum operating pressure of 30 psig for LPG gas applications involving polyethylene pipe. This design limit is established in recognition of the higher condensation temperature for LPG as compared to that of natural gas and, thus, the maximum operating pressure is recommended to ensure that plastic pipe is not subjected to excessive exposure to LPG condensates. For further information the reader is referred to PPI's TR-22, Polyethylene Piping Distribution Systems for Components of Liquid Petroleum Gases.[14]

TABLE 1-3
Service Temperature Design Factors, F_T

Maximum Continuously Applied Service Temp., °F(°C)	Temperature Compensation Factor, FT, for PE3408
≤ 80 (26)	1.00
≤ 90 (32)	0.90
≤ 100 (38)	0.78
≤ 110 (43)	0.75
≤ 120 (49)	0.63
≤ 130 (54)	0.60
≤ 140 (60)	0.50

Fluid Flow in Polyethylene Piping

Head Loss in Pipes – Darcy-Weisbach/Fanning/Colebrook/Moody

Viscous shear stresses within the liquid and friction along the pipe walls create resistance to flow within a pipe. This resistance within a pipe results in a pressure drop, or loss of head in the piping system.

The Darcy-Weisbach or Fanning formula, Equation 1-7, and the Colebrook formula, Equation 1-10, are generally accepted methods for calculating friction losses due to liquids flowing in full pipes.[15,16] These formulas recognize dependence on pipe bore and pipe surface characteristics, liquid viscosity and flow velocity.

The Darcy-Weisbach formula is:

(1-7)

$$h_f = f \frac{L V^2}{d' 2g}$$

Bending strain occurs in the pipe wall as a result of ring deflection—outer-fiber tensile strain at the pipe springline and outer-fiber compressive strain at the crown and invert. While strain limits of 5% have been proposed, Jansen [12] reported that, on tests of PE pipe manufactured from pressure-rated resins and subjected to soil pressure only, "no upper limit from a practical design point of view seems to exist for the bending strain." In other words, as deflection increases, the pipe's performance limit will not be overstraining but reverse curvature collapse.

Thus, for non-pressure applications, a 7.5 percent deflection limit provides a large safety factor against instability and strain and is considered a safe design deflection. Some engineers will design profile wall pipe and other non-pressure pipe applications to a 5% deflection limit, but allow spot deflections up to 7.5% during field inspection.

The deflection limits for pressurized pipe are generally lower than for non-pressurized pipe. This is primarily due to strain considerations. Hoop strain from pressurization adds to the outer-fiber tensile strain. But the internal pressure acts to reround the pipe and, therefore, Eq. 2-10 overpredicts the actual long-term deflection for pressurized pipe. Safe allowable deflections for pressurized pipe are given in Table 2-11. Spangler and Handy [13] give equations for correcting deflection to account for rerounding.

TABLE 2-11
Safe Deflection Limits for Pressurized Pipe

DR or SDR	Safe Deflection as % of Diameter
32.5	7.5
26	7.5
21	7.5
17	6.0
13.5	6.0
11	5.0
9	4.0
7.3	3.0

*Based on Long-Term Design Deflection of Buried Pressurized Pipe given in ASTM F1962.

Compressive Ring Thrust

Earth pressure exerts a radial-directed force around the circumference of a pipe that results in a compressive ring thrust in the pipe wall. (This thrust is exactly opposite to the tensile hoop thrust induced when a pipe is pressurized.) See Figure 2-1b. Excessive ring compressive thrust may lead to two different performance limits:

The compressive stress in the pipe wall can be compared to the pipe material allowable compressive stress. If the calculated compressive stress exceeds the allowable stress, then a lower DR (heavier wall thickness) or heavier profile wall is required.

Allowable Compressive Stress

Table 2-12 gives allowable long-term compressive stress values for PE 3408 and PE 2406 material.

TABLE 2-12
Long-Term Compressive Stress at 73°F (23°C)

Material	Long-Term Compressive Stress, lb/in^2
PE 3408	1000
PE 2406	800

The long-term compressive stress value should be reduced for elevated temperature pipeline operation. Temperature design factors used for hydrostatic pressure may be used, i.e. 0.5 @ 140°F. Additional temperature design factors may be obtained by reference to Table 1-11 in Section 1 of this chapter.

Ring Compression Example

Find the pipe wall compressive ring stress in a DR 32.5 HDPE pipe buried under 46 ft of cover. The ground water level is at the surface, the saturated weight of the insitu silty-clay soil is 120 lbs/ft^3.

SOLUTION: Find the vertical earth pressure acting on the pipe. Use Equation 2-1.

Although the net soil pressure is equal to the buoyant weight of the soil, the water pressure is also acting on the pipe. Therefore the total pressure (water and earth load) can be found using the saturated unit weight of the soil.

Next, solve for the compressive stress.

$$P_E = (120\ pcf)(46\ ft) = 5520\ psf$$

$$S = \frac{(5520\ lb/\ ft^2)(32.5)}{288} = 623\ lb/\ inch^2$$

The compressive stress is within the 1000 lb/in^2 allowable stress for HDPE given in Table 2-12.

Attachment 1

(2-21)
$$VAF = 0.88 - 0.71\frac{S_A - 1}{S_A + 2.5}$$

WHERE

VAF = Vertical Arching Factor

S_A = Hoop Thrust Stiffness Ratio

(2-22)
$$S_A = \frac{1.43\, M_S\, r_{CENT}}{EA}$$

WHERE

r_{CENT} = radius to centroidal axis of pipe, in

M_S= one-dimensional modulus of soil, psi

E = apparent modulus of elasticity of pipe material, psi

A= profile wall average cross-sectional area, in^2/in, or wall thickness (in) for DR pipe

One-dimensional modulus values for soil can be obtained from soil testing, geotechnical texts, or Table 2-14 which gives typical values. The typical values in Table 2-14 were obtained by converting values from McGrath[20].

TABLE 2-14

Typical Values of M_S, One-Dimensional Modulus of Soil

Vertical Soil Stress[1] (psi)	Gravelly Sand/Gravels 95% Std. Proctor (psi)	Gravelly Sand/Gravels 90% Std. Proctor (psi)	Gravelly Sand/Gravels 85% Std. Proctor (psi)
10	3000	1600	550
20	3500	1800	650
40	4200	2100	800
60	5000	2500	1000
80	6000	2900	1300
100	6500	3200	1450

*Adapted and extended from values given by McGrath[20]. For depths not shown in McGrath[20], the MS values were approximated using the hyperbolic soil model with appropriate values for K and n where n=0.4 and K=200, K=100, and K=45 for 95% Proctor, 90% Proctor, and 85% Proctor, respectively.

[1] Vertical Soil Stress (psi) = [soil depth (ft) x soil density (pcf)]/144

The radial directed earth pressure can be found by multiplying the prism load (pressure) by the vertical arching factor as shown in Eq. 2-23.

(2-23)
$$P_{RD} = (VAF)wH$$

TABLE 2-15
Typical range of Poisson's Ratio for Soil (Bowles [21])

Soil Type	Poisson Ratio, μ
Saturated Clay	0.4-0.5
Unsaturated Clay	0.1-0.3
Sandy Clay	0.2-0.3
Silt	0.3-0.35
Sand (Dense)	0.2-0.4
Coarse Sand (Void Ratio 0.4-0.7)	0.15
Fine-grained Sand (Void Ratio 0.4-0.7)	0.25

Next, the designer determines the Deformation Factor, D_F , by entering the Watkins-Gaube Graph with the Rigidity Factor. See Fig. 2-6. The Deformation Factor is the proportionality constant between vertical deflection (compression) of the soil layer containing the pipe and the deflection of the pipe. Thus, pipe deflection can be obtained by multiplying the proportionality constant D_F times the soil settlement. If D_F is less than 1.0 in Fig. 2-6, use 1.0.

The soil layer surrounding the pipe bears the entire load of the overburden above it without arching. Therefore, settlement (compression) of the soil layer is proportional to the prism load and not the radial directed earth pressure. Soil strain, ε_S, may be determined from geotechnical analysis or from the following equation:

(2-27)

$$\varepsilon_S = \frac{wH}{144E_S}$$

WHERE

w = unit weight of soil, pcf

H = depth of cover (height of fill above pipe crown), ft

E_S = secant modulus of the soil, psi

The designer can find the pipe deflection as a percent of the diameter by multiplying the soil strain, in percent, by the deformation factor:

 Attachment 1

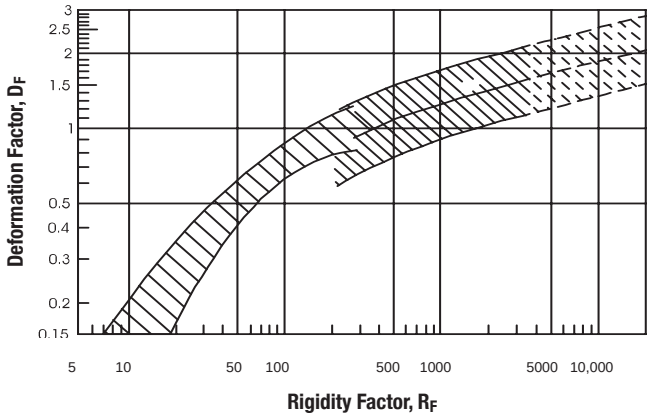


Figure 2-6 Watkins-Gaube Graph

(2-28) $$\frac{\Delta X}{D_M}(100) = D_F \varepsilon_S$$

WHERE

$\Delta X/D_M$ multiplied by 100 gives percent deflection.

Watkins – Gaube Calculation Technique

Find the deflection of a 6″ SDR 11 pipe under 140 ft of fill with granular embedment containing 12% or less fines, compacted at 90% of standard proctor. The fill weighs 75 pcf.

SOLUTION: First, calculate the vertical soil pressure equation, Eq. 2-1.

Eq. 2-1: $P_E = wH$

$P_E = (75 lb/ft^3)(140 ft)$

$P_E = 10{,}500 lb/ft^2$ or 72.9 psi

The M_S is obtained by interpolation from Table 2-14 and equals 2700. The secant modulus can be found assuming a Poisson Ratio of 0.30

$$E_S = \frac{2700\ psi\,(1+0.30)(1-2(0.30))}{(1-0.30)} = 2005\ psi$$

The rigidity factor is obtained from Equation 2-24.

$$R_F = \frac{12\,(2005)\,(11-1)^3}{28250} = 852$$

Using Figure 2-6, the deformation factor is found to be 1.2. The soil strain is calculated by Equation 2-27.

$$\varepsilon_S = \frac{75pcf * 140ft}{144 * 2005\frac{lbs}{inch^2}} \bullet 100 = 3.6\%$$

The deflection is found by multiplying the soil strain by the deformation factor:

$$\frac{\Delta X}{D_M}(100) = 1.2 * 3.6 = 4.4\%$$

Moore-Selig Equation for Constrained Buckling in Dry Ground

As discussed previously, a compressive thrust stress exists in buried pipe. When this thrust stress approaches a critical value, the pipe can experience a local instability or large deformation and collapse. In an earlier section of this chapter, Luscher's equation was given for constrained buckling under ground water. Moore and Selig[17] have used an alternate approach called the continuum theory to develop design equations for contrained buckling due to soil pressure (buckling of embedded pipes). The particular version of their equations given below is more appropriate for dry applications than Luscher's equation. Where ground water is present, Luscher's equation should be used.

The Moore-Selig Equation for critical buckling pressure follows: (Critical buckling pressure is the pressure at which buckling will occur. A safety factor should be provided.)

(2-29)

$$P_{CR} = \frac{2.4\,\varphi\, R_H}{D_M}(EI)^{\frac{1}{3}}(E_S^*)^{\frac{2}{3}}$$

WHERE

P_{CR} = Critical constrained buckling pressure, psi

φ = Calibration Factor, 0.55 for granular soils

R_H = Geometry Factor

E = Apparent modulus of elasticity of pipe material, psi

I = Pipe wall moment of Inertia, in^4/in ($t^3/12$, if solid wall construction)

E_S^* = ES/(1-μ)

E_S = Secant modulus of the soil, psi

μ_s = Poisson's Ratio of Soil

The geometry factor is dependent on the depth of burial and the relative stiffness between the embedment soil and the insitu soil. Moore has shown that for deep burials in uniform fills, R_H equals 1.0.

change cannot occur, so a longitudinal tensile stress is created along the pipe. The magnitude of this stress can be determined using Equation 3-2.

(3-2) $$\sigma = E\,\alpha\,\Delta T$$

Where terms are as defined above, and
σ = longitudinal stress in pipe, psi
E = apparent modulus elasticity of pipe material, psi

The value of the apparent modulus of elasticity of the pipe material has a large impact on the calculated stress. As with all thermoplastic materials, polyethylene's modulus, and therefore its stiffness, is dependent on temperature and the duration of the applied load. Therefore, the appropriate elastic modulus should be selected based on these two variables. When determining the appropriate time interval, it is important to consider that heat transfer occurs at relatively slow rates through the wall of polyethylene pipe; therefore temperature changes do not occur rapidly. Because the temperature change does not happen rapidly, the average temperature is often chosen for the modulus selection.

TABLE 3-1
Apparent Modulus Elasticity for HDPE Pipe Material at Various Temperatures

Load Duration	PE 3408 Apparent Elastic Modulus†, 1000 psi (MPa), at Temperature, °F (°C)							
	-20 (-29)	0 (-18)	40 (4)	60 (16)	73 (23)	100 (38)	120 (49)	140 (60)
Short-Term	300.0 (2069)	260.0 (1793)	170.0 (1172)	130.0 (896)	110.0 (758)	100.0 (690)	65.0 (448)	50.0 (345)
10 h	140.8 (971)	122.0 (841)	79.8 (550)	61.0 (421)	57.5 (396)	46.9 (323)	30.5 (210)	23.5 (162)
100 h	125.4 (865)	108.7 (749)	71.0 (490)	54.3 (374)	51.2 (353)	41.8 (288)	27.2 (188)	20.9 (144)
1000 h	107.0 (738)	92.8 (640)	60.7 (419)	46.4 (320)	43.7 (301)	35.7 (246)	23.2 (160)	17.8 (123)
1 y	93.0 (641)	80.6 (556)	52.7 (363)	40.3 (278)	38.0 (262)	31.0 (214)	20.2 (139)	15.5 (107)
10 y	77.4 (534)	67.1 (463)	43.9 (303)	33.5 (231)	31.6 (218)	25.8 (178)	16.8 (116)	12.9 (89)
50 y	69.1 (476)	59.9 (413)	39.1 (270)	29.9 (206)	28.2 (194)	23.0 (159)	15.0 (103)	11.5 (79)

† Typical values based on ASTM D 638 testing of molded plaque material specimens. An elastic modulus for PE 2406 may be estimated by multiplying the PE 3408 modulus value by 0.875.

Attachment 1

OD			Pipe inside diameter (d)	Minimum Wall Thickness (t)	Weight (w)
Nominal in.	Actual in.	SDR	in.	in.	lb. per foot
		7	3.88	0.795	5.172
		7.3	3.95	0.762	4.996
		9	4.25	0.618	4.182
		9.3	4.29	0.598	4.065
		11	4.49	0.506	3.505
5	5.563	11.5	4.54	0.484	3.368
		13.5	4.69	0.412	2.912
		15.5	4.80	0.359	2.564
		17	4.87	0.327	2.353
		21	5.00	0.265	1.929
		26	5.11	0.214	1.574
		32.5	5.20	0.171	1.270
		7	4.62	0.946	7.336
		7.3	4.70	0.908	7.086
		9	5.06	0.736	5.932
		9.3	5.11	0.712	5.765
		11	5.35	0.602	4.971
6	6.625	11.5	5.40	0.576	4.777
		13.5	5.58	0.491	4.130
		15.5	5.72	0.427	3.637
		17	5.80	0.390	3.338
		21	5.96	0.315	2.736
		26	6.08	0.255	2.233
		32.5	6.19	0.204	1.801
		7	6.01	1.232	12.433
		7.3	6.12	1.182	12.010
		9	6.59	0.958	10.054
		9.3	6.66	0.927	9.771
		11	6.96	0.784	8.425
8	8.625	11.5	7.04	0.750	8.096
		13.5	7.27	0.639	7.001
		15.5	7.45	0.556	6.164
		17	7.55	0.507	5.657
		21	7.75	0.411	4.637
		26	7.92	0.332	3.784

Attachment 1

OD			Pipe inside diameter (d)	Minimum Wall Thickness (t)	Weight (w)
Nominal in.	Actual in.	SDR	in.	in.	lb. per foot
		7	7.49	1.536	19.314
		7.3	7.63	1.473	18.656
		9	8.22	1.194	15.618
		9.3	8.30	1.156	15.179
		11	8.68	0.977	13.089
10	10.750	11.5	8.77	0.935	12.578
		13.5	9.06	0.796	10.875
		15.5	9.28	0.694	9.576
		17	9.41	0.632	8.788
		21	9.66	0.512	7.204
		26	9.87	0.413	5.878
		32.5	10.05	0.331	4.742
		7	8.89	1.821	27.170
		7.3	9.05	1.747	26.244
		9	9.75	1.417	21.970
		9.3	9.84	1.371	21.353
		11	10.29	1.159	18.412
12	12.750	11.5	10.40	1.109	17.693
		13.5	10.75	0.944	15.298
		15.5	11.01	0.823	13.471
		17	11.16	0.750	12.362
		21	11.46	0.607	10.134
		26	11.71	0.490	8.269
		32.5	11.92	0.392	6.671
		7	9.76	2.000	32.758
		7.3	9.93	1.918	31.642
		9	10.70	1.556	26.489
		9.3	10.81	1.505	25.745
		11	11.30	1.273	22.199
14	14.000	11.5	11.42	1.217	21.332
		13.5	11.80	1.037	18.445
		15.5	12.09	0.903	16.242
		17	12.25	0.824	14.905
		21	12.59	0.667	12.218
		26	12.86	0.538	9.970
		32.5	13.09	0.431	8.044

OD			Pipe inside diameter (d)	Minimum Wall Thickness (t)	Weight (w)
Nominal in.	Actual in.	SDR	in.	in.	lb. per foot
		7	11.15	2.286	42.786
		7.3	11.35	2.192	41.329
		9	12.23	1.778	34.598
		9.3	12.35	1.720	33.626
		11	12.92	1.455	28.994
16	16.000	11.5	13.05	1.391	27.862
		13.5	13.49	1.185	24.092
		15.5	13.81	1.032	21.214
		17	14.00	0.941	19.467
		21	14.38	0.762	15.959
		26	14.70	0.615	13.022
		7	12.55	2.571	54.151
		7.3	12.77	2.466	52.307
		9	13.76	2.000	43.788
		9.3	13.90	1.935	42.558
		11	14.53	1.636	36.696
18	18.000	11.5	14.68	1.565	35.263
		13.5	15.17	1.333	30.491
		15.5	15.54	1.161	26.849
		17	15.76	1.059	24.638
		21	16.18	0.857	20.198
		26	16.53	0.692	16.480
		32.5	16.83	0.554	13.296
		7	13.94	2.857	66.853
		7.3	14.19	2.740	64.576
		9	15.29	2.222	54.059
		9.3	15.44	2.151	52.541
		11	16.15	1.818	45.304
20	20.000	11.5	16.31	1.739	43.535
		13.5	16.86	1.481	37.643
		15.5	17.26	1.290	33.146
		17	17.51	1.176	30.418
		21	17.98	0.952	24.936
		26	18.37	0.769	20.346
		32.5	18.70	0.615	16.415

Attachment 1

OD			Pipe inside diameter (d)	Minimum Wall Thickness (t)	Weight (w)
Nominal in.	Actual in.	SDR	in.	in.	lb. per foot
		9	16.82	2.444	65.412
		9.3	16.98	2.366	63.574
		11	17.76	2.000	54.818
		11.5	17.94	1.913	52.677
22	22.000	13.5	18.55	1.630	45.548
		15.5	18.99	1.419	40.107
		17	19.26	1.294	36.805
		21	19.78	1.048	30.172
		26	20.21	0.846	24.619
		32.5	20.56	0.677	19.863
		9	18.35	2.667	77.845
		9.3	18.53	2.581	75.658
		11	19.37	2.182	65.237
		11.5	19.58	2.087	62.690
24	24.000	13.5	20.23	1.778	54.206
		15.5	20.72	1.548	47.731
		17	21.01	1.412	43.801
		21	21.58	1.143	35.907
		26	22.04	0.923	29.299
		32.5	22.43	0.738	23.638
		11	22.60	2.545	88.795
		11.5	22.84	2.435	85.329
		13.5	23.60	2.074	73.781
		15.5	24.17	1.806	64.967
28	28.000	17	24.51	1.647	59.618
		21	25.17	1.333	48.874
		26	25.72	1.077	39.879
		32.5	26.17	0.862	32.174
		11	24.22	2.727	101.934
		11.5	24.47	2.609	97.954
		13.5	25.29	2.222	84.697
		15.5	25.90	1.935	74.580
30	30.000	17	26.26	1.765	68.439
		21	26.97	1.429	56.105
		26	27.55	1.154	45.779
		32.5	28.04	0.923	36.934

Attachment 2

Source: "Monitoring Approaches for Landfill Bioreactors", Carson, et. al, December 2004, EPA/600/R-04/301.

4.2 Analytical Monitoring Parameters

4.2.1 Leachate Monitoring

Suggested leachate monitoring parameters for MSW bioreactor landfills to enhance operational control under RCRA and the RD&D (FR 2004) rule are divided into primary (Table 3) and secondary parameters (Table 4). The primary parameters are relatively inexpensive and easy to examine. Parameters presented in the secondary list are more research-oriented, and are more time intensive and as a result are relatively costly. Suggested analysis methods and monitoring frequencies are presented in the tables. It is the responsibility of the owner/operator of a landfill to comply with all existing local, state and federal regulations with regard to existing monitoring parameters in addition to parameters agreed upon under an RD&D project. A few monitoring parameters are evaluated further in the following sections.

Sample duplication is necessary to account for the statistical relevance of monitoring data. Caution must also be taken to hydraulically isolate bioreactor from adjacent conventional landfill cells. The separation would allow for an accurate evaluation of conditions only within the bioreactor. Hydraulic separation may be achieved in an as-built cell; however, such a separation is more difficult in retrofit bioreactor landfill cells. In the case of a retrofit bioreactor landfill, it is suggested that the zone of influence of the liquid application area be examined (see Reinhart and Townsend, 1998 for more details). Leachate samples representing the bioreactor section of the landfill should be collected only from areas directly under the zone of influence.

4.2.1.1 Leachate Temperature

Research suggests that anaerobic processes occur best within either mesophilic (30-38°C) or thermophilic (50 to 60°C) temperature ranges (McCarty 1964; Parkin and Owen 1986). Optimum methane generation from solid wastes, however, occurred

at 41°C (Harts et al. 1982). Regardless of the operational temperatures, the maintenance of a uniform temperature is considered to be fundamental to anaerobic stabilization process efficiencies. Historically, conventional landfills leachate temperature ranged from 7 to 25°C while bioreactor landfills leachate ranged from 6 to 37°C (EPA 2003).

Because landfill temperature is not externally controlled, it reflects a combination of ambient temperature conditions, microbial activities and the extent and effectiveness of insulation provided by the landfill configuration. In cold climates, for example, leachate temperatures could initially be as low as 6°C. Soon after recirculation the leachate temperatures should steadily increase. Leachate temperatures at the Outer Loop landfill in Kentucky were initially around 7°C. The leachate temperatures at the landfill steadily increased to above 30°C within a few months of the bioreactor operation (EPA 2003). While an increase in leachate temperature is reflective of waste degradation in a landfill, it is not solely indicative of biological activity.

4.2.1.2 Leachate pH

The optimum pH range for anaerobic systems ranges between 6.5 and 7.6 (Parkin and Owen 1986). Gas generation and stabilization rates have been reported to be the highest at near neutral pH levels (Pohland et al. 1993). Initially the leachate pH may be neutral, however after the onset of anaerobic conditions there may be a pH drop especially during the acid forming phase (see section 3.2). The pH drop is most likely caused by VFAs production and accumulation in the leachate. The pH, however, will tend to move to neutrality as methanogens consume these acids. Historically there may not be a measured difference between the leachate pH measured in conventional and in bioreactor landfills. The leachate pH ranged between 4.7-8.8 for conventional landfills (EPA 2003; Kjeldsen et al. 2002; Chu et al. 1994; Krung and Ham 1991) and from 5.4-8.6 for bioreactor landfills (EPA 2003; Pohland and Harper 1986).

Source: "The Performance Pipe Engineering Manual", First Edition, www.performancepipe.com

Off-Highway and Unpaved Road Loads

Off-highway vehicles may be considerably heavier than H20 or HS20 trucks, and these vehicles frequently operate on unpaved roads that may have uneven surfaces. Thus impact factors higher than 1.5 may be reached depending on the vehicle speed. Except for slow traffic, an impact factor of 2.0 to 3.0 should be considered.

During construction, both permanent and temporary underground pipelines may be subjected to heavy vehicle loading from construction equipment. A designated vehicle crossing with special design measures such as temporary pavement or structural sheeting may be prudent, as well as vehicle speed controls to limit impact loading.

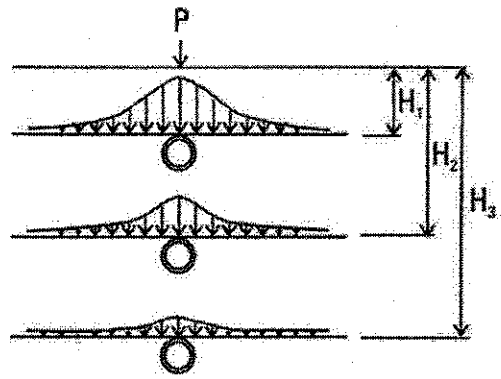
Vehicular Loads As Point Loads

There are generally two approaches for calculating vehicle live load surcharge pressure. The more conservative approach is to treat the wheel load as a concentrated (point) load. The other is to treat it as a distributed load spread over the contact area of the tire with the ground (imprint area). The pressure due to a distributed load and the pressure due to a concentrated load begin to approach the same value at a depth of about twice the square root of the loaded area.

The distributed load method gives more realistic values where the depth equals less than twice the square root of the loaded area, whereas for deeper depths concentrated loads are preferred because the calculations are simpler and typically more conservative.

The pressure distribution under a concentrated load varies with depth as illustrated in Figure 7-9. When the live load is calculated using the point load methods in the following sections, a conservative approach is to assume that the maximum pressure at the pipe crown is distributed across the entire pipe.

Figure 7-9 Concentrated Vehicular Load Pressure Distribution at Various



A key consideration in determining live load pressure on the pipe is the location of vehicle wheels relative to the pipe. A higher pressure may occur below a point between two vehicles passing in adjacent lanes than directly under a single vehicle wheel. This depends on the depth of cover.

When depths are not greater than four or five feet, the combined H20 load for two separate wheels straddling the pipe is greater than that for a single wheel directly over the pipe. Deeper than five feet, H20 loads are not usually significant because the load is attenuated significantly compared loads under one or two feet of cover. However, greater live loads may produce design significant effects at depths greater than five feet. Therefore, the designer should check load conditions for a single wheel directly over the pipe, and for two wheels spaced six feet apart and centered over the pipe.

Single Wheel Load Centered On Pipe

To check a single wheel load centered directly over the pipe, a method based on Holl's integration of Boussinesq's equation assumes that the wheel load is a concentrated (point) load. Holl's integration finds the pressure at the depth of the pipe crown that is distributed over a surface three feet long and the width of the pipe outside diameter.

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Appendix D.4
Leachate Collection Pipe Perforation Sizing

Client	County of Kaua'i	**Subject**	Leachate	**Prepared By** MJV	**Date** 4/12/13
Project	Ma'alo Landfill		Collection Pipe Perforation	**Reviewed By** KMK	**Date** 4/12/13
Conceptual Design				**Approved By** KJB	**Date** 5/29/13

LEACHATE COLLECTION PIPE PERFORATION SIZING

Objective

Determine if the proposed pipe perforations in the leachate collection pipes of Phase 1 will be able to maintain leachate flow into the pipe for the estimated leachate quantity and verify proposed granular drainage layer particle sizing is adequate for the proposed perforation sizing.

Design Criteria and Assumptions

1. Phase 1 is divided into seven collection areas as shown on Drawing 3. The shortest length of perforated leachate collection pipe draining to one sump is approximately 370 feet. The largest area draining to one pipe is approximately 8.0 acres.

2. Proposed pipe perforations are located in two rows along the bottom of the pipe and alternately spaced. Spacing of perforations, center-to-center, in each row is 5 inches. The diameter of each pipe perforation is 0.5 inches.

3. For conservatism, the peak daily leachate generation rate is used in verifying the flow through the perforations. From the leachate generation analysis calculation (Appendix D-1), the leachate generation rate is 5,240 gallons/acre/day.

4. The average particle size (D_{50}) of the granular drainage layer is 1.0 inch.

Calculations

Largest Sump Area Leachate Flow

8.0 ac x 5,240.0 gal/ac/day = 41,920 gal/day

Total Pipe Perforations

Determine the total number of perforations available on the proposed leachate collection pipe.

Where:
P = Total number of perforations available
L = Length of perforated pipe (ft).
S = Spacing center-to-center of perforations (in).
H = Number of perforation rows

Solving:

$$P_{total} = L * \left(\frac{1}{S}\right) * \left(\frac{12''}{1ft}\right) * (H)$$

For the Shortest perforated pipe draining to one sump:

$$P_{2W} = 370\,ft * \left(\frac{1}{5''}\right) * \left(\frac{12''}{1\,ft}\right) * (2) = 1{,}776$$

The shortest proposed pipe draining from one collection area in Phase 1 will have 1,776 perforations.

Flow Per Perforation

The flow through each perforation can be determined by applying Q=VAC, where:

Q = flow rate
A = area of perforation, or $(D^2/4)*\pi = 0.00136\ ft^2$.
V = in-flow velocity through each perforation, 0.1 feet per second, assumed (Qian, 2002)
C = discharge coefficient, 0.62 (Qian, 2002)

Solving:

$$Q = (A)*(V)*(C)$$

$$Q = (0.00136sf)*(0.1\,fps)*(0.62\,fps)$$

$$Q = 8.43x10^{-5}\,cfs * \left(\frac{7.48\,\text{gal}}{1\,\text{cf}}\right) * \left(\frac{60\,\text{sec}}{1\,\text{min}}\right) * \left(\frac{60\,\text{min}}{1\,\text{hr}}\right)\left(\frac{24\,\text{hr}}{1\,\text{day}}\right)$$

$$Q = 54.5\,\text{gal/day}$$

The maximum daily flow of leachate through each perforation is 54.5 gallons (54.5 gal/day/perforation).

Required Total Number of Perforations

The required total number of perforations needed to accommodate the Peak Daily Flow of leachate in the largest area draining to one sump is:

$$P_{required} = (41{,}920\,gal/day) * \left(\frac{day - perforation}{54.5\,gal}\right) = 770$$

The total number of perforations required is 770. Since 770 is less than the 1,776 perforations available, the shortest leachate collection pipe is sufficient to handle the largest drainage area. Approximately 43.4 percent of the available perforations will be required.

Grain Size Criteria of Filter Materials in Relation to Pipe Perforations

To verify specified granular drainage layer particle sizing versus perforations in the leachate collection piping and sideslope riser pipes, the U.S. Bureau of Reclamation formula for grain size criteria of filter materials next to perforations in pipes (Reference 1) is applied. The formula is:

(D_{85} of the filter nearest the pipe) / (perforation diameter) = 2 or greater

Solving the equation based upon a pipe perforation diameter of 0.5 inches we obtain:

$$\frac{D_{85}}{0.5''} = 2, solving : D_{85} \geq 1.0''$$

The required granular drainage layer against the pipe perforations at D_{85} (or the particle size at which 85 percent of the sample is smaller) should be 1 inch. The specified average particle size for the granular drainage layer, or D_{50}, is 1 inch. Therefore the D_{85} of the granular drainage layer will be larger than 1 inch and meets the requirements for particle size versus pipe perforations.

Conclusions

The leachate collection pipe, as proposed, contains more than enough perforations to handle the estimated Peak Daily Flow of leachate. The extra perforations provide a factor of safety for perforations that become partially clogged.

The specified granular drainage layer with an average particle size of 1 inch will meet the requirements for placement along piping perforated with 0.5 inch diameter holes.

References

1. Qian, Xuede; Koerner, Robert M.; Gray, Donald H., "Geotechnical Aspects of Landfill Design and Construction", 2002, pages 300-302.

Appendix D.5
Leachate Evaporation Pond Sizing

Client County of Kaua'i	**Subject** Leachate	**Prepared By** NKW	**Date** 8/20/14
Project Ma'alo Landfill	Evaporation Pond Analysis	**Reviewed By**	**Date**
Conceptual Design		**Approved By**	**Date**

LEACHATE EVAPORATION LAGOON ANALYSIS

Objective

Evaluate the ability of the proposed leachate evaporation pond to properly process the Ma'alo Landfill estimated leachate quantities.

Design Criteria and Assumptions

1. The leachate evaporation pond will function by storing all leachate generated in the landfill until the leachate evaporates. The leachate evaporation pond will also have to evaporate all rainfall which falls on and runs into the pond. To facilitate the analysis the pond is evaluated on a monthly basis.

2. The proposed evaporation pond is evaluated based on a water balance, adding the liquid entering the evaporation pond and subtracting the anticipated evaporation quantities.

3. It is assumed that the evaporation rates from the evaporation pond will be similar to pan evaporation rates due to the confined nature, and relatively shallow depth of the pond. The pond may actually evaporate more than the pan due to aerators operating and dark liner materials and the opportunity for the water to warm up in the pond more than in the pan evaporation test.

4. Estimated pan evaporation rates from two sources were reviewed (see Attachment 1). The pan evaporation rate of 78.6 inches annually for the weather station 1064.3 was used in this calculation. For comparison, the pan evaporation rate at the weather station 1062.1 is 68.24 inches/year. Weather station 1064.3 is geographically closer to the site. Therefore, a pan evaporation rate of 78.6 inches per year was used.

5. Estimated average monthly leachate generation rates based on active conditions were used in this analysis (see the Leachate Generation Analysis calculation).

6. Average monthly rainfall data based on the ten years (2003 through 2012) of available site data was used in this analysis.

7. All references to elevations correlate to the site specific vertical datum.

8. The planar area of the evaporation pond available for evaporation is 5.44 acres.

9. The calculation was performed to determine whether the pond can accommodate and evaporate leachate from all of Phase 1. The planar area of Phase 1 is also approximately 44.9 acres.

10. The gross capacity of the leachate evaporation pond is approximately 34,000 cy or 6,804,000 gallons. The bottom of the lagoon has 1-foot of gravel and the sideslopes have 8 inches of drainage material supported in place by a geoweb system. The total volume of base and sideslope material is approximately 8,600 cy or 1,730,000 gallons. Assuming 30 percent porosity of the base and sideslope material, the net volume of the evaporation lagoon is 5,593,000 gallons.

11. This calculation is performed for average monthly leachate generation and average monthly rainfall. In the event of a peak daily storm and/or peak daily leachate generation, the pond may need to be pumped down sometime during that month or year, depending on other precipitation and evaporation conditions during that year. A loadout facility will be constructed next to the pond so that a tanker truck could be used to pump out and deliver excess leachate to a wastewater treatment facility.

Calculations

The calculation of the annual water balance is based on month-to-month additions to the leachate evaporation pond due to average monthly rainfall and leachate, and subtractions due to average pan evaporation for each month. Calculations of the annual water balance are summarized in Table 1, Evaporation Pond Month-to-Month Water Balance – Assume Average Rainfall Leachate Generation and Evaporation, included as Attachment 2.

Sample calculations from Attachment 2 for the month of April, are provided below.

Phase 1 leachate (convert HELP model output for average monthly open conditions from in/ac to gallons) for the month of April:

$$\text{Phase 1 Leachate} = \left(\frac{2.2125\text{ inches}}{\text{month}}\right)\left(\frac{1\text{ foot}}{12\text{ in.}}\right)\left(\frac{43{,}560\text{ sf}}{\text{acre}}\right)\left(\frac{7.48\text{ gal.}}{1\text{ cf}}\right)\text{x } 10\text{ ac.} = 600{,}747\text{ gal/ month}$$

Phase 1 leachate (convert HELP model output for average monthly intermediate conditions from in/ac to gallons for the month of April:

$$\text{Phase 1 Leachate} = \left(\frac{0.5941\text{ inches}}{\text{month}}\right)\left(\frac{1\text{ foot}}{12\text{ in.}}\right)\left(\frac{43{,}560\text{ sf}}{\text{acre}}\right)\left(\frac{7.48\text{ gal.}}{1\text{ cf}}\right)\text{x } 34.9\text{ ac.} = 562{,}980\text{ gal/ month}$$

Total leachate generated (in inches of evaporation pond) for the month of April:

$$\text{Total leachate} = \frac{\text{(Phase 1 leachate)}}{\text{average lagoon surface area}}$$

$$= \left(\frac{\left(1{,}163{,}727\text{ gal}/\text{month}\right)\text{x } 1\text{ cf}/7.48\text{ gal}}{5.44\text{ acres x } 43{,}560\text{ sf}/\text{acre}}\right)\text{x } \frac{12\text{ in}}{1\text{ ft}} = 7.88\text{ in/month}$$

Pan Evaporation for April: 6.63 inches

$$\frac{\text{Rainfall in pond for April}}{\text{Monthly water balance (inches for April)}} \quad \frac{\text{Rx contributing area}}{\text{pond area}} = \frac{1.57\text{ in x 6 ac}}{5.44} = 1.69\text{ average monthly rainfall}$$

Monthly water balance (inches) for April:

Monthly water balance = Total leachate + Rainfall – evaporation
= 7.88 inches + 1.69 inches – 6.63 inches = 2.94 inches

Cumulative Required Storage from inches to cubic yards for the month of April:

When considering average annual leachate generation, Attachment 2, the estimated required maximum

cumulative leachate and rainfall storage volume of 3,966,800 gallons occurs during the month of June. The pond would be at ~70% of capacity. Therefore, the pond capacity of 5,593,000 gallons is enough to store the maximum average rainfall and leachate estimate while evaporating it (assuming the pond is empty in January).

Conclusion

Based on estimated average monthly leachate flows (Table 1 in Attachment 2), evaporation (Attachment 1), and rainfall, the proposed evaporation pond is able to contain anticipated leachate and rainfall quantities without overflow for more than 1 year. Some years would be expected to have less leachate and rainfall and some would have more. The leachate loadout station can be used, as required, to reduce leachate volume in the pond by pumping into tanker trucks and delivering to a WWTF. Leachate volumes entering the pond can also be reduced by installing final cover on part of Phase 1 and by reducing both the "Open/Active" area and the intermediate cover area. In the future, there may be a possibility of recirculating leachate back into the landfill, further reducing leachate volume in the evaporation pond.

Attachment 1
Hawaii Pan Evaporation Rates

Source 1: GROUND WATER ATLAS of the UNITED STATES
Alaska, Hawaii, Puerto Rico and the U. S. Virgin Islands
HA 730-N
http://capp.water.usgs.gov/gwa/ch_n/N-HItext1.html

Evapotranspiration, which is the loss of water to the atmosphere by the combination of transpiration of plants and direct evaporation from land and water surfaces, is a major component of the hydrologic budget of the islands. In the Honolulu area of Oahu, for example, actual evapotranspiration was estimated to be about 40 percent of the total water (rainfall plus irrigation) falling on or applied to the ground surface during 1946-75. Pan evaporation is the main measurement used in Hawaii to assess the amount of water loss by evapotranspiration. Over the open ocean, the estimated annual pan-evaporation rate is 65 inches. As with precipitation, pan-evaporation rates in Hawaii are related to topography. At altitudes between 2,000 and 4,000 feet, where humidity is high and sunlight intensity is reduced because of clouds, pan-evaporation rates are reduced to as low as 25 percent of the open-ocean rate. In the leeward coastal areas, wind carrying dry, warm air increases annual pan-evaporation rates to as much as 100 inches. At the summits of Mauna Kea and Mauna Loa on the island of Hawaii, annual pan-evaporation rates exceed 70 inches because of clear skies and dry air.

Source 2: U.S. Department of the Interior, Water Budget for the Island of Kauai Hawaii

Kauai Weather Stations
MONTHLY AVERAGE PAN EVAPORATION (INCHES)

	Period Of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1064.3	12 years	4.86	5.04	6.30	6.63	7.28	7.48	8.27	8.10	7.47	6.72	5.16	5.06	78.64
1062.1	16 years	4.53	4.55	5.78	6.17	6.46	6.51	7.07	6.87	6.22	5.57	4.52	4.46	68.24
LIHUE WSO AP 1020.1	27 years	5.59	6.06	7.43	8.10	9.08	9.68	10.30	10.10	9.22	8.04	6.36	5.64	96.20

Attachment 2

Table 1: Evaporation Pond Month-to-Month Water Balance -

Assume Average Rainfall, Leachate Quantities, and Evaporation

Ma'alo Landfill

Conceptual Design

Month	Avg. Mo. Rainfall[1] (in)	Avg. Mo. Leachate Phase 1[1] (Open) (in/ac)	Avg. Mo. Leachate Phase 1 (Open) (gal)	Avg. Mo. Leachate Phase 1[1] (Intermediate) (in/ac)	Avg. Mo. Leachate Phase 1[1] (Intermediate) (gal)	Total Leachate[2] (in)	Avg. mo. Rainfall Runoff to Pond (in)	Avg. Mo. Pan Evap.[3] (in)	Monthly Water Balance[4] (in)	Cumulative Water Balance[5] (in)	Cumulative Required Storage Volume (cy)	Cumulative Required Storage Volume (gal)
Jan	3.33	1.6201	439,896	0.6614	626,755	7.22	3.67	4.86	6.03	6.03	4,412	891,100
Feb	4.61	1.4182	385,075	0.7294	691,193	7.29	5.08	5.04	7.33	13.37	9,777	1,974,500
Mar	8.32	1.3228	359,172	0.4029	381,796	5.02	9.18	6.30	7.90	21.26	15,552	3,140,900
Apr	1.53	2.2125	600,747	0.5941	562,980	7.88	1.69	6.63	2.94	24.20	17,700	3,574,800
May	2.15	1.8791	510,221	0.6452	611,404	7.59	2.37	7.28	2.68	26.88	19,661	3,970,800
Jun	1.29	1.3282	360,638	0.5587	529,435	6.03	1.42	7.48	-0.03	26.86	19,641	3,966,800
Jul	1.65	1.2025	326,508	0.4097	388,239	4.84	1.82	8.27	-1.61	25.25	18,464	3,729,000
Aug	1.9	1.063	288,630	0.1877	177,868	3.16	2.10	8.10	-2.84	22.40	16,384	3,308,800
Sept	1.51	0.8147	221,211	0.1111	105,280	2.21	1.67	7.47	-3.59	18.81	13,755	2,777,900
Oct	2.63	0.4579	124,331	0.0661	62,638	1.27	2.90	6.72	-2.55	16.26	11,890	2,401,300
Nov	3.63	0.4095	111,189	0.0468	44,349	1.05	4.00	5.16	-0.11	16.15	11,812	2,385,600
Dec	5.49	1.0076	273,588	0.2673	253,298	3.57	6.06	5.06	4.57	20.72	15,151	3,059,900
TOTAL:	38.04	14.7361	4,001,205	4.6804	4,435,235	57.13	41.96	78.37				

Notes:
1. Rainfall in inches and expansion leachate generation in inches/acre obtained from HELP Model output included in the "Leachate Generation Analysis" calculation.
2. Total leachate generation is displayed in inches of evaporation pond depth at average pond area.
3. Pan evaporation data from the weather station at HILO WSO as indicated in Attachment 1.
4. Negative monthly water balance indicates evaporation is greater than the liquid entering the pond.
5. Negative water balance quantities can not be accumulated, therefore, the minimum cumulative water balance is 0.

Areas:			
	Phase 1 -- open	10.0	acres
	Phase 1 -- Intermediate	34.9	acres
	Pond area	5.44	acres
	Drainage Area to Pond	6	acres

Appendix D.6
Leachate Holding Tank Sizing

Client	County of Kaua'i	**Subject**	Leachate Holding Tank Sizing	**Prepared By**	TCR	**Date**	11/22/13
Project	Ma'alo Landfill			**Reviewed By**	JDM	**Date**	11/22/13
				Approved By	KJB	**Date**	11/22/13

LEACHATE HOLDING TANK SIZING

Objective

Determine the leachate holding tank capacity for the calculated leachate generation for Cell 1.1 and all of Phase 1 of Ma'alo Landfill under active conditions.

Design Criteria and Assumptions

1. An analysis under active conditions has been performed to estimate the maximum leachate volume. For active conditions, the peak daily leachate generation rate, as described in the Leachate Generation Analysis calculation, is 173,300 gal/day for Phase 1 based on the following peak daily leachate generation rates:
    a. Active Condition: 5,240 gal/acre/day
    b. Intermediate Condition: 3,494 gal/acre/day

2. Cell 1.1 is anticipated to include the 8.0 acre area drained by the northern most leachate collection pipe and the 6.7 acre area drained by the next leachate collection pipe to the south.

3. Filling of Cell 1.1 is anticipated to progress from north to south. Conservatively assume the areas drained by both leachate collection pipes will be under active conditions at the same time.

4. Assume thirteen, 40,000 gallon, double-wall, leachate holding tanks will be used to provide the leachate holding capacity for Phase 1. Assume that initially six will be installed for Cell 1.1.

5. The double wall leachate holding tanks provide containment in case of a leak, therefore, no additional containment area is required.

Calculations

Calculate the peak daily leachate generation rate for Cell 1.1:

Cell 1.1 leachate generation rate = (8.0 acres + 6.7 acres) x (5,240 gal/acre/day)
= 77,028 gal/day

Calculate the days of holding capacity (D);
where D = leachate holding capacity / daily leachate generation rate

Cell 1.1: $D_{Cell1.1}$ = [6 tanks x 40,000 gallons/tank] / (77,028 gal/day) = 3.1 days

Entire Phase 1: D_{PH1} = [13 tanks x 40,000 gallons/tank] / (173,300 gal/day) = 3.0 days

Client	County of Kaua'i	**Subject**	Leachate Holding Tank Sizing	**Prepared By** TCR	**Date** 11/22/13
Project	Ma'alo Landfill			**Reviewed By** JDM	**Date** 11/22/13
				Approved By KJB	**Date** 11/22/13

Conclusion

Leachate holding capacity needs change as the landfill is developed. It is anticipated that leachate holding capacity will be increased incrementally as landfill development progresses.

Six 40,000 gallon leachate holding tanks will provide approximately 3 days of holding capacity for Cell 1.1 based on estimated peak daily leachate flows assuming no final cover and no intermediate cover is in place. Thirteen 40,000 gallon leachate holding tanks will provide approximately 3 days of holding capacity for the entire Phase 1 area based on the estimated peak daily leachate flows when no final cover is in place.

There are numerous tank configurations (capacity and shape) that could be used to provide the leachate holding capacity of 240,000 gallons for Cell 1.1 or 520,000 gallons for the entire Phase 1. The leachate holding capacity is based on the assumed leachate generation rate which is dependent on landfill development, operations, and many other factors. Actual leachate holding capacity provided may vary from that assumed in this calculation.

Appendix D.7
Final Cover Equivalency Analysis

Client County of Kaua'i	**Subject** Final Cover	**Prepared By**	MJV	**Date**	4/10/13
Project Ma'alo Landfill	Equivalency Analysis	**Reviewed By**	TCR	**Date**	4/17/13
Conceptual Design		**Approved By**	KJB	**Date**	5/29/13

FINAL COVER EQUIVALENCY ANALYSIS

Objective

Evaluate and compare the infiltration through the proposed Ma'alo Landfill Phase 1 cover and the permitted bottom liner to determine the effectiveness of the proposed cover. Infiltration through the cover and bottom liner is estimated using the USEPA Hydraulic Evaluation of Landfill Performance Version 3.07 (HELP) computer modeling program.

Design Criteria and Assumptions

1. This analysis was performed to evaluate the effectiveness of the proposed final cover for the landfill.

2. The required cover specified in HAR Section 11-58.1-17 requires the same or less infiltration as the bottom liner.

3. The bottom liner will be evaluated with 12 inches of head, which is the maximum head allowed by HAR during the post closure care period.

HELP Model Version 3.07 Input:

1. Solar radiation data can be default data, user input or synthetically generated by the HELP model. Synthetically generated solar radiation data for Honolulu, Hawaii was used to simulate site weather conditions.

2. Temperature, precipitation, and average wind speed data was obtained from site records at the Lihue Airport from January 2003 through December 2012.

3. Geomembrane liner pinhole density and size were assumed to account for possible manufacturing defects during geomembrane production. The HELP Model User's Guide for Version 3.07 states that the pinhole density for a typical geomembrane is 0.5 to 1 pinhole per acre. One pinhole per acre was assumed to be present.

4. The placement quality for the geomembrane liner was assumed to be "good". A placement quality of "good" according to the HELP Model User's Guide "assumes good field installation with well prepared, smooth soil surface and geomembrane wrinkle control". The HELP Model User's Guide suggests 1 to 4 installation defects for an installation quality of "good". To be conservative, 2 installation defects per acre were assumed for the geomembrane liner.

5. Only the relatively gentle top slopes of the landfill are used in the HELP analysis. The relatively gentle slopes allow the maximum infiltration through the cover.

6. The initial moisture content of the final cover layers was computed by the HELP model software to be steady state conditions.

7. For the cover analysis the curve number was calculated by the HELP model based on the soil type and final cover slopes. Through the use of diversion berms or other engineered features, the shallowest, longest slope for the cover will be 5 percent and 130 feet. The slope and length are based on the flatter top areas of the landfill.

8. The HAR allows a maximum of 1 foot of head on the bottom liner during the post closure period. The head on the bottom liner directly affects the amount of infiltration through the bottom liner. A larger head produces greater infiltration. To determine the performance of the permitted bottom liner with a maximum of 1 foot of head the HELP model analysis of the bottom liner includes the GCL, geomembrane and only 1 foot of the drainage layer. The bottom liner HELP analysis was performed only to determine infiltration through the liner with a maximum of 1 foot of head. Therefore, rainfall and weather data does not impact the results but were input to allow the HELP model software to perform the desired calculations.

9. To maintain a head at a maximum of 1 foot during the bottom liner analysis, only the bottom liner was modeled, no run-off was allowed, and the drainage layer was modeled as a vertical percolation layer. This analysis setup maintained the head on the liner near the HAR allowed depth.

10. The permitted bottom liner system consists of a primary 60-mil HDPE geomembrane, a GCL, and a secondary 60-mil HDPE geomembrane. The program does not allow for a barrier layer to be placed between to geosynthetic liners, so the secondary geomembrane was omitted from the model.

11. A one-acre design area was used for modeling purposes to compute unit quantities.

12. Permitted Bottom Liner Inputs for Phase 1 (see also Table 2):

    - 12 inches of drainage layer
    - Geomembrane
    - GCL
    - No vegetation on cover (does not affect this analysis)
    - Evaporative zone depth = 1 in. (minimum required for HELP Model software requirements) (does not affect this analysis)
    - Maximum leaf area index = 0 (recommended by HELP Model for Bare ground conditions) (does not affect this analysis)
    - Fraction of area allowing runoff = 0 percent
    - Runoff curve number = 77.9 (HELP model calculated, Soil No. 21, 0.51% slope-minimum allowed by HELP software, 1 ft slope length) (does not affect this analysis)
    - Length of model run = 10 years (length of run based on length of available data, solar radiation data was synthetically generated for 10 years)

13. Proposed Final Cover Inputs (see also Table 1):

- 6 inch topsoil/vegetative layer
- 12 inch vegetative/protective soil layer
- Geocomposite drainage layer
- Geomembrane
- Geosynthetic Clay Liner (GCL)
- Fair vegetation on cover
- Evaporative zone depth = 22 in. (recommended by HELP Model for fair vegetation conditions for Honolulu, Hawaii). Note that the HELP model uses an actual evaporative zone depth based on the cover soil depths. The maximum evaporative zone depth is limited to 22 inches.
- Maximum leaf area index = 2 (recommended by HELP Model for fair vegetation conditions)
- Fraction of area allowing runoff = 100 percent
- Runoff curve number = 82.9 (HELP model calculated, Soil No. 9, 5% slope, 130 ft slope length)
- Length of model run = 10 years (length of run based on length of available data, solar radiation data was synthetically generated for 10 years)

Help Model General Layout

Table 1: Proposed Final Cover – HELP Model Layout

(Layer Number) Layer Description	Flow	Thickness	Saturated Hydraulic Conductivity	Soil Type/ Texture Number
(1)vertical percolation	↓	6 inches	1.9×10^{-4} cm/sec	Topsoil/Vegetative Layer/#9
(2)vertical percolation	↓	12 inches	4.2×10^{-5} cm/sec	Vegetative/Protective Soil Layer/#12
(3)lateral drainage	→	0.197 inches	$1.0 \times 10^{+1}$ cm/sec	Geocomposite/ #20
(4)40-mil LDPE geomembrane Liner	↓	0.04 inch	4.0×10^{-13} cm/sec	LDPE geomembrane/#36
(5)geosynthetic clay layer	↓	0.25 inches	5.0×10^{-9} cm/sec	GCL/#44

Table 2: Bottom Liner – HELP Model Layout

(Layer Number) Layer Description	Flow	Thickness	Saturated Hydraulic Conductivity	Soil Type/ Texture Number
(1)vertical percolation	↓	12 inches	3.0×10^{-1} cm/sec	gravel/ #21
(2)60-mil HDPE geomembrane Liner	↓	0.06 inch	2.0×10^{-13} cm/sec	geomembrane/#35
(3)Geosynthetic Clay Layer	↓	0.25 inches	5.0×10^{-9} cm/sec	GCL/#44

Table 3: Soil Texture Properties

Soil Texture	Soil Classification		Comments, Properties, and Uses
	USDA	USCS	
21	---	---	Gravel drainage layer. HELP model default soil parameter for gravel, hydraulic conductivity of 3.0×10^{-1} cm/sec
36	---	---	HELP model default parameters for Low Density Polyethylene (LDPE) geomembrane.
35	---	---	HELP model default parameters for High Density Polyethylene (HDPE) geomembrane.
20	---	---	HELP model default parameters for geocomposite (drainage net, 0.5 cm/ 0.197 inches thick)
44	---	---	Based on HELP model default parameter for a bentonite mat (0.6 cm or 0.25 inches thick) with the hydraulic conductivity changed from 3×10^{-9} cm/sec to 5×10^{-9} cm/sec.
12	SiCL	CL	Used for vegetative/protective cover. HELP model default parameter.
9	SiL	ML	Used for topsoil/vegetative cover. HELP model default parameter.

Note: All soil properties are defaults of the HELP Model, Version 3.07 unless otherwise designated.

Calculations

Calculations performed by the HELP Model are included in the output located in Attachments 1 and 2. See Table 4 for the modeling results based on peak average annual values.

Table 4: Calculated Results From HELP Analysis Output

Parameter	Average Annual Value	
	Proposed Final Cover	Permitted Bottom Liner
Total Rainfall	38.05 inches	38.05 inches
Average head: Cover Geomembrane	0.012 inches	---
Infiltration through final cover	0.010 cf/acre	---
Average head: Bottom Liner Geomembrane	---	11.658 inches
Infiltration through bottom liner system	---	10.997 cf/acre

NOTE: Refer to the attached HELP model output files Attachment 1 for the bottom liner, file name "MAALOLNR.out", and Attachment 2 for the proposed final cover, file name "MAALOCVR.out".

Conclusion

The evaluation of the proposed cover shows that the proposed cover allows less infiltration than the permitted bottom liner (see Table 4). The proposed final cover which includes a geocomposite, 40-mil geomembrane, and GCL allows approximately 0.010 cf/acre of surface water infiltration. The permitted bottom liner which includes a 60-mil geomembrane and GCL allows approximately 10.997 cf/acre of infiltration.

Attachment 1

Permitted Bottom Liner HELP Model Output

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    G:\04DEPT03\USERS\VANN\HELP30~1\MAALOLNR.D4
TEMPERATURE DATA FILE:      G:\04DEPT03\USERS\VANN\HELP30~1\MAALOLNR.D7
SOLAR RADIATION DATA FILE:  G:\04DEPT03\USERS\VANN\HELP30~1\MAALOLNR.D13
EVAPOTRANSPIRATION DATA:    G:\04DEPT03\USERS\VANN\HELP30~1\MAALOLNR.D11
SOIL AND DESIGN DATA FILE:  G:\04DEPT03\USERS\VANN\HELP30~1\BASE_HI.D10
OUTPUT DATA FILE:           G:\04DEPT03\USERS\VANN\HELP30~1\MAALOLNR.OUT


TIME:  23:50     DATE:   4/10/2013


******************************************************************************

     TITLE:  Proposed Ma'alo Landfill - Base Liner

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  21
           THICKNESS                   =     12.00   INCHES
           POROSITY                    =      0.3970 VOL/VOL
           FIELD CAPACITY              =      0.0320 VOL/VOL
           WILTING POINT               =      0.0130 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.3970 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC


                                   LAYER  2
```

```
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      2.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                         LAYER  3
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  44
THICKNESS                   =      0.25   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #21 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  1.% AND
          A SLOPE LENGTH OF    1. FEET.

SCS RUNOFF CURVE NUMBER             =     77.90
FRACTION OF AREA ALLOWING RUNOFF    =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =      1.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      0.397  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      0.397  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.013  INCHES
INITIAL SNOW WATER                  =      2.143  INCHES
INITIAL WATER IN LAYER MATERIALS    =      4.951  INCHES
TOTAL INITIAL WATER                 =      7.095  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


           EVAPOTRANSPIRATION AND WEATHER DATA
           -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
```

Lihue Hawaii

STATION LATITUDE	=	21.98 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	0
END OF GROWING SEASON (JULIAN DATE)	=	367
EVAPORATIVE ZONE DEPTH	=	1.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	11.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	70.00 %

NOTE: PRECIPITATION DATA FOR LIHUE HAWAII
WAS ENTERED FROM AN ASCII DATA FILE.

NOTE: TEMPERATURE DATA FOR LIHUE HAWAII
WAS ENTERED FROM AN ASCII DATA FILE.

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR HONOLULU HAWAII
AND STATION LATITUDE = 21.98 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 2003 THROUGH 2012

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	4.61	8.32	1.53	2.15	1.29
	1.65	1.90	1.51	2.63	3.63	5.49
STD. DEVIATIONS	2.22	3.16	11.17	0.65	2.76	0.71
	1.14	1.96	0.82	2.03	2.11	6.01
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	3.284	3.377	4.571	4.867	3.901	3.077

	2.132	2.163	1.981	2.131	3.282	3.275
STD. DEVIATIONS	1.712	1.460	2.057	2.292	3.111	2.978
	2.383	2.393	1.886	1.778	1.738	1.842

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0003	0.0002	0.0003	0.0003	0.0003	0.0002
	0.0003	0.0003	0.0002	0.0003	0.0003	0.0003
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	11.7659	11.6963	11.8288	11.7574	11.6201	11.5933
	11.5734	11.5051	11.5722	11.5940	11.7043	11.6834
STD. DEVIATIONS	0.2600	0.2808	0.3209	0.2563	0.3044	0.2668
	0.2160	0.2816	0.1688	0.2363	0.2545	0.3841

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 2003 THROUGH 2012

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.05	(12.814)	138121.5	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	38.040	(14.6453)	138086.77	99.975
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00303	(0.00005)	10.997	0.00796
AVERAGE HEAD ON TOP OF LAYER 2	11.658	(0.116)		
CHANGE IN WATER STORAGE	-0.208	(8.5924)	-754.29	-0.546

****

****

PEAK DAILY VALUES FOR YEARS 2003 THROUGH 2012

	(INCHES)	(CU. FT.)
PRECIPITATION	8.86	32161.799
RUNOFF	0.000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000009	0.03145
AVERAGE HEAD ON TOP OF LAYER 2	12.000	
SNOW WATER	0.00	0.0000

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3970
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0130

****

****

FINAL WATER STORAGE AT END OF YEAR 2012

LAYER	(INCHES)	(VOL/VOL)
1	4.7639	0.3970
2	0.0000	0.0000
3	0.1875	0.7500
SNOW WATER	0.065	

****
****

Attachment 2

Proposed Final Cover HELP Model Output

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    G:\04DEPT03\USERS\VANN\HELP30~1\MAALOCVR.D4
TEMPERATURE DATA FILE:      G:\04DEPT03\USERS\VANN\HELP30~1\MAALOCVR.D7
SOLAR RADIATION DATA FILE:  G:\04DEPT03\USERS\VANN\HELP30~1\MAALOCVR.D13
EVAPOTRANSPIRATION DATA:    G:\04DEPT03\USERS\VANN\HELP30~1\MAALOCVR.D11
SOIL AND DESIGN DATA FILE:  G:\04DEPT03\USERS\VANN\HELP30~1\COVER_HI.D10
OUTPUT DATA FILE:           G:\04DEPT03\USERS\VANN\HELP30~1\MAALOCVR.OUT


TIME:  23:49     DATE:   4/10/2013


******************************************************************************

     TITLE:  Proposed Ma'alo Landfill - Final Cover Performance

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
           THICKNESS                   =      6.00   INCHES
           POROSITY                    =      0.5010 VOL/VOL
           FIELD CAPACITY              =      0.2840 VOL/VOL
           WILTING POINT               =      0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2953 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                        LAYER  2
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  12
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4710 VOL/VOL
FIELD CAPACITY              =      0.3420 VOL/VOL
WILTING POINT               =      0.2100 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2463 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.419999997000E-04 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  20
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3119 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
SLOPE                       =      5.00   PERCENT
DRAINAGE LENGTH             =    130.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      2.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  5
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  44
THICKNESS                   =      0.25   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

```
NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A
         FAIR STAND OF GRASS, A SURFACE SLOPE OF  5.%
         AND A SLOPE LENGTH OF  130. FEET.

SCS RUNOFF CURVE NUMBER             =     82.90
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =     18.2    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      4.789  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.825  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      3.331  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =      4.976  INCHES
TOTAL INITIAL WATER                 =      4.976  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

```
NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         Lihue                 Hawaii

    STATION LATITUDE                       =  21.98 DEGREES
    MAXIMUM LEAF AREA INDEX                =   2.00
    START OF GROWING SEASON (JULIAN DATE)  =      0
    END OF GROWING SEASON (JULIAN DATE)    =    367
    EVAPORATIVE ZONE DEPTH                 =  18.2  INCHES
    AVERAGE ANNUAL WIND SPEED              =  11.60 MPH
    AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  72.00 %
    AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  66.00 %
    AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  66.00 %
    AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %


NOTE:  PRECIPITATION DATA FOR     LIHUE               HAWAII
         WAS ENTERED FROM AN ASCII DATA FILE.


NOTE:  TEMPERATURE DATA FOR     LIHUE               HAWAII
         WAS ENTERED FROM AN ASCII DATA FILE.


NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
```

COEFFICIENTS FOR HONOLULU HAWAII
AND STATION LATITUDE = 21.98 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 2003 THROUGH 2012

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	4.61	8.32	1.53	2.15	1.29
	1.65	1.90	1.51	2.63	3.63	5.49
STD. DEVIATIONS	2.22	3.16	11.17	0.65	2.76	0.71
	1.14	1.96	0.82	2.03	2.11	6.01
RUNOFF						
TOTALS	0.286	0.922	2.810	0.000	0.239	0.000
	0.081	0.072	0.001	0.053	0.196	0.954
STD. DEVIATIONS	0.478	1.179	5.324	0.001	0.747	0.000
	0.212	0.223	0.005	0.088	0.294	2.123
EVAPOTRANSPIRATION						
TOTALS	2.513	2.949	3.482	2.167	1.645	1.294
	1.419	1.900	1.502	1.898	2.752	2.642
STD. DEVIATIONS	1.102	1.088	1.975	1.279	1.315	0.713
	0.770	1.800	0.788	1.177	1.443	1.294
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.8611	0.6588	2.4646	0.1573	0.2507	0.0000
	0.0000	0.0411	0.0000	0.0089	0.3147	1.5987
STD. DEVIATIONS	1.2214	0.9789	4.6571	0.4973	0.7928	0.0000
	0.0000	0.1299	0.0000	0.0280	0.5564	2.4868
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0197	0.0166	0.0563	0.0037	0.0057	0.0000
	0.0000	0.0009	0.0000	0.0002	0.0074	0.0365
STD. DEVIATIONS	0.0279	0.0248	0.1063	0.0117	0.0181	0.0000
	0.0000	0.0030	0.0000	0.0006	0.0131	0.0568

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 2003 THROUGH 2012

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.05	(12.814)	138121.5	100.00
RUNOFF	5.613	(5.9847)	20376.23	14.752
EVAPOTRANSPIRATION	26.164	(7.1399)	94973.99	68.761
LATERAL DRAINAGE COLLECTED FROM LAYER 3	6.35579	(4.90916)	23071.504	16.70377
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.010	0.00001
AVERAGE HEAD ON TOP OF LAYER 4	0.012	(0.009)		
CHANGE IN WATER STORAGE	-0.083	(2.3472)	-300.25	-0.217

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                PEAK DAILY VALUES FOR YEARS 2003 THROUGH 2012
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              8.86         32161.799

      RUNOFF                                     7.575        27498.4902

      DRAINAGE COLLECTED FROM LAYER  3           1.40974       5117.35254

      PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000001         0.00205

      AVERAGE HEAD ON TOP OF LAYER  4            0.998

      MAXIMUM HEAD ON TOP OF LAYER  4            1.854

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)                8.9 FEET

      SNOW WATER                                 0.00             0.0000


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4542

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1831

       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 2012

LAYER	(INCHES)	(VOL/VOL)
1	0.8148	0.1358
2	3.0859	0.2572
3	0.0611	0.3102
4	0.0000	0.0000
5	0.1875	0.7500
SNOW WATER	0.000	

****
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Appendix E
Gas Extraction System Calculations

Appendix E.1
Gas Generation Analysis

Site Life Calculation

Ma'alo Landfill - Phase 1

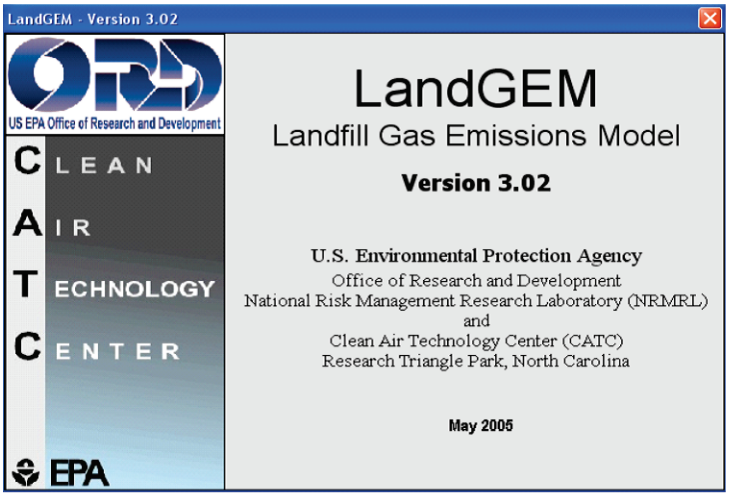
County of Kauai, Hawaii

Annual Increase:	0%	
In-place waste density	1300	pcy, or
Design Volume	4,531,000	cubic yards

Table 1 - Amount of Waste Landfilled and Airspace Consumed

Operation Year	Tonnage Annual Intake TPY	Tonnage Increase TPY	Tonnage Pounds	Annual Consumed Airspace CY	Total Consumed Airspace CY
1	82,000	0	164,000,000	126,154	126,154
2	82,000	0	164,000,000	126,154	252,308
3	82,000	0	164,000,000	126,154	378,462
4	82,000	0	164,000,000	126,154	504,615
5	82,000	0	164,000,000	126,154	630,769
6	82,000	0	164,000,000	126,154	756,923
7	82,000	0	164,000,000	126,154	883,077
8	82,000	0	164,000,000	126,154	1,009,231
9	82,000	0	164,000,000	126,154	1,135,385
10	82,000	0	164,000,000	126,154	1,261,538
11	82,000	0	164,000,000	126,154	1,387,692
12	82,000	0	164,000,000	126,154	1,513,846
13	82,000	0	164,000,000	126,154	1,640,000
14	82,000	0	164,000,000	126,154	1,766,154
15	82,000	0	164,000,000	126,154	1,892,308
16	82,000	0	164,000,000	126,154	2,018,462
17	82,000	0	164,000,000	126,154	2,144,615
18	82,000	0	164,000,000	126,154	2,270,769
19	82,000	0	164,000,000	126,154	2,396,923
20	82,000	0	164,000,000	126,154	2,523,077
21	82,000	0	164,000,000	126,154	2,649,231
22	82,000	0	164,000,000	126,154	2,775,385

23	82,000	0	164,000,000	126,154	2,901,538
24	82,000	0	164,000,000	126,154	3,027,692
25	82,000	0	164,000,000	126,154	3,153,846
26	82,000	0	164,000,000	126,154	3,280,000
27	82,000	0	164,000,000	126,154	3,406,154
28	82,000	0	164,000,000	126,154	3,532,308
29	82,000	0	164,000,000	126,154	3,658,462
30	82,000	0	164,000,000	126,154	3,784,615
31	82,000	0	164,000,000	126,154	3,910,769
32	82,000	0	164,000,000	126,154	4,036,923
33	82,000	0	164,000,000	126,154	4,163,077
34	82,000	0	164,000,000	126,154	4,289,231
35	82,000	0	164,000,000	126,154	4,415,385
36	82,000	0	164,000,000	126,154	4,541,538
37	82,000	0	164,000,000	126,154	4,667,692
38	82,000	0	164,000,000	126,154	4,793,846
39	82,000	0	164,000,000	126,154	4,920,000
40	82,000	0	164,000,000	126,154	5,046,154
41	82,000	0	164,000,000	126,154	5,172,308
42	82,000	0	164,000,000	126,154	5,298,462
43	82,000	0	164,000,000	126,154	5,424,615
44	82,000	0	164,000,000	126,154	5,550,769
45	82,000	0	164,000,000	126,154	5,676,923
46	82,000	0	164,000,000	126,154	5,803,077
47	82,000	0	164,000,000	126,154	5,929,231
48	82,000	0	164,000,000	126,154	6,055,385
49	82,000	0	164,000,000	126,154	6,181,538
50	82,000	0	164,000,000	126,154	6,307,692
51	82,000	0	164,000,000	126,154	6,433,846
52	82,000	0	164,000,000	126,154	6,560,000
53	82,000	0	164,000,000	126,154	6,686,154
54	82,000	0	164,000,000	126,154	6,812,308



Summary Report

Landfill Name or Identifier: Ma'alo Landfill, County of Kaua'i, HI

Date: Thursday, June 27, 2013

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} k L_o \left(\frac{M_i}{10} \right) e^{-k t_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation *(m^3/year)*
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate *($year^{-1}$)*
L_o = potential methane generation capacity *(m^3/Mg)*

M_i = mass of waste accepted in the ith year *(Mg)*
t_{ij} = age of the jth section of waste mass M_i accepted in the ith year *(decimal years, e.g., 3.2 years)*

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**2020**	
Landfill Closure Year (with 80-year limit)	**2055**	
Actual Closure Year (without limit)	***2055***	
Have Model Calculate Closure Year?	**Yes**	
Waste Design Capacity	**2,945,146**	*short tons*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*year^{-1}*
Potential Methane Generation Capacity, L_o	**170**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

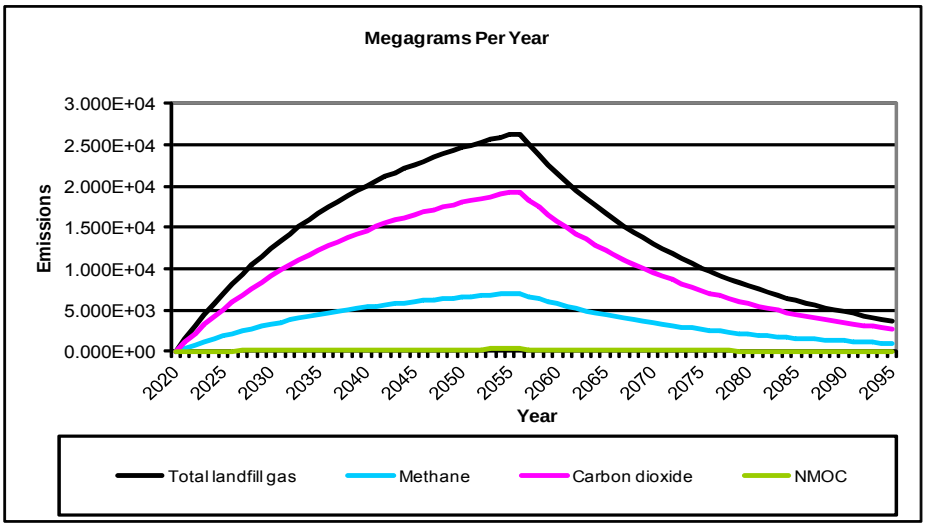
GASES / POLLUTANTS SELECTED

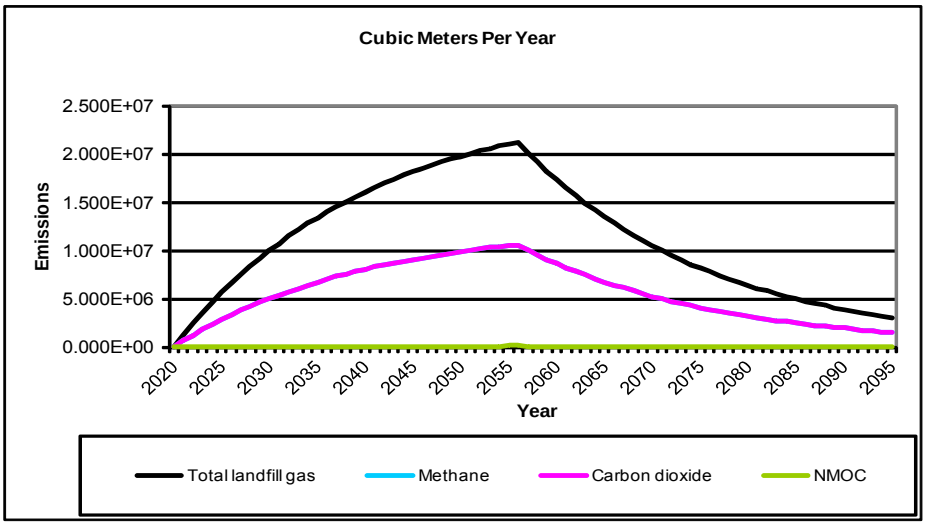
Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

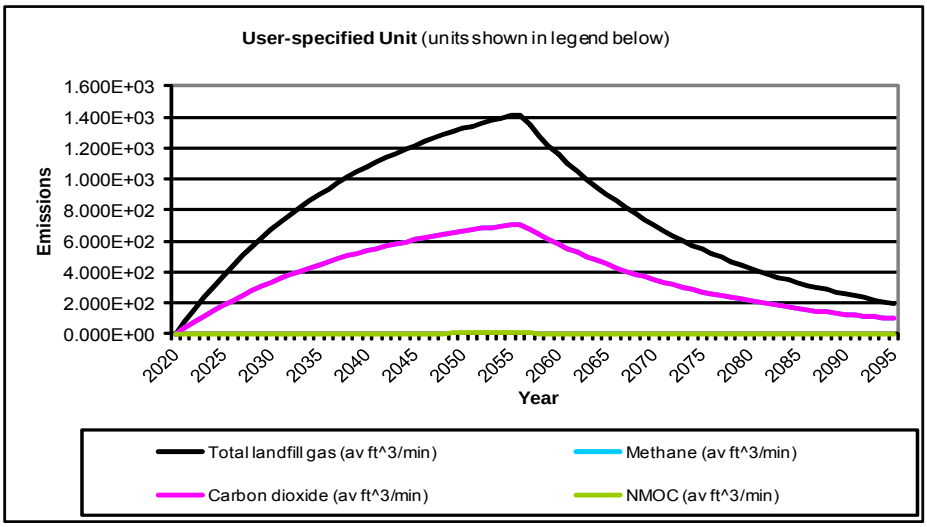
WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2020	74,545	82,000	0	0
2021	74,545	82,000	74,545	82,000
2022	74,545	82,000	149,091	164,000
2023	74,545	82,000	223,636	246,000
2024	74,545	82,000	298,182	328,000
2025	74,545	82,000	372,727	410,000
2026	74,545	82,000	447,273	492,000
2027	74,545	82,000	521,818	574,000
2028	74,545	82,000	596,364	656,000
2029	74,545	82,000	670,909	738,000
2030	74,545	82,000	745,455	820,000
2031	74,545	82,000	820,000	902,000
2032	74,545	82,000	894,545	984,000
2033	74,545	82,000	969,091	1,066,000
2034	74,545	82,000	1,043,636	1,148,000
2035	74,545	82,000	1,118,182	1,230,000
2036	74,545	82,000	1,192,727	1,312,000
2037	74,545	82,000	1,267,273	1,394,000
2038	74,545	82,000	1,341,818	1,476,000
2039	74,545	82,000	1,416,364	1,558,000
2040	74,545	82,000	1,490,909	1,640,000
2041	74,545	82,000	1,565,455	1,722,000
2042	74,545	82,000	1,640,000	1,804,000
2043	74,545	82,000	1,714,545	1,886,000
2044	74,545	82,000	1,789,091	1,968,000
2045	74,545	82,000	1,863,636	2,050,000
2046	74,545	82,000	1,938,182	2,132,000
2047	74,545	82,000	2,012,727	2,214,000
2048	74,545	82,000	2,087,273	2,296,000
2049	74,545	82,000	2,161,818	2,378,000
2050	74,545	82,000	2,236,364	2,460,000
2051	74,545	82,000	2,310,909	2,542,000
2052	74,545	82,000	2,385,455	2,624,000
2053	74,545	82,000	2,460,000	2,706,000
2054	74,545	82,000	2,534,545	2,788,000
2055	68,315	75,146	2,609,091	2,870,000
2056	0	0	2,677,405	2,945,146
2057	0	0	2,677,405	2,945,146
2058	0	0	2,677,405	2,945,146
2059	0	0	2,677,405	2,945,146

Graphs


Megagrams Per Year
Emissions
3.000E+04
2.500E+04
2.000E+04
1.500E+04
1.000E+04
5.000E+03
0.000E+00
2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
Emissions
2.500E+07
2.000E+07
1.500E+07
1.000E+07
5.000E+06
0.000E+00
2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
Emissions
1.600E+03
1.400E+03
1.200E+03
1.000E+03
8.000E+02
6.000E+02
4.000E+02
2.000E+02
0.000E+00
2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2020	0	0	0	0	0	0
2021	1.548E+03	1.239E+06	8.326E+01	4.134E+02	6.196E+05	4.163E+01
2022	3.020E+03	2.418E+06	1.625E+02	8.066E+02	1.209E+06	8.123E+01
2023	4.420E+03	3.539E+06	2.378E+02	1.181E+03	1.770E+06	1.189E+02
2024	5.752E+03	4.606E+06	3.095E+02	1.536E+03	2.303E+06	1.547E+02
2025	7.019E+03	5.620E+06	3.776E+02	1.875E+03	2.810E+06	1.888E+02
2026	8.224E+03	6.586E+06	4.425E+02	2.197E+03	3.293E+06	2.212E+02
2027	9.371E+03	7.504E+06	5.042E+02	2.503E+03	3.752E+06	2.521E+02
2028	1.046E+04	8.377E+06	5.628E+02	2.794E+03	4.188E+06	2.814E+02
2029	1.150E+04	9.207E+06	6.186E+02	3.071E+03	4.604E+06	3.093E+02
2030	1.249E+04	9.998E+06	6.717E+02	3.335E+03	4.999E+06	3.359E+02
2031	1.342E+04	1.075E+07	7.222E+02	3.586E+03	5.375E+06	3.611E+02
2032	1.432E+04	1.146E+07	7.703E+02	3.824E+03	5.732E+06	3.851E+02
2033	1.517E+04	1.214E+07	8.160E+02	4.051E+03	6.072E+06	4.080E+02
2034	1.597E+04	1.279E+07	8.594E+02	4.267E+03	6.396E+06	4.297E+02
2035	1.674E+04	1.341E+07	9.008E+02	4.472E+03	6.703E+06	4.504E+02
2036	1.747E+04	1.399E+07	9.401E+02	4.667E+03	6.996E+06	4.701E+02
2037	1.817E+04	1.455E+07	9.775E+02	4.853E+03	7.274E+06	4.888E+02
2038	1.883E+04	1.508E+07	1.013E+03	5.030E+03	7.539E+06	5.066E+02
2039	1.946E+04	1.558E+07	1.047E+03	5.198E+03	7.791E+06	5.235E+02
2040	2.006E+04	1.606E+07	1.079E+03	5.358E+03	8.031E+06	5.396E+02
2041	2.063E+04	1.652E+07	1.110E+03	5.510E+03	8.259E+06	5.549E+02
2042	2.117E+04	1.695E+07	1.139E+03	5.654E+03	8.475E+06	5.695E+02
2043	2.168E+04	1.736E+07	1.167E+03	5.792E+03	8.682E+06	5.833E+02
2044	2.217E+04	1.776E+07	1.193E+03	5.923E+03	8.878E+06	5.965E+02
2045	2.264E+04	1.813E+07	1.218E+03	6.047E+03	9.065E+06	6.090E+02
2046	2.308E+04	1.848E+07	1.242E+03	6.166E+03	9.242E+06	6.210E+02
2047	2.351E+04	1.882E+07	1.265E+03	6.278E+03	9.411E+06	6.323E+02
2048	2.391E+04	1.914E+07	1.286E+03	6.386E+03	9.572E+06	6.431E+02
2049	2.429E+04	1.945E+07	1.307E+03	6.488E+03	9.724E+06	6.534E+02
2050	2.465E+04	1.974E+07	1.326E+03	6.585E+03	9.870E+06	6.631E+02
2051	2.500E+04	2.002E+07	1.345E+03	6.677E+03	1.001E+07	6.724E+02
2052	2.532E+04	2.028E+07	1.363E+03	6.765E+03	1.014E+07	6.813E+02
2053	2.564E+04	2.053E+07	1.379E+03	6.848E+03	1.026E+07	6.897E+02
2054	2.593E+04	2.077E+07	1.395E+03	6.927E+03	1.038E+07	6.977E+02
2055	2.622E+04	2.099E+07	1.411E+03	7.003E+03	1.050E+07	7.053E+02
2056	2.636E+04	2.111E+07	1.418E+03	7.040E+03	1.055E+07	7.090E+02
2057	2.507E+04	2.008E+07	1.349E+03	6.697E+03	1.004E+07	6.744E+02
2058	2.385E+04	1.910E+07	1.283E+03	6.370E+03	9.548E+06	6.416E+02
2059	2.269E+04	1.817E+07	1.221E+03	6.060E+03	9.083E+06	6.103E+02
2060	2.158E+04	1.728E+07	1.161E+03	5.764E+03	8.640E+06	5.805E+02
2061	2.053E+04	1.644E+07	1.104E+03	5.483E+03	8.218E+06	5.522E+02
2062	1.953E+04	1.564E+07	1.051E+03	5.215E+03	7.818E+06	5.253E+02
2063	1.857E+04	1.487E+07	9.993E+02	4.961E+03	7.436E+06	4.996E+02
2064	1.767E+04	1.415E+07	9.506E+02	4.719E+03	7.074E+06	4.753E+02
2065	1.681E+04	1.346E+07	9.042E+02	4.489E+03	6.729E+06	4.521E+02
2066	1.599E+04	1.280E+07	8.601E+02	4.270E+03	6.400E+06	4.300E+02
2067	1.521E+04	1.218E+07	8.181E+02	4.062E+03	6.088E+06	4.091E+02
2068	1.446E+04	1.158E+07	7.782E+02	3.864E+03	5.791E+06	3.891E+02
2069	1.376E+04	1.102E+07	7.403E+02	3.675E+03	5.509E+06	3.701E+02

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2020	0	0	0	0	0	0
2021	1.134E+03	6.196E+05	4.163E+01	1.777E+01	4.957E+03	3.330E-01
2022	2.213E+03	1.209E+06	8.123E+01	3.467E+01	9.672E+03	6.499E-01
2023	3.239E+03	1.770E+06	1.189E+02	5.075E+01	1.416E+04	9.512E-01
2024	4.215E+03	2.303E+06	1.547E+02	6.604E+01	1.842E+04	1.238E+00
2025	5.144E+03	2.810E+06	1.888E+02	8.058E+01	2.248E+04	1.511E+00
2026	6.027E+03	3.293E+06	2.212E+02	9.442E+01	2.634E+04	1.770E+00
2027	6.868E+03	3.752E+06	2.521E+02	1.076E+02	3.001E+04	2.017E+00
2028	7.667E+03	4.188E+06	2.814E+02	1.201E+02	3.351E+04	2.251E+00
2029	8.427E+03	4.604E+06	3.093E+02	1.320E+02	3.683E+04	2.475E+00
2030	9.150E+03	4.999E+06	3.359E+02	1.433E+02	3.999E+04	2.687E+00
2031	9.838E+03	5.375E+06	3.611E+02	1.541E+02	4.300E+04	2.889E+00
2032	1.049E+04	5.732E+06	3.851E+02	1.644E+02	4.586E+04	3.081E+00
2033	1.112E+04	6.072E+06	4.080E+02	1.741E+02	4.858E+04	3.264E+00
2034	1.171E+04	6.396E+06	4.297E+02	1.834E+02	5.116E+04	3.438E+00
2035	1.227E+04	6.703E+06	4.504E+02	1.922E+02	5.363E+04	3.603E+00
2036	1.281E+04	6.996E+06	4.701E+02	2.006E+02	5.597E+04	3.760E+00
2037	1.332E+04	7.274E+06	4.888E+02	2.086E+02	5.819E+04	3.910E+00
2038	1.380E+04	7.539E+06	5.066E+02	2.162E+02	6.031E+04	4.052E+00
2039	1.426E+04	7.791E+06	5.235E+02	2.234E+02	6.233E+04	4.188E+00
2040	1.470E+04	8.031E+06	5.396E+02	2.303E+02	6.425E+04	4.317E+00
2041	1.512E+04	8.259E+06	5.549E+02	2.368E+02	6.607E+04	4.439E+00
2042	1.551E+04	8.475E+06	5.695E+02	2.430E+02	6.780E+04	4.556E+00
2043	1.589E+04	8.682E+06	5.833E+02	2.490E+02	6.945E+04	4.667E+00
2044	1.625E+04	8.878E+06	5.965E+02	2.546E+02	7.102E+04	4.772E+00
2045	1.659E+04	9.065E+06	6.090E+02	2.599E+02	7.252E+04	4.872E+00
2046	1.692E+04	9.242E+06	6.210E+02	2.650E+02	7.394E+04	4.968E+00
2047	1.723E+04	9.411E+06	6.323E+02	2.699E+02	7.529E+04	5.059E+00
2048	1.752E+04	9.572E+06	6.431E+02	2.745E+02	7.657E+04	5.145E+00
2049	1.780E+04	9.724E+06	6.534E+02	2.789E+02	7.779E+04	5.227E+00
2050	1.807E+04	9.870E+06	6.631E+02	2.830E+02	7.896E+04	5.305E+00
2051	1.832E+04	1.001E+07	6.724E+02	2.870E+02	8.006E+04	5.379E+00
2052	1.856E+04	1.014E+07	6.813E+02	2.908E+02	8.112E+04	5.450E+00
2053	1.879E+04	1.026E+07	6.897E+02	2.943E+02	8.212E+04	5.517E+00
2054	1.901E+04	1.038E+07	6.977E+02	2.978E+02	8.307E+04	5.581E+00
2055	1.921E+04	1.050E+07	7.053E+02	3.010E+02	8.397E+04	5.642E+00
2056	1.932E+04	1.055E+07	7.090E+02	3.026E+02	8.442E+04	5.672E+00
2057	1.837E+04	1.004E+07	6.744E+02	2.878E+02	8.030E+04	5.396E+00
2058	1.748E+04	9.548E+06	6.416E+02	2.738E+02	7.639E+04	5.132E+00
2059	1.663E+04	9.083E+06	6.103E+02	2.605E+02	7.266E+04	4.882E+00
2060	1.582E+04	8.640E+06	5.805E+02	2.478E+02	6.912E+04	4.644E+00
2061	1.504E+04	8.218E+06	5.522E+02	2.357E+02	6.575E+04	4.418E+00
2062	1.431E+04	7.818E+06	5.253E+02	2.242E+02	6.254E+04	4.202E+00
2063	1.361E+04	7.436E+06	4.996E+02	2.132E+02	5.949E+04	3.997E+00
2064	1.295E+04	7.074E+06	4.753E+02	2.028E+02	5.659E+04	3.802E+00
2065	1.232E+04	6.729E+06	4.521E+02	1.929E+02	5.383E+04	3.617E+00
2066	1.172E+04	6.400E+06	4.300E+02	1.835E+02	5.120E+04	3.440E+00
2067	1.114E+04	6.088E+06	4.091E+02	1.746E+02	4.871E+04	3.273E+00
2068	1.060E+04	5.791E+06	3.891E+02	1.661E+02	4.633E+04	3.113E+00
2069	1.008E+04	5.509E+06	3.701E+02	1.580E+02	4.407E+04	2.961E+00

Appendix E.2
Zone of Influence Calculations

Appendix E.2: Calculation of the Spacing of LFG Extraction Wells for Landfill Gas Extraction Systems

Purpose: To present a design procedure for determination of gas extraction well locations and relative placement/spacings.

Method: Utilization of an individual gas extraction well's Darcy radius of influence to determine well spacings to distribute an induced vacuum uniformly throughout the waste disposal area. The concept of radial fluid flow has been used in the petroleum industry for calculating flows in porous rock reservoirs towards oil and natural gas extraction wells.

Objective: As a standard design criterion, landfill gas extraction well spacing by means of the Darcy radius of influence method should indicate a reasonable effective extraction area coverage over the waste disposal area, with minimum overlap or open spaces. Placement of gas extraction wells on side slopes should be minimized to reduce air intrusion.

Definition: The radius of influence (ROI) is the radial distance from an extraction well from which the migration direction of landfill gas will be influenced by an application of vacuum. Since gas is influenced by convection forces (pressure gradient), the radius of influence is established where the measured pressure/vacuum at extreme radius (r_1) of influence is zero.

Darcy radius of influence for radial compressible fluid flow

Discussion: Darcy equation, for radial fluid flow

$$v = \left(\frac{g_C \ k}{\mu} \right) \left(\frac{dP}{dr} \right) \quad equation\ (1)$$

Where:

g_c	=	acceleration of gravity constant = 32.2 (lb_M-ft/lb_F-sec^2)
V	=	apparent flow velocity in (ft/sec) units
μ	=	absolute viscosity of the flowing fluid (landfill gas) in (lb_M/ft-sec) units
K	=	absolute permeability of the porous media (refuse) in (ft^2) units
dP	=	pressure gradient in the direction of radial flow in (lb_F/ft^2) units
dr	=	radial distance gradient in (ft) units

Definition: Permeability is defined as a measure of a porous media's ability to transmit fluids.

Assumptions necessary to develop the basic flow equations:

- Steady-state flow conditions exist/
- The pore space of the refuse is 100 percent saturated with the flowing fluid (landfill gas)/
- The viscosity of the flowing fluid is constant.
- Isothermal conditions in the refuse prevail.
- Flow is laminar, horizontal, and linear since refuse grain size is relatively small and the velocity of the fluid flow is low.

Please refer to the ideal radial flow system diagram (Figure 1). With these assumptions in mind, let

$$v = \frac{q}{A}$$

Where:

v	=	the apparent velocity of the flowing fluid (gas)
q	=	volumetric rate of fluid (gas) flow
A	=	total cross-sectional area perpendicular to flow direction
h_s	=	total extraction well length of slotted pipe

Substitute in equation (1):

$$q / A = \left(\frac{g_C \ k}{\mu} \right) \left(\frac{dP}{dr} \right) \quad equation\ (2)$$

with: A = $2\pi r h_s$ and rearranging

$$q = \left(\frac{2\pi r h_S \ g_C \ k}{\mu} \right) \left(\frac{dP}{dr} \right) \quad equation\ (3)$$

Since landfill gas is a compressible fluid, its viscosity and flow characteristics must be corrected to standard conditions.

When a flowing fluid is compressible, then q is not constant, but is a function of pressure and temperature $f(P,T)$. An expression for the standard flow rate of a gas (q_s) is obtained from Charles' law, assuming ideal gas behavior at standard conditions:

$$\frac{P_1 \ q_1}{T_1} = \frac{P_2 \ q_2}{T_2} = constant = \frac{P_S \ q_S}{T_S} \quad - \quad at\ standard\ conditions$$

Substitution in equation (3):

$$\frac{P_S \ q_S}{T_S} = \frac{Pq}{T} = \left(\frac{2\pi r h_S \ g_C \ k}{\mu \ T} \right) \left(\frac{PdP}{dr} \right) = constant$$

Where:

T_s	=	standard temperature = 60(°F) = 520(°R) constant
P_s	=	standard pressure = 14.7 (psia) = 2,116.8 (lb_F/ft^2) constant
T	=	flowing temperature of the fluid (landfill gas)

Therefore:

$$\frac{P_S q_S}{T_S} = \left(\frac{2\pi r h_S g_C k}{\mu T} \right) \left(\frac{PdP}{dr} \right) \quad equation\ (4)$$

let q_s = standard volumetric rate of fluid flow

$$q_S = (dG / dt) V\rho = (dG / dt) \pi r^2 h_T \rho$$

Where:

(dG/dt)=		landfill gas generation rate
V	=	volume of well influence, assuming uniform cylindrical geometry
V	=	$\pi r^2 h_T$
ρ	=	density of refuse; for the purposes of this calculation, assume
ρ	=	1,300 (lb_M/yd^3) = 48.15 (lb_M/ft^3)
h_T	=	total extraction well length (total well depth)

This approach assumes that all conditions are uniform, and that all gas generated at radius r_1 is extracted. Actually, only a fraction of the gas generated at some distance *"r"* from the well would be extracted, and this fraction would decrease as the radius increases.

Please refer to the ideal radial flow system diagram (Figure 1).

Substitution in equation (4):

$$\frac{P_S\,(dG/dt)\,\pi r^2\,h_T\,\rho}{T_S} = \left(\frac{2\pi r h_S\,g_C\,k}{\mu T}\right)\left(\frac{PdP}{dr}\right) \qquad equation\,(5)$$

Simplification, separation of variables, and insertion of system limits in equation (5):

$$\int_{r_0}^{r_1} r dr = \frac{2 g_C\,k T_S (h_S/h_T)}{P_S (dG/dT)\,\rho\mu T} \int_{P_0}^{P_1} PdP$$

Where:

r_o	=	radius of the extraction well pipe
r_1	=	the darcy radius of influence

Which when integrated:

$$\frac{(r_1^2 - r_0^2)}{2} = \left[\frac{g_C\,k T_S (h_S/h_T)}{P_S (dG/dt)\,\rho\mu T}\;x\;(P_1^2 - P_0^2)\right]$$

Solving for radius of influence *(r_1)*:

$$r_1 = \left[\frac{2 g_C\,k T_S (h_S/h_T)}{P_S (dG/dt)\,\rho\mu T}(P_1^2 - P_0^2) + r_0^2\right]^{1/2} \qquad equation\,(6)$$

This is the Darcy radius of influence equation.

Since a concentric cylindrical surface at distances r_1 and r_0 are assumed, perpendicular gas flow across the surface at r_1 must be much greater than that across the surface at r_0 and since $r_0 <<< r_1$, then r_0 is negligible and:

$$r_1 = \left[\frac{2 g_C K T_S (h_S / h_T)}{P_S (dG / dt) \rho \mu T} (P_1^2 - P_0^2) \right]^{1/2} \quad equation(7)$$

The maximum vacuum that can be applied in a gas extraction well is usually dependent on the length of solid pipe section specified. The relationship is that as the length of solid pipe section increases, the potential of air intrusion through the cover or side slopes decreases, therefore allowing more vacuum to be applied to the gas extraction well to maximize its effective radius of well influence. The average reasonable applied vacuum at the wellhead *(P_o)* for an active gas extraction system must be anticipated by the designer to calculate the Darcy radius of influence.

Table E.3-1 is a guideline of reasonable applied vacuum values to be utilized in equation (7).

Table E.3-1: Reasonable Applied Vacuum Values

length of solid pipe (ft)	applied vacuum (A W.C.)	applied vacuum (lb_F / ft) absolute
15	1.0	2,111.6
20	2.0	2,106.4
25	3.0	2,101.2
30	4.0	2,096.0
35	5.0	2,090.8
40	6.0	2,085.6

The following calculation demonstrates how the Darcy radius of influence can be determined for a conceptual gas extraction well location plan.

Assumptions

Average landfill gas composition:

percent methane (CH_4)	=	50 %
percent carbon dioxide (CO_2)	=	45 %
percent air (N_2/O_2)	=	5 %
Total	=	100 %

Average flowing landfill gas temperature *(T)* = 86 (°F) = 546(°R)

Average reasonable gas generation rate *(dG/dt)* = 0.128 (ft^3/lb_M–yr)

or *(dG/dt)* = 4.059×10^{-9}(ft^3/lb_M–sec)

Average reasonable applied vacuum at the wellhead *(P_o)* for an active gas extraction system with a 20-foot length of solid pipe:

P_o = 1 (inches of water column)

= 0.036 (psig)

= 2,111.6 (lb_F/ft^2) absolute

Conversion: 1.0 (psig) = 27.7 (inches of water column)

Average reasonable absolute permeability of refuse *(k)*.

k = $1.54 \times 10^{-10}(ft^2)$ [Waste Sites as Biological Reactors – Characterization and Modeling; Miller, P, 2003 Lewis Publishers]

Typical gas absolute viscosity at standard temperature conditions = 60(°F)

Absolute Viscosity Reference Values

methane (CH_4)	=	7.1×10^{-6} (lb_M/ft–sec)
carbon dioxide (CO_2)	=	9.8×10^{-6} (lb_M/ft–sec)
air (N_2/O_2)	=	1.2×10^{-5} (lb_M/ft–sec)

Standard landfill gas viscosity *(μ)* at 60(°F):

μ = $(0.5)(7.1 \times 10^{-6}) + (0.45)(9.8 \times 10^{-6}) + (0.05)(1.2 \times 10^{-5})$

μ = 8.56×10^{-6} (lb_M/ft–sec)

Determine the ratio of slotted pipe to total pipe section for typical gas extraction wells as specified by the designer.

Typical ratio value (h_s / h_T) = 0.8, assuming 15 foot of slot in a 75 foot well.

Constants utilized in the darcy radius of well influence, equation (7):

g_c	=	acceleration of gravity constant = 32.2 (lb_M–ft / lb_F –sec^2)
T_s	=	standard temperature = 520 (°R)
P_s	=	standard pressure = 2,116.8 (lb_F /ft^2)
ρ	=	density of refuse = 48.15 (lb_M /ft^3)
P_1	=	pressure/vacuum at extreme radius (r_1) of influence convention pressure gradient
P_1	=	0 (inches of water column)
P_1	=	0 (psig) = 14.7 (psia) absolute
P_1	=	2,116.8 (lb_F /ft^2) absolute

Note that $P_1 = P_s$ = 2,116.8 (lb_F /ft^2) absolute atmospheric pressure.

$$r_1 = \left[\frac{(2 \times 32.2)(1.54 \times 10^{-10})(520)(0.8)[(2{,}116.8)^2 - (2{,}111.6)^2]}{(2{,}116.8)(8.12 \times 10^{-9})(48.15)(8.56 \times 10^{-6})(546)} \right]^{1/2}$$

Substitute in equation (7) to derive the darcy radius of influence for a typical gas extraction well.

$$r_1 = \left[4.655 \times 10^4 (ft^2) \right]^{1/2}$$

Therefore: r_1 = 216 (ft) radius of well influence.

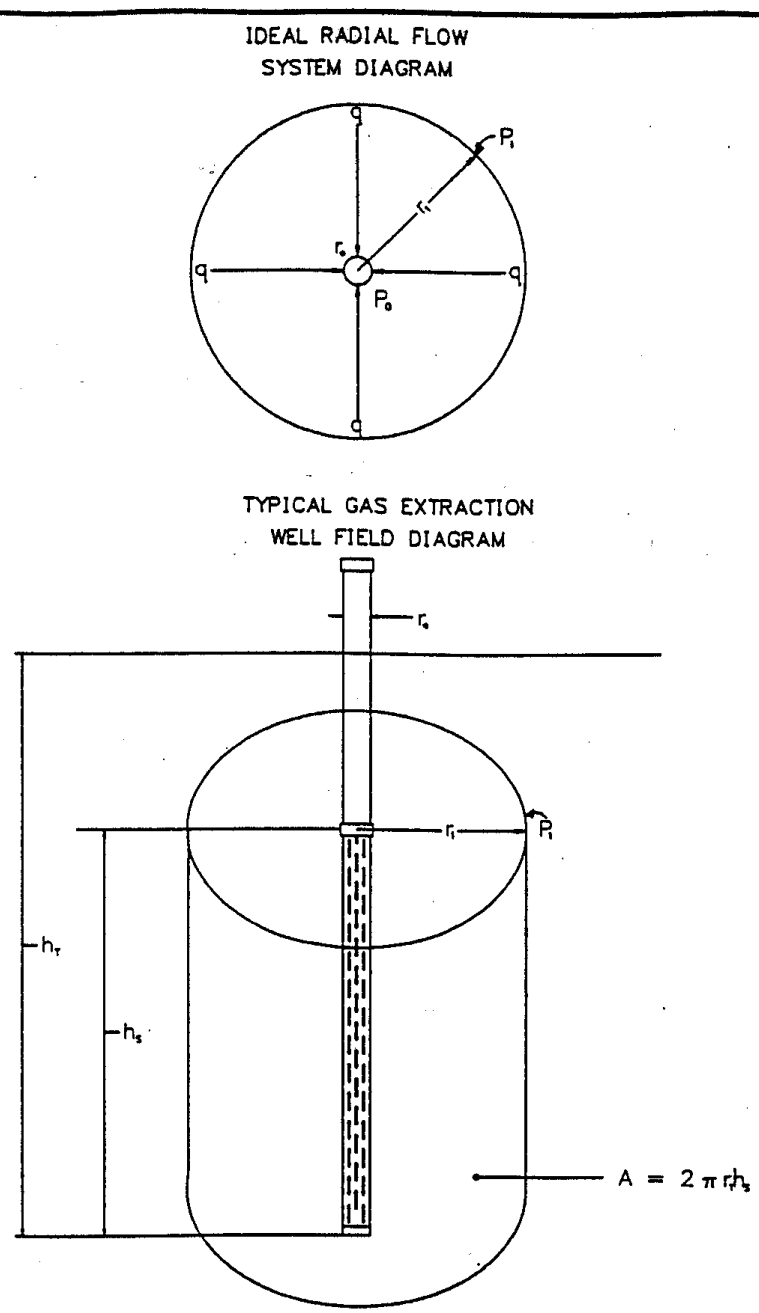


FIGURE 1: DARCY RADIUS OF INFLUENCE CONCEPTS

General Assumptions for Radius of Influence Calculation

The careful formulation of assumptions is critical and requires some knowledge of the landfill's characteristics.

Gas Generation Rate:

Landfill gas is the by-product of the anaerobic decomposition of organic material disposed of in a landfill, by methanogenic (methane producing) bacteria. Landfill gas production is assumed to have a first order reaction rate and is dependent upon the following:

- age of the landfill
- types of waste received
- location (i.e., climate and precipitation)
- moisture conditions within the refuse
- landfill cover materials and thicknesses

EPA's AP-42 "k" factor value of 0.050 $year^{-1}$ will be used. To convert this to English units for use in the ROI program, the k value must be multiplied by the theoretical yield. The theoretical yield from AP-42 is assumed to be 170 m^3 methane/Mg waste, which converts to 2.57 ft^3/lb waste. The gas generation rate is therefore, 0.129 ft^3 LFG/lb refuse/year (4.091 x 10^{-9} ft^3 LFG/lb refuse/second).

Permeability Factor:

Permeability is defined as a measure of the ability of a porous media to transmit fluids. While the permeability of refuse within a landfill can vary greatly, it is assumed to be a constant for ease of calculation. A reasonable absolute permeability value for refuse is 2.68×10^{-10} (ft^2) based on various research studies at landfills. This number was calculated by applying Darcy's Law for Linear Compressible Fluid Flow to the movement of landfill gas through refuse and assuming the following:

- Steady state flow conditions exist.
- The pore space of the refuse is 100 percent saturated with the flowing fluid (landfill gas).
- The viscosity of the flowing fluid is constant.
- Isothermal conditions in the refuse prevail.
- Flow is laminar, horizontal, and linear since refuse grain size is relatively small and the velocity of fluid flow is low.

Refuse Density:

Refuse density is a function of the types of waste received, the ratio of soils used for daily and intermediate cover, and the degree of compaction at the landfill site. A refuse density of 1,300 lbs/yd^3 will be used for the calculations for the facility based on average historical densities measured at other sites in the state.

Gas Temperature:

The temperatures within a landfill can influence the movement of landfill gas in two ways. First, since landfill gas is a compressible fluid, its viscosity and flow characteristics must be corrected to standard temperature and pressure conditions prior to using the Darcy Equation for radial fluid flow.

Secondly, a landfill's interior temperature can affect the rate at which landfill gas is generated since different types of bacteria are present at different temperatures. Methanogens (or methane producing bacteria) that generate landfill gas at temperatures below 110°F are known as mesophilic

bacteria, while those that generate gas at temperatures in excess of 110°F are called thermophilic bacteria. Although both types of bacteria produce approximately the same quality of gas, the gas generation rate is optimized in the thermophilic range.

Average Cover Depth:

The average thickness of final cover is subtracted from the refuse depth available for gas production. Soil is inert and will not contribute to the generation of landfill gas.

Maximum Radius of Influence:

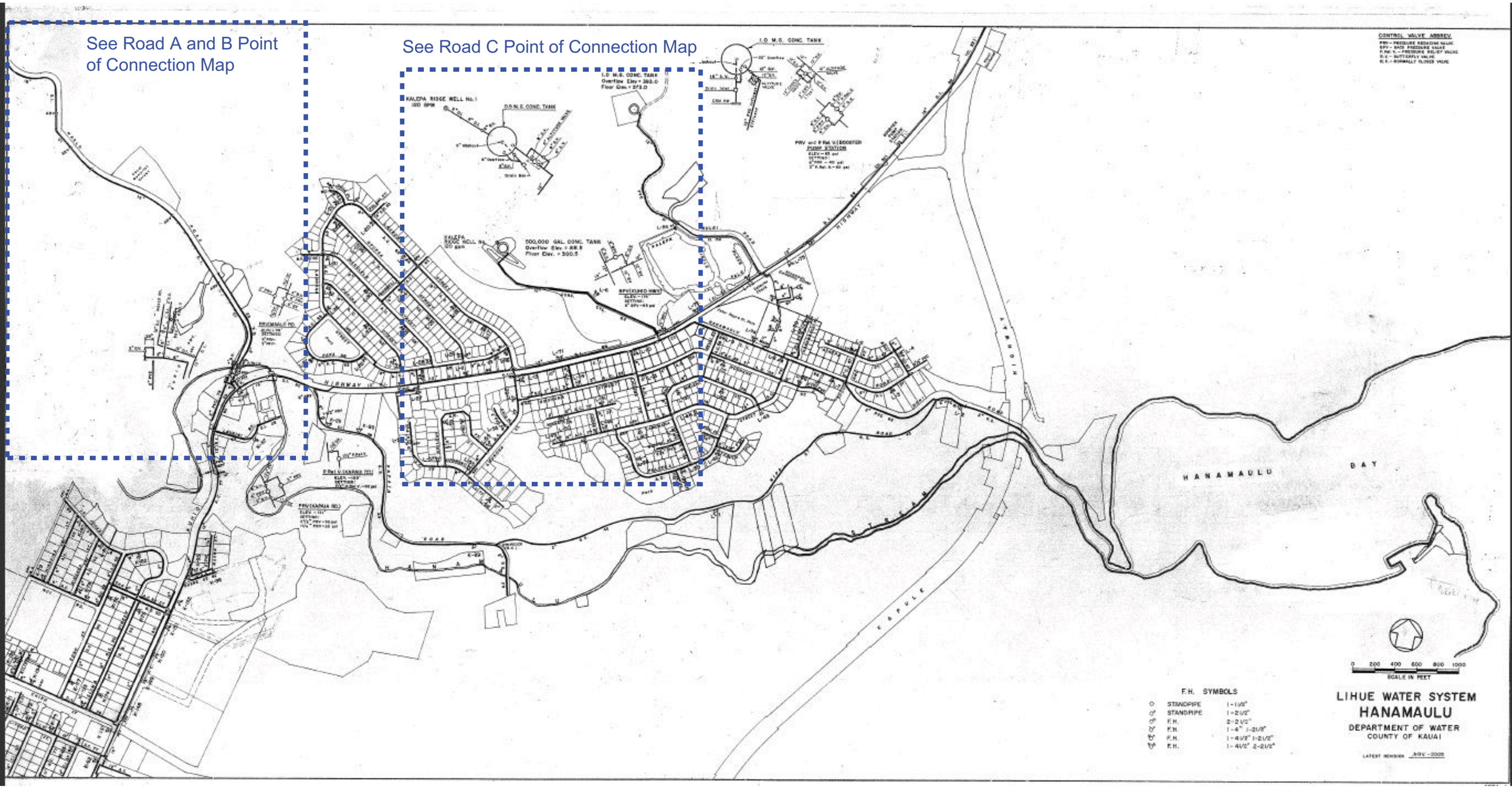
A maximum ROI of 216 feet was calculated for the facility based on the final cover system proposed at the site. However, all new extraction wells will be placed approximately 350 feet apart to accommodate waste variations.

Average Overlap Factor:

It is desirable to achieve a certain degree of overlap of the circular ROIs. Since the calculations are theoretical to begin with, the overlap provides a factor of safety to the gas control system design. If field conditions prevent gas from moving towards a particular well, an overlap helps ensure that the gas can travel to more than one collection point.

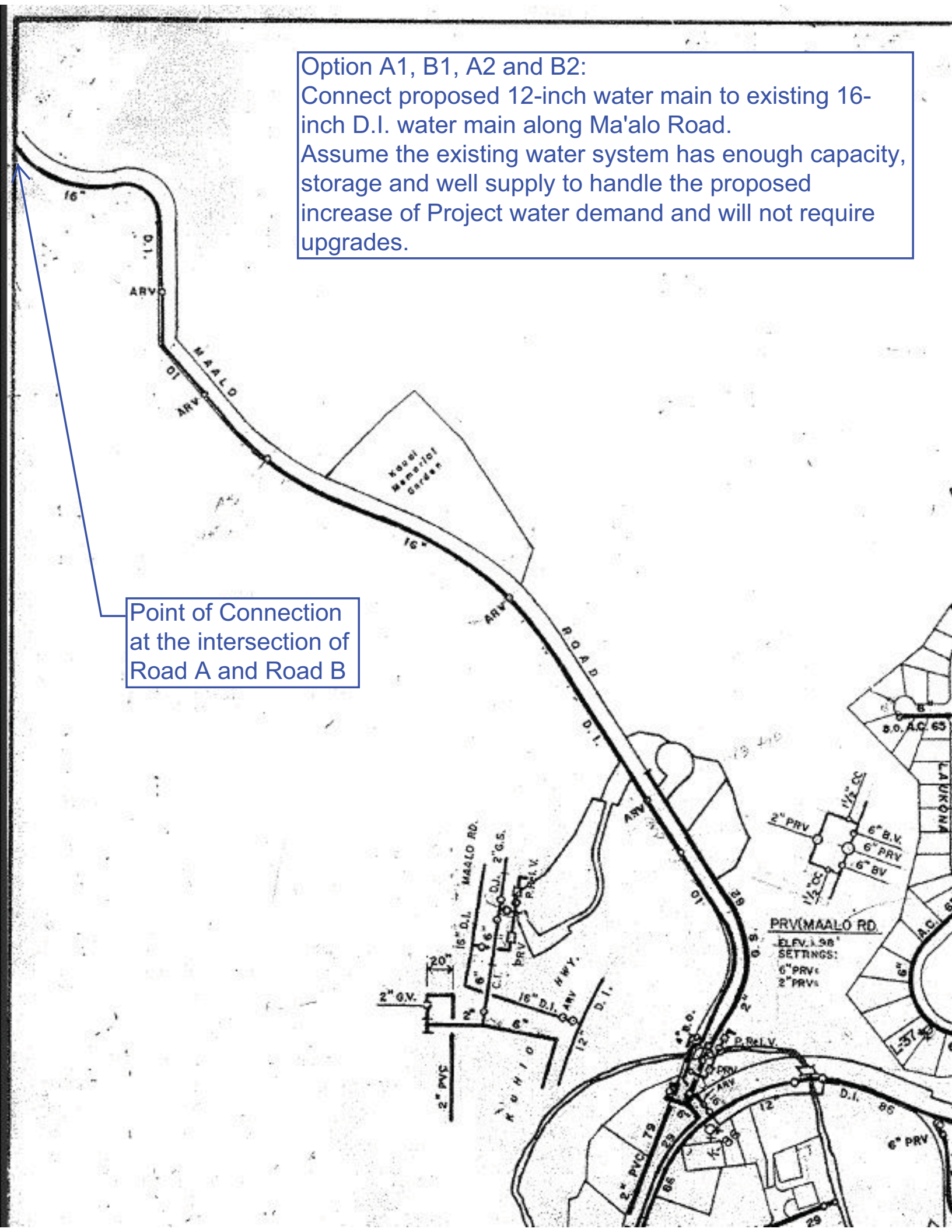
The target range of overlap values is typically 10 to 15 percent, unless the designer requires a denser well spacing. The overlap value used for the facility’s proposed well spacing is approximately 10%.

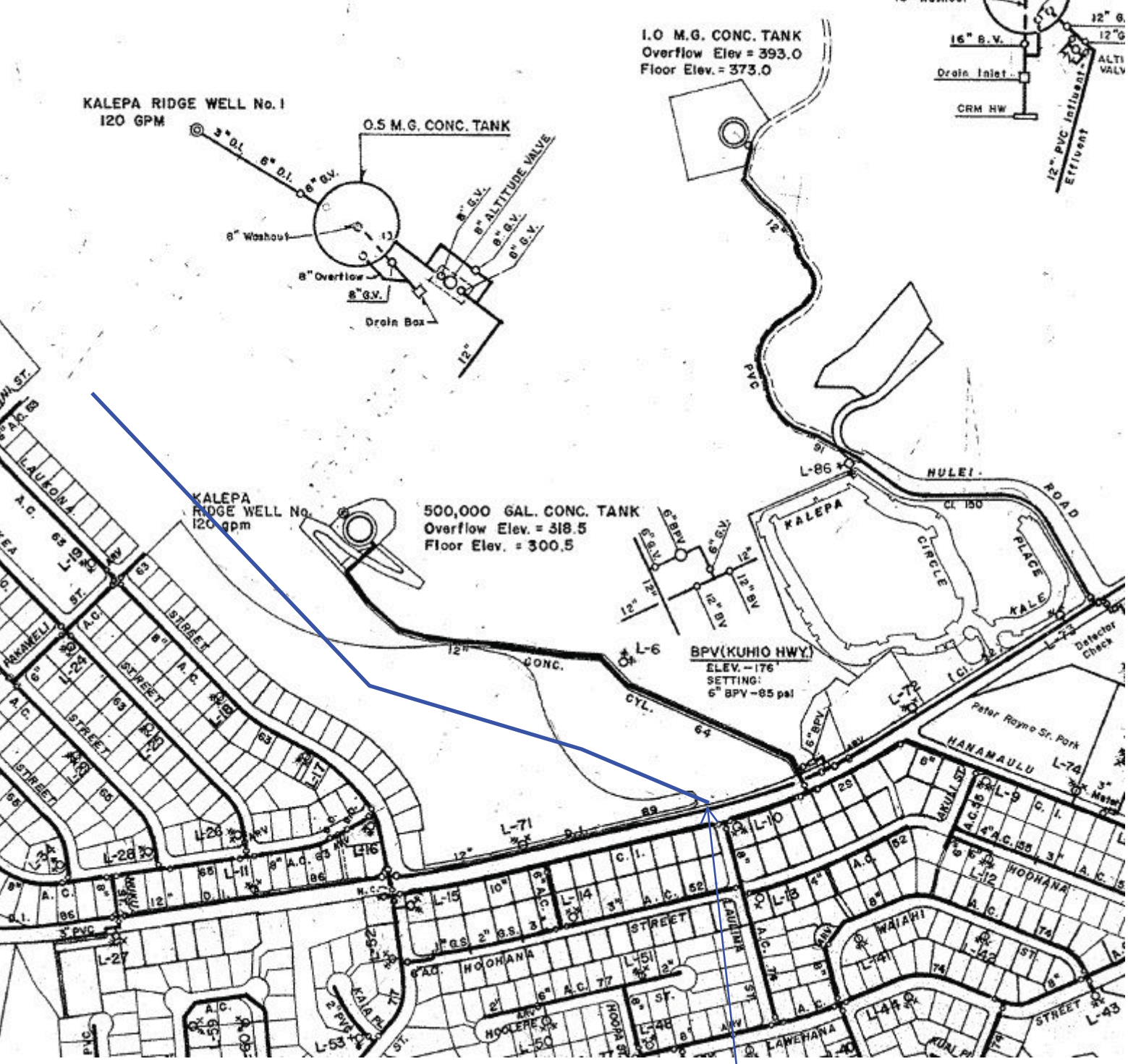
Appendix F:
Water and Wastewater Points of Connection


See Road A and B Point of Connection Map
See Road C Point of Connection Map
CONTROL VALVE ABBREV.
PRV - PRESSURE REDUCING VALVE
SPV - SUCT PRESSURE VALVE
P.R.V. - PRESSURE RELIEF VALVE
B.V. - BUTTERFLY VALVE
N.C. - NORMALLY CLOSED VALVE
I.D. M.S. CONC. TANK
KALEPA RIDGE WELL No. 1
D.S.N.S. CONC. TANK
500,000 GAL. CONC. TANK
PRV and P.R.V. (BOOSTER PUMP STATION)
HANAMAULU BAY
KAPULE
HIGHWAY
ROAD
STREET
F.H. SYMBOLS
STANDPIPE 1-1 1/2"
STANDPIPE 1-2 1/2"
F.H. 2-2 1/2"
F.H. 1-4" 1-2 1/2"
F.H. 1-4 1/2" 1-2 1/2"
F.H. 1-4 1/2" 2-2 1/2"
0 200 400 600 800 1000
SCALE IN FEET
LIHUE WATER SYSTEM
HANAMAULU
DEPARTMENT OF WATER
COUNTY OF KAUAI
LATEST REVISION NOV. - 2005

Option A1, B1, A2 and B2:
Connect proposed 12-inch water main to existing 16-inch D.I. water main along Ma'alo Road.
Assume the existing water system has enough capacity, storage and well supply to handle the proposed increase of Project water demand and will not require upgrades.

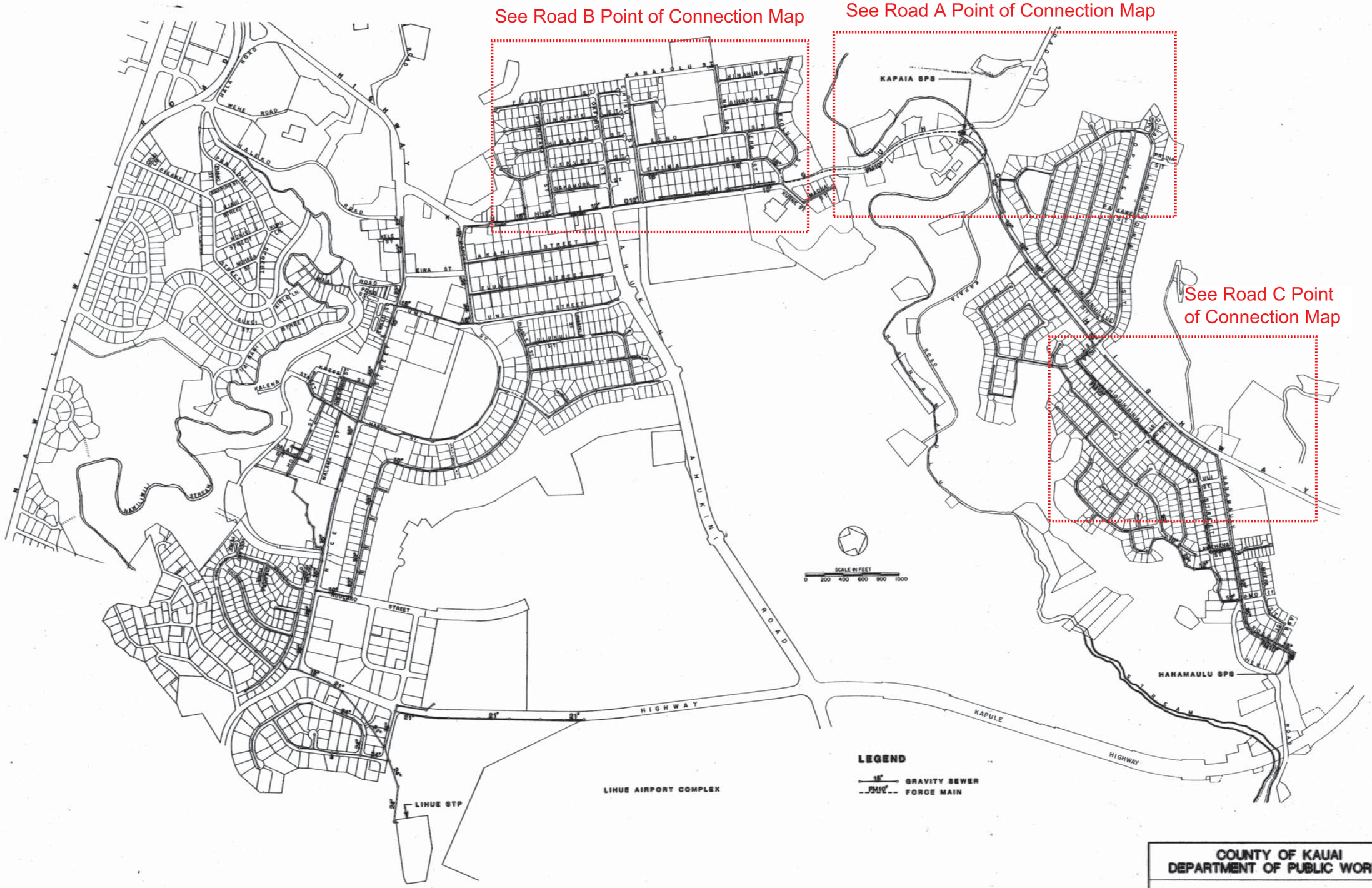
Point of Connection at the intersection of Road A and Road B





Point of Connection

Option C3:
Connect proposed 12-inch water main to existing 12-inch D.I. water main along Kuhio Highway supplied by the 1.0 MG water tank.
Assume the existing water system has enough capacity, storage and well supply to handle the proposed increase of Project water demand and will not require upgrades.

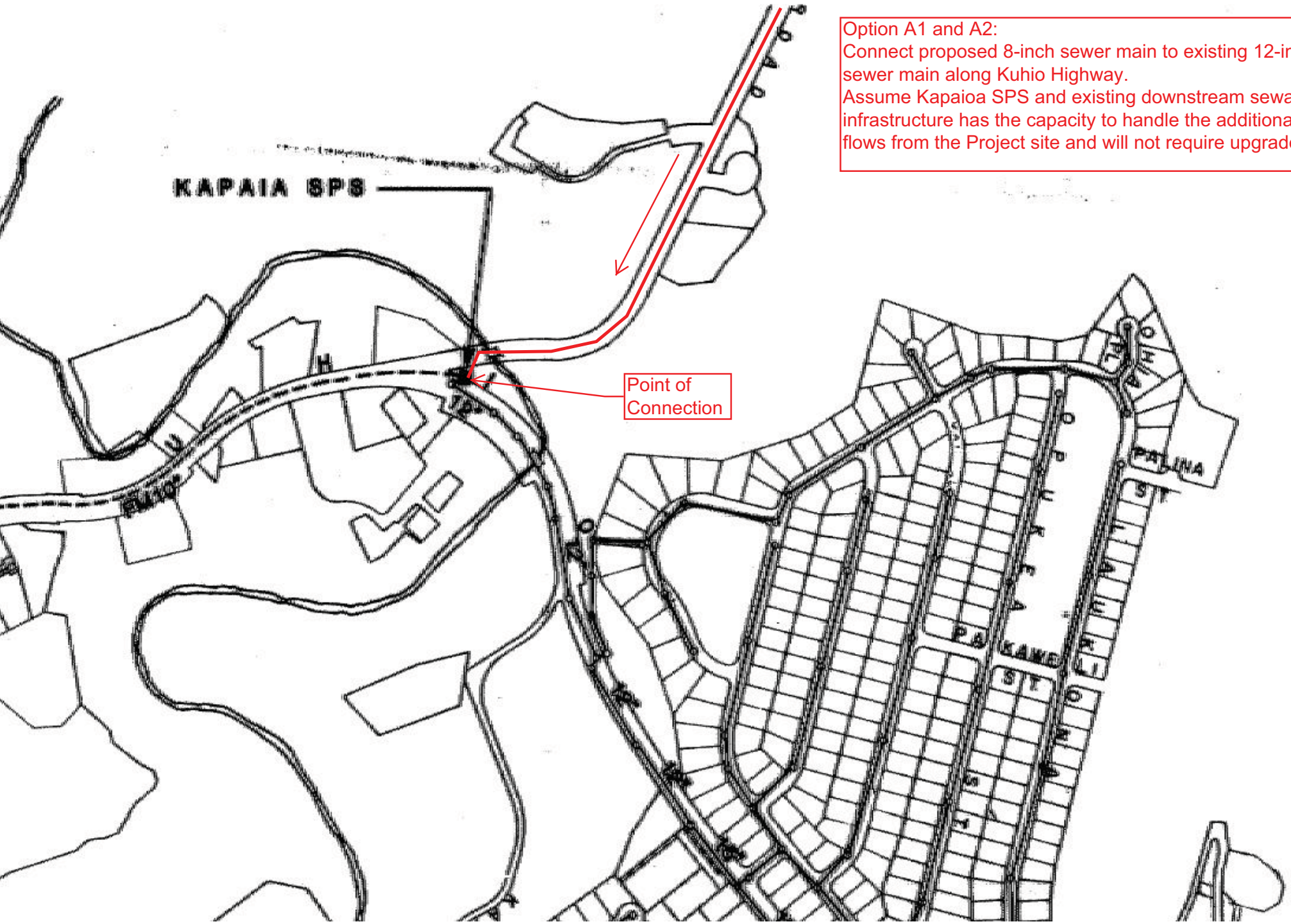


COUNTY OF KAUAI
DEPARTMENT OF PUBLIC WORKS

LIHUE SEWERAGE SYSTEM

DECEMBER 1992

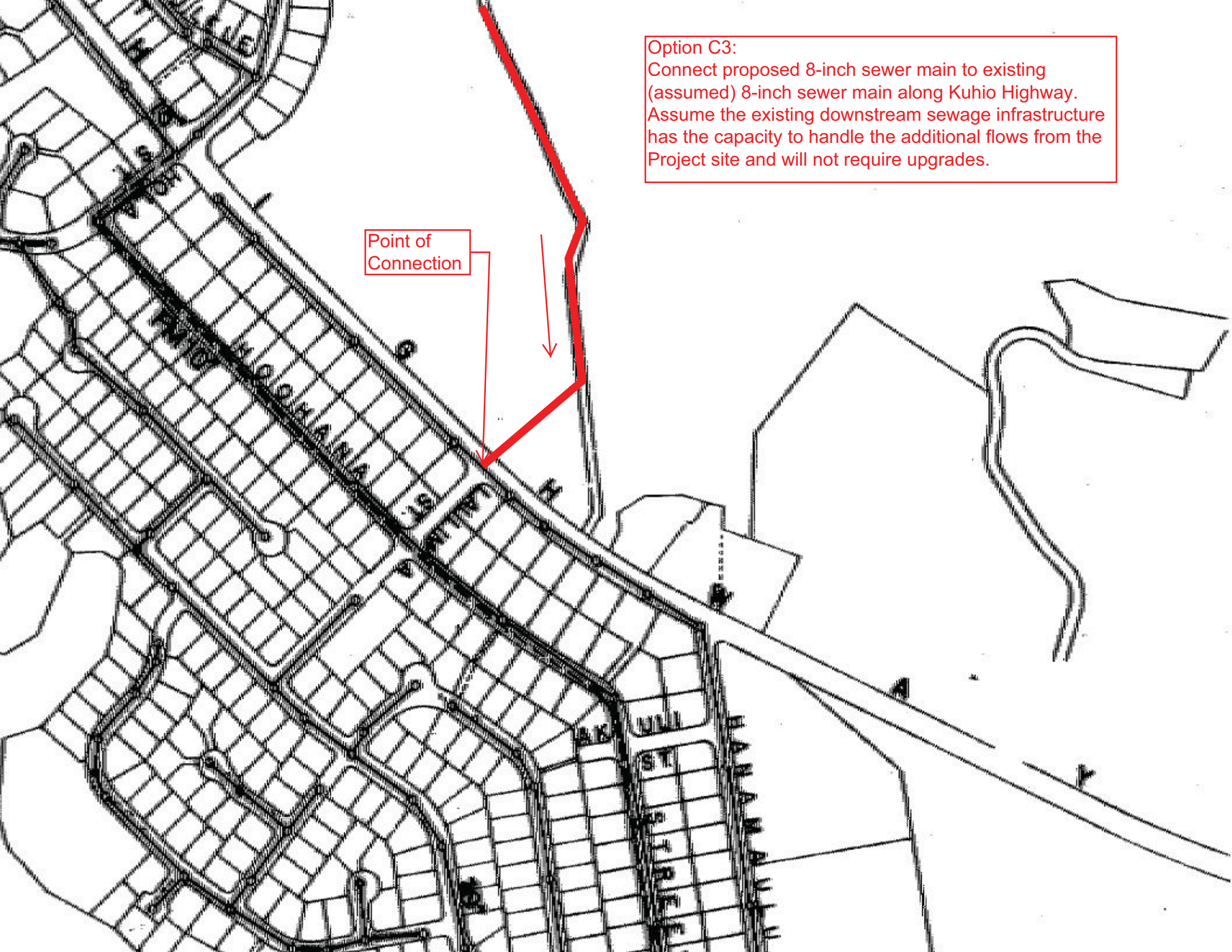
FUKUNAGA & ASSOCIATES, INC.
CONSULTING ENGINEERS
1088 KAPIOLANI BOULEVARD, 2ND FLOOR
HONOLULU, HAWAII 96814



Option A1 and A2:
Connect proposed 8-inch sewer main to existing 12-inch sewer main along Kuhio Highway.
Assume Kapaioa SPS and existing downstream sewage infrastructure has the capacity to handle the additional flows from the Project site and will not require upgrades.

Option B1 and B2:
Connect proposed 8-inch sewer main to existing (assumed) 8-inch sewer main along Ehiku Street. Assume the existing downstream sewage infrastructure has the capacity to handle the additional flows from the Project site and will not require upgrades.

Point of Connection


Option C3:
Connect proposed 8-inch sewer main to existing (assumed) 8-inch sewer main along Kuhio Highway. Assume the existing downstream sewage infrastructure has the capacity to handle the additional flows from the Project site and will not require upgrades.
Point of Connection

Appendix G:
RRP Cost Estimates

Appendix G.1
Alternative 1 Resource Recovery Park
Construction Cost Estimate

Proposed MSWLF and RRP at Ma'alo, Kaua'i, Hawaii

Alternative 1 RRP Site Development - Cost Estimate

Item		Unit	Quantity	Unit Price	Price	Comments
1.0	**Pre-Development Requirements**					
1.01	site confirmatory investigations (hydrogeological, geotechnical)	LS	1	$ 150,000	$ 150,000	estimated cost
1.02	site survey for detailed design	LS	1	$ 5,000	$ 5,000	estimated cost
				Subtotal	*$ 155,000*	
2.0	**Site Preparation (Exclude WtE Facility)**					
2.01	Erosion Control BMPs	LS	1	$ 10,000	$ 10,000	estimated cost
2.02	clear and grubbing site rough grade and proof roll existing terrain prior to facility construction	acre	55	$ 2,500	$ 137,500	estimated unit price
2.03	existing pipe line protection/decommission	LF	1,050	$ 20	$ 21,000	to be determined by the owner, estimated unit price
				Subtotal	*$ 168,500*	
3.0	**Roads (Exclude WtE Facility)**					
3.01	main road widening from 6.0m to 7.5m and upgrading	LF	3,470	$ 110	$ 381,700	including earth work and pavement, estimate unit price
3.02	perimeter roadway grading (filling + excavation)	LS	1	$ 150,000	$ 150,000	estimated cost
3.03	Paved perimeter road and internal road, including 5cm asphaltic wearing course, 10cm - asphaltic base course, 20cm - aggregate base course, and 10cm - granular subbase	SF	187,650	$ 7.78	$ 1,459,917	included 12" granular base, and asphalt base and surface courses concrete layer, ($6+$14+$50=$70/s.y., equal to $7.78/sq.ft)
				Subtotal	*$ 1,991,617*	
4.0	**Integrated Residential Drop-off Facilities**					
4.01	11,000 square feet pre-engineered reuse center and hard-to-recycle material center building	LS	1	$ 2,750,000	$ 2,750,000	pre-engineering building type
4.02	3,000 square feet pre-engineered HI-5 buy-back center building	LS	1	$ 750,000	$ 750,000	pre-engineering building type
4.03	5,000 square feet pre-engineered HHW depot/electronic waste depot building	LS	1	$ 1,250,000	$ 1,250,000	pre-engineering building type
4.04	500 square feet 8" thick concrete pad for storage of waste cooking oil, waste motor oil and filters, propane tanks, within a secure fence/cage	LS	1	$ 2,800	$ 2,800	estimated cost
4.05	public drop-off access, and platform with canopy	LS	1	$ 584,000	$ 584,000	19,700 square feet concrete pad (2200 square yard x $50=$110,000) and 7,500 square feet concrete sidewall (280 cubic yard concrete x$800=$224,000) and earth fill (6000 c.y.x$25=$150,000) , canopy $100,000, with ramp up to 2.4m platform
4.06	3,500 square feet compacted clay for white goods drop-off area	SF	3500	$ 1.11	$ 3,900	included 4" granular base
4.07	residual waste tipping area, including a covered square feet fabric building, granular or asphaltic pavement area for vehicle parking and traffic movement	LS	1	$ 450,000	$ 450,000	Fabric building type
4.08	granular parking area near reuse center building	SF	27,000	$ 2.22	$ 60,000	4" aggregate base course, 8" aggregate top course
4.09	access roads to facilities	SF	153,000	$ 2.22	$ 340,000	4" aggregate base course, 8" aggregate top course
				Subtotal	*$ 6,190,700*	
5.0	**Integrated Processing Facilities**					
5.01	35,000 square feet material recovery facility and education center building (MRF)	LS	1	$ 2,813,000	$ 2,813,000	including processing area, office, wash rooms, lunch room, storage room, electrical and mechanical room, HVAC system, and board rooms
5.02	Sorting line and processing line equipment in MRF	LS	1	$ 2,500,000	$ 2,500,000	including purchase, delivery, and installation
5.03	one (1) front-end loader for MRF	LS	1	$ 125,000	$ 125,000	including purchase, delivery, and installation
5.04	one (1) fork lift for MRF	LS	1	$ 50,000	$ 50,000	including purchase, delivery, and installation
5.05	granular parking area and access for MRF building	SF	76,500	$ 2.22	$ 170,000	4" aggregate base course, 8" aggregate top course
5.06	two (2) 80' long weigh scales one (1) scale house for MRF	LS	1	$ 200,000	$ 200,000	c/w access ramps and signal light system controlled from scale house, scale house was assumed 500 square feet footprint including openable windows adjacent to scale decks, work stations for 2 scale operators, washroom, mechanical/service room.
5.07	9-acre compacted clay pad for windrow compost facility (WCF)	LS	1	$ 900,000	$ 900,000	including supply of material, grading and compaction
5.08	one (1) chipper and grinder for WCF	LS	1	$ 500,000	$ 500,000	including purchase, delivery, and installation
5.09	one (1) front end loader for WCF	LS	1	$ 200,000	$ 200,000	including purchase, and delivery
5.10	one (1) compost turning machine for WCF	LS	1	$ 45,000	$ 45,000	estimated cost, including purchase, delivery, and installation
5.11	one (1) compost screen machine for WCF	LS	1	$ 157,100	$ 157,100	estimated cost for 612 Trommmels, purchase price only, delivery and installation are extra
5.12	windrow covers for WCF	LS	1	$ 10,000	$ 10,000	including purchase, and delivery
5.13	surface water detention pond for WCF, including aeration equipment and discharge piping	LS	1	$ 1,000,000	$ 1,000,000	including excavation, safety fencng, two aerators, and a pond liner consisting of an HDPE geomembrane and a GCL. Discharge piping and valve to surface water basin.
5.14	site office for WCF	LS	1	$ 75,000	$ 75,000	
5.15	4-acre compacted granular pad for scrap automobile processing area (SAP)	SF	175,000	$ 1.55	$ 271,250	including 8" graded aggregate in 2"- 4" layers
5.16	site office for SAP operation	LS	1	$ 75,000	$ 75,000	estimated cost, refer to item 4.14; shared office with operation for tire baling, C&D processing, white goods and miscellaneous metals shredding, baling and storage, and concrete, brick, block ,asphalt processing and storage
5.17	0.4-acre compacted granular pad for tire baling area (TB)	SF	17,500	$ 1.55	$ 27,125	including 8" graded aggregate in 2"- 4" layers
5.18	concrete slab for baling building area and apron (TB)	LS	1	$ 8,000	$ 8,000	combine with item 4.17, total cost about $35,125
5.19	625 square feet sprung-steel, fabric – covered building for tire baling (TB)	LS	1	$ 100,000	$ 100,000	Fabric building type
5.20	one tire baling machine (vertical down stroke baler) (TB)	unit	1	$ 75,000	$ 75,000	including purchase, delivery, and installation
5.21	one fork lift for tire baling (TB)	LS	1	$ 50,000	$ 50,000	same as item 5.04
5.22	5,000 square feet fabric building for white goods and miscellaneous metals shredding and baling (MSB)	LS	1	$ 375,000	$ 375,000	estimated cost
5.23	metal shedding and baling system (MSB)	LS	1	$ 1,500,000	$ 1,500,000	including purchase, delivery, and installation
5.24	37,500 square feet compacted granular pad for MSB	SF	37,500	$ 1.55	$ 58,125	combine with item 5.22, total between $1.5MM to $2.0MM

Proposed MSWLF and RRP at Ma'alo, Kaua'i, Hawaii
Alternative 1 RRP Site Development - Cost Estimate

Item		Unit	Quantity	Unit Price	Price	Comments
5.25	compacted granular base under for C&D material processing and recycling facility	SF	28,750	$ 1.55	$ 44,563	included 4" granular base, Phase 1: 12,750 sq. ft, Phase 2: 16,000 sq.ft.
5.26	C&D processing system with canopy above	LS	1	$ 800,000	$ 800,000	including purchase, delivery, and installation
5.27	C&D storage bunkers	LS	1	$ 140,000	$ 140,000	including all the bunkers for phases 1 and 2
5.28	two (2) front-end loaders for C&D operation	unit	2	$ 125,000	$ 250,000	unit price same as item 5.09
5.29	36,400 square feet compacted granular base for concrete, brick, block, asphalt processing and storage area	SF	36,400	$ 1.55	$ 56,420	unit price same as item 5.25
5.30	bunkers for concrete, brick, block, asphalt processing and storage area	LS	1	$ 100,000	$ 100,000	500 foot long in total. Estimated cost
				Subtotal	*$ 12,675,582*	
6.0	**Surface Water Management System**					
6.01	surface water management pond and related drainage culverts, headwalls, ditches, and safety fence around	LS	1	$ 1,335,500	$ 1,335,500	
				Subtotal	*$ 1,335,500*	
7.0	**Landscaping, Erosion Control, and Fencing**					
7.01	landscaping, including tree planting, and sodding	LS	1	$ 150,000	$ 150,000	estimated cost
7.02	site erosion controls, including silt fence, rock check dam, temporary sodding, erosion matting etc.	LS	1	$ 100,000	$ 100,000	estimated cost, prior, during and after construction season as needed
7.03	security gates at the site entrances and exits	unit	4	$ 8,000	$ 32,000	estimated cost, at 4 locations, entrances and exits
7.04	site security fence: to remove/reinstall existing fence	LS	1	$ 2,000	$ 2,000	relocate 1,400 foot existing fence, assumed existing fence is in good condition
7.05	site security fence: to install new security fence	LF	500	$ 18	$ 9,000	install 500 foot new fence, 72" high chain link fence
				Subtotal	*$ 293,000*	
8.0	**Utilities**					
8.01	electrical supply to buildings, processing equipment, roadway and site building area lighting	LS	1	$ 450,000	$ 450,000	estimated cost, assumed to connect existing power grid in near the site location without upgrading, existing condition to be assessed during detailed design stage
8.02	potable water supply	LS	1	$ 300,000	$ 300,000	estimated cost for drilled 8" dia well, with pump, and piping network for estimated 60 site staff. Cost for geological investigation and environmental assessment are extra
8.03	septic system	LS	1	$ 220,000	$ 220,000	quantity based on wastewater system septic tank (3 tanks) and absorption bed.
8.04	telephone and internet services, and information exchange/management system between equipment and administration offices	LS	1	$ 40,000	$ 40,000	estimated cost, service to all offices, and scale house
8.05	emergency power supply	unit	1	$ 150,000	$ 150,000	estimated cost, back-up diesel or gas generator system sufficiently large to power emergency lights at site gate and portions of site perimeter, as well as office and scale house.
				Subtotal	*$ 1,160,000*	
9.0	**Miscellaneous Items**					
9.01	signage on site, including information board, traffic sign, and safety bollards	LS	1	$ 10,000	$ 10,000	estimated cost, allowance for signs including site identification at entrances, signs identifying each building and site facility, directing internal traffic, no trespassing along site perimeter fencing.
9.02	30' long weigh scale for public vehicle at residual waste tipping area	LS	1	$ 75,000	$ 75,000	estimated cost
9.03	40' long weigh scale for transfer vehicle at residual waste tipping area	LS	1	$ 90,000	$ 90,000	estimated cost
9.04	40 cubic yard bin for public drop-off facility	unit	18	$ 5,000	$ 90,000	estimated unit price
9.05	wheel wash station and wash water supply for outbound commercial vehicles	LS	1	$ 150,000	$ 150,000	estimated cost
9.06	Equipment fueling station	LS	1	$ 35,000	$ 35,000	estimated price, assuming paved area with above-ground double-walled fuel tank for diesel, with pump, and covering shed
				Subtotal	*$ 440,000*	
				Subtotal for items 1 to 9	**$ 24,409,899**	
				Engineering & permitting - 12%	$ 2,929,188	
				CM/CQA -- 8%	$ 1,952,792	
				Subtotal	$ 29,291,879	
				Hawaii General Excise Tax - 4.166%	$ 1,220,300	
				Total	**$ 30,512,179**	
				Contingency - 15%	$ 4,576,827	
10.0	**Possible Future Waste to Energy Facility**					
10.01	site clearing and grading for waste to energy facility area (WtE)	acre	8	$ 2,500	$ 20,000	estimated unit price
10.02	existing road upgrade, site entrance for WtE site	LF	250	$ 110	$ 27,500	estimated unit price
10.03	waste to energy facility (WtE) building and equipment	LS	1	$ 150,000,000	$ 150,000,000	refer to table 37 on page 83
10.04	stormwater management pond, site security fence, landscaping, and etc. for WtE	LS	1	$ 20,000	$ 20,000	estimated cost
				Subtotal	*$ 150,067,500*	

Legend:

	prices taken from RRP Feasibility Study report (AECOM January 2013).
	prices referred to "standard prices for cost estimating, December 2010, City of Rockville, Maryland, US.

Appendix G.2
Alternative 2 Resource Recovery Park
Construction Cost Estimate

Proposed MSWLF and RRP at Ma'alo, Kaua'i, Hawaii

Alternative 2 RRP Site Development - Cost Estimate

Item		Unit	Quantity	Unit Price	Price	Comments
1.0	**Pre-Development Requirements**					
1.01	site confirmatory investigations (hydrogeological, geotechnical)	LS	0	$ 150,000	$ -	estimated cost
1.02	site survey for detailed design	LS	0	$ 5,000	$ -	estimated cost
				Subtotal	*$ -*	
2.0	**Site Preparation (Exclude WtE Facility)**					
2.01	Erosion Control BMPs	LS	1	$ 6,000	$ 6,000	estimated unit price
2.02	clear and grubbing site rough grade and proof roll existing terrain prior to facility construction	acre	31	$ 2,500	$ 77,500	estimated unit price
2.03	existing pipe line protection/decommission	LF	0	$ 20	$ -	to be determined by the owner, estimated unit price
				Subtotal	*$ 83,500*	
3.0	**Roads (Exclude WtE Facility)**					
3.01	main road widening from 6.0m to 7.5m and upgrading	LF	0	$ 110	$ -	including earth work and pavement, estimate unit price
3.02	perimeter roadway grading (filling + excavation)	LS	1	$ 80,000	$ 80,000	estimated cost
3.03	Paved perimeter road and internal road, including 5cm asphaltic wearing course, 10cm - asphaltic base course, 20cm - aggregate base course, and 10cm - granular subbase	SF	100,000	$ 7.78	$ 778,000	included 12" granular base, and asphalt base and surface courses concrete layer, ($6+$14+$50=$70/s.y., equal to $7.78/sq.ft)
				Subtotal	*$ 858,000*	
4.0	**Integrated Residential Drop-off Facilities**					
4.01	11,000 square feet pre-engineered reuse center and hard-to-recycle material center building	LS	1	$ 2,750,000	$ 2,750,000	pre-engineering building type
4.02	3,000 square feet pre-engineered HI-5 buy-back center building	LS	1	$ 750,000	$ 750,000	pre-engineering building type
4.03	5,000 square feet pre-engineered HHW depot/electronic waste depot building	LS	1	$ 1,250,000	$ 1,250,000	pre-engineering building type
4.04	500 square feet 8" thick concrete pad for storage of waste cooking oil, waste motor oil and filters, propane tanks, within a secure fence/cage	LS	1	$ 2,800	$ 2,800	estimated cost
4.05	public drop-off access, and platform with canopy	LS	1	$ 584,000	$ 584,000	19,700 square feet concrete pad (2200 square yard x $50=$110,000) and 7,500 square feet concrete sidewall (280 cubic yard concrete x$800=$224,000) and earth fill (6000 c.y.x$25=$150,000) , canopy $100,000, with ramp up to 2.4m platform
4.06	3,500 square feet compacted clay for white goods drop-off area	SF	3500	$ 1.11	$ 3,900	included 4" granular base
4.07	residual waste tipping area, including a covered square feet fabric building, granular or asphaltic pavement area for vehicle parking and traffic movement	LS	1	$ 450,000	$ 450,000	Fabric building type
4.08	granular parking area near reuse center building	SF	27,000	$ 2.22	$ 60,000	4" aggregate base course, 8" aggregate top course
4.09	access roads to facilities	SF	80,000	$ 2.22	$ 177,778	4" aggregate base course, 8" aggregate top course
				Subtotal	*$ 6,028,478*	
5.0	**Integrated Processing Facilities**					
5.01	35,000 square feet material recovery facility and education center building (MRF)	LS	1	$ 2,813,000	$ 2,813,000	including processing area, office, wash rooms, lunch room, storage room, electrical and mechanical room, HVAC system, and board rooms
5.02	Sorting line and processing line equipment in MRF	LS	1	$ 2,500,000	$ 2,500,000	including purchase, delivery, and installation
5.03	one (1) front-end loader for MRF	LS	1	$ 125,000	$ 125,000	including purchase, delivery, and installation
5.04	one (1) fork lift for MRF	LS	1	$ 50,000	$ 50,000	including purchase, delivery, and installation
5.05	granular parking area and access for MRF building	SF	76,500	$ 2.22	$ 170,000	4" aggregate base course, 8" aggregate top course
5.06	two (2) 80' long weigh scales one (1) scale house for MRF	LS	0	$ 200,000	$ -	c/w access ramps and signal light system controlled from scale house, scale house was assumed 500 square feet footprint including openable windows adjacent to scale decks, work stations for 2 scale operators, washroom, mechanical/service room. [Scales are at landfill entrance]
5.07	9-acre compacted clay pad for windrow compost facility (WCF)	LS	1	$ 900,000	$ 900,000	including supply of material, grading and compaction
5.08	one (1) chipper and grinder for WCF	LS	1	$ 500,000	$ 500,000	including purchase, delivery, and installation
5.09	one (1) front end loader for WCF	LS	1	$ 200,000	$ 200,000	including purchase, and delivery
5.10	one (1) compost turning machine for WCF	LS	1	$ 45,000	$ 45,000	estimated cost, including purchase, delivery, and installation
5.11	one (1) compost screen machine for WCF	LS	1	$ 157,100	$ 157,100	estimated cost for 612 Trommmels, purchase price only, delivery and installation are extra
5.12	windrow covers for WCF	LS	1	$ 10,000	$ 10,000	including purchase, and delivery
5.13	surface water detention pond for WCF, including aeration equipment and discharge piping	LS	1	$ 1,000,000	$ 1,000,000	including excavation, safety fencng, two aerators, and a pond liner consisting of an HDPE geomembrane and a GCL. Discharge piping and valve to surface water basin.
5.14	site office for WCF	LS	1	$ 75,000	$ 75,000	
5.15	4-acre compacted granular pad for scrap automobile processing area (SAP)	SF	175,000	$ 1.55	$ 271,250	including 8" graded aggregate in 2"- 4" layers
5.16	site office for SAP operation	LS	1	$ 75,000	$ 75,000	estimated cost, refer to item 4.14; shared office with operation for tire baling, C&D processing, white goods and miscellaneous metals shredding, baling and storage, and concrete, brick, block ,asphalt processing and storage
5.17	0.4-acre compacted granular pad for tire baling area (TB)	SF	17,500	$ 1.55	$ 27,125	including 8" graded aggregate in 2"- 4" layers
5.18	concrete slab for baling building area and apron (TB)	LS	1	$ 8,000	$ 8,000	combine with item 4.17, total cost about $35,125
5.19	625 square feet sprung-steel, fabric – covered building for tire baling (TB)	LS	1	$ 100,000	$ 100,000	Fabric building type
5.20	one tire baling machine (vertical down stroke baler) (TB)	unit	1	$ 75,000	$ 75,000	including purchase, delivery, and installation
5.21	one fork lift for tire baling (TB)	LS	1	$ 50,000	$ 50,000	same as item 5.04
5.22	5,000 square feet fabric building for white goods and miscellaneous metals shredding and baling (MSB)	LS	1	$ 375,000	$ 375,000	estimated cost
5.23	metal shredding and baling system (MSB)	LS	1	$ 1,500,000	$ 1,500,000	including purchase, delivery, and installation

Proposed MSWLF and RRP at Ma'alo, Kaua'i, Hawaii
Alternative 2 RRP Site Development - Cost Estimate

Item		Unit	Quantity	Unit Price	Price	Comments
5.24	37,500 square feet compacted granular pad for MSB	SF	37,500	$ 1.55	$ 58,125	combine with item 5.22, total between $1.5MM to $2.0MM
5.25	compacted granular base under for C&D material processing and recycling facility	SF	28,750	$ 1.55	$ 44,563	included 4" granular base, Phase 1: 12,750 sq. ft, Phase 2: 16,000 sq.ft.
5.26	C&D processing system with canopy above	LS	1	$ 800,000	$ 800,000	including purchase, delivery, and installation
5.27	C&D storage bunkers	LS	1	$ 140,000	$ 140,000	including all the bunkers for phases 1 and 2
5.28	two (2) front-end loaders for C&D operation	unit	2	$ 125,000	$ 250,000	unit price same as item 5.09
5.29	36,400 square feet compacted granular base for concrete, brick, block, asphalt processing and storage area	SF	36,400	$ 1.55	$ 56,420	unit price same as item 5.25
5.30	bunkers for concrete, brick, block, asphalt processing and storage area	LS	1	$ 100,000	$ 100,000	500 foot long in total. Estimated cost
				Subtotal	*$ 12,475,582*	
6.0	**Surface Water Management System**					
6.01	surface water management and related drainage culverts, headwalls, ditches, and safety fence around	LS	1	$ 400,000	$ 400,000	Alternative 2 RRP surface water here or all alternatives surface water on landfill cost estimate?
				Subtotal	*$ 400,000*	
7.0	**Landscaping, Erosion Control, and Fencing**					
7.01	landscaping, including tree planting, and sodding	LS	1	$ 60,000	$ 60,000	estimated cost
7.02	site erosion controls, including silt fence, rock check dam, temporary sodding, erosion matting etc.	LS	1	$ 30,000	$ 30,000	estimated cost, prior, during and after construction season as needed
7.03	security gates at the site entrances and exits	unit	0	$ 8,000	$ -	estimated cost, at _ locations, entrances and exits [included with Alternative 2 landfill]
7.04	site security fence: to remove/reinstall existing fence	LF	0	$ 4	$ -	relocate _____ foot existing fence, assumed existing fence is in good condition [included with Alternative 2 landfill]
7.05	site security fence: to install new security fence	LF	0	$ 18	$ -	install ____ foot new fence, 72" high chain link fence [included with Alternative 2 landfill]
				Subtotal	*$ 90,000*	
8.0	**Utilities**					
8.01	electrical supply to buildings, processing equipment, roadway and site building area lighting	LS	1	$ 450,000	$ 450,000	estimated cost, assumed to connect existing power grid in near the site location without upgrading, existing condition to be assessed during detailed design stage
8.02	potable water supply	LS	1	$ 300,000	$ 300,000	estimated cost for drilled 8" dia well, with pump, and piping network for estimated 60 site staff. Cost for geological investigation and environmental assessment are extra
8.03	septic system	LS	1	$ 220,000	$ 220,000	quantity based on wastewater system septic tank (3 tanks) and absorption bed.
8.04	telephone and internet services, and information exchange/management system between equipment and administration offices	LS	0	$ 40,000	$ -	estimated cost, service to all offices, and scale house
8.05	emergency power supply	unit	0	$ 150,000	$ -	estimated cost, back-up diesel or gas generator system sufficiently large to power emergency lights at site gate and portions of site perimeter, as well as office and scale house.
				Subtotal	*$ 970,000*	
9.0	**Miscellaneous Items**					
9.01	signage on site, including information board, traffic sign, and safety bollards	LS	1	$ 3,000	$ 3,000	estimated cost, allowance for signs including site identification at entrances, signs identifying each building and site facility, directing internal traffic, no trespassing along site perimeter fencing.
9.02	30' long weigh scale for public vehicle at residual waste tipping area	LS	0	$ 75,000	$ -	estimated cost
9.03	40' long weigh scale for transfer vehicle at residual waste tipping area	LS	0	$ 90,000	$ -	estimated cost
9.04	40 cubic yard bin for public drop-off facility	unit	18	$ 5,000	$ 90,000	estimated unit price
9.05	wheel wash station and wash water supply for outbound commercial vehicles	LS	1	$ 150,000	$ 150,000	estimated cost
9.06	Equipment fueling station	LS	1	$ 35,000	$ 35,000	estimated price, assuming paved area with above-ground double-walled fuel tank for diesel, with pump, and covering shed
				Subtotal	*$ 275,000*	
				Subtotal for items 1 to 9	**$ 21,180,560**	
				Engineering & Permitting - 12%	$ 2,541,667	
				CM/CQA -- 8%	$ 1,694,445	
				Subtotal	$ 25,416,672	
				Hawaii General Excise Tax - 4.166%	$ 1,058,859	
				Total	**$ 26,475,531**	
				Contingency - 15%	$ 3,971,330	
10.0	**Possible Future Waste to Energy Facility (Off-site Location Required)**					
10.01	site clearing and grading for waste to energy facility area (WtE)	acre	8	$ 2,500	$ 20,000	estimated unit price
10.02	existing road upgrade, site entrance for WtE site	LF	250	$ 110	$ 27,500	estimated unit price
10.03	waste to energy facility (WtE) building and equipment	LS	1	$ 150,000,000	$ 150,000,000	refer to table 37 on page 83
10.04	stormwater management pond, site security fence, landscaping, and etc. for WtE	LS	1	$ 20,000	$ 20,000	estimated cost
				Subtotal	*$ 150,067,500*	

Legend:

	prices taken from RRP Feasibility Study report (AECOM January 2013).
	prices referred to "standard prices for cost estimating, December 2010, City of Rockville, Maryland, US.

Appendix H:
Aerial Photograph of Proposed Project Vicinity

LEGEND

Proposed Ma'alo Landfill Site

Alternate Resource Recovery Park (RRP) Site

NOTES

1. Precision aerial mapping and photogrammetric mapping services were provided by Cooper Aerial Surveys Co.
2. Aerial photograph was taken on August 9, 2012.
3. Map Projection: UTM State Plane Hawaii Zone 4.

N

0 1,000 2,000 Feet

Figure H-1
Aerial Photograph
Conceptual Design Report
MSWLF and RRP at Ma'alo
Ma'alo, Kaua'i, Hawai'i

\\USHNL1FP003\Data\Projects\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\09_GIS\02_Maps\12_CDR MSWLF and RRP\01_MXD\H-1 - Aerial Photograph.mxd

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Appendix E
Acoustic Study for the Municipal Solid Waste Landfill, Ma‘alo, Kaua‘i, Hawai‘i
(Y. Ebisu & Associates 2018)

ACOUSTIC STUDY FOR THE MUNICIPAL SOLID WASTE LANDFILL MAALO, KAUAI, HAWAII

Prepared for:

R.M. TOWILL CORPORATION

Prepared by:

Y. EBISU & ASSOCIATES
1126 12th Avenue, Room 305
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JANUARY 2018

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CHAPTER I. SUMMARY

The future noise levels associated with the proposed Municipal Solid Waste Landfill (MSWL) at Maalo, Kauai were evaluated for their potential impact on noise sensitive receptors in the project environs. Future noise levels and potential impacts associated with landfill operations and refuse delivery vehicles were evaluated using available forecast data.

Along the landfill access roads, which are expected to service the project traffic, noise levels are expected to not exceed 59.3 Leq(h), or average noise level at the closest existing residences during the peak traffic hour, and 48.3 DNL (Day-Night Average Sound Level). These predicted refuse vehicle noise levels are 5 to 7 dB below current local and federal noise impact thresholds for roadway traffic noise sources.

Because of the remote location of the proposed landfill site (approximately one to two miles from the closest existing residences), the noise associated with the landfill operations should be well below the most stringent noise impact criteria and standards for environmental noise. The predicted noise levels from equipment operating at the landfill site are expected to be well below (by 22 to 23 DNL) current federal noise impact standards and criteria at the closest existing residences, with very low potential noise levels of 33 dBA at the closest existing residences.

Risks of adverse noise impacts from refuse delivery vehicles and equipment operating at the landfill site are expected to be very low. Adverse noise impacts are not anticipated during the construction of the proposed project. Large buffer distances of approximately one mile to the nearest noise sensitive residences south of the proposed landfill site should reduce construction noise levels to the range of 48 to 33 dBA. Much higher noise levels of 84 to 53 dBA are expected at residences along Laukona Street and Kalepa Circle during construction of the landfill access road. Adverse impacts from construction noise are not expected to be in the "public health and welfare" category due to the temporary nature of the work and due to the administrative controls available for its regulation. Instead, these impacts will probably be limited to the temporary degradation of the quality of the acoustic environment in the immediate vicinity of the construction work sites.

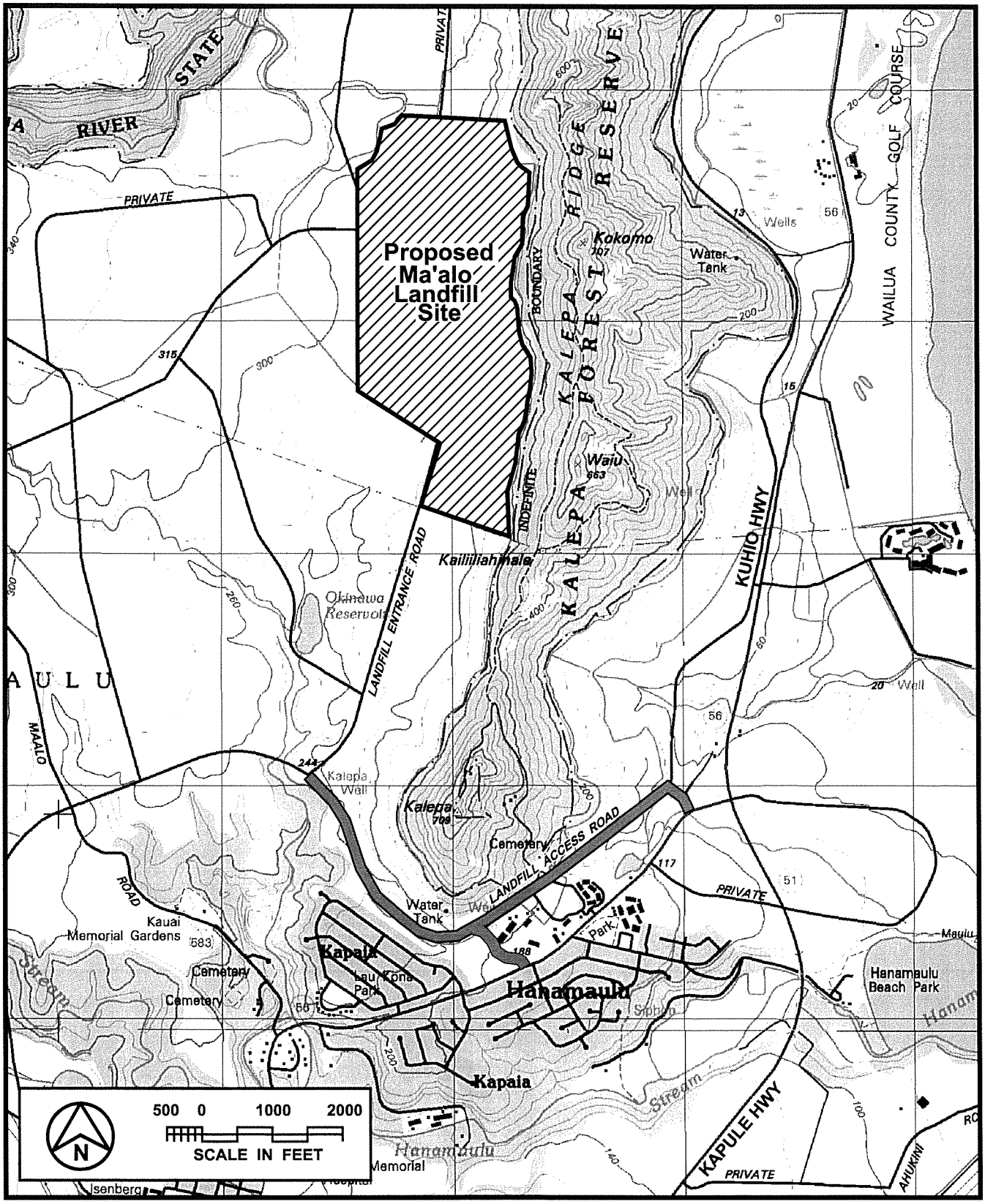
CHAPTER II. PURPOSE

The primary objective of this study was to describe the future noise levels and potential noise impacts associated with the proposed Municipal Solid Waste Landfill at Maalo, Kauai. The location of the project site is shown in Figure 1. The project site is located on undeveloped former agricultural lands approximately 1 mile west of residences in Hanamaulu.

Refuse vehicle traffic noise levels and impacts associated with the proposed project were to be determined along the primary access roadways which are expected to service the project traffic. Forecasts of refuse delivery vehicle traffic to and from the MSWL were used to model their noise levels along the landfill access road closest to existing residences. A specific objective was to determine future traffic noise levels associated with the refuse delivery vehicles, and the potential noise impacts associated with project traffic. Recommendations for minimizing traffic noise impacts were to be provided as required.

Assessments of potential long term noise impacts from heavy equipment operations at the proposed landfill site were also to be determined by comparing their predicted noise levels with existing background noise levels and published noise impact criteria and standards.

Assessments of possible noise impacts from short term construction noise were also included in the noise study objectives. Recommendations for minimizing these noise impacts were to be provided as required.



PROJECT LOCATION MAP

FIGURE 1

CHAPTER III. NOISE DESCRIPTORS AND THEIR RELATIONSHIP TO LAND USE COMPATIBILITY

The noise descriptor currently used by United States of America's federal agencies to assess environmental noise is the Day-Night Average Sound Level (DNL or Ldn). This descriptor incorporates a 24-hour average of instantaneous A-Weighted sound levels as read on a standard Sound Level Meter. The maximum A-Weighted sound level occurring while a noise source such as a heavy truck or aircraft is moving past a listener (i.e., the maximum sound level from a "single event") is referred to as the "Lmax value". The mathematical product (or integral) of the instantaneous sound level times the duration of the event is known as the "Sound Exposure Level", or Lse, which is analogous to the energy of the time-varying sound levels associated with a single event.

The DNL values represent the average noise during a typical day of the year. DNL exposure levels of 55 or less are typical of quiet rural or suburban areas. DNL exposure levels of 55 to 65 are typical of urbanized areas with medium to high levels of activity and street traffic. DNL exposure levels above 65 are representative of densely developed urban areas and areas fronting high volume roadways.

By definition, the minimum averaging period for the DNL descriptor is 24 hours. Additionally, sound levels which occur during the nighttime hours of 10:00 PM to 7:00 AM are increased by 10 decibels (dB) prior to computing the 24-hour average by the DNL descriptor. Because of the averaging used, DNL values in urbanized areas typically range between 50 and 75 DNL. In comparison, the typical range of intermittent noise events may have maximum Sound Level Meter readings between 75 and 105 dBA. A more complete list of noise descriptors is provided in Appendix B to this report. In Appendix B, the Ldn descriptor symbol is used in place of the DNL descriptor symbol.

Table 1, extracted from Reference 1, categorizes the various DNL levels of outdoor noise exposure with severity classifications. Table 2, also extracted from Reference 1, presents the general effects of noise on people in residential use situations. Figure 2, extracted from Reference 2, presents suggested land use compatibility guidelines for residential and nonresidential land uses. A general consensus among federal agencies has developed whereby residential housing development is considered acceptable in areas where exterior noise does not exceed 65 DNL. This value of 65 DNL is used as a federal regulatory threshold for determining the necessity for special noise abatement measures when applications for federal funding assistance are made.

As a general rule, noise levels of 55 DNL or less occur in rural areas, or in areas which are removed from high volume roadways. In urbanized areas which are shielded from high volume streets, DNL levels generally range from 55 to 65 DNL, and are

TABLE 1

EXTERIOR NOISE EXPOSURE CLASSIFICATION (RESIDENTIAL LAND USE)

NOISE EXPOSURE CLASS	DAY–NIGHT SOUND LEVEL	EQUIVALENT SOUND LEVEL	FEDERAL (1) STANDARD
Minimal Exposure	Not Exceeding 55 DNL	Not Exceeding 55 Leq	Unconditionally Acceptable
Moderate Exposure	Above 55 DNL But Not Above 65 DNL	Above 55 Leq But Not Above 65 Leq	Acceptable(2)
Significant Exposure	Above 65 DNL But Not Above 75 DNL	Above 65 Leq But Not Above 75 Leq	Normally Unacceptable
Severe Exposure	Above 75 DNL	Above 75 Leq	Unacceptable

Notes: (1) Federal Housing Administration, Veterans Administration, Department of Defense, and Department of Transportation.

(2) FHWA uses the Leq instead of the Ldn descriptor. For planning purposes, both are equivalent if: (a) heavy trucks do not exceed 10 percent of total traffic flow in vehicles per 24 hours, and (b) traffic between 10:00 PM and 7:00 AM does not exceed 15 percent of average daily traffic flow in vehicles per 24 hours. The noise mitigation threshold used by FHWA for residences is 67 Leq.

TABLE 2

EFFECTS OF NOISE ON PEOPLE
(Residential Land Uses Only)

EFFECTS[1] / DAY-NIGHT AVERAGE SOUND LEVEL IN DECIBELS	Hearing Loss	Speech Interference		Annoyance[2]	Average Community Reaction[4]	General Community Attitude Towards Area
		Indoor	Outdoor			
	Qualitative Description	%Sentence Intelligibility	Distance in Meters for 95% Sentence Intelligibility	% of Population Highly Annoyed[3]		
75 and above	May Begin to Occur	98%	0.5	37%	Very Severe	Noise is likely to be the most important of all adverse aspects of the community environment.
70	Will Not Likely Occur	99%	0.9	25%	Severe	Noise is one of the most important adverse aspects of the community environment.
65	Will Not Occur	100%	1.5	15%	Significant	Noise is one of the important adverse aspects of the community environment.
60	Will Not Occur	100%	2.0	9%	Moderate to Slight	Noise may be considered an adverse aspect of the community environment.
55 and below	Will Not Occur	100%	3.5	4%		Noise considered no more important than various other environmental factors.

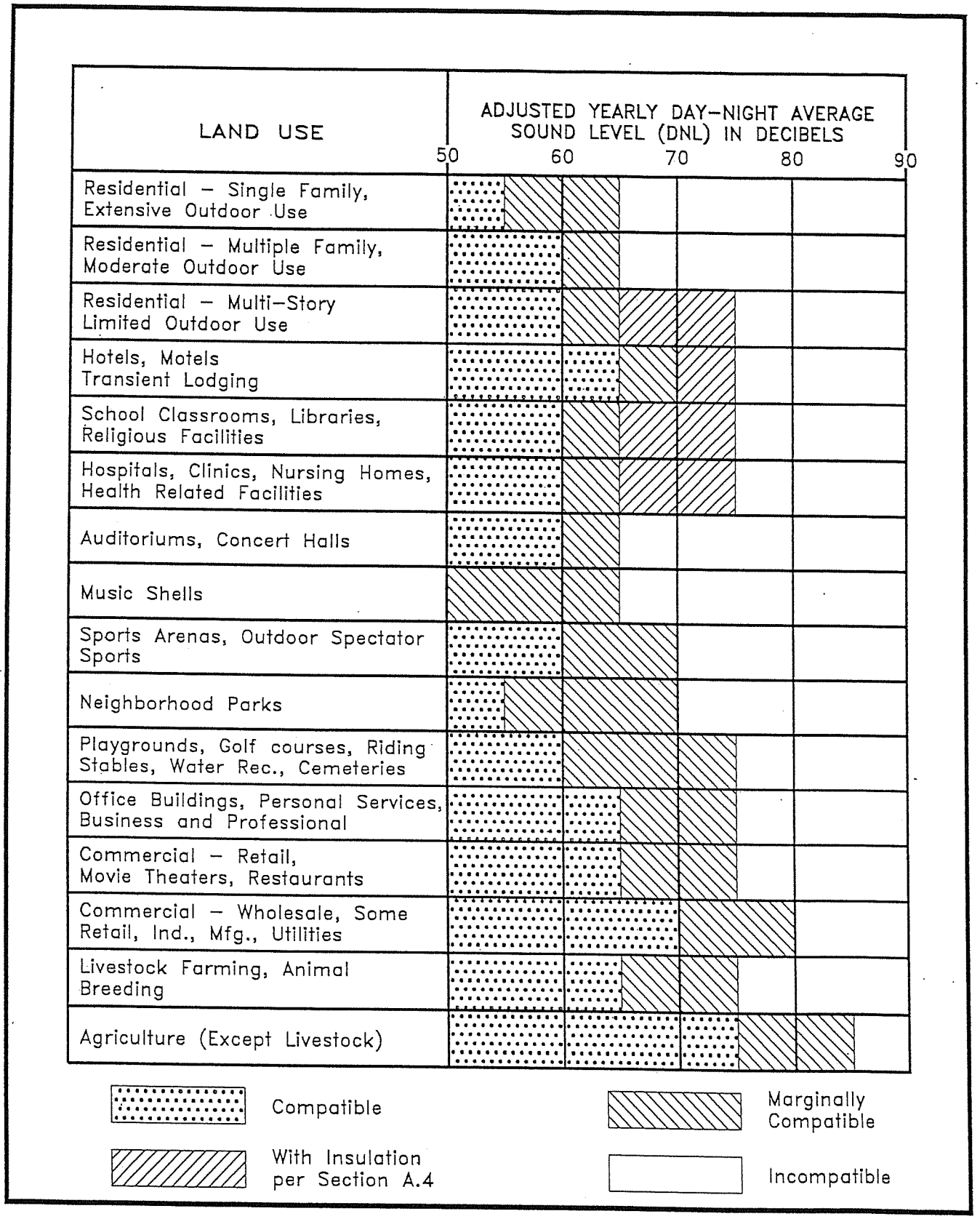
1. "Speech Interference" data are drawn from the following tables in EPA's "Levels Document": Table 3, Fig. D-1, Fig. D-2, Fig. D-3. All other data from National Academy of Science 1977 report "Guidelines for Preparing Environmental Impact Statements on Noise, Report of Working Group 69 on Evaluation of Environmental Impact of Noise."

2. Depends on attitudes and other factors.

3. The percentages of people reporting annoyance to lesser extents are higher in each case. An unknown small percentage of people will report being "highly annoyed" even in the quietest surroundings. One reason is the difficulty all people have in integrating annoyance over a very long time.

4. Attitudes or other non-acoustic factors can modify this. Noise at low levels can still be an important problem, particularly when it intrudes into a quiet environment.

NOTE: Research implicates noise as a factor producing stress-related health effects such as heart disease, high-blood pressure and stroke, ulcers and other digestive disorders. The relationships between noise and these effects, however, have not as yet been quantified.



LAND USE COMPATIBILITY WITH YEARLY AVERAGE DAY-NIGHT AVERAGE SOUND LEVEL (DNL) AT A SITE FOR BUILDINGS AS COMMONLY CONSTRUCTED.
(Source: American National Standards Institute S12.9-1998/Part 5)

FIGURE 2

usually controlled by motor vehicle traffic noise. Residences which front major roadways can be exposed to levels of 65 DNL. Due to noise shielding effects from intervening structures, interior lots are usually exposed to 3 to 10 DNL lower noise levels than the front lots which are not shielded from the traffic noise.

For the purposes of determining an acceptable level of exterior noise for residences, federal agencies have determined that an exterior noise level of 65 DNL or lower is considered acceptable. These federal agencies include the Federal Aviation Administration (FAA), Department of Defense (DOD); Federal Housing Administration, Housing and Urban Development (FHA/HUD), and Veterans Administration (VA). This standard is applied nationally (see Reference 3).

For office, commercial, industrial, and other non-noise sensitive land uses, exterior noise levels as high as 70 to 75 DNL are generally considered acceptable. Exceptions to this occur when naturally ventilated office and other commercial establishments are exposed to exterior levels which exceed 65 DNL.

For noise impact determinations regarding traffic noise, the U.S. Federal Highway Administration (FHWA) and the Hawaii State Department of Transportation, HIghways Division (HDOTH) utilize the Leq(h), or Equivalent (or Average) Hourly Sound Level metric, with 66 Leq(h) used as the noise mitigation threshold (see Reference 4). In addition, if the hourly Leq(h) associated with future motor vehicle traffic increases the background noise level by at least 15 dB [or Leq(h)], the traffic noise mitigation threshold is also exceeded. The peak traffic hour is normally used for determinations of the traffic noise Leq(h) values.

The U.S. Federal Transit Administration (FTA) utilizes the DNL metric with sliding noise impact thresholds for residences, which vary with existing background noise levels (see Reference 5). Figure 3-1 and Table 3-1 were extracted from Reference 5, with Category 2 land uses (or receptors) being residences or buildings where people normally sleep. The FTA noise limit for "No Impact" varies from 50 DNL with 40 DNL existing background noise level to 65 DNL with 70 DNL or greater background noise level. Other federal agencies have not lowered their noise impact thresholds below 65 DNL for low background noise level conditions. The FTA's 10 dB increase over existing background noise level noise impact criteria is similar to the HDOTH's 15 dB increase noise impact criteria.

Regulation of noise levels during construction of the landfill site and access roads are performed by the Hawaii State Department of Health (Reference 6) by limiting construction noise levels at the project boundaries and/or by limiting the periods of construction. Specific federal criteria and standards relating to construction noise levels are not available.

on local streets and separate roadways built exclusively for buses. In contrast, for busways and HOV lanes which are to be integrated in existing highways (e.g., the addition of new lanes or the redesignation of existing lanes on a highway), FHWA's noise abatement criteria are the appropriate noise criteria to use. Likewise, if the project is a new highway involving both general-purpose and dedicated bus/HOV lanes, the FHWA approach is followed. The FHWA criteria are briefly summarized in Section 3.3.

3.1.1 Basis of Noise Impact Criteria

The noise impact criteria in Figure 3-1 and Table 3-1 are based on comparison of the existing outdoor noise levels and the future outdoor noise levels from the proposed project. They incorporate both absolute criteria, which consider activity interference caused by the transit project alone, and relative criteria, which consider annoyance due to the change in the noise environment caused by the transit project.

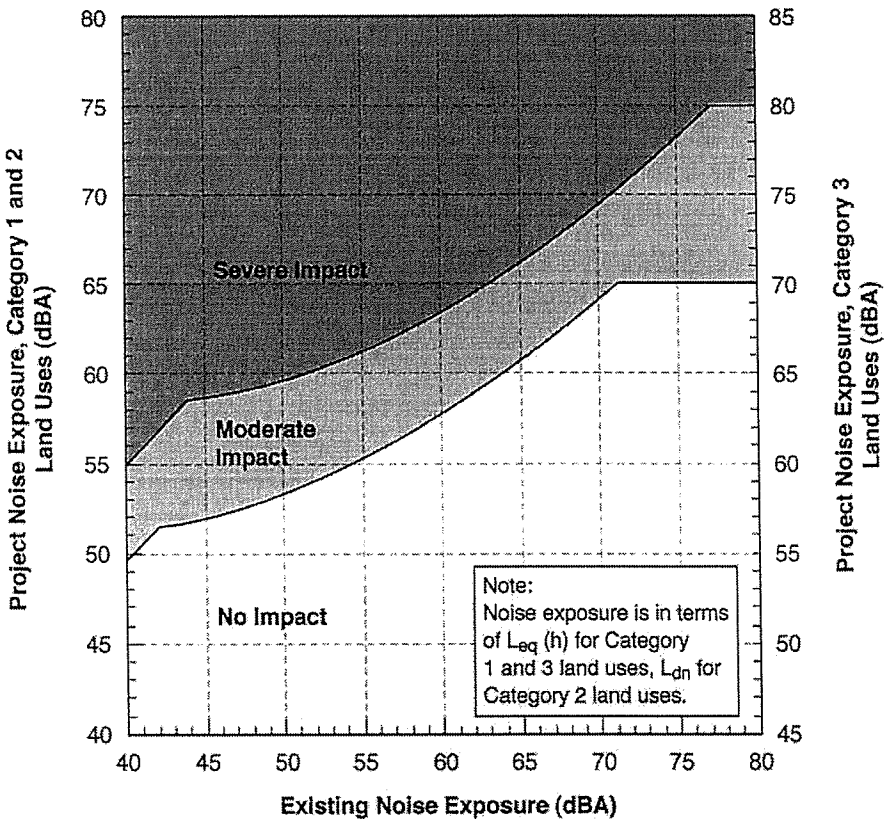


Figure 3-1. Noise Impact Criteria for Transit Projects

The noise criteria and descriptors depend on land use, as defined in Table 3-2. Further guidance on the definition of land use, the selection of the appropriate noise metric and the application of the criteria is given in Section 3.2 of this chapter, with more detailed guidelines given in Chapters 5 and 6.

(EXTRACTED FROM REFERENCE 5)

Table 3-1. Noise Levels Defining Impact for Transit Projects

Existing Noise Exposure* $L_{eq}(h)$ or L_{dn} (dBA)	Project Noise Impact Exposure,* $L_{eq}(h)$ or L_{dn} (dBA)					
	Category 1 or 2 Sites			Category 3 Sites		
	No Impact	Moderate Impact	Severe Impact	No Impact	Moderate Impact	Severe Impact
<43	< Ambient+10	Ambient + 10 to 15	>Ambient+15	<Ambient+15	Ambient + 15 to 20	>Ambient+20
43	<52	52-58	>58	<57	57-63	>63
44	<52	52-58	>58	<57	57-63	>63
45	<52	52-58	>58	<57	57-63	>63
46	<53	53-59	>59	<58	58-64	>64
47	<53	53-59	>59	<58	58-64	>64
48	<53	53-59	>59	<58	58-64	>64
49	<54	54-59	>59	<59	59-64	>64
50	<54	54-59	>59	<59	59-64	>64
51	<54	54-60	>60	<59	59-65	>65
52	<55	55-60	>60	<60	60-65	>65
53	<55	55-60	>60	<60	60-65	>65
54	<55	55-61	>61	<60	60-66	>66
55	<56	56-61	>61	<61	61-66	>66
56	<56	56-62	>62	<61	61-67	>67
57	<57	57-62	>62	<62	62-67	>67
58	<57	57-62	>62	<62	62-67	>67
59	<58	58-63	>63	<63	63-68	>68
60	<58	58-63	>63	<63	63-68	>68
61	<59	59-64	>64	<64	64-69	>69
62	<59	59-64	>64	<64	64-69	>69
63	<60	60-65	>65	<65	65-70	>70
64	<61	61-65	>65	<66	66-70	>70
65	<61	61-66	>66	<66	66-71	>71
66	<62	62-67	>67	<67	67-72	>72
67	<63	63-67	>67	<68	68-72	>72
68	<63	63-68	>68	<68	68-73	>73
69	<64	64-69	>69	<69	69-74	>74
70	<65	65-69	>69	<70	70-74	>74
71	<66	66-70	>70	<71	71-75	>75
72	<66	66-71	>71	<71	71-76	>76
73	<66	66-71	>71	<71	71-76	>76
74	<66	66-72	>72	<71	71-77	>77
75	<66	66-73	>73	<71	71-78	>78
76	<66	66-74	>74	<71	71-79	>79
77	<66	66-74	>74	<71	71-79	>79
>77	<66	66-75	>75	<71	71-80	>80

* L_{dn} is used for land use where nighttime sensitivity is a factor; L_{eq} during the hour of maximum transit noise exposure is used for land use involving only daytime activities.

(EXTRACTED FROM REFERENCE 5)

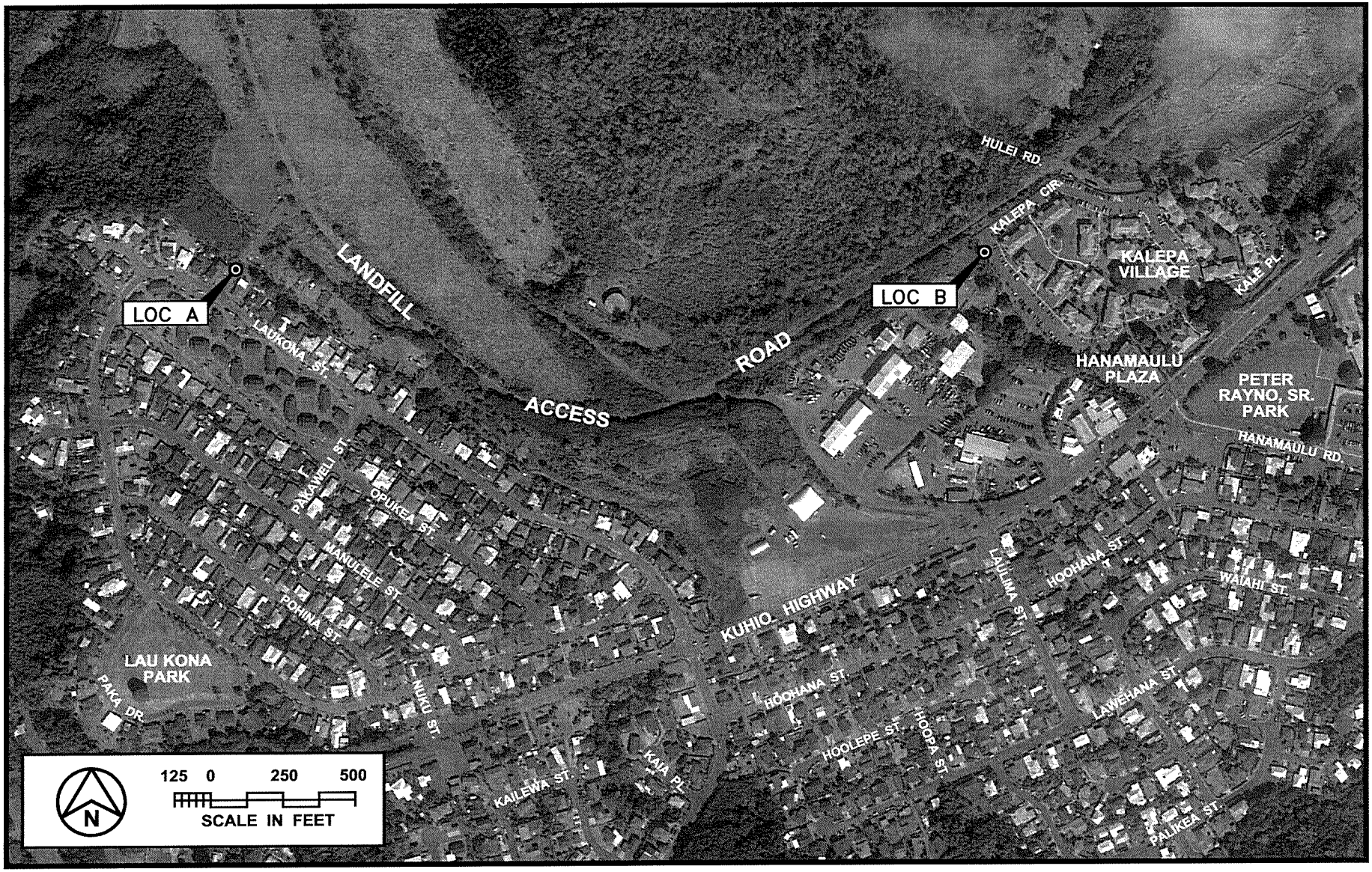
CHAPTER IV. GENERAL STUDY METHODOLOGY

General. Background and refuse vehicle noise measurements and computer noise modeling as used to describe future noise levels in the project environs. The noise from bulldozer operations at the landfill and refuse vehicle traffic noise along the access road servicing the landfill and closest to the existing residences were evaluated. Risks of adverse noise impacts from landfill operations, traffic, and short term construction noise were determined, and possible noise mitigation measures were provided as applicable.

Noise Measurements. Measurements of existing background noise levels were obtained at two locations which were considered to be representative of residential receptor locations closest to the proposed landfill site and to the access road to the landfill site. These locations are shown as Locations A and B in Figure 3. Background noise measurements were obtained in December 2017. The purpose of the background noise measurements was to allow for description of both the steady and intermittent noise levels in the residential areas closest to the proposed landfill site and to the landfill access road closest to these residential areas. The baseline DNL values of both the steady and transient background noise levels (as well as their combined sum) were estimated from these measurements and were used for evaluations of potential noise impacts associated with the proposed project.

Measurements of refuse delivery vehicles were obtained on the island of Oahu in order to validate the assumptions of the U.S. Federal Highway Administration Traffic Noise Model, Version 2.5 (FHWA TNM), which was used to calculate future traffic noise levels associated with the refuse vehicle traffic along the project's landfill access road closest to existing residences. Refuse delivery vehicles (packer and tractor trailer trucks) traveling to and from Oahu's HPOWER facility were measured at a reference distance of 50 feet, and their measured noise levels were compared with the FHWA TNM traffic noise model predictions of their noise levels at that same distance. Significant differences between measured and modeled refuse vehicle noise levels were noted and used to adjust the final traffic noise level results for the project.

Landfill Noise Levels. Existing background ambient noise levels were expected to be very low because the proposed landfill site is presently undeveloped grazing lands. Existing noise levels are probably less than 55 DNL, and are probably controlled by the natural sounds of roosters, birds, and vegetation moving with the wind, with recurring sounds of aircraft operating at Lihue Airport. Intermittent but recurring sounds of roosters, tour helicopter, and local traffic noise events probably control the daytime DNL levels at existing residents closest to the landfill site and access road. Future noise levels associated with the landfill operations were assumed to be controlled by bulldozer, dump truck, and compactor operations at the landfill site, with anticipated combined average noise level of 85 dBA at 100 feet. The noise modeling was performed using inverse square law for hemispherical spreading of a sound from a



BACKGROUND
NOISE MEASUREMENT LOCATIONS

FIGURE 3

source at or near the ground, with inclusion of molecular absorption and anomalous excess attenuation effects. The modeling equation used to predict sound levels at any given distance from a noise source was:

$$L_p = L_w - 20 \times \text{Log}(d) - [d \times a(f)] / 100 - 8$$

where:

L_p = Sound pressure level in decibels (re 2×10^{-5} Pa) at distance d (in meters),
L_w = Sound power level of noise source in decibels (re picowatt), and
a(f) = Molecular absorption plus anomalous excess attenuation in decibels per 100 meters. For the 9 standard Octave Bands from 31.5 Hz to 8,000 Hz, the a(f) values used were 0.1, 0.16, 0.27, 0.39, 0.66, 1.08, 1.9, 3.47, and 5.2.

With a maximum of 85 dBA sound pressure level at 100 feet from the landfill, predicted maximum sound pressure level at the closest residence at 5,500 feet was 37.5 dBA with all equipment operating at the south end of the landfill. With all equipment operating at the north end of the landfill, predicted maximum sound level at the closest residence at 11,000 feet was 24.2 dBA. Measured minimum daytime noise levels at Locations A and B exceeded 33.0 dBA; and ranged from 30.1 to 35.0 dBA at Location A, and from 37.6 to 40.4 dBA at Location B.

For converting the landfill equipment sound levels to DNL, it was assumed that landfill equipment would be operating for 7 hours per day between 8:00 am and 4:00 pm, 7 days per week, and 52 weeks per year. The net result of the modeling efforts was that the noise from landfill operations would not exceed 80.2 DNL at approximately 100 feet from any operating landfill equipment, or 32.6 DNL at the closest residence at 5,500 feet.

Refuse Vehicle Noise Levels. Refuse vehicle noise level predictions for the future conditions along the Landfill Access Road section closest to the existing residences shown in Figure 1 were performed using the Federal Highway Administration Traffic Noise Model, Version 2.5 (Reference 7). Traffic data entered into the noise prediction model were: roadway and receiver locations; peak hour as well as annually averaged, two-way hourly traffic volumes, average vehicle speed of 40 miles per hour; and "Loose Soil" propagation loss factor. The assumed number of daily inbound plus outbound trips of refuse vehicles were: 10 trips for residential automated refuse trucks from Monday to Thursday; and 14 trips for tractor trailer refuse trucks from Monday to Sunday. During a worst case peak traffic hour during Monday to Thursday, it was assumed that 6 automated residential refuse vehicle trips plus 6 tractor trailer refuse vehicle trips cold occur along the landfill access road (see Reference 8). This peak hour refuse vehicle traffic volume was entered into the TNM, and the resulting peak hour noise levels [LAeq (h)] at the closest existing residences were compared to the current FHWA/HDOTH traffic noise impact threshold of 66 LAeq(h). In addition,

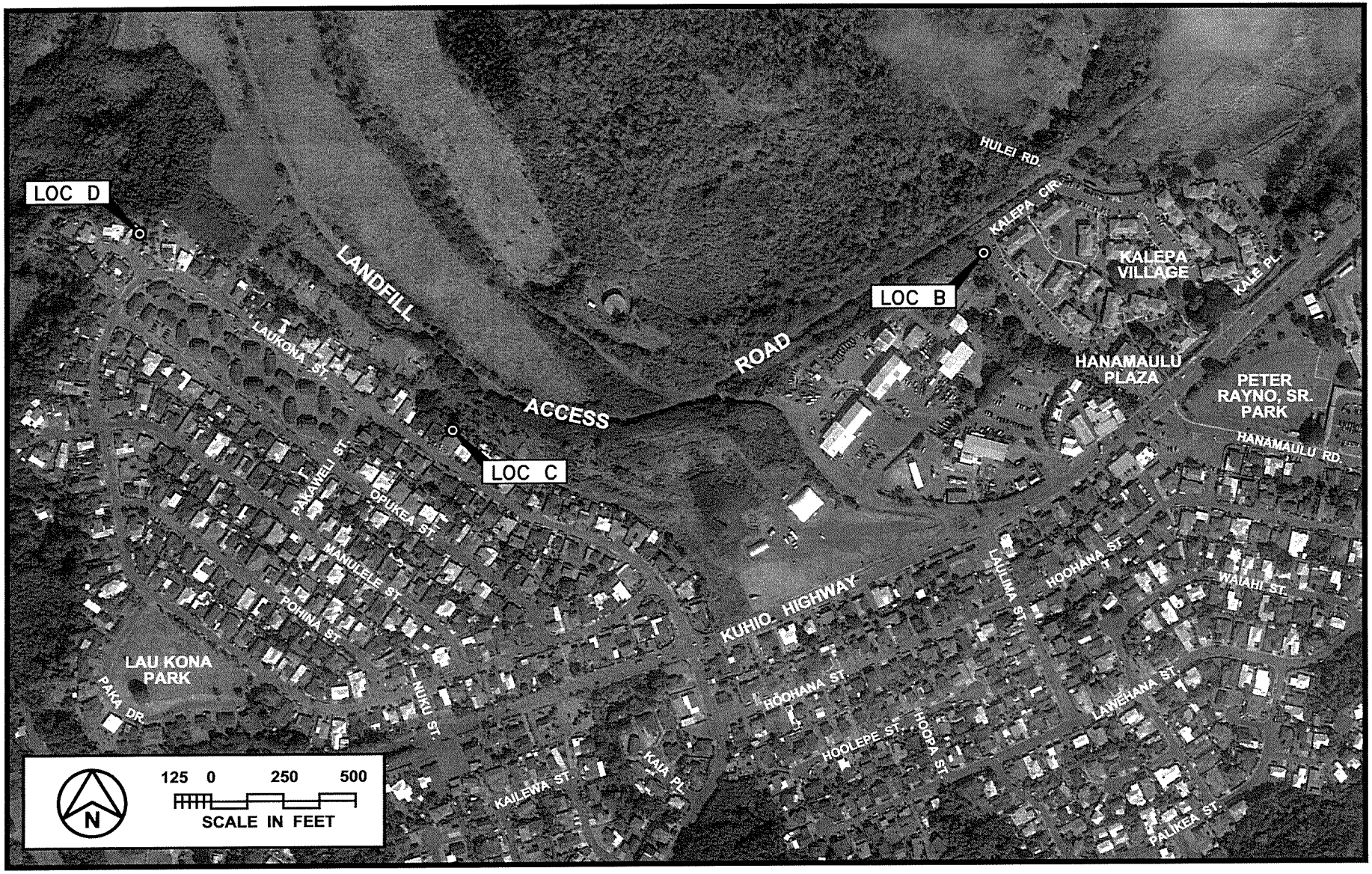
the resulting peak hour refuse vehicle noise levels were compared to the "15 dBA increase" noise impact criteria used by FHWA and HDOT.

Evaluations of potential noise impacts associated with refuse vehicle noise levels using the DNL metric required the calculation of the annually averaged number of daily refuse vehicle trips for 7 days per week and 52 weeks per year along the landfill access road shown in Figures 1, 3, and 4. When averaged over a 7 hour work day, 7 days per week, and 52 weeks per year, the annually averaged hourly, two-way volumes of refuse vehicles was: 5.7 trips per day for automated residential refuse vehicles plus 14.0 trips per day for tractor trailer refuse vehicles. The DNL associated with these daily trips were calculated at the closest existing residences using the TNM, with a Leq(h) to DNL metric conversion factor of -13.8 dB.

All refuse vehicle traffic noise calculations for the future conditions in the project environs were developed for ground level receptors without the benefit of shielding from natural or man made obstructions. Project related refuse vehicle noise levels for future conditions were calculated along the future landfill access road at existing residences where shown as Locations B, C, and D in Figure 4. This access road was previously a cane haul road, which will be improved to the paved, 2-lane roadway, with assumed refuse vehicle speed of 40 miles per hour. Calculations of future refuse vehicle noise levels were performed using the peak hour Leq metric as used by FHWA/HDOTH and using the DNL metric as used by other federal agencies.

In order to refine the refuse vehicle traffic noise level predictions of the FHWA TNM, comparisons of measured refuse vehicle traffic noise levels with FHWA TNM predictions were also performed. Table 3 presents the measured average hourly noise level of automated residential and tractor trailer refuse trucks at 50 feet distance makai from the centerline of Komohana Street (between Hanua Street and Kalaeloa Boulevard) at Campbell Industrial Park in Kapolei, Oahu. The far traffic lane was used by the inbound refuse trucks to the Honolulu HPOWER Facility, and the near outbound lane was used by the outbound refuse trucks from the HPOWER Facility. Estimated average vehicle speed during the measurements was 32 miles per hour. The results of the refuse vehicle noise measurements to/from the HPOWER Facility indicated that the FHWA TNM may be underestimating the automated residential refuse vehicle noise levels by 3.1 dBA, and underestimating the tractor trailer refuse vehicles by 3.4 dBA. Therefore, these adjustment factors were applied to the MSWL project's TNM noise modeling results which represent the peak hour Leq and annually averaged DNL noise levels of the refuse vehicles traveling to and from the MSWL at Maalo, Kauai.

Construction Noise. Evaluations of potential construction noise impacts at properties adjacent to the landfill site and access road were also performed. Recommended noise mitigation measures were provided.



REFUSE VEHICLE NOISE LEVEL PREDICTION LOCATIONS

FIGURE 4

TABLE 3
COMPARISON OF MEASURED VS. PREDICTED REFUSE VEHICLE NOISE LEVELS
(50 FEET FROM CENTERLINE OF KOMOHANA STREET; DECEMBER 27, 2017)

		------ Hourly Traffic Volume ------		---- Measured Leq(h)		--------- Predicted Leq(h)* ----	
Time of Day (HRS)	Ave. Speed (MPH)	Automated Residential	Tractor Trailer	Automated Residential	Tractor Trailer	Automated Residential	Tractor Trailer
0800 TO 0900	32	36	10	63.1	58.2	60.5	54.9
0900 TO 1000	32	52	11	65.0	58.4	62.0	55.4
1000 TO 1100	32	38	13	64.3	59.8	60.6	56.0

Note:

* Predicted Leq(h) are TNM Version 2.5 results for Heavy Trucks at 32 mph speed.

CHAPTER V. EXISTING NOISE LEVELS

Measurements of existing background noise levels at existing residences in the project area were obtained in December 2017 at measurement Locations A and B where shown in Figure 3. These measurement locations were selected due to their proximity to the landfill access road and to the landfill site. These measurements were obtained in order to characterize and quantify the existing background noise levels during periods of relative quiet as well as during periods with intermittent aircraft and motor vehicle noise events. Table 4 summarizes the hourly background noise levels obtained at Locations A and B, and Figures 5 through 8 depict typical 1 hour strip charts of dBA vs. time records obtained during the noise monitoring periods. Figures 9 and 10 are 10 minute strip charts which show more detail of the rooster, helicopter, and jet aircraft takeoff events which occurred in Figure 5 at Location A. Figures 11 and 12 are 10 minute strip charts which show more detail of rooster, helicopter, and jet aircraft takeoff events which occurred in Figures 7 and 8, respectively, at Location B. As indicated in Table 3 and Figures 5 through 12, existing background noise levels can be characterized as being relatively low at 35 to 50 dBA between the intermittent and recurring aircraft, automobile, and rooster noise events, which are clearly audible and between 10 to 25 dBA above the more steady background noise levels of the quieter periods.

Existing background noise levels during the quieter periods between aircraft, rooster, and automobile noise events were less than to 45 Leq(h) (or average hourly noise level) at Location A and less than 50 Leq(h) at Location B. Roosters were clearly the loudest recorded noise events, with maximum noise levels in the 65 to 75 dBA range. Maximum helicopter noise levels were typically in the 55 to 65 dBA range, and maximum jet aircraft noise levels were typically in the 50 to 60 dBA range.

Estimated residual (excluding roosters, helicopters, jet aircraft, and automobiles) background noise levels at Locations A and B were 45 DNL and 48 DNL, respectively. Estimated total (including residual noise, helicopters, jet aircraft, roosters, and motor vehicles) background noise levels at Locations A and B were 50 DNL and 52 DNL, respectively. These DNL levels are relatively low and considered to be "Unconditionally Compatible" for single family residences (see Tables 1 and 2 and Figure 2), despite the relatively high intermittent noise levels from roosters and other short duration noise events. By the more stringent noise impact criteria used by the FTA (see their reproduced Figure 3-1 and Table 3-1), if the noise from future refuse vehicles and landfill operations do not exceed 54 DNL to 55 DNL, noise impacts at or near Locations A through D should not occur when background noise levels are 50 DNL and 52 DNL, respectively. By the FHWA/HDOTH noise impact criteria used for the peak hour of refuse vehicle traffic, refuse vehicle traffic noise level during the peak traffic hour would need to be at least 64 Leq(h) to exceed the "15 dB increase above background noise" noise impact criteria. The 64 Leq(h) threshold was determined by adding 15 dB to the lowest background Leq(h) measured at Locations A or B (see Table 4). This 64 Leq(h) threshold is 2 Leq(h) units lower than the other 66 Leq(h) noise impact threshold used by FHWA/HDOTH (see Reference 4).

TABLE 4 - BACKGROUND NOISE MEASUREMENTS - LOCATIONS A AND B

LOCATION A: Mauka End of Palani Street
LOCATION B: Northwest Corner of Kalepa Circle

Date	Start Time	End Time	Lmax	Leq	Lmin	L10	L50	L90	Event Description
	LOCATION A: MAUKA END OF PALANI STREET								
12/21/17	0700	0800	75.7	54.7	34.9	54.0	46.1	36.3	Mostly Roosters
12/21/17	0800	0900	82.6	58.9	33.1	55.8	45.0	35.0	Mostly Roosters
12/21/17	0900	1000	71.4	51.6	34.5	52.7	43.9	36.4	Mostly Roosters
12/19/17	1000	1100	64.6	48.8	34.7	52.8	44.3	36.3	
12/19/17	1100	1200	72.1	49.0	32.8	51.5	43.0	34.8	Helos & Roosters
12/19/17	1200	1300	71.5	49.1	33.6	52.5	45.8	35.7	
12/19/17	1300	1400	70.9	49.4	34.3	50.3	43.8	36.1	
12/19/17	1500	1600	72.2	49.5	34.3	51.0	43.0	35.6	
12/19/17	1600	1700	77.9	49.8	33.4	50.2	41.4	35.3	
12/19/17	1700	1800	70.8	49.2	35.0	52.1	42.9	36.4	
	LOCATION B: NORTHWEST CORNER OF KALEPA CIRCLE								
12/20/17	0700	0800	70.4	51.0	38.9	50.7	44.1	40.1	
12/20/17	0800	0900	73.5	53.2	39.5	53.8	45.8	40.4	
12/20/17	0900	1000	75.6	51.1	40.3	54.1	45.4	41.0	
12/20/17	1000	1100	68.4	52.0	39.8	55.3	47.1	41.0	
12/20/17	1100	1200	66.3	52.6	40.4	56.0	49.9	42.0	
12/20/17	1200	1230	71.7	53.0	41.8	55.1	50.2	46.5	Cars & Helos
12/20/17	1330	1400	70.4	52.4	41.0	55.0	47.9	44.1	Cars & Helos
12/20/17	1400	1500	80.4	53.2	38.3	54.5	46.2	39.7	
12/20/17	1500	1600	89.7	59.0	40.2	54.3	47.5	41.4	Rooster Near Meter
12/20/17	1600	1700	66.5	49.0	37.7	52.1	44.7	38.9	
12/20/17	1700	1800	67.5	45.9	37.6	45.5	41.8	38.8	

Notes:

a. Leq = Average A-Weighted Sound Level (in dBA)
b. Lmax = Maximum A-Weighted Sound Level (in dBA)
c. Lmin = Minimum A-Weighted Sound Level (in dBA)
d. Lxx = A-Weighted Sound Level (in dBA) which was exceeded xx percent of the time.

FIGURE 5. 1 HOUR DBA VS. TIME RECORD AT LOCATION A
(0700 TO 0800 HOURS; December 21, 2017)

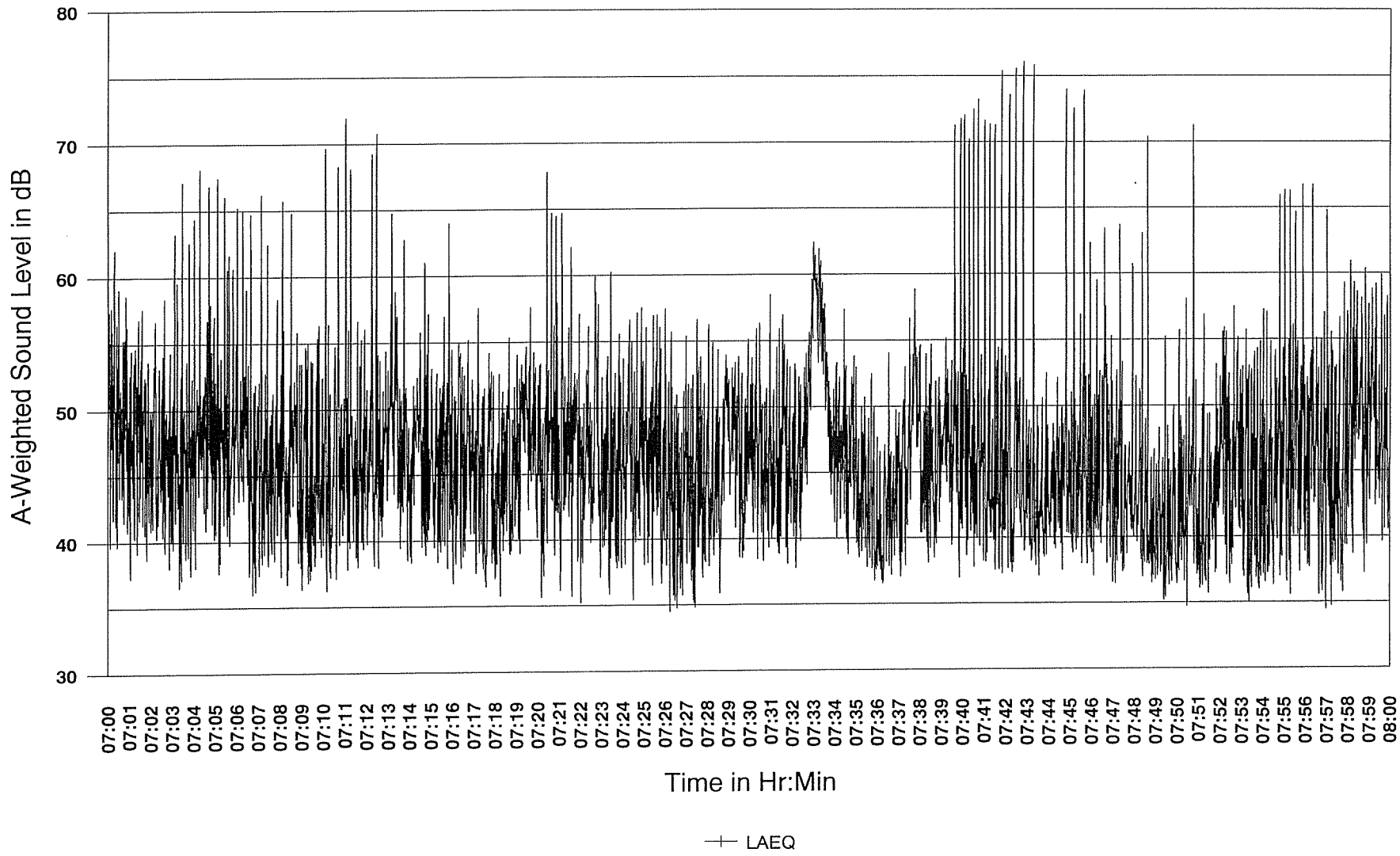


FIGURE 6. 1 HOUR DBA VS. TIME RECORD AT LOCATION A
(1500 TO 1600 HOURS; December 19, 2017)

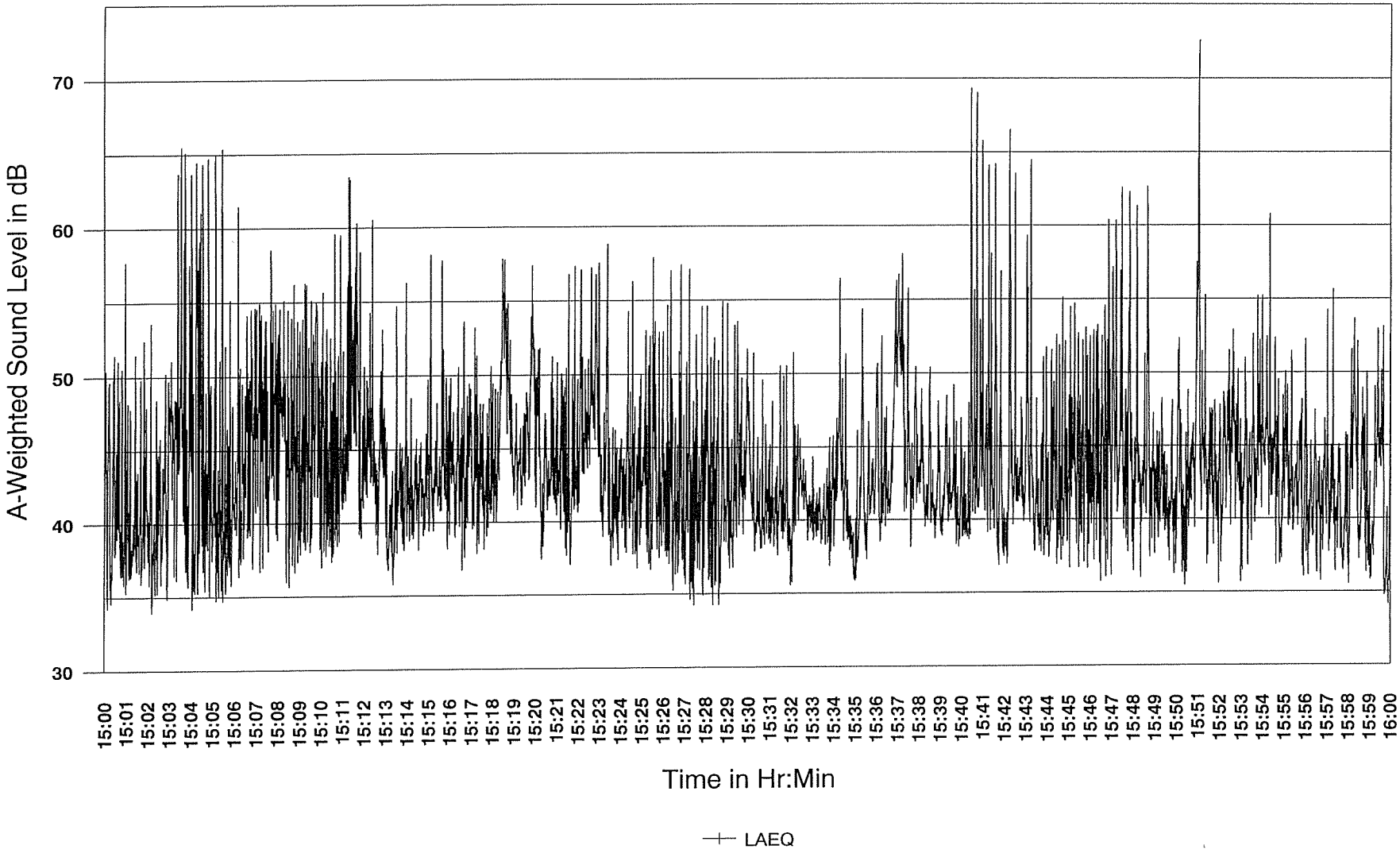


FIGURE 7. 1 HOUR DBA VS. TIME RECORD AT LOCATION B
(0800 TO 0900 HOURS; December 20, 2017)

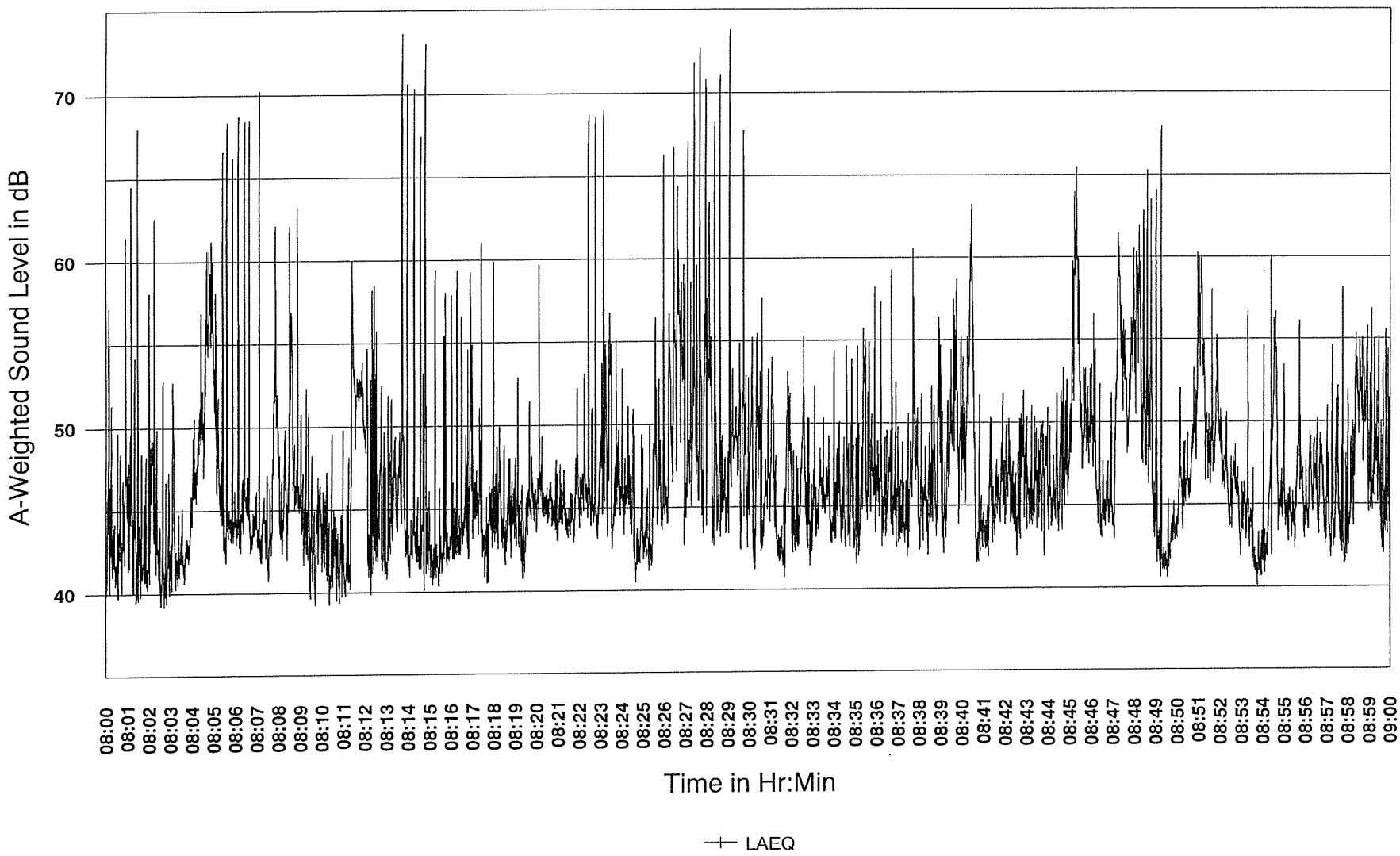


FIGURE 8. 1 HOUR DBA VS. TIME RECORD AT LOCATION B
(1500 TO 1600 HOURS; December 20, 2017)

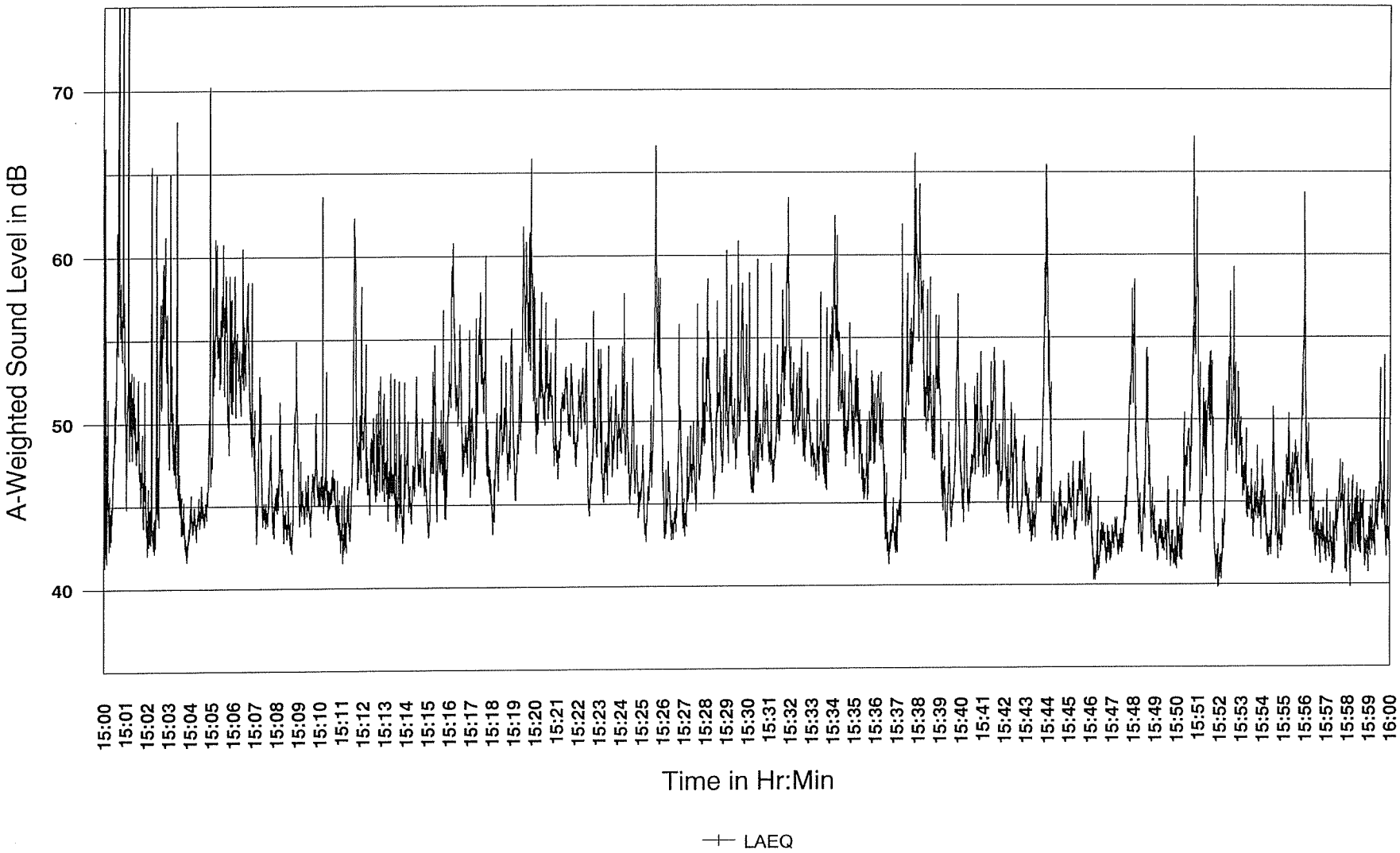


FIGURE 9. 10 MINUTE DBA VS. TIME RECORD OF HELICOPTER, JET AIRCRAFT, ROOSTER AT LOCATION A (DECEMBER 21, 2017)

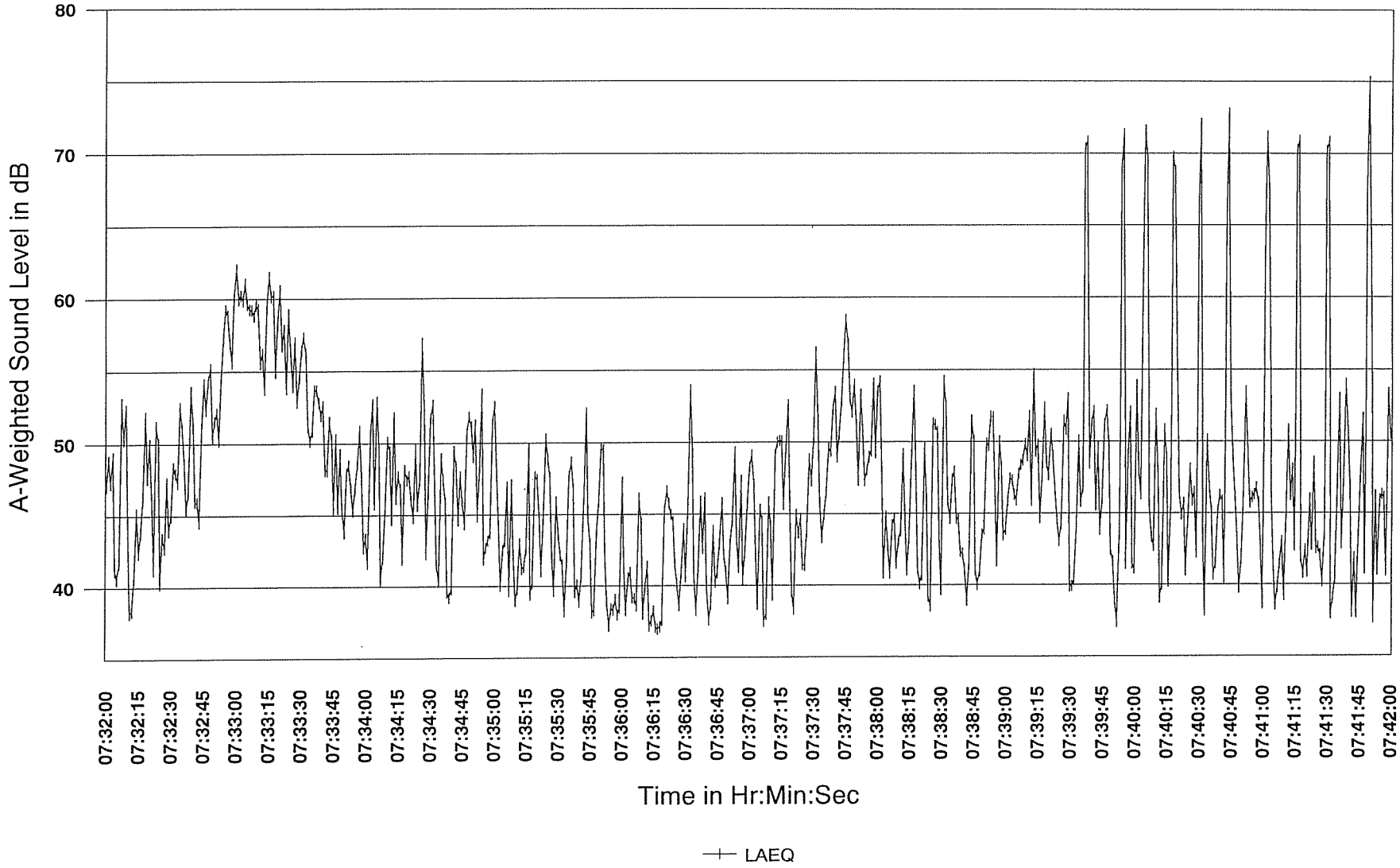


FIGURE 10. 10 MINUTE DBA VS. TIME RECORD OF ROOSTERS AT LOCATION A
(DECEMBER 21, 2017)

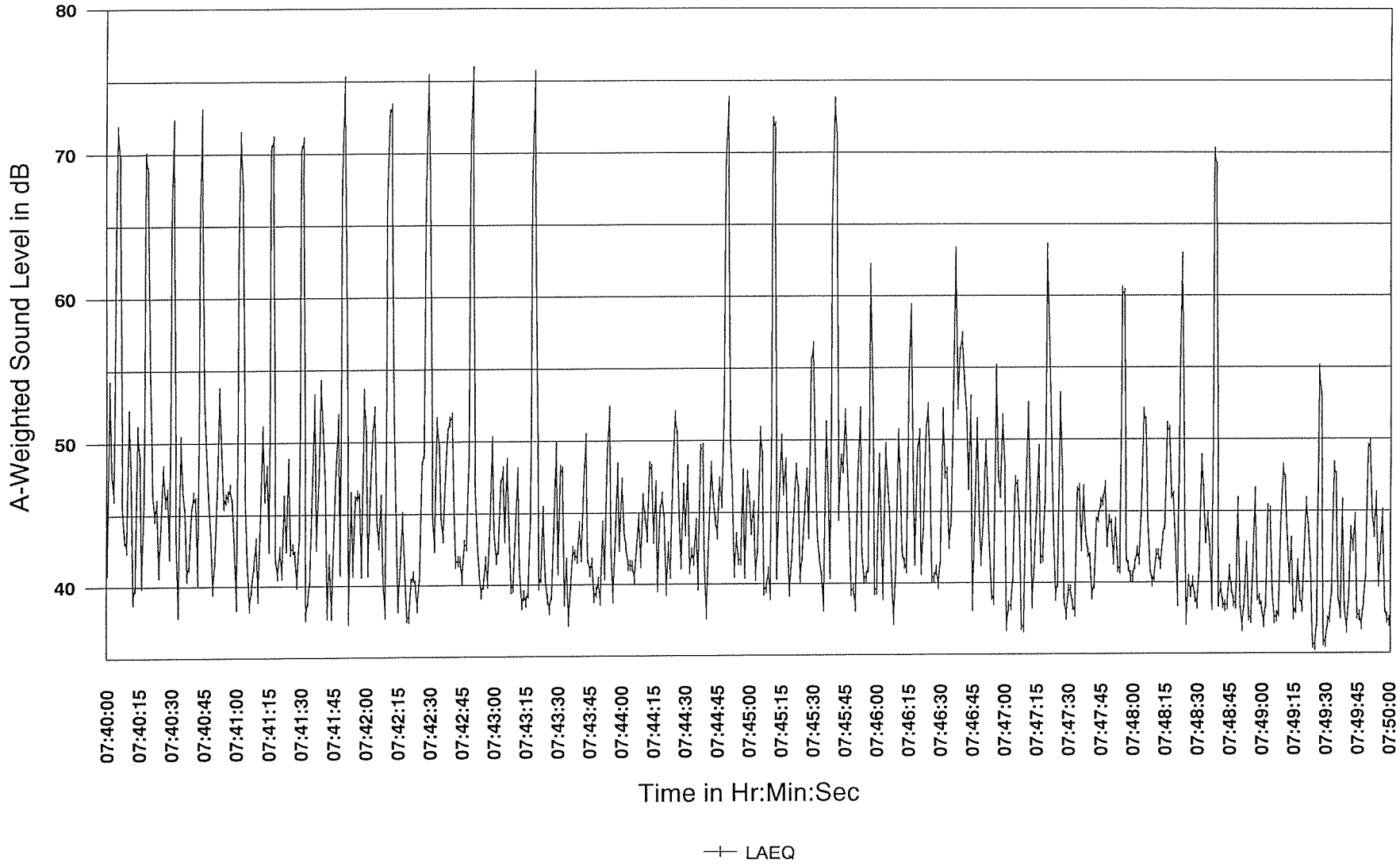


FIGURE 11. 10 MINUTE DBA VS. TIME RECORD OF ROOSTERS AT LOCATION B
(DECEMBER 20, 2017)

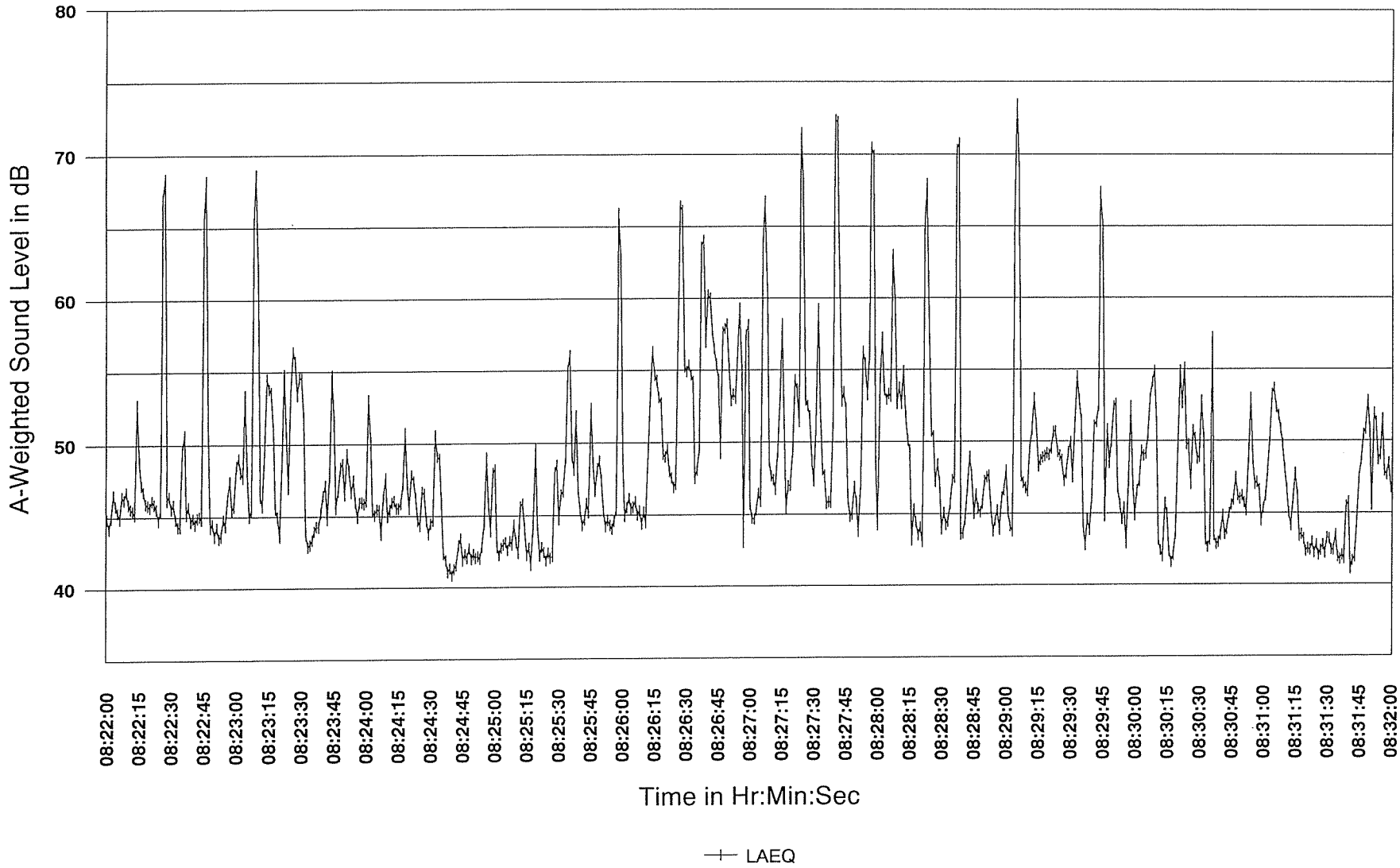
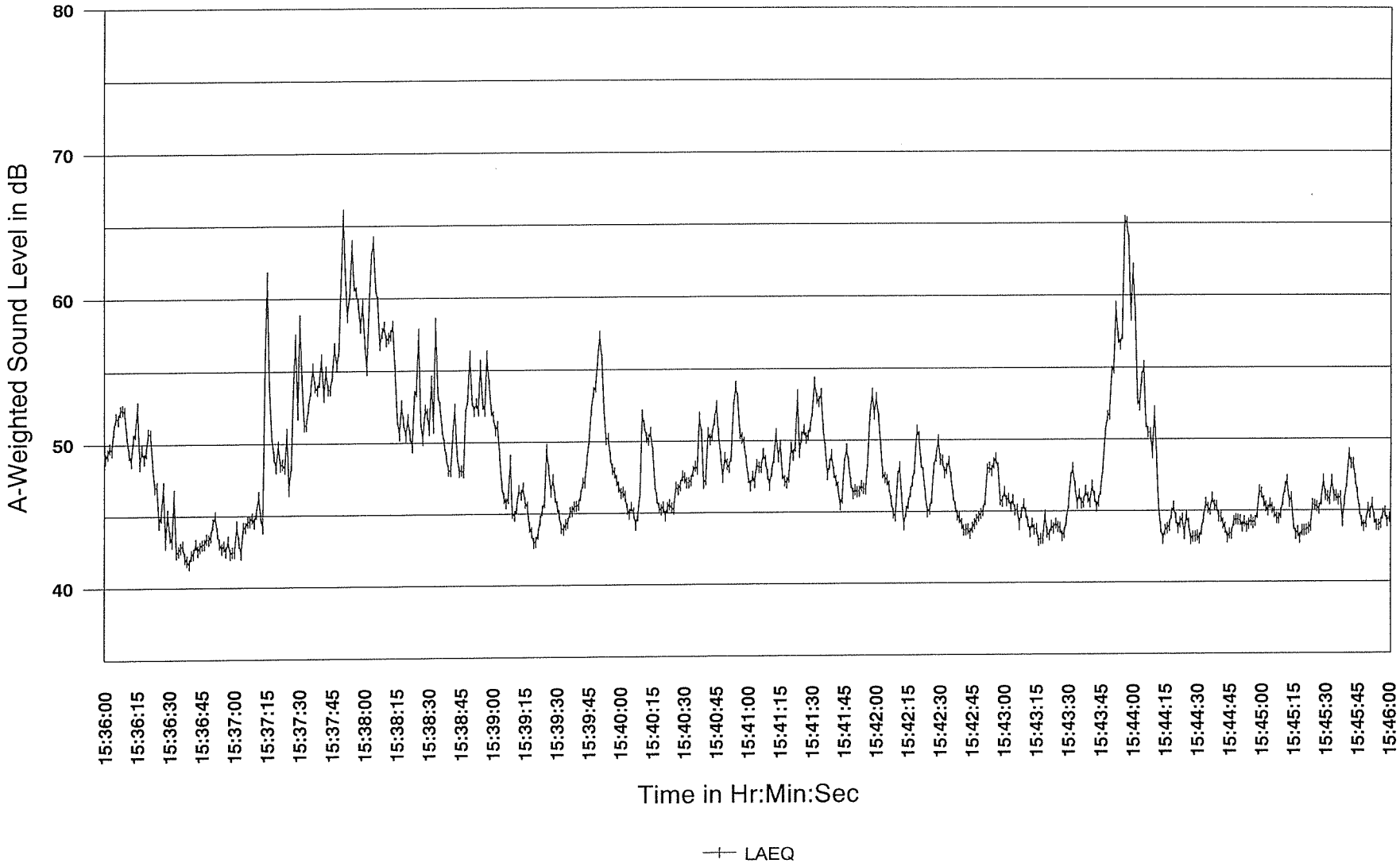


FIGURE 12. 10 MINUTE DBA VS. TIME RECORD OF HELICOPTERS AND JET AIRCRAFT AT LOCATION B
(DECEMBER 20, 2017)



CHAPTER VI. FUTURE NOISE ENVIRONMENT

Landfill Operations. Predictions of the noise levels associated with future landfill operations were based on a reference noise level of 85 dBA at 100 feet distance for the simultaneous operations of a bulldozer, dump truck, and compactor. Spherical spreading plus molecular absorption and excess ground attenuation were used to calculate combined equipment sound levels at large distances from the landfill. Estimates of the DNL values associated with bulldozer operations at the landfill were based on equipment operation for 7 hours per day between 8:00 am to 4:00 pm, 7 days per week, and 52 weeks per year. The net result of these modeling assumptions was that landfill noise levels associated with landfill equipment operations would not exceed 80.2 DNL at 100 feet or 55 DNL at 605 feet distance from the southmost boundary of the landfill. Because the closest existing residences mauka of Laukona Street are at least 5,500 feet from the landfill's south boundary, landfill noise levels should not exceed 32 DNL at the closest existing residences. Average sound levels (as read on a sound level meter) are not expected to exceed 38 dBA. Since 32 DNL is well below the 55 DNL "Unconditionally Accepable" and 54 to 55 DNL noise impact theshold which was identified using the FTA noise impact criteria, noise associated with MSWL operations at Maalo, Kauai should not exceed or approach levels which are considered to be unacceptable or incompatible for noise sensitive land uses. Audible noise from the landfill equipment (at 38 dBA) during worst case conditions is expected to be noticeable only during the very quiet periods between the normally occurring intermittent noise events which tend to exceed 45 dBA (see Figures 5 through 12).

Refuse Vehicle Traffic Noise Levels. Predictions of potential noise levels associated with refuse delivery vehicle traffic along the section of the future MSWL access road shown in Figures 1, 3, and 4 were made using the TNM, with 3.1 and 3.4 dB increases in TNM predictions applied to the automated residential and tractor trailer refuse vehicles, respectively. Tables 5, 6, and 7 present the refuse vehicle noise level predictions at noise sensitive receptor Locations B, C, and D, which are shown in Figure 4. Also shown in these tables are the assumed number of trips of automated residential (6 trips) and tractor trailer (6 trips) during a peak hour between Mondays and Thursdays. These hourly trips were used to calculate the peak hour Leq(h)'s associated with the two types of refuse vehicles, as well as their combined total Leq(h) during the peak hour. The calculated total peak hour Leq(h)'s varied from 47.3 Leq at Location D to 59.3 Leq at Location B. These predicted peak hour noise levels associated with refuse vehicle traffic on the landfill access road are well below the 66 Leq(h) FHWA/HDOTH noise impact threshold as well as below the 64 Leq(h) "15 dBA Increase" threshold used by FHWA/HDOTH. From the results presented in Tables 5, 6, and 7 at the closest existing noise sensitive receptors, it was concluded that predicted refuse vehicle noise levels would not exceed the noise mitigation thresholds currently used by FHWA/HDOTH in accordance with Reference 4.

Calculations of refuse vehicle traffic noise levels using the DNL metric were also performed, and these DNL results are shown below the peak hour Leq results in Tables

TABLE 5
PREDICTED REFUSE VEHICLE NOISE LEVELS AT NOISE SENSITIVE RECEPTOR LOCATION B
(PEAK HOUR LEQ(H) AND DNL FROM REFUSE VEHICLES; 40 MPH)

Noise Metric Used	Ave. Speed (MPH)	---- Total Refuse Vehicle Trips ----- Automated Residential	Tractor Trailer	Predicted Noise Level Automated Residential	Tractor Trailer	Predicted Total Noise Level (All Vehicles)
Peak Hour Leq(h)	40	6 Per Hour	6 Per Hour	56.1	56.4	59.3
Annual Ave.	40	5.71 Per Day	14 Per Day	42.7	46.9	48.3

TABLE 6
PREDICTED REFUSE VEHICLE NOISE LEVELS AT NOISE MEASUREMENT LOCATION C
(PEAK HOUR LEQ(H) AND DNL FROM REFUSE VEHICLES; 40 MPH)

Noise Metric Used	Ave. Speed (MPH)	---- Total Refuse Vehicle Trips ----- Automated Residential	Tractor Trailer	Predicted Noise Level Automated Residential	Tractor Trailer	Predicted Total Noise Level (All Vehicles)
Peak Hour Leq(h)	40	6 Per Hour	6 Per Hour	50.7	51.0	53.9
Annual Ave. DNL	40	5.71 Per Day	14 Per Day	36.7	40.8	42.2

TABLE 7
PREDICTED REFUSE VEHICLE NOISE LEVELS AT NOISE SENSITIVE RECEPTOR LOCATION D
(PEAK HOUR LEQ(H) AND DNL FROM REFUSE VEHICLES; 40 MPH)

Noise Metric Used	Ave. Speed (MPH)	---- Total Refuse Vehicle Trips ----- Automated Residential	Tractor Trailer	Predicted Noise Level Automated Residential	Tractor Trailer	Predicted Total Noise Level (All Vehicles)
Peak Hour Leq(h)	40	6 Per Hour	6 Per Hour	44.1	44.4	47.3
Annual Ave. DNL	40	5.71 Per Day	14 Per Day	30.1	34.3	35.7

Note:

Predicted Leq(h) and DNL values include 3.1 and 3.4 dBA increases for Automated Residential and Tractor Trailer noise levels, respectively, above TNM Version 2.5 results for Heavy Trucks at 40 mph speed.

5, 6, and 7. When using the DNL metric, the annually averaged number of daily trips by automated residential and tractor trailer refuse vehicles of 5.71 and 14.0 per day, respectively, were used as shown in the tables. Because of the annual averaging and the refuse vehicle movements for no more than 7 hours per 24-hour day, the DNL predictions were much lower than the peak hour Leq(h) predictions. Total DNL values at receptor Locations B, C, and D ranged from 35.7 to 48.3 DNL, which are well below the 55 DNL "Unconditionally Acceptable" threshold shown in Table 1 and the most stringent FTA noise impact threshold of 50 to 52 DNL which are applicable for the background noise levels measured at Locations A and B. From the results presented in Tables 5, 6, and 7 at the closest existing noise sensitive receptors, it was concluded that predicted refuse vehicle noise levels would not exceed the DNL criteria and noise mitigation thresholds currently used by federal agencies other than FHWA/HDOTH.

Combined Landfill and Refuse Vehicle Noise Levels. Existing residences on the northwest end of the Laukona Street between Locations C and D could be exposed to noise contributions from both the landfill operations and the refuse delivery vehicles following implementation of the proposed MSWL project. The DNL metric allows for combining these worst case noise contributions from the landfill plus those from refuse vehicles. Because noise contributions from the landfill operations are predicted to not exceed 32 DNL at the closest existing residences, the sum of the landfill and refuse vehicle noise levels will be controlled by the refuse vehicle noise component, which are predicted to exceed 42 DNL at the residences south of the proposed landfill access road. This is because the addition of two DNL components which differ by at least 10 DNL units produces a total DNL value which is approximately equal to the larger DNL component (which is the refuse vehicle noise). As indicated in Tables 5, 6, and 7, the refuse vehicle DNL components from Locations B through D are all predicted to exceed 47 DNL, and therefore control the total DNL levels from the MSWL project at residences along the landfill access road.

CHAPTER VII. POTENTIAL NOISE IMPACTS ASSOCIATED WITH THE PROPOSED PROJECT AND POSSIBLE MITIGATION MEASURES

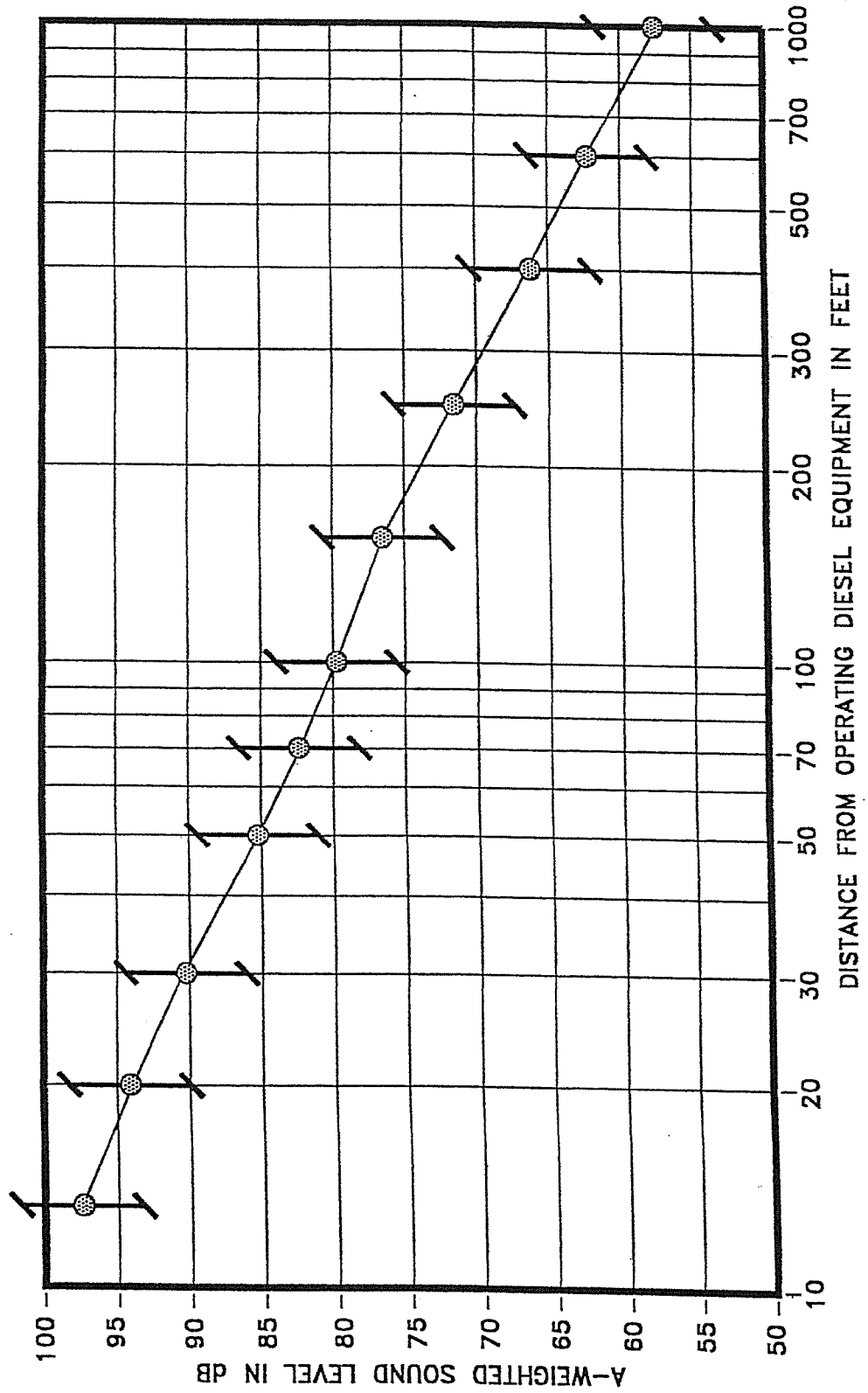
Landfill Noise Impacts. Potential impacts resulting from the noise of bulldozer, compactor, and dump truck operations at the proposed MSWL at Maalo, Kauai are expected to be minimal due to the large buffer distance of 1 to 2 miles between the operating landfill equipment and the closest existing residences along Laukona Street. Predicted landfill noise levels were 22 to 23 DNL below the most stringent federal noise criteria at the closest noise sensitive residences. For this reason, noise mitigation measures should not be required at the proposed landfill site.

Refuse Vehicle Traffic Noise Impacts. The traffic noise levels attributable to refuse delivery vehicle traffic to and from the MSWL along the landfill access road are predicted to be well below current federal and local noise mitigation thresholds for motor vehicles traveling on roadways near noise sensitive receptors. Predicted refuse vehicle noise levels during a peak hour were 5 to 7 Leq(h) below FHWA/HDOTH noise mitigation thresholds; and 6 to 7 DNL below the most stringent federal criteria at the closest noise sensitive residences. Risks of potential noise impacts from project refuse vehicle traffic are considered to be very low at existing noise sensitive receptors because of their adequate setback distances from the landfill access road. For these reasons, existing noise sensitive residences along the landfill access road should not require sound attenuation measures as a result of the proposed project.

Construction Noise Impacts. Construction noise will probably be slightly audible during construction activities at the landfill site, but less than 40 dBA at the closest residences. During roadway work along the landfill access road, construction noise levels are anticipated to be highest at existing residences along Kalepa Circle and range from 75 to 85 dBA. At existing residences along Laukona Street, construction noise levels during roadway work are predicted to range from 55 to 80 dBA.

Typical levels of exterior noise from construction activity (excluding pile driving activity) at various distances from the job sites are shown in Figure 13. Figure 13 is useful for predicting exterior noise levels at short distances (within 100 feet) from the work when visual line of sight exists between the construction equipment and the receptor. Direct line-of-sight distances from the construction equipment to existing residential buildings will range from 100 feet to 500+ feet, with corresponding average noise levels of 80 to 64 dBA (plus or minus 5 dBA). The construction noise level vs. distance curve of Figure 13 should be reduced by approximately 10 to 15 dBA when the visual line-of-sight is blocked by intervening buildings. Typical levels of construction noise inside naturally ventilated and air conditioned structures are approximately 10 and 20 dB less, respectively, than the levels shown in Figure 13.

Noise sensitive receptors who are predicted to experience the highest noise levels during construction activities are located along Kalepa Circle due to their proximity to the future landfill access road. Predicted construction noise levels at these



ANTICIPATED RANGE OF CONSTRUCTION NOISE LEVELS VS. DISTANCE

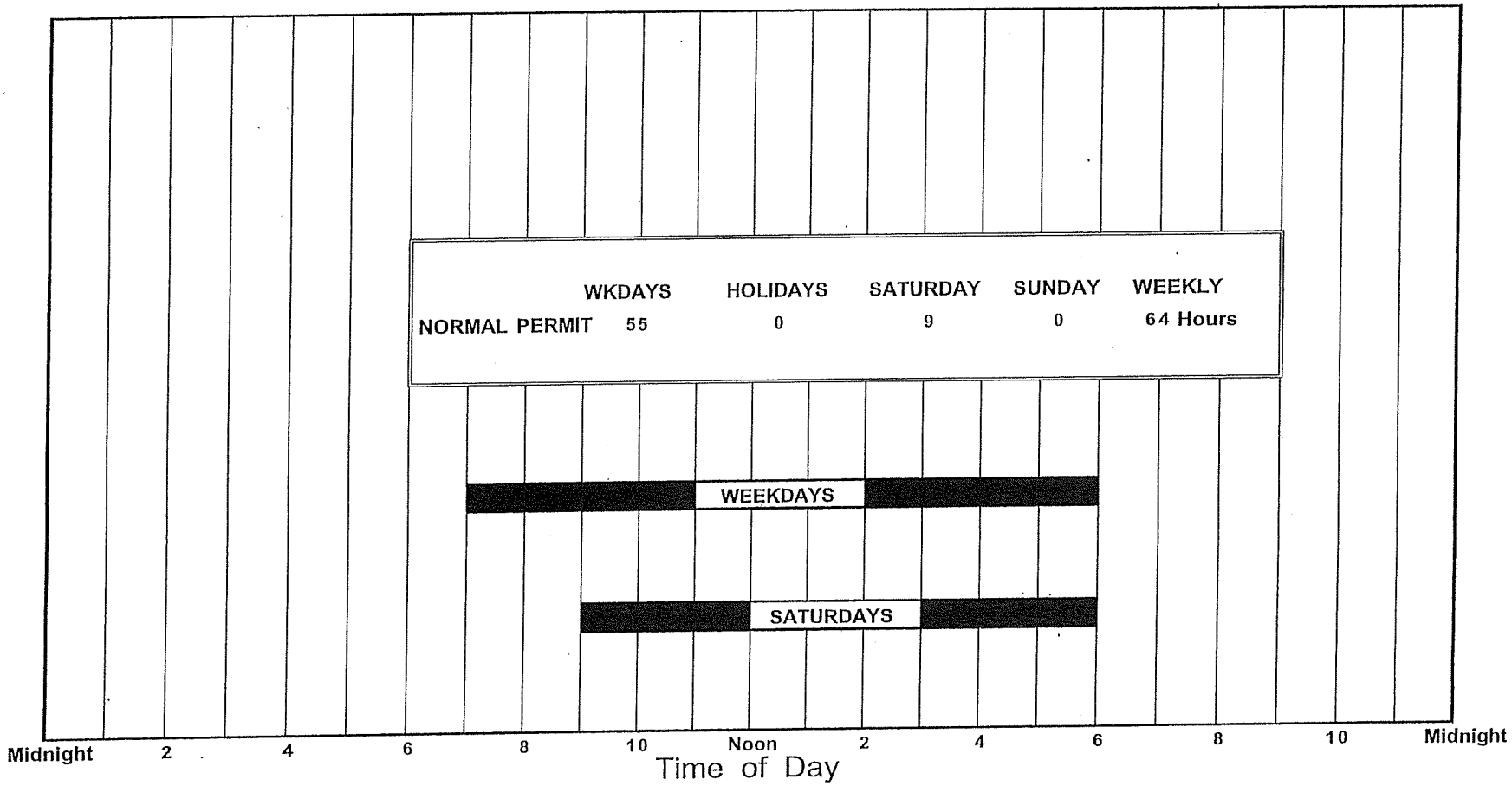
FIGURE 13

residences during the roadway construction phase of the work ranged from 75 to 85 dBA. Adverse impacts from construction noise are not expected to be in the "public health and welfare" category due to the temporary nature of the work, and due to the administrative controls available for regulation of construction noise. Instead, these impacts will probably be limited to the temporary degradation of the quality of the acoustic environment in the immediate vicinity of the project site.

Mitigation of construction noise to inaudible levels will not be practical in all cases due to the intensity of construction noise sources (75 to 85 dBA at 100 feet distance), and due to the exterior nature of the work (excavation, grading, paving, etc.). The use of properly muffled construction equipment should be required on the job site.

Severe noise impacts are not expected to occur inside air conditioned structures which are beyond 100 to 500 feet from the project construction sites. Inside naturally ventilated structures, interior noise levels (with windows or doors opened) are estimated to range between 65 to 75 dBA at 100 feet and between 49 to 59 dBA at 500 feet distances from the construction site. Closure of all doors and windows facing the construction site would generally reduce interior noise levels by an additional 5 to 10 dBA.

The incorporation of State Department of Health construction noise limits and curfew times, which are applicable throughout the State of Hawaii (Reference 6), is another noise mitigation measure which is normally applied to construction activities. Figure 14 depicts the normally permitted hours of construction. Noisy construction activities are not allowed on Sundays and holidays, during the early morning, and during the late evening and nighttime periods under the DOH permit procedures.



AVAILABLE WORK HOURS UNDER DOH PERMIT PROCEDURES FOR CONSTRUCTION NOISE

FIGURE 14

APPENDIX A. REFERENCES

(1) "Guidelines for Considering Noise in Land Use Planning and Control;" Federal Interagency Committee on Urban Noise; June 1980.

(2) American National Standard, "Sound Level Descriptors for Determination of Compatible Land Use," ANSI S12.9-1998/ Part 5; Acoustical Society of America.

(3) "Environmental Criteria and Standards, Noise Abatement and Control, 24 CFR, Part 51, Subpart B;" U.S. Department of Housing and Urban Development; July 12, 1979.

(4) "Highway Noise Policy and Abatement Guidelines;" State of Hawaii, Department of Transportation, Highways Division and U.S. Department of Transportation, Federal Highway Administration; April 18, 2016.

(5) "Transit Vehicle Noise and Vibration Impact Assessment, FTA-VA-90-1003-06; Federal Transit Administration; May 2006.

(6) "Title 11, Administrative Rules, Chapter 46, Community Noise Control;" Hawaii State Department of Health; September 23, 1996.

(7) "FHWA Highway Traffic Noise Model User's Guide;" FHWA-PD-96-009, Federal Highway Administration; Washington, D.C.; January 1998 and Version 2.5 Upgrade (April 14, 2004).

(8) 12/27/17 Email from Mr. Keith Suga to Mr. Brian Takeda.

APPENDIX B

EXCERPTS FROM EPA'S ACOUSTIC TERMINOLOGY GUIDE

Descriptor Symbol Usage

The recommended symbols for the commonly used acoustic descriptors based on A-weighting are contained in Table I. As most acoustic criteria and standards used by EPA are derived from the A-weighted sound level, almost all descriptor symbol usage guidance is contained in Table I.

Since acoustic nomenclature includes weighting networks other than "A" and measurements other than pressure, an expansion of Table I was developed (Table II). The group adopted the ANSI descriptor-symbol scheme which is structured into three stages. The first stage indicates that the descriptor is a level (i.e., based upon the logarithm of a ratio), the second stage indicates the type of quantity (power, pressure, or sound exposure), and the third stage indicates the weighting network (A, B, C, D, E.....). If no weighting network is specified, "A" weighting is understood. Exceptions are the A-weighted sound level and the A-weighted peak sound level which require that the "A" be specified. For convenience in those situations in which an A-weighted descriptor is being compared to that of another weighting, the alternative column in Table II permits the inclusion of the "A". For example, a report on blast noise might wish to contrast the LCdn with the LAdn.

Although not included in the tables, it is also recommended that "Lpn" and "LepN" be used as symbols for perceived noise levels and effective perceived noise levels, respectively.

It is recommended that in their initial use within a report, such terms be written in full, rather than abbreviated. An example of preferred usage is as follows:

The A-weighted sound level (LA) was measured before and after the installation of acoustical treatment. The measured LA values were 85 and 75 dB respectively.

Descriptor Nomenclature

With regard to energy averaging over time, the term "average" should be discouraged in favor of the term "equivalent". Hence, Leq, is designated the "equivalent sound level". For Ld, Ln, and Ldn, "equivalent" need not be stated since the concept of day, night, or day-night averaging is by definition understood. Therefore, the designations are "day sound level", "night sound level", and "day-night sound level", respectively.

The peak sound level is the logarithmic ratio of peak sound pressure to a reference pressure and not the maximum root mean square pressure. While the latter is the maximum sound pressure level, it is often incorrectly labelled peak. In that sound level meters have "peak" settings, this distinction is most important.

"Background ambient" should be used in lieu of "background", "ambient", "residual", or "indigenous" to describe the level characteristics of the general background noise due to the contribution of many unidentifiable noise sources near and far.

With regard to units, it is recommended that the unit decibel (abbreviated dB) be used without modification. Hence, DBA, PNdB, and EPNdB are not to be used. Examples of this preferred usage are: the Perceived Noise Level (Lpn was found to be 75 dB. Lpn = 75 dB). This decision was based upon the recommendation of the National Bureau of Standards, and the policies of ANSI and the Acoustical Society of America, all of which disallow any modification of bel except for prefixes indicating its multiples or submultiples (e.g., deci).

Noise Impact

In discussing noise impact, it is recommended that "Level Weighted Population" (LWP) replace "Equivalent Noise Impact" (ENI). The term "Relative Change of Impact" (RCI) shall be used for comparing the relative differences in LWP between two alternatives.

Further, when appropriate, "Noise Impact Index" (NII) and "Population Weighed Loss of Hearing" (PHL) shall be used consistent with CHABA Working Group 69 Report Guidelines for Preparing Environmental Impact Statements (1977).

TABLE I

A-WEIGHTED RECOMMENDED DESCRIPTOR LIST

TERM	SYMBOL
1. A-Weighted Sound Level	L_A
2. A-Weighted Sound Power Level	L_{WA}
3. Maximum A-Weighted Sound Level	L_{max}
4. Peak A-Weighted Sound Level	L_{Apk}
5. Level Exceeded x% of the Time	L_x
6. Equivalent Sound Level	L_{eq}
7. Equivalent Sound Level over Time (T) (1)	$L_{eq(T)}$
8. Day Sound Level	L_d
9. Night Sound Level	L_n
10. Day-Night Sound Level	L_{dn}
11. Yearly Day-Night Sound Level	$L_{dn(Y)}$
12. Sound Exposure Level	L_{SE}

(1) Unless otherwise specified, time is in hours (e.g. the hourly equivalent level is $L_{eq(1)}$). Time may be specified in non-quantitative terms (e.g., could be specified a $L_{eq(WASH)}$ to mean the washing cycle noise for a washing machine).

SOURCE: EPA ACOUSTIC TERMINOLOGY GUIDE, BNA 8-14-78,

TABLE II

RECOMMENDED DESCRIPTOR LIST

TERM	A-WEIGHTING	ALTERNATIVE[1] A-WEIGHTING	OTHER[2] WEIGHTING	UNWEIGHTED
1. Sound (Pressure)[3] Level	L_A	L_{pA}	L_B, L_{pB}	L_p
2. Sound Power Level	L_{WA}		L_{WB}	L_W
3. Max. Sound Level	L_{max}	L_{Amax}	L_{Bmax}	L_{pmax}
4. Peak Sound (Pressure) Level	L_{Apk}		L_{Bpk}	L_{pk}
5. Level Exceeded x% of the Time	L_x	L_{Ax}	L_{Bx}	L_{px}
6. Equivalent Sound Level	L_{eq}	L_{Aeq}	L_{Beq}	L_{peq}
7. Equivalent Sound Level[4] Over Time(T)	$L_{eq(T)}$	$L_{Aeq(T)}$	$L_{Beq(T)}$	$L_{peq(T)}$
8. Day Sound Level	L_d	L_{Ad}	L_{Bd}	L_{pd}
9. Night Sound Level	L_n	L_{An}	L_{Bn}	L_{pn}
10. Day-Night Sound Level	L_{dn}	L_{Adn}	L_{Bdn}	L_{pdn}
11. Yearly Day-Night Sound Level	$L_{dn(Y)}$	$L_{Adn(Y)}$	$L_{Bdn(Y)}$	$L_{pdn(Y)}$
12. Sound Exposure Level	L_S	L_{SA}	L_{SB}	L_{Sp}
13. Energy Average Value Over (Non-Time Domain) Set of Observations	$L_{eq(e)}$	$L_{Aeq(e)}$	$L_{Beq(e)}$	$L_{peq(e)}$
14. Level Exceeded x% of the Total Set of (Non-Time Domain) Observations	$L_{x(e)}$	$L_{Ax(e)}$	$L_{Bx(e)}$	$L_{px(e)}$
15. Average L_x Value	L_x	L_{Ax}	L_{Bx}	L_{px}

(1) "Alternative" symbols may be used to assure clarity or consistency.

(2) Only B-weighting shown. Applies also to C,D,E,.....weighting.

(3) The term "pressure" is used only for the unweighted level.

(4) Unless otherwise specified, time is in hours (e.g., the hourly equivalent level is Leq(1). Time may be specified in non-quantitative terms (e.g., could be specified as Leq(WASH) to mean the washing cycle noise for a washing machine.

Appendix F
New Kaua‘i Landfill Traffic and Roadways Engineering Feasibility Study (AECOM 2016)

AECOM

FINAL

NEW KAUAʻI LANDFILL TRAFFIC AND ROADWAYS ENGINEERING FEASIBILITY STUDY

County of Kauaʻi
Department of Public Works
Solid Waste Division
4444 Rice Street, Room 275
Līhuʻe, Kauaʻi, Hawaiʻi

November 2016

FINAL

NEW KAUAʻI LANDFILL TRAFFIC AND ROADWAYS ENGINEERING FEASIBILITY STUDY

Prepared for:

County of Kauaʻi
Department of Public Works
Solid Waste Division
4444 Rice Street, Room 275
Līhuʻe, Kauaʻi, Hawaiʻi

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November 2016

EXECUTIVE SUMMARY

This Traffic and Roadways Engineering Feasibility Study (TREFS) analyzes traffic impacts, recommended roadway improvements, and potential social impacts of five potential access routes between Kūhiō Highway and the site of the County of Kaua‘i’s proposed new municipal solid waste landfill (MSWLF) and resource recovery park (RRP) at Ma‘alo (the proposed project), north of Līhu‘e town. The County’s existing sole MSWLF at Kekaha is projected to reach capacity in the coming years; therefore the County seeks to establish a new MSWLF to fulfill its responsibility for properly managing and disposing of municipal solid waste on the island. While a new waste disposal facility must be operational by the time the Kekaha MSWLF reaches capacity, the RRP may be implemented incrementally over time.

An Environmental Impact Statement (EIS) is being prepared to evaluate the environmental impacts of and alternatives to the proposed project; as a result of early public outreach during the planning process, the choice of access routes to the proposed project site has emerged as an important public consideration. The proposed access route selected as a result of this analysis will become part of the proposed project that will be analyzed in the overall project EIS. Each alternative access route consists of a “road” (labelled A through E) and up to two “driveway” alternatives (labelled 1 through 3) and connects to regional access at one of five study intersections:

- *Route A1/A2:* Via Ma‘alo Road and Driveway 1 or Driveway 2. The study intersection is Ma‘alo Road/Kūhiō Highway, a stop-sign-controlled T-intersection. Total route length is 4.7–4.8 miles.
- *Route B1/B2:* Via ‘Ehiku Street, Ma‘alo Road, and Driveway 1 or 2. The study intersection is ‘Ehiku Street/Kūhiō Highway, a signalized intersection. Total route length is 5.6–5.7 miles.
- *Route C3:* Via Laulima Street and Driveway 3. The study intersection is Laulima Street/Kūhiō Highway, a stop-sign-controlled four-legged intersection. Total route length is 1.7 miles.
- *Route D3:* Via Roberts Hawaii Driveway and Driveway 3. The study intersection is Roberts Hawaii Driveway/Kūhiō Highway (a stop-sign-controlled T-intersection). Total route length is 2.2 miles.
- *Route E3:* Via Kaua‘i Beach Driveway and Driveway 3. The study intersection is Kaua‘i Beach Driveway/Kūhiō Highway (a stop-sign-controlled T-intersection). Total route length is 2.5 miles.

In addition, the traffic assessment evaluated the currently signalized Kapule Highway/Kūhiō Highway intersection, to evaluate traffic queuing issues that could potentially result from operation of the D3 and E3 alternative access routes.

This TREFS contains three major sections: a traffic assessment, an infrastructure improvements assessment, and a social impacts assessment, which are summarized in the following.

Traffic Assessment: The traffic assessment evaluated existing traffic conditions (including intersection operating conditions) and future conditions, both during initial project implementation (i.e., opening year) and in the long range (i.e., 20 years after opening year). Each future condition evaluation assessed three future scenarios:

- Projected baseline conditions (i.e., without proposed project implementation)
- Projected baseline conditions plus operation of the MSWLF
- Projected baseline conditions plus operation of the MSWLF and the RRP

Each evaluation assessed traffic impacts at each study intersection with proposed project vehicles both using and not using that intersection for access. Evaluations of each access scenario indicated

potential traffic impacts at their Kūhiō Highway intersection that should be addressed via physical and operational improvements:

- *Route A1/A2:* Would require highway intersection signalization and other significant modifications, as well as other significant improvements to the existing roadways.
- *Route B1/B2:* Would require significant improvements to the existing roadways along the length of the route, and would result in increased traffic to the roads used by the existing adjacent residences.
- *Route C3:* Would require development of the route, including signalizing the highway intersection by the time the project is fully implemented.
- *Route D3:* Would require development of the route, including signalizing the highway intersection upon full project implementation. Signalization would need to be synchronized with the existing signalization at the nearby Kapule Highway intersection to accommodate vehicle queuing during the PM peak hour.
- *Route E3:* Would require development of the route, including signalizing the intersection upon full project implementation. Signalization would need to be synchronized with the existing signalization at the nearby Kapule Highway intersection to accommodate vehicle queuing there during AM peak hour. Intersection improvements would also have to accommodate the contra-flow operation on Kūhiō Highway during the AM peak period.

The traffic assessment concluded that Route C3 (followed closely by Routes D3 and E3) is the shortest and most direct, implementable, feasible, and cost-effective access alternative.

Infrastructure Improvements Assessment: The infrastructure improvements assessment evaluated existing conditions and recommended improvements, as well as permitting, land use, and land acquisition requirements and related costs for each proposed access route. All access scenarios involve paving of most or all of the potential route, and providing underground utility service to the proposed project site.

The planning-level cost estimates for the recommended roadway and infrastructure improvements under each access scenario are:

- *Route A1:* $42.8 million
- *Route A2:* $41.4 million
- *Route B1:* $43.3 million
- *Route B2:* $41.8 million
- *Route C3:* $12.7 million
- *Route D3:* $14.6 million
- *Route E3:* $17.3 million

The infrastructure improvements assessment concluded that Route C3 (followed closely by Routes D3 and E3) is the shortest and most direct, implementable, feasible, and cost-effective proposed-project access alternative.

Social Impacts Assessment: A social impacts assessment (SIA) was conducted and supplemented by multiple public meetings to evaluate the opinions and concerns of the public. The SIA evaluated advantages and disadvantages for each proposed access route, including potential public safety, traffic, and nuisance concerns. Sources for the assessment include interviews conducted for the overall project EIS, interviews with landowners and transportation specialists, examination of traffic

engineering reports and existing roadway characteristics, and review of route maps and social characteristics of nearby communities. Findings include:

- *Route A1/A2:* Second longest route; avoids residential areas; increased truck traffic could negatively impact Wailua Falls tourist traffic, which uses Ma‘alo Road.
- *Route B1/B2:* Longest route; may result in direct traffic impacts to the residential portion of the route; improved roadway and infrastructure improvements would benefit all users; the highway intersection with the least traffic-related issues of all the alternatives.
- *Route C3:* Shortest route; signalization of intersection would benefit the Hanamā‘ulu community for which it serves as a point of egress; potential noise impacts to the residential area where the proposed route runs behind it.
- *Route D3:* Second shortest route; improved roadway would benefit all users; potential noise impacts to residents near the route; reduces traffic activity in the Hanamā‘ulu community area.
- *Route E3:* Third shortest route; signalization of intersection could increase safety for traffic accessing the Kaua‘i Beach Resort area; potential noise impacts to residents near the route; minimizes traffic activity in the Hanamā‘ulu community area.

The SIA identified pros and cons associated with each alternative access route, and concluded that access routes C3, D3, and E3 provide the best balance of feasibility, traffic impacts, cost requirements, and other impacts. As noted by community members during the public outreach process, Route E would minimize the traffic impact to the core of Hanamā‘ulu and pass fewer residences and businesses, and is therefore preferred by the local community.

Proposed Access Route: This TREFS analyzed five potential access routes from Kūhiō Highway (the principal thoroughfare in the area) to the proposed project (MSWLF and RRP at Ma‘alo). The TREFS both analyzed objective data (such as traffic impacts, recommended improvements, and related costs) and solicited the concerns and opinions from the public, particularly those most directly affected by the choice of the proposed access route. All access scenarios present potential impacts that can be addressed via physical and operational improvements.

Overall, Access Routes C, D, and E provide the best balance of feasibility, directness, traffic impacts, cost requirements, and other impacts. While these three routes are progressively longer and therefore progressively more expensive, few other significant technical advantages or disadvantages distinguish Routes C, D, and E. However, members of nearby communities expressed a preference for Access Route E, which would minimize the traffic impact to the core of Hanamā‘ulu and pass fewer residences and businesses. Therefore, while Route C is slightly preferable from a technical and financial standpoint, in order to address concerns raised by the community during the early planning process, the County has selected Access Route E as the preferred access route, which will become part of the proposed project in the overall project EIS.

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ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACB	asphalt concrete base
ACP	asphalt concrete pavement
ADA	American Disabilities Act
DOH	Department of Health, State of Hawai‘i
DOT	Department of Transportation, State of Hawai‘i
DPW	Department of Public Works, County of Kaua‘i
EB	eastbound
EIS	environmental impact statement
FS	feasibility study
ft	feet or foot
gpd	gallons per day
HCM	Highway Capacity Manual
LOS	level of service
MG	million gallons
MSW	municipal solid waste
MSWLF	municipal solid waste landfill
MUTCD	Manual on Uniform Traffic Control Devices
NB	northbound
NPDES	National Pollutant Discharge Elimination System
OR	comments from outreach activities conducted after the public meeting
PM	comments gathered at the Public Meeting
Pre	pre-public meeting comments gathered from stakeholder and landowner interviews
ROW	right-of-way
RRP	resource recovery park
SB	southbound
SIA	social impacts assessment
SWD	Solid Waste Division, County of Kaua‘i Department of Public Works
TREFS	traffic and roadways engineering feasibility study
USACE	United States Army Corps of Engineers
WB	westbound

1.0 INTRODUCTION

The County of Kaua‘i (County) Department of Public Works (DPW) Solid Waste Division (SWD) is responsible for properly managing and disposing of municipal solid waste (MSW) on the island. The existing Kekaha Municipal Solid Waste Landfill (MSWLF) is projected to reach capacity in the coming years. Therefore, a new landfill facility will be required to achieve the overall project objective of providing for the safe and proper disposal of all forms of MSW that cannot practicably be further reused, recycled, or otherwise recovered.

Based on previous facility siting efforts spanning over 12 years and culminating in a Landfill Siting Study completed in 2012 (AECOM 2012), the County proposes to develop a new MSWLF and resource recovery park (RRP) north of Līhu‘e town, makai of Ma‘alo Road (the proposed project). Potential recycling and waste diversion facilities that may be implemented at the RRP were evaluated and presented to the public in the RRP Feasibility Study (FS) (AECOM 2013). In order to provide the County additional flexibility, two implementation options for the overall project are being considered:

- MSWLF and RRP located on the same 264-acre parcel
- MSWLF located on the 264-acre parcel, and RRP located on an alternate 80-acre nearby parcel

An Environmental Impact Statement (EIS) is being prepared to evaluate the environmental impacts of and alternatives to the proposed project. As a result of the initial public scoping and outreach conducted to date, the choice of access routes has emerged as an important consideration, due to potential impacts such as traffic, noise, and safety. Therefore, this Traffic and Roadways Engineering Feasibility Study (TREFS) conducts an analysis of several feasible access route alternatives to assist in the decision-making process and provide a rational basis for selecting the proposed-project access route. For each access route, the TREFS analyzes traffic impacts, required improvements and related costs, and social impacts, including safety and nuisance concerns. The proposed access route will become part of the proposed project in the overall project EIS.

Because the RRP may undergo phased implementation over time, for the purpose of this TREFS, two proposed project scenarios are analyzed for each potential access route:

- MSWLF only
- MSWLF plus RRP

Figure 1 shows the proposed MSWLF site, the alternate RRP site (collectively, the “proposed project site”), and the potential access routes analyzed in this TREFS. Each potential route consists of a “road” designated with a letter and a “driveway” designated with a number, as shown in Figure 1. Generally, the “driveways” are former cane haul (“dirt”) roads, and several of the “roads” are paved public roadways. Based on initial feedback received, the County has identified five alternative access routes from Kūhiō Highway to the proposed project site:

- *Route A1/A2:* Via Ma‘alo Road and Driveway 1 or Driveway 2
- *Route B1/B2:* Via ‘Ehiku Street, Ma‘alo Road, and Driveway 1 or Driveway 2
- *Route C3:* Via Laulima Street and Driveway 3
- *Route D3:* Via Roberts Hawaii Driveway and Driveway 3
- *Route E3:* Via new Driveway opposite Kaua‘i Beach Driveway and Driveway 3

All these alternative access routes connect to Kūhiō Highway for regional access at one of the following five study intersections evaluated in this study:

- Ma‘alo Road/Kūhiō Highway (stop-sign-controlled T-intersection) (Route A)
- ‘Ehiku Street/Kūhiō Highway (signalized intersection) (Route B)
- Laulima Street/Kūhiō Highway (stop-sign-controlled four-legged intersection) (Route C)
- Roberts Hawaii Driveway/Kūhiō Highway (stop-sign-controlled T-intersection) (Route D)
- Kaua‘i Beach Driveway/Kūhiō Highway (stop-sign-controlled T-intersection) (Route E)

Additionally, the Kapule Highway/Kūhiō Highway (signalized) intersection was evaluated, because it is a major intersection that could be affected by operation of nearby Routes D and E.

The analyses conducted, and the public feedback gathered, during this study have provided the County information to consider in choosing the proposed access route, which will become part of the proposed project in the overall project EIS.

The report is organized as follows:

- Section 1.0 describes the background and purpose of this study, and the overall organization of this report.
- Section 2.0 presents the traffic impacts assessment for the six study intersections under the various project-access scenarios.
- Section 3.0 presents the infrastructure improvements assessment for the five alternative access routes.
- Section 4.0 presents the social impacts assessment for the five alternative access routes.
- Section 5.0 compares the five alternative access routes and identifies the proposed route.
- Section 6.0 presents a list of references cited in this document.

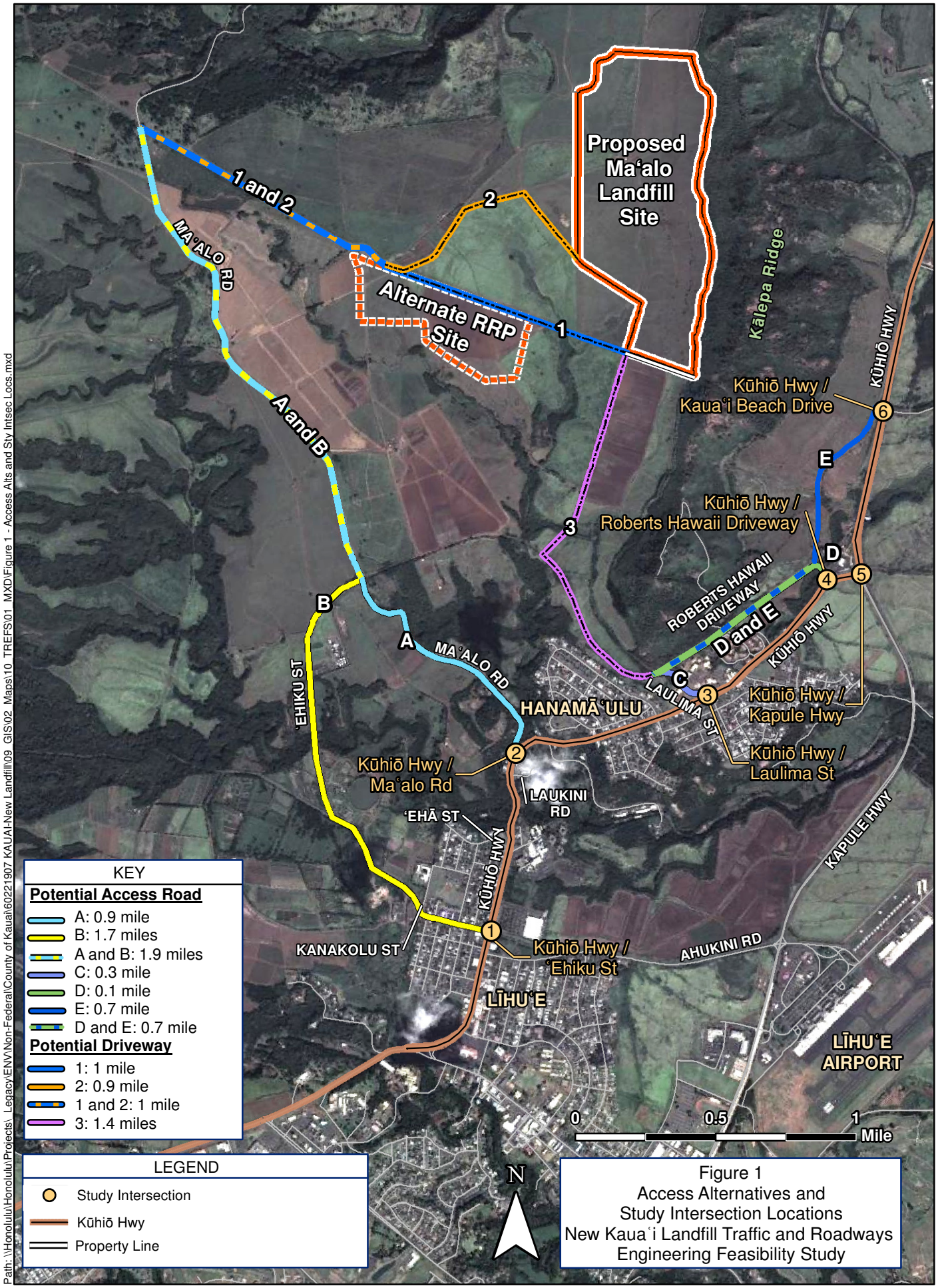


Figure 1
Access Alternatives and
Study Intersection Locations
New Kaua'i Landfill Traffic and Roadways
Engineering Feasibility Study

Path: \\Honolulu\Honolulu\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\09_GIS\02_Maps\10_TREFS\01_MXD\Figure 1 - Access Alts and Sty Intsec Locs.mxd

2.0 TRAFFIC ASSESSMENT

The objective of this traffic assessment is to quantify the proposed project’s effects on traffic operations, identify potential mitigation actions, and assess the relative traffic-related impacts of each access alternative. The assessment evaluates weekday traffic-related impacts of the proposed project at each of the six study intersections with Kūhiō Highway (‘Ehiku Street, Ma‘alo Road, Laulima Street, Roberts Hawaii Driveway, Kaua‘i Beach Driveway, and Kapule Highway), assuming the implementation of each of the project alternatives via one of the five proposed alternative access routes, for the following horizon years/scenarios:

- Existing Conditions
- Future Opening Year (assumed to be approximately 10 years from now) and Future Long-Range Year (20 years after opening):
  - Baseline (i.e., without the proposed project)
  - Baseline plus MSWLF
  - Baseline plus MSWLF and RRP

The location of the proposed project site, the six study intersections, and the five alternative access routes are shown on Figure 1.

2.1 EXISTING CONDITIONS

Existing conditions at the five access routes are evaluated below.

2.1.1 Transportation Network

The following key roadways are located throughout the proposed project study area:

- Kūhiō Highway is a State Highway traversing the northern and eastern shores of Kaua‘i, extending from Ha‘ena State Park in the north to Līhu‘e, where it terminates at Rice Street at the junction with Kaumuali‘i Highway (State Highway 50), which continues west to Kekaha. Within the study area, Kūhiō Highway is designated as State Highway 56 and runs in a southwest–northeast orientation, generally providing one lane in each direction, widening to accommodate turn pockets or additional storage at select intersections. A second northbound lane is provided from the junction with Kapule Highway in Hanamā‘ulu north to Wailuā. Primarily functioning as a rural highway, Kūhiō Highway generally lacks sidewalks within the study area, with the exception of some isolated segments partially present on one side of the street through the urbanized portions of Hanamā‘ulu and Līhu‘e. Each Access Route would have one terminus at its intersection with Kūhiō Highway.
- Ma‘alo Road is a north–south collector roadway designated as State Highway 583, connecting to Kūhiō Highway at the border between Hanamā‘ulu and Līhu‘e and continuing north to a dead-end terminus at Wailuā Falls. Within the study area, Ma‘alo Road is a paved roadway providing one travel lane in each direction. Ma‘alo Road functions primarily as a rural roadway through largely undeveloped areas with little street-fronting activity, and no sidewalks are provided on either side. Access Routes A and B would each use a portion of Ma‘alo Road.
- ‘Ehiku Street is a collector roadway generally oriented in a north–south direction, extending from Kūhiō Highway in the south to its terminus at the intersection with Ma‘alo Road in the north. Within the study area, ‘Ehiku Street is paved and provides one travel lane in each direction. Although the southern end of ‘Ehiku Street serves residential areas in Līhu‘e, sidewalks are generally not provided on either side of ‘Ehiku Street. Access Route B would use the portion of ‘Ehiku Street between Kūhiō Highway and Ma‘alo Road.

- Laulima Street is a short collector roadway generally oriented in the northeast–southwest direction, extending from Lawehana Street makai of Kūhiō Highway in the east to a privately-owned cane-haul road mauka of Kūhiō Highway in the east. Makai of Kūhiō Highway, Laulima Street is an improved roadway with one travel lane in each direction, providing local access for residential neighborhoods in Hanamā‘ulu. Mauka of Kūhiō Highway, Laulima Street is partially paved but otherwise unimproved, primarily serving as a driveway for light industrial uses along the side of the highway. Sidewalks are generally not provided on either side of Laulima Street, and the highway intersection is currently not signalized. Access Route C would use the short portion of Laulima Street mauka of Kūhiō Highway.
- The Roberts Hawaii Driveway is a short collector roadway along the mauka side of Kūhiō Highway, primarily providing local access for a vehicle maintenance and storage yard for tour operator Roberts Hawaii, Inc. The Roberts Hawaii Driveway is mostly a gravel road, with a short paved section near its intersection with Kūhiō Highway, approximately 400 feet west of the Kūhiō Highway/Kapule Highway intersection. Access Route D would include the Roberts Hawaii Driveway to connect a privately-owned cane-haul road to Kūhiō Highway.
- Kapule Highway is a north–south rural arterial located makai of Kūhiō Highway, extending from the junction with Kūhiō Highway in the north to Rice Street in Nāwiliwili in the south. Kapule Highway is designated as State Highway 51, and provides access to Līhu‘e Airport, generally featuring one travel lane in each direction. Within the study area, Kapule Highway functions as a rural highway through undeveloped areas with little street-fronting activity, and no sidewalks are provided on either side. No access route extends to Kapule Highway, but Access Routes D and E have the potential to affect traffic at the intersection of Kūhiō Highway and Kapule Highway, unless properly managed.
- Kaua‘i Beach Drive is a mauka–makai collector road providing local access from Kūhiō Highway to Nukoli‘i Beach Park and several resorts at Kaua‘i Beach. Kaua‘i Beach Drive features one travel lane in each direction, widening to two lanes in each direction within the Kaua‘i Beach resort area, but lacks sidewalks and highway signalization. Access Route E terminates on the mauka side of Kūhiō Highway, directly opposite Kaua‘i Beach Drive.

In addition to existing roadways, each Access Route uses existing cane haul roads (“dirt roads”) located on State or private property, including “Driveways” 1, 2, and 3. Access Routes A and B could be configured to use either Driveway 1 or 2, while Access Routes C, D, and E would use Driveway 3, along with cane haul roads located on private property.

Pedestrian crossings across Kūhiō Highway within the study area are present only at the signalized intersections at Hanamā‘ulu Road and Laukona Street in Hanamā‘ulu and at ‘Ehā Street and Oxford Street in Līhu‘e. The Kūhiō Highway intersections at ‘Ehiku Street, Ma‘alo Road, Laulima Street, Roberts Hawaii Driveway, and Kaua‘i Beach Drive do not have crosswalks across Kūhiō Highway. With the exception of ‘Ehiku Street, the cross-streets also have no crosswalks.

2.1.2 Kūhiō Highway Traffic Management

Traffic is managed along the 4-lane portion of Kūhiō Highway between the Kapule Highway intersection to Wailuā, using transient lane operations to increase vehicle throughput during the weekday morning peak commute periods. The transient lane is managed to provide a third, temporary contra-flow southbound travel lane during weekday mornings; at all other times, two lanes travel in both directions. If not properly designed and managed, the access routes have the potential to affect traffic along this section of Kūhiō Highway.

The transient lane operates from approximately 5:30 AM to 10:00 AM, using traffic cones placed along Kūhiō Highway from the junction at Kapule Highway in Hanamā‘ulu to the junction with State Highway 5600 (Kapa‘a Bypass Road) near Papaloa Road in Wailuā. At the Kūhiō Highway/Kapule Highway intersection, the southbound contra-flow lane is directed into the through lane to Kapule Highway, and the normal through lane is directed into the right-turn lane to the continuation of Kūhiō Highway. Because the right-turn lane is less restrictive than the through lane the queue for this

movement is significantly less that the queue for the through lane directed to Kapule Highway. As a result, some of the right-turning traffic makes a U-turn maneuver at the Roberts Hawaii Driveway, proceeding back to the Kūhiō Highway/Kapule Highway intersection, where it makes a right-turn to continue on to Kapule Highway. Turning movement counts during the weekday AM peak hour recorded approximately 120 vehicles making this U-turn movement.

At the Kūhiō Highway/Kaua‘i Beach Drive intersection, the traffic cones are placed to provide two southbound through lanes and a southbound left-turn pocket and maintain the slip lane into southbound Kūhiō Highway for westbound left-turn movements from Kaua‘i Beach Drive.

2.1.3 Intersection Operating Conditions

This intersection analysis uses the *Highway Capacity Manual* (HCM) methodology (TRB 2010), which is based on Level of Service (LOS). The LOS methodology is a qualitative description of the performance of an intersection based on average delay per vehicle. For signalized intersections, the HCM methodology determines the capacity of each lane group approaching the intersection. The LOS is then determined based on the average delay (in seconds per vehicle) incurred for the various movements within the intersection. Adjustments are typically made to the capacity of each intersection to account for local conditions. A combined weighted average delay and LOS are then presented for the intersection. For unsignalized intersections (i.e., stop-controlled), LOS is based on the average delay experienced at the worst-operating stop-controlled approaches. LOS ranges from LOS A, which indicates free-flow conditions with short delays, to LOS F, which indicates congested conditions with extremely long delays. An explanation of the LOS, including delay ranges, for signalized and unsignalized intersections is provided in Table 1.

Table 1: Criteria for Intersection Level of Service

Unsignalized Intersections			Signalized Intersections	
Description	Average Total Vehicle Delay (Seconds)	LOS Grade	Average Control Vehicle Delay (Seconds)	Description
No delay for stop-controlled approaches.	≤ 10.0	A	≤ 10.0	*Insignificant delays:* No approach phase is fully utilized and no vehicle waits longer than one red indication.
Operations with minor delays.	> 10.0 and ≤ 15.0	B	> 10.0 and ≤ 20.0	*Minimal delays:* An occasional approach phase is fully utilized. Drivers begin to feel restricted.
Operations with moderate delays.	> 15.0 and ≤ 25.0	C	> 20.0 and ≤ 35.0	*Acceptable delays:* Major approach phase may become fully utilized. Most drivers feel somewhat restricted.
Operations with some delays.	> 25.0 and ≤ 35.0	D	> 35.0 and ≤ 55.0	*Tolerable delays:* Drivers may wait through more than one red indication. Queues may develop but dissipate rapidly, without excessive delays.
Operations with high delays and long queues.	> 35.0 and ≤ 50.0	E	> 55.0 and ≤ 80.0	*Significant delays:* Volumes approaching capacity. Vehicles may wait through several signal cycles and long vehicle queues form upstream.
Operation with extreme congestion, with very high delays and long queues unacceptable to most drivers.	> 50.0	F	> 80.0	*Excessive delays:* Represents conditions at capacity, with extremely long delays. Queues may block upstream intersections.

Source: Transportation Research Board, *Highway Capacity Manual*, 2010.

Input data used to calculate the LOS included traffic volumes, existing lane configurations, traffic control types, signal operation, and traffic speeds; these data were collected at each of the study intersections over the course of three survey days: Wednesday, July 17, 2013 and Tuesday and Wednesday, September 13 and 14, 2015. Movement counts were conducted during the weekday AM and PM peak hours, which are defined as the highest volume one-hour (four consecutive 15-minute intervals) periods between the hours of 7:00 AM to 9:00 AM, and 4:00 PM to 6:00 PM, respectively. Recorded field observations included existing lane configurations, traffic control types, signal operations, traffic volume, and traffic speeds. These data were input to the Synchro 8.0 software package to calculate the LOS using the HCM methodology.

The existing lane geometries and weekday AM and PM peak hour traffic volumes at the study intersections are illustrated in Figure 2 and Figure 3, respectively. Weekday AM and PM peak hour LOS at each study intersection is summarized in Table 2. Detailed LOS output summaries are included in Appendix B.

Table 2: Level of Service – Existing Conditions

Intersection	Traffic Control	Weekday AM Peak Hour		Weekday PM Peak Hour	
		LOS	Delay	LOS	Delay
1 Kūhiō Highway/‘Ehiku Street	Signal	A	4.1	A	3.7
2 Kūhiō Highway/Ma‘alo Road	One-Way Stop	C	21.9	D	31.7
3 Kūhiō Highway/Laulima Street	Two-Way Stop	E	38.5	F	63.8
4 Kūhiō Highway/Roberts Hawaii Driveway	One-Way Stop	D	27.2	C	19.6
5 Kūhiō Highway/Kapule Highway	Signal	C	20.6	C	35.0
6 Kūhiō Highway/Kaua‘i Beach Drive	One-Way Stop	F	107.0	F	57.5

Notes:
LOS and average delay for stop-controlled intersections represents the worst stop-controlled approach.
Bold indicates LOS E or LOS F.

As shown in Table 2, the Kūhiō Highway intersections at ‘Ehiku Street, Ma‘alo Road, Roberts Hawaii Driveway, and Kapule Highway currently operate at LOS D or better during both the weekday AM and PM peak hours. The intersections at Laulima Street and Kaua‘i Beach Drive, however, currently operate at LOS E or LOS F during both the weekday AM and PM peak hours due to side-street delay. Although a detailed engineering study would be required to confirm whether a signal is warranted, an analysis of the Manual on Uniform Traffic Control Devices (MUTCD) peak-hour traffic signal warrants indicates that, under existing conditions, the Kūhiō Highway/Laulima Street intersection may not satisfy the warrant during either peak hour, and the Kūhiō Highway/Kaua‘i Beach Drive intersection may only satisfy the warrant during the weekday PM peak hour. Peak-hour traffic signal warrant worksheets are included in Appendix B.

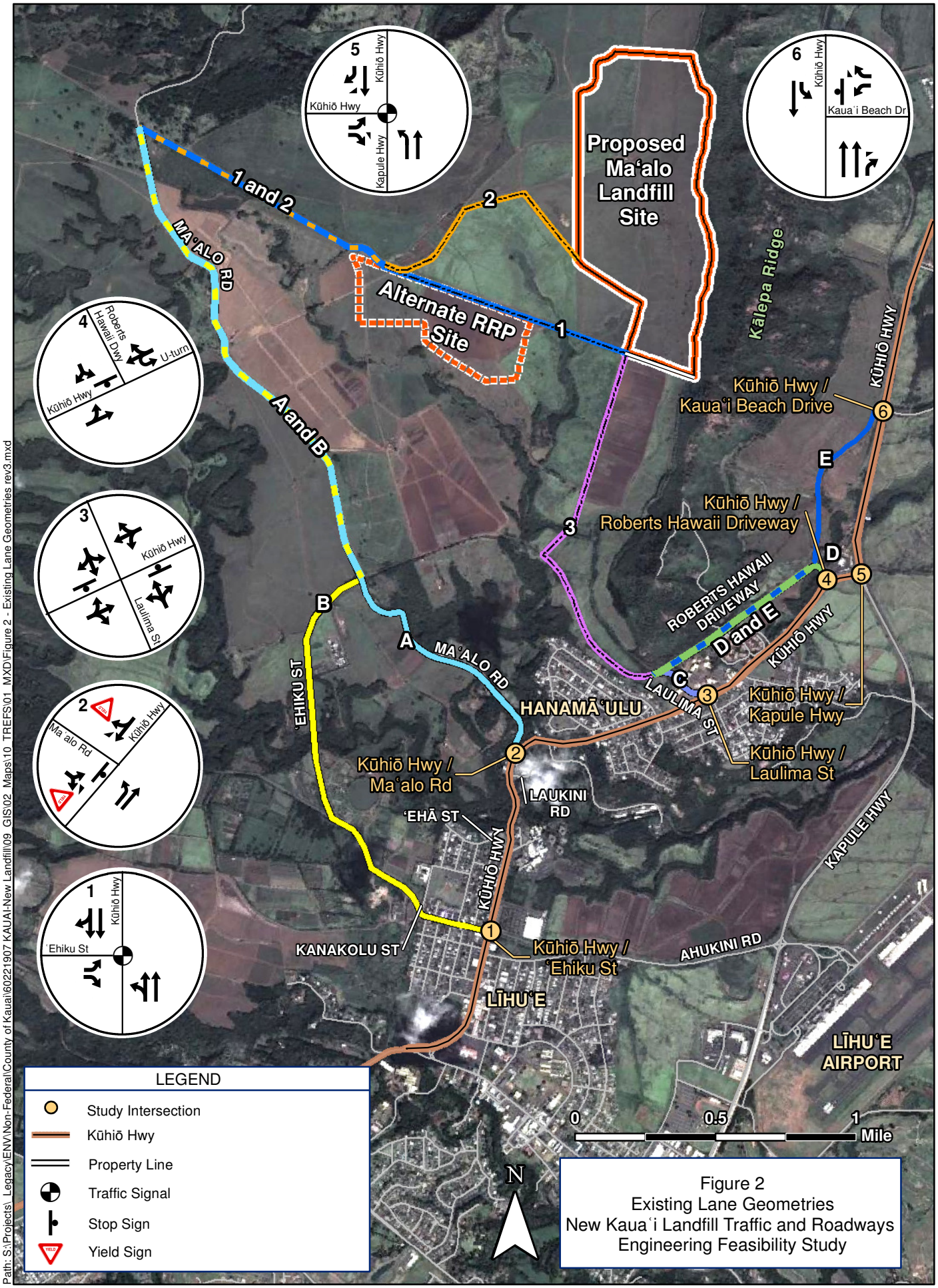


Figure 2
Existing Lane Geometries
New Kaua'i Landfill Traffic and Roadways
Engineering Feasibility Study

Path: S:\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\09_GIS\02_Maps\10_TREFS\01_MXD\Figure 2 - Existing Lane Geometries rev3.mxd

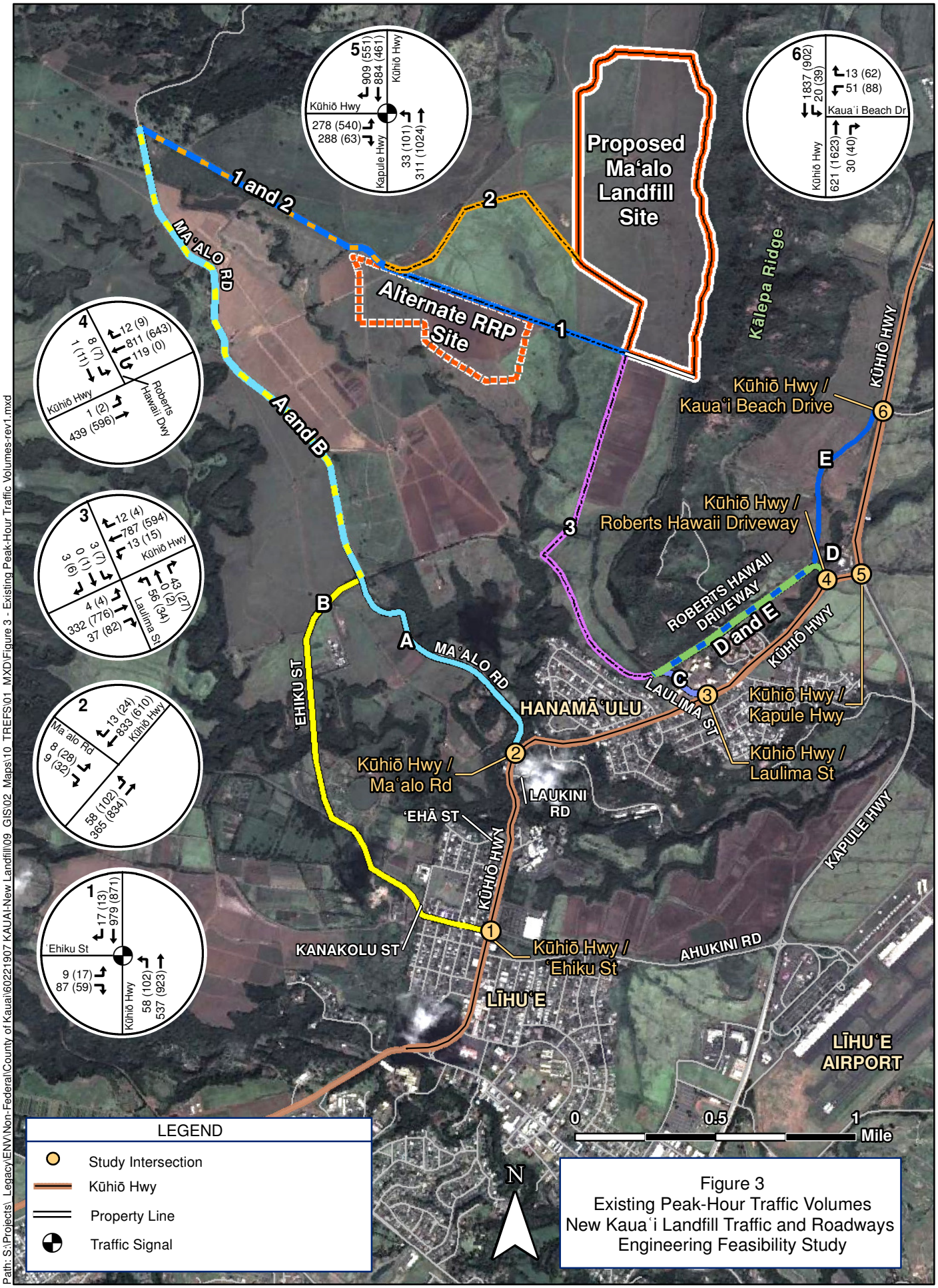


Figure 3
Existing Peak-Hour Traffic Volumes
New Kaua'i Landfill Traffic and Roadways
Engineering Feasibility Study

Path: S:\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\09_GIS\02_Maps\10_TREFS\01_MXD\Figure 3 - Existing Peak-Hour Traffic Volumes-rev1.mxd

2.2 FUTURE CONDITIONS

Anticipated future conditions were estimated with and without the proposed project. Because the RRP may be implemented in phases over time, future conditions with the project were analyzed under two scenarios: operation of the MSWLF only; and operation of both the MSWLF and the RRP. Anticipated conditions were projected both for the year that operations would commence ("Opening Year") and for 20 years after operations would commence ("Future Long-Range Year"). Thus, for each of the five Access Route alternatives, six scenarios were analyzed:

- Opening Year Baseline
- Opening Year with Landfill
- Opening Year with Landfill and RRP
- Future Long-Range Year Baseline
- Future Long-Range Year with Landfill
- Future Long-Range Year with Landfill and RRP

2.2.1 Future Baseline Conditions

Future baseline traffic conditions (i.e., without the proposed project) were forecasted by assuming a one-percent-per-year (compounded) growth rate applied to the Existing Conditions traffic volumes (Figure 3), in accordance with the *2012 State of Hawaii Data Book*, Table 1.07 (DBEDT 2012), which is consistent with the analysis performed for the RRP Feasibility Study that was conducted for the proposed project. Traffic volume summaries for Opening Year Baseline Conditions and Future Long-Range Year Baseline Conditions are provided in Appendix A.

2.2.2 Project Traffic

2.2.2.1 PROJECT TRAFFIC QUANTITY

Table 3 and Table 4 summarize the anticipated traffic due to the MSWLF and RRP, based on County-provided landfill trip generation data for the Kekaha MSWLF, and traffic projections presented in the RRP FS (AECOM 2013). These data were used to project weekday AM peak, PM peak, and daily vehicle-trip totals to and from the proposed project site for both the Opening Year and the Future Long-Range Year conditions.

Table 3: Trip Generation – Opening Year

		Weekday AM Peak Hour		Weekday PM Peak Hour	
Project Component	Daily	Inbound	Outbound	Inbound	Outbound
Landfill	220	15	15	12	15
RRP	517	130	26	22	130
Total	**737**	**145**	**41**	**34**	**145**

Table 4: Trip Generation – Future Long-Range Year

		Weekday AM Peak Hour		Weekday PM Peak Hour	
Project Component	Daily	Inbound	Outbound	Inbound	Outbound
Landfill	270	19	18	15	18
RRP	517	130	26	22	130
Total	**787**	**149**	**44**	**37**	**148**

2.2.2.2 TRIP DISTRIBUTION

The expected distribution pattern of project traffic was estimated based on a combination of the anticipated origins and destinations of trucks, as well as the general population distribution on Kaua‘i, as documented in the *2012 State of Hawaii Data Book*, Table 1.17 (DBEDT 2012). Based on this information, the following trip distribution was assumed:

- *To and from the south (via Kūhiō Highway):* 55%
- *To and from the north (via Kūhiō Highway):* 45%

2.2.3 Project Opening Year

The estimated traffic generated by the proposed landfill and RRP, summarized in Table 3 was added to the opening year baseline traffic volumes to obtain anticipated traffic volumes for the Opening Year, both with and without the RRP. Operations at the six study intersections were evaluated for each scenario and access alternative using the Synchro 8.0 software package and the HCM methodology, as described in Section 2.1.3. Anticipated traffic volumes for each access alternative under these Opening Year scenarios are included in Appendix A, and detailed LOS output summaries are included in Appendix B. The resulting LOS for Opening Year plus Landfill Conditions and Opening Year plus Landfill and RRP Conditions during both the weekday AM and PM peak hours is summarized in Table 5.

Table 5: Level of Service – Opening Year

Access Alter-native	Intersection	Weekday Peak Hour											
						Project							
		No Project				Landfill				Landfill and RRP			
		AM		PM		AM		PM		AM		PM	
		LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
‘Ehiku St.	1 Kūhiō Hwy./‘Ehiku St.	A	4.2	A	3.9	A	4.7	A	4.3	A	5.6	A	7.7
	2 Kūhiō Hwy./Ma‘alo Rd.	C	24.4	**E**	**39.1**	C	24.8	**E**	**40.0**	D	27.0	**E**	**45.3**
	3 Kūhiō Hwy./Laulima St.	**F**	**50.3**	**F**	**92.6**	**F**	**52.6**	**F**	**96.4**	**F**	**66.2**	**F**	**122.5**
	4 Kūhiō Hwy./Rob. Haw. Dwy.	D	31.1	C	21.9	D	31.6	C	22.2	D	34.9	C	23.7
	5 Kūhiō Hwy./Kapule Hwy.	C	23.7	D	42.0	C	24.1	D	43.7	C	25.5	**E**	**57.7**
	6 Kūhiō Hwy./Kaua‘i Beach Dr.	**F**	**159.2**	**F**	**90.2**	**F**	**162.4**	**F**	**92.1**	**F**	**182.5**	**F**	**107.6**
Ma‘alo Rd.	1 Kūhiō Hwy./‘Ehiku St.	*See ‘Ehiku Street Access Alternative*				A	4.2	A	3.9	A	4.1	A	4.0
	2 Kūhiō Hwy./Ma‘alo Rd.					D	25.6	**E**	**44.6**	**E**	**38.4**	**F**	**308.9**
	3 Kūhiō Hwy./Laulima St.					**F**	**52.6**	**F**	**96.4**	**F**	**66.2**	**F**	**122.5**
	4 Kūhiō Hwy./Rob. Haw. Dwy.					D	31.6	C	22.2	D	34.9	C	23.7
	5 Kūhiō Hwy./Kapule Hwy.					C	24.1	D	43.7	C	25.5	**E**	**57.7**
	6 Kūhiō Hwy./Kaua‘i Beach Dr.					**F**	**162.4**	**F**	**92.1**	**F**	**182.5**	**F**	**107.6**
Laulima St.	1 Kūhiō Hwy./‘Ehiku St.	*See ‘Ehiku Street Access Alternative*				A	4.2	A	3.9	A	4.1	A	4.0
	2 Kūhiō Hwy./Ma‘alo Rd.					C	24.8	**E**	**40.2**	D	27.0	**E**	**47.7**
	3 Kūhiō Hwy./Laulima St.					**F**	**58.9**	**F**	**105.4**	**F**	**161.0**	**F**	**415.2**
	4 Kūhiō Hwy./Rob. Haw. Dwy.					D	31.6	C	22.2	D	34.9	C	23.7
	5 Kūhiō Hwy./Kapule Hwy.					C	24.1	D	43.7	C	25.5	**E**	**57.7**
	6 Kūhiō Hwy./Kaua‘i Beach Dr.					**F**	**162.4**	**F**	**92.1**	**F**	**182.5**	**F**	**107.6**

Access Alter-native	Intersection	Weekday Peak Hour											
		No Project				Project							
						Landfill				Landfill and RRP			
		AM		PM		AM		PM		AM		PM	
		LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
Roberts Hawaii Dwy.	1 Kūhiō Hwy./‘Ehiku St.	*See ‘Ehiku Street Access Alternative*				A	4.2	A	3.9	A	4.1	A	4.0
	2 Kūhiō Hwy./Ma‘alo Rd.					C	24.8	**E**	**40.2**	D	27.0	**E**	**47.7**
	3 Kūhiō Hwy./Laulima St.					**F**	**53.0**	**F**	**97.3**	**F**	**71.9**	**F**	**128.0**
	4 Kūhiō Hwy./Rob. Haw. Dwy.					D	29.7	C	24.0	**E**	**48.9**	**E**	**77.5**
	5 Kūhiō Hwy./Kapule Hwy.					C	24.1	D	43.7	C	25.5	**E**	**57.7**
	6 Kūhiō Hwy./Kaua‘i Beach Dr.					**F**	**162.4**	**F**	**92.1**	**F**	**182.5**	**F**	**107.6**
Kaua‘i Beach Dr.	1 Kūhiō Hwy./‘Ehiku St.	*See ‘Ehiku Street Access Alternative*				A	4.2	A	3.9	A	4.1	A	4.0
	2 Kūhiō Hwy./Ma‘alo Rd.					C	24.8	**E**	**40.2**	D	27.0	**E**	**47.7**
	3 Kūhiō Hwy./Laulima St.					**F**	**53.0**	**F**	**97.3**	**F**	**71.9**	**F**	**128.0**
	4 Kūhiō Hwy./Rob. Haw. Dwy.					D	31.8	C	22.3	**E**	**35.7**	C	24.7
	5 Kūhiō Hwy./Kapule Hwy.					C	24.2	D	43.6	C	28.8	D	45.9
	6 Kūhiō Hwy./Kaua‘i Beach Dr.					**F**	**214.1**	**F**	**98.5**	**F**	**—**[(1)]	**F**	**183.2**

Notes:
LOS and average delay for stop-controlled intersections represents the worst stop-controlled approach.
Bold indicates LOS E or LOS F.
(1) Volume exceeds capacity for the westbound Kaua‘i Beach Drive approach.

Operations at each study intersection under each analysis scenario for the Opening Year are further summarized below.

2.2.3.1 Intersection #1: Kūhiō Highway/‘Ehiku Street (signalized)

- *Opening Year Baseline*: Projected to operate at LOS A during both the weekday AM and PM peak hours.
- *Opening Year with Landfill*: No change in LOS under all access alternatives.
- *Opening Year with Landfill and RRP*: No change in LOS under all access alternatives.

Overall summary: This intersection would continue to operate at LOS A in the Opening Year under all analysis scenarios and all access alternatives.

2.2.3.2 Intersection #2: Kūhiō Highway/Ma‘alo Road (unsignalized with one-way stop control)

- *Opening Year Baseline:* Projected to operate at LOS C during the weekday AM peak hour, but LOS E during the weekday PM peak hour.
- *Opening Year with Landfill:* No change in LOS under all access alternatives except the Ma‘alo Road Access Alternative. Under the Ma‘alo Road Access Alternative, intersection operations would degrade to LOS D during the weekday AM peak hour, but remain at LOS E during the weekday PM peak hour (with a marginal increase in delay). The intersection would not satisfy the MUTCD peak-hour traffic signal warrant under any access alternative.

- *Opening Year with Landfill and RRP:* For all access alternatives except the Ma‘alo Road Access Alternative, negligible change in LOS. The intersection would degrade to LOS D during the weekday AM peak hour, but remain at LOS E during the weekday PM peak hour. The intersection would not satisfy the MUTCD peak-hour traffic signal warrant.

  Under the Ma‘alo Road Access Alternative, intersection operations would degrade to LOS E during the weekday AM peak hour and LOS F during the weekday PM peak hour. The intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour, and signalization is recommended.

Overall summary: In the Opening Year Baseline (without the Project), this intersection would operate at LOS C during the weekday AM peak hour and LOS E during the weekday PM peak hour, but would not satisfy the MUTCD peak-hour traffic signal warrant. Under all access alternatives except the Ma‘alo Road Access Alternative the Project (regardless of whether or not the RRP component is included) would increase average delays, but intersection operations would generally remain similar to conditions without the Project, and the MUTCD peak-hour traffic signal warrant would not be satisfied.

Under the Ma‘alo Road Access Alternative, the intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour with both the landfill and RRP, but not with the landfill only. As a result, signalization is recommended under the Ma‘alo Road Access Alternative prior to the opening of the Project if the full build-out option (landfill plus RRP) is implemented, but not for the landfill-only option.

2.2.3.3 INTERSECTION #3: KŪHIŌ HIGHWAY/LAULIMA STREET (UNSIGNALIZED WITH TWO-WAY STOP CONTROL)

- *Opening Year Baseline:* Projected to operate at LOS F during both the weekday AM and PM peak hours. However, the intersection would not satisfy the MUTCD peak-hour traffic signal warrant during either peak hour.
- *Opening Year with Landfill:* No change in LOS under all access alternatives. The Project would result in a slight increase in average delays for all access alternatives except the Laulima Street Access Alternative, under which average delays would see a slightly larger increase. However, the intersection would not satisfy the MUTCD peak-hour traffic signal warrant under any access alternative.
- *Opening Year with Landfill and RRP:* No change in LOS under all access alternatives. For all access alternatives except the Laulima Street Access Alternative, the Project would result in a somewhat larger increase in average delays than with the landfill-only option. Under the Laulima Street Access Alternative, however, the Project would substantially increase average delays, and the intersection would satisfy the MUTCD peak-hour traffic signal warrant during both the weekday AM and PM peak hours. As a result, signalization is recommended under the Laulima Street Access Alternative.

Overall summary: In the Opening Year Baseline (without the Project), this intersection would operate at LOS F during both the weekday AM and PM peak hours, but would not satisfy the MUTCD peak-hour traffic signal warrant. Under all access alternatives except the Laulima Street Access Alternative, the Project (regardless of whether or not the RRP component is included) would increase average delays, but intersection operations would generally remain similar to conditions without the Project, and the MUTCD peak-hour traffic signal warrant would not be satisfied. Given the high levels of average delay, however, a full signal warrant analysis is recommended, including an evaluation of MUTCD four-hour and eight-hour vehicular volume traffic signal warrants.

Under the Laulima Street Access Alternative, the intersection would satisfy the MUTCD peak-hour traffic signal warrant during both the weekday AM and PM peak hours with both the landfill and RRP, but not with the landfill only. As a result, signalization is recommended under the Laulima Street

Access Alternative prior to the opening of the Project if the full build-out option (landfill plus RRP) is implemented, but not for the landfill-only option.

2.2.3.4 INTERSECTION #4: KŪHIŌ HIGHWAY/ROBERTS HAWAII DRIVEWAY (UNSIGNALIZED WITH ONE-WAY STOP CONTROL)

- *Opening Year Baseline:* Projected to operate at LOS D during the weekday AM peak hour and LOS C during the weekday PM peak hour.
- *Opening Year with Landfill:* No change in LOS under all access alternatives.
- *Opening Year with Landfill and RRP:* For the ‘Ehiku Street Access Alternative, Ma‘alo Road Access Alternative, and Laulima Street Access Alternative, no change in LOS. For the Kaua‘i Beach Drive Access Alternative, the intersection would degrade to LOS E during the weekday AM peak hour, but remain at LOS C during the weekday PM peak hour. The intersection would not satisfy the MUTCD peak-hour traffic signal warrant.

  Under the Roberts Hawaii Driveway Access Alternative, intersection operations would degrade to LOS E during both the weekday AM and PM peak hours. The intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour, and signalization is recommended.

Overall summary: This intersection would operate at LOS D during the weekday AM peak hour and LOS C during the weekday PM peak hour in the Opening Year Baseline (without the Project). Under all access alternatives except the Roberts Hawaii Driveway Access Alternative, the Project (regardless of whether or not the RRP component is included) would increase average delays, but intersection operations would generally remain similar to conditions without the Project, and the MUTCD peak-hour traffic signal warrant would not be satisfied.

Under the Roberts Hawaii Driveway Access Alternative, the intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour with both the landfill and RRP, but not with the landfill only. As a result, signalization is recommended under the Roberts Hawaii Driveway Access Alternative prior to the opening of the Project if the full build-out option (landfill plus RRP) is implemented, but not for the landfill-only option.

2.2.3.5 INTERSECTION #5: KŪHIŌ HIGHWAY/KAPULE HIGHWAY (SIGNALIZED)

- *Opening Year Baseline:* Projected to operate at LOS C during the weekday AM peak hour and LOS D during the weekday PM peak hour.
- *Opening Year with Landfill:* No change in LOS under all access alternatives.
- *Opening Year with Landfill and RRP:* No change in LOS under the Kaua‘i Beach Drive Access Alternative. Under the remaining access alternatives, intersection operations would remain at LOS C during the weekday AM peak hour, but degrade to LOS E during the weekday PM peak hour. This assumes, however, that the current signal timing and phasing plans are maintained.

Overall summary: This intersection would operate at LOS C during the weekday AM peak hour and LOS D during the weekday PM peak hour in the Opening Year Baseline (without the Project). Under the landfill-only option, the Project would slightly increase average delays, but intersection operations would generally remain similar to conditions without the Project. With both the landfill and RRP, intersection operations would degrade to LOS E during the weekday PM peak hour under all access alternatives except the Kaua‘i Beach Drive Access Alternative. It is recommended that the signal timing and phasing plans be optimized in the future to improve operations.

2.2.3.6 INTERSECTION #6: KŪHIŌ HIGHWAY/KAUA‘I BEACH DRIVE (UNSIGNALIZED WITH ONE-WAY STOP CONTROL)

- *Opening Year Baseline:* Projected to operate at LOS F during both the weekday AM and PM peak hours. The intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour, and signalization is recommended.
- *Opening Year with Landfill:* No change in LOS under all access alternatives. The Project would result in a slight increase in average delays for all access alternatives except the Kaua‘i Beach Drive Access Alternative, under which average delays would see a slightly larger increase. The intersection would continue to satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour under all access alternatives, and signalization is recommended.
- *Opening Year with Landfill and RRP:* No change in LOS under all access alternatives. For all access alternatives except the Kaua‘i Beach Drive Access Alternative, the Project would result in a somewhat larger increase in average delays than with the landfill-only option. Under the Kaua‘i Beach Drive Access Alternative, however, the Project would substantially increase average delays. The intersection would continue to satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour under all access alternatives, and signalization is recommended.

Overall summary: This intersection would operate at LOS F during both the weekday AM and PM peak hours in in the Opening Year Baseline (without the Project), and would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour even without the Project. The Project would increase average delays, particularly under the Kaua‘i Beach Drive Access Alternative, and the intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour (regardless of whether or not the RRP component is included). Therefore, further evaluation of the feasibility signalization by the Opening Year, regardless of Project implementation, is recommended for this intersection.

2.2.4 Future Long-Range Year

The estimated traffic generated by the proposed landfill and RRP in the Future Long-Range Year, summarized in Table 4, was added to the Future Long-Range year baseline traffic volumes to obtain anticipated traffic volumes for the Future Long-Range Year, both with and without the RRP. Operations at the six study intersections were evaluated for each scenario and access alternative using the Synchro 8.0 software package and the HCM methodology, as described in Section 2.1.3. Anticipated traffic volumes for each access alternative under these two Future Long-Range Year scenarios are included in Appendix A. The resulting LOS for the Future Long-Range Year with Landfill conditions and the Future Long-Range Year with Landfill and RRP conditions during both the weekday AM and PM peak hours is summarized in Table 6. Detailed LOS output summaries are included in Appendix B.

Table 6: Level of Service – Future Long-Range Year

Access Alter-native	Intersection	Weekday Peak Hour											
		No Project				Project							
						Landfill				Landfill and RRP			
		AM		PM		AM		PM		AM		PM	
		LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
‘Ehiku St.	1 Kūhiō Hwy./‘Ehiku St.	A	5.5	A	5.3	A	6.0	A	6.1	A	7.3	B	11.5
	2 Kūhiō Hwy./Ma‘alo Rd.	**E**	**35.0**	**F**	**126.8**	**E**	**35.8**	**F**	**133.6**	**E**	**39.6**	**F**	**177.8**
	3 Kūhiō Hwy./Laulima St.	**F**	**206.3**	**F**	**422.1**	**F**	**219.8**	**F**	**442.0**	**F**	**286.6**	**F**	**544.9**
	4 Kūhiō Hwy./Rob. Haw. Dwy.	**E**	**48.6**	D	31.3	**E**	**49.9**	D	31.9	**F**	**55.8**	D	34.5

Access Alter-native	Intersection	Weekday Peak Hour											
		No Project				Project							
						Landfill				Landfill and RRP			
		AM		PM		AM		PM		AM		PM	
		LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
	5 Kūhiō Hwy./Kapule Hwy.	**E**	**57.5**	**E**	**67.2**	**E**	**59.0**	**E**	**69.5**	**E**	**66.1**	**F**	**84.8**
	6 Kūhiō Hwy./Kaua‘i Beach Dr.	**F**	**530.6**	**F**	**394.4**	**F**	**541.5**	**F**	**401.7**	**F**	**593.7**	**F**	**449.8**
Ma‘alo Rd.	1 Kūhiō Hwy./‘Ehiku St.	*See ‘Ehiku Street Access Alternative*				A	5.5	A	5.4	A	5.6	A	5.8
	2 Kūhiō Hwy./Ma‘alo Rd.					**E**	**40.8**	**F**	**209.6**	**F**	**77.0**	**F**	**941.7**
	3 Kūhiō Hwy./Laulima St.					**F**	**219.8**	**F**	**442.0**	**F**	**286.6**	**F**	**544.9**
	4 Kūhiō Hwy./Rob. Haw. Dwy.					**E**	**49.9**	D	31.9	**F**	**55.8**	D	34.5
	5 Kūhiō Hwy./Kapule Hwy.					**E**	**59.0**	**E**	**69.5**	**E**	**66.1**	**F**	**84.8**
	6 Kūhiō Hwy./Kaua‘i Beach Dr.					**F**	**541.5**	**F**	**401.7**	**F**	**593.7**	**F**	**449.8**
Laulima St.	1 Kūhiō Hwy./‘Ehiku St.	*See ‘Ehiku Street Access Alternative*				A	5.5	A	5.4	A	5.6	A	5.8
	2 Kūhiō Hwy./Ma‘alo Rd.					**E**	**36.0**	**F**	**135.0**	**E**	**39.8**	**F**	**191.8**
	3 Kūhiō Hwy./Laulima St.					**F**	**267.9**	**F**	**487.3**	**F**	**655.8**	**F**	**—**[1]
	4 Kūhiō Hwy./Rob. Haw. Dwy.					**E**	**49.9**	D	31.9	**F**	**55.8**	D	34.5
	5 Kūhiō Hwy./Kapule Hwy.					**E**	**59.0**	**E**	**69.5**	**E**	**66.1**	**F**	**84.8**
	6 Kūhiō Hwy./Kaua‘i Beach Dr.					**F**	**541.5**	**F**	**401.7**	**F**	**593.7**	**F**	**449.8**
Roberts Hawaii Dwy.	1 Kūhiō Hwy./‘Ehiku St.	*See ‘Ehiku Street Access Alternative*				A	5.5	A	5.4	A	5.6	A	5.8
	2 Kūhiō Hwy./Ma‘alo Rd.					**E**	**36.0**	**F**	**135.0**	**E**	**39.8**	**F**	**191.8**
	3 Kūhiō Hwy./Laulima St.					**F**	**223.4**	**F**	**445.9**	**F**	**310.1**	**F**	**567.0**
	4 Kūhiō Hwy./Rob. Haw. Dwy.					**F**	**51.1**	**E**	**38.2**	**F**	**117.2**	**F**	**251.6**
	5 Kūhiō Hwy./Kapule Hwy.					**E**	**59.0**	**E**	**69.5**	**E**	**66.1**	**F**	**84.8**
	6 Kūhiō Hwy./Kaua‘i Beach Dr.					**F**	**541.5**	**F**	**401.7**	**F**	**593.7**	**F**	**449.8**
Kaua‘i Beach Dr.	1 Kūhiō Hwy./‘Ehiku St.	*See ‘Ehiku Street Access Alternative*				A	5.5	A	5.4	A	5.6	A	5.8
	2 Kūhiō Hwy./Ma‘alo Rd.					**E**	**36.0**	**F**	**135.0**	**E**	**39.8**	**F**	**191.8**
	3 Kūhiō Hwy./Laulima St.					**F**	**223.4**	**F**	**445.9**	**F**	**310.1**	**F**	**567.0**
	4 Kūhiō Hwy./Rob. Haw. Dwy.					**F**	**50.2**	D	32.0	**F**	**57.4**	**E**	**36.3**
	5 Kūhiō Hwy./Kapule Hwy.					**E**	**59.4**	**E**	**69.4**	**E**	**69.6**	**E**	**71.7**
	6 Kūhiō Hwy./Kaua‘i Beach Dr.					**F**	**851.3**	**F**	**433.3**	**F**	**—**[1]	**F**	**961.9**

Notes:
LOS and average delay for stop-controlled intersections represents the worst stop-controlled approach.
Bold indicates LOS E or LOS F.
[1] Volume exceeds capacity for the westbound Kaua‘i Beach Drive approach.

Operations at each study intersection under each analysis scenario for the Future Long-Range Year are summarized below.

2.2.4.1 INTERSECTION #1: KŪHIŌ HIGHWAY/‘EHIKU STREET (SIGNALIZED)

- *Future Long-Range Year Baseline:* Projected to operate at LOS A during both the weekday AM and PM peak hours.
- *Future Long-Range Year with Landfill:* No change in LOS under all access alternatives.
- *Future Long-Range Year with Landfill and RRP:* No change in LOS under all access alternatives.

Overall summary: This intersection would continue to operate at LOS A in the Future Long-Range Year under all analysis scenarios and all access alternatives.

2.2.4.2 INTERSECTION #2: KŪHIŌ HIGHWAY/MA‘ALO ROAD (UNSIGNALIZED WITH ONE-WAY STOP CONTROL)

- *Future Long-Range Year Baseline:* Projected to operate at LOS E during the weekday AM peak hour and LOS F during the weekday PM peak hour, but would not satisfy the MUTCD peak-hour traffic signal warrant.
- *Future Long-Range Year with Landfill:* No change in LOS under all access alternatives. The Project would result in a slight increase in average delays for all access alternatives except the Ma‘alo Road Access Alternative, under which average delays would see a slightly larger increase. The intersection would not satisfy the MUTCD peak-hour traffic signal warrant under any access alternative.
- *Future Long-Range Year with Landfill and RRP:* For all access alternatives except the Ma‘alo Road Access Alternative, no change in LOS. The Project would result in a somewhat larger increase in average delays than with the landfill-only option, but the intersection would not satisfy the MUTCD peak-hour traffic signal warrant

  Under the Ma‘alo Road Access Alternative, the Project would substantially increase average delays. The intersection would degrade to LOS F during the weekday AM peak hour and satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour. As a result, signalization is recommended under the Ma‘alo Road Access Alternative.

Overall summary: In the Future Year Baseline (without the Project), this intersection would operate at LOS E during the weekday AM peak hour and LOS F during the weekday PM peak hour, but would not satisfy the MUTCD peak-hour traffic signal warrant. Under all access alternatives except Route A, the Project (regardless of whether or not the RRP component is included) would increase average delays, but intersection operations would generally remain similar to conditions without the Project, and the MUTCD peak-hour traffic signal warrant would not be satisfied. Given the high levels of average delay, however, a full signal warrant analysis is recommended, including an evaluation of MUTCD four-hour and eight-hour vehicular volume traffic signal warrants.

Under the Ma‘alo Road Access Alternative, the intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour with both the landfill and RRP, but not with the landfill only. As a result, signalization is recommended under the Ma‘alo Road Access Alternative prior to the opening of the Project if the full build-out option (landfill plus RRP) is implemented, but not for the landfill-only option.

2.2.4.3 INTERSECTION #3: KŪHIŌ HIGHWAY/LAULIMA STREET (UNSIGNALIZED WITH TWO-WAY STOP CONTROL)

- *Future Long-Range Year Baseline:* Projected to operate at LOS F during both the weekday AM and PM peak hours. The intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday AM peak hour, and signalization is recommended.
- *Future Long-Range Year with Landfill:* No change in LOS under all access alternatives. The Project would result in a slight increase in average delays for all access alternatives except the Laulima Street Access Alternative, under which average delays would see a slightly

larger increase. The intersection would continue to satisfy the MUTCD peak-hour traffic signal warrant during the weekday AM peak hour under all access alternatives, and signalization is recommended.

- *Future Long-Range Year with Landfill and RRP:* No change in LOS under all access alternatives. For all access alternatives except the Laulima Street Access Alternative, the Project would result in a somewhat larger increase in average delays than with the landfill-only option, and the intersection would continue to satisfy the MUTCD peak-hour traffic signal warrant during the weekday AM peak hour. Under the Laulima Street Access Alternative, the Project would substantially increase average delays, and the intersection would satisfy the MUTCD peak-hour traffic signal warrant during both the weekday AM and PM peak hours. Signalization is recommended under all access alternatives.

Overall summary: In the Future Long-Range Year without the Project, this intersection would operate at LOS F during both the weekday AM and PM peak hours, and would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour. Under all access alternatives except the Laulima Street Access Alternative, the Project (regardless of whether or not the RRP component is included) would increase average delays, but intersection operations would generally remain similar to conditions without the Project, and the MUTCD peak-hour traffic signal warrant would be satisfied during the weekday PM peak hour.

Under the Laulima Street Access Alternative, the intersection would satisfy the MUTCD peak-hour traffic signal warrant during both the weekday AM and PM peak hours with both the landfill and RRP, but during the weekday PM peak hour only under the landfill-only option.

Signalization is recommended by the Future Long-Range Year, regardless of whether the Project is implemented or not.

2.2.4.4 Intersection #4: Kūhiō Highway/Roberts Hawaii Driveway (unsignalized with one-way stop control)

- *Future Long-Range Year Baseline:* Projected to operate at LOS E during the weekday AM peak hour and LOS D during the weekday PM peak hour, but would not satisfy the MUTCD peak-hour traffic signal warrant.
- *Future Long-Range Year with Landfill:* For the ‘Ehiku Street Access Alternative, Ma‘alo Road Access Alternative, and Laulima Street Access Alternative, no change in LOS. For the Kaua‘i Beach Drive Access Alternative, the intersection would degrade to LOS F during the weekday AM peak hour, but remain at LOS D during the weekday PM peak hour. The intersection would not satisfy the MUTCD peak-hour traffic signal warrant.

  Under the Roberts Hawaii Driveway Access Alternative, intersection operations would degrade to LOS F during the weekday AM peak hour and LOS E during the weekday PM peak hour, but the intersection would not satisfy the MUTCD peak-hour traffic signal warrant during either peak hour.
- *Future Long-Range Year with Landfill and RRP:* For the ‘Ehiku Street Access Alternative, Ma‘alo Road Access Alternative, and Laulima Street Access Alternative, the intersection would degrade to LOS F during the weekday AM peak hour, but remain at LOS D during the weekday PM peak hour. For the Kaua‘i Beach Drive Access Alternative, the intersection would degrade to LOS F during the weekday AM peak hour and LOS E during the weekday PM peak hour. The intersection would not satisfy the MUTCD peak-hour traffic signal warrant.

  Under the Roberts Hawaii Driveway Access Alternative, intersection operations would degrade to LOS F during both the weekday AM and PM peak hours. The intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour, and signalization is recommended.

Overall summary: In the Future Long-Range Year without the Project, this intersection would operate at LOS E during the weekday AM peak hour and LOS D during the weekday PM peak hour, but would not satisfy the MUTCD peak-hour traffic signal warrant. Under all access alternatives except the Roberts Hawaii Driveway Access Alternative, the Project (regardless of whether or not the RRP component is included) would increase average delays, but intersection operations would generally remain similar to conditions without the Project, and the MUTCD peak-hour traffic signal warrant would not be satisfied.

Under the Roberts Hawaii Driveway Access Alternative, the intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour with both the landfill and RRP, but not with the landfill only. As a result, signalization is recommended under the Roberts Hawaii Driveway Access Alternative prior to the opening of the Project if the full build-out option (landfill plus RRP) is implemented, but not for the landfill-only option.

2.2.4.5 INTERSECTION #5: KŪHIŌ HIGHWAY/KAPULE HIGHWAY (SIGNALIZED)

- *Future Long-Range Year Baseline:* Projected to operate at LOS E during both the weekday AM and PM peak hours.
- *Future Long-Range Year with Landfill:* No change in LOS under all access alternatives.
- *Future Long-Range Year with Landfill and RRP:* No change in LOS under the Kaua‘i Beach Drive Access Alternative. Under the remaining access alternatives, intersection operations would remain at LOS E during the weekday AM peak hour, but degrade to LOS F during the weekday PM peak hour. This assumes, however, that the current signal timing and phasing plans are maintained.

Overall summary: This intersection would operate at LOS E during both the weekday AM and PM peak hours in the Future Long-Range Year Baseline (without the Project). Under the landfill-only option, the Project would slightly increase average delays, but intersection operations would generally remain similar to conditions without the Project. With both the landfill and RRP, intersection operations would degrade to LOS F during the weekday PM peak hour under all access alternatives except Route E. It is recommended that the signal timing and phasing plans be optimized to improve operations.

2.2.4.6 INTERSECTION #6: KŪHIŌ HIGHWAY/KAUA‘I BEACH DRIVE (UNSIGNALIZED WITH ONE-WAY STOP CONTROL)

- *Future Long-Range Year Baseline:* Projected to operate at LOS F during both the weekday AM and PM peak hours. The intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour, and signalization is recommended.
- *Future Long-Range Year with Landfill:* No change in LOS under all access alternatives. The Project would result in a slight increase in average delays for all access alternatives except the Kaua‘i Beach Drive Access Alternative, under which average delays would see a slightly larger increase. The intersection would continue to satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour under all access alternatives, and signalization is recommended.
- *Future Long-Range Year with Landfill and RRP:* No change in LOS under all access alternatives. For all access alternatives except the Kaua‘i Beach Drive Access Alternative, the Project would result in a somewhat larger increase in average delays than with the landfill-only option. Under the Kaua‘i Beach Drive Access Alternative, however, the Project would substantially increase average delays. The intersection would continue to satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour under all access alternatives, and signalization is recommended.

Overall summary: In the Future Long-Range Year without the Project, this intersection would operate at LOS F during both the weekday AM and PM peak hours, and would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour. The Project would increase average delays, particularly under the Kaua‘i Beach Drive Access Alternative, and the intersection would satisfy the MUTCD peak-hour traffic signal warrant during the weekday PM peak hour (regardless of whether or not the RRP component is included). Therefore, further evaluation of the feasibility signalization by the Future Long-Range Year, regardless of Project implementation, is recommended for this intersection.

2.3 TRAFFIC ASSESSMENT RECOMMENDATIONS

2.3.1 Traffic Impact Minimization

As summarized in Table 7, Access Route B is the access route expected to generate the fewest adverse impacts to traffic operations at the study highway intersections. Although in some cases the average delay on the minor-street approaches would be substantial, they may still not satisfy the MUTCD peak-hour traffic signal warrant under some of the analysis scenarios, because traffic volumes on the minor-street approach would not meet the thresholds. Further evaluation of MUTCD traffic signal warrants (particularly the four-hour and eight-hour vehicular volume warrants) would be required, and is recommended, to determine if a signal could be warranted at these locations.

Table 7: Summary of Findings – ‘Ehiku Street Access Alternative

Intersection		Opening Year (2020)	Future Year (2040)
1	Kūhiō Highway/‘Ehiku Street	No impact.	No impact.
2	Kūhiō Highway/Ma‘alo Road	No signalization required, even under full project build-out.	Further evaluation of signal warrants recommended.
3	Kūhiō Highway/Laulima Street	Further evaluation of signal warrants recommended.	Signalization recommended, with or without Project.
4	Kūhiō Highway/Roberts Hawaii Driveway	No signalization required, even under full project build-out.	No signalization required, even under full project build-out.
5	Kūhiō Highway/Kapule Highway	Signal timing/phasing optimization recommended.	Signal timing/phasing optimization recommended.
6	Kūhiō Highway/Kaua‘i Beach Drive	Signalization recommended, with or without Project.	Signalization recommended, with or without Project.

2.3.2 Recommended Improvement Measures

Because traffic impacts are only one criterion for choosing between the proposed access alternatives, and other concerns may ultimately outweigh the incremental increase in traffic delays (which, in many cases, are not expected to be very significant), a different access route may ultimately be chosen as part of the proposed project. Therefore, recommended improvements at each study intersection have been developed for all access routes; these improvements are summarized in Table 8 and further developed in Section 3.0.

Table 8: Recommended Intersection Improvements by Access Alternative

Access Alter-native	Intersection	Existing Traffic Control	Recommended Improvement					
			Opening Year (2020)			Future Year (2040)		
				Project			Project	
			No Project	Landfill	Landfill and RRP	No Project	Landfill	Landfill and RRP
‘Ehiku St.	1 Kūhiō Highway/‘Ehiku Street	Signal	N	N	N	N	N	N
	2 Kūhiō Highway/Ma‘alo Road	OWSC	N	N	N	E	E	E
	3 Kūhiō Highway/Laulima Street	TWSC	E	E	E	S	S	S
	4 Kūhiō Highway/Roberts Hawaii Dwy.	OWSC	N	N	N	N	N	N
	5 Kūhiō Highway/Kapule Highway	Signal	N	N	O	O	O	O
	6 Kūhiō Highway/Kaua‘i Beach Drive	OWSC	S	S	S	S	S	S
Ma‘alo Rd.	1 Kūhiō Highway/‘Ehiku Street	Signal	N	N	N	N	N	N
	2 Kūhiō Highway/Ma‘alo Road	OWSC	N	N	S	E	E	S
	3 Kūhiō Highway/Laulima Street	TWSC	E	E	E	S	S	S
	4 Kūhiō Highway/Roberts Hawaii Dwy.	OWSC	N	N	N	N	N	N
	5 Kūhiō Highway/Kapule Highway	Signal	N	N	O	O	O	O
	6 Kūhiō Highway/Kaua‘i Beach Drive	OWSC	S	S	S	S	S	S
Laulima St.	1 Kūhiō Highway/‘Ehiku Street	Signal	N	N	N	N	N	N
	2 Kūhiō Highway/Ma‘alo Road	OWSC	N	N	N	E	E	E
	3 Kūhiō Highway/Laulima Street	TWSC	E	E	S	S	S	S
	4 Kūhiō Highway/Roberts Hawaii Dwy.	OWSC	N	N	N	N	N	N
	5 Kūhiō Highway/Kapule Highway	Signal	N	N	O	O	O	O
	6 Kūhiō Highway/Kaua‘i Beach Drive	OWSC	S	S	S	S	S	S
Roberts Hawaii Dwy.	1 Kūhiō Highway/‘Ehiku Street	Signal	N	N	N	N	N	N
	2 Kūhiō Highway/Ma‘alo Road	OWSC	N	N	N	E	E	E
	3 Kūhiō Highway/Laulima Street	TWSC	E	E	E	S	S	S
	4 Kūhiō Highway/Roberts Hawaii Dwy.	OWSC	N	N	S	N	E	S
	5 Kūhiō Highway/Kapule Highway	Signal	N	N	O	O	O	O
	6 Kūhiō Highway/Kaua‘i Beach Drive	OWSC	S	S	S	S	S	S
Kaua‘i Beach Dr.	1 Kūhiō Highway/‘Ehiku Street	Signal	N	N	N	N	N	N
	2 Kūhiō Highway/Ma‘alo Road	OWSC	N	N	N	E	E	E
	3 Kūhiō Highway/Laulima Street	TWSC	E	E	E	S	S	S
	4 Kūhiō Highway/Roberts Hawaii Dwy.	OWSC	N	N	N	N	N	N
	5 Kūhiō Highway/Kapule Highway	Signal	N	N	N	O	O	O
	6 Kūhiō Highway/Kaua‘i Beach Drive	OWSC	S	S	S	S	S	S

Notes:
OWSC = One-way stop control
TWSC = Two-way stop control
Recommended improvements key:

N	None (no improvements required)
E	Further evaluation of signal warrants (MUTCD peak-hour traffic signal warrant not met, but high average delays may warrant signalization)
S	Signalization (MUTCD peak-hour traffic signal warrant met)
O	Signal timing/phasing optimization

Table 9 summarizes the anticipated improvements to the projected traffic impacts and LOS that the Recommended Improvement Measures would achieve, based on an analysis of the weekday PM peak hour for the full build-out of the Project (landfill and RRP), assuming that those intersections recommended for further evaluation of signal warrants would in fact be signalized. A complete analysis of the MUTCD traffic signal warrants, including the four-hour and eight-hour

vehicular volume warrants, should be conducted to determine whether a traffic signal should be installed, based either on MUTCD traffic signal warrants or in order to improve pedestrian and/or bicycle connections and safety.

Table 9: Level of Service – With Improvements

Access Alter-native	Intersection	Opening Year (2020) plus Landfill and RRP Conditions			Future Year (2040) plus Landfill and RRP Conditions		
		Improvement	LOS Before	LOS After	Improvement	LOS Before	LOS After
‘Ehiku St.	1 Kūhiō Hwy./‘Ehiku St.	None			None		
	2 Kūhiō Hwy./Ma‘alo Rd.	None			Signalization	**F**	A
	3 Kūhiō Hwy./Laulima St.	Signalization	**F**	A	Signalization	**F**	A
	4 Kūhiō Hwy./Rob. Haw. Dwy.	None			None		
	5 Kūhiō Hwy./Kapule Hwy.	Signal optimization	**E**	C	Signal optimization	**F**	C
	6 Kūhiō Hwy./Kaua‘i Beach Dr.	Signalization	**F**	A	Signalization	**F**	B
Ma‘alo Rd.	1 Kūhiō Hwy./‘Ehiku St.	None			None		
	2 Kūhiō Hwy./Ma‘alo Rd.	Signalization	**F**	A	Signalization	**F**	B
	3 Kūhiō Hwy./Laulima St.	Signalization	**F**	A	Signalization	**F**	A
	4 Kūhiō Hwy./Rob. Haw. Dwy.	None			None		
	5 Kūhiō Hwy./Kapule Hwy.	Signal optimization	**E**	C	Signal optimization	**F**	C
	6 Kūhiō Hwy./Kaua‘i Beach Dr.	Signalization	**F**	A	Signalization	**F**	B
Laulima St.	1 Kūhiō Hwy./‘Ehiku St.	None			None		
	2 Kūhiō Hwy./Ma‘alo Rd.	None			Signalization	**F**	A
	3 Kūhiō Hwy./Laulima St.	Signalization	**F**	B	Signalization	**F**	B
	4 Kūhiō Hwy./Rob. Haw. Dwy.	None			None		
	5 Kūhiō Hwy./Kapule Hwy.	Signal optimization	**E**	C	Signal optimization	**F**	C
	6 Kūhiō Hwy./Kaua‘i Beach Dr.	Signalization	**F**	A	Signalization	**F**	B
Roberts Hawaii Dwy.	1 Kūhiō Hwy./‘Ehiku St.	None			None		
	2 Kūhiō Hwy./Ma‘alo Rd.	None			Signalization	**F**	A
	3 Kūhiō Hwy./Laulima St.	Signalization	**F**	A	Signalization	**F**	A
	4 Kūhiō Hwy./Rob. Haw. Dwy.	Signalization	**E**	A	Signalization	**F**	B
	5 Kūhiō Hwy./Kapule Hwy.	Signal optimization	**E**	C	Signal optimization	**F**	C
	6 Kūhiō Hwy./Kaua‘i Beach Dr.	Signalization	**F**	A	Signalization	**F**	B
Kaua‘i Beach Dr.	1 Kūhiō Hwy./‘Ehiku St.	None			None		
	2 Kūhiō Hwy./Ma‘alo Rd.	None			Signalization	**F**	A
	3 Kūhiō Hwy./Laulima St.	Signalization	**F**	A	Signalization	**F**	A
	4 Kūhiō Hwy./Rob. Haw. Dwy.	None			None		
	5 Kūhiō Hwy./Kapule Hwy.	None			Signal optimization	**E**	C
	6 Kūhiō Hwy./Kaua‘i Beach Dr.	Signalization	**F**	B	Signalization	**F**	D

Notably, because of the relatively low amount of traffic volume generated by the MSWLF during the peak hours, the differences between the Baseline scenarios (future traffic growth without the project) and the Baselines plus the MSWLF are minor. This indicates that a scenario without the RRP (or with minimal RRP implementation) would have minor impacts on traffic operations at the intersections evaluated; as shown in Table 9, in most cases, the LOS is not expected to be impacted by the operation of the MSWLF only). This applies to all access scenarios and both AM and PM time periods.

2.4 TRAFFIC ASSESSMENT CONCLUSION

Intersection operation is not the only factor in evaluating the alternative access routes. If it were the only factor, then Access Route B would be recommended because the existing traffic signal at that intersection would allow it to accommodate the traffic generated by the MSWLF and the RRP with the least need for traffic mitigation. However, countervailing factors are present:

- *Route A:* Routes using the Ma‘alo Road/Kūhiō Highway intersection for highway access would trigger signalization at the intersection in the ultimate development scenario. However, these routes come with a requirement for extensive improvements to both Ma‘alo Road and the Ma‘alo Road/Kūhiō Highway intersection, making Route A very expensive. Especially during interim phases of the proposed project, when this intersection is expected to be operating as an unsignalized intersection, caution should be exercised in introducing additional large vehicles at this location.
- *Route B:* The routes using ‘Ehiku Street as the primary access to/from Kūhiō Highway would require extensive and costly improvements. The ‘Ehiku Street/Kūhiō Highway intersection is located in a part of Līhu‘e that has multiple active driveway accesses and is relatively close to the Ahukini Road/Kūhiō Highway intersection that was observed to queue toward the ‘Ehiku Street/Kūhiō Highway intersection during the AM peak hour. Finally, the segment of ‘Ehiku Street between Kūhiō Highway and Kanakolu Street has direct residential driveway access on it, raising issues of safety and quality of life impacts to the adjacent properties.
- *Route C:* Using the Laulima Street/Kūhiō Highway intersection for highway access would trigger signalization of this intersection in the ultimate development scenario. With appropriate intersection improvements, this route would provide acceptable intersection operations and the most direct access route to the proposed project site. A benefit of this alternative is that it would help this intersection warrant traffic signalization earlier than other alternatives. This intersection currently experiences significant delay for traffic turning out of the subdivision during peak traffic hours. However, the traffic volumes on Laulima Street do not currently warrant traffic signalization. Helping this intersection warrant signalization sooner would enable this intersection to be signalized, significantly lessening the delay currently experienced by traffic turning out of Laulima Street.
- *Route D:* Using the Roberts Hawaii Driveway/Kūhiō Highway intersection for highway access would trigger signalization of this intersection in the ultimate development scenario. With appropriate intersection improvements, this route would provide acceptable intersection operations and the second-most-direct access route to the proposed project site, while directing some traffic away from the core of Hanamā‘ulu. Selection of this alternative would warrant traffic signalization, and signalization would be included as part of the intersection improvements. Due to the proximity of the signalized Kapule Highway/Kūhiō Highway intersection, traffic signals at the Roberts Hawaii Driveway and Kapule Highway intersections would need to be interconnected and coordinated.
- *Route E:* Using the Kaua‘i Beach Driveway/Kūhiō Highway intersection for highway access would trigger signalization of this intersection in the ultimate development scenario. With appropriate intersection improvements, this route would provide acceptable intersection operations and the third-most-direct access route to the proposed project site, while directing some traffic away from the core of Hanamā‘ulu, as requested by local residents. Recommended improvements for this alternative include traffic signalization, which is currently warranted. The traffic signal would also benefit existing traffic turning out of the Kaua‘i Beach Driveway by significantly reducing delay and increasing safety. Due to the proximity of the signalized Kapule Highway/Kūhiō Highway intersection, traffic signals on Kūhiō Highway at the Kaua‘i Beach Driveway and Kapule Highway intersections would need to be interconnected and coordinated.

In conclusion, while Route B would be expected to generate the fewest traffic impacts, overall, Route C, D, or E may provide the most cost-effective and efficient access to the MSWLF/RRP site, while minimizing impacts to the traffic operations and adjacent land uses.

3.0 INFRASTRUCTURE IMPROVEMENTS ASSESSMENT

3.1 INTRODUCTION AND PURPOSE

This infrastructure improvements assessment provides conceptual analysis of access route alternatives from Kūhiō Highway to the proposed project. The analysis evaluates the existing conditions, recommends improvements to the access routes, provides permitting, land use or land acquisition requirements and the estimated processing time, and presents planning-level cost estimates. The potential access routes analyzed in this section are as follows (see Figure 4):

- *Route A1 & A2:* Via Ma‘alo Road (Section 3.3)
- *Route B1 & B2:* Via ‘Ehiku Street (Section 3.4)
- *Route C3:* Via Laulima Street (Section 3.5)
- *Route D3:* Via Roberts Hawaii Driveway (Section 3.6)
- *Route E3:* Via Kaua‘i Beach Drive (Section 3.7)

3.2 UTILITY CONNECTIONS

Development of the selected project access route would also include utility corridor improvements, including relocation and connection to existing facilities as well as establishment of new facilities (i.e., along the driveway). Existing infrastructure in the vicinity of each route is presented in the following subsections.

3.2.1 Water

The Līhu‘e Water system in Hanamā’ulu has two known water storage tanks, a 500,000-gallon concrete tank, and a 1.0-million-gallon (MG) concrete tank, that provide water along Kūhiō Highway and Ma‘alo Road. The 500,000-gallon tank is located along Laulima Street about 1/4 mile mauka of Kūhiō Highway. The 1.0-MG concrete tank is located along Kulei Road approximately 1/2 mile mauka of Kūhiō Highway and provides water for a 12-inch water main along Kūhiō Highway and a 16-inch water main along Ma‘alo Road. Based on this preliminary analysis, a new 12-inch water main with a small booster pump station would be sufficient to meet the assumed domestic average project daily demand of 2,760 gallons per day (gpd), the required fire flow, and other County of Kaua‘i Department of Water criteria. It is also assumed that the existing water system has enough capacity, storage, and well supply to handle the proposed project water demand, and would not require upgrades. Upon selection of the proposed route, further analysis will be required to confirm these assumptions, which may include consultation with the County of Kaua‘i Department of Water.

3.2.2 Wastewater

The sewage collection system in the Līhu‘e and Hanamā’ulu area flow to the Līhu‘e Sewage Treatment Plant located just south of the Līhu‘e Airport, approximately 5 miles from the project site. Based on this preliminary analysis, a new 8-inch sewer main would be adequate to handle the additional proposed average project daily flow of 2,200 gpd. It is assumed that the existing downstream sewage infrastructure, including sewer mains and the Kapaia Sewer Pump Station, has adequate capacity to handle the additional flows from the project site and does not require any upgrades. Upon selection of the proposed route, further analysis would be required to confirm the assumptions, which may include consultation with the County of Kaua‘i Department of Public Works.

However, due to the distance between the project site and the existing sewer line points of connection, a more cost-effective alternative is to install onsite individual wastewater systems comprised of septic tanks and absorption beds. Additional environmental clearances and permitting would be required for this option; however, no problems are anticipated in obtaining the required approvals. This option would cost approximately $220,000 regardless of which access route is chosen, and is not included in the access route cost estimates presented herein (because it will be accounted for in the design of the facilities, in a separate report).

3.2.3 Electric Power and Telephone Service

Overhead electric power and telephone service is available at Ma‘alo Road and along Kūhiō Highway. Along Ma‘alo and ‘Ehiku Roads, the existing poles would require relocating to accommodate road widening. Service along routes C and D would have to be established along the entire access routes.

3.3 MA‘ALO ROAD ACCESS (ROUTES A1 AND A2)

3.3.1 Existing Conditions and Improvements

The Ma‘alo Road access routes are shown on Figure 4. The routes start at the Ma‘alo Road/Kūhiō Highway intersection and split near the proposed RRP site at the intersection of Driveways 1 and 2:

- Route A1 uses Driveway 1 to provide a direct route to the MSWLF, crossing two corrugated pipe culverts located in offsite wetland areas.
- Route A2 follows Driveway 1 to the intersection where Driveway 2 commences and bypasses the culverts and wetlands.

3.3.1.1 MA‘ALO ROAD ROADWAY IMPROVEMENTS

Ma‘alo Road is under State jurisdiction. The typical section through this area consists of two paved 10-ft lanes and 3-ft unimproved shoulders (Figure 5). Existing guardrails along the access route were observed during a site visit. The existing road includes a bridge and crosses nine existing culverts before reaching the intersection with Driveways 1 and 2. The Right-Of-Way (ROW) is 60 ft wide. The existing pavement section could not be found from as-built records.

Proposed improvements to Ma‘alo Road, which conform to the requirements of the American Association of State Highway and Transportation Officials (AASHTO) and State of Hawai‘i Department of Transportation (DOT), are:

- Widen roads and pave: 12-ft lanes with 4-ft shoulders; 2 inches asphalt concrete pavement (ACP), 6 inches asphalt concrete base (ACB), 6 inches aggregate subbase.
- Reconstruct existing culverts.
- Relocate guardrails.

3.3.1.2 MA‘ALO ROAD UTILITY IMPROVEMENTS

Along routes A1 and A2, the nearest water connection is the 16-inch main along Ma‘alo Road, where electricity and telephone service are also available. Recommended utility improvements to Ma‘alo Road are:

- Relocate power and telephone poles along Ma‘alo Road to accommodate road widening.
- Connect water to Driveway 1 and 2.
- Relocate 2-inch waterline along Ma‘alo Road.
- Relocate backflow preventer, fire hydrant, drain inlet, etc.
- Reconstruct existing culverts.

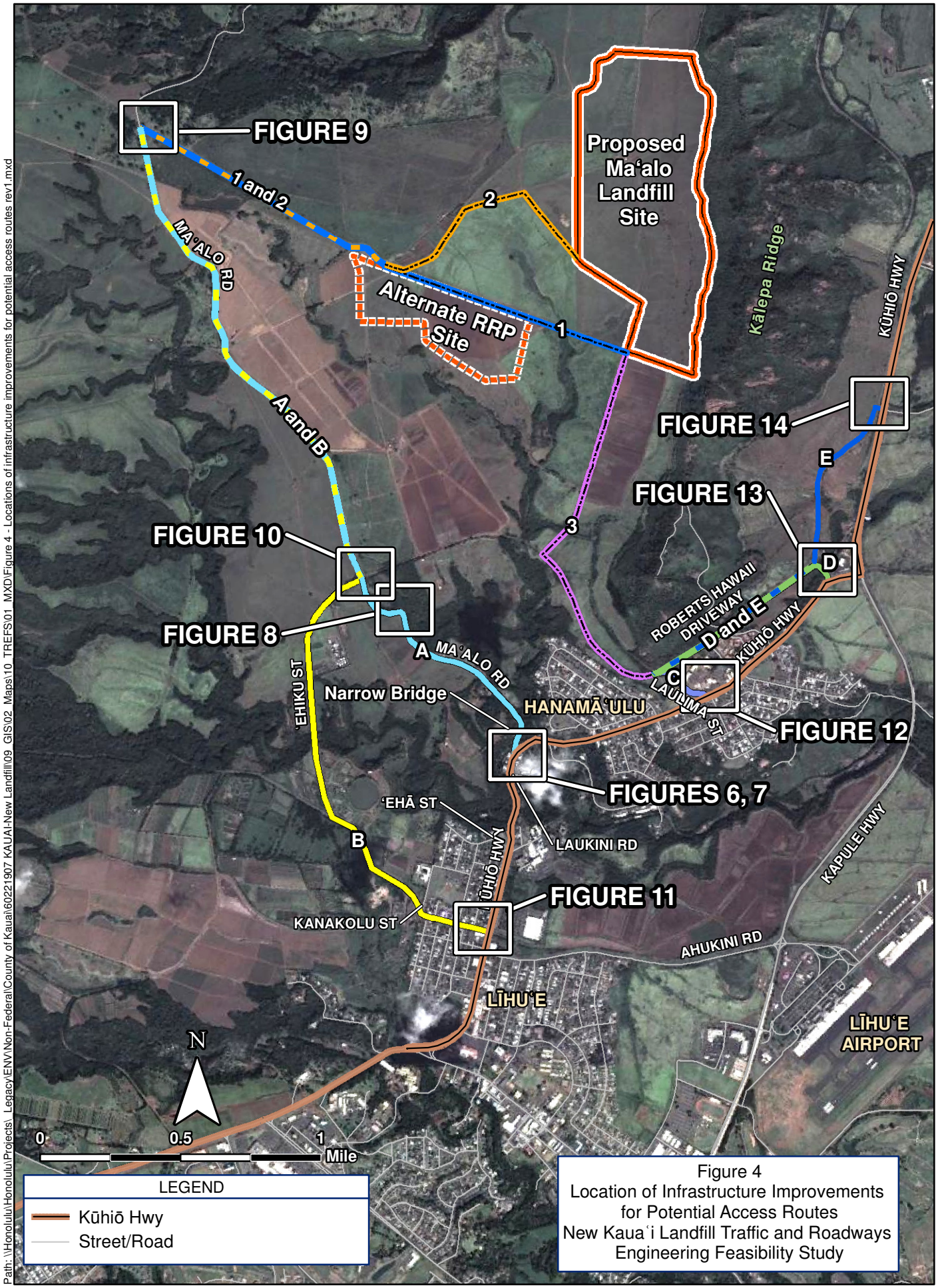
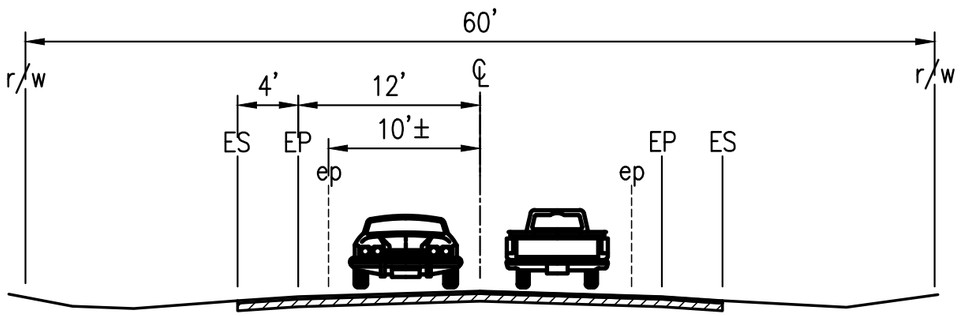
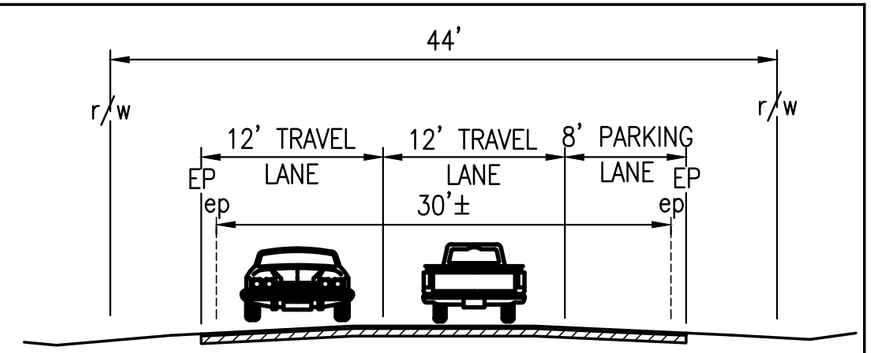


Figure 4
Location of Infrastructure Improvements for Potential Access Routes
New Kaua'i Landfill Traffic and Roadways Engineering Feasibility Study

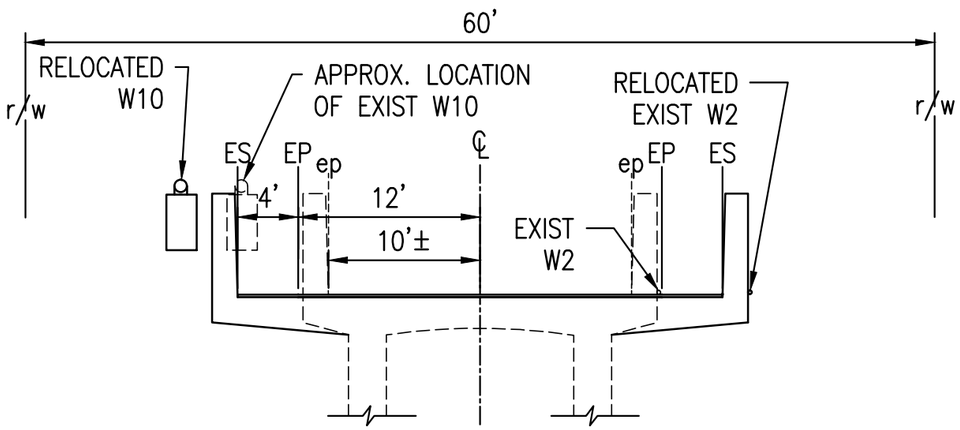
Path: \\Honolulu\Honolulu\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\09_GIS\02_Maps\10_TREFS\01_MXD\Figure 4 - Locations of infrastructure improvements for potential access routes rev1.mxd



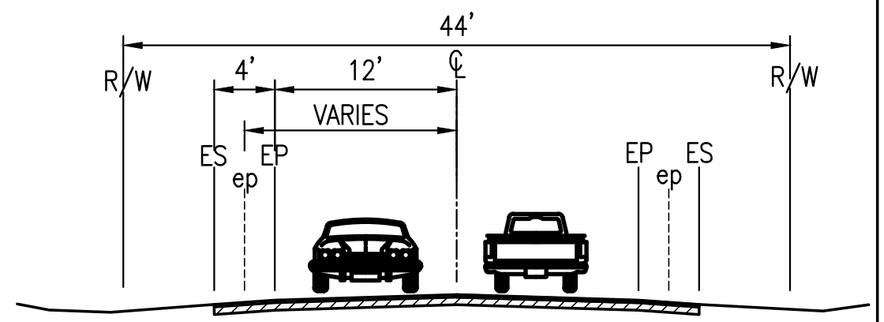
TYPICAL SECTION FOR MAALO ROAD



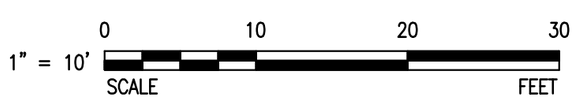
TYPICAL SECTION FOR EHIKU STREET
FROM ELIMA STREET
TO KANAKOLU STREET



TYPICAL SECTION FOR MAALO ROAD BRIDGE



TYPICAL SECTION FOR LAULIMA STREET,
ROBERT'S HAWAII DRIVEWAY ACCESS,
DRIVEWAYS "1", "2" & "3",
AND EHIKU STREET
FROM KANAKOLU STREET TO MAALO ROAD



LIST OF ABBREVIATIONS:

℄	CENTER LINE OF ROADWAY
ep	EXISTING EDGE OF PAVEMENT
ecls	existing center line striping
EP	PROPOSED EDGE OF PAVEMENT
ES	PROPOSED EDGE OF SHOULDER
r/w	EXISTING RIGHT OF WAY
R/W	PROPOSED RIGHT OF WAY

NOTES

SOURCE: HDOT PROJ. NO. ARR-0583(1) 2009, GOOGLE EARTH
DATE: 10-10-2013
DRAWN BY: AT (AECOM)

Figure 5
Typical Sections
New Kaua'i Landfill Traffic and Roadways
Engineering Feasibility Study

\\Honolulu\Honolulu\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\07 Deliverables\Task 05 TRDFS\05 DFigs 8,10-15 REV.dwg 04/19/16 11:23 AM tatsikurer

3.3.1.3 MA‘ALO ROAD/KŪHIŌ HIGHWAY INTERSECTION

The Ma‘alo Road/Kūhiō Highway intersection is a 3-way, unsignalized intersection with a left-turn lane in the northbound direction on Kūhiō Highway. The State DOT ROW is 60 ft wide. The Kapaia Bridge (Kūhiō Highway) is just east of the intersection and has a travelway width of 24 ft. The existing intersection can accommodate truck-turning movements for a WB-40 design vehicle. The existing pavement sections could not be found from as-built records.

Based on initial consultation, the State DOT suggested providing a right-turn deceleration lane southbound on Kūhiō Highway to Ma‘alo Road, and a median lane for left turns onto Kūhiō Highway northbound. The proposed intersection layout is shown on Figure 6. The right-turn lane provides taper and storage that meets the AASHTO design criteria for a design speed of 35 miles per hour.

Proposed improvements to the Ma‘alo Road/Kūhiō Highway intersection are:

- Signalize intersection.
- Widen roads and pave: 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
  - Right-turn from Kūhiō Highway southbound onto Ma‘alo Road: Increase turning radius to 40 feet to accommodate large vehicles.
- Install guardrail and end treatment.
- Fill and grade along Kūhiō Highway sloped shoulder.
- Construct retaining wall (approximately 3 ft tall) along Kūhiō Highway due to slope fill.
- Relocate utility poles, fire hydrant, backflow preventer, drain inlet, culvert.
- Acquire additional ROW (including survey maps).

Upon completion of these improvements, all turning movements at the proposed intersection will accommodate the WB-40 design vehicle.

Widening of the Kapaia Bridge on Kūhiō Highway may be necessary if the State DOT requires a deceleration lane for the intersection, in lieu of the above-proposed taper and storage. The existing bridge was built in 1932 and is approximately 30 feet wide with a 160-ft span. An additional 14-ft deceleration lane and 5-ft pedestrian walkway would require approximately 3,000 square feet of new bridge deck and structural support. ROW acquisition will also be required. A coordination meeting should be set up with State DOT to discuss the current bridge structural rating and feasibility of replacing the entire bridge. The proposed bridge widening is shown on Figure 7, and is conservatively included in the cost estimate for Route A.

A roundabout is an alternative that could conceivably be used at the Ma‘alo Road/Kūhiō Highway intersection. Benefits of a roundabout include improved safety, reduced speeds, and decreased traffic congestion. Negative aspects of a roundabout include user unfamiliarity with roundabouts and the equal-priority status of all approaches, which can slow through traffic. Land requirements for a roundabout would be an issue of particular concern at this location, as a single-lane roundabout would require an inscribed circle diameter of 105–150 ft to accommodate a WB-40 design vehicle. Lane width for the roundabout is typically 16–20 ft, resulting in an outside diameter of 120–170 ft for a roundabout at this intersection—this would require substantial ROW acquisition. Due primarily to land acquisition issues and the geometry of the area, a roundabout is not recommended and has been eliminated from further consideration. If a single-lane roundabout is desired, then further analysis would be required.

3.3.1.4 EXISTING BRIDGE ON MA‘ALO ROAD

The existing bridge on Ma‘alo Road just north of the Ma‘alo Road/Kūhiō Highway intersection is 20 ft wide with 10-ft lanes and no shoulders. The ROW is 60 ft wide.

The proposed typical section of the bridge is presented on Figure 5.

Proposed improvements to the existing bridge on Ma‘alo Road are:

- Widen bridge (32 ft clear width).
  - It is assumed at this stage that there are no issues with widening the bridge; e.g., historical preservation review or requirements.
  - *Bridge repaving:* 12-ft lanes with 4-ft shoulders; 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Relocate 2-inch waterline strapped to side of bridge.
- Relocate 12-inch waterline crossing adjacent to bridge.

3.3.1.5 Existing Sharp Curve along Ma‘alo Road

A sharp curve exists along Ma‘alo Road, as shown on Figure 8. This curve will not accommodate the WB-40 design vehicle. The existing typical section through this area consists of two 10-ft lanes with 3-ft unimproved shoulders. The ROW is 60 ft wide.

This stretch would be excavated as necessary, re-graded, and a reverse curve established. Figure 8 shows the proposed road widening in this area. Proposed improvements to the existing sharp curve along Ma‘alo Road are:

- Acquire additional ROW.
- Excavate and grade.

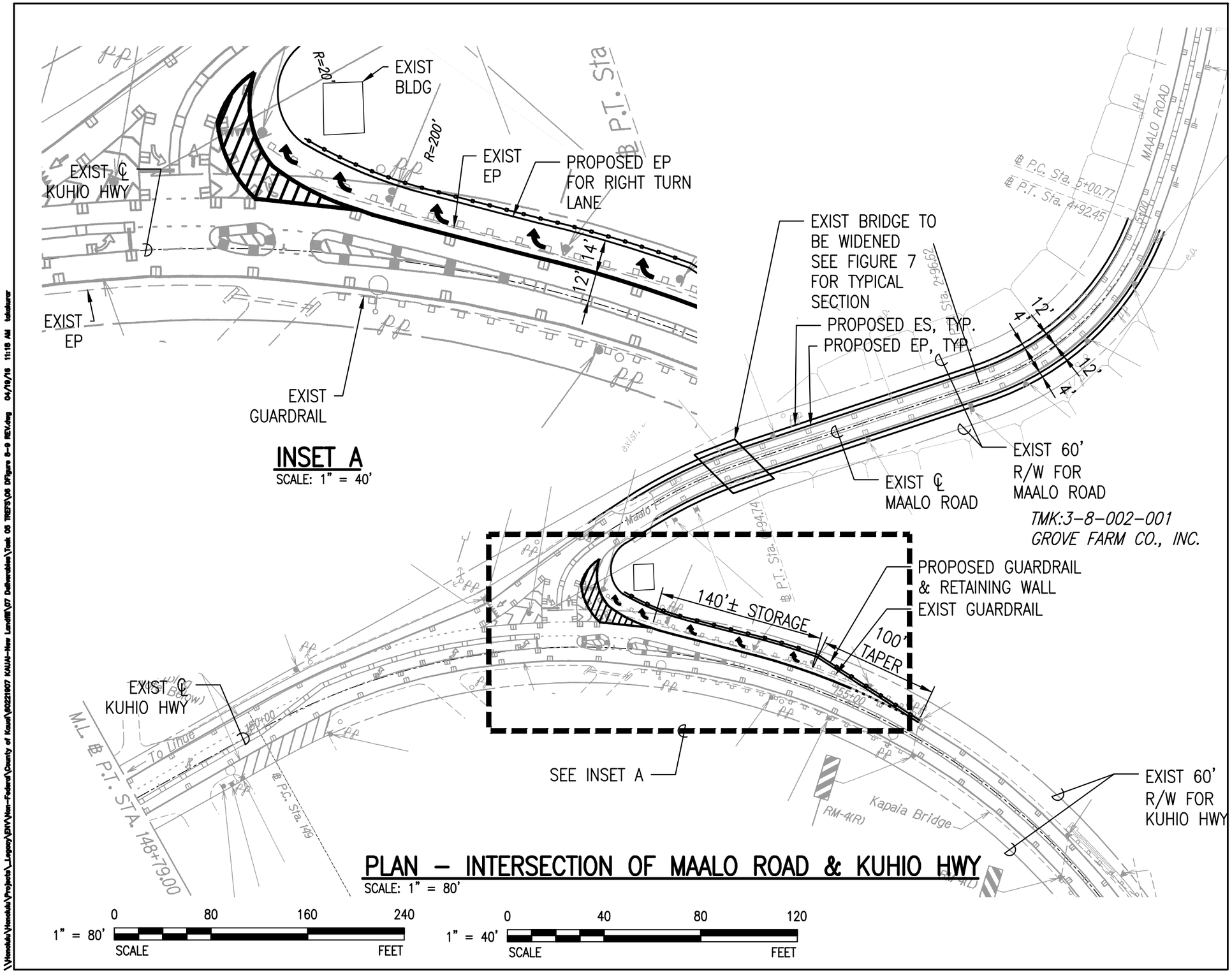
The cost of paving this area is captured under Section 3.3.1.1.

3.3.1.6 Ma‘alo Road/Driveways 1 and 2 Intersection

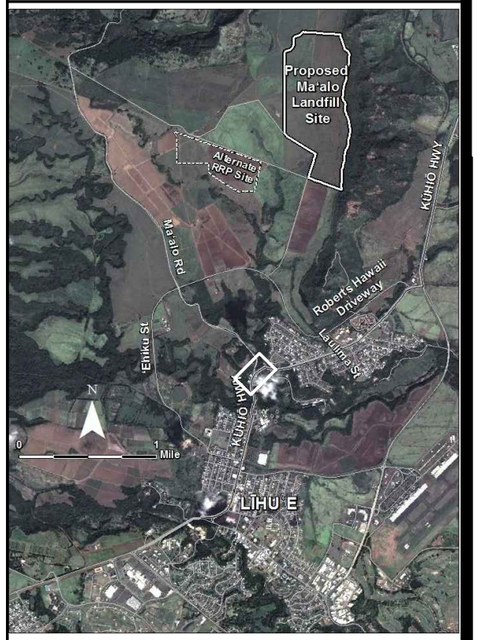
A sharp right turn exists northbound on Ma‘alo Road at the intersection with Driveways 1 and 2, as shown on Figure 9. This curve will not accommodate the WB-40 design vehicle. Ma‘alo Road currently has 10-ft lanes and 3-ft unpaved shoulders at this intersection. The land adjacent to the intersection is owned by the State of Hawai’i.

The intersection needs to be graded to accommodate the new intersection configuration. Drainage must be considered to accommodate increased surface runoff. Figure 9 shows the proposed road widening and curve alignment in this area. Proposed improvements to the Ma‘alo Road/Driveways 1 and 2 intersection are:

- Widen roads and pave: 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Acquire additional ROW (including survey maps).
- Relocate/widen double-swing gate.



KEY MAP

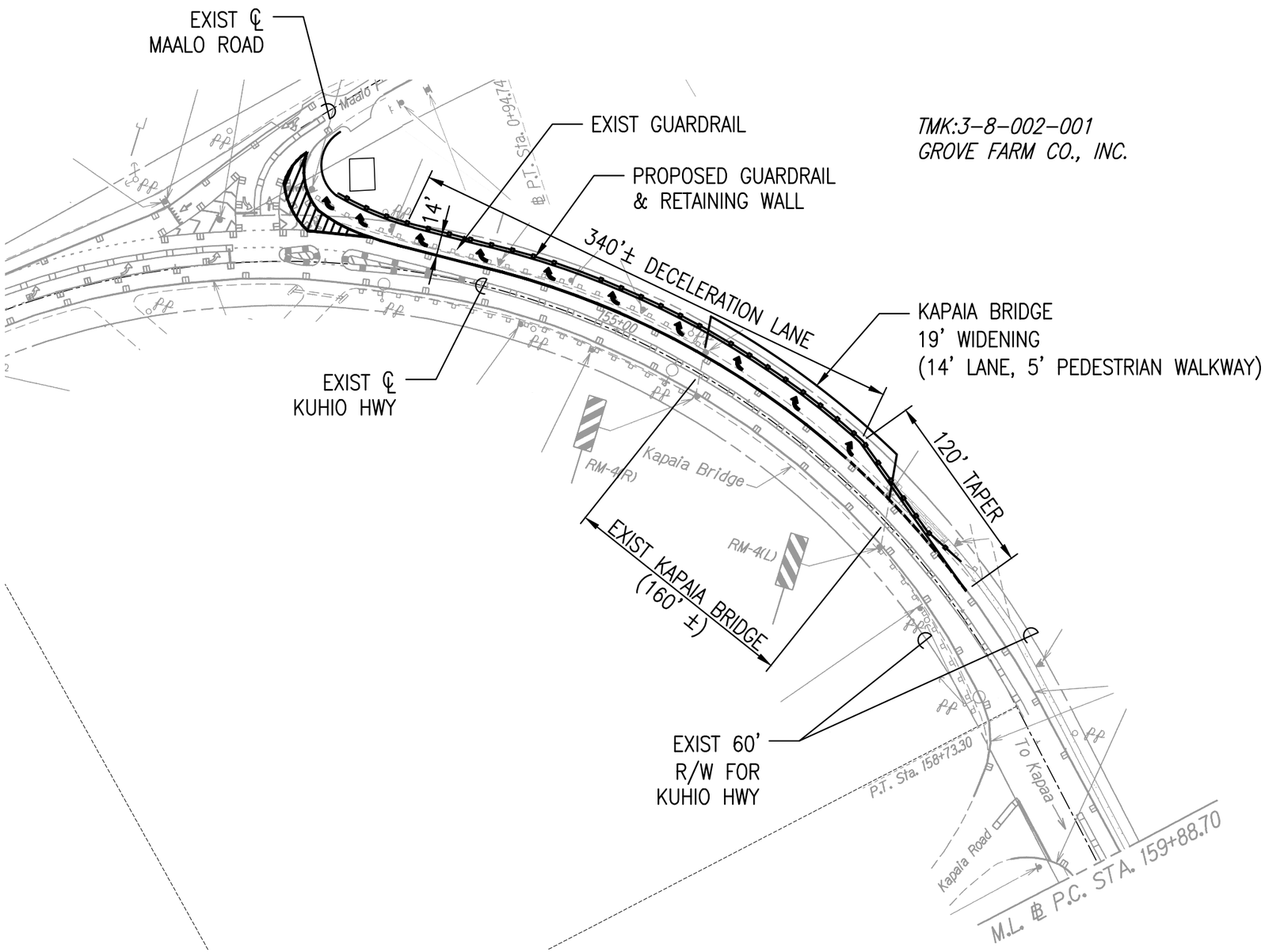


NOTES

SOURCE: HDOT PROJ. NO. ARR-0583(1) 2009
DATE: 10-10-2013

Figure 6
Plan of Ma'alo Road / Kūhiō Highway Intersection
New Kaua'i Landfill Traffic and Roadways Engineering Feasibility Study

\\Honolulu\Honolulu\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221607 KAUAI-New Landfill\07 Deliverables\Task 05 TIGPS\05 DFigure 8-9 REV.dwg 04/19/16 11:16 AM tokokurar



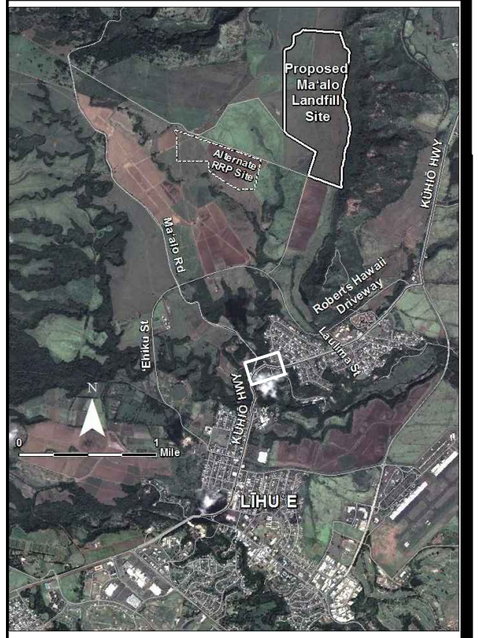
PLAN – KAPAIA BRIDGE ON KUHIO HWY

SCALE: 1" = 80'

0 80 160 240

1" = 80' SCALE FEET

KEY MAP



NOTES

SOURCE: HDOT PROJ. NO. ARR-0583(1) 2009
DATE: 10-10-2013

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Figure 7
Plan of Kapaia Bridge on Kūhiō Highway
New Kaua'i Landfill Traffic and Roadways
Engineering Feasibility Study

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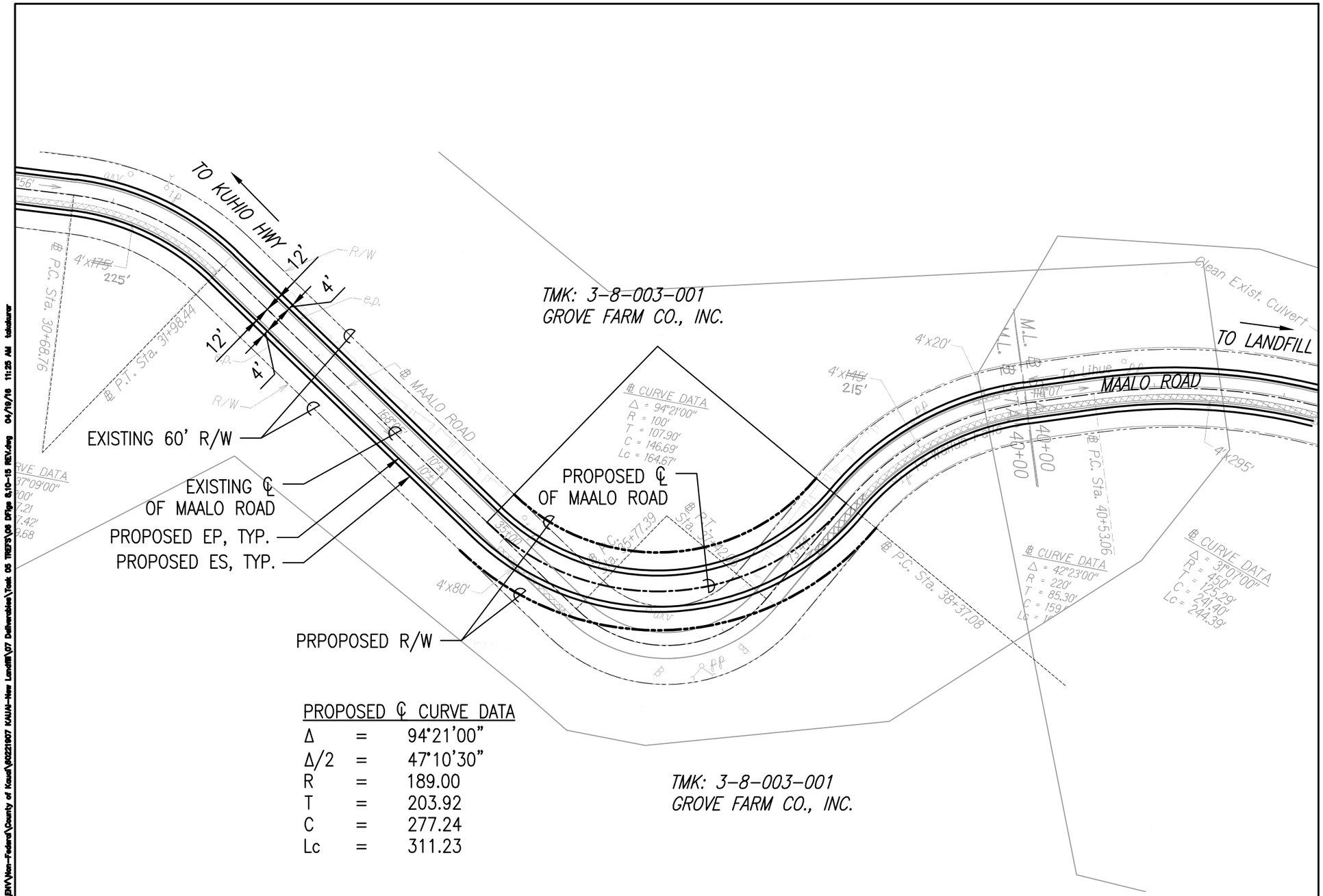
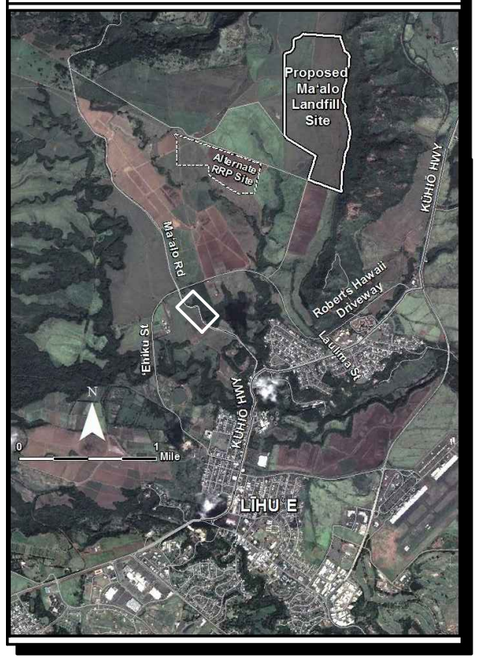


PLAN – MAALO ROAD SHARP CURVE

SCALE: 1" = 80'

KEY MAP



NOTES

SOURCE: HDOT PROJ. NO. ARR-0583(1) 2009
DATE: 10-10-2013

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Figure 8
Plan of Sharp Curve on Ma'alo Road
New Kaua'i Landfill Traffic and Roadways
Engineering Feasibility Study

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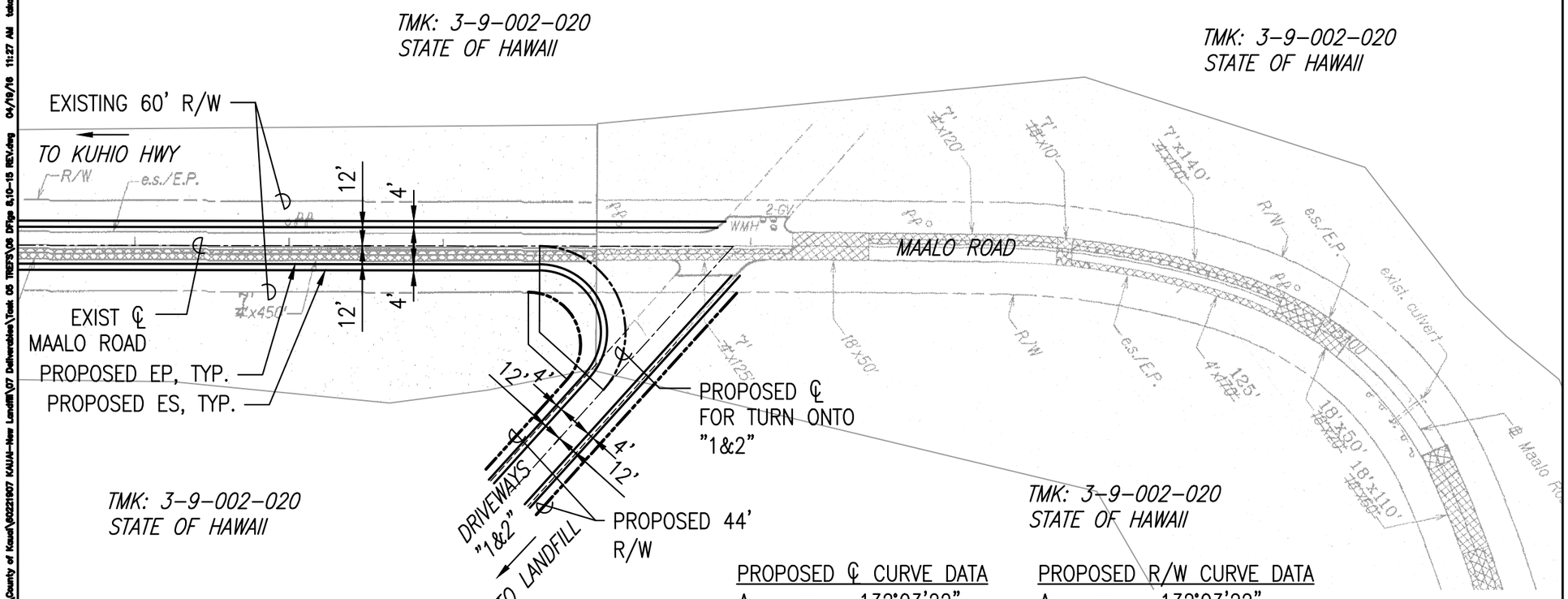


PROPOSED ℄ CURVE DATA		
Δ	=	132°03'22"
Δ/2	=	66°01'41"
R	=	56.00
T	=	125.94
C	=	102.34
Lc	=	129.07

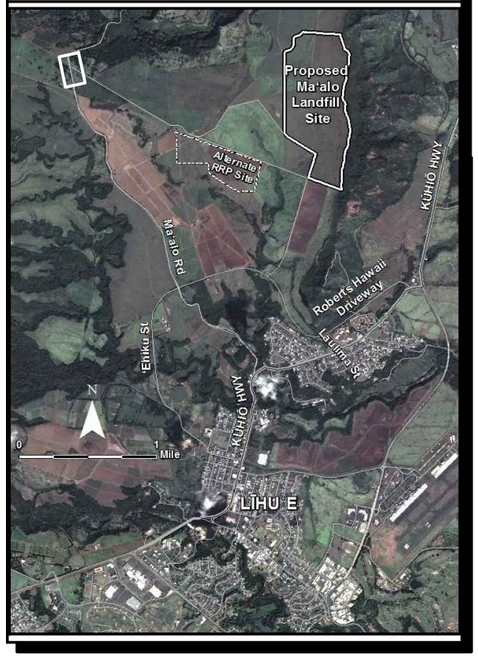
PROPOSED R/W CURVE DATA		
Δ	=	132°03'22"
Δ/2	=	66°01'41"
R	=	34.00
T	=	76.47
C	=	62.13
Lc	=	78.36

1" = 80' SCALE — 0 80 160 240 FEET

PLAN – INTERSECTION OF MAALO ROAD & DRIVEWAYS "1&2"

SCALE: 1" = 80'

KEY MAP



NOTES

SOURCE: HDOT PROJ. NO. 583A-01-07M 2007
DATE: 10-10-2013

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Figure 9
Plan of Ma'alo Road /
Driveways 1 and 2 Intersection
New Kaua'i Landfill Traffic and Roadways
Engineering Feasibility Study

\\Honolulu\Honolulu\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221607 KAUAI-New Landfill\07 Deliverables\Task 05 TREPS\05 DFigs 8,10-15 REV.dwg 04/19/16 11:27 AM tatsikurer

3.3.1.7 DRIVEWAYS 1 AND 2

Driveways 1 and 2 connect Ma‘alo Road to the project site. Driveway 1 is a direct route to the MSWLF that crosses two existing culverts. If selected as the proposed-project access route, this route will require widening of the roadway into the wetland and reconstruction of the culverts connecting portions of the wetland areas, which would trigger additional wetland mitigation requirements, i.e., U.S. Army Corps of Engineers (USACE) consultation and Clean Water Act Section 404 Permit. Because specific requirements would need to be discussed with USACE, exact requirements and associated costs cannot be determined at this time. Subject to USACE oversight, mitigation could conceivably consist of erecting barriers to keep cattle out of the wetlands, improving the wetland hydrology, or creating other wetland areas. Because requirements and costs are not currently determinable, a placeholder cost has been assumed. Driveway 2 is an alternate route with greater length; however, this route bypasses the culverts and wetland area.

Proposed improvements to the selected driveway are as follows:

- Provide chain-link fence on both sides of the driveway.
- Establish utility corridors to bring water, electricity, and phones to the proposed project site.
- Provide new pavement (including road widening): 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Widen/relocate gate.
- For Driveway 1 only: Reconstruct culverts connecting portions of the offsite wetlands, widen the road into the wetlands, and provide wetland consultation, permitting, and mitigation.
- Acquire additional ROW (including survey maps).

3.3.2 Permitting, Land Use, and Land Acquisitions

The ROW acquisitions described above are on properties currently zoned as Agricultural and Industrial. The owners of the ROW acquisition areas are Grove Farm Co., Inc. and the State of Hawai‘i. Estimated time for rezoning and ROW acquisition is 12 months.

The proposed improvements described above will require a National Pollutant Discharge Elimination System (NPDES) Form C permit from the State of Hawai‘i Department of Health (DOH). Estimated time for approval from DOH is 6 months. If Driveway 1 is selected as part of the proposed-project access route, then additional environmental requirements would be triggered, which could require 12 months or more for studies, permitting, and approval.

3.3.3 Planning-Level Cost Estimate

Table 10 and Table 11 provide the detailed cost estimates for the Ma‘alo Road access routes. The planning-level cost estimates are:

- *A1:* $42.8 million
- *A2:* $41.4 million

Due to the wetlands, the estimate for Driveway 1 is less certain than the estimate for Driveway 2.

Table 10: Access Route A1 (Ma‘alo Road, Driveway 1) Detailed Cost Estimate

Item	Description	Qty	Unit	Unit Cost	Costs
Ma‘alo Road Roadway Improvements					
	Widen roadways and repave				
	Unclassified Excavation	20,800	CY	$120	$2,496,000
	Asphalt Concrete Pavement (ACP)	5,900	tons	$180	$1,062,000
	Asphalt Concrete Base (ACB)	8,900	CY	$360	$3,204,000
	Aggregate Subbase	8,900	CY	$120	$1,068,000
	Reconstruct existing culverts	10	Ea	$10,000	$100,000
	Relocate guardrails	15,000	LF	$100	$1,500,000
		Subtotal Road Improvements			***$9,430,000***
Ma'alo Road Utility Improvements					
	Power/Telephone Pole Relocation/Installation	50	Ea	$5,000	$250,000
	Construct Water Supply Line to Driveway 1				
	Unclassified Excavation	4,500	CY	$50	$225,000
	Backfill	4,500	CY	$80	$360,000
	12-inch Pipe	10,000	LF	$150	$1,500,000
	Booster Pump Station	1	LS	$750,000	$750,000
	Relocate 2-inch waterline	1,000	LF	$100	$100,000
		Subtotal Utility Improvements			***$3,185,000***
Ma‘alo Road / Kūhiō Highway Intersection Improvements					
	Signalization	1	LS	$1,000,000	$1,000,000
	Widen roadways and repave				
	Unclassified Excavation	190	CY	$120	$23,000
	Asphalt Concrete Pavement (ACP)	60	tons	$180	$11,000
	Asphalt Concrete Base (ACB)	80	CY	$360	$29,000
	Aggregate Subbase	80	CY	$120	$10,000
	Install Guard Rail	200	LF	$100	$20,000
	Install End Treatment	1	LS	$50,000	$50,000
	Fill and Grading	200	CY	$120	$24,000
	Construct Retaining wall	100	LF	$750	$75,000
	Relocate Utility Poles, Fire Hydrant, Backflow Preventer, Drai	1	LS	$50,000	$50,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$30,000	$30,000
		Subtotal Intersection Improvements			***$1,322,000***
Kapaia Bridge on Kuhio Highway					
	Bridge widening and repaving	1	Ea	$5,000,000	$5,000,000
		Subtotal Kapaia Bridge Improvements			***$5,000,000***
Existing Bridge on Ma‘alo Road					
	Bridge widening and repaving (including waterline support)	1	Ea	$5,000,000	$5,000,000
	2-inch Waterline	100	LF	$100	$10,000
	12-inch Waterline	100	LF	$150	$15,000
		Subtotal Existing Bridge Improvements			***$5,025,000***
Existing Sharp Curve along Ma‘alo Road					
	ROW Land Acquisition (Including Survey Maps)	1	LS	$30,000	$30,000
	Excavation and Grading	400	CY	$120	$48,000
		Subtotal Sharp Curve Improvements			***$78,000***

Item	Description	Qty	Unit	Unit Cost	Costs
Ma'alo Road / Driveway 1 Intersection Improvements					
	Widen roadways and repave				
	Unclassified Excavation	60	CY	$120	$8,000
	Asphalt Concrete Pavement (ACP)	20	tons	$180	$4,000
	Asphalt Concrete Base (ACB)	30	CY	$360	$11,000
	Aggregate Subbase	30	CY	$120	$4,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$30,000	$30,000
	Relocate/widen Double-swing gate	1	EA	$1,500	$2,000
		Subtotal Driveway Intersection Improvements			***$59,000***
Driveway 1					
	Chain-link fence	20,800	LF	$50	$1,040,000
	Utility corridors (water, wastewater, electricity, and phones)				
	Power/Telephone Pole Installation	60	Ea	$5,000	$300,000
	Construct Water Supply Line to Project Site				
	Unclassified Excavation	4,700	CY	$50	$235,000
	Backfill	4,700	CY	$80	$376,000
	12-inch Pipe	10,400	LF	$150	$1,560,000
	New pavement & road widening				
	Unclassified Excavation	14,400	CY	$120	$1,728,000
	Asphalt Concrete Pavement (ACP)	4,100	tons	$180	$738,000
	Asphalt Concrete Base (ACB)	6,200	CY	$360	$2,232,000
	Aggregate Subbase	6,200	CY	$120	$744,000
	Relocate/widen Double-swing gate	3	Ea	$1,500	$5,000
	Reconstruct existing culverts	2	Ea	$10,000	$20,000
	Wetlands consultation, permitting, and mitigation	1	Ea	$1,000,000	$1,000,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$150,000	$150,000
		Subtotal Driveway 1 Improvements			***$10,128,000***
Permitting					***$50,000***
Subtotal - Route A1					$34,277,000
	Contingency (25%)				$8,570,000
Total Cost - Access Route A1					**$42,847,000**

Table 11: Access Route A2 (Ma'alo Road, Driveway 2) Detailed Cost Estimate

Item	Description	Qty	Unit	Unit Cost	Costs
Ma'alo Road Roadway Improvements					
	Widen roadways and repave				
	Unclassified Excavation	20,800	CY	$120	$2,496,000
	Asphalt Concrete Pavement (ACP)	5,900	tons	$180	$1,062,000
	Asphalt Concrete Base (ACB)	8,900	CY	$360	$3,204,000
	Aggregate Subbase	8,900	CY	$120	$1,068,000
	Reconstruct existing culverts	10	Ea	$10,000	$100,000
	Relocate guardrails	15,000	LF	$100	$1,500,000
		Subtotal Road Improvements			***$9,430,000***
Ma'alo Road Utility Improvements					
	Power/Telephone Pole Relocation/Installation	50	Ea	$5,000	$250,000
	Construct Water Supply Line to Driveway 2				
	Unclassified Excavation	4,500	CY	$50	$225,000
	Backfill	4,500	CY	$80	$360,000
	12-inch Pipe	10,000	LF	$150	$1,500,000
	Booster Pump Station	1	LS	$750,000	$750,000
	Relocate 2-inch waterline	1,000	LF	$100	$100,000
		Subtotal Utility Improvements			***$3,185,000***
Ma'alo Road / Kūhiō Highway Intersection Improvements					
	Signalization	1	LS	$1,000,000	$1,000,000
	Widen roadways and repave				
	Unclassified Excavation	190	CY	$120	$23,000
	Asphalt Concrete Pavement (ACP)	60	tons	$180	$11,000
	Asphalt Concrete Base (ACB)	80	CY	$360	$29,000
	Aggregate Subbase	80	CY	$120	$10,000
	Install Guard Rail	200	LF	$100	$20,000
	Install End Treatment	1	LS	$50,000	$50,000
	Fill and Grading	200	CY	$120	$24,000
	Construct Retaining wall	100	LF	$750	$75,000
	Relocate Utility Poles, Fire Hydrant, Backflow Preventer, Drair	1	LS	$50,000	$50,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$30,000	$30,000
		Subtotal Intersection Improvements			***$1,322,000***
Kapaia Bridge on Kuhio Highway					
	Bridge widening and repaving	1	Ea	$5,000,000	$5,000,000
		Subtotal Kapaia Bridge Improvements			***$5,000,000***
Existing Bridge on Ma'alo Road					
	Bridge widening and repaving (including waterline support)	1	Ea	$5,000,000	$5,000,000
	2-inch Waterline	100	LF	$100	$10,000
	12-inch Waterline	100	LF	$150	$15,000
		Subtotal Existing Bridge Improvements			***$5,025,000***
Existing Sharp Curve along Ma'alo Road					
	ROW Land Acquisition (Including Survey Maps)	1	LS	$30,000	$30,000
	Excavation and Grading	400	CY	$120	$48,000
		Subtotal Sharp Curve Improvements			***$78,000***

Item	Description	Qty	Unit	Unit Cost	Costs
Ma'alo Road / Driveway 2 Intersection Improvements					
	Widen roadways and repave				
	Unclassified Excavation	60	CY	$120	$8,000
	Asphalt Concrete Pavement (ACP)	20	tons	$180	$4,000
	Asphalt Concrete Base (ACB)	30	CY	$360	$11,000
	Aggregate Subbase	30	CY	$120	$4,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$30,000	$30,000
	Relocate/widen Double-swing gate	1	EA	$1,500	$2,000
		Subtotal Driveway Intersection Improvements			***$59,000***
Driveway 2					
	Chain-link fence	20,400	LF	$50	$1,020,000
	Utility corridors (water, wastewater, electricity, and phones)				
	Power/Telephone Pole Installation	60	Ea	$5,000	$300,000
	Construct Water Supply Line to Project Site				
	Unclassified Excavation	4,600	CY	$50	$230,000
	Backfill	4,600	CY	$80	$368,000
	12-inch Pipe	10,200	LF	$150	$1,530,000
	New pavement & road widening				
	Unclassified Excavation	14,200	CY	$120	$1,704,000
	Asphalt Concrete Pavement (ACP)	4,100	tons	$180	$738,000
	Asphalt Concrete Base (ACB)	6,100	CY	$360	$2,196,000
	Aggregate Subbase	6,100	CY	$120	$732,000
	Relocate/widen Double-swing gate	3	Ea	$1,500	$5,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$150,000	$150,000
		Subtotal Driveway 1 Improvements			***$8,973,000***
Permitting					***$50,000***
Subtotal - Route A2					$33,122,000
	Contingency (25%)				$8,281,000
Total Cost - Access Route A2					**$41,403,000**

3.4 'EHIKU STREET ACCESS (B1, B2)

3.4.1 Existing Conditions and Improvements

The 'Ehiku Street access is shown on Figure 4 as Routes B1 and B2. Both access routes start at the 'Ehiku Street/Kūhiō Highway intersection. 'Ehiku Street intersects with Ma'alo Road, at which point the route follows the Ma'alo Road access, including Driveways 1 and 2.

3.4.1.1 'EHIKU STREET ROADWAY IMPROVEMENTS

'Ehiku Street is under County jurisdiction from Kūhiō Highway to Kanakolu Street and is owned by Grove Farm Co., Inc. from Kanakolu Street to Ma'alo Road, with gates on each end. The existing road is paved from Kūhiō Highway to Ma'alo Road. From Kūhiō Highway to Kanakolu Street, the road has two 10-ft lanes and a 10-ft shoulder/parking area on the north side of the street. A typical section of this segment is presented in Figure 5. From Kanakolu Street to Ma'alo Road, the existing roadway is a 30-ft-wide paved road; no defined lane widths or shoulder widths are present. The ROW is 44 ft wide. The existing pavement sections could not be found from as-built records.

Proposed improvements to 'Ehiku Street, which would conform to AASHTO and Hawai'i DOT requirements, are:

- Widen roads and pave: 12-ft lanes with 4-ft shoulders; 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Acquire additional ROW along private portion of ‘Ehiku Street.

3.4.1.2 MA‘ALO ROAD ROADWAY IMPROVEMENTS

Ma‘alo Road is under State jurisdiction. The typical section through this area consists of two paved 10-ft lanes and 3-ft unimproved shoulders. Existing guardrails along the access route were observed during a site visit. The existing road consists of seven existing culverts before reaching the intersection with Driveways 1 and 2. The ROW is 60 ft wide. The existing pavement section could not be found from as-built records.

Proposed improvements to Ma‘alo Road, which conform to AASHTO and Hawai‘i DOT requirements, are:

- Widen roads and pave: 12-ft lanes with 4-ft shoulders; 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Reconstruct existing culverts.
- Relocate guardrails.

3.4.1.3 ‘EHIKU STREET/MA‘ALO ROAD UTILITY IMPROVEMENTS

Along routes B1 and B2, the nearest water connection is the 16-inch main along Ma‘alo Road, where electricity and telephone service are also available. Based on conceptual analysis, this 8-inch main is sufficient to handle the additional flow. If the 8-inch main cannot handle the additional flow, then an alternative is to connect to the 12-inch main at the intersection of ‘Ehiku Street and Kūhiō Highway. Although wastewater connection is available at the most upstream manhole along ‘Ehiku Street, it is recommended that cesspools be installed at the facility instead.

In addition to the normal utility requirements for all of the access routes, a large earthen “culvert” exists at a waterway that passes under ‘Ehiku Street, south of the Ma‘alo intersection. The channel bottom is approximately 50–75 ft below the road. The property owner has been monitoring the erosion of the culvert opening over the years as it approaches the road. Soft clay material was observed along the culvert walls during a site visit, and erosion is evident by the material that has fallen into the channel bottom. The structural integrity of the earthen culvert is unknown, and likely problematic. An extensive geotechnical analysis would be required. It is likely that this access route would require significant design and reconstruction of a new culvert, and possible work in a waterway, which is reflected in the cost estimate presented below.

Recommended utility improvements to ‘Ehiku Street and Ma‘alo Road are:

- Relocate power and telephone poles to accommodate road widening.
- Connect water to Driveway 1 and 2.
- Reconstruct waterway/culvert under ‘Ehiku Road (Including investigation, design, permitting).

3.4.1.4 MA‘ALO ROAD/‘EHIKU STREET INTERSECTION

The Ma‘alo Road/‘Ehiku Street intersection is a 4-way, unsignalized intersection. The State DOT ROW is 60 ft wide. The existing intersection cannot accommodate the WB-40 truck-turning movements, thus requiring widening of the intersection. The existing pavement sections could not be found from as-built records.

The proposed intersection layout is shown on Figure 10. Proposed improvements to the ‘Ehiku Street/Ma‘alo Road intersection are:

- Acquire additional ROW.
- Widen roads and pave: 12-ft lanes with 4-ft shoulders; 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.

Costs for these improvements are captured within the estimates for Ma‘alo Road and ‘Ehiku Street. Upon implementation of the proposed improvements, all turning movements at the proposed intersection would accommodate the WB-40 design vehicle.

3.4.1.5 ‘Ehiku Street/Kūhiō Highway Intersection

The ‘Ehiku Street/Kūhiō Highway intersection is a 4-way signalized intersection. The State DOT ROW is 60 ft wide. The existing ‘Ehiku Street/Kūhiō Highway intersection has two lanes in the northbound (Kapa‘a-bound) direction: a through lane and a left/through lane. No exclusive left-turn phase operates at the signal for northbound traffic turning left into ‘Ehiku Street. The existing intersection cannot accommodate the WB-40 truck-turning movements. The existing pavement sections could not be found from as-built records.

The proposed intersection layout is shown on Figure 11. Proposed improvements to the ‘Ehiku Street/Ma‘alo Road intersection are:

- Widen roads and pave: 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
  - Right-turn from Kūhiō Highway southbound onto ‘Ehiku Street:
    Increase turning radius to 60 feet to accommodate the large trucks.
- Construct American Disabilities Act (ADA)-accessible pedestrian ramps with signal heads on all corners of the intersection.
- Relocate electrical/traffic cabinet, master arm, traffic signal and pull boxes.
- Acquire additional ROW land (including survey maps).

Upon implementation of the proposed improvements, all turning movements at the proposed intersection would accommodate the WB-40 design vehicle.

3.4.1.6 Ma‘alo Road/Driveways 1 and 2 Intersection

A sharp right turn exists northbound on Ma‘alo Road at the intersection with Driveways 1 and 2, as described above in Section 3.3.1.6.

Proposed improvements to the Ma‘alo Road/Driveways 1 and 2 intersection are:

- Widen roads and pave: 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Acquire additional ROW land (including survey maps).
- Relocate/widen double-swing gate.

3.4.1.7 Driveways 1 and 2

Driveways 1 and 2 connect Ma‘alo Road to the project site. Driveway 1 is a direct route to the MSWLF that crosses two existing culverts in the vicinity of offsite wetlands. If selected as the proposed-project access route, this route will require wetland mitigation measures, as described above in Section 3.3.1.7. Driveway 2 is an alternate route with greater length; however, this route bypasses the culverts and wetland area.

Proposed improvements to the selected driveway are:

- Provide chain-link fence on both sides of the driveway.
- Establish utility corridors to bring water, electricity, and phones to the proposed project site.
- Provide new pavement (including road widening): 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Widen and relocate gate.
- *For Driveway 1 only:* Reconstruct culverts connecting portions of the offsite wetlands, widen the road into the wetlands, and provide wetland consultation, permitting, and mitigation.
- Acquire additional ROW land (including survey maps).

3.4.2 Permitting, Land Use, and Land Acquisitions

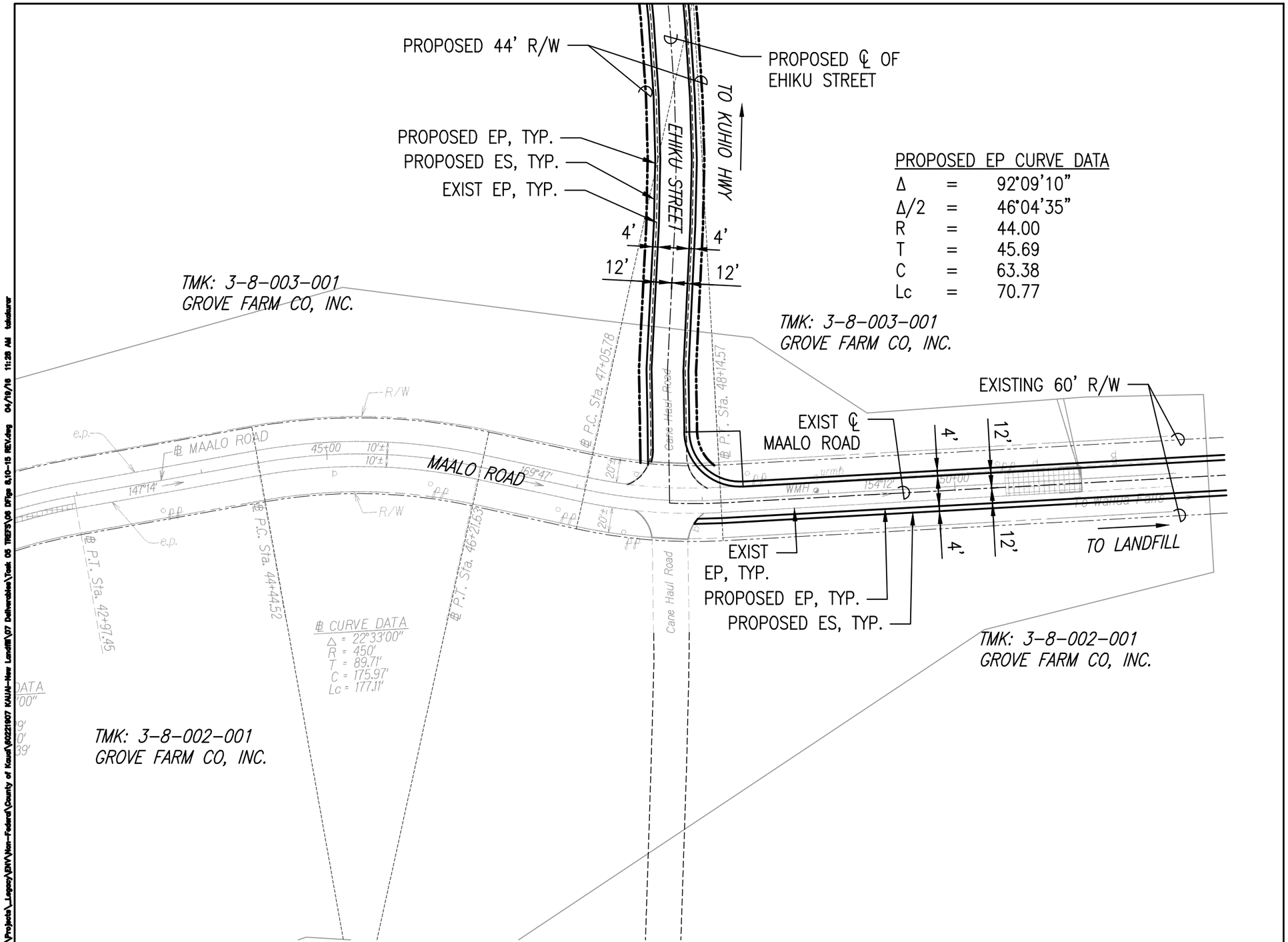
'Ehiku Street is zoned Agricultural. The ROW acquisitions described above are on properties currently zoned as Agricultural. The property owner of the ROW acquisition area is Grove Farm Co., Inc. Estimated time for rezoning and ROW acquisition is 12 months.

The proposed improvements described above would require an NPDES Form C permit from DOH. Estimated time for approval from DOH is 6 months. If Driveway 1 is selected as the proposed-project access route, then additional environmental requirements may be triggered, which could result in 12 months or more required for studies, permitting, and approval.

3.4.3 Planning-Level Cost Estimate

Table 12 and Table 13 provide detailed cost estimates for the 'Ehiku Street access routes. The planning-level cost estimates are:

- *B1:* $43.3 million
- *B2:* $41.8 million



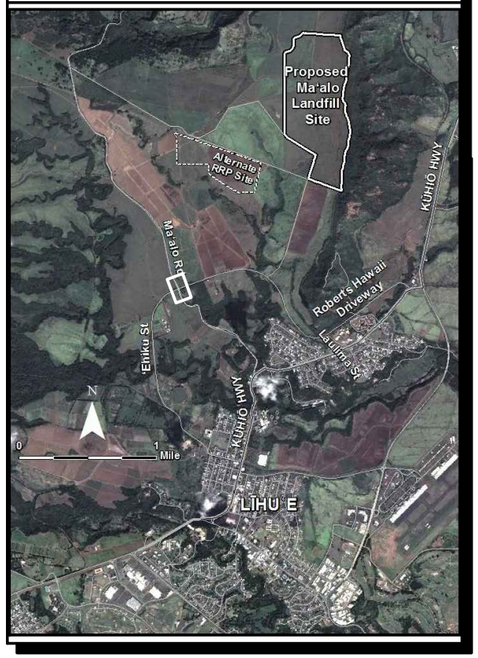
PROPOSED EP CURVE DATA

Δ	=	92°09'10"
Δ/2	=	46°04'35"
R	=	44.00
T	=	45.69
C	=	63.38
Lc	=	70.77

PLAN – INTERSECTION OF MAALO ROAD & EHIKU STREET

SCALE: 1" = 80'

KEY MAP

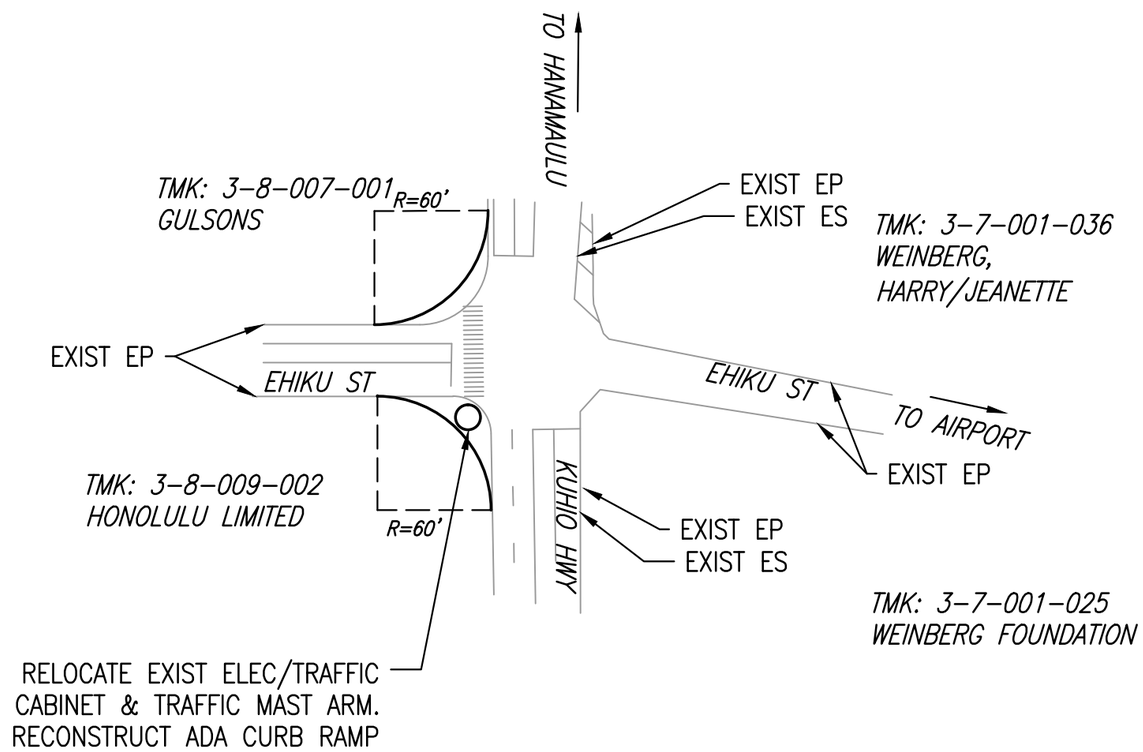


NOTES

SOURCE: HDOT PROJ. NO. ARR-0583(1) 2009
DATE: 10-10-2013

Figure 10
Plan of Ma'alo Road / 'Ehiku Street Intersection
New Kaua'i Landfill Traffic and Roadways Engineering Feasibility Study

\\Honolulu\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221607 KAUAI-New Landfill\07 Deliverables\Task 05 TIGPS\05 Dfgs 8,10-15 REV.dwg 04/19/16 11:28 AM tokidurer



1" = 80'

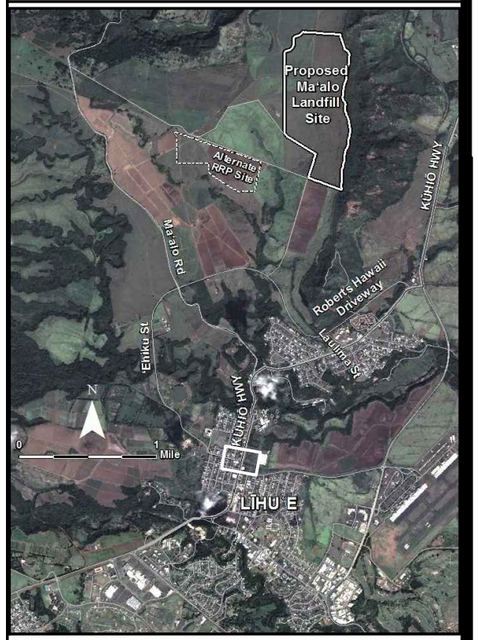
0 80 160 240

SCALE FEET

PLAN – INTERSECTION OF KUHIO HWY & EHIKU STREET

SCALE: 1" = 80'

KEY MAP



NOTES

SOURCE: GOOGLE EARTH
DATE: 12-17-2013

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Figure 11
Plan of 'Ehiku Street /
Kūhiō Highway Intersection
New Kaua'i Landfill Traffic and Roadways
Engineering Feasibility Study

\\Honolulu\Honolulu\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221607 KAUAI-New Landfill\07 Deliverables\Task 05 TRFS\06 DFigs 8,10-15 REV.dwg 04/19/16 11:30 AM tokishurer

Table 12: Access Route B1 (‘Ehiku Street, Driveway 1) Detailed Cost Estimate

Item	Description		Qty	Unit	Unit Cost	Costs
‘Ehiku Street Roadway Improvements						
	ROW Land Acquisition (Private portion of ‘Ehiku Street, including Survey Maps)		1	LS	$150,000	$150,000
	Widen roadways and repave					
		Unclassified Excavation	12,500	CY	$120	$1,500,000
		Asphalt Concrete Pavement (ACP)	3,600	tons	$180	$648,000
		Asphalt Concrete Base (ACB)	5,400	CY	$360	$1,944,000
		Aggregate Subbase	5,400	CY	$120	$648,000
			Subtotal Road Improvements			***$4,890,000***
Ma‘alo Road Roadway Improvements						
	Widen roadways and repave					
		Unclassified Excavation	13,700	CY	$120	$1,644,000
		Asphalt Concrete Pavement (ACP)	3,900	tons	$180	$702,000
		Asphalt Concrete Base (ACB)	5,900	CY	$360	$2,124,000
		Aggregate Subbase	5,900	CY	$120	$708,000
	Reconstruct existing culverts		7	EA	$10,000	$70,000
	Relocate guardrails		9,900	LF	$100	$990,000
			Subtotal Road Improvements			***$6,238,000***
Utility Improvements						
	Power/Telephone Pole Relocation/Installation		40	Ea	$5,000	$200,000
	Construct Water Supply Line to Driveway 1					
		Unclassified Excavation	4,400	CY	$50	$220,000
		Backfill	4,400	CY	$80	$352,000
		12-inch Pipe	9,740	LF	$150	$1,461,000
		Booster Pump Station	1	LS	$750,000	$750,000
			Subtotal Utility Improvements			***$2,983,000***
Reconstruct Waterway/Culvert Under ‘Ehiku Road						
	Investigate, Design, Permit, and Repair Waterway/"Culvert"		1	EA	$10,000,000	$10,000,000
			Subtotal Waterway/Culvert Repair			***$10,000,000***
‘Ehiku Street / Kūhiō Highway Intersection Improvements						
	Widen roadways and repave					
		Unclassified Excavation	200	CY	$120	$24,000
		Asphalt Concrete Pavement (ACP)	100	tons	$180	$18,000
		Asphalt Concrete Base (ACB)	100	CY	$360	$36,000
		Aggregate Subbase	100	CY	$120	$12,000
	Construct ADA-accessible pedestrian ramps with signal		4	EA	$10,000	$40,000
	Relocate Cabinet, Mast Arm, Traffic Signal & Pull Boxes		1	LS	$120,000	$120,000
	ROW Land Acquisition (Including Survey Maps)		1	LS	$30,000	$30,000
			Subtotal Intersection Improvements			***$280,000***

Item	Description	Qty	Unit	Unit Cost	Costs
Ma'alo Road / Driveway 1 Intersection Improvements					
	Widen roadways and repave				
	Unclassified Excavation	60	CY	$120	$8,000
	Asphalt Concrete Pavement (ACP)	20	tons	$180	$4,000
	Asphalt Concrete Base (ACB)	30	CY	$360	$11,000
	Aggregate Subbase	30	CY	$120	$4,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$30,000	$30,000
	Relocate/widen Double-swing gate	1	EA	$1,500	$2,000
	Subtotal Driveway Intersection Improvements				***$59,000***
Driveway 1					
	Chain-link fence	20,800	LF	$50	$1,040,000
	Utility corridors (water, wastewater, electricity, and phones)				
	Power/Telephone Pole Installation	60	Ea	$5,000	$300,000
	Construct Water Supply Line to Project Site				
	Unclassified Excavation	4,700	CY	$50	$235,000
	Backfill	4,700	CY	$80	$376,000
	12-inch Pipe	10,400	LF	$150	$1,560,000
	New pavement & road widening				
	Unclassified Excavation	14,400	CY	$120	$1,728,000
	Asphalt Concrete Pavement (ACP)	4,100	tons	$180	$738,000
	Asphalt Concrete Base (ACB)	6,200	CY	$360	$2,232,000
	Aggregate Subbase	6,200	CY	$120	$744,000
	Relocate/widen Double-swing gate	3	Ea	$1,500	$5,000
	Reconstruct existing culverts	2	Ea	$10,000	$20,000
	Wetlands consultation, permitting, and mitigation	1	Ea	$1,000,000	$1,000,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$150,000	$150,000
	Subtotal Driveway 1 Improvements				***$10,128,000***
Permitting					***$50,000***
Subtotal - Route B1					$34,628,000
	Contingency (25%)				$8,657,000
Total Cost - Access Route B1					**$43,285,000**

Table 13: Access Route B2 (‘Ehiku Street, Driveway 2) Detailed Cost Estimate

Item	Description	Qty	Unit	Unit Cost	Costs
‘Ehiku Street Roadway Improvements					
	ROW Land Acquisition (Private portion of ‘Ehiku Street, including Survey Maps)	1	LS	$150,000	$150,000
	Widen roadways and repave				
	Unclassified Excavation	12,500	CY	$120	$1,500,000
	Asphalt Concrete Pavement (ACP)	3,600	tons	$180	$648,000
	Asphalt Concrete Base (ACB)	5,400	CY	$360	$1,944,000
	Aggregate Subbase	5,400	CY	$120	$648,000
		Subtotal Road Improvements			***$4,890,000***
Ma‘alo Road Roadway Improvements					
	Widen roadways and repave				
	Unclassified Excavation	13,700	CY	$120	$1,644,000
	Asphalt Concrete Pavement (ACP)	3,900	tons	$180	$702,000
	Asphalt Concrete Base (ACB)	5,900	CY	$360	$2,124,000
	Aggregate Subbase	5,900	CY	$120	$708,000
	Reconstruct existing culverts	7	EA	$10,000	$70,000
	Relocate guardrails	9,900	LF	$100	$990,000
		Subtotal Road Improvements			***$6,238,000***
Utility Improvements					
	Power/Telephone Pole Relocation/Installation	40	Ea	$5,000	$200,000
	Construct Water Supply Line to Driveway 1				
	Unclassified Excavation	4,400	CY	$50	$220,000
	Backfill	4,400	CY	$80	$352,000
	12-inch Pipe	9,740	LF	$150	$1,461,000
	Booster Pump Station	1	LS	$750,000	$750,000
		Subtotal Utility Improvements			***$2,983,000***
Repair Waterway/Culvert Under ‘Ehiku Road					
	Investigate, Design, Permit, and Repair Waterway/"Culvert"	1	EA	$10,000,000	$10,000,000
		Subtotal Waterway/Culvert Repair			***$10,000,000***
‘Ehiku Street / Kūhiō Highway Intersection Improvements					
	Widen roadways and repave				
	Unclassified Excavation	200	CY	$120	$24,000
	Asphalt Concrete Pavement (ACP)	100	tons	$180	$18,000
	Asphalt Concrete Base (ACB)	100	CY	$360	$36,000
	Aggregate Subbase	100	CY	$120	$12,000
	Construct ADA-accessible pedestrian ramps with signal	4	EA	$10,000	$40,000
	Relocate Cabinet, Mast Arm, Traffic Signal & Pull Boxes	1	LS	$120,000	$120,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$30,000	$30,000
		Subtotal Intersection Improvements			***$280,000***

Item	Description	Qty	Unit	Unit Cost	Costs
Ma'alo Road / Driveway 2 Intersection Improvements					
	Widen roadways and repave				
	Unclassified Excavation	60	CY	$120	$8,000
	Asphalt Concrete Pavement (ACP)	20	tons	$180	$4,000
	Asphalt Concrete Base (ACB)	30	CY	$360	$11,000
	Aggregate Subbase	30	CY	$120	$4,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$30,000	$30,000
	Relocate/widen Double-swing gate	1	EA	$1,500	$2,000
	Subtotal Driveway Intersection Improvements				***$59,000***
Driveway 2					
	Chain-link fence	20,400	LF	$50	$1,020,000
	Utility corridors (water, wastewater, electricity, and phones)				
	Power/Telephone Pole Installation	60	Ea	$5,000	$300,000
	Construct Water Supply Line to Project Site				
	Unclassified Excavation	4,600	CY	$50	$230,000
	Backfill	4,600	CY	$80	$368,000
	12-inch Pipe	10,200	LF	$150	$1,530,000
	New pavement & road widening				
	Unclassified Excavation	14,200	CY	$120	$1,704,000
	Asphalt Concrete Pavement (ACP)	4,100	tons	$180	$738,000
	Asphalt Concrete Base (ACB)	6,100	CY	$360	$2,196,000
	Aggregate Subbase	6,100	CY	$120	$732,000
	Relocate/widen Double-swing gate	3	Ea	$1,500	$5,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$150,000	$150,000
	Subtotal Driveway 1 Improvements				***$8,973,000***
Permitting					***$50,000***
Subtotal - Route B2					$33,473,000
	Contingency (25%)				$8,368,250
Total Cost - Access Route B2					**$41,841,250**

3.5 LAULIMA STREET ACCESS (C3)

3.5.1 Existing Conditions and Improvements

The Laulima Street access is shown on Figure 1 as Route C3. The access route starts at the Laulima Street/Kūhiō Highway intersection and ends at the project site. If the alternate RRP site is implemented, then a portion of either Driveway 1 (approximately 1,913 linear feet) or Driveway 2 (approximately 4,865 linear feet) will be used to connect the Landfill site to the RRP site.

3.5.1.1 LAULIMA STREET ROADWAY IMPROVEMENTS

Laulima Street makai of Kūhiō Highway is under County jurisdiction. Laulima Street mauka of Kūhiō Highway is owned by Grove Farm Co, Inc. Laulima Street mauka of Kūhiō Highway extends a short distance past the commercial buildings near the highway to the existing gate, beyond which is a gravel road, designated as Driveway 3 (Figure 4). Laulima Street is a 30-ft-wide paved road, and no defined lane widths or shoulder widths are present. The existing pavement section could not be found from as-built records. A typical section is presented on Figure 5.

Proposed improvements to Laulima Street, which must conform to County of Kaua'i requirements, are:

- Acquire additional ROW.
- *Widen roads and pave:* 12-ft lanes with 4-ft shoulders; 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.

3.5.1.2 Utility Improvements

The nearest water connection is the 12-inch main along Kūhiō Highway at the intersection of Laulima Street. Although an existing 8-inch sewer main runs west along Kūhiō Highway, it is recommended that cesspools be installed at the facility instead. Electricity and telephone service is also available at the intersection of Laulima Street and Kūhiō Highway. Additionally, a 12-inch waterline may require relocating to satisfy the minimum cover requirements. Recommended utility improvements to the Laulima Street access route are:

- Construct power and telephone poles along the access route.
- Connect water to Driveway 3.

3.5.1.3 Laulima Street/Kūhiō Highway Intersection

The existing Laulima Street/Kūhiō Highway intersection is a 3-way, unsignalized intersection (Laulima Street mauka of Kūhiō Highway is not currently a public roadway). Laulima Street mauka of Kūhiō Highway is currently a private driveway that provides access to businesses. The Kūhiō Highway State DOT ROW is 60 ft wide. The existing intersection cannot accommodate the WB-40 truck-turning movements. The existing pavement sections could not be found from as-built records.

Based on discussions with the State DOT regarding this access route to the project site, coordination may be required with the future Līhu'e bypass project. The State DOT suggests including a left-turn lane in the northbound direction on Kūhiō Highway.

The proposed intersection layout is shown on Figure 12. Access to businesses will be maintained. Proposed improvements to the Laulima Street/Kūhiō Highway intersection are:

- Signalize the intersection.
- Widen roads and pave: 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
  - *Left-turn lane in both directions on Kūhiō Highway:* 11-ft lane, 100-ft storage length, 100-ft taper length.
  - *4-way intersection:* Reconfigure median islands.
- Excavation and Grading along Laulima Street sloped shoulder.
- Construct retaining wall (approximately 8 ft tall) along Laulima Street due to slope excavation.
- Construct ADA-accessible pedestrian ramps on all corners of the intersection.
- Relocate utility poles, culvert.
- Acquire additional ROW land (including survey maps).

Upon implementation of the proposed improvements, all turning movements at the proposed intersection would accommodate the WB-40 design vehicle.

3.5.1.4 Driveway 3

Driveway 3 connects Laulima Street to the proposed project site.

Proposed improvements to the driveway are:

- Provide chain-link fence on both sides of the driveway.
- Provide noise barrier on side fronting residential housing.
- Establish utility corridors to bring water, electricity, and phones to the proposed project site.
- Provide new pavement (including road widening): 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Acquire additional ROW land (including survey maps).

3.5.1.5 DRIVEWAY 1 OR 2

If the alternate RRP site is implemented, then one of the following two alternatives will be used to connect the Landfill site to the RRP site:

- Approximately 1,913 linear feet of Driveway 1
- Approximately 4,965 linear feet of Driveway 2

Driveway 1 is a direct route to the RRP site that crosses two existing culverts in the vicinity of offsite wetlands. If selected as the proposed-project access route, this route will require wetland mitigation measures, as described above in Section 3.3.1.7. Driveway 2 is an alternate, longer route that bypasses the culverts and wetland area, but may have more impact on use of the parcel.

Proposed improvements to the selected driveway are:

- Provide chain-link fence on both sides of the driveway.
- Establish utility corridors to bring water, electricity, and phones to the proposed project site.
- Provide new pavement (including road widening): 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Widen and relocate gate.
- For Driveway 1 only: Reconstruct culverts connecting portions of the offsite wetlands, widen the road into the wetlands, and provide wetlands consultation, permitting, and mitigation.
- Acquire additional ROW land (including survey maps).

3.5.2 Permitting, Land Use, and Land Acquisitions

Laulima Street mauka of the highway is zoned as Mixed Agricultural/Industrial. The ROW acquisitions described above are on properties currently zoned as Mixed Agricultural/Industrial. The property owners of the ROW acquisition areas are Grove Farm Co., Inc. and the State of Hawai'i. Estimated time for rezoning and ROW acquisition is 12 months.

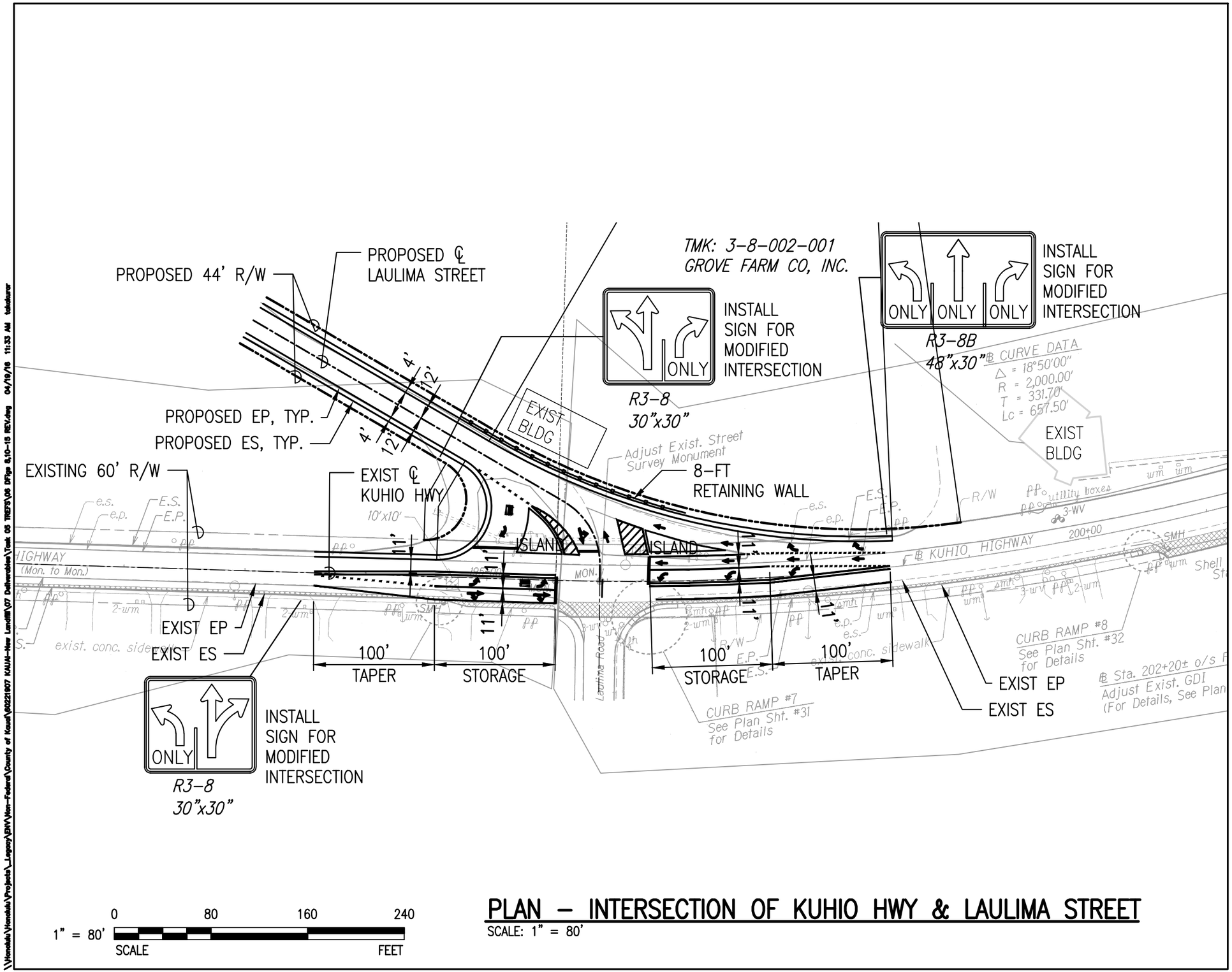
The proposed improvements described above will require an NPDES Form C permit from DOH. Estimated time for approval from DOH is 6 months.

3.5.3 Planning-Level Cost Estimate

Table 14 provides detailed cost estimates for the Laulima Street access route. The planning-level cost estimate is:

- *C3:* $12.7 million

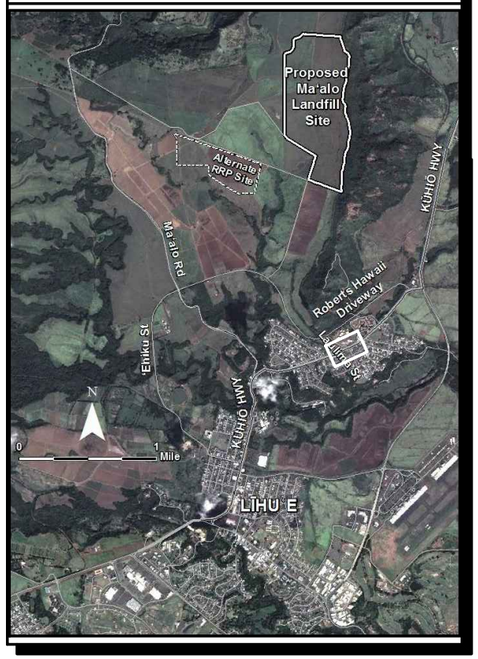
Additional costs may be incurred if the Alternate RRP site is chosen (see Section 3.8).



PLAN – INTERSECTION OF KUHIO HWY & LAULIMA STREET

SCALE: 1" = 80'

KEY MAP



NOTES

SOURCE: HDOT PROJ. NO. 56A-01-04M 2005
DATE: 10-10-2013

Figure 12
Plan of Laulima Street / Kūhiō Highway Intersection
New Kaua'i Landfill Traffic and Roadways Engineering Feasibility Study

Table 14: Access Route C3 (Laulima Street) Cost Estimate Breakdown

Item	Description	Qty	Unit	Unit Cost	Costs
Laulima Street Roadway Improvements					
	ROW acquisition	1	LS	$50,000	$50,000
	Widen roadways and repave				
	Unclassified Excavation	1,800	CY	$120	$216,000
	Asphalt Concrete Pavement (ACP)	600	tons	$180	$108,000
	Asphalt Concrete Base (ACB)	800	CY	$360	$288,000
	Aggregate Subbase	800	CY	$120	$96,000
				Subtotal Road Improvements	***$758,000***
Utility Improvements					
	Power/Telephone Pole Relocation/Installation	12	Ea	$5,000	$60,000
	Construct Water Supply Line to Driveway 3				
	Unclassified Excavation	600	CY	$50	$30,000
	Backfill	600	CY	$80	$48,000
	12-inch Pipe	1,261	LF	$150	$190,000
	Booster Pump Station	1	LS	$750,000	$750,000
				Subtotal Utility Improvements	***$1,078,000***
Laulima Street / Kūhiō Highway Intersection Improvements					
	Signalization	1	LS	$1,000,000	$1,000,000
	Widen roadways and repave				
	Unclassified Excavation	900	CY	$120	$108,000
	Asphalt Concrete Pavement (ACP)	300	tons	$180	$54,000
	Asphalt Concrete Base (ACB)	400	CY	$360	$144,000
	Aggregate Subbase	400	CY	$120	$48,000
	Construct Retaining wall	200	LF	$750	$150,000
	Construct ADA-accessible pedestrian ramps	4	EA	$10,000	$40,000
	Relocate Utility Poles, Culvert	1	LS	$50,000	$50,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$30,000	$30,000
				Subtotal Intersection Improvements	***$1,624,000***
Driveway 3					
	Chain-link fence	15,000	LF	$50	$750,000
	Utility corridors (water, wastewater, electricity, and phones)				
	Power/Telephone Pole Installation	40	Ea	$5,000	$200,000
	Construct Water Supply Line to Project Site				
	Unclassified Excavation	3,400	CY	$50	$170,000
	Backfill	3,400	CY	$80	$272,000
	12-inch Pipe	7,500	LF	$150	$1,125,000
	New pavement & road widening				
	Unclassified Excavation	10,400	CY	$120	$1,248,000
	Asphalt Concrete Pavement (ACP)	3,000	tons	$180	$540,000
	Asphalt Concrete Base (ACB)	4,500	CY	$360	$1,620,000
	Aggregate Subbase	4,500	CY	$120	$540,000
	Noise Barrier	1,500	LF	$50	$75,000
	Gate Relocation	3	EA	$1,500	$5,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$125,000	$125,000
				Subtotal Driveway 1 Improvements	***$6,670,000***
Permitting					***$50,000***
Subtotal - Route C3					$10,180,000
	Contingency (25%)				$2,545,000
Total Cost - Access Route C3					**$12,725,000**

This cost estimate includes the cost to signalize the Laulima Street/Kūhiō Highway intersection. Signalization of this intersection is recommended for this alternative when warranted. Signalization would also be desirable regardless of which access route is selected, but may not be warranted for the other routes.

3.6 ROBERTS HAWAII DRIVEWAY ACCESS (D3)

3.6.1 Existing Conditions and Improvements

The Roberts Hawaii Driveway access is shown on Figure 4 as Route D3. The access route starts at the Roberts Hawaii Driveway intersection with Kūhiō Highway and intersects with Laulima Street, at which point the route follows the Laulima Street access to the landfill. If the alternate RRP site is implemented, then a portion of either Driveway 1 (approximately 1,913 linear feet) or Driveway 2 (approximately 4,865 linear feet) will be used to connect the Landfill site to the RRP site.

The Roberts Hawaii Driveway access is owned by Visionary LLC and Grove Farm Co., Inc. The existing driveway is an 18-ft wide paved road; there are no defined lane widths or shoulder widths. The existing pavement section could not be found from as-built records.

The proposed improvements to the Roberts Hawaii Driveway access, which must conform to County of Kaua'i requirements, are:

- Acquire additional ROW.
- Widen roads and pave: 12-ft lanes with 4-ft shoulders; 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Provide noise barrier on side fronting residential housing.
- Stabilize shoulders and provide erosion control.
- Provide drainage improvements (shoulder swales, culverts, drainage outfalls).

3.6.1.1 UTILITY IMPROVEMENTS

The nearest water connection is the 12-inch main along Kūhiō Highway at the intersection of Laulima Street. Although an existing 8-inch sewer main runs west along Kūhiō Highway, it is recommended that cesspools be installed at the facility instead. Electricity and telephone service is also available at the intersection of Laulima Street and Kūhiō Highway. Additionally, a 12-inch waterline may require relocating to satisfy the minimum cover requirements. Recommended utility improvements to the Roberts Hawaii Driveway access route are as follows:

- Construct power and telephone poles along Laulima Street to Driveway 3.
- Connect water along Laulima Street to Driveway 3.

3.6.1.2 ROBERTS HAWAII DRIVEWAY/KŪHIŌ HIGHWAY INTERSECTION

The Roberts Hawaii Driveway/Kūhiō Highway intersection is a 3-way, unsignalized intersection. The State DOT ROW is 60 ft wide. The existing intersection can accommodate WB-40 truck-turning movements. The existing pavement sections could not be found from as-built records.

Based on discussions with DOT regarding this access route to the landfill, coordination is required with the Līhu'e bypass project. A left-turn lane in the northbound direction on Kūhiō Highway is required.

The proposed intersection layout is shown on Figure 13. Access to Roberts Hawaii will be maintained. Proposed improvements to the Roberts Hawaii Driveway/Kūhiō Highway intersection are:

- Signalize the intersection.
- Widen roads and pave: 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
  - *Left-turn lane in northbound direction on Kūhiō Highway:* 11-ft lane, 200-ft storage length, 100-ft taper length.
  - *Right-turn lane in southbound direction on Kūhiō Highway:* 11-ft lane, 200-ft storage length, 100-ft taper length.
- Construct ADA-accessible pedestrian ramps on two corners of the intersection.
- Acquire additional ROW land (including survey maps).

Upon implementation of the proposed improvements, all turning movements at the proposed intersection would accommodate the WB-40 design vehicle.

3.6.1.3 Driveway 3

Driveway 3 connects Laulima Street to the proposed project site.

Proposed improvements to the driveway are:

- Stabilize shoulders and provide erosion control.
- Provide chain-link fence on both sides of the driveway.
- Provide noise barrier on side fronting residential housing.
- Establish utility corridors to bring water, electricity, and phones to the proposed project site.
- Provide new pavement (including road widening): 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Acquire additional ROW land (including survey maps).

3.6.1.4 Driveway 1 or 2

If the alternate RRP site is implemented, then one of the following two alternatives will be used to connect the Landfill site to the RRP site:

- Approximately 1,913 linear feet of Driveway 1
- Approximately 4,965 linear feet of Driveway 2

Driveway 1 is a direct route to the RRP site that crosses two existing culverts in the vicinity of offsite wetlands. If selected as the proposed-project access route, this route will require wetland mitigation measures, as described above in Section 3.3.1.7. Driveway 2 is an alternate, longer route that bypasses the culverts and wetland area, but may have more impact on use of the parcel.

Proposed improvements to the selected driveway are:

- Provide chain-link fence on both sides of the driveway.
- Establish utility corridors to bring water, electricity, and phones to the proposed project site.
- Provide new pavement (including road widening): 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.

- Widen and relocate gate
- For Driveway 1 only: Reconstruct culverts connecting portions of the offsite wetlands, widen the road into the wetlands, and provide wetlands consultation, permitting, and mitigation
- Acquire additional ROW land (including survey maps)

3.6.2 Permitting, Land Use, and Land Acquisitions

The Roberts Hawaii Driveway access is zoned as Residential and Industrial. The ROW acquisitions described above are on properties currently zoned as Residential and Industrial. The property owners of the ROW acquisition areas are Visionary LLC and Grove Farm Co., Inc. Estimated time for rezoning and ROW acquisition is 12 months.

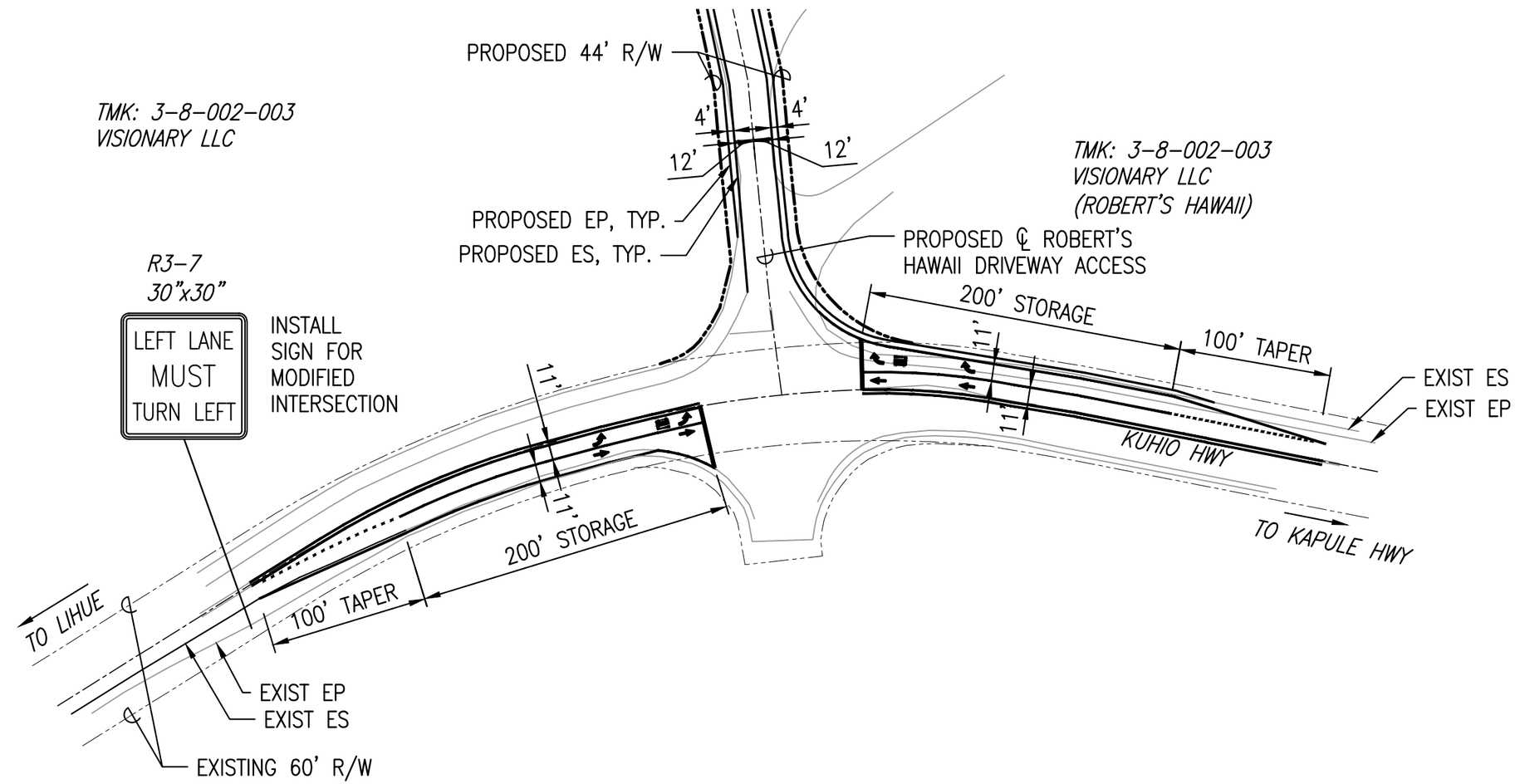
The proposed improvements described above will require an NPDES Form C permit from the State DOH. Estimated time for approval from DOH is 6 months.

3.6.3 Planning-Level Cost Estimate

Table 15 provides detailed cost estimates for the Roberts Hawaii Driveway access route. The planning-level cost estimate is:

- *D3:* $14.6 million

Additional costs may be incurred if the Alternate RRP site is chosen (see Section 3.8).

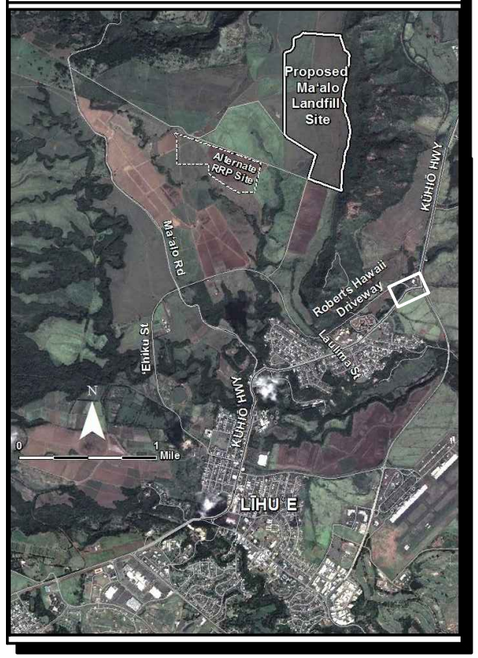


PLAN – INTERSECTION OF KUHIO HWY & ROBERT'S HAWAII DRIVEWAY ACCESS

SCALE: 1" = 80'

1" = 80' SCALE 0 80 160 240 FEET

KEY MAP



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SOURCE: GOOGLE EARTH
DATE: 10-10-2013

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Figure 13
Plan of Roberts Hawaii Driveway / Kūhiō Highway Intersection
New Kaua'i Landfill Traffic and Roadways Engineering Feasibility Study

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Table 15: Access Route D3 (Roberts Hawaii Driveway) Detailed Cost Estimate

Item	Description	Qty	Unit	Unit Cost	Costs
Roberts Hawaii Driveway Roadway Improvements					
	ROW acquisition	1	LS	$100,000	$100,000
	Widen roadways and repave				
	Unclassified Excavation	5,700	CY	$120	$684,000
	Asphalt Concrete Pavement (ACP)	1,700	tons	$180	$306,000
	Asphalt Concrete Base (ACB)	2,500	CY	$360	$900,000
	Aggregate Subbase	2,500	CY	$120	$300,000
	Noise Barrier	1,000	LF	$50	$50,000
	Shoulder Stabilization, Erosion Control	1	LS	$50,000	$50,000
	Drainage Improvements	1	LS	$100,000	$100,000
		Subtotal Road Improvements			***$2,490,000***
Utility Improvements					
	Power/Telephone Pole Relocation/Installation	12	Ea	$5,000	$60,000
	Construct Water Supply Line to Driveway 3				
	Unclassified Excavation	600	CY	$50	$30,000
	Backfill	600	CY	$80	$48,000
	12-inch Pipe	1,261	LF	$150	$190,000
	Booster Pump Station	1	LS	$750,000	$750,000
		Subtotal Utility Improvements			***$1,078,000***
Roberts Hawaii Driveway / Kūhiō Highway Intersection Improvements [a]					
	Signalization	1	LS	$1,000,000	$1,000,000
	Widen roadways and repave				
	Unclassified Excavation	900	CY	$120	$108,000
	Asphalt Concrete Pavement (ACP)	300	tons	$180	$54,000
	Asphalt Concrete Base (ACB)	400	CY	$360	$144,000
	Aggregate Subbase	400	CY	$120	$48,000
	Construct ADA-accessible pedestrian ramps	2	EA	$10,000	$20,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$30,000	$30,000
		Subtotal Intersection Improvements			***$1,404,000***
Driveway 3					
	Chain-link fence	15,000	LF	$50	$750,000
	Utility corridors (water, wastewater, electricity, and phones)				
	Power/Telephone Pole Installation	40	Ea	$5,000	$200,000
	Construct Water Supply Line to Project Site				
	Unclassified Excavation	3,400	CY	$50	$170,000
	Backfill	3,400	CY	$80	$272,000
	12-inch Pipe	7,500	LF	$150	$1,125,000
	New pavement & road widening				
	Unclassified Excavation	10,400	CY	$120	$1,248,000
	Asphalt Concrete Pavement (ACP)	3,000	tons	$180	$540,000
	Asphalt Concrete Base (ACB)	4,500	CY	$360	$1,620,000
	Aggregate Subbase	4,500	CY	$120	$540,000
	Noise Barrier	1,500	LF	$50	$75,000
	Gate Relocation	3	EA	$1,500	$5,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$125,000	$125,000
		Subtotal Driveway 1 Improvements			***$6,670,000***
Permitting					***$50,000***
Subtotal - Route D3					$11,692,000
	Contingency (25%)				$2,923,000
Total Cost - Access Route D3					**$14,615,000**

[a] Should the Kohea Loa project (a potential residential development acrioss the highway from the Roberts Hawaii Driveway intersection) proceed, it is expected to have a much larger traffic impact to this intersection than the proposed project. Therefore, the Kohea Loa project may end up bearing the cost of signalization of this intersection.

3.7 KAUA'I BEACH DRIVE ACCESS (E3)

3.7.1 Existing Conditions and Improvements

The Kaua'i Beach Drive access is shown on Figure 4 as Route E3. The access route starts at Kūhiō Highway across from Kaua'i Beach Drive and intersects with Laulima Street, at which point the route follows the Laulima Street access to the landfill. If the alternate RRP site is implemented, then a portion of either Driveway 1 (approximately 1,913 linear feet) or Driveway 2 (approximately 4,865 linear feet) would be used to connect the Landfill site to the RRP site. The Kaua'i Beach Drive access is owned by Visionary LLC and Grove Farm Co., Inc. The existing access is an unimproved road with a gate; there are no defined lane widths or shoulder widths.

The proposed improvements to the Kaua'i Beach Drive access, which must conform to County of Kaua'i requirements, are:

- Acquire additional ROW.
- Widen roads and pave: 12-ft lanes with 4-ft shoulders; 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Stabilize shoulders and provide erosion control.
- Provide drainage improvements (shoulder swales, culverts, drainage outfalls).

3.7.1.1 UTILITY IMPROVEMENTS

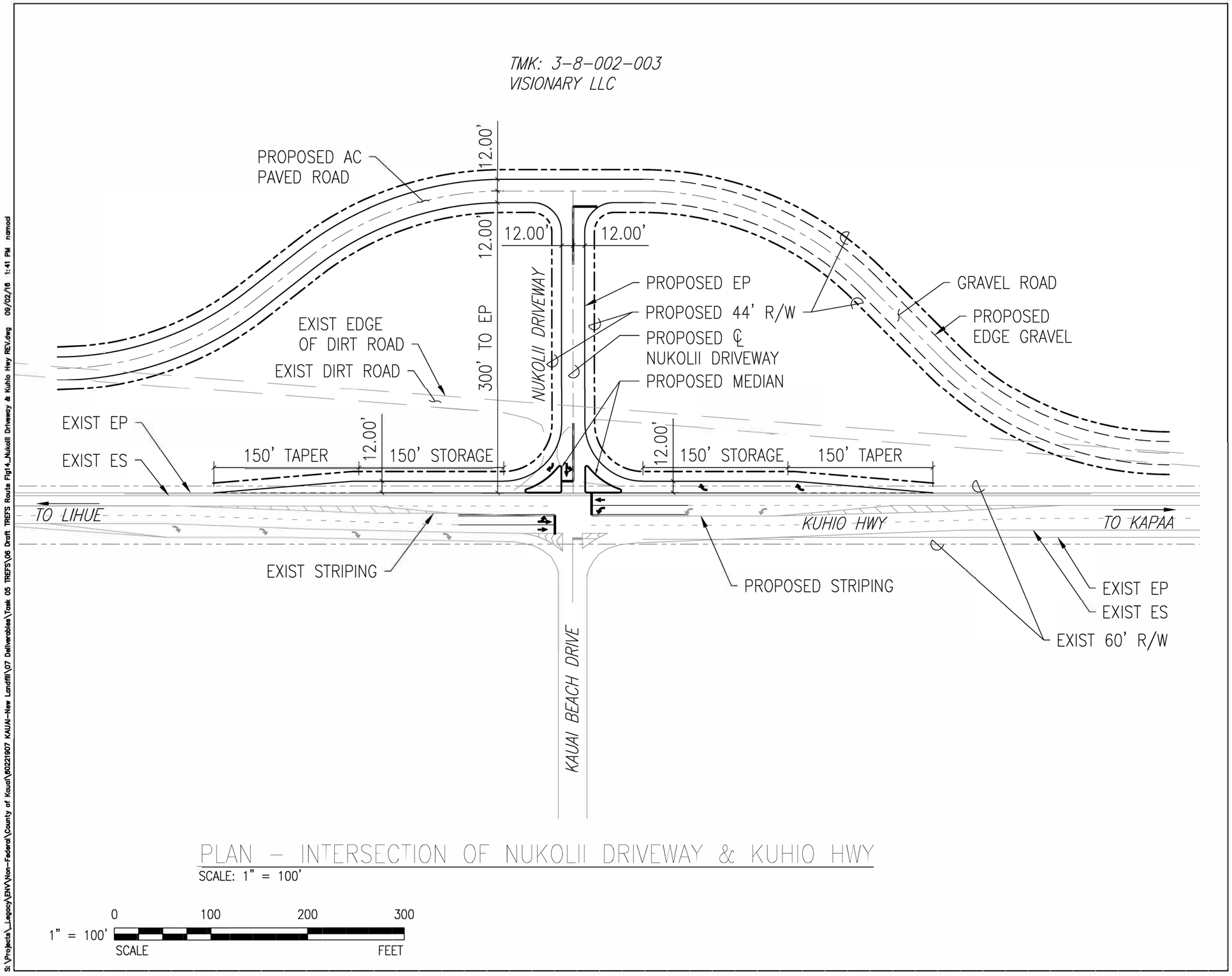
The nearest water connection is the 12-inch main along Kūhiō Highway at the intersection of Laulima Street. Although an existing 8-inch sewer main runs west along Kūhiō Highway, it is recommended that cesspools be installed at the facility instead. Electricity and telephone service is also available at the intersection of Laulima Street and Kūhiō Highway. Additionally, a 12-inch waterline may require relocating to satisfy the minimum cover requirements. Recommended utility improvements to the Kaua'i Beach Drive access route are as follows:

- Construct power and telephone poles along Laulima Street to Driveway 3.
- Connect water along Laulima Street to Driveway 3.
- Kaua'i Beach Drive/Kūhiō Highway Intersection.

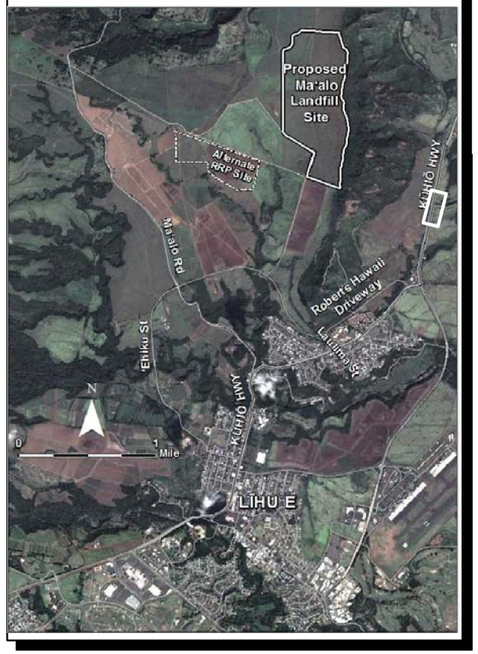
The Kaua'i Beach Dr./Kūhiō Highway intersection is a 3-way, unsignalized intersection. The State DOT ROW is 60 ft wide. The existing intersection can accommodate WB-40 truck-turning movements. The existing pavement sections could not be found from as-built records.

Based on discussions with the State DOT regarding this access route to the landfill, coordination is required with the anticipated Līhu'e bypass project.

The proposed intersection layout is shown on Figure 14.



KEY MAP



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SOURCE: GOOGLE EARTH
DATE: 10-10-2013

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Figure 14
Plan of Kaua'i Beach Drive / Kūhiō Highway Intersection
New Kaua'i Landfill Traffic and Roadways Engineering Feasibility Study

S:\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\07 Deliverables\Task 05 TREFS\06 Draft TREFS Route Fig14_Nukolii Driveway & Kuhio Hwy REV.dwg 09/02/16 1:41 PM namcol

Proposed improvements to the Kaua‘i Beach Drive/Kūhiō Highway intersection are:

- Signalize the intersection.
- Widen roads and pave: 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
  - *Right-turn lane in southbound direction on Kūhiō Highway:* 12-ft lane, 150-ft storage length, 150-ft taper length.
  - *Right-turn lane on Kaua‘i Beach Drive onto Kūhiō Highway in southbound direction:* 12-ft lane, 150-ft storage length, 150-ft taper length.
- Construct 2 raised median islands with ADA-accessible pedestrian ramps.
- Acquire additional ROW land (including survey maps).

Upon implementation of the proposed improvements, all turning movements at the proposed intersection would accommodate the WB-40 design vehicle.

3.7.1.2 Driveway 3

Driveway 3 connects Laulima Street to the proposed project site.

Proposed improvements to the driveway are similar to those proposed for Access Route D, which uses much of the same driveway:

- Stabilize shoulders and provide erosion control.
- Provide chain-link fence on both sides of the driveway.
- Provide noise barrier on side fronting residential housing.
- Establish utility corridors to bring water, electricity, and phones to the proposed project site.
- Provide new pavement (including road widening): 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.
- Acquire additional ROW land (including survey maps).

3.7.1.3 Driveway 1 or 2

If the alternate RRP site is implemented, then a portion of one of the following two alternatives will be used to connect the Landfill site to the RRP site:

- Approximately 1,913 linear feet of Driveway 1
- Approximately 4,965 linear feet of Driveway 2

Driveway 1 is a direct route to the RRP site that crosses two existing culverts in the vicinity of offsite wetlands. If selected as the proposed-project access route, this route will require wetland mitigation measures, as described above in Section 3.3.1.7. Driveway 2 is an alternate, longer route that bypasses the culverts and wetland area, but may have more impact on use of the parcel.

Proposed improvements to the selected driveway are the same as those proposed for Access Route D:

- Provide chain-link fence on both sides of the driveway.
- Establish utility corridors to bring water, electricity, and phones to the proposed project site.
- Provide new pavement (including road widening): 2 inches ACP, 6 inches ACB, 6 inches aggregate subbase.

- Widen and relocate gate.
- For Driveway 1 only: Reconstruct culverts connecting portions of the offsite wetlands, widen the road into the wetlands, and provide wetlands consultation, permitting, and mitigation.
- Acquire additional ROW land (including survey maps).

3.7.2 Permitting, Land Use, and Land Acquisitions

The Kaua‘i Beach Drive access is zoned as Residential and Industrial. The ROW acquisitions described above are on properties currently zoned as Residential and Industrial. The property owners of the ROW acquisition areas are Visionary LLC and Grove Farm Co., Inc. Estimated time for rezoning and ROW acquisition is 12 months.

The proposed improvements described above will require an NPDES Form C permit from the State DOH. Estimated time for approval from DOH is 6 months.

3.7.3 Planning-Level Cost Estimate

Table 16 provides detailed cost estimates for the Kaua‘i Beach Drive access route. The planning-level cost estimate is:

- *E3:* $17.3 million

Additional costs may be incurred if the Alternate RRP site is chosen (see Section 3.8).

Table 16: Access Route E (Kaua'i Beach Drive) Detailed Cost Estimate

Item	Description	Qty	Unit	Unit Cost	Costs
Kaua'i Beach Dr. Roadway Improvements					
	ROW acquisition	1	LS	$200,000	$200,000
	Widen roadways and repave				
	Unclassified Excavation	11,100	CY	$120	$1,332,000
	Asphalt Concrete Pavement (ACP)	3,200	tons	$180	$576,000
	Asphalt Concrete Base (ACB)	4,800	CY	$360	$1,728,000
	Aggregate Subbase	4,800	CY	$120	$576,000
	Shoulder Stabilization, Erosion Control	1	LS	$50,000	$50,000
	Drainage Improvements	1	LS	$100,000	$100,000
		Subtotal Road Improvements			***$4,562,000***
Utility Improvements					
	Power/Telephone Pole Relocation/Installation	12	Ea	$5,000	$60,000
	Construct Water Supply Line to Driveway 3				
	Unclassified Excavation	600	CY	$50	$30,000
	Backfill	600	CY	$80	$48,000
	12-inch Pipe	1,261	LF	$150	$190,000
	Booster Pump Station	1	LS	$750,000	$750,000
		Subtotal Utility Improvements			***$1,078,000***
Kaua'i Beach Dr. / Kūhiō Highway Intersection Improvements [a]					
	Signalization/lanes/painting	1	LS	$1,000,000	$1,000,000
	Widen roadways and repave				
	Unclassified Excavation	900	CY	$120	$108,000
	Asphalt Concrete Pavement (ACP)	300	tons	$180	$54,000
	Asphalt Concrete Base (ACB)	400	CY	$360	$144,000
	Aggregate Subbase	400	CY	$120	$48,000
	Construct raised median islands with ADA-accessible pedestrian ram	2	EA	$40,000	$80,000
	Gate Relocation	2	EA	$1,500	$3,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$60,000	$60,000
		Subtotal Intersection Improvements			***$1,497,000***
Driveway 3					
	Chain-link fence	15,000	LF	$50	$750,000
	Utility corridors (water, wastewater, electricity, and phones)				
	Power/Telephone Pole Installation	40	Ea	$5,000	$200,000
	Construct Water Supply Line to Project Site				
	Unclassified Excavation	3,400	CY	$50	$170,000
	Backfill	3,400	CY	$80	$272,000
	12-inch Pipe	7,500	LF	$150	$1,125,000
	New pavement & road widening				
	Unclassified Excavation	10,400	CY	$120	$1,248,000
	Asphalt Concrete Pavement (ACP)	3,000	tons	$180	$540,000
	Asphalt Concrete Base (ACB)	4,500	CY	$360	$1,620,000
	Aggregate Subbase	4,500	CY	$120	$540,000
	Noise Barrier	1,500	LF	$50	$75,000
	Gate Relocation	3	EA	$1,500	$5,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$125,000	$125,000
		Subtotal Driveway 1 Improvements			***$6,670,000***
Permitting					***$50,000***
Subtotal - Route E3					$13,857,000
	Contingency (25%)				$3,464,000
Total Cost - Access Route E3					**$17,321,000**

3.8 ALTERNATE RRP SITE ACCESS ROUTE

If the alternate RRP site is implemented, then additional costs may be required to connect the MSWLF and RRP sites via a portion of Driveway 1 or 2. Those additional costs are shown in Table 17 (Driveway 1) and Table 18 (Driveway 2).

Table 17: Detailed Cost Estimate for Portion of Driveway 1 Connecting Proposed Project to Alternate RRP Site

Item	Description	Qty	Unit	Unit Cost	Costs
Driveway 1					
	Chain-link fence	10,120	LF	$50	$506,000
	Utility corridors (water, wastewater, electricity, and phones)				
	Power/Telephone Pole Installation	10	Ea	$5,000	$50,000
	Construct Water Supply Line to Project Site				
	Unclassified Excavation	2,300	CY	$50	$115,000
	Backfill	2,300	CY	$80	$184,000
	12-inch Pipe	5,060	LF	$150	$759,000
	New pavement & road widening				
	Unclassified Excavation	7,000	CY	$120	$840,000
	Asphalt Concrete Pavement (ACP)	2,000	tons	$180	$360,000
	Asphalt Concrete Base (ACB)	3,000	CY	$360	$1,080,000
	Aggregate Subbase	3,000	CY	$120	$360,000
	Relocate/widen Double-swing gate	1	Ea	$1,500	$1,500
	Reconstruct existing culverts	2	Ea	$10,000	$20,000
	Wetlands consultation, permitting, and mitigation	1	Ea	$1,000,000	$1,000,000
	ROW Land Acquisition (Including Survey Maps)	1	LS	$75,000	$75,000
		Subtotal Driveway 1 Improvements			***$5,350,500***
Permitting					***$50,000***
Subtotal - Portion of Driveway 1					$5,401,000
	Contingency (25%)				$1,351,000
Total Cost - Portion of Driveway 1					**$6,752,000**

Note: This cost applies only if the alternate RRP site is implemented and the portion of Driveway 1 is selected as the connecting route.

Table 18: Detailed Cost Estimate for Portion of Driveway 2 Connecting Proposed Project to Alternate RRP Site

Item	Description	Qty	Unit	Unit Cost	Costs
Driveway 2					
	Chain-link fence	9,720	LF	$50	$486,000
	Utility corridors (water, wastewater, electricity, and phones)				
	Power/Telephone Pole Installation	30	Ea	$5,000	$150,000
	Construct Water Supply Line to Project Site				
	Unclassified Excavation	2,200	CY	$50	$110,000
	Backfill	2,200	CY	$80	$176,000
	12-inch Pipe	4,860	LF	$150	$729,000
	New pavement & road widening				
	Unclassified Excavation	6,800	CY	$120	$816,000
	Asphalt Concrete Pavement (ACP)	2,000	tons	$180	$360,000
	Asphalt Concrete Base (ACB)	2,900	CY	$360	$1,044,000
	Aggregate Subbase	2,900	CY	$120	$348,000
	Relocate/widen Double-swing gate	1	Ea	$1,500	$1,500
	ROW Land Acquisition (Including Survey Maps)	1	LS	$75,000	$75,000
		Subtotal Driveway 1 Improvements			***$4,295,500***
Permitting					***$50,000***
Subtotal - Portion of Driveway 2					$4,346,000
	Contingency (25%)				$1,087,000
Total Cost - Portion of Driveway 2					**$5,433,000**

Note: This cost applies only if the alternate RRP site is implemented and the portion of Driveway 2 is selected as the connecting route.

3.9 INFRASTRUCTURE IMPROVEMENTS SUMMARY AND CONCLUSION

The significant infrastructure improvements recommended for the five access routes are summarized in Section 5.0. The planning-level cost estimate summary for the potential project access routes is presented in Table 19, sorted by total cost.

Table 19: Summary of the Planning-Level Cost Estimates for the Potential Project Access Routes

Access Route	Estimated Cost ($ million)	
	Base Cost Estimate	**With 25% Contingency**
C3: Laulima Road and Driveway 3	10.2 [a]	12.7 [a]
D3: Roberts Hawaii Driveway and Driveway 3	11.7 [a]	14.6 [a]
E3: Kaua'i Beach Drive and Driveway 3	13.9 [a]	17.3 [a]
A2: Ma'alo Road and Driveway 2	33.1	41.4
B2: 'Ehiku Street and Driveway 2	33.5	41.8
A1: Ma'alo Road and Driveway 1	34.3	42.8
B1: 'Ehiku Street and Driveway 1	34.6	43.3

Note: Cost estimates for Routes A, B, and D do not include recommended signalization at Laulima.

[a] If the alternate RRP site is implemented, then additional cost for developing a portion of Driveway 1 or 2 to connect to it the project site would be:
Driveway 1: Base Cost $5.4 million, with 25% Contingency $6.8 million.
Driveway 2: Base Cost $4.3 million, with 25% Contingency $5.4 million.

Based on the planning-level cost estimates, the Laulima Street access has the lowest expected cost, followed by the Roberts Hawaii Driveway Access and Kaua'i Beach Drive. The Laulima Street

access also has the shortest and most direct route between Kūhiō Highway and the project (1.7 miles), again followed closely by the Roberts Hawaii Driveway Access and Kaua‘i Beach Drive, resulting in less pavement and utility improvement costs (and future fuel consumption for waste transport) compared to the other routes.

The Laulima Street access route (C3) is the shortest and most direct, implementable, feasible, and cost-effective project access alternative. The Roberts Hawaii Driveway (D3) and Kaua‘i Beach Driveway (E3) access routes are the next best routes, respectively, according to the infrastructure improvements assessment criteria (Routes A or B would cost approximately three times as much as Route C, and involve much more construction). Routes C, D, and E are also located on private land.

4.0 SOCIAL IMPACTS ASSESSMENT

4.1 INTRODUCTION AND PURPOSE

This Social Impacts Assessment (SIA) of potential access route alternatives was conducted to assist the County in decision making, and for input to the EIS. The assessment of the potential for traffic-associated social impacts included the solicitation of public comments and the consideration of factors such as public safety and nuisance concerns. The SIA also includes an assessment of environmental and land use entitlements, including ROW and other landowner-related issues associated with each of the potential access roads and driveway alternatives.

The SIA was designed to solicit feedback from affected communities. Community members, stakeholders, and landowners near the potential access routes for the MSWLF and RRP at Ma'alo were provided with a preliminary analysis of the potential access routes (in the form of the draft version of this TREFS report), and asked to provide their comments and concerns.

4.2 PUBLIC OUTREACH

The County conducted a variety of public outreach efforts, utilizing various media to inform the public. The material presented in this SIA was developed from several sources and was conducted in three phases:

1. During the proposed MSWLF and RRP EIS process:
   - Between October 5 and November 6, 2012, 26 interviews were conducted with people identified as stakeholders on Kaua'i for the overall proposed Landfill and RRP project as part of the EIS. These initial interviews were focused on identifying issues that should be addressed during preparation of the EIS for the proposed landfill and RRP. One of the issues identified by the stakeholders was the choice of access route, which emerged as a significant public concern. These interviews, along with other feedback gathered during the EIS process, alerted the County to the public's concerns about the access routes. In response to these concerns, the County decided to conduct this TREFS study, including this SIA for the TREFS, to analyze potential access routes and solicit public comments and feedback on the various alternatives that can connect Kūhiō Highway to the proposed project site. Several comments relating to access road issues were extracted from these initial interviews and are included in this SIA.
2. During preparation of the Draft TREFS report:
   - A second set of stakeholders was identified that included people and organizations considered likely to be able to identify issues related to the access road alternatives. Multiple attempts were made to contact all of these stakeholders. As a result, three interviews were conducted between September 26 and October 10, 2013. An additional interview was conducted with the District Manager, Hawai'i DOT, Highways Division. Their comments and concerns were noted for consideration in the Draft TREFS report, and in this SIA.
3. Following completion of the Draft TREFS report, which was published to the County website for public review on January 12, 2014:
   - A third set of stakeholders representing communities, businesses, and other entities were contacted for interviews.
   - A public outreach effort was conducted to present preliminary findings and gather comments and concerns on potential access routes, via a fact sheet and public comments sheet (Appendix C.2). The fact sheet provided information for the public to consider, including maps showing the locations of the alternative access roads and driveways, and summaries of the technical findings from the traffic and engineering analysis conducted for the Draft TREFS report. An accompanying public comment sheet was distributed for people to provide their evaluations of the access route alternatives.

The comment sheet publicized the availability of the Draft TREFS report, explained the purpose of the fact and comment sheets, and provided instructions for completing and returning the comment sheets via mail or email.

A list of private property owners with parcels located adjacent to or near the potential access routes was prepared. The properties were located in three communities: Isenberg, Laukona, and Hanamā'ulu. The fact and comment sheets were mailed to 119 landowners representing 144 parcels on January 17, 2014 (several owners owned more than one parcel in the area). One of the mailed packages was returned as undeliverable.

- A public meeting was held at the King Kaumuali‘i School Cafeteria in the Hanamā‘ulu community on January 16, 2014. The meeting was well publicized ahead of time, including radio ads, newspaper ads, and community fliers. Approximately 59 people attended. The majority of attendees were residents of the communities near the alternative access routes. The meeting began at 6:00 pm and ended at 8:35 pm, after all comments regarding the access routes had been voiced. The welcome, introductions, and consultants' presentation ended at 6:35 pm. The remainder of the time was spent gathering resident opinions and comments. Comments expressed during the meeting that related to the access route alternatives were summarized (Appendix C.1) and considered in this SIA.

  Attendees were informed of various means of providing their feedback. Materials were prepared to inform and gather written comments related to the access roads from the public. The fact and comment sheets described above were handed out to people who attended the public meeting and made available on the County Website for use by the general public.

- Another public meeting was held at the King Kaumuali‘i School Cafeteria in the Hanamā‘ulu community on September 22, 2016. The intent of the meeting was to present the potential Access Route E. The meeting publicity and format was similar to the previous meeting. Approximately 28 people attended.

Additional documentation of the public outreach process is provided in Appendix C:

- Appendix C.1 presents a summary of the January 16, 2014 public meeting.
- Appendix C.2 presents the access routes fact sheet and public comment sheet.
- Appendix C.3 presents written public comments received via mail or email during the 2014 public comment period.
- Appendix C.4 presents summaries of interviews conducted.
- Appendix C.5 presents a summary of Access Route F which was proposed as an alternative but then dismissed.
- Appendix C.6 presents a summary of the September 22, 2016 public meeting.
- Appendix C.7 presents written public comments received via mail or email during the 2016 public comment period.

4.2.1 Response Rates

Many of the public comments were obtained from the standard sources for SIAs: key stakeholder interviews and public meetings. In addition, this SIA went a step further to contact property owners whose properties were near the alternative access routes. Nevertheless, the total response set (Appendices C.3, C.4, and C.7) was quite small. Three landowners and a representative from the state DOT were contacted during the preparation of the initial SIA. All three responded and were interviewed. From the list of stakeholders prepared for the access road assessment, only two accepted the offer to be interviewed. At least 59 people attended the public meeting on January 16,

2014 and 28 people attended on September 22, 2016. Finally, between the attendees of the public meeting and the 118 property owners who were mailed surveys asking for their input, 22 returned completed forms or otherwise sent written or emailed responses.

As is often the case for SIA data collection, negative comments tended to outnumber positive comments. The system is established to identify as many issues as possible related to a proposed project. The SIA of the Ma‘alo site remained relatively positive. Members of the community pointed out that the landfill operation must be safe and clean, and not unsightly or damaging to the environment. However, over 70 percent of the stakeholders interviewed also said that the Ma‘alo site was probably the best alternative for the County and its people.

The public meetings and survey of nearby landowners were designed to gather data from persons most affected by the alternative access routes. Therefore, respondents tended to highlight localized, rather than island-wide, issues associated with individual access routes.

4.3 COMMENTS AND RESPONSES

Based on all the outreach efforts, the following comments were obtained:

- Comments made during the January 16, 2014 public outreach meeting (Appendix C.1).
- Nine written responses via completed forms and emails (Appendix C.3) during the 2014 comment period.
- Comments during interviews (Appendix C.4).
- Comments made during the September 22, 2016 public meeting (Appendix C.6).
- Twelve written responses via completed forms and emails (Appendix C. 7) during the 2016 public comment period.

The comments received were grouped by route and are provided below. While some comments stand on their own for County consideration (and do not require a response), responses are provided where appropriate. The origin of each comment is denoted as follows:

Pre = pre-public meeting comments gathered from stakeholder and landowner interviews
PM = comments gathered at the Public Meetings
OR = comments from outreach activities conducted after the public meeting

4.3.1 Access Route A Comments and Responses

4.3.1.1 ROUTE A PERCEIVED ADVANTAGES

1. Some felt that Ma‘alo Road is preferable because it already exists, and also that it may be the least expensive route to the site. (Pre, PM, OR)
   - *Response*: The estimated cost of preparing Ma‘alo Road for service as the access road is between $41.4 and $42.8 million, which is the second highest of the five routes under investigation, and significantly more expensive than Routes C or D.
2. Ma‘alo Road does not pass through or near any residential neighborhood. (Pre, PM, OR)
3. Owners of non-residential properties near the Makai end of the road have not registered any objections. (Pre)
4. Roadway improvements will benefit other users of Ma‘alo Road. (Pre, PM, OR)
   - *Response*: Anticipated roadway improvements include improvements to the highway intersection (including signalization), widening of both Ma‘alo Road and the small bridge, and straightening a sharp curve.

4.3.1.2 Route A Perceived Disadvantages

1. Impacts to traffic conditions at the intersection of Ma‘alo Road and Kūhiō Highway, including delays, safety, limited visibility, congestion. (Pre, OR)
   - *Response*: The TREFS report describes recommended mitigation measures to address these concerns, including signalization, lane relocation, etc.
2. The cost of improvements to the Kūhiō Highway intersection. (Pre, OR)
   - *Response*: The overall estimated cost of preparing Ma‘alo Road for service as a landfill access road is between $41.4 and $42.8 million, which is the second highest of the five routes under investigation, and significantly more expensive than Routes C or D.
3. Possible development delays due to traffic improvements at that intersection. (Pre)
4. Making the road safe and functional for truck traffic may require the acquisition of rights of way and that may add substantial cost and delays in the proposed project schedule. (Pre)
   - *Response*: Section 2.0 of the TREFS report describes those areas in which ROWs may need to be acquired, and the cost estimates reflect these requirements.
5. Signalization would be required. (Pre)
   - *Response*: Signalization of the Ma‘alo Road-Kūhiō Highway intersection is recommended should Route A be the proposed access route.
6. Dust at the Makai end of the road may affect commercial operations in that area. (Pre)
   - *Response*: All roadways would be paved, waste-hauling trucks are required to cover loads, and the landfill would have truck-tire cleaning devices near the exit. Unusual levels of dust are therefore not expected.
7. Truck traffic along Ma‘alo Road might negatively affect the visitor experience of those riding a tour bus to Wailua Falls. (Pre, OR)
   - *Response*: No study of visitor reactions to the access routes was conducted.

4.3.2 Access Route B Comments and Responses

4.3.2.1 Route B Perceived Advantages

1. ‘Ehiku Street avoids the cost of improvements along lower Ma‘alo Road. (Pre, OR)
   - *Response*: Route B would require improvements to ‘Ehiku Street, offsetting the gain by avoiding improvements to lower Ma‘alo Road.
2. Fewer improvements would be required for the intersection at ‘Ehiku Street and Kūhiō Highway, reducing cost and delay. (Pre)
   - *Response*: Although minor improvements would be required at the Kūhiō Highway intersection, the overall cost estimate for Route B is estimated at $41.8 to $43.3 million, the highest cost estimate among the five alternative access routes.
3. Required roadway improvements will benefit other users of ‘Ehiku Street. (Pre)
4. Visitor traffic to Wailua Falls could make use of ‘Ehiku, enhancing the visitor experience. (Pre)

4.3.2.2 Route B Perceived Disadvantages

1. ‘Ekihu Street runs through the Isenberg residential neighborhood, and is immediately adjacent to homes, churches, and businesses. Neighborhood opposition has been voiced. The neighborhood has expressed concerns regarding dust, odor, noise, safety issues for children, and difficulty accessing ‘Ehiku Street from their driveways. (Pre, PM, OR)

- *Response:* The County acknowledges the impacts to nearby properties if this route were chosen. In order to mitigate impacts, noise dampening and dust suppression measures can be implemented, and safety precautions could be undertaken.

2. Truck traffic at the intersection of 'Ehiku Street and Kūhiō Highway could cause delays at a problem-free intersection. (Pre, OR)
   - *Response:* Improvements to the 'Ehiku Street/Kūhiō Highway intersection, including extra lanes and turn-radius widening, are recommended if this intersection is chosen. The traffic study performed in the TREFS, which included data collection and traffic impacts analysis, did not suggest a change in the LOS (see Section 2.0).
3. If additional lanes were needed, it may be necessary to acquire rights of way. (Pre)
   - *Response:* Section 2.0 of the TREFS report describes those areas in which ROWs may need to be acquired, and the cost estimates reflect these requirements.
4. Some felt 'Ehiku Street would be the most expensive of the alternative access routes. (Pre, OR)
   - *Response*: Although minor improvements would be required at the Kūhiō Highway intersection, the overall cost estimate for Route B is estimated at $41.8 to $43.3 million, the highest cost estimate among the five alternative access routes.
5. Enhancing the visitor experience would be offset by the need to mix solid waste hauling and tour bus traffic along 'Ehiku Street and upper Ma'alo Road. (Pre)
   - *Response*: No study of visitor reactions to the access routes was conducted.

4.3.3 Access Route C Comments and Responses

4.3.3.1 Route C Perceived Advantages

1. Laulima Street is the shortest and most direct route to the site. (Pre, PM, OR)
2. Route C is the least expensive of the alternative routes. (Pre, PM, OR)
   - *Response*: Route C has the lowest estimated development cost, $12.7 million.
3. Laulima Street does not pass through any residential neighborhood. (Pre, PM)
   - *Response*: Laulima Street does not pass through any residential neighborhood. It does pass behind the backyards of some residential properties along Laukona Street.
4. Much of the route along Laulima is not visible from Kūhiō Highway. (Pre)
5. Required improvements to the intersection at Laulima and Kūhiō Highway, including the traffic signal, once warranted, would benefit local residents and all drivers using Kūhiō Highway during peak traffic periods. (Pre, PM, OR)
   - Response: As described in the Traffic Analysis, signalization of the intersection would be expected to improve the level of service at the intersection.
6. There is ample land along Kūhiō Highway to add turn lanes. (Pre)

4.3.3.2 Route C Perceived Disadvantages

1. The impact of truck traffic at the intersection of Laulima Street and Kūhiō Highway, already a congested area, would cause major traffic problems. (Pre, PM)
   - *Response:* Improvements to the intersection at Laulima Street and Kūhiō Highway, including turn lanes, roadway widening, and signalization, are expected to mitigate impacts to the intersection, and even result in net improvements for some approaches (see Section 2.0).

2. Bringing trucks to the center of Hanamā'ulu town would cause problems with dust, odor, and noise even with the best improvements to the intersection. (Pre, PM)
   - *Response:* Provisions for reducing noise, odor, and dust associated with solid waste transport will be implemented, as discussed in responses above, and are not expected to significantly change existing conditions along the highway (which already is used by many waste haulers today). Some of the roadway improvements have the potential to improve existing conditions, e.g., paving the existing cane-haul roads. Finally, mitigation measures such as landscaping or a sound wall can be implemented to further reduce noise, odor, and dust impacts.
3. Trucks may raise dust that would affect operations in the commercial area. (Pre)
   - *Response:* Provisions for reducing dust associated with solid waste transport will be implemented, as discussed in responses above, and are not expected to significantly change existing conditions along the highway (which already is used by many waste haulers today). Some of the roadway improvements have the potential to improve existing conditions, e.g., paving the existing cane-haul roads.
4. The part of Route C that runs parallel to Laukona Street is adjacent to the property of homeowners along that street. Dust, noise, and odor may be problems for residents there. (Pre, PM, OR)
   - *Response*: A portion of Access Route C passes behind the backyards of some residential properties along Laukona Street. Mitigation measures to address dust, noise, and odor (for example, paving the existing cane haul road, a sound wall, or berm and vegetative barrier) could be implemented.
5. Some felt that the Laulima Street route would be expensive to develop. (Pre)
   - *Response:* The cost estimate for developing Route C is $12.7 million, the lowest estimate among the five alternative routes.
6. Route C will decrease property values on Laukona Street. (PM)
   - *Response:* Route C does not run along Laukona Street, it runs 200 feet or more from Laukona Street properties' back yards. With appropriate landscaping and roadway paving, the impact of property values could be mitigated.
7. Laukona Street is an area particularly affected by excessive runoff or flooding. (PM, OR) Laukona Street is affected by flooding due to the breakdown or blockage of the stream/ditch between Laukona and the cane haul road that would become Route C. (PM)
   - *Response:* The detailed design of the access route would investigate and account for runoff and flooding, in accordance with County and other requirements. If any current drainage problems are caused by features near the roadways, then the drainage improvements associated with roadway development may alleviate existing problems.

4.3.4 Access Route D Comments and Responses

Routes C and D share the same "driveway" (i.e., Driveway 3) from the intersection of Laulima Street and the Roberts Hawaii Driveway to the site. Therefore, the two routes share many of the same advantages and disadvantages, and many of the comments and responses above also apply to Route D.

4.3.4.1 Route D Perceived Advantages

1. Roberts Hawaii Driveway avoids putting further pressure on the intersection at Laulima Street and Kūhiō Highway. (Pre, OR)
2. Route D has no negative impact on visitor traffic to Wailua Falls. (Pre)

3. Route D bypasses the commercial area, reducing or limiting problems for businesses there. (Pre)
4. Required improvements to Route D may benefit other residents and businesses in Hanamā‘ulu. (Pre, OR)
5. Route D is farthest from Hanamā‘ulu town and has less foot traffic than other routes.

4.3.4.2 Route D Perceived Disadvantages

1. The intersection of Roberts Hawaii Driveway and Kūhiō Highway is very near the intersection of Kūhiō Highway and Kapule Highway. That may cause major traffic delays in peak periods. (Pre, OR)
   - *Response:* Improvements to the intersection, including additional lanes and signalization, are recommended if this route is chosen. Additionally, pending Hawai‘i DOT concurrence with the analysis presented in this TREFS, there appears to be sufficient distance to coordinate the signals at the two intersections.
2. The Roberts Hawai‘i Driveway runs along the back side of Kalepa Villages and may cause dust, noise, or odor problems for residents there. (Pre, OR)
   - *Response:* Landscaping or other mitigation measures could reduce the impact of truck traffic behind Kalepa Village residences.
3. The part of the route that runs parallel to Laukona Street is adjacent to the property of homeowners along that street. Dust, noise, and odor may be a problem for residents there. (Pre, PM)
   - *Response:* A portion of Access Route D passes behind the backyards of some residential properties along Laukona Street. Mitigation measures to address dust, noise, and odor could be implemented (for example, paving the existing cane haul road, requiring trucks to cover loads, installing a sound or vegetative barrier).
4. Some felt that, with the addition of Roberts Hawaii Driveway to Route C, the new Route D would make it one of the most costly to develop.
   - *Response*: The estimated cost for preparing Route D is $14.6 million, the second lowest of the five alternative access routes.

4.3.5 Access Route E Comments and Responses

4.3.5.1 Route E Perceived Advantages

1. Route E will improve the intersection at the Kauai Beach Resort. (PM, OR)
2. Increased traffic through Lihue and Hanamā‘ulu will be minimized because the landfill bound traffic from Kapaa/North Kauai will access the route prior to reaching Hanamā‘ulu. (OR, PM)
3. The new intersection at Kuhio and Kauai Beach Drive will be signalized. This will make this stretch of Kuhio Hwy more manageable from a traffic standpoint and safer by slowing down the speeding that is currently occurring. (OR)
4. Traffic from Kapaa and North Kauai will not have to travel through Hanamā‘ulu or Lihue to access the landfill or RRP. (OR)
5. Cost of road way improvements for Route E is much lower compared to Routes A & B; only $5 million higher than for Route C and $3 million higher than for Route D but much more advantageous than any of those routes. (OR)
6. The route bypasses the town of Hanamā‘ulu. (OR)

4.3.5.2 Route E Perceived Disadvantages

1. Increased noise from traffic for Hanamā‘ulu residents especially where Route E passes around the base of Kalepa Hill in the vicinity of the old Hanamā‘ulu Shop area and the Kalepa Village area. (OR, PM)
   - *Response*: A noise barrier is recommended for the houses on Laukona Street. These are cane haul roads now, but they will be paved so the dust will decrease. There will be a sound wall at Kalepa Village. The EIS will address the noise impacts.
2. Landfill/RRP bound traffic will have a longer distance to travel. (OR)
3. Increased traffic especially with contraflow hours/days (OR, PM)
   - *Response*: The conceptual plans in this report describe the proposed intersection improvements. The improvements proposed at Kaua‘i Beach Drive took the current counter-flow into consideration. Currently, when the counter-flow is implemented, Kaua‘i Beach Drive remains open. It is left open to preserve the left turn lane. In the design, the turn lane into Kaua‘i Beach Drive is maintained to accommodate the left–turn lane needed in the opposite direction for the landfill access. The improvements proposed at the Kaua‘i Beach Drive intersection do not preclude future State DOT plans to improve Kūhiō Hwy to a full four-lane facility.

4.3.6 Driveway-Related Comments and Responses

4.3.6.1 Comments Specific to Driveway 1

1. Driveway 1 is straight and less expensive; Driveway 2 will be more expensive. (Pre)
   - *Response:* Driveway 1 may be the more expensive route because it must pass through a wetlands area.
2. Driveway 1 is shorter; Driveway 2 will add unacceptable lengths to drive times. (Pre)
3. Driveway 1 is less intrusive to agricultural operations in the area; Driveway 2 breaks up the current land use patterns and future land use possibilities. (Pre)

4.3.6.2 Comments Specific to Driveway 2

1. Driveway 1 traverses wetland areas; Driveway 2 is designed to avoid the wetlands. (Pre)
2. Driveway 1 may require lengthy and difficult negotiations with the Federal government; Driveway 2 may avoid those negotiations. (Pre)
   - *Response:* Driveway 1 would likely require consultation, and possibly a Section 404 permit, from the USACE.
3. Driveway 1 may be less popular among members of the community who are sensitive to wetlands issues; Driveway 2 would avoid potential controversy regarding wetlands.

4.3.6.3 Comments Specific to Driveway 3

1. Driveway 3 is straight, direct, and simple in design (PM)
2. Driveway 3 divides the landowner’s property and limits flexibility of use; Driveways 1 and 2 avoid these problems. (Pre)
3. Driveway 3 is not directly involved with wetland areas. (Pre)
   - Response: Driveway 3 does not pass through wetlands areas. However, if the RRP is located on the alternate site, then a road between the proposed landfill and the alternate RRP site would require a portion of either Driveway 1 (which traverses the wetland) or Driveway 2.

4.3.7 Comments and Responses Related to All Alternatives

4.3.7.1 Perceived Common Advantages

(None noted.)

4.3.7.2 Perceived Common Disadvantages

1. Combining Routes: Access Routes A and B approach the landfill from the west, and Access Routes C and D approach from the east. By joining the two, the loop would be completed, creating a fifth alternative access route. (Pre, PM, OR)
   - *Response*: The proposed project, establishment of the proposed landfill and RRP, is already an expensive and complicated project, and the proposed facilities do not require more than one access point. Because providing such would introduce unnecessary complication and expense into the proposed project, this approach is not recommended at this time. Should future conditions warrant, this could then be considered.
2. Hanamā‘ulu Bypass Road: Completing the loop produces a route that is similar to some proposals for a Hanamā‘ulu Bypass Road. Although people were informed that the bypass road and landfill siting issues were separate issues, many still felt they were the same issues and should be treated as such. (Pre, PM, OR)
   - *Response*: The County is still considering how to best pursue the Hanamā‘ulu Bypass Road. However, because it is not required by the landfill or RRP, and would introduce unnecessary complication and expense into this proposed project, the Hanamā‘ulu Bypass Road is not part of the proposed project.
3. Alternative Route: An additional route was suggested that runs from the highway along Ma‘alo Road to the intersection with ‘Ehiku Street, and then turns east along a cane haul road to Driveway 3. (Pre, PM, OR)
   - *Response*: Appendix C.5 presents a figure showing this additional potential route (“Access Route F), and a brief assessment of its advantages and disadvantages. Although the route may be feasible, it is generally not recommended, as it includes many of the disadvantages of Routes A and B but lacks the advantages associated with Routes C, D and E.

4.4 SIA Conclusions

This SIA was conducted to identify issues that the public wants the County to consider in choosing the proposed access route. Although soliciting input for the SIA focused largely on those most closely affected by the choice of access routes, all citizens of Kaua‘i are potentially affected by this choice. This analysis provides decision makers with perceived advantages, disadvantages, and other factors to consider in choosing a proposed access route.

Increased traffic at the respective Kūhiō Highway intersection and potential negative impacts from proposed project truck traffic to any nearby residential or commercial areas were issues identified by the public that were common to all access route alternatives.

While the SIA does not identify a ‘best choice’ among the alternative routes, and no single consideration can be the basis for selecting or rejecting a route, Access Routes C, D, and E provide the best balance of feasibility, traffic impacts, cost requirements, and other impacts, as discussed herein. Furthermore, most community members that expressed a preference between these three routes, particularly nearby residences and businesses, preferred Route E (followed by Route D), because it moves the intersection traffic farthest away from the core of Hanamā‘ulu, minimizing traffic impacts there. Whichever route is chosen, impacts associated with the selected route may warrant mitigation, in consultation with the affected public.

5.0 PROPOSED ACCESS ROUTE

This TREFS analyzed five potential access routes from Kūhiō Highway (the principal thoroughfare in the area) to the proposed project (MSWLF and RRP at Ma‘alo). The TREFS both analyzed objective data (such as traffic impacts, recommended improvements, and related costs) and solicited concerns and opinions from the public, particularly those most directly affected by the choice of the proposed access route. Several public meetings were held to gather public comments, and additional outreach and engagement was conducted through the internet and local media sources.

All access scenarios present potential traffic impacts that can be addressed via physical and operational improvements at their respective Kūhiō Highway intersection (in several cases, these improvements could improve the existing traffic in these areas). Access route improvements are recommended for all access scenarios, including paving and utility work, bringing water, electricity, and phone lines to the proposed project site, and other roadway improvements. Table 20 summarizes key features of each potential access route and the projected impacts and costs, as presented in the preceding sections.

Overall, Access Routes C, D, and E provide the best balance of feasibility, directness, traffic impacts, cost requirements, and other impacts. While these three routes are progressively longer and therefore more expensive, few other significant technical advantages or disadvantages distinguish Routes C, D, and E. However, members of nearby communities expressed a preference for Access Route E, which would minimize the traffic impact to the core of Hanamā‘ulu and pass fewer residences and businesses. Therefore, while Route C is slightly preferable from a technical and financial standpoint, in order to address concerns raised by the community during the early planning process, the County has selected Access Route E as the preferred access route, which will become part of the proposed project that will be evaluated in the overall project EIS.

Table 20: Overall Comparison of Proposed-Project Access Routes

Assessment		Ma'alo Road (Route A1, A2)		'Ehiku Street (Route B1, B2)		Laulima Street (Route C3)	Roberts Hawaii Driveway (Route D3)	Kaua'i Beach Drive (Route E3)	Overall Conclusion
Description and Existing Conditions	Route Length	4.8 miles (A1); 4.7 miles (A2)		5.6 miles (B1); 5.7 miles (B2)		1.7 miles	2.2 miles	2.8 miles	Not applicable.
	Intersection Type	Stop-sign-controlled T-intersection.		Signalized.		Stop-sign-controlled four-legged intersection.	Stop-sign-controlled T-intersection.	Unsignalized with one-way stop control.	
	Intersection LOS	C (weekday AM peak) D (weekday PM peak)		A (weekday AM & PM peaks)		E (weekday AM peak) F (weekday PM peak)	D (weekday AM peak) C (weekday PM peak)	F (weekday AM & PM peaks)	
	Key Features	Ma'alo Road is narrow with one narrow bridge near the highway intersection, no shoulders, sharp turns; main route for tourist traffic to Wailua Falls.		Route transits residential area (Isenberg neighborhood, from intersection to Kanakolu St).		Intersection is major outlet for Hanamā'ulu community; route briefly parallels a residential area (Laukona St).	Most of the initial "D" segment is a gravel road. Intersection is currently not heavily used, but could be impacted by vehicle queuing for nearby signalized Kapule Hwy intersection.	Extends Access Route D an additional 0.7 mile, minimizing traffic impacts to the core of Hanamā'ulu. Route recommended by local residents and businesses during early community outreach efforts.	
Traffic (Section 2.0)		Significant impacts to Kūhiō Hwy intersection operations. Recommended intersection improvements: • Signalize intersection when warranted. • Modify Kūhiō Hwy intersection to accommodate southbound traffic turning right into Ma'alo Rd.		Minor impacts to Kūhiō Hwy intersection operations; potentially significant impacts to residential segment (between Kūhiō Hwy and Kanakolu St). Recommended intersection improvements: • Modify existing signal operation. • Enlarge 'Ehiku St right-turn curb return radii. • Upgrade pedestrian facilities.		Once warranted, signalization of intersection is recommended regardless of which proposed-project access route is used. Recommended intersection improvements: • Signalize intersection. • Reconfigure Laulima St mauka approach. • Widen highway for northbound and southbound left-turn lanes.	Once warranted, signalization is recommended to accommodate vehicle queuing from the nearby signalized Kapule Hwy/Kūhiō Hwy intersection. Recommended intersection improvements: • Signalize intersection when warranted • Provide left-turn lane for Kapa'a-direction Kūhiō Hwy traffic. • Provide right-turn deceleration lane for Līhu'e-direction Kūhiō Hwy traffic.	Signalization is recommended (and already warranted) to accommodate vehicle queuing impacts to the nearby signalized Kapule Hwy/Kūhiō Hwy intersection. Recommended intersection improvements: • Signalize intersection. • Provide right-turn deceleration lane for Līhu'e-direction Kūhiō Hwy traffic.	Routes C, D, and E (in that order) would provide the most cost-effective and efficient access to the proposed project while minimizing impacts to the traffic operations and adjacent land uses. Route E could improve traffic and safety conditions at the intersection that currently has the worst LOS.
Infrastructure Improvement Requirements (Section 3.0)	*Improvements:*	*Cost for Route A1:*	*Cost for Route A2:*	*Cost for Route B1:*	*Cost for Route B2:*	*Cost for Route C3:*	*Cost for Route D3:*	*Cost for Route E3:*	Access Route C3 has the least cost and is the shortest and most direct route. Access Routes D and E have similar but progressively increasing costs and distances.
	Roadway	$9,430,000	$9,430,000	'Ehiku: $4,890,000 Ma'alo: $6,238,000	'Ehiku: $4,890,000 Ma'alo: $6,238,000	$758,000	$2,490,000	$4,562,000	
	Driveway	$10,128,000 [a]	$8,973,000	$10,128,000 [a]	$8,973,000	$6,670,000	$6,670,000	$6,670,000	
	Utility	$3,185,000	$3,185,000	$2,983,000	$2,983,000	$1,078,000	$1,078,000	$1,078,000	
	Hwy intersection [c]	$1,322,000	$1,322,000	$280,000	$280,000	$1,624,000 [b]	$1,404,000	$1,497,000	
	Permitting	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	
	Other	Ma'alo Road/Driveway 1 intersection: $59,000	Ma'alo Road/Driveway 2 intersection: $59,000	Ma'alo Road/Driveway 1 intersection: $59,000	Ma'alo Road/Driveway 2 intersection: $59,000				
		Kapaia bridge: $5,000,000	Kapaia bridge: $5,000,000	Reconstruct waterway/ culvert: $10,000,000	Reconstruct waterway/ culvert: $10,000,000				
		Existing bridge: $5,025,000	Existing bridge: $5,025,000						
		Existing sharp curve: $78,000	Existing sharp curve: $78,000						
	Total Cost [d]	*$42,847,000*	*$41,403,000*	*$43,285,000*	*$41,841,250*	*$12,725,000* [e]	*$14,615,000* [e]	$17,321,000	

Assessment		Ma'alo Road (Route A1, A2)	'Ehiku Street (Route B1, B2)	Laulima Street (Route C3)	Roberts Hawaii Driveway (Route D3)	Kaua'i Beach Drive (Route E3)	Overall Conclusion
Social Impacts (Section 4.0)	Perceived Advantages:	• Route is already established. • Route avoids residential areas. • Roadway and infrastructure improvements would benefit all road users and property owners along the route.	• Roadway and infrastructure improvements would benefit all road users and property owners along the route. • Required intersection and roadway improvements may be less than for Ma'alo route. • Making use of the route for Wailua Falls traffic could enhance the visitor experience.	• Shortest, most-direct, least-expensive route to the proposed project site • No impact to visitor traffic to Wailua Falls. • Intersection improvements would benefit some users	• Compared to Route C, avoids more of Hanamā'ulu town and avoids putting additional pressure on Laulima St. highway intersection. • Second-least expensive alternative. • No impact to visitor traffic to Wailua Falls. • Roadway and infrastructure improvements would benefit property owners along and near the route.	• Minimizes traffic impacts to Hanamā'ulu town. • Significantly less expensive that Routes A or B. • No impact to visitor traffic to Wailua Falls. • Would improve safety and traffic conditions at the highway intersection.	Increased traffic at the respective Kūhiō Highway intersection and potential negative impacts from proposed project traffic to any nearby residential or commercial areas are social impact issues common to all access route alternatives, but minimized with Access Route E3. As noted by community members during the public outreach process, Route E3 would reduce the traffic impact to the core of Hanamā'ulu, and is therefore preferable.
	Perceived Disadvantages:	• Increased highway intersection traffic and high cost for intersection improvements, including potential signalization. • Increased truck traffic on Ma'alo Rd. • Potential for dust for commercial operations along route. • Potential negative impacts to Wailua Falls visitors on tour buses.	• Potential safety and nuisance impacts along Isenberg residential segment of route (between Kūhiō Hwy and Kanakolu St). • Increased traffic at previously problem-free highway intersection. • Expensive alternative access route. • Mixing solid waste truck and tour bus traffic could offset any enhanced visitor experience.	• Increased truck traffic at already-busy highway intersection could cause traffic problems. • Potential for increased dust in the commercial area. • Impacts from truck traffic transiting through center of Hanamā'ulu town, and potential for dust, noise, odor, and other nuisances to Laukona St. residents. • Drainage ditch next to route segment that is parallel with Laukona St is subject to flooding.	• Proximity to nearby Kūhiō Hwy/Kapule Hwy intersection could produce traffic delays. • Potential for dust, noise, odor, and other nuisances to Kalepa Village and Laukona St. residents. • Drainage ditch next to route segment that is parallel with Laukona St may be subject to flooding.	• Potential for dust, noise, odor, and other nuisances to Kalepa Village and Laukona St residents. • Drainage ditch next to route segment that is parallel with Laukona St. may be subject to flooding. • More expensive than Access Routes C and D.	

[a] Includes $1,000,000 for wetlands mitigation.
[b] Includes $1,000,000 for signalization of intersection, which is recommended in the long-term future regardless of proposed project implementation or selected proposed-project access route.
[c] The cost estimates for Access Routes A, B, and D do not include signalization of the Laulima/Kūhiō Hwy intersection, which is recommended under all scenarios.
[d] Total cost includes 25% contingency.
[e] If the alternate RRP site is implemented, then additional cost for developing a portion of Driveway 1 or 2 to connect to it the proposed project site would be $6.8 million (Driveway 1) or $5.4 million (Driveway 2) (includes 25% contingency).

6.0 REFERENCES

AECOM Technical Services, Inc. (AECOM). 2012. *New Kaua‘i Landfill Siting Study Report*. Prepared for County of Kaua‘i, Department of Public Works. Honolulu. July.

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Transportation Research Board (TRB). 2010. *Highway Capacity Manual.* National Research Council.

Appendix A:
Intersection Volumes

Baseline Scenarios

Year	Intersection (Kūhiō Highway)	Weekday AM Peak Hour												Weekday PM Peak Hour											
		Northbound			Southbound			Eastbound			Westbound			Northbound			Southbound			Eastbound			Westbound		
		L	T	R	L	T	R	L	T	R	L	T	R	L	T	R	L	T	R	L	T	R	L	T	R
Existing	@ ‘Ehiku Street	58	537	0	0	979	17	9	0	87	0	0	0	102	923	0	0	871	13	17	0	59	0	0	0
	@ Ma‘alo Road	17	365	0	0	833	13	8	0	9	0	0	0	29	834	0	0	610	24	28	0	32	0	0	0
	@ Laulima Street	4	322	37	13	787	12	3	0	3	56	0	43	4	776	82	15	594	4	7	1	6	34	2	27
	@ Roberts Hawaii Driveway	0	0	0	8	0	1	1	439	0	119	811	12	0	0	0	7	0	11	2	596	0	0	643	9
	@ Kapule Highway	33	311	0	0	884	909	278	0	288	0	0	0	101	1024	0	0	461	551	540	0	63	0	0	0
	@ Kauai Beach Drive	0	621	30	20	1837	0	0	0	0	51	0	13	0	1623	40	39	902	0	0	0	0	88	0	62

Growth Rate (per annum)	1.0%

Opening Year (2020)	@ ‘Ehiku Street	62	576	0	0	1050	18	10	0	93	0	0	0	109	990	0	0	934	14	18	0	63	0	0	0
	@ Ma‘alo Road	18	391	0	0	893	14	9	0	10	0	0	0	31	894	0	0	654	26	30	0	34	0	0	0
	@ Laulima Street	4	345	40	14	844	13	3	0	3	60	0	46	4	832	88	16	637	4	8	1	6	36	2	29
	@ Roberts Hawaii Driveway	0	0	0	9	0	1	1	471	0	128	870	13	0	0	0	8	0	12	2	639	0	0	689	10
	@ Kapule Highway	35	333	0	0	948	975	298	0	309	0	0	0	108	1098	0	0	494	591	579	0	68	0	0	0
	@ Kauai Beach Drive	0	666	32	21	1970	0	0	0	0	55	0	14	0	1740	43	42	967	0	0	0	0	94	0	66
Future Year (2040)	@ ‘Ehiku Street	76	703	0	0	1281	22	12	0	114	0	0	0	133	1207	0	0	1139	17	22	0	77	0	0	0
	@ Ma‘alo Road	22	477	0	0	1090	17	10	0	12	0	0	0	38	1091	0	0	798	31	37	0	42	0	0	0
	@ Laulima Street	5	421	48	17	1030	16	4	0	4	73	0	56	5	1015	107	20	777	5	9	1	8	44	3	35
	@ Roberts Hawaii Driveway	0	0	0	10	0	1	1	574	0	156	1061	16	0	0	0	9	0	14	3	780	0	0	841	12
	@ Kapule Highway	43	407	0	0	1156	1189	364	0	377	0	0	0	132	1340	0	0	603	721	706	0	82	0	0	0
	@ Kauai Beach Drive	0	812	39	26	2403	0	0	0	0	67	0	17	0	2123	52	51	1180	0	0	0	0	115	0	81

Project Trips

To / from north	45%
To / from south	55%

	Weekday AM Peak Hour									Weekday PM Peak Hour								
	To / from north			To / from south			Total			To / from north			To / from south			Total		
	In	Out	Total	In	Out	Total	In	Out	Total	In	Out	Total	In	Out	Total	In	Out	Total
Opening Year (2020)																		
Landfill	7	7	14	8	8	17	15	15	30	5	7	12	7	8	15	12	15	27
RRP	59	12	70	72	14	86	130	26	156	10	59	68	12	72	84	22	130	152
Landfill + PRP	65	18	84	80	23	102	145	41	186	15	65	81	19	80	98	34	145	179
Future Year (2040)																		
Landfill	9	8	17	10	10	20	19	18	37	7	8	15	8	10	18	15	18	33
RRP	59	12	70	72	14	86	130	26	156	10	59	68	12	72	84	22	130	152
Landfill + PRP	67	20	87	82	24	106	149	44	193	17	67	83	20	81	102	37	148	185

Project Scenarios

'Ehiku Street Access Alternative

Opening Year Project Trips (Landfill)	@ 'Ehiku Street	8					7	7		8				7					5	7		8			
	@ Ma'alo Road		7			7									7			5							
	@ Laulima Street		7			7									7			5							
	@ Roberts Hawaii Driveway								7			7									7			5	
	@ Kapule Highway						7	7											5	7					
	@ Kauai Beach Drive		7			7									7			5							
Opening Year Project Trips (Landfill + RRP)	@ 'Ehiku Street	80					65	18		23				19					15	65		80			
	@ Ma'alo Road		18			65									65			15							
	@ Laulima Street		18			65									65			15							
	@ Roberts Hawaii Driveway								18			65									65			15	
	@ Kapule Highway						65	18											15	65					
	@ Kauai Beach Drive		18			65									65			15							
Future Year Project Trips (Landfill)	@ 'Ehiku Street	10					9	8		10				8					7	8		10			
	@ Ma'alo Road		8			9									8			7							
	@ Laulima Street		8			9									8			7							
	@ Roberts Hawaii Driveway								8			9									8			7	
	@ Kapule Highway						9	8											7	8					
	@ Kauai Beach Drive		8			9									8			7							
Future Year Project Trips (Landfill + RRP)	@ 'Ehiku Street	82					67	20		24				20					17	67		81			
	@ Ma'alo Road		20			67									67			17							
	@ Laulima Street		20			67									67			17							
	@ Roberts Hawaii Driveway								20			67									67			17	
	@ Kapule Highway						67	20											17	67					
	@ Kauai Beach Drive		20			67									67			17							
Opening Year (2020) + Landfill	@ 'Ehiku Street	70	576	0	0	1050	25	16	0	102	0	0	0	116	990	0	0	934	19	25	0	72	0	0	0
	@ Ma'alo Road	18	398	0	0	900	14	9	0	10	0	0	0	31	901	0	0	659	26	30	0	34	0	0	0
	@ Laulima Street	4	352	40	14	851	13	3	0	3	60	0	46	4	839	88	16	642	4	8	1	6	36	2	29
	@ Roberts Hawaii Driveway	0	0	0	9	0	1	1	477	0	128	876	13	0	0	0	8	0	12	2	646	0	0	695	10
	@ Kapule Highway	35	333	0	0	948	981	305	0	309	0	0	0	108	1098	0	0	494	596	586	0	68	0	0	0
	@ Kauai Beach Drive	0	673	32	21	1976	0	0	0	0	55	0	14	0	1747	43	42	972	0	0	0	0	94	0	66
Opening Year (2020) + Landfill + RRP	@ 'Ehiku Street	142	576	0	0	1050	83	28	0	116	0	0	0	128	990	0	0	934	29	83	0	143	0	0	0
	@ Ma'alo Road	18	410	0	0	958	14	9	0	10	0	0	0	31	959	0	0	669	26	30	0	34	0	0	0
	@ Laulima Street	4	364	40	14	909	13	3	0	3	60	0	46	4	897	88	16	652	4	8	1	6	36	2	29
	@ Roberts Hawaii Driveway	0	0	0	9	0	1	1	489	0	128	935	13	0	0	0	8	0	12	2	704	0	0	705	10
	@ Kapule Highway	35	333	0	0	948	1040	317	0	309	0	0	0	108	1098	0	0	494	606	644	0	68	0	0	0
	@ Kauai Beach Drive	0	684	32	21	2035	0	0	0	0	55	0	14	0	1805	43	42	982	0	0	0	0	94	0	66
Future Year (2040) + Landfill	@ 'Ehiku Street	86	703	0	0	1281	31	20	0	124	0	0	0	142	1207	0	0	1139	24	30	0	87	0	0	0
	@ Ma'alo Road	22	486	0	0	1098	17	10	0	12	0	0	0	38	1099	0	0	805	31	37	0	42	0	0	0
	@ Laulima Street	5	429	48	17	1038	16	4	0	4	73	0	56	5	1023	107	20	784	5	9	1	8	44	3	35
	@ Roberts Hawaii Driveway	0	0	0	10	0	1	1	582	0	156	1070	16	0	0	0	9	0	14	3	788	0	0	848	12
	@ Kapule Highway	43	407	0	0	1156	1198	372	0	377	0	0	0	132	1340	0	0	603	728	715	0	82	0	0	0
	@ Kauai Beach Drive	0	820	39	26	2412	0	0	0	0	67	0	17	0	2131	52	51	1187	0	0	0	0	115	0	81
Future Year (2040) + Landfill + RRP	@ 'Ehiku Street	158	703	0	0	1281	89	32	0	138	0	0	0	154	1207	0	0	1139	34	89	0	159	0	0	0
	@ Ma'alo Road	22	497	0	0	1157	17	10	0	12	0	0	0	38	1158	0	0	815	31	37	0	42	0	0	0
	@ Laulima Street	5	441	48	17	1097	16	4	0	4	73	0	56	5	1082	107	20	794	5	9	1	8	44	3	35
	@ Roberts Hawaii Driveway	0	0	0	10	0	1	1	594	0	156	1128	16	0	0	0	9	0	14	3	846	0	0	858	12
	@ Kapule Highway	43	407	0	0	1156	1256	383	0	377	0	0	0	132	1340	0	0	603	737	773	0	82	0	0	0
	@ Kauai Beach Drive	0	832	39	26	2470	0	0	0	0	67	0	17	0	2190	52	51	1197	0	0	0	0	115	0	81

Ma‘alo Road Access Alternative																									
Opening Year Project Trips (Landfill)	@ ‘Ehiku Street		8			8									7			8							
	@ Ma‘alo Road	8					7	7		8				7					5	7		8			
	@ Laulima Street		7			7									7			5							
	@ Roberts Hawaii Driveway								7			7									7			5	
	@ Kapule Highway						7	7											5	7					
	@ Kauai Beach Drive		7			7									7			5							
Opening Year Project Trips (Landfill + RRP)	@ ‘Ehiku Street		80			23									19			80							
	@ Ma‘alo Road	80					65	18		23				19					15	65		80			
	@ Laulima Street		18			65									65			15							
	@ Roberts Hawaii Driveway								18			65									65			15	
	@ Kapule Highway						65	18											15	65					
	@ Kauai Beach Drive		18			65									65			15							
Future Year Project Trips (Landfill)	@ ‘Ehiku Street		10			10									8			10							
	@ Ma‘alo Road	10					9	8		10				8					7	8		10			
	@ Laulima Street		8			9									8			7							
	@ Roberts Hawaii Driveway								8			9									8			7	
	@ Kapule Highway						9	8											7	8					
	@ Kauai Beach Drive		8			9									8			7							
Future Year Project Trips (Landfill + RRP)	@ ‘Ehiku Street		82			24									20			81							
	@ Ma‘alo Road	82					67	20		24				20					17	67		81			
	@ Laulima Street		20			67									67			17							
	@ Roberts Hawaii Driveway								20			67									67			17	
	@ Kapule Highway						67	20											17	67					
	@ Kauai Beach Drive		20			67									67			17							
Opening Year (2020) + Landfill	@ ‘Ehiku Street	62	584	0	0	1058	18	10	0	93	0	0	0	109	996	0	0	942	14	18	0	63	0	0	0
	@ Ma‘alo Road	26	391	0	0	893	21	15	0	18	0	0	0	38	894	0	0	654	31	37	0	43	0	0	0
	@ Laulima Street	4	352	40	14	851	13	3	0	3	60	0	46	4	839	88	16	642	4	8	1	6	36	2	29
	@ Roberts Hawaii Driveway	0	0	0	9	0	1	1	477	0	128	876	13	0	0	0	8	0	12	2	646	0	0	695	10
	@ Kapule Highway	35	333	0	0	948	981	305	0	309	0	0	0	108	1098	0	0	494	596	586	0	68	0	0	0
	@ Kauai Beach Drive	0	673	32	21	1976	0	0	0	0	55	0	14	0	1747	43	42	972	0	0	0	0	94	0	66
Opening Year (2020) + Landfill + RRP	@ ‘Ehiku Street	62	655	0	0	1072	18	10	0	93	0	0	0	109	1008	0	0	1014	14	18	0	63	0	0	0
	@ Ma‘alo Road	98	391	0	0	893	79	27	0	32	0	0	0	50	894	0	0	654	41	95	0	114	0	0	0
	@ Laulima Street	4	364	40	14	909	13	3	0	3	60	0	46	4	897	88	16	652	4	8	1	6	36	2	29
	@ Roberts Hawaii Driveway	0	0	0	9	0	1	1	489	0	128	935	13	0	0	0	8	0	12	2	704	0	0	705	10
	@ Kapule Highway	35	333	0	0	948	1040	317	0	309	0	0	0	108	1098	0	0	494	606	644	0	68	0	0	0
	@ Kauai Beach Drive	0	684	32	21	2035	0	0	0	0	55	0	14	0	1805	43	42	982	0	0	0	0	94	0	66
Future Year (2040) + Landfill	@ ‘Ehiku Street	76	713	0	0	1291	22	12	0	114	0	0	0	133	1216	0	0	1149	17	22	0	77	0	0	0
	@ Ma‘alo Road	33	477	0	0	1090	26	19	0	22	0	0	0	46	1091	0	0	798	38	45	0	52	0	0	0
	@ Laulima Street	5	429	48	17	1038	16	4	0	4	73	0	56	5	1023	107	20	784	5	9	1	8	44	3	35
	@ Roberts Hawaii Driveway	0	0	0	10	0	1	1	582	0	156	1070	16	0	0	0	9	0	14	3	788	0	0	848	12
	@ Kapule Highway	43	407	0	0	1156	1198	372	0	377	0	0	0	132	1340	0	0	603	728	715	0	82	0	0	0
	@ Kauai Beach Drive	0	820	39	26	2412	0	0	0	0	67	0	17	0	2131	52	51	1187	0	0	0	0	115	0	81
Future Year (2040) + Landfill + RRP	@ ‘Ehiku Street	76	784	0	0	1305	22	12	0	114	0	0	0	133	1228	0	0	1221	17	22	0	77	0	0	0
	@ Ma‘alo Road	104	477	0	0	1090	84	30	0	36	0	0	0	58	1091	0	0	798	48	103	0	123	0	0	0
	@ Laulima Street	5	441	48	17	1097	16	4	0	4	73	0	56	5	1082	107	20	794	5	9	1	8	44	3	35
	@ Roberts Hawaii Driveway	0	0	0	10	0	1	1	594	0	156	1128	16	0	0	0	9	0	14	3	846	0	0	858	12
	@ Kapule Highway	43	407	0	0	1156	1256	383	0	377	0	0	0	132	1340	0	0	603	737	773	0	82	0	0	0
	@ Kauai Beach Drive	0	832	39	26	2470	0	0	0	0	67	0	17	0	2190	52	51	1197	0	0	0	0	115	0	81

Laulima Street Access Alternative																									
Opening Year Project Trips (Landfill)	@ ‘Ehiku Street		8			8									7			8							
	@ Ma‘alo Road		8			8									7			8							
	@ Laulima Street	8					7	7		8				7					5	7		8			
	@ Roberts Hawaii Driveway								7			7									7			5	
	@ Kapule Highway						7	7											5	7					
	@ Kauai Beach Drive		7			7									7			5							
Opening Year Project Trips (Landfill + RRP)	@ ‘Ehiku Street		80			23									19			80							
	@ Ma‘alo Road		80			23									19			80							
	@ Laulima Street	80					65	18		23				19					15	65		80			
	@ Roberts Hawaii Driveway								18			65									65			15	
	@ Kapule Highway						65	18											15	65					
	@ Kauai Beach Drive		18			65									65			15							
Future Year Project Trips (Landfill)	@ ‘Ehiku Street		10			10									8			10							
	@ Ma‘alo Road		10			10									8			10							
	@ Laulima Street	10					9	8		10				8					7	8		10			
	@ Roberts Hawaii Driveway								8			9									8			7	
	@ Kapule Highway						9	8											7	8					
	@ Kauai Beach Drive		8			9									8			7							
Future Year Project Trips (Landfill + RRP)	@ ‘Ehiku Street		82			24									20			81							
	@ Ma‘alo Road		82			24									20			81							
	@ Laulima Street	82					67	20		24				20					17	67		81			
	@ Roberts Hawaii Driveway								20			67									67			17	
	@ Kapule Highway						67	20											17	67					
	@ Kauai Beach Drive		20			67									67			17							
Opening Year (2020) + Landfill	@ ‘Ehiku Street	62	584	0	0	1058	18	10	0	93	0	0	0	109	996	0	0	942	14	18	0	63	0	0	0
	@ Ma‘alo Road	18	400	0	0	901	14	9	0	10	0	0	0	31	901	0	0	662	26	30	0	34	0	0	0
	@ Laulima Street	13	345	40	14	844	20	10	0	11	60	0	46	11	832	88	16	637	10	14	1	15	36	2	29
	@ Roberts Hawaii Driveway	0	0	0	9	0	1	1	477	0	128	876	13	0	0	0	8	0	12	2	646	0	0	695	10
	@ Kapule Highway	35	333	0	0	948	981	305	0	309	0	0	0	108	1098	0	0	494	596	586	0	68	0	0	0
	@ Kauai Beach Drive	0	673	32	21	1976	0	0	0	0	55	0	14	0	1747	43	42	972	0	0	0	0	94	0	66
Opening Year (2020) + Landfill + RRP	@ ‘Ehiku Street	62	655	0	0	1072	18	10	0	93	0	0	0	109	1008	0	0	1014	14	18	0	63	0	0	0
	@ Ma‘alo Road	18	471	0	0	916	14	9	0	10	0	0	0	31	913	0	0	734	26	30	0	34	0	0	0
	@ Laulima Street	84	345	40	14	844	78	22	0	26	60	0	46	23	832	88	16	637	20	73	1	86	36	2	29
	@ Roberts Hawaii Driveway	0	0	0	9	0	1	1	489	0	128	935	13	0	0	0	8	0	12	2	704	0	0	705	10
	@ Kapule Highway	35	333	0	0	948	1040	317	0	309	0	0	0	108	1098	0	0	494	606	644	0	68	0	0	0
	@ Kauai Beach Drive	0	684	32	21	2035	0	0	0	0	55	0	14	0	1805	43	42	982	0	0	0	0	94	0	66
Future Year (2040) + Landfill	@ ‘Ehiku Street	76	713	0	0	1291	22	12	0	114	0	0	0	133	1216	0	0	1149	17	22	0	77	0	0	0
	@ Ma‘alo Road	22	488	0	0	1100	17	10	0	12	0	0	0	38	1099	0	0	808	31	37	0	42	0	0	0
	@ Laulima Street	16	421	48	17	1030	24	12	0	14	73	0	56	13	1015	107	20	777	12	17	1	18	44	3	35
	@ Roberts Hawaii Driveway	0	0	0	10	0	1	1	582	0	156	1070	16	0	0	0	9	0	14	3	788	0	0	848	12
	@ Kapule Highway	43	407	0	0	1156	1198	372	0	377	0	0	0	132	1340	0	0	603	728	715	0	82	0	0	0
	@ Kauai Beach Drive	0	820	39	26	2412	0	0	0	0	67	0	17	0	2131	52	51	1187	0	0	0	0	115	0	81
Future Year (2040) + Landfill + RRP	@ ‘Ehiku Street	76	784	0	0	1305	22	12	0	114	0	0	0	133	1228	0	0	1221	17	22	0	77	0	0	0
	@ Ma‘alo Road	22	559	0	0	1114	17	10	0	12	0	0	0	38	1111	0	0	879	31	37	0	42	0	0	0
	@ Laulima Street	87	421	48	17	1030	83	24	0	28	73	0	56	26	1015	107	20	777	22	76	1	89	44	3	35
	@ Roberts Hawaii Driveway	0	0	0	10	0	1	1	594	0	156	1128	16	0	0	0	9	0	14	3	846	0	0	858	12
	@ Kapule Highway	43	407	0	0	1156	1256	383	0	377	0	0	0	132	1340	0	0	603	737	773	0	82	0	0	0
	@ Kauai Beach Drive	0	832	39	26	2470	0	0	0	0	67	0	17	0	2190	52	51	1197	0	0	0	0	115	0	81

Roberts Hawaii Driveway Access Alternative																									
Opening Year Project Trips (Landfill)	@ ‘Ehiku Street		8			8									7			8							
	@ Ma‘alo Road		8			8									7			8							
	@ Laulima Street		8			8									7			8							
	@ Roberts Hawaii Driveway				7		8	8					7				7		8	7					5
	@ Kapule Highway						7	7											5	7					
	@ Kauai Beach Drive		7			7									7			5							
Opening Year Project Trips (Landfill + RRP)	@ ‘Ehiku Street		80			23									19			80							
	@ Ma‘alo Road		80			23									19			80							
	@ Laulima Street		80			23									19			80							
	@ Roberts Hawaii Driveway				18		23	80					65				65		80	19					15
	@ Kapule Highway						65	18											15	65					
	@ Kauai Beach Drive		18			65									65			15							
Future Year Project Trips (Landfill)	@ ‘Ehiku Street		10			10									8			10							
	@ Ma‘alo Road		10			10									8			10							
	@ Laulima Street		10			10									8			10							
	@ Roberts Hawaii Driveway				8		10	10					9				8		10	8					7
	@ Kapule Highway						9	8											7	8					
	@ Kauai Beach Drive		8			9									8			7							
Future Year Project Trips (Landfill + RRP)	@ ‘Ehiku Street		82			24									20			81							
	@ Ma‘alo Road		82			24									20			81							
	@ Laulima Street		82			24									20			81							
	@ Roberts Hawaii Driveway				20		24	82					67				67		81	20					17
	@ Kapule Highway						67	20											17	67					
	@ Kauai Beach Drive		20			67									67			17							
Opening Year (2020) + Landfill	@ ‘Ehiku Street	62	584	0	0	1058	18	10	0	93	0	0	0	109	996	0	0	942	14	18	0	63	0	0	0
	@ Ma‘alo Road	18	400	0	0	901	14	9	0	10	0	0	0	31	901	0	0	662	26	30	0	34	0	0	0
	@ Laulima Street	4	353	40	14	852	13	3	0	3	60	0	46	4	839	88	16	645	4	8	1	6	36	2	29
	@ Roberts Hawaii Driveway	0	0	0	15	0	9	9	471	0	128	870	20	0	0	0	14	0	20	9	639	0	0	689	15
	@ Kapule Highway	35	333	0	0	948	981	305	0	309	0	0	0	108	1098	0	0	494	596	586	0	68	0	0	0
	@ Kauai Beach Drive	0	673	32	21	1976	0	0	0	0	55	0	14	0	1747	43	42	972	0	0	0	0	94	0	66
Opening Year (2020) + Landfill + RRP	@ ‘Ehiku Street	62	655	0	0	1072	18	10	0	93	0	0	0	109	1008	0	0	1014	14	18	0	63	0	0	0
	@ Ma‘alo Road	18	471	0	0	916	14	9	0	10	0	0	0	31	913	0	0	734	26	30	0	34	0	0	0
	@ Laulima Street	4	425	40	14	866	13	3	0	3	60	0	46	4	851	88	16	717	4	8	1	6	36	2	29
	@ Roberts Hawaii Driveway	0	0	0	27	0	24	81	471	0	128	870	78	0	0	0	73	0	92	21	639	0	0	689	25
	@ Kapule Highway	35	333	0	0	948	1040	317	0	309	0	0	0	108	1098	0	0	494	606	644	0	68	0	0	0
	@ Kauai Beach Drive	0	684	32	21	2035	0	0	0	0	55	0	14	0	1805	43	42	982	0	0	0	0	94	0	66
Future Year (2040) + Landfill	@ ‘Ehiku Street	76	713	0	0	1291	22	12	0	114	0	0	0	133	1216	0	0	1149	17	22	0	77	0	0	0
	@ Ma‘alo Road	22	488	0	0	1100	17	10	0	12	0	0	0	38	1099	0	0	808	31	37	0	42	0	0	0
	@ Laulima Street	5	432	48	17	1039	16	4	0	4	73	0	56	5	1023	107	20	787	5	9	1	8	44	3	35
	@ Roberts Hawaii Driveway	0	0	0	19	0	11	12	574	0	156	1061	24	0	0	0	17	0	24	11	780	0	0	841	19
	@ Kapule Highway	43	407	0	0	1156	1198	372	0	377	0	0	0	132	1340	0	0	603	728	715	0	82	0	0	0
	@ Kauai Beach Drive	0	820	39	26	2412	0	0	0	0	67	0	17	0	2131	52	51	1187	0	0	0	0	115	0	81
Future Year (2040) + Landfill + RRP	@ ‘Ehiku Street	76	784	0	0	1305	22	12	0	114	0	0	0	133	1228	0	0	1221	17	22	0	77	0	0	0
	@ Ma‘alo Road	22	559	0	0	1114	17	10	0	12	0	0	0	38	1111	0	0	879	31	37	0	42	0	0	0
	@ Laulima Street	5	503	48	17	1054	16	4	0	4	73	0	56	5	1036	107	20	858	5	9	1	8	44	3	35
	@ Roberts Hawaii Driveway	0	0	0	30	0	26	83	574	0	156	1061	83	0	0	0	76	0	96	23	780	0	0	841	28
	@ Kapule Highway	43	407	0	0	1156	1256	383	0	377	0	0	0	132	1340	0	0	603	737	773	0	82	0	0	0
	@ Kauai Beach Drive	0	832	39	26	2470	0	0	0	0	67	0	17	0	2190	52	51	1197	0	0	0	0	115	0	81

Kauai Beach Drive Access Alternative																									
Opening Year Project Trips (Landfill)	@ ‘Ehiku Street		8			8								7			8								
	@ Ma‘alo Road		8			8								7			8								
	@ Laulima Street		8			8								7			8								
	@ Roberts Hawaii Driveway								8			8								7				8	
	@ Kapule Highway						8	8										8	7						
	@ Kauai Beach Drive	8					7	7		8				7				5	7		8				
Opening Year Project Trips (Landfill + RRP)	@ ‘Ehiku Street		80			23								19			80								
	@ Ma‘alo Road		80			23								19			80								
	@ Laulima Street		80			23								19			80								
	@ Roberts Hawaii Driveway								80			23								19				80	
	@ Kapule Highway						23	80										80	19						
	@ Kauai Beach Drive	80					65	18		23				19				15	65		80				
Future Year Project Trips (Landfill)	@ ‘Ehiku Street		10			10								8			10								
	@ Ma‘alo Road		10			10								8			10								
	@ Laulima Street		10			10								8			10								
	@ Roberts Hawaii Driveway								10			10								8				10	
	@ Kapule Highway						10	10										10	8						
	@ Kauai Beach Drive	10					9	8		10				8				7	8		10				
Future Year Project Trips (Landfill + RRP)	@ ‘Ehiku Street		82			24								20			81								
	@ Ma‘alo Road		82			24								20			81								
	@ Laulima Street		82			24								20			81								
	@ Roberts Hawaii Driveway								82			24								20				81	
	@ Kapule Highway						24	82										81	20						
	@ Kauai Beach Drive	82					67	20		24				20				17	67		81				
Opening Year (2020) + Landfill	@ ‘Ehiku Street	62	584	0	0	1058	18	10	0	93	0	0	0	109	996	0	0	942	14	18	0	63	0	0	0
	@ Ma‘alo Road	18	400	0	0	901	14	9	0	10	0	0	0	31	901	0	0	662	26	30	0	34	0	0	0
	@ Laulima Street	4	353	40	14	852	13	3	0	3	60	0	46	4	839	88	16	645	4	8	1	6	36	2	29
	@ Roberts Hawaii Driveway	0	0	0	9	0	1	1	479	0	128	878	13	0	0	0	8	0	12	2	646	0	0	698	10
	@ Kapule Highway	35	333	0	0	948	983	306	0	309	0	0	0	108	1098	0	0	494	599	586	0	68	0	0	0
	@ Kauai Beach Drive	8	666	32	21	1970	7	7	0	8	55	0	14	7	1740	43	42	967	5	7	0	8	94	0	66
Opening Year (2020) + Landfill + RRP	@ ‘Ehiku Street	62	655	0	0	1072	18	10	0	93	0	0	0	109	1008	0	0	1014	14	18	0	63	0	0	0
	@ Ma‘alo Road	18	471	0	0	916	14	9	0	10	0	0	0	31	913	0	0	734	26	30	0	34	0	0	0
	@ Laulima Street	4	425	40	14	866	13	3	0	3	60	0	46	4	851	88	16	717	4	8	1	6	36	2	29
	@ Roberts Hawaii Driveway	0	0	0	9	0	1	1	550	0	128	892	13	0	0	0	8	0	12	2	658	0	0	769	10
	@ Kapule Highway	35	333	0	0	948	997	378	0	309	0	0	0	108	1098	0	0	494	670	598	0	68	0	0	0
	@ Kauai Beach Drive	80	666	32	21	1970	65	18	0	23	55	0	14	19	1740	43	42	967	15	65	0	80	94	0	66
Future Year (2040) + Landfill	@ ‘Ehiku Street	76	713	0	0	1291	22	12	0	114	0	0	0	133	1216	0	0	1149	17	22	0	77	0	0	0
	@ Ma‘alo Road	22	488	0	0	1100	17	10	0	12	0	0	0	38	1099	0	0	808	31	37	0	42	0	0	0
	@ Laulima Street	5	432	48	17	1039	16	4	0	4	73	0	56	5	1023	107	20	787	5	9	1	8	44	3	35
	@ Roberts Hawaii Driveway	0	0	0	10	0	1	1	585	0	156	1071	16	0	0	0	9	0	14	3	788	0	0	851	12
	@ Kapule Highway	43	407	0	0	1156	1199	374	0	377	0	0	0	132	1340	0	0	603	731	715	0	82	0	0	0
	@ Kauai Beach Drive	10	812	39	26	2403	9	8	0	10	67	0	17	8	2123	52	51	1180	7	8	0	10	115	0	81
Future Year (2040) + Landfill + RRP	@ ‘Ehiku Street	76	784	0	0	1305	22	12	0	114	0	0	0	133	1228	0	0	1221	17	22	0	77	0	0	0
	@ Ma‘alo Road	22	559	0	0	1114	17	10	0	12	0	0	0	38	1111	0	0	879	31	37	0	42	0	0	0
	@ Laulima Street	5	503	48	17	1054	16	4	0	4	73	0	56	5	1036	107	20	858	5	9	1	8	44	3	35
	@ Roberts Hawaii Driveway	0	0	0	10	0	1	1	656	0	156	1085	16	0	0	0	9	0	14	3	800	0	0	923	12
	@ Kapule Highway	43	407	0	0	1156	1213	446	0	377	0	0	0	132	1340	0	0	603	802	727	0	82	0	0	0
	@ Kauai Beach Drive	82	812	39	26	2403	67	20	0	24	67	0	17	20	2123	52	51	1180	17	67	0	81	115	0	81

Appendix B:
Intersection Level of Service Calculations and MUTCD Traffic Signal Warrants (available under separate cover)

Appendix C:
Social Impacts Assessment Supporting Information

Appendix C.1:
Summary of TREFS Public Meeting
King Kaumualiʻi School Cafeteria, Hanamāʻulu
January 16, 2014

Subject: Summary of TREFS Public Meeting

Presenters: Consultants: Frank Cioffi, Wayne Yoshioka, Brian Takeda, Jim Dannemiller
County of Kaua‘i: Mayor Bernard Carvalho, Larry Dill, Donald Fujimoto, Troy Tanigawa, Nadine Nakamura, Beth Tokioka

Attendees: At start: 39.[1] Total signed in by meeting's end: 54.

Following is a summary of the TREFS Community Meeting held January 16, 2014, at the King Kaumuali‘i Elementary in Hanamā‘ulu, Kaua‘i, to discuss potential new landfill and resource recovery park access route alternatives. Comments and responses are not directly quoted. Comments relevant to the access route choice are summarized at the end of this document.

MEETING SUMMARY

Opening Remarks: Donald Fujimoto opened the meeting at 6:10 pm and introduced Mayor Carvalho. The Mayor thanked everyone for attending and asked that even if parties might disagree on the issues that everyone make every effort to listen to and respect each other's opinions.

Frank Cioffi next presented the project's Traffic and Roadways Engineering Feasibility Study (TREFS). Wayne Yoshioka provided additional information on study details involving traffic and infrastructure. Jim Dannemiller discussed the results of interviews from area residents on social issues associated with each of the access road alternatives.

Frank Cioffi provided a follow-up summary on the purpose and reason for the TREFS Study and this public meeting and accepted public comments starting at approximately 6:35 pm.

Respondent (R): A Clarification: On Wayne's numbers especially the Traffic Assessment, referencing the Level of Services table: what do those numbers measure? Answer (A): (Wayne) The numbers are "delay in seconds", the average delay at a specific intersection, for the worst approach route. Laulima's 161 seconds might be considered very high.

The resident continued: Did you look at roundabouts or left turn only options, any options other than signalization? A: AECOM did look at roundabouts. Roundabouts require a lot of right of way and in Laulima you don't have room for it. Having no left turns means trucks can only turn in from the right turn. Frank reinforced need for real estate.

R: Do you guys still have the bypass road as an alternative access road? We used to talk about that (in previous discussions of landfill at Ma‘alo). You'd take most of these problems away if you just used the bypass road. Respondent noted that the four routes discussed here are similar to some bypass road routes that have been seen or discussed in the last several months. A: (Larry Dill) The bypass road was part of this (discussion of a landfill at Ma‘alo) in the past. But from a traffic engineering point of view, it is not necessary to include the bypass road in the landfill project, due to the availability of alternative access routes. The bypass road is still on the table and being considered, but not as part of the landfill project.

[1] Attendance was largely local residents. Seven participants identified themselves as members or as representing an organization or association and three signed in as representatives of government agencies. The other 30 were residents of Hanamā‘ulu, including several members of the Hanamā‘ulu Community Association. At one point, a participant stated that she had alerted every household living along Laukona Street and asked them to attend. During the meeting, several persons identified themselves as residents of Laukona Street.

R: So is this a temporary solution we are working on? A: (Larry Dill) The connections in Hanamā‘ulu and Lihue, would be needed now to access the site.

R: Seems like the bypass road is a win-win-win for all of this. So right now, this is temporary, right? A: (Larry Dill) What’s being done here works neatly with the bypass road project.

R: The draft impact (EIS) has not been released. Kekaha is dry, Ma‘alo is wet, and you are spending all this money. R continued with a formal statement against locating a landfill (see attached), and then left the premises.

R: I’d like to pick up again on the bypass road. It should be an alternative to all of these options. For several reasons it is better than any of these options. I wonder if the Isenberg people have been notified of this major change in the project. Have they been contacted? The bypass road was the original proposal (as the access route) when this landfill site was first presented to this community, and it must be included in the package. Otherwise, you are opening up for delays for not looking at all the alternatives. We are under a lot of stress to meet the deadline and if you don’t look at all the alternatives, you will get sued. And this is not a separate part of the landfill. The bypass road was part of that presentation and this (the routes presented tonight) is a change. It has to be considered. A: (Frank Cioffi) We agree that the choice of access route is part of the overall landfill project, and it will be addressed in the EIS. R: The bypass road takes the trucks out before they get to Hanamā‘ulu Road at all, the bypass road is the solution to this problem.

R: (Laukona Street resident) Regarding the bypass road, routes C and D affect Kalepa Village. Laukona Street affects 50-60 homes and nobody has been informed about the landfill. The people in Isenberg will all be affected. I live on Laukona Street. My property is going to be worthless. My property is going to be on the road to the dump. They haven’t contacted one person on those two roads.

A: The County has notified the Kaua‘i residents through several media.

R: How many trucks will there be. A: (Frank) Those numbers in the report, which is available for anyone to download from the County website.

R: I walk down Laukona Street to the bus and additional traffic on Laukona would not be safe. Are they going to let the bus come up to my house to pick me up? A: Laukona Street is not a potential access route; two of the potential access routes pass *behind* some of the properties on Laukona.

R: The question about numbers (traffic counts) seems important and needs to be available. A: (Wayne) Agreed. The material is available on the County website now.

R: Three of the four routes (B, C, and D) all go past residential areas. Takes me back to the haul cane days. Trucks went by all the time. Trade winds blew the dust. We are downwind of the landfill site now. I was born and raised in Kapaia Valley. I live in Laukona, right across the mountain. When you talk about haul cane trucks, there used to be 50 trucks a day. Dust pollution was really bad. We already had that problem with haul cane trucks. Ma‘alo road is the only way to go to get there. The prevailing trade winds are going to bring everything down through the Kapaia Valley.

R: The EIS is not done and the total project isn’t, either. Shouldn’t you do the EIS before you get public comment? A: (Frank) We are trying to get public input before we complete the Draft EIS, because the County wants to consider public concerns now, during early planning. There will be another comment period after the Draft EIS is published.

R: To clarify, these meetings are preliminary, before the draft EIS, right? A: (Frank) Yes.

R: When you measured truck traffic for various routes; on route B, would that include traffic already on there for the power plant fuel trucks? R: (Frank) Yes.

R: (JoAnn Yukimura): This (a location on the map) is an “alternate RRP site”. Alternate to what? A: (Frank) The other alternative is to have the RRP on the proposed landfill site. The EIS will evaluate both alternative locations for the RRP. R: So, how much traffic will be generated by that? Do you have numbers? A: (Frank) Those numbers are in the report. R: So you have estimated separate costs for landfill and RRP? A: (Frank) Yes. R: Will you have traffic figures for the bypass road, too? A: (Wayne) Briefly explains what numbers appear in the report. R: Are we projecting traffic for By-Pass all the way to Puhi? R: (Wayne) What we have in the report is consistent with bypass road traffic, but this analysis did not look at the bypass road. A: (Larry Dill) The By-Pass road project would include its own analysis and a separate set of community meetings to study the impacts of that issue.

R: If you get us to OK the bypass road now, we won’t get to decide on it later. You’re using this to get the bypass road through.

R: I have lived in Hanamāʻulu all my life. I understand about wind. I always catch the breeze from Kalepa Ridge. Will the wind be affected? I already catch dust coming down from the mountain. If you put trucks up there, what happens? Just want to make sure it’s a good site for trash near Laukona. Most of the people on Laukona are elderly and have no access to computers. How they supposed to know this is going on?

R: Why don't we get the bypass done first and then do this? If we are going to do this, we might as well do it well. My Dad drove cane trucks his whole life. Let me run the trucks behind your back yard and see how you would like it.

R: Problem is why put a landfill near Līhuʻe? It’s going to make the whole town smell. I live on Laukona. It’s 100 yards from my house to the road. Used to get all the dust from the haul cane trucks and the noise. I remember.

R: One other thing about the current landfill. The site is 1.5 miles away and the people say they can hear the trucks when they go by. Can get the smell from the trucks.

R: Why is this on our side? When the stuff starts breaking down, and the stuff gets in the water, and then our kids get sick, who’s going to guarantee nothing will happen? A: (Frank) There are safeguards in place for all landfill operations. In Hawaiʻi, the Department of Health oversees landfill operations and monitors operations over and past the life of the landfill. R: I live on Laukona and my kids play on the cane haul roads. That’s their playground. I don’t think it should be there.

R: Three of the four routes are near residential areas. We should use the other one. Do we have a plan for mitigation? A: (Frank) The purpose of this meeting is to identify concerns. We can then look at options to mitigate noise, dust, and other concerns.

R: So what about the smell? You can smell the landfill from far away.

R: Again. I worked at the landfill for five years. Does anybody besides me remember the wet years? What it’s like when the wet years come? Kekaha is in the driest and flattest site on the island. The biggest problem for landfill is floods. If a flood comes there is nothing we can do. It washes everything down with it. When I worked there, there was one storm in December and the guys who were working the landfill were supposed to build spillways but they didn’t and it flooded the landfill, the scale house, the road. This is in Kekaha in the driest part of the island. The siting of any landfill in a wet area is very dangerous.

R: You used existing roads. Did you look at any other routes? For instance, you could come up Ma‘alo Road to where it intersects ‘Ehiku and then turn right along an old cane road to driveway three. Have you looked at that route? It would eliminate some of Ma‘alo and not go near anyone’s residential property.

R: Where is the funding coming from? A: (Larry Dill) Many funding vehicles are being considered. We have not made that choice yet. We will come to Council when we have more information.

R: Well folks, I was born and raised here, worked for Līhu‘e plantation 24 years. My Dad, my grandfathers worked hard on that plantation. I was an irrigation overseer for 24 years. Started 1950. I know about rainfall. Yes, storms came through and right where the trash area[2] is now there’s a reservoir. In 1950 we got tremendous storms. Reservoirs couldn’t take the water. The dam broke and water went down to Hanamā‘ulu Beach and luckily nobody got killed. Looking at the site, I changed my mind. I don’t want um there. Change the site. A: (Frank) I wasn’t going to address the previous comment about the potential for floods, as it doesn’t relate to the roadway alternatives, but we are looking at the potential for surface water impacts and other issues in the overall EIS. The site is not located in a flood zone. In fact, on closer look at the site (referring to figure), you can see that the existing topography actually diverts flow from most of the watershed away from the site, down to the Okinawa reservoir and away from the site. Additionally, a surface water control system would be developed for the site, including diverting any offsite flows from run-on, and managing site runoff.

R: So you will get the EIS. And it will get you a probability of a major flood happening. What are you going to compare it too? A: (Brian Takeda) We are looking at many different types of landfill operations and methods other than landfill.

R: Why aren’t we looking at access roads to the other sites? A: (Frank) The County is responding to comments that people were concerned about the access road to Ma‘alo. R: But how can we decide among the alternatives if we don’t see any access roads to the other sites? Why are we not looking at roads getting to the other sites? A: Access roads for the other potential sites were analyzed in the 2012 Siting Study report, which you can download from the County website.

R: (Joann Yukimura) Isn’t it true that the site selection study has been completed and you chose Ma‘alo, and are now asking about access roads to Ma‘alo, the site that was chosen? People want you to make that clear. A: (Wayne) Yes, that’s true. Ma‘alo is the proposed site.

R: Isn’t it true also that you could look at a zero waste solid waste plan? Are you looking at alternative methods? A: (Frank) Yes we are. R: Are you looking at zero waste as an alternative? A: We can look at that.

R: I find it really interesting. Why don’t they put it in Princeville? (Laughter from crowd.) I want to know why that’s funny. It’s OK to put it in place where there are ten or twelve people on a property but not where there are lots of wealthy people. And it’s also true that we are getting the rehab facility. These are working people. This is a safe neighborhood, a peaceful, quiet, safe place. And I am concerned that the county doesn’t care about this community and they are going to out the landfill, the dump because that’s what it is, in our community. A: (Brian Takeda) Please refer to previous siting efforts, including the Siting Study Report for an explanation why this Ma‘alo is the proposed site (discusses the methods used to evaluate potential sites). The decision criteria can be seen in the report – I can assure you that nobody ever considered whether they would rather place a landfill near one type of community or another.

[2] R was referring to the landfill site.

R: But why not put it somewhere where it does not affect the community. My house is going to be worth nothing. Hanamā‘ulu has changed. It is now a place that is affordable, if you put the dump there, all of us are living on the road to the dump. With a rehab facility on the same road. They are making it worse. You’d think the County would be in favor of lifting everybody up. I just don’t get it.

R: If the project moves forward in the community, when is there a discussion about our community benefits package. A: (Mayor Carvalho) The whole community needs a landfill. Nobody wants a landfill. It’s a tough decision. All you can do is play by the rules. I’m hoping that we are faithfully following the process before us and that you are included every step of the way. We have tried our very best to follow the process. There is a host community benefits package. We need to see what the benefits will be. Because you would be the hosts of the landfill in this beautiful community, those benefits would go to you. Tonight is about the access roads. There’s much more to come, many decisions to be made. I really appreciate the discussion.

R: Considering the rain: If you follow Ma‘alo Road all the way to the falls, the lowest part of that road is (did not understand the location referenced). If for some reason we got rain to flood that whole basin, the water would come down on the left side of Immaculate Conception Church and anything below that would be flooded, damaged.

R: About the flood. Here in Laukona, a couple months ago, the ditch by the cane haul road flooded and dumped water into people’s back yards. Just regular rain now. Most of the time when it rains you have brown water always running to the highway, down the middle of Laukona Street.

R: (JoAnn Yukimura) Part of the problem with choosing the site was that you chose it before you planned the access roads, and now you find you didn’t look at the access roads and now you’re coming to the community to get input. A: (Donald Fujimoto) That is not true; access roads were considered, and continue to be.

R: You owe it to the community to consider all the alternatives. If this landfill was accepted based on access through Ma‘alo Road, how can you come back to us now? A: (Wayne) We found out from the community that they were concerned about the access road and they wanted us to consider some options. The County is trying to be responsive to public concerns.

R: Ma‘alo Road is the only road that could work.

R: Clarification about access. I went on the county tour of the site. We did go down the Ma‘alo Road. Is your route A that route? A: (Frank) Yes, I was on the bus that day we went to the proposed site. R: If ‘Ehiku Street was considered, does that include realignment of Aukina Street. A: (Frank) No, that's part of the long-range plan.

R: So Ma‘alo site is basically the go-to site? It is the proposed site. If that falls through, you start all over again, right? A: (Frank) Yes, Ma‘alo is the proposed site.

R: I am concerned about the site. But I agree that if it becomes a site, Laulima Street would be the best route. We’re trying to see how we can fund it, too. I think cost is more important than some of the other issues. And the traffic light would be good. Right now all our traffic lights are affected by storms or even heavy rain. Having a signal light there would be good.

R: I know the flooding issue is important, but the shorter routes that are closer to residential areas are easier to swallow. It’s becoming our back yards. You don’t necessarily smell the dump you smell the trucks. I wish the bypass road were being considered.

R: Comment. We want everybody to know and to be kept abreast. I sign in, give my contact information, and we never get told when the next meeting is. Where do these names and information

go? And we never hear from anyone again. The County has done a very poor job over the years. It's so easy by computer. One button and hundreds of people have been notified. This list should all be notified of workshops, etc. People who attended the Isenberg tracts meeting about the drug rehab study could have been notified about this meeting. A: We can make sure to follow up with those who signed in and left a means of contact.

There being no more questions or comments related to the access routes, Donald Fujimoto called the meeting to a close at 8:35 pm.

Mayor Carvalho thanked the participants for attending and promised that further information on the project will be forthcoming.

SUMMARY OF COMMENTS REGARDING ACCESS ROUTE ALTERNATIVES

Many of the comments did not pertain to the access route alternatives. All of the consolidated comments below referenced the access roads and/or driveways. Some of these comments were echoed by more than one respondent, and worded slightly differently.

1. Several attendees stated that Route A was the best route, primarily because it does not pass near residential areas.
2. Several attendees were concerned with negative impact of truck traffic affecting residents along 'Ehiku Street if Route B were implemented.
3. Several attendees indicated that Routes C and D would have a negative impact on property values along Laukona Street.
4. Several attendees indicated that Routes C and D would have a negative impact on dust, odor, and noise along Laukona Street.
5. It was stated that Laukona Street already floods (receives large amounts of brown water runoff) due to breakdown or blockage of the ditch next to the cane haul road suggested as part of Routes C & D. Accordingly, Several attendees indicated that Routes C and D would have a negative impact on excessive runoff or floods along Laukona Street.
6. One person stated that Route C would have a negative impact on residents of Kalepa Village.
7. Several attendees indicated that Route C would cost the County the least, is the most direct, and is therefore the best alternative. Also, it was noted that improvements at the Laulima-Kūhiō interchange (the traffic light) would be a benefit.
8. One person stated that Routes C and D would have a negative impact on residents of Kalepa Village.

List of Signed-in Meeting Attendees

Access Road Alternatives for the Proposed New Kaua‘i Landfill & Resource Recovery Park
Traffic & Roadways Engineering Feasibility Study (TREFS)

Community Meeting
King Kaumuali‘i Elementary School, Hanamā‘ulu, Kaua‘i

Thursday, January 16, 2014, 6:00 pm to 8:00 pm

Name		Organization (if any)	Contact info
1	Jerry Ornellas	KCFB	jerryo@hawaii.edu
2	Michael Wong		
3	Joe Bunao	Self	joebunao@msn.com
4	Ken Taylor	Self	taylork021@hawaii.rr.com
5	K. Horide		
6	Glen Mukein	Self	glenruth2030@gmail.com
7	Basilia Asuncion	Self	
8	Consolacion Manera	Self	
9	Yudare T.Y. Hirano	Self	
10	Bernard Bernardo	Self	trdbb@hotmail.com
11	Wendy Raebeck	Self	wendywailua@gmail.com
12	Deane & Joaquina Alahem	Self	651-0212
13	Keola Aki	Self/SW	kreaki@gmail.com
14	Tito Villaneueva	Self	tito.villanueva@amr.net
15	Florentino Duterte	H.A.	
16	Dennis Sareta	UPW Release	
17	Roy K. Sasaki	Kaua‘i Island Ministries	kahurocky@yahoo.com
18	Chad Corpuz		808-482-1970
19	Keith Suga	County of Kaua‘i	
20	D. Kaliko Santos	OHA Kaua‘i	kalikos@oha.org
21	Pat Gegen	Zero Waste Kaua‘i	psgegen@hotmail.com
22	Laurie Kelekoma	Hanamā‘ulu Community Assn.	lauriekelekoma@hotmail.com
23	Juanito Gonzalez	Hanamā‘ulu	808-245-2473
24	Ricky Banquel	None	Hanamā‘ulu
25	William Buddingh		buddingh@hawaiiantel.net
26	Theresa Koki	County	tkokie@Kaua‘i.gov

Name		Organization (if any)	Contact info
27	William Neil Rapozo	Hanamā‘ulu Community Assn.	nrapozo@hawaiiantel.net
28	Mildred Rapozo	Hanamā‘ulu	
29	Dario Sirioroko	State	
30	Jonathan Corbillon	None	None
31	Jyden Wong	None	None
32	Javen Wong	None	None
33	Shanice Sanay	None	None
34	Jetta Wong	None	None
35	Larry Dill	County of Kaua‘i	
36	Michael V. Layota	None	808-651-8168
37	Shawn de Mille		surfpakalas@hotmail.com
38	Regina Carvalho	Community Member	
39	Eddie Sarita	Hanamā‘ulu Community Assn.	esarita2011@live.com
40	Nadine Nakamura	County of Kaua‘i	
41	Pauline Kulsch	None	808-652-9807
42	Gene Costa	None	808-554-5979
43	Ted Juarnge		808-245-3027
44	Rayne Regush	Sierra Club	808-651-1318
45	Bryson Vivas	County of Kaua‘i	
46	Clara Nuiwa		808-245-3947
47	Geraldine Duarte	None	808-246-6065
48	Cheryl Soon	SSFM	808-356-1268
49	JoAnn Yukimura	Council	808-652-3988
50	Bonnie Bator	‘Ohana	808-822-5547
51	Kami Kearnsam	‘Ohana	808-639-8628
52	Peter Kepo	Hanamā‘ulu Sr. Softball	808-482-1461
53	Hank Ibia	Hanamā‘ulu	808-652-5221
54	Wanda Shibata	Gov Office	808-374-3100

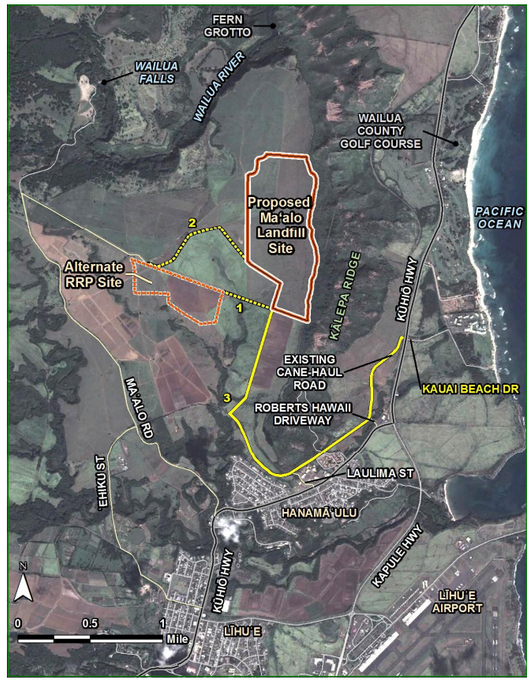
Appendix C.2:
Access Routes
Fact Sheet and Public Comment Sheet

Access Route E: Kaua‘i Beach Drive Access — Length: 2.9 miles

Route E begins at the Kūhiō Highway intersection with Kaua‘i Beach Drive. The route runs along an existing cane haul road to Roberts Hawaii Driveway, from where the route is identical to Route D.

The following improvements would be recommended for Route E:

- Modify the highway intersection and install a traffic signal synchronized with the one at the nearby Kupule Hwy / Kūhiō Hwy intersection
- Widen and pave Kaua‘i Beach Drive and the existing cane haul roads
- Estimated cost for roadway improvements: **$17.3 million** (plus $5.4–$6.8 million if the Alternate RRP site is implemented)



Community Meeting:

Access Road Alternatives for the Proposed New Municipal Solid Waste Landfill and Resource Recovery Park

The County of Kaua‘i Department of Public Works, Solid Waste Division, will host a community meeting to present the preliminary findings of a feasibility study conducted to evaluate potential access roads for the proposed New Municipal Solid Waste Landfill and Resource Recovery Park, which are being evaluated in a State of Hawai‘i Environmental Impact Statement (EIS).

The goal of the meeting is to present the preliminary traffic and engineering findings for the potential access routes, and to obtain public comments and concerns regarding the potential access route alternatives.

Meeting is from 6:00 pm to 8:00 pm on the following date and location:

Thursday, September 22, 2016
King Kaumuali‘i Elementary
Hanamā‘ulu, Kaua‘i

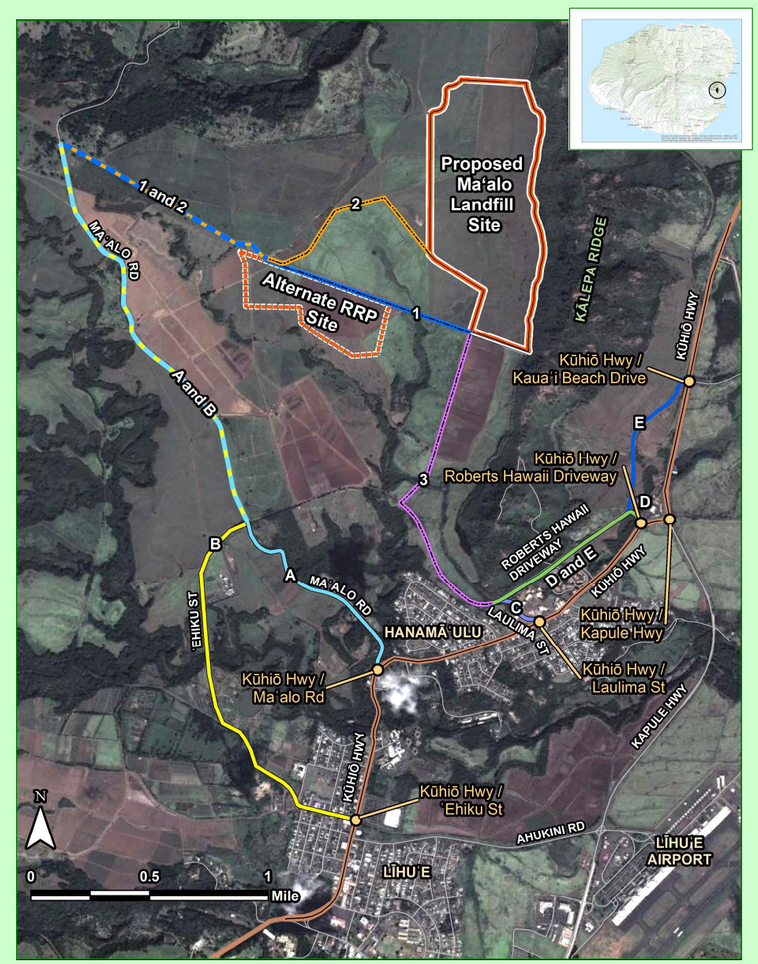
Access Routes Fact Sheet

September 2016

The Proposed New Municipal Solid Waste Landfill and Resource Recovery Park at Ma‘alo, Kaua‘i

The County of Kaua‘i proposes to establish a new municipal solid waste landfill at Ma‘alo, a 280-acre parcel of grass and pasture land located between Līhu‘e and Wailua. More than 100,000 tons of municipal solid waste are generated on Kaua‘i each year, and the County’s only existing landfill at Kekaha is reaching capacity and needs to be closed.

To help select the best route for landfill vehicles to use between the Proposed Landfill site and Kūhiō Highway, the County is conducting a *Traffic and Roadways Engineering Feasibility Study* (TREFS) and requesting public input and comments. The study assesses traffic impacts, required roadway improvements, and social impacts for five potential access routes (A, B, C, D, E).



To better assess the social impacts of vehicles using any one of the potential routes to access the Proposed Landfill and Resource Recovery Park, the County seeks more input from residents, businesses, and property owners.

This fact sheet presents an overview of the five potential routes so you can be better informed when completing the enclosed public comment sheet.

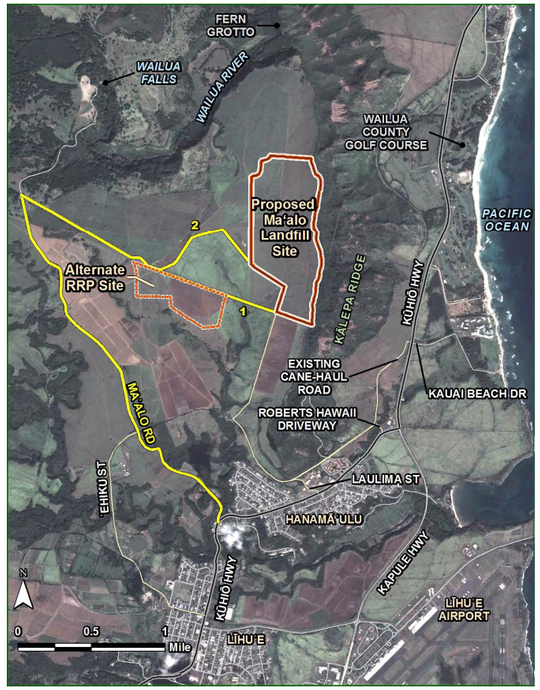
Thank you for your input.

Access Route A: Ma‘alo Road — Length: 4.7–4.8 miles

Route A follows Ma‘alo Road from its Kūhiō Highway junction for 1.8 miles to an intersection with an existing cane haul road; after 1 mile the route would either continue straight for another 1 mile directly to the Proposed Landfill site (Driveway 1), or detour slightly north to avoid a wetland (Driveway 2).

The following improvements would be recommended for Route A:

- Modify the highway intersection; install a traffic signal when conditions warrant
- Widen a small bridge and straighten a sharp curve on Ma‘alo Road
- Widen and repave Ma‘alo Road; widen and pave the cane haul roads; provide utilities
- Estimated cost for roadway improvements: **$41.4–$42.9 million**

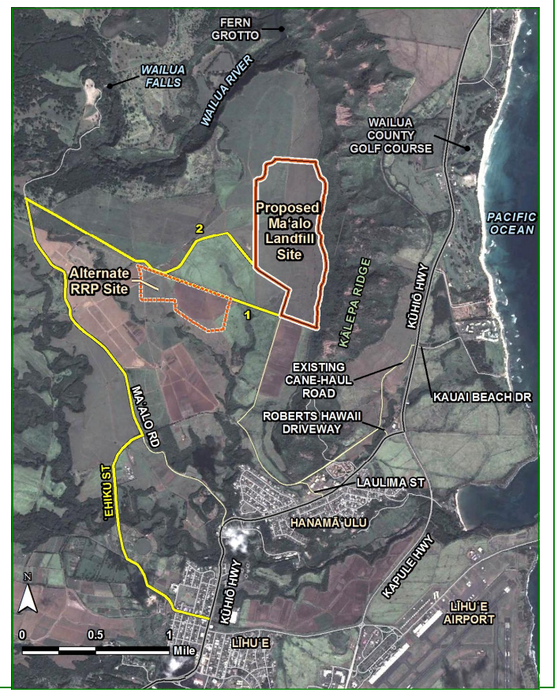


Access Route B: ‘Ehiku Street — Length: 5.6–5.7 miles

Route B follows ‘Ehiku Street from its Kūhiō Highway junction past the Isenberg neighborhood of Līhu‘e and continues to the junction at Ma‘alo Road. From there, the route to the Proposed Landfill site is the same as Route A (using either Driveway 1 or Driveway 2).

The following improvements would be recommended for Route B:

- Modify the highway intersection and signal operation; upgrade pedestrian facilities
- Modify the intersection of ‘Ehiku Street and Ma‘alo Road
- Reconstruct a large culvert under ‘Ehiku Road
- Widen & repave ‘Ehiku Street & Ma‘alo Road; widen and pave cane haul roads; provide utilities
- Estimated cost for roadway improvements: **$41.9–$43.3 million**

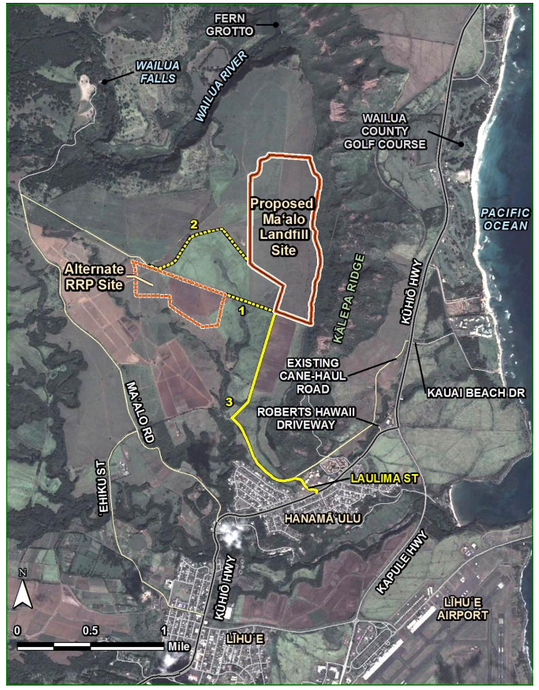


Access Route C: Laulima Street — Length: 1.7 miles

Route C follows Laulima Street from its Kūhiō Highway junction to a nearby cane haul road (Driveway 3), where it runs behind Hanamā‘ulu’s Laukona Street before continuing north to the Proposed Landfill site.
If the Alternate RRP site is implemented, a portion of Driveway 1 or 2 would also be developed.

The following improvements would be recommended for Route C:

- Modify the highway intersection and install a traffic signal (recommended in the future regardless)
- Widen and repave Laulima Street; widen and pave the cane haul roads
- Estimated cost for roadway improvements: **$12.8 million** (plus $5.4–$6.8 million if Alternate RRP site is implemented)

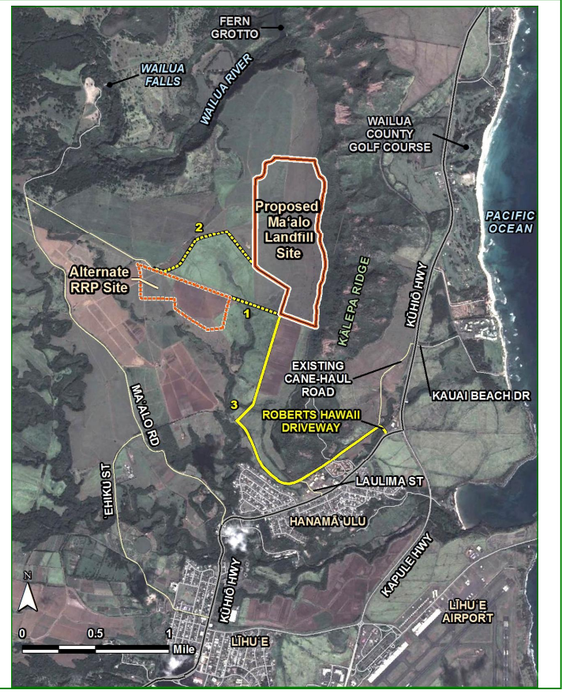


Access Route D: Roberts Hawaii Driveway — Length: 2.2 miles

Route D begins at the driveway at the Roberts Hawaii depot on Kūhiō Highway and follows an existing cane-haul road to Driveway 3 and the Proposed site. If the Alternate RRP site is implemented, a portion of Driveway 1 or 2 would also be developed.

The following improvements would be recommended for Route D:

- Modify the highway intersection and install a traffic signal synchronized with the one at the nearby Kupule Hwy / Kūhiō Hwy intersection
- Widen and pave Roberts Hawaii Driveway and the cane haul roads
- Estimated cost for roadway improvements: **$14.6 million** (plus $5.4–$6.8 million if Alternate RRP site is implemented)



Access Route E: KAUAʻI BEACH DRIVE

(E1) **Advantages for Access Route E:**

(E2) **Disadvantages for Access Route E:**

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kauaʻi [Zipcode or Community: _____]
2. On the island of Niʻihau
3. On another island in Hawaiʻi
4. Outside the State

If you would like to receive feedback on the results of this survey, please provide your contact information (postal or email address) below. All contact items are voluntary.

Name and Address:

e-mail address:

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ACCESS ROUTES PUBLIC COMMENT SHEET

Proposed New Municipal Solid Waste Landfill and Resource Recovery Park at Maʻalo, Kauaʻi

BACKGROUND INFORMATION

The enclosed **Fact Sheet** describes the potential Access Routes A, B, C, D, and E, and summarizes the preliminary results of the **REVISED DRAFT TRAFFIC AND ROADWAYS ENGINEERING FEASIBILITY STUDY (TREFS).** Further details of the potential access routes are provided in the Revised Draft TREFS report, available on the County of Kauaʻi's New Landfill website: **www.kauai.gov/NewLandfillSite**

For each route, the TREFS report provides detailed analysis of existing and projected traffic conditions and impacts; recommended improvements and associated cost estimates; and a preliminary evaluation of the potential social impacts.

PUBLIC OUTREACH

This public outreach is being conducted in response to public concerns regarding the access routes expressed during meetings held for the ongoing project Environmental Impacts Statement (EIS) process. The County is committed to soliciting and considering all reasonable public concerns regarding the potential access routes. No final decision regarding the proposed access route has been made, and the proposed access route will be further analyzed during the ongoing EIS process. Public comments will be considered, along with other engineering, environmental, and cost data to assist the County of Kauaʻi in selecting the best access route to the Maʻalo Landfill Site.

INSTRUCTIONS

Please review the Fact Sheet, and preferably the Draft TREFS report, which are intended to summarize the analyses performed, prior to providing your comments this comment sheet. For each route, please list the advantages and disadvantages, if any, you think that access route has for the site, the nearby communities, or the residents and businesses of the County of Kauaʻi.

If you feel that one of the advantages or disadvantages is most important, please circle it. If you feel that any particular route has no advantages or disadvantages, please leave that section empty. Attach a separate sheet, if necessary, and please remember to circle or otherwise indicate the most important advantage or disadvantage of this route, if applicable.

Comments can be submitted via e-mail to: KauaiLandfillAccessRoute@aecom.com

or via mail to: AECOM
Attn: Kauai New Landfill/RRP Access Roads
1001 Bishop Street, Suite 1600
Honolulu, HI 96813

All responses must be received by Monday, October 17, 2016.

Access Route A: MA'ALO ROAD

(A1) **Advantages for Access Route A (and Driveway 1 or 2):**

(A2) **Disadvantages for Access Route A (and Driveway 1 or 2)**

Access Route B: 'EHIKU STREET

(B1) **Advantages for Access Route B (and Driveway 1 or 2)**

(B2) **Disadvantages for Access Route B (and Driveway 1 or 2)**

Access Route C: LAULIMA STREET

(C1) **Advantages for Access Route C:**

(C2) **Disadvantages for Access Route C:**

Access Route D: ROBERTS HAWAII DRIVEWAY

(D1) **Advantages for Access Route D:**

(D2) **Disadvantages for Access Route D:**

Appendix C.3:
2014 Written Public Comments

From: [redacted]
Sent: Friday, January 17, 2014 6:46 PM
To: AMER-US-HI Honolulu-KauaiAccessRoads
Subject: Comments ehiku st.

(B2) disadvantages for access route B- I would like to express my concerns about you using ehiku st. As an access route. First off I think it would be a big safety concern if you would choose this route because it would be running through a neighborhood with children and we have a park which is used by a lot of different sports for children!!!! Also I live on Ehiku st. And I have 3 young boys 7, 4, and 2. Which would be a great hazard for them with all the big trash trucks going by!!! It would also create a lot more traffic on Ehiku st. Which would make it a lot more difficult and dangerous for my wife and I to get out of our driveway with all those added vehicles passing through!!!! It will also make a lot more noise in our neighborhood!!!! Lastly you guys should put the landfill where Joann yukimura lives because she is so against burning the trash to produce energy!!!!!!!!!!

(D1) Advantages for access route D- if you guys do have to make the landfill in Ma'alo than I would have to say use the Roberts entrance because it is the furthest away from all neighborhoods!!! It would also be a lot cheaper than the Ehiku st. Route. You would also have a lot less foot traffic compared to any other of the access route.

Could you please send me an e-mail back to say that you did receive my concerns and comments.

Thank you for your time.

From: [redacted]
Sent: Friday, January 17, 2014 1:06 PM
To: AMER-US-HI Honolulu-KauaiAccessRoads
Subject: Public Comments on TREFS: Access Route Alternatives for the Proposed New Landfill and RRP

[redacted]

January 17, 2014

AECOM
Attn: Kauai New Landfill/RRP Access Roads
1001 Bishop Street Suite 1600
Honolulu, HI 96813

To Whom it may Concern:

Rather than information on access routes to the proposed Ma'alo Landfill, the majority of those present at the January 16 public meeting were more interested in discussing the choice of Ma'alo as the preferred dump site. Before offering my opinion on the Ma'alo site, I would like to express thoughts about access routes:

In September, 2010, Mayor Carvalho announced that Ma'alo had jumped from 6th to 1st place as the preferred new landfill site. A major selling point of the Ma'alo site was that it would provide the opportunity to develop a bypass road between Wailua and Puhi. Oddly, at the January 16 presentation, a bypass road was not even mentioned or considered as a route to the proposed landfill. Even after brought up by members of the audience, the presenters attempted to steer away from discussing a bypass road.

The bypass road that was described in 2010 would avoid heavy traffic as well as populated communities. **IF** Ma'alo becomes our next landfill, a bypass road as originally proposed, between Rapozo Crossing on the west and across Kaua'i Beach Resort from east, would keep the huge dump trucks off our busy streets, avoid communities, and alleviate heavy traffic in Hanama'ulu and Lihu'e Town.

I understand that, until we find a better solution for our trash problems, Kaua'i needs a landfill. However, I strongly believe that the Ma'alo site presents a very real threat, not only to our environment, but also to the health and well being of mankind. A landfill, whose lifespan is 264 years, sited at high elevation, surrounded by wetlands and at

least 4 reservoirs, with more than 600 households located only several miles below, and hundreds of miles of irrigation ditches used for as much as 1000 acres of agricultural land to produce food for human consumption, is a very scary thing, not just for Hanama'ulu, but for all of Kaua'i.

I strongly suggest that our county reconsider Ma'alo as the chosen site for our landfill.

Sincerely,

Driveways 1 and 2 (Access Routes A and B)

(E1) **Advantages for Driveway 1 / Disadvantages for Driveway 2:**

(E2) **Disadvantages for Driveway 1 / Advantages for Driveway 2:**

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kaua'i [Zipcode or Community: _____]
2. On the island of Ni'ihau
3. On another island in Hawai'i
4. Outside the State

(QG2) **How long have you lived in the County of Kaua'i (years):** _____

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Name and Address:

e-mail address:

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Access Routes Public Comment Sheet

Proposed New Municipal Solid Waste Landfill and Resource Recovery Park at Ma'alo, Kaua'i

Background Information

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Public Outreach

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Instructions

Please review the Fact Sheet, and preferably the Draft TREFS report, which are intended to summarize the analyses performed, prior to providing your comments this comment sheet. For each route, please list the advantages and disadvantages, if any, you think that access route has for the site, the nearby communities, or the residents and businesses of the County of Kaua'i.

If you feel that one of the advantages or disadvantages is most important, please circle it. If you feel that any particular route has no advantages or disadvantages, please leave that section empty. Attach a separate sheet, if necessary, and please remember to circle or otherwise indicate the most important advantage or disadvantage of this route, if applicable.

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or via mail to: AECOM
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1001 Bishop Street, Suite 1600
Honolulu, HI 96813

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Access Route A: MA'ALO ROAD

(A1) **Advantages for Access Route A:**

DOES NOT IMPACT EXISTING RESIDENCES

(A2) **Disadvantages for Access Route A:**

TOO LONG/EXPENSIVE
PLUS LENGTH INCREASE DELIVERY COSTS IN FUTURE

Access Route B: 'EHIKU STREET

(B1) **Advantages for Access Route B:**

NONE

(B2) **Disadvantages for Access Route B:**

TOO LONG/EXPENSIVE
PLUS LENGTH INCREASES DELIVERY COSTS IN FUTURE
IMPACTS KUHIO HIGHWAY WHERE MOST CROWDED

Access Route C: LAULIMA STREET

(C1) **Advantages for Access Route C:**

CHEAPEST LEAST EXPENSIVE

(C2) **Disadvantages for Access Route C:**

IMPACTS EXISTING RESIDENCES

Access Route D: ROBERTS HAWAII DRIVEWAY

(D1) **Advantages for Access Route D:**

2ND LEAST EXPENSIVE
LESS IMPACT ON EXISTING RESIDENCES

(D2) **Disadvantages for Access Route D:**

Driveways 1 and 2 (Access Routes A and B)

(E1) **Advantages for Driveway 1 / Disadvantages for Driveway 2:**

(E2) **Disadvantages for Driveway 1 / Advantages for Driveway 2:**

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kaua'i [Zipcode or Community: Lihue]
2. On the island of Ni'ihau
3. On another island in Hawai'i
4. Outside the State

(QG2) **How long have you lived in the County of Kaua'i (years):** 31 plus yrs

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Access Route A: MA'ALO ROAD

(A1) **Advantages for Access Route A:**

(A2) **Disadvantages for Access Route A:**

Access Route B: 'EHIKU STREET

(B1) **Advantages for Access Route B:**

(B2) **Disadvantages for Access Route B:**

Access Route C: LAULIMA STREET

(C1) **Advantages for Access Route C:**

(C2) **Disadvantages for Access Route C:**

Access Route D: ROBERTS HAWAII DRIVEWAY

(D1) **Advantages for Access Route D:**

1. COST ALTHOUGH NOT CHEAPEST HAS MORE AREA TO INSTALL INTERSECTION
2. DOES NOT IMPACT NEIGHBORHOODS

(D2) **Disadvantages for Access Route D:**

INCREASE TRAFFIC FROM WESTSIDE. MORE TRAFFIC ON NUHOU RD., PIKAKE ST, NAWILIWILI + KAPULA HIWAY

Driveways 1 and 2 (Access Routes A and B)

(E1) **Advantages for Driveway 1 / Disadvantages for Driveway 2:**

(E2) **Disadvantages for Driveway 1 / Advantages for Driveway 2:**

-avoids area w/wetland

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kaua'i [Zipcode or Community: 96766]
2. On the island of Ni'ihau
3. On another island in Hawai'i
4. Outside the State

(QG2) **How long have you lived in the County of Kaua'i (years):** (life) 53 years

If you would like to receive feedback on the results of this survey, please provide your contact information (postal or email address) below. All contact items are voluntary.

Name and Address: [redacted]

e-mail address: [redacted]

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Access Routes Public Comment Sheet

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or via mail to: AECOM
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1001 Bishop Street, Suite 1600
Honolulu, HI 96813

All responses must be received by February 10, 2014.

Access Route A: MA'ALO ROAD

(A1) Advantages for Access Route A:

Would improve road - a plus for those visitors going up to Wailua Falls too.

(A2) Disadvantages for Access Route A:

Cost

Access Route B: 'EHIKU STREET

(B1) Advantages for Access Route B:

Partial improvements to Maalo Rd (see above)
- lesser impact on Neighborhood

(B2) Disadvantages for Access Route B:

Cost due to length of road access
- longer route

Access Route C: LAULIMA STREET

(C1) Advantages for Access Route C:

Most cost effective - giving community another traffic light
- may help morning traffic back-up
- shortest length

(C2) Disadvantages for Access Route C:

another traffic light w/in a short distance

Access Route D: ROBERTS HAWAII DRIVEWAY

(D1) Advantages for Access Route D:

(D2) Disadvantages for Access Route D:

- may be flood-prone
- traffic light so close to the Hanamaulu intersection

Driveways 1 and 2 (Access Routes A and B)

(E1) **Advantages for Driveway 1 / Disadvantages for Driveway 2:**

(E2) **Disadvantages for Driveway 1 / Advantages for Driveway 2:**

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kaua'i [Zipcode or Community: Hanamaulu, Laukona St.
2. On the island of Ni'ihau
3. On another island in Hawai'i
4. Outside the State

(QG2) **How long have you lived in the County of Kaua'i (years):** 70+ yrs.

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e-mail address:

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Access Routes Public Comment Sheet

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Background Information

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All responses must be received by February 10, 2014.

Access Route A: MA'ALO ROAD

(A1) **Advantages for Access Route A:**

This is the only route I support

(A2) **Disadvantages for Access Route A:**

How about Ma'Alo rd that ~~into~~ has existing haul ouna rd to cross route C.

I live on the Laulima St. routes please reconsider not happy about Landfill already. Thank you.

Access Route B: 'EHIKU STREET

(B1) **Advantages for Access Route B:**

(B2) **Disadvantages for Access Route B:**

Access Route C: LAULIMA STREET

(C1) **Advantages for Access Route C:**

(C2) **Disadvantages for Access Route C:**

Access Route D: ROBERTS HAWAII DRIVEWAY

(D1) **Advantages for Access Route D:**

(D2) **Disadvantages for Access Route D:**

Driveways 1 and 2 (Access Routes A and B)

(E1) **Advantages for Driveway 1 / Disadvantages for Driveway 2:**

(E2) **Disadvantages for Driveway 1 / Advantages for Driveway 2:**

Goes through agricultural land

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kaua'i [Zipcode or Community: 96746]
2. On the island of Ni'ihau
3. On another island in Hawai'i
4. Outside the State

(QG2) **How long have you lived in the County of Kaua'i (years):** 64

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e-mail address:

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Background Information

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Instructions

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Access Route A: MA'ALO ROAD

(A1) Advantages for Access Route A:

Existing road

(A2) Disadvantages for Access Route A:

Road too narrow
Would take traffic through agricultural area
Long route
Traffic congestion possible
Cost

Access Route B: 'EHIKU STREET

(B1) Advantages for Access Route B:

(B2) Disadvantages for Access Route B:

Too close to housing
Traffic congestion possible
Cost

Access Route C: LAULIMA STREET

(C1) Advantages for Access Route C:

Short route

(C2) Disadvantages for Access Route C:

Too close to housing

Access Route D: ROBERTS HAWAII DRIVEWAY

(D1) Advantages for Access Route D:

Avoids transit through populated areas
Is ~~the~~ a shortest route
Direct access from East & North Kauai

(D2) Disadvantages for Access Route D:

Possible congestion at intersection
Still relatively close to housing but less than other options.

Driveways 1 and 2 (Access Routes A and B)

(E1) **Advantages for Driveway 1 / Disadvantages for Driveway 2:** Disagree!

(E2) **Disadvantages for Driveway 1 / Advantages for Driveway 2:** Disagree!

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kaua'i [Zipcode or Community: _____]
2. On the island of Ni'ihau
3. On another island in Hawai'i
4. Outside the State

(QG2) **How long have you lived in the County of Kaua'i (years):** 18 yrs.

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1001 Bishop Street, Suite 1600
Honolulu, HI 96813

All responses must be received by February 10, 2014.

Access Route A: MA'ALO ROAD

(A1) **Advantages for Access Route A:** Disagree!

(A2) **Disadvantages for Access Route A:** Disagree!

Access Route B: 'EHIKU STREET

(B1) **Advantages for Access Route B:** Disagree!

(B2) **Disadvantages for Access Route B:** Disagree!

Access Route C: LAULIMA STREET

(C1) **Advantages for Access Route C:** Disagree!

(C2) **Disadvantages for Access Route C:** Disagree!

Access Route D: ROBERTS HAWAII DRIVEWAY

(D1) **Advantages for Access Route D:** Disagree!

(D2) **Disadvantages for Access Route D:** Disagree!

Driveways 1 and 2 (Access Routes A and B)

(E1) **Advantages for Driveway 1 / Disadvantages for Driveway 2:** DENIED

(E2) **Disadvantages for Driveway 1 / Advantages for Driveway 2:** DENIED

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kaua'i [Zipcode or Community: _____]
2. On the island of Ni'ihau
3. On another island in Hawai'i
4. Outside the State

(QG2) **How long have you lived in the County of Kaua'i (years):** 35 yrs.

If you would like to receive feedback on the results of this survey, please provide your contact information (postal or email address) below. All contact items are voluntary.

Name and Address:

e-mail address:

If provided, your contact information will be maintained for communication purposes only, until the Final EIS is issued. No information you supply on this form will be released to any person or agency without your prior permission. No information reported during the course of this project will be attributed to any individual or any agency without prior approval. Data will be reported in aggregate form only.

Access Routes Public Comment Sheet

Proposed New Municipal Solid Waste Landfill and Resource Recovery Park at Ma'alo, Kaua'i

Background Information

The enclosed **Fact Sheet** describes the potential Access Routes A, B, C, and D, and summarizes the preliminary results of the **Draft Traffic and Roadways Engineering Feasibility Study (TREFS).** Further details of the potential access routes are provided in the Draft TREFS report, available on the County of Kaua'i's New Landfill website: **www.kauai.gov/NewLandfillSite**

For each route, the Draft TREFS report provides detailed analysis of existing and projected traffic conditions and impacts; recommended improvements and associated cost estimates; and a preliminary evaluation of the potential social impacts.

Public Outreach

This public outreach is being conducted in response to public concerns regarding the access routes expressed during meetings held for the ongoing project Environmental Impacts Statement (EIS) process. The County is committed to soliciting and considering all reasonable public concerns regarding the potential access routes. No final decision regarding the proposed access route has been made, and the proposed access route will be further analyzed during the ongoing EIS process. Public comments will be considered, along with other engineering, environmental, and cost data to assist the County of Kaua'i in selecting the best access route to the Ma'alo Landfill Site.

Instructions

Please review the Fact Sheet, and preferably the Draft TREFS report, which are intended to summarize the analyses performed, prior to providing your comments this comment sheet. For each route, please list the advantages and disadvantages, if any, you think that access route has for the site, the nearby communities, or the residents and businesses of the County of Kaua'i.

If you feel that one of the advantages or disadvantages is most important, please circle it. If you feel that any particular route has no advantages or disadvantages, please leave that section empty. Attach a separate sheet, if necessary, and please remember to circle or otherwise indicate the most important advantage or disadvantage of this route, if applicable.

Comments can be submitted via e-mail to: KauaiAccessRoads@aecom.com
or via mail to: AECOM
Attn: Kauai New Landfill/RRP Access Roads
1001 Bishop Street, Suite 1600
Honolulu, HI 96813

All responses must be received by February 10, 2014.

Access Route A: MA'ALO ROAD

(A1) **Advantages for Access Route A:** DENIED

(A2) **Disadvantages for Access Route A:** DENIED

Access Route B: 'EHIKU STREET

(B1) **Advantages for Access Route B:** DENIED

(B2) **Disadvantages for Access Route B:** DENIED

Access Route C: LAULIMA STREET

(C1) **Advantages for Access Route C:** DENIED

(C2) **Disadvantages for Access Route C:** DENIED

Access Route D: ROBERTS HAWAII DRIVEWAY

(D1) **Advantages for Access Route D:** DENIED

(D2) **Disadvantages for Access Route D:** DENIED

PO Box 30848
Anahola, Hawai`i 96703-0848

16 January 2014

County of Kaua`i Department of Public Works
4444 Rice Street
Lihu`e, Hawai`i 96766 Contact: Donald Fujimoto

Subject: ***Feasibility study regarding proposed access routes to proposed landfill and Resource Recovery Park on Ma`alo Road; site improvements and related costs. Shibai***

Dear Mr. Fujimoto and To Whom It May Concern:

Aloha! It is futile (wasted resources) for site improvements and related costs to construct the new Municipal Solid Waste Landfill (*MSWL*) at Ma`alo and Resource Recovery Park (*RRP*) at Grove Farm

Is not the duty of County of Kaua`i to uphold health and scrutinize proposals that could impact ground water?

Why is the County of Kaua`i willing to forfeit/ sacrifice/compromise future generations through ignorance? 'Mandated Recycling' would solve 'related costs' to forthcoming generations yet to come.

The County of Kaua`i ought to have established a 'Task Force' for 'Mandated Recycling': incentives for those who recycle and fines for those not in compliance; decades ago.

To be effective: the 'Task Force' would be self sustaining: fee's from commercial ventures, *PMRF*, Visitor Industry & its 'spin off ventures' (Airport, Resorts/ Restaurants, et cetera) 'snow birds', timeshares, residents, Costco/Wal-Mart, etc. etc. – fines & incentives for those entities/residents in compliance ***versus*** both costs environmental and monetary of building new *MSWL* at Ma`alo (being A 1 agriculture land with irrigation, wetland delineation and BEAUTIFUL).

There exists – "flawed technology" – involved with the presumption of placing a landfill at Ma`alo for the next three hundred (300) years; due to the surrounding wetlands; adjacent to Ma`alo. Flooding will cause a calamity!

Those whom currently are in positions with the County of Kaua`i need to be held accountable when a natural disaster occurs as the result of continuing forward with this ill-fated, inopportune proposal to construct (*MSWL)* dump/landfill at Ma`alo and a Resource Recovery Park (*RRP*) on Grove Farm landholdings.

There's something very stinking about this. It's 2014, who in their right mind would allow this 'relationship of convenience' with a large landowner (Grove Farm Company, Inc.), the state of Hawaii and County of Kaua`i?

Please have some common sense: leachate pollution of groundwater and the reef that surround Kaua`i is not worth the archaic marriage of 'relationship of convenience' that this foul, horrendous proposal entails. Ma`alo is A1 agriculture land, with irrigation, wetland delineation, artesian wells and shamefully, greedy, self-interested people carelessly move forward with stupidity… lack of common sense; *all* for the all mighty dollar. This shibai has got to stop. Water is the substance of life; how dare your gluttony spill forth to cover Ma`alo with rubbish!

Aloha `Aina *– Ua Mau Ke Ea O Ka `Aina I Ka Pono –*

Sincerely with *ALOHA*,

Bonnie P. Bator and `Ohana

Appendix C.4:
Summary of Interview Comments

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County of Kaua‘i
Socioeconomic Assessment of Proposed Solid Waste Landfill at Ma‘alo
Access Roads Assessment Component
Version: July 2013

Interview

Raymond J. McCormick, District Engineer, Kaua‘i, Department of Transportation

Tuesday, October 13, 2013, his office

Record name, address, employer or other organization respondent may represent.

1. A solid waste landfill operation has been proposed for the site known as Ma‘alo. How familiar are you with the Ma‘alo site? [If necessary, use the site map to show the respondent the general layout of the Ma‘alo site.]
2. Are you generally in favor of or opposed to placing the next Kaua‘i landfill at Ma‘alo?
3. Why do you say that? [Not all issues offered, not the order or relative importance assigned to access roads among all other issues.]

Mr. McCormick has been with the Hawai‘i Department of Transportation on Kaua‘i for many years and has been involved in discussions of Kaua‘i Solid Waste Landfill sites since their inception. He has participated in project meetings and community meetings on the issues involved. He has had several conversations with the County Department of Solid Waste Management on specific issues in and around the Ma‘alo Landfill site. Mr. McCormick felt that he was well informed on the Ma‘alo site and other transportation-related issues in the area of the proposed site.

Any final decision to locate the next landfill at Ma‘alo will depend on the outcome of the Environmental Impact Statement. What we are interested in today is the location of access roads and driveways to get to the site. I have a map with some alternative road alignments overlaid on it. None of the alignments are final in any way, but engineers have calculated that each of them is a feasible alternative. We would like you to go over them with us and get your opinion on what you think might be the advantages and disadvantages of each one. Our major interest is in advantages and disadvantages that will affect the people in the surrounding communities, rather than engineering issues or cost factors. [Show map and discuss each alignment in turn. At each alternative alignment ask the following questions.]

4. What are the advantages of this one, as it will affect the community? What are the disadvantages you see? [Record positive and negative issues for each if any.]

   A: (See Potential Access Road A): Mr. McCormick spoke at length about potential access road A. He was not in favor of this alternative. He felt the intersection of Ma‘alo Road and Kūhiō Highway presented serious problems for traffic and driver safety. He felt those issues might take considerable money and time to resolve and that would not be beneficial to a project with a short timeframe. He noted several roadway alignment problems along Ma‘alo Road between Kūhiō Highway and the point where Ma‘alo Road intersects ‘Ehiku Road (see attached Potential Access Road B). Those included some very tight turns, narrow roadways, and the narrow bridge. He also noted that the State did not have easements along Ma‘alo Road and that might require acquiring easements or property. Property acquisition would require additional funding and time that would complicate the completion of site preparations. He also noted that tourist traffic along Ma‘alo Road would be negatively affected by trucks accessing the landfill site and may pose a danger to Kaua‘i’s visitors. He felt potential access road A was not a good choice for the Ma‘alo Solid Waste Landfill access road.

B. (See Potential Access Road B): Mr. McCormick studied this route for a few minutes and then said he thought it was a very good solution for Ma‘alo Road problems. By using ‘Ehiku Road, potential access road B avoids virtually all of the major problems of potential access road A, with the exception of visitor traffic. He thought that might be an advantage. The new route to the waterfall might pull visitor traffic off Kūhiō Highway and the lower end of Ma‘alo Road. It would be preferable for its both scenic advantages and traffic safety. He mentioned that the alignment takes potential access road B through the Isenberg Neighborhood and noted that could be a public relations issue. He did not feel that it seriously compromised the many advantages of potential access road B, however.

C. (See Potential Access Road C): Mr. McCormick studied the map for a few minutes. He then said this would be an acceptable access road alignment. It had the advantage of leaving Kūhiō Highway at the industrial park and therefore avoided passing through residential areas. He also noted that there was available land on the mauka side of Kūhiō Highway that could be used to get trucks off the road before turning. He realized, however that signalization of the intersection would probably be required. He said he could accept potential access road C, but that it was not superior to potential access road B.

D. (See Potential Access Road D): Mr. McCormick did not find any advantage in the alternative. While it might avoid placing a signal at the intersection of Laulima Road and Kūhiō Highway, it would be difficult to get trucks on and off Kūhiō Highway so close to the intersection of Kūhiō Highway and Kapule Highway. In peak periods, traffic backs up well beyond the point where potential access road D enters Kūhiō Highway. He recognized the benefit to the Hanamā‘ulu Neighborhood this would provide, but felt the traffic issues would offset that advantage.

5. Out of all of the alternatives, which alignment do you think will be best for the community and landfill users?

Mr. McCormick is strongly in favor of potential access road alignment B. He continues to be very strongly opposed to potential access road A and feels potential access road D will not work. He said he could accept potential access road C, but that it was not as good an option as potential access road B.

To connect the Ma‘alo landfill site and the RRP site, Mr. McCormick prefers driveway alignment 2 to driveway alignment 1. He understands the wetlands issue well and feel that routing any roadways through wetlands areas will involve negotiations and mitigations that will be very costly. The major problem would be the time it would take to deal with the Federal government on wetlands issues. Wetlands issues can also open the way for local residents to re-evaluate the site selection. He was very strongly in favor of potential driveway alignment 2.

6. What is the most important advantage of the alignment you chose?

Mr. McCormick reiterated all of the favorable points he listed earlier (see B, above). If he had to pick one of those, it would be avoiding the traffic safety and realignment problems associated with using the lower end of Ma‘alo Road.

7. Is there any alignment that you find wholly unacceptable? If so, which one is that?

None was “wholly unacceptable,” but potential access road A and potential access road D are not good options.

8. And why do you say that?

See 7 above.

County of Kaua‘i
Socioeconomic Assessment of Proposed Solid Waste Landfill at Ma‘alo
Access Roads Assessment Component
Version: July 2013

Interview

Anonymous

Thursday, October 3, 2013
Līhu‘e, Hawai‘i 96766

Record name, address, employer or other organization respondent may represent.

1. A solid waste landfill operation has been proposed for the site known as Ma‘alo. How familiar are you with the Ma‘alo site? [If necessary, use the site map to show the respondent the general layout of the Ma‘alo site.]
2. Are you generally in favor of or opposed to placing the next Kaua‘i landfill at Ma‘alo?
3. Why do you say that? [Not all issues offered, not the order or relative importance assigned to access roads among all other issues.]

Respondent has been involved in deliberations and planning for a possible landfill operation in the Kalepa-Ma‘alo area throughout the last three Kaua‘i Mayoral Administrations. He is very familiar with all the issues involved. He was interviewed in the previous set of stakeholder interviews for this Socioeconomic Impact Assessment (SIA). At that time, he registered general approval of the site in its current configuration and says that he still strongly supports Ma‘alo as the best site for the next landfill on Kaua‘i. He and his company also have many concerns and interests related to the details of the proposed project. He continues to work toward a plan that will work for all.

Any final decision to locate the next landfill at Ma‘alo will depend on the outcome of the Environmental Impact Statement. What we are interested in today is the location of access roads and driveways to get to the site. I have a map with some alternative road alignments overlaid on it. None of the alignments is final in any way, but engineers have calculated that each of them is a feasible alternative. We would like you to go over them with us and get your opinion on what you think might be the advantages and disadvantages of each one. Our major interest is in advantages and disadvantages that will affect the people in surrounding communities, rather than engineering issues or cost factors. [Show map and discuss each alignment in turn. At each alternative alignment ask the following questions.]

4. What are the advantages of this one, as it will affect the community? What are the disadvantages you see? [Record positive and negative issues for each if any.]

   A. (See Potential Access Road A): That’s just Ma‘alo Road. That’s not really an access road. It’s already there. (Redirected the conversation toward the driveways). Any of those (1, 2, or 1 & 2) would work. I’m not sure why they don’t just use the roads that are there. There’s already a blacktop road that runs from Ma‘alo Road to the site (he indicated the earlier site of the RRP, a section between driveway alignment 2 and driveway alignment 3). That just seems easier. Things keep changing all the time. I wish they would just choose a plan and go with it.

   B. (See Potential Access Road B): That’s never going to work. This community (indicated the Isenberg subdivision) will never go for it. They are vocal and powerful (paraphrasing). The roadway is already there, but it just has too many problems. I know the Department (Planning) and the State have a lot of issues about the intersection at Ma‘alo and Kūhiō Highway, but we may just have to deal with those. B is not going to work.

C. (See Potential Access Road C): I don’t like this alignment. The problem is driveway alignment 3. It splits this agricultural land and it’s just not the right way to go. Farmers will have a problem here. But the real issue is why they don’t connect through here [indicates a section of roadway connecting the intersection of Access Road C and Driveway 3 with the point at which Ma‘alo Road meets ‘Ehiku Street (A and B)]. That would complete the loop and allow access from two directions. It would also follow the existing roadways and save time and money. This led to a discussion of the “loop” and the fact that “the loop” was essentially the bypass road. Respondent noted that there had been an announcement that planning for the bypass had already begun, and that it would change the need for access roads. I suggested that there had been a decision to treat the bypass road and the landfill site as separate projects. Respondent said it was more realistic to treat them together, but accepted the decision. He maintained, throughout, however, that the connection of the two sets of roadways (A or A & B vs. C/D) made the most sense and was best for the community.

D. (See Potential Access Road D): Access road alignment D is not much different from alignment C. It still brings the road onto the wrong side of the property. It still uses driveway 3, which benefits no one. It still doesn’t complete the loop. I can see it’s better than C because it gets the trucks out of Hanamā‘ulu, but it’s not a choice I can support.

5. OK, out of all of the alternatives, which alignment do you think will be best for the community and landfill users?

I don’t like any of them. If you’re going to do something like this (the set of alternatives), then just use Ma‘alo Road. You can’t go through ‘Ehiku because of community reaction. Driveway 3 doesn’t work for the community. Just do the work on Ma‘alo Road. It’s dangerous now and everyone who uses it would benefit from straightening it out a little and fixing the bridge.

6. What is the most important advantage of the alignment you chose?

It is not a great solution. Many of us have been working with the administration since Brian Baptiste was mayor. We have worked these things out a dozen times. We have told them that we wanted to avoid splitting agricultural properties and that they should use existing roadways if they can. I think we will have to get back, talk with the administration, and find out how to fix these things.

7. Is there any alignment that you find wholly unacceptable? If so, which one is that?

Nothing is impossible. Nearly everyone wants to see this go through. We can get together with the County and work this out.

Respondent appreciated the effort to get these preliminary plans out to them before any public announcement or adoption in the plan.

8. In addition, why do you say that?

N/A

9. If the respondent proposes an alternative that is not on the map, describe that alignment and the rationale for choosing it.

See above.

County of Kaua‘i
Socioeconomic Assessment of Proposed Solid Waste Landfill at Ma‘alo
Access Roads Assessment Component

Interview

Anonymous

Līhu‘e, Kaua‘i, Hawai‘i, 96766
Monday, January 13, 2014

This interview used the Information Sheet and the Data Gathering Sheet used for the Public Meeting and the landowner survey as a basis for the interview.

Respondent has been with his current employer for the major part of his career and has been in his current position for about ten years. He is quite familiar with the area near his current place of employment, including traffic patterns along Kūhiō Highway. He is aware of the planning effort that has led up to the choice of the Ma‘alo Landfill Site. He was not aware of exactly where the site was to be located. He understands the need for a new landfill site and generally approves of the County's effort to locate a suitable site. He has heard that the Ma‘alo Site may be better situated than other alternative site locations. Respondent was not familiar with all of the characteristics of the site, but felt it was out-of-the-way and not near anyone's home.

What we are interested in today is the location of access roads and driveways to get to the site. I have some maps showing four alternative road alignments. None of the alignments is final in any way, but engineers have calculated that each of them is a feasible alternative. We would like you to go over them with us and get your opinion on what you think might be the advantages and disadvantages of each one. Our major interest is in advantages and disadvantages that will affect the people in the surrounding communities, rather than engineering issues or cost factors. What are the advantages of this one, as it will affect the community? What are the disadvantages you see?

A. Access Route A, Ma‘alo Road: Respondent recognized Ma‘alo Road and knew it to be a scenic route that ended at Wailua Falls. He saw no reason why it could not be used as an access road for the landfill. He knew the intersection of Ma‘alo Road and Kūhiō Highway was a dangerous intersection that had been the scene of several serious accidents in the past. He said that intersection would have to be "fixed" if Ma‘alo Road was to be used for truck traffic.

B. Access Route B, ‘Ehiku Street: Respondent was less familiar with the ‘Ehiku Street route. He suspected it was largely comprised of cane haul roads that had not been used in several years. He also said that the lower end of the road passed by the AT&T offices and a warehouse and two churches. That might be a problem for those businesses. Although this route was close to his current place of employment, he did not think it would have any impact on the company or its operations. He noted that route B was longer than route A and that might make it more expensive to build.

C. Access Route C, Laulima Street: Being less familiar with the Laulima Street routes, Respondent had fewer comments about that route. He thought it was a much shorter route and that might make it less expensive to build. Being even father from his current place of employment than ‘Ehiku Street, he felt it would have no impact on the company or its clients.

D. Access Route D: Roberts Hawai‘i Driveway: Respondent was not familiar with the Roberts Hawai‘i Driveway and took a moment to become familiar with the map. He asked what the development between the driveway and Kūhiō Highway was. When I told him it was Kalepa Village, he recognized the site. He thought the access road might pass very near the Kalepa Village and was concerned that it may cause hardship for residents there. The trucks would cause noise, and dust along their back yards. The location was far from his current place of employment so it would have no impact on their operations.

E. Driveways 1 and 2, Access Routes A and B: Respondent said he was not familiar with the area in which those driveways would be located. Driveway 1 seemed a straighter, more direct route to the landfill site and was therefore preferable to driveway 2. He saw no other advantages or disadvantages for either driveway.

County of Kaua‘i
Socioeconomic Assessment of Proposed Solid Waste Landfill at Ma‘alo
Access Roads Assessment Component

Interview

Anonymous

January 13, 2014
Līhu‘e, Hawai‘i 96766

This interview used the Information Sheet and the Data Gathering Sheet used for the Public Meeting and the landowner survey as a basis for the interview.

Respondent, by virtue of his many years of public service, is very much aware of the proposed municipal solid waste landfill site at Ma‘alo. He is also familiar with the history and issues surrounding the landfill and understood the need to consider access routes to the site. This interview was the first time he had seen maps of the four alternative access routes.

What we are interested in today is the location of access roads and driveways to get to the site. I have some maps showing four alternative road alignments. None of the alignments is final in any way, but engineers have calculated that each of them is a feasible alternative. We would like you to go over them with us and get your opinion on what you think might be the advantages and disadvantages of each one. Our major interest is in advantages and disadvantages that will affect the people in the surrounding communities, rather than engineering issues or cost factors. What are the advantages of this one, as it will affect the community? What are the disadvantages you see?

A. Access Route A, Ma‘alo Road: Ma‘alo Road would be the choice that would come first to mind for most residents of Kaua‘i, he thought. It had been talked about for some time, and many understand the advantages and disadvantages of the route. One of its advantages might be that Ma‘alo Road has been considered to be the most likely access road to a Ma‘alo landfill site. The route is direct and does not pass by private residences.

   He thought Route A might be costly to develop because the road was narrow and has some sharp turns in it. Respondent recalled Council conversations about the problems posed by the intersection of Ma‘alo Road and Kūhiō Highway. He expected that it would require significant redesign of the intersection, signalization, and pull-off lanes. Ma‘alo Road is also a very long route, that takes the landfill trucks almost to Wailua Falls before meeting with driveway 1 to approach the site. He felt there must be a shorter route, using other cane haul roads, to get to the site from Ma‘alo Road. We spend several minutes going over the maps to identify possible routes to the site. He noted also that tour buses used Ma‘alo Road to take visitors to the Falls. Improvements to the road would have to take into consideration the fact that buses would be passing trucks on a frequent basis.

B. Access Route B, ‘Ehiku Street: Respondent had heard talk of using ‘Ehiku Street as a possible route to the Ma‘alo Landfill Site. He said it had been proposed as a means of avoiding the problems of improving the intersection at Ma‘alo Road and Kūhiō Highway and some of the highest cost of improving the lower end of Ma‘alo Road. He agreed those would be advantages of the ‘Ehiku route. He also felt that the cane haul roads would make a solid base for improving ‘Ehiku Street to its intersection with Ma‘alo Road.

Respondent noted that the local community, residents of the Isenberg Neighborhood, had already voiced opposition to the idea of using ‘Ehiku Street as a landfill access road. They had come together to successfully oppose locating a drug rehabilitation facility near their neighborhood. That demonstrated their ability and willingness to organize in support of their positions. He also felt that Route B, ‘Ehiku Street, was the longest route to the landfill site and was likely to be the most expensive to develop. The more serious disadvantage, however, was community opposition.

C. Access Route C, Laulima Street: The most obvious advantage of Route C, Respondent said, was the fact that it was short and direct. That might mean that it would have lower cost than the other routes and may provide fewer obstacles to overcome. The section along Laulima Street north of Kūhiō Highway passed by the industrial area but did not pass by any residences.

   The biggest disadvantage was its impact on traffic at the intersection of Laulima Street and Kūhiō Highways. Hanamā‘ulu residents were already telling him about the traffic delays all along Kūhiō as it passes through their town. The added truck traffic at Laulima Street would be a serious addition to the traffic flow. He hoped that traffic engineers could solve that problem, but wondered if improvements at the Laulima intersection would be enough. Looking at the map he also wondered if the road might pass too near residences along Laukona Street.

D. Access Route D: Roberts Hawai‘i Driveway: Respondent thought the Roberts Hawai‘i Driveway was an interesting solution to many of the problems associated with Route C. Although the driveway made the route longer, it would have a solid base and it avoided the traffic problems associated with the Laulima Street Intersection with Kūhiō Highway. That would probably save some money and would certainly be preferred by residents of Hanamā‘ulu Town.

   He wondered, however, if the Roberts Hawai‘i Driveway solution would not just move the problem down the road. Trucks would now use the Roberts Hawai‘i Driveway entrance from Kūhiō Highway causing traffic problems there. If traffic engineers could solve that problem, it would remove a major disadvantage of Route D. He noticed, too, that Roberts Hawai‘i Driveway passed near the north side of the Kalepa Villages Neighborhood. The access road would pass closer to Kalepa than it would to Laukona Street residences.

E. Driveways 1 and 2, Access Routes A and B: Respondent asked why there were two alternative driveways to get from the Ma‘alo Landfill Site to the RRP. I explained that driveway 2 was developed to avoid possible problems associated with wetland areas near driveway 1. He considered that to be a serious disadvantage for driveway 1. It is not impossible to develop roadways through wetlands, but the regulations governing use of wetland areas were usually time consuming and perhaps costly in the end.

When the formal part of the interview was finished, Respondent returned to the conversation about alternative ways to get from Ma‘alo Road to the landfill site. He was now looking for an additional route from Kūhiō Highway to the Ma‘alo Landfill Site. He suggested several alternatives, and then settled on a route that used Ma‘alo Road from Kūhiō Highway to the intersection of Ma‘alo Road and ‘Ehiku Street, turned east across a cane haul road to the intersection of Laulima Street and driveway 3, and then proceeded along driveway 3 to the landfill site. This route, he felt, would eliminate serious downsides from ‘Ehiku Street and those parts of Routes C and D that pass near residences, without incurring serious additional disadvantages.

Appendix C.5:
Access Route F

The following figure shows Routes F1 and F2, which were suggested as potential alternative access routes during the January 16, 2014 TREFS Public Meeting. Some Social Impacts Assessment (SIA) respondents felt it would be useful to combine some elements of Routes A and B, with parts of C and D. Route F1 follows Ma‘alo Road from its Kūhiō Highway junction for 1.8 miles to an intersection with ‘Ehiku Street, where it turns right along an existing cane haul road. It proceeds eastward to the intersection with driveway 3 and then directly to the landfill site. Route F2 follows ‘Ehiku Street from its Kūhiō Highway to an intersection with Ma‘alo Road and then continues eastward along the path described above. If the alternate RRP site is implemented, then a portion of either Driveway 1 or 2 would be required, as shown in the figure.

The following improvements would be recommended for Route F1, as discussed in the analysis for Route A:

- Modify and signalize the highway intersection.
- Widen a small bridge and straighten a sharp curve on Ma‘alo Road.
- Widen and repave Ma‘alo Road; widen and pave the cane haul roads; provide utilities.

The following improvements would be recommended for Route F2, as discussed in the analysis for Route A:

- Modify and signalize the highway intersection.
- Widen a small bridge and straighten a sharp curve on Ma‘alo Road.
- Widen and repave Ma‘alo Road; widen and pave the cane haul roads; provide utilities.

The following improvements would be recommended for the new, approximately 0.7 mile long access route segment (labelled “F” in the figure below):

- Rebuild or bridge a washed-out and collapsed former culvert area just west of Driveway 3.
- Widen and pave the cane haul road; provide utilities.

Driveways 1, 2, and 3 would also require the improvements described in the main TREFS report.

The assessment of Routes F1 and F2 can be taken as the combination of advantages and disadvantages of their two components parts, as described in the main body of the SIA (TREFS report, Section 4). In general terms, both Routes F1 and F2 would likely have cost, traffic, and improvement requirements similar to those required for Routes A or B, without providing the primary benefits of Routes C or D, such as a shorter route, less expense, or less negative traffic impacts.

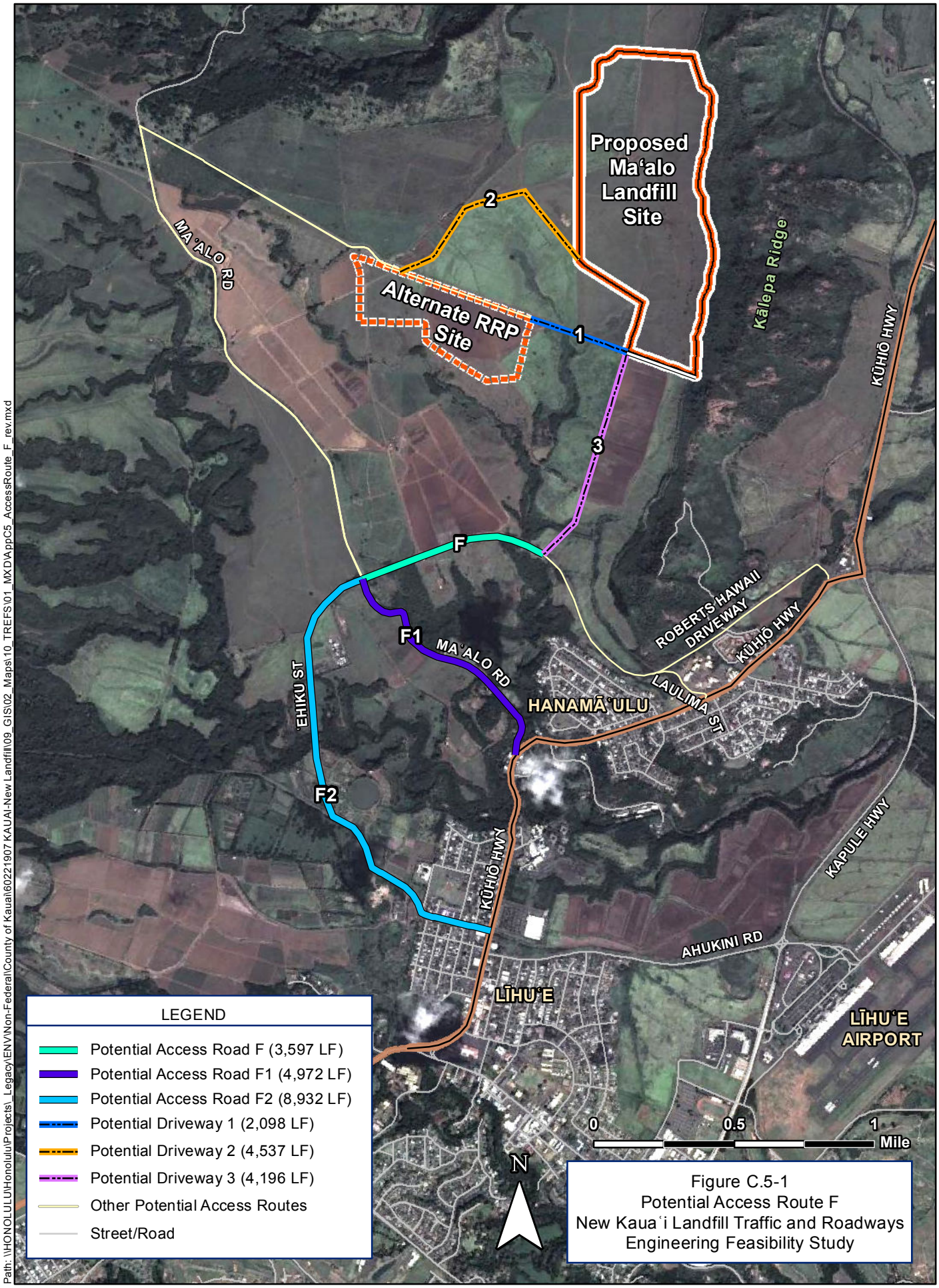


Figure C.5-1
Potential Access Route F
New Kaua'i Landfill Traffic and Roadways
Engineering Feasibility Study

Path: \\HONOLULU\Honolulu\Projects_Legacy\ENV\Non-Federal\County of Kauai\60221907 KAUAI-New Landfill\09_GIS\02_Maps\10_TREFS\01_MXD\AppC5_AccessRoute_F_rev.mxd

Appendix C.6:
Summary of TREFS Public Meeting
King Kaumualiʻi School Cafeteria, Hanamāʻulu
September 22, 2016

Subject: Summary of TREFS Public Meeting

Presenters: Consultants: Frank Cioffi, Wayne Yoshioka, Julie Zimmerman, Mark Hofferbert
County of Kaua‘i: Wally Rezentes, Jr, Troy Tanigawa, Keith Suga, Donn Kakuda

Attendees: 28

Following is a summary of the Traffic and Roadways Engineering Feasibility Study (TREFS) Community Meeting held September 22, 2016, at the King Kaumuali‘i Elementary School in Hanamā‘ulu, Kaua‘i, to discuss potential new landfill and resource recovery park access route alternatives, including the addition of Route E. Comments and responses are not directly quoted. Comments relevant to the access route choice are summarized at the end of this document.

MEETING SUMMARY

Opening Remarks: Wally Rezentes, Jr, County of Kaua‘i Managing Director, opened the meeting at 6:10 pm. Mr. Rezentes spoke on behalf of Mayor Carvalho. Mr. Rezentes explained that the County has explored multiple sites to figure out best fit for Kaua‘i’s new landfill. The County has invested a lot of time and effort in community meetings to find the right fit for the project. The right people are available tonight to answer questions about the project.

Frank Cioffi presented the project’s revised TREFS. A TREFS Community Meeting was previously held January 16, 2014 to discuss the potential new landfill and resource recovery park access route alternatives. Comments from that meeting led the County to research another route near the Kaua‘i Beach Resort, referred to as Route E, which has been analyzed and included in the revised draft TREFS report. Wayne Yoshioka provided additional information on study details involving traffic and infrastructure. Frank Cioffi provided a follow-up summary on the purpose and reason for the TREFS Study and accepted public comments and questions.

Respondent (R): I see that it is roughly $41 million dollars to put the road in. What is the cost of the landfill?
Answer (A): Each route has a different estimated cost. Each cost is a best estimate at this time as we won’t know the actual cost until it is bid out.

R: How many trucks will go to the landfill per day?
A: During morning peak hours of opening year, there is estimated to be 15 inbound and 15 outbound trucks for the landfill alone. Afternoon peak hours are estimated at 12 inbound and 15 outbound trucks. The longer range estimates 19 inbound and 18 outbound in the morning, and 15 inbound and 18 outbound in the afternoon. We are talking about fairly large trucks and other types of vehicles, each which have different types of impact. To be conservative in the analysis, we assumed all trucks were arriving and departing at the commuter peak. The report also took into consideration the existing traffic data at Kekaha Landfill and looked at Kaua‘i traffic growth projections.

R: For Ma‘alo Road, when I look at Route E, it seems like Route E would not impact Maalo Road because the people would be on the main highway. (Question regarding the *Traffic Assessment-Long-Range Future Year, When Intersection Used as Access Route* table on Slide 12).
A: The table shows impacts to Ma‘alo Road when Ma‘alo Road is the alternative access to the landfill. As an aside, all the alternatives have impacts at all of the intersections because cars are coming from around the island, but the majority of impacts would be when cars actually turn into each of these roads to go to the landfill. We are focusing on the intersection that is associated with that access alternative. Whichever route is ultimately chosen, the corresponding intersection with be mitigated (i.e. traffic light). With this mitigation, all of the routes (excluding Route B as there is already a traffic light at ‘Ehiku Street) will have a significant improvement in wait times.

R: Route B has left out a few disadvantages. There is a park near the road where kids have football practice in the afternoon and cross the street. There is also a church that has functions in the afternoon. Any alternative that has to do with residents that can smell the trucks and the exhausts should be eliminated from consideration.
A: Both Cioffi and Yoshioka acknowledged the concerns with the 'Ehiku portion of Route B as affecting the evaluation of the access alternatives.

R: I was trying to look at the ridge- both the apartments and the neighborhood- won't the trucks go through the neighborhoods and wake people up? Where do the trucks come from in the morning? Do they leave from the landfill?
A: Trucks don't leave from the landfill- they park at base yards and start their pick-ups from there and then go to the landfill for drop off. Kekaha Landfill opens at 8:00am. With regard to general noise impacts from access routes, cost estimate includes implementing noise mitigation barriers along the routes in the vicinity of Laukona Street and Kalepa Circle.

R: Have we solved the problem with the FAA on the landfill? If we don't solve the problem, can we even do the landfill?
A: The County is currently working on addressing FAA concerns and going through the process they recommended.

R: Would this landfill site have been chosen if the cost of the road had been known?
A: We did look at the cost of the road during the Siting Study. At that time, we were looking at Maalo Road, Route A, and thought that would be the route, which is very expensive; however, Routes C, D, and E are significantly less expensive than Routes A or B.

R: Is this study being done in the context of a regional traffic and transportation study?
A: No, we did the study in support of the new landfill project. The primary purpose of these access routes is to get to the landfill. The common thread of the study is that all the routes touch Kūhiō Highway. This is not a bypass route. Each road goes to the project site.

R: When you come up with a final decision, what do you weigh it on? Do you weight it on traffic, cost?
A: The final preferred access route will go through the EIS process so this will not be the last time to comment on these issues. We do our best to account for and balance all the concerns. If the only concern was cost the choice would be Route C; however, the County wants to hear the community's feedback and concerns so cost is not the only factor that weighs into the final decision. There is no single metric that is used.

R: I live on 'Ehiku Street and if the access route goes through this area, my property value will drop in half. That really concerns me. I am surprised that more of the other people that live on that road aren't here. I am also concerned about the kids that cross the road every day. There have already been some close calls with the current traffic.
A: Both Cioffi and Yoshioka acknowledged the concern of the resident.

R: For the Roberts Hawaii alternative (Route D), was the proposed housing development across the street taken into consideration?
A: Yes, the analysis took that into consideration. We plan to reach out to them again.

R: I like Option E best. It might actually make the whole thing slightly better anyway because all the garbage trucks are going that way anyway headed for Kekaha Landfill, so this road will divert them.
A: Cioffi and Yoshioka acknowledged the comment.

R: If you mitigated the options by improvements at each intersection, all intersections would be improved except for 'Ehiku Street because they already have a stoplight. I agree that Route E would

be the best option, but you would also help the town of Hanamā‘ulu if you improved the Laulima Street intersection and put in a traffic signal.
A: Laulima would benefit from a signal no matter what and will probably have a signal eventually, regardless of this project. The landfill project would help warrant a signal earlier than it would otherwise. There are rules and guidelines about how and when to install a traffic signal. Certain parameters must be met before a signal is warranted per Manual on Uniform Traffic Control Devices (MUTCD) guidelines. Right now, Kūhiō Highway at Laulima doesn’t quite warrant a signal

R: I have lived here all of my life and raised my child here. The lifespan of the landfill is 240 years so we all won’t be here. I grew up in a time when there was sugar and it was very dusty and all kinds of issues. We became accustomed it. The plantation has closed and now we have come accustomed to our quiet neighborhood. The most important concern for me is the traffic and that those trucks do not come through our neighborhood. We have accepted the landfill when no one else wanted it so the best thing you can do is move the traffic elsewhere. We have been very accommodating. For me and our community, I think the best option is Route E. It will also improve the intersection at Kaua‘i Beach Resort. That road is supposed to be 35 mph, but you’re lucky if someone goes 40 mph. If eventually the bypass is built, that is a whole other issue.
A: Cioffi and Yoshioka acknowledged the comment.

R: I can hear the desirability of Route E- how will that affect the counterflow and the flow of the traffic along Kūhiō Highway? Recently in the Council, we were discussing the proposed improvements on Rice Street and they said that the two things that slow down traffic and cause traffic congestion are traffic lights and left turns. How is that going to affect what is already a problem? How do you do counterflow in a situation like that?
A: There are conceptual plans in the report that describe the proposed intersection improvements. The improvements proposed at Kaua‘i Beach Drive took the current counterflow into consideration. Currently, when the countra-flow is implemented, they don’t shut down Kaua‘i Beach Drive. They leave it open and preserve the left turn lane. In our design, we also maintain the turn lane into Kaua‘i Beach Drive and also accommodate the left–turn lane needed in the opposite direction for the landfill access. More importantly, the improvements we are proposing at the Kaua‘i Beach Drive intersection do not preclude future State DOT plans to improve Kūhiō Hwy to a full four-lane facility.

R: How will the traffic signal (at Kaua‘i Beach Drive) affect the flow of traffic on Kūhiō Highway? Won’t the proposed traffic signal slow traffic down on Kūhiō Highway?
A: If done properly, it would work with the Kapule Highway intersection traffic signal. It would have to be coordinated so that the Kapule and Kaua‘i Beach Drive signals work together. With regard to slowing traffic down, right now, the major capacity constraint is at the Kapule Highway /Kūhiō Hwy intersection. Coordinating the Kapule and Kaua‘i Beach Drive traffic signals will not alleviate this constraint, but it will not exacerbate the current constraint.

R: Could Kaua‘i Beach Resort help with the funding and compensate the County for some of the improvements since Route E would help improve their intersection?
A: We would leave that to the County to discuss with Kaua‘i Beach Resort.

R: If parts of these routes include part of the proposed Bypass Road, has that been looked at?
A: This is not a bypass and nothing regarding the Bypass Road has been analyzed.

R: The chart shows that if you took away the RRP, it would solve a lot of the traffic impacts. If the RRP was located next to the harbor, it would be much easier. There are already roads to the harbor and truck loads of recyclable materials will be going to the harbor anyway. To have the traffic go inland and then back to the harbor is a lot of traffic that you don’t need if it’s better sited.
A: That is a legitimate point of view. However, a lot of communities have found that locating recycling facilities near landfills helps increase the recycling because you make one trip. A lot of communities have found that these co-locations encourage recycling.

R: Can you explain the buffers that you mentioned before?
A: We recommended a noise barrier for the houses on Laukona Street. These are cane haul roads now, but they will be paved so the dust will go down. There will be a sound wall at Kalepa Village. The EIS will address the noise impacts.

SUMMARY OF COMMENTS REGARDING ACCESS ROUTE ALTERNATIVES

Many of the comments did not pertain to the access route alternatives. All of the consolidated comments below referenced the access roads and/or driveways. Some of these comments were echoed by more than one respondent, and worded slightly differently.

1. Several attendees were concerned with negative impact of truck traffic affecting residents along 'Ehiku Street if Route B were implemented.
2. One attendee indicated that Route B would have a negative impact on property values.
3. Several attendees were in favor or Route E.

List of Signed-in Meeting Attendees

Community Meeting
King Kaumuali‘i Elementary School, Hanamā‘ulu, Kaua‘i
Thursday, September 22, 2016, 6:00 pm to 8:00 pm

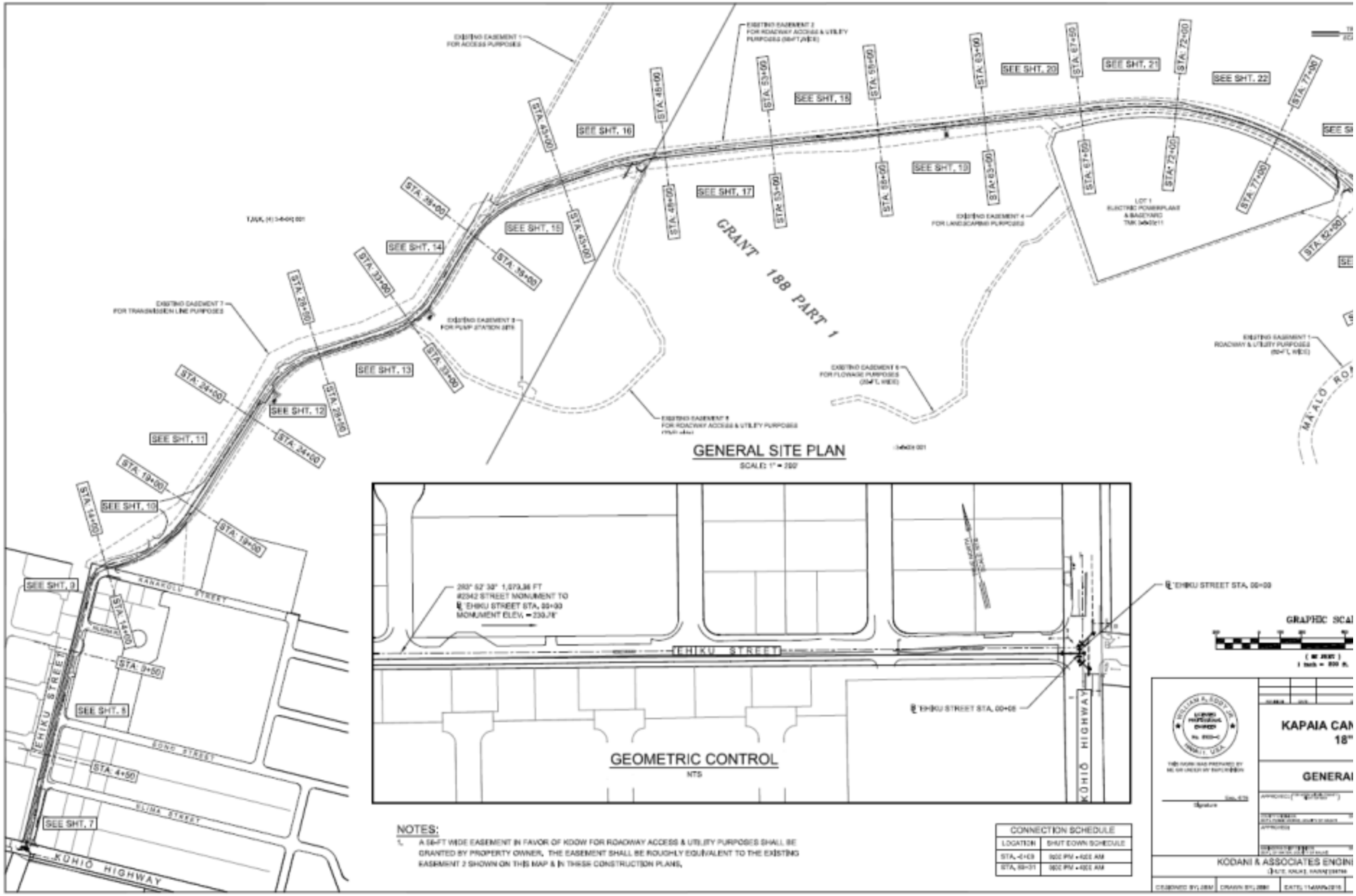
Name		Organization (if any)
1	Dennis Fujimoto	The Garden Island
2	Randall Francisco	
3	Keola Aki	
4	Dario Siborboro	Hanamā‘ulu
5	Henry Delgado	Hanamā‘ulu
6	Laurie Kelekomo	HCA
7	Clayton Cataluna	Hanamā‘ulu
8	Suzette O. Naito	Hanamā‘ulu
9	Ida Kurumoto	
10	Ginger Bray	Puna Aha Moku
11	Angelina Pegeder	
12	Donn Kakuda	COK
13	Troy Tanigawa	COK
14	Juanito Gonzalez	
15	Wally Rezendes Jr	COK
16	Keith Suga	COK
17	John and Debbie Barklow	
18	Jessica Else	Newspaper
19	Felicia Cowden	KKCR
20	Andy	HCA
21	Larry Maysuwaki	FCF of Kaua‘i
22	Eddie Sarita	Han. Comm Assn
23	Mark Hofferbert	AECOM
24	M/M Robert S. Odoya	State of Hawaii Teachers
25	Joann Yukimura	County Council
26	Julie Zimmerman	AECOM
27	Frank Cioffi	AECOM
28	Wayne Yoshioka	AECOM

Appendix C.7:
2016 Written Public Comments

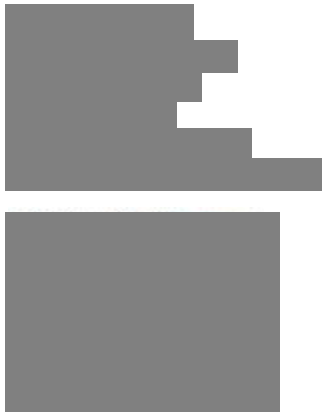
From: [redacted]
Sent: Monday, September 19, 2016 9:56 AM
To: AMER-US-HI Hilo-Kauai Land fill Access Route
Subject: Coordination with Waterline Project on Ehiku & Ma'alo St

To Whom it May Concern,

The Department of Water will be constructing a new 18” water main from Ehiku Street at Kuhio Highway to Ma ‘alo Road as shown in the screenshot below. We are anticipating construction to start in the later half of 2017.


GENERAL SITE PLAN
GRANT 188 PART 1
GEOMETRIC CONTROL
NOTES:
CONNECTION SCHEDULE
KUHIO HIGHWAY
EHIKU STREET
KANAKOLU STREET
KONO STREET
KLIMA STREET
MA'ALO ROAD
KODANI & ASSOCIATES ENGINEERING

Thank you,



From: [redacted]
Sent: Sunday, September 25, 2016 12:52 PM
To: AMER-US-HI Hilo-Kauai Land fill Access Route
Subject: Comments and feedback on the five proposed routes

Dear Sirs,

Please note the proposed new Landfill is in violation of the Code of Federal Regulation (CFR)

The construction of a landfill within 6 Miles of an airport is a violation of CFR 49 U.S.C. § 44718, and a construction of a landfill within 5 miles of airport runway is a violation of CFR 40 § 258.10

http://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=907c127915e9a1d0560c447d7443b3b8&mc=true&n=pt40.27.258&r=PART&ty=HTML

https://www.law.cornell.edu/uscode/text/49/44718

According to the County own paperwork the proposed new landfill is approx. 3.5 miles away from the airport.

The building of any access road to a not supposed to be there landfill is wasting money. Regardless if the costs are 12 or 43 million dollars. Then when the federal Government finds out, and they will find out latest that time when an approaching jet [at south wind conditions] will collide with the wildlife [birds] and the airline files the required FAA report. Worst case: A landing plane crashes before reaching the runway.

Regards

[redacted]

From: [redacted]
Sent: Monday, September 26, 2016 1:40 PM
To: AMER-US-HI Hilo-Kauai Land fill Access Route
Subject: Landfill Route

The Kauai Beach Route makes the best sense. It will improve the intersection. That's my vote.

From: [redacted]
Sent: Tuesday, September 27, 2016 9:45 PM
To: AMER-US-HI Hilo-Kauai Land fill Access Route
Subject: Landfill Route

Aloha,
I am writing in regards to the proposed routes to the new landfill. As a person who grew up in Hanamaulu, more specifically, on Laukona Street where one of the proposed routes is located behind the homes, i am concerned. I am concerned the traffic running behind the homes of Laukona Street, how that may affect the value of the homes, and most importantly, how it may affect keeping the peace. Nevertheless, for years we've been able to enjoy the comfort and privacy in our backyards and being able to appreciate the beauty of Kalepa Mountain. I'd like to keep it that way for the years to come. Creating a route behind the homes takes the peace and privacy away from what we've been accustomed to for years.
I think the best and reasonable route would be route A, making an adjacent road from Maalo Road to the landfill. This would not disturb any homes or nearby communities.
Thank you for taking the time to read my email and hope that you would take my sincere thoughts and opinions into consideration.
--
[redacted]

From: [redacted]
Sent: Friday, September 30, 2016 10:30 AM
To: AMER-US-HI Hilo-Kauai Land fill Access Route
Cc: [redacted]
Subject: Access Routes Public Comment Sheet - Proposed New Muncipal Solid Waste Landfill and Resource Recovery Park at Ma'alo, Kauai
Attachments: ACCESS ROUTES PUBLIC COMMENT SHEET.docx

Aloha
Attached herewith is my comment on the above subject matter.
[redacted]

ACCESS ROUTES PUBLIC COMMENT SHEET

PROPOSED NEW MUNICIPAL SOLID WASTE LANDFILL AND RESOURCE RECOVERY PARK AT MA'ALO, KAUAI

My name is [redacted]. I am a resident of Hanamaulu. I am also the president of the Hanamaulu Community Association. I attended the public meeting held by the Dept. of Public Works, County of Kauai at King Kaumualii School cafeteria on Sept. 22, 2016 to discuss the Access Road Alternatives for the Proposed New Municipal Solid Waste Landfill & Resource Recovery Park.

I believe that **Route E** at Kuhio Highway & Kauai Beach Drive is the most favorable of the 5 routes being considered.

Advantages:

1. Increased traffic through Lihue & Hanamaulu will be minimized because the landfill-bound traffic from Kapaa/North Kauai will access the route prior to reaching Hanamaulu. The same type of traffic particularly the county trash trucks from West Kauai will be or can be routed using Nawiliwili Road & Kapule Hwy to reach Route E's entrance. Other types of traffic will only be of Puhi & Lihue residents or industrial users who want access to the landfill or RRP and they will most likely either use Ehiku St. onto the existing cane haul road (if it is open to public traffic) or Ma'alo Road from Kapaia. Common sense dictates that Hanamaulu residents either use Route E or Ma'alo Road. Business traffic particularly from contractors & other industrial types inbound from West Kauai can be required to use the same roads as for the county trucks. I don't believe west Kauai residents will drive to the new landfill anymore than I would want to drive to the Kekaha Landfill to dispose of my trash.

2. The new intersection at Kuhio & Kauai Beach Drive will be signalized. This will make this stretch of Kuhio Hwy more manageable from a traffic standpoint and safer by slowing down the speeding that is currently occurring. It will make it much safer for those visitors & residents patronizing the Nukolii Resort area to access & egress the area. It may also encourage the State DOT to prioritize widening Kuhio Hwy from Wailua River Bridge to Lihue Airport to 4 lanes from the current 3 lanes.

3. It is important to bear in mind that Kapaa & North Kauai is where more than 50% of Kauai's population and visitors live and stay and where a lot of trash will be generated. As mentioned in No. 1 above, traffic from this part of Kauai will not have to travel through Hanamaulu or Lihue to access the landfill or RRP.

4. Cost of road way improvements for Route E is much lower compared to Routes A & B; only $5 million higher than for Route C and $3 million higher than for Route D but much more advantageous than any of those routes.

Disadvantages:

1. Increased noise from traffic for Hanamaulu residents especially where Route E passes around the base of Kalepa Hill in the vicinity of the old Hanamaulu Shop area and the Kalepa Village area. There are measures, however, that can be constructed to mitigate this negative situation such as building a concrete wall barrier along with heavy landscaping.

2. Landfill/RRP bound traffic having to use the circuit route as described in No. 1 above will have a longer distance to travel.

(end)

From: [redacted]
Sent: Wednesday, October 12, 2016 12:57 PM
To: AMER-US-HI Hilo-Kauai Land fill Access Route
Subject: Kauai Access Route Comments
Attachments: Ma'alo Landfill Site.pdf

Access Route A: Ma'alo Road:
Advantages: None
Disadvantages: All the Landfill traffic will have to go right through Hanama'ulu Town and Lihue. Too expensive.

Access Route B: Ehiku Street:
Advantages: None
Disadvantages: **Emergency corridor for main Kauai hospital. Safety concerns on Ehiku Street; used by kids, elderly, joggers, dog walkers. Close to churches, parks, and neighborhood center. Property value drop.**
Most expensive route.
Please see attached letter.

Access Route C: Laulima Street
Advantages: Cheapest
Disadvantages: Major disruption to traffic and life in Hanama'ulu.

Access Route D: Roberts Hawaii Driveway
Advantages: Close to major highway so no extra traffic through residential areas in either Lihue or Hanama'ulu
Disadvantages: None.

Access Route E: Kauai Beach Drive Access
Advantages: Access from major highway with a new traffic light and holding/turns lanes. Does not go through any residential areas.
Disadvantages: None.

[redacted]. The long side of our house fronts Ehiku Street.

The county is preparing to designate the access route to the Ma'alo Landfill Site, which is behind Hanamaulu Town. There are five potential access routes with three of them going through Lihue and Hanamaulu neighborhoods. It is those three that are the concern.

These three access routes are part of the emergency corridor for the main hospital on Kauai. When these trucks break down in Lihue or Hanamaulu, there is no place for them to turn off so a lane would be shut down for hours, limiting ambulance and emergency vehicle access.

At least 64 transfer and private garbage trucks will be converging from all over the island every day in Lihue. According to the County, that will be 27 in the morning and 37 in the afternoon. Think about that for a minute. What will that be like in 5 years with the Resource and Recovery Park (Recycling Center) up and running? The Lihue traffic congestion on Kuhio Hwy is already unacceptable right now.

The Ehiku Street access route will be a devastating disruption to the Isenberg, Lihue Camp A and Camp B neighborhoods. The amount of youngsters that go back and forth on this street has to be a safety concern, along with the dog walkers, joggers, and, in particular, the three elderly ladies that use it on their daily walks. Also, it is the main street to access the Lihue Neighborhood Center, the Isenberg Park, and the several churches.

Last but not least, what about the inevitable drop in property values of the houses on this route and the adjoining streets? Who wants all this traffic, diesel fumes, noise, and stench in their front yard?

The construction of this access route is the longest and most expensive one proposed, which should be a big concern for all taxpayers on the island. If this proposed landfill gets approved, the Roberts or the Kauai Beach Drive access routes are the shortest, least expensive, and least disruptive.

From: [redacted]
Sent: Monday, October 17, 2016 3:18 PM
To: AMER-US-HI Hilo-Kauai Land fill Access Route
Subject: Comments and Feedback on Proposed Routes

[redacted]

October 17, 2016

AECOM
Attn: Kauai New Landfill/RRP Access Roads
1001 Bishop St., Site 1600
Honolulu, HI 96813

Dear Sir:

I am writing this at the zero hour as in my mind I knew from the very beginning the people of Hanamaulu do not have the political power to make a difference in their own community. I believe the choice of the landfill site is a done deal. We have been duped the "Armpit of Kauai", "Little Manila", and the "Slums".

The thought of the landfill being placed in our community is shameful to say the least. We have low cost housing, affordable rentals, a school, two churches and now the up and coming development of the triangle at the Kapule By-Pass intersection carrying a price tag of upwards of $400K. The residents of Isenberg Tract have the audacity to say putting the access road in their area will lower the value of their homes. What about the people who call Hanamaulu their home? What about the children who attend King Kaumualii School? Don't they matter? Not to mention the noise, dust and smell that WILL come with the landfill.

We have lived in Hanamaulu for most of our married life, raised three children, two of whom have chosen to make their homes in Hanamaulu as well and have raised their children here too. This plantation town is a stone's throw away from the county seat, the airport, and shopping malls. Enough is enough! Every time a community doesn't want a project in their area Hanamaulu becomes the dumping ground. I say place the landfill somewhere else away from people and children. The cost factor always comes into the picture. Aren't our people and our children worth far more than what it will cost to build an access road?

Thank you for your time and consideration in this matter.

Sincerely,

From: [redacted]
Sent: Tuesday, October 18, 2016 8:26 AM
To: AMER-US-HI Hilo-Kauai Land fill Access Route
Subject: Public Comment Regarding Access Route Alternatives for the Proposed New Landfill and RRP

Follow Up Flag: Follow up
Flag Status: Completed

I am concerned about the using of Ehiku Street (Route B) as a alternative access route connecting to Kuhio Highway. Currently Ehiku Street is being used as a connecting route to Lihue Neighborhood Center as well as the Mormon Church, which in itself have created additional traffic flow. Due to the location of Isenberg Park, many youth activities are being held there throughout the week. In addition, Ehiku Street itself is also being used as a walking route for many residence. By using Ehiku Street as an access route for the proposed new landfill will absolutely creating more traffic to the already heavily used street and resulting potentially dangerous condition for drivers and walkers.

Mahalo,
[redacted]

Access Route E: KAUA'I BEACH DRIVE

(E1) **Advantages for Access Route E:**

I like E best, because it impacts Hanamaulu least.
All the trucks are on Kuhio anyway.
It is least impacting on the congestion where Kuhio splits from Kapule.

(E2) **Disadvantages for Access Route E:**

Sound at Kalepa Ridge.

Tall sound wall would be good, behind Laukona St. & Kalepa Ridge

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kaua'i [Zipcode or Community: 96754]
2. On the island of Ni'ihau
3. On another island in Hawai'i
4. Outside the State

If you would like to receive feedback on the results of this survey, please provide your contact information (postal or email address) below. All contact items are voluntary.

Name and Address: [redacted]

e-mail address: [redacted]

If provided, your contact information will be maintained for communication purposes only, until the Final EIS is issued. No information you supply on this form will be released to any person or agency without your prior permission. No information reported during the course of this project will be attributed to any individual or any agency without prior approval. Data will be reported in aggregate form only.

Access Route E: KAUA'I BEACH DRIVE

(E1) **Advantages for Access Route E:** THIS ROUTE COMPLETELY BYPASSES THE TOWN OF HANAMAULU. THE COUNTY COULD ASK KAUAI RESORT TO SHARE THE COST OF THE SIGNAL LIGHT ON KUHIO HWY. & THE COUNTY SHOULD GIVE THE HANAMAULU TOWN ASSOCIATION A FEE FOR EACH TRUCK DUMPING AT THE SITE. (THE TOWN COULD SAY NO TO THIS SITE)

(E2) **Disadvantages for Access Route E:**

DUMPING SHOULD BE REGULATED, SAY FROM 8:00-8:00PM TO CUT DOWN THE NOISE OF THE TRAFFIC.

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kaua'i [Zipcode or Community: Kaua 96756
2. On the island of Ni'ihau
3. On another island in Hawai'i
4. Outside the State

If you would like to receive feedback on the results of this survey, please provide your contact information (postal or email address) below. All contact items are voluntary.

Name and Address:

e-mail address:

If provided, your contact information will be maintained for communication purposes only, until the Final EIS is issued. No information you supply on this form will be released to any person or agency without your prior permission. No information reported during the course of this project will be attributed to any individual or any agency without prior approval. Data will be reported in aggregate form only.

ACCESS ROUTES PUBLIC COMMENT SHEET

Proposed New Municipal Solid Waste Landfill and Resource Recovery Park at Ma'alo, Kaua'i

BACKGROUND INFORMATION

The enclosed **Fact Sheet** describes the potential Access Routes A, B, C, D, and E, and summarizes the preliminary results of the **REVISED DRAFT TRAFFIC AND ROADWAYS ENGINEERING FEASIBILITY STUDY (TREFS).** Further details of the potential access routes are provided in the Revised Draft TREFS report, available on the County of Kaua'i's New Landfill website: **www.kauai.gov/NewLandfillSite**

For each route, the TREFS report provides detailed analysis of existing and projected traffic conditions and impacts; recommended improvements and associated cost estimates; and a preliminary evaluation of the potential social impacts.

PUBLIC OUTREACH

This public outreach is being conducted in response to public concerns regarding the access routes expressed during meetings held for the ongoing project Environmental Impacts Statement (EIS) process. The County is committed to soliciting and considering all reasonable public concerns regarding the potential access routes. No final decision regarding the proposed access route has been made, and the proposed access route will be further analyzed during the ongoing EIS process. Public comments will be considered, along with other engineering, environmental, and cost data to assist the County of Kaua'i in selecting the best access route to the Ma'alo Landfill Site.

INSTRUCTIONS

Please review the Fact Sheet, and preferably the Draft TREFS report, which are intended to summarize the analyses performed, prior to providing your comments this comment sheet. For each route, please list the advantages and disadvantages, if any, you think that access route has for the site, the nearby communities, or the residents and businesses of the County of Kaua'i.

If you feel that one of the advantages or disadvantages is most important, please circle it. If you feel that any particular route has no advantages or disadvantages, please leave that section empty. Attach a separate sheet, if necessary, and please remember to circle or otherwise indicate the most important advantage or disadvantage of this route, if applicable.

Comments can be submitted via e-mail to: KauaiLandfillAccessRoute@aecom.com

or via mail to: AECOM
Attn: Kauai New Landfill/RRP Access Roads
1001 Bishop Street, Suite 1600
Honolulu, HI 96813

All responses must be received by Monday, October 17, 2016.

Access Route A: MA'ALO ROAD

(A1) **Advantages for Access Route A (and Driveway 1 or 2):**

(A2) **Disadvantages for Access Route A (and Driveway 1 or 2)**

Access Route B: 'EHIKU STREET

(B1) **Advantages for Access Route B (and Driveway 1 or 2)**

(B2) **Disadvantages for Access Route B (and Driveway 1 or 2)**

Access Route C: LAULIMA STREET

(C1) **Advantages for Access Route C:**

(C2) **Disadvantages for Access Route C:**

Access Route D: ROBERTS HAWAII DRIVEWAY

(D1) **Advantages for Access Route D:**

(D2) **Disadvantages for Access Route D:**

Access Route E: KAUA'I BEACH DRIVE

(E1) **Advantages for Access Route E:**

(E2) **Disadvantages for Access Route E:**

Increased traffic especially with contra flow hours/days.

Will public/tourists be able to use road to access Waikua Falls or is road only for transfer trash trucks?

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kaua'i [Zipcode or Community: Hanamaulu]
2. On the island of Ni'ihau
3. On another island in Hawai'i
4. Outside the State

If you would like to receive feedback on the results of this survey, please provide your contact information (postal or email address) below. All contact items are voluntary.

Name and Address:

e-mail address:

If provided, your contact information will be maintained for communication purposes only, until the Final EIS is issued. No information you supply on this form will be released to any person or agency without your prior permission. No information reported during the course of this project will be attributed to any individual or any agency without prior approval. Data will be reported in aggregate form only.

ACCESS ROUTES PUBLIC COMMENT SHEET

Proposed New Municipal Solid Waste Landfill and Resource Recovery Park at Ma'alo, Kaua'i

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Access Route A: MA'ALO ROAD

(A1) Advantages for Access Route A (and Driveway 1 or 2):

Minimal impact to residential areas.

(A2) Disadvantages for Access Route A (and Driveway 1 or 2)

- High cost
- Safety issue due to tourist traffic: unfamiliar with road, speeding.

Access Route B: 'EHIKU STREET

(B1) Advantages for Access Route B (and Driveway 1 or 2)

(B2) Disadvantages for Access Route B (and Driveway 1 or 2)

- High cost
- Negative impact (safety, noise, aesthetics, etc.) to existing neighborhood and park.

Access Route C: LAULIMA STREET

(C1) Advantages for Access Route C:

- Lesser cost (of 5 proposals) is attractive/advantage.

(C2) Disadvantages for Access Route C:

- Impact (dust & noise) to existing homes and businesses can be minimized with wall and trees/landscaping.

Access Route D: ROBERTS HAWAII DRIVEWAY

(D1) Advantages for Access Route D:

(D2) Disadvantages for Access Route D:

- Increased traffic onto Kuhio Hwy. from Kohea Loa Housing subdivision being developed - 450 units being proposed.
- Impact to existing rush hour traffic (am & pm)

Access Route E: KAUA'I BEACH DRIVE

(E1) **Advantages for Access Route E:**

It will be Easy to get out From Kauai Beach DR. When a TRAffic Light is instalL TRAffic Should Move a Lot better for the Intersection.

(E2) **Disadvantages for Access Route E:**

they is Know Dis Advantages for the Garagetrucks to drive out of Resident AREA. IN case of Breakdown.

General Questions for Respondents

(QG1) **Where do you currently live (circle one):**

1. One the island of Kaua'i [Zipcode or Community: 96766]
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(B2) **Disadvantages for Access Route B (and Driveway 1 or 2)**

Access Route C: LAULIMA STREET

(C1) **Advantages for Access Route C:**

(C2) **Disadvantages for Access Route C:**

Access Route D: ROBERTS HAWAII DRIVEWAY

(D1) **Advantages for Access Route D:**

(D2) **Disadvantages for Access Route D:**

Appendix G
Wildlife Hazard Assessment
(SWCA 2016)

PROPOSED MAʻALO LANDFILL PROJECT WILDLIFE HAZARD ASSESSMENT

August 2016

Prepared For

AECOM
1001 Bishop Street, Suite 1600
Honolulu, HI 96813

Prepared By

SWCA Environmental Consultants
1001 Bishop Street, Suite 2800
Honolulu, HI 96813

Proposed Maʻalo Landfill Project
Wildlife Hazard Assessment
Kauaʻi, Hawaiʻi

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SWCA Project No. 29003

August 26, 2016

EXECUTIVE SUMMARY

The County of Kauaʻi (County) proposes to construct and operate a new Municipal Solid Waste Landfill and a Resource Recovery Park (RRP) at the Maʻalo site on the island of Kauaʻi, Hawaiʻi. The proposed Maʻalo landfill is located approximately 12,200 feet (2.3 miles) from the Lihue Airport (LIH) airport operations area (AOA) and the proposed limits of waste would be approximately 13,300 feet (2.5 miles) from the nearest LIH runway. Due to the proximity of the Maʻalo site to LIH, the Hawaiʻi State Department of Transportation (HDOT) has expressed concerns that the proposed project, if not properly designed and managed, could attract wildlife that may pose a threat to air traffic at LIH. In response to HDOT's concerns, the County conducted a Landfill Wildlife Hazard Assessment (LWHA) in general accordance with *Wildlife Hazard Management at Airports: A Manual for Airport Personnel* (Clearly and Dolbeer 2005). The LWHA team conducted 24 wildlife surveys over a 12-month period in the vicinity of both the existing Kekaha Landfill and the proposed Maʻalo site. This report details the findings of the assessment and provides recommendations for landfill design features and operational procedures that could avoid or mitigate potential wildlife hazards.

The study relied on data collected from the Federal Aviation Administration Wildlife Strike Database, existing literature, and field surveys. Strike data for LIH, as well as Hilo and Kahului Airports, and other existing literature indicate that some species of wading birds (including cattle egret [*Bubulcus ibis*]) and shorebirds (including Pacific golden plover [*Pluvialis fulva*]), Hawaiian goose [*Branta sandvicensis*], and columbids, munias, and larks are top hazard concerns for the reviewed airports. These avian groups are attributed to over 60% of the airport's strikes (cumulatively), are identified as requiring significant deterrence efforts at LIH, are identified as a zero tolerance species, or are present at or near the airfield in large flocks.

The LWHA team conducted field surveys at the existing Kekaha Landfill and around the proposed Maʻalo site. Survey data collected at the Kekaha Landfill provided insight into which avian species utilize the existing landfill, which landfill features attract avian species, which species utilize those features, and how they utilize the features. These data were used to determine which specific landfill features may be wildlife attractants, which species may be attracted to a landfill at the proposed Maʻalo site, and how those species might utilize the proposed landfill. While the proposed site is windward and the existing site is leeward, many of the same avian species are present in the vicinity of each site. The goal of the surveys at and around the proposed Maʻalo Landfill site was to assess the existing conditions and wildlife movements at and around the proposed site, identify the species currently present, and assess which species have the potential to cause hazards to aircraft in the area if a landfill were established at the proposed site.

The survey data clearly show that cattle egret and common myna (*Acridotheres tristis*) have a strong attraction to the existing Kekaha landfill. These birds actively fly to and from the landfill throughout daylight hours and utilize the active face of the landfill (the area where waste is being landfilled on a given day) for foraging and the inactive face (soil covered landfill areas) of the landfill for loafing. Over 50% of the cattle egret observations at the Kekaha landfill included birds in flight. Birds in flight are a greater concern to aircraft than birds on the ground, particularly when the birds attain the altitude of the airspace. The birds loafing on the soil-covered face appeared to be resting between foraging attempts on the active face. Cattle egret and common myna are present in large numbers in the Maʻalo area. Cattle egret were observed flying through the proposed Maʻalo site to access existing roosts in the site vicinity and they loaf and forage on site among the cattle that currently use the site. There are a number of existing cattle egret roosts in both the Kekaha and Maʻalo study areas. At Kekaha, the biologists observed cattle egrets flying from roosts that are up to 2.9 miles away from the landfill to forage at the landfill. There are four cattle egret roosts within 2.9 miles of the proposed Maʻalo site and LIH is roughly 2.3 miles from the proposed site. Based on the data, it is reasonable to expect that, unless the potential attractant can be controlled, cattle egret could make long flights to access a landfill at the proposed

Maʻalo site. These flights would have the potential to cross through LIH aircraft flight patterns. In addition, the proposed Maʻalo site is situated below the flight path of LIH-based helicopters. Birds attracted to a landfill at the Maʻalo site could potentially traverse the flight path of low flying helicopter traffic.

Cattle egret and common myna are among the species most commonly observed at the two sites. While some columbids (spotted and zebra doves [*Streptopelia chinensis* and *Geopelia striata*]) are attracted to many features at the Kekaha Landfill, they were not observed traveling long distances at high altitudes to access the landfill.

Rock pigeons (*Columba livia*) were observed in the agricultural fields near the landfill and were observed flying over the landfill, but they were not observed on the active face and are apparently not attracted to any of the landfill features at Kekaha. The Maʻalo survey data indicates that rock pigeons frequently make long flights between urban areas, gulches, and trees in the Maʻalo study area. Rock pigeons are known to be attracted to urban areas for foraging and may travel long distances to access forage areas. While the lack of rock pigeon attraction to the Kekaha Landfill suggests that a potential landfill at Maʻalo would not attract the species at higher numbers than the current site conditions (agricultural fields and pasture), the potential for attraction to some landfill features that may be different at Maʻalo than Kekaha due to differences in rainfall (e.g., retention ponds) warrants consideration as possible attractants. If these areas are not properly designed and managed, they could become attractants, and rock pigeons might make long, high elevation flights to access a landfill at the Maʻalo site.

The Maʻalo site experiences greater precipitation than the Kekaha site, which could create more attractive water features at Maʻalo than what was observed at Kekaha. Considering the wetter conditions at Maʻalo, wading and water birds may have a stronger attraction to a landfill at Maʻalo than what was observed at Kekaha. In addition, owls and geese were observed at both sites and may utilize a landfill in the Maʻalo area. These guilds are discussed below:

- Based on the Kekaha Landfill and Maʻalo survey data, several wading and water bird species may have limited attraction to a leachate pond, storm water basin, drainage area, or short grass areas at the proposed landfill. There could be greater attraction to these features in the Maʻalo area due to higher rainfall (e.g., if permanent water were allowed to accumulate in a leachate pond or infiltration basin). Since species in these avian groups are known to make long flights that could interfere with aircraft, inclusion of design elements and operational procedures to deter these species from the proposed landfill are warranted.

- Owls are attracted to the Kekaha Landfill and have been observed foraging at the Maʻalo site. Owls are known to travel long distances to access foraging areas. Tall grass could provide nesting and foraging habitat for pueo (*Asio flammeus sandwichensis*). Operational procedures to reduce the small mammal prey base and nesting opportunities at the Maʻalo site should be implemented to minimize owl attraction to the proposed landfill.

- Hawaiian geese are attracted to the green waste piles and other vegetated areas at the existing Kekaha landfill; there is no indication that Hawaiian geese are attracted to the active face. This species was observed foraging and roosting in grassy and agricultural areas near the proposed Maʻalo site, and is routinely observed flying through the site at various times of day. While apparently not attracted to waste, Hawaiian geese may be attracted to other suitable features at the proposed Maʻalo Landfill for shelter, roosting, or nesting. Habitat management activities are therefore recommended to deter Hawaiian goose attraction.

The surveys reveal that existing features and land use at the Maʻalo site and its vicinity currently attract wildlife. Introduction of the proposed landfill has potential to increase the area's attraction to wildlife, if

the landfill was not properly designed and managed. Avian attractants near airports are a concern to aviation; therefore, this LWHA recommends that the County design the landfill in such a way that minimizes wildlife attraction to the facility, and that the County prepare and implement an operational Landfill Wildlife Management Plan (LWMP). Landfill design recommendations in this LWHA include putrescible waste management alternatives, landscape guidelines, waterbody design guidelines, and structure design guidelines. Once the landfill is operational, the LWMP should implement passive wildlife management, including designation of a landfill wildlife coordinator, obtaining and maintaining permits, and managing wildlife habitat. The LWMP should provide for active wildlife controls as well. Active wildlife controls could include hazing and lethal removal of select species. Various options for these actions are provided in Chapter 4 of this LWHA.

Several species that are protected under the federal and Hawaiʻi Endangered Species Acts (ESAs) occur in and around the proposed Maʻalo site. Threatened or endangered species did not appear to be attracted to any waste-handling operations at the existing Kekaha landfill, but did show attraction to water features adjacent to the Kekaha landfill). The recommended landfill design modifications and LWMP procedures, which will be selected in consultation with the United States Fish and Wildlife Service (USFWS) and Hawaiʻi Department of Land and Natural Resources (DLNR), are expected to reduce these species' potential attraction to the landfill. Therefore, current data does not suggest that focused hazing or removal of threatened or endangered species would be required at the proposed landfill. If, however, any threatened or endangered species become attracted to the landfill despite the designed deterrent measures, the individuals may be subject to indirect harassment. Harassment is considered a form of "take" under the federal and state ESAs. Therefore, coordination with USFWS and Hawaiʻi DLNR would be necessary while designing the landfill features and developing the recommended LWMP, and permits or other agreements may be required.

In addition, lethal control of cattle egret would require the County to obtain a Migratory Bird Treaty Act (MBTA) Depredation Permit. In November 2013, USFWS published a Proposed Rule for a Migratory Bird Permit Control Order for Introduced Migratory Bird Species in Hawaiʻi (USFWS 2013). If approved, the control order would provide a mechanism for USFWS to issue a MBTA take permit for the control of cattle egret to benefit Hawaiʻi's native wildlife species. If conducted appropriately, cattle egret abatement activities at the Kekaha Landfill and/or the proposed Maʻalo Landfill can be complementary to other current efforts to control cattle egret populations on the island.

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Appendix A. List of Species Observed at the Kekaha and Maʻalo Study Areas
Appendix B. Regulatory Agency Comments on the Draft Wildlife Hazard Assessment

1 INTRODUCTION

The presence of wildlife in and around airports increases the risk of wildlife/aircraft strikes, which poses a threat to human safety and can cause substantial damage to aircraft. Animals commonly involved in wildlife strikes include a variety of avian species, elk, deer, and canines. Flocking and large birds are of particular concern for airports because they can cause substantial damage to aircraft. To reduce the potential for wildlife strikes with aircraft, the Federal Aviation Administration (FAA) issued Advisory Circular (AC) 150/5200-33B, *Hazardous Wildlife Attractants on or near Airports* (AC 33B) (FAA 2007), which provides guidance to public-use airports about certain land uses that may attract hazardous wildlife. AC 33B discusses waste disposal projects, agricultural activities, water management facilities, wetlands, dredge spoil containment areas, golf courses, and other land uses that may attract hazardous wildlife. These land uses are discussed in relation to three separation zones around airports. Perimeter A includes a 5,000-foot buffer from the nearest air operations area (AOA) of airports that serve piston-powered aircraft. Perimeter B includes a 10,000-foot buffer from the nearest AOA of airports that serve turbine-powered aircraft. Perimeter C includes a 5-mile buffer around airports to protect approach, departure, and circling airspace. Because the land uses discussed above are known to attract hazardous wildlife, the FAA discourages these land uses within Perimeters A and B. For projects that are located outside of Perimeters A and B but within Perimeter C, the FAA may review and comment on development plans to determine if the changes present potential wildlife hazards to aircraft operations (FAA 2007). AC 33B indicates that proposed land use changes that may attract hazardous wildlife within the three separation distances should be avoided, eliminated, or mitigated.

For further guidance on the construction or establishment of new municipal solid waste landfills (MSWLF) near a public airport, the FAA issued AC 150/5200-34A, *Construction or Establishment of Landfills near Public Airports* (AC 34A) (FAA 2006). AC 34A provides guidance to public airports that should be used to comply with MSWLF site limitations contained in Title 49, Section 44718(d) of the United States Code (U.S.C.), as amended by Section 503 of the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century. Specifically, Section 44718(d), as amended, was enacted to limit the construction or establishment of a landfill within 6 miles of certain smaller public airports (FAA 2006). The Lihue Airport (LIH) is not the type of smaller public airport the statute applies to (FAA 2014).

The County of Kauaʻi (County) is responsible for properly managing municipal solid waste on Kauaʻi, in the safest and most efficient manner practicable. The island's only existing MSWLF, at Kekaha, is projected to reach capacity in the coming years. Therefore, the County proposes to construct and operate a new MSWLF and a Resource Recovery Park (RRP) at the Maʻalo site. The proposed Maʻalo Landfill is located approximately 12,200 feet from the LIH AOA and falls outside of Perimeters A & B, but within Perimeter C of the separation criteria established in AC 33B. The proposed limits of waste would be approximately 13,300 feet (2.5 miles) from the nearest LIH runway, but LIH does not meet the definition of a small public airport under AC 34A. Therefore, the site limitations contained in 49 U.S.C. 44718(d), as amended, do not apply to the proposed project. Similarly, the proposed Maʻalo Landfill lies outside of the 5,000-foot and 10,000-foot buffer zones from airports that are prohibited in both the Federal and the state landfill regulations (40 Code of Federal Regulations Section 258.10(a) and Hawaiʻi Administrative Rules Section 11-58.1-13(a)).

Due to the proximity of the Maʻalo site to LIH, the Hawaiʻi State Department of Transportation (HDOT) has expressed concerns that the proposed project could attract wildlife that may pose a threat to air traffic at LIH. In response to HDOT's concerns, the County retained SWCA Environmental Consultants (SWCA) and AECOM to conduct a Landfill Wildlife Hazard Assessment (LWHA). The objective of the LWHA is to evaluate baseline conditions and wildlife attractants present at on the proposed site, and the potential of the proposed project to create new or exacerbate existing wildlife hazards to air carrier operations at LIH. The LWHA identifies specific avian attractants, avian species, and their movements in

the vicinity of the proposed landfill that may threaten safe operations at LIH. This data may be used to develop design and operational mitigation measures tailored to minimize potential hazards. SWCA and AECOM reviewed available information, completed the 12-month field study, and have prepared this LWHA to document the findings of the study. Regulatory agency comments on the LWHA are included in Appendix B. This report summarizes the results of the assessment and provides recommendations for potential landfill design features and operations that could avoid or mitigate wildlife hazards.

1.1 Study Area Locations

The LWHA team observed wildlife activity at the existing Kekaha Landfill and at the proposed Maʻalo Landfill and RRP site (refer to Figures 1–3). These two study areas are located on opposite sides of the island. The existing Kekaha MSWLF is located on the leeward (west) side of Kauaʻi, approximately 1.75 miles north of Kekaha town on the Kaumualiʻi Highway. As shown in Figure 2, the Kekaha study area focuses on the existing landfill and approximately 2,978 acres around the Kekaha MSWLF. The study area extends from Kekaha town, north to the Sunrise Capital shrimp farm, and up to approximately 2 miles inland from the coast, near the foothills. The Kekaha study area captures a variety of wildlife habitats including the existing landfill, agricultural areas, wooded areas, coastline, urban development, and aquatic sites.

The proposed Maʻalo site (270 acres) and alternate RRP site (80 acres) are located on the windward (east) side of Kauaʻi, approximately 2.2 miles northwest of LIH, east of Maʻalo Road. As shown in Figure 3, the Maʻalo study area includes approximately 12,777 acres of variable terrain and extends from approximately Nāwiliwili Bay in the south to the Wailua River in the north, and, from the coast in the east to the foothills of Mount Waiʻaleʻale in the west. The study area includes a portion of the approach, departure, and western circling airspace for LIH. As discussed in Section 3.3.2.2, some of the cattle egrets that currently forage in and around the Maʻalo site roost in locations beyond this defined study area.

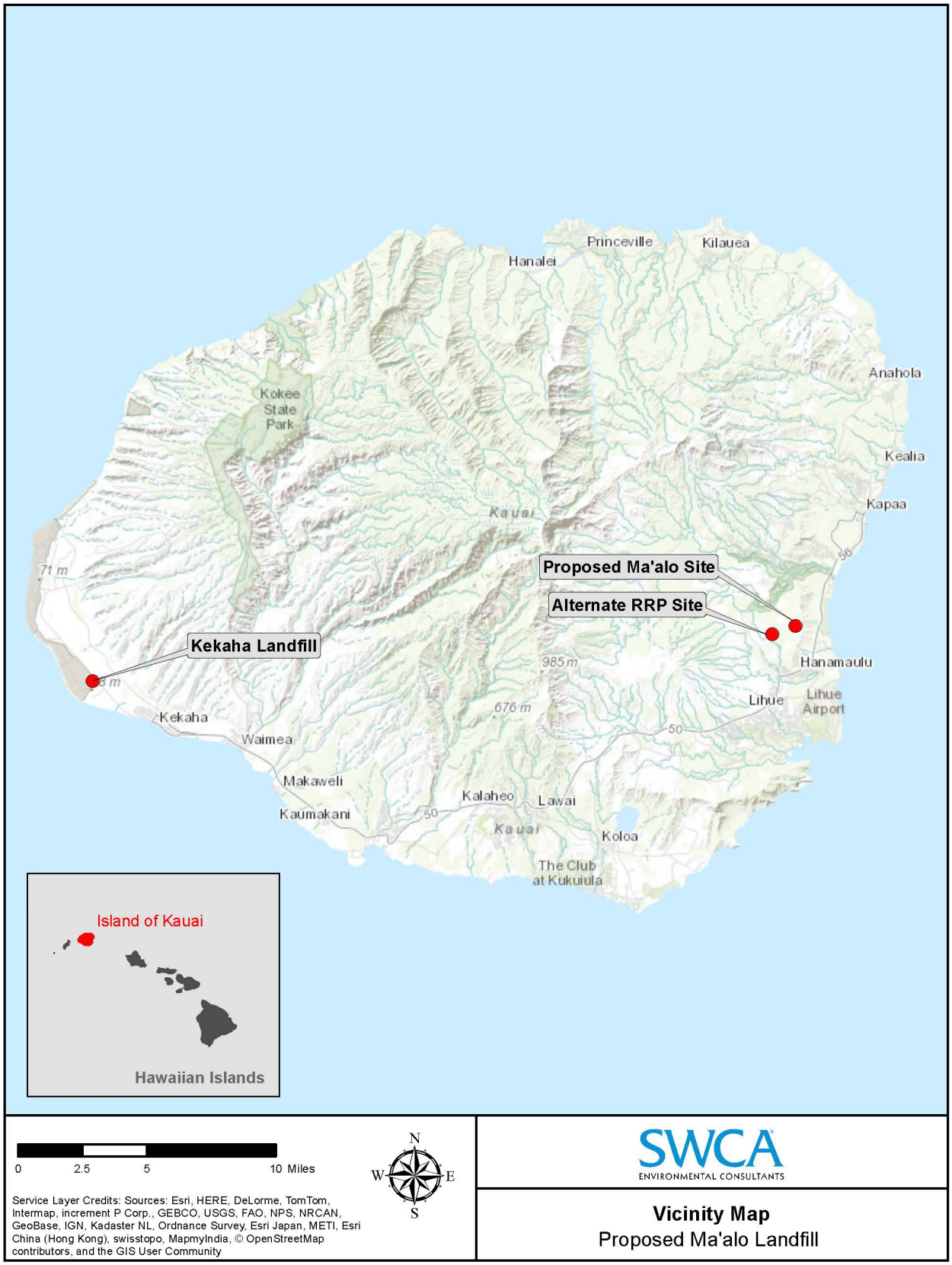
2 METHODS

The objective of this LWHA is to assess the potential for the proposed MSWLF to attract hazardous wildlife to the proposed landfill and around LIH, identify features of concern, and identify potential management alternatives. Assessing wildlife hazards for a facility that does not exist presents a challenge associated with predicting which species' behaviors are likely to be affected by the land use change, and how those species' behaviors may be affected. To address this challenge, the LWHA team studied the existing wildlife activity at the proposed Maʻalo Landfill site to determine what species are currently using the area. In addition, the LWHA team studied the wildlife activity at the existing Kekaha Landfill to establish a baseline of which species are attracted to which existing landfill features, and how these species utilize the landfill. The LWHA study includes but is not limited to reviews of existing data and field surveys.

2.1 Data Review

Wildlife Hazard Assessments (WHA) and wildlife strike data for airports are commonly studied and documented as part of airport-specific wildlife hazard management programs. These on-going studies and the associated FAA Wildlife Hazard Strike Database provide site-specific data for airports throughout the nation. In order to obtain a snap shot of the wildlife hazards that are experienced at LIH and other Hawaii airports with similar situations, the LWHA team reviewed the FAA Wildlife Hazard Strike Database and current WHAs/Wildlife Hazard Management Plans (WHMPs) for LIH and other Hawaiian airports that are situated near landfills.

Figure 1. Project Vicinity Map



The following resources were reviewed:

- *Wildlife Hazard Assessment, Lihue Airport LIH*, United States Department of Agriculture Wildlife Services (USDAWS), January 10, 2005.
- *Wildlife Hazard Management Plan Lihue Airport, Annex 1,* November 8, 2010.
- *Wildlife Hazard Management Plan, Hilo International Airport*. February 28, 2013.
- Federal Aviation Administration Wildlife Strike Database for LIH, Hilo International Airport (ITO), and Kahului Airport (OGG), Embry-Riddle Aeronautical University, 2014.

2.2 Field Surveys

The project team conducted wildlife surveys at and around the two sites over the course of 12 consecutive months (August 2014 through August 2015) following guidelines described in *Wildlife Hazard Management at Airports: A Manual for Airport Personnel* (Cleary and Dolbeer 2005). The following bullets summarize the survey activities. Sections 2.2.1 and 2.2.2, below, describe methods specific to each site.

- Point-count surveys for all wildlife were conducted twice per month, at each site, for 1 year to detect seasonal and daily patterns and movements. Each survey point was observed two times during each visit. The survey timing was coordinated to capture different times of day at each site throughout the survey period. In general, each point was surveyed during the morning hours, afternoon hours, and evening hours each month. The biologists observed each point for 5 minutes to identify general wildlife movements and uses in the viewable area. All observed activity was recorded on a data form and entered into a database (refer to Appendix A). Data includes species observed, number of individuals, activity, location, and direction of movements, along with a rough estimation of altitude.
- In addition to the point-count surveys, the biologists conducted inspections of various facilities, gulches, urban areas, aquatic sites, and surrounding areas to determine whether these features attracted wildlife.
- Nighttime spotlight surveys were performed four times during the year and consisted of approximately 2 hours of spotlighting wildlife at the Maʻalo and Kekaha sites. The biologists drove through the sites using a spotlight to detect wildlife by looking for eye shine. This provides information regarding nocturnal species' use of the sites.
- Based on feedback from USDAWS, the LWHA team conducted cattle egret (*Bubulcus ibis*) roost surveys in the vicinity of the sites. Three evenings of helicopter surveys were conducted within a 2-hour time window between 1.5 hours before sunset and 0.5 hour after sunset. One helicopter survey was conducted in the vicinity of the Kekaha landfill and two helicopter surveys were conducted in the Maʻalo vicinity. The biologists recorded roost locations using the Global Positioning System and estimated the number of birds using the roosts. The flight path directions of birds arriving were also recorded for each roost.
- To determine the roost locations for the cattle egrets that currently use the Kekaha Landfill and the Maʻalo Site (and vicinity), ground-based cattle egret roost surveys were also conducted, in the dawn and dusk hours. When a roost was identified, the numbers of egrets using the roost were estimated, and flight patterns to and from the roost were determined.

To facilitate the identification of avian movements in the study areas, the LWHA team divided both the study areas into zones, as shown in Figures 2 and 3. The Kekaha study area included five zones, and the Maʻalo study area included 10 zones. The zone boundaries were based on geographic features that are easily identifiable in the field.

The zones were established to assist the surveyors in identifying trends in avian movements. For instance, avian species are often observed utilizing the same flight paths at certain times of day. By establishing observation zones, the biologist can document that an avian species moves from one zone to another zone. This allows the LWHA team to hone in on the routine avian flight paths that occur in the study areas.

2.2.1 Kekaha Landfill

Survey data collected at the Kekaha Landfill provided insight into which avian species utilize the existing landfill on Kauaʻi. The intent of the survey methodology at Kekaha was to identify which landfill features and adjacent areas are attractive to avian species, which species utilize the features, and how they utilize the features. To accomplish this, the survey team established six survey points at the landfill. Recognizing that an operational landfill is dynamic, the survey team established the points based on the landfill features and adjacent areas of interest. Due to the dynamic nature of an operational landfill, the survey points were adjusted throughout the survey period. However, the features that each point focused on remained consistent. Figure 2 shows the Kekaha survey area and general location of the survey points. The following bullets provide brief discussions of the survey points and the features of interest near each point:

- **Kekaha 1 (K1):** K1 was located at the leachate evaporation pond located between the landfill entrance and the landfill office. K1 allowed for direct observation of the active leachate pond, the stormwater infiltration basin, the public drop-off area, the office, and the eastern slope of the landfill. Data from K1 provides information on avian species attracted to engineered aquatic features, developed areas, and the finished and vegetated slope of the landfill.

- **Kekaha 2 (K2):** K2 was situated on the southern finished and vegetated slope of the landfill. This point provided a view of the drainages and windrows that border and bisect the landfill, and agricultural areas located to the south and east. Data collected from K2 provided information on avian species utilization of the finished and vegetated slopes of the landfill, adjacent agricultural areas, adjacent windrows and woodlands, and movements between these features and the active face of the landfill.

- **Kekaha Active Face (KAF):** KAF was located at the active portion of the landfill, the location of which changed over the course of the study but was generally in the northwestern portion of the landfill. This area included the uncovered waste pile and soil-covered waste areas that are utilized for soil and equipment staging. In general, the active face includes all areas where equipment was operating while placing and compacting waste. The focus of KAF was to document the species that utilize the active face. Data collected at KAF provided insight on which species are attracted to the active face, how the species access the active face, and how and when they utilize it.

- **Kekaha Inactive Face (KIF):** KIF was located on the landfill face but outside of the active area. This area included the portions of the landfill face that were compacted and covered with soil (interior cover). Portions of the inactive areas were graded and vegetated. Typically, these areas are situated adjacent to the active face but outside of the currently active area. Data collected at KIF provide information on how avian species utilize those portions of the landfill that are not active, are covered with soil, and/or vegetation, but have not been completed with final cover.

Figure 2. Kekaha Landfill Study Area

- **Kekaha Shrimp Ponds (KSP):** KSP was located at the top of the landfill, facing the shrimp ponds located north of the landfill. KSP focused on identifying which species are attracted to the manmade aquatic features and the trees between the landfill and the shrimp ponds.

- **Kekaha Green Waste (KGW):** KGW was located at the Kekaha green waste collection area on the vegetated portions of the closed Kekaha Phase I Landfill. At this point, the surveyors focused on which species are utilizing the active and inactive portions of the green waste stockpiles. This point includes the unprocessed green waste piles, the chipped and piled green waste rows, and vegetated portions of the closed Kekaha Phase I Landfill.

2.2.2 Maʻalo Site

The goal of the surveys at and around the proposed Maʻalo Landfill site was to assess the existing conditions, attractants, and wildlife movements at and around the proposed site with emphasis on locations relative to LIH flight patterns. The biologists collected data on wildlife uses and movements in the area to assess existing hazards and determine which wildlife movements might be affected by the proposed project. To accomplish this, the LWHA team conducted point count surveys at nine fixed points and also conducted windshield surveys in the area of concern. Windshield surveys involved documenting observed avian movements and activities while driving between survey points and through and around the survey area. The survey points were situated near the proposed Maʻalo site and LIH flight paths. Figure 3 shows the Maʻalo survey area and general location of the survey points. Each survey point provided views of attractants such as gulches, waterbodies, developed areas, etc. The windshield survey routes varied based on the wildlife movements observed during each survey event.

3 RESULTS

3.1 Existing Wildlife Attractants in the Study Areas

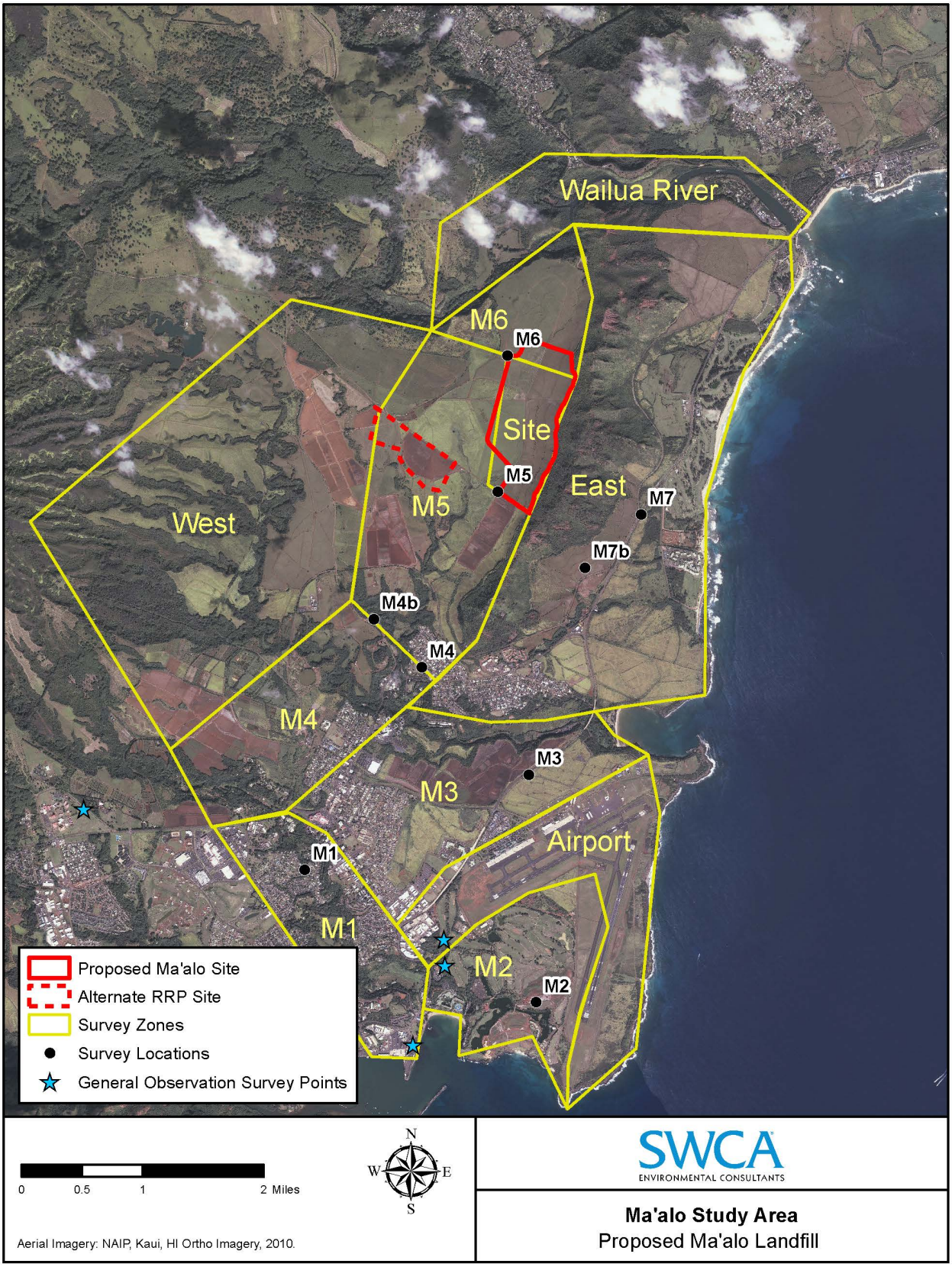
Wildlife attractants can generally be classified as food, water, and cover. The guiding document for identifying wildlife habitat is AC 33B, *Hazardous Wildlife Attractants on or near Airports*. The areas of interest for this study were identified with field surveys and geographic information system (GIS) data. Both color aerial photography and infrared imagery (raster imagery) were used for this analysis. The imagery was obtained from the State of Hawaiʻi Office of Planning, Hawaiʻi Statewide GIS Program (State of Hawaiʻi 2015). For the purposes of this study, it is not important to identify individual plant species, but rather to identify various habitat types such as forest, grassland, agricultural field, water, etc. The wildlife attractants in the Maʻalo and Kekaha study areas include non-native forests, agricultural fields and grazing lands, gulches, waterbodies, golf courses, and development. These habitats are discussed below and shown in Figures 4 and 5.

3.1.1 Non-native Forests

Forests in the vicinity of Maʻalo are comprised mainly of dense tall stature Albizia trees (*Falcataria moluccana*, *Albizia chinensis*), while forests in the vicinity of the Kekaha Landfill are mainly shorter stature kiawe (*Prosopis pallida*) and koa haole (*Leucaena leucocephala*).

Albizia trees typically occur in dense stands with a thick grassy understory, mostly of guinea grass (*Urochloa maxima*). These dense nearly monotypic stands are generally low in bird diversity; vocalizations of small canopy or understory birds such as the Japanese white-eye (*Zosterops japonicus*), house finch (*Carpodacus mexicanus*), and hwamei (*Garrulax canorus*) are typically heard. The stands are normally too dense to accommodate larger birds such as cattle egret within the habitat, but these species can be found along the edges.

Figure 3. Ma'alo Site Study Area



A recently planted eucalyptus plantation is present near the proposed Maʻalo site. Trees in the plantation were approximately 2 to 5 feet tall when this study began; by the end of the survey work, some trees had grown to approximately 25 feet. Based on communications with the plantation maintenance crew, the owners plan on harvesting the trees every 3 to 5 years.

Kiawe/koa haole non-native forest can consist of dense stands (e.g., closely spaced stands of koa haole) or more open stands with trees spaced further apart with a grassy understory. The bird diversity in dense stands is very similar to the Albiza forest—while the more open stands have greater small bird diversity (Japanese white-eye, Japanese bush warbler [*Horornis diphone*], northern cardinals [*Cardinalis cardinalis*], hwamei, various species of finches, etc.), larger birds are also able to fly and roost within the more open stands and can include birds such as barn owls (*Tyto alba*), pueo (*Asio flammeus sandwichensis*), and cattle egret.

3.1.2 Agriculture and Grazing Lands

Agricultural and grazing lands occur at the proposed Maʻalo site and in its vicinity (Zones: Site, M5, M6, and parts of M3, M4, and East), while Kekaha is mainly surrounded by agricultural lands (Zones: D4 and D2). Grazing lands comprise the entire proposed Maʻalo landfill site, and agricultural (crop) lands comprise the entire alternate RRP site at Maʻalo.

Corn is the most abundant crop in the study areas. The cornfields go through a cycle of growth, followed by harvesting, then fallow fields. Harvesting cycles do not appear to be synchronized. Fields in various stages of growth (or fallow) are often present. Nēnē (Hawaiian geese) were observed foraging and bedding down in recently harvested or recently fallow fields with low vegetative cover located near the Maʻalo sites. Rock pigeons (*Columba livia*) were observed foraging in recently harvested fields in flocks of more than a hundred birds. The introduced barn owl and native pueo were seen hunting over agricultural lands at dusk. Rose-ringed parakeets (*Psittacula krameri*) forage in large flocks in patches where corn is left unharvested. Cattle egret were regularly noted loafing and foraging in recently harvested or fallow fields, and often follow behind machinery to collect insects and reptiles. Spotted and zebra doves (*Streptopelia chinensis* and *Geopelia striata*), common myna (*Acridotheres tristis*), and large flocks of finches were typically observed foraging and loafing in agricultural fields and unpaved roads.

Grazing lands are those areas being actively grazed by cattle and goats. Grazing lands attract cattle egret, which are often seen perched on cattle or foraging in the grass. All finch species present can be expected to feed on seed heads of the grasses within grazing lands.

3.1.3 Gulches

Gulches are more abundant near the Maʻalo site than the Kekaha site. Three main watercourses run through the survey area: Nāwiliwili Stream (Zones M1 and M4), Hanamāʼulu Stream (Zones M3, M4, and M5), and Wailua River (Wailua River and Zone M6). Trees common in gulches, particularly along banks of streams are hau (*Hibiscus tiliaceus*), kiawe, parasol leaf tree (*Macaranga tanarius*), ironwood (*Casuarina equisetifolia*), and African tulip tree (*Spathodea campanulata*). Gulches provide roosting opportunities for communal species such as cattle egret and common myna and are flight corridors for many species. Cattle egrets were often seen flying along gulches at dawn and dusk as they commuted between their roosts and foraging grounds.

3.1.4 Wetlands and Waterbodies

Waterbodies present in the Maʻalo and Kekaha study areas include reservoirs and irrigation ditches within agricultural and grazing lands. Ponds and lagoons are present as water features within golf courses near the proposed Maʻalo site. Shrimp ponds are adjacent to the Kekaha Landfill (Zone D3).

Small patches of wetland, irrigation ditches, reservoirs, and ponds are present within the agricultural and grazing fields in both study areas. The United States Army Corps of Engineers (USACE) has confirmed that the proposed Maʻalo site "does not contain waters of the US, nor any adjacent wetlands" (USACE 2013). The reservoirs near the sites are primarily steep-banked with fluctuating water levels. Hawaiian ducks (*Anas wyvilliana*) are often observed using the reservoirs and in small ponds after rain. Irrigation ditches may harbor the native Hawaiian moorhen (*Gallinula chloropus sandvicensis*) and Hawaiian coot (*Fulica alai*). Hawaiian stilts (*Himantopus mexicanus knudseni*) were observed foraging in ephemeral patches of standing water and in shallow areas within irrigation ditches. Large irrigation canals are often tree lined and cattle egrets were observed roosting in trees along the banks (e.g., Zone D2 at Kekaha Landfill).

Several shrimp ponds are present at Kekaha. Most of the active ponds were covered with netting that excludes birds. Several ponds immediately adjacent to the active landfill had shallow standing water and were often used by Hawaiian stilt, black-crowned night heron (*Nycticorax nycticorax*), cattle egret, spotted and zebra doves, and common myna for foraging and loafing. The Hawaiian stilt was observed on two occasions in the Kekaha Landfill leachate evaporation pond, when water was present.

Ponds and lagoons are often present within golf courses as water features (Zone M3 and East). These ponds were used by all native Hawaiian water birds (Hawaiian moorhen, Hawaiian coot, Hawaiian duck, Hawaiian stilt, and black-crowned night heron) for foraging. Water birds appear to be more prevalent around water features on the golf course as compared to reservoirs within agricultural areas, likely because of the proximity of short grass in golf courses available for loafing and foraging. Cattle egret roost in trees growing next to lagoons (e.g., in hau trees at Kauaʻi Lagoons Golf Course in Zone M2).

3.1.5 Golf Courses and Resorts

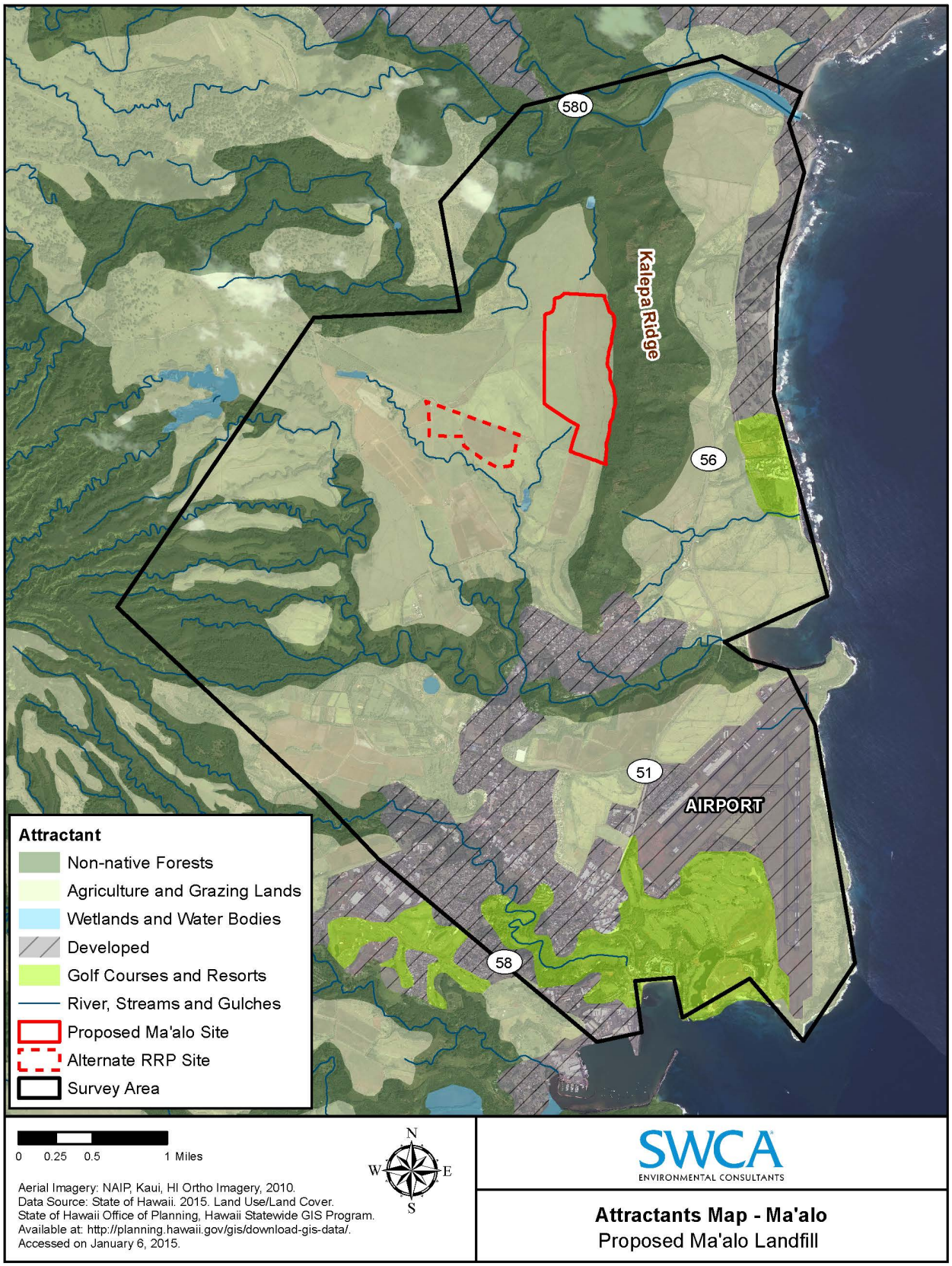
Golf courses and resorts are present in the general vicinity of the proposed Maʻalo site. These landscaped areas feature mowed or short grasses, scattered trees, and water features such as ponds or lagoons. Golf courses and resorts are attractive to many of the introduced birds in Hawaiʻi as well as to native water birds and Hawaiian goose, which loaf or forage on the short grass and utilize the water features. Other introduced birds such as cattle egrets, common myna, spotted and zebra doves, chickens, and finches are ubiquitous. The Pacific golden plover (*Pluvialis fulva*) is also common, and other migrants, such as the ruddy turnstone (*Arenaria interpres*), are occasionally present.

3.1.6 Development

Developments, including residential subdivisions, retail facilities, industrial areas, and schools were present in both survey areas. Most developments had paved roads, scattered ornamental and fruit trees, and mowed grass. Scattered trees and mowed grass are attractive to many of the introduced birds in Hawaiʻi for roosting and foraging. Birds such as cattle egrets, common myna, spotted and zebra doves, chickens, and finches are ubiquitous in developed areas throughout Kauaʻi. The Pacific golden plover is also common, particularly in grassy lawns around houses and cemeteries.

Figure 4. Kekaha Landfill Attractant Map

Figure 5. Ma'alo Site Attractant Map



3.2 Existing Data Analysis

To gain insight about which species present significant challenges to wildlife hazard management at Hawaiian airports, the LWHA team evaluated existing data from some of the Hawaiian airports that are situated near existing landfills. The reviewed data included strike reports that occurred from January 1, 2004, through December 16, 2014 at LIH, Hilo International Airport (ITO), and Kahului Airport (OGG). Based on the existing data, the following groups of avian species pose hazard concerns:

- **Wading Birds and Shorebirds:** Pacific golden plover is responsible for the most documented strikes at all the reviewed airports. Other birds from this guild included sanderling (*Calidris alba*), ruddy turnstone, cattle egret, and Hawaiian stilt.

- **Cattle egret:** Cattle egret are only documented to have been involved in two strikes at the three reviewed airports from January 1, 2004, through December 16, 2014. However, they are large flocking birds, abundant on Kauaʻi, and have been documented to travel over 15 kilometers daily to access a feeding site (Paton et al. 1986); therefore, they are a concern for aviation managers.

- In 1982, the FAA contracted the United States Fish and Wildlife Service (USFWS) to study the ecology of cattle egrets in the Hilo area. The goal was to postulate potential cattle egret control methods at ITO (Paton et al. 1986). A combination of lethal control for short-term problems and deterrent methods for long-term problems were recommended.

- **Columbids:** Based on the number of documented strikes, spotted dove, zebra dove, mourning dove (*Zenaida macroura*), and rock pigeon are among the top four groups (cumulatively) of species involved with aircraft strikes at all the reviewed airports.

- **Owls:** Based on the number of documented strikes, barn owl and short-eared owl (*Asio flammeus*) are among the top four groups of species involved with aircraft strikes at LIH and OGG.

- **Munias:** Based on the number of documented strikes, chestnut-breasted mannikin (*Lonchura castaneothorax*), nutmeg mannikin (*L. punctulata*), and tricolored munia (*L. malacca*) are among the top four groups of species involved with aircraft strikes at LIH and ITO. Chestnut-breasted mannikin is among the top five species requiring deterrence at LIH (USDAWS 2005).

- **Hawaiian goose:** FAA considers geese to be a no-tolerance species at airports (Cleary and Dolbeer 2005). HDOT has spent considerable resources on the management of this species at LIH and other Hawaiian airports.

- **Larks:** Western meadowlarks (*Sturnella neglecta*) are among the top five species requiring deterrence at LIH (USDAWS 2005). Based on the number of documented strikes, skylark (*Alauda arvensis*) is among the top four groups of species involved with aircraft strikes at OGG.

These avian groups represent hazard concerns for the reviewed airports because they are attributed to over 60% of the airport's strikes (cumulatively), identified as requiring significant deterrence efforts, identified as a zero tolerance species, or are present at or near the airfields in large flocks.

3.2.1 Lihue Airport Wildlife Hazard Assessment

According to the LIH WHA, egrets, doves, plovers, owls, ducks, and geese are hazards to aircraft at LIH (USDAWS 2005). The 2005 LIH WHA analyzed available data from strikes that occurred from 1995 through 2003. The study concluded that 24.13% of the strikes involved unknown species, 28.26% of the

strikes involved Pacific golden plover, 14.7% involved zebra dove, 8.6% involved chestnut-breasted mannikin, 6.93% involved barn owl, 5.83% involved Hawaiian short-eared owl, spotted dove accounted for 5.27%, western meadowlark accounted for 8.7%, and common myna accounted for 4.35% of the documented strikes (USDAWS 2005).

USDAWS conducts capture and relocation efforts, dispersal techniques, and lethal removal to deter wildlife from interfering with air operations at LIH. In 2003, the five species with the greatest number of individuals deterred included chestnut-breasted mannikin, Pacific golden plover, zebra dove, western meadowlark, and spotted dove (USDAWS 2005).

Although cattle egret and Hawaiian goose were not among the species most often struck or deterred at LIH, these species are likely a significant concern to LIH operations due to their presence near and on the airfield, size, and flocking behavior. An adult Hawaiian goose can weigh between 3.4 and 6.7 pounds. Birds that weigh over 4 pounds exceed the airframe and engine certification standards for wildlife strikes (Cleary and Dolbeer 2005). The FAA recommends zero tolerance of geese on airfields (Cleary and Dolbeer 2005). Adult cattle egrets weigh an average of 0.75 pound (Sibley 2003). Cattle egrets gather in large flocks and make daily dawn and dusk flights to roost sites at elevations that can conflict with incoming/outgoing aircraft. Hawaiian geese and cattle egrets are capable of causing substantial damage to aircraft, if involved in a strike. Significant numbers of cattle egret are currently present in the golf course between and adjacent to LIH's two runways, and throughout the site vicinity, and an ongoing program is underway to remove Hawaiian geese from the area.

3.3 Field Survey Results

Avian point-count survey data were compiled into a Microsoft Access database to facilitate analysis. The data were analyzed to identify avian wildlife and their movements. This was accomplished by categorizing the observed avian species into guilds. A guild is a group of species that use environmental resources in similar ways. Guilds do not always follow taxonomic classifications. For the purpose of this study, guilds were assigned based on the species' observed behaviors and their expected responses to common management actions. Identification of the various guilds using the Kekaha Landfill and Ma'alo site environments allowed the biologists to accurately identify which resources attract the guilds.

Once the species were categorized in guilds, the number of individuals observed, average group size, and group range of each guild were determined. The number of individuals observed cannot be interpreted as a population count because the same individuals were likely recorded on multiple surveys. Average group size is defined as the average number of individuals recorded per observation, and range represents the minimum and maximum number of individuals recorded during any observation.

3.3.1 Kekaha Landfill

3.3.1.1 KEKAHA AREA AVIAN SURVEYS

A total of 27,687 birds were observed during the avian surveys at Kekaha Landfill. Table 1 summarizes the avian point-count survey results for each avian guild observed during the surveys. Appendix A includes a list of species observed and the guild to which each species was assigned. A discussion of each guild follows Table 1. Figure 6 includes a map of the most common avian movements observed at the Kekaha Landfill.

Figure 6. Common Avian Movements at the Kekaha Landfill

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Table 1. Summary of Avian Point-Count Results at the Kekaha Landfill

Avian Guild	No. of Individuals Observed	Average Group Size (Range)	% of Individuals Observed
Sturnidae	13,493	19 (1–600)	49
Wading Birds and Shorebirds	9,686	10 (1–500)	35
Columbids	2,362	4 (1–130)	9
Sparrows, Finches, and Munias	1,158	4 (1–25)	4
Game Birds	699	3 (1–16)	3
Geese	121	4 (1–11)	<1
Ground Feeding Birds	95	1 (1–4)	<1
Gleaning Birds	24	1 (1–4)	<1
Owls	19	1 (1–5)	<1
Water Birds	5	2 (1-2)	<1
Seabirds	2	1 (1–1)	<1
Unidentified Birds	23	8 (1-20)	<1
Total Birds	**27,687**	**10 (1–600)**	**n/a**

Sturnidae

Common myna is in the Sturnidae family, along with starlings. These species are gregarious and travel, forage, roost, and nest in large groups. Common myna is the only Sturnidae species observed in the Kekaha study area. During the surveys, common myna was documented on 716 occasions. In total, these occurrences included 13,493 observed individuals. The most common activity observed among the common myna involved low altitude local movements from the adjacent trees and shrubs to the Phase II landfill. Once on the Phase II landfill, most the individuals were standing/loafing on the soil-covered face or foraging on the active face. Groups ranging from 200 to 600 common mynas were commonly observed standing/loafing on the soil-covered face, presumably staging or resting between feedings at the active face. Out of 716 common myna observations, 141 (19.7%) observations included common myna making long flights to access the landfill. The data indicate that common myna are attracted to the landfill for foraging. While at the landfill, they make short flights between the soil-covered face and the active face. The typical behavior is to roost in the trees surrounding the landfill, forage on the active face, rest on the soil-covered face, then return to the trees.

Wading Birds and Shorebirds

Typically, wading birds and shorebirds have long legs to wade through water or grass, long necks to extend towards prey, and sharp bills to capture prey. These birds hunt by standing motionless in grass or water and capture prey with quick strikes or by probing substrates for insects with their long bills. In the Kekaha study area, the guild is represented by cattle egret, Pacific golden plover, black-crowned night heron, and Hawaiian stilt. Approximately 35% of the birds observed in the Kekaha area were from this guild, most of which were cattle egrets.

Cattle egrets were observed at and near the Kekaha Landfill during all survey events and account for 94% of the wading bird observations. Most occurrences involved individuals loafing on the various landfill

features, foraging in the adjacent shrimp ponds, and conducting long flights at various altitudes through the survey areas. Groups including as many as 90 individuals were noted making long flights to or from the landfill. Thirty observations included cattle egrets making long flights at estimated altitudes exceeding 100 feet above ground level. Many flights were directly to or from a roost to the landfill. Due to their flocking behavior, large size, attraction to the landfill, and tendency to make long flights to access foraging and roosting areas, cattle egret are a concern to aviation on Kaua'i.

Photo 1. View of cattle egret loafing on the soil-covered face at Kekaha Landfill.

Pacific golden plover were observed on 15 occasions, primarily between October 2014 and January 2015. Pacific golden plover were observed at the leachate pond, the soil covered face, and green waste piles at the landfill. Based on the low number of observations, it appears that Pacific golden plover has little attraction to the landfill. The remaining observations involved movements between the adjacent agricultural fields, beach, and woodlands. There is no indication that this species is attracted to the active face of the landfill.

Black-crowned night herons and Hawaiian stilts account for 5% of the wading birds observed in the Kekaha study area. Most of these observations were associated with these species foraging in the adjacent shrimp ponds or making long flights to access the shrimp ponds. These species have not been observed utilizing the active landfill face for foraging; however, both species were observed on ten occasions foraging and/or loafing at the leachate evaporation pond, when water was present.

Columbids

The columbid guild is comprised of rock pigeon, spotted dove, zebra dove, and unidentified dove species. In 578 observations, 2,362 columbids were documented. Thirteen observations included spotted and zebra doves on the active face; conversely, 130 observations included individuals on the soil-covered face and 179 observations included vegetated areas on the landfill. Zebra doves and spotted doves were observed on the landfill; however, rock pigeons were largely observed utilizing the agricultural fields adjacent to the landfill. The zebra dove and spotted dove utilized the landfill for foraging, loafing/standing, local movements, and perching. These data indicate that zebra doves and spotted doves are attracted to many features in the landfill setting, but rock pigeons are mostly attracted to agricultural areas near the landfill.

There were only 29 observations of long flights to or from the landfill, four of which were reported at greater than 100 feet above ground level. This indicates that columbids are not traveling long distances to access the landfill.

Sparrows, Finches, and Munias

This guild is represented by smaller flocking bird species that forage on and near the ground, in brush, and in tree canopies. They fly from location to location, gathering seeds and insects. At the Kekaha study area, species in this guild include African silverbill (*Lonchura cantans*), chestnut munia (*Lonchura atricapilla*), nutmeg mannikin, house sparrow (*Passer domesticus*), Java sparrow (*Padda oryzivora*), house finch, and red avadavat (*Amandava amandava*). Species from this guild were observed on 270 occasions during the survey period. Of these observations, 24% included individuals on the active face and soil-covered face of the current Phase II Landfill. Most of the occurrences on the Phase II Landfill included house sparrows. The remaining observations occurred in the adjacent woodlands, grassy areas, and shrubs. The surveyors did not observe any of these species conducting long flights to access the landfill. The data indicate that the sparrows, finches, and munias at Kekaha are there because of the vegetated areas around the landfill. Occasionally a few individuals will leave the vegetated areas to forage for insects on the active face.

Game Birds

In the Kekaha study area the game bird guild includes Kauaʻi chicken, black francolin (*Francolinus francolinus*), gray francolin (*F. pondicerianus*), and Erckel's francolin (*F. erckelii*). Game birds spend most of their time on or near the ground, only making short, low-elevation flights when necessary. Game birds were observed 203 times throughout the survey period. Ninety-five percent of the observations included Kauaʻi chicken, which are prevalent throughout the island of Kauaʻi. Nearly all of the Kauaʻi chicken observations included individuals foraging or loafing at various portions of the landfill. In general, game birds remain on or close to the ground and do not make long-flights. The data and game bird flight behaviors indicate that Kauaʻi chickens are attracted to the landfill for foraging purposes but are not expected to make long flights to access the landfill.

Geese

The Hawaiian goose is the only species from the geese guild observed in the Kekaha study area. Only three Hawaiian goose observations included groups making long flights over the active face of the landfill. All of these flights crossed over the active face and terminated in the vicinity of the shrimp ponds. Of the Hawaiian goose observations, 50% were associated with the adjacent shrimp ponds (originated or terminated in Zone D3). Eleven observations including 40 individuals (some of which are likely repeat sightings) indicated an attraction to the green waste piles and/or the vegetated areas in and around the closed Phase I portions of the landfill. Most of these observations included loafing geese. One observation of 10 individuals foraging in the short grass in the Phase I Landfill was noted. Based on the survey data, it appears that Hawaiian geese are attracted to the shrimp ponds or adjacent vegetation in Zone D3 and have some attraction to the green waste piles and grass areas in various portions of the landfill. There is no indication that Hawaiian geese are attracted to the active face, leachate pond, stormwater basin, or other MSW management facilities at the landfill.

Ground Feeding Birds

At Kekaha, this group includes northern cardinal, red-crested cardinal (*Paroaria coronata*), and northern mockingbird (*Mimus polyglottos*). Although these species are not closely related, they have a tendency to feed on the ground in search of seeds, insects, and fruit. These species were observed on 78 occasions. Only eight of these observations were at Phase II Landfill features (all on the soil-covered face). Sixty-three percent of the observations were associated with the vegetated areas at or adjacent to the green waste pile and Phase I Landfill. Based on the data, the cardinals and northern mockingbird do not appear

to be attracted to the landfill features, but are in the area due to the trees and shrubs surrounding the landfill.

Gleaning Birds

Gleaning birds move up, down, and around vegetation gathering insects from leaf and stem surfaces. This feeding technique keeps the birds close to vegetation except when the bird flies from one tree/shrub to another. These flights are typically short and stay within the target vegetation type. Gleaning bird species observed at Kekaha include Japanese bush warbler and Japanese white-eye. These species were observed or detected by vocalizations on 19 occasions in the vegetated areas adjacent to the landfill. There is no indication that gleaning birds are attracted to any of the landfill features.

Owls

Barn owl and short-eared owl comprise this guild. These two species were observed 13 times during the Kekaha surveys. All the barn owl observations occurred in the early evening hours and involved foraging or interactions with other owls in the vegetated portions of the Kekaha Landfill. Short-eared owls were observed at various times of day on and off the landfill. Owls are attracted to the landfill by the small mammal prey base that is assumed to exist there. There is no evidence that owls are making long, high-altitude flights to access the landfill. It appears they are roosting or perching in the nearby trees in the daytime and foraging at the landfill in the evening.

Water Birds

Hawaiian duck was observed on two occasions in the vicinity of the shrimp ponds located north of the Kekaha landfill. Hawaiian moorhen was observed once in a marshy area located several miles north of the landfill. Water birds were not observed utilizing the landfill property. There is no indication that water birds are attracted to the landfill, the landfill leachate pond, or the landfill infiltration basin. These features were generally dry during the survey period, which decreases the pond's attraction to water birds.

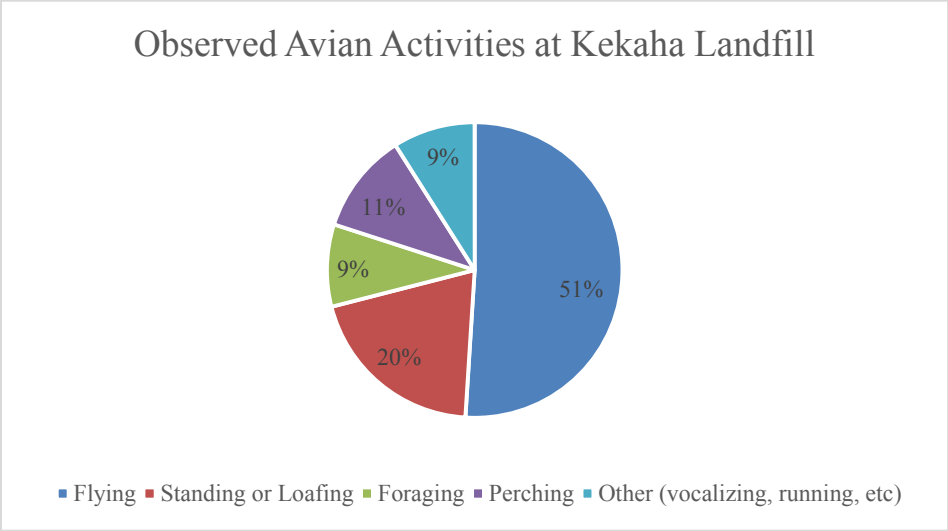
Seabirds

The seabird guild consists of species that spend most of their life on or near the sea. Laysan albatross (*Phoebastria immutabilis*) and great frigatebird (*Fregata minor*) were the only seabirds observed in the Kekaha study area. In both instances, these individuals were observed soaring or making a long flight in the proximity of the ocean just west of the landfill. There is no indication that seabirds are attracted to the landfill.

3.3.1.2 COMMON AVIAN ACTIVITIES AT AND AROUND KEKAHA LANDFILL

The survey efforts document a variety of avian activities in the survey area. Some activities are rarely observed, such as nest building. Other activities are very common, such as local movements. Analysis of the common activities observed provides insight on how avian species utilize the landfill. Out of 2,893 observations, 51% involved avian species flying to, from, or around the landfill. Twenty percent of the observations included avian species loafing or standing on the landfill property. Some of these birds were loafing near the active face of the landfill between foraging activities. Nine percent of the observations included avian species foraging on the landfill. Foraging opportunities are the main attraction to the landfill and the active face is the main source of resources. The relatively small number of observations attributed to foraging is a result of the birds foraging behaviors. Most of the birds were in flight or loafing around the active face and moving into the active face for many short duration foraging attempts.

Graph 1. Observed Avian Activities



In terms of numbers of birds observed, the most utilized features at the landfill by decreasing order of use are the soil-covered face (landfill areas with intermediate cover), active face, green waste pile, and leachate pond and infiltration basin. During operating hours, the number of birds observed utilizing the soil-covered face and active face ranges between 28 and 2,548 birds per survey, most of which are common myna and cattle egret. The average number of birds observed utilizing the active face and soil-covered face during landfill operating hours was 567 individuals per survey.

Photo 2. View of cattle egret foraging on the active face at Kekaha Landfill.

The second most utilized feature is the active face. Based on data from eight of the surveys there is an average of 49 birds on the active face while the canvas is applied (waste is temporarily covered with a canvas tarp). Conversely, there is an average of 109 birds on the active face while the canvas is not applied. This indicates that the general attraction to the landfill for foraging decreases once the canvas is applied to the active face. However, the common mynas do not leave the landfill immediately following application of the canvas; instead, they move to the soil-covered face to loaf.

3.3.1.3 KEKAHA AREA CATTLE EGRET ROOSTS

A total of eight nighttime cattle egret roosts and one daytime roost were identified by land based and helicopter surveys in the vicinity of the Kekaha landfill and surrounding area (refer to Figure 6). The biologists confirmed that birds from the six roosts that are within 2.9 miles of the landfill regularly utilize the landfill. These roosts include a day roost located immediately adjacent to the landfill that is only used during the daytime by birds that are foraging at the landfill. One night roost is approximately 0.5 mile east of the landfill in a tree-lined irrigation channel situated between agricultural fields. Two additional roosts are located along the same irrigation channel approximately 0.6 mile and 1.3 miles, respectively, north of the landfill. A night roost is located at Kekaha Beach Park approximately 1.6 miles southwest of the landfill. The Kekaha Beach roost is seasonal and utilized as a rookery. The sixth roost is located in a forested irrigation channel near Hukipo Road between agricultural fields immediately inland of Kekaha town.

Three other cattle egret roosts were identified, but it is not known whether they are used by birds that forage at the landfill. Two of these roosts are located in the town of Waimea at a distance of 5.3 and 5.9 miles east of the landfill. One of these two roosts is located in a tree at the edge of a reservoir between Haina Road and Waimea Canyon Drive. The furthest roost is located in trees along the eastern bank of the Waimea River. The largest night roost was identified by helicopter approximately 5.6 miles northwest of Kekaha Landfill near Polihale Beach Park. There were approximately 300–400 birds at the Polihale Beach Park roost, with many flocks arriving from the southwest around dusk.

3.3.1.4 KEKAHA SPOTLIGHT SURVEYS

The biologists conducted four spotlight surveys at the Kekaha Landfill in October 2014, November 2014, February 2015, and May 2015. The spotlight surveys were conducted to document which species utilize the landfill after sunset. Barn owl, short-eared owl, and Kauaʻi chicken were observed foraging in the landfill on all survey events. Numerous feral cats and dogs were foraging at the landfill after sunset as well. Hawaiian stilt were heard in the adjacent shrimp ponds after sunset. The common myna and cattle egret appeared to leave the landfill area after sunset.

3.3.2 Proposed Maʻalo Site

3.3.2.1 MAʻALO AREA AVIAN SURVEYS

A total of 21,593 birds were observed during the avian point-count surveys in the Maʻalo study area. Table 2 summarizes the avian point-count survey results for each avian guild. A brief discussion of each guild follows Table 2. Figure 7 includes a map of the common avian movements in the Maʻalo survey area.

Figure 7. Common Avian Movements at the Proposed Ma'alo Site

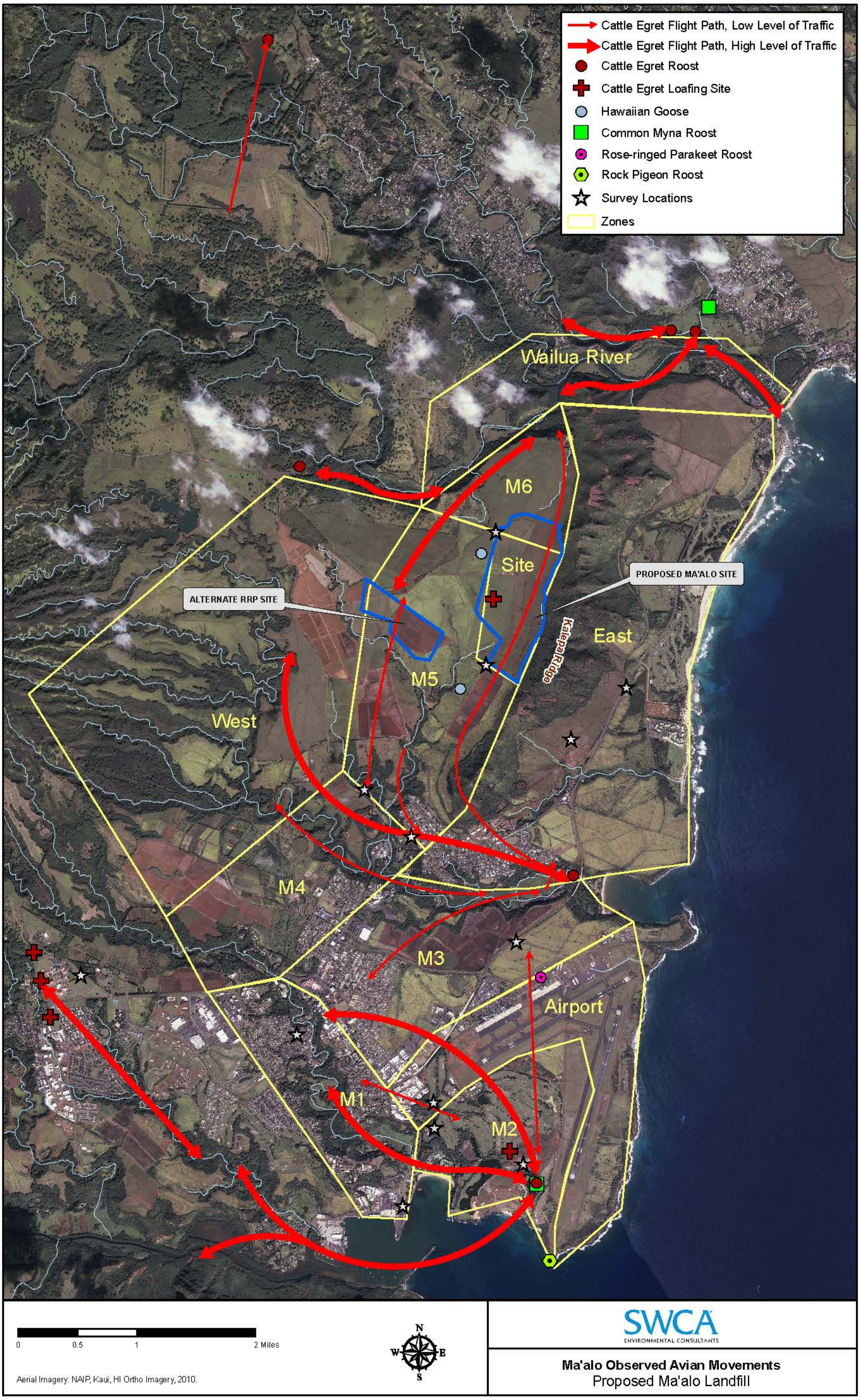


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Table 2. Summary of Avian Point-Count Results at the Proposed Maʻalo Site

Avian Guild	No. of Individuals Observed	Average Group Size (Range)	% of Individuals Observed
Columbids	6,248	9 (1–350)	29
Sparrows, Finches, and Munias	4,518	9 (1–129)	21
Wading Birds and Shorebirds	4,414	5 (1–311)	20
Sturnidae	2,416	4 (1–90)	11
Game Birds	1,363	6 (1–52)	6
Ground Feeding Birds	847	3 (1–40)	4
Parakeets	574	21 (1–200)	3
Water Birds	562	8 (1–80)	3
Gleaning Birds	350	2 (1–24)	2
Geese	269	6 (1–30)	1
Owls	4	1 (1–1)	<1
Unidentified Birds	28	3 (1–6)	<1
Total Birds	**21,593**	**6 (1–350)**	**n/a**

Columbids

The columbid guild is comprised of rock pigeon, spotted dove, zebra dove, and unspecified dove species. Columbids are abundant throughout the Maʻalo study area, accounting for 29% of the Maʻalo observations. The highest concentration of columbid observations is located around Hanamāʼulu town. In the Kekaha study area, some columbids appeared to be attracted to the landfill for foraging but were not making long flights to access the landfill. Conversely, the Maʻalo survey data indicates that columbids make numerous long flights between urban areas, gulches, and trees. Twenty percent of the long flights exceeded 100 feet in altitude and included up to 45 individuals. In all cases, these high altitude flights included rock pigeons. Rock pigeons were not attracted to the active face at Kekaha.

Groups of over 100 and up to 350 rock pigeons were routinely observed in the Maʻalo study area. While some columbids (spotted dove and zebra dove) were attracted to the Kekaha Landfill features and could be attracted to a new landfill at the Maʻalo site, rock pigeons were not attracted to the Kekaha Landfill. It is possible they would be attracted to some features of a new Maʻalo landfill. Based on the observed columbids attraction to the Kekaha Landfill and the observed columbid activities in the Maʻalo study area, rock pigeons may make long, high elevation flights to access a landfill at the Maʻalo site. These flights could conflict with LIH operations and warrant monitoring.

Sparrows, Finches, and Munias

In the Maʻalo study area, species in this guild include red avadavat, nutmeg mannikin, Java sparrow, house sparrow, house finch, chestnut munia, common waxbill (*Estrilda astrild*), and African silverbill. These species were observed throughout the Maʻalo study area with higher concentrations in Zones M2, M4, and M5. These zones include wooded areas, open space, and water features that attract these species.

Out of the 525 observations of the species in this guild in the Maʻalo area, only two observations included a long flight, which were at low altitude. This is consistent with the Kekaha data, which indicates that the species in this guild largely stay within the wooded areas around the landfill. This, coupled with the feeding behaviors of these species, suggests that they are not likely to make long flights to access a landfill at the Maʻalo site. Based on the survey data and the species' behaviors, species in this guild are not expected to fly through LIH flight paths to access a landfill at the Maʻalo site.

Wading Birds and Shorebirds

Wading birds and shorebirds observed in the Maʻalo study area included Pacific golden plover, ruddy turnstone, Hawaiian stilt, black-crowned night heron, and cattle egret. Of these species, cattle egret accounted for the most observations (77%) and Pacific golden plover with the second most observations (18%). Based on the Kekaha Landfill survey data, which shows that Pacific golden plover, Hawaiian stilt, and black-crowned night heron are attracted to the shrimp ponds, these species may have limited attraction to a leachate pond, stormwater basin, or short grass areas at the proposed landfill. However, at Maʻalo the potential attraction to these features may be reduced due to the presence of many other available natural and manmade foraging areas and water features in the area. Nevertheless, since these species are known to make long flights that could interfere with aircraft, inclusion of design elements and operational procedures to deter these species from the proposed landfill are warranted.

Cattle egret are abundant in the Maʻalo area in its current condition, and already pose a hazard to aircraft, as defined in AC 33B. Based on the Kekaha survey data, cattle egrets are expected to be attracted to the proposed landfill. At the Kekaha Landfill, cattle egret were observed making long flights between the landfill and roosting sites. In the Maʻalo study area, cattle egret were routinely observed making long flights in the morning and evening hours to and from roost sites. Most of these flights tend to follow gulches and follow Kalepa Ridge through the proposed site. There are multiple cattle egret roost sites in the Maʻalo area and around LIH that cattle egret could make daily movements to and from the proposed landfill for foraging. Such flights have the potential to conflict with LIH operations.

Sturnidae

Common myna is the only species in the Sturnidae guild that was observed in the Maʻalo study area. Common myna accounts for 11% of all the avian observations. This species is widely distributed in the survey area with observations documented in all of the 11 survey zones. The highest concentration of observations is located in Zone M5, located immediately west of Kalepa Ridge and of the proposed Maʻalo site. The second highest concentration of common myna observations was in Zone M2, which includes the Kauaʻi Lagoons Golf Course. Common myna have a roost in this location, where up to 90 individuals have been documented. The birds at the golf course are rarely observed making long flights. Most observations at the golf course include local movements and loafing.

Out of 510 common myna observations, only three observations included long flights occurring at an altitude greater than 100 feet. One observation occurred at Survey Point M5 located near the southern boundary of the proposed Maʻalo site. Two high altitude flights were observed in the "east" survey zone near point M7. Common myna have a night roost in the false kamani trees (*Terminalia catappa*) near M7. In total, common myna were observed making long flights on 36 occasions; most of these occurred at altitudes less than 100 feet. This data reinforces the observations at the Kekaha landfill where common myna do not appear to be traveling long distances to access foraging areas. Therefore, it is unlikely that common myna located near the airport would fly through LIH flight paths or the AOA to access a foraging area at the Maʻalo site. However, common myna currently occur in large numbers throughout the Maʻalo study area and are attracted to landfills. Inclusion of design elements and operational procedures are recommended to deter common myna from the proposed landfill.

Game Birds

In the Maʻalo study area, the game bird guild includes Kauaʻi chicken, ring-necked pheasant (*Phasianus colchicus*), Indian peafowl (*Pavo cristatus*), black francolin, gray francolin, and Erckel's francolin. Ninety-five percent of the individuals observed included Kauaʻi chicken, which were widely distributed in the survey area.

Game birds spend most of their time on or near the ground, only making short, low elevation flights. None of the game bird observations in the Maʻalo study area included long flights. Feral and naturalized chickens are territorial and devoted to a limited range once the range is established. For these reasons, game birds are not expected to make long flights across LIH flight paths to access a landfill at the Maʻalo site.

Ground Feeding Birds

At Maʻalo, the ground feeding bird guild included northern and red-crested cardinals, white-rumped shama (*Copsychus malabaricus*), northern mockingbird, western meadowlark, and hwamei. Many of these species are nuisance species on airfields because they fly low to the ground, moving from one foraging location to another. Many of these low and short flights cross movement areas. However, when distant from the airfield on a site such as Maʻalo, these low short flights are not hazardous to aircraft because they occur far below the aircraft altitude.

These species were observed throughout the Maʻalo study area in vegetated areas. This is consistent with the Kekaha Landfill study area. At Kekaha, the ground feeding birds tend to stay around the vegetated areas surrounding the landfill. The ground feeding birds in the Maʻalo area are expected to have the same tendency if a landfill was constructed and operated at the proposed location, and are not expected to make long flights across LIH flight paths to access a landfill at the Maʻalo site.

Parakeets

Rose-ringed parakeet is commonly observed in areas around the proposed Maʻalo site and the airport. Parakeets are gregarious and forage, roost, and fly through the treetops in large groups. Two flights were noted to exceed 100 feet altitude. In the wild, these birds feed on fruit, seeds, and buds that are taken from living vegetation. Groups of up to 200 individuals have been observed foraging in agricultural areas (corn) and making long flights around the proposed site.

Large groups of rose-ringed parakeets have been observed flying through Zone M5 to the southeast towards Hanamāʼulu/Lihue. They may have been headed to a roost at the Kukui Grove Shopping Center at Lihue or a roost that is located in the LIH parking lot. These flights currently exist and may currently cross helicopter traffic patterns in the Maʻalo area. Due to rose-ringed parakeet's diet preferences, the introduction of a landfill in the Maʻalo area is not expected to alter the bird's movements.

Water Birds

In the Maʻalo study area, the water bird guild includes Hawaiian coot, Hawaiian moorhen, Hawaiian duck, and an unspecified duck species. Most of the observations were associated with groups loafing or foraging in and around manmade waterbodies at Kauaʻi Lagoons Golf Course. Twenty-one observations included individuals in natural areas including creeks, waterbodies, ditches, and long grass habitats. Two occurrences involved a single bird flying over 100 feet altitude. In the Kekaha study area waters birds are attracted to the adjacent shrimp ponds and a nearby marsh but have no attraction to the landfill property. This may be due to the lack of regular standing water in such features as the leachate pond at the Kekaha Landfill. Similar features at a new landfill at the Maʻalo site could contain more water due to higher rainfall, and could be more attractive to water birds.

Based on the Kekaha and Maʻalo site data, water birds may have limited attraction to water features or short grass areas at the proposed landfill. However, at Maʻalo the attraction may be reduced due to the presence of many other available natural and manmade habitat areas in the area. Since these species are known to make long flights that could interfere with aircraft, inclusion of design elements and operational procedures to deter water birds from the proposed landfill are recommended.

Gleaning Birds

In the Maʻalo study area the gleaning bird guild includes Japanese white-eye, red-billed leiothrix (*Leiothrix lutea*), and Japanese bush warbler. As mentioned above, this group of birds forages by flying around vegetation and gleaning insects from the foliage. This behavior keeps them close to the target vegetation resulting in short, low-elevation flights. Most of the gleaning bird observations included Japanese white-eye, the other species were rarely observed.

Eighty-eight percent of the observations included the birds flying or vocalizing among natural (unmaintained) vegetation types such as tall grass, shrubs, or trees. This is similar to the behavior of the gleaning birds observed at the Kekaha Landfill study area. Based on the feeding and sheltering behaviors of gleaning birds, it is unlikely that the introduction of a new landfill at the Maʻalo site would result in gleaning birds making long flights through LIH airspace to access the landfill.

Geese

The Hawaiian goose and Canada goose (*Branta canadensis*) were the only species from the geese guild observed in the Maʻalo study area. Canada goose was only observed on one occasion, at the Kauaʻi Lagoons Golf Course; all other observations included the Hawaiian goose. The Hawaiian goose was observed in Zones M2, M3, M5, M6, and Site. All but one of the Hawaiian goose observations were in agricultural areas, grass areas, or a waterbody. Several observations included long flights with potential to interfere with LIH aircraft; however, most observations were associated with loafing in fields.

The Kekaha survey data indicates the Hawaiian goose has some attraction to the green waste stockpiles and short grass areas at the landfill. In addition, the size and flocking behavior of all geese species makes them a significant concern to aviation. Considering this, design features and operational procedures to minimize Hawaiian goose (or Canada goose) attraction to the landfill are recommended.

Owls

Barn owls and short-eared owls were observed during spotlight surveys at the proposed Maʻalo site and roosting in trees at the Kauaʻi Lagoons Golf Course. Barn owls, and potentially short-eared owls, would probably be attracted to a landfill at the Maʻalo site by the small mammal prey base that would likely occur at the landfill. If the small mammal prey base was left unchecked, owls may travel long distances to forage at the site. Procedures to reduce the small mammal prey base are recommended.

3.3.2.2 MAʻALO CATTLE EGRET ROOSTS

During the study, the biologists observed historical (known) cattle egret roost sites and also located previously undocumented roost sites. The intent was to gather general information regarding cattle egret flight paths between roosting and foraging sites. Prior to beginning the study, USDAWS provided the approximate locations of four known cattle egret roosts. These data, coupled with the survey data, provided updated information on the cattle egret roosts in the vicinity of LIH. The surveys confirmed the presence of seven cattle egret night roosts plus one potential sub-roost identified around the Maʻalo site vicinity.

- **Wailua River (Opaekaa Falls) Roost, including a nearby 'sub-roost':** A large roost site supporting 200 or more birds is located immediately north of the Wailua River near Opaekaa Falls. A smaller 'sub-roost' was also identified very close to the main roost. Birds access these roosts by flying up and down the Wailua River and crossing over to the Opaekaa tributary of Wailua River from various directions. The roost also receives birds from the general direction of LIH and Kapaʻa. The survey data indicates that numerous cattle egrets pass through and around the proposed Maʻalo site in the evening hours to access the roost(s). The biologists observed 50 to 75 birds in a tree at the edge of Wailua River and several flocks of five to 25 birds arriving from the south during the helicopter survey.

- **Wailua Reservoir Roost:** This historically known roost is still active. Ground based and helicopter surveys observed 180 to 200 birds utilizing the roost just before sunset. Helicopter surveys observed a majority of birds arriving from the south, but a small number of birds arrived from the north. Multiple evening surveys from Zone M5, which includes the proposed Maʻalo site, confirmed that large groups (up to 200) of cattle egret fly northeast and northwest towards Wailua River, potentially roosting at the Wailua Reservoir Roost at night.

- **Hanamāʼulu Stream Roost (aka Kapule Roost):** This historically known roost, located near the Hanamāʼulu Bridge and Hipa Road, is still active. On the morning of October 3, 2014, the Hanamāʼulu Stream Roost supported approximately 100 birds. Most birds were roosting in the hau trees on the mauka side of the bridge. During the ground-based surveys, cattle egret were observed flying to and from this roost along gulches of Hanamāʼulu Stream and its tributaries. Several tributaries of Hanamāʼulu Stream extend into Zone M5, which is adjacent to the proposed site. The helicopter and ground-based surveys confirmed that some of the cattle egrets from the Hanamāʼulu roost fly up the tributaries and through the proposed Maʻalo site.

- **Kauaʻi Lagoons Roost:** This historically known roost is active and was observed to have an estimated 300 birds utilizing the roost at various times. The roost is located in hau trees along the freshwater lagoon on the hotel grounds. Common myna also roost in the neighboring trees. The dusk helicopter survey and ground-based surveys indicate that birds arrive from all directions, but primarily from the west. Egrets primarily utilize Nāwiliwili Gulch, and the mauka side of the Hāʼupu Mountain Ridge in both directions to access daytime foraging areas. Flights in this location routinely exceed 100 feet above ground level. In addition, many cattle egret were observed loafing on the maintained grass of the helicopter landing pads of LIH; individuals were observed flying to this location from the south, presumably from the Kauai Lagoons roost.

- **Maʻalo Road Roost:** This small roost was identified during the May 22, 2015, helicopter survey. At the time of the survey, the roost supported approximately 20 cattle egrets and was located adjacent to a small reservoir in a farm. Cattle egret accessed the roost from the general direction of Zone M6.

- **Halenanahu Reservoir Roost:** This small roost was located west of Puhi. During the helicopter survey, 15 cattle egrets were using the roost. However, the general defoliation of the trees suggests that they are likely used as a night roost by a larger group.

- **Rice Ranch Roost:** This historical roost was still active during the May 22, 2015, helicopter survey. The roost is located adjacent to a reservoir on Rice Ranch and supported approximately 100 birds. Another 50 to 75 cattle egret were observed approximately 500 meters to the south of the main roost, perched in a kiawe tree and loafing with cattle.

3.3.2.3 MAʻALO SPOTLIGHT SURVEYS

Spotlight surveys conducted at the Maʻalo site confirmed that feral pig and barn owl are common on the site after sunset. Barn owl and feral pig use the site for foraging. A short-eared owl was observed in the proposed site as well. Hawaiian geese were routinely observed along the border of the proposed site. The Hawaiian geese appear to be using the agricultural areas just west and south of the site as a night roosting area. Cattle egret were not observed in or passing through the site after nightfall.

3.4 Summary of Avian Survey Results

The intent of the surveys at the existing landfill and near the Maʻalo site was to gather information regarding wildlife uses of the two areas that can assist in developing hazardous wildlife management plans for the proposed Maʻalo site. The following bullets summarize the data collected at the two sites that is applicable to the Maʻalo site.

The following species of potential concern are those considered most likely to pose a potential risk to airport operations. It is recommended that these potential risks be managed via changes to the proposed facility design, or operational wildlife management measures.

- Cattle egret are attracted to the Kekaha Landfill and adjacent shrimp ponds. They are known to roost up to 3 miles from the landfill and fly to and from the landfill throughout the day. In general, others have documented cattle egret flying 15 kilometers to access foraging areas (Paton et al. 1986). Cattle egret are abundant in the Maʻalo study area and currently make routine flights through the existing Maʻalo site to access roosting areas. It is likely that cattle egret in the Maʻalo area would utilize the proposed Maʻalo Landfill for foraging, if it was made available to them. Based on their flocking behavior and tendency to make long flights at high altitudes, cattle egret could cross LIH flight paths to access a landfill at the proposed Maʻalo site. Design elements and operational procedures to deter this species from the proposed landfill are recommended.

- Common myna are clearly attracted to Kekaha Landfill for foraging. However, the common myna do not appear to be traveling long distances to access the landfill. Common myna is currently widely distributed in the Maʻalo survey area. Similar to the Kekaha site, common myna were rarely observed making long flights in the Maʻalo study area; most movements were localized. Therefore, common myna near LIH are not anticipated to cross LIH movement areas to access the proposed Maʻalo site. However, their movements at the Maʻalo site could interfere with low flying (less than 100 feet) helicopter travel over the Maʻalo site. Due to the common mynas presence in the Maʻalo area and their attraction to landfills, inclusion of design elements and operational procedures to deter common myna from the proposed landfill are recommended.

- Based on the Kekaha Landfill and Maʻalo survey data, Pacific golden plover, ruddy turnstone, Hawaiian stilt, black-crowned night heron, and other water birds may have limited attraction to a leachate pond, stormwater basin, or short grass areas at the proposed landfill. They have not been observed to be attracted to the active face of the landfill. Since these species are known to make long flights that could interfere with aircraft, inclusion of design elements and operational procedures to deter these species from the proposed landfill are recommended.

- Owls are attracted to the Kekaha landfill and are currently present at the Maʻalo site. Procedures to reduce the small mammal prey base at the Maʻalo site are recommended.

- Hawaiian goose is attracted to the green waste piles at the closed Phase I Kekaha Landfill for refuge; there is no indication that Hawaiian goose is attracted to the active face of the Phase II Kekaha Landfill. This species currently utilizes an irrigation ditch and agricultural areas near the

proposed Maʻalo site for a night roost, and was observed flying through the site during the day. Design elements and operational procedures to deter these species from the proposed landfill are recommended.

The following species were observed at the existing Kekaha landfill or the proposed Maʻalo site, but are considered less likely to pose a potential risk to airport operations.

- Spotted doves and zebra doves are attracted to many features at the Kekaha Landfill, but these species are not making long flights to access the landfill. Rock pigeons did not show an attraction to the Kekaha Landfill features. The Maʻalo survey data indicates that rock pigeons make numerous long flights between urban areas, gulches, and trees in the Maʻalo study area. While rock pigeons are not currently attracted to the Kekaha landfill features, they could be attracted to features at the proposed Maʻalo landfill due to the abundance of rainfall on the windward side of the island (e.g., a leachate pond with permanent water). If this is the case, based on flight observations in the Maʻalo study area, rock pigeons could make long, high-elevation flights to access a landfill at the Maʻalo site; therefore, design elements and operational procedures to deter these species from the proposed landfill are recommended.

- Sparrows, finches, munias, gleaning birds, and ground feeding birds are present at the Kekaha Landfill. These species tend to stay close to the vegetated areas around the landfill and occasionally make short flights from the vegetated areas to forage for insects on the active landfill face. These species and other similarly behaving species are present in the Maʻalo study area and were rarely observed making long flights. Based on the survey data and the species' behaviors, species in these guilds are not expected to fly through LIH flight paths to access a landfill at the Maʻalo site.

4 RECOMMENDATIONS

Wildlife attractants near airports include food, water, cover, and perches. Solid waste landfills provide these resources in ways that allow wildlife to exploit them. Managing these resources is the most effective solution for reducing wildlife attraction because it minimizes or eliminates the attractants. SWCA has developed the following potential wildlife management options for the proposed Maʻalo site. These recommendations are based on data gathered from 1 year of surveys at the existing Kekaha Landfill and the proposed Maʻalo site. The County, in consultation with HDOT and other stakeholders, should evaluate and prioritize these recommendations based on feasibility with respect to effectiveness, personnel availability, permitting requirements, cost, and/or available resources, while keeping in mind the potential hazard to aircraft safety.

4.1 Landfill Design Alternatives

The presence of putrescible waste and other food materials attracts wildlife to landfills. The most effective means of reducing wildlife attraction to a waste management facility would be to design the facility in such a way that makes the waste inaccessible to wildlife. The following design recommendations are provided with the sole purpose of reducing wildlife attraction to a facility at the Maʻalo site. It is understood that practicability factors such as cost, resource availability, environmental considerations, site availability, and community considerations shape the decisions regarding facility designs. Although these are important factors, they are beyond the scope of this study and are not considered.

Since the presence of putrescible waste and water at the proposed Maʻalo site would likely attract cattle egret and other avian species that could be hazardous to aviation, the County should consider design

alternatives that would reduce or eliminate the wildlife accessibility to the waste and water features. Potential design considerations include:

1. **Putrescent Waste.** Controlling putrescent waste would be a key measure in mitigating hazards. Several options may be pursued.

    a. **Source Separation.** Food waste and other organic material are the primary MSW constituents that attract wildlife to the landfill active face. Source separation involves providing a separate container at the curb for residents to place putrescible waste items. The putrescible waste container could be collected by an enclosed truck that is designated for putrescible waste. Some counties and municipalities have successfully imposed a ban on food waste in trash. This single measure would go a long way towards reducing the wildlife attractant at the active face of the landfill. The County is already planning a pilot study to evaluate the feasibility of source separation of non-greenwaste organics.

        i. The putrescible waste truck could deliver the waste to a tipping floor or other enclosed structure. Waste that is deposited and stored in a completely covered structure is not accessible to wildlife. Wildlife attraction to odor from ventilation systems is a concern with depositing and sorting waste in covered structures. Masking odors, however, would not be sufficient for reducing wildlife attraction to a covered waste management structure. Rather, in order for this measure to be effective, the structure would need to include a system that filters or eliminates odors from the structure exhaust. There are a variety of commercially available products that neutralize odors via chemical processes. Potential systems include but are not limited to atomizers and misters. If the County pursues an indoor facility, the facility should include one or more systems that neutralize or otherwise filter out odors.

        ii. The putrescible waste could be processed and stored in the covered structure until it can be deposited and immediately covered in the landfill active face, or taken to another site for processing. This may include bailing the putrescible waste and taking it to the landfill face at the end of the day, where it could be immediately dumped, compacted, and permanently covered.

    b. **Landfill Gas Odors.** Decomposing waste produces carbon dioxide, methane, water vapors, carbon monoxide, hydrogen sulfide, and volatile organic compounds. The hydrogen sulfide and volatile organic compounds emit landfill gas odors that may attract wildlife. To reduce the potential wildlife attraction, the County should consider installing a system or systems designed to destroy odor-causing gases. Such technologies may include a gas collection and vacuum system that is connected to: 1) flares or other gas destroying devices; 2) a scavenger system that saturates raw landfill gas with water and passes it through a media bed that adsorbs and filters the hydrogen sulfide from the gas stream; 3) liquid-redox system that passes raw landfill gas through a catalyst solution and converts hydrogen sulfide to elemental sulfur; 4) the use of bacteria in biological treatments; 5) caustic scrubbers; or 6) activated carbon systems.

    c. **Food Containers.** Many food products are delivered to restaurants, stores, and consumers in cardboard boxes. The cardboard boxes are often sorted for recycling in RRPs and retain the smell and small scraps of the food product. Based on observations at another RRP, the smell and remnant food scraps can attract avian species to the area where cardboard boxes are staged and processed. The attraction to the cardboard is eliminated after the cardboard is bailed. If the County intends to stage and sort cardboard

(or other recyclable containers) at the RRP site, the County should consider designating an enclosed structure at the RRP for cardboard processing and bailing.

d. **Binding Agents and Protective Netting.** While source separation is preferred, it may also be possible to decrease the attractiveness of putrescent waste at the working face using a combination of continually spray-applied polymer mix materials or chemical additives and the use of protective netting or grid wires surrounding the working face. For example, many mainland landfill sites successfully use products such as Posi-Shell® (a blend of clay binders, reinforcing fibers, and polymers) as spray-applied mortars that dry in the form of a thin, durable stucco, eliminating waste exposure and odors. The additive would need to be frequently applied, driving up costs but increasing airspace.

   A study at the Nanticoke Landfill near E.A. Link Airport in New York (now known as the Greater Binghamton Airport) concluded that applying binding agents alone was not sufficient to deter wildlife attraction to the landfill face (Curtis et al. 1993). Considering the findings of the Nanticoke Landfill study and currently accepted wildlife control procedures, binding agents alone should not be expected to completely deter wildlife, and would have to be combined with other design features and management procedures, such as those outlined below.

2. **Water Features.** At the Kekaha Landfill, the leachate evaporation pond, infiltration basin, and other manmade water features are typically dry and do not attract many water or wading birds. The Maʻalo area receives significantly more rain than the Kekaha area. Therefore, water features at Maʻalo would be more prone to have standing water. Standing water may attract Pacific golden plover, Hawaiian stilt, Hawaiian coot, or other wading and water bird species. The following design elements should be considered to deter avian attraction to any manmade waterbodies at Maʻalo.

   a. Storm water basins should be designed for a maximum 48-hour detention period for the design storm and remain completely dry between storms (Cleary and Dolbeer 2005).

   b. Design any drainage ditches or other waterbodies so that they are as deep as possible, have steep sides (approximately 2:1), side substrate of rock or concrete, no vegetation, and minimal water surface area (Cleary and Dolbeer 2005). This will deter wading birds from standing on the banks and water birds from landing on the water. Cattle egret and other wading birds are less likely to use deep drainages. Ensure that the design is easily maintained to be void of vegetation or covered. Drainpipes, culverts, and screens should be easily maintainable so they can be kept clear of debris and drainage is not impeded.

   c. If standing water is expected to remain for more than 48 hours, consider the installation of physical barriers to waterbodies. Such barriers may include:

      i. Floating balls, also known as Bird Balls or Bird Deterrent Balls. These are approximately 4-inch balls made of plastic, foam, or other buoyant material. The balls float on the water surface and deter birds from landing or wading into the water.

      ii. Grid wire. Installation of a wire grid system above the water surface will deter birds from landing in the water. At Maʻalo, the birds of concern vary from medium to large in size. Installing the grid system so that it runs in various crisscross patterns at two elevations would form a non-penetrable grid. Many of the Hawaiian waterbirds are federally protected species. If a grid wire system is

employed, the system should be designed to minimize the potential for entangling Hawaiian waterbirds.

iii. Fountain. Install and continuously operate a large fountain in the waterbody. The fountain should disturb at least 30% of the water surface. This may deter water birds from landing in the waterbody.

3. **Landscaping.** Common mynas, cattle egret, and other avian species utilize the various trees and shrubs adjacent to the Kekaha Landfill for roosting and shelter. Design for the Maʻalo Landfill should avoid placing shrubs, ornamental trees, or hedgerows within 1,000 feet of the working face, and should avoid the use of species that produce fruit or berries, which may attract rose-ringed parakeets and gleaning birds. Avoid placing trees and shrubs in a way that will result in overlapping or closed canopies. Birds are less attracted to vegetation with open canopies. Additional landscaping considerations are provided in Section 4.2.4, below.

4. **Structures.** Utilize structure designs that reduce perching and roosting opportunities. Columbids often roost on structures with overhanging ledges. Common myna and other small birds often perch on power lines, antennas, and other tall objects. Site designs should avoid structures that provide over hanging ledges or tall objects for roosting and perching.

5. **Lighting.** Facility lighting should incorporate USFWS recommendations for minimizing attraction of seabirds. These recommendations can be found on the Kaua‘i Seabird Habitat Conservation Program’s website (http://www.kauai-seabirdhcp.info), and include:

    a. Avoid up-lighting by shielding light fixtures and aiming the fixtures downward.

    b. Utilize full cutoff fixtures, full shielded wall-pack and wall-mount fixtures, fully shielded walkway bollards, or other fully shielded light designs that meet the project needs.

6. **Agriculture.** Currently the agricultural areas that are adjacent to the proposed site attract flocks of Hawaiian geese for loafing, foraging, and roosting, and parakeets, columbids, and gleaning birds for foraging. It is anticipated that the County would not utilize all the acquired lands for active landfill management at least in the early years of site operation. This would leave some lands in the landfill property open for other uses. The County should not consider or plan on utilizing undeveloped lands around the landfill for agriculture, grazing, or other activities that would attract wildlife to the area. Vegetated areas on the landfill property that are not actively managed for landfill uses should be subject to an active vegetation management program (refer to Section 4.2.4).

4.2 Operational Measures

4.2.1 Prepare and Implement a Landfill Wildlife Management Plan

Implementation of the above mentioned landfill design elements could reduce wildlife attraction to the landfill. However, the design elements must be reinforced with operational procedures that focus on continued wildlife abatement and monitoring. The County should prepare a Landfill Wildlife Management Plan (LWMP) that details operational procedures aimed at reducing wildlife attraction and abating nuisance wildlife. The LWMP should be a living document that is subject to regular evaluation and modifications to ensure its effectiveness at meeting the wildlife management goals. At a minimum, the following elements should be included in the LWMP:

- Identification of a Wildlife Coordinator, Wildlife Control Staff, and a Wildlife Working Group; their roles and responsibilities; and communication procedures.
  - Detailed communication procedures should include monitoring radio communications from LIH Air Traffic Control Tower (ATCT) to be informed of incoming helicopter traffic.
- A staff wildlife management training program.
- A list of prioritized wildlife management actions and their completion dates.
- A list of materials and supplies needed to implement the LWMP.
- Wildlife control permit(s) monitoring and reporting requirements and methods.
- Vegetation and landfill cover management and maintenance methods.
- Wildlife control procedures including cattle egret population control.
- Continued wildlife and wildlife control monitoring.
- Procedures for communicating with LIH and resource agencies in regards to wildlife control activities.
- A schedule for annual reevaluation of the LWMP and means of coordinating the reevaluations with USFWS, USDA, and LIH.

4.2.2 Designate a Wildlife Coordinator

The County should appoint a Wildlife Coordinator to manage all wildlife management activities at the landfill. The Wildlife Coordinator could be part of an existing staff position. A good candidate would be an individual that understands wildlife/habitat interactions and landfill operations. The Wildlife Coordinator should be responsible for the following activities:

- Forming and maintaining a working group that includes LIH, USDAWS, and HDOT staff who are responsible for airport wildlife hazard management on Kaua‘i. This working group should establish lines of communication and meet regularly to discuss wildlife hazard abatement activities, trends in wildlife movements, and other topics related to wildlife damage control.
- Coordinate with neighboring land managers, such as the tree plantation managers, to address wildlife issues outside the landfill boundaries.
- Identify and coordinate cattle egret population reduction efforts at active roosts near the landfill.
- Conducting and/or coordinating all wildlife management activities at the landfill.
- Identify and designate safe “shooter positions” for cattle egret lethal control efforts.
- Ensuring that all individuals responsible for wildlife hazard management are properly trained.
- Ensuring that all landfill personnel are familiar with the requirements and procedures of abating wildlife at the landfill.
- Obtaining and maintaining all appropriate wildlife control permits and supplies, as necessary.
- Be responsible for continued wildlife monitoring to ensure the effectiveness of management actions. Identify and implement adjustments to the wildlife control measures, as appropriate

- Keep detailed records of wildlife management activities.

4.2.3 Maintain Appropriate Permits to Control Wildlife

The County will probably need to obtain a Migratory Bird Treaty Act (MBTA) Depredation Permit from USFWS and the state. Cattle egret and other species that can be expected to utilize a landfill at the Maʻalo site are protected under the MBTA. These birds are attracted to various landfill features and should be hazed to deter the attraction. However, hazing alone may prove to be ineffective over time. The County may consider augmenting the hazing with lethal removal of individuals. This would require a MBTA Depredation Permit unless alternative permission is obtained. The County should keep an active Depredation Permit at all times so that delays can be avoided if "take" of individuals or nest removal of a migratory bird is necessary.

At a minimum, the County should obtain an MBTA take permit for cattle egret. In November 2013, USFWS published a Proposed Rule for a Migratory Bird Permit Control Order for Introduced Migratory Bird Species in Hawaiʻi (USFWS 2013). If approved, the control order would provide a mechanism for USFWS to issue a MBTA take permit for the control of cattle egret to benefit Hawaiʻi's native wildlife species. The wildlife abatement activities conducted in accordance to a MBTA take permit at Hawaiʻi's landfills can further promote cattle egret population control, benefitting Hawaiʻi's native wildlife.

In addition, many of the species that could be attracted to the landfill are protected under the federal and Hawaiʻi Endangered Species Acts (ESAs); such species may include Hawaiian duck, Hawaiian coot, Hawaiian stilt, Hawaiian goose, and Hawaiian moorhen. These species could be attracted to water features at a landfill. Implementation of the recommended water feature design features would reduce the attraction. However, harassment or lethal take of these species would require an Incidental Take Permit from USFWS and/or an Incidental Take License from the state. More discussion of regulatory permits is provided in Section 5.

4.2.4 Active Face Management

To reduce available foraging opportunities, the active face of the landfill should be kept as small as possible and should be covered often. This will minimize exposed waste availability and reduce avian attraction to the active face. Putrescible waste is the main wildlife attractant at landfills. Therefore, the active face should be managed so that putrescible waste is not accessible to wildlife. This may be accomplished by bailing the waste prior to deposition; stockpiling, depositing, and immediately covering the waste at the end of the day; liberal application of spray-on binding agents; or some combination of these methods. Section 4.1 above discusses landfill design considerations that incorporate these methods.

4.2.5 Landfill Vegetative Cover Management

Habitat management is the most effective technique for reducing wildlife attraction to an area. Based on the current site conditions, it is anticipated that the inactive portions of the proposed landfill would likely be covered with guinea grass (*Megathyrsus maximus*) or a similar grass species. The following recommendations are provided for managing the vegetative cover on inactive portions of the landfill:

- Many bird species need grit, or very small rocks, to aid in digestion. They are often attracted to bare areas to forage for grit. Bare areas should be immediately vegetated with grasses or turf to reduce the amount of bare area on and around the landfill.

- Hawaiian goose and other species may be attracted to tall grass areas for nesting and short grass areas for loafing or grazing. To reduce these attractions, the grasses on and around the landfill should be maintained between 7 to 9 inches. Grasses below 7 inches may attract Hawaiian goose,

Pacific golden plover, cattle egret, and other species for loafing or grazing/foraging. Grasses that exceed 9 inches may attract Hawaiian goose and other species for nesting. The grasses and other herbaceous plants should be mowed before they develop seed heads, which provide food for wildlife and insects, or an alternative with less maintenance requirements, such as AstroTurf, may be considered.

- All engineered waterbodies should be maintained free of vegetation. Trees and shrubs should not be permitted to become established in waterbodies or drainage ways at or around the landfill.
- County managed lands that are not being used for landfill purposes should not be used for agricultural or grazing purposes.

4.3 Active Wildlife Control

Cattle egret, common myna, columbids, and other avian species are expected to be attracted to the landfill. The habitat management and operational measures discussed above will reduce the attraction. However, it is anticipated that some nuisance species will still attempt to capitalize on any foraging opportunities that are provided. The following active control measures are recommended to augment the designed operational measures discussed above. A successful wildlife control program would implement the habitat management and active controls in coordination with each other.

4.3.1 Implement Hazing

Cattle egret are a large flocking species that will likely be attracted to the landfill. When one or two individuals land at the landfill, it attracts more individuals, resulting in a rapid increase in birds. Due to their size and flocking behavior, cattle egret should be treated as a "zero tolerance" species at the landfill and should be hazed immediately upon their arrival. If groups of other bird species are observed near the landfill, they should be hazed immediately, as well. It is highly recommended that any landfill have the personnel, equipment, and permits required to conduct hazing measures on an immediate and as-needed basis. Potential options for hazing at the proposed Maʻalo Landfill are provided below.

4.3.1.1 COORDINATE HAZING ACTIVITIES WITH LIH

The proposed Maʻalo site is situated below one of the current LIH helicopter flight paths. If birds were hazed while a helicopter was in the area, the potential to disperse the birds into the helicopter's path exists. To avoid this potential, landfill staff conducting hazing must be aware of on-coming helicopters prior to hazing birds. This will require monitoring ATCT and pilot communications. The landfill operators must monitor LIH air operations radio channel(s) to ensure that birds are not hazed into oncoming air traffic.

Another means of avoiding helicopter and wildlife incursions would be to encourage helicopters to maintain higher altitudes in the vicinity of the site or modify their current flight paths to avoid the proposed site vicinity. Enforcement of the minimum required helicopter altitudes could mitigate a portion of the potential hazard. In general, the rules that govern tour flight heights in Hawaiʻi are found in Code of Federal Regulations Title 14, Part 136, Subpart C, Appendix A (*Special Operating Rules for Air Tour Operators in the State of Hawaiʻi*), which states that "no person may conduct an air tour in Hawaiʻi: (a) below an altitude of 1,500 feet above the surface over all areas of the State of Hawaiʻi, and (b) closer than 1,500 feet to any person or property." However, it appears that helicopter tour companies in Hawaiʻi all have deviation authority from the FAA to fly as low as 500 feet in site-seeing areas and to transition between site-seeing areas at 1,000 feet. If helicopters maintain 1,500 feet in the vicinity of the landfill, the potential for dispersing birds into their flight path would be greatly reduced. Similarly, altering the current

helicopter flight paths, if possible, such that the helicopters don't use the "saddle" area of Kalepa Ridge near the proposed site, could also greatly reduce the potential risk.

4.3.1.2 PYROTECHNICS

Pyrotechnics are noise-producing devices that effectively disperse birds in most situations and can be used to flush and direct flocks of birds in a desired direction. Hand-held/launched pyrotechnic devices such as 15-millimeter screamers and bangers or 12-gauge shell-crackers can be acquired and employed for effective hazing operations. Pyrotechnics should be employed at the landfill multiple times a day, year-round, even if only small numbers of cattle egret are in the area. Pyrotechnics methods must be changed over time to maintain effectiveness.

4.3.1.3 LONG RANGE ACOUSTIC DEVICES

Long Range Acoustic Devices (LRADs) send potentially harmful tones long distances with remarkable accuracy. LRADs can be portable hand-held devices, vehicle-mounted devices, or coupled with avian radar systems. Hand-held and vehicle-mounted LRADs are similar to megaphones but project louder and clearer tones over a greater distance. These types of LRADs require personnel to identify the target wildlife then aim and activate the LRAD at the target. An LRAD coupled with an avian radar system can detect a potentially hazardous flock of birds and activate the LRAD. The LRAD can be remotely activated from a control center or automatically triggered by the radar.

Standard pyrotechnics are limited to producing a loud report that is audible to receptors in a general area. Unlike standard pyrotechnics, LRADs can project loud reports, human voices, or wildlife calls directly towards a targeted receptor. When broadcasting a wildlife distress call, the operator is utilizing bioacoustics to deter wildlife.

4.3.1.4 BIOACOUSTICS

Bioacoustic deterrents broadcast recorded bird distress or alarm calls. Depending on the species, the calls may create differing responses; while some are attracted to the calls, others may flee the area. For this reason, the sound source must be properly placed so the birds fly away from the landfill. In addition, bioacoustics must be supplemented with other techniques such as pyrotechnics. As with all hazing methods, use of bioacoustics may require consultation with USFWS.

Important considerations when using bioacoustic deterrents include:

- Identify the bird species in need of dispersal and use the distress call of that species. A variety of calls may be tried to determine the most effective selection for a particular species.
- Some bird species do not respond to distress calls.
- Vehicles broadcasting distress calls should remain idle to allow birds to identify the source of the disturbance before reacting.
- Distress calls should not be played indefinitely because birds can become habituated to them.
- The effectiveness of distress calls is dramatically increased when combined with other frightening techniques, especially pyrotechnics.

4.3.2 Lethal Control

In review of the Draft LWHA for the proposed Ma'alo project, both USDA and USFWS indicated that these agencies recommend lethal control of cattle egret (USDA 2015; USFWS 2016). Lethal control of cattle egret, rock pigeon, spotted dove, zebra dove, barn owl, and common myna should be implemented to reinforce the other design and management actions. At the proposed landfill, lethal control of cattle egret, common myna, columbids, and other non-native species would be necessary when the efficacy of the other control measures is reduced by habituation. Many species become habituated to pyrotechnics and other deterrents, thus reducing the efficacy of the deterrent. Lethal removal of an individual from a group of individuals that is strategically timed to correspond with other deterrents may reinforce the perceived threat of the deterrent. For example, shooting several cattle egrets simultaneously with launching a pyrotechnic can reinforce the cattle egrets perceived threat of the pyrotechnic. The County should be prepared to implement lethal control to augment their hazing efforts..

USFWS and state-issued depredation permits are required to implement lethal removal of migratory bird species including cattle egret. Typically, the permits specify the species, the numbers of birds that can be taken, and the technique to be used. Cattle egret are known to prey on Hawaiʻi's native wildlife and are a conservation concern on the islands. Implementing a cattle egret control program that includes lethal removal of cattle egret at the landfill could assist ongoing wildlife conservation efforts on Kauaʻi. It is recommended that the Landfill Wildlife Coordinator work with USFWS, USDAWS, and Hawaiʻi DLNR to develop a cattle egret control program that is complementary to current wildlife conservation efforts in the area.

Under most depredation permit conditions, birds may only be lethally removed in conjunction with a continuing non-lethal control program. Unless otherwise directed, carcasses, nests, and eggs must be completely destroyed or incinerated. In addition, personnel participating in the depredation program must attend and receive certification through a hunter's safety or gun handling safety course. Many of the nonnative bird species on Kauaʻi, including many of the birds identified as species of potential concern (Section 3-4), are not federally protected in the United States and do not require a federal depredation permit.

4.3.2.1 SMALL MAMMAL PREY BASE

Although rodents have not been observed during the surveys, roof rats (*Ratus ratus*), house mouse (*Mus musculus*), Norway rat (*Rattus norvegicus*), and Pacific rat (*Rattus exulans*) may occur at the proposed landfill site. These small mammals forage at landfills and are an important prey base for owls. The presence of small mammals at the proposed landfill may attract owls to the landfill for foraging. Owls often forage several miles from their nesting area. Therefore, there is the potential for owls to make long flights through LIH flight paths to access the proposed landfill site. To reduce the landfill's potential attraction to owls, the County should actively control the small mammal prey base on the property. Common small mammal control methods include trapping, fumigation, habitat modification, and use of toxic baits (University of California, Davis 2010). The method of control is dependent on the seasonal life cycle of the population.

4.3.3 Wildlife Control on Neighboring Properties

The proposed Maʻalo site is situated among agricultural fields, grazing lands, and a new eucalyptus plantation. Like the Maʻalo site itself, these land uses are wildlife attractants in their current state. Adding a landfill to the area would likely change the wildlife attraction, uses, and movements on and around the site. One conceivable change could be the creation of a new daytime cattle egret roost in the nearby eucalyptus plantation (cattle egret at the Kekaha Landfill utilize trees adjacent to the landfill for a daytime roost while foraging at the landfill). This situation could be created at the Maʻalo site when a landfill is

located next to a tree plantation. For this reason, the County should coordinate with neighboring land managers and implement active wildlife control measures on the neighboring lands. The County should make efforts to include cattle egret lethal control efforts at nearby roosts on neighboring properties, if practicable. These efforts will help reduce cattle egret use of the proposed landfill and serve to promote native species conservation efforts in the area.

5 REGULATORY IMPLICATIONS

The following sections evaluate the regulatory implications of the recommended management actions. These discussions provide a brief overview of the various federal and state regulations that the landfill should consider when designing and implementing a wildlife control program.

5.1 Federal Endangered Species Act

Section 9 of the federal ESA prohibits the "take" of any federally listed endangered species (16 U.S.C. 1538(a)). The federal ESA defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S.C. 1532(19)). If it is not possible to design an otherwise lawful land use activity in a manner that avoids take of a listed species, either directly or through habitat modification, Section 10(a)(1)(B) of the federal ESA (16 U.S.C. 1539(a)(1)(B)) authorizes USFWS to issue an "incidental take permit," allowing take that is "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity." Some federal agencies are also able to take endangered species in accordance with an "incidental take statement" issued under Section 7 of the federal ESA.

Hawaiian goose, Hawaiian stilt, Hawaiian coot, Hawaiian duck, and Hawaiian moorhen have been observed in the vicinity of the proposed Maʻalo Landfill site. Although they are not attracted to the active face of the Kekaha landfill, these species could be attracted to various other features of the proposed landfill, and could be subject to hazing or "harassment" under the wildlife control program. Since the recommended habitat management activities would reduce the potential of these species to occupy the area in large numbers, lethal take of the species' should not be necessary. Implementation of wildlife attraction deterrents such as grass management, elimination of standing water on the proposed facility, and use of bird balls in waterbodies might be sufficient to avoid the need for take permits to cover harassment activities. The County should continue to coordinate with USFWS while preparing the LWMP so that the need for an Incidental Take Permit can be avoided. The LWMP should include a wildlife training program to ensure that all staff involved with lethal removal of cattle egret and other non-native avian species are trained in the identification and avoidance of ESA-protected species.

5.2 Hawaiʻi Revised Statutes

5.2.1 Chapter 195D

The purpose of Chapter 195D of the Hawaiʻi Revised Statutes (HRS) is "to insure the continued perpetuation of indigenous aquatic life, wildlife, and land plants, and their habitats for human enjoyment, for scientific purposes, and as members of ecosystems…" (HRS Section 195D-1). HRS Section 195D-4 states that any endangered or threatened species of fish or wildlife recognized by the federal ESA shall be so deemed by state statute. As under the federal ESA, the unauthorized "take" of such endangered or threatened species is prohibited (HRS Section 195D-4(e)). Under HRS Section 195D-4(g), the Board of Land and Natural Resources, after consultation with the state's Endangered Species Recovery Committee, may issue a temporary Incidental Take License to allow a take otherwise prohibited if the take is incidental to the carrying out of an otherwise lawful activity.

As discussed above, Hawaiian goose, Hawaiian stilt, Hawaiian coot, Hawaiian duck, and Hawaiian moorhen have been observed in the vicinity of the proposed Maʻalo Landfill site. These species may be attracted to various features of the proposed landfill and could be subject to hazing or "harassment" under the wildlife control program. An Incidental Take License may be required to harass these species.

5.2.2 Chapter 183D-62

Chapter 183D-62 of the HRS states "Taking, injuring, or destroying wild birds [is] prohibited. Except as provided in section 183D-61 (take permits), no person shall intentionally, knowingly, or recklessly take, catch, injure, kill, or destroy, or attempt to take, catch, injure, kill, or destroy, any wild bird, or to keep or have possession of any wild bird, dead or alive, or to damage or destroy a nest of any wild bird." Cattle egret and other bird species that may be subject to lethal removal under the recommended wildlife control program are protected under HRS Section 183D-62. The County must obtain the appropriate state permit before implementing the recommended lethal control program.

5.3 Migratory Bird Treaty Act

The MBTA of 1918 (implemented by 16 U.S.C. 703–712) prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by USFWS. Even though the MBTA does not have provisions for allowing unauthorized take, the MBTA recognizes that some migratory birds may be killed by aircraft despite implementing measures to avoid take of birds. Acknowledging that large populations of certain bird species can cause damage to aircraft and threaten human safety, USFWS, by regulation and permit, has provided for controlled take of certain species in specific areas at specified times. Before the County conducts any management activities that would result in take of birds protected by the MBTA, the County should obtain an MBTA take permit from USFWS.

In order to obtain an MBTA take permit, the County would submit the Final LWHA to USFWS with a completed application for a depredation permit (Form 3-200) and the $50.00 filing fee. Prior to issuing the permit, USFWS may forward the application and LWHA to USDAWS for review. If USDAWS concurs with the need for a depredation permit, they will issue a letter of concurrence to USFWS. On some occasions, USDAWS may make additional recommendations for wildlife control to be included as stipulations on the permit. Once USFWS has received the USDAWS recommendations, they should issue the permit as requested. MBTA Depredation Permits are species specific.

5.4 Animal Control Act of 1931

Under this act, the United States Department of Agriculture (USDA) can manage wildlife injurious to agricultural interests, other wildlife, or human health and safety, including wildlife hazards to aircraft. This act permits USDA to manage wildlife that may pose hazards to aviation. The County may wish to discuss with USDA whether they may be able to perform the recommended wildlife control program.

5.5 Federal Insecticide, Fungicide, and Rodenticide Act

The United States Environmental Protection Agency oversees the registration, labeling, classification, and use of pesticides, as stated in the Federal Insecticide, Fungicide, and Rodenticide Act. Persons using restricted-use pesticides, applying any pesticides to the land of another, or applying any pesticides for hire, must be a Certified Applicator, or working under the direct supervision of a Certified Applicator, and then may only use pesticides covered by the Certified Applicator's certification. If the County, for example, uses a rodenticide to eradicate small mammals or an herbicide to manage the vegetation, then the County and their contractor must comply with this act.

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Appendix A.
List of Species Observed at the Kekaha and Ma'alo Study Areas

List of Species Observed at the Kekaha and Ma'alo Study Areas

Species	ALPHA Code	Guild	Sites Observed	
			Kekaha	Ma'alo
Unidentified finch	UNFI	Sparrows, Finches, and Munias		X
red avadavat *Amandava amandava*	REAV	Sparrows, Finches, and Munias	X	X
nutmeg mannikin *Lonchura punctulata*	NUMA	Sparrows, Finches, and Munias	X	X
Java sparrow *Padda oryzivora*	JASP	Sparrows, Finches, and Munias	X	X
house sparrow *Passer domesticus*	HOSP	Sparrows, Finches, and Munias	X	X
house finch *Carpodacus mexicanus*	HOFI	Sparrows, Finches, and Munias	X	X
chestnut munia *Lonchura atricapilla*	CHMU	Sparrows, Finches, and Munias	X	X
common waxbill *Estrilda astrild*	COMW	Sparrows, Finches, and Munias		X
African silverbill *Lonchura cantans*	AFSI	Sparrows, Finches, and Munias	X	X
rose-ringed parakeet *Psittacula krameri*	RRPA	Parakeets		X
rock pigeon *Columba livia*	ROPI	Columbids	X	X
spotted dove *Streptopelia chinensis*	SPDO	Columbids	X	X
zebra dove *Geopelia striata*	ZEDO	Columbids	X	X
unidentified dove	UNDO	Columbids	X	X
unidentified shorebird	UNSB	Wading Birds and Shorebirds	X	
Pacific golden-plover *Pluvialis fulva*	PAGP	Wading Birds and Shorebirds	X	X
ruddy turnstone *Arenaria interpres*	RUTU	Wading Birds and Shorebirds		X
Hawaiian stilt *Himantopus mexicanus knudseni*	HAST	Wading Birds and Shorebirds	X	X
black-crowned night-heron *Nycticorax nycticorax*	BCNH	Wading Birds and Shorebirds	X	X
cattle egret *Bubulcus ibis*	CAEG	Wading Birds and Shorebirds	X	X

Species	ALPHA Code	Guild	Sites Observed	
			Kekaha	Ma'alo
red junglefowl *Gallus gallus*	REJU	Game Birds	X	X
unidentified francolin	UNFR	Game Birds	X	
black francolin *Francolinus francolinus*	BRFR	Game Birds	X	
Erckel's francolin *Francolinus erckelii*	ERFR	Game Birds		X
gray francolin *Francolinus pondicerianus*	GRAF	Game Birds		X
ring-necked pheasant *Phasianus colchicus*	RNEP	Game Birds		X
Indian peafowl *Pavo cristatus*	INPE	Game Birds		X
Hawaiian coot *Fulica alai*	HACO	Water Birds		X
unidentified duck *Anatinae*	UNDU	Water Birds		X
Hawaiian duck *Anas wyvilliana*	HAWD	Water Birds	X	X
Hawaiian moorhen *Gallinula chloropus sandvicensis*	HAMO	Water Birds		X
white-tailed tropicbird *Phaethon lepturus*	WTTR	Seabirds		X
great frigatebird *Fregata minor*	GREF	Seabirds	X	
Laysan albatross *Phoebastria immutabilis*	LAAL	Seabirds	X	
unidentified owl	UNOW	Owls	X	
barn owl *Tyto alba*	BANO	Owls	X	X
short-eared owl *Asio flammeus sandwichensis*	SEOW	Owls	X	
common myna *Acridotheres tristis*	COMY	Sturnidae	X	X
Hawaiian goose *Branta sandvicensis*	HAGO	Geese	X	X
Canada goose *Branta canadensis*	CANG	Geese		X

Species	ALPHA Code	Guild	Sites Observed	
			Kekaha	Ma'alo
red-billed leiothrix *Leiothrix lutea*	RBLE	Gleaning Birds		X
Japanese bush warbler *Horornis diphone*	JABW	Gleaning Birds	X	X
Japanese white-eye *Zosterops japonicus*	JAWE	Gleaning Birds	X	X
northern cardinal *Cardinalis cardinalis*	NOCA	Ground Feeding Birds	X	X
northern mockingbird *Mimus polyglottos*	NOMO	Ground Feeding Birds	X	X
red-crested cardinal *Paroaria coronata*	RCCA	Ground Feeding Birds	X	X
western meadowlark *Sturnella neglecta*	WEME	Ground Feeding Birds		X
white-rumped shama *Copsychus malabaricus*	WRSH	Ground Feeding Birds		X
hwamei *Garrulax canorus*	HWAM	Ground Feeding Birds		X

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Appendix B.
Regulatory Agency Comments on the Draft Wildlife Hazard Assessment

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawaii 96850

In Reply Refer To:
2015-TA-0082

Frank Cioffi, P.E.
Senior Engineer
AECOM
1001 Bishop Street, Ste. 1600
Honolulu, Hawaii 96813

DEC 2 4 2014

Subject: Technical Assistance for the Proposed Maalo Landfill and Resource Recovery Park, Lihue, Kauai

Dear Mr. Cioffi:

The U.S. Fish and Wildlife Service (Service) received your letter, dated November 24, 2014, requesting our comments on the proposed Maalo Landfill and Resource Recovery Park (RRP) on the island of Kauai, as a pre-consultation for the associated draft Environmental Impact Statement (EIS). The County of Kauai (County) proposes to develop and operate a new Municipal Solid Waste Landfill (MSWLF) on 270 acres owned by the State of Hawaii (within TMK 4-3-9-002:020), near Maalo Road. The RRP may be constructed either on the MSWLF site or at a nearby property on 80 acres owned by a private landowner (within TMK 4-3-8-002:001), pending discussions between the County and the landowner. The MSWLF infrastructure includes access roads, utilities, an office shop area, stormwater infiltration basin, leachate aeration pond, scale house, drop-off area, and internal roadways. The RRP involves recycling, reuse, reduction, and other waste diversion components. In addition, AECOM, on behalf of the County of Kauai, is conducting a Landfill Wildlife Hazard Assessment (LWHA) to evaluate the potential hazard of the proposed landfill to air carrier operations at Lihue Airport and develop wildlife hazard mitigation recommendations for potential inclusion in the project description. The following comments are provided to assist the County of Kauai and AECOM in preparing the draft EIS and associated LWHA, in accordance with the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C 1531 *et seq.*).

We reviewed the information you provided and pertinent information in our files, including data compiled by the Hawaii Biodiversity and Mapping Program, as it pertains to federally listed species and designated critical habitat. The following species are known to occur or transit through the proposed project area: the endangered Hawaiian black-necked stilt (*Himantopus mexicanus knudseni)*, Hawaiian moorhen (*Gallinula chloropus sandvicensis*), Hawaiian coot

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(*Fulica alai*), Hawaiian duck (*Anas wyvilliana*) (hereafter collectively referred to as Hawaiian waterbirds); the endangered Hawaiian goose (*Branta sandvicensis*); the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus)*; and the endangered Hawaiian petrel (*Pterodroma sandwichensis*), the threatened Newell's shearwater (*Puffinus auricularis newelli*), and a candidate for listing the band-rumped storm-petrel (*Oceanodroma castro*) (hereafter collectively referred to as seabirds). There is no designated critical habitat within the vicinity of the proposed project area. We provide the following recommendations to avoid and minimize project impacts to listed species and candidate species.

Hawaiian Goose
In order to avoid impacts to Hawaiian geese, we recommend a biologist familiar with the nesting behavior of the Hawaiian goose survey the area prior to the initiation of any work, or after any subsequent delay in work of three or more days (during which birds may attempt nesting). If a nest is discovered, work should cease immediately and our office should be contacted for further guidance. Furthermore, all on-site project personnel should be apprised that Hawaiian geese may be in the vicinity of the project at any time during the year. If a Hawaiian goose (or geese) appears within 100 feet of ongoing work, all activity should be temporarily suspended until the Hawaiian goose (or geese) leaves the area of its own accord.

Hawaiian Hoary Bat
The Hawaiian hoary bat roosts in both exotic and native woody vegetation and, while foraging, will leave young unattended in "nursery" trees and shrubs when they forage. If trees or shrubs suitable for bat roosting are cleared during the breeding season, there is a risk that young bats could inadvertently be harmed or killed. To minimize impacts to the endangered Hawaiian hoary bat, woody plants greater than 15 feet tall should not be disturbed, removed, or trimmed during the bat birthing and pup rearing season (June 1 through September 15). Site clearing should be timed to avoid disturbance to Hawaiian hoary bats in the project area.

Seabirds
Seabirds, including the Newell's shearwater, Hawaiian petrel, and band-rumped storm petrel fly at night and are attracted to artificially-lighted areas resulting in disorientation and subsequent fallout due to exhaustion. Seabirds are also susceptible to collision with objects that protrude above the vegetation layer, such as utility lines, guy-wires, and communication towers. Additionally, once grounded, they are vulnerable to predators and are often struck by vehicles along roadways. Construction activities should only occur during daylight hours. We also recommend the lighting in the project area be fully shielded or full cut-off luminary fixtures, such that the bulb can only be seen from below using the lowest wattage bulbs possible. Any increase in the use of nighttime lighting, particularly during peak fallout period (September 15 through December 15), could result in additional seabird injury or mortality.

Hawaiian Waterbirds
Our information suggests that your project may result in standing water or creation of open water, thus attracting Hawaiian waterbirds to the site. In particular, the Hawaiian stilt is known to nest in sub-optimal locations (e.g., any ponding water) if water is present. Hawaiian waterbirds attracted to sub-optimal habitat may suffer adverse impacts, such as predation and

reduced reproductive success, and thus the project may create an attractive nuisance. We recommend you continue to work with our office during project planning so that we may assist you in developing measures to avoid impacts to Hawaiian waterbirds (e.g., fencing, vegetation control, predator management).

The Service understands that AECOM, on behalf of the County, is conducting a LWHA to determine how the project could affect wildlife hazards at Lihue Airport. In addition to the work described in the LWHA Preliminary Study Plan, you stated that the AECOM is arranging to conduct aerial surveys for cattle egret (*Bubulcus ibis*) roosts. Additional information regarding proposed design modifications and management activities to address potential hazards is necessary to assess potential impacts to listed species. You stated that AECOM anticipates releasing a preliminary LWHA report, including the preliminary assessment of hazards and design and operational management measures, at the end of January 2015. We request to receive a copy of the preliminary LWHA report once it is available for release. You also stated a meeting is tentatively scheduled for February 17, 2015 with the State of Hawaii Department of Transportation (HDOT) to discuss the preliminary LWHA report. We look forward to coordinating with you on our availability and further details pertaining to meeting to discuss the report.

The draft EIS should address all potential impacts to federally listed species and candidate species, and should outline conservation measures to avoid and minimize these impacts. If it is determined that the proposed project may affect federally listed species, the County of Kauai should apply for an incidental take permit under section 10(a)(1)(B) of the ESA. A section 10 permit application must include a habitat conservation plan that identifies the effects of the action on listed species and their habitats, and defines measures to minimize and mitigate those adverse effects.

Additionally, we recommend you incorporate the attached best management practices into your project description to avoid and minimize impacts to water resources that have the potential to occur during grading, excavation, and other construction activities.

We appreciate your efforts to conserve endangered species. Please contact Adam Griesemer, Endangered Species Biologist (phone: 808-285-8261, email: adam_griesemer@fws.gov) should you have any questions pertaining to this response.

Sincerely,

for Aaron Nadig
Assistant Field Supervisor:
Oahu, Kauai, NWHI, Am.Samoa

Cc: Dennis Neves, HDOT
Larry Dill, County of Kauai

U.S. Fish and Wildlife Service
Recommended Standard Best Management Practices

The U.S. Fish and Wildlife Service recommends that the measures below be incorporated into projects to minimize the degradation of water quality and minimize the impacts to fish and wildlife resources.

1. Turbidity and siltation from project-related work shall be minimized and contained within the vicinity of the site through the appropriate use of effective silt containment devices and the curtailment of work during adverse tidal and weather conditions.

2. Dredging/filling in the marine environment shall be scheduled to avoid coral spawning and recruitment periods and sea turtle nesting and hatching periods.

3. Dredging and filling in the marine/aquatic environment shall be designed to avoid or minimize the loss special aquatic site habitat (beaches, coral reefs, wetlands, etc.) and the function of such habitat shall be replaced.

4. All project-related materials and equipment (dredges, barges, backhoes, etc.) to be placed in the water shall be cleaned of pollutants prior to use.

5. No project-related materials (fill, revetment rock, pipe, etc.) should be stockpiled in the water (intertidal zones, reef flats, stream channels, wetlands, etc.) or on beach habitats.

6. All debris removed from the marine/aquatic environment shall be disposed of at an approved upland or ocean dumping site.

7. No contamination (trash or debris disposal, non-native species introductions, attraction of non-native pests, etc.) of adjacent habitats (reef flats, channels, open ocean, stream channels, wetlands, beaches, forests, etc.) shall result from project-related activities. This shall be accomplished by implementing a litter-control plan and developing a Hazard Analysis and Critical Control Point Plan (HACCP – see http://www.haccpnrm.org/Wizard/default.asp) to prevent attraction and introduction of non-native species.

8. Fueling of project-related vehicles and equipment should take place away from the water and a contingency plan to control petroleum products accidentally spilled during the project shall be developed. Absorbent pads and containment booms shall be stored onsite, if appropriate, to facilitate the clean-up of accidental petroleum releases.

9. Any under-layer fills used in the project shall be protected from erosion with stones (or core-loc units) as soon after placement as practicable.

10. Any soil exposed near water as part of the project shall be protected from erosion (with plastic sheeting, filter fabric etc.) after exposure and stabilized as soon as practicable (with native or non-invasive vegetation matting, hydroseeding, etc.).

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawaii 96850

JAN 2 6 2016

In Reply Refer To:
01EPIF00-2016-TA-0162

Mr. Frank Cioffi, P.E.
Senior Engineer
AECOM
1001 Bishop Street, Ste. 1600
Honolulu, HI 96813

Subject: Comments on the Maalo Landfill Project Wildlife Hazard Assessment, Kauai

Dear Mr. Cioffi:

The U.S. Fish and Wildlife Service (Service) received your email, dated December 15, 2015, requesting our comments on the Landfill Wildlife Hazard Assessment (LWHA) for the proposed Maalo Landfill and Resource Recovery Park (RRP) on the island of Kauai. The County of Kauai (County) proposes to develop and operate a new Municipal Solid Waste Landfill (MSWLF) on 270 acres owned by the State of Hawaii (within TMK 4-3-9-002:020), near Maalo Road. The RRP may be constructed either on the MSWLF site or at a nearby property on 80 acres owned by a private landowner (within TMK 4-3-8-002:001), pending discussions between the County and the landowner. The MSWLF infrastructure includes access roads, utilities, an office shop area, stormwater infiltration basin, leachate aeration pond, scale house, drop-off area, and internal roadways. The RRP involves recycling, reuse, reduction, and other waste diversion components. AECOM and SWCA, on behalf of the County, conducted the LWHA to evaluate the potential hazard of the proposed landfill to air carrier operations at Lihue Airport and develop wildlife hazard mitigation recommendations for potential inclusion in the project description. The County anticipates preparing a Landfill Wildlife Management Plan (LWMP) to select practicable design and operational measures to minimize the attractiveness of the proposed landfill to species of concern.

We provided comments during the early development of this project in December 2014 (Service File 2015-TA-0182) to assist the County in preparing the draft Environmental Impact Statement (EIS). In our letter, we provided the following to assist you in your project planning: (1) recommended measures to avoid and minimize impacts to federally listed species; and (2) Best Management Practices (BMPs) to preserve aquatic habitat function. In February 2015, we provided additional assistance regarding recommended measures to avoid impacts to the Hawaiian stilt (*Himantopus mexicanus knudseni)*, Hawaiian moorhen (*Gallinula chloropus sandvicensis*), Hawaiian coot (*Fulica alai*), and Hawaiian duck (*Anas wyvilliana*) (hereafter collectively referred to as Hawaiian waterbirds), and the Hawaiian goose (*Branta sandvicensis*). The following comments are provided to assist the County in the finalization of the LWHA and

preparing the LWMP and draft EIS, in accordance with the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C 1531 *et seq.*).

Maalo Area Avian Surveys. This section provides information on the activity of avian species based on survey observations in the Maalo Study Area, including Hawaiian waterbirds and the Hawaiian goose. Additional information regarding survey observations is necessary to assess potential impacts to Hawaiian waterbirds and Hawaiian goose at the Maalo Site. Please provide the Service with point counts for survey locations M5 and M6 at the Maalo Site, and any observations of nests for each of the following species: the Hawaiian stilt, Hawaiian moorhen, Hawaiian coot, Hawaiian duck, and Hawaiian goose.

Landfill Design Alternatives. The LHWA incorporates the Service's recommendations, provided in our February 17, 2015 email, regarding the use of floating bird deterrent balls or grid system to minimize attraction of Hawaiian waterbirds to standing water features. The wire grid system should be designed to minimize potential for entanglement of Hawaiian waterbirds and/or Hawaiian geese, should these species attempt to land on the wires.

The design of structures should incorporate our recommendations regarding exterior lighting to avoid and minimize attraction of seabirds, including the Hawaiian petrel (*Pterodroma sandwichensis*), the Newell's shearwater (*Puffinus auricularis newelli*), and the band-rumped storm-petrel (*Oceanodroma castro*) to artificially-lighted areas. If lights cannot be eliminated due to safety or security concerns, then lighting should be positioned low to the ground, be motion-triggered, and be shielded and/or full cut-off.

In addition, measures to avoid impacts to Hawaiian hoary bat (*Lasiurus cinereus semotus)* should be incorporated in the design of infrastructure. The Hawaiian hoary bat forages for insects from as low as three feet to higher than 500 feet above ground. When barbed wire is used for fencing, bats can become entangled. Barbed wire should not be used for fencing as part of the proposed project.

Operational Measures. The LWHA states the LWMP will be a living document that is subject to regular evaluation. The LWMP should include an adaptive management section that describes the process for making changes to operational measures, if necessary, based on the results of monitoring.

Active Wildlife Control. The LWHA recommends hazing of cattle egrets (*Bubulcus ibis*) attracted to the landfill waste features. Hazing activities for cattle egrets in areas where a Hawaiian waterbird(s) and/or Hawaiian goose (geese) are present may result in the injury or death of a waterbird(s) and/or goose (geese) due to collision with structures. Although design and operational measures described in the LWHA will minimize the attraction of Hawaiian waterbirds to water features and Hawaiian geese to grass areas, the implementation of these measures does not ensure that no Hawaiian waterbirds or Hawaiian geese will be attracted to the proposed landfill. Additionally, based on cattle egret movements in the Maalo Study Area as described in the LWHA, the hazing of cattle egrets attracted to the proposed landfill may increase the air traffic of cattle egrets in the direction of Kauai Lagoons, protected Hawaiian waterbird habitat.

Cattle egrets depredate the young of Hawaiian waterbirds, and on managed wetlands, increased cattle egret foraging behavior has been documented just as endangered waterbird chicks are hatching. In addition to cattle egrets, the landfill odors will attract other non-native predators of Hawaiian waterbirds and Hawaiian geese to the proposed landfill, such as feral cats and rats. We recommend implementing a predator control program at the Maalo site to remove feral cats, rats, and cattle egret to minimize predation and/or reduced breeding success of Hawaiian waterbirds and Hawaiian geese that may utilize surrounding areas. To further reduce the number of cattle egrets attracted to the landfill and help conserve Hawaiian waterbirds nesting in surrounding areas, we recommend the County coordinate with landowners of neighboring lands and the State of Hawaii Division of Forestry and Wildlife (DOFAW) to remove cattle egrets at nearby roost locations using lethal control. The County would need to obtain a Migratory Bird Treaty Act (MBTA) Depredation Permit and authorization from DOFAW to control cattle egrets.

The County should continue to coordinate with us while preparing the LWMP to incorporate measures to avoid impacts to listed species. Please provide a copy of the draft LWMP to the Service once it is available to be released.

We appreciate your efforts to conserve endangered species. Please contact Adam Griesemer, Endangered Species Biologist (phone: 808-285-8261, email: adam_griesemer@fws.gov) should you have any questions pertaining to this response.

Sincerely,

Aaron Nadig
Island Team Manager
Oahu, Kauai, Northwestern Hawaiian
Islands and American Samoa

cc: Mr. Ford Fuchigama, HDOT
Mr. Larry Dill, County of Kauai

DAVID Y. IGE
GOVERNOR

FORD N. FUCHIGAMI
DIRECTOR

Deputy Directors
JADE T. BUTAY
ROSS M. HIGASHI
EDWIN H. SNIFFEN
DARRELL T. YOUNG

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:

DIR 1.11161

August 5, 2016

Mr. Lyle Tabata
Acting County Engineer
Public Works Department
4444 Rice Street, Suite 275
Lihue, Hawaii 96766

Subject: New Landfill Wildlife Hazard Assessment

Dear Mr. Tabata:

We have reviewed the New Landfill Wildlife Hazard Assessment report that was submitted to the Hawaii Department of Transportation, Airports Division (HDOTA). While the report does confirm that the New Landfill will attach wildlife, the report does not address any mitigation plan of wildlife in this area. We are willing to conduct another review of your proposed project once we receive the mitigation plan.

The Federal Aviation Administration (FAA) and HDOTA has concerns with regards to possible project activities to airport compatible land uses and minimizing hazardous wildlife attractants to air and surface operations will assist us in making a better assessment.

Should you have any questions, please contact Mr. David Rodriguez, Special Assistant to the Director at (808) 587-2165 or email: david.j.rodriguez@hawaii.gov.

Sincerely,

FORD N. FUCHIGAMI
Director of Transportation