SECTION VI

GROUNDWATER AND LEACHATE MONITORING PLAN

GROUNDWATER MONITORING PLAN KEKAHA SANITARY LANDFILL PHASE II KEKAHA, KAUA‘I, HAWAI‘I

County of Kaua‘i
Department of Public Works
4444 Rice Street
Lihu‘e, Kaua‘i 96766

August 2013

GROUNDWATER MONITORING PLAN
KEKAHA SANITARY LANDFILL PHASE II
KEKAHA, KAUA‘I, HAWAI‘I

Prepared for:

County of Kaua‘i
Department of Public Works
4444 Rice Street
Lihu‘e, Kaua‘i 96766

Prepared by:

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August 2013

Qualified Groundwater Scientist Certification

I declare to the best of my professional knowledge and belief, I meet the definition of a Qualified Groundwater Scientist as defined in HAR Title 11 Chapter 58.1-16. By means of this Certification/Re-Certification, I attest that this Groundwater Monitoring Plan satisfies the requirements and criteria of HAR Title 11 Chapter 58.1-16: the number, locations, and depths of the proposed groundwater monitoring network will yield samples that will adequately represent the quality of background groundwater, and will represent the quality of groundwater passing the relevant point of compliance.

Upon approval of this monitoring plan, this certification will be placed in the operating record.

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ACRONYMS AND ABBREVIATIONS

%	percent
°C	degree Celsius
ASTM	American Society for Testing and Materials
bgs	below ground surface
$CaCO_3$	calcium carbonate
CFR	Code of Federal Regulations
COC	chain-of-custody
COD	chemical oxygen demand
CUSUM	cumulative sum
DOH	Department of Health, State of Hawaiʻi
DQR	data quality review
EPA	Environmental Protection Agency, United States
FR	Federal Register
ft	foot/feet
GCL	geosynthetic clay liner
GMP	groundwater monitoring plan
H_2SO_4	sulfuric acid
HAR	Hawaiʻi Administrative Rules
HCl	hydrochloride acid
HDPE	high-density polyethylene
HNO_3	nitric acid
HRS	Hawaiʻi Revised Statutes
ID	identification
IDW	investigation-derived waste
in.	inch
KLF	Kekaha Landfill
LFG	landfill gas
MDL	method detection limit
mL	milliliter
MS	matrix spike
MSD	matrix spike duplicate
msl	mean sea level
MSW	municipal solid waste
MW	monitoring well
NaOH	sodium hydroxide
no.	number
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
POC	point-of-compliance
PQL	practical quantitation limit
QA	quality assurance
QAPP	quality assurance program plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
RPD	relative percent difference
SSI	statistically significant increase
SVOC	semivolatile organic compound
TDS	total dissolved solids
TOC	total organic carbon
U.S.	United States
USGS	United States Geological Survey

VOA	volatile organic analysis
VOC	volatile organic compound
WBZ	water bearing zone
WMH	Waste Management of Hawaii

1.0 INTRODUCTION

This Groundwater Monitoring Plan (GMP) describes methods and procedures for monitoring groundwater and leachate for the Phase II portion of the Kekaha Landfill (KLF). This GMP replaces the previous *Groundwater Monitoring Plan Kekaha Landfill Phase II,* dated December 2007 (Earth Tech 2007). The County of Kauaʻi owns and operates the KLF, which is located near the town of Kekaha in the coastal area on the southwest side of the island of Kauaʻi. The KLF facility, as permitted, currently consists of two noncontiguous landfill phases, the Phase I landfill (which was closed in 1993) and the Phase II landfill. Two previous vertical expansions of the Phase II landfill were implemented beginning in the late 1990s. The County of Kauaʻi is now proposing a third vertical expansion of the Phase II landfill to provide additional airspace while potential future landfill sites on Kauaʻi are evaluated and eventually permitted.

The most recent expansion of the Phase II landfill was a lateral expansion designated as Cell 1, which was constructed in 2010 and added approximately 6.4 acres to the west end of the Phase II landfill, increasing the total permitted footprint of the Phase II landfill to 38.5 acres. Unless otherwise noted, the term "Phase II landfill" as used in this GMP includes all of the original Phase II Landfill area, the Cell 1 lateral expansion, and the existing and proposed vertical expansions.

The proposed vertical expansion will include construction of an additional engineered waste disposal unit within the permitted area of the Phase II Landfill (including the Cell 1 area). The vertical expansion will not alter the permitted limit-of-waste footprint, which will remain at 38.5 acres. The proposed maximum height of the final cover system upon closure of the vertical expansion is 120 feet above mean sea level (msl). Construction of the vertical expansion will make use of the existing, continuous, Phase II Subtitle D base liner system that underlies all of the Phase II landfill, including Cell 1. The expansion will provide an estimated 656,000 cubic yards of gross airspace, based on the proposed expansion limits and a final cover elevation of 120 feet above msl. Based on current landfill waste density and daily disposal rates, the vertical expansion could extend the operating life of the KLF facility by approximately 5.2 years.

The vertical expansion will include minor modifications to the existing landfill drainage system. Surface water drainage structures will be modified slightly to accommodate runoff from the extended sideslopes required for the vertical expansion. Surface water runoff discharges to an infiltration ditch located between the Phase I and Phase II landfills, as well as to infiltration ditches located around the perimeter of the Phase II landfill. The existing 2-acre infiltration basin and infiltration ditch are adequate to manage the increased surface water flow rates associated with the vertical expansion, and therefore will not require any modifications.

1.1 SITE BACKGROUND

The KLF is located near the southwest coast of the Island of Kauaʻi, about 2 miles west of the town of Kekaha, at mile marker 28 of Kaumualiʻi Highway (Highway 50). As shown on Figure 1-1, the seaward boundary of the landfill site is located approximately 4,000 feet northeast of the ocean shoreline.

Phase I of the KLF occupies approximately 33 acres and varies in elevation from 10 to 50 feet above mean sea level (msl). The County of Kauaʻi 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. However, the final cover of 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 (U.S.) Environmental Protection Agency (EPA) *Solid Waste Disposal Facility Criteria*, under Resource Conservation and Recovery Act (RCRA) Subtitle D, published as 40 Code of Federal Regulations (CFR) Part 258.

- State of Hawaiʻi Department of Health (DOH) *Solid Waste Management Control and Interim Guidelines for Landfill Closure*, Draft, Hawaiʻi Administrative Rule (HAR) Title 11, Chapter 58.

The KLF Phase II Landfill was constructed in 1993 and is bounded by Kaumualiʻi Highway to the northeast, an unpaved access road and agricultural area to the southeast, an aquaculture facility to the northwest, and the Phase I Landfill to the southwest. The Phase II Landfill was constructed to meet RCRA Subtitle D criteria and is currently an active municipal solid waste (MSW) landfill. The Phase II Landfill facility is owned by the County of Kauaʻi, Department of Public Works, and operated by Waste Management of Hawaii (WMH).

The Phase II Landfill was initially permitted for filling to a maximum elevation of 37 feet above msl. In 1998, a vertical expansion was proposed to raise the maximum fill elevation in order to accommodate wastes generated by Hurricane Iniki in 1992. This vertical expansion was approved and the KLF was permitted to a maximum elevation of 60 feet above msl. In November 2004, the DOH approved a second vertical expansion of the Phase II facility to a maximum permitted elevation of 85 feet above msl.

The original Phase II landfill base liner and leachate collection system slope downward toward the northeast from about 12 feet to 7 feet above msl. The Phase II sideslopes have a slope ratio of 3.5:1 (horizontal:vertical), and the top deck area slopes at 3 percent (%) from the center toward the perimeter. The original Phase II liner area (i.e., not including Cell 1) encompasses 32 acres and is subdivided into 14 lined subcells (each about 2.3 acres). The subcells were constructed to drain toward the northeast edge of the landfill where the leachate is collected in two sumps.

The original Phase II base liner system consists of the following (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 facing up
- Single-sided textured 60-mil HDPE geomembrane (textured side down) against bentonite component of the GCL on the sideslopes
- Smooth 60-mil HDPE geomembrane against bentonite component of the GCL on the base
- Sand drainage layer (base and sideslope)

1.2 PROGRAM OVERVIEW

This GMP describes the methods and procedures developed to monitor groundwater and leachate for the KLF Phase II Landfill. Locations of the existing Phase II monitoring wells are shown on Figure 1-2.

All elements of the monitoring program described in this GMP comply with the following regulations and permit requirements:

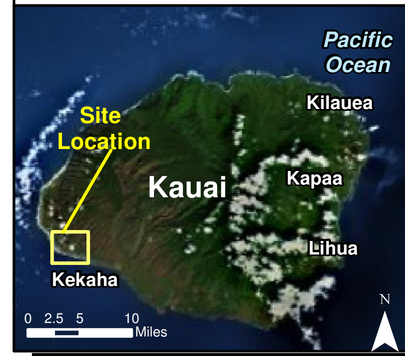
- 40 CFR part 258 (Subtitle D)
- Chapter 342H, Hawaiʻi Revised Statutes (HRS)
- HAR, Title 11 – DOH, Chapter 58.1 – *Solid Waste Management Control* (DOH 1994)
- *State of Hawaiʻi Landfill Groundwater Monitoring Guidance Document* (DOH Guidance Document), Version 1.8 – September 2002 – DOH Solid and Hazardous Waste Branch (DOH 2002)

- Permit Number (No.) LF-0104-04, issued by the DOH, Office of Solid Waste Management on April 7, 2005, and Permit No. LF-0053-09, issued by DOH on November 16, 2009

The State of Hawaiʻi is authorized to implement 40 CFR Part 258 (Subtitle D), and has adopted all elements of this federal statute into applicable state regulations (listed above) and the facility permit. The activities described in this plan constitute the detection monitoring program proposed for the KLF Phase II. This GMP will serve as a technical guidance document for personnel performing site monitoring during the active life of the facility, and during the closure and post-closure periods.

The KLF Phase II detection monitoring program described in this GMP is based on the distinct hydrogeologic characteristics of the area and the potential influence of the landfill on the hydrogeologic system as it currently exists and is projected to exist in the future. Detection monitoring involves the effective use of monitoring parameters (or "indicator" parameters) and locations to provide the earliest possible detection of a potential release from a facility. The objective of this program is to select proper sampling locations and parameters, estimate background concentration ranges for groundwater in the landfill area (i.e., local groundwater that has not been affected by chemicals released from the Phase II Landfill), and evaluate potential changes in water quality using an effective statistical methodology. The statistical methodology must be environmentally sensitive and account for the probability of false positive (i.e., indication of a release when none exists) and false negative errors (i.e., falsely concluding there is no release).

LOCATION MAP



LEGEND

Roads

NOTES

1. Map projection is Hawaii State Plane, Zone 4, NAD83.
2. Base map: ArcGIS Bring Map Aerial

N

0 1,000 2,000 4,000 Feet

Figure 1
Site Location Map
Kekaha Landfill
Kauai, Hawaii

P:\ENV\Non-Federal\County of Kauai\60135722 KAUAI-Kekaha Cell 1\07 Deliverables\GIS\02_MXD\Figure 1 - Site Location Map.mxd

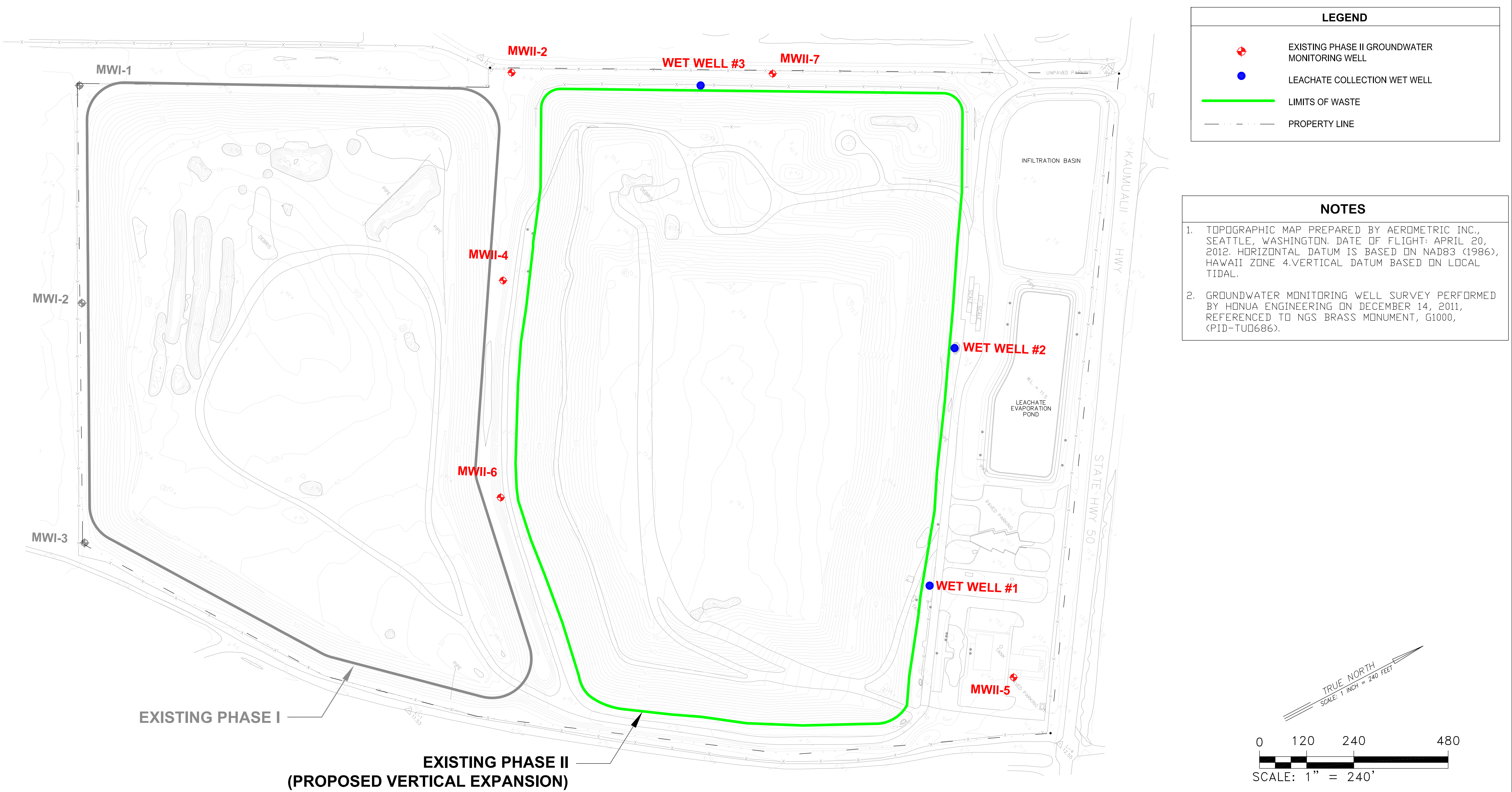


Figure 1-2
Existing Phase I and Phase II Monitoring Well Network

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Groundwater Monitoring Plan
Kekaha Landfill Phase II

This GMP describes the hydrogeologic setting of the facility, the design of the proposed groundwater monitoring network, the basis for the monitoring network configuration, the frequency of planned monitoring events, chemical analyses to be performed on environmental samples, sampling methods and data management protocols, and an appropriate site-specific statistical methodology.

Section 2.0, *Hydrogeologic Setting,* describes the geology and hydrogeology of the region and the landfill site.

Section 3.0, *Groundwater Monitoring*, discusses the rationale for selecting monitoring parameters, and lists the general analytical parameters required for detection monitoring. This section includes descriptions and references to explain the process of compiling the set of chemical parameters to be analyzed as part of the KLF Phase II detection monitoring program. In addition, this section provides justification for the placement of the monitoring network (based on the hydrogeology of the site), well construction details, and existing facility conditions.

Section 4.0, *Leachate Monitoring*, describes the approach that has been developed to characterize leachate generated at the facility. Chemicals that occur in site leachate are the most effective monitoring parameters; the leachate monitoring results will therefore be used to identify site-specific detection monitoring parameters for groundwater at the KLF.

Section 5.0, *Data Evaluation Methods*, describes the evaluation methods and procedures that will be used to ensure early detection of a release from the facility. This section includes a discussion of statistical methods appropriate for analysis of information collected as part of the KLF Phase II detection monitoring program for the site, as well as detection verification procedures.

Section 6.0, *Field Monitoring and Sampling Procedures*, describes the sampling procedures that will be followed for all sample points throughout the course of detection monitoring at the KLF. Sample preparation, collection, preservation, shipment, and documentation (through chain-of-custody [COC] manifest) are also discussed in this section.

Section 7.0, *Laboratory Analysis Plan*, describes the laboratory quality assurance (QA)/quality control (QC) procedures, analyte reporting limits, and analytical methodologies that will be used at the facility.

Section 8.0, *Data Quality Review, Reporting, and Recordkeeping*, presents the qualitative data QA review, reporting, and recordkeeping measures that will be implemented.

Section 9.0, *References*, lists the technical reports and regulatory documents used to prepare this GMP.

The detection monitoring activities outlined in this GMP will be performed to verify attainment of performance objectives for the site at appropriate points of compliance, in accordance with Solid Waste Disposal Facility Criteria (and its revisions), initially promulgated on October 9, 1991 in 40 CFR Part 258 (Subtitle D). The regulations include requirements for the location, design, and installation of groundwater monitoring systems and set standards for groundwater sampling and analysis. The regulations also provide specific statistical methods and decision standards for identifying significant changes in groundwater quality. The program described herein is designed to fully comply with Subtitle D requirements.

Environmental monitoring is required at the KLF Phase II in accordance with conditions specified in the facility permit LF-0053-09 issued by DOH on November 16, 2009. This permit was issued to the facility operator (WMH) under the provisions of the HRS Chapter 342H and HAR Title 11, Chapter 58.1 (DOH 1994).

2.0 HYDROGEOLOGIC SETTING

The KLF is located within the Kekaha-Mana coastal plain, approximately 4,000 feet northeast of the Pacific Ocean shoreline. The arch-shaped coastal plain covers an area approximately 15 miles long and 2 miles wide between the leeward shore of Kauaʻi and the slopes of the interior mountains.

The coastal plain is a relatively flat outwash plain composed of alluvium washed down from the uplands, calcareous and earthy lagoon deposits, and calcareous beach and dune sands. Surface soils in the site area are classified in the Jaucas-Mokuleia Association, and are more specifically defined as Jaucas loamy fine sands that are deep, nearly level to moderately sloping, excessively drained and well drained soils that have coarse-textured underlying materials (USDA SCS 1972).

2.1 CLIMATE AND TOPOGRAPHY

The Kekaha-Mana coastal plain is relatively arid compared to the rest of Kauaʻi due to the “rain-shadow” effect. Average annual rainfall in the area averages between 10 to 40 inches per year, while areas near the center of the island average more than 280 inches of rain per year (Oregon Climate Services 1998).

2.2 REGIONAL GEOLOGY

The geologic formations of the Kekaha-Mana coastal plain consists primarily of older alluvium and contemporary coralline and marl sedimentary rocks of marine, littoral, and terrestrial origin (Sanifill and Baquerizo 1996). These sedimentary rocks were deposited in lagoon and estuarine environments and in a flanking terrestrial environment. The thickness of the coastal plain sedimentary deposits ranges from zero on the inland edge to more than 400 feet along the seaward edge of the plain. The surface deposits (to a depth of 50 feet) consist predominantly of loose sand, coral fragments, and shell debris. The sedimentary deposits beneath the KLF are estimated to be over 400 feet thick, and are underlain by basalt; the top of the basalt is a drowned, wave-cut bench sloping gently seaward (Sanifill and Baquerizo 1996).

2.3 REGIONAL HYDROGEOLOGY

Two aquifers with distinctly different hydrogeologic properties underlie the Kekaha-Mana coastal plain: a coastal plain aquifer within the near-surface sedimentary (caprock) deposits and a deep aquifer within the underlying fractured basalt. The basaltic aquifer occurs within lava flows of the Nāpali Formation. This aquifer typically yields large quantities of water from wells and shafts with relatively little drawdown, reflecting generally high hydraulic conductivity, estimated by the U.S. Geological Survey (USGS) as approximately 400 feet/day. Saturated sediments of the caprock formation (the caprock aquifer) overlie the basaltic aquifer and retard the seaward discharge of groundwater from the deeper aquifer. According to the USGS, the regional average hydraulic conductivity of the coastal plain aquifer is relatively low, i.e., approximately 0.12 feet/day (Burt 1979).

The uppermost groundwater is encountered within the coastal plain aquifer at approximately 5–7 feet below ground surface (bgs), which is about 3–5 feet above msl. The water table level in the site area is artificially controlled by pumping stations in the area operated and maintained by the State of Hawaii Agribusiness Development Corporation and the Kekaha Agricultural Association, in coordination with the U.S. Navy. The primary pumping station in the Kekaha area (Kawaiele) is a drainage pumping station comprised of three pumps that can achieve a flow of 50 mgd. If the groundwater management system pumps were shut down, lower elevations on the Mana Plain would be flooded due to a rise in the groundwater level (Sanifill and Baquerizo 1996).

2.4 SITE GEOLOGY

Borings have been advanced to more than 50 feet below existing grade without reaching the bottom of the coastal plain aquifer, and it is estimated that the thickness of the coastal plain aquifer may exceed 400 feet beneath the landfill area (Sanifill and Baquerizo 1996). The upper 50 feet of these deposits consist of surficial alluvial sediments composed of loose, sand-size coral and shell debris. Below a depth of 50 feet, these deposits become increasingly consolidated and indurated, and represent the coralline and marl sedimentary rocks reported in regional investigations.

2.5 SITE HYDROGEOLOGY

Shallow groundwater underlying the KLF occurs within the surficial sedimentary deposits of the coastal plain aquifer; the water table ranges in depth from approximately 1 feet to 5 feet msl. The historical water level monitoring data indicate that groundwater typically flows toward the ocean in a west-southwest direction, with a hydraulic gradient of approximately 0.0005 feet per foot. However, as shown on the groundwater table contour maps presented in Appendix A, the historical monitoring data indicate that the direction of groundwater flow at the site can periodically shift more than 90 degrees toward the north and more than 60 degrees toward the south relative to the typical west-southwest flow direction, and the gradient sometimes becomes essentially flat.

Several factors may contribute to periodic shifts in the groundwater flow direction at the landfill. The direction of the local hydraulic gradient is likely affected by variations in pumping rates for the groundwater management system wells and other production wells near the site, including the water levels maintained in the irrigation canals near the site. These nearby wells are used to supply water for irrigation and other non-potable purposes, and to draw down the groundwater table to prevent saturation of surface soil by the brackish groundwater, thus allowing cultivation of sugarcane and other crops on the Mana Plain. Infiltration from leaks in the aquaculture (shrimp farm) ponds located immediately northwest of the Phase II Landfill site also probably contribute to periodic localized fluctuations in the hydraulic gradient and direction. Similarly, the landfill's storm- and surface-water control systems, particularly the infiltration basin, may affect localized groundwater flow patterns, especially after rain events. As discussed below, tidal study results suggest that tidal effects do not significantly influence the prevailing groundwater flow direction; however, short-term tidal effects may also contribute to the flow direction and gradient variations indicated by the historical monitoring data.

Although the shallow groundwater beneath the KLF occurs within the caprock formation, the local hydraulic conductivity is significantly greater than the 0.12 feet/day regional average value reported by the USGS (Burt 1979). The results of an aquifer test performed during the week of October 16, 1995 indicate that the hydraulic conductivity of the caprock aquifer underlying the KLF site is approximately 162 feet/day (6×10^{-2} centimeters per second). The aquifer test was implemented by pumping monitoring well MWI-1(Figure 1-2) at a rate of 0.56 cubic feet per minute for approximately 36 hours while measuring the corresponding drawdown at monitoring well MWII-5. The hydraulic conductivity value reported from this test is approximately three orders of magnitude greater than the 0.12 feet/day value reported by the USGS for the regional coastal plain sedimentary aquifer (Burt 1979). This difference is likely due to the unconsolidated nature of the surficial alluvial sediments in the shallow coastal plain aquifer underlying the KLF. Based on previous geotechnical investigations of soil types, and the relatively flat hydraulic gradients, the higher conductivity value is likely more representative of site conditions than the lower value reported in the literature.

The vertical component of groundwater flow at the site is negligible; therefore, the groundwater flows horizontally beneath the facility, ultimately discharging to the ocean southwest of the site. The KLF monitoring wells therefore target the upper interval of the coastal plain aquifer.

2.5.1 Tidal Effects

Recharge to the uppermost water bearing zone (WBZ) of the coastal plain aquifer underlying the KLF occurs in the upland areas northeast of the facility. Groundwater flows within the Napali basaltic lava from areas of greater elevation and into the sedimentary coastal plain aquifer. The groundwater enters the coastal sedimentary units at their contact with the upland basalts, flows seaward, and discharges to the Pacific Ocean. Total dissolved solids (TDS) concentrations increase significantly from inland (Mauka) areas to seaward (Makai) areas as the groundwater flows through the coastal sediments and mixes with sea water. However, the results of an April 1994 tidal study indicate that tidal effects do not significantly influence the prevailing groundwater flow direction within the coastal plain aquifer at the site (Sanifill and Baquerizo 1996).

2.5.2 Hydrogeochemistry

Spatial and temporal variations in the hydrogeochemical characteristics of groundwater at the KLF are significant due to the effects of seawater intrusion, which vary during the tidal cycle and with distance from the shoreline. The TDS and major cation and anion concentrations (i.e., calcium, potassium, magnesium, chloride, bicarbonate, and sulfate) indicate a significant degree of natural chemical variability at the site. Infiltration from the aquaculture (shrimp farm) ponds located immediately northwest of the Phase II Landfill site also probably contribute to variations in the hydrogeochemical characteristics of groundwater at the KLF.

3.0 GROUNDWATER MONITORING

This section describes the KLF Phase II groundwater monitoring program, including details of the monitoring well network, the monitoring parameters, the intra-well detection monitoring approach, and the sampling schedule. The monitoring program utilizes an intra-well detection monitoring approach in accordance with HAR Title 11, Chapter 58.1 and the DOH *State of Hawai'i Landfill Groundwater Monitoring Guidance Document* (DOH 2002) to evaluate whether leachate from the Kekaha Phase II Landfill waste cells may be impacting groundwater. The rationale for the site-specific groundwater monitoring program is based on local hydrogeologic conditions, landfill site history and physical characteristics, and concentrations of the chemical constituents present in the Phase II Landfill leachate and the local groundwater.

3.1 GROUNDWATER MONITORING NETWORK

The groundwater monitoring network consists of a series of monitoring wells installed at locations determined most likely to provide the earliest possible detection of a release from the landfill waste unit. The monitoring system and its details have been developed after a comprehensive evaluation of the site hydrogeology, operational history, and the proposed vertical expansion. Monitoring well screen placement locations (both horizontal and vertical positions) were determined through interpretation of site-specific investigations and regional geologic and hydrogeologic information (Section 2.5).

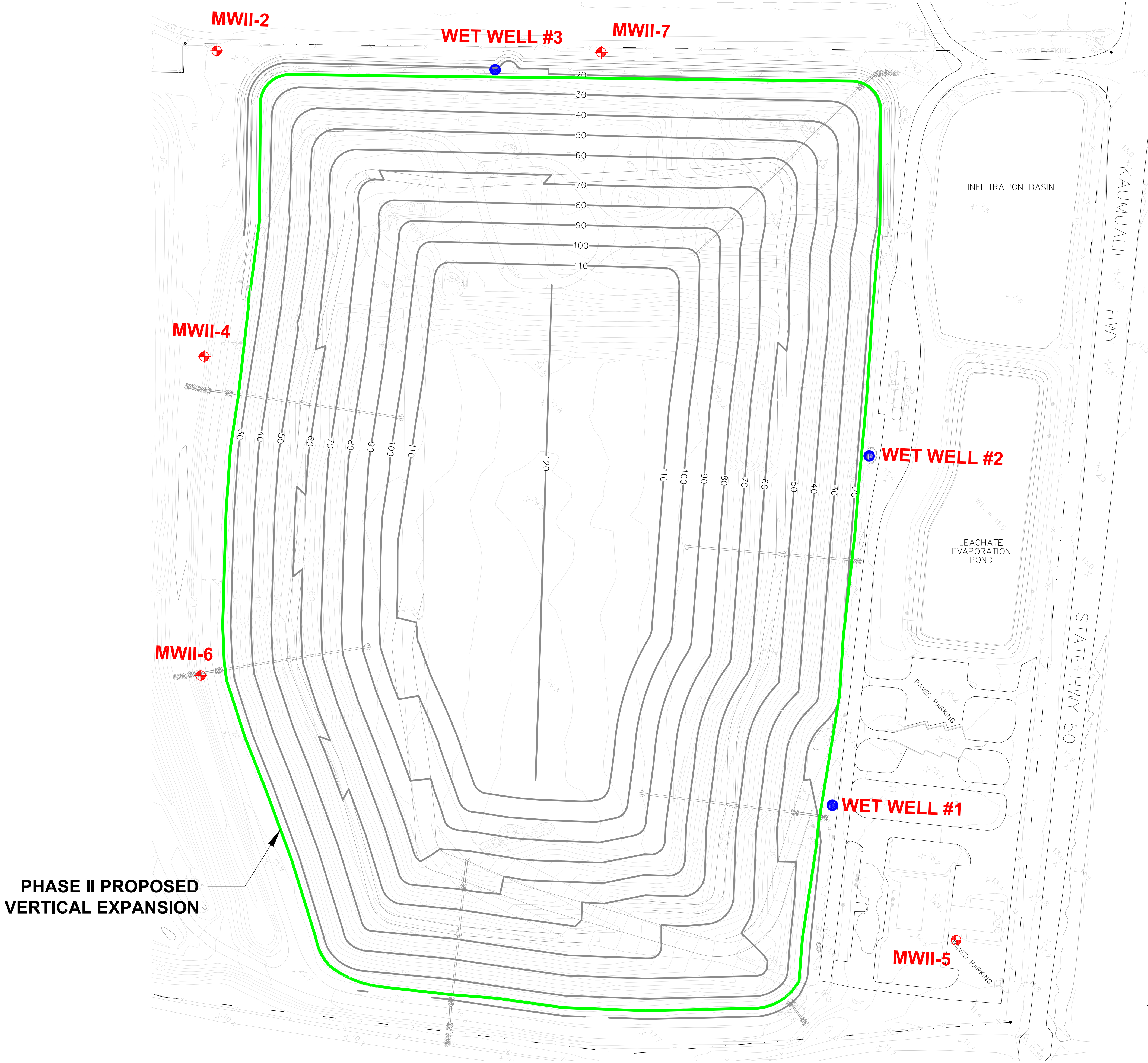
Detection monitoring at the Kekaha Landfill site will be performed on a semi-annual basis utilizing five point-of-compliance (POC) wells, including MWII-2, MWII-4, MWII-5, MWII-6, and MWII-7. These wells are situated at locations that are hydraulically downgradient, either under prevailing flow conditions or during periods when the flow directions shift, and which therefore can intercept potential primary migration pathways, as controlled by the hydrogeologic setting. Their purpose as POC wells is to provide the earliest possible detection, should a release occur from the facility. Table 3-1 lists the monitoring well locations and well construction/completion statistics. Table 3-2 describes the function of each monitoring well selected for the monitoring network.

Figure 3-1 illustrates the proposed monitoring well network configuration. The rationale for the network well placement and utilization is based on the local groundwater flow direction and the location of the potential contaminant source area at the site. The targeted detection monitoring zone is defined as the hydrostratigraphic unit nearest to the natural ground surface that provides the earliest possible detection of a potential release from the facility. Groundwater monitoring wells at the Kekaha Landfill Phase II are therefore positioned so that their well screens lie at the top of the upper-most WBZ within the coastal plain aquifer. Well construction details are presented in Table 3-1.

Monitoring well inspections will be performed on a semi-annual basis during the routine detection monitoring events, or more frequently if necessary. The groundwater sampling team will visually inspect each well and the surrounding area and record the observations on a well inspection form. Information to be documented as part of each well inspection includes the following:

- Condition of the well identification plate or sign
- Evidence that the well was recently painted
- Condition of the locking mechanism to confirm that the well is locked and the key works
- The integrity of well construction and sampling equipment including:
  - Physical surroundings (e.g., high weeds, standing water, cleanliness, nearby activities)
  - Condition of dedicated pumps
  - Condition of protective casing
  - Obstructions or kinks in well casing

  - Condition of concrete footing (e.g., cracked or raised concrete, water in annular space)
  - Grease around top of well on threaded caps
  - Fit of cap
- Weather conditions during observations including:
  - Wind direction (as necessary to evaluate the potential impact of upwind sources of volatile chemicals)
  - Whether or not sampling was performed downwind
- Visible evidence of contamination
- Well "guard-post" condition (if applicable)



LEGEND

(red well symbol)	EXISTING PHASE II GROUNDWATER MONITORING WELL
(blue dot)	LEACHATE COLLECTION WET WELL
(green line)	LIMITS OF WASTE
(dash-dot line)	PROPERTY LINE

NOTES

1. TOPOGRAPHIC MAP PREPARED BY AEROMETRIC INC., SEATTLE, WASHINGTON. DATE OF FLIGHT: APRIL 20, 2012. HORIZONTAL DATUM IS BASED ON NAD83 (1986), HAWAII ZONE 4.VERTICAL DATUM BASED ON LOCAL TIDAL.
2. GROUNDWATER MONITORING WELL SURVEY PERFORMED BY HONUA ENGINEERING ON DECEMBER 14, 2011, REFERENCED TO NGS BRASS MONUMENT, G1000, (PID-TU0686).
3. GRADES SHOWN DEPICT TOP OF FINAL COVER SYSTEM. MAXIMUM FINAL COVER ELEVATION IS 120 FEET.

TRUE NORTH
SCALE: 1" INCH = 180 FEET

0 90 180 360
SCALE: 1" = 180'

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Figure 3-1
Proposed Phase II Monitoring Well Network

Groundwater Monitoring Plan
Kekaha Landfill Phase II

Table 3-1: Monitoring Well Construction Specifications

MW ID No.	MW Location	MW Status	Easting	Northing	Top of Casing Elevation[a] (ft msl)	Date Installation Completed	Total Well Depth[b] (ft btoc)	Elevation of Bottom of Well (ft msl)	Boring Diameter (in.)	Well Diameter (in.)	Elevation of Well Screen Interval[c] (ft msl)	Dedicated Bladder Pump Intake Elevation[e] (ft msl)	Well Construction Details[f]	Groundwater Surface Elevation Range[h] (ft msl)	Range of Observed Surface Elevation (ft)	Average Groundwater Surface Elevation (ft msl)	Average Water Column Thickness (ft)
MWII-2	Northwest end of Phase II Landfill Cell #2; adjacent to site boundary fence line and MWII-1	POC detection well. Long-term monitoring of groundwater level and chemistry. Currently monitored.	1555586.09	55282.30	14.70	01/21/93	18.0	3.3 below msl	10	2	7.7 above msl to 2.3 below msl	0.2 above msl	Above Grade (3 ft above surface grade) 0-0.5ft bgs: Concrete 0.5-1 ft bgs: Hawaiian II-I Grout 0-4 ft bgs: 2-in. dia. sch. 40 PVC Solid Casing 4-14 ft bgs: 2-in dia. sch. 40 PVC Slotted Casing (0.02-in. slots) 1-2 ft bgs: California Silica Sand #60 2-15 ft bgs: Colorado Silica Sand #10-20	2.86 – 4.23	1.37	3.22	5.52
MWII-4[g]	Midway between northwest and southeast corners of Phase II Landfill Cell #2; adjacent to MWII-3	POC detection well. Long-term monitoring of groundwater level and chemistry. Currently monitored.	1556009.39	54892.15	20.38	01/22/93	13.0	7.4 above msl	10	2	17.4 above msl to 7.4 above msl	9.88 above msl	Flush-Mounted (completed at grade) 0-1 ft bgs: Concrete 1-13 ft bgs: Colorado Silica Sand #10-20 0-3 ft bgs: 2-in. dia. sch. 40 PVC Solid Casing 3-13 ft bgs: 2-in dia. sch. 40 PVC Slotted Casing (0.02-in. slots)	2.76 – 3.80	1.04	3.08	4.22
MWII-5	Northeast of Phase II Landfill Cell #1; adjacent to office building	POC detection well. Long-term monitoring of groundwater level and chemistry. Currently monitored.	1557574.44	55178.02	12.41	01/23/93	13.0	0.6 below msl	10	2	9.4 above msl to 0.6 below msl	1.91 above msl	Flush-Mounted (completed at grade) 0-1 ft bgs: Concrete 1-13 ft bgs: Colorado Silica Sand #10-20 0-3 ft bgs: 2-in. dia. sch. 40 PVC Solid Casing 3-13 ft bgs: 2-in dia. sch. 40 PVC Slotted Casing (0.02-in. slots)	2.76 – 5.10	2.34	3.31	3.37
MWII-6	Southwest of Phase II Landfill Cell #2	POC detection well. Long-term monitoring of groundwater level and chemistry. Currently monitored.	1556410.64	54512.11	22.14	10/09/94	38.0	15.9 below msl	10	2	7.1 above msl to 12.9 below msl	7.88 below msl	Flush-Mounted (completed at grade). Information not available.	1.06 – 3.81	2.75	3.22	16.12
MWII-7	Northwest of Phase II Landfill Cell #1; adjacent to site boundary fence line	POC detection well. Long-term monitoring of groundwater level and chemistry. Currently monitored.	1556039.23	55767.77	10.16	11/19/08	26.0	15.8 below msl	10	2	4.7 above msl to 15.3 below msl	10.34 below msl	Above Grade (+2 ft above surface grade) 0-2 ft bgs: Concrete 2-3 ft bgs: Bentonite Seal 3-24 ft bgs: Monterey #3 Sand 0-3.5 ft bgs: 2-in. dia. sch. 40 PVC Solid Casing 3.5-23.5 ft bgs: 2-in dia. sch. 40 PVC Slotted Casing (0.01-in. slots)	2.78 – 4.86	2.08	2.17	17.47

Notes:
[a] Estimated; to be surveyed or measured upon completion
[b] Top of casing elevations are from the December 2011 survey conducted by Honua Engineering, Inc.
[c] Estimated; based on monitoring well construction logs
[d] Estimated; based on HLA (1993) and December 2011 Honua Engineering, Inc. survey
[e] Estimated; based on depth of screen interval
[f] Well construction details are from HLA (1993), HLA (1995), and AMEC (2009). Well installation logs are provided in Appendix B.
[g] HLA well construction details for MWII-4 are clearly erroneous (indicating well bottom above groundwater table measured in the well). Actual well depths will be confirmed in the field and table updated.
[h] Groundwater elevation data range between July 12, 1999 through February 24, 2013.

bgs	below ground surface
btoc	below top of casing
dia.	diameter
ft	feet
ID	identification
in.	inch
N/A	not applicable
msl	mean seal level
MW	monitoring well
POC	Point-of-Compliance
sch.	schedule

Table 3-2: Groundwater Monitoring Well Network Summary

MW ID Number	MW Location	Function of Well as Part of KLF Phase II Groundwater Monitoring Network
MWII-2	Northwest end of Phase II Landfill Cell #2; adjacent to site boundary fence line	POC well for long-term monitoring of groundwater level and chemistry in the shallow WBZ downgradient or crossgradient of the Phase II Landfill (depending on groundwater flow conditions at the time of monitoring). Background groundwater chemistry has already been established for MWII-2; therefore, this well will be monitored on a semi-annual basis for intra-well detection monitoring.
MWII-4	Southwestern edge of the Phase II Landfill; adjacent to perimeter road	Long-term monitoring of groundwater level and chemistry in shallow WBZ along the south-western edge of the Phase II Landfill (well is adjacent to Perimeter Road). Background groundwater chemistry has already been established for MWII-4; therefore, this well will be monitored on a semi-annual basis for intra-well detection monitoring.
MWII-5	Northeast of Phase II Landfill Cell #1; adjacent to office building	Long-term monitoring of groundwater level and chemistry in shallow WBZ north-eastern of the Phase II Landfill (well is adjacent to office building). Background groundwater chemistry has already been established for MWII-5; therefore, this well will be monitored on a semi-annual basis for intra-well detection monitoring.
MWII-6	Southern edge of Phase II Landfill; adjacent to perimeter road	Long-term monitoring of groundwater level and chemistry in shallow WBZ, along southern edge of Phase II Landfill (well is adjacent to Perimeter Road). Background groundwater chemistry has already been established for MWII-6; therefore, this well will be monitored on a semi-annual basis for intra-well detection monitoring.
MWII-7	Northwest of Phase II Landfill Cell #1; adjacent to site boundary fence line	POC well for long-term monitoring of groundwater level and chemistry in the shallow WBZ downgradient or crossgradient of the Phase II Landfill (depending on groundwater flow conditions at the time of monitoring). Background groundwater chemistry has already been established for MWII-7; therefore, this well will be monitored on a semi-annual basis for intra-well detection monitoring.

3.2 DETECTION MONITORING PARAMETERS

The technical rationale used to select appropriate monitoring parameters for the KLF detection monitoring program is based on: (1) HAR Title 11, Chapter 58.1 (DOH 1994), (2) the *State of Hawaii Landfill Groundwater Monitoring Guidance Document* (DOH 2002), and (3) historical data representing concentrations of the chemical constituents present in the local groundwater and the Phase II Landfill leachate.

HAR Title 11, Chapter 58.1 (DOH 1994) specifies that MSW landfills should routinely monitor groundwater for the 15 metals and 47 volatile organic compounds (VOCs) listed in Appendix I of Chapter 58.1. This is the same list of monitoring parameters contained in the Federal Subtitle D regulations (40 CFR Part 258, Appendix I). This list includes many parameters which are generally viewed as ineffective monitoring parameters because of their limited mobility in most subsurface environments, or because they are not constituents of typical MSW landfill leachate. The EPA intended the Appendix I analytes to be default parameters for use in those states which have not yet obtained Subtitle D authorization. In accordance with 40 CFR Part 258.54 (a)(1) and (2), the EPA has allowed authorized states, including Hawai'i, to approve alternative lists of site-specific monitoring parameters. Therefore, this plan describes the approach for selecting site-specific groundwater monitoring parameters for the KLF Phase II detection monitoring program.

As noted in the *State of Hawaii Landfill Groundwater Monitoring Guidance Document* (DOH 2002), a combination of VOCs plus a carefully selected "short list" of site-specific water quality parameters (referred to herein as "site-specific detection monitoring parameters") will typically provide the most reliable monitoring parameters for most MSW landfills.

VOCs can be highly effective monitoring parameters for providing an early indication of a potential release from a landfill because they are: (1) rarely detected in background groundwater samples; (2) detected more frequently than any other class of organic compounds in MSW landfill leachate; (3) analytically sensitive (i.e., they can be detected at extremely low concentrations); and (4) relatively mobile in groundwater. Although commonly present in MSW landfill leachate, semivolatile organic compounds (SVOCs), as a group, are significantly less mobile than VOCs in most subsurface environments and do not typically provide for substantial additional monitoring benefits.

The detection monitoring parameter data for the Kekaha Phase II Landfill POC wells will be subjected to statistical analysis as described in Section 5.0 to identify any statistically significant concentration increases that would trigger assessment monitoring (or an ASD if the detection is unrelated to a release from the landfill). In addition to VOCs and site-specific detection monitoring parameters, the Kekaha Phase II Landfill groundwater samples will be analyzed for supplemental geochemical parameters to provide additional data for evaluating site groundwater conditions. Data representing the supplemental parameters will not be used for routine detection monitoring statistical analysis, but can be used to evaluate local hydrogeologic conditions and distinguish between background groundwater impacts and groundwater impacted by leachate released from the landfill.

3.2.1 Approach for Selection of Site-Specific Detection Monitoring Parameters

Site-specific detection monitoring parameters for the KLF Phase II monitoring program have been selected based on regulatory requirements and chemical-specific properties (including persistence, detectability, and mobility). As a class, VOCs are detected more frequently than any other class of organic compounds in MSW landfill leachate. However, other chemical parameters referenced in HAR Title 11, Chapter 58.1 (DOH 1994) are not often found in landfill leachates. Research by Dr. Gibbons and others indicates that in addition to VOCs, certain leachate indicators (e.g., TDS, alkalinity) and metals (e.g., magnesium, calcium, potassium) are more frequently detected in leachate than other constituents specified in the regulations (DOH 2002).

Because of these factors, a detection monitoring program based solely on the extensive list of parameters specified in the HAR Title 11 Chapter 58.1 regulations would be less effective than a program based on site-specific background groundwater and leachate chemistry data. Appropriate detection monitoring parameters for the KLF Phase II site were therefore identified based on background data representing concentrations of the constituent chemicals detected in both groundwater and leachate at the site, as well as the migration potential of the detected constituents. Characterization of background groundwater and leachate quality becomes progressively more accurate as detection monitoring continues at a site; therefore, the list of site-specific detection monitoring parameters may be updated based on new data as it becomes available (any changes to the list of detection monitoring parameters will require DOH approval).

The first step for selection of site-specific detection monitoring parameters was to identify chemicals that have been detected in the Phase II Landfill leachate at concentrations significantly higher than in groundwater. The resulting list of potential detection monitoring parameters was then refined by identifying and removing parameters that would provide redundant coverage (e.g., specific conductivity and TDS). From the remaining parameters, those anticipated to provide the earliest and most reliable indication of a release were selected as detection monitoring parameters for statistical evaluation purposes. This determination was based on the relative mobility of the chemicals in soil and groundwater, local hydrogeologic conditions, the detectability and likelihood of false positive results for each parameter (based on existing analytical methods), and concentration changes that might be expected during migration through the unsaturated and saturated zones beneath the facility (e.g., due to variations in pH or redox conditions). As described in Section 4.0, an established leachate database exists for KLF Phase II. Leachate samples have been collected and analyzed on an annual basis for an extensive list of parameters from three monitoring points (Wet Wells-1, -2, and -3) as shown on Figure 3-1. Wet Wells-1 and -2 have been sampled since 1994 and Wet Well-3 has been sampled since 2010. Analytical parameters include Subtitle D Appendix I constituents, major cations and anions, major leachate indicator parameters, metal constituents, VOCs, and field measurements.

The *State of Hawaii Landfill Groundwater Monitoring Guidance Document* (DOH 2002) recommends that potential detection monitoring parameters should first be screened by calculating the concentration contrast between leachate and groundwater, and suggests that an effective monitoring parameter should exhibit a concentration in leachate at least five times greater than the upper background limit in groundwater. If insufficient contrast exists for a specific chemical, then that chemical may be eliminated from further consideration as a potential site-specific detection monitoring parameter.

The effectiveness of the KLF Phase II monitoring program will be enhanced by using this approach because only those parameters that have been actually detected in the leachate and that pass specific performance criteria are identified as site-specific detection monitoring parameters for statistical evaluation. As leachate data are generated by annual or other leachate sampling events, the detection monitoring parameter list will be re-evaluated and updated, as appropriate. If the data indicate that additional parameters should be added to the detection monitoring list, then background concentrations for the additional parameters will be estimated, and the parameters will be added to the program upon receiving DOH approval. Conversely, if parameters proposed for routine detection monitoring are not found in the site leachate during repeated sampling events, these parameters may be deleted from the KLF Phase II detection monitoring program (also upon receipt of DOH approval).

Average constituent concentrations based on the historical analytical data were calculated for the Phase II groundwater monitoring wells and leachate sumps (Wet Wells 1, 2, and 3). Ratios between monitoring well groundwater and leachate concentrations were then calculated for each constituent. These ratios were evaluated to identify potential site-specific detection monitoring parameters by determining if there are significant differences between the historical concentrations reported for the Phase II groundwater monitoring wells and the Phase II leachate.

Table 3-3 lists the constituent concentrations for the Phase II monitoring wells and leachate sumps, along with the average concentrations for the Phase II groundwater and leachate, and the corresponding leachate/groundwater concentration ratios. As shown Table 3-3, 5 constituents have average leachate/groundwater concentration ratios of five or greater: total alkalinity, total iron, total manganese, COD, and TOC. The ratios for dissolved constituents could not be estimated because dissolved constituents were not analyzed in the leachate samples.

Table 3-3: Comparison of Phase II Groundwater and Phase II Leachate Data

Constituent	Units	MWII-2	MWII-4	MWII-5	MWII-6	MWII-7	Wet Well-1	Wet Well-2	Wet Well-3	WET Well Average	Phase II Monitoring Well Average	Ratio	Acceptable Indicator Parameter	Comments
Alkalinity, bicarbonate (as caco3)	MG/L	411.90	456.33	313.90	403.82	326.47	1231.47	1566.67	1308.00	1368.71	382.49	3.58	N	Ratio too Low
Alkalinity, carbonate (as caco3)	MG/L	5.95	6.90	6.90	6.82	5.00	6.05	5.00	5.00	5.35	6.32	0.85	N	Ratio too Low
Alkalinity, total (as caco3)	MG/L	411.90	452.05	313.90	403.82	326.47	1231.47	1566.67	1308.00	1368.71	381.63	3.59	N	Ratio too Low
Ammonia (as n)	MG/L	0.22	0.98	0.71	1.25	0.86	81.85	152.78	3.67	79.43	0.80	**98.76**	**Y**	
Antimony, dissolved	UG/L	1.43	10.00	10.00	10.00	10.55	NA	NA	NA	NA	8.40	NA	N	Dissolved Metals Not Analyzed For Leachate
Antimony, total	MG/L	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.06	0.04	0.01	4.66	N	Ratio too low; All Non Detect Values
Arsenic, dissolved	MG/L	0.01	0.02	0.03	0.04	0.01	NA	NA	NA	NA	0.02	NA	N	Dissolved Metals Not Analyzed For Leachate
Arsenic, total	MG/L	0.02	0.02	0.03	0.03	0.01	0.16	0.18	0.02	0.06	0.02	2.74	N	Ratio too Low
Barium, dissolved	UG/L	3.54	4.09	3.36	4.04	8.09	NA	NA	NA	0.00	4.63	NA	N	Dissolved Metals Not Analyzed For Leachate
Barium, total	MG/L	0.27	0.18	0.18	0.15	0.01	0.11	0.19	0.10	0.13	0.16	0.85	N	Ratio too Low
Beryllium, dissolved	UG/L	4.43	4.43	4.43	4.43	3.40	NA	NA	NA	NA	4.22	NA	N	Dissolved Metals Not Analyzed For Leachate
Beryllium, total	MG/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	1.94	N	Ratio too Low
Bromide	MG/L	1.14	1.47	1.05	1.65	15.45	7.32	6.59	1.04	4.98	4.15	1.20	N	Ratio too Low
Cadmium, dissolved	UG/L	1.84	3.06	5.20	1.84	2.41	NA	NA	NA	NA	2.87	NA	N	Dissolved Metals Not Analyzed For Leachate
Cadmium, total	MG/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	N	Ratio too Low
Calcium, dissolved	MG/L	47.75	36.04	42.07	42.92	141.76	NA	NA	NA	NA	62.11	NA	N	Dissolved Metals Not Analyzed For Leachate
Calcium, total	MG/L	57.51	55.47	46.97	47.05	144.11	90.65	82.89	50.20	74.58	70.22	1.06	N	Ratio too Low
Chemical oxygen demand	MG/L	13.53	11.26	13.73	11.46	60.01	271.11	412.22	71.18	251.50	22.00	**11.43**	**Y**	
Chloride	MG/L	295.38	342.14	223.52	371.82	4116.35	402.01	634.44	188.60	408.35	1069.84	0.38	N	Ratio too Low
Chromium, dissolved	UG/L	6.11	10.00	8.67	8.69	7.54	NA	NA	NA	NA	8.20	NA	N	Dissolved Metals Not Analyzed For Leachate
Chromium, total	MG/L	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.01	0.02	0.01	2.98	N	Ratio too Low
Cobalt, dissolved	UG/L	20.53	20.19	21.43	21.43	16.83	NA	NA	NA	NA	20.08	NA	N	Dissolved Metals Not Analyzed For Leachate
Cobalt, total	MG/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	1.89	N	Ratio too Low
Copper, dissolved	UG/L	9.73	9.61	9.47	9.47	7.20	NA	NA	NA	NA	9.10	NA	N	3.2.2 Dissolved Metals Not Analyzed For Leachate
Copper, total	MG/L	0.01	0.01	0.01	0.01	0.01	0.14	0.01	0.00	0.05	0.01	6.27	N	Leachate Avg Biased High Due to 1 WW-I Outlier (1.3 MG/L)
Cyanide	MG/L	0.00	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.78	N	Ratio too Low
Iron, dissolved	MG/L	0.06	0.05	0.05	0.14	0.14	NA	NA	NA	NA	0.09	NA	N	Dissolved Metals Not Analyzed For Leachate
Iron, total	MG/L	0.11	0.17	0.08	0.19	0.18	13.03	12.73	5.17	10.31	0.14	**72.31**	**Y**	
Lead, dissolved	UG/L	8.43	8.43	8.43	8.43	14.56	NA	NA	NA	NA	9.65	NA	N	Dissolved Metals Not Analyzed For Leachate
Lead, total	MG/L	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.45	N	Ratio too Low
Magnesium, dissolved	UG/L	96,000.00	88500.00	63777.78	92222.22	322117.65	NA	NA	NA	NA	132523.53	NA	N	Dissolved Metals Not Analyzed For Leachate
Magnesium, total	MG/L	109.19	102.38	66.63	103.06	307.33	169.16	245.56	181.60	198.77	137.72	1.44	N	Ratio too Low
Manganese, dissolved	UG/L	6.04	9.01	6.92	10.96	12.36	NA	NA	NA	NA	9.06	NA	N	Dissolved Metals Not Analyzed For Leachate
Manganese, total	MG/L	0.01	0.01	0.01	0.01	0.01	0.45	0.71	0.27	0.48	0.01	**49.17**	**Y**	
Mercury, dissolved	UG/L	0.2	0.20	0.20	0.20	0.17	NA	NA	NA	NA	0.19	NA	N	Dissolved Metals Not Analyzed For Leachate
Mercury, total	UG/L	0.2	0.2	0.20	0.20	0.20	0.18	0.18	0.17	0.18	0.20	0.89	N	Ratio too Low
Nickel, dissolved	UG/L	34.53	12.64	23.73	34.59	7.71	NA	NA	NA	NA	22.64	NA	N	Dissolved Metals Not Analyzed For Leachate
Nickel, total	MG/L	0.01	0.00	0.03	0.02	0.02	0.03	0.07	0.04	0.05	0.02	3.03	N	Ratio too Low

Constituent	Units	MWII-2	MWII-4	MWII-5	MWII-6	MWII-7	Wet Well-1	Wet Well-2	Wet Well-3	WET Well Average	Phase II Monitoring Well Average	Ratio	Acceptable Indicator Parameter	Comments
Nitrogen, nitrate-nitrite	MG/L	5.31	0.20	0.08	0.09	3.54	0.22	3.62	2.99	2.27	1.84	1.23	N	Ratio too Low
pH (Field)	STD	7.43	7.24	7.39	7.25	7.47	7.20	7.04	5.90	6.72	7.36	0.91	N	Ratio too Low
Potassium, dissolved	MG/L	26.30	23.00	9.50	37.33	66.95	NA	NA	NA	NA	32.62	NA	N	Dissolved Metals Not Analyzed For Leachate
Potassium, total	MG/L	31.69	30.62	10.26	50.11	67.67	75.04	105.22	39.08	73.11	38.07	1.92	N	Ratio too Low
Selenium, dissolved	UG/L	15.00	13.57	15.00	13.70	15.93	NA	NA	NA	0.00	14.64	NA	N	Dissolved Metals Not Analyzed For Leachate
Selenium, total	MG/L	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.01	0.01	0.45	N	Ratio too Low
Silicon, dissolved	UG/L	9,706.67	11466.67	12466.67	9633.33	11588.24	NA	NA	NA	0.00	10972.31	NA	N	Dissolved Metals Not Analyzed For Leachate
Silicon, total recoverable	UG/L	9,644.44	11222.22	12111.11	9611.11	11688.89	29111.11	37888.89	40600.00	35866.67	10855.56	3.30	N	Ratio too Low
Silver, dissolved	UG/L	8.70	7.47	8.73	10.00	8.85	NA	NA	NA	0.00	8.75	NA	N	Dissolved Metals Not Analyzed For Leachate
Silver, total	MG/L	0.03	0.03	0.03	0.04	0.01	0.04	0.02	0.00	0.02	0.03	0.74	N	Ratio too Low
Sodium, dissolved	UG/L	172,611.11	206666.67	128333.33	183333.33	2118647.06	NA	NA	NA	0.00	561918.30	NA	N	Dissolved Metals Not Analyzed For Leachate
Sodium, total	MG/L	198.44	226.38	116.69	238.59	2020.00	266.18	387.78	236.20	296.72	560.02	0.53	N	Ratio too Low
Specific conductance (field)	um/cm	1,464.80	1666.67	1129.16	1621.95	11000.63	3887.67	4291.33	2278.00	3485.67	3376.64	1.03	N	Ratio too Low
Sulfate	MG/L	105.95	87.14	21.63	127.18	586.41	40.40	45.84	43.12	43.12	185.66	0.23	N	Ratio too Low
Sulfide	MG/L	NA	NA	NA	NA	NA	0.90	1.00	1.00	0.97	0.00	NA	N	Insufficient Historical Data for GW
Thallium, dissolved	UG/L	10.00	10.00	10.00	10.00	12.19	NA	NA	NA	0.00	10.44	NA	N	Dissolved Metals Not Analyzed For Leachate
Thallium, total	MG/L	16.67	0.01	0.01	0.01	36.37	0.00	0.01	0.01	0.01	10.61	0.00	N	Ratio too Low
Total dissolved solids	MG/L	1,005.56	1077.22	701.50	1146.84	6809.41	1727.58	2277.78	200.00	1401.79	2148.11	0.65	N	Ratio too Low
Total organic carbon (toc)	MG/L	1.84	1.83	1.74	2.93	2.55	69.83	143.67	1582.00	598.50	2.18	**274.81**	**Y**	
Vanadium, dissolved	UG/L	5.26	3.19	7.54	5.29	5.87	NA	NA	NA	0.00	5.43	NA	N	Ratio too Low
Vanadium, total	MG/L	0.01	0.00	0.02	0.01	0.00	0.02	0.02	0.01	0.02	0.01	2.21	N	Ratio too Low
Zinc, dissolved	UG/L	17.87	18.03	17.87	20.00	19.60	NA	NA	NA	0.00	18.67	NA	N	Dissolved Metals Not Analyzed For Leachate
Zinc, total	MG/L	0.01	0.01	0.01	0.01	0.02	0.05	0.03	0.01	0.03	0.01	2.39	N	Ratio too Low

Notes:
Based on historical sampling data from March 1996 through February 2013.
— not analyzed
[a] Ratio WW Average / Phase II MW Average

3.2.3 Site-Specific Detection Monitoring Parameters

The constituents listed in Table 3-4 were selected as site-specific groundwater monitoring parameters for intra-well statistical analysis. The constituents selected as site-specific groundwater monitoring parameters are likely to provide clear indications of a potential leachate release because evaluation of the historical Phase II groundwater data and leachate data indicates that they have leachate/groundwater concentration ratios of five or greater, and they can be readily distinguished from constituents present in the local groundwater due to site-specific hydrogeologic conditions (e.g., the effects of seawater intrusion on groundwater chemistry).

Several of the trace metal and mineral parameters referenced in HAR Title 11, Chapter 58.1 (DOH 1994) have been consistently present in KLF background groundwater samples at levels that would likely mask a release from the Phase II Landfill waste cells, and were therefore not selected as site-specific groundwater monitoring parameters. However, as discussed below, these constituents are included on the list of supplemental geochemical parameters. These parameters are generally the same as the major dissolved chemicals found in sea water (sodium, calcium, potassium, magnesium, chloride, and sulfate) because the facility is located near the ocean. Comparison of the concentrations of these parameters in background groundwater samples with concentrations of the major ions present in typical sea water suggests that the elevated constituent levels in groundwater are likely caused by the effects of sea water intrusion (Sanifill and Baquerizo 1996). An additional source of dissolved chemicals similar to those found in seawater may be associated with the nearby aquaculture (shrimp farm) ponds located immediately northwest of the Phase II Landfill site.

Concentration limits based on both statistical and non-statistical methods, as appropriate, will be established for each of the detection monitoring parameters (as described in Section 5.0). As additional leachate data are generated throughout the course of landfill operations, the detection monitoring parameter list will be re-evaluated and updated as required. If parameters are added to the site-specific detection-monitoring list, background concentrations will be determined using appropriate statistical methods and added to the long-term monitoring program after the changes are approved by the DOH. If parameters are removed from the site-specific detection-monitoring list (with DOH approval), they may be added to the Supplemental Geochemical Parameters list.

Table 3-4: Site-Specific Groundwater Monitoring Parameters (for intra-well statistical analysis)

Site Specific Monitoring Parameters (for statistical analysis)
• Ammonia (as N) • COD • Iron (total) • Manganese (total) • TOC

COD chemical oxygen demand
TOC total organic carbon

3.2.4 Supplemental Geochemical Parameters

The supplemental geochemical parameters listed in Table 3.5 have been selected to provide additional data for non-statistical analysis as necessary to evaluate the general chemical characteristics of groundwater at the site and identify natural and anthropogenic mechanisms that may affect groundwater quality. The supplemental geochemical parameter data will not be evaluated statistically, but can be used on an as-needed basis to evaluate data reliability and potential changes in groundwater quality without affecting the site-wide false-positive statistical error rate for the site-specific detection monitoring parameters. For example, the major cation and anion data can be used to construct Piper and Stiff geochemical plots, which can be useful for distinguishing between background groundwater and groundwater impacted by leachate released from the landfill.

In January 2006 sampling conducted for the Kekaha Phase II monitoring program, a statistically significant increase (SSI) in total arsenic was detected in a sample from monitoring well MWII-6.

Waste Management of Hawaii prepared an ASD report to investigate possible sources of the arsenic (WMI 2007). The ASD report concluded that the elevated arsenic concentrations were attributable to naturally occurring arsenic mobilized from the aquifer matrix due to the geochemical effects of landfill gas (LFG) generated by the Phase I municipal solid waste (MSW), and were not likely to represent a release of inorganic constituents from the MSW. Therefore, arsenic would not be a reliable monitoring parameter for determining whether leachate is impacting groundwater, and is not included on the list of site-specific detection monitoring parameters. However, arsenic will continue to be monitored as a supplemental geochemical parameter with the other metals listed in Appendix I of 40 CFR Part 258 (Subtitle D), as indicated in Table 3-5.

Table 3-5: Kekaha Phase II Landfill Supplemental Geochemical Parameters

Supplemental Geochemical Parameters (for non-statistical analysis)

- Metals (dissolved) listed in Appendix I of 40 CFR Part 258 (Subtitle D)
- Bicarbonate (as $CaCO_3$)
- Carbonate (as $CaCO_3$)
- Calcium, dissolved
- Chloride
- Magnesium, dissolved
- Nitrate-Nitrite (as N)
- Potassium, dissolved
- Sodium, dissolved
- Sulfate
- Total Alkalinity (as $CaCO_3$)
- TDS
- Specific Conductance, pH, Temperature, and Turbidity (field measurements)

Note: Nitrate-nitrite as N will be analyzed instead of nitrate-N due to the short holding time required for analysis of nitrite-N for calculation of nitrate-N.
$CaCO_3$ calcium carbonate
TDS total dissolved solids

3.2.5 Summary of Kekaha Sanitary Landfill Phase II Groundwater Monitoring Parameters

The full list of parameters identified for the Phase II detection monitoring program is presented in Table 3-6. Groundwater and leachate data collected during future Phase II Landfill monitoring events will be evaluated to determine whether any parameters should be added to or deleted from this list. Proposed changes in the list of parameters will be submitted to the DOH for review and approval, and background concentrations for additional parameters will be estimated as required for future statistical analysis.

Table 3-6: Summary of Kekaha Phase II Landfill Groundwater Monitoring Parameters

Appendix I Constituents

- Chemicals listed in Appendix I of 40 CFR Part 258 (Subtitle D)

Major Cations and Anions, Not listed in Appendix I of 40 CFR Part 258 (Subtitle D)

- Calcium, dissolved
- Magnesium, dissolved
- Manganese, dissolved
- Potassium, dissolved
- Sodium, dissolved
- Chloride
- Sulfate
- Carbonate (as $CaCO_3$)
- Bicarbonate (as $CaCO_3$)

Major Leachate Indicators, Not listed in Appendix I of 40 CFR Part 258 (Subtitle D)

• TDS • TOC • Alkalinity, total (as $CaCO_3$) • Ammonia (as N) • COD • Iron, dissolved • Nitrate-Nitrite (as N)
Field Measurements
• Specific conductance, pH, temperature, and turbidity

Note: Nitrate-nitrite as N will be analyzed instead of nitrate-N due to the short holding time required for analysis of nitrite-N for calculation of nitrate-N.
$CaCO_3$ calcium carbonate
COD chemical oxygen demand
TDS total dissolved solids
TOC total organic carbon

3.3 INTRA-WELL DETECTION MONITORING APPROACH

MWII-2, MWII-4, MWII-5, MWII-6, and MWII-7 will be used as POC wells for intra-well detection monitoring at the Kekaha Phase II Landfill in accordance with the statistical evaluation methods and procedures described in Section 5.0. Intra-well detection monitoring is generally preferable to inter-well monitoring because it eliminates the spatial component of background groundwater chemistry variability inherent in the alternative approach, i.e., inter-well monitoring. This spatial component contributes a significant portion of the variability in background conditions that must be accounted for by the statistical methodology. Spatial variability is a particularly important issue for the Kekaha site due to temporal variations in the groundwater flow direction, the presence of the unlined Phase I Landfill, the proximity of the downgradient wells to the ocean shoreline, and neighboring land uses (particularly the aquaculture facility located immediately northwest of the Phase II Landfill).

Wells not already impacted by inorganic waste constituents are preferred for intra-well monitoring; however, the intra-well approach can still be effective if chemical concentrations in groundwater potentially impacted by one source (e.g., the Phase I Landfill) show stable trends over time, such that departures from the trends can be identified in order to detect a potential release from another source (e.g., the Phase II Landfill).

Intra-well monitoring requires eight independent groundwater sampling events (but no less than six) to establish background conditions for each well prior to statistical evaluation. Data representing independent sampling events are required to account for seasonal trends or other causes of temporal variability and achieve adequate statistical sensitivity. The background data will be evaluated to identify potential anomalies and outliers before they are used for statistical analysis as described in Section 5.0.

If a SSI is detected and verified for one or more of the site-specific detection monitoring parameters, or if one or more VOC concentrations exceeding the practical quantitation limits (PQLs) are reported and verified and the exceedance(s) cannot be attributed to a source other than the Phase II Landfill, then assessment monitoring will be conducted within 90 days in accordance with HAR Chapter 11-58.1 (DOH 1994).

3.4 UPGRADIENT GROUNDWATER SAMPLING

Monitoring of upgradient wells is not required for intra-well groundwater monitoring because data representing the chemical characteristics of groundwater at each well location are compared to historical data representing the same well to identify statistically significant changes. However, upgradient data may be useful to evaluate the chemical characteristics of groundwater entering the landfill area from upgradient sources and assess the potential impact of off-site chemical sources on the groundwater, if required.

Historically monitoring well MWII-5 has been utilized as an upgradient monitoring well at the KLF; however, as shown in the groundwater contour figures provided in Appendix A, recent gauging data indicate that there may be periods during which the groundwater flows cross-gradient toward MWII-5. Several factors, such as localized drawdown at nearby production wells or irrigation canals (discussed in detail in Section 2.5) may contribute to the apparent shift in the groundwater flow direction in the vicinity of MWII-5. Based on the recommendation of the DOH, MWII-5 will be utilized as a POC monitoring well, unless additional data show conclusively that the monitoring well is upgradient of the landfill. Therefore, groundwater samples will be collected from the MWII-5 on a semi-annual basis and analyzed for the parameters listed in Table 3.6. Additionally MWII-5 data will be used for statistical analysis of the site-specific detection monitoring parameters as described in Section 5.0.

3.5 GROUNDWATER MONITORING SCHEDULE

Detection monitoring of the existing POC wells (MWII-2, MWII-4, MWII-5, MWII-6 and MWII-7) will be conducted on a semi-annual basis.

4.0 LEACHATE MONITORING

An established leachate database exists for KLF Phase II. Landfill leachate samples have been collected from Wet Wells-1 and -2 on an annual basis since April 1994, and from Wet Well-3 since 2010, and analyzed for an extensive list of parameters. Leachate monitoring is not specifically required by HAR Title 11 Chapter 58.1 regulations; however, the DOH Guidance Document (DOH 2002) recommends collecting leachate data to maintain a database of potential source information and evaluate the suitability of site-specific monitoring parameters.

4.1 LEACHATE MONITORING SYSTEM

As part of the KLF Phase II monitoring program, leachate samples will be collected from the three existing leachate collection sumps to supplement the historical leachate data. The leachate collection sumps will be sampled on a semi-annual basis for the first two years following initial placement of MSW in the Phase II vertical expansion and then the sampling frequency will be reduced to annually.

4.2 LEACHATE MONITORING PARAMETERS

The leachate samples will be analyzed for the constituents listed in Table 4-1, and the results will be compared to the groundwater monitoring data. If chemical parameters that meet site-specific detection monitoring criteria (as outlined in Section 3.2.1) are detected in the leachate, those parameters may be proposed for addition to the KLF Phase II detection monitoring program. New analytes may also be proposed for addition to the list of leachate monitoring parameters. Conversely, as the leachate database becomes more fully developed, parameters that are not found in the site leachate may be removed from the KLF Phase II detection monitoring program (with DOH approval).

Table 4-1: Summary of Kekaha Phase II Landfill Leachate Monitoring Parameters

Appendix II Constituents
• Chemicals listed in Appendix II of 40 CFR Part 258 (Subtitle D)
Major Cations and Anions, Not listed in Appendix II of 40 CFR Part 258 (Subtitle D)
• Calcium • Magnesium • Manganese • Potassium • Sodium • Chloride • Sulfate • Carbonate (as $CaCO_3$) • Bicarbonate (as $CaCO_3$)
Major Leachate Indicators, Not listed in Appendix II of 40 CFR Part 258 (Subtitle D)
• TDS • TOC • Alkalinity, total (as $CaCO_3$) • Ammonia (as N) • COD • Iron • Nitrate-Nitrite (as N)
Field Measurements
• Specific conductance, pH, temperature, and turbidity

Note: Nitrate-nitrite as N will be analyzed instead of nitrate-N due to the short holding time required for analysis of nitrite-N for calculation of nitrate-N.

$CaCO_3$ calcium carbonate
COD chemical oxygen demand
TDS total dissolved solids
TOC total organic carbon

5.0 DATA EVALUATION METHODS

The following subsections describe the methods and procedures for statistical and non-statistical evaluation of the KLF Phase II monitoring data. These methods and procedures represent a conservative approach to evaluation of groundwater chemistry data and incorporate state-of-the-art statistical and other evaluation methodologies.

5.1 STATISTICAL METHODOLOGY FOR EVALUATION OF INORGANIC PARAMETERS

Consistent with the existing groundwater monitoring program at the KLF, an intra-well monitoring strategy using Shewhart-Cumulative Sum (CUSUM) control charts will be used for routine detection monitoring. Shewhart-CUSUM control charts are useful because they are capable of detecting both sudden and gradual changes in groundwater chemistry (DOH 2002). Shewhart-CUSUM control charts will be constructed for each well to provide a statistical and visual tool for detecting trends and abrupt changes in inorganic groundwater chemistry. The combined Shewhart-CUSUM procedure assumes that the data are independent and normally distributed. The most important assumption is independence (DOH 2002). Therefore, care should be taken to never sample wells more frequently than sample independence can be demonstrated based on site-specific hydrogeologic factors. The assumption of normality is somewhat less of a concern because the data can usually be adequately transformed for most applications. Non-detects can be replaced by one-half of the PQL without serious consequence, although this procedure should be applied only to constituents that are detected in at least 25% of all samples. For data sets with less than 25% detected values in the background data set, non-parametric prediction limits will be used in lieu of Shewhart-CUSUM control charts.

Intra-well monitoring eliminates the spatial component of background groundwater chemistry variability inherent in the alternative approach (i.e., inter-well monitoring) from the statistical evaluation. For intra-well comparisons, a minimum of 8 background samples (i.e., from each well in the monitoring program) are required for parametric (i.e., Shewhart-CUSUM) tests and 13 background samples for non-parametric (i.e., Prediction Limit) tests. Background data has already been collected from all of the proposed monitoring wells. Statistical evaluation of groundwater monitoring data will continue to be performed using DUMPStat statistical modeling software, developed consistent with EPA and American Society for Testing and Materials (ASTM) guidance on groundwater monitoring at Subtitle D and Subtitle C facilities (DOH 2002).

5.2 NON-STATISTICAL METHODOLOGY FOR EVALUATION OF VOCS

VOCs have been demonstrated to be effective indicators of a release from MSW landfills. However, because these compounds are rarely detected in background groundwater samples, establishing monitoring well-specific limits for VOCs is generally not an option. Therefore, a detection monitoring decision rule based on laboratory-specific PQLs will be used to identify statistically significant monitoring results with respect to VOCs. It is generally accepted that when a landfill releases leachate to groundwater, multiple constituents contained in the leachate are associated with the source fluids and are subsequently detected by the groundwater monitoring program. A single constituent at very low concentration (i.e., below the PQL) typically is not the signature that is produced from a release. The calculation of laboratory-specific PQLs already incorporates a measure of the statistical uncertainty that is associated with the measurement process (Sanifill and Baquerizo 1996). Therefore, any VOC detected and verified at a concentration above the PQL is considered statistically significant, and would therefore trigger assessment monitoring (or an ASD if the detection is unrelated to a release from the landfill).

PQLs are designed to assure that the measured value reported for an analyte is close to the actual quantitative value. Method detection limits (MDLs), on the other hand, indicate that the analyte is present in the sample with a specified degree of confidence (Sanifill and Baquerizo 1996). For analytes with estimated concentrations greater than the MDL but less than the PQL, it can only be concluded that the true concentration is greater than zero; the actual concentration cannot be quantified. The actual concentration corresponding to an analytical result between the PQL and the

MDL (often referred to as a "trace" result or a "J-flagged" result) may actually be less than the MDL. Therefore, a comparison of a detected concentration to a maximum contaminant level, or any other concentration limit, is not meaningful unless the concentration is greater than the PQL. Although the use of VOC results reported between the MDL and PQL are not appropriate for identifying a potential leachate release, such trace/J-flagged results can be used to guide further investigation in the event that long-term, repeatable trace/J-flagged results are observed.

5.3 DETECTION VERIFICATION PROCEDURE

If groundwater analysis results have been collected, checked for QA and QC, consistency, and are determined to be above the appropriate statistical level (i.e., the Shewhart-CUSUM control chart limit or non-parametric prediction limit for inorganic monitoring parameters, or the PQL for one or more VOCs), the results should be verified in accordance with the objective of 40 CFR Part 258.53, HAR Chapter 11-58.1 (DOH 1994), and the DOH Guidance Document (DOH 2002).

Verification resampling is an integral part of the statistical methodology described by the EPA's *Addendum to Interim Final Guidance Document – Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities* (EPA 1992). Without verification resampling, much larger statistical limits would be required to achieve site-wide false positive rates of 5% or less. Furthermore, the resulting false negative rate would be greatly increased. The procedures described in Section 5.3.1 and Section 5.3.2 will be performed for chemicals initially identified at concentrations above the statistical limits. Verification samples should be analyzed only for those chemicals that initially exceed their statistical limits; otherwise, an unacceptably high false-positive error rate can be expected (e.g., if tetrachloroethylene [PCE] is the only compound detected during an EPA Method 8260B scan (EPA 1997), then only PCE is targeted and reported by the laboratory during the retest).

5.3.1 Volatile Organic Compounds

If concentrations above statistical limits (i.e., PQLs) are reported for one or more VOCs in groundwater samples from the POC wells, then one immediate resample and analysis should be conducted. If any single VOC is detected at a concentration above the PQL in the verification resample, a SSI will be recorded and assessment monitoring will be initiated or, if the exceedance is not likely to be associated with a release from the facility, an ASD will be performed.

5.3.2 Inorganic Constituents

If one or more of the inorganic parameters are detected at concentrations above their statistical limits (i.e., Shewhart-CUSUM control chart limits or non-parametric Prediction Limits), one verification resample will be collected at the next scheduled sampling event. If verification of an elevated parameter is confirmed for one discrete verification resample, a SSI will be recorded and assessment monitoring will be initiated or, if the exceedance is not likely to be the result of a release from the facility, an ASD will be performed.

5.4 QUALIFIER AND OUTLIER GROUNDWATER DATA EVALUATION

This section outlines the evaluation methodology that will be used for detection of a release from the facility using PQLs as the concentration limits for VOCs, and Shewhart-CUSUM control charts for the other site-specific detection monitoring parameters.

As the background database is updated, it will be necessary to examine the database for outliers, anomalies, and trends that might confound evaluation methods. Outliers and anomalies are inconsistently large or small values that can occur due to sampling, laboratory, transportation, or transcription errors, or even by chance alone. Significant trends indicate a source of systematic error, or an actual contamination occurrence, which must be evaluated and corrected. The inclusion of such values in the historical database could lead to misinterpretation of the data set, which could result in high rates of false positive errors and/or false negative errors.

To reduce the possibility of this type of systematic error, outliers will be removed from consideration before the data are analyzed to establish background water quality parameters. The outlier detection procedure will be performed for those wells that have at least four measurements for a given constituent using time versus concentration graphs. Parameter concentrations that appear anomalous (i.e., that are five times or greater than the previous results) will be verified during the next sampling event or after a reasonable period of time to ensure sample independence (e.g., three months). If the potential outlier result is not verified, the anomalous sample result will be removed from the database. Any detected systematic trends in the background database will be evaluated and reported to the DOH in a timely manner.

For the detection monitoring parameters, routine data will be evaluated based on time versus concentration plots for each constituent. If a significant trend, such as an unexpected geochemical signature, is indicated on a Piper or Stiff diagram or an anomalously high concentration (i.e., greater than five times average background concentration) is verified for a constituent after results have been been subject to QA/QC, then the DOH will be notified in a timely manner. Potential outlier data should be evaluated in an associated Data Quality Report prepared by the laboratory to determine the quality and integrity of the data in question. Information provided in the Data Quality Report will be important for evaluating the significance of the analysis result(s) and determining whether a result represents an outlier, a cross-contaminated value, or other laboratory error.

In addition, leachate characterization will be performed on a continuing basis, and the results will be used to modify the list of detection monitoring parameters (if modification is warranted and the DOH approves). Source characterization is an effective technique for reducing false positive and false negative errors because groundwater concentrations indicating a potential release must be correlated with source concentrations (i.e., source concentrations must be greater and in appropriate contrast with groundwater concentrations). Therefore, if a chemical is detected in groundwater at a concentration of concern but is either not detected in leachate or is detected in leachate at a much lower concentration, then the data indicate that the chemical is not attributable to a release from the landfill. If the evaluation indicates that leachate represents a potential source of a chemical, then verification re-sampling (i.e., outlier assessment) will be conducted.

5.5 ASSESSMENT MONITORING

If a SSI has been detected and verified for one or more of the detection monitoring parameters identified in Section 3.2.2 and the increase cannot be attributed to a source other than the Phase II Landfill, assessment monitoring will be conducted in accordance with HAR Chapter 11-58.1 within 90 days (DOH 1994). This requires sampling all downgradient wells for analysis of Subtitle D Appendix II constituents. After the results of this initial assessment monitoring sampling event are received, assessment monitoring would then continue on a semi-annual basis. A letter addendum to this GMP will be developed if assessment monitoring becomes necessary. Further guidance on assessment monitoring is provided in the DOH Guidance Document (DOH 2002) and ASTM D7048. (ASTM 2004a).

6.0 FIELD MONITORING AND SAMPLING PROCEDURES

The field procedures for monitoring, sampling, and analysis or groundwater and leachate at the KLF Phase II described in this section will be performed in accordance with the DOH Landfill Guidance Document (DOH 2002; Appendix C) and the Waste Management *Groundwater, Surface Water, & Leachate Sampling Guide,* March 5, 2004 Version 1.0 (WMI 2004; Appendix D). Methods and procedures for laboratory analysis and QA/QC for the monitoring program are described in Section 7.0.

6.1 GROUNDWATER ELEVATION MEASUREMENTS

Water levels in the monitoring wells must be measured during a single event prior to purging or sampling of any well, and the time between measurements should be as short as possible to provide the data required to accurately evaluate the magnitude and direction of the hydraulic gradient.

6.2 SAMPLE COLLECTION AND HANDLING PROCEDURES

Groundwater samples for chemical analysis will be collected begin after the monitoring wells have been properly developed and purged. All sampling activities will be performed in accordance with the general requirements for groundwater, surface water, and leachate sample collection presented in the DOH Landfill Guidance Document and the Waste Management Sampling Guide. The Waste Management Sampling Guide is derived, in part, from the following ASTM Environmental Standards:

- ASTM Standard D1129-06a, (2006) – *Standard Terminology Related to Water*
- ASTM Standard D3370-95a, (2003) – *Standard Practices for Sampling Water from Closed Conduits*
- ASTM Standard D4840-99, (2004d) – *Standard Guide for Sampling Chain-of-Custody Procedures*
- ASTM Standard D3694-96, (2004c) – *Standard Practice for Preparation of Sample Containers and for Preservation of Organic Constituents*
- ASTM Standard D5088-02, (2002) – *Standard Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites*

All sampling team members shall review The Waste Management Sampling Guide prior to initiation of routine or special sampling events at the KLF. All monitoring well construction information and documentation of completed sampling events shall be filed and available on site. All sampling team members must sign a Signature Page, verifying that they have read and understand the requirements specified in the Waste Management Sampling Guide, and have noted any exceptions to the Sampling Guide.

Site conditions at the KLF or site-specific regulatory requirements may necessitate a deviation from the Waste Management Sampling Guide as described herein. Any such deviation must be documented by the sampling team leader in coordination with the Environmental Protection Manager or the Waste Management, Inc. West Group Hydrogeologist.

6.2.1 Monitoring Well Purging

A dedicated pump will be installed in each monitoring well, and will be used to purge the well before groundwater samples are collected. Before well purging begins, the groundwater level will be measured. Each well will be purged at a rate that does not create substantial drawdown. The purging rate will be reduced if the drawdown rate appears to exceed the recovery rate. The purge water will be sampled at regular intervals (approximately every 5 minutes) and analyzed in the field for temperature, pH, electrical conductance, and turbidity (field parameters). A minimum of four readings will be taken. Purging will be considered complete when three consecutive readings stabilize to within 10% of each other.

6.2.2 Sample Collection Methods

The wells will be sampled directly from the Teflon discharge tube of the dedicated pumps. If a well is slow to recharge, a sample will be collected no later than 2 hours after purging is completed. Water samples will be placed into appropriate laboratory-supplied containers. Samples will be preserved immediately after collection. Samples for VOC analysis will have zero headspace (no air bubbles trapped in the sample). When filling bottles containing preservative, the bottles will not be allowed to overflow any more than is necessary to eliminate headspace. Pre-measured amounts of preservative reagents are supplied with the sample bottles by the laboratory. Analytical methods identify the specific preservative (if any), and specify how much preservative is required. Bottles will not be overfilled, and will be inverted (once capped) to mix the preservative with the sample. Bottle lids will not be placed on the ground or interchanged among sample bottles.

6.2.2.1 FILTERED SAMPLES

Groundwater samples to be analyzed for dissolved metals and TOC will be filtered through a 0.45-micron membrane in-line filter, transferred to a container, and preserved with nitric acid (for metals) or sulfuric acid (for TOC) to a pH less than 2.0. Prior to collecting the filtered samples, approximately 500 milliliters (mL) of groundwater will be discharged through the filter.

6.2.3 Sample Labeling

A sample label with adhesive backing will be affixed to each individual sample container. Clear tape will be placed over each label to prevent loss of information on the label. The following minimum information will be recorded with a waterproof marker on each label:

- Project name or number
- Sample identification number
- Date and time of collection
- Sample preservatives (if applicable)
- Analysis to be performed

The sample labels will be obtained from the analytical laboratory, or printed on adhesive labels.

6.2.4 Chain-of-Custody

Sample integrity depends on strict COC procedures to track the sample containers and samples from the time the empty sample bottles leave the laboratory to the issuance of the analytical laboratory results.

To maintain the COC, the samples will be either in sight of the assigned custodian, locked in a tamper-proof location, or sealed with a tamper-proof seal. A record of sample bottle possession and any transfers of samples will be maintained, and documented on the COC Form. The signature of the responsible party, time, and date will be recorded on the COC Form immediately before sealing the container for transport to the laboratory, and each time the sample container is transferred to the custody of another person.

Sample identification numbers, sample matrix, number of containers, date, and time of sampling will be recorded on the COC Form. The required analytical methods, use of pre-filtration bottles, and any problems with the sample will also be noted on the form. Upon receipt of the sample cooler by the laboratory, the seal will be broken, and the condition of the samples, temperature, date, and time will be recorded on the COC Form.

6.2.5 Sample Handling and Storage

After collection, samples will be immediately placed in insulated coolers and chilled to 4 degrees Celsius (°C) with frozen gel packs. Each cooler will be "locked" with a custody seal. The sampling team will record sample designations on COC Forms and Field Information Forms. Both forms will be reviewed to ensure completeness, and all paperwork (with the exception of carbon copies that are held for documentation purposes) will be placed in a plastic bag, sealed, and placed inside the container. Analytical methods, sample containers, preservatives, and holding times for each analytical method are listed in Section 7.0. The containers and packing materials provided by the laboratory will be designed to prevent breakage and spillage during shipping. Shock-resistant bottle holders or other materials will be used for this purpose. Volatile organic analysis (VOA) vials will be arranged such that they are never in direct contact with the ice packs.

6.3 EQUIPMENT DECONTAMINATION

All non-disposable, non-dedicated equipment that contacts potentially contaminated groundwater will be decontaminated prior to reuse. Equipment will be decontaminated by steam cleaning or by a non-phosphate detergent scrub, followed by tap water and distilled or deionized water rinses. Decontamination will be performed on plastic sheeting. Clean equipment will be stored on plastic sheeting in an uncontaminated area. Equipment stored for an extended period will also be covered by plastic sheeting.

6.4 INVESTIGATION-DERIVED WASTE MANAGEMENT

Investigation-derived waste (IDW) will include water generated during decontamination of the sampling equipment, well development, and purge water. IDW will be minimized throughout the fieldwork as much as possible. It is anticipated that the water IDW will be disposed of onsite per the State Landfill Groundwater Monitoring Guidance (DOH 2002).

6.5 LOGBOOKS

A bound field notebook with consecutively numbered, water-repellent pages will be maintained. The logbook will be clearly identified with the name of the site, name of the logkeeper, and the beginning and ending dates of the entries. Data forms, with predetermined formats for logging field data, will be incorporated into the logbook. This logbook will serve as the primary record of field activities. The logbook will reference data maintained in other logs (e.g., groundwater sampling logs). The logbook will provide detailed entries in chronological order that will allow a reviewer to reconstruct the field activities. The logbook will be maintained in a clean area and used only when outer gloves have been removed. Entries on the data forms and in the logbook will meet the same requirements. Logbook entries will be corrected by drawing a single line through the incorrect entry, and then initialing and dating the change. Corrections of more than a simple mistake will be accompanied by an explanation. At the end of each day, the logkeeper will sign that day's entries. The logkeeper will photocopy completed pages weekly. A technical review of the logbook will be conducted by the field manager.

7.0 LABORATORY ANALYSIS PLAN

This section describes the methods and procedures for laboratory analysis and QA/QC for the Kekaha Phase II Landfill groundwater and leachate sampling program. The procedures are drawn extensively from the Waste Management Sampling Guide (WMI 2004).

7.1 PROGRAM QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Duplicate, trip blank, equipment blank, and field blank samples will be collected and analyzed as required to provide QA/QC data for the KLF Phase II detection monitoring program, as described below.

7.1.1 Duplicates

Duplicate samples will be collected in the field from the POC wells and leachate sumps Duplicates should not be physically different in color, turbidity, or other physical parameters. Sampling locations (monitoring wells or leachate sumps) from which duplicates are collected must be identified in the field records along with any information/observations that may be useful to explain potentially anomalous results (e.g. physical differences between samples, prevailing winds, upwind contaminant sources, etc.). Each duplicate should be collected using matching sets of laboratory-supplied sample containers by alternating between the regular sample containers and the duplicate sample containers. The duplicates should be blind (i.e., the well designation is not listed on the COC form). Once a duplicate is collected, it must be handled and shipped in the same manner as the rest of the samples.

7.1.2 Trip Blanks

Trip blanks are a required part of the field sampling QA/QC program. They are used to detect VOC contamination that may be introduced in the field (either atmospheric or from sampling equipment), in transit (to or from the sampling site), or in the bottle preparation, sample log-in, or sample storage stages at the laboratory. Laboratory method blanks are used during the analytical process to detect any laboratory introduced contamination that may occur during analysis.

Trip blanks are samples of VOC-free water (e.g., deionized) prepared at the laboratory. They remain with the sample bottles while in transit to the site, during sampling, and during the return trip to the laboratory. Trip blank sample bottles must not be opened at any time during this process. Upon return to the laboratory, trip blanks will be analyzed for VOCs using the same procedures and methods that are used for the collected field samples. For the KLF, one trip blank will be placed in each cooler containing VOCs.

Trip blank results should be reported in the laboratory results as separate samples, using the designations TB-(well#) as their sample point designation.

7.1.3 Field Blanks

Field blanks are a required part of the field sampling QA/QC program. The purpose of the field blank is to detect contamination that might be introduced into the groundwater samples through the air. For sites with sampling programs involving VOCs, at least one field blank should be analyzed for the first 20 samples or less. At least one field blank sample should be collected for each day of sampling, and for each subsequent 20 samples, whichever is greater. For the KLF, sampling is typically completed in one day, and comprises less than 20 samples, so a single field blank will be collected during each monitoring event.

Field blanks must be prepared in the field (at the sampling site) using laboratory-supplied bottles and deionized or laboratory reagent-quality water. Each field blank is prepared by pouring the deionized water into the sample bottles at the location of one of the wells in the sampling program. The well at which the field blank is prepared must be identified on a Field Information Form, along with any observations that may help explain anomalous results (e.g., prevailing wind direction, up-wind potential sources of contamination, etc.). Once a field blank is collected, it is handled and shipped in the same manner as the rest of the samples.

7.1.4 Equipment Blanks

At the KLF, all sampling equipment is dedicated, and in general, equipment blanks are not required or collected. For non-dedicated equipment, if used, decontamination procedures consist of rinsing the equipment once with deionized or laboratory reagent quality water, brushing the equipment with a laboratory-quality soap, and triple rinsing the equipment with deionized or laboratory reagent quality water.

Equipment blank samples will be collected (if required) by pouring deionized or laboratory reagent quality water into the sampling device (e.g., the bailer) and then placed in the sample container with the proper preservative. If the corresponding groundwater samples are filtered, then the field blank water should be filtered after it has contacted the sampling device and before it is placed in the sample container.

Equipment blank results should be reported in the laboratory results as separate samples, using the designations EB-(well#) as their sample point designation.

7.2 LABORATORY QUALITY CONTROL PROCEDURES

The QA program for the laboratory is described in their Quality Assurance Program Plan (QAPP), which is available from the laboratory upon request. The QAPP describes mechanisms the laboratory employs to ensure that all data reported meets or exceeds all applicable EPA and State requirements. It describes the laboratory's experience, its organizational structure, and procedures in place to ensure quality of the analytical data. The QAPP outlines the sampling, analysis, and reporting procedures used by the laboratory. The laboratory is responsible for the implementation of and adherence to the QA and QC requirements outlined in the QAPP.

Audits are an important component of the QA program at the laboratory. Audits are conducted by the laboratory. Internal system and performance audits should be conducted periodically to ensure adherence by all laboratory departments to the QAPP.

Data quality reviews (DQR), or the equivalent, are requests submitted to the laboratory to formally review results that differ from historical results, or that exceed certain permit requirements or QC criteria. The laboratory should prepare a formal written response to each DQR explaining the discrepancy. The DQR is the first line of investigation following any anomalous result.

7.3 PRACTICAL QUANTITATION LIMITS

Laboratory-specific PQLs should be used as the reporting limits for applicable low-detection-frequency analytes (particularly organic compounds). The EPA developed the concept of the PQL to address the issue of analytical variability. The PQL concept was developed for compliance with the Safe Drinking Water Act (50 Federal Register [FR] 46906, Nov. 13, 1985) where it is defined: "The PQL thus represents the lowest level achievable by good laboratories within specified limits during routine laboratory operating conditions." The EPA states in 52 FR 25699 (July 8, 1987): The EPA developed the PQL concept to define a measurement concentration that is time and laboratory independent for regulatory purposes. MDLs, although useful to individual laboratories, do not provide a uniform measurement concentration that can be used to set standards.

The EPA's defined MDL, as published in 40 CFR 136, has limited application. The Agency acknowledges that "MDLs are not necessarily reproducible over time in a given laboratory, even when the same analytical procedures, instrumentation and sample matrix are used" (50 FR 46906, Nov. 13, 1985). As indicated in 52 FR 25699, the MDLs have had a tendency to be misunderstood by regulatory agencies developing policies for how low concentration standards (in this case, "detection of a contaminant") can be established. The use of MDLs may result in false positives, because (as the EPA has acknowledged) MDLs are ideal limits that cannot be reliably measured by even the best laboratories. Therefore, in its regulatory programs, the EPA has determined that the PQL is a more appropriate measure for compliance purposes.

While the EPA has defined PQLs, these limits are often based on consensus rather than operational definitions and experimental evidence. The actual PQL limit that may be achieved in a specific laboratory for a specific chemical may be higher or lower than the PQLs listed in SW-846 (EPA 1997). In contrast to the PQL, which is a measure of analytical precision, the MDL is a hypothesis test that leads to the binary decision of whether or not an analyte is present or absent in a sample. The MDL is defined by the EPA as the "minimum concentration of a substance that can be measured and reported with 99% confidence that the true value is greater than zero" (50 FR 46906, Nov. 13, 1985).

7.4 Analytical Methods

Table 7-1 and Table 7-2 summarize the analytical methodologies to be used by the laboratory for the routine analysis of groundwater and leachate, and list the sample containers, preservatives, and holding times for each analytical method. All methods are EPA-approved and are fully described in the laboratory method and standard operating procedure documents. The laboratory may substitute EPA-approved methods upon notification and approval of the DOH Environmental Protection Manager.

Table 7-1: Groundwater Analytical Methods, Sample Containers, Volumes, Preservatives, and Holding Times

Analytical Parameters	Method Number	Quantity	Container	Preservative	Holding Time
VOCs App. I (preserved)	SW846 8260B	3	40 mL Glass-VOA vial	HCl and Cool to 4°C	14 days
VOCs App. I (unpreserved)	SW846 8260B	3	40 mL Glass-VOA vial	Cool to 4°C	3 days
Metals, Dissolved	SW846 6020A/6010C	1	500 mL Polyethylene	HNO_3 pH<2	3 months
Metals, Total	SW846 6020A/6010C	1	500 mL Polyethylene	HNO_3 pH<2	3 months
TOC, Field Filtered	SM 5310B	1	500 mL Amber Glass	H_2SO_4 pH<2	28 days
COD	EPA 410.4	1	500 mL Amber Glass	H_2SO_4 pH<2	28 days
Nitrate-Nitrite as Nitrogen	EPA 353.2				
Ammonia as Nitrogen	EPA 350.1				
Alkalinity: Total, Bicarbonate & Carbonate	SM 2330B	1	1000 mL unpreserved Polyethylene	Cool to 4°C	14 days
TDS	SM 2540C				7 days
Chloride, Sulfate, Bromide	EPA 300.1				28 days

HCl hydrochloride acid
HNO_3 nitric acid
H_2SO_4 sulfuric acid

Table 7-2: Leachate Analytical Methods, Sample Containers, Volumes, Preservatives, and Holding Times

Analytical Parameters	Method Number	Quantity	Container	Preservative	Holding Time
VOCs App. II (preserved)	SW846 8260B	3	40 mL Glass-VOA vial	HCl and Cool to 4°C	14 days
VOCs App. II (unpreserved)	SW846 8260B	3	40 mL Glass-VOA vial	Cool to 4°C	3 days
SVOCs App. II	SW846 8270D	8	1000 mL Amber Glass	Cool to 4°C	7 days
Herbicides App. II	SW846 8151A				
Organochlorine Pesticides App. II	SW846 8081B				
Dioxin App. II	SW846 8280B				
PCBs as Aroclors App. II	SW846 8082A				
Total Metals and Mercury App. II	SW846 6020A/6010C/7470A	1	500 mL Polyethylene	HNO_3 pH<2	6 months
COD	EPA 410.4	2	500 mL l Amber Glass	H_2SO_4 pH<2	28 days
TOC	SM 5310B				
Nitrate-Nitrite as Nitrogen	EPA 353.2				
Ammonia as Nitrogen	EPA 350.1				
Total Cyanide	SM 9012B	1	250 mL Poly	NaOH pH>12	7 days
Total Sulfide	SM 4500	1	250 mL Poly	ZnAcetate/NaOH	14 days

Analytical Parameters	Method Number	Quantity	Container	Preservative	Holding Time
Alkalinity: Total, Bicarbonate & Carbonate	SM 2330B	1	1000 mL unpreserved Polyethylene	Cool to 4°C	14 days
TDS	SM 2540C				7 days
Chloride, Sulfate, Bromide	EPA 300.1				28 days

NaOH sodium hydroxide
PCB polychlorinated biphenyl

8.0 DATA QUALITY REVIEW, REPORTING, AND RECORDKEEPING

Prior to submittal of a monitoring report to the DOH, several data evaluation, reporting, and recordkeeping tasks will be implemented. The following sections, drawn extensively from the Waste Management Sampling Guide (WMI 2004), describe the evaluation, reporting, and recordkeeping procedures that should be followed upon receipt of an analytical report.

8.1 DATA QUALITY REVIEW

Each analytical report received from the laboratory shall undergo two levels of quality assessment. These quality assessment procedures are described below.

8.1.1 Initial QA/QC Checks

Before data are subjected to statistical analysis, a qualified hydrogeologist or groundwater scientist shall evaluate the data by examining the QC information accompanying the data report from the laboratory. Relevant QC data include measures of accuracy (percent recovery), precision (relative percent difference [RPD]), and sample contamination (blank determinations). Data that fail any of these checks should be flagged for closer evaluation and a DQR. Results of the DQR must be submitted with the analytical data in the routine monitoring report (see Section 7.2 for a description of DQR). A brief summary of relevant QC data follows. A more complete description should be contained in the laboratory QAPP.

Accuracy defines the relationship between the laboratory's measurement of a sample's concentration and the "true", but unknown concentration of the sample. Because the "true" concentration is unknown, accuracy must be measured indirectly by determining the percent recovery of a sample called the matrix spike (MS). The MS is analyzed under the same conditions as the groundwater sample and its concentration is determined. Because the MS has a known concentration, the percent recovery can be calculated. It is assumed that the groundwater sample behaves exactly like the MS and thus the "true" concentration of the submitted groundwater sample can be back-calculated. Control criteria for percent recovery are taken from regulatory method requirements.

Precision is the assessment of the variability that can be expected in data resulting from the analytical procedures employed. It provides a measure of the reproducibility, which is estimated through duplicate measurements of a MS. Two MS samples are prepared, an MS and a matrix spike duplicate (MSD). The MS and MSD samples are analyzed along with the unknown sample and the RPD between the two spikes is determined. Control criteria for RPDs are taken from regulatory method requirements.

The potential for sample contamination is assessed by measurements of "blank" samples. Blanks are samples of ultra-pure laboratory water that are not spiked with any analytes and are carried through the field sampling and laboratory environments. These samples are known as "field," "lab," and "equipment" blanks. It is assumed that any analytes that occur in the field or laboratory, which might add to the concentration of the analyte in the sample, will be picked up by the blank samples and measured. If any of the analytes of interest are found in the blank samples, it is an indication of potential contamination of the unknown sample.

8.1.2 Qualitative Data Evaluation

Following the initial QA/QC checks, all data will undergo a second level of review by graphing historical trends and comparing new results with these historical trends to flag visual outliers or other anomalous data. If a clearly anomalous result is found, a DQR will be initiated with the laboratory to ascertain whether laboratory error is involved. In addition, field information should be checked for anomalous occurrences or observations that might help to explain an outlier result.

8.2 DATA RECORDKEEPING REQUIREMENTS

The laboratory maintains all analytical data indefinitely. The laboratory ensures that, at each stage of a process where a permanent data record is required, security measures are in place to guarantee the integrity of the data. Standard operating procedures are in place for computer security, computer data storage, and data back-up.

8.3 DATA REPORTING REQUIREMENTS

Monitoring data will be submitted in reports that summarize all monitoring activities that took place during the preceding time periods in accordance with state and federal regulations. A semi-annual/mid-year report will be submitted to the DOH detailing the results and events of the previous six months. The semi-annual report will include graphs of all analytical data from each monitoring point and background monitoring point, as required, except for those constituents for which no new data were collected since the previous submittal. Monitoring reports summarizing results, exceedances, and/or deficiencies in the sample data will be submitted to the DOH and WMH within 90 days of receipt of final data. Each report will include electronic files (e.g., laboratory data reports).

9.0 REFERENCES

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50 Federal Register (FR) 46906, Nov. 13, 1985.

52 Federal Register (FR) 25699, July 8, 1987.

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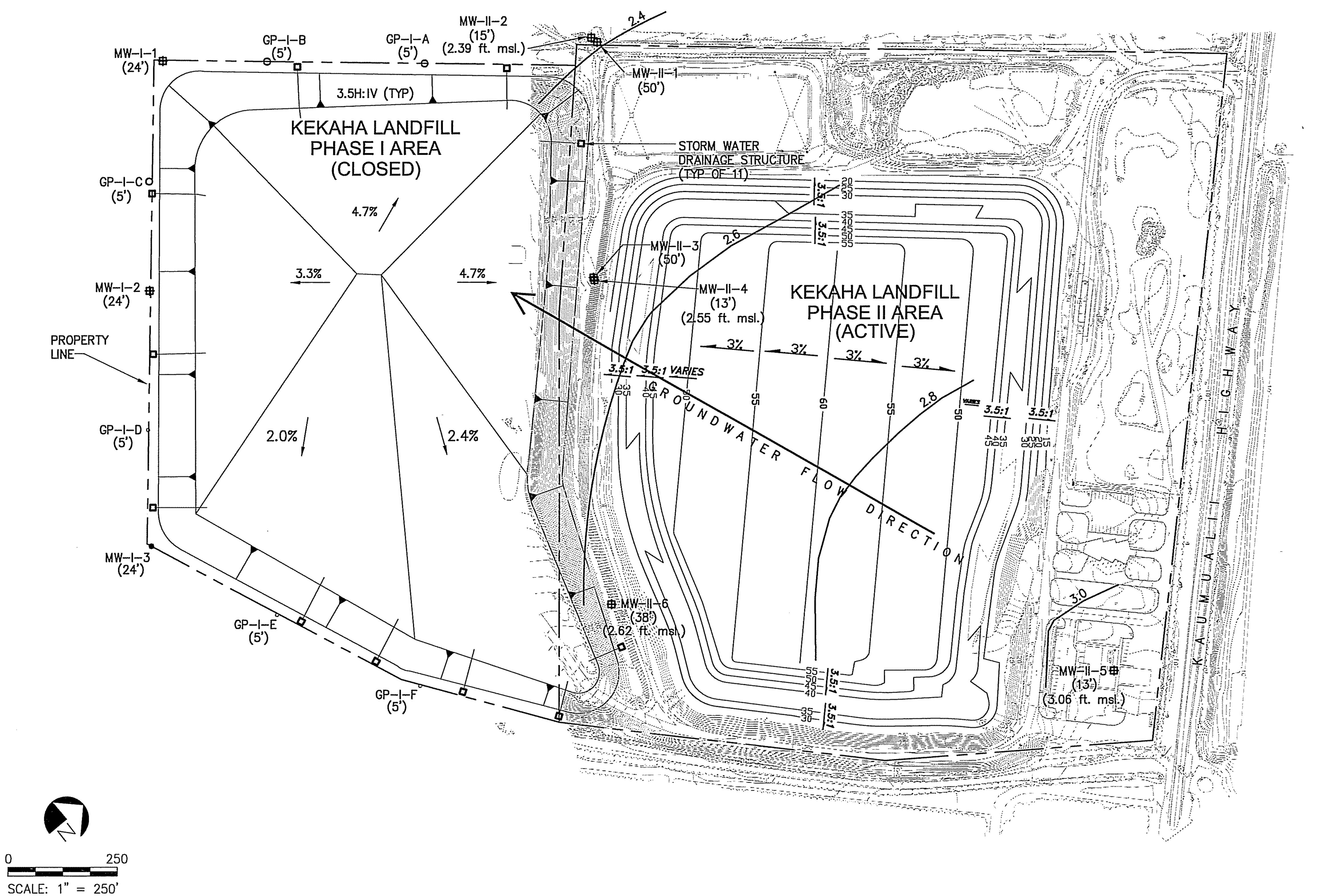
Appendix A
Kekaha Sanitary Landfill Historical Groundwater Table Contour Maps



LEGEND

GP-I-A (2') ELEV. ft. msl.	GAS PROBE AND DEPTH
MW-I-1 (2') ELEV. ft. msl.	PHASE I GROUNDWATER MONITORING WELLS AND DEPTH
MW-II-4 (2') ELEV. ft. msl.	PHASE II GROUNDWATER MONITORING WELLS AND DEPTH

NOTE:

1. INFORMATION SHOWN ON THIS FIGURE WAS OBTAINED FROM "POST CONSTRUCTION REPORT, KEKAHA SANITARY LANDFILL, PHASE I CLOSURE, KEKAHA, KAUAI", BY HARDING LAWSON AND ASSOCIATES, DATED FEBRUARY 16, 1996 AND AIR SURVEY HAWAII, INC., JANUARY 16, 1996

2. GROUNDWATER MONITORING WELLS MW-II-2, MW-II-4, MW-II-5 AND MW-II-6 WERE SAMPLED FOR THE PHASE II GROUNDWATER MONITORING PROGRAM.

EARTH TECH

KEKAHA LANDFILL, PHASE II
GROUNDWATER MONITORING SITE LAYOUT MAP
JULY 1, 2005 TO DECEMBER 31, 2005

FIGURE 2

LEGEND

MW-II-4 ⊞ ELEV. ft. msl.	PHASE II GROUNDWATER MONITORING WELLS
—— 2.6 ——	GROUNDWATER POTENTIOMETRIC SURFACE

NOTE:

1. INFORMATION SHOWN ON THIS FIGURE WAS OBTAINED FROM "PRELIMINARY ENGINEERING REPORT, KEKAHA LANDFILL PHASE II SECOND VERTICAL EXPANSION, KEKAHA, KAUAI", BY EARTH TECH, INC., DECEMBER, 2003.

2. GROUNDWATER MONITORING WELLS MW-II-2, MW-II-4, MW-II-5 AND MW-II-6 WERE SAMPLED FOR THE PHASE II GROUNDWATER MONITORING PROGRAM.

3. PHASE II AREA SURFACE CONTOURS ARE FOR PROPOSED LANDFILL CAP

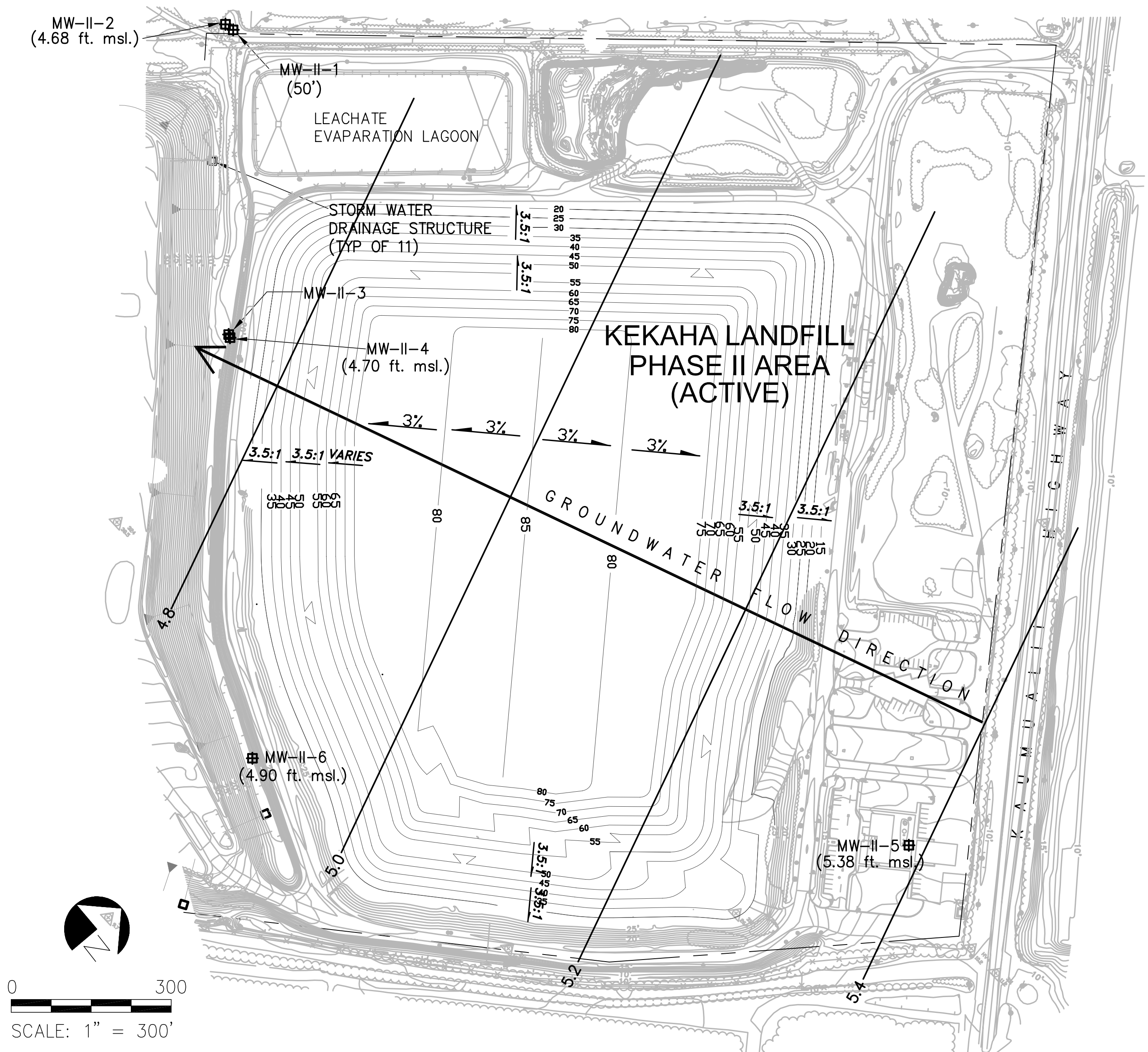


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (July 25, 2006)
Kauai, Hawaii

LEGEND

MW-II-4 ⊞ ELEV. ft. msl.	PHASE II GROUNDWATER MONITORING WELLS
—— 2.6 ——	GROUNDWATER POTENTIOMETRIC SURFACE

NOTE:

1. INFORMATION SHOWN ON THIS FIGURE WAS OBTAINED FROM "POST CONSTRUCTION REPORT, KEKAHA SANITARY LANDFILL, PHASE I CLOSURE, KEKAHA, KAUAI", BY HARDING LAWSON AND ASSOCIATES, DATED FEBRUARY 16, 1996 AND AIR SURVEY HAWAII, INC., JANUARY 16, 1996

2. GROUNDWATER MONITORING WELLS MW-II-2, MW-II-4, MW-II-5 AND MW-II-6 WERE SAMPLED FOR THE PHASE II GROUNDWATER MONITORING PROGRAM.

3. PHASE II AREA SURFACE CONTOURS ARE FOR PROPOSED LANDFILL CAP

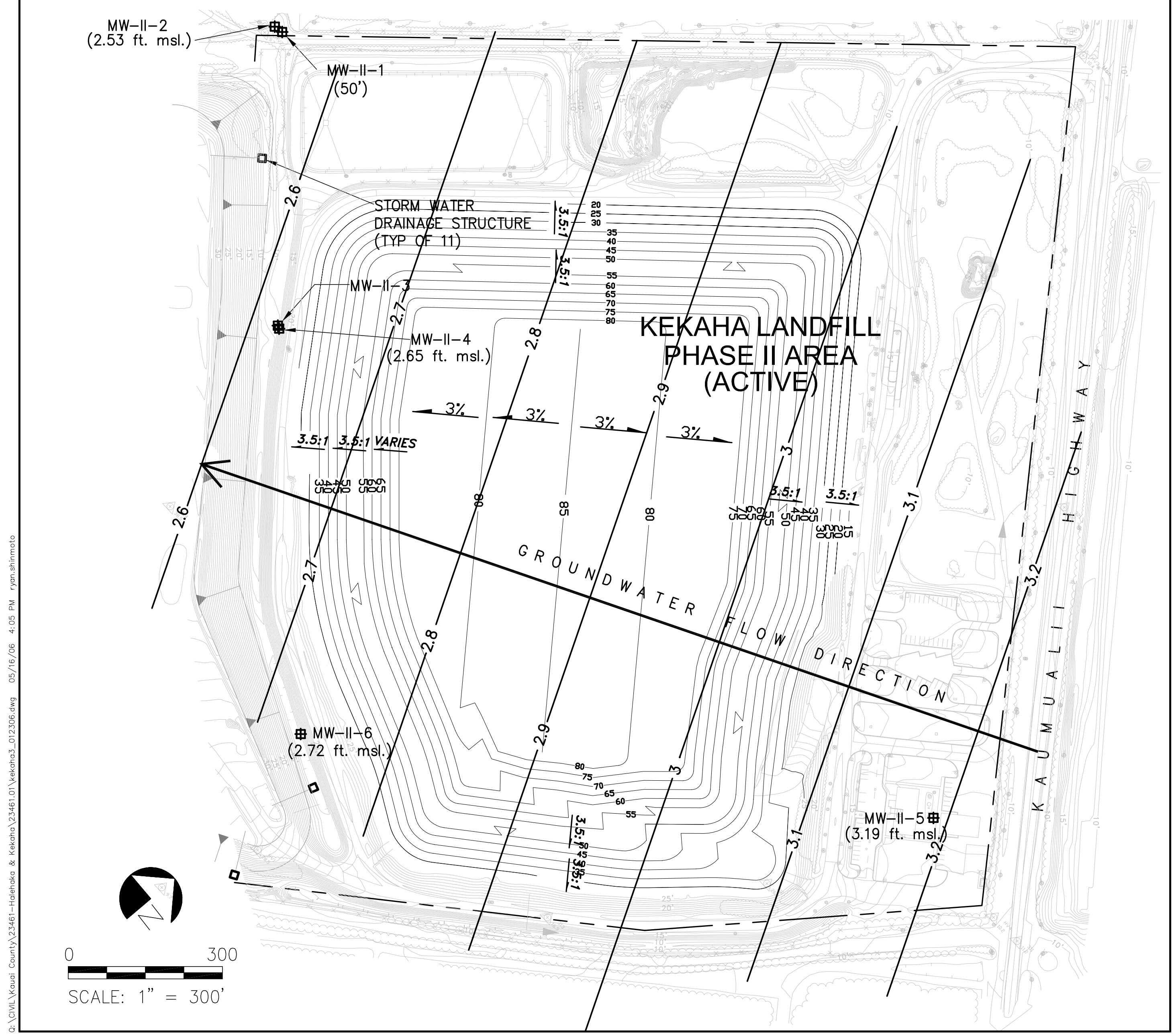


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill
Kauai, Hawaii

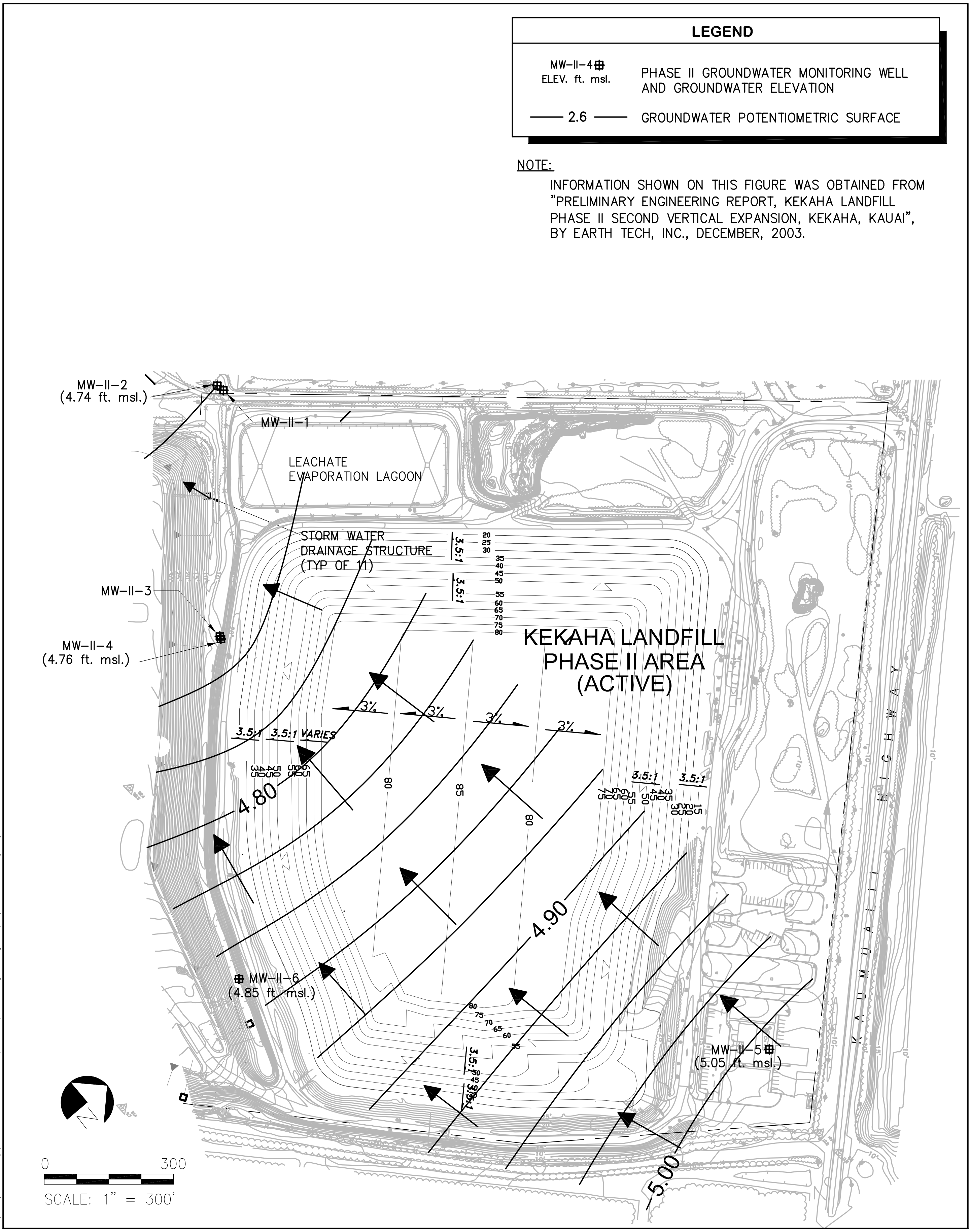


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (Feb 2007)
Kauai, Hawaii

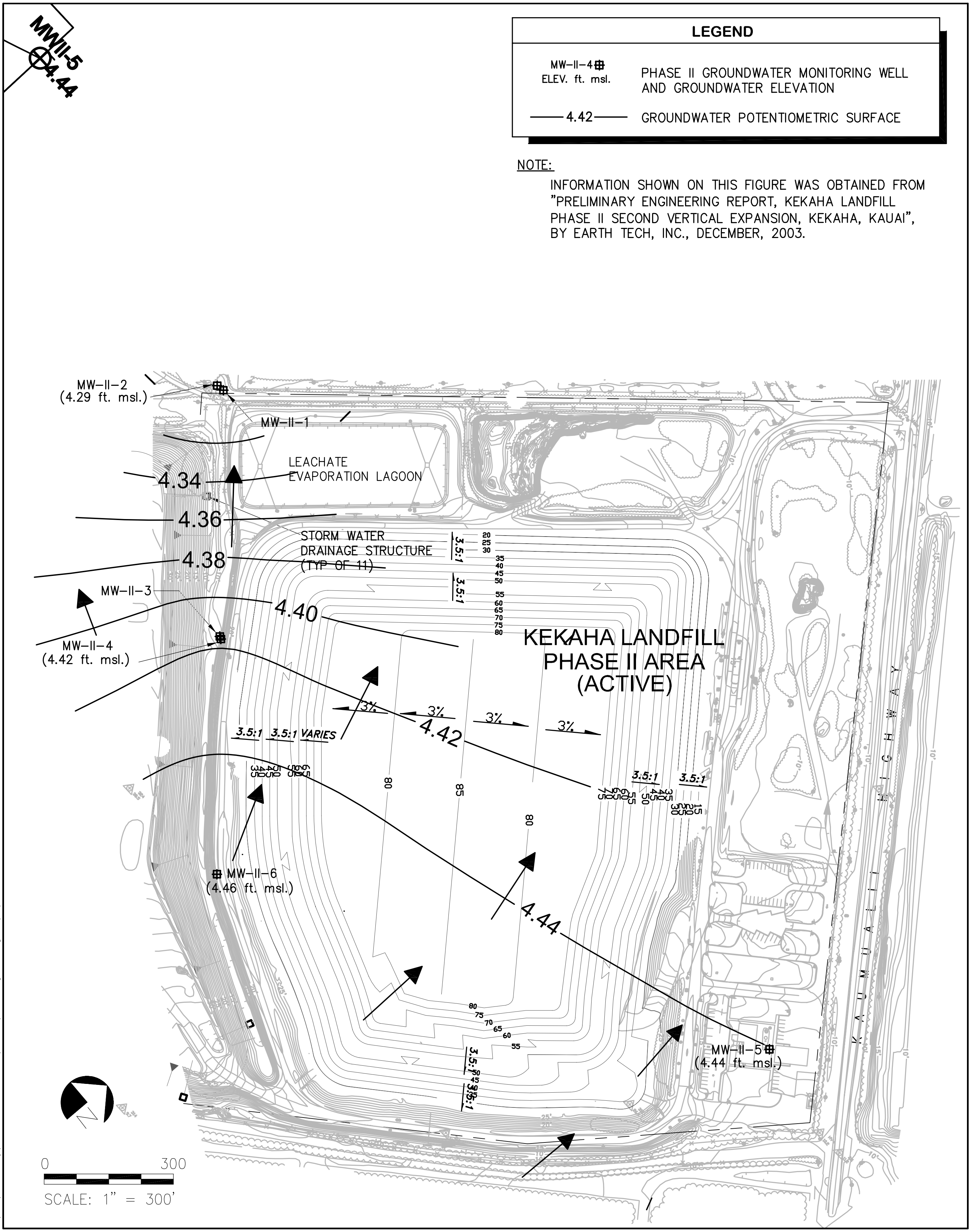


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (October 2007)
Kauai, Hawaii

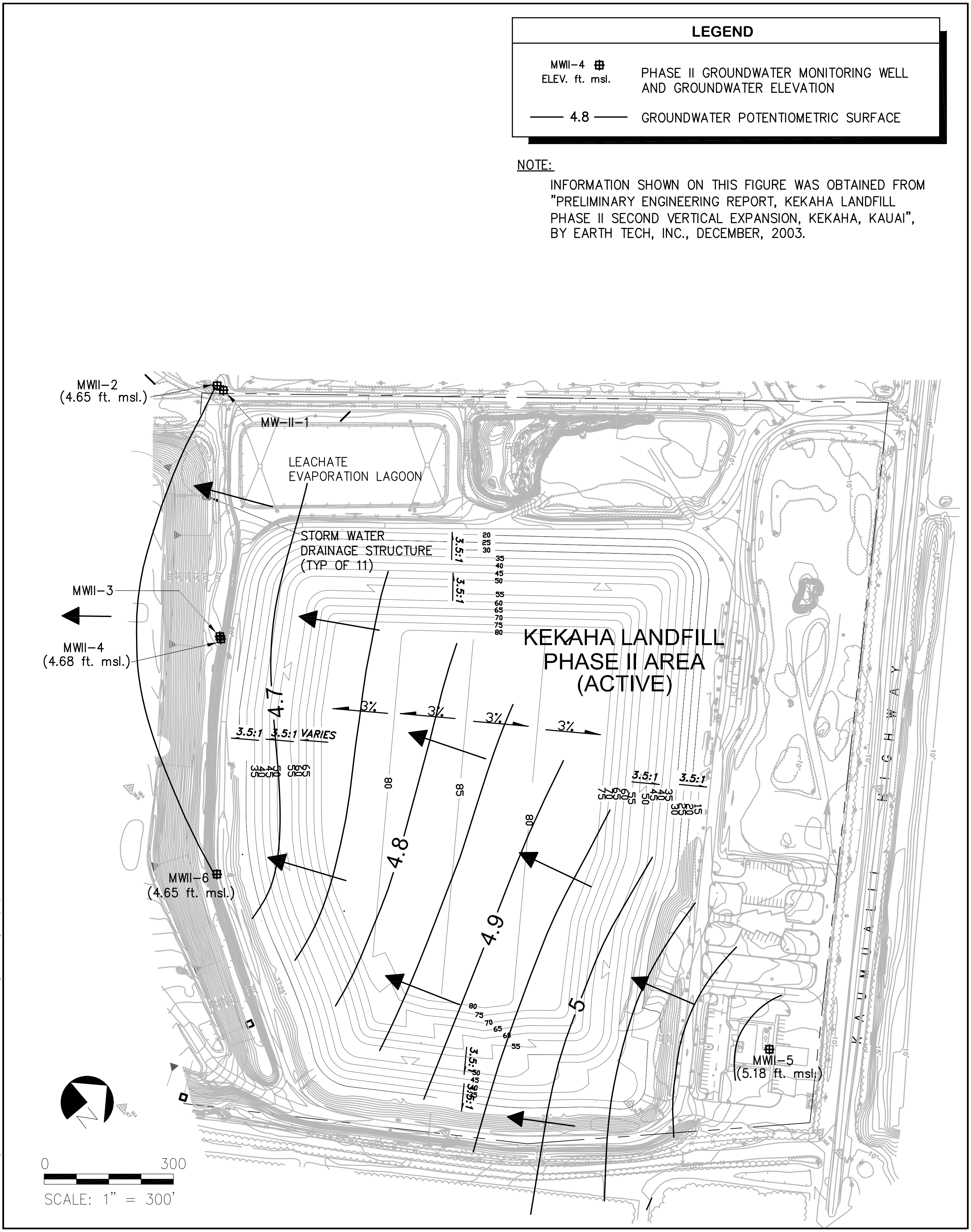


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (March 11, 2008)
Kauai, Hawaii

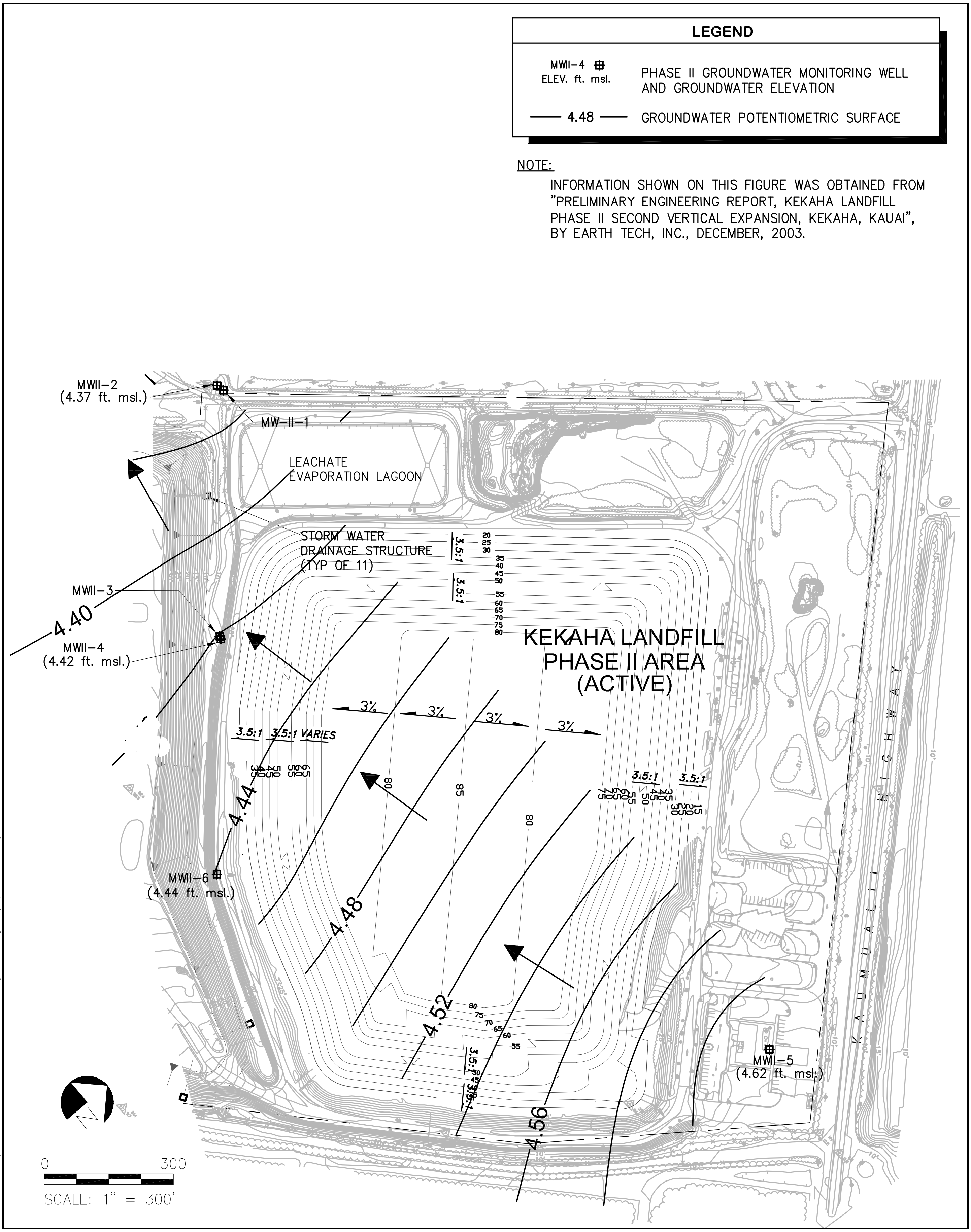


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (June 10, 2008)
Kauai, Hawaii

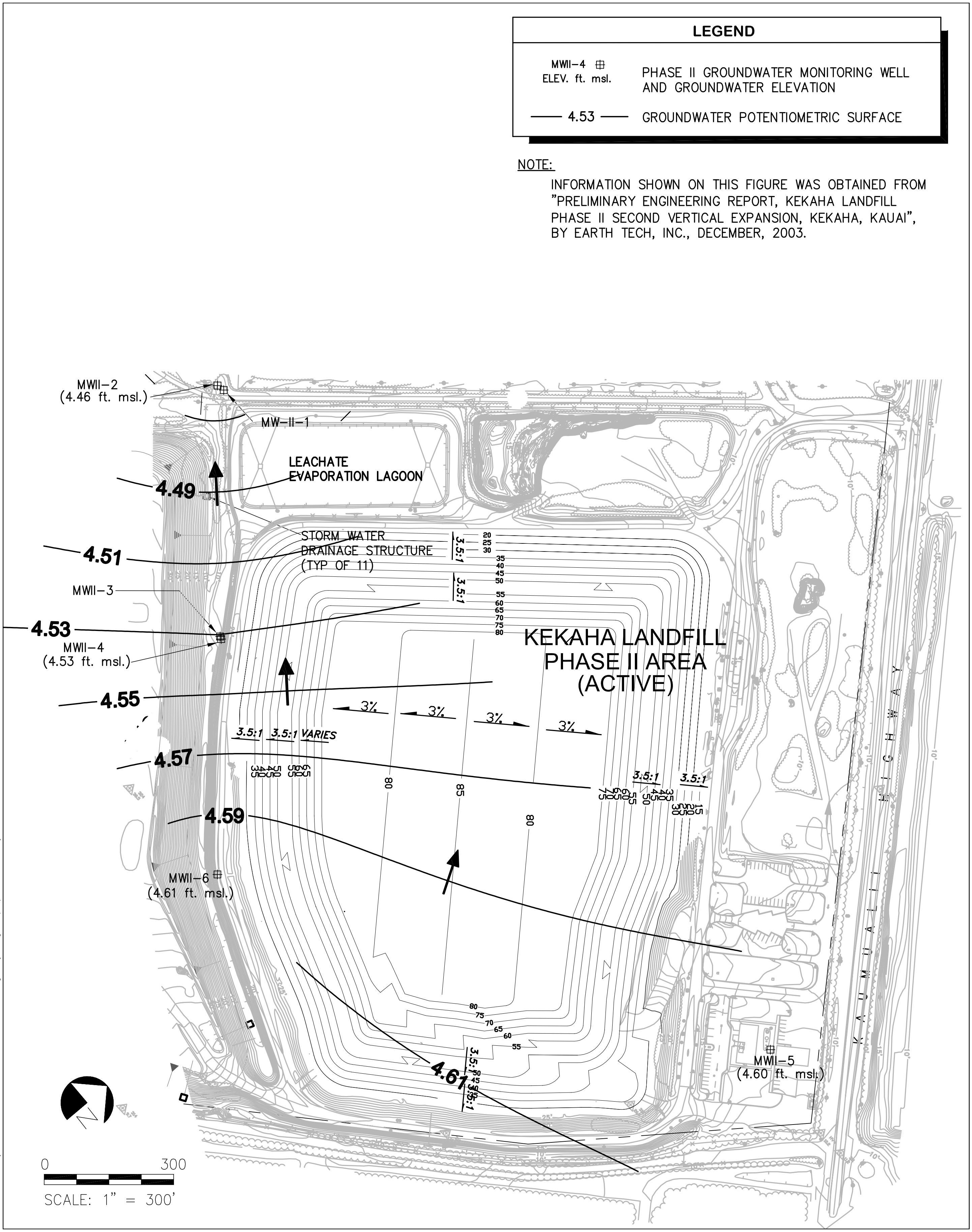


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (July 29, 2008)
Kauai, Hawaii

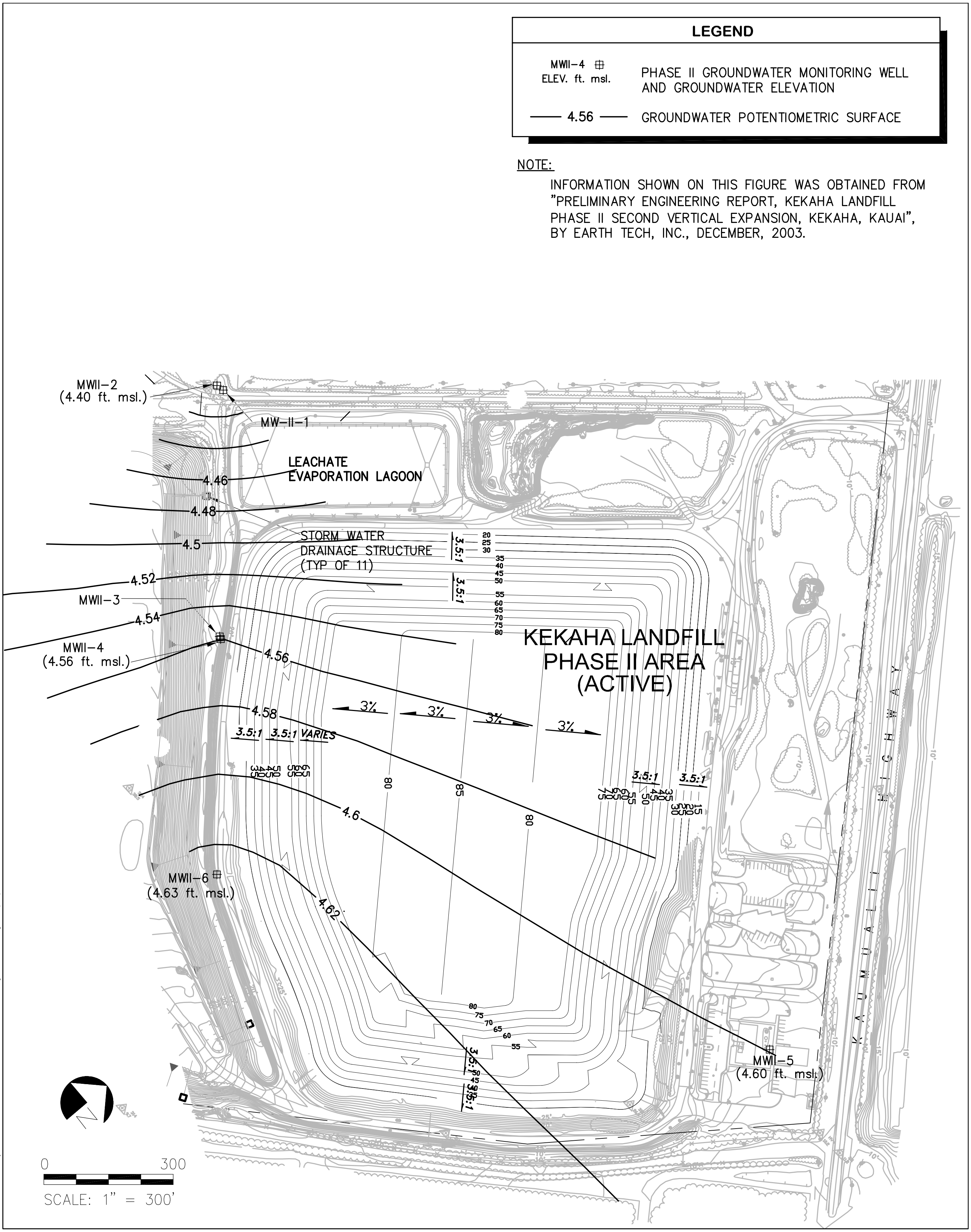


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (November 10, 2008)
Kauai, Hawaii

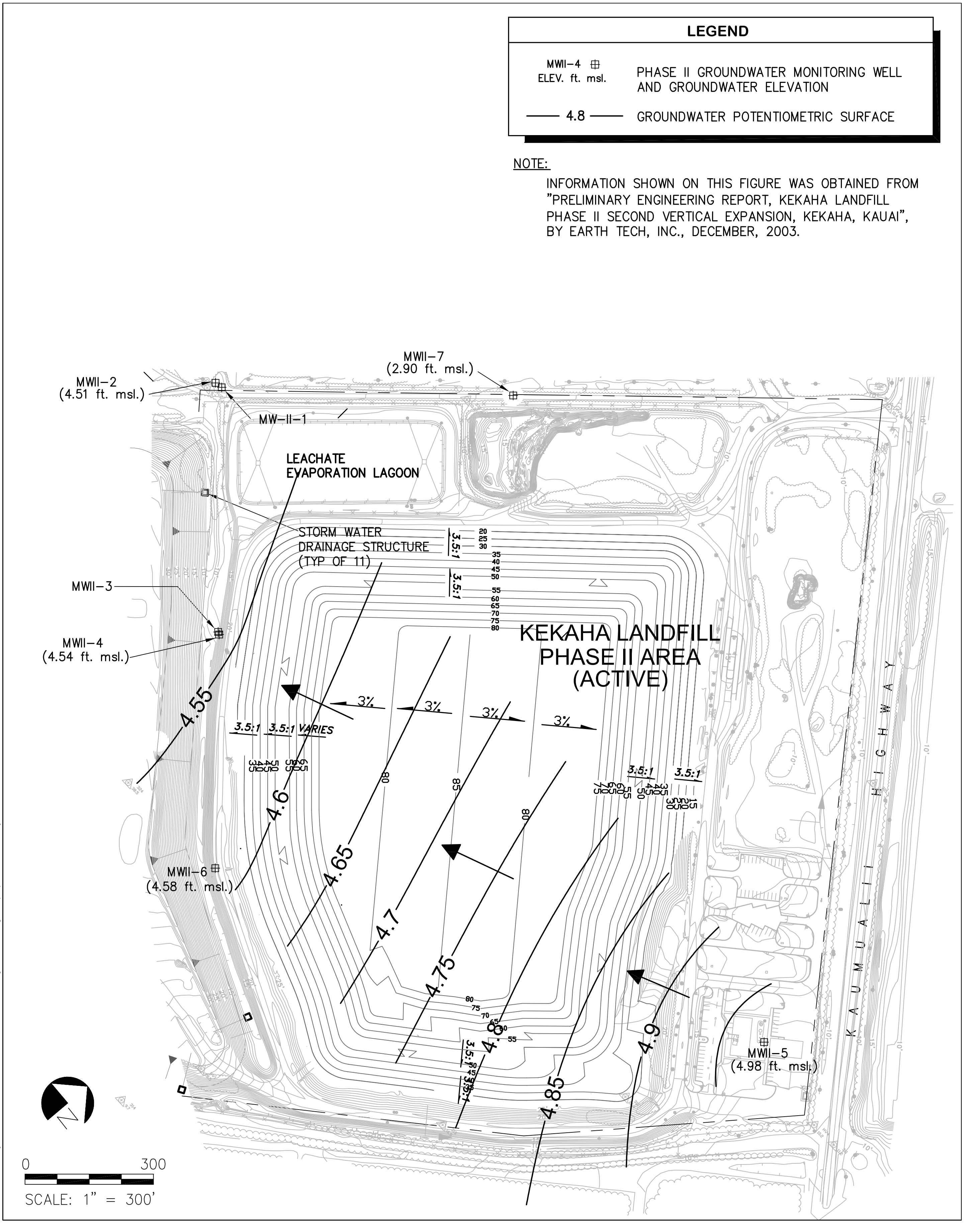


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (March 9, 2009)
Kauai, Hawaii

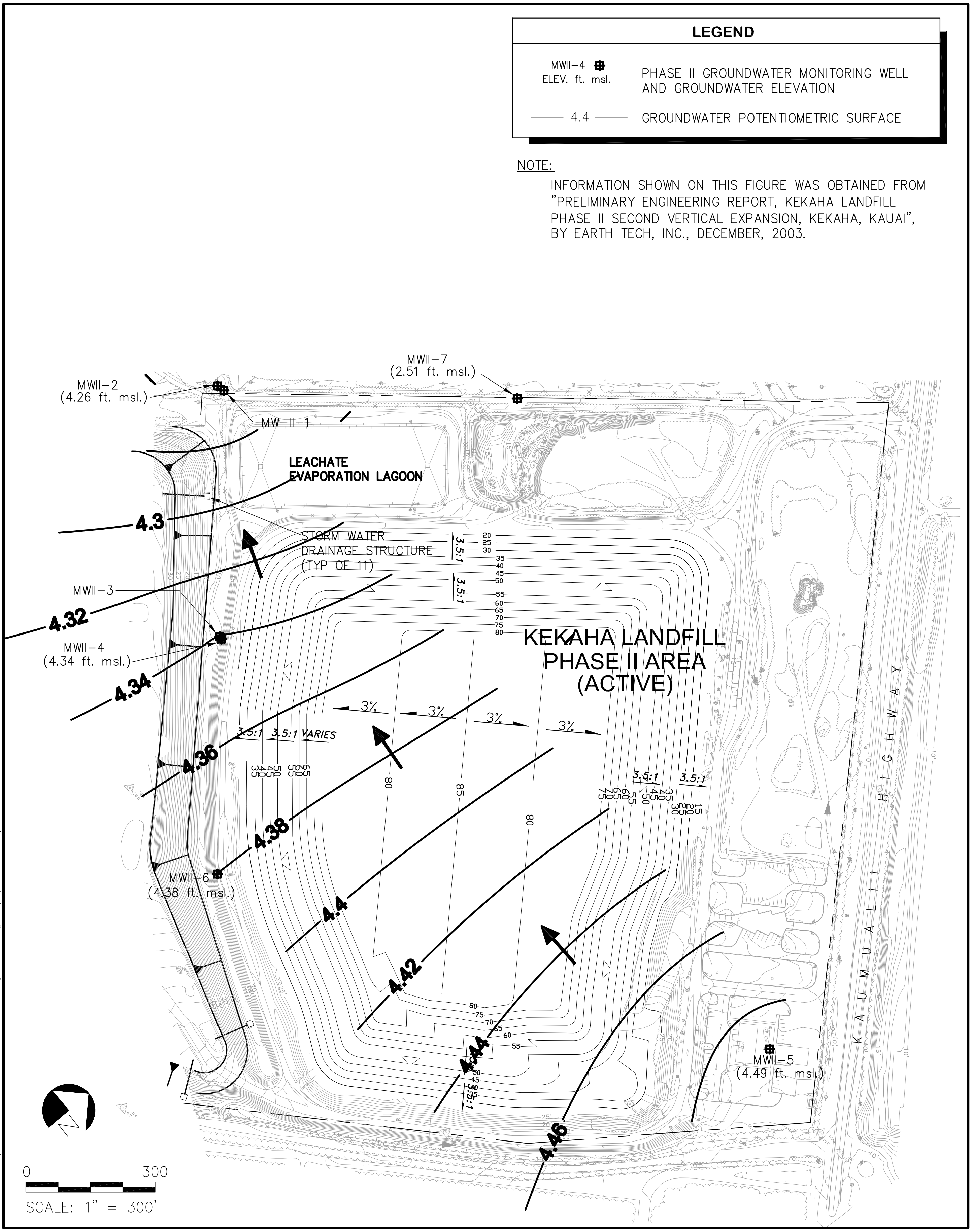


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (May 18, 2009)
Kauai, Hawaii

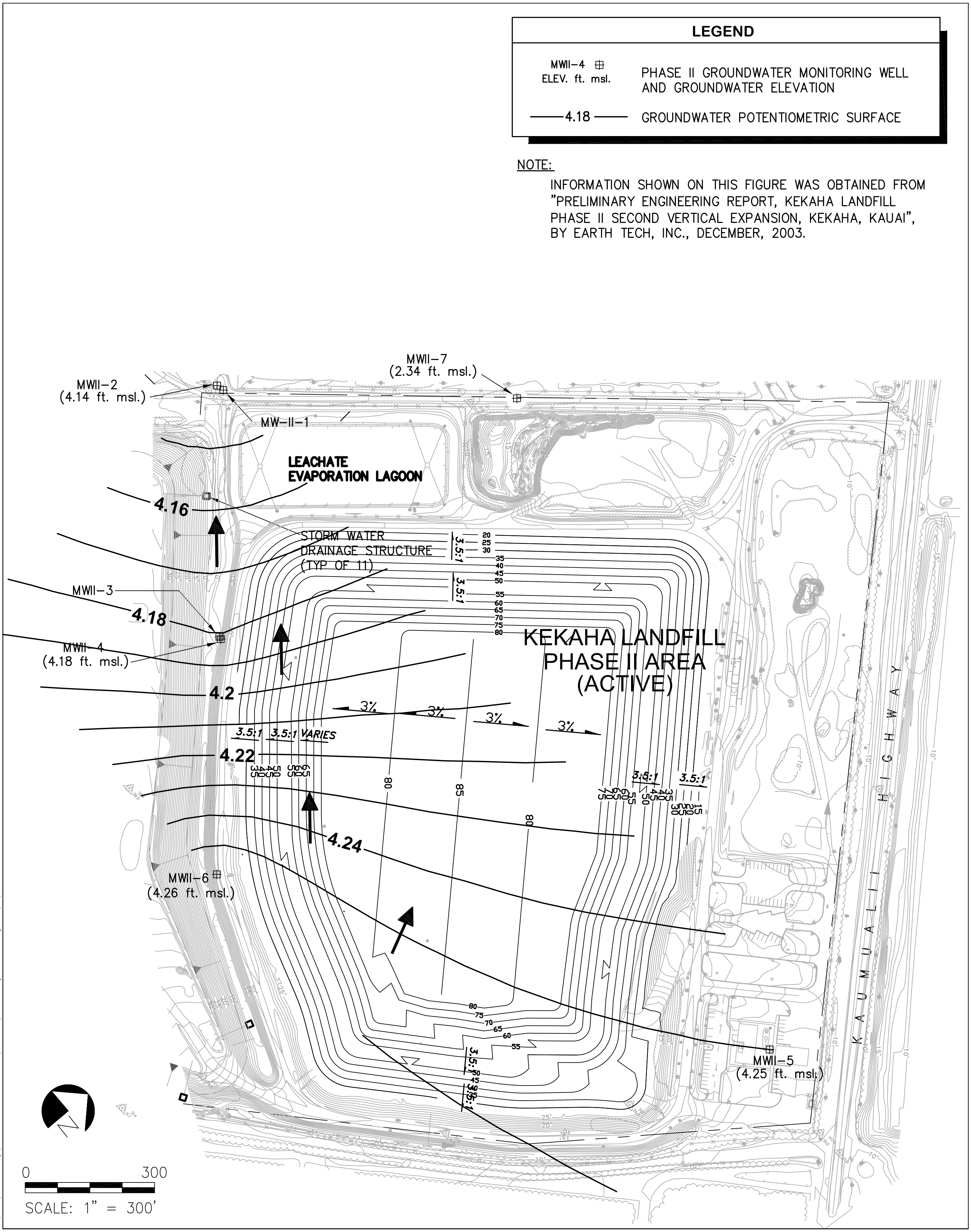


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (July 20, 2009)
Kauai, Hawaii

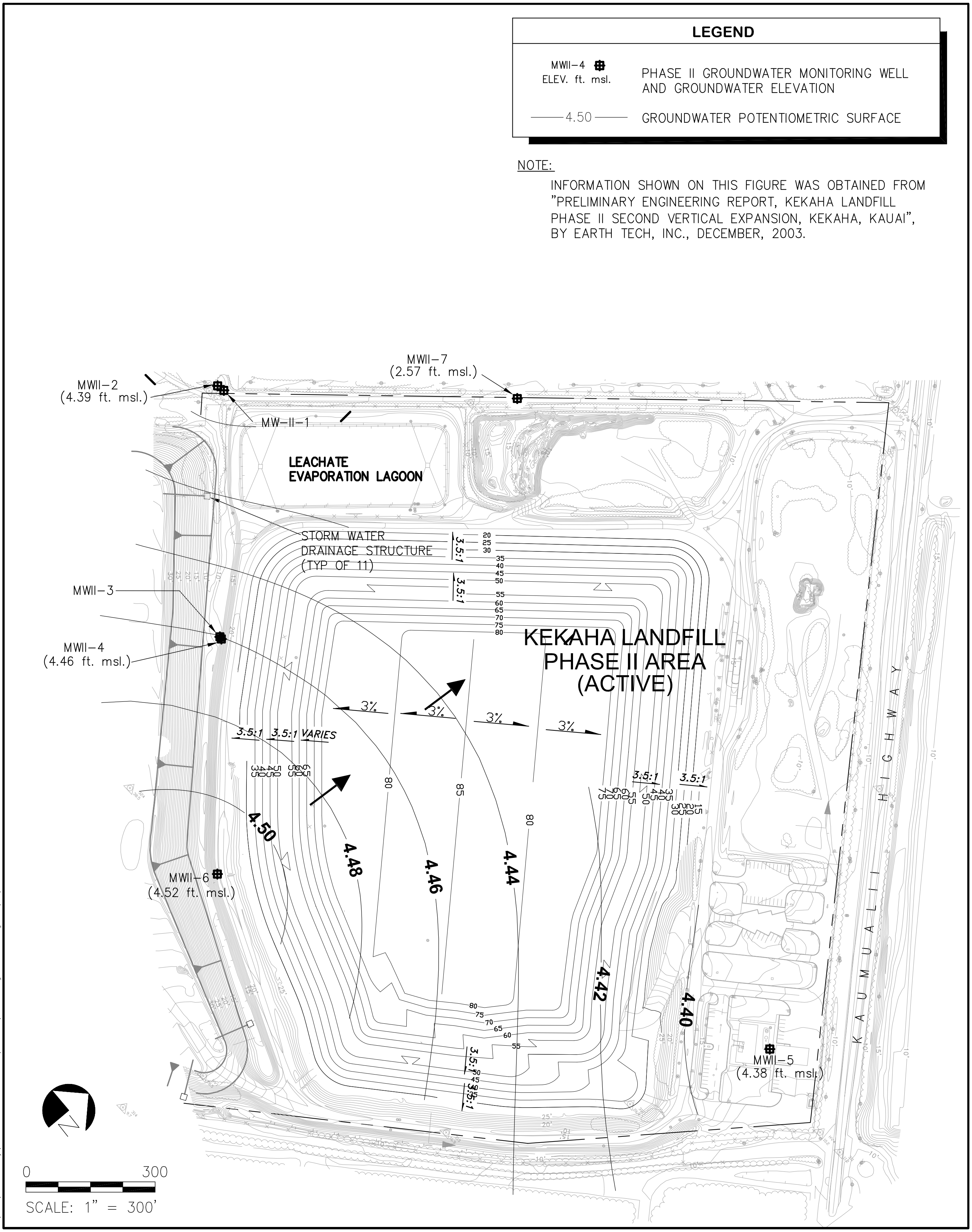


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (November 2, 2009)
Kauai, Hawaii

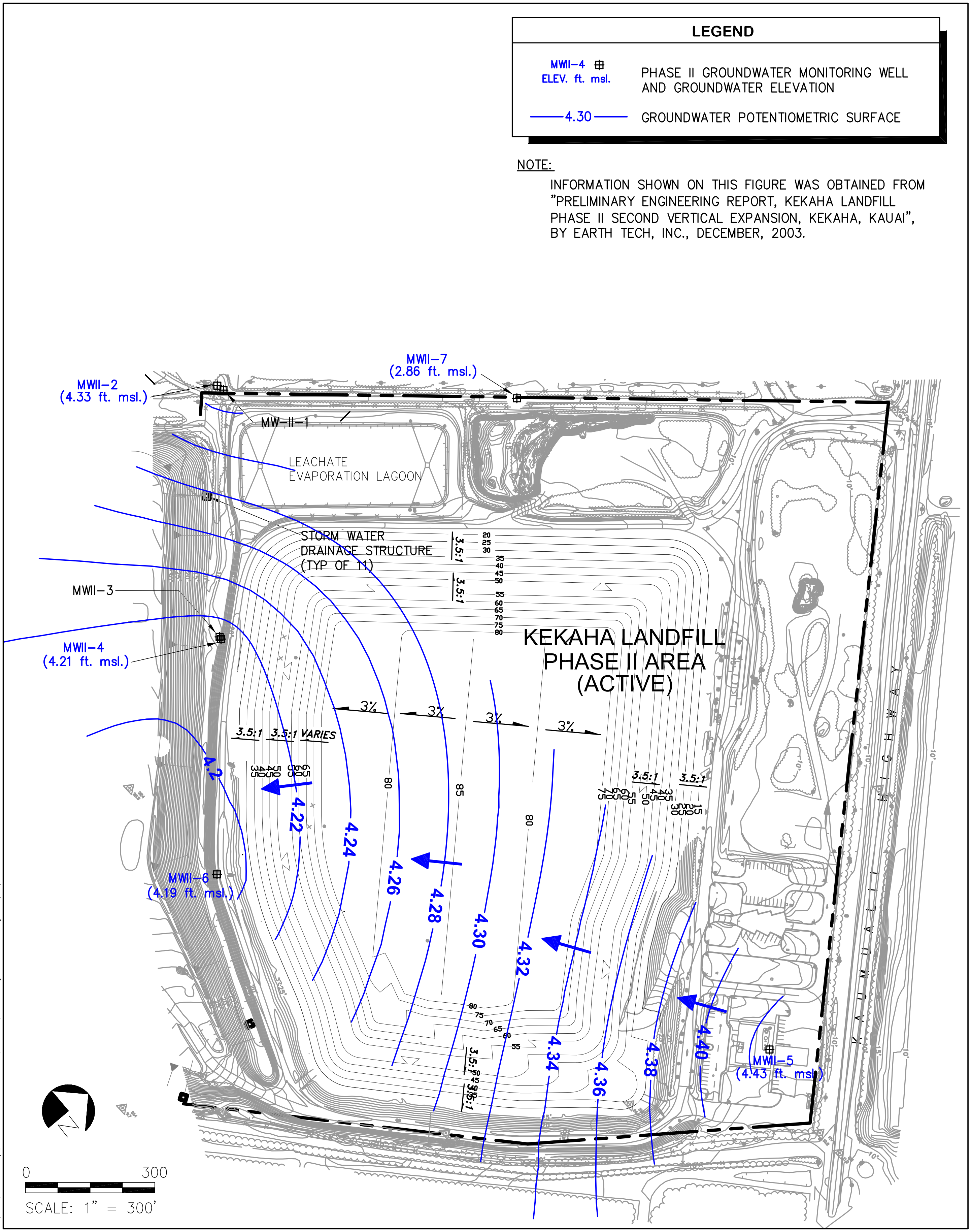


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (February 22, 2010)
Kauai, Hawaii

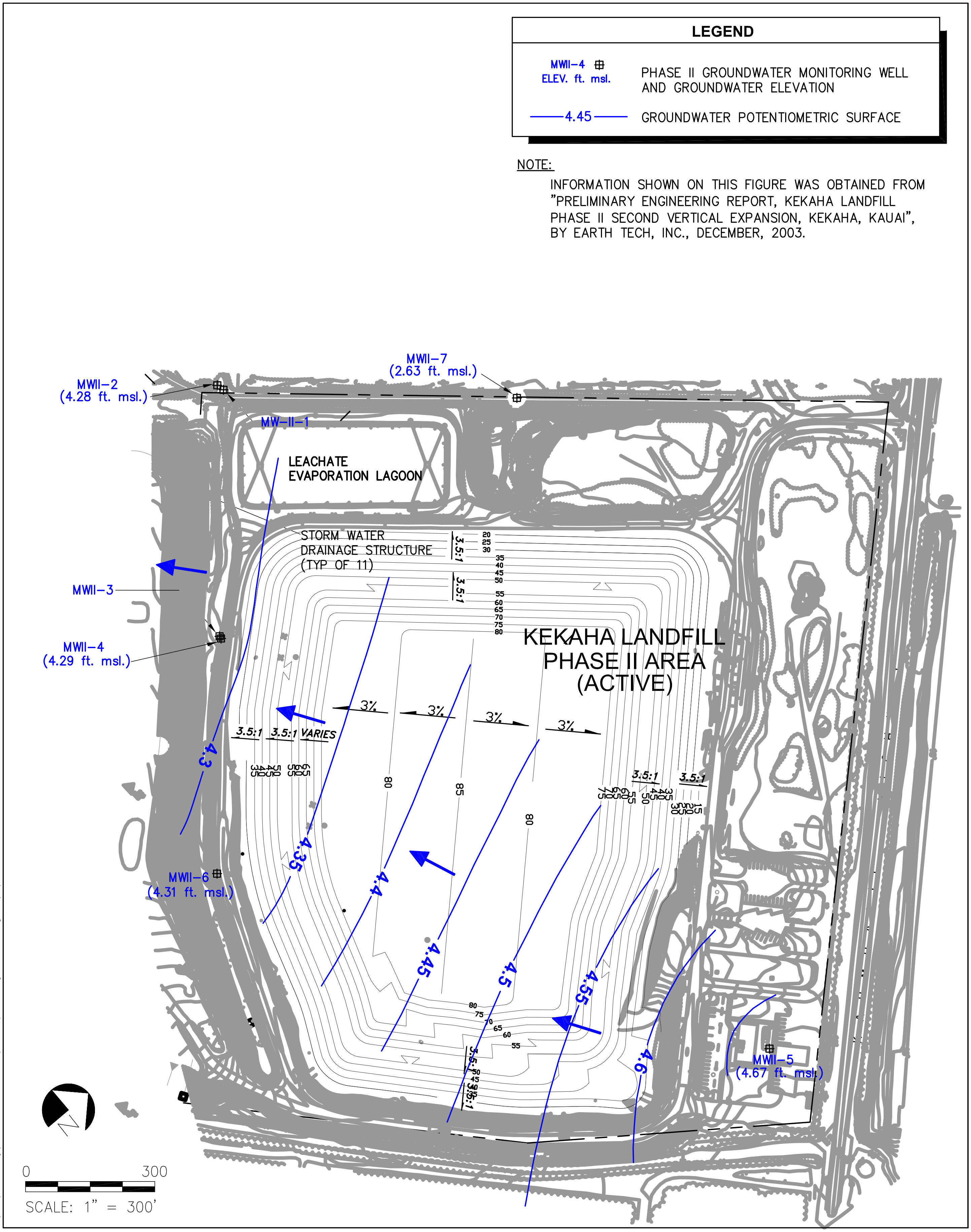


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (June 1, 2010)
Kauai, Hawaii

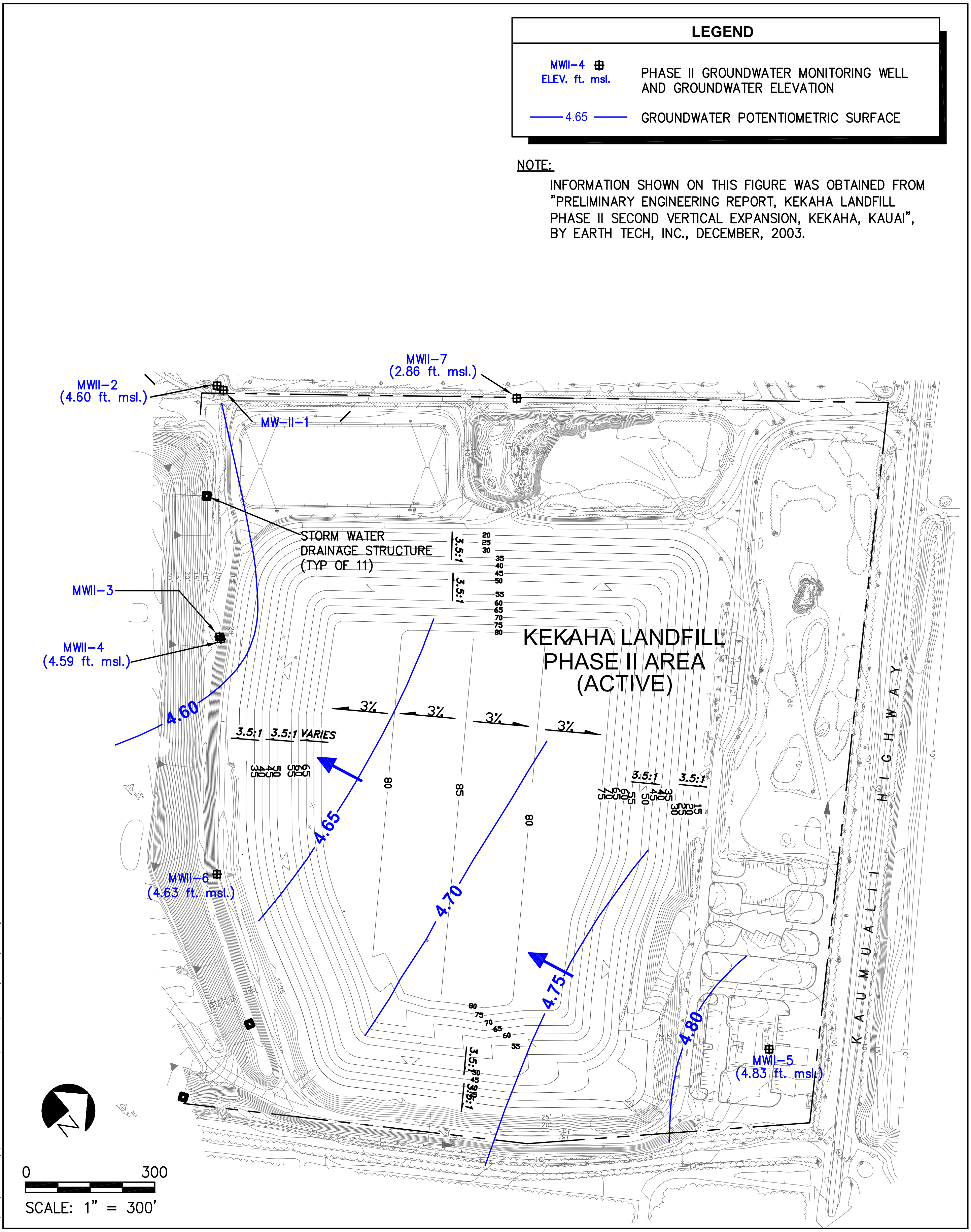


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (August 23, 2010)
Kauai, Hawaii

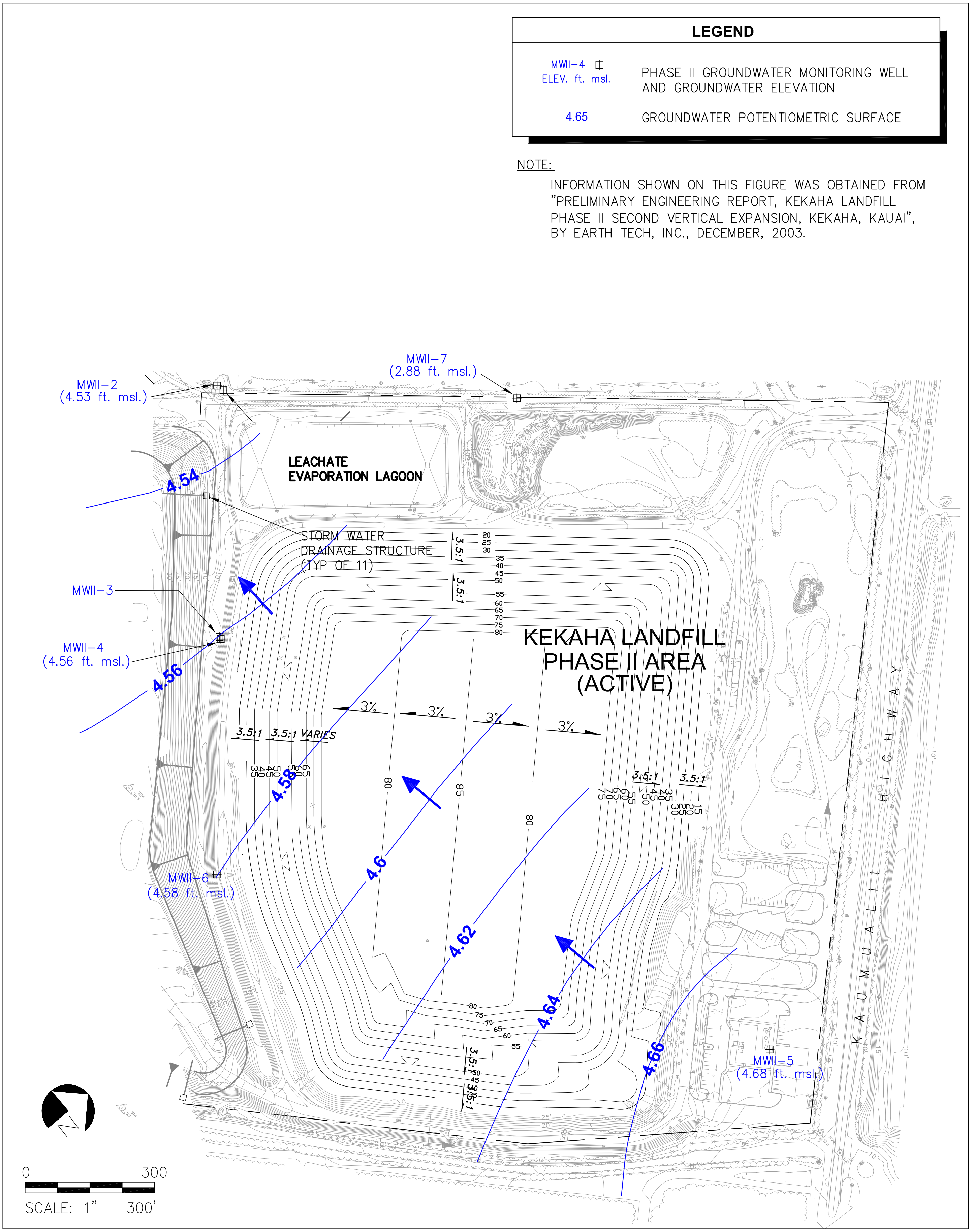


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (November 16, 2010)
Kauai, Hawaii

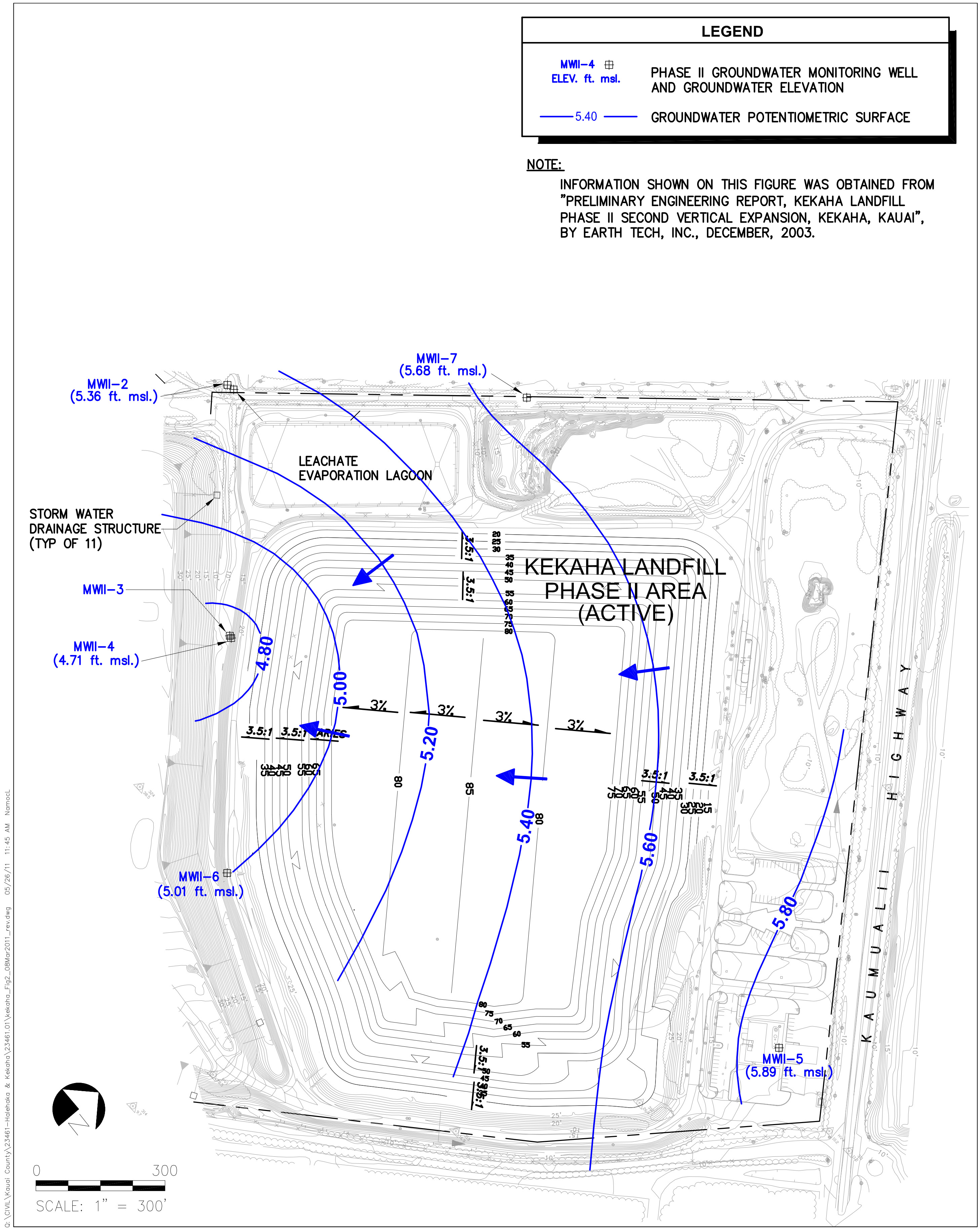


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (March 8, 2011)
Kauai, Hawaii

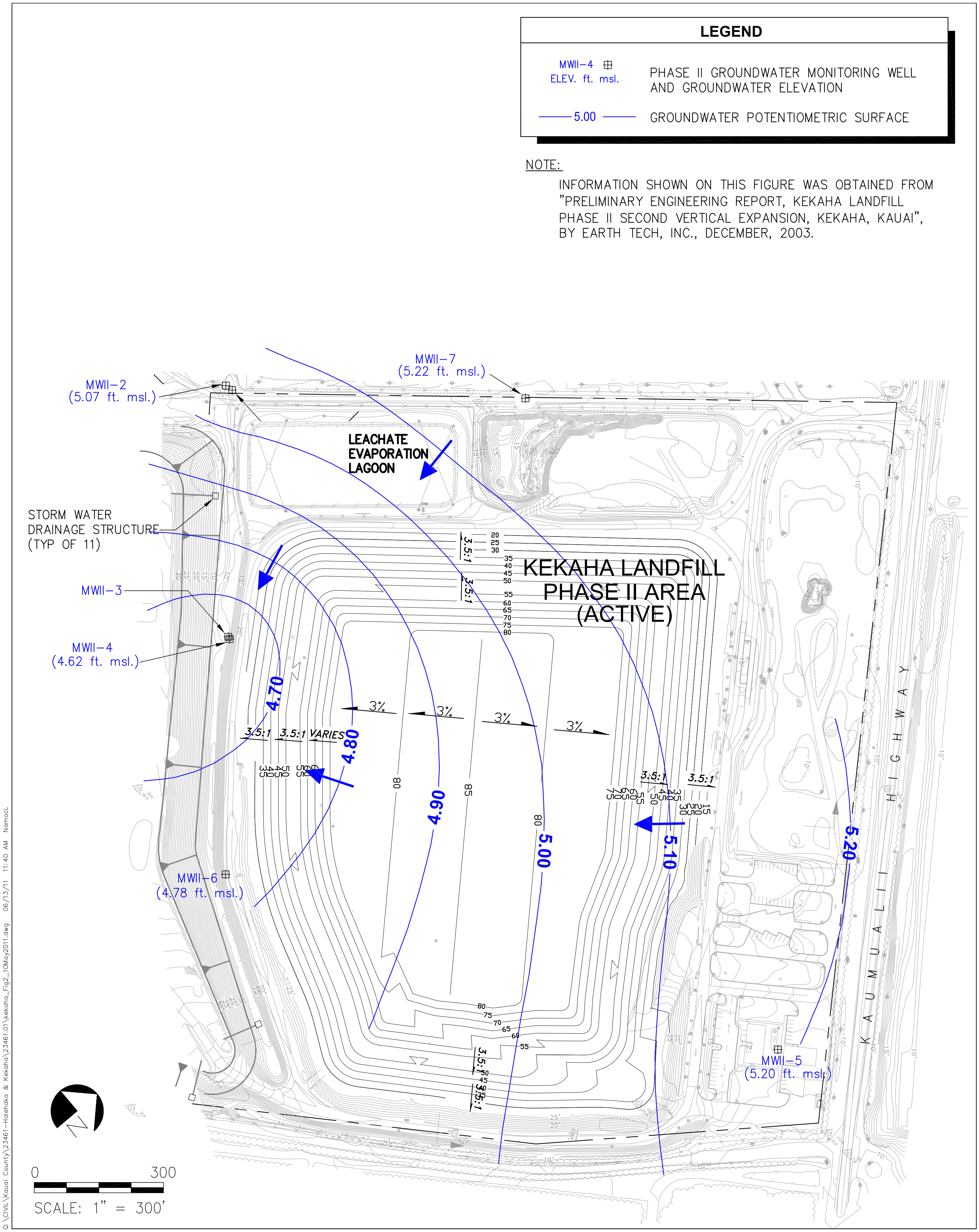


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (May 10, 2011)
Kauai, Hawaii

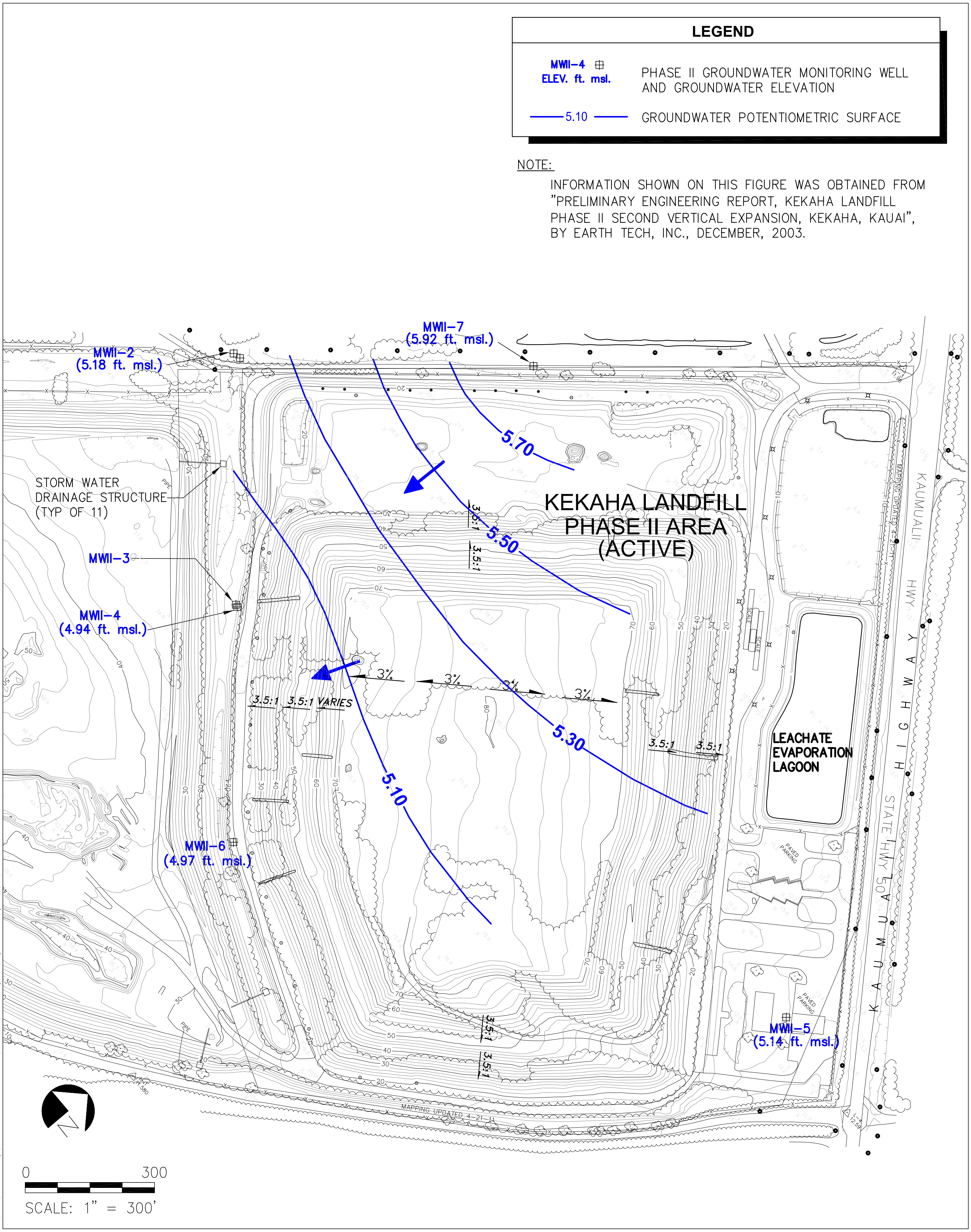
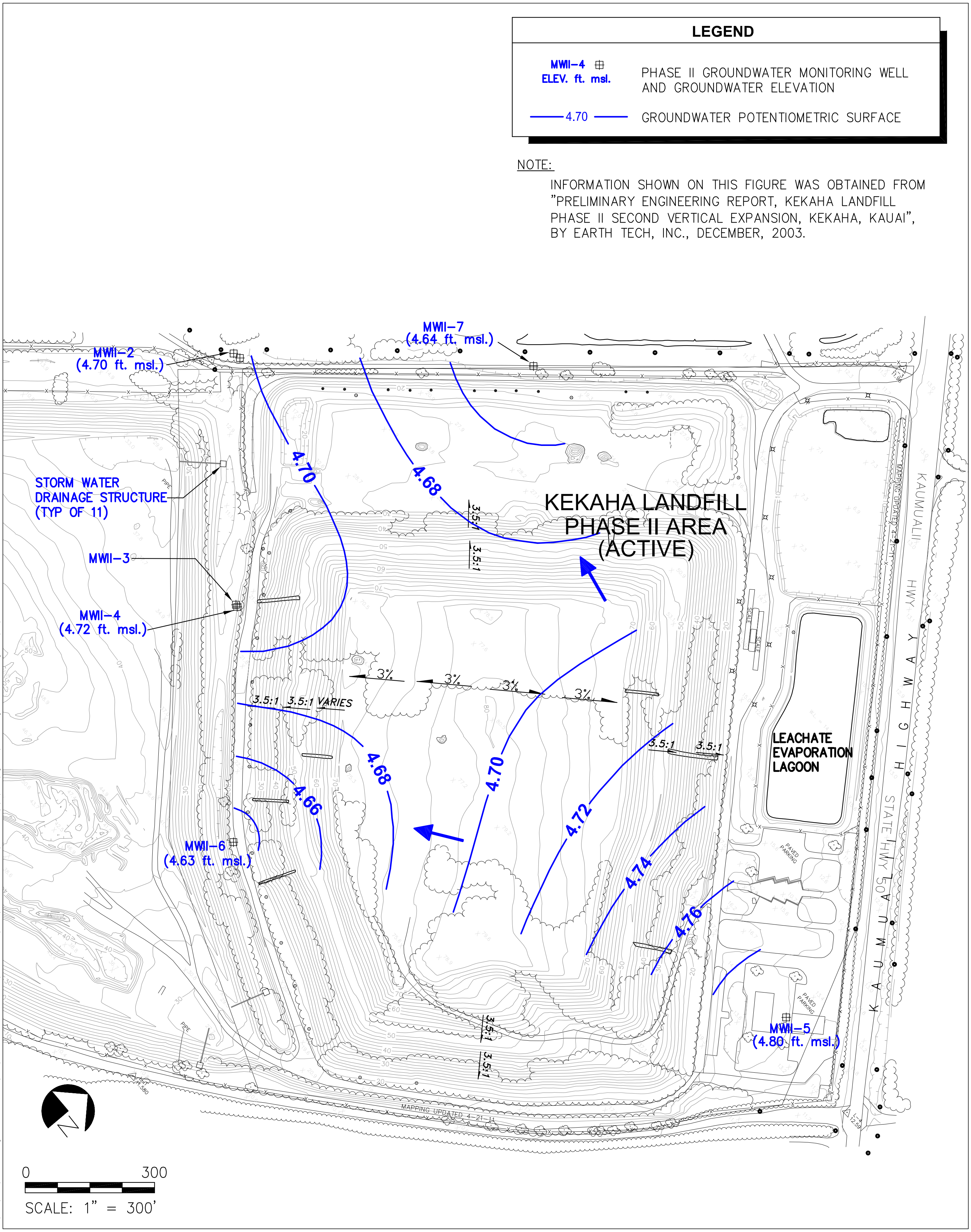


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (August 2, 2011)
Kauai, Hawaii



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Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (November 16, 2011)
Kauai, Hawaii

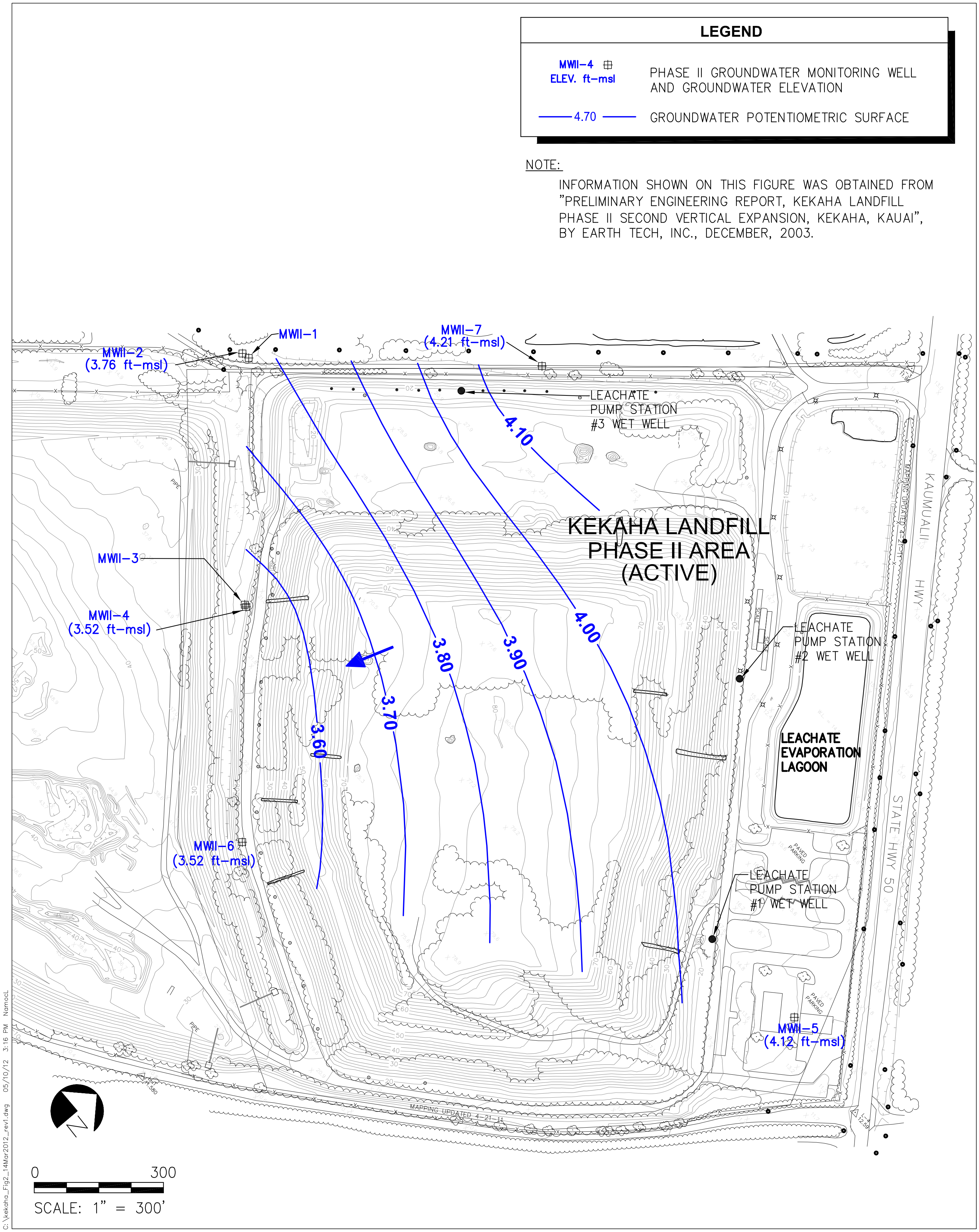


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II (March 14, 2012)
Kauai, Hawaii

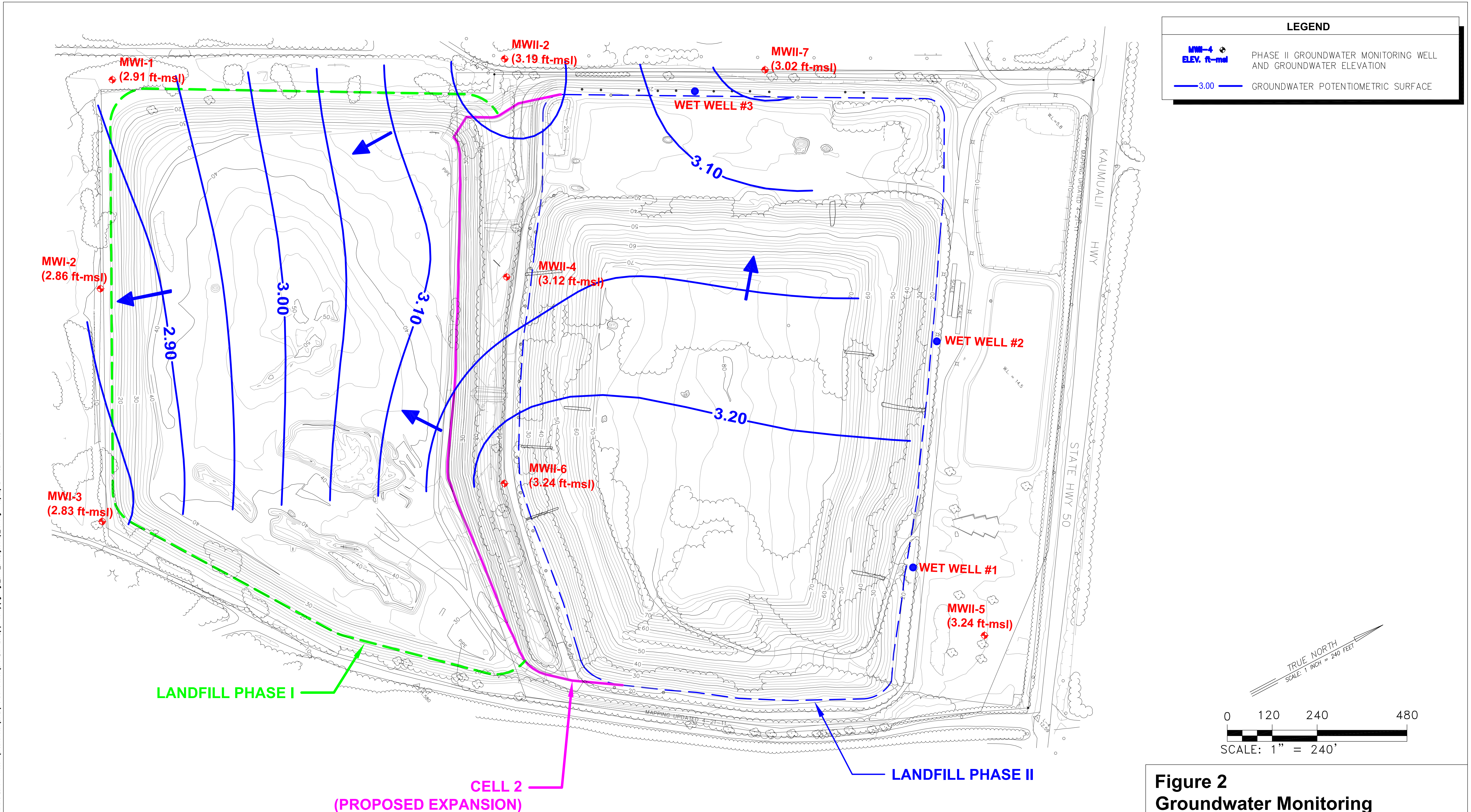


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II
(June 5, 2012)
Kauai, Hawaii

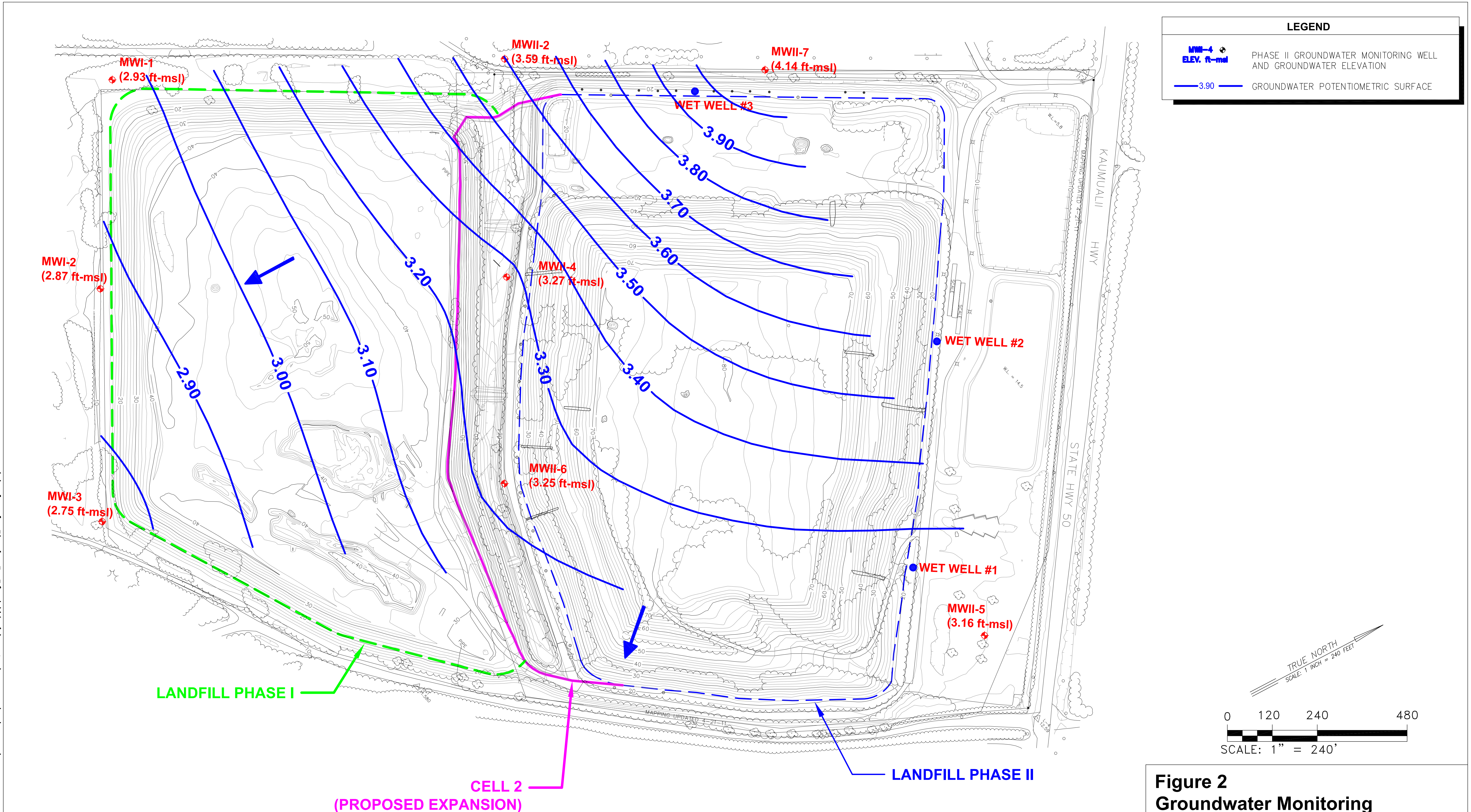


Figure 2
Groundwater Monitoring
Site Layout Map
Kekaha Landfill Phase II
(August 27, 2012)
Kauai, Hawaii

AECOM

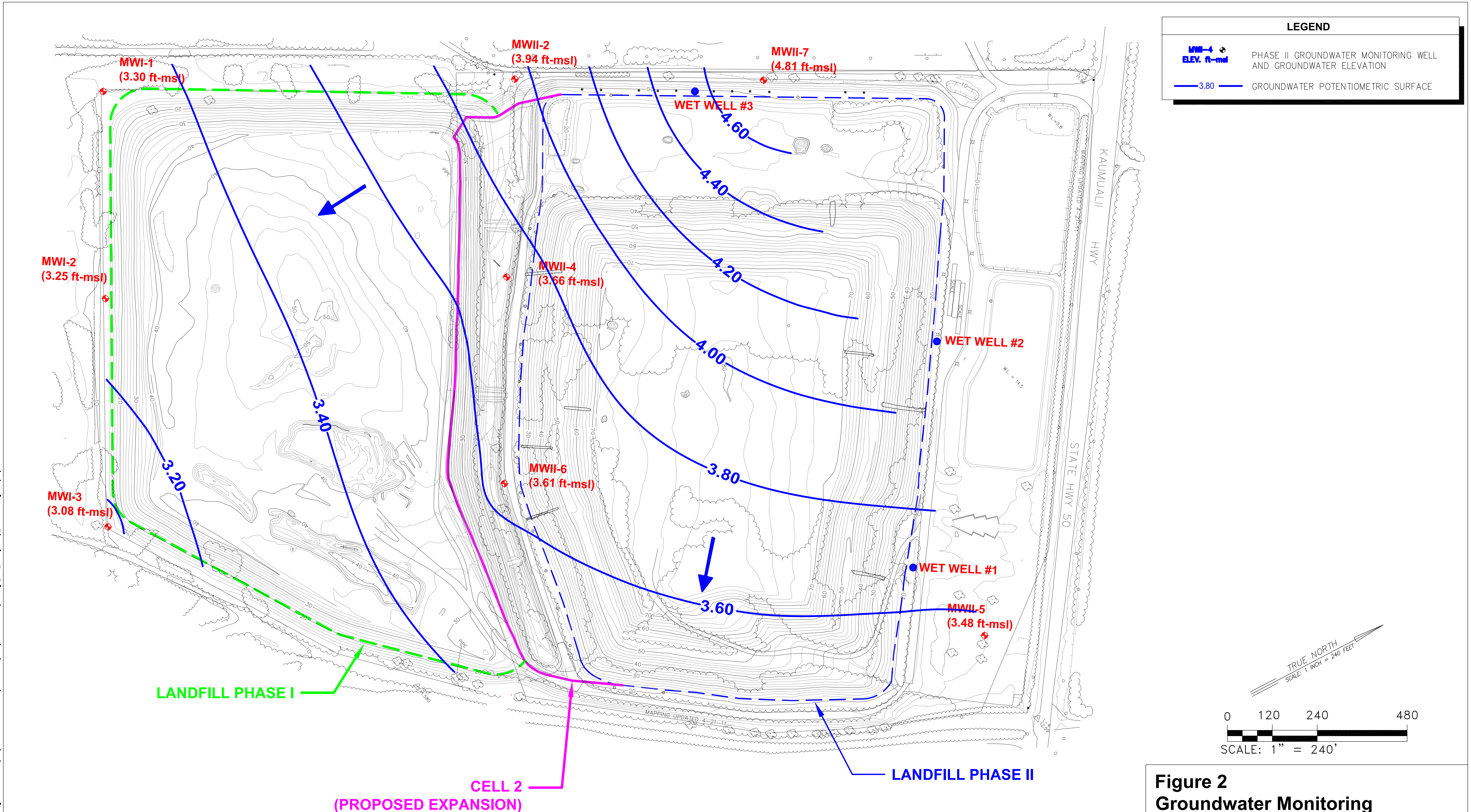


Figure 2
Groundwater Monitoring Site Layout Map
Kekaha Landfill Phase II
(November 13, 2012)
Kauai, Hawaii

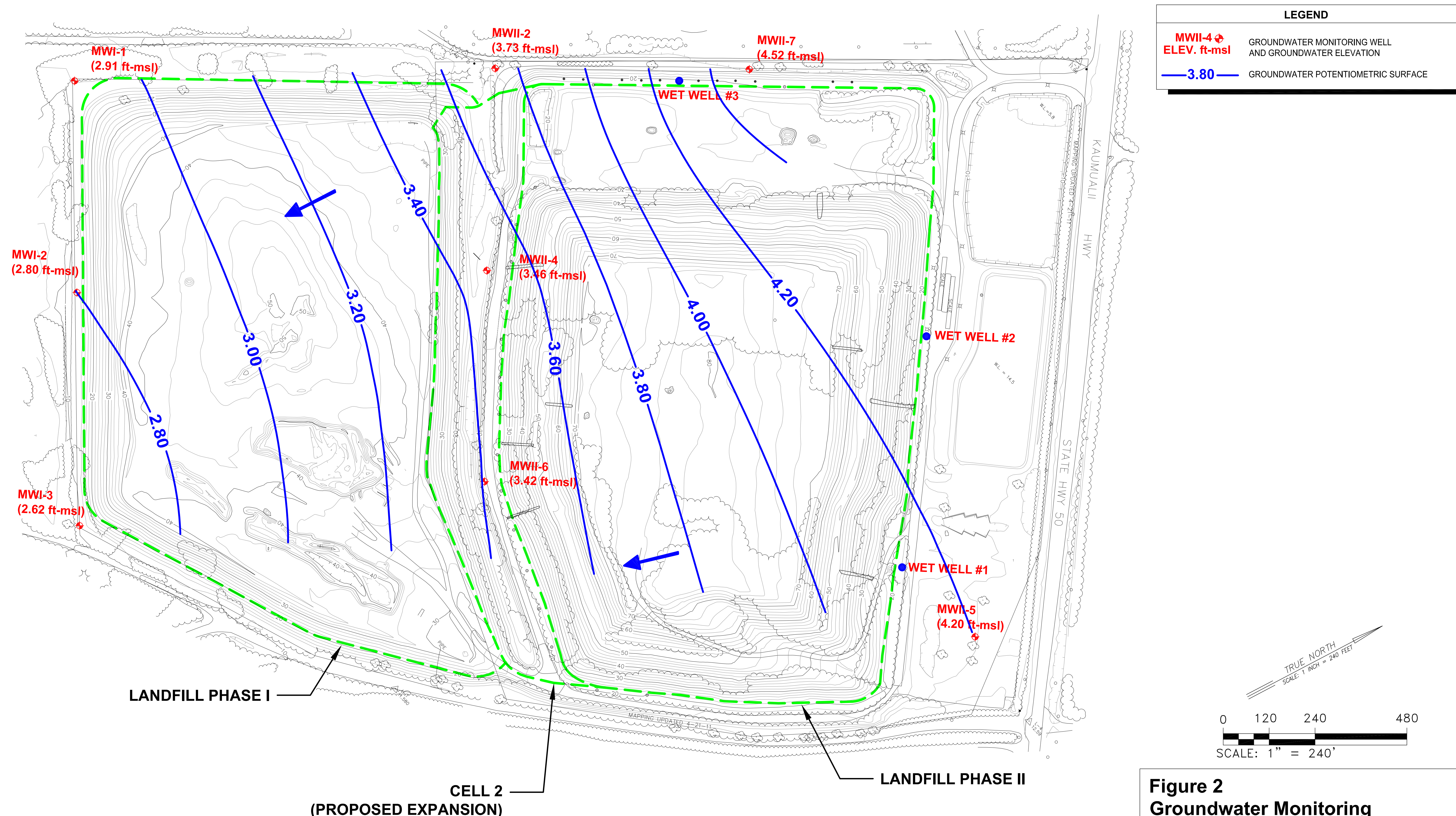


Figure 2
Groundwater Monitoring
Site Layout Map
Kekaha Landfill Phase II
(February 24, 2013)
Kauai, Hawaii

AECOM

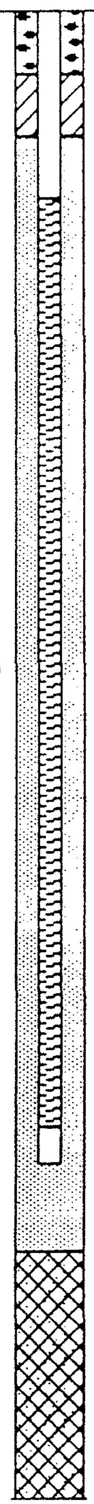
Appendix B
Well Installation Logs

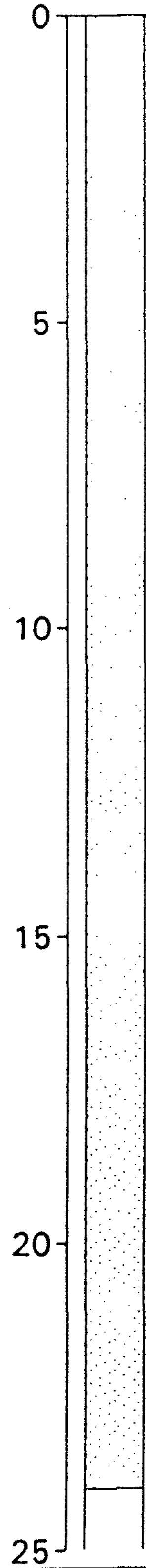
MWI-1

Harding Lawson Associates. 1995. Installation of Groundwater Wells and Gas Probes, Kekaha Landfill Phase I Closure, Kekaha, Kaua'i, Hawai'i. June.

Top of Casing **12.98 ft (MSL)**

Equipment	Mobile B-34		
Elevation	~ 11 feet	*Date*	05/26/95





LIGHT BROWN SAND (SP), loose, dry, coralline, with shell fragments.

Becomes medium dense.

Becomes moist.

Small pieces of coralline sandstone.

Water level at 8.6 feet, 15:21, 6/2/95.

Color change to light gray, wet, with abundant shell fragments.

Color change to very light gray.

End of boring at 24 feet.

Harding Lawson Associates
Engineering and Environmental Services

Log of Monitoring Well MW-I-1 *(Sheet 1 of 1)*

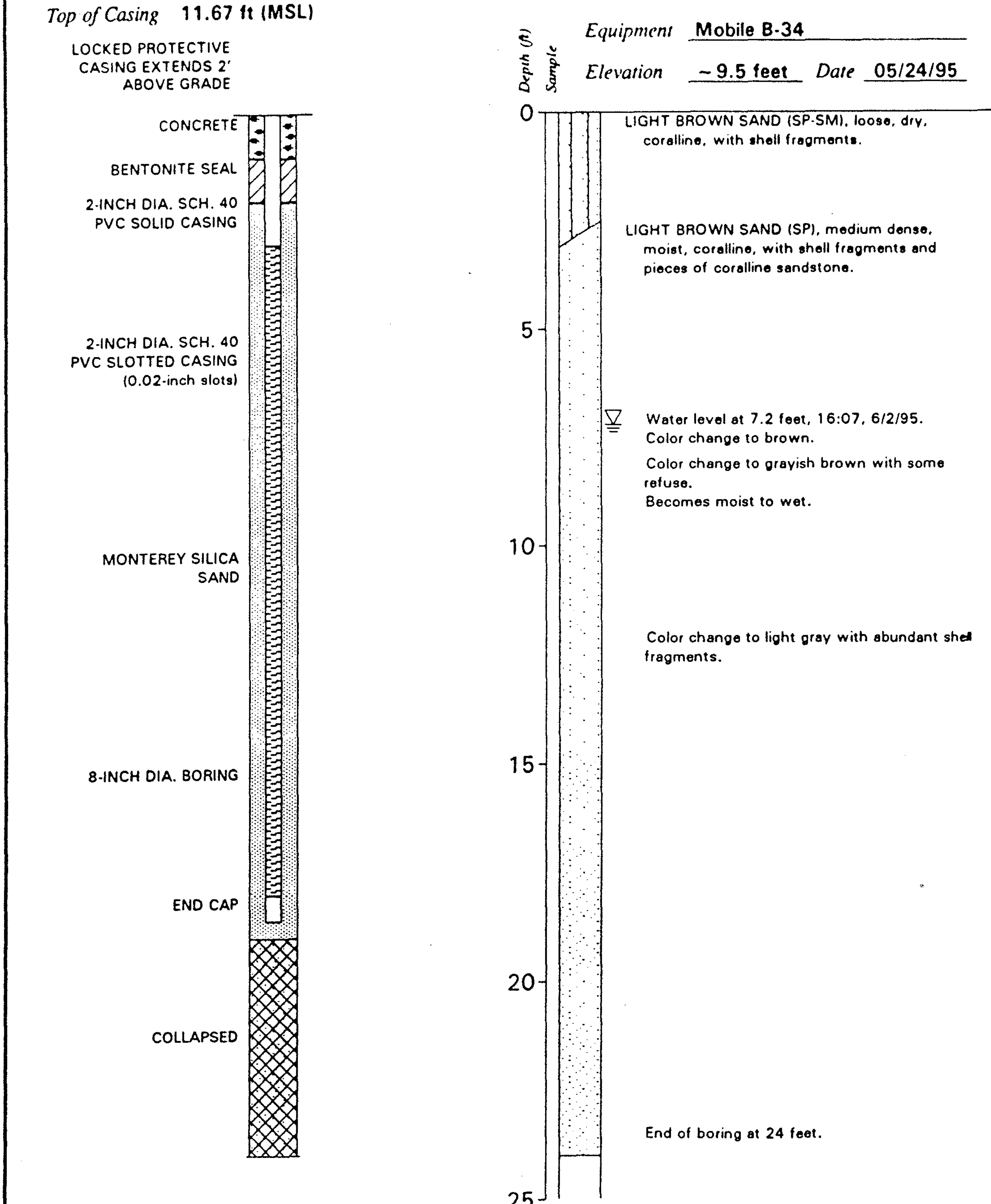
Kekaha Landfill Phase I
Kekaha, Kauai, Hawaii

FIGURE **2**

DRAWN	*JOB NUMBER*	*APPROVED*	*FILE*	*DATE*	*REVISED DATE*
kar	22924.804		KLFWI	6/95	

MWI-2

Harding Lawson Associates. 1995. Installation of Groundwater Wells and Gas Probes, Kekaha Landfill Phase I Closure, Kekaha, Kaua'i, Hawai'i. June.



Harding Lawson Associates
Engineering and Environmental Services

Log of Monitoring Well MW-I-2 *(Sheet 1 of 1)*
Kekaha Landfill Phase I
Kekaha, Kauai, Hawaii

FIGURE 3

DRAWN	JOB NUMBER	APPROVED	FILE	DATE	REVISED DATE
kar	22924.804	[illegible]	KLFWI	6/95	

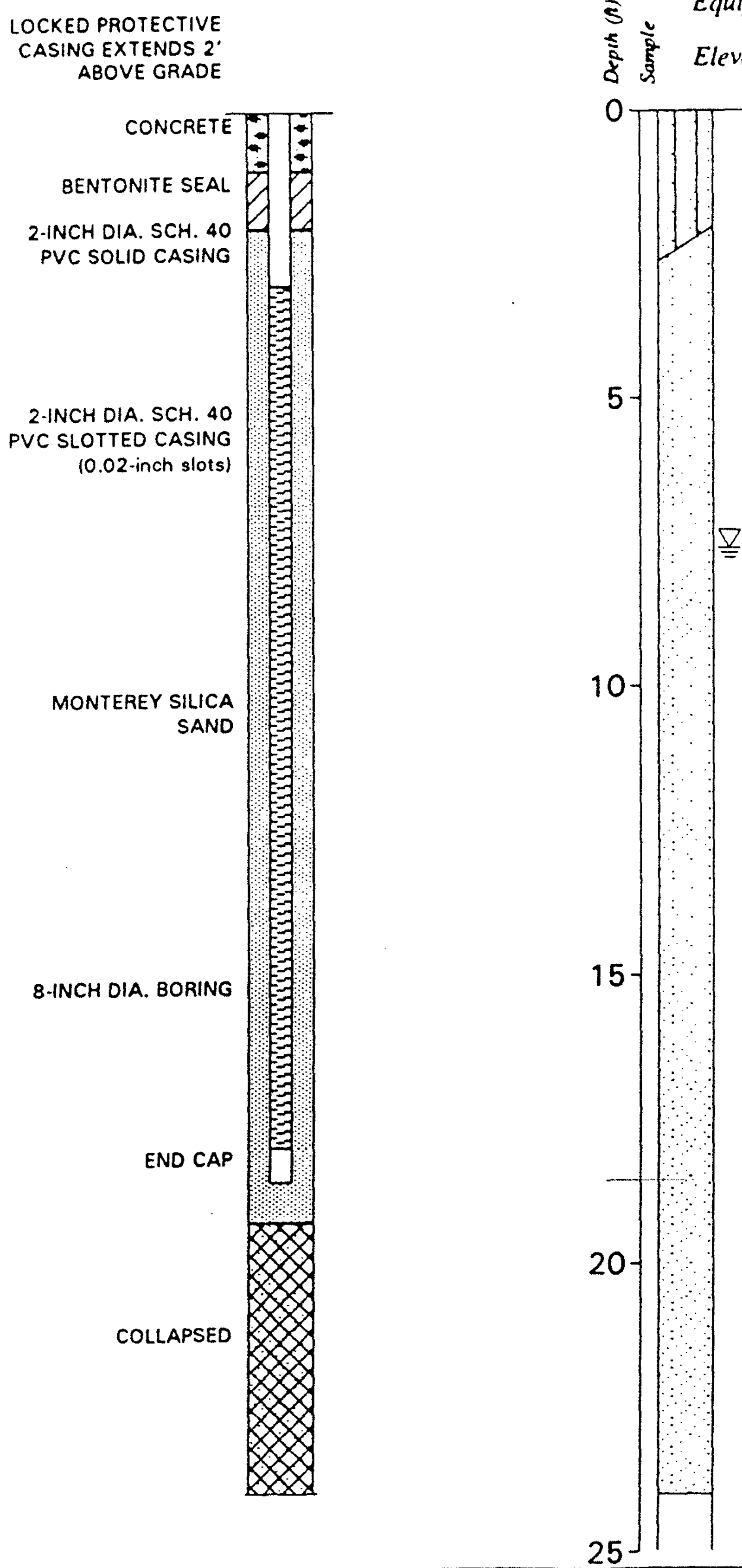
MWI-3

Harding Lawson Associates. 1995. Installation of Groundwater Wells and Gas Probes, Kekaha Landfill Phase I Closure, Kekaha, Kaua'i, Hawai'i. June.

Top of Casing **12.08 ft (MSL)**

Equipment Mobile B-34

Elevation ~ 10 feet *Date* 05/25/95



LIGHT BROWN SAND (SM-SP), loose, dry, coralline.

BROWN SAND (SP), medium dense, moist, coralline, with shell fragments.

Color change to light brown, with abundant shell fragments.

Water level at 7.6 feet, 16:46, 6/2/95. Color change to very light brown.

Becomes moist to wet.

Color change to light gray.

End of boring at 24 feet.

Harding Lawson Associates
Engineering and Environmental Services

Log of Monitoring Well MW-I-3 *(Sheet 1 of 1)*
Kekaha Landfill Phase I
Kekaha, Kauai, Hawaii

FIGURE **4**

DRAWN	JOB NUMBER	APPROVED	FILE	DATE	REVISED DATE
kar	[illegible]	[illegible]	[illegible]		

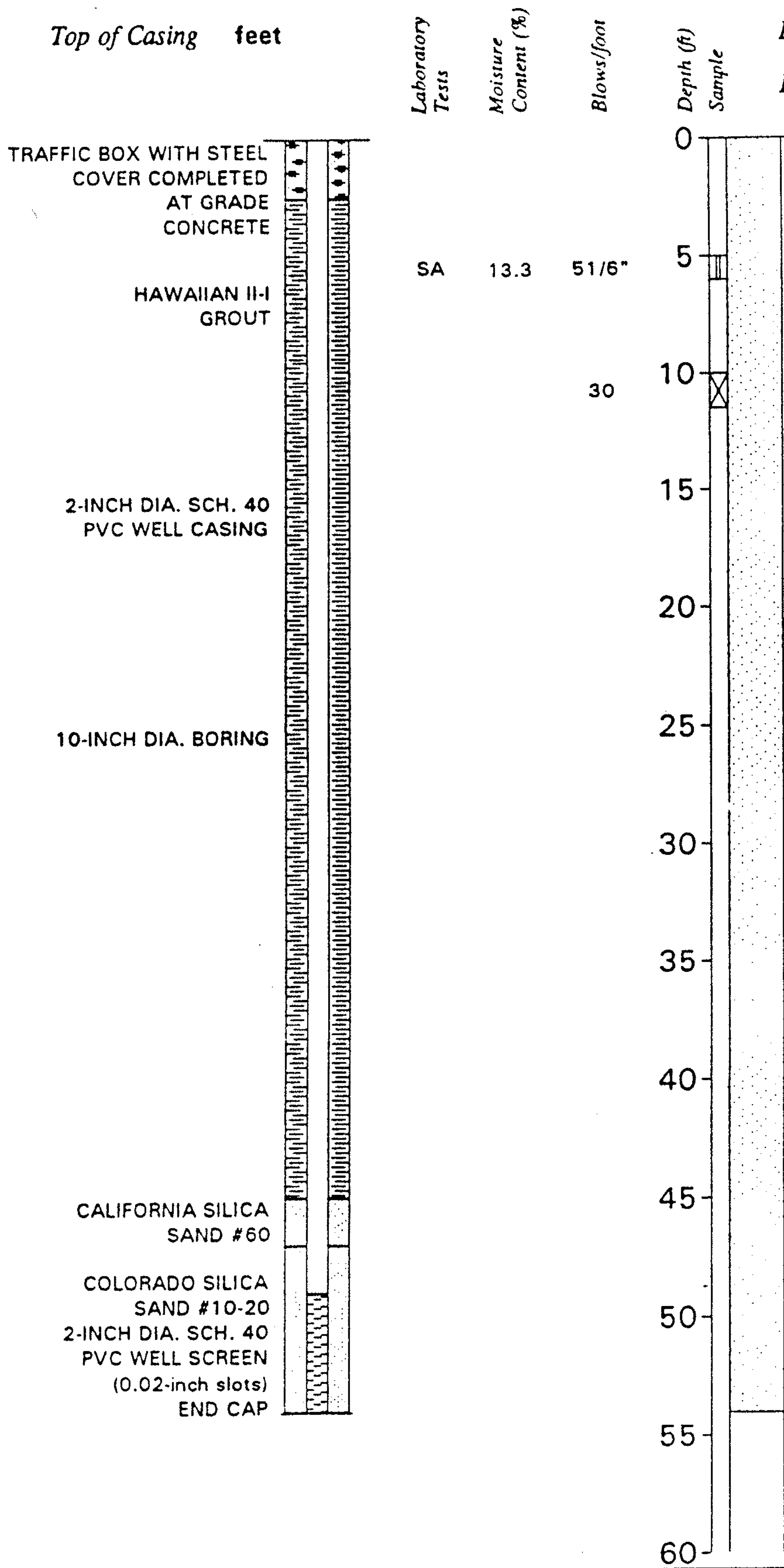
MWII-1

Harding Lawson Associates. 1993. Engineering Report, Kekaha Landfill Phase II, Kekaha, Kaua'i, Hawai'i. August.

Top of Casing feet

Equipment Mobile B-61

Elevation feet *Date* 01/21/93



LIGHT BROWN CALCAREOUS SAND (SP), very dense, fine, moist.

Becomes saturated.
Water level at 6.5 feet, 7:15, 1/22/93

Becomes yellow-brown, dense, medium to coarse.

Becomes gray.

End of boring at 50 feet.

Harding Lawson Associates
Engineering and Environmental Services

Log of Monitoring Well MW-II-1
Kekaha Phase II Design
Kekaha, Kauai, Hawaii

PLATE A-

DRAWN	*JOB NUMBER*	*APPROVED*	*FILE*	*DATE*	*REVISED DA*
kar	22897.204	PBC	KEKII	2/93	

MWII-2

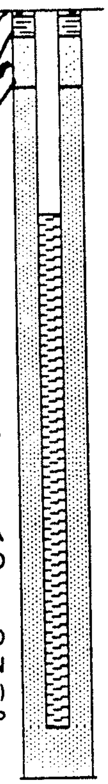
Harding Lawson Associates. 1993. Engineering Report, Kekaha Landfill Phase II, Kekaha, Kaua'i, Hawai'i. August.

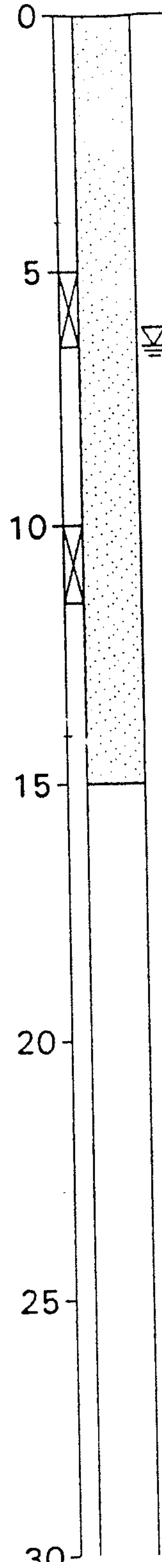
Top of Casing feet

Equipment Mobile B-61

Elevation feet *Date* 01/22/93

Laboratory Tests	*Moisture Content (%)*	*Blows/foot*	*Depth (ft)*	*Sample*





LIGHT BROWN CALCAREOUS SAND (SP), medium dense to dense, fine to medium, moist.

Becomes saturated.
Water level at 6.5 feet, 9:55, 1/22/93

Becomes white, light brown, medium to coarse.

End of boring at 15 feet.

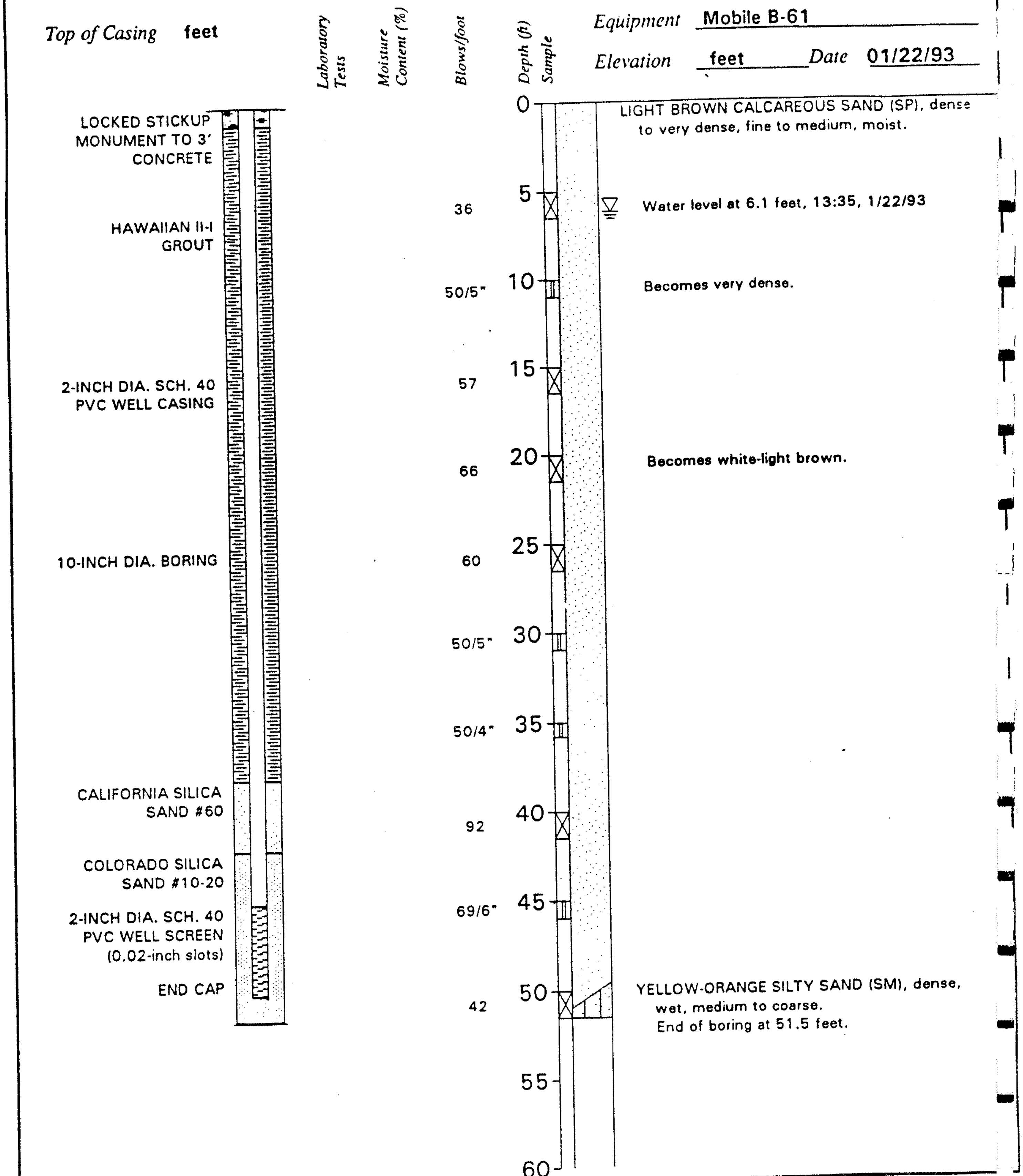
Harding Lawson Associates
Engineering and Environmental Services

Log of Monitoring Well MW-II-2
Kekaha Phase II Design
Kekaha, Kauai, Hawaii

PLATE **A-2**

DRAWN	*JOB NUMBER*	*APPROVED*	*FILE*	*DATE*	*REVISED DATE*
kar	22897.204	PBC	KEKII	2/93	

Harding Lawson Associates. 1993. Engineering Report, Kekaha Landfill Phase II, Kekaha, Kaua'i, Hawai'i. August.



Harding Lawson Associates Engineering and Environmental Services	**Log of Monitoring Well MW-II-3** Kekaha Phase II Design Kekaha, Kauai, Hawaii		PLATE A-3
DRAWN kar	JOB NUMBER 22897.204	APPROVED PBC	FILE KEKII
DATE 2/93	REVISED DATE		

MWII-4

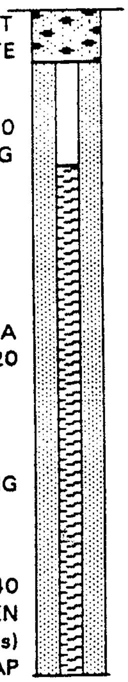
Harding Lawson Associates. 1993. Engineering Report, Kekaha Landfill Phase II, Kekaha, Kaua‘i, Hawai‘i. August.

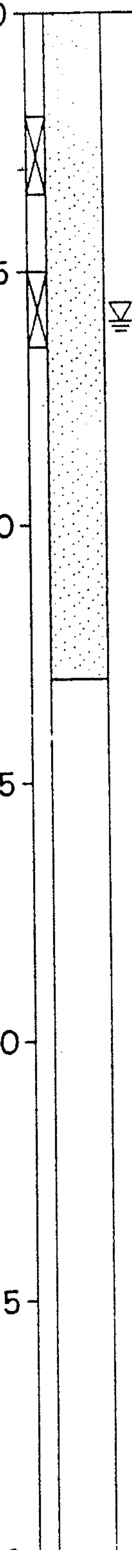
Top of Casing **feet**

Equipment Mobile B-61

Elevation feet *Date* 01/22/93

Laboratory Tests	Moisture Content (%)	Blows/foot	Depth (ft)	Sample	Description
			0		LIGHT BROWN CALCAREOUS SAND (SP), dense, fine to medium, moist.
		36			
			5		
		50			Water level at 6.0 feet, 16:20, 1/22/93
			10		
					End of boring at 13 feet.
			15		
			20		
			25		
			30		





Harding Lawson Associates
Engineering and
Environmental Services

Log of Monitoring Well MW-II-4

Kekaha Phase II Design
Kekaha, Kauai, Hawaii

PLATE **A-4**

DRAWN	JOB NUMBER	APPROVED	FILE	DATE	REVISED DATE
kar	22897.204	PBC	KEKII	2/93	

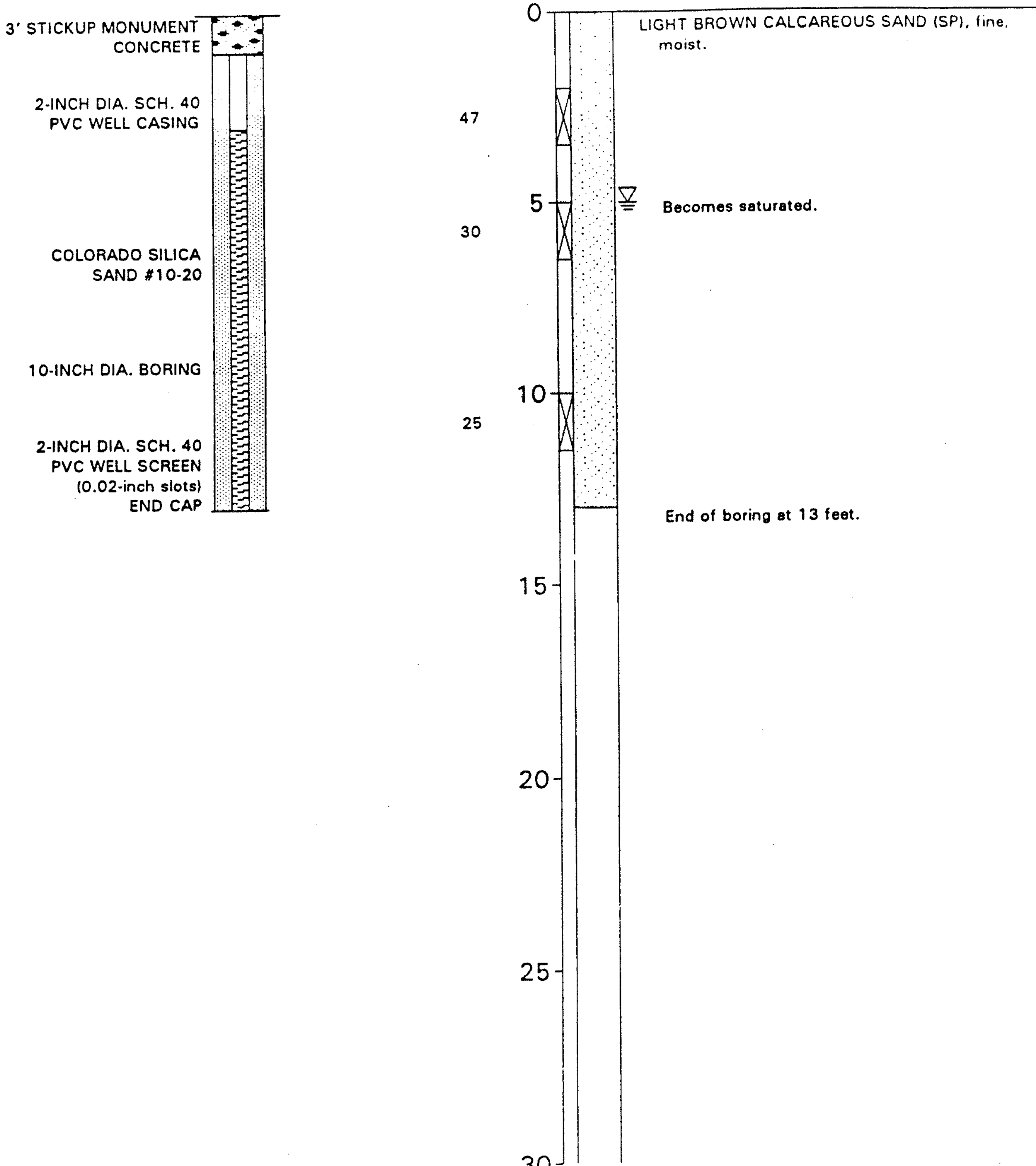
MWII-5

Harding Lawson Associates. 1993. Engineering Report, Kekaha Landfill Phase II, Kekaha, Kaua'i, Hawai'i. August.

Top of Casing feet

Equipment Mobile B-61

Elevation feet *Date* 01/23/93



Harding Lawson Associates
Engineering and
Environmental Services

Log of Monitoring Well MW-II-5
Kekaha Phase II Design
Kekaha, Kauai, Hawaii

PLATE A-5

DRAWN	JOB NUMBER	APPROVED	FILE	DATE	REVISED DATE
kar	22897.204	PBC	KEKII	2/93	

AMEC. 2008. Kekaha Phase II Landfill Well Construction (letter) Report. December.

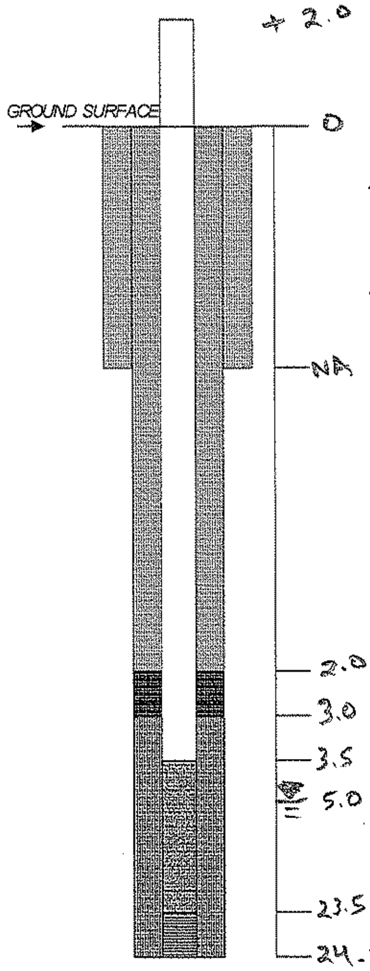
amec

WELL COMPLETION RECORD

JOB NO.: ______ WELL NO. MW-II-07 HYDROGEOLOGIST: Jeremy Haney

CLIENT: City and County of Kaui DRILLER: Tim Robertson

WELL LOCATION: Kekaha landfill DATE/TIME: Nov 19, 2008



Well Head Elevation +2ft

Ground Surface Elev. ?

Well Head Completion Method

concrete monument + bollards

Drilling Method/Rig Type

hollow stem auger

Surface ~~Casing:~~ monument Type Steel

Diameter 8in

Length 5ft

MATERIALS

Cement (bags) 4

Sand (ft^3) 7 bags

Casing Material (ft.) 5 ft

Bentonite (ft^3) 1 Bag

Top of Bentonite 2.0 ft.

Top of Filter Pack 3.0 ft.

Top of Screen 3.5 ft.

Bottom of Screen 23.5 ft.

Bottom of Hole 24.0 ft.

DETAILS OF CONSTRUCTION

Date Completed 11/19/08

Borehole Diameter (in.) 8in

Type and Size of Casing (in.) Scd 40 PVC 2in

Type and Size of Screen (in.) " ~~20~~ 20ft

Screen Perforation Diameter (in.) 0.010

Screen Length (ft.) 20ft

Centralizer Depths (ft.) NA

Completion Technique

1. Type of Filter Pack and Placement Method

   Sand Monterey #3

2. Type of Bentonite and Placement Method

   pellets

3. Type of Grout Mixture and Placement Method

   cement

Description of Potential Problems With Well:

None

NOTE: ALL DEPTHS ARE REFERENCED TO GROUND SURFACE

Development Technique

Surge + pump