Attachment P-3.2

Facility Design (Engineering Report)

Engineering Report

Kekaha Municipal Solid Waste Landfill, Phase II Vertical Expansion

Kekaha, Kaua’i, Hawai’i

NOVEMBER 29, 2023

PROJECT NUMBER 197-220048

PRESENTED TO

County of Kaua’i Solid Waste Division
4444 Rice Street, Suite 295
Lihue HI 96766

SUBMITTED BY

Tetra Tech BAS, Inc.
21700 E Copley Drive, Suite 200
Diamond Bar CA 91765

P +1.909.860.7777
F +1.909.860.8017
tetratech.com

REPORT CERTIFICATION

The material and data in this report were prepared under the supervision and direction of the undersigned.

Not for Construction

Garth R. Bowers, P.E. 11/29/2023
Technical Director/Senior Operations Director

GARTH R. BOWERS
LICENSED PROFESSIONAL ENGINEER
No. 20139-C
Exp 4/30/24
HAWAII U.S.A.
11/29/23

Not for Construction

Paul J. Stout, P.E. 11/29/2023
Vice President

PAUL STOUT
LICENSED PROFESSIONAL ENGINEER
No. 12145
Exp 4/30/24
HAWAII U.S.A.
11/28/23

EXECUTIVE SUMMARY

The County of Kaua‘i (County) proposes to vertically expand Phase II at the Kekaha Municipal Solid Waste Landfill (KLF) facility to provide additional air space volume for placement of refuse while the siting, designing, and construction phases for a lateral expansion or new landfill facility are completed. The purpose of this document is to summarize the engineering design approach and calculations demonstrating the conformance of the vertical expansion design with the applicable regulatory design requirements. The KLF facility (consisting of Phases I and II) is located in a coastal area on the southwest side of the island of Kaua‘i. The County opened the Phase I landfill in 1953 and accepted solid wastes in this Phase until operations ceased on October 8, 1993 after the opening of Phase II. Phase II of the KLF facility, constructed in 1993 to meet RCRA Subtitle D criteria, is situated immediately to the northeast of Phase I and is currently an active municipal solid waste landfill (MSWLF). Based on the original permit and several subsequent lateral and vertical expansions, the Phase II facility has a maximum permitted elevation of 120 feet above mean sea level (msl) and is estimated to reach its capacity in 2027.

The proposed vertical expansion of Phase II would increase its maximum permitted elevation to 171.5 feet msl and would add an additional approximately 405,300 CY of new airspace for waste disposal, compared to the existing permitted volume, which would equate to approximately 38.6 months of disposal capacity beyond the life of the currently permitted facility.

The KLF facility currently has an existing constructed Subtitle D-compliant base liner system installed per the requirements of the existing site permits. No changes to this base liner system are proposed for this vertical expansion. Although no changes are proposed to the existing leachate collection system as part of the proposed vertical expansion of Phase II, additional load will be added to the leachate collection and recovery system (LCRS) piping in the center of the Phase II area due to the extended waste column thickness within the vertical expansion area. Therefore, Tetra Tech evaluated the effect of the increased waste thickness on the existing leachate collection pipes under the peak thickness of the vertical expansion, and the resulting factors of safety and anticipated deflection/strain on the LCRS piping remain acceptable. The proposed changes from the vertical expansion are not expected to substantially affect the production and migration of leachate in the 30-year timeframe. Compared with the results of modeling of the currently permitted design, the vertical expansion will change both the peak day and average annual leachate generation by less than one (1) percent and the direction of the change is inconsistent (the peak day rate is predicted to increase slightly, while the average annual rate is predicted to decrease slightly. The final geometry of the proposed Phase II vertical expansion, with a maximum elevation of 171.5 ft msl, was verified for slope stability at final buildout. The surface water management system for the vertical expansion has been developed to accommodate the flow directions and grade changes from the proposed vertical expansion and will tie into the existing permitted surface water management system at the limits of the vertical expansion.

The proposed vertical expansion will have two major effects on the landfill gas (LFG) generation at the KLF. Due to the additional waste tonnage to be accepted as a result of the vertical expansion, the total LFG generation rate and subsequently the LFG collected in the gas collection and control system (GCCS) will increase. Tetra Tech evaluated the major GCCS header piping and flare station as it relates to the increase in site flow and identified that the major GCCS header piping and flare station is adequately sized to accommodate the anticipated increase in LFG flow and major losses associated with undersized piping are not anticipated. Additionally, the existing GCCS infrastructure existing at the site within the vertical expansion footprint will be impacted by the additional fill. To address the impacted existing GCCS infrastructure, Tetra Tech has prepared Permit Design Plans detailing two phases of improvements recommended to maintain gas collection as the vertical expansion is constructed.

Based on the evaluations conducted in this report, the proposed Phase II vertical expansion is feasible and will serve to alleviate the County’s vital and time-sensitive needs. The existing Phase II capacity is currently being consumed and additional landfill airspace resulting from this vertical expansion is critical for the island of Kaua'i. Therefore, it is recommended that the proposed Phase II vertical expansion be submitted for approval and the additional capacity be utilized for waste disposal while the County pursues additional alternatives for continued management of waste generated on the island of Kaua'i.

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
%	Percent
ac	Acre
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
County	County of Kaua'i Solid Waste Division
CY	Cubic Yard
DOH	Hawai'i Department of Health
EPA	US Environmental Protection Agency
ft	Feet
GCCS	Gas Collection and Control System
GCL	Geosynthetic Clay Liner
HAR	Hawai'i Administrative Rule
HDPE	High-density Polyethylene
KLF	Kekaha Municipal Solid Waste Landfill
LandGEM	Landfill Gas Emissions Model
LCRS	Leachate Collection and Recovery System
LFG	Landfill Gas
msl	Mean Sea Level
MSWLF	Municipal Solid Waste Landfill
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service (formerly SCS - Soil Conservation Service)
pcy	Pounds per Cubic Yard
psi	Pounds per Square Inch
RCRA	Resource Conservation and Recovery Act
SDR	Standard Dimension Ratio
SF	Square Feet

1.0 INTRODUCTION

The County of Kaua'i (County) proposes to vertically expand Phase II at the Kekaha Municipal Solid Waste Landfill (KLF) facility to provide additional air space volume for placement of refuse while the siting, designing, and construction phases for a new landfill facility are completed. The proposed vertical expansion would extend the existing permitted sideslopes of the existing Phase II upward to a new permitted maximum elevation of the landfill final cover of 171.5 feet (ft) above mean sea level (msl). This proposed vertical expansion will be within the existing permitted footprint of the Phase II landfill area at the KLF and will be constructed above the existing Resource Conservation and Recovery Act (RCRA) Subtitle D base liner, constructed as the Phase II; Phase II, Cell 1; and Phase II, Cell 2 base liner systems.

The purpose of this document is to summarize the engineering design approach and calculations demonstrating the conformance of the vertical expansion design with the applicable regulatory design requirements. Where regulatory design requirements are not affected by the proposed expansion, the reader is directed to the previously approved engineering reports for the existing KLF, including the original Phase II design and the previous lateral and vertical expansions.

1.1 SITE BACKGROUND

The KLF facility (consisting of Phases I and II) is located in a coastal area on the southwest side of the island of Kaua'i as illustrated on Sheet C-001 of the attached Permit Design Drawings. The KLF is located at mile marker 28 of the Kaumuali'i Highway (Highway 50) about 2 miles west of Kekaha. Phases I and II were originally constructed as non-contiguous landfills, but were made contiguous with the construction of Phase II, Cell 2 at the facility per the approval of the Solid Waste Management Permit LF-0042-16 issued in 2019. Drawing C-100 illustrates the general features of the existing landfill facilities, which will remain.

1.2 PHASE I

Phase I occupies approximately 33 acres and varies in elevation from 10 to 50 ft msl. The County opened the Phase I landfill in 1953 and accepted solid wastes at the facility until operations ceased on October 8, 1993. The Phase I landfill has no base liner system beneath the refuse and no leachate collection system.

The final cover for the Phase I landfill was designed and constructed in accordance with the following environmental rules and regulations in effect at the time of construction:

- United States Environmental Protection Agency (EPA) *Solid Waste Disposal Facility Criteria*, under the RCRA Subtitle D, published as 40 Code of Federal Regulations (CFR) Part 258 on October 9, 1991.
- State of Hawai'i Department of Health (DOH) *Solid Waste Management Control and Interim Guidelines for Landfill Closure*, Draft, Hawai'i Administrative Rule (HAR) Title 11, Chapter 58 (DOH 1994).

1.3 PHASE II

Phase II of the KLF facility, constructed in 1993 to meet RCRA Subtitle D criteria, is situated immediately to the northeast of Phase I and is currently an active municipal solid waste landfill (MSWLF). Phase II was initially permitted to a maximum elevation of 37 ft msl. To accommodate waste generated by Hurricane Iniki in 1992, a vertical expansion was proposed and approved in 1998 to raise the maximum fill elevation to 60 ft msl. In 2004, the County prepared, submitted, and gained approval of a vertical expansion to 85 ft msl. In 2009, Phase II was expanded laterally to the northwest with the approval of Cell 1. In 2013, the County obtained a permit for a vertical expansion of the Phase II landfill to a maximum elevation of 120 feet msl. In 2019, Phase II was expanded laterally to the southwest with the approval of Cell 2.

The Phase II landfill is bounded by Kaumualiʻi Highway to the northeast, an unpaved access road and agriculture to the southeast, aquaculture to the northwest, and the Phase I landfill to the southwest. The Phase II landfill base liner elevations and leachate collection system vary from approximately 12 ft above msl to approximately 7 ft above msl and drains towards the northeast. The permitted Phase II landfill has maximum sideslopes of 3.5:1 (horizontal: vertical), will have a 3 percent (%) top slope. The Phase II liner area encompasses 44 acres and is subdivided into 14 lined subcells (each about 2.3 acres).

The existing Phase II landfill base liner system consists of (bottom to top):

- Granular subbase.
- Geosynthetic Clay Liner (GCL) consisting of a smooth 20-mil high-density polyethylene (HDPE) geomembrane with an adhered bentonite powder layer on one side (Gundseal). The GCL was installed with the smooth side in direct contact with the granular subbase and the bentonite component side up.
- Single-sided textured 60-mil HDPE geomembrane (textured side down) against the GCL on the sideslope.
- Smooth 60-mil HDPE geomembrane against the GCL on the base.
- Sand drainage layer (base and sideslope).

The existing base liner system for Cell 1 of Phase II consists of (bottom to top):

- Prepared subbase grade
- Subbase 60-mil HDPE geomembrane, textured on both sides
- GCL
- 60-mil HDPE geomembrane (upper component), textured on both sides
- Nonwoven cushion geotextile
- 12-inch granular drainage layer (leachate collection)
- Nonwoven separator geotextile
- 24-inch operations layer

The existing base liner system for Cell 2 of Phase II consists of (bottom to top):

- Prepared subbase grade
- Geosynthetic reinforcement grid (Phase 1 sideslope overlay for Subcells A and D)
- Nonwoven cushion geotextile
- Secondary 60-mil HDPE geomembrane (lower component) (see note)
- GCL (as alternative to lower soil component requirement)
- Primary 60-mil HDPE geomembrane (upper component), textured on both sides
- Nonwoven cushion geotextile
- 12-inch granular drainage layer (leachate collection)
- Nonwoven separator geotextile
- 24-inch operations layer

Note: Both the primary and secondary geomembranes in Cell 2 are textured on both sides of the geomembrane except for the secondary geomembrane on the portion of the base liner that overlays directly upon the Phase 1 sideslope. Secondary geomembrane residing on the Phase 1 sideslope is single-sided textured with the texturing in direct contact with the geotextile layers of the GCL. This system orientation of texturing is to provide a slip surface for the base liner system to relax should a waste depression occur under the Cell 2 base liner on the Phase 1 sideslope.

Placement of refuse has been completed over the entire base liner of Phase II. Refuse placement is currently occurring above the most recently permitted Phase II, Cell 2 liner, laying back over the existing waste placed over the original Phase II liner.

Phase II is currently owned and operated by the Kaua'i County Solid Waste Division, and is the only permitted MSWLF on the island of Kaua'i.

2.0 DESIGN AND CAPACITY

The proposed vertical expansion will be an extension of the existing approved design for Phase II and is not intended to change components of the existing design which are not affected by the vertical expansion. This section discusses the changes in the geometric configuration of the landfill and the resulting changes in capacity that will be provided by implementing the proposed vertical expansion.

Accompanying this report are drawings titled *Permit Design Drawings for the Phase II – Vertical Expansion, Kekaha Municipal Solid Waste Landfill, Kaua'i County, Hawai'i*, prepared by Tetra Tech, dated May 2023 and attached to this Engineering Report. These drawings are referenced in the following sections highlighting the components and design demonstrations of the proposed lateral expansion.

2.1 BASE LINER DESIGN

The KLF facility currently has an existing constructed Subtitle D-compliant base liner system installed per the requirements of the existing site permits, as discussed in Section 1.3 above. No changes to this base liner system are proposed for this vertical expansion.

2.2 VERTICAL EXPANSION GEOMETRY

The existing permitted design 3.5:1 (horizontal:vertical) sideslopes are proposed to be extended above the currently permitted top deck elevation (nominally 120 ft msl) to a new top deck elevation with a maximum final cover elevation of 171.5 ft msl as indicated on Permit Design Drawings Sheet C-102. Benches were established at the tie-in grade to the existing permitted final cover surface and approximately halfway up the proposed vertical expansion to address slope stability (See Section 3 below) and stormwater management (See Section 4 below). The top deck was established at a lateral slope of 3% from the ridgeline at 171.5 ft msl to the nearest edge of the top deck to match the existing permitted top deck slope, but was limited to a minimum deck width of 100 feet to allow for maneuvering of the largest piece of equipment currently operated by the County on the landfill top deck, a Caterpillar 836K compactor. The combination of the existing permitted top deck geometry, 3.5:1 sideslopes, benching requirements (see Section 3.0), and minimum top deck requirements result in the maximum final cover elevation of 171.5 ft msl shown on Permit Design Drawings Sheet C-102.

The lateral footprint area of the proposed vertical expansion is 566,700 square feet (SF) or 13.0 acres (ac). The total volume of the proposed vertical expansion is 407,700 cubic yards (CY). Although the proposed vertical expansion is located entirely within the currently permitted footprint of Phase II and there is therefore no increase in footprint that will be under the permitted final cover at closure, the slope-corrected area of final cover will increase by 21,600 SF due to the longer sideslopes in the proposed vertical expansion and the final cover volume will increase by 2,400 CY. Therefore, the net increase in landfill disposal airspace resulting from the proposed vertical expansion will be 405,300 CY.

2.3 FINAL COVER DESIGN

No changes are proposed to the existing permitted final cover section (shown for reference on Permit Design Drawings Sheet C-501). This permitted final cover design consists of the following components (from top to bottom):

- 18-inch vegetative/protective soil layer
- Geocomposite drainage layer
- 40-mil linear low-density polyethylene liner (double-sided textured)
- GCL
- 6-inch minimum grading layer
- 12 inches of intermediate cover material
- Top of waste

2.4 LANDFILL CAPACITY

As discussed above in Section 2.2, additional airspace resulting from the proposed vertical expansion of Phase II will be located above the existing permitted final cover top deck (nominal elevation of 120 ft msl) and will include approximately 405,300 CY of new airspace for waste disposal, compared to the existing permitted volume. Assuming an annual waste intake rate of 89,000 tons/year and an average in-place waste mass density of 1,300 pounds per cubic yard (pcy), this would extend the life of the KLF facility by approximately 2.96 years (or 35.5 months) beyond the life of the currently permitted facility.

For the Phase II landfill as a whole (including the proposed vertical expansion together with the previously permitted original Phase II landfill area and its horizontal and vertical expansions), the total airspace from liner subgrade to top of final cover would be 5,154,000 CY. Of that total, approximately 213,000 CY is occupied by drainage layer and protective cover soils over the base liner and 222,000 CY will be occupied by final cover. This will result in approximately 4,719,000 CY of operational airspace occupied by waste and daily/intermediate cover soils.

3.0 GEOTECHNICAL DESIGN

A slope stability evaluation was performed for the critical cross sections of the proposed design configuration presented in Section 2.0 of this report. The review and evaluation were completed in accordance with the EPA Solid Waste Disposal Facility Criteria, Technical Manual, November 1993. Design criteria were based upon geotechnical values as included in the Engineering Report issued for Phase II, Cell 2 as issued by AECOM in October 2017 (AECOM, 2017), and a preliminary slope stability analysis developed by Geosyntec in 2021 (Geosyntec Consultants, 2021).

3.1 BUILDOUT SLOPE STABILITY EVALUATION

The final geometry of the proposed Phase II vertical expansion, with a maximum elevation of 171.5 ft msl, was verified for slope stability at final buildout. The final buildout condition represents the facility's final shape after waste placement has ceased and final cover has been installed. Top deck lateral slopes are designed to be sloped at 3%. Final cover sideslopes are designed to be sloped at a ratio of 3.5H:1V.

The buildout stability analysis included two different failure scenarios based upon the geometry of the facility, and the failure condition. The first failure scenario analyzed the stability of the landfill against a block type failure, with failure surfaces originating on or near the top deck of the landfill and exiting through a zone containing the base liner and waste mass immediately above the base liner. The second failure scenario involved circular type failures that reside primarily within the waste mass and along the base liner. Both scenarios were modeled on each critical slope of each landfill slope.

Based on the assumptions detailed in Appendix A, a factor of safety was calculated using the slope stability software, Slope/W, which is part of the GeoStudio 2021 software suite. The scenarios were evaluated in the cross-sections as presented in Appendix A. The cross-sections were positioned in what is believed to be the most critical locations. Sheet C-301 of the design drawings roughly shows the location of the cross-sections, which were positioned perpendicularly to the slope directions and are roughly northwest (Shrimp side) to southeast (Waimea side), and northeast (Mauka side) to southwest (Makai side). The calculated factor of safety was compared to the minimum factor of safety of 1.5 for each static scenario, in general accordance with previous slope stability analyses and EPA guidelines (EPA, 1993). The calculated factor of safety was achieved in all cases. Modeled factors of safety are summarized in Table 3-1.

Table 3-1. Buildout Slope Stability Factor of Safety Summary

Cross-Section	Condition	Failure Condition	Minimum Factor of Safety	Calculated Factor of Safety
Northwest (Shrimp)	Static	Block	1.5	3.7
	Static	Circular	1.5	1.6
Northeast (Mauka)	Static	Block	1.5	3.9
	Static	Circular	1.5	1.5
Southeast (Waimea)	Static	Block	1.5	4.0
	Static	Circular	1.5	1.5
Southwest (Makai)	Static	Block	1.5	3.8
	Static	Circular	1.5	1.7

No changes were made to the liner design as part of the Phase II expansion. The design as detailed in Section 3.0 for Phase II (including the original Phase II liner, and the subsequent additions of Phase II, Cell 1 and Phase II, Cell 2) was incorporated in the model and the analysis performed. Stability parameters (material unit weight, cohesion, interface friction angle) were derived from previous slope stability efforts performed by AECOM in 2017 and Geosyntec in 2021. The landfill with the proposed Cell 2 expansion is expected to remain stable based on assumed minimum interface friction angles and soil and waste mass properties presented in Appendix A.

3.1.1 Summary of Assumptions

The waste mass properties were defined based on AECOM 2017 and Geosyntec 2021. According to AECOM 2017, the site currently maintains a compacted waste density of 62 pcf for new waste (including daily cover soils) and 72 pcf for older waste. Geosyntec used 62 pcf for all waste, as did this analysis. Waste mass properties are dependent upon the degree of compaction, lift thickness, composition of the waste stream, moisture, and the amount of daily cover soil or alternate daily cover used. Shear stress was calculated using the equation developed by (Zekkos, 2005) for MSW based upon normal stress at $P_{\circ}$ = 1 atm. The equation and results are below:

$$\tau = 15 + \sigma_n' \cdot \tan\left[36 - 5 \cdot \log\left(\frac{\sigma_n'}{Po}\right)\right]$$

Table 3-2. Shear Stress versus Normal Stress via Zekkos (2005).

Normal Stress (σ_n') (PSF)	**Shear Stress (τ)** (PSF)
0	313
1000	1084
2000	1773
3000	2433
4000	3074
5000	3703
6000	4320
7000	4929
8000	5531
9000	6126
10000	6715
11000	7300
12000	7879
13000	8455
14000	9026
15000	9594

16000	10159
17000	10721
18000	11279

AECOM, Geosyntec, and Tetra Tech used 110 and 115 pcf for the Phase I and Phase II unit weight of the liner.

In addition to the waste mass properties, the critical interface of the proposed base liner system requires consideration. The critical interface governs overall site stability. Based upon the proposed base liner system design and angles of friction, the critical interface is between the GCL and the operations layer. AECOM 2017 modeled the liner with a cohesion of 0 pcf and internal friction angle of 6°. Based upon Geosyntec (2021), the original Phase II liner has an interface friction angle of 5.7° and 100 cohesion of psf, while the Cell 1 and 2 liners have an interface friction angle of 10.4° and 0 psf of cohesion. The more conservative Geosyntec parameters for the original Phase II liner were used for evaluating slope stability.

Kekaha is not located in a seismic impact zone based on the 1998 evaluation of the site by an EMCON subcontractor as part of their Addendum Operations Manual. In accordance with this finding AECOM (2017), Geosyntec (2021), and this report did not evaluate the pseudo-static stability of the site, and no additional seismic evaluation was included in this Engineering Report. Based on (2021) USGS National Seismic Hazard Model (NSHM) updates, there has been minimal changes between the 2021 model and earlier NSHM modeling on Kauai and in the area of the KLF.

Further details are in Appendix A.

4.0 SURFACE WATER MANAGEMENT

The surface water management system for the vertical expansion is shown on Sheet C-103 of the Permit Design Drawings. The proposed surface water management system has been revised to accommodate the flow directions and grade changes from the proposed vertical expansion and will tie into the existing permitted surface water management system at the limits of the vertical expansion (i.e., at the diversion berms at the upper end of the sideslopes in the permitted design).

Tetra Tech has analyzed the runoff which will occur from the areas with revised grading. The new design was based on the design concept for the existing permitted design with diversion berms and benches conveying runoff to riprapped downdrains. Drainage area delineations were developed and named to match the larger watershed nomenclature from the existing permitted design. The upper end of the downdrains in each of the four existing watersheds affected by the vertical expansion (watersheds A, B, C and F) will be extended upward as necessary and tied into the proposed diversion berms and benches from the proposed vertical expansion.

4.1 STORMWATER HYDROLOGY

Tetra Tech analyzed stormwater flows using similar input assumptions and modeling methodology to that of the existing permitted design. The existing permitted design was modeled in SEDCAD+ using a TR-55 modeling methodology for estimating runoff volumes (AECOM, 2017). Since the model files for the AECOM analysis were not available, Tetra Tech utilized the WinTR55 software developed by the Natural Resources Conservation Service (NRCS) to determine runoff in each of the subwatershed drainage areas shown on Sheet C-103. Similar to the AECOM analysis for the existing permitted design, a runoff curve number of 79 was utilized for all drainage areas within the landfill and a Type I storm distribution was utilized to develop the precipitation hyetograph.

Similar to the AECOM analysis, runoff was calculated for the 100-year and 25-year return interval events. Although the AECOM analysis utilized estimated rainfall totals from isopluvial maps for the 100-year, 1 hour storm event and the 25-year, 24-hour events, more precise location-specific rainfall information is now available for Kaua'i from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, which provides design rainfall totals for storm return intervals ranging from 1 year through 1000 years and storm durations ranging from 5 minutes through 60 days. Atlas 14 data for the weather station KEKAHA 944 (51-2161) was selected which is adjacent to the site. Storm data from Atlas 14 for the 1-yr through 100-yr return intervals (24-hour duration) were entered into the WinTR-55 model and the model developed a storm intensity for the duration of the time of concentration for each subwatershed using the SCS Type I rainfall distribution. Since the subwatershed areas in the vertical expansion area are small and connected to each other by relatively short, steep downdrains, times of concentration and travel times were all near or under the 5-minute duration peak intensity inherent in the TR-55 methodology. In two of the watersheds (C and F), time of concentrations varied enough between subwatersheds that the peak flows from the subwatersheds were not coincident and minor attenuation from subwatershed lag is predicted (therefore the peak flow from the watershed outlet is slightly less than the sum of the peak flows from each subwatershed. However, since travel times were all less than 5 minutes, no attenuation of peak flows due to routing lag was assumed to develop conservative estimates of peak flows in each of the hydraulic structures (diversion berms, benches, and downchute flumes) in the vertical expansion area.

Atlas 14 data and WinTR-55 model results are provided in Appendix B. The modeled peak flow rates for each of the subwatersheds within the vertical expansion area are summarized in Table 4-1 below:

Table 4-1. Subwatershed Hydrology Summary.

Subwatershed	25-yr peak flowrate (Q_{25}) (cfs)	100-yr peak flowrate (Q_{100})(cfs)
A1-1	1.52	2.07
A1-2	6.66	9.04
A1-3	3.79	5.05
A1-4	1.54	2.10
A1 Outlet	**13.50**	**18.34**
B1-1	2.62	3.56
B1-2	0.42	0.58
B1-3	2.22	3.01
B1-4	0.82	1.12
B1 Outlet	**6.08**	**8.27**
C2-1	3.32	4.51
C2-2	14.58	19.81
C2-3	4.07	5.53
C2-4	4.03	5.47
C2 Outlet	**25.35**	**34.44**
F2-1	1.25	1.69
F2-2	3.35	4.55
F2-3	8.23	11.18
F2-4	2.53	3.44
F2 Outlet	**14.34**	**19.47**

4.2 STORMWATER HYDRAULICS

For permit-level design, it was assumed that a single diversion berm and bench channel design would be utilized throughout the vertical expansion area sized to the largest peak flow that would be experienced by any of the diversion berms or bench channels under the design storm. For diversion berms, with a longitudinal slope of 3%, the largest modelled flow was that from subwatershed C2-2, with a 100-year peak flow of 19.81 cubic feet per second (cfs). For bench channels with a longitudinal slope of 1%, the largest modeled flow was from subwatershed F2-3, with a 100-year peak flow of 11.18 cfs.

Because of the variability of flows and contributing areas for each individual downchute flume, they were sized individually based on the 100-year flow anticipated to contribute to each flume section.

Flows were analyzed based on a Manning's equation methodology and assuming a minimum of 0.5 feet of freeboard for channels and 0.9 feet of freeboard for diversion berms (since flows overtopping a diversion berm would be directed away from the designed flow path due to the downward slope of the landfill beyond the berm). Freeboard of 1 foot or more for downchute flumes is recommended due to the high flow velocities and resulting strongly supercritical flows predicted.

The resulting design for diversion berms is a 2-foot high, 2:1 sideslope berm as depicted on Permit Design Drawing Sheet C-506, Detail 4, Type C.

The resulting design for bench channels is a 2-foot deep, 2-foot bottom width channel with 2:1 sideslopes as depicted on Permit Design Drawing Sheet C-506, Detail 4, Type A.

The resulting design sizes for the downchute flumes are shown below in Table 4-2:

Table 4-2. Downchute/Flume Dimensions Summary.

Downchute/Flume ID	Bottom Width (B)(ft)	Depth (D)(ft)	Top Width (W)(ft)
A0	1	1.5	7
A1	1	2.0	9
B1	1	1.5	7
C0	1	1.5	7
C1	1	1.5	7
C2	2	2.0	10
F1	1	1.5	7
F2	2	2.0	10

A culvert will also be required to convey the flows from downchute/flume C1 into downchute/flume C2, along with the flows from the road ditch above the watershed C flume alignment (which drains subwatershed C2-2. This could be accomplished with a single 18-inch corrugated HDPE culvert installed at a 10% longitudinal slope. Alternative configurations of pipe diameter, longitudinal slope, pipe material, and numbers of pipes could be utilized based on the final construction-level design for this culvert.

Hydraulic calculations for these structures are provided in Appendix B.

The proposed design configuration shown on the Permit Design Drawings meets these design criteria and a detailed design of the stormwater management system will be completed during construction-level design of the final cover of the KLF.

5.0 LANDFILL GAS MIGRATION AND MONITORING

The proposed vertical expansion will have two major effects to the landfill gas (LFG) at the KLF. Due to the additional waste tonnage to be accepted as a result of the vertical expansion in Cell 2, the total LFG generation rate and subsequently the LFG collected in the gas collection and control system (GCCS) will increase per the Landfill Gas Emissions Model (LandGEM), discussed in Section 5.1 below. Additionally, the existing GCCS infrastructure existing at the site within the vertical expansion footprint will be impacted by the additional fill.

5.1 LANDFILL GAS FLOW EFFECTS

To examine the potential LFG flow increase due to the vertical expansion, a model was created using the USEPA LandGEM Model Version 3.03 for LFG generation rates. The model, located in Appendix C, predicts a total peak site LFG flow of 599 standard cubic feet per minute (scfm) in year 2028 as a result of the additional waste tonnage accepted for the proposed vertical expansion. Given a current LFG flow of 423 scfm, the site flow is not anticipated to increase significantly as a result of the proposed expansion. Tetra Tech evaluated the major GCCS header piping and flare station as it relates to the increase in site flow and identified that the major GCCS header piping and flare station is adequately sized to accommodate the anticipated increase in LFG flow and major losses associated with undersized piping are not anticipated.

5.2 GAS COLLECTION AND CONTROL SYSTEM IMPACTS

The vertical expansion will result in filling of portions of the existing GCCS. The footprint of the vertical expansion will in existing vertical LFG extraction wells and lateral piping to be buried. To address the impacted existing GCCS infrastructure, Tetra Tech has prepared Permit Design Plans detailing two phases of improvements recommended to maintain gas collection as the vertical expansion is constructed. These plans are considered permit-level; individual recommended components of the GCCS improvements may be adjusted based on the on-going performance of the existing system and the results of future compliance monitoring.

The first phase of the GCCS improvements pertains to the initial vertical expansion and details the raising or remoting of existing vertical LFG extraction wells in areas where a relatively minimal amount of fill is anticipated, referenced in Sheet C-112 (GCCS Construction Site Plan – Phase I) of the Permit Design Drawings. Where more significant amounts of fill are anticipated, the existing vertical LFG extraction wells will have remote wellheads and related lateral piping installed along the side slopes of the cell so that the wells can continue to operate and be maintained outside of the limits of the vertical expansion. The installation of a number of new vertical LFG extraction wells in areas lacking adequate LFG collection coverage are also included in the first phase of GCCS improvements. The anticipated fill placed from the first phase of GCCS improvements will be placed prior to the commencement of the second and final phase of GCCS improvements that will address the vertical expansion filling to reach the final fill limit.

The second phase of the proposed GCCS improvements addresses LFG collection impacts once the final fill limit has been reached and includes additional vertical LFG extraction wells and related lateral piping in new waste placed as part of the vertical expansion to provide adequate LFG collection coverage. This phase is anticipated to occur when nearing or at the final fill limit and is referenced in the Permit Design Drawings on Sheet C-113 (GCCS Final Fill Plan). The existing perimeter header will largely be maintained as it currently exists in a shallow trench and will be utilized as a tie in point for the additional LFG extraction wells. It should be noted that the section of header piping that is located around the southeast perimeter of Cell 2 will be replaced per a design prepared by Geosyntec Consultants, the construction of which is currently under contracted and scheduled to be completed by February 4, 2024. The existing header is anticipated to be cut and capped below grade in place.

6.0 LEACHATE MANAGEMENT

6.1 EXISTING LCRS PIPE STRENGTH EVALUATION

Although no changes are proposed to the existing leachate collection system as part of the proposed vertical expansion of Phase II, additional load will be added to the LCRS piping in the center of the Phase II area due to the extended waste column thickness within the vertical expansion area. Therefore, Tetra Tech evaluated the effect of the increased waste thickness on the existing leachate collection pipes under the peak thickness of the vertical expansion.

Per AECOM (2017), the existing leachate piping within Phase II is 8-inch HDPE pipe with a Standard Dimension Ratio (SDR) of 9.3. Due to the stress caused by the weight of refuse placed over it, the pipe must be sized with sufficient wall thickness to withstand wall crushing, wall buckling, and ring deflection.

For the analysis an eight-inch diameter, HDPE pipe with SDR of 9.3 was used. This pipe has a compressive yield strength of 3,000 pounds per square inch (psi) and has an elastic modulus of 110,000 pounds per square inch (psi). A coarse-grained soil with little or no fines and a modulus of soil reaction, E', of 3000 psi was utilized to analyze pipe wall buckling and pipe ring deflection. Information on the configuration of perforations in the LCRS piping for the original Phase II area (i.e., the area directly under the vertical expansion area) was not available; however, it was assumed that the pipe is perforated with 1/2-inch diameter perforations with 4 perforations per row per foot of length of the pipe to match the configuration that was designed by AECOM for the Phase II, Cell 2 area.

The design stress for 3.0 feet of cover soil, 156.5 feet of waste, and 2 feet of protective cover soil over the LCRS (the column under the peak thickness of the proposed vertical expansion was estimated to be 74.6 psi (See Appendix D, LCRS Structural Integrity Calculations). The following factors of safety for pipe structural stability were greater than the allowable factors of safety and ring deflections and long-term circumferential strains were less that the maximum allowable as presented in Appendix D:

- Pipe wall crushing, FS = 8.08 initial, 3.77 long-term;
- Pipe wall buckling, FS = 9.88 initial, 4.42 long-term;
- Maximum pipe ring deflection, (%) = 4.31 initial, 6.44 long-term;
- Long-term Circumferential Strain (%) = 0.98

In addition, an update was performed to the foundation settlement analysis included in AECOM (2013) to assess the effects on leachate pipe slope due to te additional waste placemet from the vertical expansion in the center of the Phase II landfill. The assumptions and input parameters for the analysis from AECOM (2013) were maintained, but the waste thickness was increased at the points on the two cross-sections analyzed that would be affected by the proposed vertical expansion. This resulted in a steepening of the leachate pipe slopes upgradient of the ridgeline of the vertical expansion and a flattening of the leachate pipe slopes downgradient of the ridgeline of the vertical expansion, but he pipe slopes are predicted to remain within the same range of slopes as that approved from the AECOM (2013) analysis, including maintaining positive slope toward the leachate sumps.

A copy of the original AECOM (2013) analysis table (Attachment 3 of Appendix B in the AECOM (2013) Engineering Report) and an updated analysis of Points H and F on Sections LCM-7 and LCM-12, respectively, are included in Appendix D.

6.2 EFFECTS ON LEACHATE GENERATION FROM INCREASED WASTE COLUMN THICKNESS

The proposed vertical expansion of Phase II will increase the thickness of the waste column under the peak elevation of Phase II, compared with the existing permitted waste thickness. Tetra Tech evaluated the potential effects of this thicker waste column on leachate generation at the KLF.

6.2.1 Methodology

AECOM previously performed HELP version 3.07 modeling, which was presented in AECOM (2017), and though their model was not available, their results and assumptions were available. These results and assumptions were utilized in the development of HELP version 4.0.1 model. All assumptions from AECOM (2017) were utilized with the exception of precipitation, temperature, and solar radiation. Precipitation, temperature, and solar radiation data sets was developed using the NSRDB database and imported into HELP 4.0, and a 30-year data set was developed and analysis was run (see Appendix E, "Kekaha Ph II Crnt Pmt – 30 yrs").

The change in elevation of the final grade was calculated using design drawings for the current permit from AECOM (2017) and the proposed vertical expansion discussed elsewhere in this report and depicted in the Permit Design Drawings. Since there is no change to the liner or final cover sections, the change in permitted height for the Phase II landfill will only change the maximum waste column thickness in the HELP model. The waste column thickness was increased from 1,248 to 1,852 inches. The original model based on AECOM 2017's MSW layer was then updated accordingly, and a second iteration of the model run (see Appendix E, "Kekaha Ph II Prop Vert Exp-30").

6.2.2 Results

Key results are summarized for both analyses in Table 6-1

Table 6-1. Existing Final Grade versus Proposed Final Grade

Summarized Result	Currently Permitted Final Grade	Proposed Expansion Final Grade	Percent Difference
Peak Drainage Collected from Layer 4 (CF)	472.4	474.1	<1% increase
Average Lateral Drainage Collected from Layer 4 (CF)	9,043.9	9,040.9	<1% decrease

6.2.3 Conclusions

The proposed changes to the Final Grade of Cell 1 are not expected to substantially affect the production and migration of leachate in the 30-year timeframe. Compared with the results of modeling of the currently permitted design, the vertical expansion will change both the peak day and average annual leachate generation by less than 1 percent and the direction of the change is inconsistent (the peak day rate is predicted to increase slightly, while the average annual rate is predicted to decrease slightly. Since the production and migration of leachate are not anticipated to change substantially, the current approved capacity of the Leachate Evaporation Pond was considered to be sufficient and was not reevaluated.

7.0 ENVIRONMENTAL PERMITS, CONSULTATIONS, AND APPROVALS

Implementation of the proposed action requires coordination and consultation with the federal, state, and county agencies for the following permits, clearances, or approvals:

Environmental Assessment (EA). Compliance with the Hawai‘i Environmental Policy Act (HEPA) (HRS Chapter 343) environmental review is required for any agency action that includes one or more triggers identified in HRS § 343-5(a) and HAR § 11-200.1, which are the implementing rules for compliance with HRS Chapter 343. The proposed action includes use of state land and county funds, which triggers HEPA environmental review per § 343-5(a)(1).

Solid Waste Management Permit (SWMP). Solid waste management activities at the KLF are currently authorized under the SWMP No. LF-0042-16, issued by the DOH Solid and Hazardous Waste Branch. The proposed action will require a modification to SWMP No. LF-0042-16.

Covered Source Permit (CSP) Modification. A CSP Permit (Title V Air Permit) is required to comply with the New Source Performance Standards found in 40 Code of Federal Regulations (CFR) Part 60, Subpart WWW. Covered sources include those sources that are major sources of air emissions and sources subject to a federal performance or control technology standard. The proposed action will require a modification to CSP Permit No. 0802-01-C.

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 Historic Preservation Division (SHPD), prior to commencement. SHPD determined that no historic properties would be affected by the proposed action because no historic properties exist within the Phase II area (October 11, 2013; Log No. 2013.5499; Doc. No. 1310SL09).

Clean Water Act (CWA) § 402 National Pollutant Discharge Elimination System (NPDES) Permit(s). Section 402 of the CWA establishes the NPDES program regulating the discharge of pollutants to waters of the United States. The administrative authority is DOH Clean Water Branch (CWB). In 2007 and 2013, the County submitted a request for Exclusion from NPDES General Permit Coverage for Storm Water Associated with Industrial Activity for KLF to the CWB to exempt the KLF from the NPDES requirements. The request for exclusion was verbally granted by HDOH July 1, 2021. No NOI-C NPDES permit is needed as there is no construction associated with the proposed action.

Special Use Permit (SUP), Use Permit, and Class IV Zoning Permit. The portion of the KLF within Tax Map Key (TMK) 1-2-002:001(por.), lies within the state agricultural district (i.e., phase II) and subject to the requirements of HRS Chapter 205. The entire KLF is also destinated as county agriculture district and subject to the Kaua‘i Comprehensive Zoning Ordinance. The Kaua‘i Planning Commission issued SUP SP-93-9, use permit U-93-56, and class IV zoning permit Z-IV-93-64 in 1993 to allow land classified in the county agricultural zone to be used for landfill purposes. As the KLF involved more than 15 acres of land, the SUP also required approval by the state Land Use Commission (LUC) (Petition Docket No. SP93-384). The County of Kaua`i Planning Department determined that the proposed action is permissible under the existing land use entitlements (K. Hull, County of Kaua`i Planning Department. personal communication – email to A. Fraley, June 15, 2023). No modification to the SUP, use permit, and class IV zoning permit is required.

Conservation District Use Application (CDUA) Permit. The portion of the KLF within Tax Map Key (TMK) 1-2-002:009 lies within the state conservation district (i.e., phase I and a portion of cell 2). A CDUP (KA-3625) was obtained for the phase II, cell 2 lateral expansion in 2012. The proposed action would take place entirely within TMK 1-2-002:001(por.), which is outside of the conservation district. Therefore, no CDUA permit is required.

Special Management Area (SMA) Permit. The portion of the KLF within TMK 1-2-002:009 lies within the SMA (i.e., phase I and a portion of cell 2). An SMA use permit (SMA(U)20-12-4) was obtained for the phase II, cell 2 lateral expansion in 2012. The proposed action would take place entirely within TMK 1-2-002:001(por.), which is outside the SMA. Therefore, no SMA permit is required.

Grading Permit. Per County of Kauai Ordinance 808, §22-7.6(b), a grading permit is not required for a sanitary landfill such as Kekaha Phase II, subject to applicable County, State, and Federal government regulations or laws.

Federal Aviation Administration (FAA) Notice of Proposed Construction or Alteration. The Pacific Missile Range Facility–Barking Sands Airport is approximately 3 miles northwest of the KLF. Due to the facility's proximity to the airport, the FAA and PMRF have evaluated the KLF multiple times in the last 10 to 15 years with no concerns noted. The FAA must be notified of any construction that may affect the National Airspace System under provisions of 14 CFR 77. A "Determination of No Hazard" is anticipated for the proposed action.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the evaluations conducted in this report, the proposed Phase II vertical expansion is feasible and will serve to alleviate the County's vital and time-sensitive needs. The existing Phase II capacity is currently being consumed and additional landfill airspace resulting from this vertical expansion is critical for the island of Kaua'i. Therefore, it is recommended that the proposed Phase II vertical expansion be submitted for approval and the additional capacity be utilized for waste disposal while the County pursues additional alternatives for continued management of waste generated on the island of Kaua'i.

9.0 BIBLIOGRAPHY

AECOM. (2013). *Draft Engineering Report, Kekaha Landfill Phase II Vertical Expansion.* Honolulu.

AECOM. (2017/2018). *Engineering Report, Kekaha Sanitary Landfill Phase II, Cell 2 Lateral Expansion, Kekaha, Kaua'i, Hawai'i.* Honolulu.

AECOM. (2020). *Cell 2 Base Liner Construction Drawings, Phase II Lateral Expansion, Kekaha Sanitary Landfill.* Honolulu.

Department of Health, State of Hawai'i (DOH). (1994, January). Hawaii Administrative Rules (HAR), Title 11, Chapter 58.1: Solid Waste Management Control.

EPA. (1993). *Solid Waste Disposal Facility Criteria: Technical Manual.* Solid Waste and Emergency Response.

Geosyntec Consultants. (2021). Unpublished Preliminary Slope Stability Analyses.

Zekkos, D. (2005). *Evaluation of Static and Dynamic Properties off Municipal Solid Waste.* Berkeley: PhD Thesis, Department of Civil and Environmental Engineering, University of California.

TABLES

DRAWINGS

C-001	Cover Sheet
C-100	Existing Conditions
C-101	Subbase Grading Plan
C-102	Final Cover Grading Plan
C-103	Surface Water Management Plan
C-110	Existing GCCS Conditions
C-111	Final Cover Plan with Existing GCCS As-Builts
C-112	GCCS Construction Site Plan – Phase I
C-113	GCCS Final Fill Plan – Phase II
C-301	Landfill Cross Sections
C-501	Liner and LCRS Details (From AECOM, 2017)
C-502	Phase II, Cell 2 Leachate Collection Details (From AECOM, 2020)
C-503	Leachate Transfer Pipe Detail (From AECOM, 2017)
C-504	Phase II, Cell 1 to Cell 2 Base Liner Tie-In Detail (From AECOM, 2017)
C-505	Stormwater Details
C-510	GCCS Details
C-511	GCCS Details
C-512	GCCS Details
C-513	GCCS Details
C-514	GCCS Details
C-515	GCCS Details
C-516	GCCS Details
C-517	GCCS Details
C-518	GCCS Details

ABBREVIATIONS

Ø/DIA	DIAMETER
DWG	DRAWING
ELEV	ELEVATION
E	EASTING
EG	EXISTING GRADE
FT	FEET
FG	FINAL GRADE
HDOH	HAWAII DEPARTMENT OF HEALTH
HDPE	HIGH DENSITY POLYETHYLENE
LCRS	LEACHATE COLLECTION AND REMOVAL SYSTEM
MIN	MINIMUM
N	NORTHING
(NIC)	NOT IN CONTRACT
NTS	NOT TO SCALE
%	PERCENT
PERF	PERFORATED
PVC	POLYVINYL CHLORIDE
R/W	RIGHT OF WAY
S	SLOPE
SDR	STANDARD DIMENSION RATIO
SG	SUBGRADE
TYP	TYPICAL
WSEL	WATER SURFACE ELEVATION
W/	WITH

DETAIL INDICATOR:

SHEET ON WHICH DETAIL IS REFERENCED:

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SHEET ON WHICH DETAIL APPEARS:

ANCHOR TRENCH
DETAIL 1 / C-501
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A / C-501 — SECTION LETTER; SHEET NUMBER ON WHICH SECTION APPEARS

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NOTES:

1. THE EXISTING UTILITIES SHOWN ON THESE DRAWINGS ARE APPROXIMATE, AND UTILITY LINES MAY EXIST WHERE NONE ARE SHOWN. SOME INFORMATION MAY HAVE BEEN DERIVED FROM INFORMATION PROVIDED TO THE ENGINEER BY OTHERS. SUCH INFORMATION MAY BE INCOMPLETE OR MAY BE OBSOLETE BY THE TIME CONSTRUCTION COMMENCES. CONTACT BLUE STAKE AT 811 AND ANY NON-PARTICIPATING UTILITY COMPANIES AT LEAST 48 HOURS BEFORE CONSTRUCTION. THE CONTRACTOR SHALL EXCAVATE AND VERIFY THE HORIZONTAL AND VERTICAL LOCATIONS OF PERTINENT UTILITIES, LANDFILL LINERS, AND OTHER EXISTING FEATURES IN OR NEAR THE AREA OF WORK, WHETHER INDICATED ON THESE DRAWINGS OR NOT. SHOULD A CONFLICT EXIST, THE CONTRACTOR SHALL NOTIFY THE ENGINEER AS SOON AS POSSIBLE. THE CONTRACTOR SHALL EXERCISE DUE CARE TO AVOID DISTURBING ANY UNDERGROUND UTILITIES. THE CONTRACTOR SHALL COORDINATE ANY POTENTIAL DISRUPTIONS IN UTILITY SERVICE WITH THE UTILITY COMPANIES AFFECTED AT LEAST 24 HOURS PRIOR TO THE DISRUPTION. THE CONTRACTOR SHALL REPAIR DAMAGE TO EXISTING UTILITIES AT THE CONTRACTOR'S EXPENSE.
2. CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND COORDINATE SITE CONDITIONS WITH THE DRAWINGS PRIOR TO CONSTRUCTION, ANY DISCREPANCIES OR OMISSIONS SHALL BE RESOLVED WITH THE PROJECT ENGINEER. DO NOT USE SCALED DIMENSIONS.

USA NORTH 811 Call 811 Before You Dig

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PERMIT DESIGN DRAWINGS FOR THE

PHASE II - VERTICAL EXPANSION

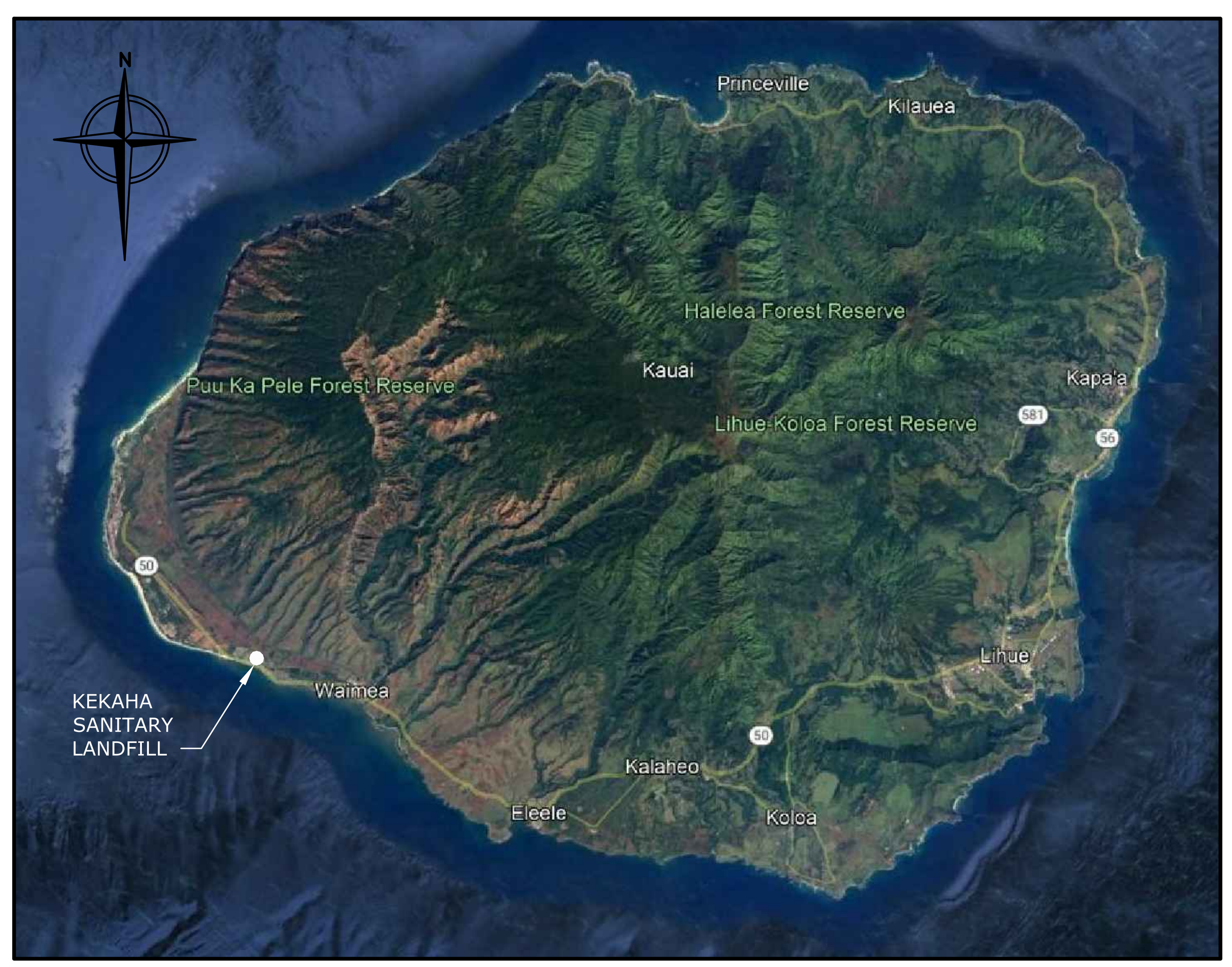
KEKAHA MUNICIPAL SOLID WASTE LANDFILL

KAUA'I COUNTY, HAWAII

PREPARED FOR

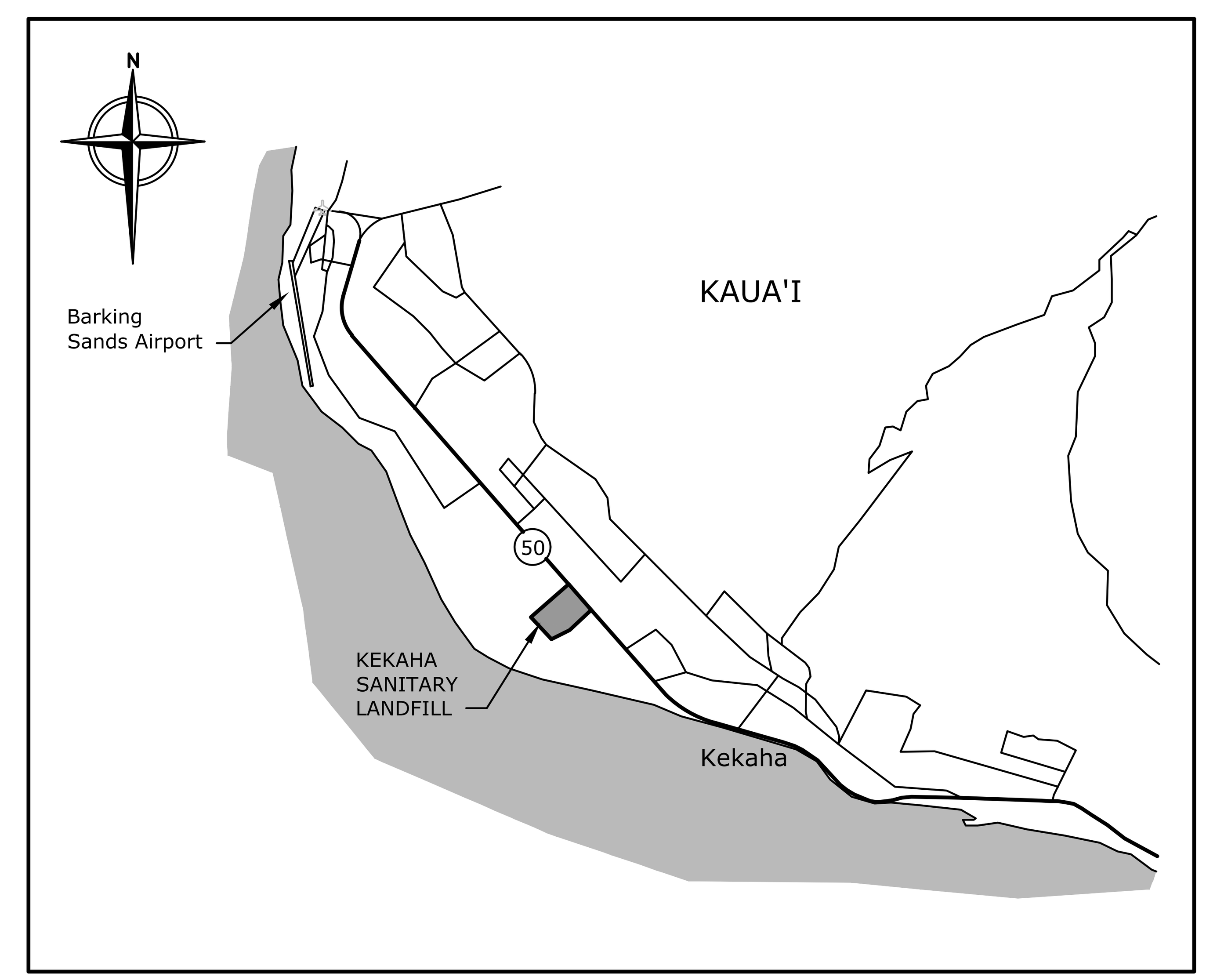
COUNTY OF KAUA'I DEPARTMENT OF PUBLIC WORKS SOLID WASTE DIVISION

NOVEMBER 2023



SOURCE: GOOGLE EARTH 2022

VICINITY MAP



SOURCE: MAP DATA 2022 GOOGLE

LOCATION MAP

SHEET INDEX

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

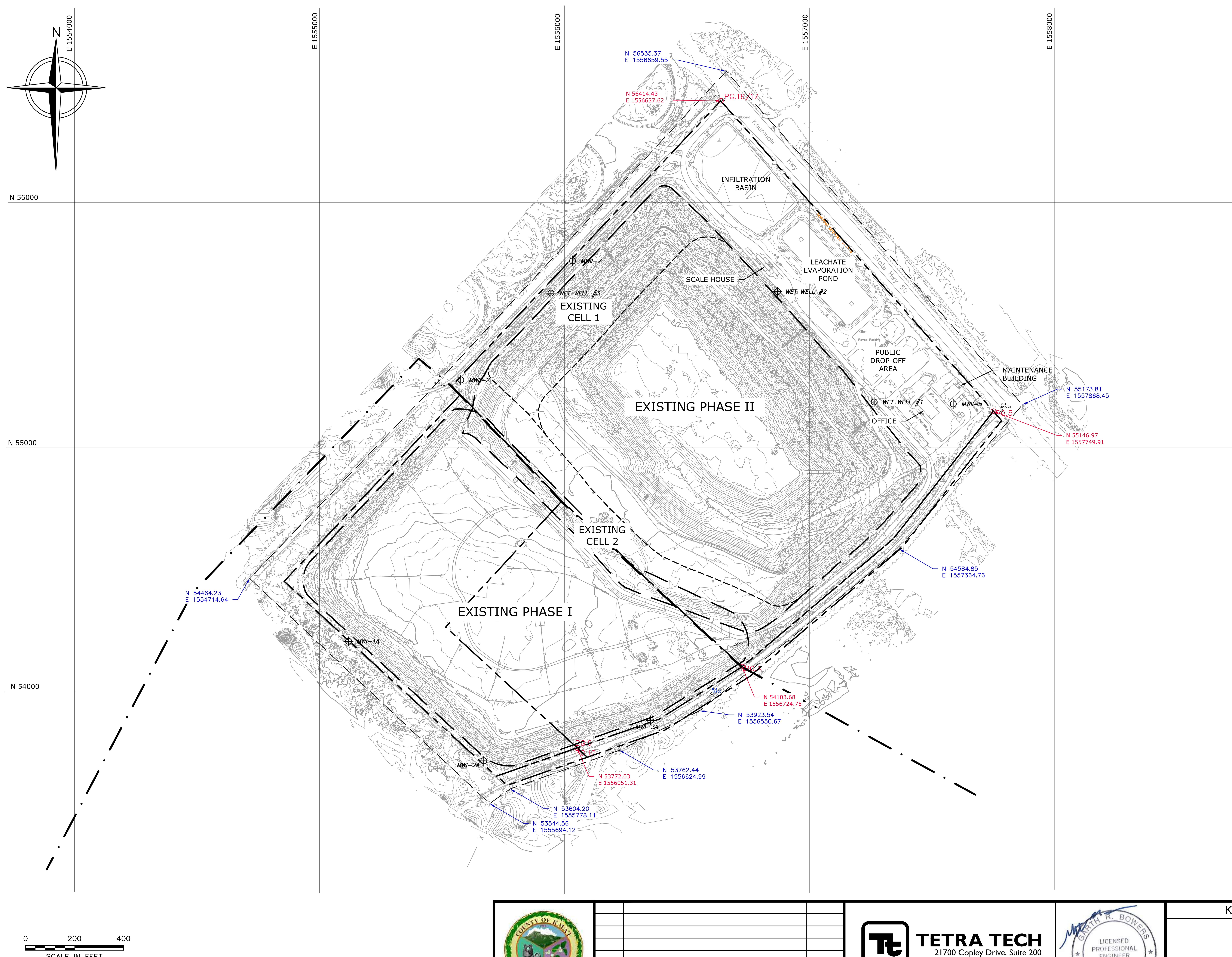
REV	REVISION DESCRIPTION	DATE

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

GARTH R. BOWERS LICENSED PROFESSIONAL ENGINEER No. 20139-C Exp 4/30/24 HAWAII U.S.A. 11/29/23

KEKAHA MUNICIPAL SOLID WASTE LANDFILL		
PHASE II - VERTICAL EXPANSION		
COVER SHEET		
DESIGNED BY : GRB	CHECKED BY : CHM	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB	FILE : 220048-C-001_COVER SHEET.dwg

SHEET **C-001**



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⊕ WET WELL #2	WET WELL
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NOTES:

1. TOPOGRAPHIC CONTOURS PREPARED BY WALKER ASSOCIATES. DATE OF PHOTOGRAPHY: OCTOBER 2022
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986) HAWAII STATE PLANE ZONE 4. VERTICAL DATUM BASED ON LOCAL TIDAL, WHICH IS SITE-SPECIFIC AND CORRELATES TO DESIGNATED USGS BRASS MONUMENT G1000 PLUS 1.21 FEET (AECOM, 2018).

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COUNTY OF KAUAI · STATE OF HAWAII

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

GARTH R. BOWERS · LICENSED PROFESSIONAL ENGINEER · No. 20139-C · Exp 4/30/24 · HAWAII U.S.A. · 11/28/23

KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

EXISTING CONDITIONS

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3. LINER SUBGRADE TOPO FROM GEOSYNTEC (2022), PREPARED FROM BEST AVAILABLE RECORD DATA FOR PHASE II (1993); PHASE II, CELL 1 (2013); AND PHASE II, CELL 2 (2019)

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21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

GARTH R. BOWERS
LICENSED PROFESSIONAL ENGINEER
No. 20139-C
HAWAII U.S.A.
Exp 4/3-/24
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KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

SUBBASE GRADING PLAN

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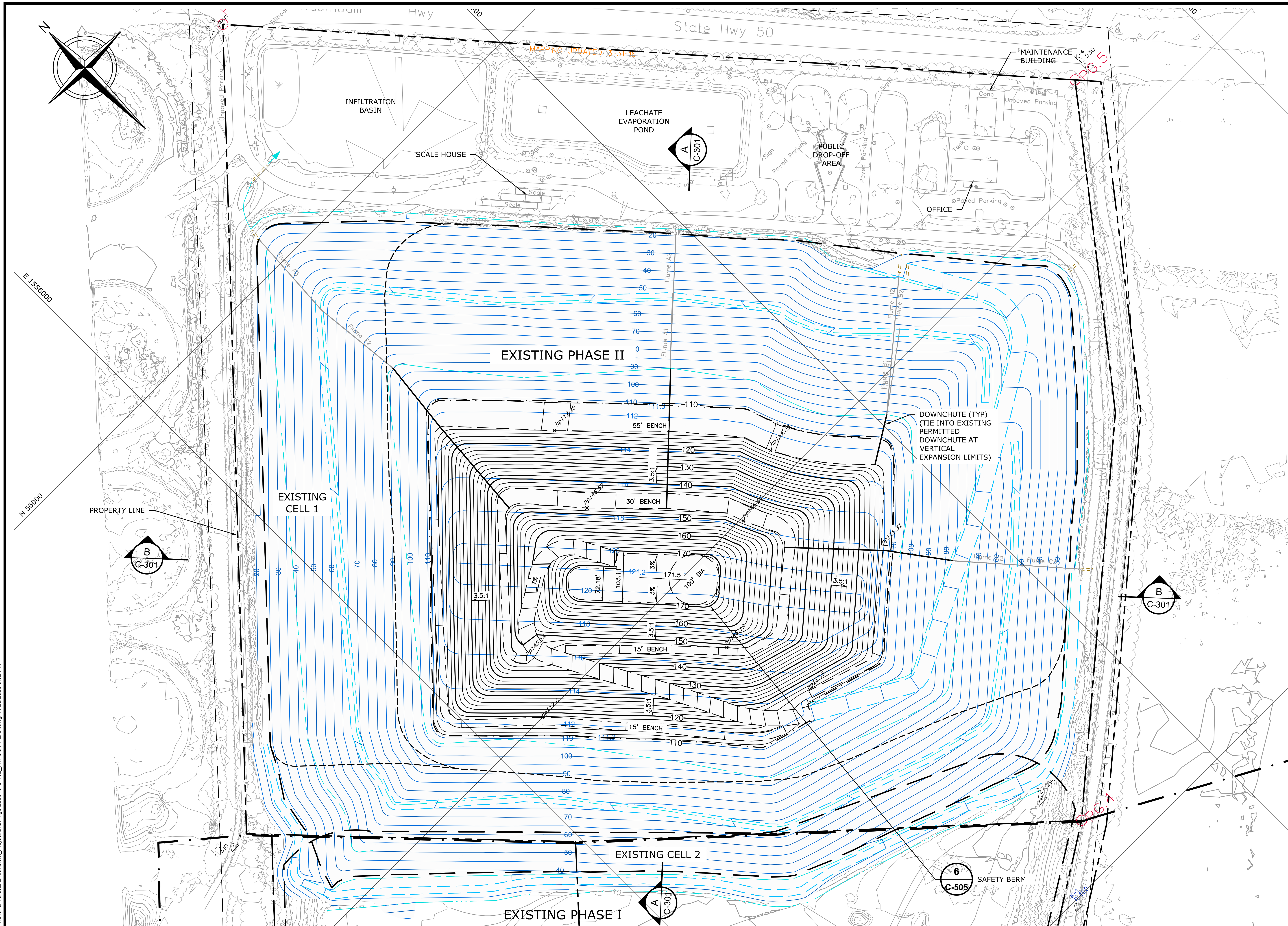

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- PROPOSED FINAL COVER CONTOUR (2FT INTERVAL)
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PH2 PERMIT FC vs VERT EXPAN:
NET = 407,700 CY (FILL)

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1. TOPOGRAPHIC CONTOURS PREPARED BY WALKER ASSOCIATES. DATE OF PHOTOGRAPHY: OCTOBER 2022.
2. HORIZONTAL DATUM IS BASED ON NAD83 (1986) HAWAII STATE PLANE ZONE 4. VERTICAL DATUM BASED ON LOCAL TIDAL, WHICH IS SITE-SPECIFIC AND CORRELATES TO DESIGNATED USGS BRASS MONUMENT G1000 PLUS 1.21 FEET (AECOM, 2018).

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TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

GARTH R. BOWERS
LICENSED PROFESSIONAL ENGINEER
No. 20139-C
Exp 4/3-/24
HAWAII U.S.A.
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KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

FINAL COVER GRADING PLAN

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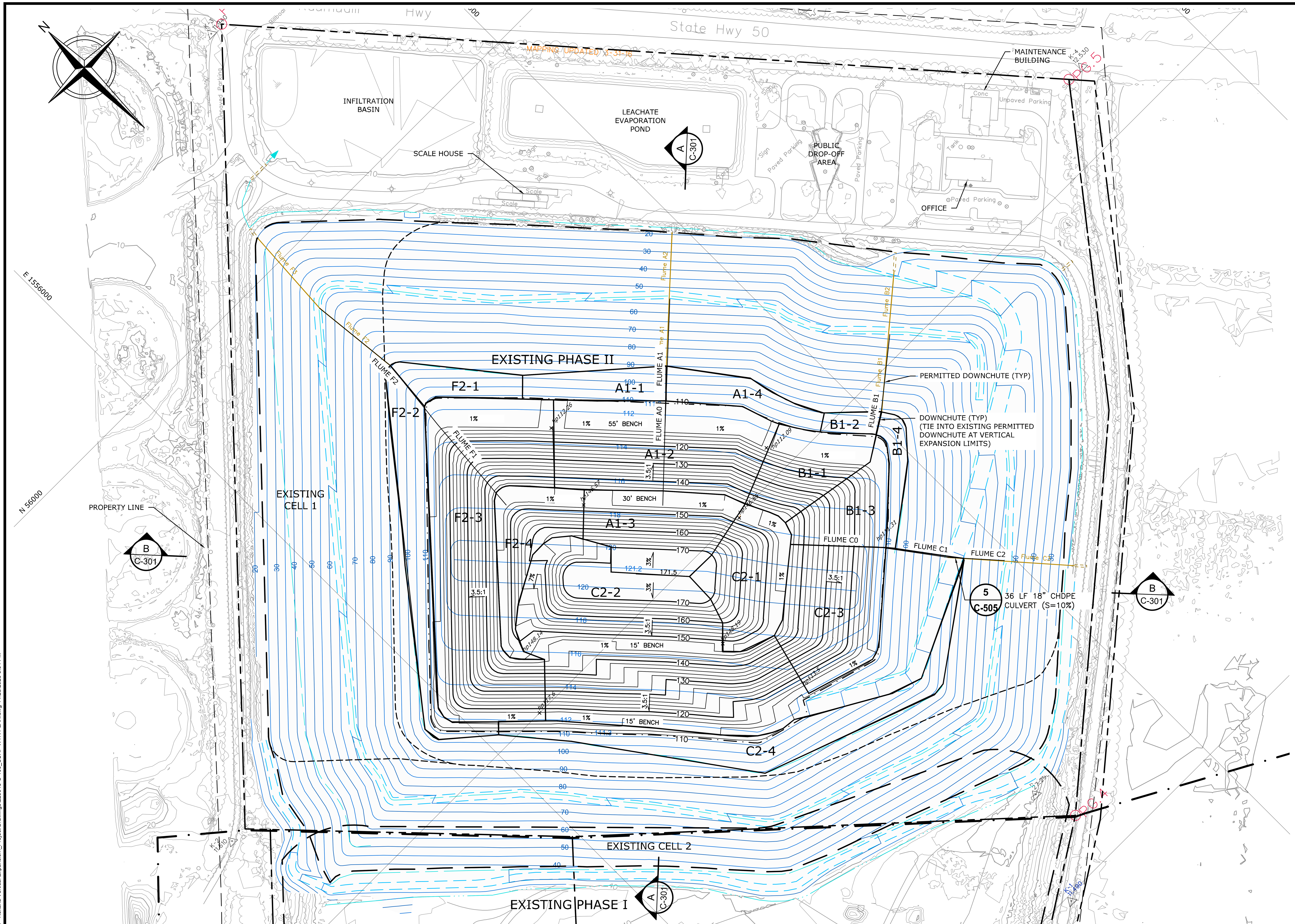

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- PROPOSED FINAL COVER CONTOUR (2FT INTERVAL)
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1. TOPOGRAPHIC CONTOURS PREPARED BY WALKER ASSOCIATES. DATE OF PHOTOGRAPHY: OCTOBER 2022.
2. PHASE II AREA TOPOGRAPHY UPDATED BY AIRFRAME LLC , MAY 5, 2021.
3. HORIZONTAL DATUM IS BASED ON NAD83 (1986) HAWAII STATE PLANE ZONE 4. VERTICAL DATUM BASED ON LOCAL TIDAL,WHICH IS SITE-SPECIFIC AND CORRELATES TO DESIGNATED USGS BRASS MONUMENT G1000 PLUS 1.21 FEET (AECOM, 2018).

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

0 100 200
SCALE IN FEET

X:\PROJECTS\KAUAI COUNTY\197-220048 - Kekaha Vertical Expansion_Project Drawings\220048-C-103_SURF WTR PLAN.dwg 11/28/2023 3:54 PM

REV	REVISION DESCRIPTION	DATE

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

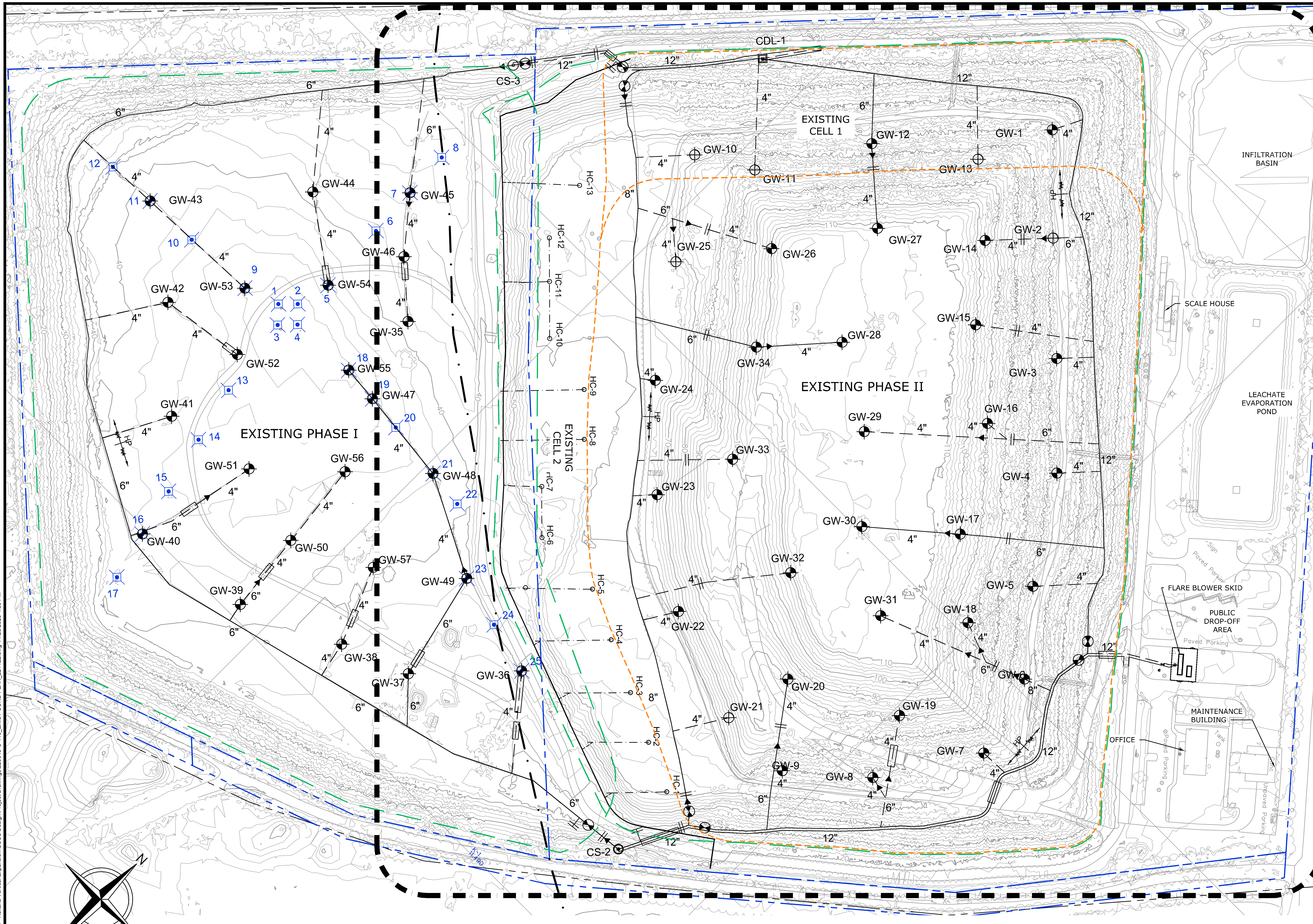
GARTH R. BOWERS LICENSED PROFESSIONAL ENGINEER No. 20139-C HAWAII U.S.A. Exp 4/30/24 11/28/23

KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

SURFACE WATER MANAGEMENT PLAN

SHEET C-103

DESIGNED BY : GRB	CHECKED BY : CHM	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB	FILE : 220048-C-103_SURF WTR PLAN.dwg



0 100 200
SCALE IN FEET

LEGEND:

- PROPERTY LINE (APPROXIMATE)
- EASEMENT PROPERTY LINE
- LANDFILL WASTE PHASE LIMIT
- EXISTING CELL LIMIT
- EXISTING INDEX CONTOUR (10FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (2FT INTERVAL)
- MWI-3A 4.48 — GROUNDWATER MONITORING WELL & WSEL
- WET WELL #2 — WET WELL
- HP — HIGH POINT IN HEADER
- LANDFILL HORIZONTAL COLLECTOR WITH CLEANOUT RISER
- LANDFILL GAS COLLECTION BELOW GRADE HEADER/LATERAL
- CONDENSATE LINE
- CONDENSATE SUMP
- BLIND FLANGE
- FLANGE
- GW-30 — GAS EXTRACTION WELL
- VALVE
- REDUCER
- 18 GW-55 — EXISTING LANDFILL GAS VENT WITH WELLHEAD
- DRIPLEG
- EXISTING ROAD CROSSING
- 24 — EXISTING GAS VENT

SEE SHEETS C-111 TO C-113 FOR ENLARGED AREA

NOTES:

1. TOPOGRAPHIC CONTOURS PROVIDED BY KAUAI COUNTY. DATE OF PHOTOGRAPHY: OCTOBER 22, 2022
2. PHASE II AREA TOPOGRAPHY UPDATED BY AIRFRAME LLC , MAY 5, 2021.
3. HORIZONTAL DATUM IS BASED ON NAD83 (1986). HAWAII ZONE 4. VERTICAL DATUM BASED ON LOCAL TIDAL.
4. THE AS-BUILT GCCS WAS PROVIDED BY KAUAI COUNTY DATED MAY 15, 2015.
5. THE LOCATIONS OF THE HORIZONTAL COLLECTORS ARE DRAWN IN APPROXIMATELY ACCORDING TO THE AS BUILT SURVEY COMPLETED BY ESAKI SURVEYING AND MAPPING, INC. ON SEPTEMBER 29, 2021.

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

REV	REVISION DESCRIPTION	DATE

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

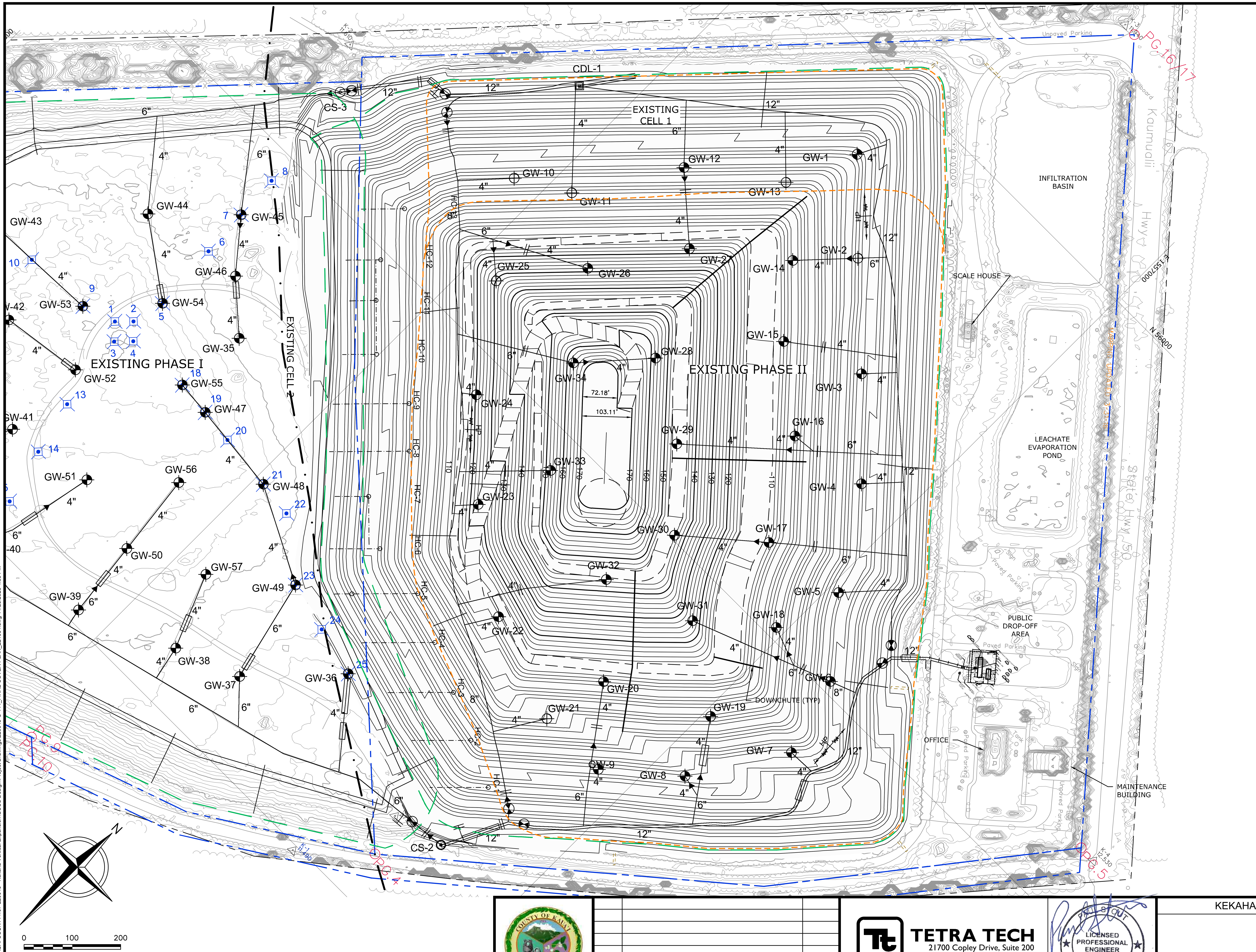
LICENSED PROFESSIONAL ENGINEER No. 12145 HAWAII U.S.A.

KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

EXISTING GCCS CONDITIONS

SHEET
C-110

DESIGNED BY : GRB/CME	CHECKED BY : AMN	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB/PJS	FILE : 220048-C-110_EXIST COND PLAN_221122.dwg



LEGEND:

- PROPERTY LINE
- EASEMENT PROPERTY LINE
- LANDFILL WASTE PHASE LIMIT
- EXISTING CELL LIMIT
- EXISTING INDEX CONTOUR (10FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (2FT INTERVAL)
- PERMITTED FINAL COVER CONTOUR (10FT INTERVAL)
- PERMITTED FINAL COVER CONTOUR (5FT INTERVAL)
- PROPOSED FINAL COVER CONTOUR (10FT INTERVAL)
- PROPOSED FINAL COVER CONTOUR (2FT INTERVAL)
- GROUNDWATER MONITORING WELL & WSEL
- WET WELL
- HIGH POINT IN HEADER
- LANDFILL GAS COLLECTION HEADER/LATERAL
- CONDENSATE LINE
- CONDENSATE SUMP
- BLIND FLANGE
- FLANGE
- GAS EXTRACTION WELL
- VALVE
- REDUCER
- EXISTING LANDFILL GAS VENT WITH WELLHEAD
- DRIPLEG
- EXISTING ROAD CROSSING
- EXISTING GAS VENT

NOTES:

1. TOPOGRAPHIC CONTOURS PREPARED BY WALKER ASSOCIATES. DATE OF PHOTOGRAPHY: FEBRUARY 24, 2019
2. PHASE II AREA TOPOGRAPHY UPDATED BY AIRFRAME LLC , MAY 5, 2021.
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4. THE AS-BUILT GCCS WAS PROVIDED BY KAUAI COUNTY DATED MAY 15, 2015.

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

REV	REVISION DESCRIPTION	DATE

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

LICENSED PROFESSIONAL ENGINEER No. 12145 HAWAII U.S.A.

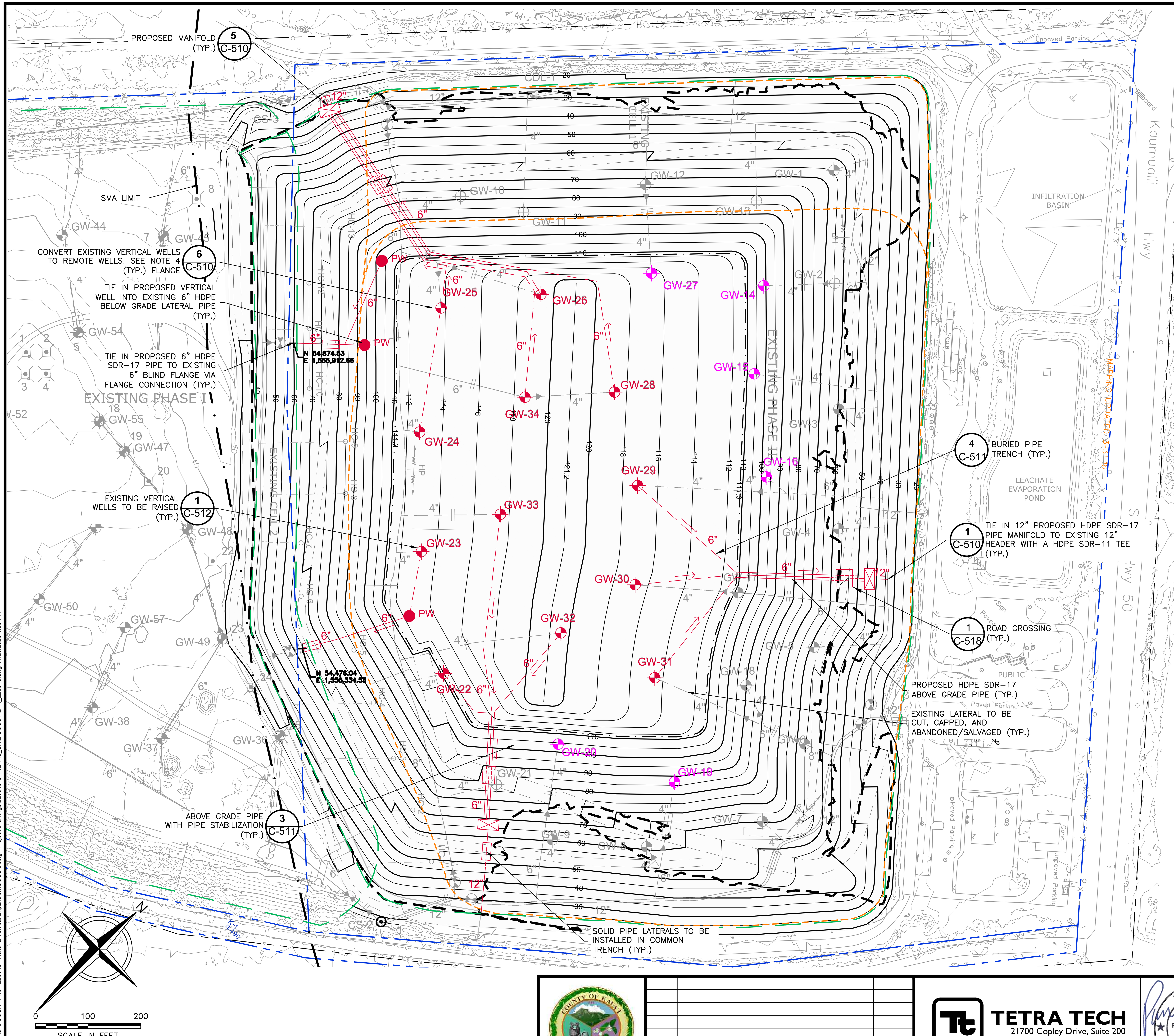
KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

FINAL COVER PLAN

SHEET C-111

DESIGNED BY : GRB/CME	CHECKED BY : AMN	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB/PJS	FILE : 220048-C-111_FINAL COVER PLAN_221031.dwg

X:\PROJECTS\KAUAI COUNTY\197-220048 - Kekaha Vertical Expansion\GCCS Design\Project Drawings\220048-C-111_FINAL COVER PLAN_221031.dwg 11/28/2023 4:33 PM



LEGEND:

- PROPERTY LINE
- EASEMENT PROPERTY LINE
- LANDFILL WASTE PHASE LIMIT
- EXISTING CELL LIMIT
- EXISTING INDEX CONTOUR (10FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (2FT INTERVAL)
- CURRENT PERMITTED FINAL COVER CONTOUR (10FT INTERVAL)
- CURRENT PERMITTED FINAL COVER CONTOUR (2FT INTERVAL)
- CURRENT LIMIT OF AREA BELOW FINAL COVER GRADE
- GROUNDWATER MONITORING WELL & WSEL
- WET WELL
- HIGH POINT IN HEADER
- LANDFILL HORIZONTAL COLLECTOR WITH CLEANOUT RISER
- LANDFILL GAS COLLECTION BELOW GRADE HEADER/LATERAL
- CONDENSATE LINE
- CONDENSATE SUMP
- BLIND FLANGE
- FLANGE
- GAS EXTRACTION WELL
- VALVE
- REDUCER
- EXISTING LANDFILL GAS VENT WITH WELLHEAD
- DRIPLEG
- HEADER CASING
- EXISTING GAS VENT
- PROPOSED ABOVE GRADE HDPE SDR-17 PIPE
- PROPOSED BELOW GRADE HDPE SDR-17 PIPE
- EXISTING WELL TO BE RAISED
- EXISTING WELL TO BE REMOTED
- PROPOSED VERTICAL EXTRACTION WELL
- PROPOSED MANIFOLD
- PROPOSED ROAD CROSSING
- SLOPE OF PIPE

EXISTING WELLS TO BE RAISED		
GW-14	GW-15	GW-16
GW-19	GW-20	GW-27

EXISTING WELLS TO BE REMOTED		
GW-22	GW-23	GW-24
GW-25	GW-26	GW-28
GW-29	GW-30	GW-31
GW-32	GW-33	

NOTES

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3. HORIZONTAL DATUM IS BASED ON NAD83 (1986). HAWAII ZONE 4. VERTICAL DATUM BASED ON LOCAL TIDAL, WHICH IS SITE-SPECIFIC AND CORRELATES TO DESIGNATED USGS BRASS MONUMENT G1000 PLUS 1.21 FEET (AECOM, 2018).
4. WELLHEADS TO BE LOCATED ON EDGE OF TOP DECK NEXT TO SIDE SLOPE. LOCATIONS MAY REQUIRE FIELD MODIFICATIONS BASED ON TOPOGRAPHY AT TIME OF CONSTRUCTION.
5. THE AS-BUILT GCCS WAS PROVIDED BY KAUAI COUNTY DATED MAY 15, 2015.
6. THE LOCATIONS OF THE HORIZONTAL COLLECTORS ARE DRAWN IN APPROXIMATELY ACCORDING TO THE AS BUILT SURVEY COMPLETED BY ESAKI SURVEYING AND MAPPING, INC. ON SEPTEMBER 29, 2021.

CONSTRUCTION NOTES:

1. CONTRACTOR TO SURVEY AND STAKE PIPING ALIGNMENTS WITH GRADES AND OBTAIN APPROVAL FROM THE ENGINEER AND OWNER PRIOR TO PROCEEDING.
2. THE CONTRACTOR SHALL LAY OUT THE PIPE TO CONFORM TO FIELD CONDITIONS. PROVIDE 36" MINIMUM COVER AND 5% MINIMUM SLOPE CROSSING BELOW PERIMETER AND MAIN HAUL ROADS. PROVIDE MINIMUM PIPE DRAINAGE SLOPES OF 3% WITHIN WASTE LIMIT AND 0.5% OUTSIDE OF WASTE LIMIT. CONTRACTOR RESPONSIBLE FOR CUT (12" MAX, UNLESS OTHERWISE NOTED PER PLAN) AND FILL BENEATH PIPE TO ENSURE PROPER DRAINAGE, AS APPROVED BY THE ENGINEER AND OWNER.
3. FEATURES, CONTOURS, AND ELEVATIONS OF THESE BASE MAPS ARE APPROXIMATE INDICATIONS OF CURRENT AND FUTURE CONDITIONS. CONTRACTOR IS RESPONSIBLE FOR INSPECTING WORK AREAS AT PRE-BID SITE WALK AS CURRENT CONDITIONS FOR BIDDING PURPOSES. CONTRACTOR SHALL VERIFY THE ACTUAL LOCATIONS OF THESE ELEMENTS PRIOR TO, AND DURING CONSTRUCTION, AND SHALL FINALIZE THE GAS SYSTEM LOCATIONS TO ACCOMMODATE FINAL FIELD CONDITIONS, AS APPROVED BY THE ENGINEER AND OWNER.
4. ALL CONNECTIONS TO EXISTING PIPING SHALL BE CONFIRMED BY THE CONTRACTOR PRIOR TO BIDDING. SOME CONNECTIONS MAY REQUIRE EXCAVATION.
5. CONTRACTOR SHALL BE RESPONSIBLE FOR MAKING ALL DISCONNECTIONS AND RECONNECTIONS FOR INSTALLATION OF NEW PIPING WHERE NECESSARY.
6. WORK SHALL NOT VARY FROM DESIGN WITHOUT APPROVAL OF THE ENGINEER. WORK THAT VARIES FROM DESIGN WITHOUT APPROVAL WILL BE SUBJECT TO REWORK TO MAINTAIN ADHERENCE TO THE APPROVED DESIGN. ANY REWORK AS A RESULT WILL NOT BE PAID FOR.
7. ALL PIPING GREATER THAN 6 INCHES IN DIAMETER SHALL BE PRESSURE TESTED FOR 1 HOUR AT 10 PSIG. GREATER THAN 10% DROP IN PRESSURE OVER 1 HOUR SHALL INDICATE A LEAK EXISTS AND SHALL BE REPAIRED AND RETESTED. PIPE SHALL BE TESTED IN SEGMENTS NO LONGER THAN 2,000 FEET UNLESS APPROVED BY THE ENGINEER.
8. CONTRACTOR TO REMOVE AND REUSE EXISTING WELLHEADS, PUMPS, PIPING AND FITTINGS WHERE APPLICABLE. CAP ALL ABANDONED PIPE. IF ABANDONED PIPE IS HDPE, USE FUSED ON HDPE CAP. IF ABANDONED PIPE IS PVC, USE PVC SCH 40 CAP SECURED WITH SET SCREWS AT 90° AND CEMENT.
9. ALL EXISTING PIPING THAT IS NOT IN USE, AS DIRECTED BY THE ENGINEER, SHALL BE RELOCATED BY THE CONTRACTOR TO THE ON-SITE STORAGE FACILITY.
10. CONTRACTOR TO USE FACTORY MOLDED/FABRICATED CONCENTRIC REDUCER FITTINGS AS NECESSARY.
11. CONTRACTOR TO PROTECT IN PLACE THE EXISTING ABOVE AND BELOW GRADE LATERALS DURING CONSTRUCTION. IF EXISTING PIPING NEEDS TO BE RELOCATED TEMPORARILY DURING CONSTRUCTION, THE CONTRACTOR WILL ENSURE CONSTANT SLOPE IS MAINTAINED ON THE PIPE AND THE LATERALS WILL BE RETURNED TO THEIR EXISTING CONDITION FOLLOWING CONSTRUCTION ACTIVITIES.
12. ELECTROFUSION COUPLERS SHALL NOT BE USED UNLESS APPROVED BY THE ENGINEER AND OWNER.

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

REV	REVISION DESCRIPTION	DATE

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

LICENSED PROFESSIONAL ENGINEER No. 12145 PAUL STOUT HAWAII U.S.A.

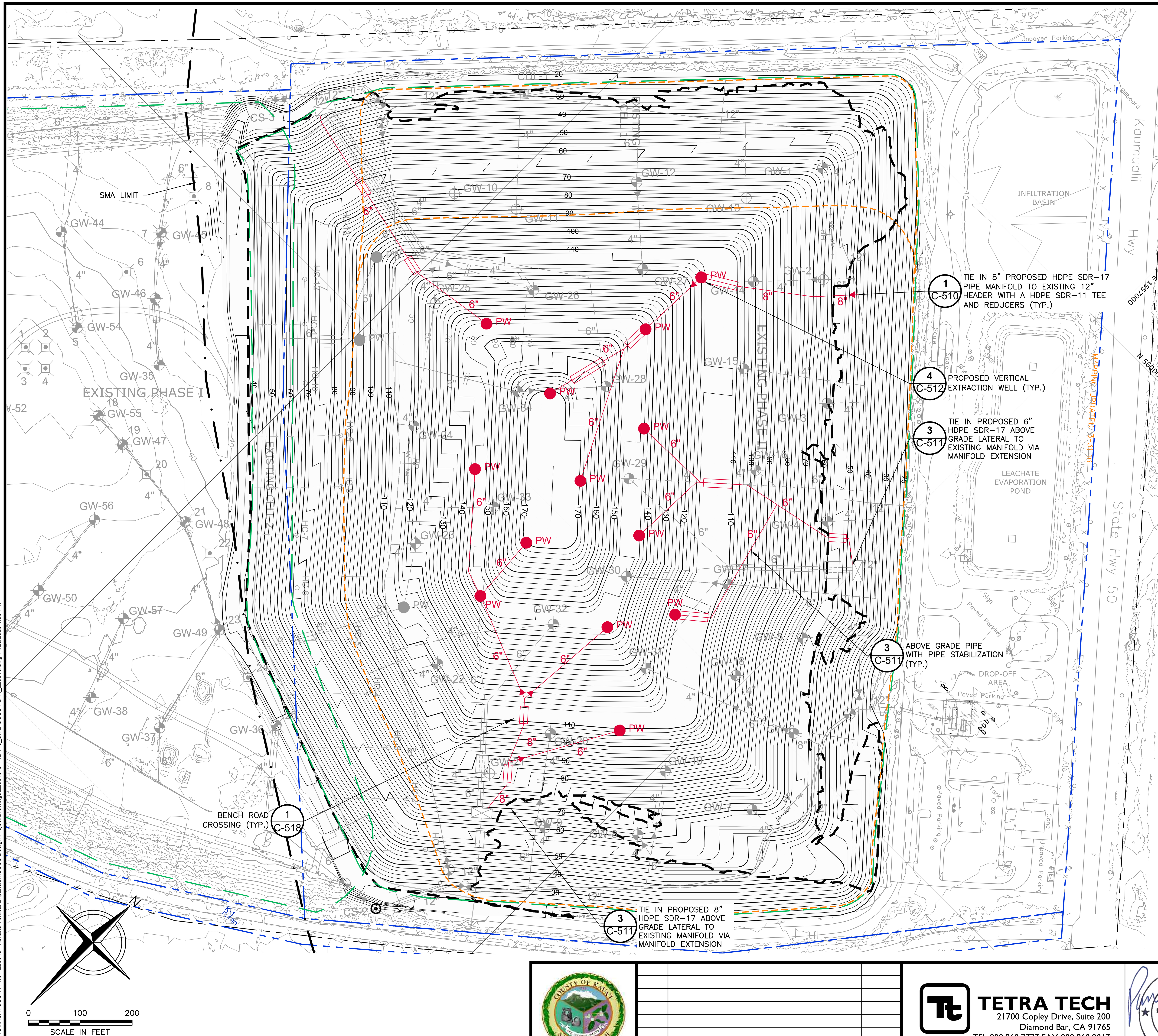
KEKAHA MUNICIPAL SOLID WASTE LANDFILL

PHASE II - VERTICAL EXPANSION

GCCS CONSTRUCTION SITE PLAN - PHASE I

SHEET C-112

DESIGNED BY : GRB/CME	CHECKED BY : AMN	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB/PJS	FILE : 220048-C-112-113_SITE GCCS PLAN_220315.dwg



LEGEND:

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- EASEMENT PROPERTY LINE
- LANDFILL WASTE PHASE LIMIT
- EXISTING CELL LIMIT
- EXISTING INDEX CONTOUR (10FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (2FT INTERVAL)
- PROPOSED FINAL COVER CONTOUR (10FT INTERVAL)
- PROPOSED FINAL COVER CONTOUR (2FT INTERVAL)
- CURRENT LIMIT OF AREA BELOW FINAL COVER GRADE
- GROUNDWATER MONITORING WELL & WSEL
- WET WELL
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- CONDENSATE SUMP
- BLIND FLANGE
- GAS EXTRACTION WELL
- VALVE
- REDUCER
- EXISTING LANDFILL GAS VENT WITH WELLHEAD
- DRIPLEG
- HEADER CASING
- EXISTING GAS VENT
- PROPOSED VERTICAL EXTRACTION WELL
- PROPOSED ABOVE GRADE HDPE SDR-17 PIPE
- PROPOSED MANIFOLD
- PROPOSED ROAD CROSSING
- PROPOSED REDUCER

NOTES:

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11. CONTRACTOR TO PROTECT IN PLACE THE EXISTING ABOVE AND BELOW GRADE LATERALS DURING CONSTRUCTION. IF EXISTING PIPING NEEDS TO BE RELOCATED TEMPORARILY DURING CONSTRUCTION, THE CONTRACTOR WILL ENSURE CONSTANT SLOPE IS MAINTAINED ON THE PIPE AND THE LATERALS WILL BE RETURNED TO THEIR EXISTING CONDITION FOLLOWING CONSTRUCTION ACTIVITIES.
12. ELECTROFUSION COUPLERS SHALL NOT BE USED UNLESS APPROVED BY THE ENGINEER AND OWNER.
13. CONTRACTOR SHALL PREPARE BID ASSUMING THAT THE WELLS WILL BE INSTALLED PRIOR TO LATERAL PIPING. LATERAL PIPING ALIGNMENTS AND ROUTES SUBJECT TO CHANGE PENDING INSTALLED WELL GAS QUALITY AND ASSOCIATED SCOPE ADJUSTMENTS WILL BE ASSESSED VIA THE PROVIDED UNIT PRICE VALUES IN THE BID.

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

REV	REVISION DESCRIPTION	DATE

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

PAUL STOUT LICENSED PROFESSIONAL ENGINEER No. 12145 HAWAII U.S.A.

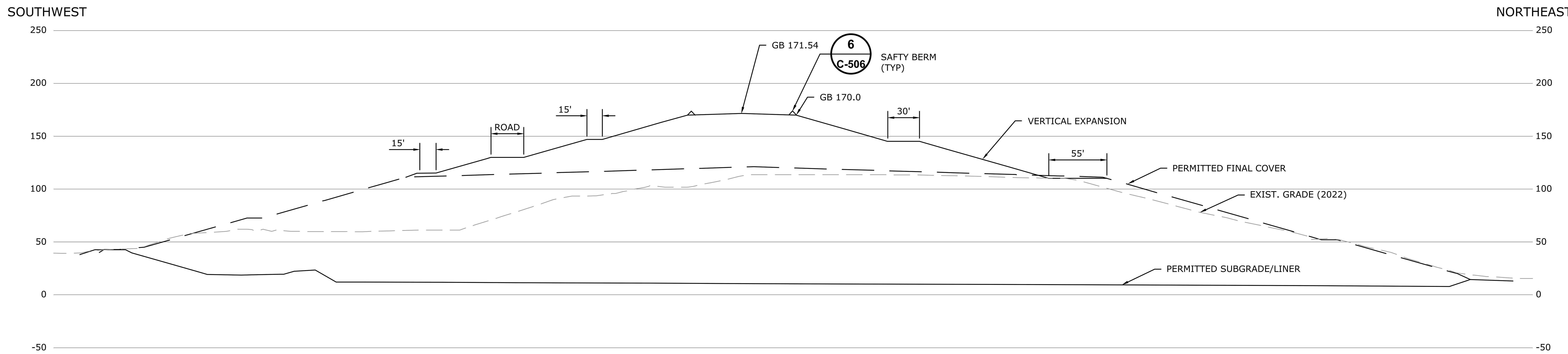
KEKAHA MUNICIPAL SOLID WASTE LANDFILL

PHASE II - VERTICAL EXPANSION

GCCS FINAL FILL PLAN - PHASE II

SHEET C-113

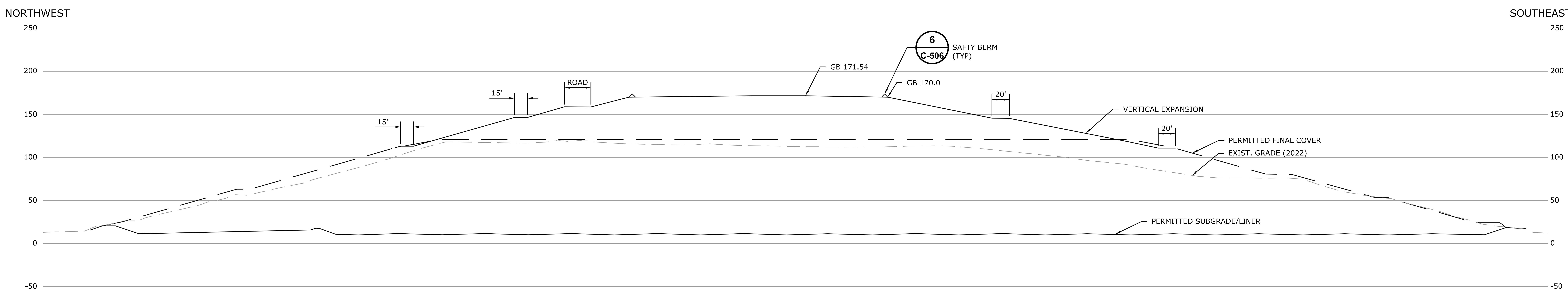
DESIGNED BY : GRB/CME	CHECKED BY : AMN	DATE : NOV 2023	
DRAWN BY : MDC/GVP	APPROVED BY : GRB/PJS	FILE : 220048-C-112-113_SITE GCCS PLAN_220315.dwg	



SOUTHWEST-NORTHEAST

SECTION A / C-301

SCALE: 1"=60'



NORTHWEST-SOUTHEAST

SECTION B / C-301

SCALE: 1"=60'

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

REV	REVISION DESCRIPTION	DATE

COUNTY OF KAUAI – STATE OF HAWAII

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

GARTH R. BOWERS
LICENSED PROFESSIONAL ENGINEER
No. 20139-C
HAWAII U.S.A.
Exp 4/3-/24
11/28/23

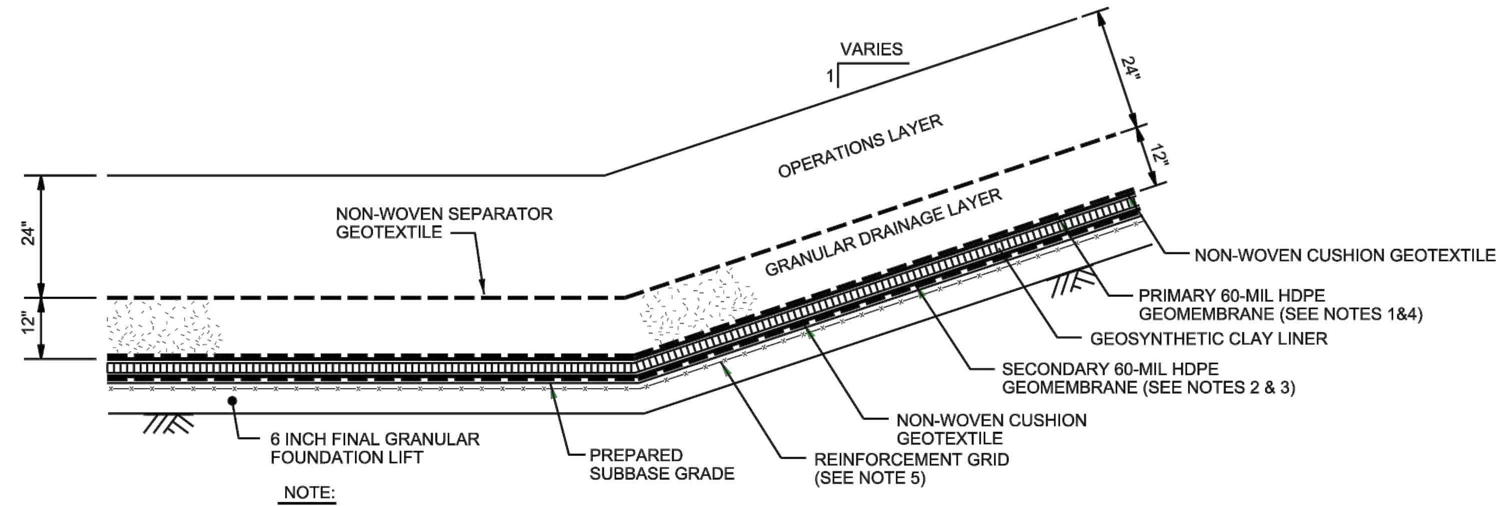
KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

LANDFILL CROSS-SECTIONS

DESIGNED BY :	GRB	CHECKED BY : CHM	DATE : NOV 2023
DRAWN BY :	MDC/GVP	APPROVED BY : GRB	FILE : 220048-C-301_LF SECTIONS.dwg

SHEET
C-301

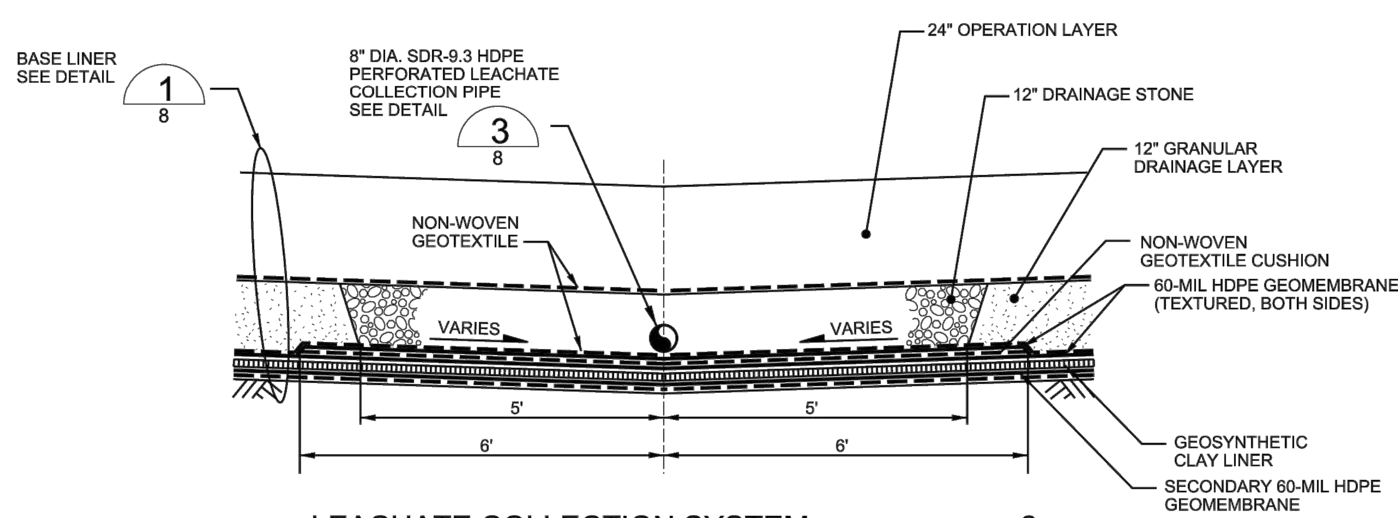
X:\PROJECTS\KAUAI COUNTY\197-220048 - Kekaha Vertical Expansion_Project Drawings\220048-C-301_LF SECTIONS.dwg 11/28/2023 3:57 PM



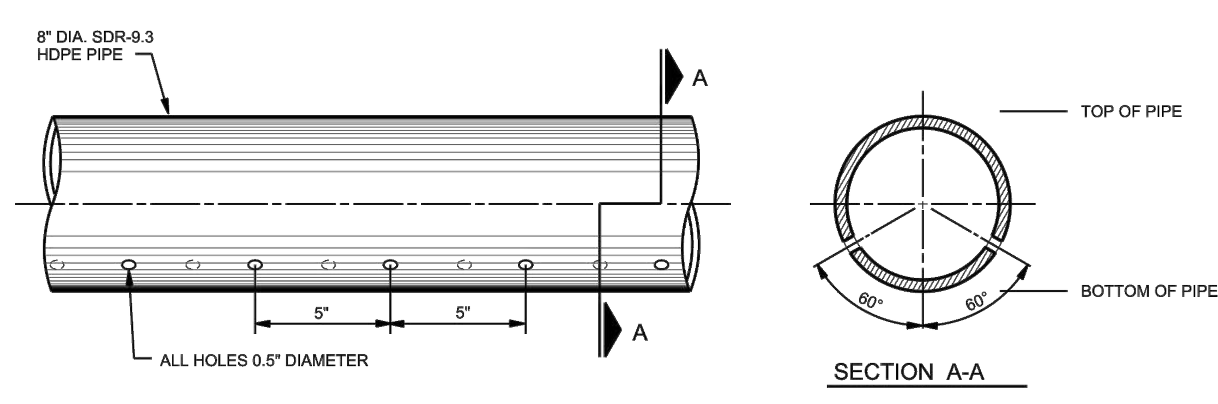
NOTE:

1. PRIMARY 60-MIL HDPE GEOMEMBRANE OVER PHASE I SIDESLOPE IS SINGLE-SIDED TEXTURED. SMOOTH SIDE OF GEOMEMBRANE IS UP AND IN DIRECT CONTACT WITH NON-WOVEN CUSHION GEOTEXTILE FOR THE GRANULAR DRAINAGE LAYER. EXTEND PRIMARY SINGLE-SIDED TEXTURED GEOMEMBRANE 5 FEET PAST TOE OF SLOPE WHERE EXTRUSION WELDED TO PRIMARY DOUBLE-SIDED TEXTURED GEOMEMBRANE.
2. SECONDARY 60-MIL HDPE GEOMEMBRANE OVER PHASE 1 SIDESLOPE IS SINGLE-SIDED TEXTURED. SMOOTH SIDE OF GEOMEMBRANE IS DOWN AND IN CONTACT WITH NON-WOVEN CUSHION GEOTEXTILE. EXTEND SECONDARY SINGLE-SIDED TEXTURED GEOMEMBRANE 5 FEET PAST TOE OF SLOPE WHERE EXTRUSION WELDED TO SECONDARY DOUBLE-SIDED TEXTURED GEOMEMBRANE.
3. SECONDARY 60-MIL HDPE GEOMEMBRANE ON PHASE II SIDESLOPE AND CELL 2 BASE IS TEXTURED ON BOTH SIDES.
4. PRIMARY 60-MIL HDPE GEOMEMBRANE ON PHASE II SIDESLOPE AND CELL 2 BASE IS TEXTURED ON BOTH SIDES.
5. REINFORCEMENT GRID TO BE INSTALLED ON PHASE I SIDESLOPES IN SUBCELLS A AND D. REFER TO APPENDIX F OF ENGINEERING REPORT FOR MATERIAL PROPERTIES. REFER TO DRAWING NO. 2 FOR LOCATIONS.

BASE LINER DETAIL 1
NTS



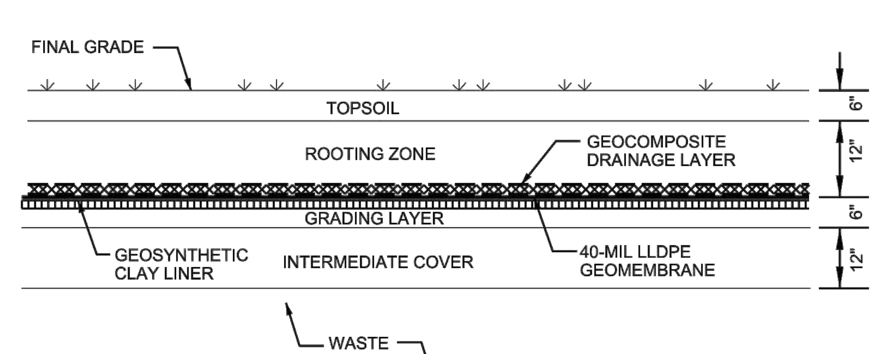
LEACHATE COLLECTION SYSTEM 2
NTS



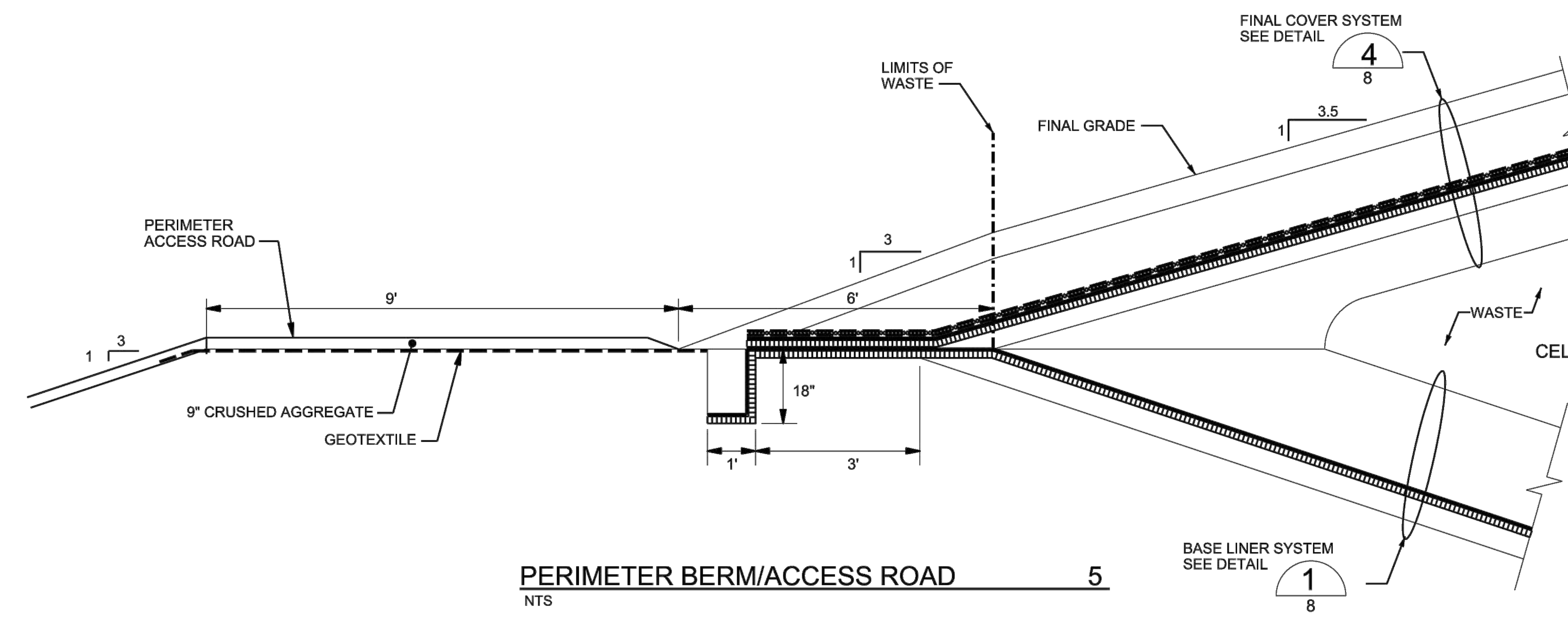
NOTE:

1. ALL HOLES TO BE ALTERNATELY STAGGERED.

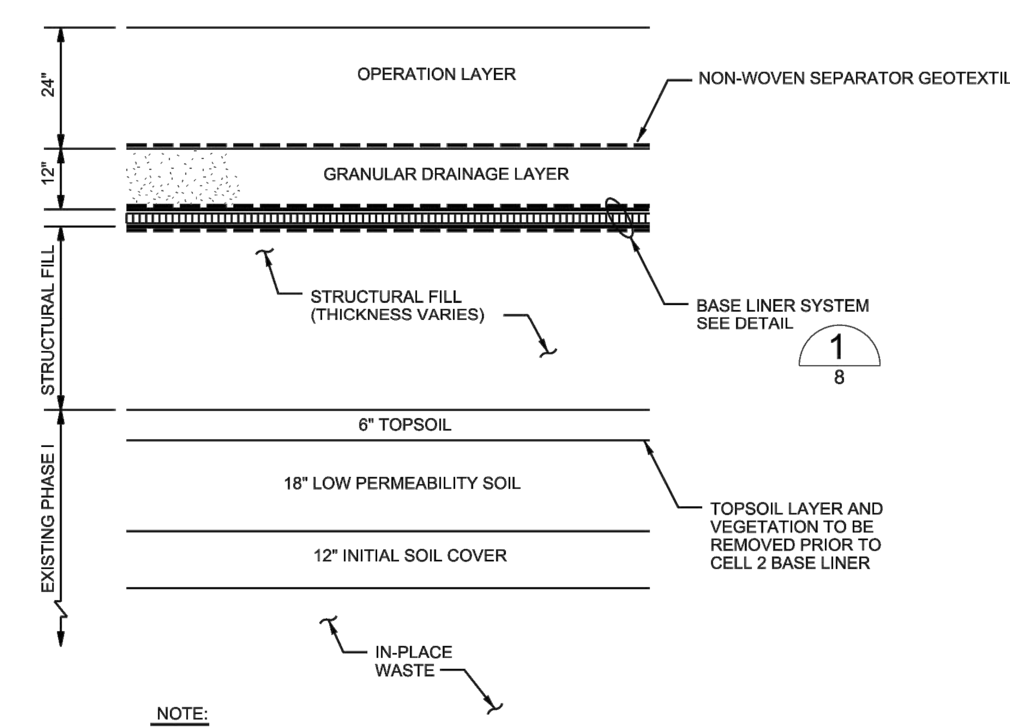
PERFORATED LEACHATE COLLECTION PIPE 3
NTS



FINAL COVER SYSTEM 4
NTS



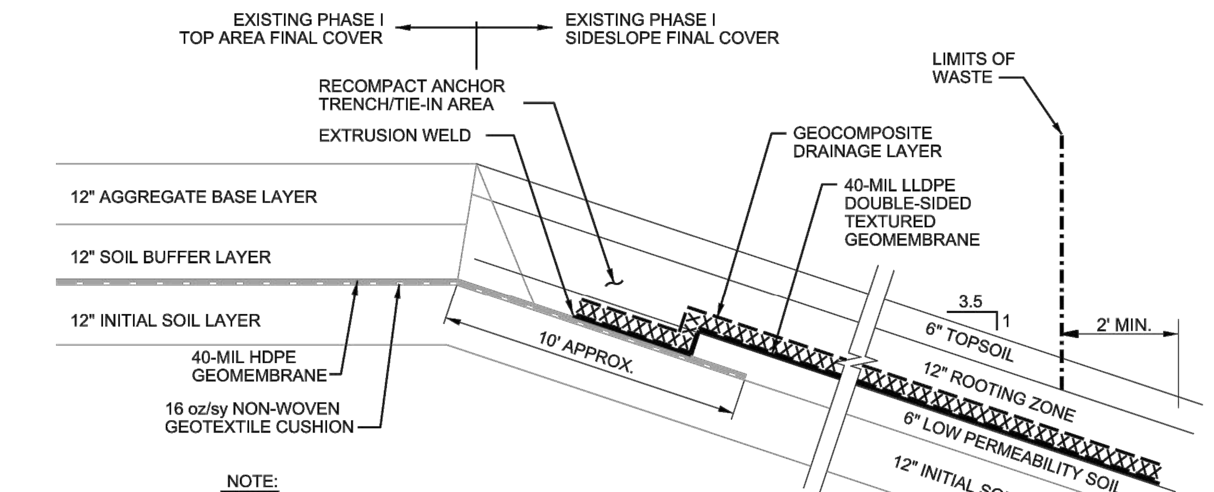
PERIMETER BERM/ACCESS ROAD 5
NTS



NOTE:

1. EXISTING PHASE 1 SIDESLOPE FINAL COVER CONFIGURATION TAKEN FROM DRAWING C-10 "POST CONSTRUCTION REPORT, KEKAHA SANITARY LANDFILL, PHASE I CLOSURE, KEKAHA, KAUAI, HAWAII". DATED FEBRUARY 16, 1996 BY HARDING LAWSON ASSOCIATES.

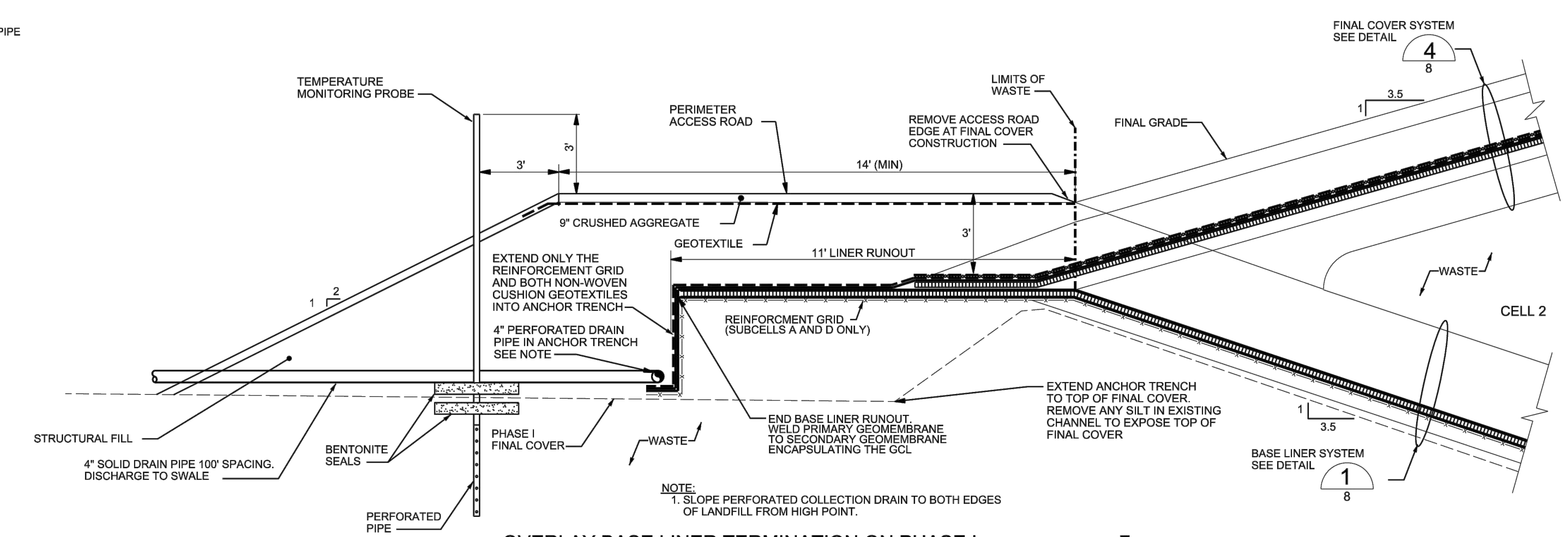
OVERLAY BASE LINER DETAIL (ONTO PHASE I) 6
NTS



NOTE:

1. GEOMEMBRANE PLACEMENT SEQUENCE TO INCLUDE THE FOLLOWING:
   A. STRIP AND STOCKPILE TOPSOIL.
   B. STRIP AND STOCKPILE TOP 12" OF 18" LOW PERMEABILITY LAYER.
   C. SMOOTH DRUM ROLL REMAINING LOW PERMEABILITY SOIL SURFACE
   D. EXCAVATE ANCHOR TRENCH TAKING CARE TO PROTECT EXISTING GEOMEMBRANE AND GEOTEXTILE.
   E. REMOVE ROCKS AND OTHER DELETERIOUS MATERIAL LARGER THAN 1 INCH IN DIAMETER FROM EXISTING LOW PERMEABILITY SOIL SURFACE AND TOPSOIL.
   F. PLACE GEOMEMBRANE AND WELD TO EXISTING GEOMEMBRANE.
   G. PLACE NEW GEOCOMPOSITE DRAINAGE LAYER.
   H. PLACE 12" ROOTING ZONE USING LOW GROUND PRESSURE EQUIPMENT.
   I. REPLACE TOPSOIL USING LOW GROUND PRESSURE EQUIPMENT.
2. WHEN DEPLOYING GEOCOMPOSITE DRAINAGE LAYER OVER TEXTURED GEOMEMBRANE, A RUBSHEET SHALL BE USED BETWEEN THE TWO MATERIALS AND REMOVED AFTER FINAL MATERIAL POSITIONING.
3. LIMITS OF EXISTING GEOMEMBRANE TO BE FIELD LOCATED AND VERIFIED.
4. PLACEMENT SEQUENCE, LIMITS, AND CONFIGURATION MAY BE MODIFIED AT TIME OF CONSTRUCTION BASED ON FIELD CONDITIONS AND ENGINEER'S APPROVAL.

PHASE I GEOMEMBRANE EXTENSION 8
NTS



NOTE:

1. SLOPE PERFORATED COLLECTION DRAIN TO BOTH EDGES OF LANDFILL FROM HIGH POINT.

OVERLAY BASE LINER TERMINATION ON PHASE I 7
NTS

NO	REVISIONS	DRN	CHK	DATE
4	MODIFIED DETAIL 1 NOTES, MODIFIED DETAILS 7 AND 8	CFF	NKW	12/2015
3	MODIFIED DETAIL 1 NOTES, ADDED DETAIL 8 AND MODIFIED DETAIL 6	DRB	KJB	03/2013
2	ADDED GCL TO COVER CROSS-SECTION ON DETAILS 4,5, AND 7	DRB	KJB	01/2013
1	UPDATED DETAILS, NOTES, MATERIAL SELECTION AND ANCHOR TRENCHING.	DRB	KJB	12/2012

NANCY K. WRIGHT LICENSED PROFESSIONAL ENGINEER No. 16394-C HAWAII U.S.A.

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APRIL 30, 2018
EXPIRATION DATE OF THE LICENSE

DRN DRB
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CHK FLC/MRH
APP KJB

PREPARED BY AECOM

ENGINEERING REPORT
KEKAHA LANDFILL PHASE II-CELL 2 LATERAL EXPANSION KEKAHA SANITARY LANDFILL
KAUAI, HAWAII

DETAILS

DATE DECEMBER 2015
PROJECT NO 60197394
FILENAME
SHEET NO
DRAWING NO 8

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

NOTE:
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REV	REVISION DESCRIPTION	DATE

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

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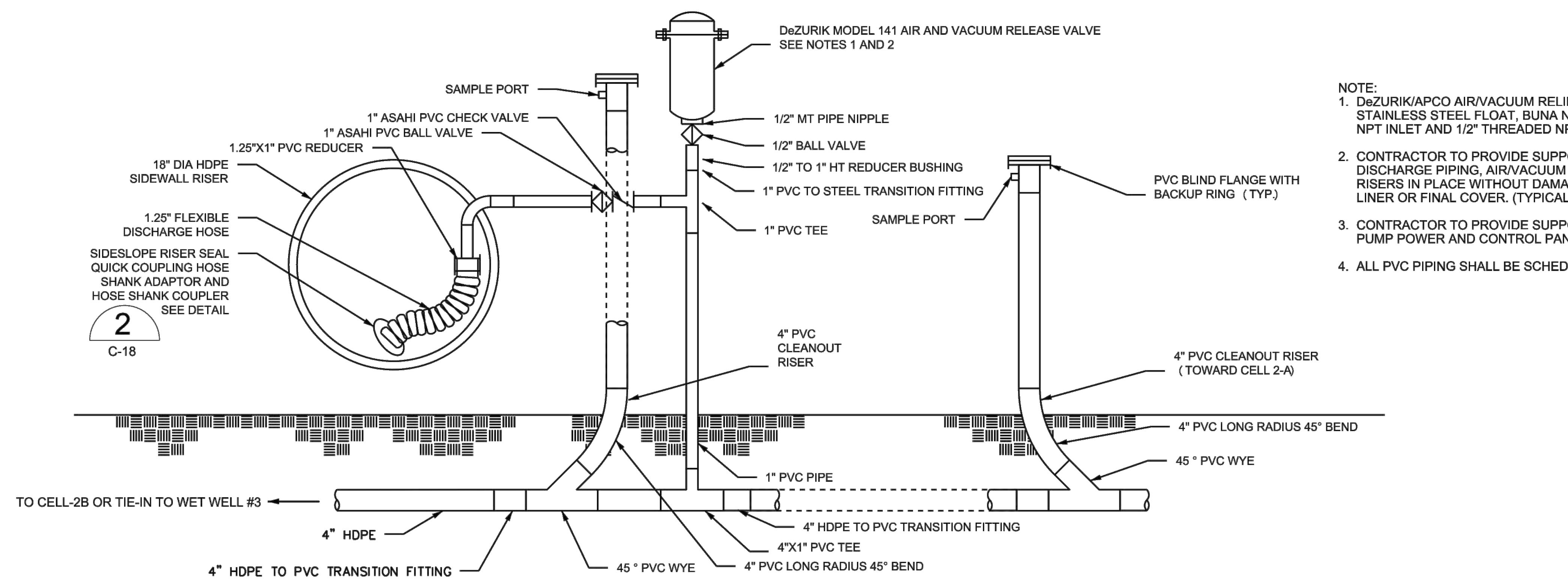
KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION
LINER AND LCRS DETAILS (FROM AECOM, 2017)

DESIGNED BY : GRB	CHECKED BY : CHM	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB	FILE : 220048-C-501_LF DETAILS.dwg

SHEET C-501

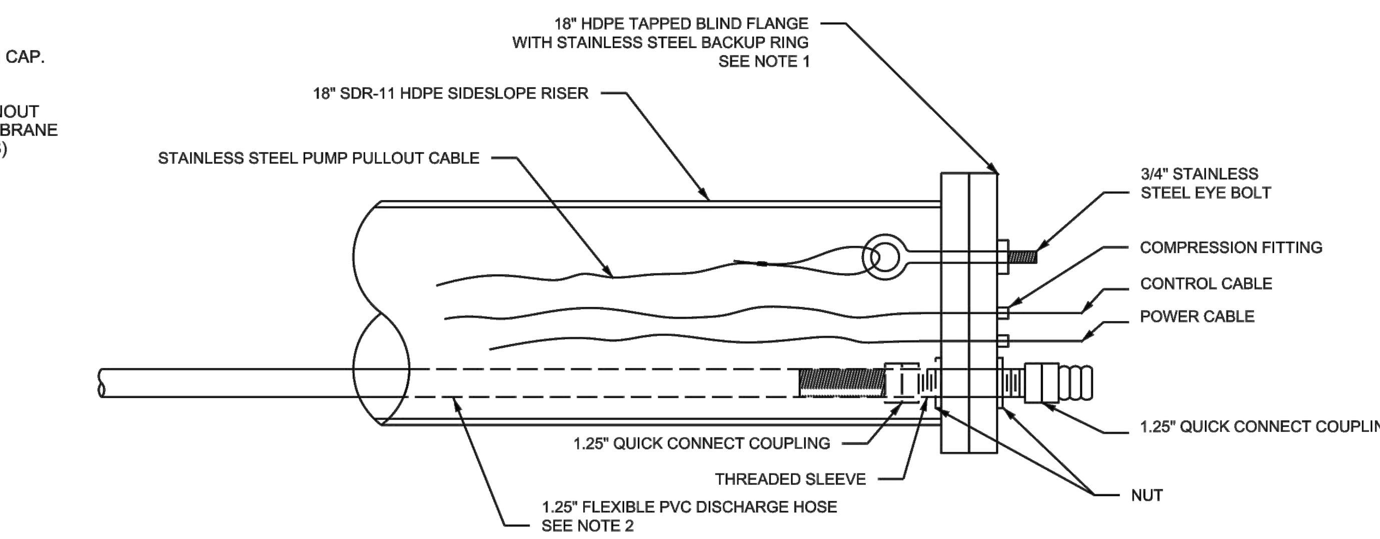
X:\PROJECTS\KAUAI COUNTY\197-220048 - Kekaha Vertical Expansion_Project Drawings\220048-C-501_LF DETAILS.dwg 11/28/2023 3:59 PM



NOTE:
1. DeZURIK/APCO AIR/VACUUM RELIEF VALVE MODEL 141, STAINLESS STEEL FLOAT, BUNA N SEAT, 1/2" THREADED NPT INLET AND 1/2" THREADED NPT OUTLET WITH MUSHROOM CAP.
2. CONTRACTOR TO PROVIDE SUPPORT STRUCTURE TO HOLD DISCHARGE PIPING, AIR/VACUUM RELEASE VALVE, AND CLEANOUT RISERS IN PLACE WITHOUT DAMAGING UNDERLYING GEOMEMBRANE LINER OR FINAL COVER. (TYPICAL, ALL PIPE RISER LOCATIONS)
3. CONTRACTOR TO PROVIDE SUPPORT STRUCTURE TO HOLD PUMP POWER AND CONTROL PANELS.
4. ALL PVC PIPING SHALL BE SCHEDULE 80 PVC.

UPSLOPE DETAIL (LOOKING AT TOP OF SIDESLOPE RISER WITH TRANSFER PIPING)(TYPICAL) 1

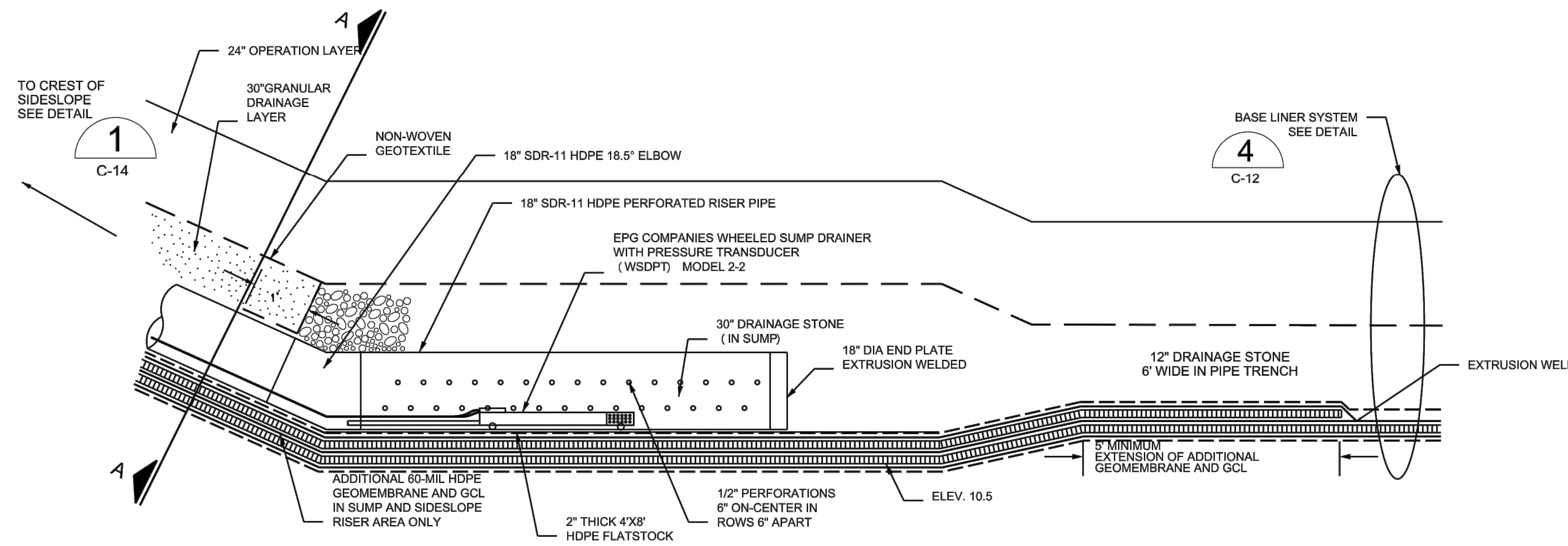
NTS



NOTE:
1. TWO TAPPED BLIND FLANGES REQUIRED WITH ATTACHED FITTINGS AT EACH SUMP RISER LOCATION. ONE PUMP AND HOOKUPS TO BE INSTALLED. OTHER RISER AND (PLUGGED) TAPPED BLIND FLANGE READY FOR USE WHEN NEEDED IN FUTURE.
2. PROVIDE 1/4" WEEPHOLE IN DISCHARGE HOSE 25' FROM PUMP. PUT PAINT MARK AT WEEPHOLE.

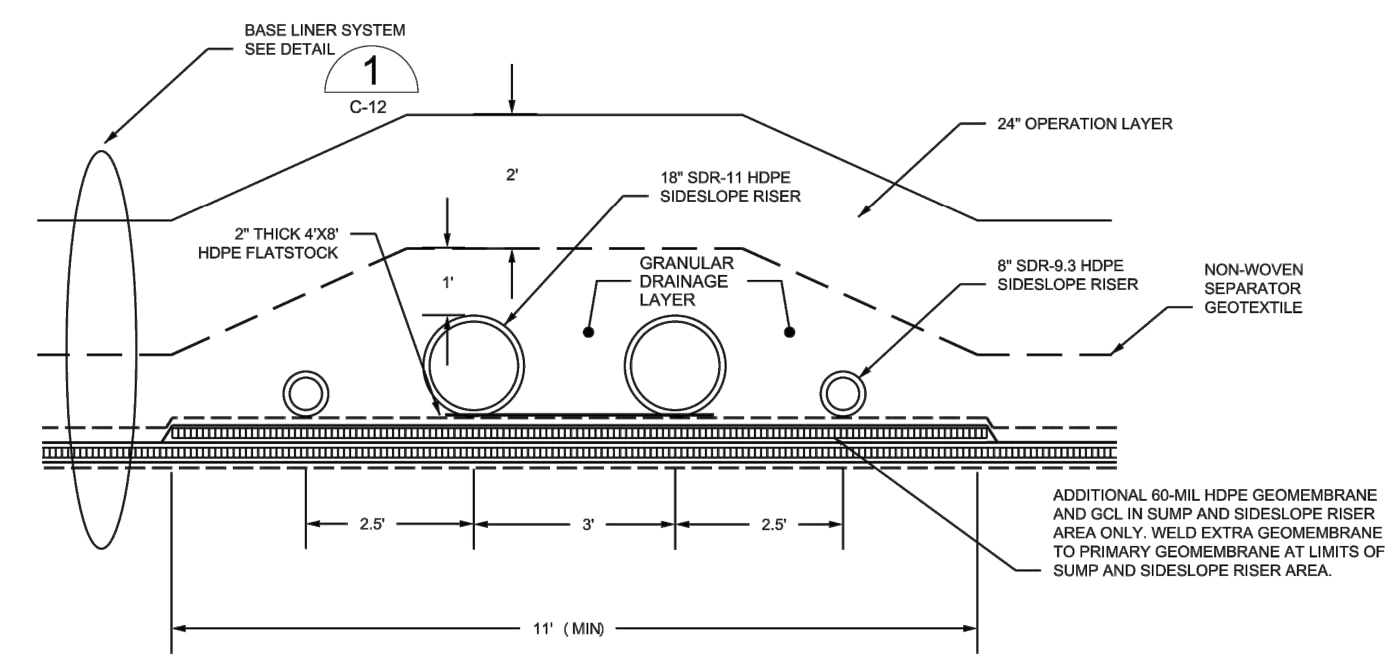
TOP OF SIDESLOPE RISER SEAL 2

NTS

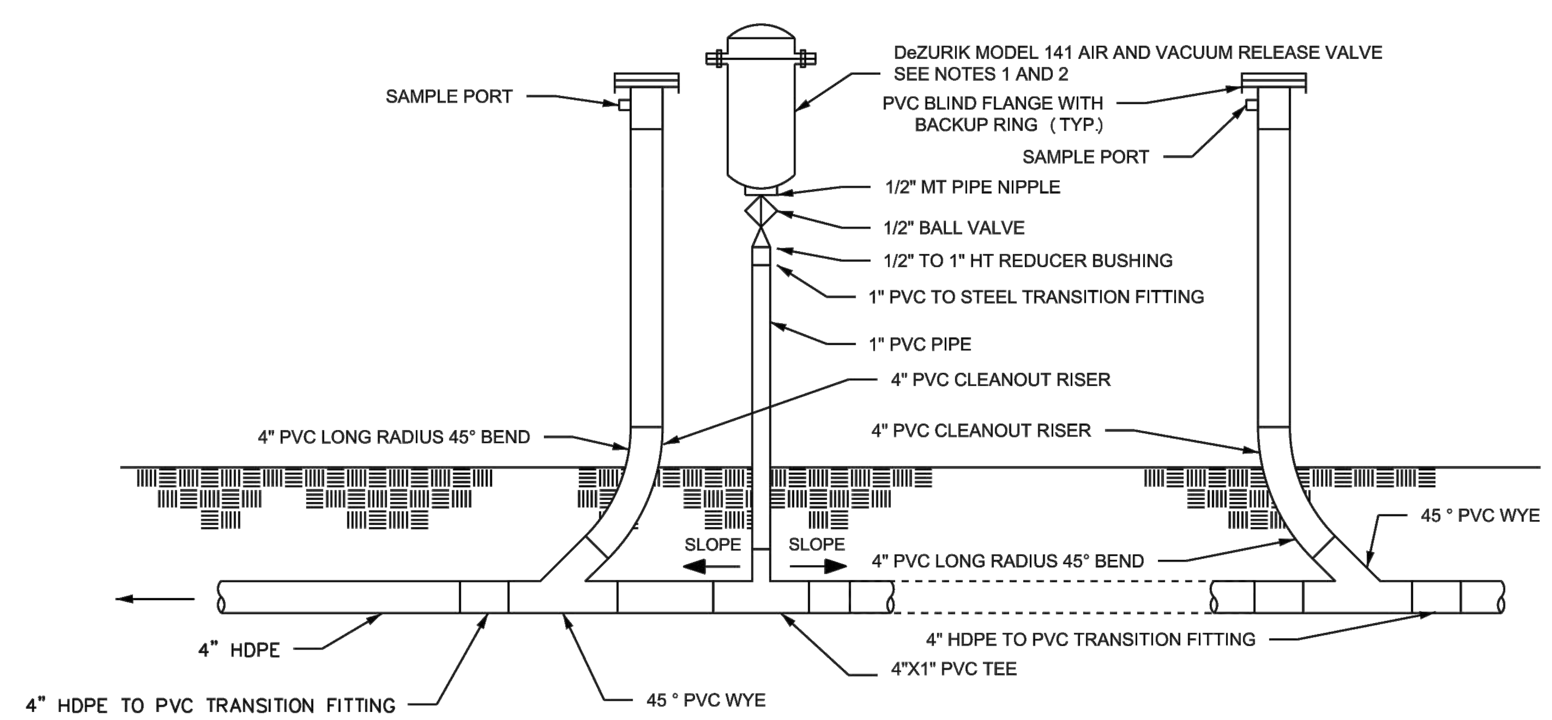


TYPICAL LEACHATE COLLECTION SUMP 3

NTS

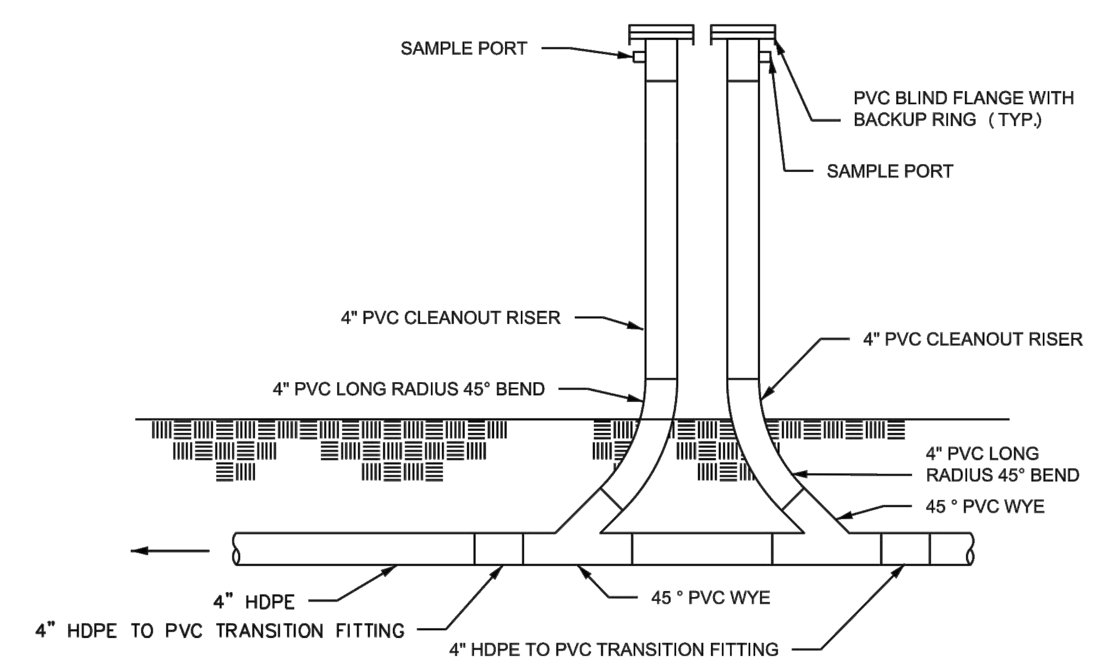


SECTION A-A



LEACHATE TRANSMISSION PIPE HIGH POINT 4

NTS



LEACHATE TRANSMISSION PIPE CLEANOUT RISERS 5

NTS

NO	REVISIONS	DRN	CHK	DATE
1	ISSUED FOR CONSTRUCTION	TPB	NKW	09/04/2018

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APRIL 30, 2020
EXPIRATION DATE OF THE LICENSE

DRN TPB
DES NKW
CHK MRH
APP NKW

PREPARED BY AECOM

CELL 2 BASE LINER CONSTRUCTION DRAWINGS PHASE II LATERAL EXPANSION KEKAHA SANITARY LANDFILL KAUAI, HAWAII

LEACHATE COLLECTION DETAILS

DATE SEPTEMBER, 2018
PROJECT NO 60558519
FILENAME
SHEET NO
DRAWING NO C-15

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

X:\PROJECTS\KAUAI COUNTY\197-220048 - Kekaha Vertical Expansion_Project Drawings\220048-C-502_LF DETAILS.dwg 11/28/2023 4:00 PM

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REV	REVISION DESCRIPTION	DATE

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

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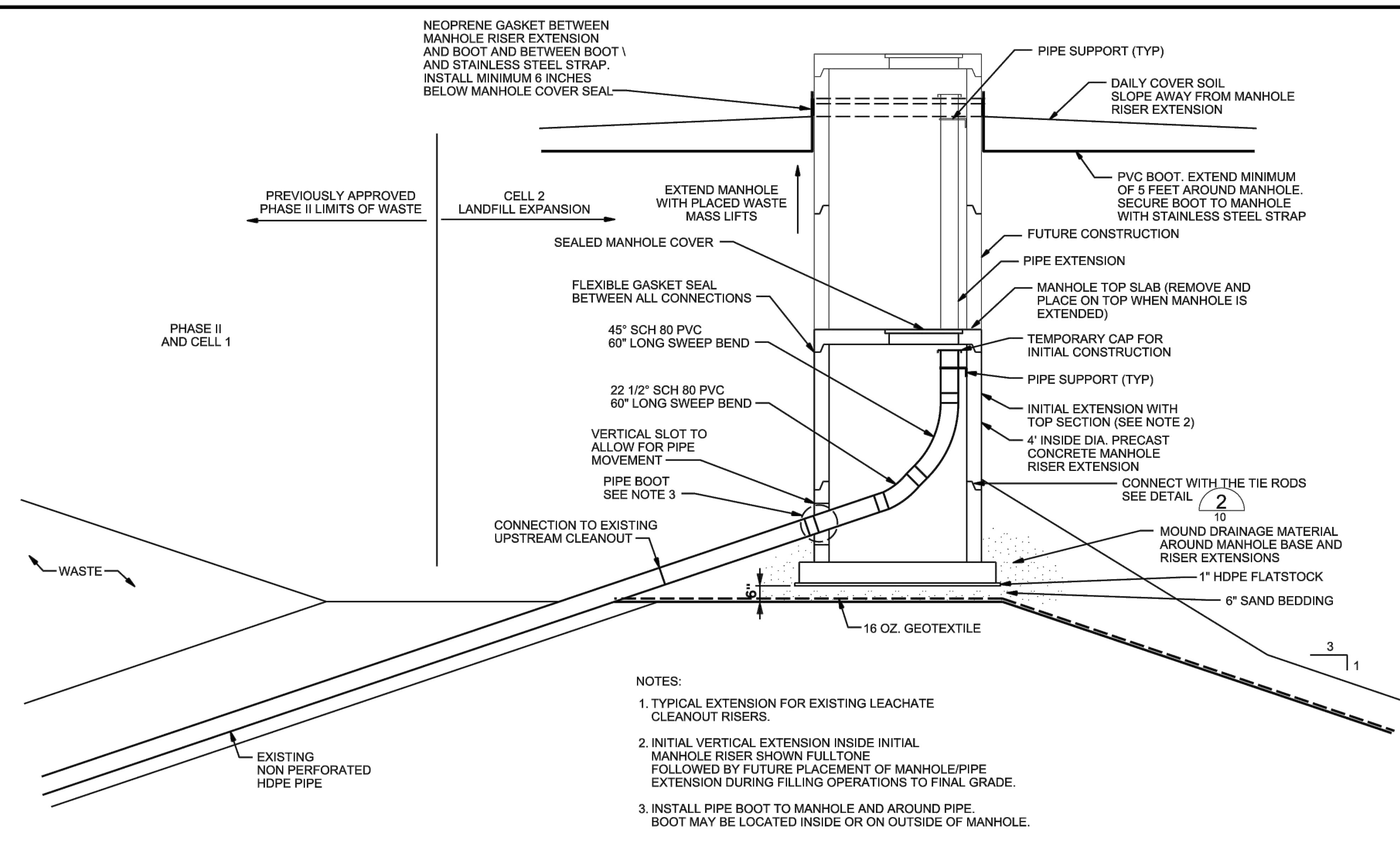
KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

PHASE II, CELL 2 LEACHATE COLLECTION DETAILS (FROM AECOM, 2020)

DESIGNED BY : GRB	CHECKED BY : CHM	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB	FILE : 220048-C-502_LF DETAILS.dwg

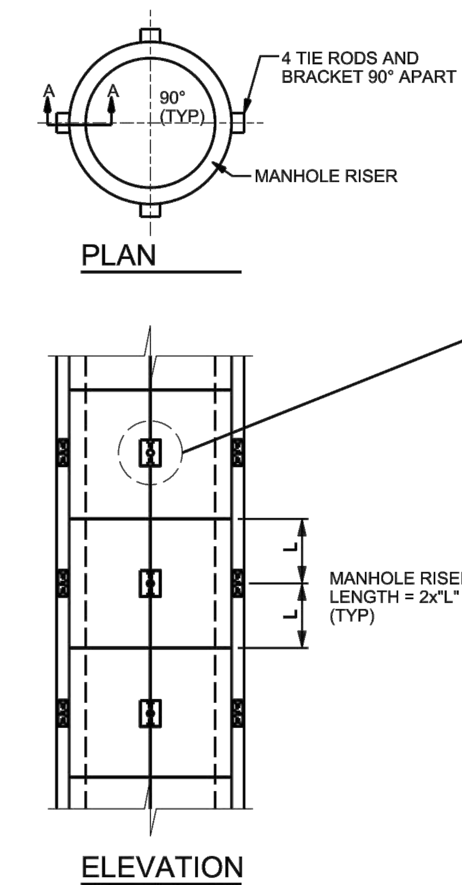
SHEET
C-502

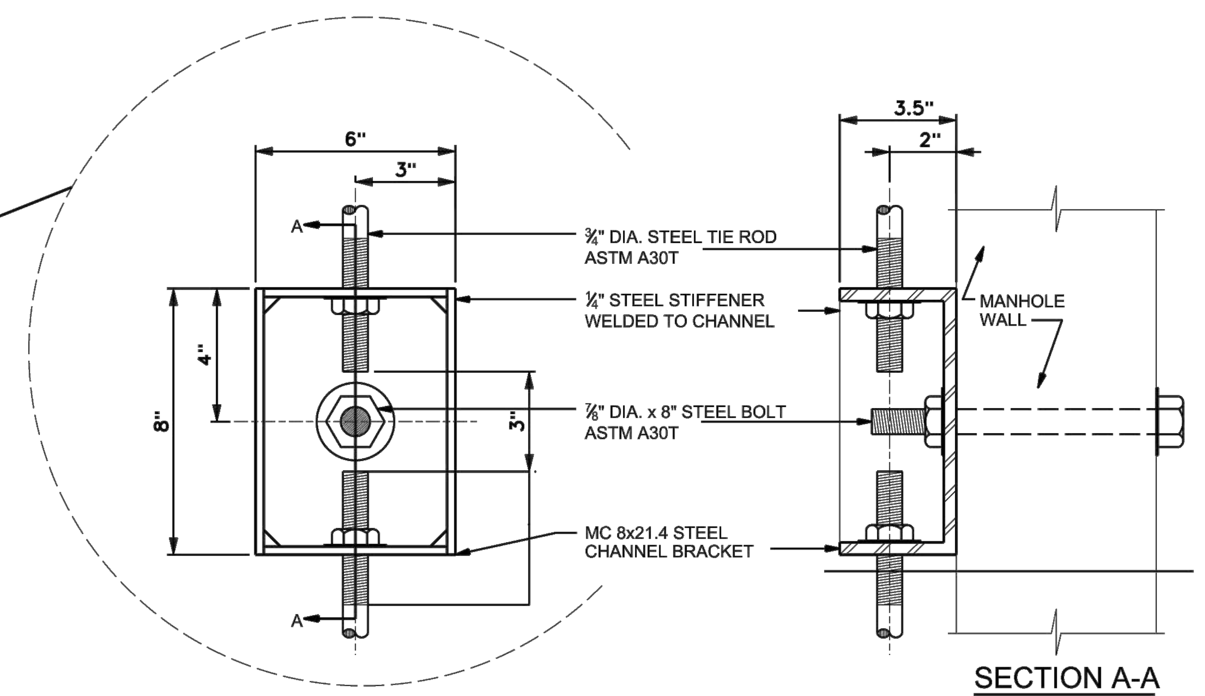


NOTES:

1. TYPICAL EXTENSION FOR EXISTING LEACHATE CLEANOUT RISERS.
2. INITIAL VERTICAL EXTENSION INSIDE INITIAL MANHOLE RISER SHOWN FULLTONE FOLLOWED BY FUTURE PLACEMENT OF MANHOLE/PIPE EXTENSION DURING FILLING OPERATIONS TO FINAL GRADE.
3. INSTALL PIPE BOOT TO MANHOLE AND AROUND PIPE. BOOT MAY BE LOCATED INSIDE OR ON OUTSIDE OF MANHOLE.

VERTICAL LEACHATE CLEANOUT AND MANHOLE RISER EXTENSIONS 1
NTS

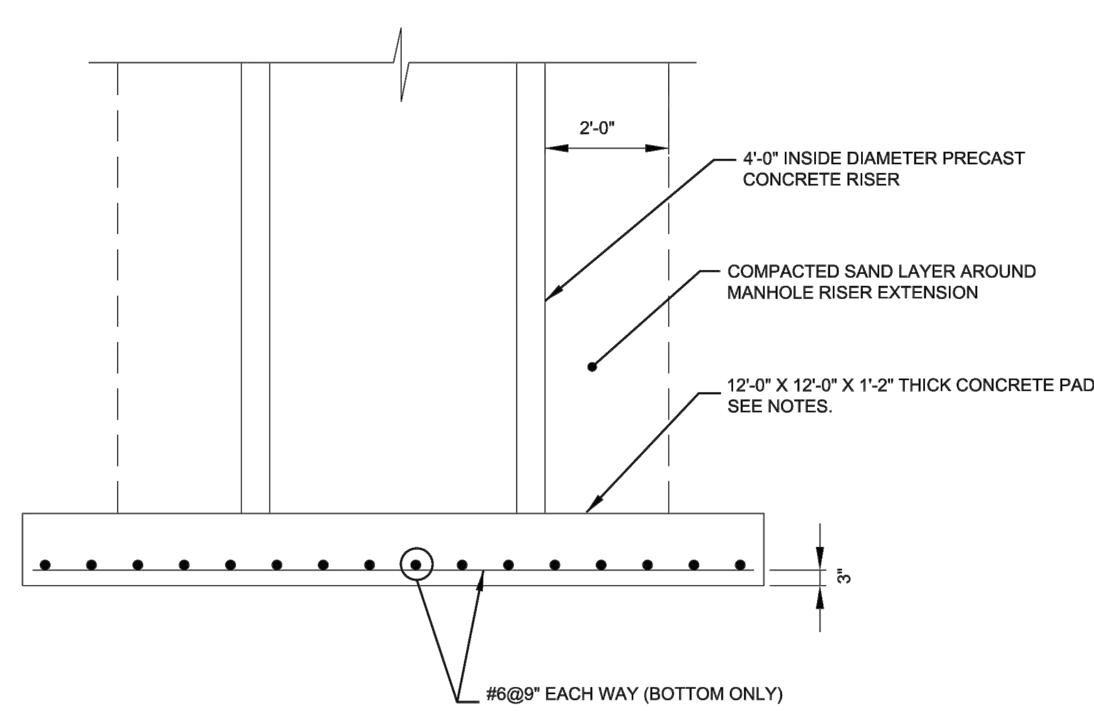




NOTES:

1. MAINTAIN ALL MANHOLE RISER SECTIONS LEVEL AND PLUMB. PROVIDE CAST IRON SPACERS BETWEEN RISER SECTIONS IF NECESSARY TO ADJUST TO LEVEL CONDITIONS.
2. EPOXY COAT ALL EXPOSED METAL SURFACES AND BOLTS IMMEDIATELY FOLLOWING INSTALLATION.
3. STAINLESS STEEL CAN BE SUBSTITUTED FOR ALL COMPONENTS.

MANHOLE TIE ROD AND BRACKET 2
NTS



MANHOLE BASE DETAIL 3
NTS

NOTES:

1. CONCRETE PAD
   A. ACTUAL PAD DIMENSIONS AND REINFORCEMENT MAY VARY AT TIME OF CONSTRUCTION DUE TO FIELD CONDITIONS.
2. CONCRETE MIX
   A. CLASS A:
      1. MINIMUM 6 BAGS OF CEMENT PER CUBIC YARD OF CONCRETE.
      2. MINIMUM 28 DAY COMPRESSIVE STRENGTH OF 4000 PSI.
   B. FURNISH AND DELIVER CONCRETE IN ACCORDANCE WITH ASTM C94.
   C. AIR CONTENT 6 +/- 1 %, ASTM C260.
   D. SLUMP: 4 +/- 1 IN.
   E. WATER/CEMENT RATIO: 0.45 MAXIMUM, MIXING WATER TO BE POTABLE.
   F. CEMENT: ASTM C150 TYPE 1.
   G. AGGREGATES: FINE TO BE NATURAL SAND, COARSE TO BE CRUSHED GRAVEL ASTM C33, SIZE (3/4 INCH MAXIMUM).
   H. APPLY ASTM C309 TYPE 1 OR 1-D CURING COMPOUND IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS, CURE AND SEAL J-20 BY DAYTON SUPERIOR OR EQUAL.
   I. EXPOSED CONCRETE SURFACES TO HAVE SURFACE DEFECTS PATCHED AND PROJECTING FINS KNOCKED OFF.
   J. PATCH HONEYCOMBING, STONE POCKETS, SPALLS, AND OTHER IRREGULARITIES WITH PATCHING MORTAR, SIKATOP BY SIKA CORPORATION OR EQUAL.
   K. EXTERIOR EXPOSED SLAB TO HAVE A FLOAT AND BROOM FINISH.
3. REINFORCEMENT
   A. DEFORMED BARS CONFORMING TO ASTM A615, GRADE 60.
   B. DO NOT WELD OR FIELD BEND REINFORCING BARS.
   C. #6 REINFORCING BAR:
      1. LAPPED SPLICE LENGTH = 30 INCHES
      2. EMBEDMENT LENGTH = 24 INCHES.

NO	REVISIONS	DRN	CHK	DATE
2	REMOVED DETAIL 5 LEACHATE TRANSFER PIPE TIE-IN TO LCM-1	CFF	NKW	12/2015
1	ADD PVC PIPE BOOT TO MANHOLE, DETAIL 1	DRB	KJB	10-23-12

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SIGNATURE
APRIL 30, 2018
EXPIRATION DATE OF THE LICENSE

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DES	NKW/TCR
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APP	KJB

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ENGINEERING REPORT
KEKAHA LANDFILL PHASE II-CELL 2 LATERAL EXPANSION KEKAHA SANITARY LANDFILL
KAUAI, HAWAII

DETAILS

DATE DECEMBER 2015
PROJECT NO 60197394
FILENAME
SHEET NO
DRAWING NO 10

NOTE:
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COUNTY OF KAUAI — STATE OF HAWAII

REV	REVISION DESCRIPTION	DATE

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

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KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION
LCRS RISER DETAILS (FROM AECOM, 2017)

DESIGNED BY : GRB	CHECKED BY : CHM	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB	FILE : 220048-C-503_LF DETAILS.dwg

SHEET
C-503

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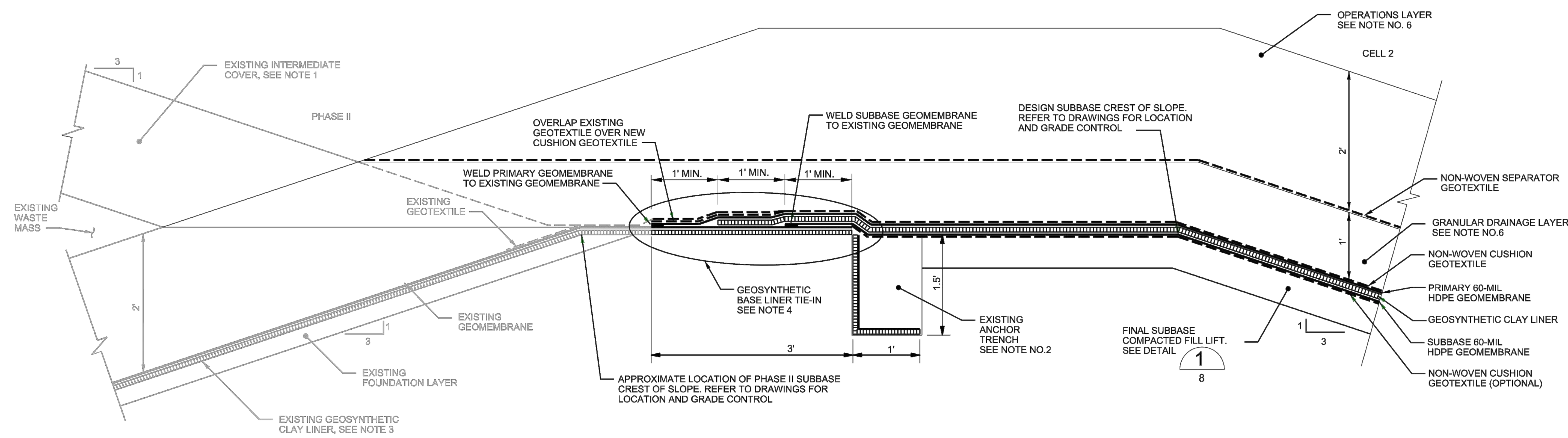

NOTES:

1. CONTRACTOR TO EXPOSE EXISTING ANCHOR TRENCH, GEOSYNTHETIC BASE LINER AND DRAINAGE LAYER OF PHASE II. COORDINATE WITH OWNER ACCESS TO TIE-IN AREA TO AVOID CONFLICT WITH SITE OPERATION. EXPOSURE ACTIVITIES WILL INCLUDE AT A MINIMUM REMOVAL OF EXISTING INTERMEDIATE COVER, EXISTING SOILS OVERLYING THE ANCHOR TRENCH AND BERM. CARE IS TO BE TAKEN DURING REMOVAL OF SOILS DIRECTLY IN CONTACT GEOSYNTHETICS. EXPOSURE ACTIVITIES TO BE CONSTANTLY MONITORED BY QUALITY ASSURANCE CONSULTANT AND DOCUMENTED. EXCESS DAMAGE AND RESULTING REPAIRS CAUSED FROM EXPOSING TIE-IN AREA WILL BE RESPONSIBILITY OF CONTRACTOR. CONTRACTOR TO MAINTAIN SURFACE WATER CONTROL FROM TIE-IN AREA.
2. CUT GEOSYNTHETICS ENTERING ANCHORING TRENCH AT ANCHOR TRENCH EDGE. PROTECT EXPOSED EDGE FROM DRYING AND MOISTURE. REMOVE ALL REMAINING PORTIONS OF GEOSYNTHETICS FROM ANCHOR TRENCH. BACKFILL ANCHOR TRENCH WITH STRUCTURAL FILL AND COMPACT PER PROJECT SPECIFICATIONS.
3. EXISTING GEOSYNTHETIC CLAY LINER (GCL) OF PHASE II IS COMPRISED OF A BENTONITE LAYER WITH A GEOMEMBRANE CARRIER. THE GEOMEMBRANE IS IN DIRECT CONTACT WITH THE SUBBASE. CARE TO BE TAKEN NOT TO PULL GCL FROM OVERLYING GEOMEMBRANE DURING TIE-IN CONSTRUCTION.
4. CONSTRUCT GEOSYNTHETIC BASE LINER TIE-IN IN THE FOLLOWING ORDER:
   A. INSTALL NEW SUBBASE GEOMEMBRANE AND WELD TO EXISTING GEOMEMBRANE WITH A MINIMUM 1-FOOT OVERLAP.
   B. INSTALL NEW GEOSYNTHETIC CLAY LINER (GCL) ON TOP OF SUBBASE GEOMEMBRANE WITH MINIMUM 2-FOOT OVERLAP ONTO EXISTING GEOMEMBRANE.
   C. INSTALL NEW PRIMARY GEOMEMBRANE OVER NEW GCL AND WELD TO EXISTING GEOMEMBRANE MINIMUM 1-FOOT PAST NEW GCL OVERLAP.
   D. INSTALL NEW NON-WOVEN CUSHION GEOTEXTILE OVER PRIMARY GEOMEMBRANE. OVERLAP EXISTING GEOTEXTILE ON NEW NON-WOVEN GEOTEXTILE A MINIMUM OF 2 FEET AND HEAT BURNISH FIELD OVERLAP SEAM. REPAIR THINNED OR TORN PORTIONS OF THE EXISTING GEOTEXTILE WITH NEW NON-WOVEN GEOTEXTILE AS NEEDED.
   E. INSTALL GRANULAR DRAINAGE LAYER.
   F. INSTALL NEW NON-WOVEN SEPARATOR GEOTEXTILE.
   G. INSTALL OPERATIONS LAYER.
5. WHEN DEPLOYING GCL OR GEOTEXTILES OVER TEXTURED GEOMEMBRANE OR WHEN DEPLOYING TEXTURED GEOMEMBRANE OVER GCL OR GEOTEXTILES, A RUBSHEET SHALL BE USED BETWEEN THE TWO MATERIALS AND REMOVED AFTER FINAL MATERIAL POSITIONING.
6. INSTALL GRANULAR DRAINAGE LAYER AND OPERATIONS LAYER OVER TIE-IN AREA PRIOR TO PLACEMENT OF MATERIALS ON SIDESLOPES. PLACEMENT OF MATERIALS ON SIDESLOPES TO OCCUR FROM TOE OF SLOPE UP SIDESLOPE.
7. ALL NEW GEOMEMBRANE IS TEXTURED ON BOTH SIDES.

PHASE II / CELL I TO CELL 2 BASE LINER TIE-IN DETAIL 1
NTS

NO	REVISIONS	DRN	CHK	DATE
2	REMOVED DETAIL 2	CFF	NKW	12/2015
1	NEW DRAWING, DETAIL 1 MOVED FROM DRAWING 9	DRB	KJB	03/2013

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APRIL 30, 2018
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DRN DRB
DES NKW/TCR
CHK FLC/MRH
APP KJB

PREPARED BY AECOM

ENGINEERING REPORT
KEKAHA LANDFILL PHASE II-CELL 2 LATERAL EXPANSION KEKAHA SANITARY LANDFILL
KAUAI, HAWAII

DETAILS

DATE DECEMBER 2015
PROJECT NO 60197394
FILENAME
SHEET NO
DRAWING NO 14

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TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

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KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

PHASE II, CELL 1 TO CELL 2 BASE LINER TIE-IN-DETAIL (FROM AECOM, 2017)

DESIGNED BY : GRB	CHECKED BY : CHM	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB	FILE : 220048-C-505_LF DETAILS.dwg

SHEET
C-504

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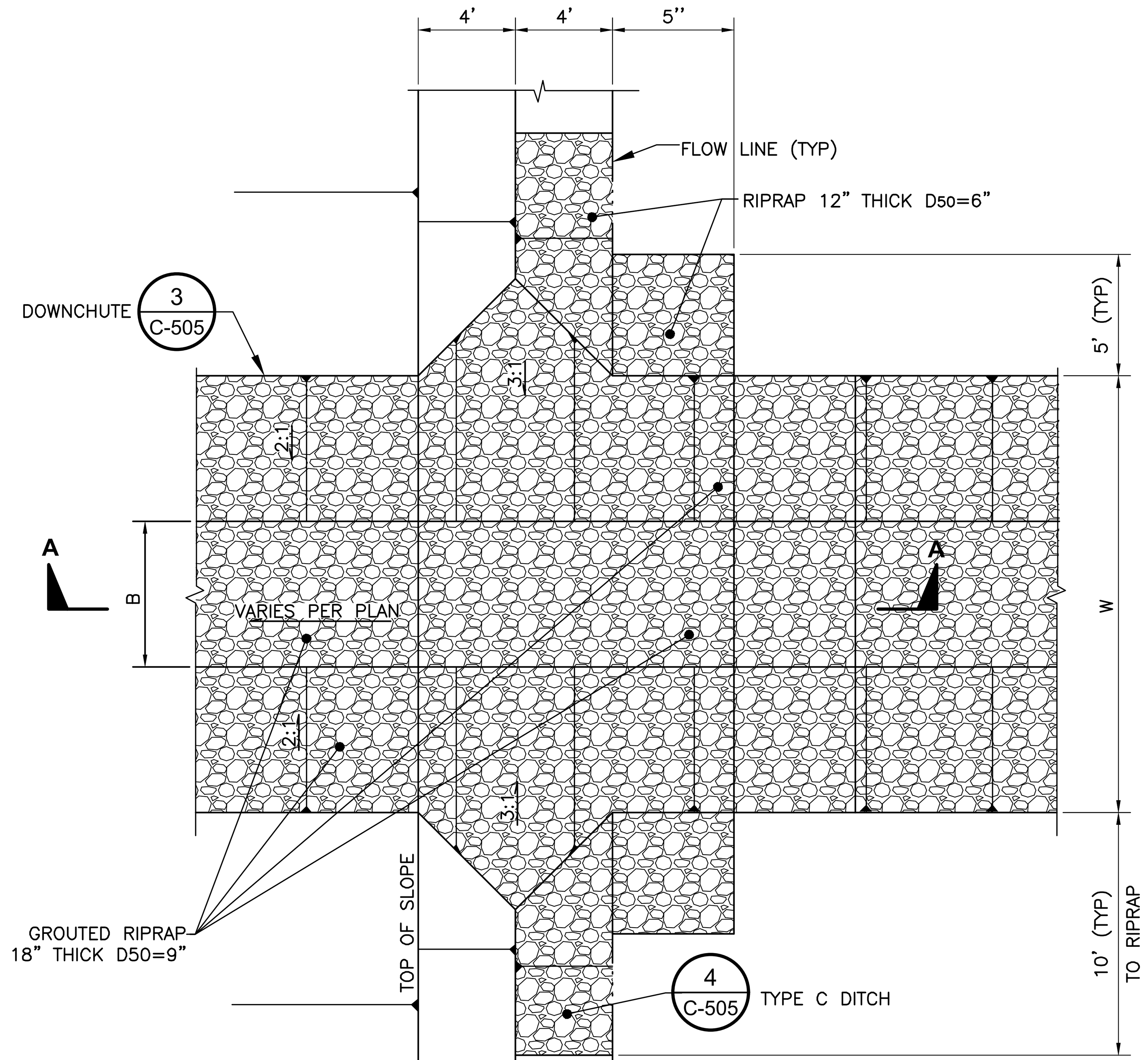

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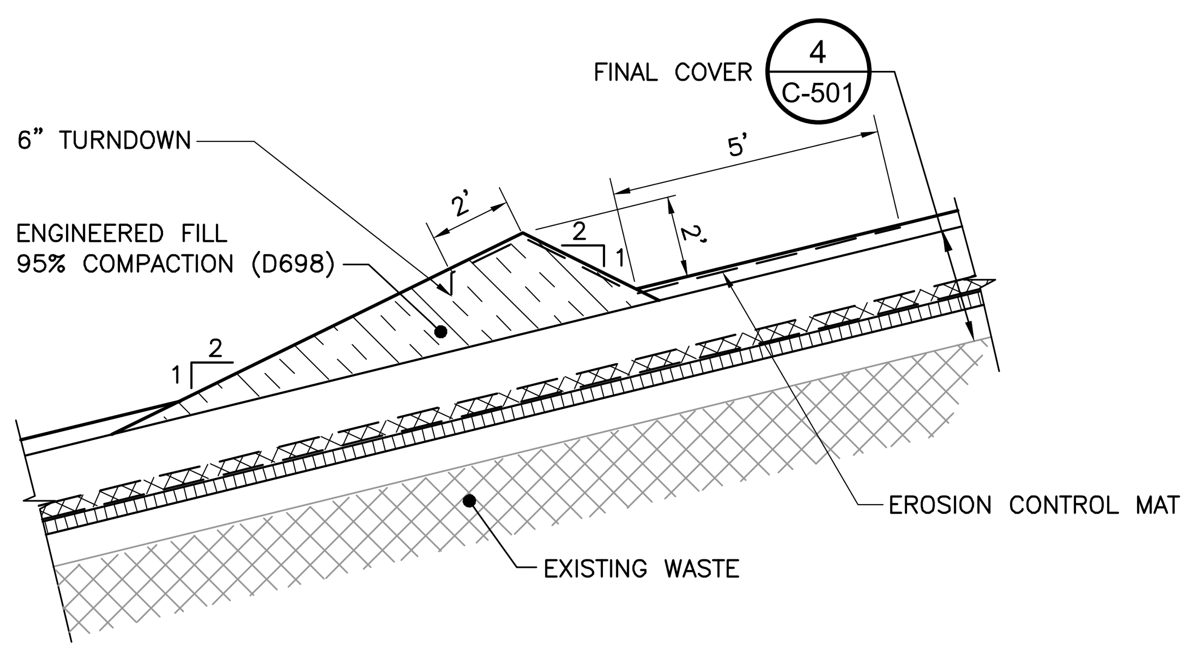
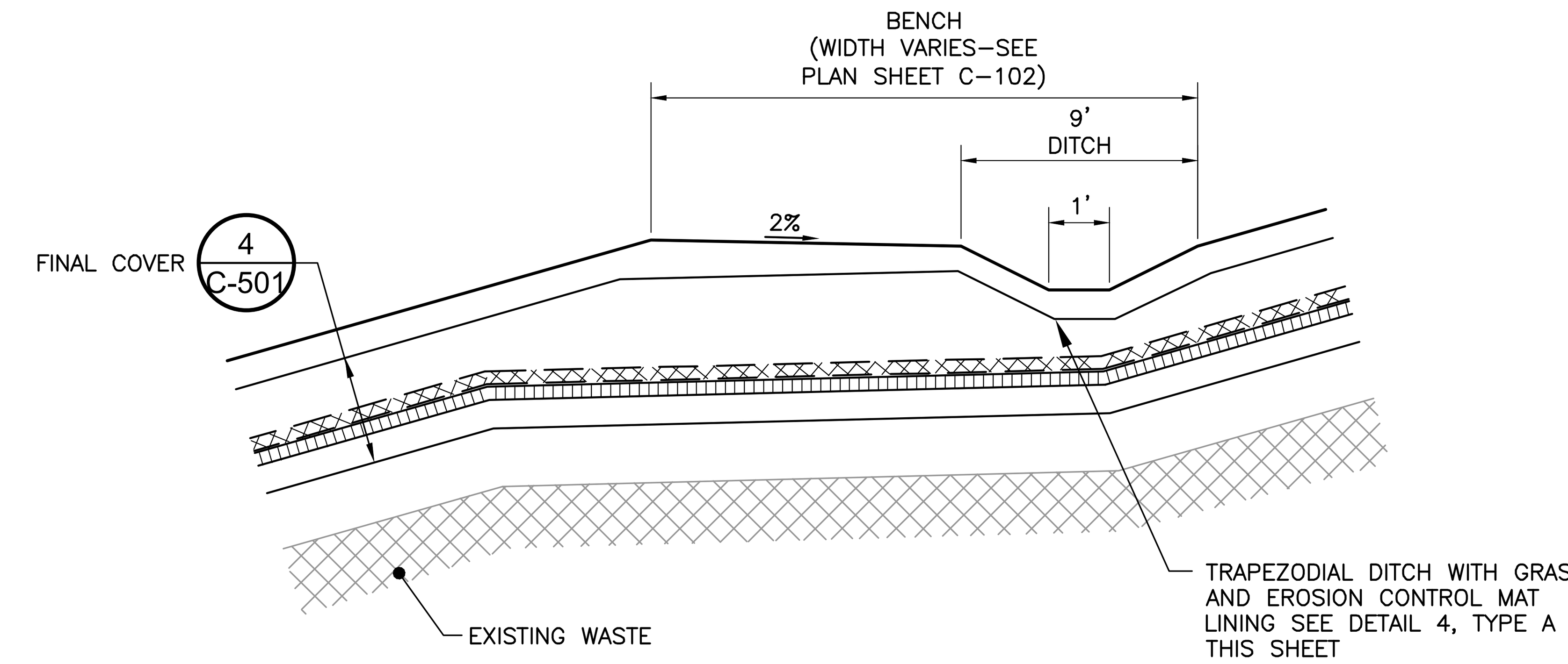


SECTION A-A

DOWNCHUTE FLUME/DIVERSION BERM JUNCTION

DETAIL (1 / C-505)

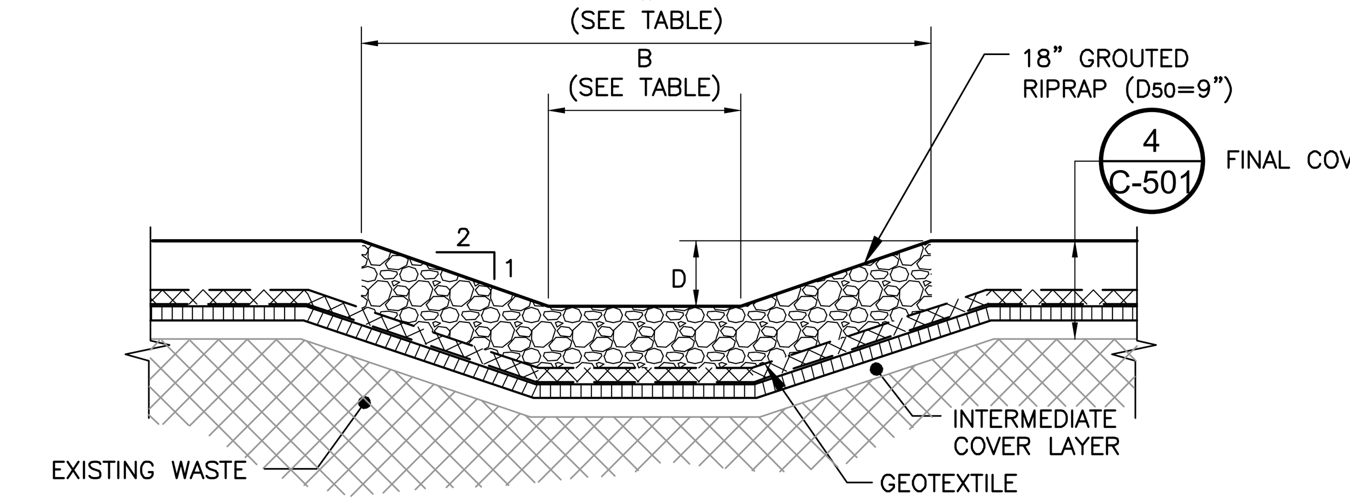
SCALE: NOT TO SCALE



FINAL COVER BENCH PROFILE

DETAIL (2 / C-505)

SCALE: NOT TO SCALE

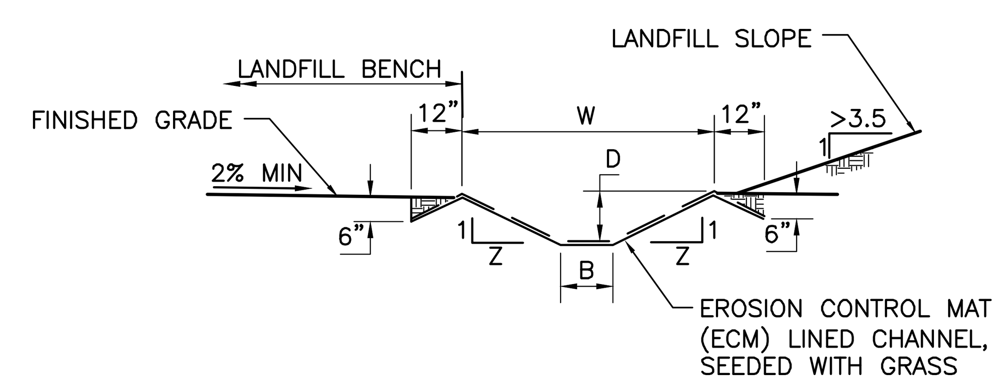


	DIMENSION		
DOWNCHUTE/FLUME ID	TOP WIDTH W (FT)	BOTTOM WIDTH B (FT)	DEPTH D (FT)
A0	7	1	1.5
A1	9	1	2
B1	7	1	1.5
C0	7	1	1.5
C1	7	1	1.5
C2	10	2	2
F1	7	1	1.5
F2	10	2	2

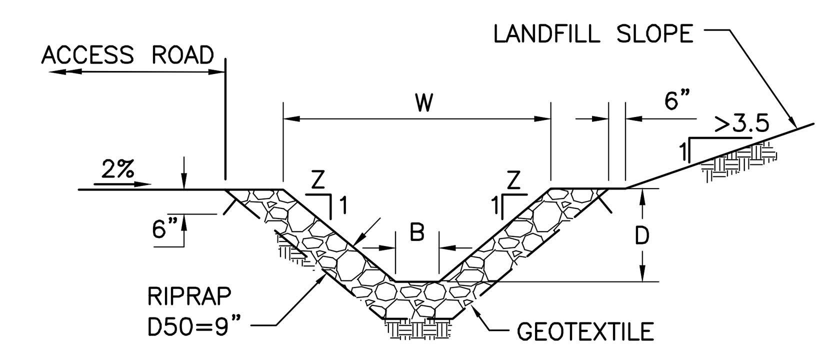
DOWNCHUTE

DETAIL (3 / C-505)

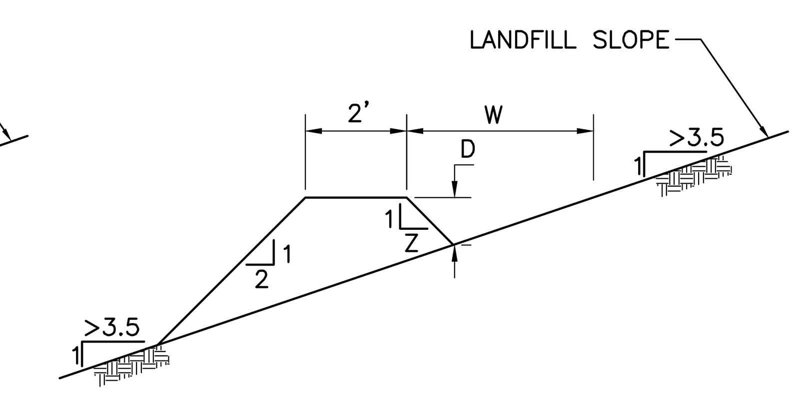
SCALE: NOT TO SCALE



TYPE A DITCH, BENCH/TERRACE



TYPE B DITCH, ACCESS ROAD



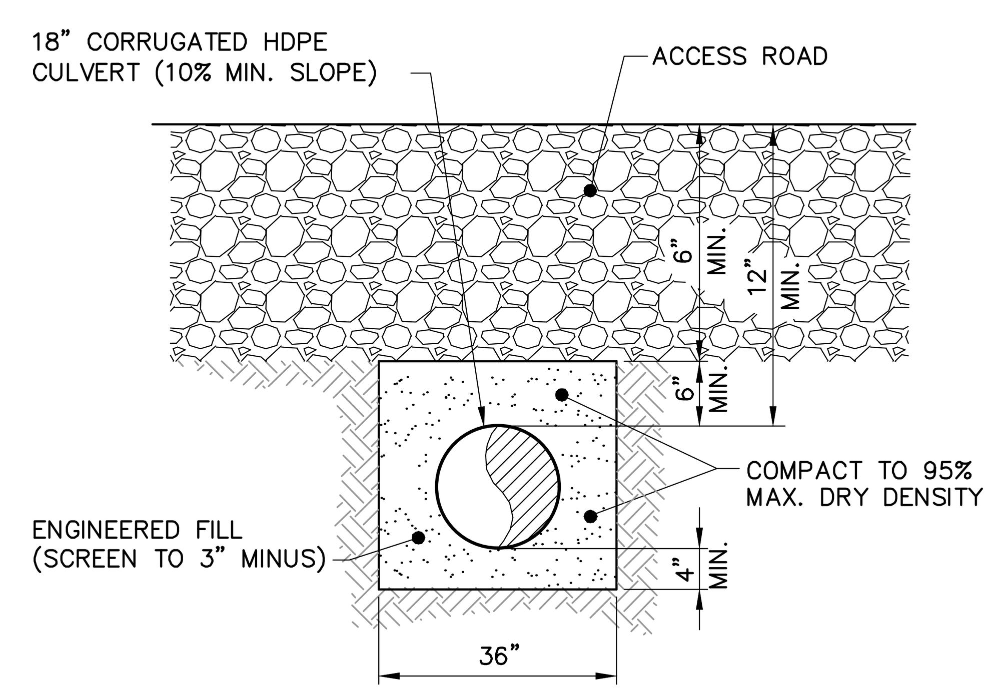
TYPE C DITCH, SIDESLOPE DIVERSION BERM

	DIMENSION			SIDE SLOPE		
TYPE	W (FT)	B (FT)	D (FT)	Z	SHAPE	LINING
A	9	1	2	2.0	TRAPEZOIDAL	GRASS LINED WITH ECM
B	8	2	1.5	2.0	TRAPEZOIDAL	ROCK RIPRAP
C	11	0	2	2.0	V–SHAPED	GRASS LINED WITH ECM

DRAINAGE DITCH DETAIL

DETAIL (4 / C-505)

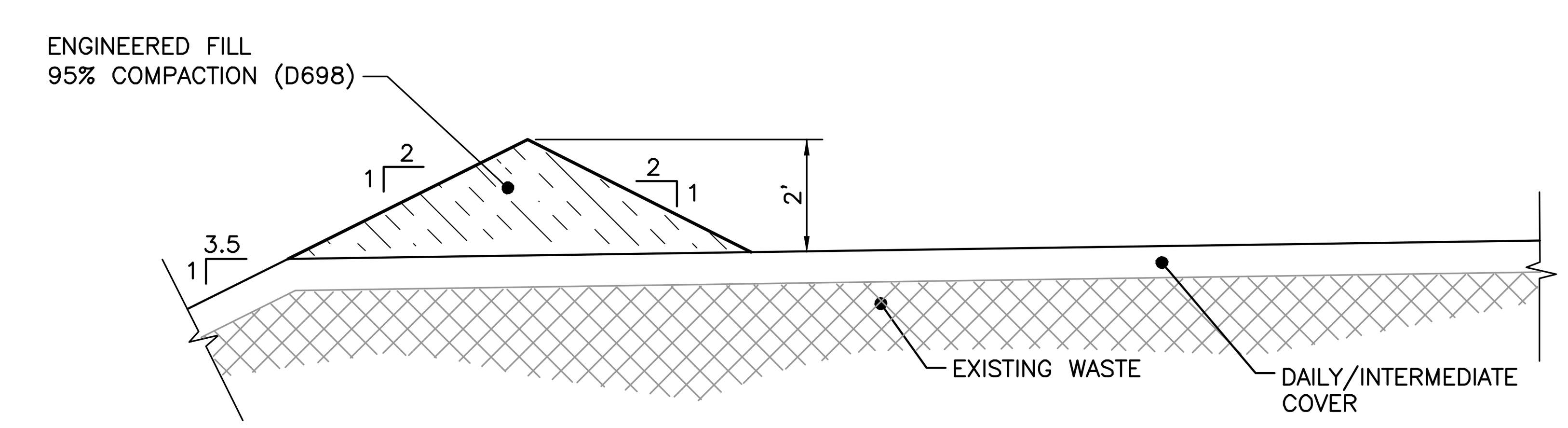
SCALE: NOT TO SCALE



CULVERT TRENCH

DETAIL (5 / C-505)

SCALE: NOT TO SCALE



SAFETY BERM

DETAIL (6 / C-505)

SCALE: NOT TO SCALE

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TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

GARTH R. BOWERS
LICENSED PROFESSIONAL ENGINEER
No. 20139-C
Exp 4/30/24
HAWAII U.S.A.
11/28/23

KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

STORMWATER DETAILS

DESIGNED BY : GRB	CHECKED BY : CHM	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB	FILE : 220048-C-506_LF DETAILS.dwg

SHEET
C-505

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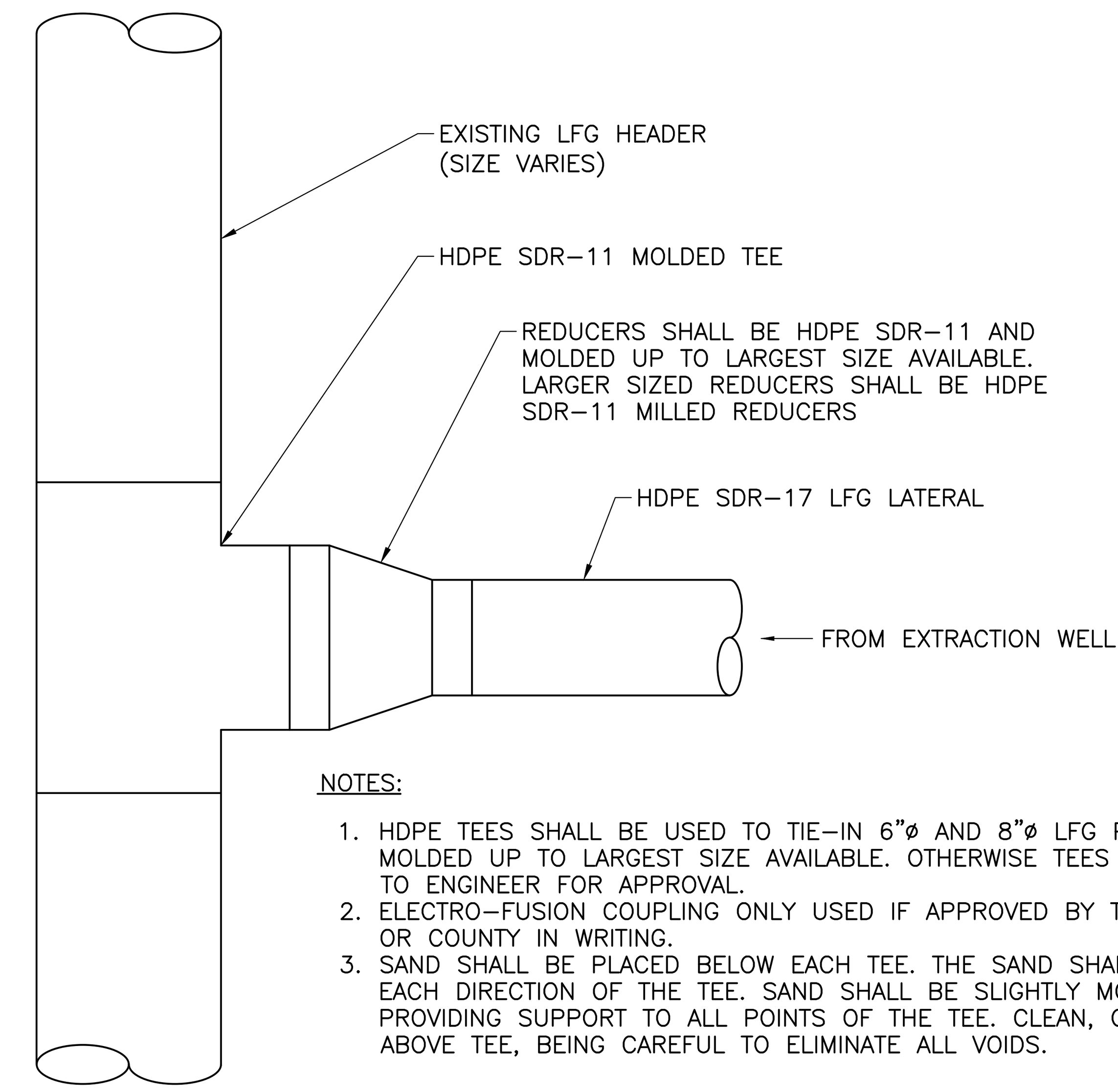


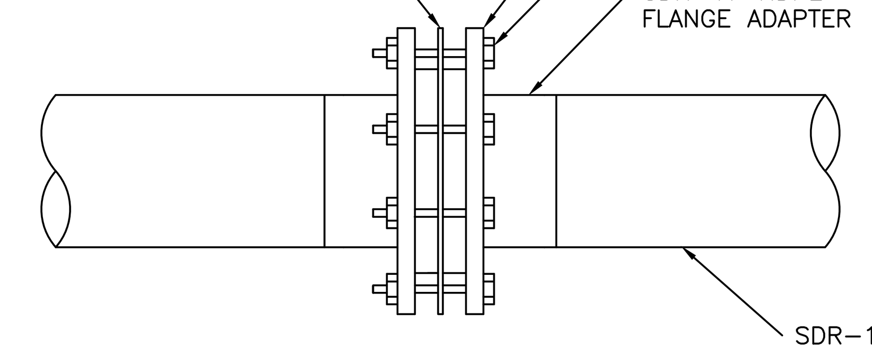
NOTES:

1. HDPE TEES SHALL BE USED TO TIE-IN 6"ø AND 8"ø LFG PIPE OR HEADER. TEES SHALL BE MOLDED UP TO LARGEST SIZE AVAILABLE. OTHERWISE TEES SHALL BE FABRICATED AND SUBMITTED TO ENGINEER FOR APPROVAL.
2. ELECTRO-FUSION COUPLING ONLY USED IF APPROVED BY TETRA TECH OR THE COUNTY OF KAUAI OR COUNTY IN WRITING.
3. SAND SHALL BE PLACED BELOW EACH TEE. THE SAND SHALL BE INSTALLED SO IT EXTENDS IN EACH DIRECTION OF THE TEE. SAND SHALL BE SLIGHTLY MOISTENED AND HAND-TAMPED PROVIDING SUPPORT TO ALL POINTS OF THE TEE. CLEAN, GRADED SOIL SHALL BE HAND-TAMPED ABOVE TEE, BEING CAREFUL TO ELIMINATE ALL VOIDS.

LANDFILL GAS LATERAL CONNECTION WITH TEE

DETAIL 1 / C-510

SCALE: NOT TO SCALE



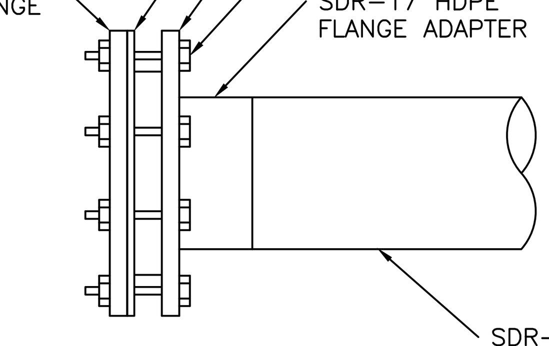
NOTES:

1. 5 MIL PLASTIC SHALL BE TAPED AROUND ALL BURIED FLANGE CONNECTIONS.
2. VALVE LOCATED BETWEEN FLANGES WITH APPROPRIATE SPACERS.
3. IF USING VALVE, EVERY OTHER BOLT INSTALLED THROUGH BOTH FLANGES, AND EVERY OTHER BOLT THROUGH FLANGE ON HEADER SIDE THROUGH VALVE ONLY. VALVE IS ASAHI TYPE 57 (2"-14"), TYPE 56 (16"), TYPE 75 (18"-24"), OR PDCPD (28"-40") BUTTERFLY VALVE. GEAR OPERATED, PVC BODY PPDISK, NITRILE OR VITON SEATS AND SEALS.
4. VALVE INCLUDES HDPE FLANGE ADAPTER, D.I. BACKUP RING, AND GALVANIZED OR ZINC PLATED NUTS, BOLTS AND WASHERS, HDPE VALVE SPACER OR ROUTER FLANGE ADAPTER TO ALLOW VALVE TO FULLY OPEN.

FLANGE ASSEMBLY

DETAIL 2 / C-510

SCALE: NOT TO SCALE



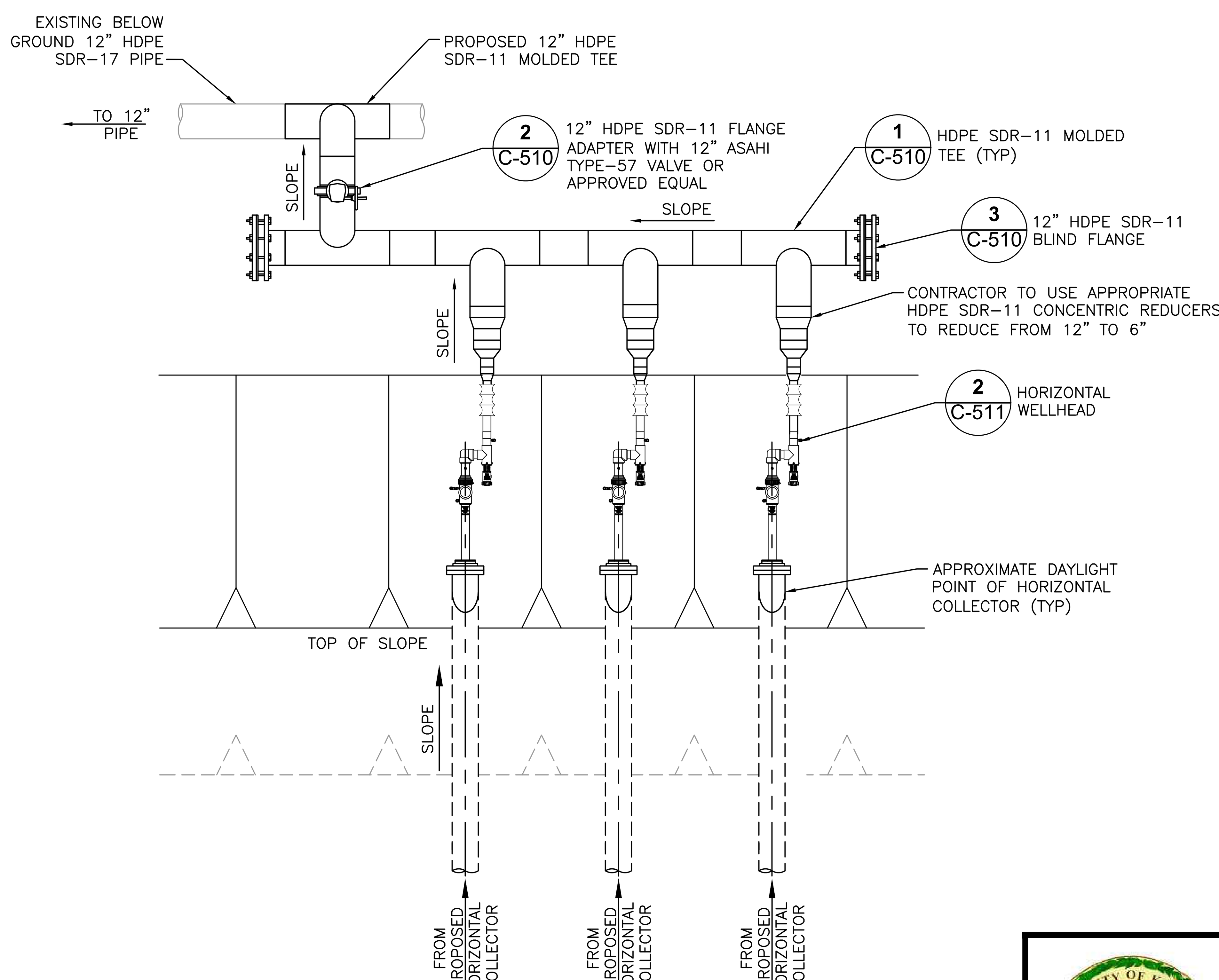
NOTES:

1. TAPE 5 MIL PLASTIC AROUND ALL BLIND FLANGES.

BLIND FLANGE ASSEMBLY

DETAIL 3 / C-510

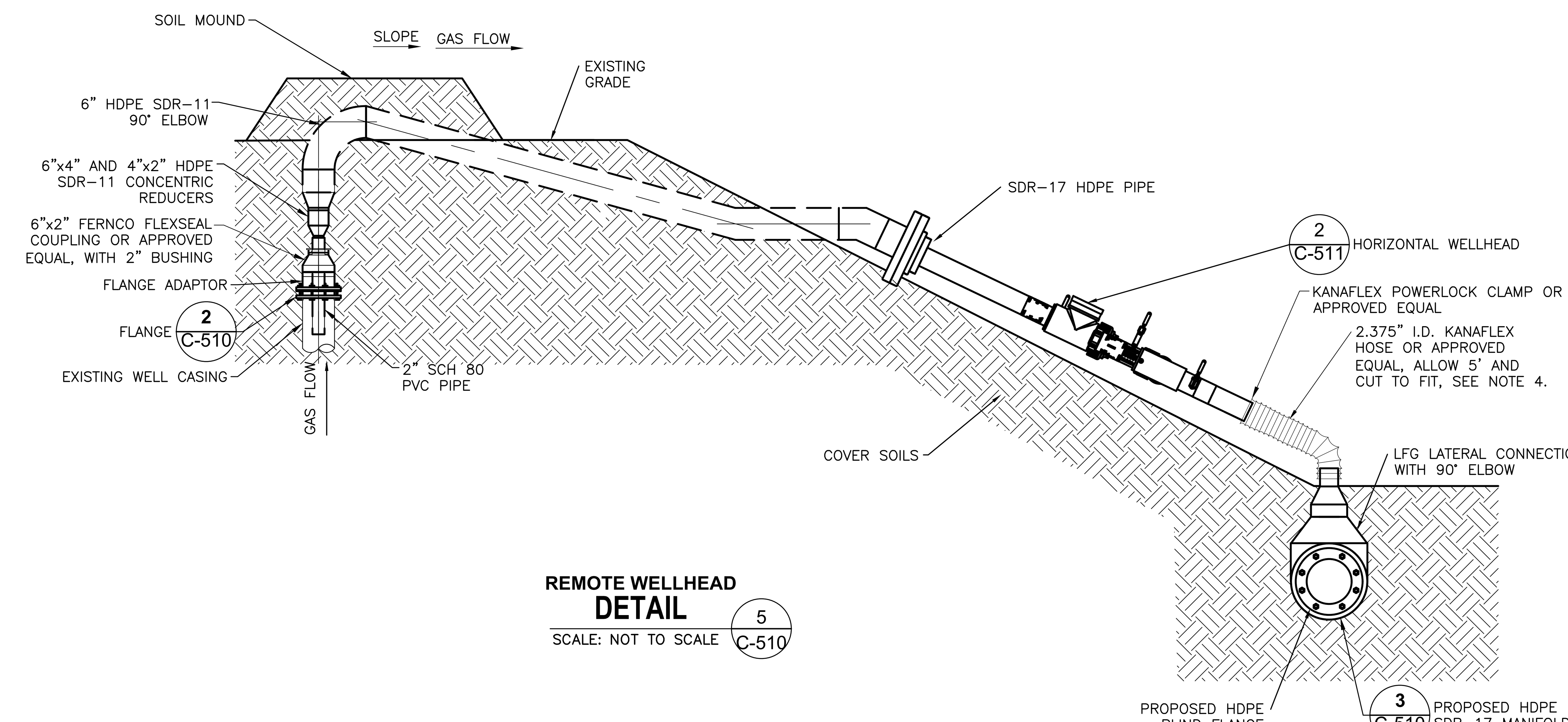
SCALE: NOT TO SCALE



WELLHEAD MANIFOLD FOR HORIZONTAL COLLECTORS

DETAIL 4 / C-510

SCALE: NOT TO SCALE



REMOTE WELLHEAD

DETAIL 5 / C-510

SCALE: NOT TO SCALE

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TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

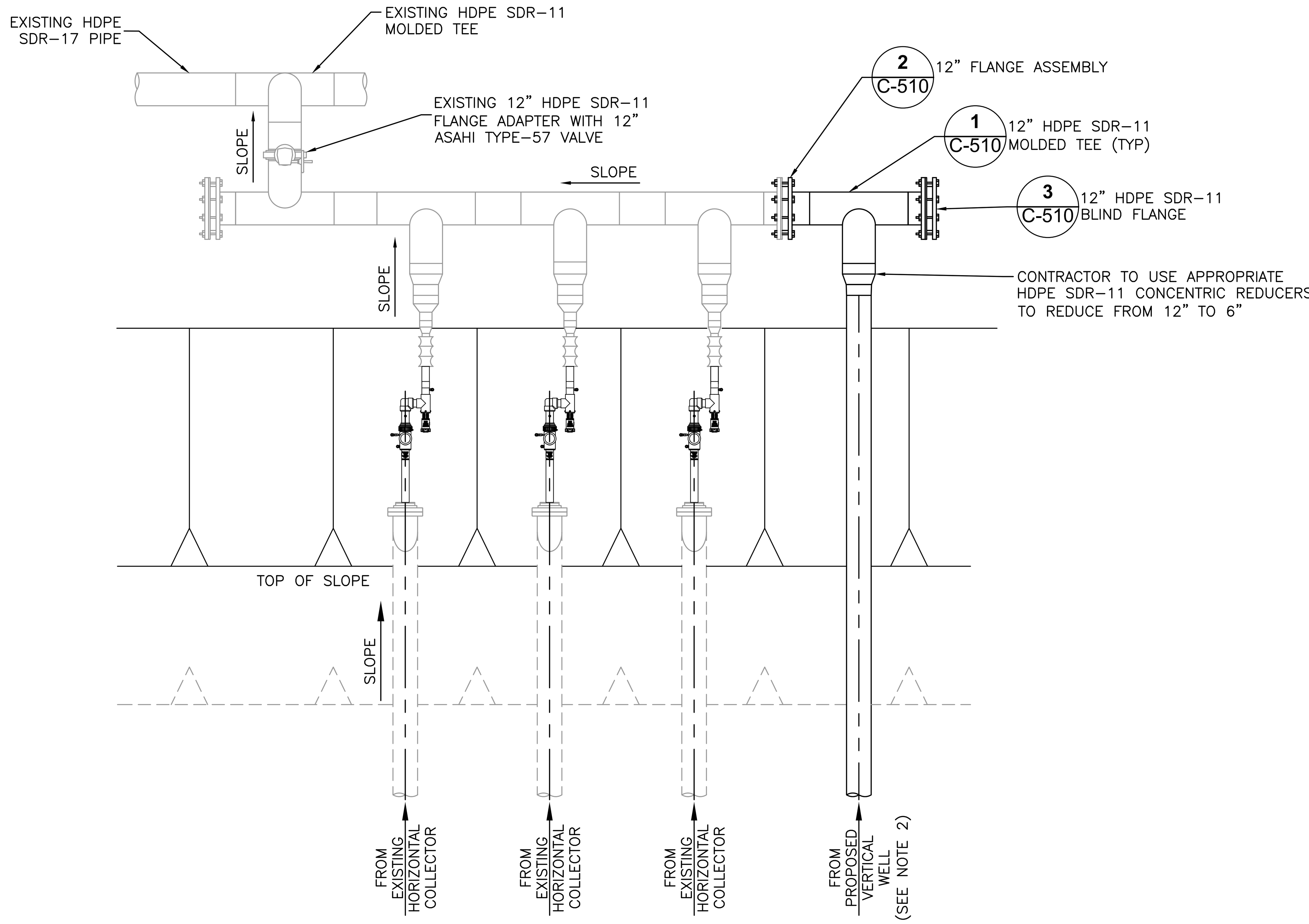
LICENSED PROFESSIONAL ENGINEER No. 12145 HAWAII U.S.A.

KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

GCCS DETAILS

DESIGNED BY : GRB/CME	CHECKED BY : AMN	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB/PJS	FILE : 220048-C-510_LF DETAILS.dwg

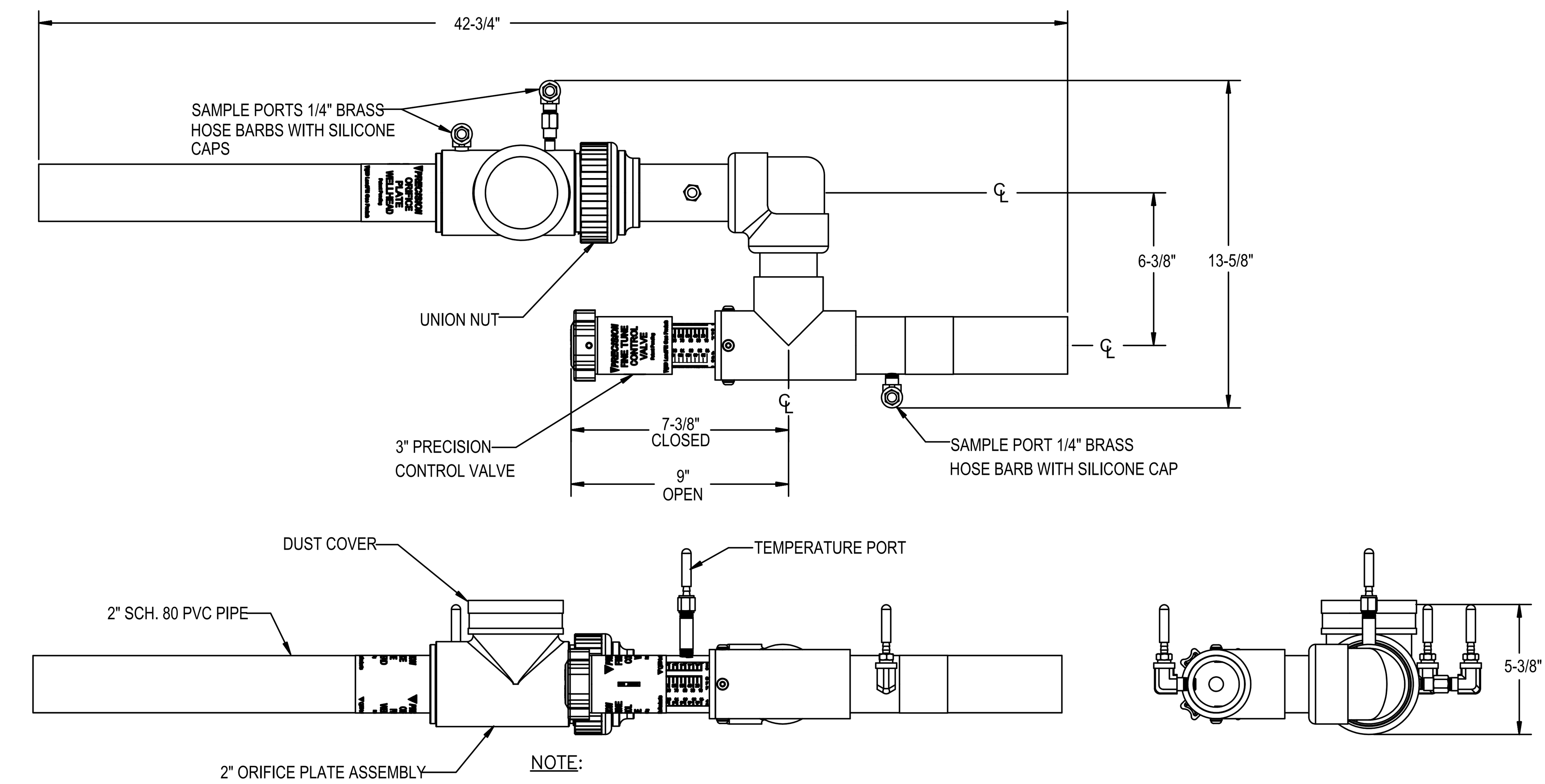
SHEET **C-510**



NOTE:
1. CONTRACTOR TO BED WITH CLEAN SOILS OR SAND TO PROVIDE APPROPRIATE SLOPE.
2. CONTRACTOR TO CHECK DRAINAGE SLOPE OF ALL WELLS AND PIPING BEING CONNECTED TO CONNECTION MANIFOLD TO ASSURE DRAINAGE IS MAINTAINED.

MANIFOLD EXTENSION

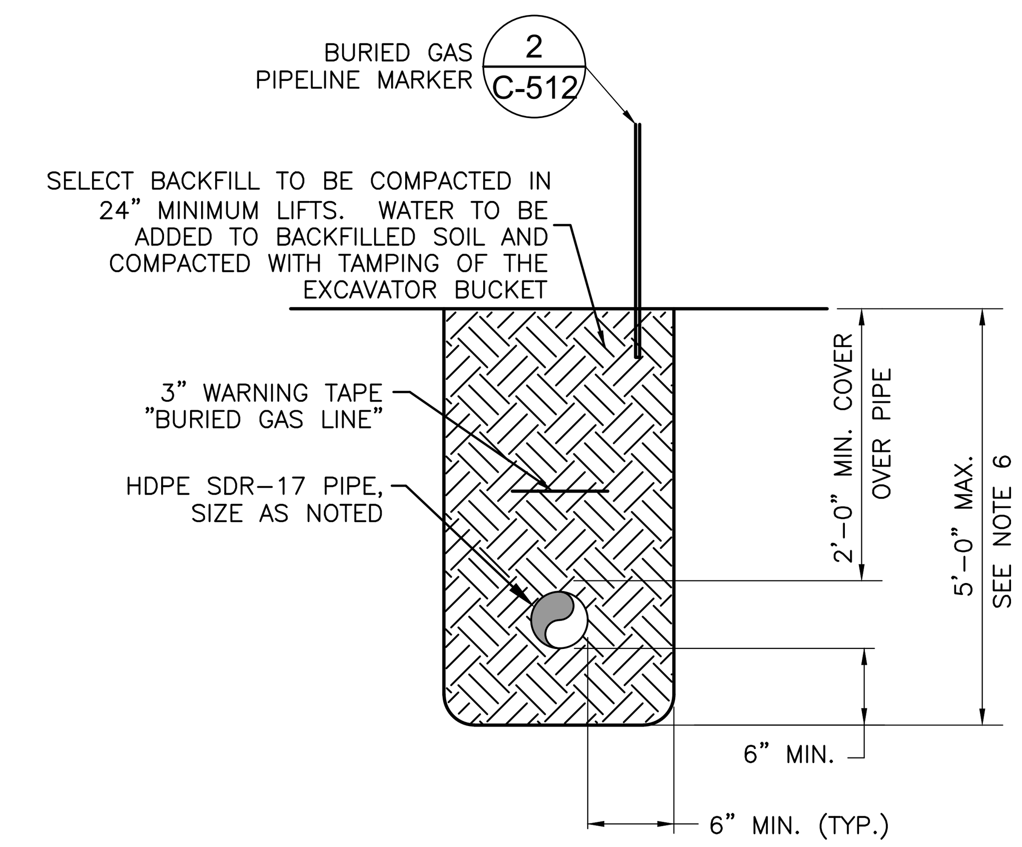
DETAIL 1 C-511
SCALE: NTS



NOTE:
1. WELLHEAD ASSEMBLY TO BE QED ORP315HL 2-INCH WELLHEAD OR APPROVED EQUAL.

2-INCH HORIZONTAL WELLHEAD

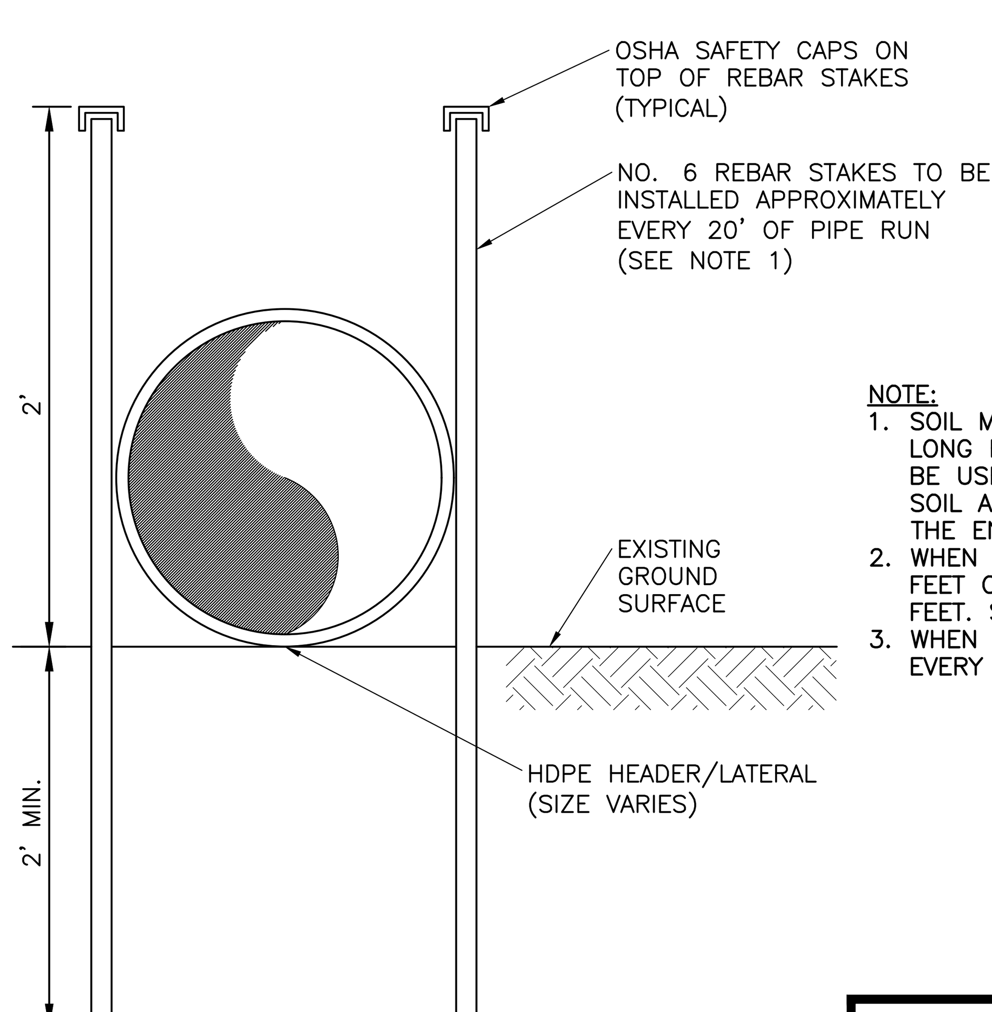
DETAIL 2 C-511
SCALE: NOT TO SCALE



NOTES:
1. PROVIDE MINIMUM PIPE DRAINAGE SLOPES OF 3% WITHIN WASTE LIMIT AND 1% OUTSIDE THE WASTE LIMIT, AS APPROVED BY THE OWNER/ENGINEER.
2. SLOPE PIPE THROUGH BENCH CROSSING TO MAXIMUM EXTENT POSSIBLE BUT NOT LESS THAN 5%.
3. PROVIDE BURIED GAS PIPELINE MARKER, SEE DETAIL 6 SHEET DS3 WHICH STATES "CAUTION BURIED GAS PIPING" OR APPROVED EQUAL.
4. BURIED GAS PIPELINE MARKERS TO BE SPACED AT A MAXIMUM OF 50' APART ON LANDFILL AND MAXIMUM AT 20' SPACING NEAR FLARE (SHEET 3B AND 3C).
5. BURIED PIPING 12" IN DIAMETER OR GRADER TO HAVE 6" MIN OF BEDDING UP TO CENTERLINE OF PIPE.
6. CONTRACTOR SHALL NOT TRENCH DEEPER THAN 5' BELOW GROUND SURFACE WITHOUT OBTAINING PERMISSION FROM ENGINEER PRIOR. ADDITIONAL FEES ASSOCIATED WITH TRENCHING DEEPER THAN 5' WITHOUT PRIOR APPROVAL WILL NOT BE PAID.

BURIED PIPE TRENCH

DETAIL 4 C-511
SCALE: NOT TO SCALE



NOTE:
1. SOIL MOUNDS MAY BE USED FOR STABILIZATION ON LONG RUNS WITH LITTLE ELEVATION CHANGE. REBAR TO BE USED ON SIDE SLOPES. SOME PIPES MAY REQUIRE SOIL AND REBAR FOR STABILIZATION AS DIRECTED BY THE ENGINEER.
2. WHEN USE OF SOIL MOUNDS IS APPROPRIATE, TWO FEET OF SOIL SHALL BE PLACED OVER PIPE FOR FIVE FEET. SOIL MOUND SPACING EVERY 50' OF PIPE RUN.
3. WHEN USE OF REBAR IS APPROPRIATE, REBAR SPACED EVERY 20' OF PIPE RUN.

ABOVE GRADE HEADER/LATERAL

DETAIL 3 C-511
SCALE: NOT TO SCALE

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TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

LICENSED PROFESSIONAL ENGINEER No. 12145 HAWAII U.S.A. Exp. 4/30/2? 11/28/23

KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION

GCCS DETAILS

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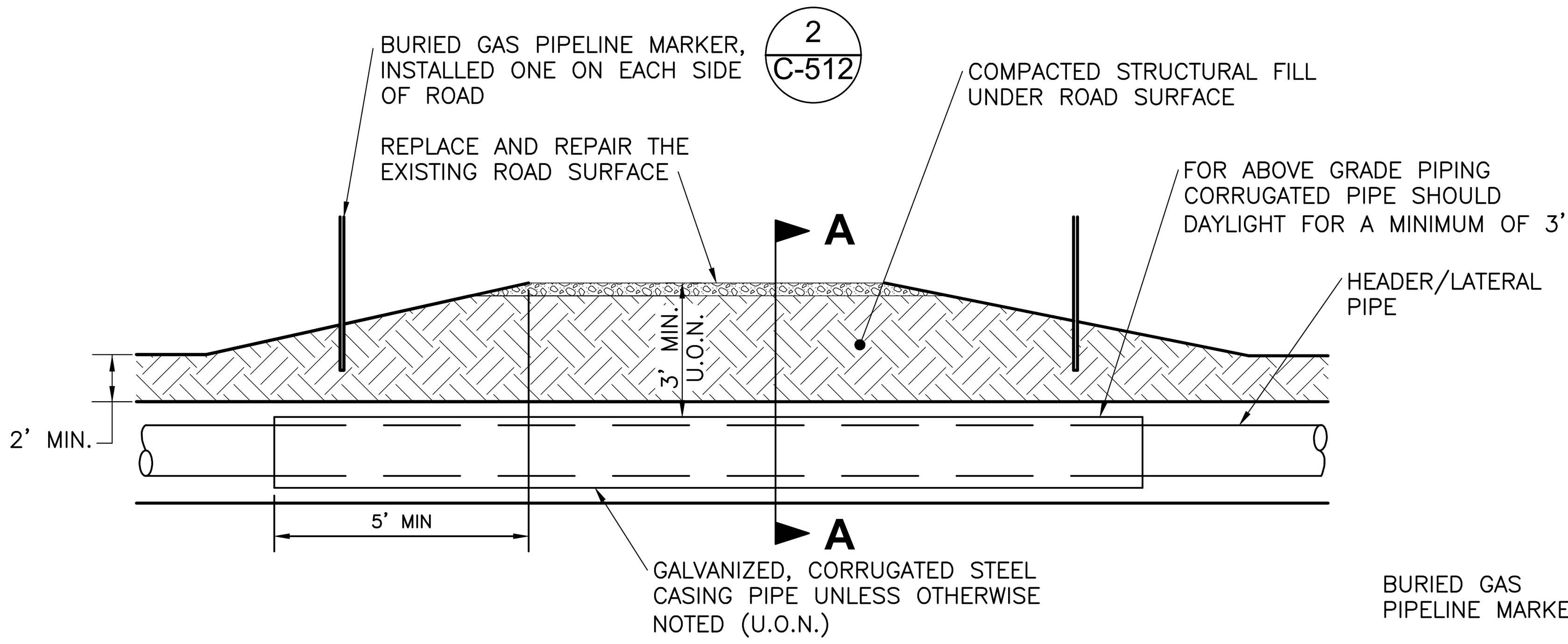
SHEET
C-511

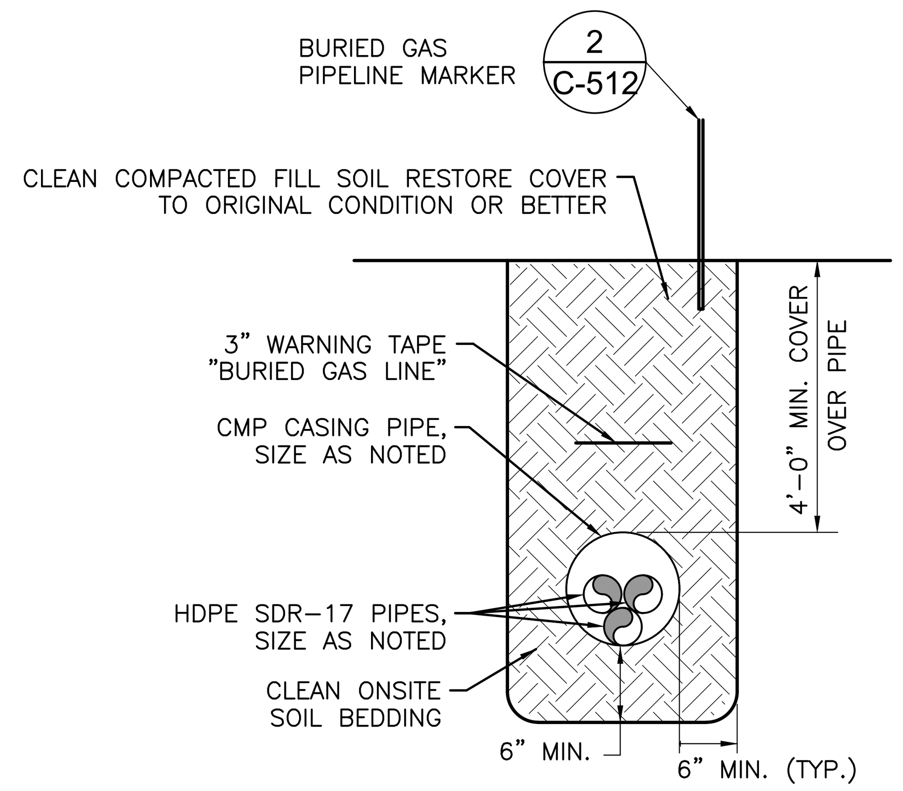


PIPE SCHEDULE	
6" LATERAL PIPE	12" CASING PIPE OR APPROVED EQUAL
8" LATERAL PIPE	12" CASING PIPE OR APPROVED EQUAL
12" LATERAL PIPE OR 2"x6" LATERAL PIPE	18" CASING PIPE OR APPROVED EQUAL
3"x6" LATERAL PIPE	24" CASING PIPE OR APPROVED EQUAL

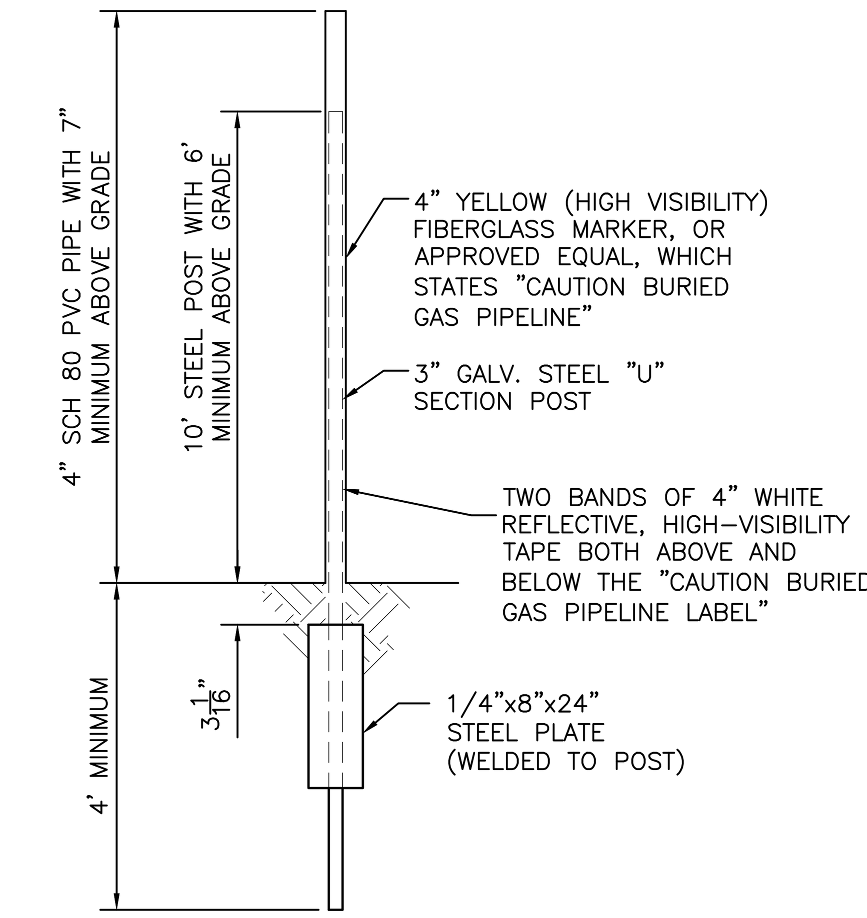
NOTE:
1. CONTRACTOR TO LAY OUT THE PIPE TO CONFORM TO FIELD CONDITIONS. PROVIDE 4' MINIMUM COVER AND 5% MINIMUM PIPE SLOPE CROSSING BELOW PERIMETER AND MAIN HAUL ROADS.
2. PROVIDE BURIED GAS PIPELINE MARKER, SEE DETAIL 6 SHEET DS3 WHICH STATES "CAUTION BURIED GAS PIPING" OR APPROVED EQUAL AT BOTH SIDES OF ROAD CROSSING.

TYPICAL ROAD CROSSING

DETAIL 1 C-512
SCALE: NOT TO SCALE



SECTION A-A

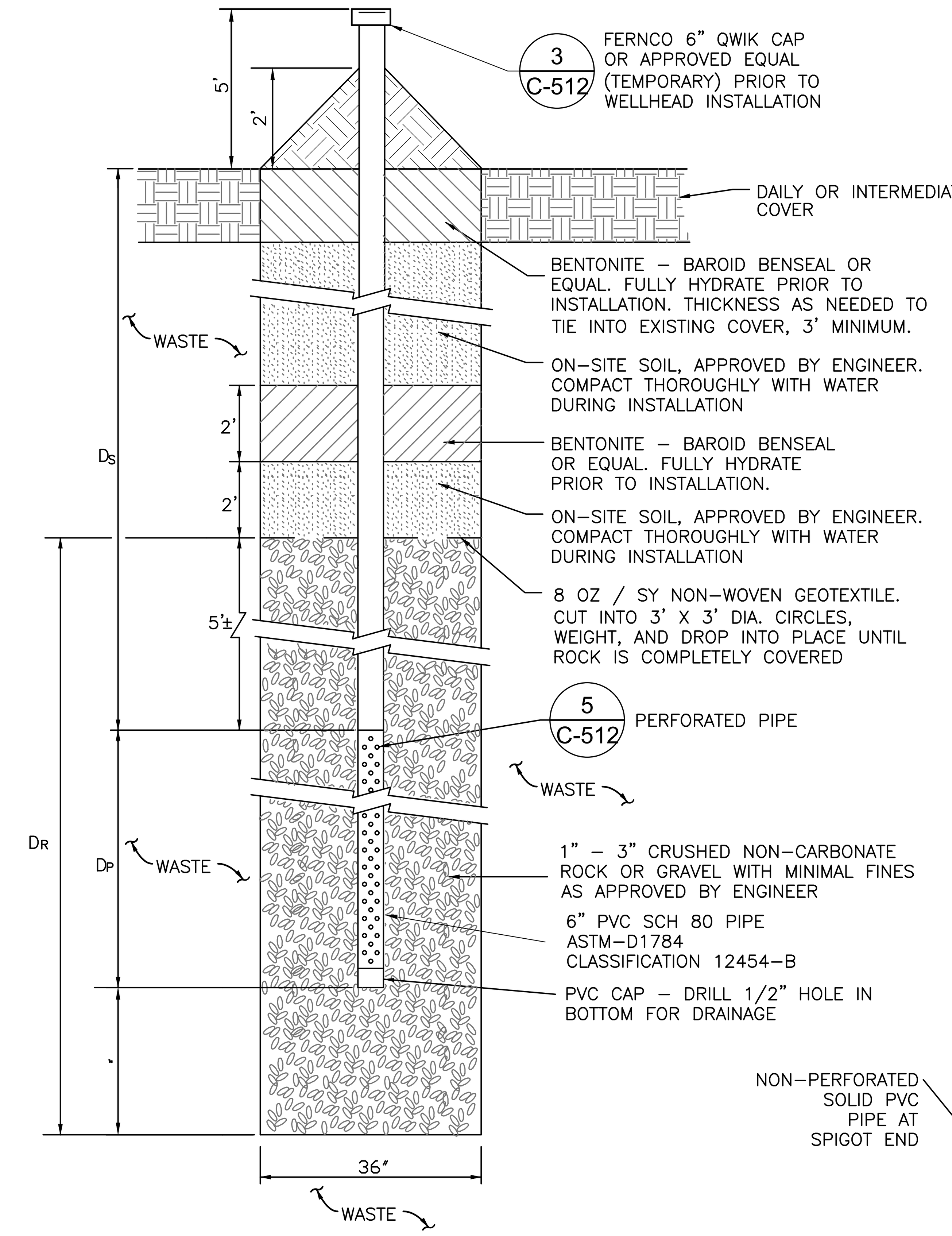


NOTE:
1. TYPICAL BURIED GAS PIPELINE MARKER OR EQUIVALENT HIGH VISIBILITY MARKERS TO BE USED.

BURIED GAS PIPELINE MARKER

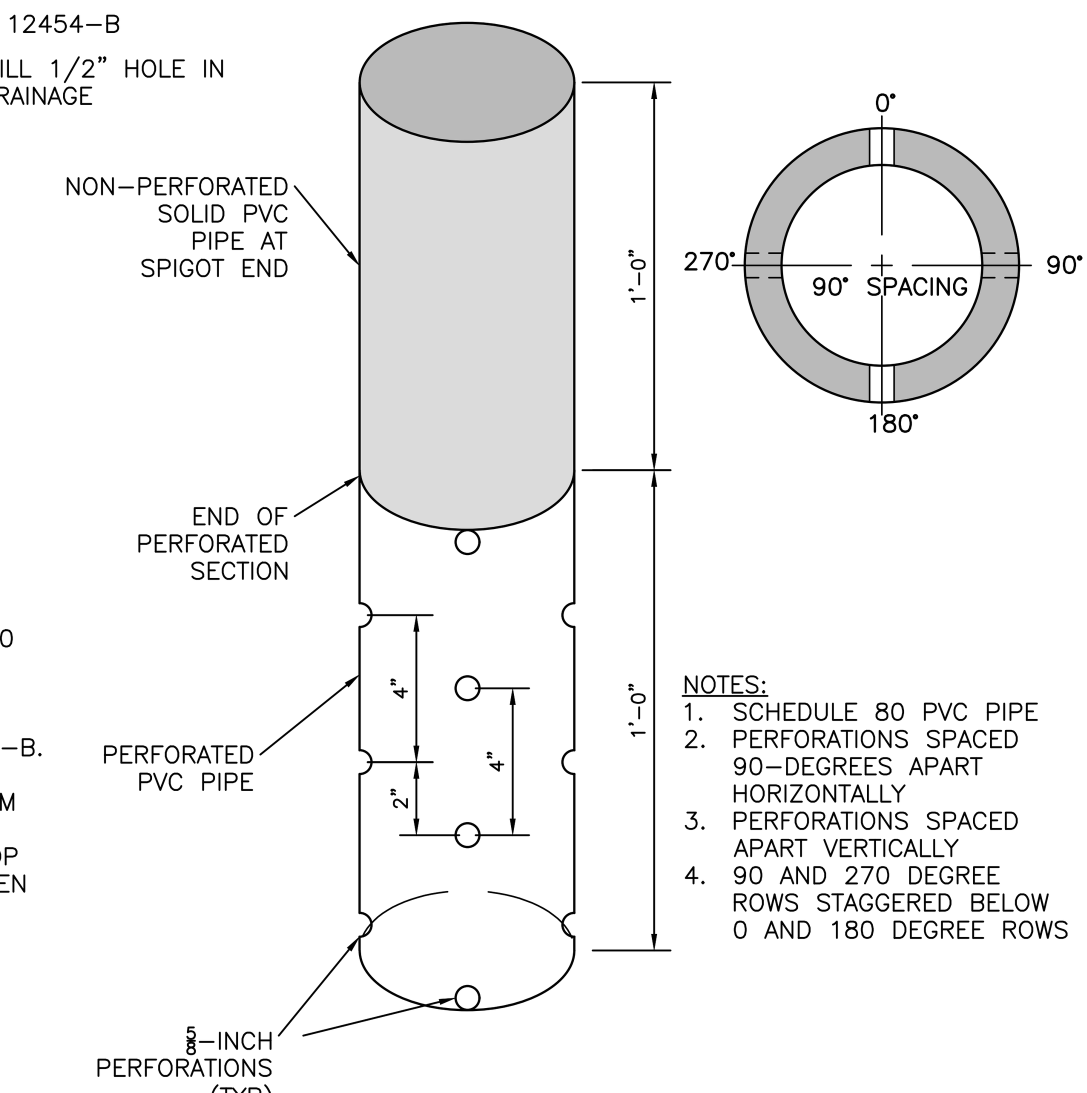
DETAIL 2 C-512
SCALE: NOT TO SCALE

TYPICAL LFG EXTRACTION WELL



DETAIL 4 C-512
SCALE: NOT TO SCALE

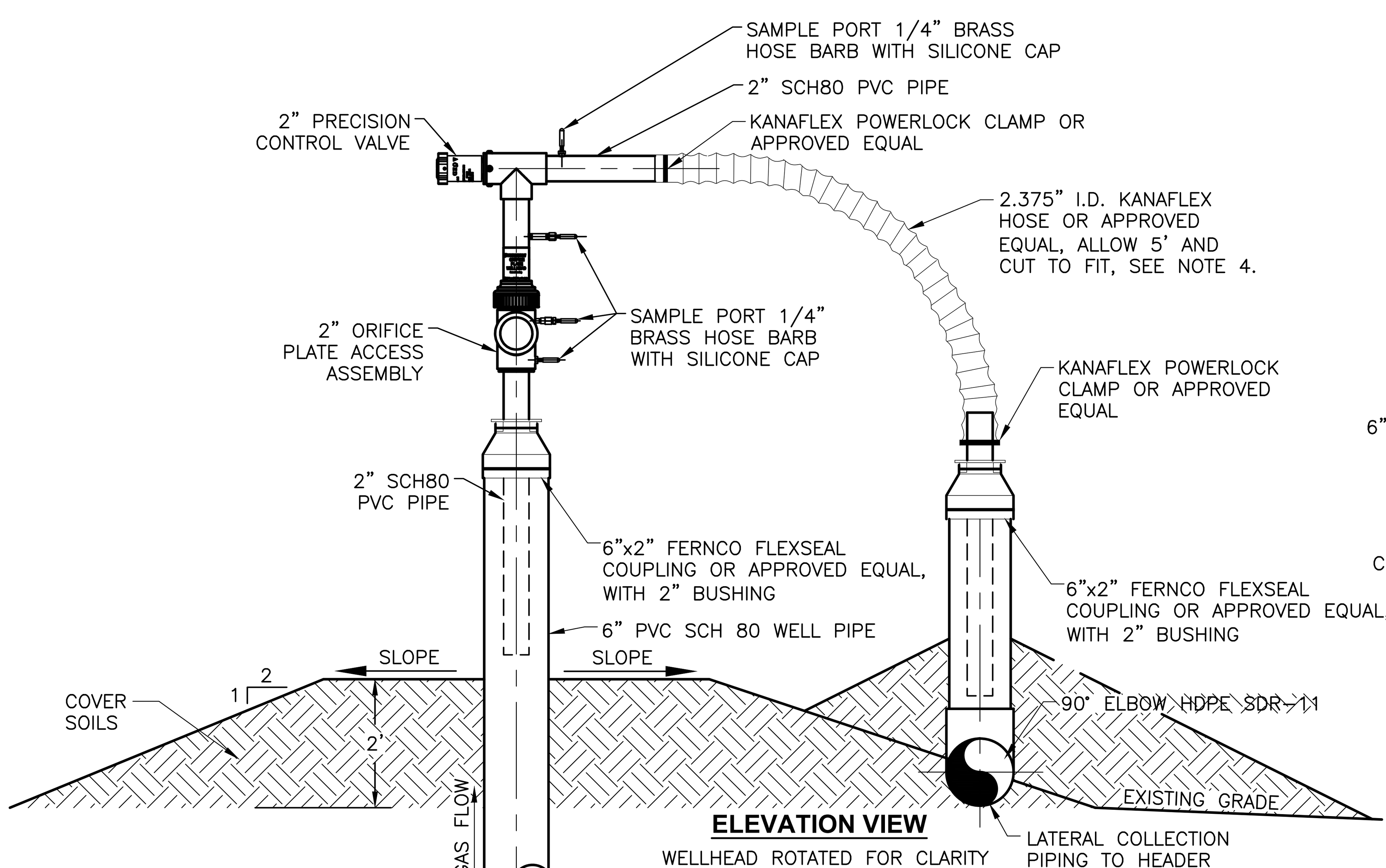
NOTES:
1. WELL PIPE TO BE BELL AND SPIGOT OR JOINED WITH PVC SCH 80 COUPLINGS.
2. PVC SOLVENT WELD AND INSTALL FOUR 1/4" BY 1" LONG GALVANIZED LAG BOLTS @ 90° ON CENTER ON EACH JOINT.
3. PVC WITH MINIMUM ASTM D-1784 CELL CLASSIFICATION OF 12454-B.
4. D_R = DEPTH OF ROCK
   D_S = DEPTH OF SOLID PIPE (BELOW GRADE) - 25 FEET MINIMUM
   D_P = LENGTH OF PERFORATED PIPE
5. MINIMUM 15 FEET SEPARATION BETWEEN BASE OF BORING AND TOP OF LINER SYSTEM, PROVIDE MINIMUM 20 FEET SEPARATION BETWEEN BASE OF BORING AND TOP OF LINER SYSTEM ON LINER SIDE SLOPES.
6. 1"-3" NON-CARBONATE GRAVEL WITH MINIMAL FINES.
7. WELL DRILLING WILL NOT COMMENCE UNTIL BOTTOM LINER ELEVATIONS ARE IDENTIFIED AND VERIFIED BY PROJECT SURVEYOR, DESIGN ENGINEER, AND CQA REPRESENTATIVE.
8. WELL DRILLING TABLE WILL BE MANAGED BY THE CLIENT OR A DESIGNATED REPRESENTATIVE TO ENSURE ONLY THE VERIFIED WELL DEPTHS ARE PRESENT, AND THAT DRILLER AND CQA REPRESENTATIVE HAVE THE IDENTICAL INFORMATION PRIOR TO DRILLING.



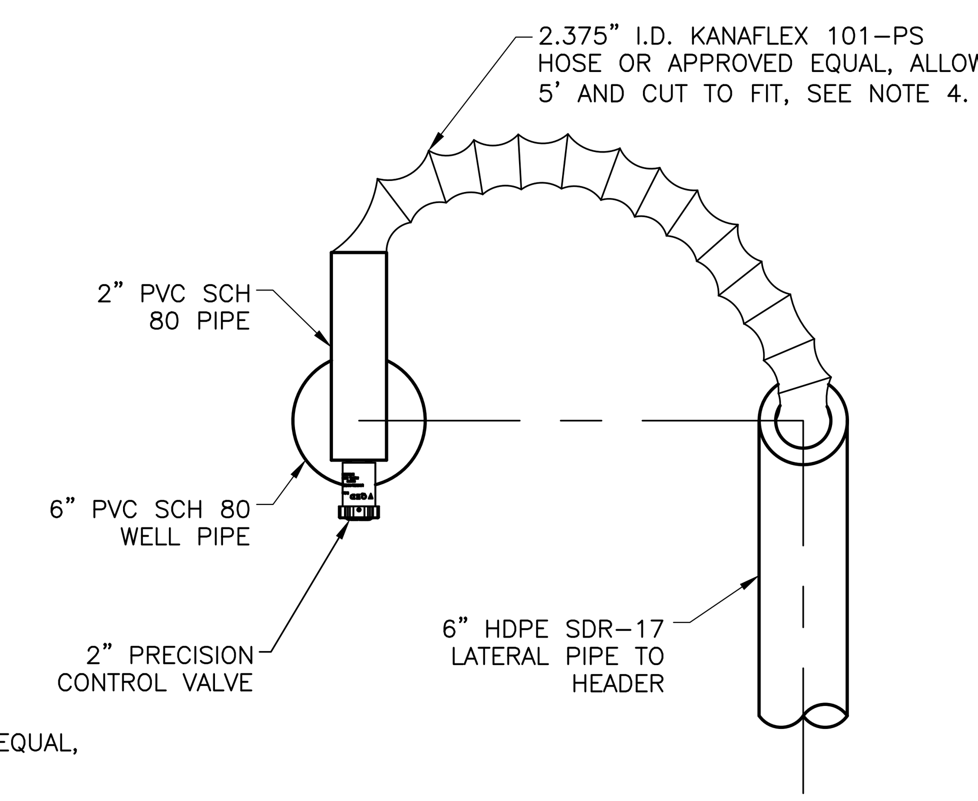
NOTES:
1. SCHEDULE 80 PVC PIPE
2. PERFORATIONS SPACED 90-DEGREES APART HORIZONTALLY
3. PERFORATIONS SPACED APART VERTICALLY
4. 90 AND 270 DEGREE ROWS STAGGERED BELOW 0 AND 180 DEGREE ROWS

PERFORATED PIPE

DETAIL 5 C-512
SCALE: NOT TO SCALE



ELEVATION VIEW
WELLHEAD ROTATED FOR CLARITY SEE PLAN VIEW BELOW FOR ACTUAL ALIGNMENT OF WELLHEAD



PLAN VIEW

NOTES:
1. WELLHEAD ASSEMBLY QED ENVIRONMENTAL SYSTEMS 2-INCH WELLHEAD OR APPROVED EQUAL.
2. PROVIDE HIGH VISIBILITY REFLECTIVE TAPE AROUND TOP 1-FOOT OF WELL CASING AND LATERAL PIPE.
3. INSTALL FLEX HOSE WITH EXCESS HOSE TO ALLOW MOVEMENT OF LATERAL BUT CONFIGURED AS NECESSARY TO PREVENT SAG AND WATER ACCUMULATION. ALL INSTALLATIONS SHALL BE INSPECTED BY ENGINEER PRIOR TO APPROVAL.
4. WELLHEAD SHALL BE INSTALLED 90° FROM LATERAL PIPE, SEE PLAN VIEW DETAIL.

VERTICAL WELLHEAD

DETAIL 3 C-512
SCALE: NOT TO SCALE

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21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

LICENSED PROFESSIONAL ENGINEER No. 12145 HAWAII U.S.A.

KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION
GCCS DETAILS

SHEET **C-512**

DESIGNED BY : GRB/CME	CHECKED BY : AMN	DATE : NOV 2023
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INSTRUCTIONS:

PREPARE AND ORGANIZE REQUIRED SUPPLIES AT THE VERTICAL LANDFILL GAS EXTRACTION WELL LOCATION PRIOR TO PERFORMING ANY WORK.

SUPPLIES INCLUDE:

- CORDLESS DRILL
- CHOP SAW / RECIPROCATING SAW
- GENERATOR
- HEX–HEAD STYLE BIT FOR DRILL
- HEX–HEAD STYLE HAND SCREWDRIVER
- SIX–INCH DIAMETER STEEL SHEET METAL PLATE OR EQUIVALENT (TO BLOCK FLOW INTO VACUUM RISER DURING FUSION)
- 4–GAS METER (TO WEAR FOR SAFETY)
- FLAME IONIZATION DETECTOR (FID) (TO MEASURE SURFACE EMISSIONS)

FOR PVC/CPVC PIPE

- LAG SCREWS – 3/8" DIAMETER X 3/4" LENGTH
- OATEY→ PVC HEAVY DUTY ORANGE CEMENT (TO JOIN PLASTIC PIPE AND FITTINGS) WHICH COMPLIES WITH ASTM F493. (SEE SPECIFICATIONS SECTION 33 51 16.23)
- OATEY→ PVC INDUSTRIAL GRADE PURPLE PRIMER (TO REMOVE GLOSS AND PREPARE PIPE FOR SOLVENT WELDING) WHICH COMPLIES WITH ASTM F656. (SEE SPECIFICATIONS SECTION 33 51 16.23)
- OATEY→ CPVC HEAVY DUTY ORANGE CEMENT (TO JOIN PLASTIC PIPE AND FITTINGS) WHICH COMPLIES WITH ASTM F493. (SEE SPECIFICATIONS SECTION 33 51 16.23)
- OATEY→ CPVC INDUSTRIAL GRADE PURPLE PRIMER (TO REMOVE GLOSS AND PREPARE PIPE FOR SOLVENT WELDING) WHICH COMPLIES WITH ASTM F656. (SEE SPECIFICATIONS SECTION 33 51 16.23)
- CLEAR CLEANER (TO QUICKLY REMOVE DIRT, GREASE, AND MOISTURE FROM PIPES AND FITTINGS BEFORE SOLVENT WELDING). (SEE SPECIFICATIONS SECTION 33 51 16.23)
- APPLICATION SWABS
- PVC/CPVC BELL AND SPIGOT STYLE PIPING – MATERIAL AND SIZE TO MATCH EXISTING WELL CASING (SEE SPECIFICATIONS SECTION 33 51 16.23)
- PVC/CPVC CONNECTION COUPLERS (SEE SPECIFICATIONS SECTION 33 51 16.23)
- BENTONITE – 8–MESH OR FINER (SEE SPECIFICATIONS SECTION 31 23 23.14)

FOR HDPE PIPE / ELECTRO–FUSION WELDING

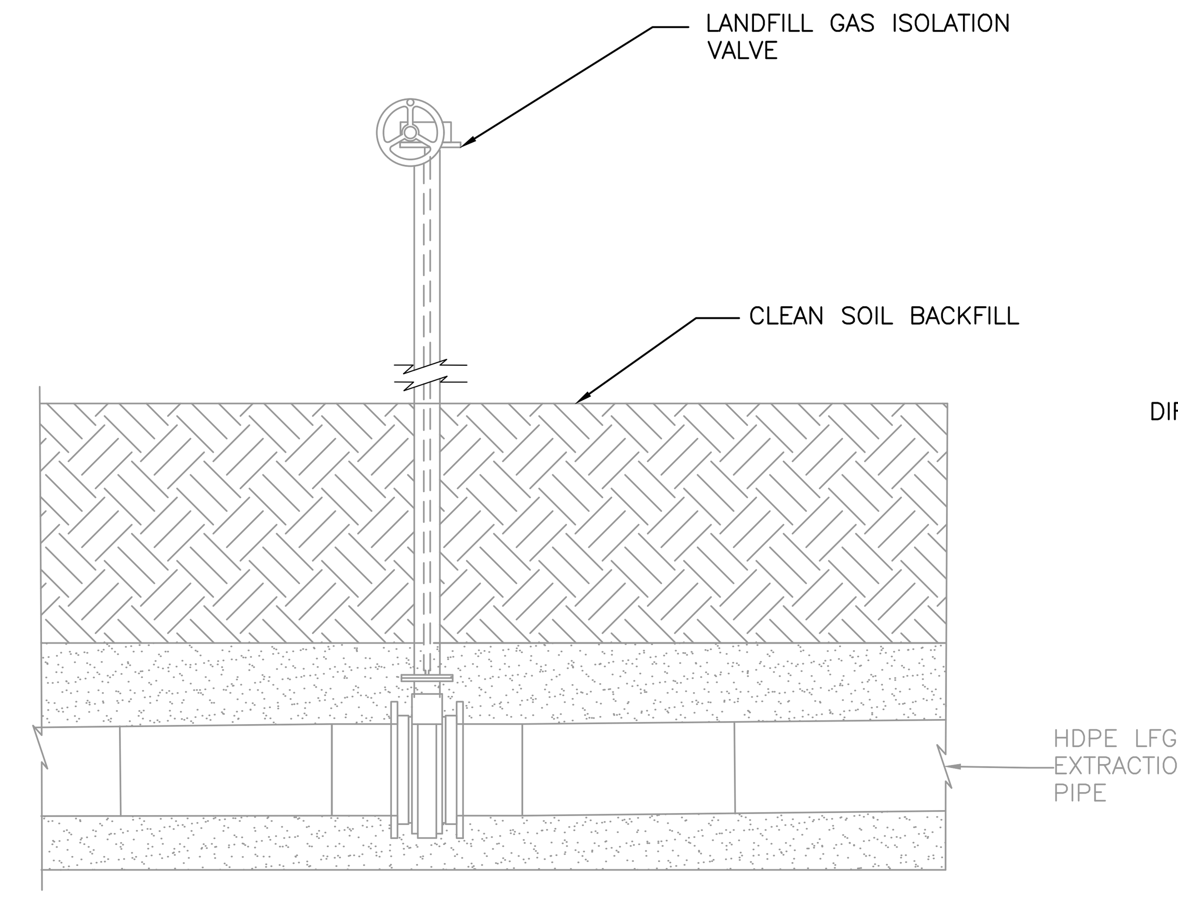
- GENERATOR OF SUFFICIENT POWER TO SERVICE ELECTRO–FUSION EQUIPMENT.
- MCELROY PIT BULL OR EQUIVALENT ELECTRO–FUSION MACHINERY – FOUR–INCH/SIX–INCH (IF ELECTRO–FUSION COUPLERS ARE APPROVED BY THE SITE ENGINEER).
- ELECTRO–FUSION COUPLER(S) (IF ALLOWED BY SITE ENGINEER).
- PIPE SCRAPING EQUIPMENT CAPABLE OF SCRAPING PIPE ENDS OR TAPPING TEE SURFACES, EXTENDING BEYOND THE AREA TO BE COVERED BY THE FITTING.
- ANCILLARY EQUIPMENT: WELDING TENT, SOLVENT BASED MARKER AND CLEAN, DRY LINT–FREE CLOTH OR PAPER TOWEL.

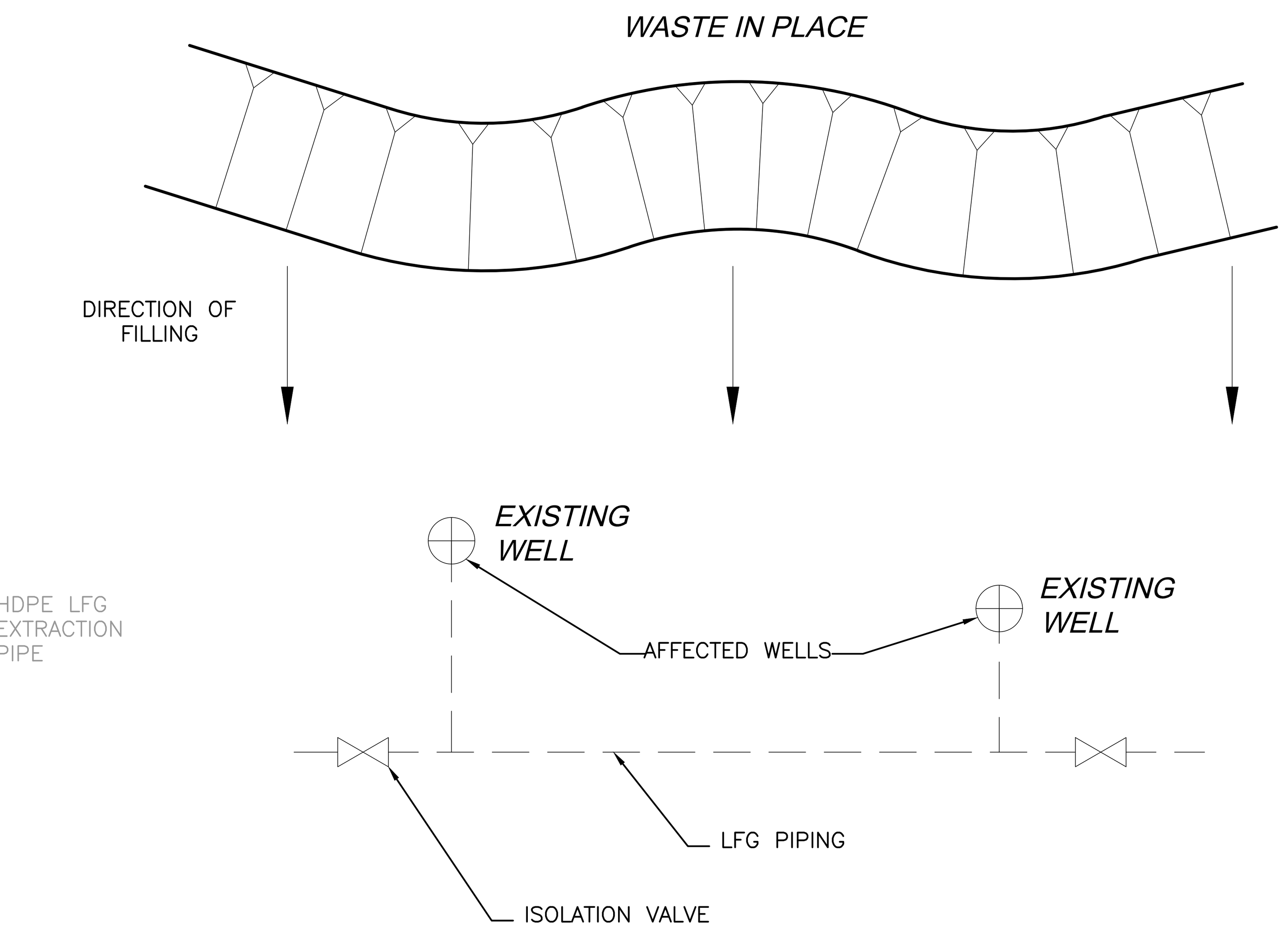
FOR HDPE PIPE / BUTT FUSION WELDING

- GENERATOR OF SUFFICIENT POWER TO SERVICE BUTT FUSION EQUIPMENT.
- MCELROY PIT BULL OR EQUIVALENT ELECTRO–FUSION MACHINERY – FOUR–INCH/SIX–INCH
- ANCILLARY EQUIPMENT: WELDING TENT, SOLVENT BASED MARKER AND CLEAN, DRY LINT–FREE CLOTH OR PAPER TOWEL.

STEP 1
ORGANIZE SUPPLIES

NOTE: WELL RAISING SOP INCLUDES STEPS 1–11 IN SHEETS C–513 THROUGH C–518





INSTRUCTIONS:

- THE FIELD TECHNICIAN SHOULD DETERMINE FROM THE OPERATIONS MANAGER THE EXTENT OF THE WASTE FILLING OPERATIONS AND THE DESIRED FINAL ELEVATION OF THE SUBJECT AREA IN ORDER TO DETERMINE THE QUANTITY AND LOCATION(S) OF AFFECTED WELLS, THE IDEAL METHOD(S) AND LOCATION(S) TO ISOLATE THE SYSTEM VACUUM PIPING, AND TO PROPERLY PREPARE THE NECESSARY QUANTITY OF RISER MATERIALS AND LFG PIPING ADDITIONS OR CHANGES.
- THE FIELD TECHNICIAN SHOULD LOCATE (IF APPLICABLE) ISOLATION VALVES ON ADJACENT HEADER/LATERAL PIPING TO ISOLATE THE AFFECTED WELL(S) FROM THE SYSTEM VACUUM AND DETERMINE THE QUANTITY OF WELLS AFFECTED BY CLOSING THE VALVE(S). THE FIELD TECHNICIAN SHOULD CONSULT THE SITE ENVIRONMENTAL MANAGER/ENGINEER PRIOR TO CLOSING THE ISOLATION VALVES, SHOULD THE FLARE/ENGINE FACILITY (IF APPLICABLE) BE AFFECTED. WHEN THE WELL RAISING PROCESS IS COMPLETE, THE FIELD TECHNICIAN SHOULD OPEN ISOLATION VALVES THAT WERE CLOSED.
- THE FIELD TECHNICIAN SHOULD COMMUNICATE ALL WELL RAISING PLANS TO THE OPERATIONS MANAGER SO THAT PRECAUTIONARY MEASURES MAY BE EXPLAINED TO OPERATIONS PERSONNEL.
- FILLING OPERATIONS SHOULD AVOID THE SUBJECT AREA(S) UNTIL THE FIELD TECHNICIAN HAS PROPERLY PREPARED THE WELL(S) AND RISER(S) FOR RAISING.
- IF SITE OPERATIONS REMOVES SURFACE SOIL PRIOR TO WASTE PLACEMENT, THE FIELD TECHNICIAN SHOULD INFORM THE OPERATIONS MANAGER TO LEAVE A MINIMUM FIVE–FOOT OFFSET OF UNTOUCHED SURFACE SOIL AROUND THE WELL CASING TO AVOID POTENTIAL DAMAGE TO THE WELL CASING(S) AND LATERAL RISER(S).

STEP 2
FIELD COMMUNICATION ON OPERATIONS AND WELL RAISING PLANS

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

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TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

PAUL STOUT LICENSED PROFESSIONAL ENGINEER No. 12145 HAWAII U.S.A. Exp 4/30/24 11/28/23

KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION
GCCS DETAILS

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SHEET **C-513**

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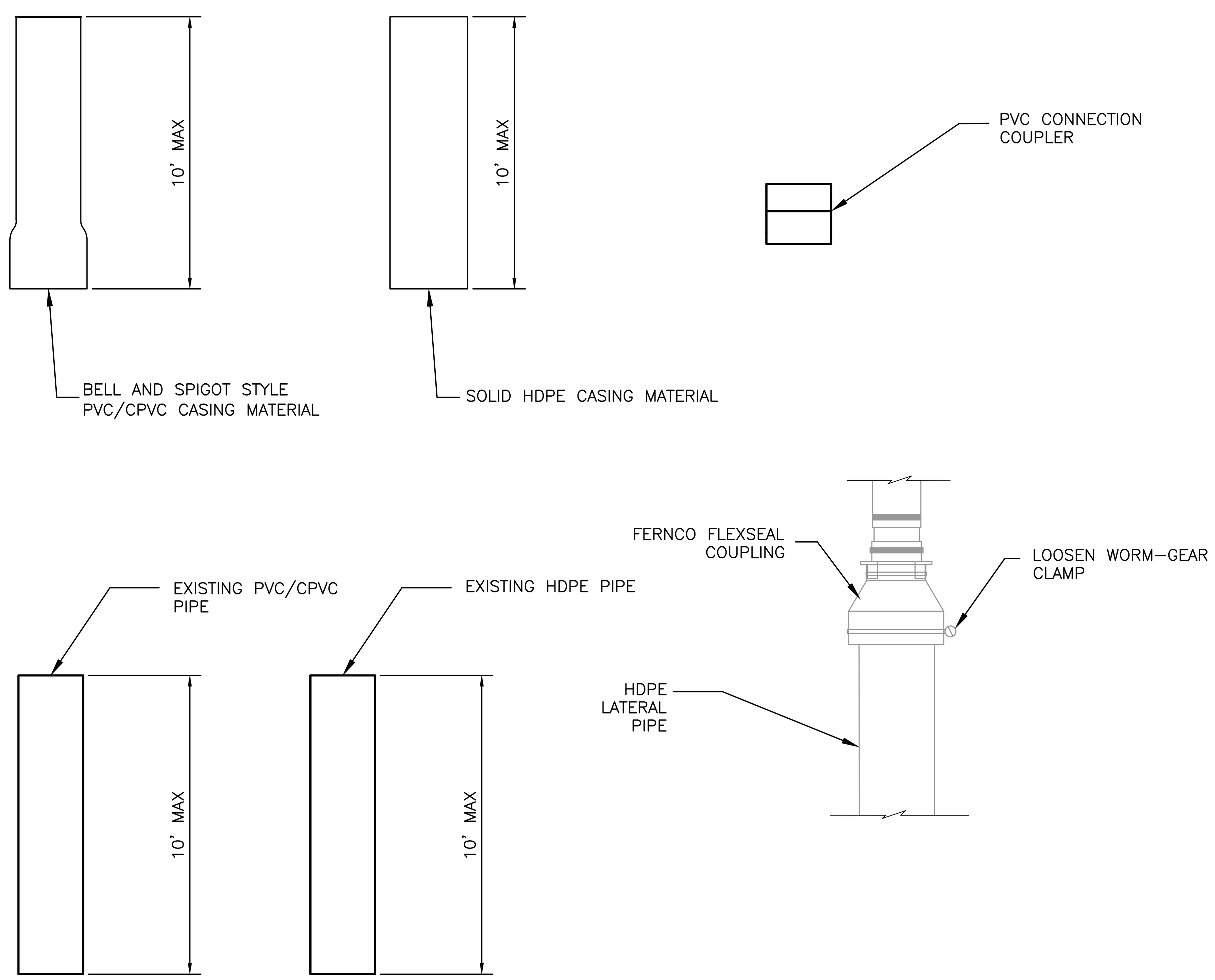

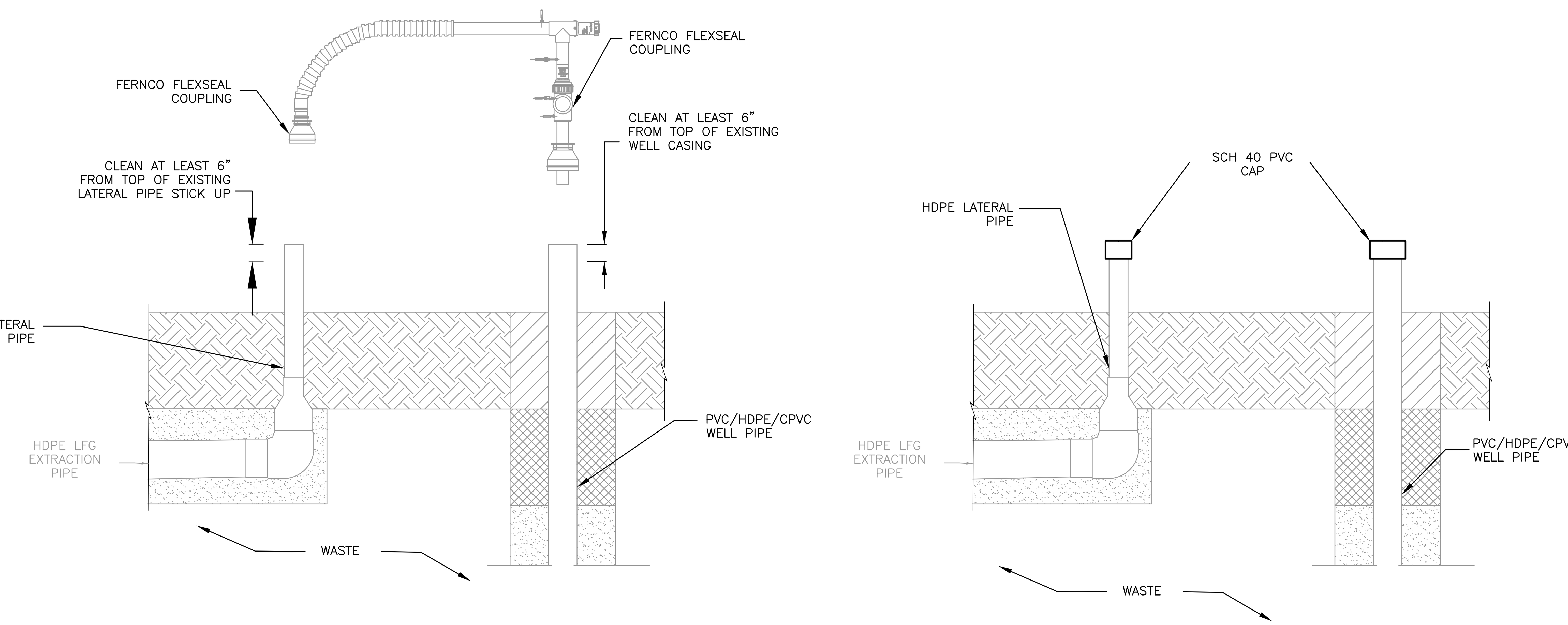

INSTRUCTIONS:

- UPON DETERMINING THE LOCATION OF THE SUBJECT WELL(S) AND QUANTITY OF MATERIALS REQUIRED TO COMPLETE THE RAISING OF THE WELL(S), THE FIELD TECHNICIAN SHOULD LOAD ALL NECESSARY MATERIALS FOR THE SUBJECT WELL(S) INTO THE SITE VEHICLE.
- WELL CASING RISER SEGMENTS SHOULD BE CUT INTO LENGTHS NOT EXCEEDING 10 FEET FOR EASE OF INSTALLATION, AND TO AVOID DAMAGE TO THE WELL CASING CAUSED BY THE STRESSES FROM WIND AND MATERIAL WEIGHT. MULTIPLE SEGMENTS OF RISER PIPING MAY BE REQUIRED AT EACH WELL DURING A FILLING OPERATION. USE BELL AND SPIGOT TYPE PIPING FOR EASE OF INSTALLATION FOR PVC/CPVC WELL CASING.
- TO CONNECT SHORTER SEGMENTS OF CASING RISER MATERIALS, USE PVC/CPVC CONNECTION COUPLERS INSTEAD OF BELL AND SPIGOT TYPE PIPING. IF SMALL SEGMENTS WITH CONNECTION COUPLERS ARE USED, THE TECHNICIAN SHOULD PREPARE THE SEGMENT BY ATTACHING THE CONNECTION COUPLER TO THE END OF THE RISER SEGMENT WITH PRIMER, GLUE, AND FOUR LAG SCREWS.
- PLEASE SEE DRAWING ABOVE FOR DETAILED REPRESENTATION OF WELL RAISING PREPARATION.

STEP 3
PREPARATION FOR WELL RAISING PROCEDURE

INSTRUCTIONS:

- THE RELEVANT ISOLATION VALVE(S) SHOULD BE CLOSED PRIOR TO REMOVING THE WELLHEAD, IN ORDER TO MINIMIZE AIR INTRUSION INTO THE GCCS. THE FIELD TECHNICIAN SHOULD NOT CLOSE ANY ISOLATION VALVE WITHOUT CONSULTING THE SITE ENVIRONMENTAL MANAGER/ENGINEER.
- THE TECHNICIAN SHOULD REMOVE THE WELLHEAD, FIRST BY LOOSENING THE LOWEST STAINLESS STEEL WORM-GEAR CLAMP ON THE FERNCO FLEXSEAL COUPLING OF THE WELLHEAD TO THE WELL CASING USING A HEX-HEAD STYLE HAND SCREWDRIVER, AND THEN LOOSENING THE LOWEST WORM-GEAR CLAMP ON THE FERNCO FLEXSEAL COUPLING OF THE FLEX-HOSE TO THE HDPE LFG EXTRACTION PIPE. REMOVE THE WELLHEAD AND FLEX-HOSE SIMULTANEOUSLY TO AVOID DAMAGE TO THE WELLHEAD AND PLACE ON A CLEAN SURFACE.
- PLACE A SCH40 PVC CAP ONTO THE HDPE EXTRACTION PIPE RISER AND WELL CASING RISER IMMEDIATELY FOLLOWING DISCONNECTION OF THE FLEX-HOSE IN ORDER TO MINIMIZE AIR INTRUSION INTO THE GCCS.
- PLEASE SEE DRAWING ABOVE FOR DETAILED REPRESENTATION OF WELLHEAD REMOVAL.

STEP 4
REMOVE WELLHEAD

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21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

LICENSED PROFESSIONAL ENGINEER No. 12145 HAWAII U.S.A. Exp 4/30/24 11/28/23

KEKAHA MUNICIPAL SOLID WASTE LANDFILL
PHASE II - VERTICAL EXPANSION
GCCS DETAILS

DESIGNED BY : GRB/CME	CHECKED BY : AMN	DATE : NOV 2023
DRAWN BY : MDC/GVP	APPROVED BY : GRB/PJS	FILE : 220048-C-510_LF DETAILS.dwg

SHEET **C-514**

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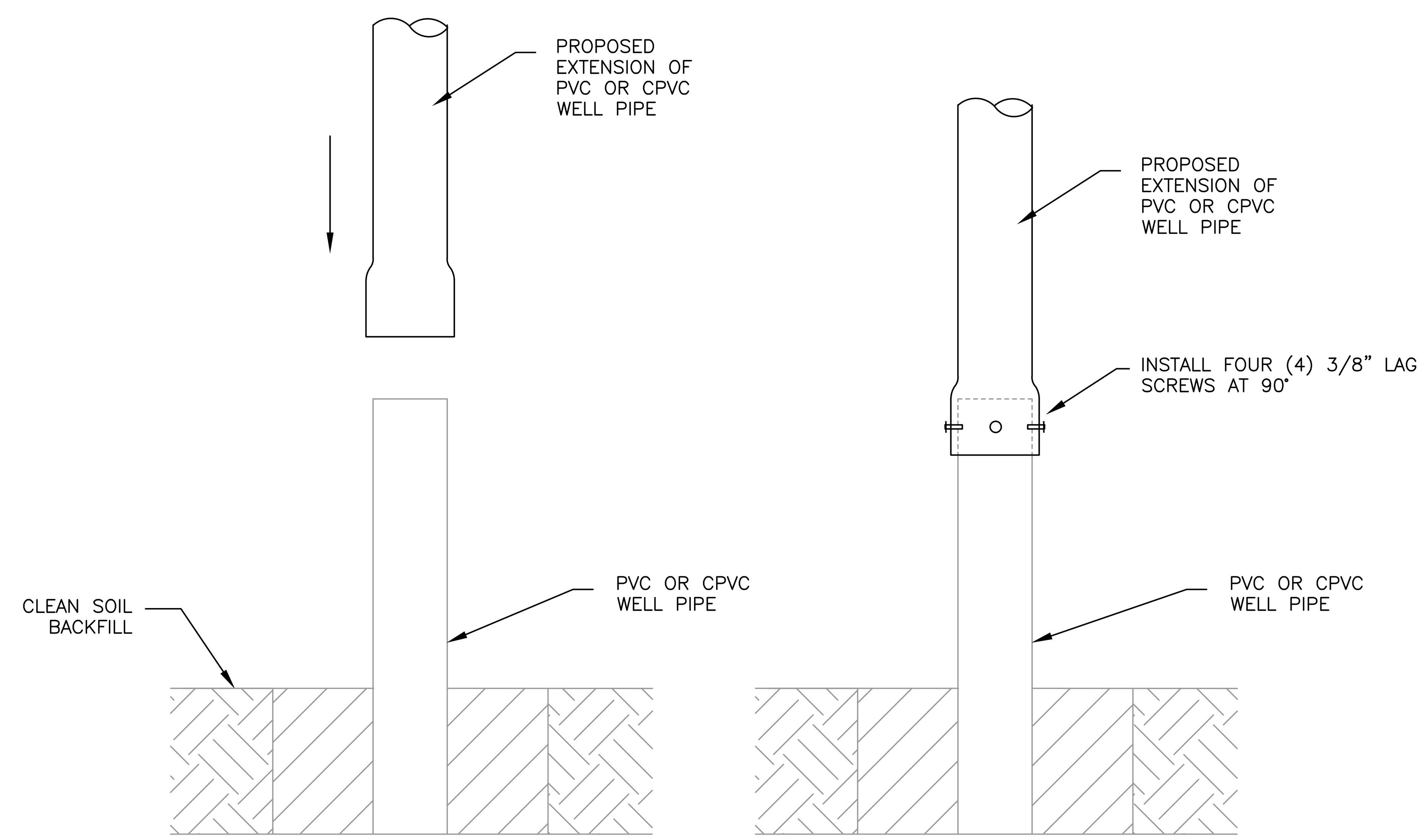
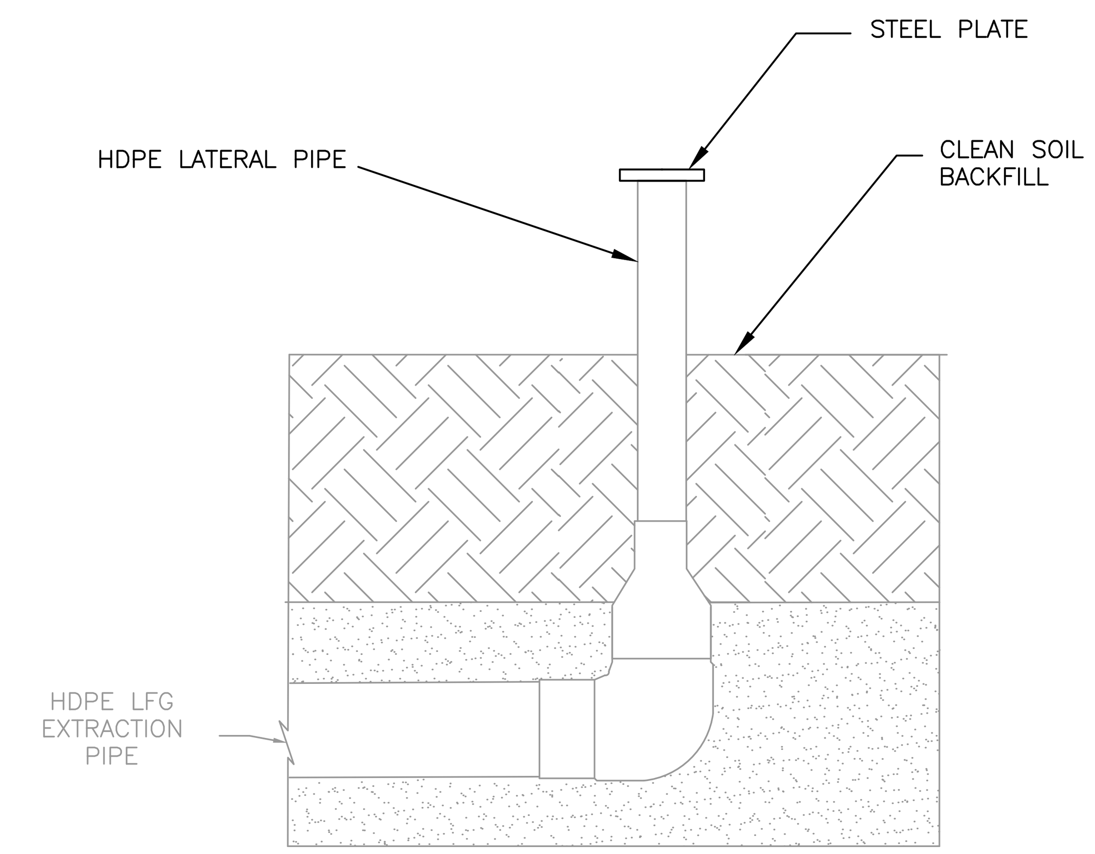
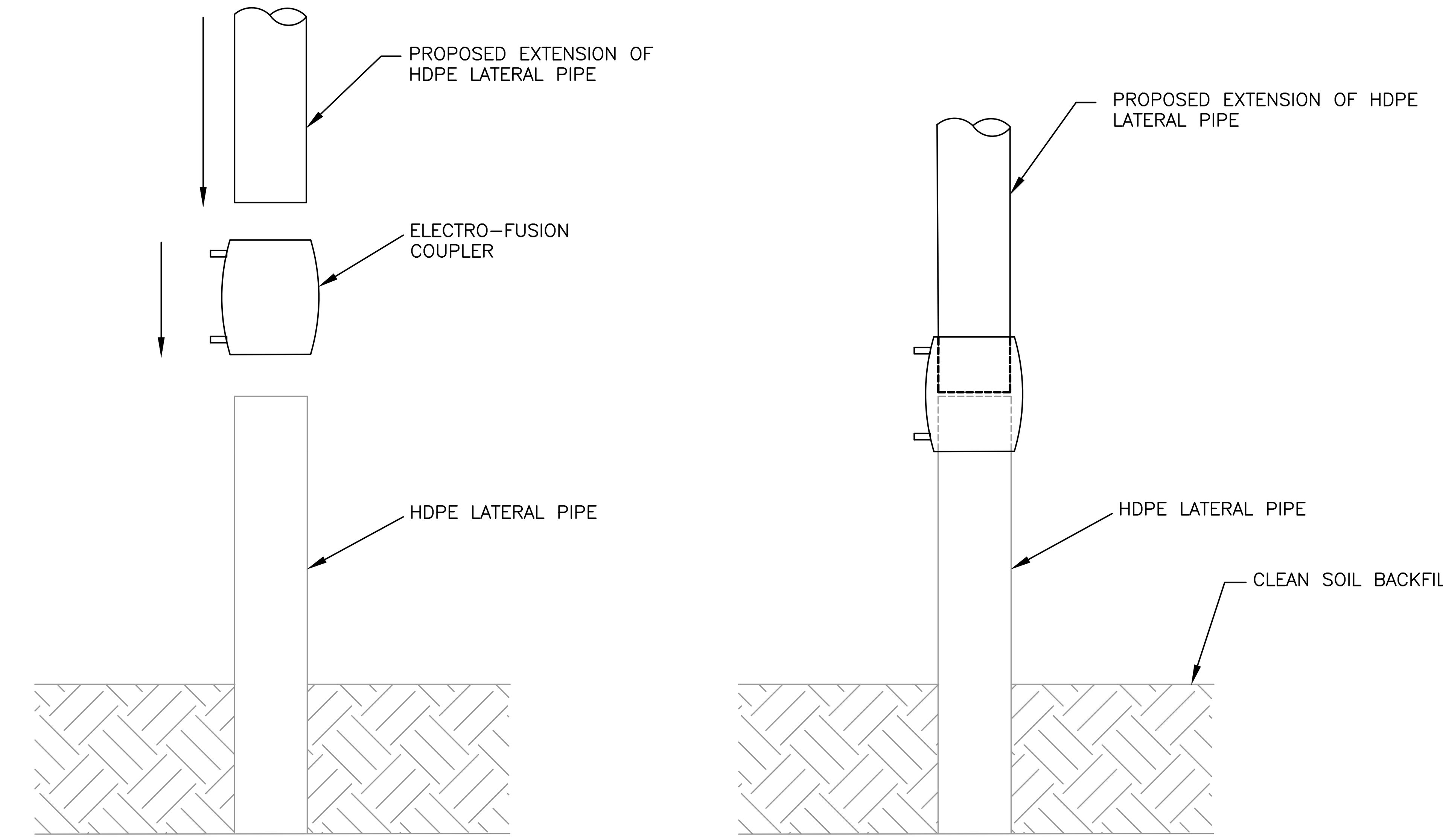




OPTION 1



OPTION 2

INSTRUCTIONS:

- ONCE THE DESIRED LENGTH OF RISER PIPING HAS BEEN ASSEMBLED, ATTACH A SCH40 PVC CAP TO THE TOP END OF THE RISER PIPING, TO MINIMIZE LFG EMISSIONS DURING FILLING OPERATIONS, USING A SINGLE SCREW. ADDITIONALLY, A HIGHLY VISIBLE FLAG SHOULD BE TAPED TO THE TOP OF EACH RISER SEGMENT IN ORDER TO INCREASE THE VISIBILITY OF THE MATERIALS TO THE OPERATORS.

FOR PVC/CPVC

- INSPECT THE EXISTING WELL CASING FOR HOLES, DAMAGE, OR EXCESS FOREIGN MATERIAL BUILD-UP. CLEAN OFF THE OUTER PORTION OF THE TOP OF THE WELL CASING AS NEEDED.
- APPLY PCV/CPVC PRIMER TO OUTER PORTION OF THE TOP OF THE EXISTING WELL CASING, WITH A MINIMUM VERTICAL APPLICATION LENGTH EQUAL TO THE LENGTH OF THE BELL/COUPLER OVERLAP, AND APPLY PRIMER TO THE INNER SURFACE OF THE BELL/COUPLER PORTION OF THE RISER SEGMENT.
- SWIFTLY APPLY PCV/CPVC GLUE TO THE SURFACES APPLIED WITH PRIMER, AVOIDING DRYING OF THE GLUE PRIOR TO CONNECTION.
- SLIDE THE BELL/COUPLER PORTION OF THE RISER PIPE OVER THE EXISTING WELL CASING, ENSURING THE FULL LENGTH OF THE BELL OR HALF OF THE LENGTH OF THE COUPLER OVERLAPS THE EXISTING WELL CASING.
- INSTALL FOUR LAG SCREWS AT A 90-DEGREE OFFSET AT THE MIDPOINT OF THE BELL/COUPLER.

FOR HDPE

- FOLLOW PROCEDURE IN STEP 6.

STEP 5
INSTALL WELL CASING RISER SEGMENT

INSTRUCTIONS:

- ONCE THE DESIRED LENGTH OF HDPE RISER PIPING HAS BEEN ASSEMBLED, ATTACH A SCH40 PVC CAP TO THE TOP END OF THE RISER PIPING TO MINIMIZE AIR INTRUSION INTO THE GCCS. ALSO, A HIGHLY VISIBLE FLAG SHOULD BE TAPED TO THE TOP OF EACH RISER SEGMENT IN ORDER TO INCREASE THE VISIBILITY OF THE MATERIALS TO THE OPERATORS.

OPTION 1: BUTT FUSION WELDING (NOT SHOWN)

- REMOVE THE SCH40 PVC CAP FROM THE EXISTING RISER AND COVER WITH A STEEL PLATE TO MINIMIZE AIR INTRUSION INTO THE GAS COLLECTION SYSTEM.
- PLACE THE HDPE FUSION MACHINE ONTO THE EXISTING RISER PIPE, SECURING THE MACHINE TO THE EXISTING PIPE.
- PLACE THE RISER SEGMENT ONTO THE HDPE FUSION MACHINE AND SECURE.
- PERFORM FUSION, PER THE FUSION MACHINE'S MANUFACTURER'S INSTRUCTIONS.

OPTION 2: ELECTRO-FUSION WELDING (WHEN APPROVED BY SITE ENGINEER)

- REMOVE THE SCH40 PVC CAP FROM THE HDPE LFG EXTRACTION PIPE RISER AND SLIDE THE ELECTRO-FUSION COUPLER OVER THE RISER, ENSURING HALF OF THE LENGTH OF THE COUPLER OVERLAPS THE RISER.
- QUICKLY PLACE THE RISER SEGMENT INTO THE CONNECTION OF THE ELECTRO-FUSION COUPLER AND THE LFG EXTRACTION PIPE RISER, MINIMIZING AIR INTRUSION INTO THE GCCS, SHOULD ISOLATION OF THE LATERAL PIPING NOT APPLY.
- PERFORM FUSION, PER THE ELECTRO-FUSION MACHINE'S MANUFACTURER'S INSTRUCTIONS.

STEP 6
INSTALL VACUUM LATERAL RISER SEGMENT

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

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COUNTY OF KAUAI · STATE OF HAWAII

REV	REVISION DESCRIPTION	DATE

TETRA TECH
21700 Copley Drive, Suite 200
Diamond Bar, CA 91765
TEL 909.860.7777 FAX 909.860.8017

LICENSED PROFESSIONAL ENGINEER No. 12145 HAWAII U.S.A. Exp. 4/30/24 11/28/23

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PHASE II - VERTICAL EXPANSION

GCCS DETAILS

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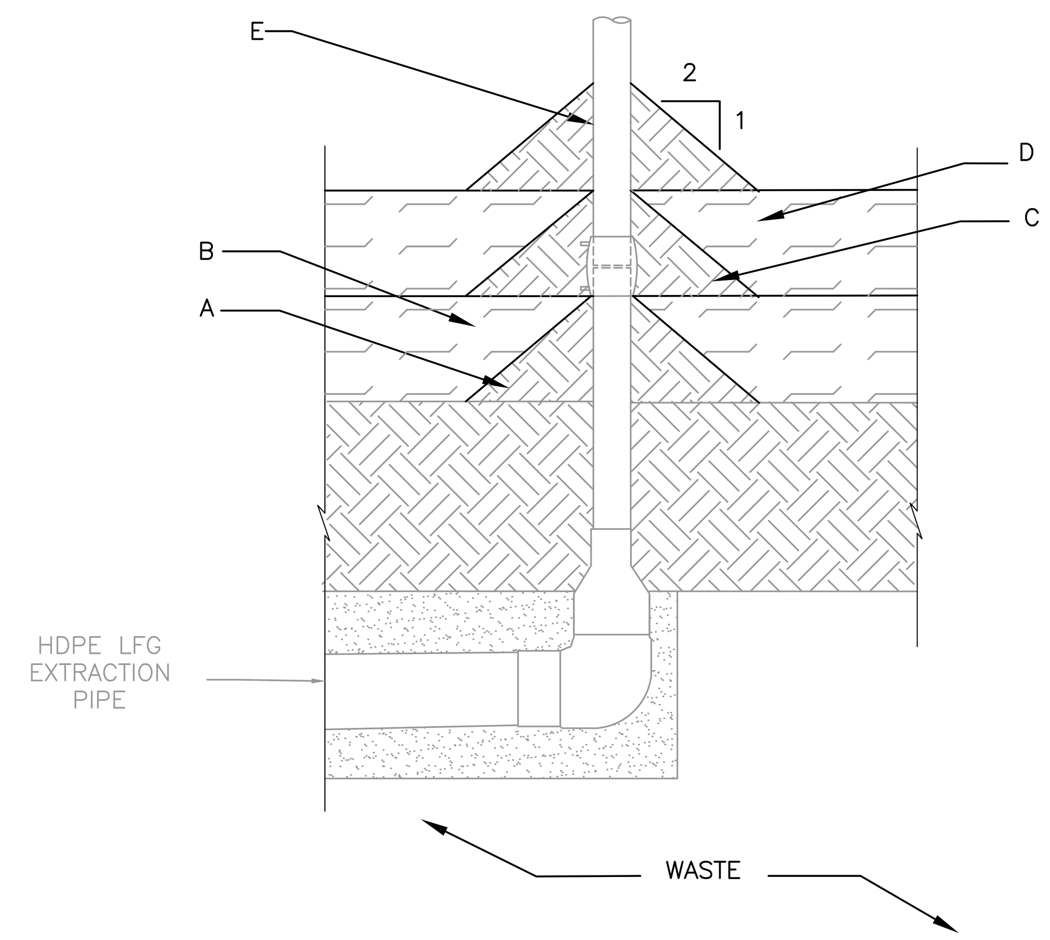
SHEET
C-515



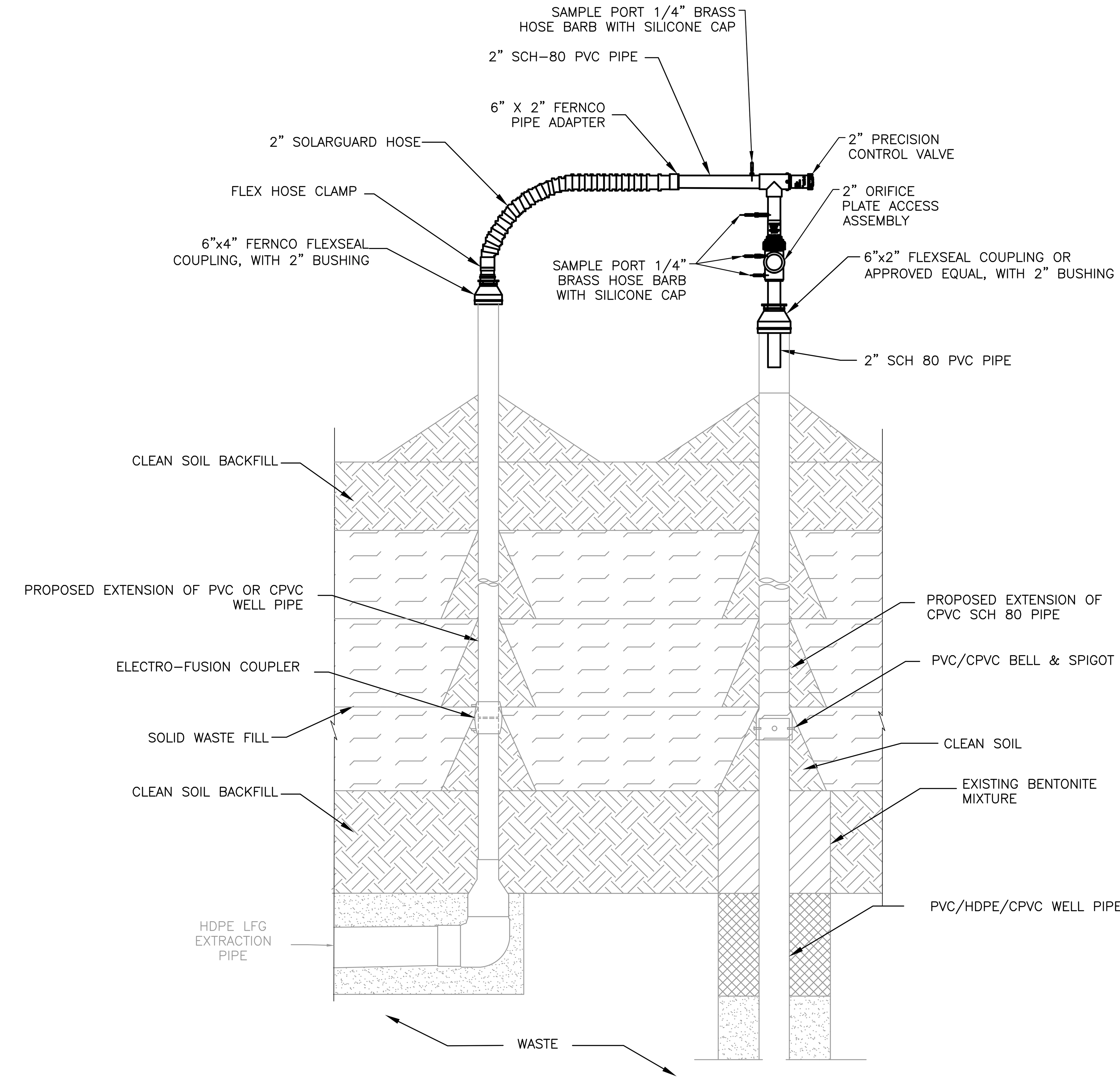
INSTRUCTIONS:

- GENTLY PLACE SOIL AROUND THE WELL CASING AND LATERAL RISER WITH AN EXCAVATOR OR BACKHOE BUCKET, FREQUENTLY HYDRATING THE SOIL AROUND THE WELL CASING AS SOIL IS PLACED.

  A. INITIAL SOIL MOUND
  B. FIRST LIFT OF SOLID WASTE FILL
  C. SECOND SOIL MOUND
  D. SECOND LIFT OF SOLID WASTE FILL
  E. REPEAT AS NEEDED

- THE FIELD TECHNICIAN SHOULD COMMUNICATE FREQUENTLY WITH THE OPERATIONS MANAGER AND FIELD PERSONNEL TO COORDINATE THE APPLICATION OF SOIL AROUND THE RISERS AS NEEDED AT VARIOUS ELEVATIONS OF THE WASTE COMPACTION PROCESS.
- DO NOT PUSH THE SOIL TOWARD THE CASING OR LATERAL RISER AS THIS MAY CAUSE HDPE PIPE TO PINCH AND PVC OR CPVC MATERIALS TO BREAK OR CRACK. THIS COULD POTENTIALLY BLOCK SYSTEM VACUUM FROM REACHING THE WELLHEAD OR LEAD TO AIR LEAKING INTO THE GCCS.
- THE FIELD TECHNICIAN SHOULD FREQUENTLY INSPECT THE ORIENTATION OF THE RISER MATERIALS TO ENSURE BOTH RISERS ARE VERTICAL. RISER MATERIALS INSTALLED AT AN ANGLE ARE AT GREATER RISK OF DAMAGE DUE TO THE WEIGHT OF THE WASTE ABOVE AND FORCES FROM LANDFILL SETTLEMENT. PHYSICAL BARRIERS, SUCH AS K-RAILS, MAY BE PLACED AROUND THE SOIL MOUNDS TO FURTHER PROTECT THE WELLS DURING WASTE PLACEMENT.
- THE FIELD TECHNICIAN SHOULD BE PRESENT AS WASTE IS PLACED AND COMPACTED AROUND THE WELL CASING TO ENSURE THE RISERS ARE NOT STRUCK, PUSHED, OR DAMAGED BY THE OPERATIONS EQUIPMENT.
- ALL OPERATIONS PERSONNEL SHOULD BE MADE AWARE OF THE WELL CASING AND LATERAL RISER PIPE, AND BE CAUTIOUS WHILE MANEUVERING HEAVY MACHINERY IN THE VICINITY OF THE SUBJECT PIPES.
- OPERATORS MUST AVOID PUSHING WASTE AGAINST THE VERTICAL PIPES AND SOIL MOUND AS DOING SO MAY RESULT IN DAMAGE TO PIPING MATERIALS.
- REPEAT THE HYDRATED SOIL PLACEMENT PROCESS WITH AN EXCAVATOR OR BACKHOE BUCKET AS NEEDED THROUGHOUT THE WASTE PLACEMENT PROCESS, ENSURING UNIFORMLY HYDRATED SOIL SURROUNDS THE WELL CASING AND LATERAL RISER PIPING, UNTIL THE DESIRED SURFACE ELEVATION IS ATTAINED.
- DO NOT REMOVE THE PVC CAP FROM THE TOP OF THE RISER SEGMENTS UNLESS ADDITIONAL RISER MATERIALS ARE NEEDED.
- IF ADDITIONAL RISER SEGMENTS ARE NEEDED, REPEAT STEPS 5 AND 6.

STEP 7
SOIL AND WASTE PLACEMENT OPERATIONS



INSTRUCTIONS:

- UPON COMPLETION OF THE FINAL SURFACE BY SITE OPERATIONS, REMOVE THE CAPS FROM THE RISER MATERIALS, AND REINSTALL THE WELLHEAD, WORM-GEAR CLAMPS, AND FLEX HOSE WHICH WERE REMOVED FROM THE SUBJECT WELL.
- BUTT FUSION WELDING NOT SHOWN.

STEP 8
WELLHEAD INSTALLATION

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

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GCCS DETAILS

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SHEET
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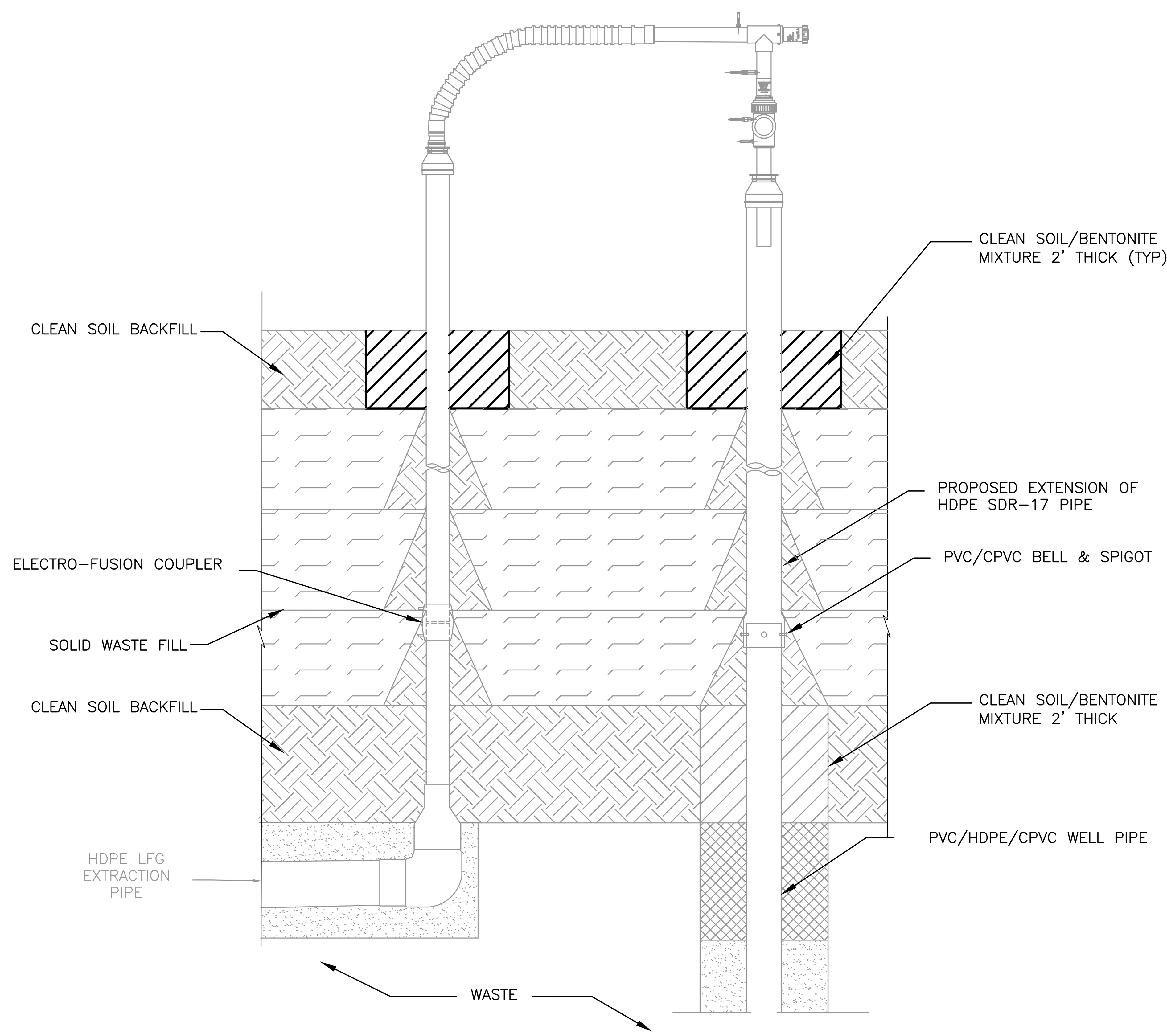
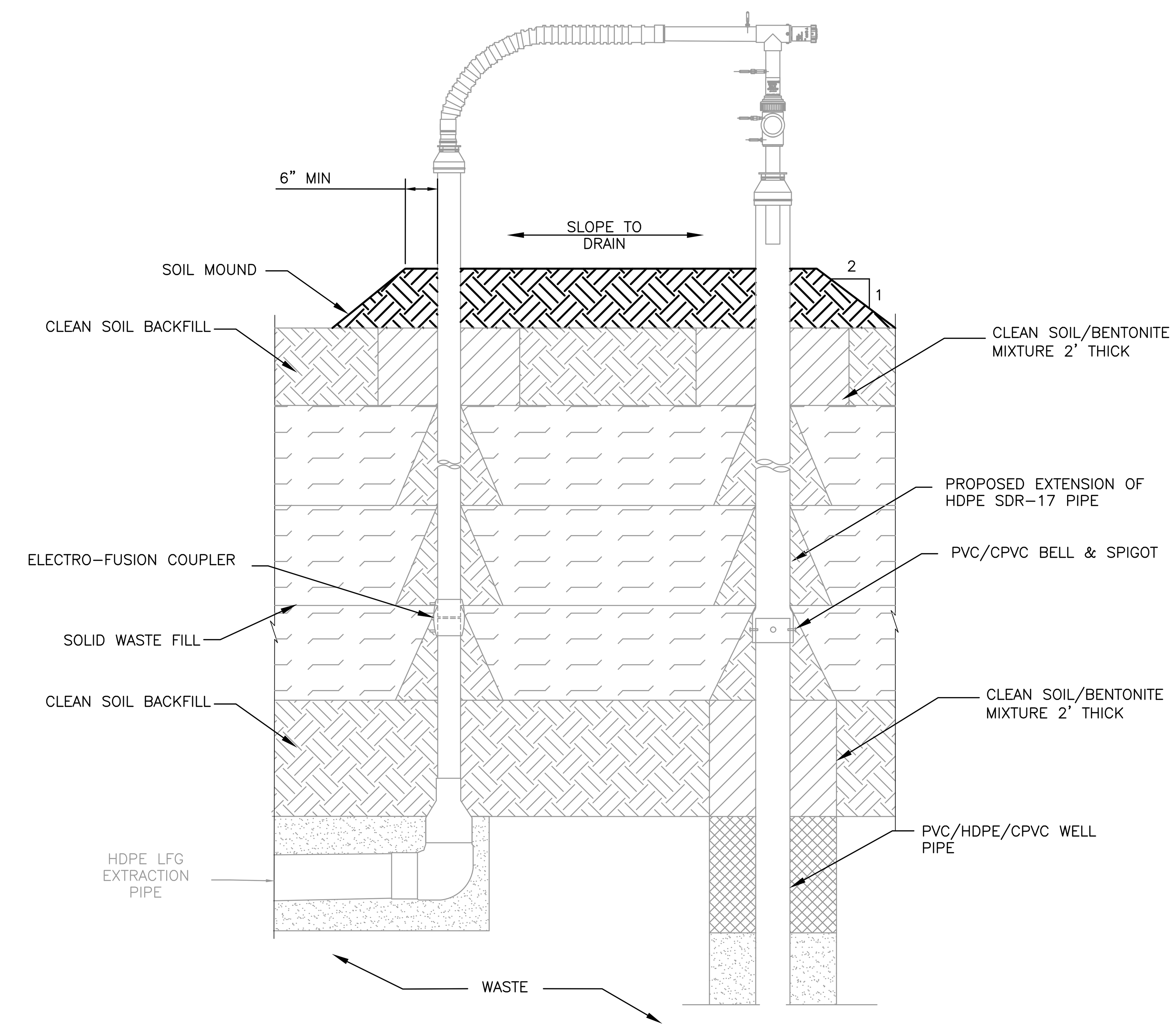


INSTRUCTIONS

- PREMIX BENTONITE ABOVE GROUND. MIX 8 BAGS OF BAROID BENSEAL 8-MESH BENTONITE OR EQUIVALENT WITH MANUFACTURERS RECOMMENDED AMOUNT OF WATER FOR EACH BORE SEAL. ENSURE MIXTURE IS COMPLETELY BLENDED ABOVE GRADE PRIOR TO APPLICATION.
- EXCAVATE A ONE TO TWO-FOOT DEEP HOLE IN A 2-FOOT RADIUS AROUND THE WELL CASING WITH A BACKHOE, EXCAVATOR, OR SHOVEL.
- POUR PRE-MIXED BENTONITE INTO EXCAVATION.
- BENTONITE SEALS SHOULD BE INSTALLED TO THE GROUND SURFACE AND ALLOWED TO SIT UNCOVERED FOR 24-HOURS.
- A FIELD TECHNICIAN SHOULD TEST FOR SURFACE EMISSIONS AROUND THE WELL CASING WITH AN FID. SHOULD THE FID REVEAL SURFACE EMISSIONS OF GREATER THAN OR EQUAL TO 200 PARTS PER MILLION, ADDITIONAL HYDRATED BENTONITE MATERIALS SHOULD BE PLACED AND THE SEAL RETESTED.

STEP 9
BENTONITE SEAL



INSTRUCTIONS:

- UPON APPROVAL OF THE BENTONITE SEAL BY THE FIELD TECHNICIAN, A TWO-FOOT TALL SOIL MOUND SHOULD BE GENTLY PLACED AROUND THE WELL CASING, ONE FOOT IN RADIUS BEYOND THE EXCAVATION.
- THE SOIL MATERIALS SHOULD BE POURED FROM THE BUCKET JUST ABOVE THE GROUND SURFACE TO AVOID HIGH VELOCITY SOIL MATERIALS DAMAGING THE INTEGRITY OF THE BENTONITE SEAL.
- THE SOIL MOUND SHOULD BE GENTLY COMPACTED AT THE TOP TO ALLOW FOR A STABLE SURFACE FOR THE FIELD TECHNICIAN TO STAND UPON.

STEP 10
SOIL MOUND

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

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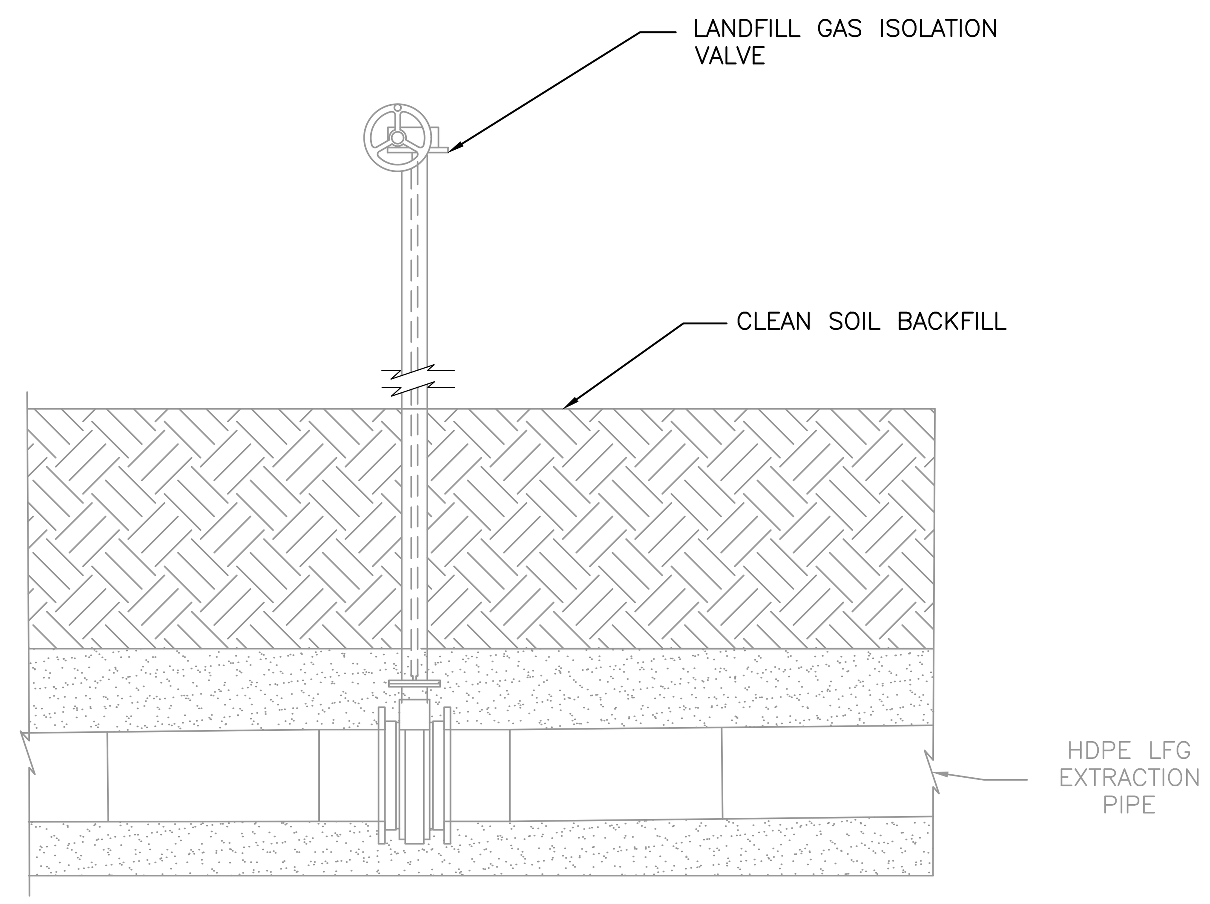
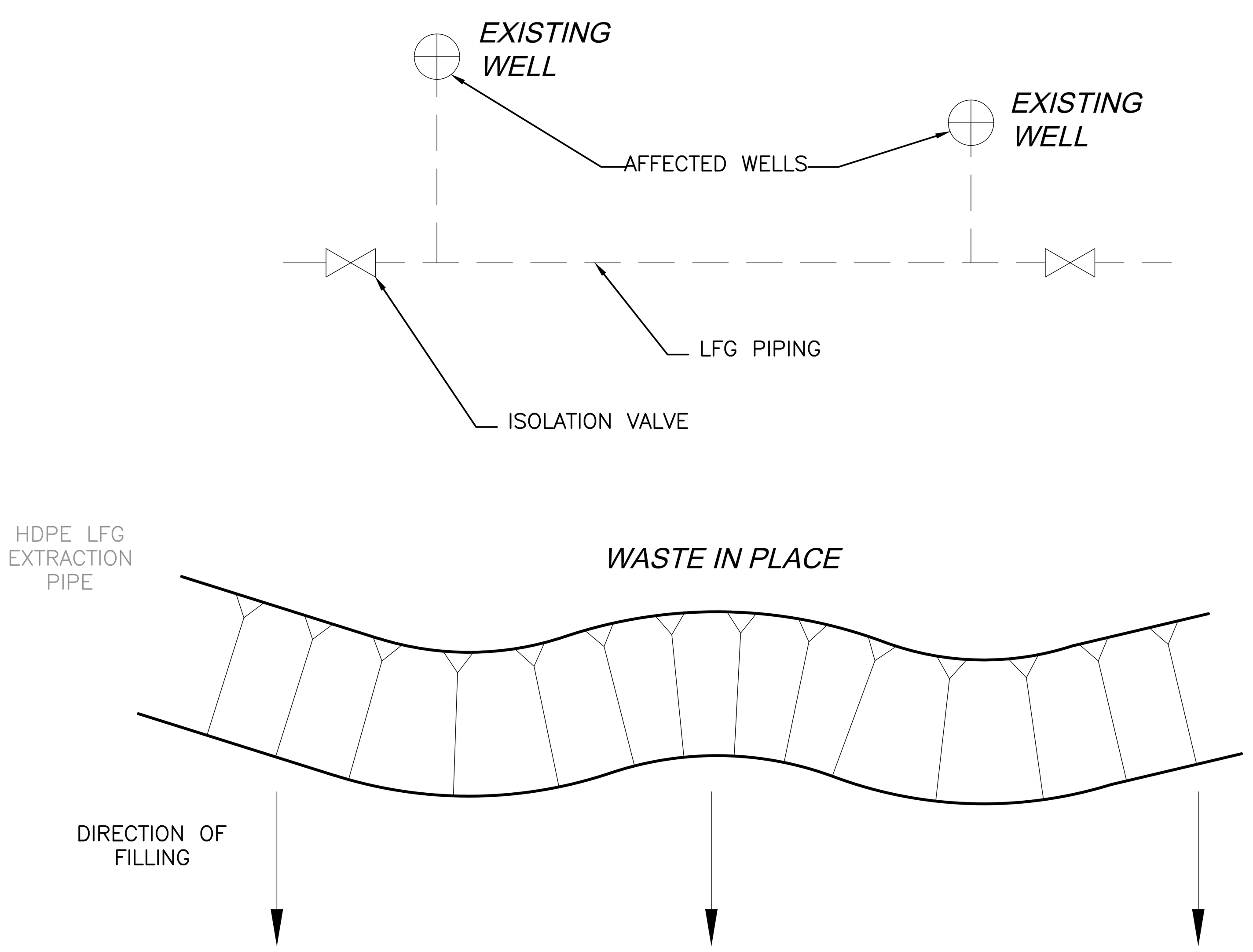
SHEET
C-517





INSTRUCTIONS:

- UPON COMPLETION OF FILLING OPERATIONS IN THE VICINITY OF THE AFFECTED WELLS, THE TECHNICIAN SHOULD COORDINATE WITH THE ENVIRONMENTAL MANAGER/ENGINEER TO ALLOW FOR COMPLIANCE RECORDING DURING THE RE-APPLICATION OF THE SYSTEM VACUUM TO THE SUBJECT WELLS, AS WELL AS THE STARTUP OF THE FLARE/ENGINE FACILITY (IF APPLICABLE).

STEP 11
OPEN ISOLATION VALVES

ISSUED FOR PERMITTING - NOT FOR CONSTRUCTION

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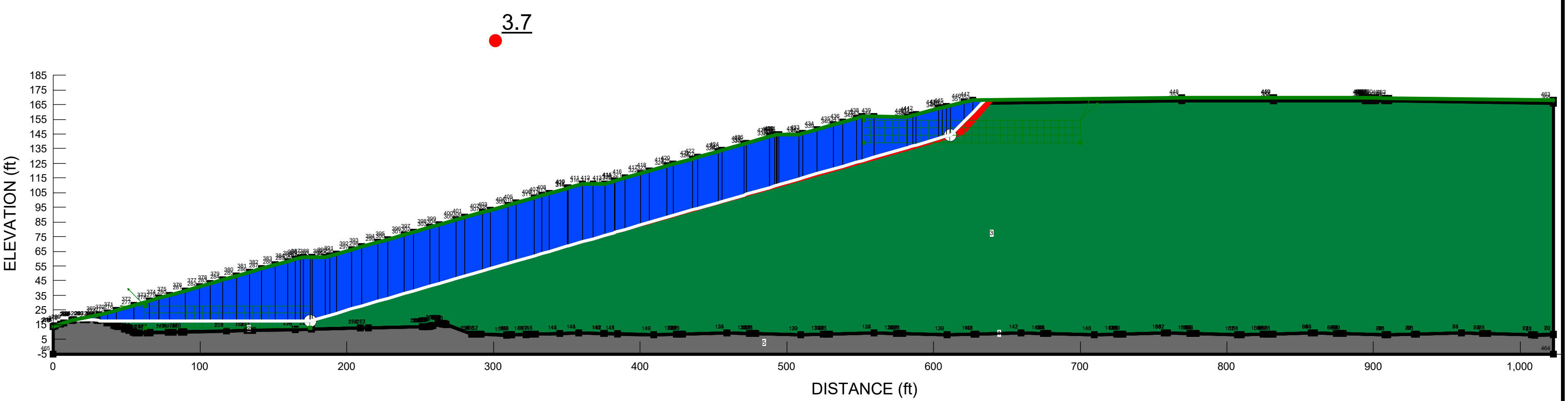
APPENDIX A

SLOPE STABILITY CROSS-SECTIONS



Color	Name	Model	Unit Weight (pcf)	Constant Unit Wt. Above Water Table (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)				
	Cover	Mohr-Coulomb	115		0	30
	Liner (Liner Cell 1 & 2 (2017))	Mohr-Coulomb	115		0	10.4
	Liner (Phase II 2013)	Mohr-Coulomb	100		100	5.7
	Waste (Zekkos)	Shear/Normal Fn.	62	62		

Analysis Notes:
Direction of movement: Right to Left
Number of Slices: 40
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1
Horz Seismic Coef.: 0

TETRA TECH

Kekaha LF, Phase 2, NW Slope

Slope Stability Analysis:
Static (Block) - (Zekkos)

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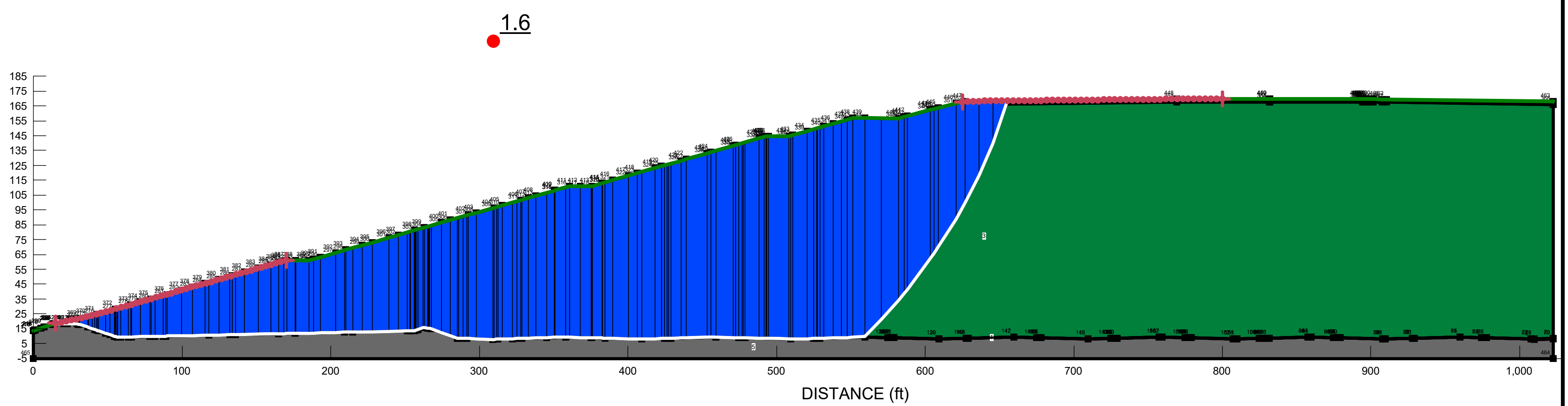
Last Edited By: Munich, Chad



Color	Name	Model	Unit Weight (pcf)	Constant Unit Wt. Above Water Table (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)				
	Cover	Mohr-Coulomb	115		0	30
	Liner (Liner Cell 1 & 2 (2017))	Mohr-Coulomb	115		0	10.4
	Liner (Phase II 2013)	Mohr-Coulomb	100		100	5.7
	Waste (Zekkos)	Shear/Normal Fn.	62	62		

Analysis Notes:
Direction of movement: Right to Left
Number of Slices: 60
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1
Horz Seismic Coef.: 0

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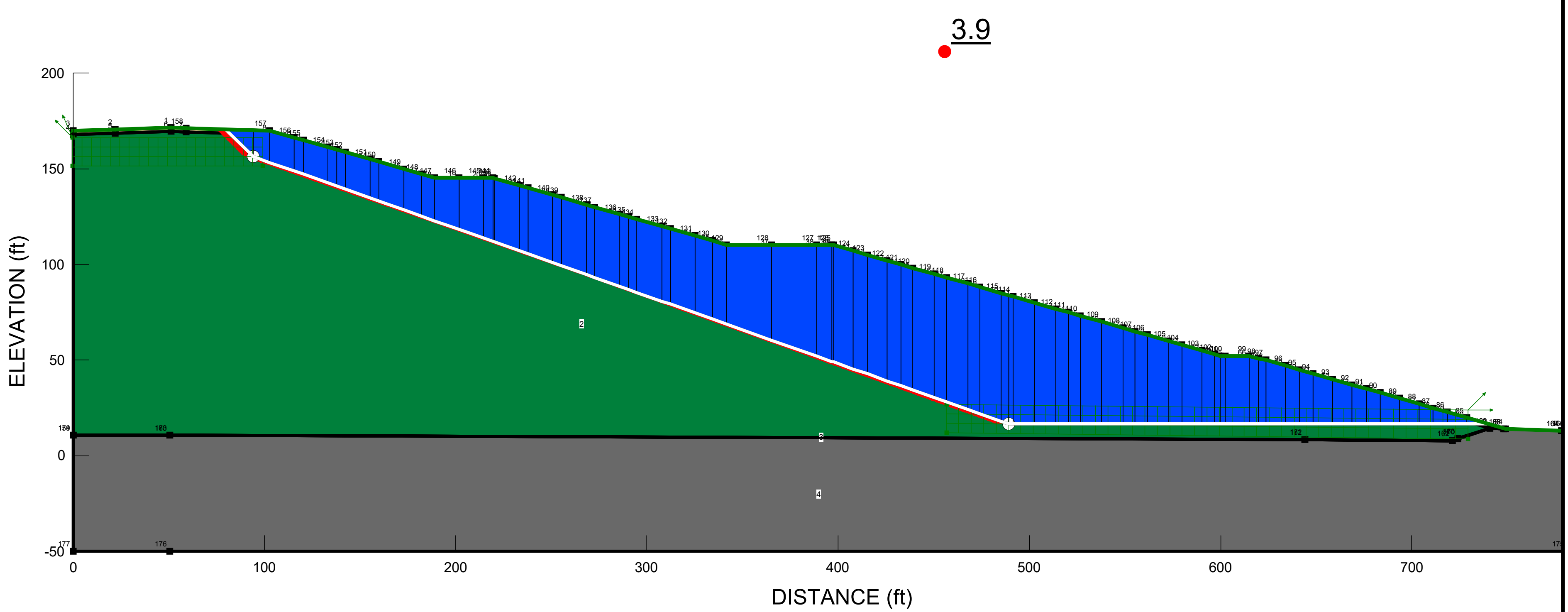
Last Edited By: Munich, Chad

TETRA TECH

Kekaha LF, Phase 2, NW Slope

Slope Stability Analysis:
Static (Circular) - (Zekkos)



Color	Name	Model	Unit Weight (pcf)	Constant Unit Wt. Above Water Table (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)				
	Cover	Mohr-Coulomb	115		0	30
	Liner (Phase II 2013)	Mohr-Coulomb	100		100	5.7
	Waste (Zekkos)	Shear/Normal Fn.	62	62		

Analysis Notes:
Direction of movement: Left to Right
Number of Slices: 40
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1
Horz Seismic Coef.: 0

TETRA TECH

Kekaha LF, Phase 2, NE Slope

Slope Stability Analysis:
Static (Block) - (Zekkos)

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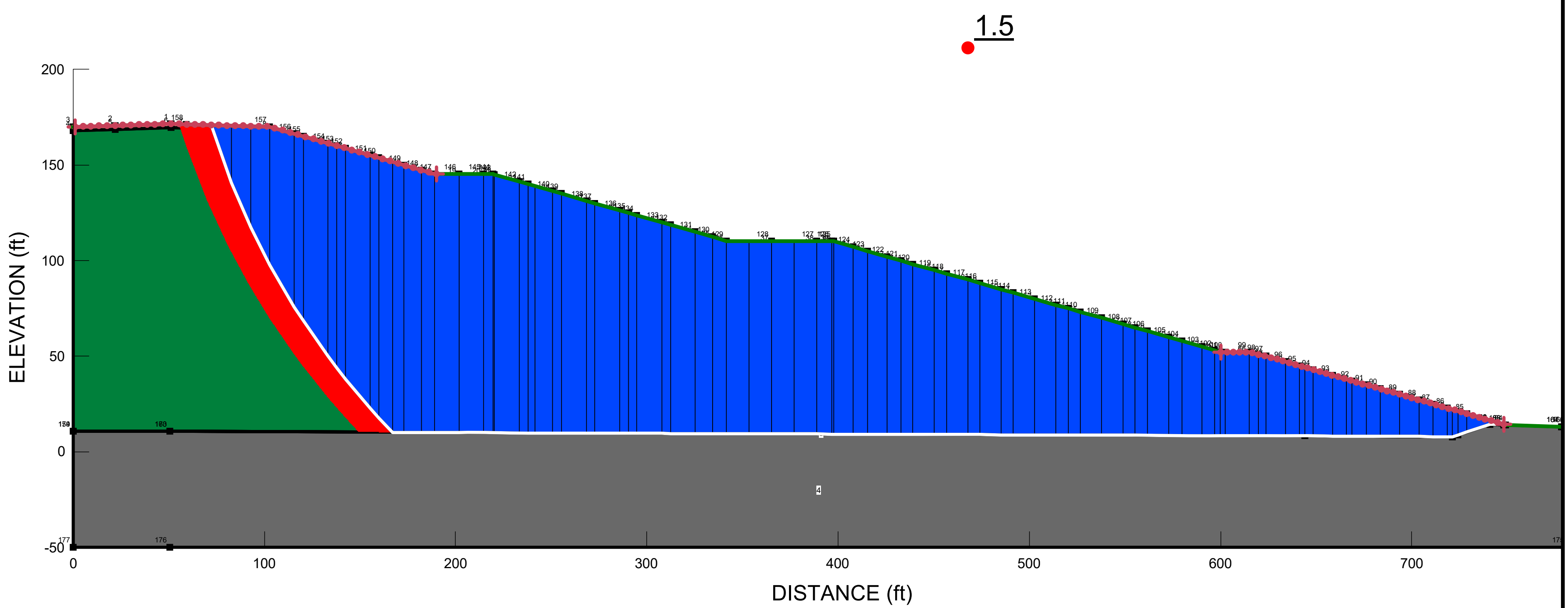
Last Edited By: Munich, Chad



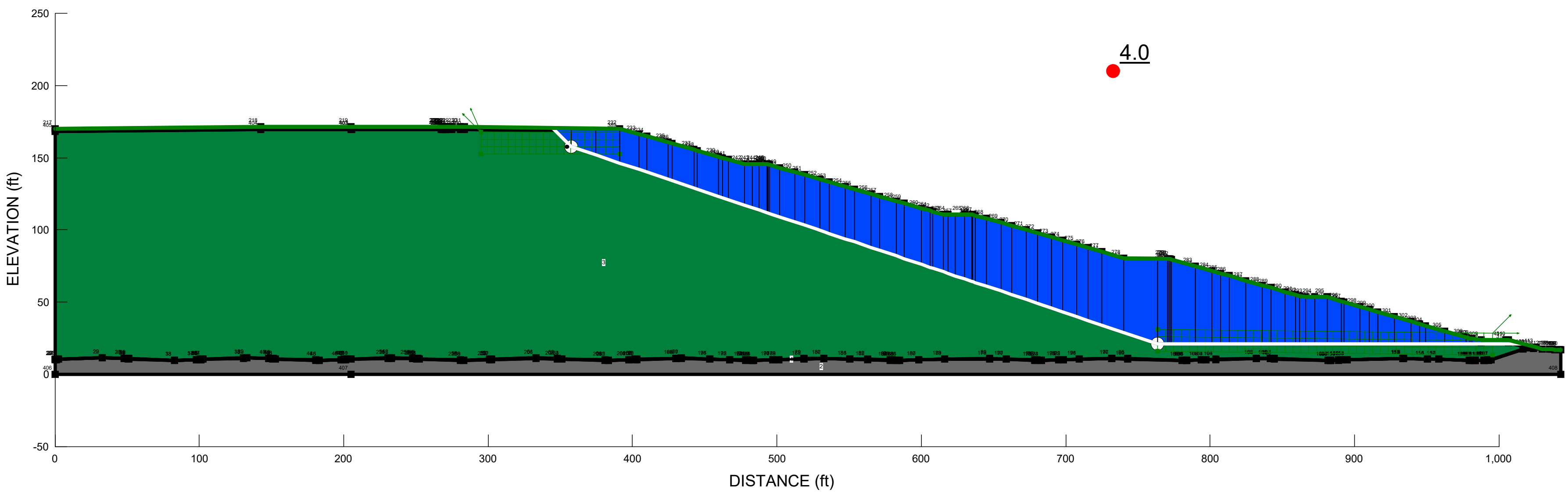
Color	Name	Model	Unit Weight (pcf)	Constant Unit Wt. Above Water Table (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)				
	Cover	Mohr-Coulomb	115		0	30
	Liner (Phase II 2013)	Mohr-Coulomb	100		100	5.7
	Waste (Zekkos)	Shear/Normal Fn.	62	62		

Analysis Notes:
Direction of movement: Left to Right
Number of Slices: 60
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1
Horz Seismic Coef.: 0

TETRA TECH

Kekaha LF, Phase 2, NE Slope

Slope Stability Analysis:
Static (Circular) - (Zekkos)



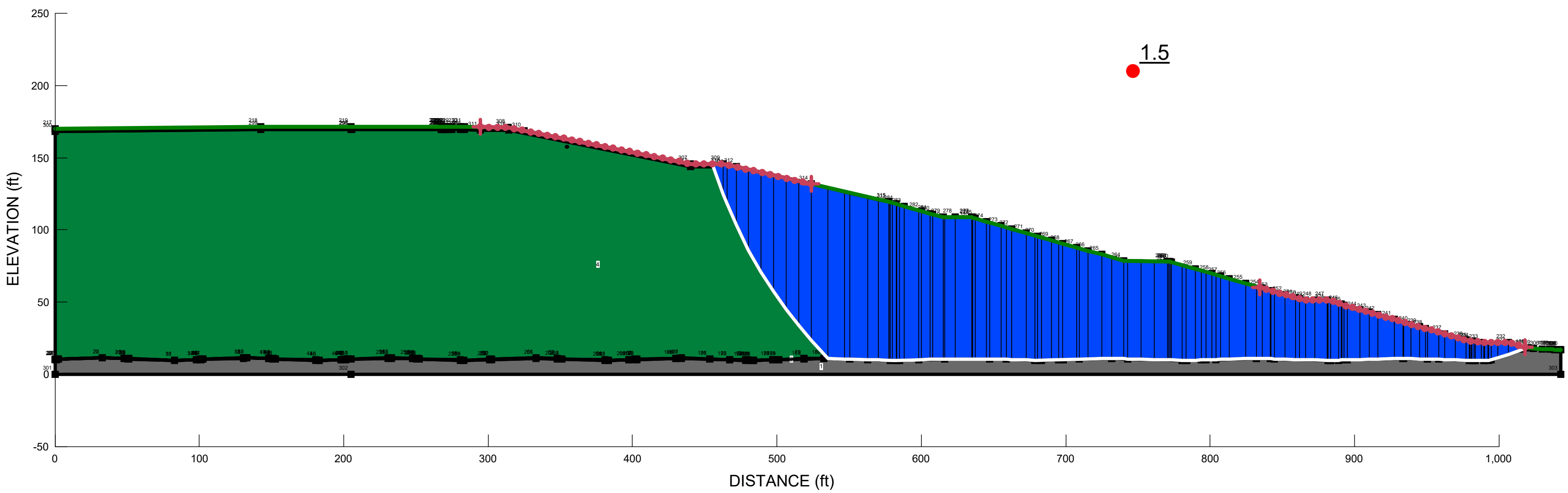
Color	Name	Model	Unit Weight (pcf)	Constant Unit Wt. Above Water Table (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)				
	Cover	Mohr-Coulomb	115		0	30
	Liner (Phase II 2013)	Mohr-Coulomb	100		100	5.7
	Waste (Zekkos)	Shear/Normal Fn.	62	62		

Analysis Notes:
Direction of movement: Left to Right
Number of Slices: 40
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1
Horz Seismic Coef.: 0

TETRA TECH

Kekaha LF, Phase 2, SE Slope

Slope Stability Analysis:
Static (Block) - (Zekkos)



Color	Name	Model	Unit Weight (pcf)	Constant Unit Wt. Above Water Table (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)				
	Cover	Mohr-Coulomb	115		0	30
	Liner (Phase II 2013)	Mohr-Coulomb	100		100	5.7
	Waste (Zekkos)	Shear/Normal Fn.	62	62		

Analysis Notes:
Direction of movement: Left to Right
Number of Slices: 60
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1
Horz Seismic Coef.: 0

TETRA TECH

Kekaha LF, Phase 2, SE Slope

Slope Stability Analysis:
Static (Circular) - (Zekkos)

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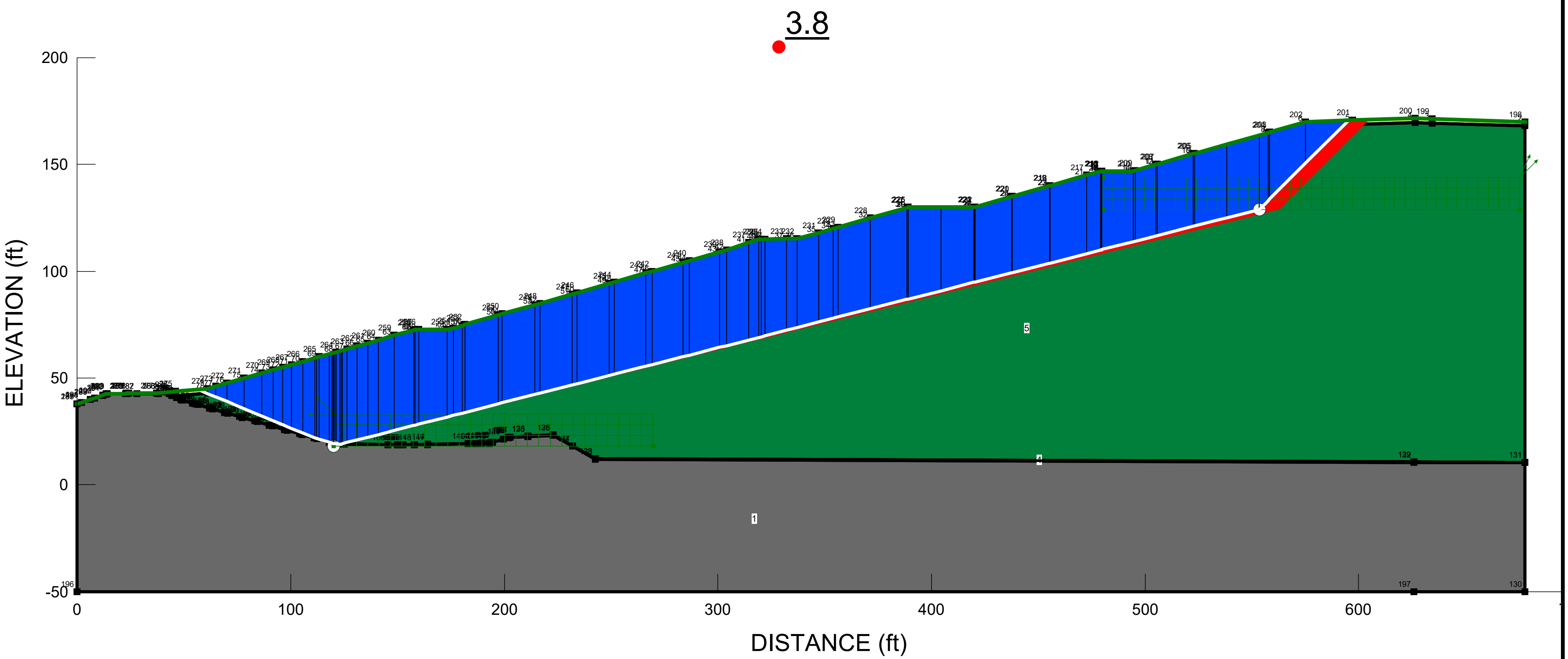

Color	Name	Model	Unit Weight (pcf)	Constant Unit Wt. Above Water Table (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)				
	Infiltration Layer	Mohr-Coulomb	135		0	35
	Liner (Liner Cell 1 & 2 (2017))	Mohr-Coulomb	115		0	10.4
	Liner (Phase II 2013)	Mohr-Coulomb	100		100	5.7
	Waste (Zekkos)	Shear/Normal Fn.	62	62		

Analysis Notes:
Direction of movement: Right to Left
Number of Slices: 40
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1
Horz Seismic Coef.: 0

TETRA TECH

Kekaha LF, Phase 2, SW Slope

Slope Stability Analysis:
Static (Block) - (Zekkos)

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Last Edited By: Munich, Chad

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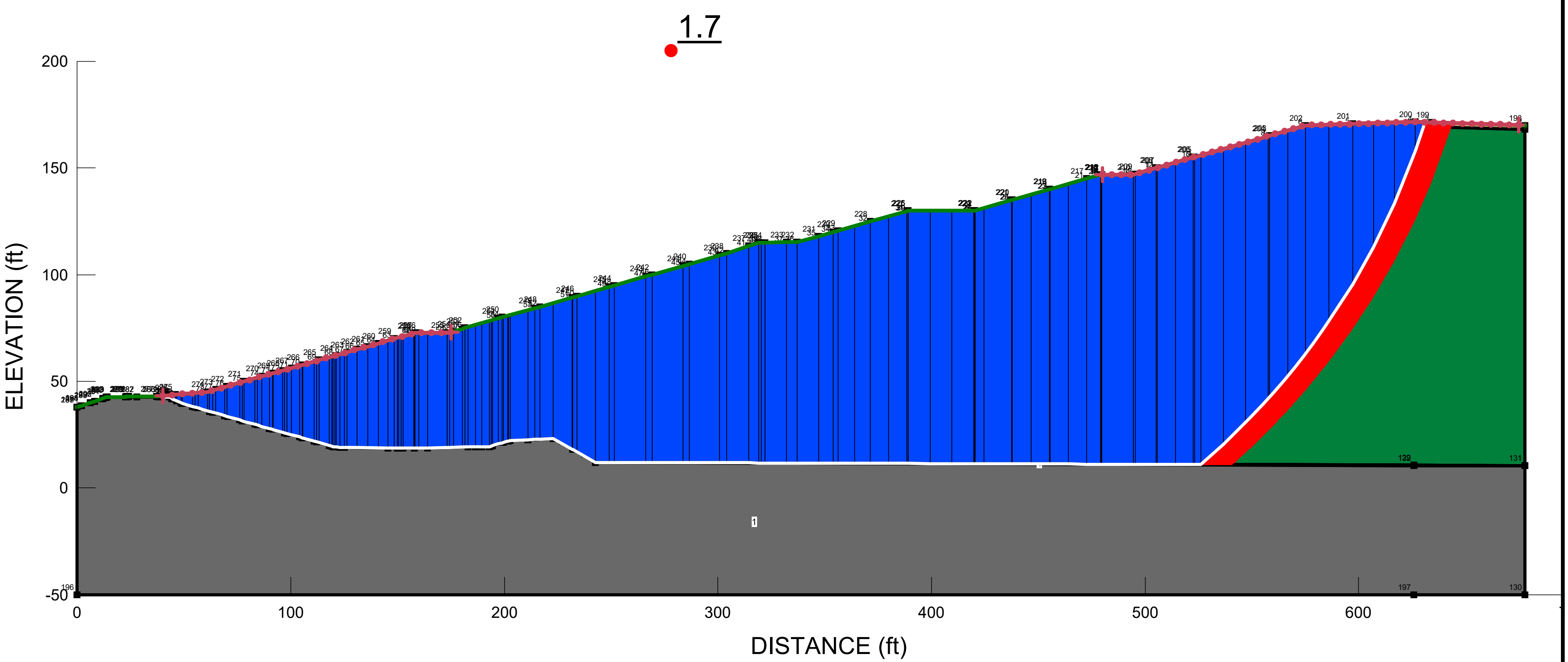
Last Edited By: Munich, Chad



Color	Name	Model	Unit Weight (pcf)	Constant Unit Wt. Above Water Table (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)				
	Infiltration Layer	Mohr-Coulomb	135		0	35
	Liner (Liner Cell 1 & 2 (2017))	Mohr-Coulomb	115		0	10.4
	Liner (Phase II 2013)	Mohr-Coulomb	100		100	5.7
	Waste (Zekkos)	Shear/Normal Fn.	62	62		

Analysis Notes:
Direction of movement: Right to Left
Number of Slices: 60
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1
Horz Seismic Coef.: 0

TETRA TECH

Kekaha LF, Phase 2, SW Slope

Slope Stability Analysis:
Static (Circular) - (Zekkos)

APPENDIX B

STORMWATER CALCULATIONS

General Information
Homepage
Progress Reports
FAQ
Glossary

Precipitation Frequency
Data Server
GIS Grids
Maps
Time Series
Temporals
Documents

Probable Maximum Precipitation
Documents

Miscellaneous
Publications
Storm Analysis
Record Precipitation

Contact Us
Inquiries

USA.gov

NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES

Data description

Data type: Precipitation depth **Units:** English **Time series type:** Partial duration

Select location

1. Manually:

a) By location (decimal degrees, use "-" for S and W) Latitude: Longitude: Submit

b) By station (list of HI stations): HUKIPO 945 (51-2161)

c) By address Search

2. Use map:

a) Select location
Move crosshair or double click

b) Click on station icon
Show stations on map

Map bookmarks:

Project area
Hawaii
Maui, Molokai, Lanai, Kahoolawe
Oahu
Kauai, Niihau

Location information:
Name: Kekaha, Hawaii, USA*
Station name: KEKAHA 944
Site ID: 51-2161
Latitude: 21.9703°
Longitude: -159.7111°
Elevation: 9 ft

* Source: ESRI Maps
** Source: USGS

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 4, Version 3

PF tabular PF graphical Supplementary information Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.316** (0.288-0.350)	**0.403** (0.367-0.450)	**0.521** (0.470-0.581)	**0.604** (0.542-0.679)	**0.713** (0.628-0.808)	**0.794** (0.686-0.905)	**0.869** (0.736-1.00)	**0.947** (0.780-1.10)	**1.05** (0.826-1.24)	**1.12** (0.851-1.35)
10-min	**0.468** (0.427-0.519)	**0.598** (0.545-0.667)	**0.772** (0.697-0.862)	**0.896** (0.804-1.01)	**1.06** (0.932-1.20)	**1.18** (1.02-1.34)	**1.29** (1.09-1.49)	**1.40** (1.16-1.64)	**1.55** (1.23-1.84)	**1.66** (1.26-2.00)
15-min	**0.588** (0.537-0.651)	**0.751** (0.684-0.838)	**0.969** (0.875-1.08)	**1.13** (1.01-1.26)	**1.33** (1.17-1.50)	**1.48** (1.28-1.69)	**1.62** (1.37-1.87)	**1.76** (1.45-2.06)	**1.95** (1.54-2.31)	**2.08** (1.58-2.51)
30-min	**0.827** (0.755-0.917)	**1.06** (0.963-1.18)	**1.36** (1.23-1.52)	**1.58** (1.42-1.78)	**1.87** (1.65-2.12)	**2.08** (1.80-2.37)	**2.28** (1.93-2.63)	**2.48** (2.04-2.89)	**2.74** (2.17-3.25)	**2.93** (2.23-3.53)
60-min	**1.09** (0.994-1.21)	**1.39** (1.27-1.55)	**1.80** (1.62-2.00)	**2.08** (1.87-2.34)	**2.46** (2.17-2.79)	**2.74** (2.37-3.12)	**3.00** (2.54-3.46)	**3.27** (2.69-3.81)	**3.61** (2.85-4.28)	**3.86** (2.93-4.64)
2-hr	**1.38** (1.26-1.53)	**1.76** (1.61-1.97)	**2.26** (2.04-2.52)	**2.62** (2.35-2.94)	**3.08** (2.71-3.49)	**3.42** (2.97-3.91)	**3.74** (3.17-4.32)	**4.05** (3.34-4.73)	**4.46** (3.53-5.29)	**4.75** (3.63-5.73)
3-hr	**1.59**	**2.04**	**2.63**	**3.04**	**3.58**	**3.96**	**4.33**	**4.70**	**5.15**	**5.48**

	(1.45-1.77)	(1.86-2.29)	(2.37-2.95)	(2.72-3.44)	(3.14-4.07)	(3.41-4.54)	(3.66-5.02)	(3.86-5.50)	(4.06-6.14)	(4.16-6.63)
6-hr	**1.97** (1.80-2.20)	**2.57** (2.33-2.88)	**3.34** (3.00-3.75)	**3.88** (3.46-4.38)	**4.57** (4.00-5.20)	**5.06** (4.36-5.81)	**5.54** (4.67-6.41)	**5.98** (4.92-7.01)	**6.56** (5.16-7.82)	**6.97** (5.29-8.43)
12-hr	**2.42** (2.20-2.71)	**3.20** (2.90-3.58)	**4.19** (3.77-4.70)	**4.90** (4.37-5.52)	**5.80** (5.08-6.59)	**6.45** (5.55-7.38)	**7.07** (5.95-8.17)	**7.67** (6.30-8.97)	**8.44** (6.64-10.0)	**8.98** (6.81-10.8)
24-hr	**2.98** (2.66-3.33)	**3.94** (3.52-4.40)	**5.20** (4.63-5.82)	**6.15** (5.46-6.90)	**7.39** (6.53-8.32)	**8.33** (7.32-9.43)	**9.27** (8.10-10.5)	**10.2** (8.85-11.7)	**11.4** (9.81-13.2)	**12.4** (10.5-14.4)
2-day	**3.62** (3.28-3.98)	**4.74** (4.29-5.22)	**6.30** (5.69-6.95)	**7.53** (6.79-8.33)	**9.23** (8.27-10.3)	**10.6** (9.43-11.8)	**11.9** (10.6-13.4)	**13.4** (11.8-15.1)	**15.4** (13.4-17.5)	**17.0** (14.6-19.5)
3-day	**3.91** (3.54-4.30)	**5.14** (4.66-5.67)	**6.86** (6.20-7.58)	**8.22** (7.41-9.10)	**10.1** (9.05-11.2)	**11.6** (10.3-12.9)	**13.1** (11.6-14.7)	**14.7** (12.9-16.6)	**16.9** (14.7-19.3)	**18.7** (16.0-21.5)
4-day	**4.20** (3.81-4.62)	**5.54** (5.02-6.12)	**7.42** (6.70-8.20)	**8.90** (8.02-9.86)	**11.0** (9.83-12.2)	**12.6** (11.2-14.1)	**14.3** (12.6-16.0)	**16.1** (14.1-18.1)	**18.5** (16.0-21.1)	**20.4** (17.5-23.5)
7-day	**4.69** (4.26-5.18)	**6.24** (5.65-6.88)	**8.37** (7.56-9.24)	**10.1** (9.06-11.1)	**12.4** (11.1-13.8)	**14.2** (12.7-15.9)	**16.1** (14.2-18.1)	**18.1** (15.9-20.5)	**20.8** (18.0-23.8)	**23.0** (19.7-26.4)
10-day	**5.10** (4.63-5.63)	**6.79** (6.16-7.51)	**9.12** (8.25-10.1)	**11.0** (9.88-12.1)	**13.5** (12.1-15.0)	**15.5** (13.8-17.3)	**17.5** (15.4-19.7)	**19.6** (17.2-22.2)	**22.5** (19.5-25.7)	**24.7** (21.2-28.5)
20-day	**6.02** (5.46-6.65)	**8.07** (7.29-8.89)	**10.9** (9.77-12.0)	**13.0** (11.7-14.4)	**15.9** (14.2-17.7)	**18.2** (16.1-20.3)	**20.4** (18.0-22.9)	**22.8** (19.9-25.7)	**26.0** (22.4-29.6)	**28.4** (24.2-32.6)
30-day	**6.94** (6.27-7.64)	**9.28** (8.39-10.2)	**12.5** (11.2-13.7)	**14.9** (13.3-16.5)	**18.2** (16.2-20.2)	**20.7** (18.3-23.1)	**23.2** (20.4-26.1)	**25.8** (22.5-29.2)	**29.2** (25.2-33.4)	**31.9** (27.2-36.8)
45-day	**8.07** (7.31-8.91)	**10.8** (9.78-11.9)	**14.5** (13.0-16.0)	**17.3** (15.5-19.1)	**21.0** (18.7-23.3)	**23.8** (21.1-26.6)	**26.7** (23.5-29.9)	**29.5** (25.9-33.4)	**33.4** (28.9-38.1)	**36.3** (31.1-41.7)
60-day	**9.23** (8.34-10.2)	**12.3** (11.1-13.6)	**16.4** (14.8-18.2)	**19.6** (17.6-21.7)	**23.8** (21.3-26.5)	**27.0** (24.0-30.2)	**30.2** (26.7-33.9)	**33.5** (29.3-37.8)	**37.9** (32.8-43.2)	**41.2** (35.3-47.4)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in CSV format: Precipitation frequency estimates Submit

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Water Prediction (OWP)
1325 East West Highway
Silver Spring, MD 20910
Page Author: HDSC webmaster
Page last modified: April 21, 2017

WinTR-55 Current Data Description

--- Identification Data ---

User: CEB
Date: 10/26/2022
Project:
Units: English
SubTitle:
Areal Units: Acres
State: Hawaii
County: Kauai
Filename: \\tt.local\gfs\USVolume2\Legacy\tts619fs2\PROJECTS\KAUAI COUNTY\197-220048 - Kekaha Vertical Ex

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DAA1-1		Outlet	0.39	79	0.100
DAA1-2		Outlet	1.71	79	0.100
DAA1-3		Outlet	0.97	79	0.100
DAA1-4		Outlet	0.41	79	0.120

Total area: 3.48 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.94	5.2	6.15	7.39	8.33	9.27	2.98

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type I
Dimensionless Unit Hydrograph: <standard>

Kauai County, Hawaii

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS		
DAA1-1	1.52 9.93	2.07 9.93
DAA1-2	6.66 9.93	9.04 9.93
DAA1-3	3.79 9.93	5.15 9.93
DAA1-4	1.54 9.94	2.10 9.94
REACHES		
OUTLET	13.50	18.34

Kauai County, Hawaii

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 25-Yr (cfs)	100-Yr (cfs)
SUBAREAS		
DAA1-1	1.52	2.07
DAA1-2	6.66	9.04
DAA1-3	3.79	5.15
DAA1-4	1.54	2.10
REACHES		
OUTLET	13.50	18.34

WinTR-55 Current Data Description

--- Identification Data ---

User: CEB
Project:
SubTitle:
State: Hawaii
County: Kauai
Filename: \\tt.local\gfs\USVolume2\Legacy\tts619fs2\PROJECTS\KAUAI COUNTY\197-220048 - Kekaha Vertical Ex

Date: 10/26/2022
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DAB1_1		Outlet	0.67	79	0.100
DAB1_2		Outlet	0.11	79	0.100
DAB1_3		Outlet	0.57	79	0.100
DAB1_4		Outlet	0.21	79	0.100

Total area: 1.56 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.94	5.2	6.15	7.39	8.33	9.27	2.98

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type I
Dimensionless Unit Hydrograph: <standard>

Kauai County, Hawaii

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS		
DAB1_1	2.62 9.93	3.56 9.93
DAB1_2	0.42 9.93	0.58 9.93
DAB1_3	2.22 9.93	3.01 9.93
DAB1_4	0.82 9.93	1.12 9.93
REACHES		
OUTLET	6.08	8.27

Kauai County, Hawaii

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 25-Yr (cfs)	100-Yr (cfs)
SUBAREAS		
DAB1_1	2.62	3.56
DAB1_2	0.42	0.58
DAB1_3	2.22	3.01
DAB1_4	0.82	1.12
REACHES		
OUTLET	6.08	8.27

WinTR-55 Current Data Description

--- Identification Data ---

User: CEB
Project:
SubTitle:
State: Hawaii
County: Kauai
Filename: \\tt.local\gfs\USVolume2\Legacy\tts619fs2\PROJECTS\KAUAI COUNTY\197-220048 - Kekaha Vertical Ex

Date: 10/26/2022
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DAC3_1		Outlet	0.85	79	0.100
DAC3_2		Outlet	4.36	79	0.202
DAC3_3		Outlet	1.13	79	0.149
DAC3_4		Outlet	1.18	79	0.184

Total area: 7.52 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.94	5.2	6.15	7.39	8.33	9.27	2.98

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type I
Dimensionless Unit Hydrograph: <standard>

Hydrograph Peak/Peak Time Table

Kauai County, Hawaii

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 25-Yr (cfs)	100-Yr (cfs)
SUBAREAS		
DAC3_1	3.32	4.51
DAC3_2	14.58	19.81
DAC3_3	4.07	5.53
DAC3_4	4.03	5.47
REACHES		
OUTLET	25.35	34.44

WinTR-55 Current Data Description

--- Identification Data ---

User: CEB
Project:
SubTitle:
State: Hawaii
County: Kauai
Filename: \\tt.local\gfs\USVolume2\Legacy\tts619fs2\PROJECTS\KAUAI COUNTY\197-220048 - Kekaha Vertical Ex

Date: 10/26/2022
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DAF2-1		Outlet	0.32	79	0.100
DAF2-2		Outlet	0.91	79	0.133
DAF2-3		Outlet	2.65	79	0.262
DAF2-4		Outlet	0.68	79	0.125

Total area: 4.56 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.94	5.2	6.15	7.39	8.33	9.27	2.98

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type I
Dimensionless Unit Hydrograph: <standard>

CEB

Kauai County, Hawaii

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS		
DAF2-1	1.25 9.93	1.69 9.93
DAF2-2	3.35 9.95	4.55 9.95
DAF2-3	8.23 10.05	11.18 10.04
DAF2-4	2.53 9.94	3.44 9.94
REACHES		
OUTLET	14.34	19.47

CEB

Kauai County, Hawaii

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 25-Yr (cfs)	100-Yr (cfs)
SUBAREAS		
DAF2-1	1.25	1.69
DAF2-2	3.35	4.55
DAF2-3	8.23	11.18
DAF2-4	2.53	3.44
REACHES		
OUTLET	14.34	19.47

Mannings Equation Calculator for Trapezoidal Channels with known Q

Prepared by: CEB
Date: 11/15/2022
Checked by:
Date: 11/18/2022

Project Name: Kekaha Landfill Vertical Expansion
Project Number:
Descption: Diversion Berms and Bench Flows

$$Q = \frac{1.486 R^{2/3} S_o^{1/2} A}{n}$$

$$\frac{b}{V_{p100} Y_{p100}} \le 1.15$$

Where: Q = Flow Rate (cfs)
n= Manning's n
A = Flow Area (ft^2)
R = Hydraulic Radius (ft)
So = Sf = Bed Slope (ft/ft)

b = Channel Bottom Width (ft)
V_{p100} = Peak Velocity for 100-yr Event
Y_{p100} = Peak Flow Depth for 100-yr Event

(Note: Triangular Channels are a special case with bottom width = 0)
(Note: For rectangular channels enter negative number for sideslopes)

Enter Data in Blue Text Cells

Reach	Slope (ft/ft)	n	Bottom Width (ft)	Sideslope1 (x:1)	Sideslope2 (x:1)	Depth (ft)	V (fps)	Q (cfs)	Regime	Low Flow Problems?	Area (SF)	WP (ft)	Hyd. Rad. (ft)	Top Width (ft)	Hyd. Depth (ft)	Nf	Act. Sideslope1	Act Sideslope2	Low Flow Check Result
Berm C2-2	0.03	0.027	0	3.5	2	1.089	6.08	19.83	Super	No Low-Flow Channel Incision Predicted	3.2613	6.3991	0.5096	5.9895	0.5445	1.4522	3.5	2	0.9044782
Berm F2-3	0.01	0.027	1	2	2	1.005	3.70	11.18	Sub	Low Flow Channel Incision Predicted	3.0251	5.4945	0.5506	5.02	0.6026	0.8391	2	2	1.351344
Road	0.07	0.027	2	2	2	0.67	8.52	19.07	Super	No Low-Flow Channel Incision Predicted	2.2378	4.9963	0.4479	4.68	0.4782	2.1718	2	2	0.8196653

Reference: Chow, Ven Ti. Open-Channel Hydraulics. New York: McGraw-Hill Inc. 1959.
City of Tucson, Drainage Design and Floodplain Management Manual. 1989.

Mannings Equation Calculator for Trapezoidal Channels with known Q

Prepared by: CEB
Date: 11/15/2022
Checked by: GRB
Date: 11/18/2022

Project Name: Kekaha Landfill Vertical Expansion
Project Number:
Desciption: Diversion Berms and Bench Flows

$$Q = \frac{1.486 R^{2/3} S_o^{1/2} A}{n}$$

$$\frac{b}{V_{p100} Y_{p100}} \le 1.15$$

Where:
Q = Flow Rate (cfs)
n= Manning's n
A = Flow Area (ft^2)
R = Hydraulic Radius (ft)
So = Sf = Bed Slope (ft/ft)

b = Channel Bottom Width (ft)
V_{p100} = Peak Velocity for 100-yr Event
Y_{p100} = Peak Flow Depth for 100-yr Event

(Note: Triangular Channels are a special case with bottom width = 0)
(Note: For rectangular channels enter negative number for sideslopes)

Enter Data in Blue Text Cells

Reach	Slope (ft/ft)	n	Bottom Width (ft)	Sideslope1 (x:1)	Sideslope2 (x:1)	Depth (ft)	V (fps)	Q (cfs)	Regime	Low Flow Problems?	Area (SF)	WP (ft)	Hyd. Rad. (ft)	Top Width (ft)	Hyd. Depth (ft)	Nf	Act. Sideslope1	Act Sideslope2	Low Flow Check Result
A0	0.285	0.035	1	2	2	0.35	8.55	5.09	Super	No Low-Flow Channel Incision Predicted	0.5950	2.5652	0.2319	2.4	0.2479	3.0270	2	2	0.8017822
A1	0.285	0.035	1	2	2	0.66	12.04	18.44	Super	No Low-Flow Channel Incision Predicted	1.5312	3.9516	0.3875	3.64	0.4207	3.2723	2	2	0.4579481
A1 Pmt	0.285	0.035	1	2	2	0.66	12.04	18.44	Super	No Low-Flow Channel Incision Predicted	1.5312	3.9516	0.3875	3.64	0.4207	3.2723	2	2	0.4579481
B1	0.285	0.035	1	2	2	0.45	9.78	8.37	Super	No Low-Flow Channel Incision Predicted	0.8550	3.0125	0.2838	2.8	0.3054	3.1205	2	2	0.635904
B1 Pmt	0.285	0.035	2	2	2	0.34	9.20	8.38	Super	No Low-Flow Channel Incision Predicted	0.9112	3.5205	0.2588	3.36	0.2712	3.1137	2	2	1.0740193
C0	0.285	0.035	1	2	2	0.33	8.29	4.54	Super	No Low-Flow Channel Incision Predicted	0.5478	2.4758	0.2213	2.32	0.2361	3.0056	2	2	0.8482987
C1	0.285	0.035	1	2	2	0.5	10.36	10.36	Super	No Low-Flow Channel Incision Predicted	1.0000	3.2361	0.3090	3	0.3333	3.1610	2	2	0.5793751
C2	0.285	0.035	2	2	2	0.73	13.89	35.08	Super	No Low-Flow Channel Incision Predicted	2.5258	5.2647	0.4798	4.92	0.5134	3.4157	2	2	0.4853141
C2 Pmt	0.285	0.035	1	2	2	0.89	14.21	35.17	Super	No Low-Flow Channel Incision Predicted	2.4742	4.9802	0.4968	4.56	0.5426	3.4007	2	2	0.3604494
F1	0.207	0.035	1	2	2	0.32	6.95	3.65	Super	No Low-Flow Channel Incision Predicted	0.5248	2.4311	0.2159	2.28	0.2302	2.5520	2	2	1.0255139
F2	0.255	0.035	2	2	2	0.56	11.40	19.92	Super	No Low-Flow Channel Incision Predicted	1.7472	4.5044	0.3879	4.24	0.4121	3.1295	2	2	0.6641865
F2 Pmt	0.255	0.035	1	2	2	0.7	11.77	19.77	Super	No Low-Flow Channel Incision Predicted	1.6800	4.1305	0.4067	3.8	0.4421	3.1184	2	2	0.4613779

Reference: Chow, Ven Ti. Open-Channel Hydraulics. New York: McGraw-Hill Inc. 1959.
City of Tucson, Drainage Design and Floodplain Management Manual. 1989.

Mannings Equation Calculator for Circular Channels flowing at any depth up to full (invalid for pressure flow)

Project Name: Kekaha Vertical Expansion
Project Numbe 220048
Description: Culvert at road crossing

Prep by: CEB
Date: 11/15/2022
Chkd by: GRB
Date: 11/18/2022

Enter Data in Blue Text Cells

Reach Description	Bed Slope (ft/ft)	n (unitless)	Pipe Diameter (ft)	Flow Depth (ft)	Velocity (ft/s)	Volumetric Flow Rate (ft^3/s)	Regime	Flow Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Average Width (ft)	Froude Number (unitless)
1	0.10000	0.010	1.500	0.92	26.389	29.988	Super	1.136	2.699	0.421	1.235	4.848

Notes:

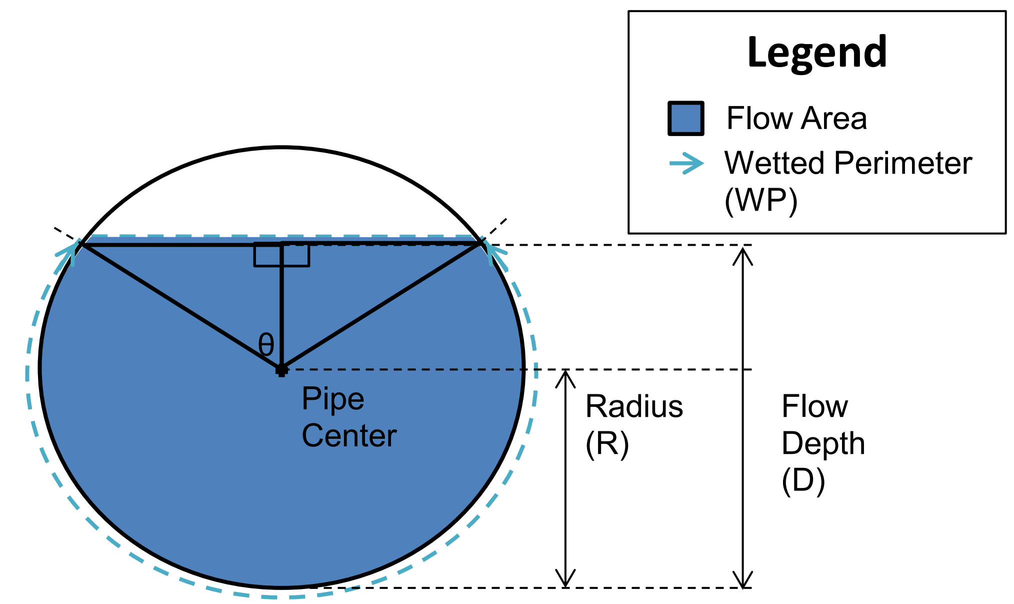
1. Based on Mannings Equation - $Q=(1.49/n)*R^{2/3}*S^{1/2}*A$
2. Calculation of flow area and wetted perimeter for given diameter and flow depth from geometric analysis of circular form

Froude Number (N_f) = $\dfrac{\left(\frac{Q}{b_{avg}}\right)}{\sqrt{g*\left(\frac{A}{b_{avg}}\right)^3}}$

Mannings Equation:

Volumetric Flow Rate (Q) = $\dfrac{1.486*A*R^{2/3}*\sqrt{S_o}}{n}$

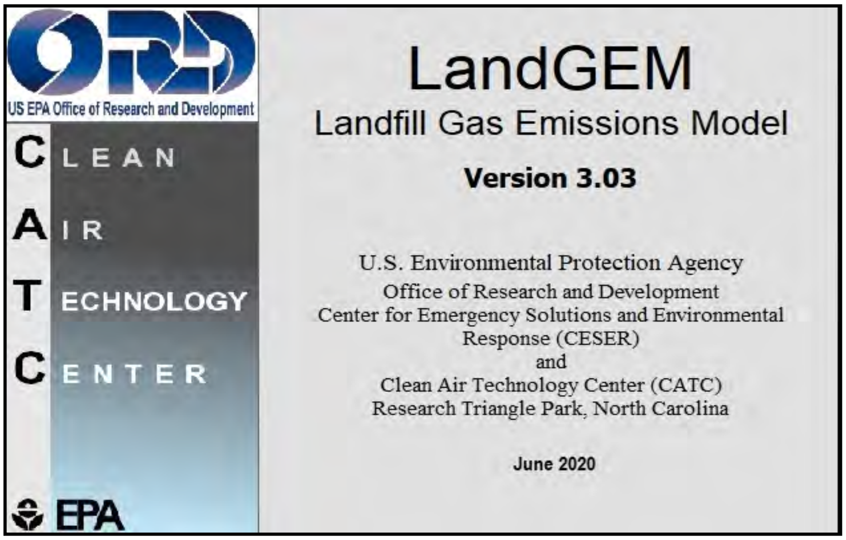
Where:
n = Manning's Roughness Coefficient
Q = Volumetric Flow Rate = Flow Area*Velocity (ft^3/s)
b_{avg} = Average Width = Flow Area/Flow Depth (ft)
A = Flow Area = Total Area - Saggita Area (ft^2)
g = Gravitational Acceleration (32.2 ft/s^2)
R = Hydraulic Radius = Flow Area/Wetted Perimeter (ft)
S_o = Bed Slope (ft/ft)



Reference: Lindeburg, M.R. 2008. Professional Publications, Inc. Belmont, CA.

APPENDIX C

LANDGEM MODELING



Summary Report

Landfill Name or Identifier: Kekaha Landfill

Date: Thursday, November 10, 2022

Description/Comments:

Historical tonnages are from waste acceptance data provided by the County of Kauai in the 2015 LandGEM and via email for 2015-2022. Total approximate capacity is 3,668,871 short tons for the Phase I and II waste-in-place and the additional capacity from vertical expansion. K value of 0.02 based on rainfall of 21.8 in and Lo value of 100 m3/Mg from site flows (noaa.gov). A decreasing rate of 3.9% was used to calculate tonnages for 2023-2027.

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_0 = potential methane generation capacity (*m^3/Mg*)

M_i = mass of waste accepted in the i^{th} year (*Mg*)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} 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	**1985**	
Landfill Closure Year (with 80-year limit)	**2027**	
Actual Closure Year (without limit)	***2027***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity	**3,668,871**	*short tons*

MODEL PARAMETERS

Methane Generation Rate, k	**0.020**	*$year^{-1}$*
Potential Methane Generation Capacity, L_0	**100**	*m^3/Mg*
NMOC Concentration	**600**	*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)*
1985	35,533	39,086	0	0
1986	72,959	80,255	35,533	39,086
1987	72,959	80,255	108,492	119,341
1988	72,959	80,255	181,451	199,596
1989	72,959	80,255	254,410	279,851
1990	72,959	80,255	327,369	360,106
1991	72,959	80,255	400,328	440,361
1992	72,959	80,255	473,287	520,616
1993	100,492	110,541	546,246	600,871
1994	78,035	85,838	646,738	711,412
1995	114,275	125,703	724,773	797,250
1996	196,973	216,670	839,048	922,953
1997	84,825	93,307	1,036,021	1,139,623
1998	58,409	64,250	1,120,845	1,232,930
1999	61,445	67,590	1,179,255	1,297,180
2000	66,207	72,828	1,240,700	1,364,770
2001	70,147	77,162	1,306,907	1,437,598
2002	67,908	74,699	1,377,055	1,514,760
2003	73,693	81,062	1,444,963	1,589,459
2004	78,605	86,465	1,518,655	1,670,521
2005	81,055	89,160	1,597,260	1,756,986
2006	82,043	90,247	1,678,315	1,846,146
2007	81,922	90,114	1,760,357	1,936,393
2008	79,306	87,237	1,842,279	2,026,507
2009	71,343	78,477	1,921,585	2,113,744
2010	63,404	69,744	1,992,928	2,192,221
2011	64,543	70,997	2,056,332	2,261,965
2012	64,080	70,488	2,120,875	2,332,962
2013	74,545	82,000	2,184,955	2,403,450
2014	74,545	82,000	2,259,500	2,485,450
2015	74,077	81,485	2,334,045	2,567,450
2016	76,127	83,740	2,408,123	2,648,935
2017	78,990	86,889	2,484,250	2,732,675
2018	83,114	91,425	2,563,240	2,819,564
2019	82,965	91,261	2,646,354	2,910,989
2020	79,742	87,716	2,729,318	3,002,250
2021	80,091	88,100	2,809,060	3,089,966
2022	82,037	90,241	2,889,151	3,178,066
2023	78,803	86,683	2,971,188	3,268,307
2024	75,696	83,266	3,049,991	3,354,990

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2025	72,712	79,983	3,125,688	3,438,256
2026	69,846	76,830	3,198,400	3,518,240
2027	67,092	73,801	3,268,245	3,595,070
2028	0	0	3,335,337	3,668,871
2029	0	0	3,335,337	3,668,871
2030	0	0	3,335,337	3,668,871
2031	0	0	3,335,337	3,668,871
2032	0	0	3,335,337	3,668,871
2033	0	0	3,335,337	3,668,871
2034	0	0	3,335,337	3,668,871
2035	0	0	3,335,337	3,668,871
2036	0	0	3,335,337	3,668,871
2037	0	0	3,335,337	3,668,871
2038	0	0	3,335,337	3,668,871
2039	0	0	3,335,337	3,668,871
2040	0	0	3,335,337	3,668,871
2041	0	0	3,335,337	3,668,871
2042	0	0	3,335,337	3,668,871
2043	0	0	3,335,337	3,668,871
2044	0	0	3,335,337	3,668,871
2045	0	0	3,335,337	3,668,871
2046	0	0	3,335,337	3,668,871
2047	0	0	3,335,337	3,668,871
2048	0	0	3,335,337	3,668,871
2049	0	0	3,335,337	3,668,871
2050	0	0	3,335,337	3,668,871
2051	0	0	3,335,337	3,668,871
2052	0	0	3,335,337	3,668,871
2053	0	0	3,335,337	3,668,871
2054	0	0	3,335,337	3,668,871
2055	0	0	3,335,337	3,668,871
2056	0	0	3,335,337	3,668,871
2057	0	0	3,335,337	3,668,871
2058	0	0	3,335,337	3,668,871
2059	0	0	3,335,337	3,668,871
2060	0	0	3,335,337	3,668,871
2061	0	0	3,335,337	3,668,871
2062	0	0	3,335,337	3,668,871
2063	0	0	3,335,337	3,668,871
2064	0	0	3,335,337	3,668,871

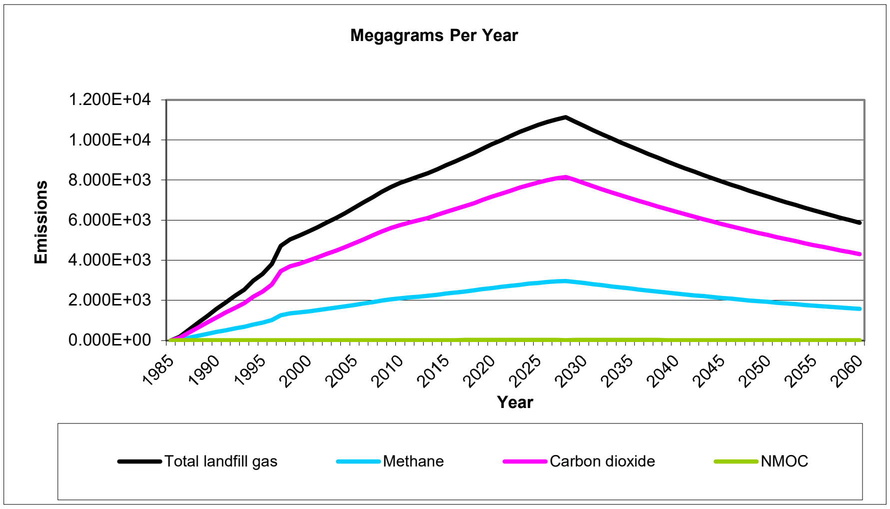
Pollutant Parameters

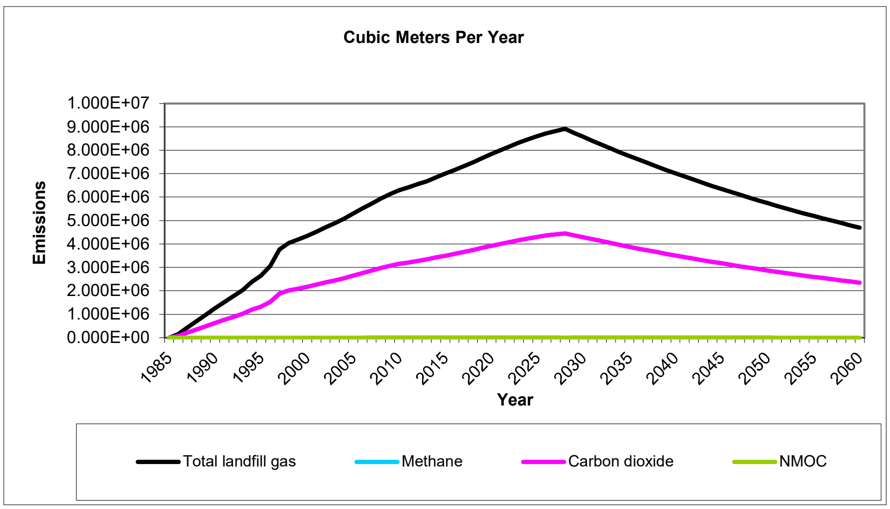
		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

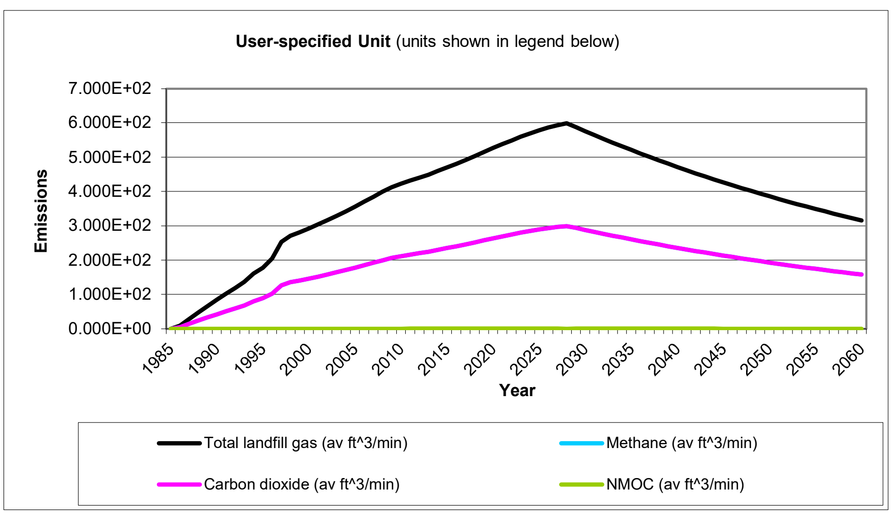
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
1.200E+04
1.000E+04
8.000E+03
6.000E+03
4.000E+03
2.000E+03
0.000E+00
Emissions
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
2060
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
1.000E+07
9.000E+06
8.000E+06
7.000E+06
6.000E+06
5.000E+06
4.000E+06
3.000E+06
2.000E+06
1.000E+06
0.000E+00
Emissions
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
2060
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
7.000E+02
6.000E+02
5.000E+02
4.000E+02
3.000E+02
2.000E+02
1.000E+02
0.000E+00
Emissions
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
2060
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)*
1985	0	0	0	0	0	0
1986	1.759E+02	1.409E+05	9.464E+00	4.699E+01	7.043E+04	4.732E+00
1987	5.336E+02	4.273E+05	2.871E+01	1.425E+02	2.136E+05	1.436E+01
1988	8.842E+02	7.081E+05	4.757E+01	2.362E+02	3.540E+05	2.379E+01
1989	1.228E+03	9.833E+05	6.607E+01	3.280E+02	4.916E+05	3.303E+01
1990	1.565E+03	1.253E+06	8.419E+01	4.180E+02	6.265E+05	4.210E+01
1991	1.895E+03	1.517E+06	1.020E+02	5.062E+02	7.587E+05	5.098E+01
1992	2.219E+03	1.777E+06	1.194E+02	5.926E+02	8.883E+05	5.969E+01
1993	2.536E+03	2.031E+06	1.364E+02	6.774E+02	1.015E+06	6.822E+01
1994	2.983E+03	2.389E+06	1.605E+02	7.969E+02	1.194E+06	8.025E+01
1995	3.310E+03	2.651E+06	1.781E+02	8.843E+02	1.325E+06	8.906E+01
1996	3.811E+03	3.051E+06	2.050E+02	1.018E+03	1.526E+06	1.025E+02
1997	4.710E+03	3.772E+06	2.534E+02	1.258E+03	1.886E+06	1.267E+02
1998	5.037E+03	4.033E+06	2.710E+02	1.345E+03	2.017E+06	1.355E+02
1999	5.226E+03	4.185E+06	2.812E+02	1.396E+03	2.093E+06	1.406E+02
2000	5.427E+03	4.346E+06	2.920E+02	1.450E+03	2.173E+06	1.460E+02
2001	5.647E+03	4.522E+06	3.038E+02	1.508E+03	2.261E+06	1.519E+02
2002	5.883E+03	4.711E+06	3.165E+02	1.571E+03	2.355E+06	1.583E+02
2003	6.103E+03	4.887E+06	3.283E+02	1.630E+03	2.443E+06	1.642E+02
2004	6.347E+03	5.082E+06	3.415E+02	1.695E+03	2.541E+06	1.707E+02
2005	6.610E+03	5.293E+06	3.556E+02	1.766E+03	2.647E+06	1.778E+02
2006	6.880E+03	5.510E+06	3.702E+02	1.838E+03	2.755E+06	1.851E+02
2007	7.150E+03	5.726E+06	3.847E+02	1.910E+03	2.863E+06	1.924E+02
2008	7.414E+03	5.937E+06	3.989E+02	1.980E+03	2.969E+06	1.995E+02
2009	7.660E+03	6.134E+06	4.121E+02	2.046E+03	3.067E+06	2.061E+02
2010	7.862E+03	6.295E+06	4.230E+02	2.100E+03	3.148E+06	2.115E+02
2011	8.020E+03	6.422E+06	4.315E+02	2.142E+03	3.211E+06	2.157E+02
2012	8.181E+03	6.551E+06	4.401E+02	2.185E+03	3.275E+06	2.201E+02
2013	8.336E+03	6.675E+06	4.485E+02	2.227E+03	3.337E+06	2.242E+02
2014	8.540E+03	6.838E+06	4.595E+02	2.281E+03	3.419E+06	2.297E+02
2015	8.740E+03	6.998E+06	4.702E+02	2.334E+03	3.499E+06	2.351E+02
2016	8.933E+03	7.153E+06	4.806E+02	2.386E+03	3.577E+06	2.403E+02
2017	9.133E+03	7.314E+06	4.914E+02	2.440E+03	3.657E+06	2.457E+02
2018	9.344E+03	7.482E+06	5.027E+02	2.496E+03	3.741E+06	2.514E+02
2019	9.570E+03	7.663E+06	5.149E+02	2.556E+03	3.832E+06	2.574E+02
2020	9.791E+03	7.840E+06	5.268E+02	2.615E+03	3.920E+06	2.634E+02
2021	9.992E+03	8.001E+06	5.376E+02	2.669E+03	4.001E+06	2.688E+02
2022	1.019E+04	8.160E+06	5.483E+02	2.722E+03	4.080E+06	2.741E+02
2023	1.040E+04	8.324E+06	5.593E+02	2.777E+03	4.162E+06	2.796E+02
2024	1.058E+04	8.472E+06	5.692E+02	2.826E+03	4.236E+06	2.846E+02
2025	1.074E+04	8.604E+06	5.781E+02	2.870E+03	4.302E+06	2.890E+02
2026	1.089E+04	8.722E+06	5.860E+02	2.909E+03	4.361E+06	2.930E+02
2027	1.102E+04	8.826E+06	5.930E+02	2.944E+03	4.413E+06	2.965E+02
2028	1.114E+04	8.917E+06	5.991E+02	2.975E+03	4.459E+06	2.996E+02
2029	1.092E+04	8.741E+06	5.873E+02	2.916E+03	4.370E+06	2.936E+02
2030	1.070E+04	8.567E+06	5.756E+02	2.858E+03	4.284E+06	2.878E+02
2031	1.049E+04	8.398E+06	5.642E+02	2.801E+03	4.199E+06	2.821E+02
2032	1.028E+04	8.232E+06	5.531E+02	2.746E+03	4.116E+06	2.765E+02
2033	1.008E+04	8.069E+06	5.421E+02	2.691E+03	4.034E+06	2.711E+02
2034	9.877E+03	7.909E+06	5.314E+02	2.638E+03	3.954E+06	2.657E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2035	9.681E+03	7.752E+06	5.209E+02	2.586E+03	3.876E+06	2.604E+02
2036	9.489E+03	7.599E+06	5.106E+02	2.535E+03	3.799E+06	2.553E+02
2037	9.301E+03	7.448E+06	5.004E+02	2.485E+03	3.724E+06	2.502E+02
2038	9.117E+03	7.301E+06	4.905E+02	2.435E+03	3.650E+06	2.453E+02
2039	8.937E+03	7.156E+06	4.808E+02	2.387E+03	3.578E+06	2.404E+02
2040	8.760E+03	7.014E+06	4.713E+02	2.340E+03	3.507E+06	2.357E+02
2041	8.586E+03	6.876E+06	4.620E+02	2.294E+03	3.438E+06	2.310E+02
2042	8.416E+03	6.739E+06	4.528E+02	2.248E+03	3.370E+06	2.264E+02
2043	8.250E+03	6.606E+06	4.439E+02	2.204E+03	3.303E+06	2.219E+02
2044	8.086E+03	6.475E+06	4.351E+02	2.160E+03	3.238E+06	2.175E+02
2045	7.926E+03	6.347E+06	4.264E+02	2.117E+03	3.173E+06	2.132E+02
2046	7.769E+03	6.221E+06	4.180E+02	2.075E+03	3.111E+06	2.090E+02
2047	7.615E+03	6.098E+06	4.097E+02	2.034E+03	3.049E+06	2.049E+02
2048	7.465E+03	5.977E+06	4.016E+02	1.994E+03	2.989E+06	2.008E+02
2049	7.317E+03	5.859E+06	3.937E+02	1.954E+03	2.929E+06	1.968E+02
2050	7.172E+03	5.743E+06	3.859E+02	1.916E+03	2.871E+06	1.929E+02
2051	7.030E+03	5.629E+06	3.782E+02	1.878E+03	2.815E+06	1.891E+02
2052	6.891E+03	5.518E+06	3.707E+02	1.841E+03	2.759E+06	1.854E+02
2053	6.754E+03	5.409E+06	3.634E+02	1.804E+03	2.704E+06	1.817E+02
2054	6.621E+03	5.301E+06	3.562E+02	1.768E+03	2.651E+06	1.781E+02
2055	6.489E+03	5.196E+06	3.491E+02	1.733E+03	2.598E+06	1.746E+02
2056	6.361E+03	5.094E+06	3.422E+02	1.699E+03	2.547E+06	1.711E+02
2057	6.235E+03	4.993E+06	3.355E+02	1.665E+03	2.496E+06	1.677E+02
2058	6.112E+03	4.894E+06	3.288E+02	1.632E+03	2.447E+06	1.644E+02
2059	5.990E+03	4.797E+06	3.223E+02	1.600E+03	2.398E+06	1.612E+02
2060	5.872E+03	4.702E+06	3.159E+02	1.568E+03	2.351E+06	1.580E+02
2061	5.756E+03	4.609E+06	3.097E+02	1.537E+03	2.304E+06	1.548E+02
2062	5.642E+03	4.518E+06	3.035E+02	1.507E+03	2.259E+06	1.518E+02
2063	5.530E+03	4.428E+06	2.975E+02	1.477E+03	2.214E+06	1.488E+02
2064	5.420E+03	4.340E+06	2.916E+02	1.448E+03	2.170E+06	1.458E+02
2065	5.313E+03	4.254E+06	2.859E+02	1.419E+03	2.127E+06	1.429E+02
2066	5.208E+03	4.170E+06	2.802E+02	1.391E+03	2.085E+06	1.401E+02
2067	5.105E+03	4.088E+06	2.746E+02	1.364E+03	2.044E+06	1.373E+02
2068	5.004E+03	4.007E+06	2.692E+02	1.337E+03	2.003E+06	1.346E+02
2069	4.905E+03	3.927E+06	2.639E+02	1.310E+03	1.964E+06	1.319E+02
2070	4.807E+03	3.850E+06	2.587E+02	1.284E+03	1.925E+06	1.293E+02
2071	4.712E+03	3.773E+06	2.535E+02	1.259E+03	1.887E+06	1.268E+02
2072	4.619E+03	3.699E+06	2.485E+02	1.234E+03	1.849E+06	1.243E+02
2073	4.528E+03	3.625E+06	2.436E+02	1.209E+03	1.813E+06	1.218E+02
2074	4.438E+03	3.554E+06	2.388E+02	1.185E+03	1.777E+06	1.194E+02
2075	4.350E+03	3.483E+06	2.340E+02	1.162E+03	1.742E+06	1.170E+02
2076	4.264E+03	3.414E+06	2.294E+02	1.139E+03	1.707E+06	1.147E+02
2077	4.179E+03	3.347E+06	2.249E+02	1.116E+03	1.673E+06	1.124E+02
2078	4.097E+03	3.280E+06	2.204E+02	1.094E+03	1.640E+06	1.102E+02
2079	4.016E+03	3.215E+06	2.160E+02	1.073E+03	1.608E+06	1.080E+02
2080	3.936E+03	3.152E+06	2.118E+02	1.051E+03	1.576E+06	1.059E+02
2081	3.858E+03	3.089E+06	2.076E+02	1.031E+03	1.545E+06	1.038E+02
2082	3.782E+03	3.028E+06	2.035E+02	1.010E+03	1.514E+06	1.017E+02
2083	3.707E+03	2.968E+06	1.994E+02	9.901E+02	1.484E+06	9.972E+01
2084	3.633E+03	2.909E+06	1.955E+02	9.705E+02	1.455E+06	9.774E+01
2085	3.561E+03	2.852E+06	1.916E+02	9.513E+02	1.426E+06	9.581E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2086	3.491E+03	2.795E+06	1.878E+02	9.325E+02	1.398E+06	9.391E+01
2087	3.422E+03	2.740E+06	1.841E+02	9.140E+02	1.370E+06	9.205E+01
2088	3.354E+03	2.686E+06	1.805E+02	8.959E+02	1.343E+06	9.023E+01
2089	3.288E+03	2.633E+06	1.769E+02	8.782E+02	1.316E+06	8.844E+01
2090	3.223E+03	2.580E+06	1.734E+02	8.608E+02	1.290E+06	8.669E+01
2091	3.159E+03	2.529E+06	1.699E+02	8.437E+02	1.265E+06	8.497E+01
2092	3.096E+03	2.479E+06	1.666E+02	8.270E+02	1.240E+06	8.329E+01
2093	3.035E+03	2.430E+06	1.633E+02	8.107E+02	1.215E+06	8.164E+01
2094	2.975E+03	2.382E+06	1.601E+02	7.946E+02	1.191E+06	8.003E+01
2095	2.916E+03	2.335E+06	1.569E+02	7.789E+02	1.167E+06	7.844E+01
2096	2.858E+03	2.289E+06	1.538E+02	7.634E+02	1.144E+06	7.689E+01
2097	2.802E+03	2.243E+06	1.507E+02	7.483E+02	1.122E+06	7.537E+01
2098	2.746E+03	2.199E+06	1.477E+02	7.335E+02	1.099E+06	7.387E+01
2099	2.692E+03	2.155E+06	1.448E+02	7.190E+02	1.078E+06	7.241E+01
2100	2.638E+03	2.113E+06	1.420E+02	7.047E+02	1.056E+06	7.098E+01
2101	2.586E+03	2.071E+06	1.391E+02	6.908E+02	1.035E+06	6.957E+01
2102	2.535E+03	2.030E+06	1.364E+02	6.771E+02	1.015E+06	6.819E+01
2103	2.485E+03	1.990E+06	1.337E+02	6.637E+02	9.948E+05	6.684E+01
2104	2.436E+03	1.950E+06	1.310E+02	6.506E+02	9.751E+05	6.552E+01
2105	2.387E+03	1.912E+06	1.284E+02	6.377E+02	9.558E+05	6.422E+01
2106	2.340E+03	1.874E+06	1.259E+02	6.251E+02	9.369E+05	6.295E+01
2107	2.294E+03	1.837E+06	1.234E+02	6.127E+02	9.184E+05	6.170E+01
2108	2.248E+03	1.800E+06	1.210E+02	6.005E+02	9.002E+05	6.048E+01
2109	2.204E+03	1.765E+06	1.186E+02	5.887E+02	8.823E+05	5.928E+01
2110	2.160E+03	1.730E+06	1.162E+02	5.770E+02	8.649E+05	5.811E+01
2111	2.117E+03	1.695E+06	1.139E+02	5.656E+02	8.477E+05	5.696E+01
2112	2.075E+03	1.662E+06	1.117E+02	5.544E+02	8.310E+05	5.583E+01
2113	2.034E+03	1.629E+06	1.095E+02	5.434E+02	8.145E+05	5.473E+01
2114	1.994E+03	1.597E+06	1.073E+02	5.326E+02	7.984E+05	5.364E+01
2115	1.955E+03	1.565E+06	1.052E+02	5.221E+02	7.826E+05	5.258E+01
2116	1.916E+03	1.534E+06	1.031E+02	5.118E+02	7.671E+05	5.154E+01
2117	1.878E+03	1.504E+06	1.010E+02	5.016E+02	7.519E+05	5.052E+01
2118	1.841E+03	1.474E+06	9.904E+01	4.917E+02	7.370E+05	4.952E+01
2119	1.804E+03	1.445E+06	9.708E+01	4.819E+02	7.224E+05	4.854E+01
2120	1.769E+03	1.416E+06	9.515E+01	4.724E+02	7.081E+05	4.758E+01
2121	1.734E+03	1.388E+06	9.327E+01	4.631E+02	6.941E+05	4.663E+01
2122	1.699E+03	1.361E+06	9.142E+01	4.539E+02	6.803E+05	4.571E+01
2123	1.666E+03	1.334E+06	8.961E+01	4.449E+02	6.669E+05	4.481E+01
2124	1.633E+03	1.307E+06	8.784E+01	4.361E+02	6.537E+05	4.392E+01
2125	1.600E+03	1.281E+06	8.610E+01	4.275E+02	6.407E+05	4.305E+01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
1985	0	0	0	0	0	0
1986	1.289E+02	7.043E+04	4.732E+00	3.029E-01	8.452E+01	5.679E-03
1987	3.911E+02	2.136E+05	1.436E+01	9.190E-01	2.564E+02	1.723E-02
1988	6.481E+02	3.540E+05	2.379E+01	1.523E+00	4.248E+02	2.854E-02
1989	8.999E+02	4.916E+05	3.303E+01	2.115E+00	5.900E+02	3.964E-02
1990	1.147E+03	6.265E+05	4.210E+01	2.695E+00	7.518E+02	5.051E-02
1991	1.389E+03	7.587E+05	5.098E+01	3.264E+00	9.105E+02	6.117E-02
1992	1.626E+03	8.883E+05	5.969E+01	3.821E+00	1.066E+03	7.162E-02
1993	1.859E+03	1.015E+06	6.822E+01	4.367E+00	1.218E+03	8.186E-02
1994	2.186E+03	1.194E+06	8.025E+01	5.138E+00	1.433E+03	9.630E-02
1995	2.426E+03	1.325E+06	8.906E+01	5.701E+00	1.591E+03	1.069E-01
1996	2.793E+03	1.526E+06	1.025E+02	6.563E+00	1.831E+03	1.230E-01
1997	3.452E+03	1.886E+06	1.267E+02	8.112E+00	2.263E+03	1.521E-01
1998	3.692E+03	2.017E+06	1.355E+02	8.675E+00	2.420E+03	1.626E-01
1999	3.830E+03	2.093E+06	1.406E+02	9.001E+00	2.511E+03	1.687E-01
2000	3.977E+03	2.173E+06	1.460E+02	9.346E+00	2.607E+03	1.752E-01
2001	4.139E+03	2.261E+06	1.519E+02	9.726E+00	2.713E+03	1.823E-01
2002	4.311E+03	2.355E+06	1.583E+02	1.013E+01	2.826E+03	1.899E-01
2003	4.473E+03	2.443E+06	1.642E+02	1.051E+01	2.932E+03	1.970E-01
2004	4.651E+03	2.541E+06	1.707E+02	1.093E+01	3.049E+03	2.049E-01
2005	4.844E+03	2.647E+06	1.778E+02	1.138E+01	3.176E+03	2.134E-01
2006	5.043E+03	2.755E+06	1.851E+02	1.185E+01	3.306E+03	2.221E-01
2007	5.240E+03	2.863E+06	1.924E+02	1.231E+01	3.435E+03	2.308E-01
2008	5.434E+03	2.969E+06	1.995E+02	1.277E+01	3.562E+03	2.393E-01
2009	5.614E+03	3.067E+06	2.061E+02	1.319E+01	3.680E+03	2.473E-01
2010	5.762E+03	3.148E+06	2.115E+02	1.354E+01	3.777E+03	2.538E-01
2011	5.878E+03	3.211E+06	2.157E+02	1.381E+01	3.853E+03	2.589E-01
2012	5.995E+03	3.275E+06	2.201E+02	1.409E+01	3.930E+03	2.641E-01
2013	6.109E+03	3.337E+06	2.242E+02	1.436E+01	4.005E+03	2.691E-01
2014	6.259E+03	3.419E+06	2.297E+02	1.471E+01	4.103E+03	2.757E-01
2015	6.405E+03	3.499E+06	2.351E+02	1.505E+01	4.199E+03	2.821E-01
2016	6.547E+03	3.577E+06	2.403E+02	1.538E+01	4.292E+03	2.884E-01
2017	6.694E+03	3.657E+06	2.457E+02	1.573E+01	4.388E+03	2.948E-01
2018	6.848E+03	3.741E+06	2.514E+02	1.609E+01	4.489E+03	3.016E-01
2019	7.014E+03	3.832E+06	2.574E+02	1.648E+01	4.598E+03	3.089E-01
2020	7.176E+03	3.920E+06	2.634E+02	1.686E+01	4.704E+03	3.161E-01
2021	7.323E+03	4.001E+06	2.688E+02	1.721E+01	4.801E+03	3.226E-01
2022	7.469E+03	4.080E+06	2.741E+02	1.755E+01	4.896E+03	3.290E-01
2023	7.618E+03	4.162E+06	2.796E+02	1.790E+01	4.994E+03	3.356E-01
2024	7.754E+03	4.236E+06	2.846E+02	1.822E+01	5.083E+03	3.415E-01
2025	7.875E+03	4.302E+06	2.890E+02	1.850E+01	5.162E+03	3.469E-01
2026	7.983E+03	4.361E+06	2.930E+02	1.876E+01	5.233E+03	3.516E-01
2027	8.078E+03	4.413E+06	2.965E+02	1.898E+01	5.296E+03	3.558E-01
2028	8.161E+03	4.459E+06	2.996E+02	1.918E+01	5.350E+03	3.595E-01
2029	8.000E+03	4.370E+06	2.936E+02	1.880E+01	5.244E+03	3.524E-01
2030	7.841E+03	4.284E+06	2.878E+02	1.843E+01	5.140E+03	3.454E-01
2031	7.686E+03	4.199E+06	2.821E+02	1.806E+01	5.039E+03	3.385E-01
2032	7.534E+03	4.116E+06	2.765E+02	1.770E+01	4.939E+03	3.318E-01
2033	7.385E+03	4.034E+06	2.711E+02	1.735E+01	4.841E+03	3.253E-01
2034	7.238E+03	3.954E+06	2.657E+02	1.701E+01	4.745E+03	3.188E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2035	7.095E+03	3.876E+06	2.604E+02	1.667E+01	4.651E+03	3.125E-01
2036	6.955E+03	3.799E+06	2.553E+02	1.634E+01	4.559E+03	3.063E-01
2037	6.817E+03	3.724E+06	2.502E+02	1.602E+01	4.469E+03	3.003E-01
2038	6.682E+03	3.650E+06	2.453E+02	1.570E+01	4.380E+03	2.943E-01
2039	6.550E+03	3.578E+06	2.404E+02	1.539E+01	4.294E+03	2.885E-01
2040	6.420E+03	3.507E+06	2.357E+02	1.509E+01	4.209E+03	2.828E-01
2041	6.293E+03	3.438E+06	2.310E+02	1.479E+01	4.125E+03	2.772E-01
2042	6.168E+03	3.370E+06	2.264E+02	1.449E+01	4.044E+03	2.717E-01
2043	6.046E+03	3.303E+06	2.219E+02	1.421E+01	3.964E+03	2.663E-01
2044	5.926E+03	3.238E+06	2.175E+02	1.393E+01	3.885E+03	2.610E-01
2045	5.809E+03	3.173E+06	2.132E+02	1.365E+01	3.808E+03	2.559E-01
2046	5.694E+03	3.111E+06	2.090E+02	1.338E+01	3.733E+03	2.508E-01
2047	5.581E+03	3.049E+06	2.049E+02	1.311E+01	3.659E+03	2.458E-01
2048	5.471E+03	2.989E+06	2.008E+02	1.286E+01	3.586E+03	2.410E-01
2049	5.362E+03	2.929E+06	1.968E+02	1.260E+01	3.515E+03	2.362E-01
2050	5.256E+03	2.871E+06	1.929E+02	1.235E+01	3.446E+03	2.315E-01
2051	5.152E+03	2.815E+06	1.891E+02	1.211E+01	3.378E+03	2.269E-01
2052	5.050E+03	2.759E+06	1.854E+02	1.187E+01	3.311E+03	2.224E-01
2053	4.950E+03	2.704E+06	1.817E+02	1.163E+01	3.245E+03	2.180E-01
2054	4.852E+03	2.651E+06	1.781E+02	1.140E+01	3.181E+03	2.137E-01
2055	4.756E+03	2.598E+06	1.746E+02	1.118E+01	3.118E+03	2.095E-01
2056	4.662E+03	2.547E+06	1.711E+02	1.095E+01	3.056E+03	2.053E-01
2057	4.570E+03	2.496E+06	1.677E+02	1.074E+01	2.996E+03	2.013E-01
2058	4.479E+03	2.447E+06	1.644E+02	1.053E+01	2.936E+03	1.973E-01
2059	4.390E+03	2.398E+06	1.612E+02	1.032E+01	2.878E+03	1.934E-01
2060	4.303E+03	2.351E+06	1.580E+02	1.011E+01	2.821E+03	1.896E-01
2061	4.218E+03	2.304E+06	1.548E+02	9.912E+00	2.765E+03	1.858E-01
2062	4.135E+03	2.259E+06	1.518E+02	9.716E+00	2.711E+03	1.821E-01
2063	4.053E+03	2.214E+06	1.488E+02	9.523E+00	2.657E+03	1.785E-01
2064	3.973E+03	2.170E+06	1.458E+02	9.335E+00	2.604E+03	1.750E-01
2065	3.894E+03	2.127E+06	1.429E+02	9.150E+00	2.553E+03	1.715E-01
2066	3.817E+03	2.085E+06	1.401E+02	8.969E+00	2.502E+03	1.681E-01
2067	3.741E+03	2.044E+06	1.373E+02	8.791E+00	2.453E+03	1.648E-01
2068	3.667E+03	2.003E+06	1.346E+02	8.617E+00	2.404E+03	1.615E-01
2069	3.595E+03	1.964E+06	1.319E+02	8.447E+00	2.356E+03	1.583E-01
2070	3.523E+03	1.925E+06	1.293E+02	8.279E+00	2.310E+03	1.552E-01
2071	3.454E+03	1.887E+06	1.268E+02	8.115E+00	2.264E+03	1.521E-01
2072	3.385E+03	1.849E+06	1.243E+02	7.955E+00	2.219E+03	1.491E-01
2073	3.318E+03	1.813E+06	1.218E+02	7.797E+00	2.175E+03	1.462E-01
2074	3.252E+03	1.777E+06	1.194E+02	7.643E+00	2.132E+03	1.433E-01
2075	3.188E+03	1.742E+06	1.170E+02	7.491E+00	2.090E+03	1.404E-01
2076	3.125E+03	1.707E+06	1.147E+02	7.343E+00	2.049E+03	1.376E-01
2077	3.063E+03	1.673E+06	1.124E+02	7.198E+00	2.008E+03	1.349E-01
2078	3.002E+03	1.640E+06	1.102E+02	7.055E+00	1.968E+03	1.322E-01
2079	2.943E+03	1.608E+06	1.080E+02	6.915E+00	1.929E+03	1.296E-01
2080	2.885E+03	1.576E+06	1.059E+02	6.779E+00	1.891E+03	1.271E-01
2081	2.828E+03	1.545E+06	1.038E+02	6.644E+00	1.854E+03	1.245E-01
2082	2.772E+03	1.514E+06	1.017E+02	6.513E+00	1.817E+03	1.221E-01
2083	2.717E+03	1.484E+06	9.972E+01	6.384E+00	1.781E+03	1.197E-01
2084	2.663E+03	1.455E+06	9.774E+01	6.257E+00	1.746E+03	1.173E-01
2085	2.610E+03	1.426E+06	9.581E+01	6.133E+00	1.711E+03	1.150E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2086	2.558E+03	1.398E+06	9.391E+01	6.012E+00	1.677E+03	1.127E-01
2087	2.508E+03	1.370E+06	9.205E+01	5.893E+00	1.644E+03	1.105E-01
2088	2.458E+03	1.343E+06	9.023E+01	5.776E+00	1.611E+03	1.083E-01
2089	2.409E+03	1.316E+06	8.844E+01	5.662E+00	1.580E+03	1.061E-01
2090	2.362E+03	1.290E+06	8.669E+01	5.550E+00	1.548E+03	1.040E-01
2091	2.315E+03	1.265E+06	8.497E+01	5.440E+00	1.518E+03	1.020E-01
2092	2.269E+03	1.240E+06	8.329E+01	5.332E+00	1.488E+03	9.995E-02
2093	2.224E+03	1.215E+06	8.164E+01	5.227E+00	1.458E+03	9.797E-02
2094	2.180E+03	1.191E+06	8.003E+01	5.123E+00	1.429E+03	9.603E-02
2095	2.137E+03	1.167E+06	7.844E+01	5.022E+00	1.401E+03	9.413E-02
2096	2.095E+03	1.144E+06	7.689E+01	4.922E+00	1.373E+03	9.227E-02
2097	2.053E+03	1.122E+06	7.537E+01	4.825E+00	1.346E+03	9.044E-02
2098	2.013E+03	1.099E+06	7.387E+01	4.729E+00	1.319E+03	8.865E-02
2099	1.973E+03	1.078E+06	7.241E+01	4.636E+00	1.293E+03	8.689E-02
2100	1.934E+03	1.056E+06	7.098E+01	4.544E+00	1.268E+03	8.517E-02
2101	1.895E+03	1.035E+06	6.957E+01	4.454E+00	1.243E+03	8.349E-02
2102	1.858E+03	1.015E+06	6.819E+01	4.366E+00	1.218E+03	8.183E-02
2103	1.821E+03	9.948E+05	6.684E+01	4.279E+00	1.194E+03	8.021E-02
2104	1.785E+03	9.751E+05	6.552E+01	4.194E+00	1.170E+03	7.862E-02
2105	1.750E+03	9.558E+05	6.422E+01	4.111E+00	1.147E+03	7.707E-02
2106	1.715E+03	9.369E+05	6.295E+01	4.030E+00	1.124E+03	7.554E-02
2107	1.681E+03	9.184E+05	6.170E+01	3.950E+00	1.102E+03	7.404E-02
2108	1.648E+03	9.002E+05	6.048E+01	3.872E+00	1.080E+03	7.258E-02
2109	1.615E+03	8.823E+05	5.928E+01	3.795E+00	1.059E+03	7.114E-02
2110	1.583E+03	8.649E+05	5.811E+01	3.720E+00	1.038E+03	6.973E-02
2111	1.552E+03	8.477E+05	5.696E+01	3.646E+00	1.017E+03	6.835E-02
2112	1.521E+03	8.310E+05	5.583E+01	3.574E+00	9.972E+02	6.700E-02
2113	1.491E+03	8.145E+05	5.473E+01	3.503E+00	9.774E+02	6.567E-02
2114	1.461E+03	7.984E+05	5.364E+01	3.434E+00	9.581E+02	6.437E-02
2115	1.432E+03	7.826E+05	5.258E+01	3.366E+00	9.391E+02	6.310E-02
2116	1.404E+03	7.671E+05	5.154E+01	3.299E+00	9.205E+02	6.185E-02
2117	1.376E+03	7.519E+05	5.052E+01	3.234E+00	9.023E+02	6.062E-02
2118	1.349E+03	7.370E+05	4.952E+01	3.170E+00	8.844E+02	5.942E-02
2119	1.322E+03	7.224E+05	4.854E+01	3.107E+00	8.669E+02	5.825E-02
2120	1.296E+03	7.081E+05	4.758E+01	3.046E+00	8.497E+02	5.709E-02
2121	1.271E+03	6.941E+05	4.663E+01	2.985E+00	8.329E+02	5.596E-02
2122	1.245E+03	6.803E+05	4.571E+01	2.926E+00	8.164E+02	5.485E-02
2123	1.221E+03	6.669E+05	4.481E+01	2.868E+00	8.002E+02	5.377E-02
2124	1.197E+03	6.537E+05	4.392E+01	2.812E+00	7.844E+02	5.270E-02
2125	1.173E+03	6.407E+05	4.305E+01	2.756E+00	7.689E+02	5.166E-02

APPENDIX D

EXISTING LCRS PIPE STRENGTH EVALUATION

Calcs By: Garth R. Bowers, PE (AZ) 10/12/22
Checked By: Mark Swyka/Carl Bueter

REQUIRED: **Determine maximum depth of waste a 8-inch diameter, SDR 9.3, HDPE pipe is adequate to support at Kekaha Sanitary Landfill**

METHOD: Use the critical loading to analyze the pipe for the following four design criteria:

1. Ring deflection
2. Pipe buckling
3. Wall crushing
4. Circumferential strain

REFERENCES:

1. Driscopipe, Product and Technical Information, 1991
2. Wilson-Fahmy, R.F. and Koerner, R.M. (1994). Finite Element Analysis of Plastic Pipe *Behavior in Leachate Collection and Removal Systems, GRI Report #12.*
3. Uni-Bell PVC Pipe Association (1997). *Deflection: The Pipe/Soil Mechanism*
4. Caterpillar Tractor Company, *Caterpillar Performance Handbook,* Edition 27, October 1996.
5. US Dept. of Agriculture, Natural Resources Conservation Service (2005). *Structural Design of Flexible Conduits*, National Engineering Handbook, Part 636, Chapter 52

SOLUTION:

A. Pipe Properties

8-inch dia., SDR 9.3, Perforated HDPE pipe

thickness of pipe wall	$t =$	0.928	in	calculated
inside diameter	$D_i =$	6.769	in	calculated
outside diameter	$D_o =$	8.625	in	
SDR	SDR =	9.3		AECOM
mean diameter of pipe	$D_m =$	7.697	in	
mean pipe radius	$R =$	3.849	in	

slots/perforations: Perforated				Assumed
width or diameter	$d =$	0.5	inch	Assumed
number of slots/row/foo	$n =$	4		Assumed

pipe modulus of elasticity:

Initial	$E_P =$	110000	psi
Long-term (50 year)		22000	psi

pipe compressive yield strength:

Initial	$P_A =$	3000	psi
Long-term (50 year)		1400	psi

Calcs By: Garth R. Bowers, PE (AZ) 10/12/22
Checked By: Mark Swyka/Carl Bueter

B. Bedding Material Properties

Gravel bedding

deflection lag factor	L_f =	1.5
bedding constant	K =	0.1
modulus of soil reaction	E_s =	3000

C. Loading on the Pipe

The allowable waste height is determined based on trial and error

3.0	final cover @	115	pcf	345	psf
2.0	. ops cover @	115	pcf	230	psf
156.5	solid waste @	65	pcf	10,173	psf
		Total load	P =	10,748	psf
			=	74.6	psi

Total load with correction for pipe slots/perforations,

$$P_T = \frac{P}{(1 - n.d/12)}$$

Slotted

$$P_T = \frac{P}{(1 - n.(d/12))}$$

Perforated

P_T = 89.6 psi

C. Ring Deflection

Allowable ring deflection $(\Delta Y/D_m)_{allow}$ = 7.50 %

Based on the modified Iowa deflection equation, the ring deflection ratio,

$$\frac{\Delta Y}{D_m} = \frac{L_f K P_T R^3}{E_P I + 0.061 E_s R^3}$$

Where: ΔY = vertical pipe deflection (in)
I = moment of inertia (in^3)

$$I = \frac{t^3}{12}$$

I = 0.06660 in^4/in

Therefore,

	Deflection		Note
	Initial	Long-Term	
	(%)	(%)	

$\Delta Y/D_m$	4.31	6.44	Ring Deflection is Acceptable

Calcs By: Garth R. Bowers, PE (AZ) 10/12/22
Checked By: Mark Swyka/Carl Bueter

D. Wall Buckling

Acceptable factor of safety = 2

The critical buckling pressure, P_{cr} in psi, is given by,

$$P_{cr} = 0.55\left[E_S \frac{E_P I}{0.149 R^3}\right]^{1/2}$$

Therefore,

	Unit	Initial	Long-Term	Note
P_{cr}	(psi)	885	396	-
P_T	(psi)	89.6	89.6	-
$FS = P_{cr}/P_T$	-	9.88	4.42	F.S. is Acceptable

E. Wall Crushing

Acceptable factor of safety = 2

Ignoring bending, the axial stress P_{SA} in psi is given by,

$$P_{SA} = \frac{P_T D_m}{2A_W}$$

A_w = area of pipe wall/unit circumference of pipe, in^2/in = t
= 0.928 in^2/in

Therefore,

	Unit	Initial	Long-Term	Note
P_{SA}	(psi)	371	371	-
P_A	(psi)	3000	1400	-
$FS = P_A/P_{SA}$	-	8.08	3.77	F.S. is Acceptable

Calcs By: Garth R. Bowers, PE (AZ) 10/12/22
Checked By: Mark Swyka/Carl Bueter

F. Circumferential Strain

Allowable Long-term Strain = 5 %

The total circumferential strain is a combination of:

(i) strain due to ring deflection or flexure, ε_f

(ii) strain due to hoop stress, ε_h

(iii) strain due to Poisson's effect corresponding to longitudinal strain, ε_p

Ignoring longitudinal strain,

$$\varepsilon = \varepsilon_f \pm \varepsilon_h$$

Where,

$$\varepsilon_f = \left(\frac{t}{D_m}\right)\left(\frac{3\Delta Y/Dm}{1 - 2\Delta Y/D_m}\right)$$

$\varepsilon_f =$ 0.0267 = 2.67 %

$$\varepsilon_h = \frac{P_T \; D_m}{2 \; t \; E_P}$$

$\varepsilon_h =$ 0.0169 = 1.69 %

and, if the hoop strain is due to vacuum or external load, as it is in the case of an LCRS pipe, the applicable operator is minus.

Therefore,

$\varepsilon = \varepsilon_f - \varepsilon_h =$ 0.98	%	Strain is Acceptable

CONCLUSION:

1. Ring Deflection:	**Ring Deflection is Acceptable**
2. Factor of Safety Against Pipe Buckling:	**F.S. is Acceptable**
3. Factor of Safety Against Wall Crushing:	**F.S. is Acceptable**
4. Long-term circumferential Strain:	**Strain is Acceptable**

APPENDIX E

HELP MODELING

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Kekaha Ph II Crnt Pmt - 30 yrs **Simulated On:** 11/16/2022 14:01

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SiCL - Silty Clay Loam
Material Texture Number 12

Thickness	=	12	inches
Porosity	=	0.471	vol/vol
Field Capacity	=	0.342	vol/vol
Wilting Point	=	0.21	vol/vol
Initial Soil Water Content	=	0.2623	vol/vol
Effective Sat. Hyd. Conductivity	=	4.20E-05	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer (Waste)
Municipal Solid Waste (MSW) (900 pcy)
Material Texture Number 18

Thickness	=	1248	inches
Porosity	=	0.671	vol/vol
Field Capacity	=	0.292	vol/vol
Wilting Point	=	0.077	vol/vol
Initial Soil Water Content	=	0.292	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-03	cm/sec

Layer 3

Type 1 - Vertical Percolation Layer
Operations Layer
Material Texture Number 43

Thickness	=	24	inches
Porosity	=	0.437	vol/vol
Field Capacity	=	0.062	vol/vol
Wilting Point	=	0.024	vol/vol
Initial Soil Water Content	=	0.0705	vol/vol
Effective Sat. Hyd. Conductivity	=	6.00E-03	cm/sec

Layer 4

Type 2 - Lateral Drainage Layer
G - Gravel
Material Texture Number 21

Thickness	=	12	inches
Porosity	=	0.397	vol/vol
Field Capacity	=	0.032	vol/vol
Wilting Point	=	0.013	vol/vol
Initial Soil Water Content	=	0.032	vol/vol
Effective Sat. Hyd. Conductivity	=	3.00E-01	cm/sec
Slope	=	2.8	%
Drainage Length	=	260	ft

Layer 5

Type 4 - Flexible Membrane Liner

HDPE Membrane

Material Texture Number 35

Thickness	=	0.06	inches
Effective Sat. Hyd. Conductivity	=	2.00E-13	cm/sec
FML Pinhole Density	=	1	Holes/Acre
FML Installation Defects	=	2	Holes/Acre
FML Placement Quality	=	3	Good

Layer 6

Type 3 - Barrier Soil Liner

GCL

Material Texture Number 44

Thickness	=	0.24	inches
Porosity	=	0.75	vol/vol
Field Capacity	=	0.747	vol/vol
Wilting Point	=	0.4	vol/vol
Initial Soil Water Content	=	0.75	vol/vol
Effective Sat. Hyd. Conductivity	=	5.00E-09	cm/sec

Note: Initial moisture content of the layers and snow water were specified by the user.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	95.5	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	1	acres
Evaporative Zone Depth	=	10	inches
Initial Water in Evaporative Zone	=	2.623	inches
Upper Limit of Evaporative Storage	=	4.71	inches
Lower Limit of Evaporative Storage	=	2.1	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	369.82	inches
Total Initial Water	=	369.82	inches

Total Subsurface Inflow = 0 inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	48.33	Degrees
Maximum Leaf Area Index	=	0	
Start of Growing Season (Julian Date)	=	0	days
End of Growing Season (Julian Date)	=	367	days
Average Wind Speed	=	3.47	mph
Average 1st Quarter Relative Humidity	=	72	%
Average 2nd Quarter Relative Humidity	=	66	%
Average 3rd Quarter Relative Humidity	=	66	%
Average 4th Quarter Relative Humidity	=	70	%

Note: Evapotranspiration data was obtained for Kekaha, Hawaii

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
2.763333	1.72	1.539	0.701	0.645	0.278333
0.807333	0.540667	0.828	2.288667	2.802	3.342333

Note: Precipitation was simulated using NOAA data for the following weather stations: KEKAHA 944, HI US, KEKAHA 944, HI US, KEKAHA 944, HI US

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
70.8	70.7	71.6	73	74.3	76.8
77.9	78.4	78.1	76.9	75	72.4

Note: Temperature was simulated using NOAA data for the following weather stations: KEKAHA 944, HI US, KEKAHA 944, HI US, KEKAHA 944, HI US
Solar radiation was simulated using NSRDB data for the following location:
0

Average Annual Totals Summary

Title: Kekaha Ph II Crnt Pmt - 30 yrs
Simulated on: 11/16/2022 14:05

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	18.26	[12.17]	66,268.1	100.00
Runoff	7.491	[7.135]	27,193.9	41.04
Evapotranspiration	8.161	[3.58]	29,625.7	44.71
Subprofile1				
Lateral drainage collected from Layer 4	2.4914	[2.2633]	9,043.9	13.65
Percolation/leakage through Layer 6	0.000006	[0.000004]	0.0225	0.00
Average Head on Top of Layer 5	0.0373	[0.0339]	---	---
Water storage				
Change in water storage	0.1114	[1.3385]	404.5	0.61

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: Kekaha Ph II Crnt Pmt - 30 yrs
Simulated on: 11/16/2022 14:05

	Peak Values for Years 1 - 30*	
	(inches)	(cubic feet)
Precipitation	5.72	20,763.6
Runoff	5.107	18,537.6
Subprofile1		
Drainage collected from Layer 4	0.1301	472.4
Percolation/leakage through Layer 6	0.000000	0.0009
Average head on Layer 5	0.7111	---
Maximum head on Layer 5	1.3484	---
Location of maximum head in Layer 4	13.28 (feet from drain)	
Other Parameters		
Snow water	0.0000	0.0000
Maximum vegetation soil water	0.3927 (vol/vol)	
Minimum vegetation soil water	0.2100 (vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: Kekaha Ph II Crnt Pmt - 30 yrs
Simulated on: 11/16/2022 14:05
Simulation period: 30 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	4.2897	0.3575
2	364.4160	0.2920
3	3.7231	0.1551
4	0.5538	0.0461
5	0.0000	0.0000
6	0.1800	0.7500
Snow water	0.0000	---

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Kekaha Ph II Prop Vert Exp-30 **Simulated On:** 11/16/2022 14:26

Layer 1
Type 1 - Vertical Percolation Layer (Cover Soil)
SiCL - Silty Clay Loam
Material Texture Number 12

Thickness	=	12	inches
Porosity	=	0.471	vol/vol
Field Capacity	=	0.342	vol/vol
Wilting Point	=	0.21	vol/vol
Initial Soil Water Content	=	0.2623	vol/vol
Effective Sat. Hyd. Conductivity	=	4.20E-05	cm/sec

Layer 2
Type 1 - Vertical Percolation Layer (Waste)
Municipal Solid Waste (MSW) (900 pcy)
Material Texture Number 18

Thickness	=	1852	inches
Porosity	=	0.671	vol/vol
Field Capacity	=	0.292	vol/vol
Wilting Point	=	0.077	vol/vol
Initial Soil Water Content	=	0.292	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-03	cm/sec

Layer 3
Type 1 - Vertical Percolation Layer
Operations Layer
Material Texture Number 43

Thickness	=	24	inches
Porosity	=	0.437	vol/vol
Field Capacity	=	0.062	vol/vol
Wilting Point	=	0.024	vol/vol
Initial Soil Water Content	=	0.0705	vol/vol
Effective Sat. Hyd. Conductivity	=	6.00E-03	cm/sec

Layer 4
Type 2 - Lateral Drainage Layer
G - Gravel
Material Texture Number 21

Thickness	=	12	inches
Porosity	=	0.397	vol/vol
Field Capacity	=	0.032	vol/vol
Wilting Point	=	0.013	vol/vol
Initial Soil Water Content	=	0.032	vol/vol
Effective Sat. Hyd. Conductivity	=	3.00E-01	cm/sec
Slope	=	2.8	%
Drainage Length	=	260	ft

Layer 5

Type 4 - Flexible Membrane Liner

HDPE Membrane

Material Texture Number 35

Thickness	=	0.06	inches
Effective Sat. Hyd. Conductivity	=	2.00E-13	cm/sec
FML Pinhole Density	=	1	Holes/Acre
FML Installation Defects	=	2	Holes/Acre
FML Placement Quality	=	3	Good

Layer 6

Type 3 - Barrier Soil Liner

GCL

Material Texture Number 44

Thickness	=	0.24	inches
Porosity	=	0.75	vol/vol
Field Capacity	=	0.747	vol/vol
Wilting Point	=	0.4	vol/vol
Initial Soil Water Content	=	0.75	vol/vol
Effective Sat. Hyd. Conductivity	=	5.00E-09	cm/sec

Note: Initial moisture content of the layers and snow water were specified by the user.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	95.5	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	1	acres
Evaporative Zone Depth	=	10	inches
Initial Water in Evaporative Zone	=	2.623	inches
Upper Limit of Evaporative Storage	=	4.71	inches
Lower Limit of Evaporative Storage	=	2.1	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	546.188	inches
Total Initial Water	=	546.188	inches

Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	48.33	Degrees
Maximum Leaf Area Index	=	0	
Start of Growing Season (Julian Date)	=	0	days
End of Growing Season (Julian Date)	=	367	days
Average Wind Speed	=	3.47	mph
Average 1st Quarter Relative Humidity	=	72	%
Average 2nd Quarter Relative Humidity	=	66	%
Average 3rd Quarter Relative Humidity	=	66	%
Average 4th Quarter Relative Humidity	=	70	%

Note: Evapotranspiration data was obtained for Kekaha, Hawaii

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
2.763333	1.72	1.539	0.701	0.645	0.278333
0.807333	0.540667	0.828	2.288667	2.802	3.342333

Note: Precipitation was simulated using NOAA data for the following weather stations:
KEKAHA 944, HI US, KEKAHA 944, HI US, KEKAHA 944, HI US

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
70.8	70.7	71.6	73	74.3	76.8
77.9	78.4	78.1	76.9	75	72.4

Note: Temperature was simulated using NOAA data for the following weather stations:
KEKAHA 944, HI US, KEKAHA 944, HI US, KEKAHA 944, HI US
Solar radiation was simulated using NSRDB data for the following location:
0

Average Annual Totals Summary

Title: Kekaha Ph II Prop Vert Exp-30
Simulated on: 11/16/2022 14:30

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	18.26	[12.17]	66,268.1	100.00
Runoff	7.491	[7.135]	27,193.9	41.04
Evapotranspiration	8.161	[3.58]	29,625.7	44.71
Subprofile1				
Lateral drainage collected from Layer 4	2.4906	[2.2609]	9,040.9	13.64
Percolation/leakage through Layer 6	0.000006	[0.000004]	0.0225	0.00
Average Head on Top of Layer 5	0.0373	[0.0338]	---	---
Water storage				
Change in water storage	0.1123	[1.3414]	407.5	0.61

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: Kekaha Ph II Prop Vert Exp-30
Simulated on: 11/16/2022 14:31

	Peak Values for Years 1 - 30*		
	(inches)		(cubic feet)
Precipitation	5.72		20,763.6
Runoff	5.107		18,537.6
Subprofile1			
Drainage collected from Layer 4	0.1306		474.1
Percolation/leakage through Layer 6	0.000000		0.0009
Average head on Layer 5	0.7137		---
Maximum head on Layer 5	1.3532		---
Location of maximum head in Layer 4	13.32	(feet from drain)	
Other Parameters			
Snow water	0.0000		0.0000
Maximum vegetation soil water	0.3927	(vol/vol)	
Minimum vegetation soil water	0.2100	(vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: Kekaha Ph II Prop Vert Exp-30
Simulated on: 11/16/2022 14:31
Simulation period: 30 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	4.2897	0.3575
2	540.7840	0.2920
3	3.7420	0.1559
4	0.5600	0.0467
5	0.0000	0.0000
6	0.1800	0.7500
Snow water	0.0000	---