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Environmental Protection &
Sustainability Division

COUNTY OF MAUI
DEPARTMENT OF
ENVIRONMENTAL MANAGEMENT
2050 MAIN STREET, SUITE 2B
WAILUKU, MAUI, HAWAII 96793

April 2, 2019

Ms. Lene Ichinotsubo, Acting Chief
Solid and Hazardous Waste Branch
Hawaii Department of Health
2827 Waimano Home Road
Pearl City, Hawaii 96782

Dear Ms. Ichinotsubo:

SUBJECT: **GROUNDWATER AND LEACHATE MONITORING PLAN**
CENTRAL MAUI LANDFILL
PUUNENE, MAUI

Enclosed for your review and approval is the Groundwater and Leachate Monitoring Plan for Central Maui Landfill updated March 2019.

Both a hard copy and electronic copy are enclosed. This updated Plan incorporates previous review comments and discussion points from conferences and emails.

Should you have any questions, please call Elaine Baker at (808) 270-7872.

Sincerely,

Shayne R. Agawa

for ERIC A. NAKAGAWA, Acting Director
Department of Environmental Management

Attachments
cc: Sergio Cocchia, Ch2m

REPORT

APR - 4 2019

Groundwater and Leachate Monitoring Plan

Central Maui Landfill
Puunene, Maui

Prepared for

The County of Maui
Department of Environmental Management
Solid Waste Division

Updated March 2019

ch2m

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Acronyms and Abbreviations

A-Mehr	A-Mehr, Inc.
amsl	above mean sea level
ANOVA	analysis of variance
ASD	alternative source demonstration
AST	aboveground storage tank
ASTM	ASTM International
bgs	below ground surface
BMP	best management practice
BOD	biochemical oxygen demand
BTEX	benzene, toluene, ethylbenzene, and xylenes
CFR	*Code of Federal Regulation*
CH2M	CH2M HILL Engineers, Inc.
CL	control limit
CMLF	Central Maui Landfill
CoC	chain of custody
COD	chemical oxygen demand
COPC	constituent of potential concern
County	County of Maui
CSM	conceptual site model
CUSUM	cumulative sum
DQE	data quality evaluation
DWS	Department of Water Supply
EAL	environmental action limit
EB	equipment blank
EKO	Maui EKO Systems
ESI	Environmental Simulations, Inc.
Ext	[SWMU Phase V-B] Extension
FD	field duplicate
FOG	fats, oil, and grease
ft/ft	feet per foot
ft/day	feet per day
ft/year	feet per year
gpm	gallon(s) per minute
HAR	Hawaii Administrative Rules
HDOH	State of Hawaii Department of Health
HGL	Hydrogeologic Inc.
HRS	Hawaii Revised Statutes
HVOC	halogenated volatile organic compound
ID	identification
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
MAX	maximum
MCL	maximum contaminant level
MFA	Masa Fujioka & Associates
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
mgd	million gallons per day

MHHW	mean higher high water
MHW	mean high water
MLLW	mean lower low water
MLW	mean low water
MS	matrix spike
MSD	matrix spike duplicate
MSWLF	municipal solid waste landfill
MW	monitoring well
NA	not applicable
NELAP	National Environmental Laboratory Accreditation Program
new Permit	*Solid Waste Management Permit No. LF-0074-13, Central Maui Landfill Phases I, II & IV, V, V-B Ext. and Entrance Facility, Pulehu Road, Puunene, Maui*
NFG	National Functional Guidelines
NOAA	National Oceanic and Atmospheric Administration
NTU	nephelometric turbidity unit
old Permit	Solid Waste Management Permit No. LF-0089-08
PC	principal component
PCA	principal component analysis
PW	production well
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFE	Ronald M. Fukumoto Engineering, Inc.
SDWA	Safe Drinking Water Act
SDWB	Safe Drinking Water Branch
SHWB	Solid and Hazardous Waste Branch
SSI	significant statistical increase
SWFPR	site-wide false positive rate
SWMU	solid waste management unit
SWPCP	Stormwater Pollution Control Plan
TB	trip blank
TDS	total dissolved solids
TEF	tidal efficiency factor
TMK	tax map key
TOC	total organic carbon
TSS	total suspended solids
Unified Guidance	*Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*
UPL	upper prediction limit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOA	volatile organic analysis
VOC	volatile organic compound
WKWWRF	Wailuku-Kahului Wastewater Reclamation Facility
WWS	Waimea Water Services

1 Introduction

This document was prepared by CH2M HILL Engineers, Inc. (CH2M), a wholly owned direct subsidiary of Jacobs,[1] for the County of Maui Department of Environmental Management (the County) to update the 2012 Groundwater and Leachate Monitoring Plan for the Central Maui Landfill (CMLF). The update to the existing monitoring plan is necessary to incorporate additional data collected after 2012 and to address the special conditions included in *Solid Waste Management Permit No. LF-0074-13, Central Maui Landfill Phases I, II & IV, V, V-B Ext. and Entrance Facility, Pulehu Road, Puunene, Maui* (new Permit) issued by the State of Hawaii Department of Health (HDOH) Solid and Hazardous Waste Branch (SHWB) on February 26, 2018.

1.1 Project Background

Groundwater monitoring has been conducted at CMLF since 1995 in compliance with requirements identified in Hawaii Administrative Rules (HAR) Title 11, Chapter 58.1 (11-58.1), and Solid Waste Management Permit No. LF-0089-08 issued by HDOH SHWB in 2009 (old Permit). Based on the results of baseline monitoring activities conducted at CMLF in 1995, a detection monitoring program was developed for CMLF in 1996 (Masa Fujioka & Associates [MFA], 1996).

In subsequent years, several upgrades to the plan were implemented, mainly following the construction of solid waste management units (SWMUs) Phase IV and Phase V. The 1996 detection monitoring program (original plan) was revised in 2011 to incorporate upgrades and include new available information. The updated Groundwater and Leachate Monitoring Plan was submitted to the HDOH SHWB in November 2011 (A-Mehr, Inc. [A-Mehr], 2011). The HDOH SHWB provided comments in a letter to the County dated July 5, 2012, and responses to the HDOH SHWB comments were provided and a revised plan submitted in November 2012 (A-Mehr, 2012). Although no formal approval was received from HDOH SHWB on responses to the HDOH SHWB comments, the revised plan has been implemented at CMLF since 2012.

Since the submittal of the November 2012 revised *Groundwater and Leachate Monitoring Plan for Central Maui Landfill* (Groundwater and Leachate Monitoring Plan) (A-Mehr, 2012), the following work has been performed to collect and evaluate additional data, and gain a better understanding of the groundwater flow characteristics at the CMLF site:

- Assessment monitoring between 2012 and 2016 (see Section 2.4.2 for details)
- Pump replacements between 2013 (MW-3 and MW-5) and 2015 (MW-2)
- Survey of monitoring well ground surfaces and top of casing elevations in 2014
- Synoptic groundwater level measurements and well network analysis in 2014 (Section 2.6.1)
- Development of a conceptual site model (CSM) in 2016 (Section 2)
- Development in 2016 of (1) a new statistical method for evaluating groundwater monitoring data and (2) well-specific upper prediction limits (UPLs) (revised in 2018; see Section 6.1)
- Evaluation of tidal influence on groundwater levels in 2017 (Section 2.6.1)
- Groundwater flow modeling in 2017 (Sections 2.6.2 and 3.1.2)

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[1] CH2M was acquired by Jacobs in December 2017. For consistency, work performed by Jacobs for this project will be attributed to CH2M, and any references will be provided under the name used at the time.

- Preparation of this Groundwater and Leachate Monitoring Plan to address new Permit requirements

The new data and the overall monitoring program for CMLF were discussed through the County's response to comments provided by HDOH SHWB on the UPLs and Groundwater Monitoring Plan updates, the implementation of the new Permit, and during two meetings held at the HDOH SHWB office in Oahu on October 11, 2017, and January 3, 2018. County and contractor responses to comments are provided in Appendix A, and minutes for the two HDOH SHWB meetings are included in Appendix B. During these meetings, it was agreed with HDOH SHWB to include new data in an updated Groundwater and Leachate Monitoring Plan for CMLF to be submitted within 90 days of the issuance of the new Permit.

1.2 Project Objectives and Scope

The main goal of this updated Groundwater and Leachate Monitoring Plan is to describe the hydrogeological and statistical evaluation methods to be used and provide guidance for groundwater and leachate monitoring that will be conducted at the appropriate points of compliance for the CMLF. The monitoring program will be performed in accordance with the *Code of Federal Regulations* (CFR), Title 40, Part 258 (Subtitle D); HAR 11-58.1; and State of Hawaii Landfill Groundwater Monitoring Guidance (HDOH, 2002). Specific objectives of the plan include the following:

- Summarize past investigations and monitoring activities.
- Present new data produced after 2012.
- Provide an updated CSM.
- Provide recommendations to upgrade the existing monitoring network.
- Discuss the groundwater and leachate monitoring programs.
- Present the revised UPLs.
- Discuss evaluation approach and reporting for groundwater detection monitoring.

Once approved by HDOH SHWB, this plan will be integrated with the new Permit and will supersede previous monitoring plans. As new data will become available, this Groundwater and Leachate Monitoring Plan may need to be updated in the future.

1.3 Regulatory Framework

The CMLF is subject to the regulations contained in 40 CFR 258 (Subtitle D), which establish the minimum national criteria under the Resource Conservation and Recovery Act (RCRA) for all municipal solid waste landfills. The United States Environmental Protection Agency (USEPA) has commended the State of Hawaii for maintaining the lead role in the implementation and enforcement of the Subtitle D regulations through approved permit programs.

Requirements contained in HAR 11-58.1 reflect rules from 40 CFR 258. Regulations in HAR 11-58.1-16 provide the requirements for developing and implementing a groundwater and leachate monitoring program designed to identify and respond to potential releases to the uppermost aquifer beneath a landfill in the State of Hawaii. Pursuant to HAR 11-58.1, the HDOH SHWB issued the new Permit for CMLF (Permit No. LF-0074-13) on February 26, 2018.

Other regulatory guidance documents that are applicable to groundwater and leachate monitoring at CMLF and were considered for the preparation of this Groundwater and Leachate Monitoring Plan include the following:

- Landfill Groundwater Monitoring Guidance Document, Version 1.8 (HDOH, 2002); and

- *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance* (Unified Guidance) (USEPA, 2009).

1.4 Landfill Permit

The new Permit was issued by HDOH SHWB on February 26, 2018, under the provisions of Hawaii Revised Statutes (HRS), Chapter 342H, Solid Waste Pollution, and HAR 11-58.1, Solid Waste Management Control. Through the permit renewal, the County was authorized to maintain existing SWMUs Phase I & II, maintain and operate SWMUs Phases IV and V, construct and operate the new SWMU Phase V-B Extension (Ext), and operate a materials drop-off facility.

The new Permit identifies requirements related to groundwater and leachate monitoring in Special Conditions II, Section G. The new Permit is included in Appendix C. Exhibit 1 summarizes the new Permit-specific requirements that are relevant to this Groundwater and Leachate Monitoring Plan, mapping each requirement to the relevant section of the document where compliance and implementation of each requirement is discussed.

Exhibit 1. Mapping of New Permit Requirements

Permit Requirement	Document Section where Requirement is Addressed
Submit a new Groundwater and Leachate Monitoring Plan within 90 days of the issuance of the new Permit. The plan should discuss the need for/installation of the new Phase V-B Ext sump and additional monitoring wells, in accordance with HAR 11-58.1-16. The current monitoring plan shall be implemented until the HDOH has approved the new monitoring plan.	Sections 2.3 and 4.1 (Phase V-B Ext sump) Sections 3.1.2 and 3.2.1 (Additional monitoring wells)
Groundwater	
Install new monitoring wells as approved by the HDOH SHWB in an updated Groundwater and Leachate Monitoring Plan.	Sections 3.1.2 and 3.2.1
Within 30 days of the installation of the new monitoring wells, submit a Well Completion Report with construction details for the wells.	Section 3.1.2
Maintain access to and integrity of all monitoring wells and periodically validate top of casing elevations. The HDOH SHWB shall be notified immediately if any monitoring wells are destroyed or damaged.	Sections 3.1.2 and 3.3
Perform groundwater sampling for all monitoring wells on a quarterly basis, unless otherwise approved by HDOH SHWB. Groundwater levels shall be measured before sampling. Samples shall be analyzed in accordance with the existing Groundwater and Leachate Monitoring Plan (A-Mehr, 2012) and requirements of HAR 1-58.1-16, unless an alternate detection monitoring program has been approved by HDOH SHWB.	Sections 3.2 and 3.3
Collect, handle, and manage all samples in accordance with USEPA SW-846, *Test Method for Evaluating Solid Waste*, and analyze using an independent third-party laboratory. Groundwater detection monitoring results shall be submitted to HDOH SHWB within 45 days of sampling and analysis.	Section 5

Exhibit 1. Mapping of New Permit Requirements

Permit Requirement	Document Section where Requirement is Addressed
Provide statistical analysis and documentation in each report that adequately supports each assumption, position, and/or conclusion, including methodology and statistical data for evaluating baseline, detection monitoring data, trends, and/or changes to the detection monitoring parameter list.	Section 6.1
Evaluate results to determine if there is an indication of leachate impact to groundwater.	Section 6.2
Leachate	
Submit a construction quality assurance plan 30 days before the construction and extension of the Phase V-B Ext leachate sump riser pipe.	Section 4.1
Maintain access to and integrity of all leachate sumps and periodically validate top of casing elevations. The HDOH SHWB shall be notified immediately if any of the leachate sumps are destroyed or damaged.	Section 4.1
Implement leachate management measures in accordance with the Operation Plan, including removal of leachate to maintain a maximum level of 30 centimeters (12 inches) above the bottom of the liner around sumps IV-B and V-B Ext, leachate levels of compliance in manhole, pumping and storage of leachate to ASTs, inspection of ASTs, and management and disposal of leachate removed from the ASTs.	Sections 2.3 and 4.1
Implement leachate level monitoring requirements.	Sections 2.3 and 4.1
Collect leachate samples on at least a semiannual basis and submit analytical results to HDOH SHWB within 45 days of sampling and analysis. Leachate samples shall be analyzed for parameters listed in 40 CFR Part 258, Appendix II and major leachate indicators, unless an alternate parameter list has been approved by HDOH SHWB.	Section 4

Note:

AST = aboveground storage tank

1.5 Report Organization

This Groundwater and Leachate Monitoring Plan is organized as follows:

- **Section 1 – Introduction**. Discusses project background and objectives, briefly presents the regulatory framework, and summarizes the new Permit requirements that are relevant for this Groundwater and Leachate Monitoring Plan.
- **Section 2 – Updated Conceptual Site Model**. Presents the updated CSM for CMLF based on new data collected in the recent past.
- **Section 3 – Groundwater Monitoring**. Discusses the details of the updated groundwater monitoring program, including an analysis of the monitoring network and the optimized short list of monitoring constituents, statistical methodology and applicable well-specific criteria, groundwater monitoring frequency, and groundwater sampling procedures.

- **Section 4 – Leachate Monitoring**. Discusses the details of the updated leachate monitoring program, including the updated leachate monitoring network, list of leachate monitoring constituents, monitoring frequency, and leachate sampling procedures.
- **Section 5 – Quality Assurance and Quality Control**. Presents contractor quality assurance (QA) information, including field and laboratory quality control (QC) procedures, sample management and handling, and laboratory data validation.
- **Section 6 – Data Evaluation and Reporting**. Briefly discusses reporting requirements and the approach that will be followed in evaluating results to identify potential impacts to groundwater from landfill operations.
- **Section 7 – References**. Provides a list of documents cited in this Groundwater and Leachate Monitoring Plan.
- **Tables, Figures, and Appendices** providing supporting information referenced in the text sections are provided at the end of the report.

2 Updated Conceptual Site Model

After the submittal of the November 2012 revised Groundwater and Leachate Monitoring Plan (A-Mehr, 2012), a revised CSM for CMLF was prepared by CH2M for the County in February 2016 (CH2M, 2016a) to evaluate and summarize existing site data, evaluate the groundwater monitoring network, assess potential leachate effects on groundwater underlying the facility, and identify potential data gaps. The preparation of the CSM was discussed and agreed upon with HDOH SHWB during the January 2015 meeting (meeting minutes provided in Appendix B). After submittal in 2016, the County received comments on the draft CSM document from HDOH SHWB in September 2017. Comments were addressed and responses were provided to HDOH. In concurrence with HDOH, a final version of the CSM document was submitted to HDOH in January 2018 (CH2M, 2018b). However, the final CSM submitted in 2018 did not incorporate new data collected and evaluated for the CMLF after the draft CSM had been prepared (2015-2016). New data collected after preparation of the draft CSM included an evaluation of tidal influence on groundwater flow characteristics, groundwater modeling conducted to evaluate the impact of pumping at the production well on groundwater flow at the CMLF, and new groundwater and leachate sampling results. Newly collected data helped provide a better understanding of groundwater flow characteristics at the site

This section reconciles old and new data to compile site-specific information into one document and provide an updated CSM for CMLF. As such, some information may be redundant with what was already included in the final CSM document submitted in January 2018, which may be referred to for additional details. The updated CSM described herein provides the foundation upon which the updated groundwater and leachate monitoring programs discussed in Sections 3 and 4 are based.

2.1 Climate

There are typically two seasons in Hawaii, a dry season and a wet season. The dry season (May through September) has warm temperatures and steady trade winds that blow 80 to 95 percent of the time (Blumenstock and Price, 1967; Sanderson, 1993), with lower precipitation. The wet season (October through April) has cooler temperatures and less persistent trade winds, with higher precipitation. Statewide storm rainfall is more common during the rainy season, when high- and low-pressure systems and frontal systems pass near the Islands (Giambelluca et al., 1986).

Weather on Maui, as on other islands, is highly influenced by the tradewinds that originate from the north Pacific anticyclone, a region of high atmospheric pressure usually located northeast of the islands. The mountains of the Hawaiian Islands obstruct tradewind air flow, creating a wetter climate on the north- and northeast-facing (windward) mountain slopes, and a drier climate on the southwest-facing (leeward) mountain slopes (Sanderson, 1993). As moist air ascends windward mountain slopes, it cools and can form clouds. Persistent tradewinds and orographic lifting of moist air result in recurrent clouds and frequent rainfall on windward slopes and near the peaks of all but the tallest mountains of the Hawaiian Islands (Giambelluca et al., 1986).

On an island-wide basis, mean rainfall on Maui is about 81 inches per year. On the isthmus where the CMLF is located (Figure 2-1), average annual rainfall is significantly lower. The weather station closest to CMLF is the Puunene 396 station (station identification [ID] No. 518543). According to the Western Regional Climate Center, the average annual rainfall at the Puunene Station between 1950 and 2016 was 18.2 inches per year. The annual average rainfall at the Puunene Station has statistically decreased between 1950 and 2012, when it reached a historic low of 4.72 inches (Table 2-1). In 2008, a period of drought started that lasted 6 years, with an average annual rainfall between 2008 and 2013 of 8.9 inches per year (i.e., a decrease in average annual rainfall of more than 50 percent). After 2014, the average rainfall returned to normal values.

2.2 Site Description and Land Use

The Island of Maui is characterized by two shield volcanoes: the older West Maui Volcano (also known as West Maui Mountain) and the younger East Maui Volcano (known as Haleakala). The broad, gently sloping land between the two volcanoes, where the CMLF is located, is referred to as the isthmus.

The CMLF is located on the eastern side of the isthmus between West Maui and Haleakala, approximately 3 miles from the Pacific Ocean coastline at Kahului. Figure 2-1 presents a general vicinity map showing the approximate location of the facility. The Tax Map Key (TMK) identification for the facility is TMK (2) 3-8-03:19.

The landfill is surrounded by agricultural fields to the northwest, west, and east, and quarrying facilities and concrete batch plant operation to the north and south. The agricultural field area to the northwest is currently owned by the County and is planned for future development to construct solid waste facilities (A-Mehr, 2017b).

The CMLF lies in a topographic low area associated with the Kalialinui Gulch, which is aligned roughly northwest-southeast across the central part of the parcel (Figure 2-2). Natural topography has been extensively modified by quarrying and landfilling activities. Maximum elevations at the site range from approximately 310 feet above mean sea level (amsl) for the Phase IV disposal area to 360 feet amsl for the Phase I & II areas. Kalialinui Gulch is about 20 feet below natural grade, with bottom elevations of about 210 feet amsl at the northern property boundary and 270 feet amsl at the southern (A-Mehr, 2012).

Figure 2-2 shows the general layout of the CMLF facility, including the various phases of landfilling. The facility is effectively divided into two main parts by Kalialinui Gulch, an erosional drainage feature that trends roughly northwest-southeast across the longitudinal center of the CMLF parcel. There are eight SWMUs existing or currently planned for development at the CMLF facility. Phase I & II and future Phase III are situated on the eastern side of Kalialinui Gulch, and Phases IV-A, IV-B, V-A, V-B, V-B Ext, and the future Phase VI are located west of the gulch.

SWMU Phase I & II were operational between 1987 and 2005, filled to approved final grades in November 2005, and subsequently closed and capped during 2006-2007. After SWMU Phase I & II were closed, the following additional SWMUs were developed and are currently active: Phase IV-A, Phase IV-B, Phase V-A, and Phase V-B. Construction of Phase V-B Ext is planned to start in Fiscal Year 2018 and anticipated to be completed in Fiscal Year 2019. Phase III is currently being used for co-composting of biosolids and green waste by Maui EKO Systems (EKO) under contract with the County, and is planned to be used as landfill in the future. Phase VI was formerly mined for aggregate by Ameron (now HC&D, LLC) and was planned to be acquired by the County as a potential expansion area for the landfill in the future until it was purchased by another party.

Stormwater infiltration occurs site wide in unpaved portions of the property surrounding the active and closed landfill cells. A stormwater infiltration basin, which receives runoff from the site, is located immediately adjacent to downgradient monitoring well MW-5, located approximately 250 feet northeast of the north-northeastern boundary of the Phase IV-A fill area (Figure 2-2). A stormwater basin that receives runoff from the current Co-Composting Area (future Phase III fill area), is located on the northern boundary of the future Phase III fill area and adjacent to downgradient monitoring well MW-2 (Figure 2-2).

The CMLF is permitted by the State as a special permitted land use within agricultural base zoning. County zoning for the property is agricultural and interim. It lies about 1.5 miles southeast of the urban zone area of Puunene and about 2.6 miles southeast of the conservation zone associated with the Kanaha Pond State Wildlife Sanctuary. A rectangle of urban-zoned land approximately 750 by 900 feet in dimension lies southwest and across Pulehu Road from the CMLF, but this land remains vacant. Current land uses at the CMLF and in surrounding areas, as well as site features that are significant to the development of this updated CSM, are depicted on Figure 2-2.

2.3 Landfill Characteristics

The CMLF is a landfill permitted to accept solid wastes as defined in HAR 11-58.1-03. Solid waste is received at the CMLF from residential, commercial, industrial, and construction and demolition activities. The landfill consists of five main areas (phases I through V) currently used or planned for future use to dispose of solid waste, and some support facilities. Some of the SWMUs are further subdivided in multiple phases.

SWMU Phases I through III occupy approximately 59 acres east of Kalialinui Gulch. Phase I & II, consisting of approximately 40 acres, operated as SWMUs for approximately 19 years. These phases were filled to approved final grades during 2005, and were subsequently closed and capped during 2006 and 2007. The cap is inspected and maintained regularly. Phase III has been used for co-composting of green waste and biosolids from the three County wastewater reclamation facilities (Kihei, Lahaina, and Wailuku-Kahului) since 1995, and is planned for use as a landfill SWMU in the future. Based on the Draft Environmental Impact Statement for the Renewable Energy Conversion and Sludge Processing at the Wailuku-Kahului Wastewater Reclamation Facility (WKWWRF) (County of Maui Department of Environmental Management, 2017), wastewater biosolids produced at the three wastewater reclamation facilities are planned to be processed at the WKWWRF starting September 2019, when co-composting activities are anticipated to end at CMLF.

SWMU Phases IV and V occupy a total of approximately 40 acres west of Kalialinui Gulch and collectively make up the currently active cells of the CMLF. Waste placement in this portion of the facility began in Phase IV-A during 2005 and has subsequently extended through Phases IV-B, V-A, and V-B. These phases were constructed with bottom and side-slope composite liners consisting of a geosynthetic clay layer with a permeability of $1x10^{-7}$ centimeter per second or less, overlain by a 80-mil high-density polyethylene liner.

The landfill is situated in a former quarry. The designer drawings show that the bottom of the landfill in Phase I & II is 255 feet above mean sea level (amsl) in the southern end of Phase I, sloping to an elevation of about 211 feet amsl near the northern end of Phase II. The bottom elevations of refuse in Phases IV and V range from an elevation of 230 feet amsl in the southern part of Phase V to 200 feet amsl in the northern part of Phase IV-B. As previously noted, Phase III is currently used by the County for composting and no refuse has been placed in this phase. Consequently, the base of refuse currently in place at the CMLF lies at least 200 feet above the groundwater level of the uppermost aquifer, and possibly as much as 250 feet above groundwater in some parts of Phase II.

The leachate collection system meets construction specifications in the Permit and consists of the following:

- **SWMU Phase I & II** - Neither Phase I nor Phase II was constructed with a geosynthetic bottom liner as they were constructed and placed into operation before the adoption of HAR 11-58.1-14(c) landfill liner requirements. These units are equipped with a dendritic leachate collection system connected to a pipe with laterals placed at the lowest point of Phase II (Manhole 4).
- **SWMU Phase IV-A** - Leachate from Phase IV-A is collected via a geocomposite drainage layer above the liner that drains leachate from the waste to an external, self-contained concrete wet well that has a compliance level for the leachate of 207 feet amsl.
- **SWMU Phases IV-B and V** - The liner system of Phases IV-B and V are connected and converge to a sump located in Phase IV-B that has a compliance level for the leachate of 212 feet amsl.

- **SWMU V-B Ext** - Leachate for Phase V-B Ext (currently under construction) will be collected via a sump in the northern corner of the SWMU, which will have a compliance level for the leachate of 228 feet amsl.

Leachate from the Phase IV-A wet well is pumped via an automated pump that is triggered by a high level sensor. Leachate removal from the IV-B sump is through its own dedicated and automated pump and piping system. Leachate removal from the Phase I & II manhole and future V-B Ext sump is directly into pumper trucks. In accordance with the new Permit, leachate collected through the sump/manhole collection system is temporarily stored in above ground storage tanks and then spread at the active disposal face (no more than 2,000 gallons per day), reintroduced outside of the active face of active SWMUs using infiltration galleries and laterals (except for future Phase V-B Ext), or transported to a public wastewater treatment facility offsite.

No leachate was detected in the Phase I & II manhole (wet well) during the 2017 fiscal year, while 907,000 gallons of leachate were collected in the Phase IV-A and Phase IV-B sumps, of which 310,000 gallons were disposed of offsite while the remainder was recirculated or reused onsite for litter control and improved waste compaction (A-Mehr, 2017a). Leachate is collected periodically and analyzed for the HAR 11-58.1-16, Appendix II Parameter list. A summary of leachate analytical results is included in Appendix D.

2.4 Previous Investigations

Information on the site hydrogeology and groundwater characteristics has been developed through site investigations, monitoring well network construction, and groundwater monitoring activities.

2.4.1 Reviewed Documentation

Key documents that provide information used during completion of this document include the following:

- Final *Water Quality Protection Standard and Corrective Action and Control Limits for the Central Maui Landfill* (MFA, 1996): Established the initial site groundwater monitoring program.
- *Hydrogeological Characterization Report, Central Maui Sanitary Landfill, Puunene, Maui, Hawaii* (MFA, 1997): Documented installation of site groundwater monitoring wells MW-1, MW-2, and MW-3, and summarized the site hydrogeology.
- *Hydrogeologic Characterization and Background Detection Monitoring, Central Maui Landfill, Phase IV, Puunene, Hawaii* (Earth Tech, 2002): Documented installation of site monitoring wells MW-4, MW-5, and MW-6 and supplemented the hydrogeologic characterization of the landfill performed by MFA.
- Semiannual groundwater detection monitoring reports (URS, 2014a and 2014b) and groundwater assessment monitoring report (URS, 2012): described the results of semiannual groundwater detection monitoring and assessment monitoring conducted at CMLF between 2012 and 2014 under the old Permit.
- Final *Groundwater and Leachate Monitoring Plan for Central Maui Landfill* (A-Mehr, 2012): Presented the revised Groundwater and Leachate Monitoring Plan that summarized site history and site physical setting, included recommendations for monitoring network modifications, and described the groundwater and leachate monitoring programs implemented at CMLF.
- *Central Maui Landfill Groundwater Well Network Analysis* (Element Environmental, LLC [Element], 2014): Provided an evaluation of the current groundwater monitoring network and the results of a

pressure transducer study to continuously monitor groundwater levels and to evaluate the groundwater hydraulic gradient beneath the facility.

- *Calculation of Upper Prediction Limits, Central Maui Landfill Facility Groundwater Monitoring* (CH2M, 2016b): Provided the HDOH SHWB with the background, rationale, methodology, and outcome of changing the statistical method for evaluation of groundwater monitoring data at CMLF from control-chart limits (CLs) to UPLs. Comments from HDOH SHWB on the UPL memorandum have been addressed and the UPL calculations revised, as described in Section 6 and Appendix E of this Groundwater and Leachate Monitoring Plan.
- Final *Conceptual Site Model, Central Maui Landfill* (CH2M, 2018b): Updated the CSM for the site to evaluate and summarize site data, evaluate the groundwater monitoring network (including a review of previous recommendations provided in the 2012 Groundwater Monitoring Plan), assessed if multiple lines of evidence indicate that there may be leachate effects on groundwater underlying the facility, and identify potential data gaps.
- Quarterly groundwater detection monitoring reports: Described the results of quarterly groundwater detection monitoring conducted at CMLF between 2014 and 2017, under the old Permit.

These documents, along with other available groundwater document resources for the island of Maui and the state of Hawaii, helped to develop the updated CSM described herein and the Groundwater Monitoring Program outlined in Section 3.2.

2.4.2 Assessment Monitoring (2012-2014)

To address the concerns expressed by HDOH SHWB on the assessment monitoring program implemented at CMLF between June 2012 and June 2016 (see Response to Comments on the UPL Technical Memorandum in Appendix A), a brief summary of the assessment monitoring activities is provided in this section. The Assessment Monitoring technical memorandum is included in Appendix F.

Assessment monitoring was initiated at CMLF in March 2012 after an exceedance of the iron control limit (CL) was confirmed at downgradient monitoring well MW-5 in December 2011. In compliance with HAR 11-58.1-16, samples collected in March 2012 from three downgradient monitoring wells (MW-2, MW-3, and MW-5) were analyzed for the full list of the 40 CFR Appendix II constituents. Analysis of Appendix II parameters resulted in four new constituents (chromium, lead, nickel, and vanadium) detected in groundwater that had not previously been part of the detection monitoring program (URS, 2012). Per HAR 11-58.1-16 requirements, background levels for these constituents were established by conducting eight independent monitoring events over 2 years (e.g., quarterly sampling conducted between June 2012 and December 2014) and revising the CLs to calculate and adopt the new UPLs.

Assessment monitoring with sampling for Appendix II constituents was also initiated at the following monitoring wells:

- Crossgradient well MW-4 in July 2013 for an exceedance of the chloride CL in April 2013. The July 2013 analysis of Appendix II constituents at monitoring well MW-4 resulted in no detections.
- Upgradient well MW-1 in July 2014 for an exceedance of the magnesium CL. The July 2014 analysis of Appendix II constituents at well MW-1 resulted in detections of zinc and vanadium, which had already been monitored at downgradient monitoring wells as part of the Appendix II Assessment Monitoring since March 2012 (vanadium) and April 2014 (zinc).

In compliance with HAR 11-58.1-16(e)(2) and (e)(4)(C), while background values for the detected Appendix II constituents were being established, analysis of the full list of Appendix II constituents was repeated at different wells with different schedules for comparison against the original Appendix II sampling results (URS, 2014a and b). A schedule summary for the complete Appendix II constituent testing follows:

- MW-1 – July 2014 and June 2015
- MW-2 – March 2012, April 2014, and June 2015
- MW-3 – March 2012, April 2014, and June 2015
- MW-4 – July 2013, October 2013, December 2013, and June 2015
- MW-5 – March 2012, April 2014, and June 2015
- MW-6 – June 2015

No additional Appendix II parameters were detected during these sampling events, except for zinc at wells MW-2, MW-3, and MW-5 in April 2014 and at well MW-1 in July 2014, and 3&4-methylphenol at well MW-4 in October 2013. While zinc was verified to be present during subsequent Appendix II sampling and was added to the assessment monitoring constituents list to establish background concentrations, 3&4-methylphenol was not added to the assessment monitoring program because the detection was not confirmed during the December 2013 sampling (URS, 2014a).

A summary of Appendix II assessment monitoring results is provided in Table 2-2. Per HAR 11-58.1-16 sections (d)(3)(C) and (e)(7)(B), the County discussed in the 2015 Detection Monitoring Report (CH2M, 2016c) and in the final CSM report (CH2M, 2018b) the potential that sources other than the landfill (such as natural variation) had caused the exceedances of the 2010 CLs, which had triggered assessment monitoring in March 2012. After the last Appendix II assessment monitoring sampling was conducted in June 2015, no additional Appendix II sampling was deemed necessary in 2016 because none of the detected constituents exceeded the newly calculated UPLs adopted in 2016 and those constituents that had no UPL (chromium, lead, and nickel [nickel only for MW-1 and MW-3]) were not detected. Therefore, the detection monitoring program was resumed in compliance with HAR 11-58.1-16 sections (e)(5) and (e)(7)(B), Section 4.2 of the Unified Guidance (USEPA, 2009), and the USEPA Federal Subtitle D regulations. The rationale for this determination is further discussed in Appendix F (see Appendices D and G for historical leachate and groundwater concentrations, respectively).

2.5 Site Geology

The CMLF is located along the northern flank of Haleakala in an area that is transitional between Haleakala's rugged highlands to the southeast and the central isthmus to the northwest. Alluvial soil or fill material is present at the site to a depth of approximately 20 feet below ground surface (bgs) or less. The underlying unsaturated zone consists primarily of basalt lava flow deposits with associated flow top rubble (clinker), tuff, cinder or spatter deposits, and intermittent clayey saprolite intervals, representing deeply weathered, formerly subaerial horizons. Soil horizons in the subsurface occur at erosional unconformities, and are the result of extended periods of volcanic acquiescence during which significant erosion of the surface occurred. These soil horizons were later buried by lava flows associated with subsequent active volcanism.

2.6 Hydrogeology and Site Groundwater Characteristics

Basal aquifers in Hawaii typically reside in basalt formations, forming a lens that rests upon and partially displaces the underlying, denser seawater. Within the area of the CMLF site, flank lavas of the Honomanu series are fully covered by younger lavas of the Kula series. Unconfined basal aquifers are known to exist in both the Kula and Honomanu series basalt lava formations; in some areas, perched aquifers have been identified. The basal aquifers within the Honomanu series lavas are the principal developable freshwater aquifers on Maui. The Honomanu basal aquifer in the vicinity of the CMLF extends generally from the dike complexes of Haleakala to the adjacent coastline north of the site near Kahului (Hargis and Peterson, 1974; Gingerich, 2008).

The aquifers underlying the CMLF are part of the Paia aquifer system, which is in turn part of the larger Central aquifer sector on Maui. Mink and Lau (1990) indicate that both a shallow aquifer, classified as being high-level, unconfined, and perched, and a basal unconfined flank aquifer are potentially present within the aquifer system underlying the area of CMLF. However, no high-level or perched aquifer has been identified at the CMLF site during previous investigations. The basal aquifer identified at the CMLF is classified as an unconfined flank aquifer currently used as a fresh drinking water source, which is irreplaceable and moderately vulnerable to contamination (MFA, 1997; Mink and Lau, 1990). The basal groundwater lens underlying the site occurs primarily within lava flows of the Kula and Honomanu series lavas. Monitoring wells at the site are screened within the flank basal aquifer, which constitutes the uppermost aquifer under HAR 11-58.1-16(b)(1).

The flank lava flows of the Kula and Honomanu series underlying the site generally dip from southeast to northwest. Because of the differing hydraulic properties associated with the underlying basalt lava flow sequence and structure, anisotropy is expected in groundwater flow, with preferential groundwater flow in the direction of lava deposition and horizontal hydraulic conductivity typically 10 to 100 times greater than vertical hydraulic conductivity (El-Kadi and Moncur, 2006; Lau and Mink, 2006; Burnham et al., 1977). Net groundwater flow within the underlying basal aquifer is toward the northwest (United States Geological Survey [USGS], 2005), which is consistent with the general direction of deposition of the lava flows in which the uppermost aquifer is located.

The static groundwater level at the CMLF ranges from approximately 300 feet bgs in the southern part of the landfill (wells MW-1 and MW-6) to about 220 feet bgs in the northern part of the landfill (wells MW-2 and MW-5). Groundwater elevations typically are between 3 and 3.2 feet above mean sea level amsl in the upgradient, southeastern portion of the CMLF site (well MW-1) and approximately 2.7 feet amsl in the downgradient, northern portion of the site (wells MW-2 and MW-5), resulting in a hydraulic gradient generally towards the northwest.

2.6.1 Summary of Tidal Effect on Groundwater Flow

Element conducted continuous monitoring of water levels at the CMLF between August 15 and October 16, 2013 (Element, 2013), using Solinst transducers deployed in the six monitoring wells and the newly installed production well (PW). The continuous groundwater levels measured by Element in 2013 clearly showed the harmonic tidal fluctuation (Figure 2-3) typical of sites located close to the coast in Hawaii, with two high water levels (mean high water [MHW] and mean higher high water [MHHW]) and two low water levels (mean low water [MLW] and mean lower low water [MLLW]) per tidal cycle. Anomalous static (one-time) groundwater elevations and inconsistent groundwater maps are frequent at these sites affected by tidal fluctuations, unless continuous water level readings are taken and tidal evaluations are made.

At any point where groundwater tidally fluctuates (as is the case at CMLF), the magnitude and direction of the hydraulic gradient fluctuates about the mean or regional hydraulic gradient. The net effect of these fluctuations on groundwater flow can be determined using the mean groundwater elevations and the mean hydraulic gradient. As part of the tidal effect evaluation, groundwater levels measured by Element in 2013 were processed by CH2M using a method developed by Serfes (1991) to evaluate the influence of tidal fluctuations on groundwater flow characteristics and provide a net groundwater flow direction and gradient for the CMLF site. This method is used to evaluate groundwater flow in coastal aquifers and allows the removal of the lunar tidal influence to estimate the net groundwater flow direction.

A summary of methods and findings for the tidal evaluation is provided here; more details can be found in the evaluation of tidal effect on groundwater flow information included in Appendix H.

Data downloaded from the monitoring stations, together with tidal information obtained from the National Oceanic and Atmospheric Administration (NOAA) Kahului Harbor Station (NOAA Station ID 1615680), were evaluated to determine the influence of tidal fluctuations on groundwater movement beneath the CMLF site.

A representative 71-hour subset of the data collected by Element in 2013 was selected (August 22, 2013, at 00:00 hours to August 24, 2013, at 23:00 hours) for evaluation of both tidal influences and groundwater flow conditions.

Lag times between the NOAA station and each of the monitoring wells were estimated considering the time difference when each high or low tide condition was observed during the selected 71-hour period at each monitoring station compared to the NOAA station. Lag times between the earliest and the latest monitoring well were also calculated (Table 2-3). Faster responses to tidal fluctuations in the monitoring wells were generally observed in well MW-3. The slowest responses were generally recorded in monitoring wells MW-4 and MW-6, which, together with well MW-1, are located farthest from the ocean.

The tidal efficiency of a well, defined as the ratio of the amplitudes of the curves representing the groundwater table and tidal elevations, was also calculated to compare the influence of tidal fluctuations on groundwater elevations between measurement points. To evaluate tidal influences, hourly water level data from site wells (monitoring wells MW-1 through MW-6 and production well PW) were compared to levels observed at the NOAA station during the 71-hour period. The tidal efficiency factors (TEFs) were calculated as the ratio of the standard deviations of the two sets of readings. As summarized in Table 2-4, tidal efficiencies ranged between 5 percent (wells MW-1 and MW-3) and 8 percent (MW-4, MW-5, and MW-6) during the 71-hour period.

Mean groundwater elevations were calculated using the Serfes (1991) method, which is used to filter diurnal and semidiurnal lunar and solar harmonics from 71 hourly water level measurements. This method uses moving averages, with different sequence of means to yield a filtered mean level for the median time of the 71-hour period (Appendix H). Based on the 71-hour mean groundwater elevations, an average hydraulic gradient ranging from approximately $1.4\text{x}10^{-4}$ feet per foot (ft/ft) (in the eastern portion of the site) to approximately $5.8\text{x}10^{-5}$ ft/ft (in the western portion of the site) is estimated for the uppermost, basal aquifer beneath CMLF. The average hydraulic gradient estimated for the site is $9.7\text{x}10^{-5}$ ft/ft. The net groundwater flow during the 71-hour period was toward north-northwest (Figure 2-4), which is consistent with the regional, oceanward groundwater flow (USGS, 2005).

Based on the data collected as part of tidal effect evaluation during the 71-hour period, the following general conclusions are made:

- Groundwater beneath CMLF is influenced by tidal fluctuations, with the tidal pressure wave amplitude and time varying significantly among different site wells. The tidal pressure wave is characterized by the harmonic tidal fluctuation typical of sites located close to the coast in Hawaii, with two high water levels (MHW and MHHW) and two low water levels (MLW and MLLW). Groundwater level fluctuations recorded in the 71-hour period were up to approximately 0.24 feet, which is significant considering the relatively flat average hydraulic gradient ($9.7\text{x}10^{-5}$ ft/ft) at the site.
- As indicated by curves with lower amplitudes and lower TEFs, wells MW-1 and MW-3 are less influenced by tidal fluctuation (possibly because of fracture geometry, distance from the ocean, or both), which could explain anomalies observed when taking static manual groundwater level measurements.
- The average groundwater level at the production well over the 71-hour period is basically the same as at well MW-2, and similar to well MW-5. Significant differences observed when taking static

manual groundwater level measurements at these wells are therefore attributed to the effect of tidal fluctuation on groundwater elevations and flow.

- The lag time between the ocean and the site is 4 to 6 hours ± 1 hour.
- Lag time between wells on site can be significant (average of 3 hours ± 1 hour), which could also explain anomalous groundwater elevations observed when taking static manual groundwater level measurements.
- The net groundwater flow estimated for the CMLF site is toward the north-northwest, consistent with the regional flow.
- The combination of groundwater level fluctuations, low hydraulic gradient and significant lag time between monitoring wells at the site, together with the nature of the aquifer (fractured basalt, with potentially different fracture geometry resulting in different ways each well communicates with the aquifer), is the most plausible explanation of anomalous groundwater elevations recorded when taking static (one-time) water levels measured in site monitoring wells. The tide pressure wave is observed at each well at different times (with significant lag times), which causes anomalous groundwater elevations because of fluctuating groundwater levels (with the low hydraulic gradient typical of CMLF, even a fluctuation of a few inches can cause significant anomalies). The anomalous static groundwater elevations often result in inconsistent groundwater flow directions interpreted from groundwater contours calculated from static (one-time) water levels for the CMLF site.

2.6.2 Summary of Production Well Pumping Effect on Groundwater Flow

Groundwater flow modeling was conducted to evaluate the potential influence of daily pumping activities at the production well PW on groundwater flow conditions. Well PW was installed by the County to supply water for dust control and irrigation activities at the CMLF. The modeling also provides insight for assessing the adequacy of the CMLF monitoring well network for detection monitoring. A summary of the findings is included in this section, and a technical memorandum with the detailed modeling results is included in Appendix I.

A finite-difference numerical groundwater flow model was developed using MODFLOW-SURFACT (HGL, 2008) in conjunction with Groundwater Vistas, Version 6.0 (GW-Vistas 6.0) (ESI, 2011) pre- and post-processing software package as the primary graphical user interface. The groundwater flow model was constructed based on the understanding of the regional and local hydrogeology, and was calibrated under both steady-state and transient (variable with time) conditions. Steady-state calibration used the water levels measured at the six monitoring wells and production well between August 22 and 24, 2013 (corrected to remove influence from tidal fluctuations), as calibration targets (Figure 2-4). The model was further calibrated under transient conditions by simulating a 24-hour constant-rate pumping test at production well PW with a pumping rate of 160 gallons per minute (gpm). The goal of the transient calibration was to match a drawdown of 0.36 feet at the end of the 24-hour pumping period, as observed during the constant-rate pumping test conducted during well installation (Waimea Water Services LLC (WWS), 2012).

To assess the potential impact of the daily pumping activity at well PW, the calibrated model was used to simulate a scenario of daily pumping at 160 gpm for 75 minutes, necessary to fill the 12,000-gallon-capacity water storage tank. Figure 2-5 shows the model-simulated drawdown contours at the end of the 75-minute pumping period, while Figure 2-6 shows the model-simulated hydrographs of water levels over time at the production well and the 6 monitoring wells. Both figures indicate that the daily pumping activities at the production well have very little impact on groundwater flow at the CMLF. The model calculates a maximum drawdown of 0.06 feet at production well PW, caused by the 75 minutes of pumping; the drawdown is estimated to fully recover within 180 minutes (3 hours).

The calibrated model was also used to simulate a scenario of daily pumping at production well PW at 160 gpm for 866 minutes (or approximately 14 hours) to meet future water demand associated with the County's plans to expand the existing landfill to provide additional and improved municipal solid waste disposal and landfill diversion facilities. Figure 2-7 shows the model-simulated drawdown contours at the end of the 75-minute pumping period, while Figure 2-8 shows the model-simulated hydrographs of water levels over time at production well PW and the six monitoring wells. Both figures indicate that the projected future daily pumping activities at the production well have little impact on groundwater flow at the CMLF. The model calculates a maximum drawdown of 0.09 feet at production well PW caused by the 14 hours of pumping; the drawdown is estimated to fully recover 24 hours after pumping is ceased.

2.6.3 Groundwater Flow Characteristics

Monitoring wells at the CMLF are screened within the flank basal aquifer, which under HAR 11-58.1-16(b)(1) constitutes the uppermost aquifer (see Section 2.5 for a discussion of site geology). The flank lava flows of the Kula and Honomanu series underlying the site generally dip from southeast to northwest, with preferential groundwater flow in the direction of lava deposition and horizontal hydraulic conductivity typically 10 to 100 times greater than vertical hydraulic conductivity (El-Kadi and Moncur, 2006; Lau and Mink, 2006; Burnham et al., 1977). As a result of this anisotropy and of the effect of tidal fluctuation discussed in Section 2.6.1, the net groundwater flow within the underlying basal aquifer is toward the north-northwest, which is consistent with the general direction of deposition of the lava flows in which the uppermost aquifer is located.

The hydraulic conductivity and average linear groundwater velocity for the basal aquifer beneath the CMLF site were estimated considering findings from slug tests and constant-rate pumping tests conducted at the site in the past. In 1997, MFA conducted single-well (slug) tests on wells MW-1, MW-2, and MW-3. The tests yielded hydraulic conductivity values ranging from 8.5 to 19 feet per day (ft/day) (URS, 2011). In 2001, Earth Tech conducted additional single-well slug tests on wells MW-4, MW-5, and MW-6 that yielded hydraulic conductivity values of 52, 380 and 240 ft/day, respectively (URS, 2010). Collectively, this range of values from slug tests provides a geometric mean hydraulic conductivity for the site of 60 ft/day in the uppermost aquifer (CH2M, 2018b).

Pumping tests were also conducted at production well PW after installation to evaluate pump size and allowable flow rate. The constant-rate pumping test indicated that the basal aquifer is highly conductive with a specific capacity for well PW of approximately of approximately 440 gpm per foot. Hydraulic conductivity values were estimated from specific capacity using empirical equations developed by Rotzoll and El-Kadi (2008), which yields a hydraulic conductivity value ranging between approximately 1,500 and 2,560 ft/day (456 and 780 meters per day). An average hydraulic conductivity of 2,030 ft/day (approximately 620 meters per day) is estimated for the site using constant-rate pumping test data.

Considering the range in the average hydraulic conductivities estimated through slug tests (geometric mean K = 60 ft/day) and pumping tests (average K= 2,030 ft/day), average hydraulic gradient (i) of $9.7\text{x}10^{-5}$ ft/ft, and an assumed porosity (n) of 0.15 (Singhal and Gupta, 2010), the average linear groundwater velocity (v) within the basal aquifer beneath the CMLF site calculated using the equation $v = Ki/n$ is estimated between 0.04 ft/day (14 feet per year [ft/year], or 4 meters per year) and 1.3 ft/day (478 ft/year, or 146 meters per year), respectively. Because slug tests evaluate near-well aquifer properties and therefore sometimes underestimate hydraulic conductivity, the hydraulic conductivity values derived from the well PW pumping test data are probably more accurate. Consequently, the average linear groundwater velocity value estimated based on pumping test data (478 ft/year, or 146 meters per year) is considered more representative of actual aquifer conditions.

2.6.4 Groundwater Geochemistry

Groundwater general chemistry data for samples collected from 2015 through 2017 were evaluated using piper diagrams to synthesize normalized concentrations of negatively charged ions or anions (such as bicarbonate, carbonate, chloride, and sulfate) and positively charged ions or cations (such as calcium, magnesium, potassium, and sodium) on one graphical plot with axes in units of percent for each ion. Piper diagrams can be useful for understanding differences in general chemistry between wells and trends in chemistry between well locations across a site.

Piper diagrams for CMLF monitoring well sampling results for March 2017, June 2017, September 2017, and 2015 through 2017, together with data for a sample of typical sea water, are provided on Figures 2-9 through 2-12, respectively. As shown on Figures 2-9 through 2-12, data points are generally clustered together, indicating similar general chemical composition, except for downgradient monitoring well MW-2. Well MW-2 shows higher chloride and bicarbonate plus carbonate, moving toward the composition of typical sea water, relative to the other wells. As shown on Figure 2-12, there is an apparent trend in chemistry from upgradient well MW-6 to downgradient well MW-2 in the direction toward the composition of typical seawater.

2.6.5 Background Groundwater Concentrations

As further described in Section 3.1 and inferred from Figure 2-4, monitoring wells MW-1 and MW-6 are located upgradient of the CMLF, well MW-4 is located upgradient/crossgradient, and wells MW-2, MW-3, and MW-5 are located downgradient of various landfill SWMUs.

The analytical results for samples collected from monitoring wells along the upgradient edges of the facility (wells MW-1 and MW-6) are interpreted to be representative of the background groundwater quality conditions (i.e., the quality of groundwater migrating from upgradient areas onto the CMLF landfill property). Monitoring well MW-4 is located upgradient/crossgradient of SWMU Phase I & II, but probably too close to the edge of the waste to be considered representative of background groundwater concentrations.

Table 2-5 includes average concentrations for constituents detected in groundwater that are also present in leachate with a frequency of detection of at least 20 percent. In general, the two background wells resemble each other in chemistry, with reported average concentrations calculated over the past two decades that are very similar, with the following exceptions:

- Ammonia, barium, chromium, copper, and lead were detected in well MW-1 but not in well MW-6. However, detections in well MW-1 are very limited in number and are reported only for the first 2 years of monitoring.[2]
- Slightly higher chloride, total dissolved solids (TDS), and zinc average concentration in well MW-1 compared to well MW-6.
- Lower nickel average concentration in well MW-1 compared to well MW-6.

2.7 Constituents of Potential Concern

Constituents of potential concern (COPCs) are defined as chemicals detected in environmental media that are potentially accessible for human or ecological exposure. For the purpose of the groundwater detection monitoring program at the CMLF site, COPCs are defined as those constituents detected in leachate that could cause potential impacts to groundwater. Constituents that are detected in groundwater, but not in leachate (e.g., manganese, selenium, and silver), and constituents that are

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[2] Lead is not included in Table 2-5 because it was rarely detected in leachate (detection frequency of less than 20 percent).

detected in groundwater at concentrations higher than in leachate (e.g., nitrate, sulfate, and vanadium) are not considered landfill leachate-related COPCs (see Section 3.2.1 for more details).

Leachate-related COPCs in groundwater include the following (Table 2-5):

- Total organic carbon (TOC)
- TDS
- Alkalinity
- Aromatic volatile organic compounds (VOCs), including benzene, toluene, ethylbenzene, and xylenes (BTEX)
- Halogenated VOCs (HVOCs)
- Metals
- Ammonia

As further discussed in Section 3.2.1, this list of COPCs does not represent the list of constituents that should be monitored at the CMLF site as part of the groundwater detection monitoring program.

2.8 Potential Sources and Release Mechanisms

2.8.1 Potential Landfill Sources

The landfill and associated leachate is a potential source for dissolved constituents in groundwater beneath the facility. The SWMU Phase I & II are unlined; however, they are capped, and a dendritic leachate collection system is in place that terminates at Manhole 4, located at the boundary with Phase III, from which the leachate can be pumped. Because Phase I & II were constructed without a RCRA Subtitle D compliant liner, the potential for leachate infiltration from the base of Phase I & II into the underlying fractured basalt exists. However, data from previous investigations (Dames and Moore, 1998; CML, 2001) indicate that dry conditions prevail within Phase I & II waste mass, and observations made at the existing observation Manhole 4 since the closure of Phase I & II indicate no significant accumulation of leachate has occurred. A review of site records indicates that no leachate was detected in Manhole 4 during inspections conducted in fiscal year 2017. This indicates that the cover is preventing infiltration of storm water to these two waste management units.

The SWMUs Phase IV and Phase V are constructed with RCRA Subtitle D compliant composite liners to capture leachate, which is monitored and periodically removed from two collection systems at the northwestern end of the site. Leachate observations and removal records indicate that leachate generated in these SWMUs is being collected by the liner systems per the design specifications. For leachate to be released from Phases IV and V, the following would have to exist:

- A perforation in the liner and underlying geosynthetic clay layer at a location that would allow accumulated leachate to pass through the perforation to the underlying fractured basalt; and
- A defect in the leachate collection system piping or well/sump that would allow accumulated leachate to pass through to the underlying basalt.

Based on the engineering design criteria, operational records during initial fill operations at Phases IV and V, and leachate observations at the two sumps, it appears that the leachate collection system is operating per the design criteria and that leachate being generated in Phases IV and V is being adequately captured. Therefore, leachate resulting from potential breach to the containment system at Phases IV and V is considered an unlikely potential contaminant source.

2.8.2 Potential Alternative Sources

In addition to the landfill and associated leachate, there are other potential sources of dissolved constituents located both onsite and offsite upgradient of the facility. Potential alternate sources include the following (see Figure 2-2 for locations of the following land uses):

- Co-composting of green waste and biosolids within Phase III of the landfill
- Infiltration of stormwater that may have come in contact with contaminant sources
- Rock quarry and truck loading plant
- Agricultural areas upgradient of the landfill
- Seawater intrusion and mixing
- Trace elements naturally occurring in the basalt aquifer

The following sections provide additional details regarding dissolved constituents typically associated with each of the potential source areas listed above.

Co-composting of Green Waste and Biosolids

Co-composting operations at the facility currently include processing, composting, and blending of green waste and biosolids from the Kihei, Lahaina, and Wailuku-Kahului wastewater reclamation facilities, under HDOH Solid Waste Management Permit No. CO-0039-12 issued on February 19, 2014. Biosolids from the wastewater reclamation facilities are mixed with grit (untreated sewage), greenwaste, untreated and unpainted pallets and wood waste, mixed grease and sewage waste, and byproducts generated from fats, oil, and grease (FOG) operations to create a compost product that is subsequently sold for gardening and landscaping uses. Potable water is applied via a water truck or hose for dust control during composting operations.

Depending on the feedstock and the chosen composting technology, leachate, condensate, and runoff are generated. Composting leachate is currently collected at the active windrow piles and reused along the process in the sludge bay, premix pile, or both.

Based on general knowledge and laboratory analyses of biosolids from the wastewater reclamation facilities and leachate from the co-composting process, potential types of groundwater impacts related to green waste composting operations include the following:

- Changes in the pH of the groundwater
- Changes in biochemical oxygen demand (BOD)
- Increase in total suspended solids (TSS)
- Changes in the concentration of TDS
- Changes in chemical oxygen demand (COD)
- Input of dissolved constituents associated with petroleum, oils, and lubricants
- Input of nutrients including nitrogen and phosphorous
- Input of ammonia, chloride, and potassium
- Input of dissolved ions, such as calcium, sodium, and sulfate;
- Input of dissolved metals including barium, chromium, copper, iron, magnesium, manganese, mercury, vanadium, and zinc;
- Input of chlorine;

- Input of HVOCs; and
- Input of volatile fatty acids.

Stormwater Infiltration

Stormwater runoff can contain a variety of potential dissolved constituents derived from multiple sources including vehicles, airborne particulates, pavement erosion, co-composting activities, and impacted surface soils. Stormwater acts as a transport mechanism carrying suspended and dissolved constituents to potential human or ecological receptors. Stormwater infiltration has the potential to introduce pollutants into the subsurface, and to thereby impact groundwater quality. The County has implemented a stormwater pollution control and countermeasures plan to minimize the potential impacts of stormwater. Engineered controls implemented at the facility include the cap on closed SWMUs Phase I & II and daily cover on active landfill faces, which limit infiltration of precipitation into the landfill cells. Surface runoff is routed via a series of drainage swales to retention basins where the stormwater evaporates or infiltrates to the subsurface.

Potential types of groundwater impacts related to infiltration of stormwater that may have come in contact with landfill waste, co-composting material, or chemicals from agricultural lands include the following:

- Input of nutrients including nitrogen and phosphorous
- Input of dissolved metals including zinc, lead, copper, and cadmium
- Input of dissolved constituents associated with petroleum, oils, and lubricants
- Increase in TSS
- Input of potassium

Rock Quarry and Aggregate Plant

Quarry developments by their nature remove topsoil and overburden materials within the rock extraction area; these activities may change aquifer recharge characteristics and increase aquifer vulnerability. The impacts of these activities on the aquifer underlying the CMLF, if any, have not been evaluated to date. The quarrying activities at Phase VI have removed a significant amount of material, lowering the grade within the quarried area by up to approximately 60 feet from its original level. It is expected that the fractured rock exposed at the surface within the quarry area may transmit water discharged as part of the quarrying operation and surface runoff downward to the underlying aquifer. Dissolved constituents related to quarry operations may potentially be transferred by the water migrating downward through the basalt.

Potential types of groundwater impacts related to rock quarry operations include the following:

- Changes in groundwater pH.
- Changes in BOD.
- Increase in TSS.
- Changes in nitrate concentrations.
- Changes in COD.
- Input of dissolved constituents associated with petroleum, oils, and lubricants.
- Potential increase in metal concentrations (such as iron, vanadium and zinc), which are present in basalt. This may occur as a result of the rock being exposed to the atmosphere, causing oxidation and weathering thereby releasing metal constituents that could potentially migrate to groundwater.

Agricultural Operations

Agricultural fields surround the CMLF. Sugar cane was the primary crop produced in the surrounding agricultural lands. Although sugar cane production ended in late 2016, chemicals used during production may still be present in surface and shallow subsurface soil, constituting a potential alternative nonpoint source. In the 2000 National Water Quality Inventory, states reported that agricultural nonpoint source pollution was the leading source of water quality impacts on surveyed rivers and lakes, the second largest source of impairments to wetlands, and a major contributor to contamination of surveyed estuaries and groundwater (USEPA, 2002b).

Depending on the type and amount of constituents present, both soil and groundwater quality can be affected by dissolved constituents transported by irrigation water and stormwater runoff from agricultural areas. Potential types of groundwater impacts relating to sugar cane production operations include the following:

- Input of herbicides and pesticides
- Input of dissolved inorganic constituents including arsenic and mercury
- Input of dissolved constituents associated with petroleum, oils, and lubricants
- Input of nutrients including nitrogen, potassium, and phosphorous
- Increase in TSS

In addition to potentially contributing dissolved constituents to underlying aquifers, irrigation of agricultural lands can impact underlying groundwater as irrigation water is the main source of recharge for the underlying aquifer and can impact the thickness and depth of the transition zone between seawater and freshwater within the aquifer. In the area of the site, historical sugar cane production has impacted the aquifer underlying the Central Maui isthmus area, including the groundwater underlying the site (USGS, 2007). Preliminary research done by the USGS during the 1970s indicates that prior to approximately 1890, groundwater in the area of the CMLF was likely brackish. As sugar production increased, pumpage from the aquifer system underlying the site and application of irrigation water increased significantly. Application of imported fresh irrigation water far exceeded the rate of pumpage from the aquifer, resulting in a reduction in salinity of the aquifer between 1910 and 1970. This phenomenon was exacerbated by large recharge rates from irrigation water, with thickening of the freshwater lens, which ultimately resulted in falling of the transition zone. Data developed by the Hawaiian Commercial and Sugar Company from water samples collected at wells located near the site indicate that the mean annual chloride content in the underlying aquifer decreased from more than 1,200 milligrams per liter (mg/L) in 1910 to approximately 400 mg/L in 1970. The current range of chloride concentration in groundwater at the site is lower than that recorded in 1970, indicating that chloride concentrations have continued to decrease over time since 1970.

As sugar cane production and irrigation have decreased and ceased in the recent past, concentrations of chloride (and other major ions found in seawater) are expected to slowly increase over time because of lower recharge rates which can ultimately result in rising of the transition zone between freshwater and seawater (a phenomenon that has already been observed in the Maui aquifer systems). Therefore, the volume of irrigation water applied in the agricultural lands surrounding the site is considered to be a key factor influencing the concentrations of chloride in the aquifer, and potentially the concentrations of other dissolved constituents present in groundwater.

Seawater Intrusion and Mixing

In an unconfined aquifer that contacts the ocean at the shoreline, fresh groundwater, which is less dense than seawater, floats as a lens-shaped layer on top of underlying seawater, and the weight of the overlying freshwater depresses the seawater below sea level. In unconfined flank basalt aquifers in Hawaii, freshwater recharge typically moves downgradient and eventually discharges to low-lying coastal areas and into the sea. However, development of freshwater aquifers in Hawaii and decrease in groundwater recharge from irrigation and rainfall can reduce the weight of the overlying freshwater, resulting in a net decrease in the thickness of the freshwater lens and significant decline in water levels. In some cases where the freshwater lens is relatively thin, either because of natural conditions or where significant pumping or lower recharge effects occur, mixing of freshwater and the underlying seawater can occur. This migration or mixing of seawater into the freshwater aquifer is known as seawater intrusion.

The interface between the salty groundwater below and fresh groundwater above is a transition zone of gradually mixing fresh and saline waters. Under natural, undeveloped conditions, the location of this zone will move slightly as the tide rises or falls and as recharge fluctuates seasonally. However, when a well is used to pump fresh groundwater from near the transition zone, the equilibrium can be disturbed and the groundwater flow and mixing pattern can be altered. As water is pumped out of the water-bearing zone, the transition zone moves upward toward the well. Prolonged or large-scale pumping can raise the transition zone to the well, which may then draw in salty water. Similarly, seasonal fluctuations in precipitation, drought periods (with lower rainfall for extended periods), and a reduction in irrigation rates can result in a decrease in groundwater recharge, exacerbating seawater intrusion phenomena. Seawater intrusion within Maui aquifers due to the introduction of pumpage in 1948 and the reduction in recharge in the 1980s and 1990s is a documented phenomenon (USGS, 2000).

The location of the transition zone depends on several natural and human-made conditions: the relative densities of seawater and freshwater, the tides, the volume of water removed from that aquifer system via pumping wells, the rate of groundwater recharge (affected by precipitation and irrigation), and the hydraulic characteristics of the aquifer. Because these conditions vary locally, the depth to the transition zone below sea level varies from one place to another on the island.

Increased concentrations of chloride and other seawater ions in groundwater are a potential indicator of seawater intrusion. It is unknown what the exact thickness of the freshwater lens underlying the CMLF is, and whether seawater intrusion has the potential to impact ion concentrations in groundwater at the site. To further evaluate the evidence for potential seawater intrusion at the site, a comparison was made between site groundwater chemistry and the typical chemistry of seawater, as described in Section 2.6.4.

Seawater mixing may have a slight influence on groundwater chemistry beneath the CMLF. The groundwater data indicated a correlation between TDS and dominance of chloride in the water chemistry signature, suggesting a slight increasing influence of seawater chemistry progressing from upgradient well MW-6 northward toward the coast to downgradient well MW-2. It is expected that increased mixing of seawater and groundwater would be accompanied by increasing TDS and chloride dominance.

According to a study conducted by USGS that considered a 78-year period (1926-2004), estimated mean groundwater recharge in central and west Maui (study area of 51,000 acres) decreased 44 percent from 1979 to 2004 in Central Maui (USGS, 2007), mainly because of reduction in agricultural irrigation. Periods of lower-than-average rainfall have further reduced recharge. During the period 1926–1979, groundwater recharge averaged 693 million gallons per day (mgd), with average irrigation of 437 mgd and average rainfall of 897 mgd. A significant decline was observed during the period 2000–2004, with groundwater recharge averaging 391 mgd, irrigation averaging 237 mgd, and rainfall averaging 796 mgd. This decline in groundwater recharge, aggravated by the recent cessation of sugar cane production and a drought period with 50 percent lower than average rainfall between 2008 and 2013 (as measured at the Puunene Weather Station),[3] may have caused the rising of the transition zone, resulting in

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[3] As shown by the total annual precipitation data provided by the Western Regional Climate Center, average rainfall between 2008 and 2013 was 8.9 inches per year, versus an average calculated between 1950 and 2016 of 18.1 inches per year (https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?hi8543).

increasing concentrations for chloride and other seawater ions observed in groundwater across the site between 2010 and 2015.

As irrigation, pumpage, and precipitation patterns change, seawater intrusion phenomena are also expected to change, affecting groundwater geochemistry and quality over time.

Trace Elements in Basalt Aquifer

As with all aquifers, groundwater in basalt aquifers naturally contains a range of trace elements that originate from weathering and dissolution of minerals contained in the basalt and any relict soil horizons that may have formed between eruptive episodes. Because the basalt in Maui is geologically young (Haleakala volcanics are roughly 410,000 to 860,000 years old) and is composed of readily-weathered minerals, chemical alteration of basalt minerals is an ongoing process and should be considered when evaluating the presence and significance of chemical concentrations in groundwater (Macdonald et al., 1983; Swain, 1973). In addition, seawater, which underlies and surrounds the freshwater lens monitored in the uppermost aquifer beneath CMLF, also contains a broad range of trace elements at concentrations ranging from less than 1 mg/L to less than 1 microgram per liter (i.e., 0.001 mg/L). Trace elements that are of particular interest because their documented presence in CMLF groundwater are vanadium and zinc.

Vanadium is well-documented as a trace element in basalt aquifer groundwater and has been the subject of a public notice regarding its natural occurrence in Hawaii groundwater used for domestic supply (HDOH, 2014). As reported by the County of Maui Department of Water Supply (DWS) in the 2016 Drinking Water Quality Report prepared under the Safe Drinking Water Act (SDWA), vanadium is present in Maui drinking water sources at concentrations up to 0.036 mg/L (County of Maui, 2016). Vanadium was also detected in 100 percent of 30 water samples analyzed by USGS as part of the National Water Quality Assessment Program for Oahu (Anthony et al., 2004), where concentrations of vanadium ranged from 0.009 to 0.06 mg/L. The vanadium average concentrations calculated for CMLF monitoring wells between 1995 and 2017 are within these ranges, from a low of 0.017 mg/L in downgradient well MW-5 to a high of 0.023 mg/L in upgradient/background well MW-6 located near the rock quarry and aggregate plant (Figure 2-2). Moreover, vanadium is a naturally occurring metal in basalt and soils in Hawaii. A study completed by AECOM for HDOH in 2012 evaluated metals and other major ion concentrations in soils on the seven main Hawaiian Islands. Vanadium was detected in 100 percent of the 141 soil samples analyzed during this investigation, with concentrations ranging from 0.25 to 1,090 milligrams per kilogram (mg/kg). The two samples collected nearest to the CMLF (about 3 miles north of the site) had concentrations of 149 and 162.5 mg/kg (AECOM, 2012).

Zinc in groundwater is less well-documented because, like vanadium, it is not regulated under the SDWA. However, unlike vanadium, which is required to be monitored as an unregulated constituent under Phase 3 of the Unregulated Constituent Monitoring Regulation (77 Federal Register p. 26072-26101), zinc is not required to be monitored. Consequently, little information exists on the occurrence of zinc in groundwater in Hawaii. Oki et al. (1999) reported a zinc concentration of 0.01 mg/L for a well at the Kaloko-Honokohau National Historical Park on the island of Hawaii. Zinc has also been reported in the Pearl Harbor basal aquifer at a concentration of 0.0035 mg/L. These concentrations are similar in magnitude, but slightly less, than the average concentrations observed in CMLF monitoring wells between 1995 and 2017, which ranged from 0.012 mg/L in well MW-4 to 0.026 mg/L in well MW-2. Similar to vanadium, zinc is also a naturally occurring metal in basalt and soils in Hawaii. Zinc was detected in 100 percent of the 125 soil samples analyzed during the 2012 AECOM study, with concentrations ranging from 3.57 to 1,200 mg/kg. The two samples collected nearest to the CMLF (about 3 miles north of the site) had concentrations of 153 and 349 mg/kg (AECOM, 2012). Therefore, it is considered likely that at least a portion of the dissolved zinc typically present in groundwater beneath the facility is derived through dissolution of naturally occurring zinc in the basalt that comprises the aquifer matrix.

Other trace elements that are typically found in basalt on the Hawaiian Islands are aluminum, barium, beryllium, chromium, cobalt, copper, iron, manganese, nickel, potassium, and titanium (100 percent detections in the 2012 study by AECOM). However, except for iron and potassium, these elements are generally found at very low concentrations or not detected in groundwater beneath CMLF. Iron and potassium are present in the basal aquifer beneath CMLF at average concentrations up to 0.1 and 15.1 mg/L, respectively. The AECOM 2012 study shows that iron was detected in 100 percent of the 104 samples collected across the state, with the concentrations ranging between 1,713 and 260,082 mg/kg; the two samples collected nearest to the CMLF (about 3 miles north of the site) had iron concentrations of 86,100 and 89,900 mg/kg (AECOM, 2012). Potassium was also detected in 100 percent of the 92 samples collected, with a concentration ranging between 37 and 10,850 mg/kg; the sample collected nearest to the CMLF (about 8 miles southeast of the site) had a potassium concentration of 673 mg/kg (AECOM, 2012). Therefore, it is considered likely that at least a portion of the dissolved iron and potassium typically present in groundwater beneath the facility is derived through dissolution of naturally occurring elements in the basalt that comprises the aquifer matrix.

2.9 Fate and Transport of Dissolved Constituents

Fate and transport of dissolved constituents in the subsurface are affected by the physical properties of the subsurface materials and the physiochemical and biological properties of the constituents. The three most important processes affecting the behavior and partitioning of constituents in the subsurface are hydrodynamic, abiotic, and biotic processes. Hydrodynamic processes influence the movement of groundwater and dissolved constituents in the subsurface, and include advection, dispersion, diffusion, and preferential groundwater flow. Chemicals that are nonreactive will move through the subsurface environment with the groundwater and will be unaffected by abiotic or biotic processes. Constituents that have the potential to be reactive may be affected by abiotic or biotic processes if the subsurface geochemical conditions are favorable to the reactions that affect the constituents. Abiotic processes are transformations resulting from interactions between the constituent and the subsurface materials through which the constituent is moving. Constituent concentrations in groundwater may be altered by adsorption to subsurface materials, geochemical controls on solubility, volatilization, or ion exchange. Biotic processes are transformations resulting from the activity of microorganisms, and can influence constituent transport by degrading the constituent, immobilizing the constituent, or using the constituent in metabolic processes.

The aquifer underlying the CMLF is found in fractured basalt bedrock. Because of the effects of fracture geometry and spacing and the presence of erosional unconformities, the fate and transport of constituents at sites underlain by fractured rock are complex and difficult to predict and measure than at sites where the subsurface consists of granular porous media. In general, constituents originating within the landfill would occur in leachate and could be released to fractured rock beneath the landfill cells through imperfections or defects in the liner or leachate recovery systems. Leachate potentially released from the landfill could migrate downward through interconnected fractures in the basalt bedrock until reaching groundwater. Upon reaching groundwater, the fluids could mix with the groundwater, and constituents would partition into it. Once partitioned into groundwater, the fate and transport of dissolved constituents would then be influenced by the processes described above. Anisotropic conditions in fractured basalt could affect the travel of fluids migrating down from the landfill cells, and also the localized flow of groundwater beneath the landfill. The results of the pressure transducer study conducted by Element (2014) and subsequent evaluation of tidal effects on groundwater conducted by CH2M (Section 2.6.1) indicate that the fractured basalt conditions may have localized effects on groundwater flow, but the net hydraulic gradient is downgradient to the north-northwest. Ultimately, it is anticipated that net groundwater flow, and therefore constituent transport, would be in the downgradient direction.

Organic and inorganic compounds and elements have their own distinct set of physiochemical characteristics that affect their behavior in the environment. The potential for a particular constituent to be mobile within the subsurface depends on the particular properties of the constituent, along with the subsurface conditions.

Groundwater affected by municipal solid waste landfill (MSWLF) leachate typically is characterized by elevated concentrations of dissolved ions and geochemical effects caused by the biochemical oxygen demand exerted by dissolved organic matter in leachate, which is actively degraded by bacteria leading to anaerobic conditions at and in the immediate vicinity of the landfill. Bicarbonate alkalinity commonly is elevated near landfills because of the carbon dioxide produced by microbial respiration. Sulfate may be present as well, particularly if the landfill received gypsum wallboard as a component of its waste stream; however, under highly reducing conditions, sulfate may be converted to sulfide by bacterial respiration. If present, sulfide may exert controls on dissolved metal solubility and mobility by precipitation of essentially insoluble metal sulfides.

Constituents that are susceptible to geochemical reduction, particularly iron and manganese along with arsenic, may enter solution at and in the immediate vicinity of a landfill because (for iron and manganese) these metals have greater solubility in their reduced valence state rather than in the oxidized form. Arsenic is often observed in groundwater at MSWLFs because iron oxyhydroxides are potent sorbents for arsenic. If ferric (+3) iron is reduced to ferrous (+2) iron in minerals within the aquifer matrix such that the iron enters solution, adsorbed arsenic also will be released to solution in groundwater. Consequently, even if arsenic is not present at appreciable concentrations in the MSWLF refuse, groundwater near the landfill may reflect locally elevated arsenic concentrations because of naturally occurring arsenic entering solution, along with iron, as a result of the depressed oxidation-reduction (redox) conditions exerted by landfill leachate on groundwater.

The effect of leachate on groundwater quality dissipates as one moves downgradient because of a variety of factors, including the following:

- Dispersion and diffusion - Can attenuate concentrations by mixing between a plume potentially associated with a release from a landfill and nearby, unaffected groundwater. These processes also can attenuate the reducing conditions associated with landfill leachate by reducing concentrations of dissolved organic matter in groundwater, limiting the lateral extent of reducing conditions.
- Recharge downgradient of the landfill – Similar to dispersion, recharge water from precipitation and irrigation can attenuate concentrations of dissolved constituents and geochemically reducing conditions with increasing distance away from a landfill.
- Cation exchange processes – As described by Christensen et al. (1992) cation exchange involves a cation associating and exchanging site with another cation that is expelled. In many aquifers, the cation exchange sites are saturated with calcium, magnesium, and, at low pH, with protons. In saline soils, sodium will dominate. Upon exposure to leachate, having a different relative cationic composition than the natural groundwater, these saturating cations will be expelled and move with the leachate front in concentrations in excess of the leachate concentrations. This effect is so pronounced that a “hardness halo” is commonly observed in the immediate vicinity of landfills because of monovalent cations being exchanged for divalent cations, namely calcium and magnesium. Hardness is a water quality property directly related to the concentration of divalent cations in water. Clay minerals that may be present in the aquifer from subaerial soil development and mineral weathering between volcanic eruptive sequences can also play an important role in attenuating the concentration of monovalent cations, namely sodium and potassium, at the CMLF.

Because of these processes, many landfill water quality effects tend to dissipate fairly rapidly with distance away from the landfill. The elevated calcium and magnesium concentrations associated with cation exchange are themselves attenuated by cation exchange processes farther downgradient, as the sodium and potassium concentrations decrease because of dispersion and recharge mixing. Iron and manganese, along with artificially elevated arsenic concentrations, tend to decrease rapidly as groundwater moves away from the geochemical effect of the landfill and the geochemically reduced groundwater (in other words, redox conditions associated with anaerobic groundwater) returns to its typical aerobic nature. Similarly, elevated alkalinity typically decreases rapidly with distance away from a landfill and its microbial population. Because of its geochemically conservative (i.e., essentially nonreactive) nature, chloride tends to have the greatest persistence of common MSWLF leachate constituents.

In summary, many of the chemical effects of MSWLF leachate may potentially occur at or in the immediate vicinity of the downgradient portion of the landfill, and only certain constituents (such as chloride) exhibit the ability to form more laterally extensive plumes. However, observed variations in chloride concentrations in the aquifer underlying the site may be, in part, as a result of natural variations caused by seawater intrusion unrelated to the landfill operations.

2.10 Evaluation of Landfill Impact on Groundwater Quality

As further described in Section 3.1 and inferred from Figure 2-4, monitoring wells MW-1 and MW-6 are located upgradient of the CMLF, well MW-4 is located upgradient/crossgradient, and wells MW-2, MW-3, and MW-5 are located downgradient of the closed, active, and future landfill SWMUs.

The MSWLFs have well-documented effects on groundwater quality (Apgar and Langmuir, 1972; Baedecker and Back, 1979; Nicholson et al., 1982, and Christensen et al., 1992). Among the typical effects of MSWLFs on the chemistry of groundwater are the following:

- Elevated concentrations of multiple leachate constituents normally not detected (or present at low concentrations) in groundwater
- Substantially elevated TDS because of the ionic strength of landfill leachate
- Elevated bicarbonate alkalinity related to dissolved carbon dioxide in water originating from respiration of microbes degrading refuse in the landfill
- Elevated sodium and chloride concentrations because of the prevalence of materials containing these ions in municipal solid waste refuse (however these constituents can also be attributed to seawater intrusion effects)
- An increase in hardness from ion exchange processes where monovalent ions (especially sodium and, to a lesser extent, potassium) are exchanged on clay minerals for divalent ions (specifically, calcium and magnesium)
- Geochemically reduced groundwater, as indicated by the following factors:
  - Depressed or negative redox values
  - Elevated concentrations of dissolved (ferrous) iron
  - Depressed or below-reporting-limit values for oxidized anions such as sulfate and nitrate, as the sulfur and nitrate ions are converted to sulfide and ammonium

2.10.1 General CMLF Conditions

Analysis of leachate samples collected from the Phase IVA and IVB leachate sumps are consistent with typical MSWLF conditions summarized above. For example, leachate samples collected over the past 11 years indicate the following (Table 2-5):

- **Elevated TDS –** Leachate TDS has ranged from 1,370 to 4,308 mg/L, with an average concentration of 2,877 mg/L.
- **Elevated total and bicarbonate alkalinity –** Leachate total alkalinity ranged from 107 to 2,300 mg/L, with an average concentration of 1,424 mg/L.
- **Elevated sodium and chloride concentrations –** Both chloride and sodium are present in leachate at relatively high concentrations, with chloride ranging from 170 to 1,600 mg/L (average of 751 mg/L) and sodium concentrations ranging from 192 to 925 mg/L (average of 528 mg/L). However, groundwater chloride and sodium data should be used with caution because both ions are major components of seawater; spatial and temporal variability in the concentrations of these ions in basal aquifer groundwater, which occurs as a comparatively lower-density freshwater lens floating on higher-density seawater, are expected and have been described in the literature (Lau and Mink, 2006). In fact, chloride concentrations in groundwater in Hawaii are used as an indicator of seawater intrusion (Swain, 1973), and concentrations of these constituents in groundwater beneath the landfill (including upgradient and crossgradient wells) are relatively high up to 259 and 216 mg/L, respectively.
- **Increased hardness –** Although this effect is related more to water quality evolution that occurs when leachate interacts with minerals in the unsaturated and saturated zones of the subsurface, leachate at CMLF has elevated concentrations of divalent metals (calcium and magnesium) compared with what has been detected in groundwater. Specifically, leachate has average concentrations of 302 mg/L for magnesium and 69 mg/L for calcium. Increased hardness, or a "hardness halo," has not been observed in groundwater at CMLF.
- **Geochemically reducing conditions –** Leachate at CMLF is consistent with geochemically reducing conditions in the landfill, as indicated by the presence of reduced nitrogen (ammonia), elevated dissolved ferrous iron concentrations (up to 23 mg/L, with an average concentration of 5.67 mg/L), and low sulfate concentrations (mostly non-detected [37 percent detections] or below 2.5 mg/L, with an overall average concentration for the detections of 9.69 mg/L). If leachate were impacting groundwater, it would be expected that groundwater in the affected area would exhibit more reduced (anaerobic) conditions than unaffected groundwater (background conditions). This is not the case at CMLF wells, where dissolved oxygen is relatively high (generally between 5 and 10 mg/L), the redox potential is positive, and ammonia and ferrous iron are generally not detected or are present at low concentrations. Sulfate concentrations are elevated across the site (and higher than leachate), and they are probably affected by seawater intrusion.

Based on comparison of typical landfill effects and leachate quality with the groundwater quality data presented in Table 2-5 and Appendix G, no clear indication exists of landfill effects on groundwater quality at CMLF. While exceedances of the old CLs were observed in the past for TOC, chloride, nitrate, magnesium, sodium, and sulfate, and concentrations of some constituents (such as chloride and magnesium) were generally higher in downgradient well MW-2 compared to other wells, total alkalinity and metals are generally higher in the upgradient wells. In addition, no increasing trend of concentrations for a group of typical leachate constituents is observed, exceedances of CLs in the past were limited to one or two constituents during a single monitoring event, and the VOCs that are present in leachate have not been detected in groundwater samples collected from site wells.

However, increasing concentrations of the seawater ions chloride, calcium, magnesium, potassium, sodium, and TDS were observed between approximately 2010 and 2015 at all site monitoring wells, including the upgradient/background wells (see Appendix E, Attachment 1). After 2015, concentrations of these seawater ions started to decrease at all wells except monitoring well MW-2 where concentrations of some of these constituents (e.g., calcium, chloride, and TDS) continued to increase. This is evident also from Table 7 of Appendix E, which includes the results of the Mann Kendall statistical trend testing conducted on groundwater concentrations between 2008 and 2017. From this table, it is evident that calcium, chloride, nickel, sulfate, and TDS are increasing with statistical significance only at monitoring well MW-2.

Groundwater samples collected from MW-2 show a significantly different chemical signature and distinct behavior compared to other site monitoring wells (see Section 7 of Appendix E for more details), suggesting a potential longer-term impact from external sources. The temporary increase in seawater ion concentrations observed at all wells between approximately 2010 and 2015 is possibly the result of a period of drought recorded at the Puunene weather station, with an average annual rainfall between 2008 and 2013 of 8.9 inches per year (more than 50 percent lower than the average recorded between 1950 and 2017 [see Section 2.1 for more details]). This drought, together with the constantly decreasing commercial agriculture irrigation rates in recent years, may have caused a significant reduction in fresh-water recharge to the aquifer, resulting in thinning of the freshwater lens with subsequent rising of the transition zone. This phenomenon can cause mixing of salt water with the fresh water lens, resulting in increasing concentrations of the typical seawater ions in groundwater in the unconfined basal aquifer beneath the site. The consistent presence and similar temporal variation for seawater constituents at upgradient/background monitoring wells indicate that the episodic increase in concentrations was likely caused by natural/background variation, rather than landfill-related releases to groundwater.

The presence of the same constituents in groundwater at concentrations fluctuating over time, hovering close to and sometimes slightly exceeding the old CLs at all site wells, including upgradient/ background wells, is indicative of background aquifer conditions. Additional evidence of no leachate impact includes the presence of some of these constituents at concentrations in groundwater higher than in leachate (e.g., nitrate, nickel, sulfate and vanadium).

As indicated in Table 2-5, the presence of sulfate and nitrate in groundwater above reporting limits in all wells (and at concentrations greater than in leachate), and the absence of dissolved iron, together with the aerobic nature of the groundwater (positive redox values and several mg/L of dissolved oxygen [see Appendix G]) all suggest the lack of a water quality signature characteristic of leachate releases from a MSWLF. In addition, many constituents that are present at relatively high concentrations in leachate (such as BTEX and halogenated VOCs) are not detected in groundwater.

Therefore, it is concluded that based on recent and historical data there is no evidence that leachate is impacting groundwater quality beneath the landfill.

Slight temporal fluctuations in dissolved constituent concentrations are expected to continue to occur in groundwater at the site because of contributing factors such as ongoing effects of changes in pumping and irrigation activities, annual rainfall, seawater intrusion, and other potential point sources of dissolved constituents. It is therefore recommended that a shorter list of monitoring constituents be developed based on observed site conditions, targeting those constituents that are (1) routinely detected in leachate at concentrations significantly higher than groundwater, (2) mobile, and (3) less influenced by temporal fluctuation in background concentrations (further discussed in Section 3.2.1). This shorter list of constituents would also decrease the number of false-positive results unnecessarily triggering assessment monitoring, while reducing the overall monitoring costs, as recommended in the HDOH Landfill Groundwater Monitoring Guidance (HDOH, 2002).

2.10.2 Evaluation of Higher and Increasing Concentrations in Compliance Monitoring Well MW-2

Higher concentrations of some seawater ions (e.g., calcium and chloride) and TDS have been observed in groundwater monitoring well MW-2, where concentrations started to increase in 2010 and have continued to increase even after 2015, when they started to decrease at other wells. This indicates that seawater intrusion may have been a factor for the sitewide increase between 2010 and 2015, but also that other factors may be contributing to the higher and increasing concentrations in monitoring well

MW-2. Although the concentrations of these constituents remain below the 2016 UPLs, concentrations of some groundwater constituents are statistically increasing over time, indicating a potential impact to groundwater. To better understand the potential causes for the higher and increasing concentrations of the seawater ions and TDS in MW-2, an additional evaluation was conducted.

Monitoring well MW-2 is located at the downgradient edge of landfill cell Phase III, approximately 670 feet (at its closest point) from the downgradient boundary of the closed SWMU Phase I & II (Figure 2-2). Phase III is currently leased to an external contractor (EKO) that uses the area for co-composting activities. No solid waste disposal is conducted in this area. The co-composting activities started in 1993 and have been conducted by EKO since 1995.

A general description of the Co-composting Area and process follows, along with an evaluation of the potential causes of increasing concentrations of seawater ions and TDS in groundwater at monitoring well MW-2.

Co-composting Area and Processes

The Phase III area comprises approximately 18 acres, of which approximately 8 acres are used for co-composting processing activities. The Co-composting Area is surrounded by the following (Figure 2-2):

- Ameron Quarry and Aggregate Plant to the north and northeast (i.e., mostly downgradient of the Co-composting Area and monitoring well MW-2)
- Closed CMLF SWMU Phase I & II to the south and southeast (upgradient of MW-2)
- Active CMLF SWMU Phases IV and V to the west and south (crossgradient of well MW-2).

Sludge from the Kahului, Kihei, and Lahaina wastewater treatment facilities is processed at the Co-composting Area, together with green waste, agricultural byproducts, and other organic materials, to produce a compost product sold in-state as soil amendment. The area is also used for storage and packaging of the finished product. Activities at the Co-composting Area are regulated by the HDOH through the following:

- Solid Waste Management Permit No. CO-0039-12 for Co-Composting and FOG Recycling Facility County of Maui and EKO Systems, Inc. dba Maui EKO Systems, Inc., Central Maui Landfill, Phase III, Puunene, Maui, TMK: 3-8-03:019, issued by the HDOH SHWB on February 19, 2014.
- The conditions of the National Pollutant Discharge Elimination System General Permit specified in HAR Chapter 11-55, Appendix B, requiring a Stormwater Pollution Control Plan (SWPCP) to be prepared to allow discharge of stormwater at industrial facilities. The SWPCP for the EKO compost recycling facility at CMLF was prepared by Brown and Caldwell (Brown and Caldwell, 2017).

The co-composting process includes several treatment and stockpiling stages, which are summarized in this section (see Figure 2-13 for a schematic). The biosolids, grit, mixed grease and sewage waste, biodiesel production byproducts, and grease trap waste are received in the sludge bay and receiving pit (feature 1 on Figure 2-13). From the receiving pit, the sludge and biosolids are loaded to the premix pile (feature 2 on Figure 2-13) and mixed with green waste to then be treated at the aerated, active windrow piles (feature 3 on Figure 2-13) of Composting Phase 1 for approximately 3 months (Ronald M. Fukumoto Engineering, Inc. [RFE], 1995). The active windrow piles are situated on bulking agents composed of mulch and screen rejects to capture leachate percolating through the piles. The piles are also covered with 6 to 12 inches of the same bulking material to prevent rainwater infiltration. Condensation traps and a leachate recovery system are connected to the aeration fans of the active windrow piles to collect moisture, which is piped underground to the sealed leachate condensation sump/septic tank (feature 4 on Figure 2-13). The sump is monitored by operations staff and excess leachate is pumped to the sludge bay (feature 1 on Figure 2-13), premix pile (feature 2 on Figure 2-13), or both (Brown and Caldwell, 2017). Extra runoff moisture from Composting Phase 1 is collected in the condensation swale (feature 5 on Figure 2-13), which in the past appeared to discharge to the stormwater basin (feature 6 on Figure 2-13) located at the northern boundary of the Co-composting Area, in proximity of monitoring well MW-2. In 2015, the County received a notice of violation for improper implementation of best management practices (BMPs) resulting in sediment-laden process water discharging to the stormwater basin (HDOH, 2015). Since then, this discharge has been mitigated by the construction of mulched material berms at downgradient locations.

After Phase 1 treatment, the compost product is staged at the Phase 2 curing piles (feature 7 on Figure 2-13) for at least another 3 months (RFE, 1995). Finished compost is screened into various piles at the Phase 3 finished product piles (feature 8 on Figure 2-13), where each batch is labeled and kept segregated from other batches before being loaded for delivery at the bulk product loading and shipping area (feature 9 on Figure 2-13).

Based on construction design documents and the SWPCP, BMPs are implemented to manage stormwater at the site. Berms were built around the site to retain runoff from a 25-year, 24-hour storm within the site and to divert offsite runoff around the site. A ditch along the southern boundary and a swale along the eastern boundary diverts runoff away from the landfill, and Kalialinui Gulch serves as a natural diversion along the southwesterly side of the Co-composting Area. In addition, the Co-composting Area is graded with a minimum slope of 2 percent to prevent ponding at the site.

The stormwater basin adjacent to monitoring well MW-2 (feature 6 on Figure 2-13) was designed with an 18-inch thick layer of impervious clay material (RFE, 1995). However, based on information provided by County representatives, this impervious clay layer was excavated during construction activities conducted to enlarge the capacity of the stormwater basin after a big storm event in 1996. As discussed in the 2017 SWPCP (Brown and Caldwell, 2017), stormwater from the basin currently infiltrates into the underlying soil, evaporates, and is used for compost moisture conditioning, or is used as irrigation water along the grass-lined structural BMPs.

Based on the construction design documents (RFE, 1995), boring log for well MW-2, and information provided by County representatives and site staff, the Co-composting Area surface consists of compacted crusher waste (aggregate rock similar to ¾-inch-minus gravel) on top of silty clay and gravel (probably weathered basalt) and basalt (see Appendix I for the MW-2 boring log).

Potential Causes of Higher and Increasing Concentrations in MW-2

An evaluation was conducted of potential sources causing the higher and increasing concentrations of seawater ions and TDS in monitoring well MW-2. Available information was reviewed, including groundwater concentrations over time and activities conducted in the vicinity of and hydraulically upgradient of MW-2.

The concentrations of seawater ions and TDS in monitoring well MW-2 have fluctuated over time. Results of trend analysis using the Mann-Kendall test on groundwater data collected at the site between 2008 and 2017 show an overall statistical increase for the following constituents at well MW-2 (see Table 2-6 and Table 7 of Appendix E): calcium, chloride, magnesium, nickel, nitrate-N, potassium, sodium, sulfate, and TDS. As is evident from the tables and Attachment 1 of Appendix E, this increase in concentration has been more significant and consistent in well MW-2 compared to other wells after approximately 2010. Some constituents (i.e., calcium, chloride, nickel, sulfate, and TDS) are statistically increasing only at well MW-2 (no trend identified or decreasing trend is observed at other wells).

Based on the location of MW-2, potential sources located hydraulically upgradient that could have caused higher and increasing concentrations in this well include seawater intrusion phenomena, solid waste disposal activities conducted within SWMU Phase I and II, and ongoing co-composting activities conducted within Phase III since 1993. The relevance of these potential sources to the higher and increasing concentrations of seawater ions and TDS in monitoring well MW-2 is discussed below.

Seawater Intrusion – Increasing concentrations of seawater ions were observed in samples collected from all site monitoring wells between 2010 and 2015, after which concentrations started to decrease, except at monitoring well MW-2 (see the figures in Attachment 1 of Appendix E). This temporary increase is interpreted as being attributable to decreasing aquifer recharge, which possibly occurred because of a period of drought recorded at the Puunene weather station between 2008 and 2013 (where average annual rainfall was more than 50 percent lower than the average rainfall recorded between 1950 and 2017). Declining recharge has been aggravated by decreasing irrigation in the recent years, resulting in rising of the seawater/fresh groundwater transition zone, with increasing concentrations of seawater ions in the unconfined basal aquifers of central Maui. This temporary effect is possibly reflected in the aquifer beneath the CMLF, with some temporal delay (approximately 2 years). In 2015, concentrations of seawater ions and TDS in all wells except MW-2 started to decrease. Although seawater intrusion may have been a factor in the temporary increase in concentrations between 2010 and 2015 at monitoring well MW-2, a different chemical signature and distinct behavior is observed at this well, where concentrations are noticeably higher and continued to increase consistently after 2015 for some constituents (such as calcium, chloride, nickel, sulfate) and TDS (see additional discussion on MW-2 chemical signature/behavior in Appendix E). It is therefore possible that other potential causes are responsible for the higher and increasing concentrations at well MW-2.

Solid Waste Disposal Activities at Phase I and II – SWMU Phase I & II reached its final grade in 2005, and the cell was closed with a low permeable and vegetated cap in 2006. Since monitoring started in 2006, no leachate was ever observed at the collection system present at the lowest point of the unlined subgrade of the closed SWMU Phase I & II. The lack of disposal activities and lack of leachate for the past 13 years suggest that it is very unlikely that this SWMU is the cause of higher and increasing concentrations of seawater ions and TDS in monitoring well MW-2. In addition, groundwater modeling and evaluations conducted for the CMLF in 2017 (see Section 2.6.2 for more details) show that well MW-3 is not only physically closer to the downgradient boundary of SWMU Phase I & II, but also more directly downgradient of this SWMU compared to well MW-2 (Figure 2-4). It is assumed that if concentrations in well MW-2 were higher and increasing because of leachate generated within SWMU Phase I & II (one line of evidence), the same (or more prominent) chemical signature and behavior and trend would be observed in well MW-3 (a second line of evidence), but it is not. Therefore, based on this lack of multiple lines of evidence, it is concluded that it is unlikely that increasing concentrations in well MW-2 are originating from SWMU Phase I & II.

Co-composting Activities within Phase III – The SWPCP (Brown and Caldwell, 2017) identifies potential sources of stormwater pollution present within the Co-composting Area. The most significant sources that are relevant to the potential migration of chemical constituents to groundwater are stormwater runoff coming into contact with equipment and materials (including compost) stored uncovered in various areas of the site (e.g., the receiving pits and composting piles) and excess process water/leachate generated within the windrow piles of Composting Phase 1 mixed with stormwater runoff and conveyed through the condensation swale. Activities within the Co-composting Area are conducted on compacted crusher waste base layer, a permeable granular material, laying on top of silty clay and gravel. In addition, in the past, the condensation swale collecting excess moisture from the windrow piles mixed with stormwater runoff appeared to be connected to the stormwater basin located at the northern boundary of the Co-composting area, in close proximity to monitoring well MW-2. The lack of an impermeable layer or liner at the surface across the Co-composting Area and the potential reuse of runoff water from the stormwater basin back into the composting process or as irrigation water create a potential pathway for the migration of chemical constituents from the Co-composting Area into the subsurface and eventually to groundwater. Overflow from the stormwater basin to adjacent areas, where MW-2 is located, and then to Kalialinui Gulch is also a potential source of concern (in case of an intense rain event in excess of a 25-year, 24-hour storm).

In 2015, the County received a notice of violation for improper implementation of BMPs and process water from the Compost Phase I operation (windrow piles) mixed with stormwater runoff mobilizing to the stormwater basin (HDOH, 2015). Since 2015, discharge of process water runoff into the stormwater basin has been mitigated by constructing downstream berms from mulched material.

To further evaluate the Compost Phase I operations as a potential source responsible for higher and increasing concentrations of ion constituents in groundwater at well MW-2, a liquid sample was collected in March 2018 from the condensation sump/septic tank that collects leachate from Compost Phase 1 (feature 4 on Figure 2-13). The sample was analyzed for chloride, nitrate, sulfate, total metals/major ions, and TDS. Analytical results are presented in Table 2-6, where Compost Phase 1 leachate concentrations are also compared to concentrations present in groundwater at monitoring well MW-2. As highlighted in red text in Table 2-6, it is evident that concentrations for all the constituents that are statistically increasing in groundwater (i.e., calcium, chloride, magnesium, nickel, nitrate-N, potassium, sodium, sulfate, and TDS) are significantly higher in Compost Phase I leachate than in groundwater (with the exception of nitrate-N). The Compost Phase 1 leachate/groundwater concentration contrast for these constituents ranges from 5.4 to 390. Nitrate-N concentrations are higher in groundwater, with a Compost Phase 1 leachate/groundwater contrast of 0.03 (similar to the landfill leachate/groundwater contrast observed for SWMU Phase IV leachate). Compost Phase 1 concentrations are also significantly higher than the SWMU Phase IV leachate average concentrations (see Table 2-5 for SWMU Phase IV leachate average concentrations).

Therefore, biosolids processed at the Co-composting Area in future Phase III of the landfill and the Compost Phase 1 leachate are rich in the same constituents that are noticeably higher and increasing in groundwater at monitoring well MW-2 compared to other wells. Runoff within the Co-composting Area, mixed with process water observed in the past ponding at the surface and discharging to the stormwater basin, may have led to migration of these constituents to the aquifer in the vicinity of MW-2 through infiltration via the surface soil and then fractures in basalt. The absence of an impermeable pavement at the surface of the process/stockpile areas of the Co-composting Area may have facilitated infiltration phenomena. Also, as reported in the SWPCP (Brown and Caldwell, 2017) overflow of water from the stormwater basin possibly occurred in the past during intense rain, resulting in flooding of the area around well MW-2,[4] with possible pathways for the potential migration of constituents to the aquifer through the fractured basalt and at the surface between the well annular space and the soil/basalt formation.

It is therefore concluded that the most plausible source responsible for higher and increasing groundwater concentrations in monitoring well MW-2 are the effects of the nearby co-composting activities conducted within Phase III of the landfill. Ponding and discharge of runoff and process water to the stormwater basin adjacent to MW-2 documented in the past have been mitigated and, although they may no longer represent a concern, the effects of past activities may still be seen in the aquifer today (e.g., the effects of precipitation changes on aquifer recharge that is ultimately impacting groundwater quality is observed 2 to 3 years later). However, the lack of an impermeable layer at the stockpile/treatment portions of the Co-composting Area and at the bottom of the stormwater basin, along with the possible overflow or reuse of water from the stormwater basin, remain potential concerns; runoff mixed with processed water or compost material infiltrating into the ground and percolating to the aquifer still represents a potential migration pathway. Although the co-composting activities within Phase III of the landfill are planned to end in 2019, some mitigation measures have already been implemented after the notice of violation in 2015 and no exceedances of the current UPLs have been observed in the recent past, with concentrations that started to decrease in early 2018 (see Attachment 1 of Appendix E and the most recent groundwater detection monitoring report [CH2M,

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[4] Per the SWPCP (Brown and Caldwell, 2017), the stormwater basin is sized for a 25-year, 24-hour storm and could overflow to the adjacent areas in the event of a larger storm event.

2018a]). In addition, the County is working with EKO to evaluate additional control measures as necessary, to further mitigate potential migration. These may include preventing process water from coming in contact with stormwater runoff or not reusing water from the stormwater basin for irrigation purposes. In addition, the County will continue monitoring detection monitoring constituent concentrations in groundwater at monitoring well MW-2 in the near future (before co-composting activities end) to further evaluate higher and increasing concentrations at monitoring well MW-2 over time. Although the latest groundwater monitoring results from 2018 were received as this document was being submitted and have not been included in the statistical evaluations, the preliminary data show that constituent concentrations in MW-2 in 2018 are generally lower compared to December 2017 (CH2M, 2018a). This reinforces the conclusions that UPLs are currently not exceeded, monitoring should continue, and additional assessment is needed to evaluate long-term trends at monitoring well MW-2.

3 Groundwater Monitoring

This section presents the updated groundwater monitoring program, which will be implemented at the CMLF to monitor groundwater quality and potential impacts from landfill leachate that may occur in the future. The current groundwater monitoring network is presented and an assessment is conducted to evaluate if and where additional monitoring wells are needed to improve the current monitoring network. Groundwater monitoring constituents, background and applicable protection standards, monitoring frequency, and groundwater sampling procedures are also discussed in this section.

3.1 Groundwater Monitoring Well Network

The groundwater monitoring network at a landfill site should consist of groundwater and leachate monitoring points positioned at locations that allow the earliest possible and reliable detection of a potential release from the landfill SWMUs. Compliance wells should be located laterally along the downgradient edge of the SWMUs to intercept the primary migration pathways controlled by hydrodynamic processes, such as advection and other related mechanisms. Background wells should also be installed at landfill sites to intercept groundwater migrating to the site from upgradient locations. The number of monitoring wells required at a landfill can vary significantly based on site-specific characteristics, such as the facility size and physical settings, groundwater flow characteristics, and number of leachate sumps.

A detailed description of the current monitoring network is provided in Section 3.1.1. The findings from the monitoring network analysis conducted for the CMLF are presented in Section 3.1.2.

3.1.1 Current Monitoring Network

The current groundwater monitoring network includes six monitoring wells distributed throughout the site in areas located hydraulically upgradient, crossgradient, and downgradient of closed, active, and future landfill SWMUs. Groundwater monitoring well locations are shown on Figure 2-4, while well construction information (including ground surface elevation, screen interval, well depth, and well diameter) is provided in Table 3-1.

Based on the updated understanding of groundwater flow at the site (as described in Section 2.6), the groundwater monitoring network at CMLF consists of upgradient/crossgradient monitoring wells and downgradient compliance monitoring wells that are screened in the shallow portion of the uppermost aquifer, as defined in HAR 11-58.1-03, and are therefore considered suitable for the groundwater detection program at CMLF. Another well is located hydraulically downgradient of SWMU Phase V-B. This well (PW) is used to supply water for dust control and irrigation activities at the CMLF, and it is not considered suitable for the detection monitoring program because it is open to the aquifer approximately 15 feet below the water table of the uppermost aquifer.

Upgradient and Crossgradient Wells

Three wells (MW-1, MW-4, and MW-6) are located at upgradient/crossgradient locations. These wells have been used in the past to collect groundwater samples under the detection and assessment monitoring programs. Their future use will vary depending on their location as described in the following paragraphs. A brief description for each monitoring well is provided here, while a summary of locations and uses is included in Table 3-2.

Upgradient Monitoring Wells

- **MW-1, located hydraulically upgradient of the closed SWMU Phase I & II.** This well is considered representative of background groundwater conditions. This well is not considered a compliance well, but will be retained to monitor groundwater elevations and quality representative of upgradient/background conditions. Data produced from this well will be used to perform interwell (i.e., between-well) evaluations and alternative source demonstration (ASD) in the event of UPL exceedances that may occur at downgradient compliance monitoring wells using intrawell (i.e., within-well) statistical analysis.

- **MW-6, located hydraulically upgradient of the active SWMUs Phase V-B and future SWMU Phase V-B Ext.** This well is considered representative of background groundwater conditions. This well is not considered a compliance well, but will be retained to monitor groundwater elevations representative of upgradient/background conditions. Well MW-6 will not be sampled under the detection monitoring program because it is located close to the edge of a vertical bluff and poses a potential safety hazard for the sampling field crew. Sampling at well MW-6 under the detection monitoring program may be re-evaluated if Phase VI of the landfill is developed and used as a SWMU in the future.

Crossgradient Wells

- **MW-4, located hydraulically upgradient/cross-gradient of closed SWMU Phase I & II.** Although it is located immediately northeast of closed SWMU Phase I & II, well MW-4 is very close to the edge of the waste and is not considered representative of background groundwater conditions. This well is not considered a compliance well, but will be retained to monitor groundwater elevations and quality at upgradient/crossgradient locations. Data produced from this well will be used to perform interwell evaluations and ASDs in the event of UPL exceedances that may occur at downgradient compliance wells using intrawell statistical analysis.

Compliance Wells

Three wells are located at downgradient locations. These wells have been used in the past to collect groundwater samples under the detection and assessment monitoring programs and will continue to be used in the future as compliance wells to evaluate potential landfill impacts to groundwater quality. A brief description for each monitoring well is provided here, while a summary of locations and uses is included in Table 3-2.

- **MW-2, located hydraulically downgradient of closed SWMU Phase I & II and future SWMU Phase III** (where co-composting of biosolids and green waste processing are currently conducted). Although it is not within 150 meters of the downgradient edge of closed SWMU Phase I & II (i.e., point of compliance per HAR 11-58.1-14(e)), MW-2 is considered suitably located for use as a compliance well to monitor groundwater quality downgradient of both Phase I & II and future Phase III. Data produced from this well can be used to perform intrawell statistical evaluations and determine if monitoring constituents are present in groundwater above the revised UPLs. However, because of the increasing concentrations of seawater ions and TDS in groundwater after 2010, to meet stationarity requirements for this well, intrawell statistical testing should be limited to data collected before 2011.
- **MW-3, located hydraulically downgradient of closed SWMU Phase I & II.** This well is within 150 meters of the downgradient edge of closed SWMU Phase I & II, and is considered a compliance well to monitor groundwater quality downgradient of this SWMU. Data produced from this well will be used to perform intrawell statistical evaluations and determine if monitoring constituents are present in groundwater above the revised UPLs.
- **MW-5, located hydraulically downgradient of active SWMU Phase IV and Phase V.** This well is within 150 meters of the downgradient edge of SWMU Phase V and is considered a compliance well to monitor groundwater quality downgradient of this SWMU. Data produced from this well will be used to perform intrawell statistical evaluations and determine if monitoring constituents are present in groundwater above the revised UPLs.

3.1.2 Monitoring Network Analysis

Qualitative evaluations of the current groundwater monitoring network were conducted in the past (A-Mehr, 2012 and CH2M, 2018a), and resulted in identifying a potential need for additional monitoring wells downgradient of the active and future SWMUs. Based on new available data and considering the updated understanding of the net groundwater flow beneath the site, groundwater flow modeling was conducted to better evaluate the actual need and locations for additional monitoring wells.

Forward particle tracking analysis was conducted using a calibrated groundwater flow model developed for the CMLF (see the modeling results presented in Appendix I). The objective of this analysis was to evaluate the suitability of the existing groundwater monitoring well network for detecting a potential release from the CMLF, and to assist in the placement of an additional monitoring well or wells, if necessary. Particle tracking was performed to simulate particle path lines representative of groundwater flow paths using MODPATH in the GW-Vistas 6.0 platform (ESI, 2011).

This simulation assumes a potential release within Phases III, IV, and V of the CMLF, with potentially contaminated groundwater particles released along the middle portion of each cell, as shown on Figure I-11 of Appendix I. The simulation also included a scenario of a potential release from the current leachate collection wet well in Phase IV-A and leachate sump in Phase IV-B, and future leachate collection sumps for Phases III and V-B Ext (Figure 3-1). The model calculates the trajectories of the particles as they move downgradient, resulting in groundwater advective flow zones that represent the primary migration pathways of potential groundwater contamination from a significant release under the flow conditions simulated by the model. It should be noted that the particle tracking analysis only accounts for transport by advection, and other transport processes such as hydraulic dispersion and diffusion are not considered (i.e., the actual advective flow zones are probably larger).

Figure I-11 of Appendix I confirms that monitoring well MW-2 is located appropriately to detect a release from future SWMU Phase III. The figure also suggests that additional wells are needed to detect a potential release from Phases IV and V, and the planned leachate collection sump within future Phase III. Based on the particle tracking analysis, the following wells will be installed within overlapping advective flow zones to improve the current monitoring network:

- Two additional compliance monitoring wells (MW-7 and MW-8) in the area downgradient of SWMU Phase IV and V, between the production well PW and monitoring well MW-5 (Figure 3-1), to detect potential leachate impacts from current and future leachate collection sumps and liners within SWMUs Phases IV, V, and V-B Ext.
- One additional compliance monitoring well in the area downgradient of the future leachate collection sump in Phase III if and when SWMU Phase III is developed (Figure 3-1). It is recommended that this well be installed in advance of SWMU development to evaluate groundwater baseline concentrations downgradient of future Phase III sump in advance of landfilling activities in this portion of the landfill.

Areas recommended for additional monitoring wells are shown on Figure 3-1. The new monitoring network will include compliance wells located laterally along the downgradient edge of the active SWMUs to intercept the primary groundwater migration pathways and potential contamination at the earliest possible time. Modeling results confirm that future monitoring well MW-7 will be strategically located in the area where the groundwater advective flow zones for a potential release originating from the liner within SWMUs Phases IV-A and V-A and leachate sumps IV-B and future V-B Ext overlap (see Figure I-11 in Appendix I). Future monitoring well MW-8 will be strategically located where the groundwater advective flow zones for a potential release originating from the liner within SWMUs Phases IV-B and V-A overlap. Future monitoring well MW-9 will be strategically located to capture the advective flow zone for a potential release originating from the future sump in Phase III.

Figure 3-1 shows overlap areas that extends up to 150 meters from the downgradient edge of the SWMU (i.e., point of compliance per HAR 11-58.1-14(e)). As agreed upon with HDOH during a meeting held on January 3, 2018, at the SHWB office in Pearl City, no compliance monitoring well is planned directly downgradient of SWMU Phase IV-A wet well for the following reasons:

- The wet well consists of a small capacity (500-gallon) polyethylene tank collecting leachate within a concrete manhole that is double-sealed with an epoxy UV protection coat and an epoxy lining coat to maximize the hydraulic seal of the secondary containment. Placing a well directly downgradient of the SWMU Phase IV-A wet well would provide limited additional benefit and ability to detect a release from the landfill, compared to future wells MW-7 and MW-8.
- This wet well is collecting leachate exclusively from SWMU Phase IV-A, a relatively small (10-acre) unit that is reaching capacity and will be closed and capped in 1.5 to 2 years.
- As shown in Figure 3-1 and on Figure I-11 in Appendix I, monitoring wells MW-7 and MW-8 would provide adequate coverage of groundwater flow from SWMUs Phase IV-B, Phase V-A, Phase V-B, Phase V-B Ext. and most of Phase IV-A, and better overall spatial coverage (spacing of the wells) of the area downgradient of the landfill.
- The advective flow zones from a hypothetical release point/area in Figure I-11 are simulated using the forward particle tracking tool from MODPATH, which accounts for groundwater flow by advection only. Because other transport mechanisms such as hydraulic dispersion, diffusion, and retardation (sorption/desorption) are not accounted for by the model, it is expected that the actual groundwater particle pathlines generating from a potential source within the landfill (e.g., leachate collection wet well/sump or liner failure) would spread over a much larger and irregular area. Therefore, in the unlikely event that a release occurred within the Phase IV-A wet well, the groundwater impact from the release is expected to be detected in monitoring wells MW-5 or future MW-7.

The exact location of each compliance well will be verified in the field within the overlap area based on actual field conditions. After installation, a survey will be conducted to determine well coordinates and top of casing elevation; a well installation report will be submitted to the HDOH SHWB office within 30 days of installation and surveying of the last well.[5]

3.2 Groundwater Monitoring Program

Groundwater monitoring at CMLF will include detection monitoring for a select list of monitoring wells and constituents, as described below. Per HAR 11-58.1-16(d)(C), assessment monitoring will be implemented if a significant statistical increase (SSI) is observed for one or more of the detection monitoring constituents through an exceedance of the UPLs confirmed at any of the compliance wells during retesting that cannot be attributed to the following other factors:

- Error in sampling, analysis, or statistical evaluation
- Natural variation in groundwater quality
- Outside sources demonstrated through an ASD to be the cause of the SSI

The detection monitoring program is described in Section 3.2.1. The assessment monitoring program is described in Section 3.2.2. Additional details on data evaluation are provided in Section 6.

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[5] The additional monitoring wells were installed in November and December 2018. The well installation report was prepared and submitted to HDOH SHWB as the final version of this Leachate and Groundwater Monitoring Plan was being prepared.

3.2.1 Detection Monitoring

Detection monitoring is required at municipal solid waste landfills at groundwater monitoring wells, in accordance with HAR 11-58.1-16(d). Monitoring wells, constituents, and frequency of detection monitoring are discussed in the following sections.

Detection Monitoring Wells

Detection monitoring will be conducted at the current and future compliance (downgradient) monitoring wells and select background (upgradient and crossgradient) monitoring wells. Although groundwater levels will be measured at well MW-6, no groundwater samples will be collected in the future at this well because of safety concerns (the well is in proximity of a vertical bluff). Sampling at well MW-6 may be re-evaluated in the future if Phase VI is developed to be used as a SWMU.

The following monitoring wells will be monitored during detection monitoring:

- Upgradient Background Wells
  - MW-1 (groundwater level gauging and groundwater sampling/analysis)
  - MW-4 (groundwater level gauging and groundwater sampling/analysis)
  - MW-6 (groundwater level gauging)
- Downgradient Compliance Wells
  - MW-2 (groundwater level gauging and groundwater sampling/analysis)
  - MW-3 (groundwater level gauging and groundwater sampling/analysis)
  - MW-5 (groundwater level gauging and groundwater sampling/analysis)
  - Future MW-7 (groundwater level gauging and groundwater sampling/analysis)
  - Future MW-8 (groundwater level gauging and groundwater sampling/analysis)
  - Future MW-9 (groundwater level gauging and groundwater sampling/analysis)

Detection Monitoring Constituents

State (HAR 11-58.1) and federal (40 CFR 258) regulations require municipal solid waste landfills to routinely monitor for numerous constituents included in Appendix I of 40 CFR 258 (15 heavy metals and the full list of VOCs). However, USEPA has provided authorized states, such as Hawaii, the flexibility to approve alternative lists of site-specific monitoring (indicator) constituents (40 CFR 258.54 (a) (1) and (2)). This flexibility and authority for the State of Hawaii to approve an alternative and optimized indicator constituents list is captured in HAR 11-58.1-16(d)(1)(A) and (B).

Many of the Appendix I constituents are not considered effective in detecting potential releases from the CMLF because of their absence in leachate, very low mobility, or both. Therefore, a site-specific indicator constituent list was developed for the detection monitoring program at the CMLF. Federal (Unified Guidance [USEPA, 2009]) and ASTM International (ASTM, 2017) guidance documents, together with site-specific information (leachate and groundwater characteristics), were considered in developing an optimized list of indicator constituents for the CMLF. The indicator constituent selection process included the following basic principles and steps:

1. **Leachate composition**. Based on analytical results of samples collected at leachate monitoring points within CMLF SWMUs Phase IV-A and Phase IV-B over the 2006-2017 monitoring period,

leachate mean concentrations were calculated.[6] Constituents with less than 20 percent detections were not considered representative of the average leachate composition and not carried further in the selection process.

2. **Concentration contrast**. Sufficient contrast is generally assumed when the leachate concentration is consistently and sufficiently higher than the concentration in groundwater to account for the effects of dilution and attenuation. For screening constituents and developing an optimized primary constituents list, a concentration contrast of 10 is considered conservative by USEPA, which identifies typical contrast factors between 10 and 20 (USEPA, 1996). The ASTM guidance (ASTM, 2017) recommends a contrast of 10 times for a source area greater than 0.5 acre. Therefore, a contrast of 10 was initially used in the selection process to be consistent with USEPA and ASTM guidance. If insufficient contrast exists for a specific constituent (i.e., leachate average concentration approximately the same or lower than groundwater average concentration), then the specific constituent was eliminated from further consideration for compliance monitoring.
3. **Redundancy**. Constituents with the same physical and chemical characteristics were minimized where possible, giving preference to those that are more effectively detected in groundwater.
4. **Constituent physical and chemical characteristics**. Preference was given to constituents that have higher mobility, detectability, and persistence, which make them more effective indicators to detect a potential release from the landfill.

Leachate data from 11 years of monitoring (2006-2017) conducted at wet well IV-A and sump IV-B (see Figure 2-2 for locations) were evaluated against groundwater data collected at compliance monitoring wells MW-2, MW-3, and MW-5 between 1995 and 2017, to identify an optimized list of constituents for detection monitoring at the CMLF. The results of the selection process are discussed below. As summarized in Table 2-5, from the first two steps of the selection process, the following was found:

- A total of 25 leachate constituents were carried to the second step. The constituents 1,1-dichloroethane, carbonate alkalinity, lead, methyl ethyl ketone, selenium, and vanadium were discarded because of detection frequencies in leachate lower than 20 percent. Acetone and chlorine residual were also discarded because the former is considered a typical laboratory contaminant, while the latter is typically not monitored in groundwater.
- Alkalinity and nitrate (as N) have been reported inconsistently in the past, as described below. They were carried over to the second step and further evaluated based on the following assumptions:
  - Alkalinity – Alkalinity in leachate has been reported as carbonate (as $CaCO_3$), bicarbonate (as $CaCO_3$), and total alkalinity (as $CaCO_3$). Alkalinity in groundwater has been reported interchangeably as bicarbonate alkalinity (as $CaCO_3$) and total alkalinity (as $CaCO_3$). Starting in December 2014, total alkalinity (as $CaCO_3$) has consistently been reported. From leachate and groundwater historical results, when bicarbonate and total alkalinity were reported separately, it is evident that at acidic and neutral pH conditions found in the CMLF leachate and groundwater, total alkalinity and bicarbonate alkalinity are equivalent and can be used interchangeably. Available literature confirms this assumption. The USGS *Study and Interpretation of the Chemical Characteristics of Natural Waters* (USGS, 1985) discusses the main components of alkalinity in natural waters (including groundwater) and their relationships with pH. The USGS (1985) document confirms that the main alkalinity components in natural waters are carbonate and bicarbonate, and shows that carbonate is present only at pH greater

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[6] Since leachate monitoring started in 2006, no leachate was ever observed at the collection system present at the lowest point of the unlined subgrade of closed SWMU Phase I & II. Leachate mean concentrations were therefore calculated considering only samples collected at the leachate collection points within SWMUs Phase IV-A and Phase IV-B.

than 8.3. At the pH values observed in the CMLF groundwater (e.g., average pH of 7.1 at compliance wells MW-3 and MW-5), alkalinity can be attributed entirely to dissolved bicarbonate. Therefore, “total alkalinity (as $CaCO_3$)” and “bicarbonate alkalinity (as $CaCO_3$)” can be considered the same constituent. To calculate alkalinity average concentrations, total alkalinity was used for leachate and groundwater data.

  - Nitrate-nitrite. This constituent has been reported interchangeably as “nitrate” and “nitrate-nitrite” in leachate. In groundwater, it was reported as “nitrate (as N)” before 2015, after which it was reported as “nitrate-nitrite (as N)”. As discussed in the literature (U.S. Department of Health and Human Services, 2017), and confirmed by leachate data with “nitrate” and “nitrate-nitrite” almost always reported at the same concentration, nitrite is easily oxidized to nitrate, and nitrate is the compound predominantly found in groundwater. Therefore, “nitrate-nitrite (as N)” and “nitrate (as N)” were considered the same constituent for purposes of calculating representative nitrate concentrations in groundwater at site compliance wells.

- For the 25 leachate constituents carried over from step 1, the leachate/groundwater concentration contrast was calculated considering the average concentrations over the entire monitoring periods (2006-2017 for leachate and 1995-2017 for groundwater). Concentration contrast was calculated using the following formula:

$$\text{Concentration contrast} = \frac{\text{Mean historical leachate concentration in wet well IV-A and sump IV-B combined}}{\text{Mean historical groundwater concentration at MW-X}}$$

Only five constituents have a contrast higher than 10, the value recommended by USEPA and ASTM; as a result, the threshold contrast to further evaluate constituents was lowered. From the first two steps of the selection process, constituents with a leachate/groundwater concentration contrast higher than 2, the value recommended by HDOH for organic constituents, were further evaluated to develop a site-specific, optimized constituents list for detection monitoring at the CMLF. A detailed discussion on leachate/groundwater contrast and constituents selection follows:

  - **Maximum** - BTEX and the halogenated volatile organic compounds (HVOCs) 1,4-dichlorobenzene, 1,2-dichloroethane, cis-1,2-dichloroethylene, and vinyl chloride have been detected in leachate with average concentrations ranging from 1.2 to 55 mg/L. These constituents were not detected in groundwater at any of the compliance wells between 1995 and 2017. Ammonia (in well MW-5), barium (in well MW-5), chromium (in wells MW-2 and MW-5), copper (in well MW-5), and nickel (in well MW-3) were either not detected in groundwater or had less than 10 percent detection frequencies, which did not allow a calculation of mean groundwater concentration. The contrast for these constituents that are detected in leachate but not detected in groundwater is identified in the Leachate/Groundwater Contrast portion of Table 2-5 as maximum (“MAX”) for constituents with no detections in groundwater, and as not applicable (“NA”) for those groundwater constituents with detection frequencies of less than 20 percent that did not allow a reasonable estimate of the average concentrations. Ammonia, BTEX, and HVOCs are therefore carried over and selected as detection monitoring constituents. Based on the relatively wide range of or low detection frequencies for barium (0 to 47 percent), chromium (0 to 12 percent), copper (0 to 33 percent), and nickel (4 to 100 percent) in the monitoring wells and in consideration of their physical-chemical characteristics, lack of mobility in groundwater relative to other constituents, and frequent presence as background in Hawaiian aquifers, these metals are discarded from further consideration as indicator constituents.

  - **100 to 200** - Ammonia (in wells MW-2 and MW-3) and barium (in well MW-2) have a contrast greater than 100, with less than 50 percent detection frequency in groundwater at compliance wells. As already discussed above, ammonia is selected as detection monitoring constituent, while barium is discarded.

  - **10 to 99** – Barium (in well MW-3), iron, and TOC have a contrast between 10 and 100. Of these, barium and iron have less than 50 percent detection frequency in groundwater at compliance wells, while TOC has between 71 and 79 percent detection frequency. Iron and TOC are selected as detection monitoring constituents, while barium is discarded because of its physical-chemical characteristics and presence as background in Hawaiian aquifers.
  - **2 to 9.9** - Total alkalinity, calcium, chloride, chromium (in well MW-3), copper (in wells MW-2 and MW-3), magnesium (in wells MW-2 and MW-5), potassium, sodium, and TDS have a contrast between 2 and 10. Of these, chromium and copper have less than 50 percent detection frequency in groundwater at compliance wells, while other constituents have a 100 percent rate of detection. Of these, total alkalinity, calcium, chloride, magnesium, potassium, sodium, and TDS are selected as detection monitoring constituent, while chromium and copper are discarded because of their physical-chemical characteristics and presence as background in Hawaiian aquifers.
  - **1 to 1.9** - Nickel (in well MW-2) and zinc (in wells MW-3 and MW-5) have a contrast between 1 and 1.9. Nickel in well MW-2 has only 32 percent detection frequency in groundwater at compliance wells, while the zinc detection frequencies in wells MW-3 and MW-5 are greater than 50 percent. These constituents are discarded because of the low leachate/groundwater concentration contrast.
  - **Less than 1** - Mean concentrations of nitrate, sulfate, and zinc (in well MW-2) are higher in groundwater than leachate (i.e., contrast less than 1), with detection frequencies in groundwater at compliance wells that are greater than 50 percent. These constituents are therefore discarded because of the low leachate/groundwater concentration contrast.

As discussed above, some constituents commonly used as indicator parameters at landfills, such as nitrate and sulfate, were not carried over in the selection process because average concentrations in groundwater at the CMLF (including in upgradient/background monitoring wells) are higher than in leachate. In summary, the following constituents are retained and will be part of the site-specific, optimized constituents list used for detection monitoring at the CMLF:

- Major cations and anions
  - Calcium
  - Magnesium
  - Potassium
  - Sodium
- Major leachate indicators
  - Ammonia
  - Chloride
  - Iron
  - TOC
  - TDS
  - Total alkalinity
- Organic constituents
  - BTEX

- HVOCs (including 1,4-dichlorobenzene, 1,2-dichloroethane, cis-1,2-dichloroethylene, and vinyl chloride)

The major cations and anions and major leachate indicators fit the Unified Guidance (USEPA, 2009) definition of "*reliable indicators selected for formal detection monitoring testing and contributing to the site-wide false positive rate (SWFPR)*" (Group 1), except for ammonia, which has very low detection frequency. Ammonia fits in the second group specified in the Unified Guidance as "*other analytes which may be occasionally or even frequently detected and will be monitored for general groundwater quality information but not tested.*" The hazardous constituents BTEX and HVOCs fit in the third group of constituents specified in the Unified Guidance as "*those meeting the 'never detected' criteria.*" Therefore, of the 12 constituents retained as the site-specific optimized constituents for detection monitoring at the CMLF, 9 (calcium, magnesium, potassium, sodium, chloride, iron, TOC, TDS, and Total alkalinity) will be statistically evaluated using UPLs because they are reliable indicators selected for formal detection monitoring testing per the Unified Guidance (USEPA, 2009).

Despite the relatively low leachate/groundwater contrast, some constituents, such as chloride, potassium, and TDS, were retained and included in the detection monitoring list because they are typical landfill leachate indicator constituents and support development of a sufficient number of indicator constituents consistent with the Unified Guidance (USEPA, 2009) to calculate the revised UPLs. A few of the indicator constituents indicated above (such as ammonia, BTEX, and HVOCs) are not directly incorporated into the formal statistical testing for detection monitoring because they are rarely, if ever, detected at site compliance wells.

By limiting the statistically-evaluated constituents to the most useful indicators, the overall number of statistical tests can be reduced to help meet the cumulative annual SWFPR of 10 percent recommended in the Unified Guidance (USEPA, 2009). The Unified Guidance recommends a comprehensive detection monitoring program design, based on two key performance characteristics: adequate statistical power and a low predetermined SWFPR. The SWFPR is measured on a sitewide basis and partitioned among the total number of annual statistical tests. The total number of statistical tests depends on the number of monitoring constituents, compliance wells, and periodic evaluations. Fewer tests imply a lower single-test false negative error rate, and therefore an improvement in statistical power.

Detection monitoring Frequency

In accordance with HAR 11-58.1-16(d)(2), 40 CFR 258.54(b), and the HDOH 2002 Landfill Guidance, detection monitoring will be conducted on a semiannual basis (every 6 months). As further described in Appendix E, semiannual sampling will allow independent testing for the retesting strategy in case of an exceedance of the UPLs.

Semiannual sampling is considered adequate to detect a potential release from the landfill and safe for potential receptors downgradient of the landfill. Based on an average linear groundwater velocity of up to 478 ft/year (146 meters per year) estimated for groundwater flow beneath the landfill (Section 2.6.3), contaminated groundwater from a potential release source would travel approximately 240 feet (or 72 meters) in 6 months. Current and future compliance wells are located more than 230 feet from the existing and future sumps, where a potential release is more likely to occur. Therefore, it is estimated that it would take more than 6 months for contaminated groundwater to travel from a potential source to the point of compliance, and semiannual monitoring is adequate for the CMLF site.

Groundwater monitoring requirements (including locations, frequency and monitoring constituents) are summarized in Table 3-2.

3.2.2 Assessment Monitoring

Assessment monitoring is required whenever an SSI over background has been detected and verified through an exceedance of the UPLs confirmed during retesting (see Section 6 for more details on data evaluation and rationale to trigger assessment monitoring). Unless an ASD is completed, assessment monitoring will be initiated in accordance with HAR 11-58.1-16(e). Monitoring wells, constituents, and frequency of assessment monitoring are described in the following sections.

Assessment Monitoring Wells

As required by HAR 11-58.1-16(e)(2), assessment monitoring will be conducted at current and future compliance (downgradient) monitoring wells, and at upgradient/crossgradient monitoring wells as needed (see Section 3.2.2.2 and Section 6.2 for more details). The following monitoring wells will be monitored (as needed) during assessment monitoring:

- Upgradient Background Wells
  - MW-1
  - MW-4
- Downgradient Compliance Wells
  - MW-2
  - MW-3
  - MW-5
  - Future MW-7
  - Future MW-8
  - Future MW-9

Assessment Monitoring Constituents and Frequency

As required by HAR 11-58.1-16(e)(2), within 90 days of triggering assessment monitoring (and annually thereafter), groundwater samples will be collected and analyzed for constituents identified under 40 CFR 258 Appendix II. One sample will be collected from each downgradient well.

For any 40 CFR 258 Appendix II constituent detected in the downgradient wells, eight independent samples will be collected and analyzed from each background (upgradient/crossgradient) and compliance (downgradient) well to establish background concentrations.

Within 90 days (and on a semiannual basis thereafter), compliance and background (upgradient/crossgradient) monitoring wells will be sampled and analyzed for the detection monitoring constituents and constituents detected during 40 CFR 258 Appendix II assessment monitoring.

The 40 CFR 258 Appendix II sampling will be repeated every year until assessment monitoring is terminated and the detection monitoring program is re-established. Assessment monitoring exit strategies are further described and identified in Section 6.2.

3.3 Groundwater Sampling Procedures

This section describes the groundwater monitoring and sampling procedures that will be implemented in the field at the CMLF site during the detection and assessment monitoring programs. Groundwater monitoring locations are described in Section 3.1 and shown on Figure 2-4, while sampling frequency is discussed in Section 3.2.

During each monitoring event and upon arrival at each monitoring well location, the conditions of the well will be observed and recorded in the field book. Information to be noted and recorded may include well identification, conditions of wellhead monument, lock, well casing, and evidence of any surface contamination and tampering. Static groundwater levels will be measured at the beginning of each monitoring event at all monitoring wells. Groundwater purging and sampling activities will start only after groundwater level measurement activities are completed at all monitoring well locations.

3.3.1 Groundwater Elevation Monitoring

During each monitoring event, depths to groundwater will be measured at all onsite monitoring wells (including the production well PW) at the beginning of the first working day, before starting sampling of the first well. If possible, measurements will be taken when well PW is turned off. Because groundwater at the site is tidally influenced, depths to groundwater will be measured at all wells as quickly as is reasonably possible (approximately within a 1-hour period) to mitigate potential effects of tidally influenced groundwater fluctuations on the groundwater elevation, groundwater contour, and hydraulic gradient calculations.[7]

At each well, depth to groundwater will be measured to the nearest 0.01 feet from the top of the sounding tube or well slip cap using an electronic water sounding probe equipped with a 500-foot tape. Groundwater elevations will be then calculated by subtracting the depth to groundwater from the surveyed, measuring-point elevations (Table 3-1).

3.3.2 Groundwater Sample Collection

During each monitoring event, groundwater samples will be collected from all monitoring wells included in the specific monitoring program. A low-flow purging and sampling technique will be adopted to allow stabilization of groundwater quality parameters during purging before collecting the groundwater sample at each monitoring well.

Field testing instruments will be calibrated in accordance with the manufacturer's recommendations before starting sampling activities each day. Field meter calibration logs and groundwater sampling logs will be completed to document proper instrument calibration and purging activities.

The dedicated groundwater pump installed at each well will be used to purge groundwater before sample collection. Constant and low flow rates (between 0.1 and 0.5 liters per minute) achievable with dedicated micropurge pumps are recommended during purging and sampling activities because high flow rates can cause mixing of the standing water column within the well with an increase in turbidity, which can ultimately result in biased high results for certain constituents that tend to absorb to colloidal particles. To achieve low-flow sampling conditions, the County is planning to replace existing electric submersible Grundfos pumps with dedicated low-flow bladder pumps.[8]

During well purging, the water level in the well will be frequently monitored with the water level sounding probe and water-quality parameters will be measured with a Horiba multiparameter water quality meter and turbidimeter, or equivalent, using a flow-through cell. Field-measured water-quality parameters will include temperature, pH, specific conductance, turbidity, dissolved oxygen, salinity, and oxidation-reduction potential. Well purging will continue until the water

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[7] Although it is expected that small fluctuations in groundwater elevation across the site will occur during a 1-hour measurement period, the tidal evaluation described in Section 2.6.1 shows that the lag time between wells across the site (i.e., the time difference when the tidal pressure wave is observed in each well) can be significant (average of 3 hours ± 1 hour), causing anomalous static manual groundwater level measurements.

[8] Low-flow bladder pumps were installed in all existing and new monitoring wells in December 2018.

quality parameters are stable during three consecutive readings taken at 3- to 5-minute intervals within the following tolerances:

- ± 0.1 for pH
- ± 3 percent for specific conductance
- ± 10 percent or a value of less than 1 mg/L, for dissolved oxygen
- ± 10 percent or less than 10 nephelometric turbidity units (NTU), for turbidity
- ± 10 millivolts for oxidation-reduction potential

Once stabilization of parameters is achieved, the groundwater sample will be collected directly from the discharge tube of the sampling pump using laboratory-supplied containers. Samples requiring filtration (such as dissolved metals and TDS) will be filtered in the field using a 0.45-micron disposable, in-line filter.

Containers will be filled slowly to avoid turbulence and avoid air bubbles in the containers, which could increase turbidity and cause volatilization of VOCs. Sample containers will be properly labeled, placed into coolers with ice, and shipped under chain-of-custody (CoC) records to the analytical laboratory of choice via overnight courier. A security seal will be placed on each cooler to detect tampering during shipping.

3.3.3 Investigation-derived Waste Disposal

If no evidence of gross contamination (e.g., odor or oily sheen) is observed during purging and sampling activities, water extracted from monitoring wells during sampling will be discharged onto the ground and allowed to percolate away from the well from which it was purged. Grossly contaminated water potentially extracted during purging and sampling activities will be containerized and disposed of in accordance with state and federal regulations. Nonreusable sampling equipment (such as pump tubing, filters, or similar) and personal protective equipment will be disposed of as municipal waste.

4 Leachate Monitoring

Leachate monitoring and sampling are not specifically required by federal Subtitle D or Hawaii State regulations. However, they are included in the new Permit, Special Conditions G.8 and G.9, and generally recommended by HDOH to be conducted routinely to evaluate potential source information and suitability of the site monitoring parameters (HDOH, 2002). The leachate collection system and leachate management for CMLF, as required in the new Permit, Special Conditions G.7, are described in Section 2.3. This section describes leachate monitoring locations, constituents, frequency, and procedures.

4.1 Leachate Monitoring Locations

Leachate monitoring is currently conducted at the following leachate collection points within active and closed SWMUs, as shown on Figure 3-1:

- SWMU Phase I & II - A dendritic leachate collection system connected to a pipe is present at the lowest point of closed SWMU Phase I & II to collect leachate. The system is monitored through Manhole 4, which has a compliance level of 1 foot of leachate in the manhole.
- SWMU Phase IV-A - Leachate from this SWMU is collected via a self-contained concrete wet well (also referred to as a manhole) that has a compliance level for the leachate of 207 feet amsl.
- SWMU Phases IV-B and V – The sump located in Phase IV-B is connected to and serves both SWMUs Phase IV-B and Phase V; the compliance level for the leachate in this sump is 212 feet amsl.
- Future SWMU Phase V-B Ext is currently under construction and will include a leachate collection sump at the northern corner of the SWMU; this sump will have a compliance level for the leachate of 228 feet amsl. Construction of the Phase V-B Ext riser pipe will be in accordance with a construction quality plan submitted to HDOH SHWB at least 30 days before construction.

Approximate locations of leachate collection points are shown on Figure 3-1. Access and integrity of leachate monitoring points will be maintained, and HDOH SHWB will be notified if any of the monitoring points are damaged or destroyed. Additional details on leachate collection and monitoring locations are provided in Section 2.3 of this report.

4.2 Leachate Monitoring Constituents and Frequency

Per the new Permit requirements, periodic leachate monitoring and sampling will be conducted at all existing and future leachate collection points, as follows.

In accordance with the requirements specified in the new Permit for CMLF (Permit No. LF-0074-13), leachate level monitoring will be conducted according to the following schedule:

- **Closed SWMUs Phase I & II (Manhole 4)** – Minimum once per week.
- **Phase IV-A Leachate Manhole** - Minimum once per week.
- **Phase IV-B Leachate Sump** - Minimum once per week.
- **Future Phase V-B Ext Leachate Sump** - Minimum once per operational day, and after rain events until the select waste layer has been completely installed; minimum two times per week thereafter.
- **All leachate collection points** – After storm events.

If measured leachate levels exceed the levels summarized in Section 4.1, levels in leachate collection points will be monitored at a higher frequency. Monitoring will be performed before and after leachate pumping on a daily basis until the level has remained within the allowable limit for a period of 1 week. All monitoring activities and measured levels will be recorded in field records maintained by the County.

A sample of leachate will be collected from each collection point on a semiannual basis for laboratory analysis. Leachate samples will be analyzed for constituents listed in 40 CFR 258 Appendix II, and major leachate indicators including cations/anions per the Hawaii Landfill Groundwater Monitoring Guidance (HDOH, 2002). Manhole 4 within SWMU Phase I & II has been dry since it was restored in 2005. If leachate is detected in sufficient volume during monitoring, a sample will be collected also at this location.

Leachate monitoring requirements (including locations, frequency and monitoring constituents) are summarized in Table 4-1.

4.3 Leachate Sampling Procedures

Samples will be collected at each leachate collection point following procedures described in this section. Before opening and accessing the leachate collection point enclosure, appropriate safety precautions will be taken to minimize exposure to landfill gas potentially present in the sump or manhole. These may include opening the enclosure from an upwind position, letting the manhole vent for a few minutes, and monitoring ambient air and manhole head space for volatile and combustible constituents using field-portable instruments before starting sample collection procedures.

Once it is determined to be safe to access the collection point (i.e., no evidence of hazardous or combustible conditions), a disposable, single-use bailer will be used to collect a leachate sample at each monitoring location. Disposable bailers are highly recommended to avoid cross-contamination between monitoring points. No purging is required before leachate sample collection. The disposable bailer will be slowly lowered within the collection point and retrieved to the surface once full. Containers will be filled slowly to avoid turbulence and air bubbles, which could increase turbidity and cause volatilization of VOCs.

Samples will be collected in laboratory-supplied containers, properly labeled, placed into coolers with ice, and shipped under CoC to the analytical laboratory of choice via overnight courier. Sampling information will be logged in a dedicated field book or field forms.

5 Quality Assurance and Quality Control

To maximize data quality and representativeness of groundwater and leachate results, QA/QC procedures will apply during the sampling and analysis processes. Although the QA/QC field and laboratory procedures were developed for and mainly apply to groundwater sampling, the general concepts will also apply to leachate samples.

The QA/QC procedures include QC samples collected in the field; standard operating procedures to be followed during sample collection, sample handling, and sample shipping; laboratory QC samples and approved analytical methods; and data quality evaluation of analytical results. Details on QA/QC procedures are provided in the following sections.

5.1 Field Quality Control

Field QC procedures will apply during sampling activities in the field. Before mobilization, past field logs and CoC records will be reviewed to evaluate groundwater quality and sampling processes/plan followed during previous events and maximize consistency during subsequent sampling events, which will result in increased sample representativeness.

Once in the field, QC samples will be collected to evaluate sampling, decontamination, and shipping procedures, as follows:

- A field duplicate (FD) sample will be collected at one compliance monitoring well. The FD sample will be collected together with the parent sample, following the same procedures and analyzing it for the same constituents.
- A source water blank sample will be collected if nondedicated equipment is used and equipment decontamination procedures are conducted in the field.[9] This sample will consist of laboratory-certified (or ASTM) water used for equipment decontamination poured in containers provided by the lab and tested for the same constituents analyzed on normal environmental samples during that specific sampling event (see Section 3.2.1 and 3.2.2). This sample will help to evaluate potential cross-contamination from the equipment decontamination process.
- An equipment blank (EB) sample will also be collected if nondedicated equipment is used and equipment decontamination procedures are conducted in the field. The EB sample will consist of laboratory-certified (or ASTM) water poured on or through nondedicated sampling equipment after decontamination is completed. The water will be collected in laboratory containers provided by the lab and tested for the same constituents analyzed on normal environmental samples during that specific sampling event (see Section 3.2.1 and 3.2.2). Similar to the source water blank, this sample will also help evaluating potential cross-contamination from the equipment decontamination process.
- A trip blank (TB) sample will accompany sample containers shipped to the laboratory for VOCs analysis. The TB sample will consist of a prefilled, volatile organic analysis (VOA) vial that will travel in the same cooler as the parent samples and will be analyzed for VOCs only. This sample will help evaluating potential cross-contamination potentially occurring during sample handling and shipping.

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[9] Dedicated sampling pumps were installed in all monitoring wells and source water blank and EB samples should not be necessary. However, nondedicated sampling equipment may be used in the future in the event that dedicated pumps need to be serviced at the time of detection monitoring sample collection. Source water blank and equipment blank samples would be collected only if nondedicated sampling equipment is used during a sampling event.

5.2 Sample Packing and Shipping

After collection, all groundwater samples collected at the site will be managed following the handling, packing, and shipping instructions described in this section, to ensure sample integrity and maximize representativeness and quality of the data. At the end of each sampling event, or more frequently if the sampling event extends longer than 2 to 3 days, samples will be shipped to the laboratory via Federal Express (FedEx) overnight shipping.

Sample packaging procedures are as follows:

- Determine the maximum allowable weight of each cooler (FedEx limit is 150 pounds).
- When reusing packaging, remove all inappropriate marks and labels. If the labels and marks cannot be removed, cross them out so that they are not visible.
- Place each container in a resealable plastic bag (or similar) and seal, squeezing as much air as possible from the bag before closing. Glass containers will be wrapped in bubble wrap before being contained in the resealable bag.
- Tape the drain plug of the cooler on the outside (if present).
- Place approximately 2 inches of material, such as asbestos-free vermiculite, perlite, or bubble wrap sheets, in the bottom of the cooler.
- Place two large plastic bags (e.g., a thick trash bag) inside each other to create a double liner inside the cooler.
- Place the bottles upright in the plastic bag, with enough room for ice to be placed among and around the containers, and insulate with enough bubble wrap to deter breakage.
- To provide uniform cooling, fill the inner plastic bag within the cooler with wet ice. Seal both inner and outer plastic bag to ensure that ice is well contained during transport.
- Do not use “blue ice,” as its heat capacity is lower than regular ice. Do not use dry ice. For the receiving laboratory to have an accurate method of assessing the temperature of samples, a temperature blank will be placed in every cooler. Be sure the temperature blank is kept cool during sampling activities so that it remains at a cool temperature consistent with the temperature of the samples when received by the laboratory.
- Sample containers for VOC analyses will be accompanied with a trip blank that will be analyzed for VOCs only to evaluate potential cross contamination during transport.
- Fill the remaining space in the cooler with inert cushioning material (as needed).
- Prepare a CoC form for each cooler, specifying sample ID, collection date and time, analytical plan, special instructions, project number and purchase order information, and points of contacts for the lab. The CoC form will be signed by the sampler and other persons (as needed) relinquishing the cooler before drop off at FedEx. A photo will be taken of the CoC form before putting it in a resealable bag. The bag containing the CoC form will be taped to the inside lid of the cooler.
- The cooler will be closed and latched, wrapped with strapping tape, and sealed with a custody seal to detect any potential tampering during transport. Appropriate labels (e.g., "This Side Up" and "Fragile") will be placed on all four sides of the cooler, the original shipping document affixed on top or front of the cooler.
- A copy of the shipping documents and CoC forms for each cooler will be emailed to the laboratory as soon as possible to notify them that samples have been shipped so that the laboratory is prepared to receive the samples. The sample shipper or sample coordinator will verify with the

laboratory that samples have been received, that the requested laboratory analyses will be run, and there are no compliance issues with sample labeling, packaging, container and preservative, or temperature.

5.3 Laboratory Analysis and Quality Control

Laboratory analysis of groundwater and leachate samples will be conducted at offsite laboratories specialized in environmental sample analysis. Although they could change in the future, the laboratories that are currently used for chemical analyses are the following:

- **Groundwater** – Eurofins Calscience, Garden Grove, California, a laboratory that is certified under the National Environmental Laboratory Accreditation Program (NELAP) and accepted for regulatory purposes by the HDOH, Safe Drinking Water Branch (SDWB).
- **Leachate** - Test America, Irvine, California, a laboratory that is certified under NELAP and accepted for regulatory purposes by the HDOH SDWB.

Analytical methods used for analysis of groundwater and leachate samples are indicated in Table 5-1 and Table 5-2, respectively. These methods are consistent with USEPA standard procedures.

During groundwater analysis, the laboratory will follow a strict QC protocol, which will include the analysis of the following laboratory samples at the frequency required by the analytical method or laboratory QA/QC standard procedures:

- Method blank samples
- Surrogate spike samples (as required by the method)
- Internal standards
- Laboratory control samples (LCSs) and LCS duplicates (LCSDs)
- Matrix spike (MSs) and MS duplicates (MSDs)

5.4 Data Quality Evaluation

Laboratory data, including groundwater sample and laboratory QC samples, will be evaluated by a chemist to assess data quality of analytical results for groundwater samples collected after each sampling event. Individual method requirements, guidelines from the October 1999 USEPA Contract Laboratory National Functional Guidelines (NFG) for Organic Data Review, and the July 2002 USEPA Contract Laboratory NFG for Inorganic Data Review will be used as the basis for this assessment.

This data quality evaluation (DQE) is intended as a general data quality assessment designed to summarize data issues. The goal of this assessment will be to demonstrate that a sufficient number of representative samples were collected, the resulting analytical data can be used to support the decision-making process, and the data quality objectives are met.

The DQE will cover field samples, including normal samples, FD samples, source water blank samples (as needed), EB samples (as needed), and TB samples. In general, the assessment of data will include a review of (1) CoC documentation, (2) holding-time compliance, (3) the required field and laboratory QC samples, (4) method blanks, (5) LCSs and LCSDs, (6) surrogate spike recoveries for organic analyses, (7) MSs and MSDs, and (8) laboratory duplicates.

Data flags will be assigned, as needed. These flags, as well as the reason for each flag, will be entered in summary tables. Multiple flags may be applied to specific sample method, matrix, and analyte combinations, but there will be only one final flag. The final flag is applied to the data and is the most conservative of the applicable validation flags.

6 Data Evaluation and Reporting

This section describes the criteria by which groundwater monitoring data will be evaluated at the CMLF. These criteria are compliant with applicable federal and state regulations and guidance. After a summary of the methodology that will be applied to statistically evaluate groundwater sampling results against background (UPLs) is provided in Section 6.1, Section 6.2 includes a practical summary on how the data will be collected and evaluated during groundwater detection and, if necessary, assessment monitoring at the CMLF site.

6.1 Statistical Methodology and Applicable Protection Standards

In compliance with HAR 11-58.1-16(c)(7), the County developed Upper Shewart-CUSUM [cumulative sum] CLs in 2000, and revised them in 2005 and 2010. In June 2016, on behalf of the County, CH2M requested and obtained approval from HDOH to re-evaluate the CLs for the site, based on the revised CSM (CH2M, 2016a). As part of the evaluation, CH2M reviewed regulatory requirements specified in HAR 11-58.1-16(c)(8) and state guidance documents (HDOH, 2002), as well as the more recently completed Unified Guidance (USEPA, 2009). Separate constituent-specific and well-specific UPLs were calculated for the six site monitoring wells included in the groundwater monitoring program at that time (MW-1 through MW-6); these have been used since June 2016 for comparison with future concentrations within each well (intrawell evaluation) to evaluate whether those concentrations are consistent with previous concentrations. Although the UPL calculation approach was approved in 2016, the HDOH SHWB provided additional comments on the UPL approach in 2017 (see the response to comment information in Appendix A). Comments were addressed by the County, which agreed to re-evaluate and revise the UPLs in full compliance with the USEPA 2009 Unified Guidance (see meeting minutes in Appendix B).

A thorough evaluation of available data was completed to select the most appropriate statistical approach and calculate UPLs for the optimized list of nine detection monitoring constituents selected for statistical analysis (calcium, magnesium, potassium, sodium, chloride, iron, TOC, TDS, and total alkalinity), as discussed in Section 3.2.1. A summary of the statistical evaluation results is provided in this section; Appendix E includes a comprehensive report detailing the statistical data review, procedures used for calculation of the UPLs, and results.

6.1.1 Data Preparation and Statistical Evaluation

The available groundwater monitoring data were explored statistically using the methods recommended in the Unified Guidance (USEPA, 2009) to prepare the data and select the most representative data set. A brief summary of the statistical evaluations conducted is provided in this section, with additional details in Appendix E.

Data Preparation – Data preparation included analysis of duplicate samples, outliers, and data qualifiers. For statistical analysis of parameters with duplicate sample results, only the parent sample was used for statistical comparisons. Non-detect data with multiple reporting limits were evaluated using the Kaplan-Meier method (Helsel, 2005; Singh et al., 2006; Kaplan and Meier, 1958), which is recommended by practitioners and the Unified Guidance (USEPA, 2009) to manage environmental data sets containing multiple censored observations. Estimated concentrations (constituent concentrations denoted with the “J” qualifier) were treated as qualified detected concentrations for the purposes of statistical analysis.

Temporal Monitoring Record Selection – A statistical trend analysis was conducted on data collected at the site since the beginning of groundwater monitoring (1995-2017). The Mann-Kendall test was used to evaluate temporal variability and select the most appropriate monitoring record. A total of 54 constituent-well pairs (obtained by multiplying the six monitoring wells [MW-1, MW-2, MW-3, MW-4, MW-5, and MW-6] times the nine constituents selected for statistical analysis [calcium, magnesium, potassium, sodium, chloride, iron, TOC, TDS, and total alkalinity])[10] were evaluated for groundwater monitoring data collected between 1995 and 2017. As shown in Appendix E, of the 54 constituent-well pairs, there were 38 cases (70.4 percent) with a significant calculated trend, 17 of them representing significantly decreasing trends and 21 representing significantly increasing trends. The time series plots provided in Attachments 1 and 2 of Appendix E support the results of the trend analysis and suggest higher variability in data collected before approximately 2008. Because of the significantly higher variability in data collected before approximately 2008, background concentrations for wells MW-3 and MW-5 at the CMLF have been established using data collected from June 2008 through September 2017. Older background data (February 1996 through December 2011) are being used for well MW-2 because of the temporal trends in constituent concentrations observed in this well starting in January 2012. These timeframes provide a minimum of 10 years of groundwater monitoring data at the CMLF.

Evaluation of Outliers - Groundwater data were visually inspected using graphical representations and formally evaluated using Dixon's (1953) and Rosner's (1983) tests to identify and remove potential outliers. Statistical outliers were further evaluated using nonparametric methods, including interquartile range and median absolute deviation scores (Wilcox, 2010). The only extreme statistical outliers that were excluded from further calculations were the total alkalinity results for all wells in December 2011 and for MW-2 in December 2001, either because they occurred in a single sampling event (December 2011) or they appear to be extreme observations (2001 and 2011), or both.

Temporal Independence - The rank von Neumann Ratio test was used to test the background data for serial correlation. The sample autocorrelation function was also used to evaluate serial correlation in the data. The test results indicate that, except for iron and TDS, concentrations of the proposed detection monitoring constituents generally exhibit pairwise correlation, but the correlation between consecutive sample pairs is not expected to adversely affect calculations.

Temporal Variability - A nonparametric analysis of variance (ANOVA) method, the Kruskal-Wallis test, was applied to the data to test for temporal variability. Except for calcium and chloride, the selected detection monitoring constituents exhibit temporal dependence. Adjustment of the data to address temporal dependence/correlation and spatial variability is not advised for CMLF because of the tendency to skew or bias measurements at wells with no observable temporal dependence. Variance calculations of dependent, positively autocorrelated data are likely to be biased low. However, the characteristics of the groundwater population at the CMLF are based on sample measurements collected over 10 years of groundwater monitoring, which provides an adequate period of time for evaluation of the range of concentrations to calculate statistical variability in groundwater concentrations around the mean.

Seasonality - The nonparametric Kruskal-Wallis test was also used to test the data for seasonality. Based on evaluation of precipitation data for Maui, samples collected during the months from May through October represented the "dry" season and the remaining months represented the "wet" season. Data from 2008 to 2017 show that there is no statistically significant seasonal variation.

Temporal Trend Analysis - Temporal trend analysis was performed on the 2008-2017 data set using the nonparametric Mann-Kendall test. Of 63 cases evaluated with the Mann-Kendall test, there were 21 cases (33.3 percent) with a significant calculated trend, 8 of them representing significantly decreasing

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[10] As discussed in Section 3.2.1, some of the indicator constituents selected for detection monitoring (such as ammonia, BTEX, and HVOCs) are not directly incorporated into the formal statistical testing because they are rarely, if ever, detected at site compliance wells.

trends and 13 significantly increasing trends. Compared to the trend analysis results shown in Appendix E for the entire monitoring record, concentrations of the proposed detection monitoring constituents in downgradient wells MW-3 and MW-5 from June 2008 through 2017 and in downgradient well MW-2 from 1996 through 2011 are more stable and support development of background concentrations.

Spatial Variability - The Kruskal-Wallis test was used to check the data for spatial variability using the monitoring wells as the relevant statistical factor. The results indicate that, except for iron and TOC, the detection monitoring constituents exhibit significant spatial variation.

Distribution Goodness-of-Fit Testing - Goodness-of-fit tests were performed to determine the probability that the data set for each constituent-well combination could have come from the tested distribution. The results of the goodness-of-fit testing show that most of the constituent-well data can be assumed to follow a normal distribution. The exceptions are iron and TOC across the entire monitoring well network.

6.1.2 Development of Upper Prediction Limits

After data preparation and statistical evaluation, it is concluded that the 2008-2017 background data generally satisfy the following key statistical assumptions outlined in the Unified Guidance (USEPA, 2009) for the development of UPLs:

- Statistical independence of background measurements
- Temporal stationarity
- Lack of statistical outliers
- Correct distribution assumptions of background when a parametric statistical approach was selected
- Minimum background measurements

The background data exhibit significant natural spatial variability. Intrawell UPLs are therefore calculated for compliance wells to minimize the likelihood that spatial variability will contribute to invalid statistical limits. Well-specific UPLs are developed for compliance monitoring wells MW-2, MW-3, and MW-5. No UPLs are calculated for upgradient monitoring wells MW-1, MW-4, and MW-6, because they are representative of background conditions and should not be used to calculate prediction limits for regulatory compliance evaluations. Including noncompliance wells in the prediction limits calculation would result in a larger number of comparisons, which would increase the SWFPR, resulting in higher probability that a release is indicated even though no release has occurred.

Although the data did exhibit temporal nonstationarity in the form of weak secular trends[11] and autocorrelation, the characteristics of the groundwater population at the CMLF are based on sample measurements collected over 10 years of groundwater monitoring. Using a 10-year-long temporal record provides an adequate evaluation of the range of concentrations to calculate variability in groundwater concentrations around the mean.

Parametric and nonparametric UPLs were calculated for the CMLF following the Unified Guidance (USEPA, 2009) recommendations. A UPL was calculated for each of the nine formal detection monitoring constituents selected for statistical analysis at the three downgradient compliance monitoring wells (MW-2, MW 3, and MW 5). For wells MW-3 and MW-5, UPLs were developed using data collected from June 2008 through September 2017. For well MW-2, UPLs were developed using data collected between 1996 and 2011. Table 6-1 presents the UPLs and supporting summary statistics, including the number of detects, the number of analyses, the frequency of detection, minimum and maximum detected values, minimum and maximum detection limits for non-detects, and the distributional assumption. Also

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[11] A secular trend at a monitoring well indicates that the mean is not stationary, but is changing over time.

included in the table are the mean, median, standard deviation, and upper 95th and 99th percentiles. Groundwater protection standards (USEPA maximum contaminant level [MCL] and HDOH environmental action limit [EAL]) are included in Table 2-5.

As shown in Table 6-1, there are several constituents for which the background data were not normally distributed or could not be transformed to fit a normal distribution. For these cases, a nonparametric UPL based on the maximum value was used. For the remaining constituent-well pairs, UPLs were calculated based on a parametric method, and the Kaplan-Meier approach was used for each calculated UPL when the data included non-detects. The final background sample sizes meet the minimum required power requirements as specified in the Unified Guidance (USEPA, 2009) and are appropriate to verify that an apparent detection exceeds background. The per-test significance level (alpha) is not achieved for UPLs developed using a nonparametric method with a background sample size of between 24 and 28. This results in a slightly higher false positive rate for the nonparametric UPLs developed for MW-3 and MW-5 than targeted based on a 10 percent SWFPR.

The Unified Guidance (USEPA, 2009) recommends that prediction limits be combined with retesting for maintaining a low SWFPR while providing high statistical power. As discussed in Section 8 of Appendix E, a one-of-two retesting strategy will be used to verify concentrations when constituents are detected above background. With this retesting approach, an apparent statistically significant increase (i.e., a constituent exceeding the well- and constituent-specific UPL) cannot be confirmed or denied until the results of the resampling event have been obtained. The sample for the retesting strategy will be collected before the next detection monitoring event at the monitoring well and for the constituent exceeding the UPL. With a semiannual sampling frequency proposed for groundwater detection monitoring, retesting within 3 months of the UPL exceedance is recommended.

Because of temporal changes in ambient groundwater quality, background data should not be regarded as a single fixed quantity. The Unified Guidance (USEPA, 2009) recommends that background data should be updated periodically so compliance samples can be tested against data that best represent the current background conditions. A minimum of four to eight new samples are required to allow a statistical comparison between the new data and the initial background data. Using this principle with semiannual sampling, the UPL values at the CMLF should be updated at least every 4 years, assuming no confirmed release is identified. In cases when a release is confirmed, the background will not be updated; instead, appropriate regulatory action at the site should be taken.

Background data will also be updated to calculate the statistical background limits (UPLs) for any new monitoring well that may be installed in the future. Consistent with the Unified Guidance (USEPA, 2009), HAR 11-58.1-16(d)(2), and the HDOH Landfill Guidance (HDOH, 2002) eight independent samples will be collected from each well on a quarterly basis for analysis of the detection monitoring constituents to establish background concentrations.

6.2 Evaluation of Groundwater Monitoring Results

This section is intended to provide practical guidance on how data will be evaluated during groundwater detection and, if necessary, assessment monitoring at the CMLF. A graphical representation is included to guide data interpretation and outline the decision-making process applicable for the CMLF.

As discussed in Section 3.2, the groundwater monitoring program for CMLF includes detection and, if necessary, assessment monitoring. The strategies, data interpretation, and decision-making process to conduct detection monitoring, together with triggers and exit strategies for assessment monitoring, are described here and summarized on Figure 6-2.

Groundwater detection monitoring will be conducted in compliance with HAR 11-58.1-16(d) on a semiannual schedule at all site monitoring wells, except MW-6 (see Section 3.2.1 for details on detection monitoring locations). Groundwater samples will be collected during wet (November-April) and dry

(May-October) seasons using low-flow sampling methods. Samples will be analyzed for the detection monitoring constituents identified in Section 3.2.1. Monitoring results will be submitted to HDOH SHWB within 45 days of sampling and analysis.

If concentrations of detection monitoring constituents are below the established UPLs at downgradient compliance wells MW-3 and MW-5 (and any other compliance monitoring well for which UPLs may be established in the future), detection monitoring will continue on a semiannual schedule.

If concentrations of detection monitoring constituents are above their respective UPLs at any of the compliance wells, retesting will be conducted within 90 days (but not earlier than 30 days)[12] by collecting a sample at each compliance well where exceedances of the UPLs are detected. Samples for retesting will be analyzed only for those constituents exceeding their respective UPLs. If the exceedance of the UPL is confirmed during retesting, it will be concluded that an SSI in concentration of that specific constituent occurred. The County will place a notice in the operating record of CMLF within 24 hours and will notify the HDOH SHWB director that the notice was placed in the operating record. If concentrations are less than the UPLs during retesting, detection monitoring will continue on a semiannual schedule.

In accordance with HAR 11-58.1-16(d)(3)(C), in case of an SSI, groundwater monitoring data will be further evaluated to determine if a source other than a SWMU caused the increase or the SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Groundwater sampling results from compliance monitoring wells will be compared against upgradient/background wells and recent leachate results. The following lines of evidence will be evaluated to demonstrate that the landfill is not impacting groundwater and that the SSI may be from an alternative source:

- Exceedances of UPLs limited in number and magnitude; in case of an actual release of leachate from an SWMU, elevated concentrations of multiple leachate constituents normally not detected (or present at low concentrations) are expected to be observed in groundwater.
- Constituent concentrations in groundwater higher than those in landfill leachate from the recent leachate monitoring event will be an indication that the landfill SWMUs are not causing the impact.
- Constituent concentrations in groundwater in upgradient/background wells higher than in compliance wells will indicate that the source of the impact is from upgradient locations or natural variation.
- Low concentrations of TDS, alkalinity, chloride and sodium, together with geochemical conditions indicative of oxidized conditions (such as elevated oxygen and redox potential, low dissolved iron, and background concentrations of nitrate and sulfate) are other potential indications that groundwater is not impacted by landfill SWMUs.

If it is determined that an alternative source caused the SSI, the County will prepare an ASD report and will submit it to the HDOH SHWB within 90 days of the SSI finding. If no alternative source or error is demonstrated, assessment monitoring will be initiated in compliance with HAR 11-58.1-16(e). One sample will be collected at each of the compliance monitoring wells within 90 days of retesting, and annually thereafter. Samples will be analyzed for constituents identified under 40 CFR 258 Appendix II.

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[12] A minimum time interval between samples of 30 days is estimated using Darcy's equation (v=Ki/n), as recommended in Chapter 14 of the USEPA Unified Guidance. Using slug test data to estimate hydraulic conductivity (k) (geometric mean of 60 ft/day), an average hydraulic gradient (i) of 9.7×10^{-5} ft/ft, and an effective porosity (n) of 0.15, a linear velocity of 0.039 ft/day (or 0.47 inch/day) is estimated. Considering a diameter for the well+filter pack system of approximately 10 inches, approximately 21 days are estimated for a groundwater particle to flow through the complete monitoring well diameter. As also discussed in the USEPA Unified Guidance, other retardation factors, such as matrix interaction, should be considered in the calculation and the actual time for groundwater to flow through the monitoring well may be greater. To account for retardation factors, the geometric mean hydraulic conductivity from slug test (which evaluate near-well aquifer properties and sometimes underestimate k) was considered and the minimum time interval between samples is rounded to 30 days.

As recommended in the HDOH Landfill Guidance (HDOH, 2002), for any 40 CFR 258 Appendix II constituent detected in the downgradient wells, eight independent samples will be collected and analyzed from each background (upgradient/crossgradient) and compliance (downgradient) well on a quarterly schedule to establish background concentrations (though UPLs will be calculated for compliance wells only). After obtaining results from the initial or subsequent 40 CFR 258 Appendix II sampling, the County will place a notice in the operating record of CMLF within 24 hours and will notify the HDOH SHWB director that the notice was placed in the operating record. If no Appendix II constituents are detected in the sample collected within 90 days of retesting, compliance wells will be resampled for the 40 CFR 258 Appendix II constituents after 1 year. If concentrations are still less than the reporting limit after two consecutive sampling events, CMLF will return to the detection monitoring program subject to approval by HDOH; otherwise, background concentrations for the detected 40 CFR 258 Appendix II constituents will be established as indicated above.

Once background concentrations are established for detected Appendix II constituents, the detected 40 CFR 258 Appendix II constituents will be analyzed for during semiannual detection monitoring, while the full list of 40 CFR 258 Appendix II is analyzed annually until assessment monitoring is terminated. Results will be evaluated as follows:

- If concentrations of 40 CFR 258 Appendix II constituents are at or below the background values (UPLs) for two consecutive sampling events, HDOH SHWB will be notified and detection monitoring will be re-established.
- If concentrations of any of the 40 CFR Appendix II constituents are above the background values (UPLs), but all concentrations are below the groundwater protection standards, assessment monitoring will continue with at least annual sampling and analysis of the full list of 40 CFR 258 Appendix II constituents at compliance wells, and eight quarterly sampling events at compliance and background wells to establish background concentrations (UPLs) for any new 40 CFR 258 Appendix II constituents that may be detected. In accordance with HAR 11-58.1-16(e)(8), the groundwater protection standards will consist of the following:
  - For constituents for which an MCL has been promulgated under Section 1412 of the Safe Drinking Water Act under 40 CFR, part 141, the MCL for that constituent.
  - For constituents for which MCLs have not been promulgated, the HDOH risk-based EALs, or the background value (UPL) for that constituent if an EAL is not available.
  - For constituents for which the background level is higher than the MCL, the background concentration (UPL).
- If one or more of the 40 CFR 258 Appendix II constituents are detected at statistically significant levels above the groundwater protection standards, the County will notify the HDOH SHWB within 14 days, and additional characterization and assessment of corrective measures will start within 90 days in accordance with HAR 11-58.1-16(e)(7)(A). Alternatively, in accordance with HAR 11-58.1-16(e)(7)(B) an ASD will be completed to demonstrate that a source other than the landfill is responsible for the contamination or the SSI is the result of an error in sampling, analysis, statistical evaluation, or natural variation. A report documenting this demonstration will be submitted to HDOH SHWB within 90 days of the finding and assessment monitoring will continue.

7 References

A-Mehr, Inc. (A-Mehr). 2011. *Groundwater and Leachate Monitoring Plan for Central Maui Landfill*. Prepared for County of Maui, Department of Environmental Management, Solid Waste Division. November, revised November 2012.

A-Mehr, Inc. (A-Mehr). 2012. *Groundwater and Leachate Monitoring Plan for Central Maui Landfill*. Prepared for County of Maui, Department of Environmental Management, Solid Waste Division. November 2.

A-Mehr, Inc. (A-Mehr). 2017a. *Closure and Post-Closure Plan, Central Maui Landfill, Puunene, Maui, Hawaii.* Prepared for County of Maui, Department of Environmental Management, Solid Waste Division. February.

A-Mehr, Inc. (A-Mehr). 2017b. *Preliminary Engineering Report for Central Maui Landfill Integrated Solid Waste Management Facility Extension Area*. Prepared for County of Maui, Department of Environmental Management, Solid Waste Division. May.

AECOM. 2012. *Hawaiian Islands Soil Metal Background Evaluation Report*. May.

Anthony, S.S., C.D. Hunt, Jr., AMD Brasher, L.D. Miller, and M.S. Tomlinson. 2004. *Water Quality on the Island of Oahu, Hawaii, 1999-2001*. U.S. Geological Survey Circular 1239. 41 pp.

Apgar, M.A. and D. Langmuir. 1972. "Ground-Water Pollution Potential of a Landfill Above the Water Table." *Ground Water*, v. 9, no. 6, p.76-94. November-December.

ASTM International (ASTM). 2017. *Standard Guide for Optimization of Groundwater Monitoring Constituents for Detection Monitoring Programs for Waste Disposal Facilities.* ASTM Standard D7045-17.

Baedecker, M.J. and W. Back. 1979. "Hydrogeological Processes and Chemical Reactions at a Landfill." 1979. *Ground Water*, v. 17 no. 5, p 429-437. September-October.

Blumenstock, D.I., and Price, Saul. 1967. *Climate of Hawaii, in Climates of the States*, No. 60-51, Climatography of the United States. U.S. Department of Commerce.

Brown and Caldwell. 2017. *Maui EKO Systems Stormwater Pollution Control Plan*. Prepared for EKO Systems. August.

Burnham, W.L., S.P. Larson, and H.H. Cooper. 1977. *Distribution of Injected Wastewater in the Saline-Lava Aquifer, Wailuku-Kahului Wastewater Treatment Facility, Kahului, Maui Hawaii*. United States Geological Survey Open-File Report 77-496. pp. 58.

CH2M HILL (CH2M). 2016a. *Conceptual Site Model, Central Maui Landfill, Puunene, Hawaii.* Prepared for The County of Maui, Department of Environmental Management, Solid Waste Division. February.

CH2M HILL (CH2M). 2016b. *Calculation of Upper Prediction Limits, Central Maui Landfill Facility Groundwater Monitoring*. Technical Memorandum. Prepared for Kevin Kihara, Hawaii Department of Health, Solid and Hazardous Waste Branch. October 16.

CH2M HILL (CH2M). 2016c. *March, June, and September 2015 Detection Monitoring Report*, Central Maui Landfill, Puunene, Hawaii. May.

CH2M HILL (CH2M). 2018a. *June and September 2018 Detection Monitoring Report, Puunene, Hawaii.* Prepared for The County of Maui, Department of Environmental Management, Solid Waste Division. December.

CH2M HILL (CH2M). 2018b. *Final Conceptual Site Model, Central Maui Landfill, Puunene, Hawaii.* Prepared for The County of Maui, Department of Environmental Management, Solid Waste Division. January.

Christensen, T.H, R. Cossu, and R. Stegmann. 1992. *Landfilling of Waste: Leachate*. E & FN Spon, an imprint of Chapman & Hall, London. 521 pp.

CML. 2001. *Leachate Line Cleaning, Central Maui Landfill, Phases I And II Report*. December.

County of Maui. 2016. *2016 Drinking Water Quality Report*. Department of Water Supply.

County of Maui. 2017. *Draft Environmental Impact Statement, Renewable Energy Conversion and Sludge Processing at the Wailuku-Kahului Wastewater Reclamation Facility (WKWWRF)*. Department of Environmental Management. Prepared by Maui All Natural Alternative (MANA). December.

Dames and Moore, 1998. *Technical Memorandum, Evaluation of Waste Density*. December.

Dixon, W.J. 1953. "Processing Data for Outliers." *Biometrics*, 9, 74-89.

Earth Tech. 2002. *Hydrogeologic Characterization and Background Detection Monitoring, Central Maui Landfill, Phase IV, Puunene, Hawaii.*

El-Kadi, AI and J.E.T. Moncur. 2006. *The History of Groundwater Management and Research in Hawaii.* Proceedings of Jeju-Hawaii Water Forum. Jeju, Korea. July.

Element Environmental, LLC (Element). 2014. *Central Maui Landfill Groundwater Well Network Analysis.* February.

Element Environmental, LLC (Element). 2013. *Synoptic Water Level Data for Central Maui Landfill*. Excel Spreadsheet.

Environmental Simulations, Inc. (ESI). 2011. *Guide to Using Groundwater Vistas, Version 6*. Reinholds, Pennsylvania.

Giambelluca, T.W., M.A. Nullet, and T.A. Schroeder. 1986. *Rainfall Atlas of Hawai'i*. Hawai'i Department of Land and Natural Resources, Division of Water and Land Development. Report R76, 267 p.

Gingerich, S.B. 2008. "Ground-Water Availability in the Waiuku Area, Maui, Hawai'i." *U.S. Geological Survey Scientific Investigations Report* 2008-5236.

Hargis, D.R. and F.L. Peterson. 1974. "Effects of Well Injection on a Basaltic Ghyben-Herzberg Aquifer." *Ground Wate*r, Volume 12, No. 1. January–February 1974, pp 4-9.

Helsel, D.R. 2005. *Nondetects and Data Analysis. Statistics for Censored Environmental Data*. John Wiley and Sons, NY.

Hydrogeologic Inc. (HGL). 2008. *MOD-HMS/MODFLOW-SURFACT ver. 4.0 User's manual. A Comprehensive MODFLOW-Based Hydrologic Modeling System*.

Kaplan, E.L. and O. Meier. 1958. Nonparametric Estimation from Incomplete Observations. *Journal of the American Statistical Association*, Vol. 53. 457-481.

Lau, L.S. and J.F. Mink. 2006. *Hydrology of the Hawaiian Islands.* University of Hawaii Press.

Macdonald, G.A., A.T. Abbott, and F.L. Peterson. 1983. *Volcanoes in the Sea: the Geology of Hawaii.* University of Hawaii Press. 517 pp.

Masa Fujioka & Associates (MFA). 1996. *Water Quality Protection Standard and Control Limits for the Central Maui Class III Landfill*.

Masa Fujioka & Associates (MFA). 1997. *Hydrogeological Characterization Report, Central Maui Sanitary Landfill, Puunene, Maui, Hawaii.* January 31.

Mink, J.F. and L.S. Lau. 1980. Hawaiian Groundwater Geology and Hydrogeology, and Early Mathematical Models. Technical Report No. 62. Water Resource Research Center, Honolulu. September.

Mink, J.F. and S.L. Lau. 1990*. Aquifer identification and classification for Maui: Groundwater Protection Strategy for Hawaii*. Water Resources Research Center Technical Report no. 185. 47 p.

Nicholson, R.V. J.A. Cherry, and E.J. Reardon. *Migration of Constituents at a Landfill: A Case Study*. Volume 6: Hydrogeochemistry. 1983. Journal of Hydrology. Vol. 63.

Oki, D.S., G.W. Tribble, W.R. Souza, and E.L. Bolke. 1999. *Ground-Water Resources in Kaloko-Honokohau National Historical Park, Island of Hawaii, and Numerical Simulation of the Effects of Ground-Water Withdrawals*. U.S. Geological Survey Water-Resources Investigations Report 99-4070. 58 pp.

Ronald M. Fukumoto Engineering, Inc. [RFE]. 1995. *Drainage and Erosion Control Report for Co-composting Project Pad No. 2 and 3, TMK: (2) 3-8-03: 19, Puunene, Maui, Hawaii*. Prepared for the Solid Waste Division, Department of Public Works and Waste Management, County of Maui. August.

Rosner, B. 1983. ”On the Detection of Many Outliers.” *Technometrics*, 17, 221-227.

Rotzoll, K., and A.I. El-Kadi. 2008. “Estimating Hydraulic Conductivity from Specific Capacity for Hawaii Aquifers, USA.” *Hydrogeology Journal,* August 2008.

Sanderson, Marie. 1993. “Introduction, Chapter 1.” Sanderson, Marie, ed., *Prevailing trade winds: Honolulu, Hawai‘i*. University of Hawai‘i Press, p. 1–11.

Serfes. 1991. “Determining the Mean Hydraulic Gradient of Groundwater Affected by Tidal Fluctuations.” *Groundwater*, Vol. 29, no. 4, July-August 1991.

Singh, A., R. Maichle, and S. Lee. 2006. *On the Computation of a 95% Upper Confidence Limit of the Unknown Population Mean Based Upon Data Sets with Below Detection Limit Observations*. EPA/600/R-06/022, March.

Singhal, B.B.S. and R. P. Gupta. 2010. *Applied Hydrogeology of Fractured Rocks: Second Edition*. Springer Science Business Media. 408 p.

State of Hawaii Department of Health (HDOH). 2002. “Landfill Groundwater Monitoring Guidance Document” Version 1.8. Solid and Hazardous Branch. September.

State of Hawaii Department of Health (HDOH). 2014. *Statement Regarding Vanadium in Drinking Water*. 1p*.* May 29.

State of Hawaii Department of Health (HDOH). 2015. *Field Citation Docket Nos. 2015-CW-EO-49FC 7 2015-CW-EO-50FC, Notice of General Permit Coverage (NGPC), National Pollutant Discharge Elimination System (NPDES), Violations of the Hawaii Water Pollution Regulations, Central Maui Sanitary Landfill – Phase II (Maui Eko System) & Phase IV, File Nos. HI R50C026 and R50B344, Island of Maui, Hawaii.* November 25.

Swain. L.A. 1973. *Chemical Quality of Ground Water in Hawaii*. Report R48. Prepared by the U.S. Geological Survey in cooperation with the Department of Land and Natural Resources, Division of Water and Land Development. 62 pp.

URS. 2011. *Semi-Annual Groundwater Monitoring Report, December 2010, Central Maui Landfill*. April.

URS. 2012. *2012 Groundwater Assessment Monitoring Report, Central Maui Landfill, March 2012.* May.

URS. 2014a. *Semiannual Groundwater Monitoring Report, Central Maui Landfill, December 2013.* February.

URS. 2014b. *Semiannual Groundwater Monitoring Report, Central Maui Landfill, July 2014.* October.

U.S. Department of Health and Human Services. 2017. *Public Health Service Agency for Toxic Substances and Disease Registry, Toxicological Profile for Nitrate and Nitrite*. July.

U.S. Environmental Protection Agency (USEPA). 1996. *Soil Screening Guidance, Technical Background Document*. Report EPA-540-R95-128. Office of Solid Waste and Emergency Response. May.

U.S. Environmental Protection Agency (USEPA). 1999. *Contract Laboratory National Functional Guidelines for Organic Data Review.* OSWER 9240.1-05A-P, EPA540/R-99/008. October.

U.S. Environmental Protection Agency (USEPA). 2002a. *Contract Laboratory National Functional Guidelines for Inorganic Data Review.* EPA-540-R-04-004, OSWER 9240.1-45. July.

U.S. Environmental Protection Agency (USEPA). 2002b. *National Water Quality Inventory, 2000 Report.* August.

U.S. Environmental Protection Agency (USEPA). 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*. EPA 530/R-09-007. Office of Research and Development. March.

U.S. Environmental Protection Agency (USEPA). 2015. *ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations*. EPA/600/R-07/041. Office of Research and Development. October.

United States Geological Survey (USGS). 1985. *Study and Interpretation of the Chemical Characteristics of Natural Waters*.

United States Geological Survey (USGS). 2000. *The Response of the Iao Aquifer to Ground-Water Development, Rainfall, and Land-Use Practices Between 1940 and 1998, Island of Maui, Hawaii*. Water-Resources Investigations Report 2000-4223.

United States Geological Survey (USGS). 2005. *Central Maui Area Groundwater Levels, May 17, 2005 (7:30 a.m. to 2:30 p.m.)*. https://hi.water.usgs.gov/studies/synoptic/central_maui/synoptic_2005.png.

United States Geological Survey (USGS). 2007. *Effects of Agricultural Land-Use Changes and Rainfall on Groundwater Recharge in Central and West Maui, Hawai'i, 1926-2004.* Scientific Investigation Report 2007-5103.

Waimea Water Services (WWS). 2012. *Owner's Well Report, Puunene Solid Water Well (State Well No. 5125-07).* December 21.

Watermark Numerical Computing (WNC). 2010. PEST, Model-Independent Parameter Estimation User Manual, 5th edition.

Wilcox, Rand R. 2010. *Fundamentals of Modern Statistical Methods*. March.

Figures

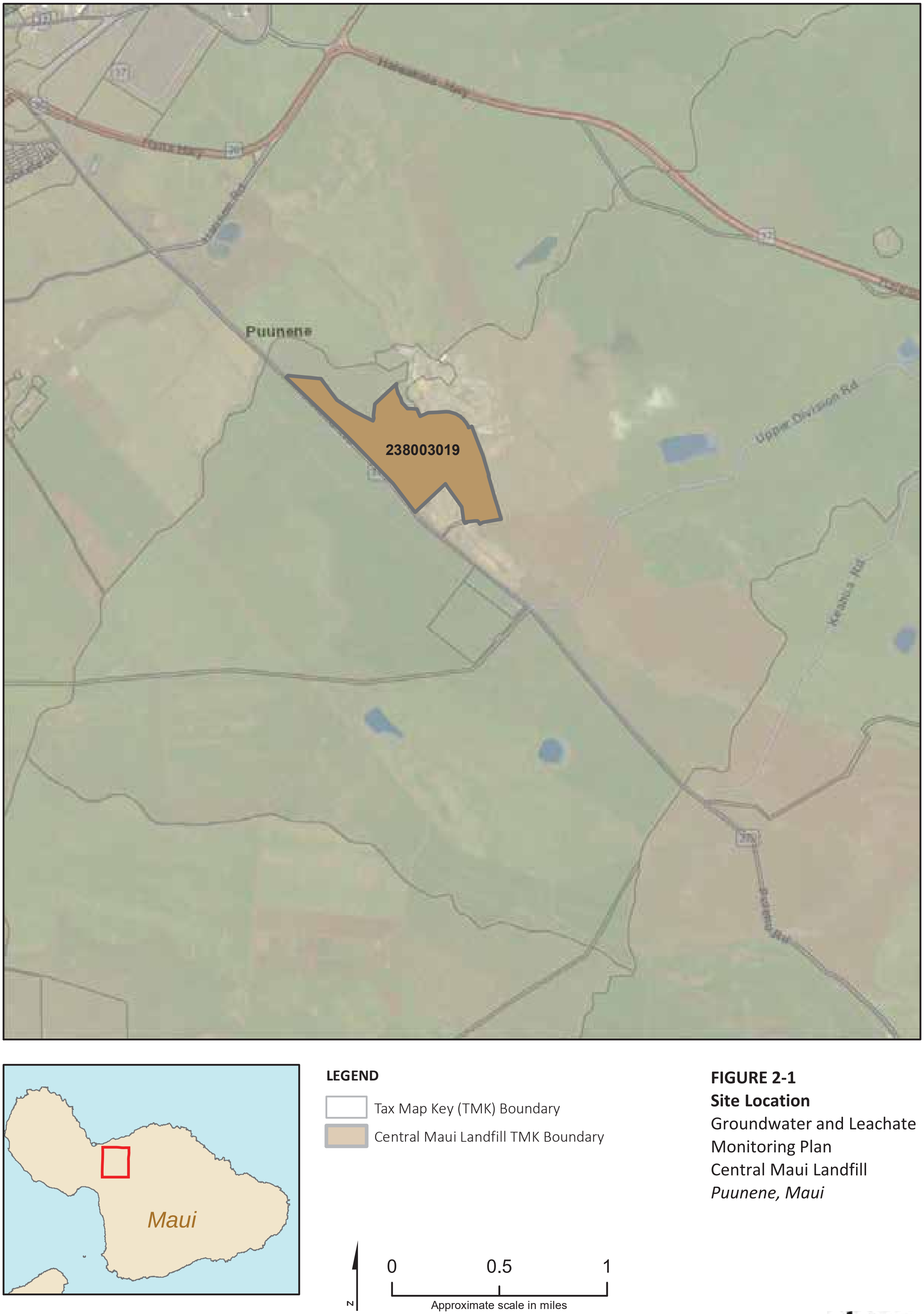

FIGURE 2-1
Site Location
Groundwater and Leachate
Monitoring Plan
Central Maui Landfill
Puunene, Maui

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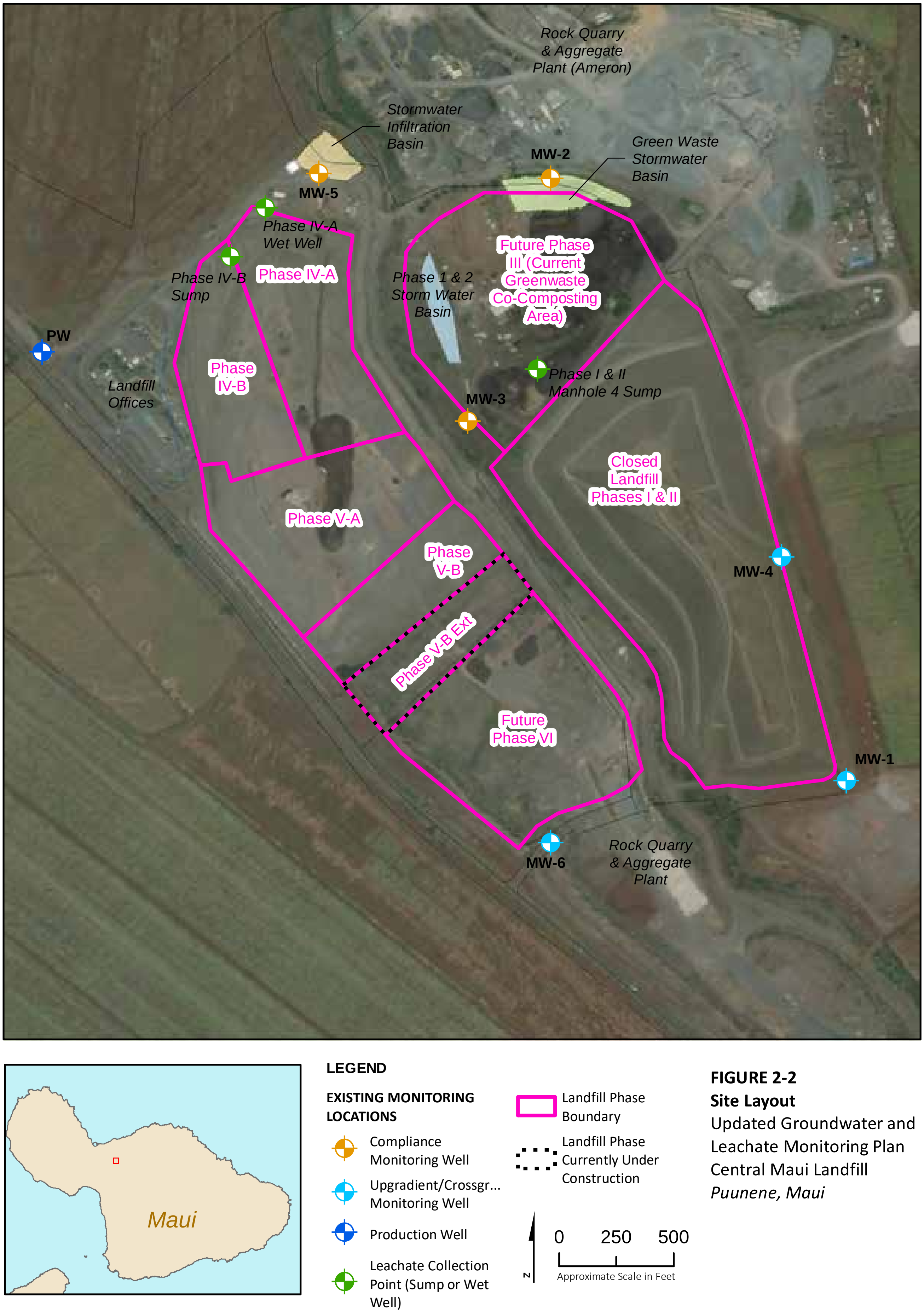


FIGURE 2-2
Site Layout
Updated Groundwater and Leachate Monitoring Plan
Central Maui Landfill
Puunene, Maui

ch2m

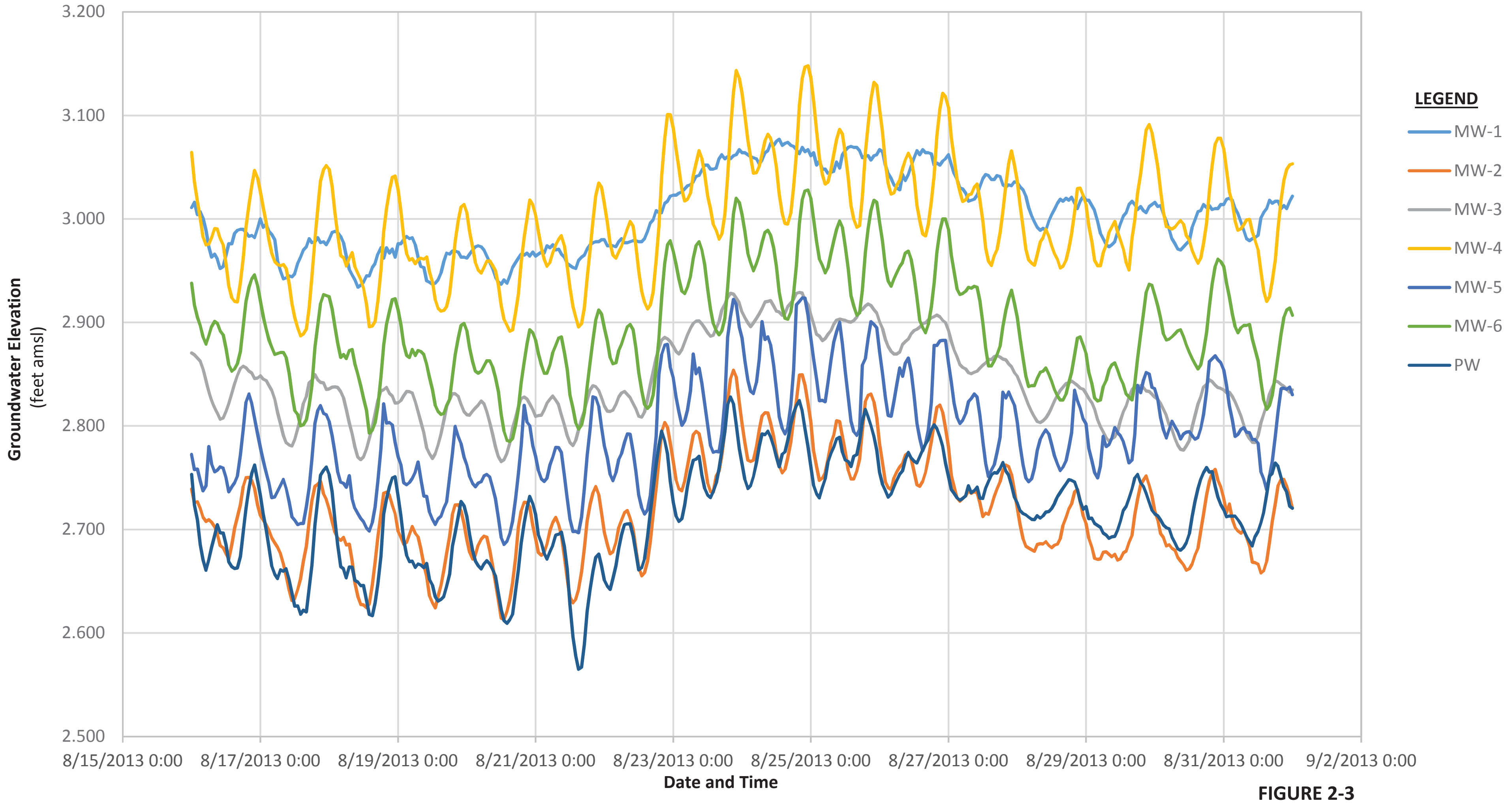
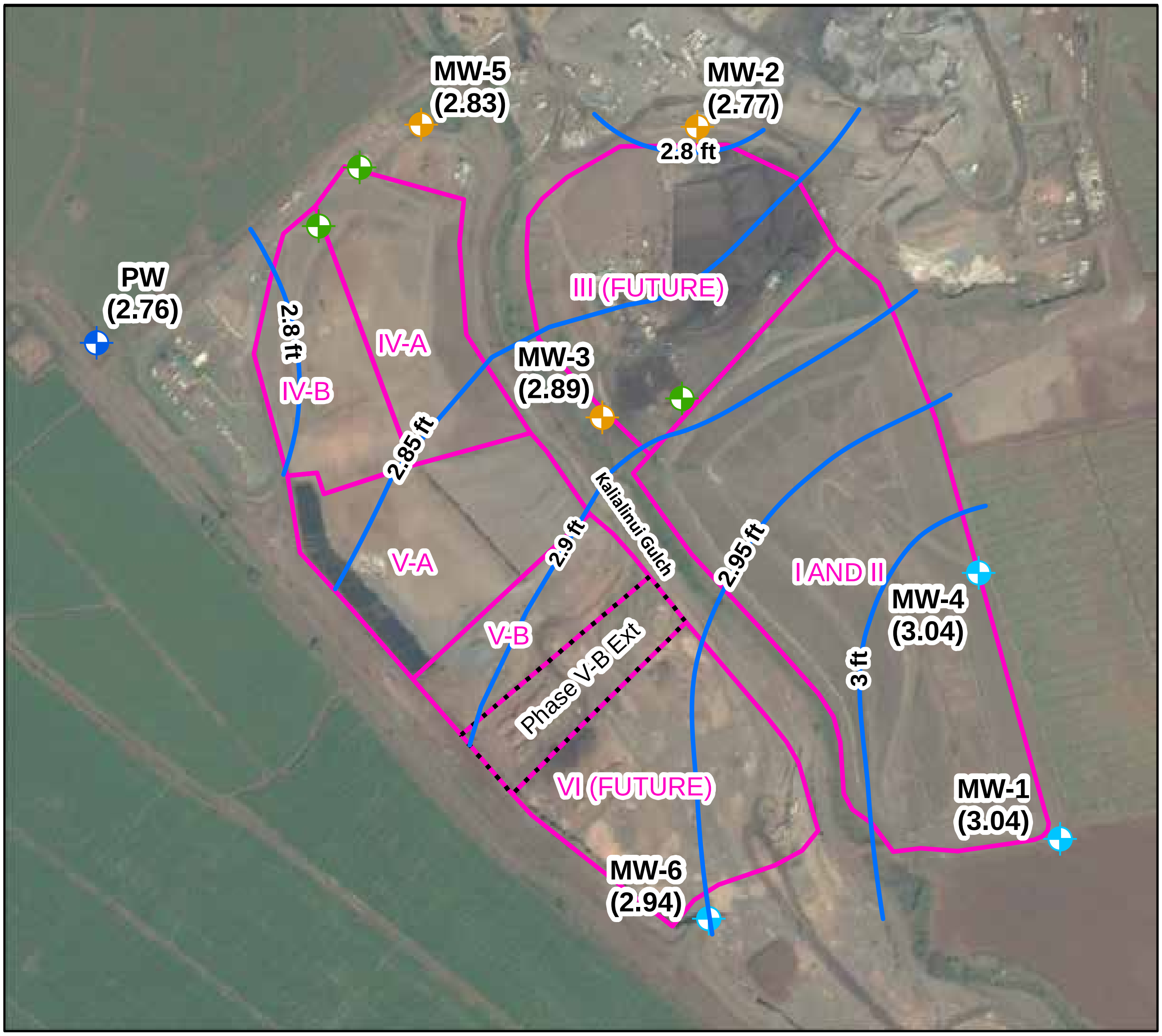
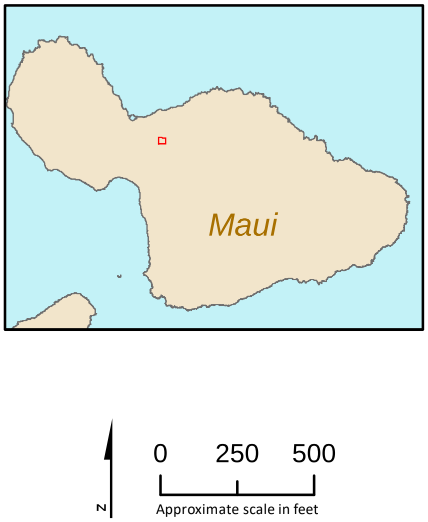


FIGURE 2-3
Harmonic Tidal Fluctuations
Groundwater and Leachate
Monitoring Plan
Central Maui Landfill
Puunene, Maui

Notes: Element Environmental LLC conducted continuous monitoring of water levels at the site between August 15, 2013 and October 16, 2013 (Element, 2013)

amsl = above mean sea level





Notes:
- Average hydraulic gradient = 1.0 E-04 foot/foot
- Seepage velocity = 14 feet/year to 478 feet/year
- Hourly measurements from 2013 continuous synoptic water level measurements (Element, 2014). Groundwater flow characteristics have been modeled using the software Surfer 8.0.
- This figure represents the average groundwater equipotential lines and the horizontal hydraulic gradient during the 71-hour period (between 8/22/2013, 00:00 hours and 8/24/2013, 23:00 hours). The average hydraulic gradient has been estimated using groundwater elevations between monitoring wells MW-4 and MW-2, and MW-4 and PW.
- Groundwater elevations (indicated along contour lines and in parenthesis for each well) are in feet above mean sea level.

ACRONYMS:
ft = feet (above mean sea level)

LEGEND

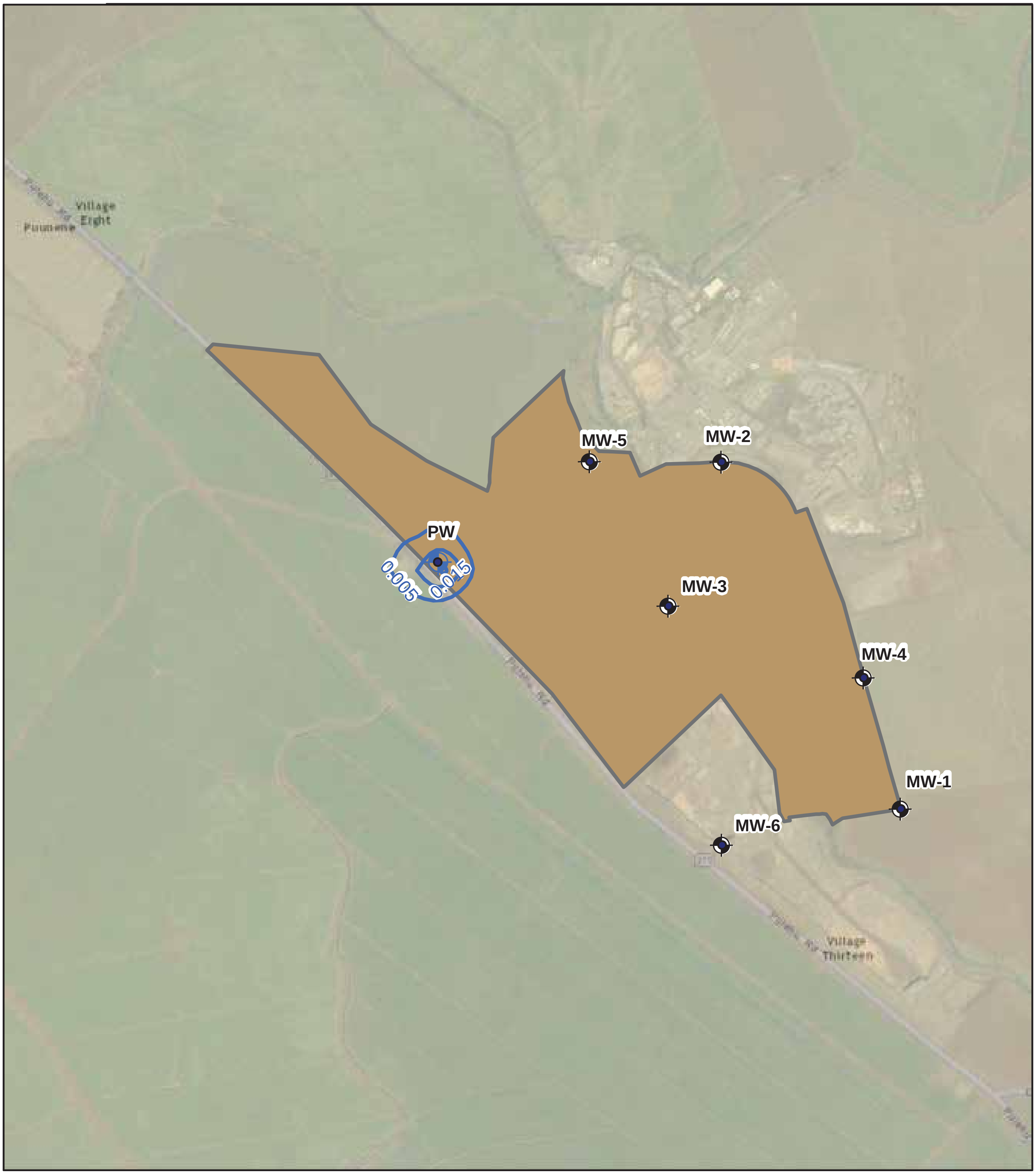
EXISTING MONITORING LOCATIONS

- ⊕ Compliance Monitoring Well
- ⊕ Upgradient/Crossgradient Monitoring Well
- ⊕ Production Well
- ⊕ Leachate Collection Point (Sump or Wet Well)
- ▭ Landfill Phase Boundary
- ⬚ Landfill Phase Currently Under Construction
- — Inferred Groundwater Potentiometric Contour

FIGURE 2-4
71-Hour Mean Groundwater Contour Map
Groundwater and Leachate Monitoring Plan
Central Maui Landfill
Puunene, Maui

ch2m

\\NALA\PROJ\GIS_LIBRARY\MAUI LANDFILL\MXDS\UPDATED_LEACHATE_PLAN\FIG_2-4_CM_71HR_GW_LEVELS.MXD ANELSON9 2/8/2018 10:40:58 AM



LEGEND

▬ Simulated drawdownl contours (ft)

⊕ Existing Monitoring Well

⊕ Production Well

N

0 0.125 0.25

Approximate scale in miles

FIGURE 2-5
Simulated Drawdown Contours
Current PW Daily Pumping
Groundwater and Leachate
Monitoring Plan
Central Maui Landfill
Puunene, Maui

C:\MAUI\MAPFILES\FIG6_DRAWDOWN_DAILY.MXD KSUN 4/14/2017 9:47:46 AM

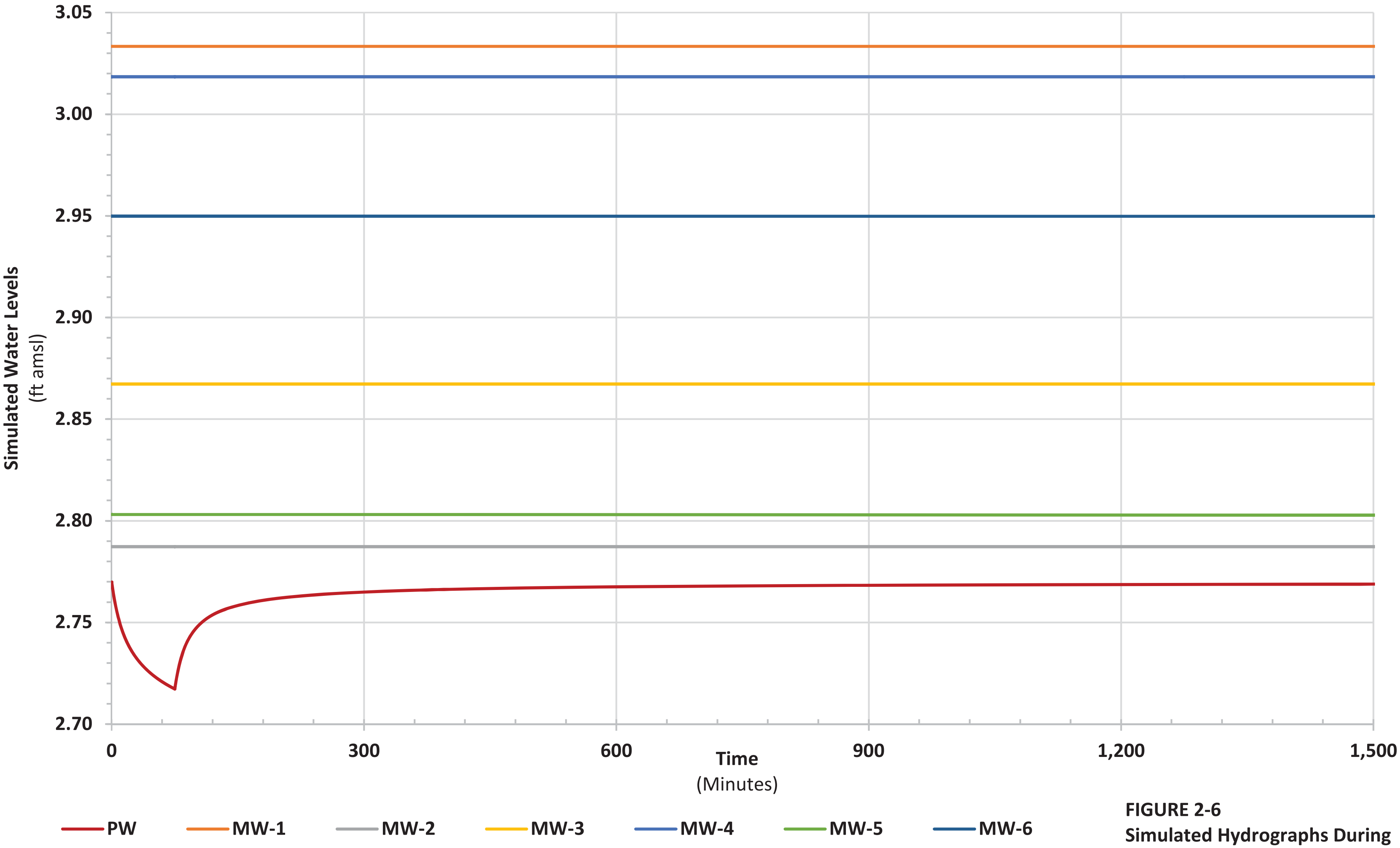
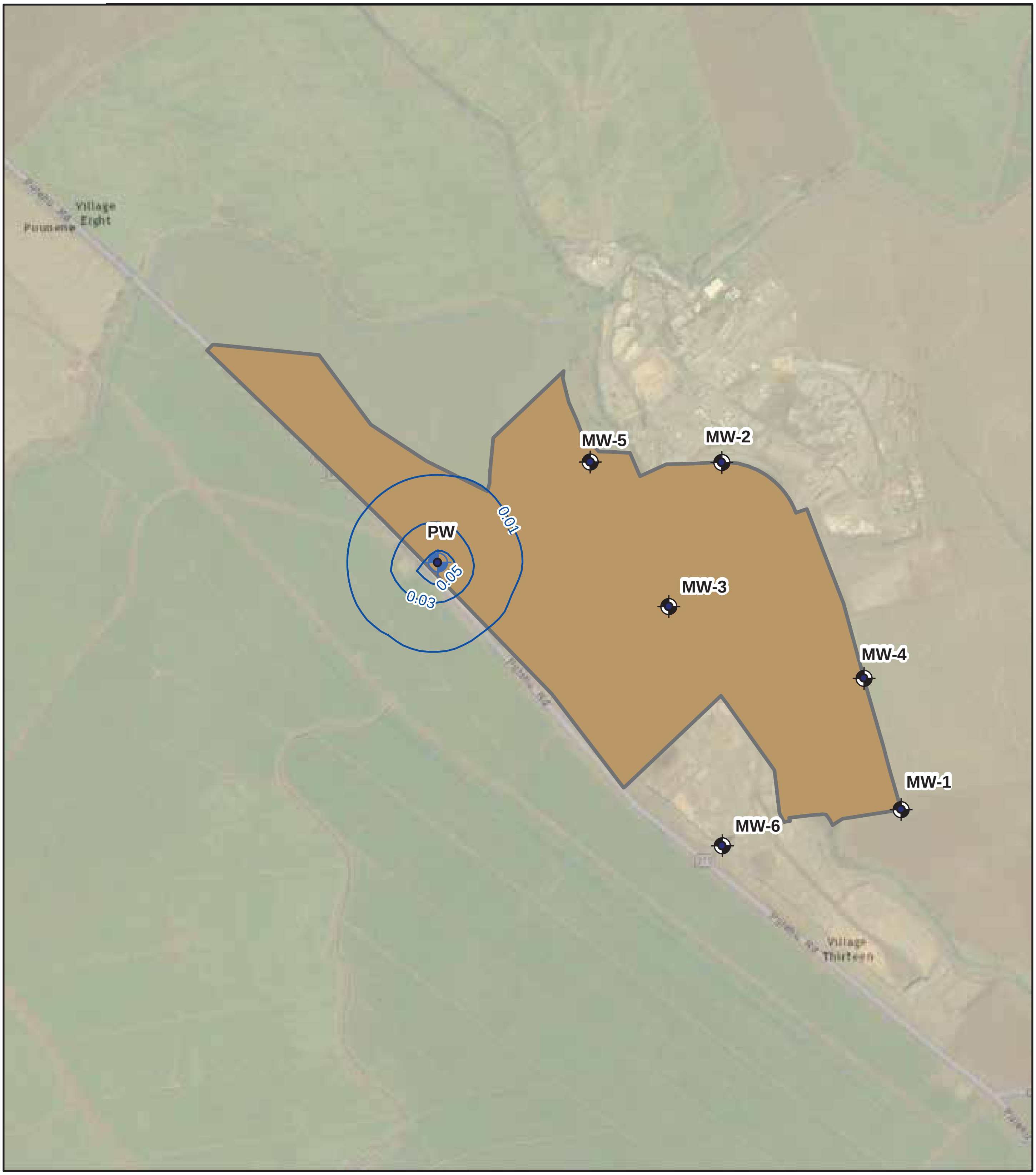


FIGURE 2-6
Simulated Hydrographs During Current PW Daily Pumping
Groundwater and Leachate Monitoring Plan
Central Maui Landfill
Puunene, Maui



N

0 0.125 0.25

Approximate scale in miles

LEGEND

Simulated drawdownl contours (ft)

Existing Monitoring Well

Production Well

FIGURE 2-7
Simulated Drawdown Contours
Future PW Daily Pumping
Groundwater and Leachate
Monitoring Plan
Central Maui Landfill
Puunene, Maui

ch2m:

C:\MAUI\MAPFILES\FIG9_DRAWDOWN_DAILY_P2.MXD KSUN 5/27/2017 2:44:05 PM

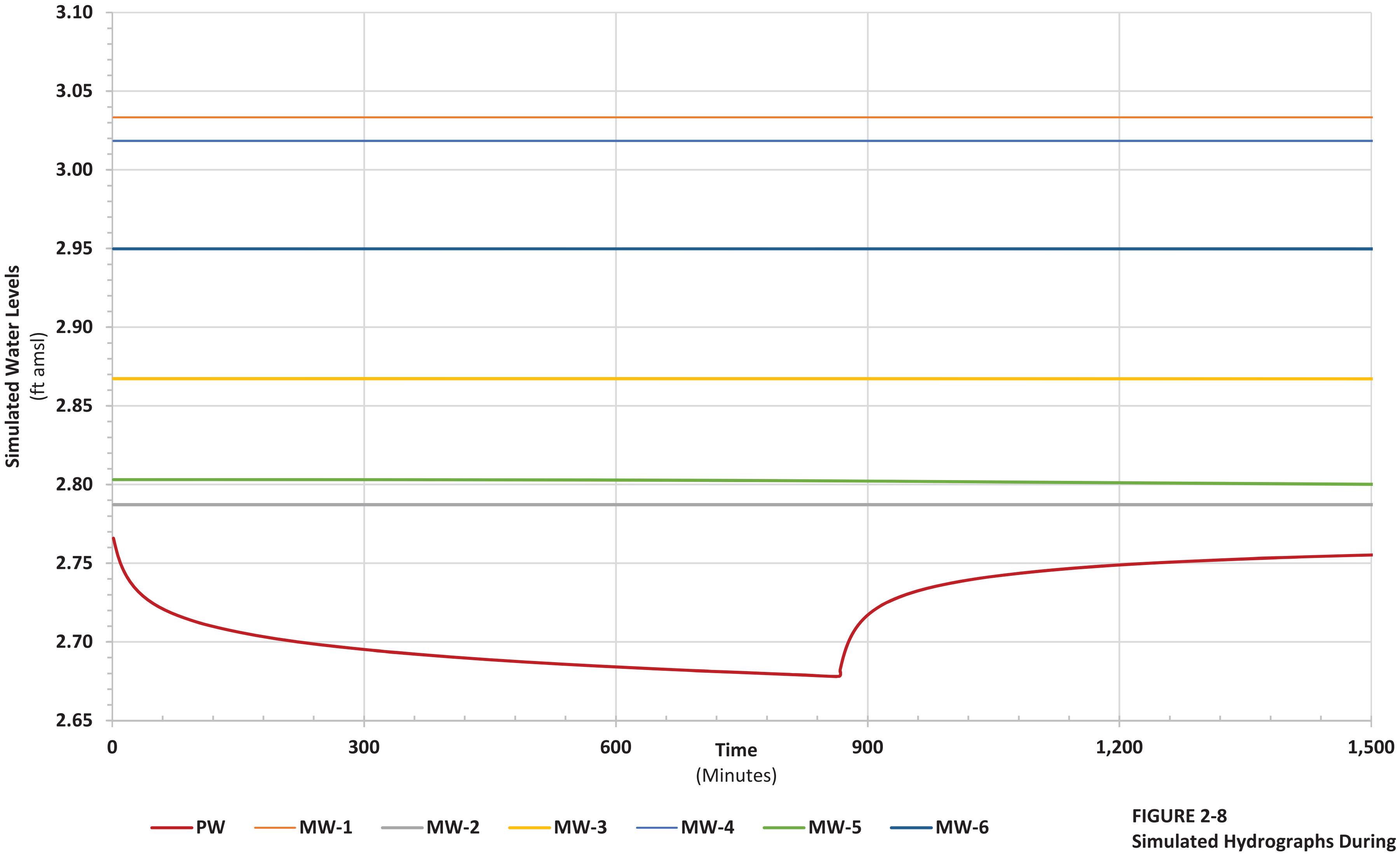


FIGURE 2-8
Simulated Hydrographs During Future PW Daily Pumping
Groundwater and Leachate Monitoring Plan
Central Maui Landfill
Puunene, Maui

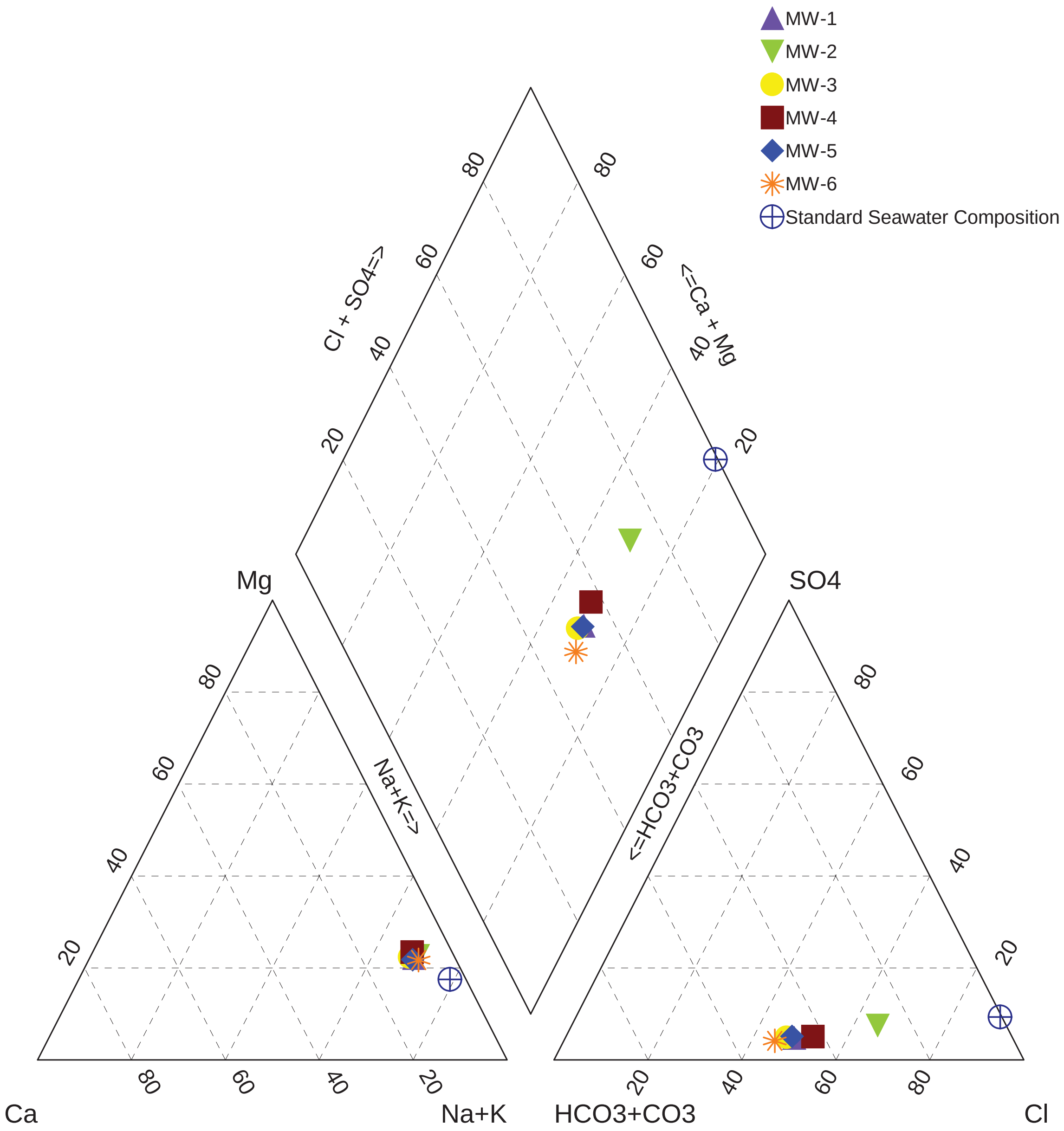


FIGURE 2-9

Piper Diagram - March 2017

Groundwater and Leachate
Monitoring Plan
Central Maui Landfill
Puunene, Maui

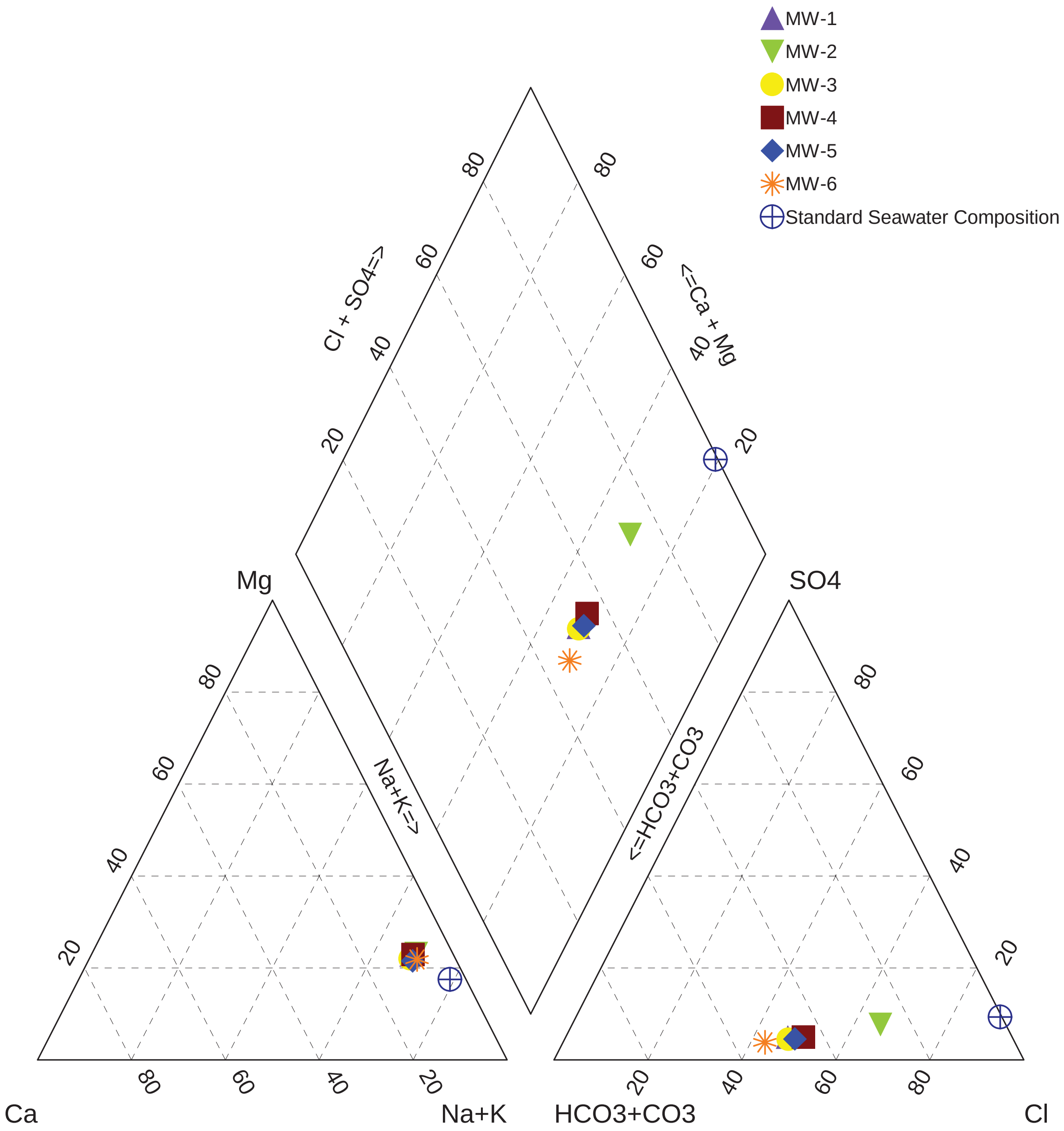


FIGURE 2-10

Piper Diagram - June 2017

Groundwater and Leachate
Monitoring Plan
Central Maui Landfill
Puunene, Maui

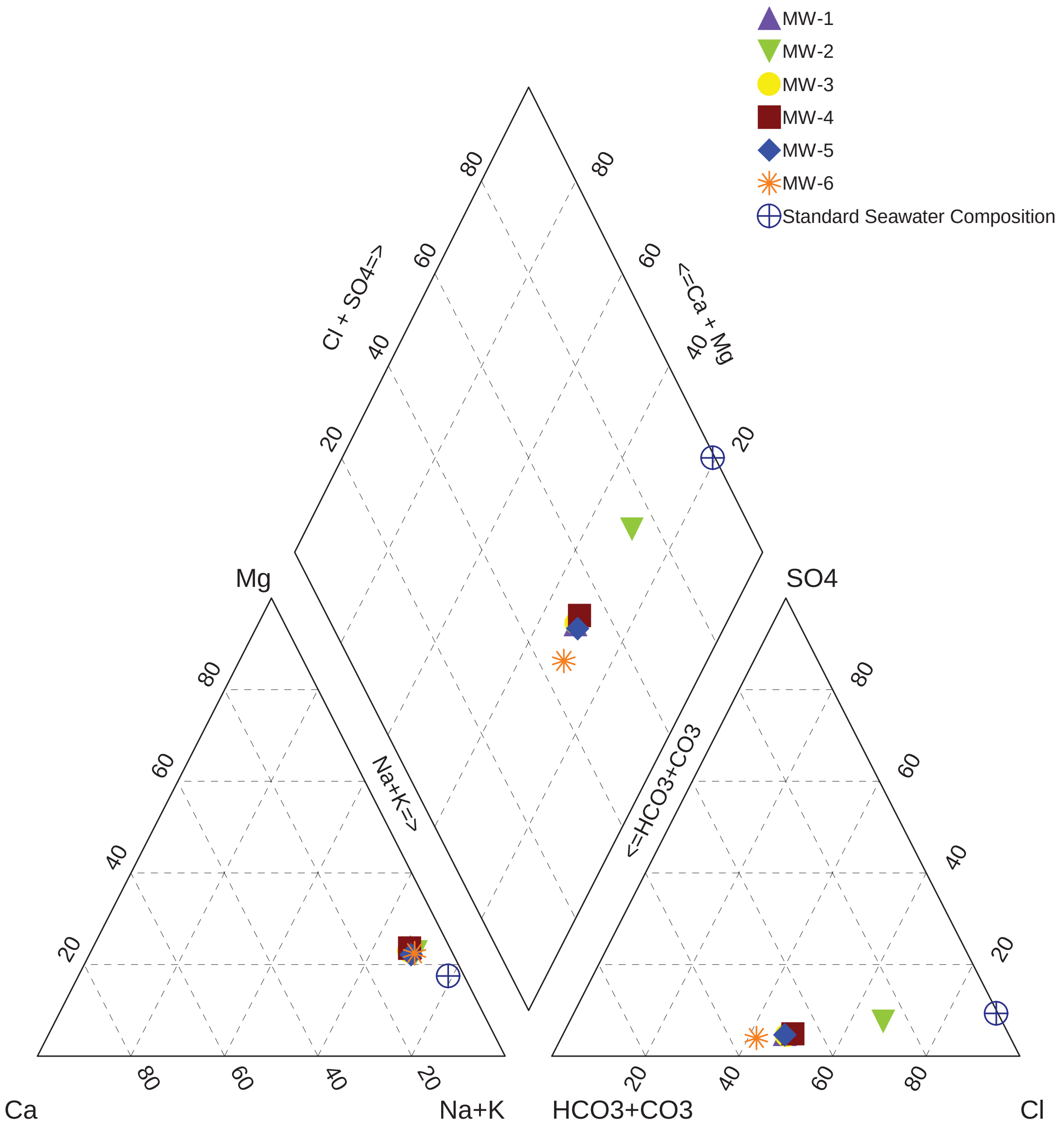


FIGURE 2-11

Piper Diagram - September 2017

Groundwater and Leachate
Monitoring Plan
Central Maui Landfill
Puunene, Maui

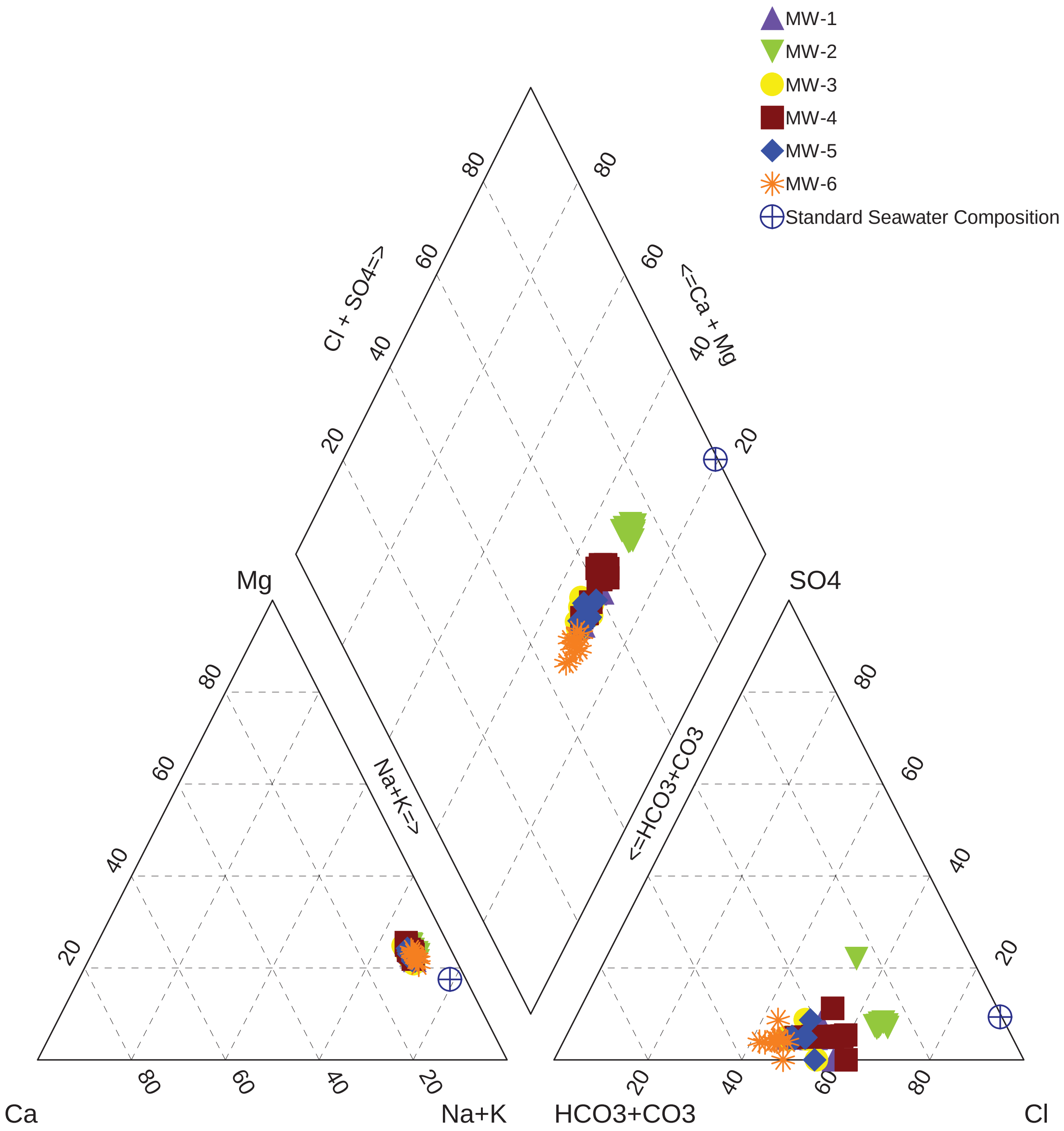
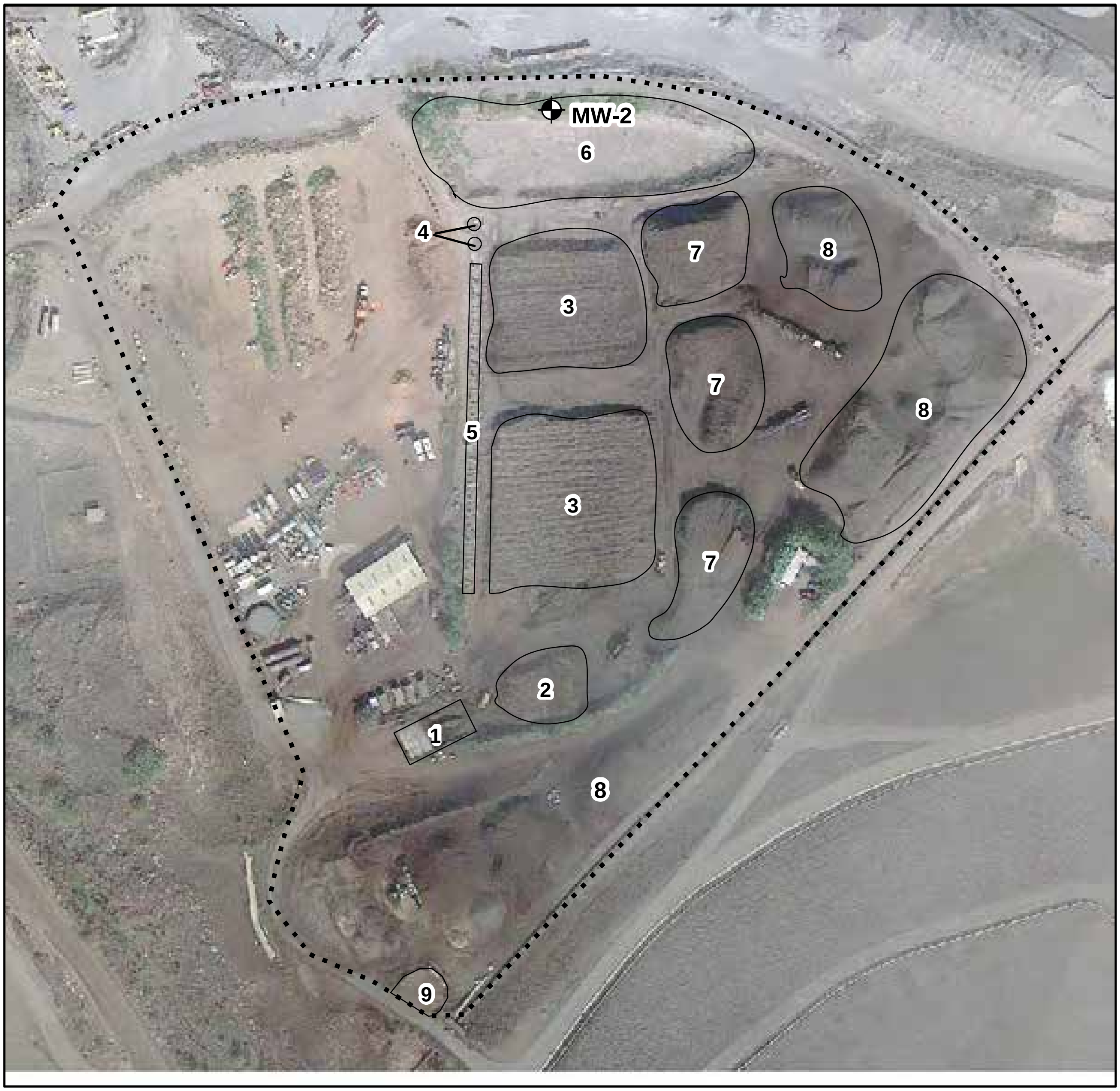
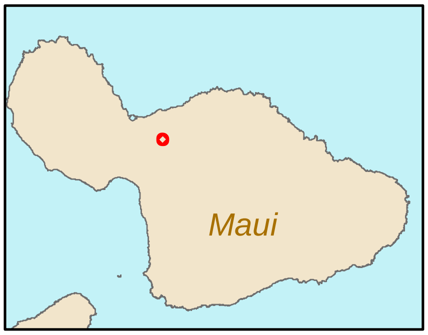
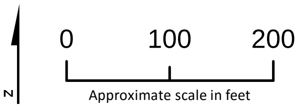


FIGURE 2-12
Piper Diagram - All Data
2015-2017
Groundwater and Leachate
Monitoring Plan
Central Maui Landfill
Puunene, Maui







Acronyms:
FOG = fats, oils, and grease

Note: Locations are approximate

LEGEND

⁚⁚⁚ Co-Composting Facility Boundary

⊕ Existing Monitoring Well

1) Sludge Bay (biosolids and FOG liquids)

2) Compost PreMix Compost Phase 1

COMPOST PHASE 1

3) Active Windrow Piles

4) Leachate Condensation Sump

5) Compost Condensation Swale

6) Stormwater Basin

COMPOST PHASE 2

7) Curing PIles Compost

COMPOST PHASE 3

8) Finished Product Piles

9) Bulk Product Loading and Shipping

FIGURE 2-13
Co-composting Facility Layout
Groundwater and Leachate
Monitoring Plan
Central Maui Landfill
Puunene, Maui

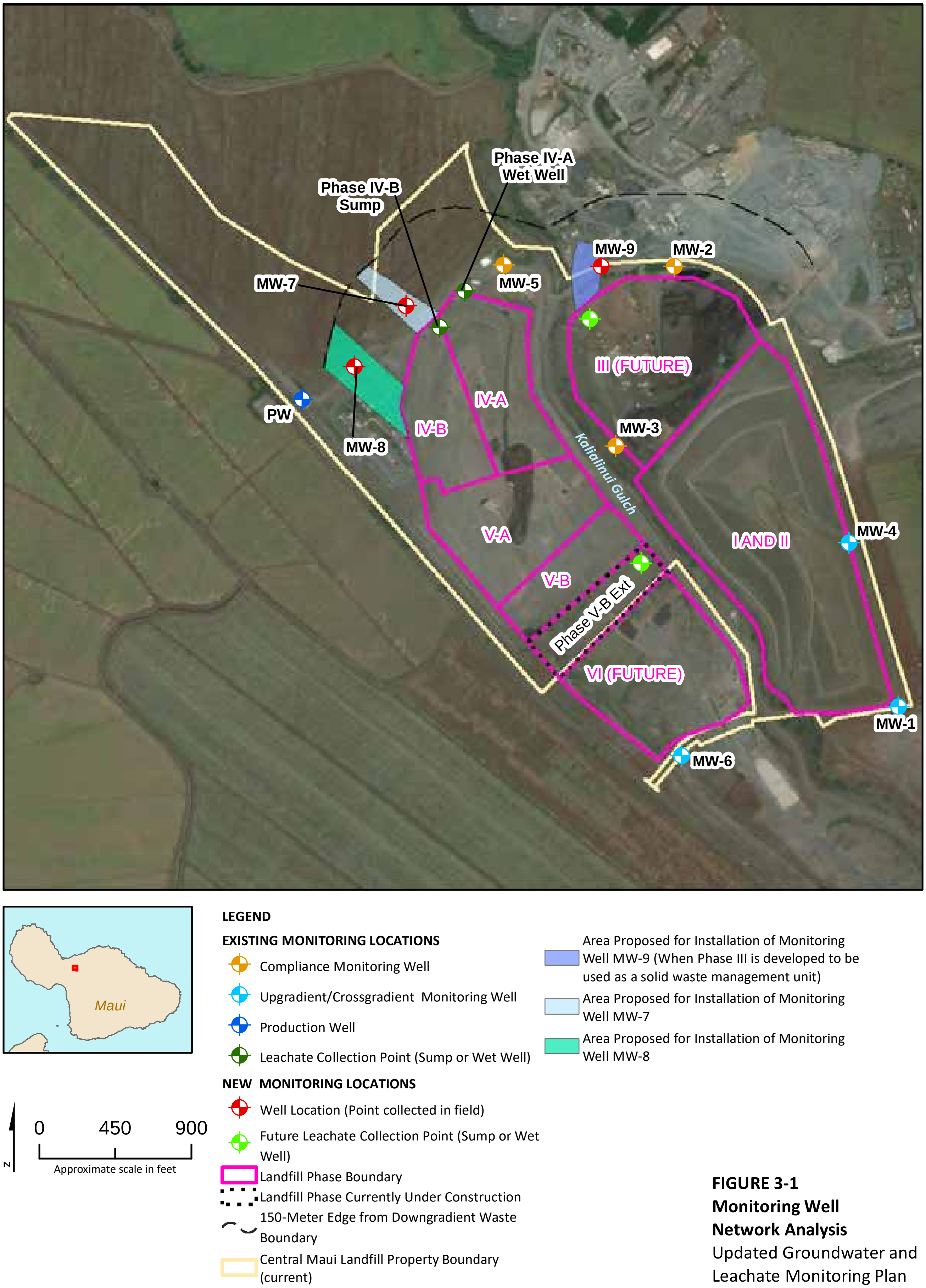
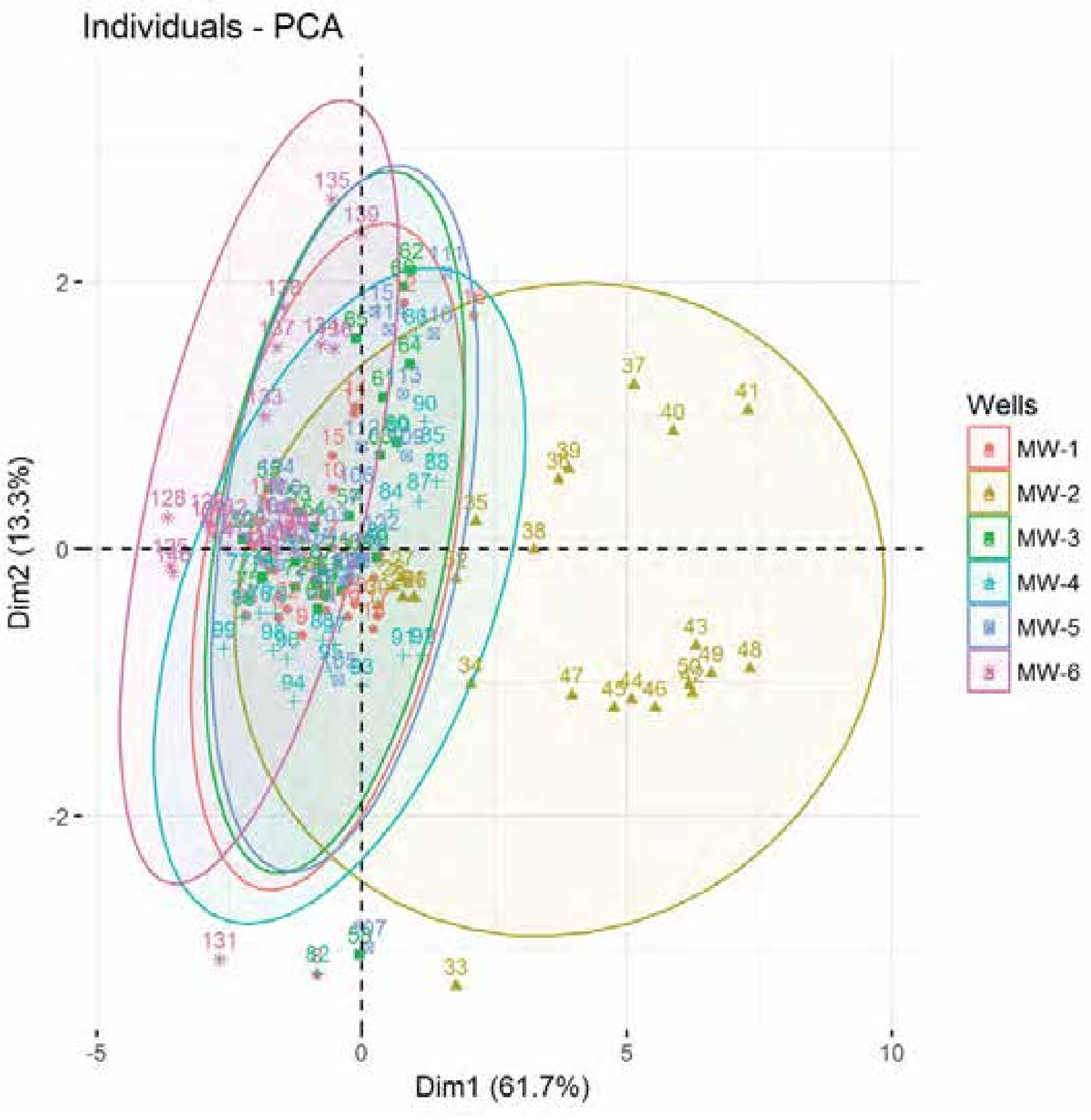


FIGURE 3-1
Monitoring Well Network Analysis
Updated Groundwater and Leachate Monitoring Plan
Central Maui Landfill
Puunene, Maui

ch2m

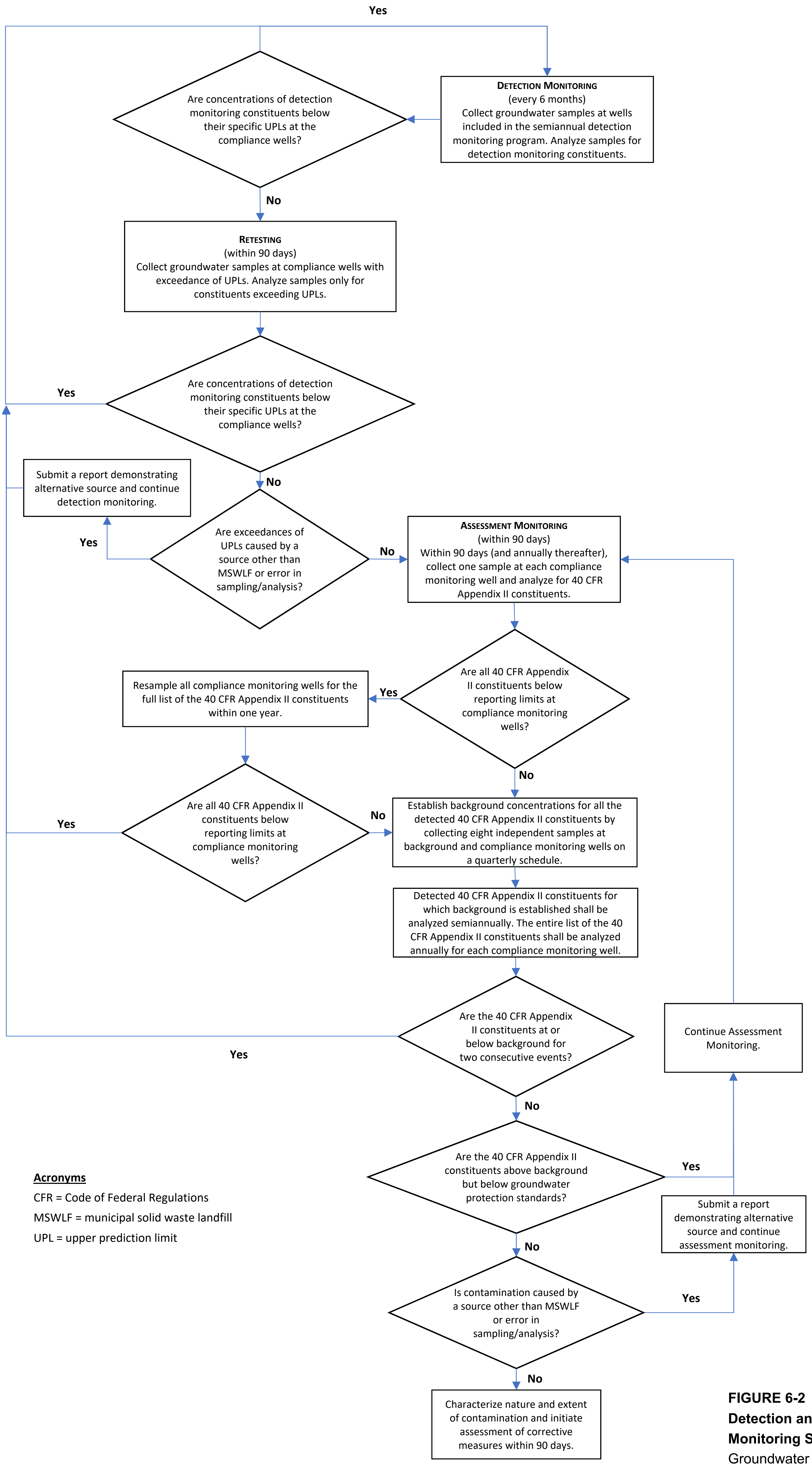
\\NALA\PROJ\GIS_LIBRARY\MAUI LANDFILL\MXDS\UPDATED_LEACHATE_PLAN\FIG3-1_CM_71HR_GW_LEVELS_V4.MXD AR055181 3/12/2019 2:10:31 PM



Note:
The plot includes well-Specific 95% bivariate confidence ellipses. Numbers correspond to the sample number.

PCA = principal component analysis

FIGURE 6-1
PCA Individuals Plot
Groundwater and Leachate
Monitoring Plan
Central Maui Landfill
Puunene, Maui, Hawaii



Acronyms

CFR = Code of Federal Regulations

MSWLF = municipal solid waste landfill

UPL = upper prediction limit

FIGURE 6-2
Detection and Assessment Monitoring Strategies
Groundwater and Leachate Monitoring Plan
Central Maui Landfill
Puunene, Maui

Tables

TABLE 2-1

Annual Rainfall - Weather Station Puunene 396

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Year	Monthly Rainfall												Annual
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Rainfall
1950	7.64	0.61	1.22	5.68	0.25	0	0.2	1.44	0.07	0.17	10.18	8.66	36.12
1951	2.18	6.41	8.35	0.09	0	0.09	0.08	0.07	0.09	3.05	0.13	1.97	22.51
1952	5.57	0.5	0.63	0.12	0.03	0.02	0.39	0.1	0.08	1.54	0.58	0.39	9.95
1953	0.74	1.9	1.77	0.47	0.55	0	0.03	0.01	0	0.19	0.49 a	1.99	8.14
1954	0.54	0.92	3.09	1.55	0.56	0.03	0.61	0.2	0.02	0.26	2.36	7.68	17.82
1955	2.74	3.73	2.6	0.13	0.1	0	0.17	0.27	0.02	0.01	2.34	11.77	23.88
1956	6.83	4.82	0.5	1.48	0.03	0.13	0.32	0.23	0.26	1.4	1.9	0.16 p	18.06
1957	1.9	2.29	0.07	0.68	0.15	0	0.23	1.26	0	0.2	4.76	3.66 a	15.2
1958	0.67	0.77	5.28	0.13	0.53	0.18	0.83	1.52	0.24	1.83	0.35	4.55	16.88
1959	10.13 a	6.61	0.48	1.41	0.8	0.02	0.06	0.02	0.03	0.03	1.27 b	0.81	21.67
1960	0.54	2.27	2.22	0.39	0.11	0.03	0.82	0.02	0.89	0.04	0.81	2.29	10.43
1961	4.57	3.31	0	5.01	0.12	0.07	0.07	0.02	0.14	4.15	5.5	0.61	23.57
1962	5.93	1.28	4.57	0.18	0.45	0	0.07	0.26	0.05	0.41	0.16	1.98	15.34
1963	6.57	1.96	4.1	1.47	2.49	0.04	0.12 a	0	1.15	0.78	0.32	1.09	20.09
1964	1.7	0.39	1.83	0.28	0.12	0.1	0.15	0.06	0.12	0.09	3.9	4.2	12.94
1965	3.88	4.73	3.57	1.08	0.23	0.07	0.82	0.32	0.6	2.23 a	9.69	1.94	29.16
1966	1.32	5.71	1.01	0.85	0.23	0	0.26	0.14	0.4	0.68	3.19	1.12	14.91
1967	4.04	1.86	10.35 a	1.13	1.98	2.15	1.58	1.07	0.01	0.77	1.52	5.4	31.86
1968	5.12	6.51	5.32	1.26	2.55	0.02	0.31	0.06	0.13	0.36	3.97	8.64	34.25
1969	8.88 a	1.99 a	1.7	1.95	0.2	0.23	0.21	0.23	0.07	0.32	0.19	3.13 c	19.1
1970	3.15 c	2.08 a	0.18	1.14	0.07	0	0.09	0.09	0.13	0.11	5.02 c	1.1 c	13.16
1971	14.03 b	0.87	2.94	1	0	0.79	0	0.27	0.11	0	0.1	0.1	20.21
1972	0.89	3.51	3.5	0.22	0	0.47	0.02	1.22	0.04	0.57	0.26	2.31	13.01
1973	2.66	0.81	0.71	0.27	0.66	0	0	0.01	0	0.4	0.91	3.08	9.51
1974	9.62	1.09	2.94	0.61	0.03	0.45	0.16	0.03	0.82	1.09	1.93	0.15	18.92
1975	3.14	3.73 a	1.83 a	0.04	0	0	0.09	0.32	0	0.24	1.98	0.06	11.43
1976	1.76 u	2.52 b	3.63 b	0.54	0.04	0	0.04	0.01	0.09	0.36	1.95 a	0.04	10.98
1977	0.22	0.35	1.84	3.94 a	0.48	0.14	0.3	0.41	0	0.41	0.15	1.71	9.95
1978	0.83	0.29	2.52	0.22	0.94	0.36	0.22	0.73	0.13	2.24	5.35 a	5.22	19.05
1979	6.85 b	7.56 b	5.01	2.98 b	0	0.04	0.14 a	0.32	0.09	0.68	1	3.03	27.7
1980	9.92 a	4.82	2.29	2.11	0.29	0.12	0.32	0.38	0.12	0.27	0.22	1.93	22.79
1981	0.53	2.37	0.36	0.59	1.5	0	0	0.55	0.86	0.8	1.71	3.03	12.3
1982	10.48	3.74	6.45	3.03	0.07	0.24	0.19	1.03	0.51	2.49 v	1.93	6.96	37.12
1983	0.55	0.09	0.58	0.04	0.88	0	0.23	0.52	0.13	1.23	0.68	8.62	13.55
1984	2.22	0.56	1.46	0.55	0.2	0	0.13	0.24	0.1	0.06	1.29	0.52 l	7.33
1985	1.54 r	2.28	1.27	0.18	0.87	0	0.38	0.57	0	7.34	4.49	2.12	21.04
1986	1.72	2.16	5.47	2.85	0.74	0.4	0.13	0.13	0.05	0.95	1.41	2.85	18.86
1987	3	2.28	0.46	4.78	4.02	0	0.34	0.09	1.76	0.03	2.35	5.38	24.49
1988	7.18	0.9	0.87	1.32	0.01	0	0	0.12	0.08	0.63	3.62	11.03	25.76
1989	1.43	4.9	3.96	14.27	0.05	0.01	1.35	0.35	0.11	6.46	1.85	4.83	39.57
1990	7.24	5.52	4.21	0	0.6	0.2	0.07	0	0.18	0.63	5.56	6.27	30.48
1991	2.3	4.35	1.88	0.12	0.49	0	0.07	0.83	0.91	0.3	0	1	12.25
1992	4.05	1.7	0.18	0.61	2.36	0.04	1.18	0.07	0.92	2.12	5.88	3.84	22.95
1993	3.96	0.19	1.95	1.09	0.74	0	0.52	0.75	0.11	1.75	3.25	0.59	14.9
1994	0.88	2.38	7.65	0.86	0	0.67	1.18	0.2	0.57	0	1	0.33	15.72
1995	3.93	1.2	2.76	1.44	0.3	0	0.13	0.19	0	1.3	0.45	3.3	15
1996	4.61	3.18	5.18	0.81	1.13	0.07	0.1	0.08	0.22	0	7.44	11.56	34.38
1997	8.28	1.4	4.11	1.67	1.4	0.04	0.55	0	0	0.91	1.51	4.6	24.47
1998	0.62	0.88	0.25	0.89	0.08	----- z	0.08	0	0.38	0	1.19	0.35	4.72 a
1999	2.7	2.68	1.19	0.14	0.65	0	0	0	0	0.5	0.13	2.93	10.92
2000	1.02	0	0	1.89	0	0	0.26	0.9	0.42	0.29	4.93	0.05	9.76
2001	0.08	0.77	0.3	0.13	0.08	0.34	0.4	0.37	0.05	1.33	2.4	3.19	9.44
2002	2.77	1.12	1.47	0.92	2.1	0	0.46	0.02	0	6.43	0.43	0.56	16.28
2003	2.49	4.31	2.03	0	0	0.15	0.27	0.18	0	0	1.23	3.58	14.24
2004	8.39	2.16	7.82	3.46	2.2	0	0.1	0.65	0.03	0.25	1.93	1.86	28.85
2005	5.89	1.37	4.78	0.49	0.22	0.15	0.16	0	0.67	0.38	2.6	0.13	16.84
2006	0.53	1.19	6.46	0.22	0.56	0.02	0.06	0.01	0.04	4.71	3.51	10.78 d	28.09
2007	0.72	1.19	2.49	0.85	0	0.01	0.02	0.07	0.01	0.07	2.11	9.08	16.62
2008	0.84	0.42	0.07	0.41	0	0.01	0.26	0.32	0.09	0.08	0.35	4.92	7.77
2009	3.66	0.19	2.34	0.52	0.02	0.04	0	0.86	0.05	0.1	0.73	1.58	10.09
2010	1.16	0.57	1.27	0.44	0	0	0	0	0.09	0.17	0.68	2.55	6.93
2011	4.81	2.34	0.67	0.02	0.7	0	0.2	0.04	----- z	0	0.2	1	9.98 a
2012	0	0.65	2.06	0.26	0	0.57	0	0.22	0.57	0	0.19	0.04	4.56
2013	1.32	2.12	1.59	0	0.61	0	0.95	0.25	0.17	0	4.72	2.52	14.25
2014	5.44	2.18	7.57	3.25	1.3	0.1	0.91	0.47	0.83	0.73	2.11	5.4	30.29
2015	2.03	1.53	8.46	2.11	----- z	0	0.53	2.12	0.23	1.19	3.71	0.4	22.31 a
2016	0.4	0.64	1.85	1.04	3.25	0.23	0.66	0.3	1.1	0.19	----- z	----- z	9.66 b
Average	3.7	2.3	2.8	1.3	0.6	0.1	0.3	0.4	0.3	1.0	2.3	3.3	18.2

Notes:

a = 1 day missing, b = 2 days missing, c = 3 days, etc.

z = 26 or more days missing (-----)

Individual months not used for annual or monthly statistics if more than 5 days are missing.

Source: Western Regional Climate Center (https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?hi8543)

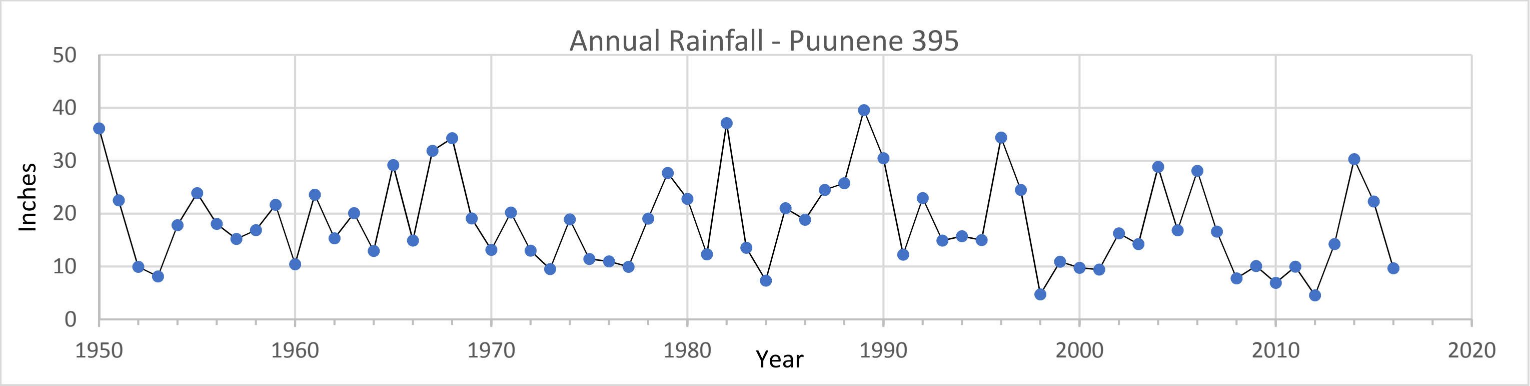


TABLE 2-2

Appendix II Constituent Detections

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Constituent	Unit	Monitoring Well	2016 UPL (Effective June 2016)	MCL	EAL	Leachate Average Concentration (2006-2017)	Leachate Average Concentration (2006-2011)	Assessment Monitoring Appendix II Concentrations						
								3/20/2012	7/17/2013	10/30/2013	12/5/2013	4/9/2014	7/9/2014	6/22/2015
Chromium	mg/L	MW-1	NC	0.1	0.016[a]	0.016	0.016	NA	NA	NA	NA	NA	ND (0.01)	ND (0.01)
		MW-2	NC					ND (0.005)	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-3	NC					ND (0.005)	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-4	NC					NA	NA	0.150	0.0375	NA	NA	ND (0.01)
		MW-5	NC					0.054	NA	NA	NA	0.0144	NA	ND (0.01)
Lead	mg/L	MW-1	NC	0.015	0.015[a]	0.006	0.009	NA	NA	NA	NA	NA	ND (0.01)	ND (0.01)
		MW-2	NC					0.018	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-3	NC					0.020	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-4	NC					NA	NA	ND (0.01)	ND (0.01)	NA	NA	ND (0.01)
		MW-5	NC					0.018	NA	NA	NA	ND (0.01)	NA	ND (0.01)
Nickel	mg/L	MW-1	NC	NA	0.005[a]	0.020	0.011	NA	NA	NA	NA	NA	ND (0.01)	ND (0.01)
		MW-2	0.0298					ND (0.01)	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-3	NC					ND (0.01)	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-4	0.367					NA	NA	0.249	0.251	NA	NA	0.163
		MW-5	0.246					0.300	NA	NA	NA	0.204	NA	0.0522
Vanadium	mg/L	MW-1	0.0349	NA	0.09[a]	0.010	0.011	NA	NA	NA	NA	NA	0.0208	0.0216
		MW-2	0.0349					0.021	NA	NA	NA	0.0211	NA	0.0178
		MW-3	0.0291					0.020	NA	NA	NA	0.0213	NA	0.0187
		MW-4	0.0329					NA	NA	0.0224	0.0192	NA	NA	0.0173
		MW-5	0.0266					0.025	NA	NA	NA	0.0187	NA	0.0185
Zinc	mg/L	MW-1	0.0983	5	0.022[a]	0.025	0.023	NA	NA	NA	NA	NA	0.0299	0.0112
		MW-2	0.184					ND (0.02)	NA	NA	NA	0.0270	NA	0.012
		MW-3	0.239					ND (0.02)	NA	NA	NA	0.0329	NA	0.0106
		MW-4	0.196					NA	NA	ND (0.01)	NA	NA	NA	0.0214
		MW-5	0.162					ND (0.02)	NA	NA	NA	0.0159	NA	0.0254

Note:

Appendix II metals are total concentrations.

Concentrations on 6/22/2015 are dissolved.

EALs identified with an "a" are based on drinking water concerns.

C/I = commercial industrial sites

DWT = drinking water threatened

EAL = HDOH environmental action level (risk-based; C/I; >150m SW; DWT)

HDOH = State of Hawaii Department of Health

MCL = maximum contaminant level (SDWA, Primary and Secondary Drinking Water Regulations)

NA = not available or not analyzed

NC = not calculated (because the constituent was mostly ND)

ND = not detected (reporting limit indicated in paranthesis)

SDWA = Safe Drinking Water Act

SW = surface water

TABLE 2-3

Tidal Evaluation Lag Times

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Tide Event	**Tide Observation**		**Lag Time**		
	Earliest Well	**Latest Well**	**Earliest Well - Latest Well** (hr)	**Earliest Well - NOAA** (hr)	**Latest Well - NOAA** (hr)
Peak 1	MW-3	MW-4, MW-6, PW	2	4	6
Trough 2	PW	MW-4, MW-6	3	3	6
Peak 2	PW	MW-6	3	4	7
Trough 3	MW-3, PW	MW-4, MW-6	2	4	6
Peak 3	MW-5	MW-4, MW-6, PW	2	3	5
Trough 4	MW-3, PW	MW-4, MW-6	3	3	6
Peak 4	MW-3, PW	MW-4, MW-6	2	5	7
Trough 5	PW	MW-4, MW-5, MW-6	2	3	5
Peak 5	MW-5	MW-3	3	3	6
Trough 6	PW	MW-4, MW-6	3	3	6
Peak 6	MW-2, MW-3, PW	MW-4, MW-6	3	4	7
		Average at High Tide	2.5	3.8	6.3
		Average at Low Tide	2.6	3.2	5.8

Note:

NOAA Station # 1615680 located at Kahului Harbor, approximately 3.8 miles from the site.

hr = hour(s)

MW = monitoring well

NOAA = National Oceanic and Atmospheric Administration

TABLE 2-4

71-Hour Mean Groundwater Elevations and Tidal Efficiencies

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Monitoring Well ID	**Approximate Distance from Ocean** (feet)	**71-Hour Filtered Mean Water Elevation** (feet amsl)	**Average Relative Tidal Efficiency** (percent)	**Standard Deviations**
MW-1	19,356	3.04	5	0.036
MW-2	16,611	2.77	7	0.052
MW-3	17,203	2.89	5	0.038
MW-4	18,436	3.04	8	0.059
MW-5	15,937	2.83	8	0.056
MW-6	18,882	2.94	8	0.054
PW	15,950	2.76	7	0.049
NOAA	0	1.42	100	0.697

Notes:

Data collected from August 22, 2013, 00:00, through August 24, 2013, 23:00.

amsl = above mean sea level

ID = identification

MW = monitoring well

TABLE 2-5

Summary Statistics and Leachate/Groundwater Contrast

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Constituent	Conc. Unit	Action Level								Leachate Concentration				Mean Groundwater Concentration												Leachate/Groundwater Contrast					
		UPL						MCL	EAL	Detections (percent)	MIN	MAX	Mean	Upgradient/Crossgradient Wells						Downgradient (Compliance) Wells						Upgradient/Crossgradient Wells			Downgradient (Compliance) Wells		
		MW-1	MW-2	MW-3	MW-4	MW-5	MW-6							MW-1		MW-4		MW-6		MW-2		MW-3		MW-5		MW-1	MW-4	MW-6	MW-2	MW-3	MW-5
														Conc.	Detections (percent)	Conc.	Detections (percent)	Conc.	Detections (percent)	Conc.	Detections (percent)	Conc.	Detections (percent)	Conc.	Detections (percent)						
Alkalinity, total (as CaCO3)[1]	mg/L	550	501	560	485	557	595	NA	NA	100	107	2300	1424	269	100	247	100	273	100	274	100	247	100	261	100	5.3	5.8	5.2	5.2	5.8	5.5
Ammonia	mg/L	NC	NC	NC	NC	NC	NC	NA	NA	100	0.56	59	13.5	0.064	32	NA	15.4	ND	0	0.135	47	0.087	37	NA	8	211	NC	MAX	100	155	NC
Barium	mg/L	NC	NC	NC	NC	NC	NC	2	0.22[b]	100	0.079	1.9	0.408	0.005	33	ND	0	ND	0	0.004	47	0.005	35	ND	0	82	MAX	MAX	102	82	MAX
Benzene	μg/L	NC	NC	NC	NC	NC	NC	5	5[a]	43	0.76	7	1.91	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Calcium	mg/L	29.5	38.6	27.7	29.3	27.9	26.1	NA	NA	100	17.3	170	69	20.4	100	22.5	100	18.2	100	23.6	100	23.5	100	22.3	100	3.4	3.1	3.8	2.9	2.9	3.1
Chloride	mg/L	287	505	282	318	304	216	250	NA	100	170	1600	751	185	100	205	100	161	100	259	100	180	100	192	100	4.1	3.7	4.7	2.9	4.2	3.9
Chromium	mg/L	NC	NC	NC	NC	NC	NC	0.1	0.011[b]	24	0.004	0.056	0.009	NA	8	NA	5	ND	0	ND	0	0.004	12	ND	0	NC	NC	MAX	MAX	2.3	MAX
Copper	mg/L	NC	NC	NC	NC	NC	NC	1.3	0.0029[b]	57	0.011	0.19	0.025	0.005	22	ND	0	ND	0	0.004	33	0.006	17	ND	0	5.0	MAX	MAX	6.3	4.2	MAX
1,4-Dichlorobenzene	μg/L	NC	NC	NC	NC	NC	NC	75	5[c]	37	1.35	5.7	1.72	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
1,2-Dichloroethane	μg/L	NC	NC	NC	NC	NC	NC	5	5[a]	28.6	0.83	8.8	1.8	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
cis-1,2-Dichloroethylene	μg/L	NC	NC	NC	NC	NC	NC	70	70[a]	28	1.6	8.54	1.88	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Ethylbenzene	μg/L	NC	NC	NC	NC	NC	NC	700	7.3[b]	26	1.67	20	2.71	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Iron	mg/L	NC	0.215	NC	0.126	0.959	0.73	0.3	NA	100	0.962	23	5.67	0.052	10	0.078	43	0.079	33	0.079	23	0.062	19	0.108	48	109	73	72	72	91	53
Magnesium	mg/L	47.6	72.9	40.7	48.6	42	43.8	NA	NA	100	88.8	477	302	30.8	100	33.2	100	29.1	100	37.5	100	30.8	100	31.3	100	10	9.1	10	8.1	10	9.6
Nickel	mg/L	NC	0.0298	NC	0.367	0.246	0.148	NA	0.005[b]	71	0.011	0.051	0.021	NA	7	0.219	100	0.11	100	0.013	32	NA	4	0.178	100	NC	0.10	0.19	1.6	NC	0.12
Nitrate-N[2]	mg/L	10.2	25.9	10.3	9.35	10.4	9.56	10	NA	39	0.03	1.1	0.125	18.9	99	4.6	98	4.86	98	24	99	22.6	99	4.98	98	0.01	0.03	0.03	0.01	0.01	0.03
Potassium	mg/L	20.9	25.1	18.5	18.8	18.3	20.8	NA	NA	97	21.1	68.9	37.2	13.8	100	13.8	100	13.6	100	15.1	100	13.6	100	14.5	100	2.7	2.7	2.7	2.5	2.7	2.6
Sodium	mg/L	242	379	217	239	219	221	NA	NA	100	192	925	528	175	100	174	100	168	100	216	100	168	100	174	100	3.0	3.0	3.1	2.4	3.1	3.0
Sulfate	mg/L	74.1	300	75.3	96.6	75.2	69	250	NA	37	0.59	129	9.69	26.1	93	29.4	98	24.2	98	42.6	96	26.1	94	29	98	0.37	0.33	0.40	0.23	0.37	0.33
TDS	mg/L	975	1400	1080	1080	1050	945	500	NA	100	1370	4308	2877	739	100	672	100	631	100	840	100	677	100	675.6	100	3.9	4.3	4.6	3.4	4.2	4.3
TOC	mg/L	76.3	69.3	76	67.4	76.3	80.6	NA	NA	100	3.6	980	113	8.1	76	5.79	71	7.1	77	8.85	79	8.69	73	8.68	71	14	20	16	13	13	13
Toluene	μg/L	NC	NC	NC	NC	NC	NC	0.001	0.0098[b]	29	1.2	62.8	4.44	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Vinyl Chloride	μg/L	NC	NC	NC	NC	NC	NC	2	2[a]	29	1.0	6.18	1.29	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Xylenes	μg/L	NC	NC	NC	NC	NC	NC	0.01	0.0013[b]	60	1.38	37	7.11	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Zinc	mg/L	0.0983	0.184	0.239	0.196	0.162	0.0769	5	0.022[b]	57	0.02	0.061	0.025	0.027	40	0.015	39	0.018	62	0.029	55	0.025	55	0.021	62	0.93	1.7	1.4	0.86	1.0	1.2

Note:

[1] Alkalinity in groundwater was reported as bicarbonate alkalinity (as CaCO3) until 10/2014 and as total alkalinity (as CaCO3) after 12/2014. For leachate concentrations both total and bicarbonate alkalinity were reported and were in most cases the same. Leachate data and literature show that at pH levels observed at the site, bicarbonate alkalinity is equivalent to total alkalinity because other carbonate (the other major alkalinity in natural waters) is stable only at higher pH values. When both toal and bicarbonate alkalinity were available (and they were in most cases the same), only total alkalinity was considered.

[2] Nitrogen in groundwater was reported as "nitrate (as N)" until 12/2014. After 12/2014 "nitrate-nitrite (as N)" was reported; because nitrite is unstable and easily oxidized to nitrate, nitrate is the compound predominantly found in groundwater (US Department of Health and Human Services, 2017). Therefore concentrations of nitrogen reported as “nitrate-nitrite (as N)” and “nitrate (as N)" are generally the same.

This table includes only constituents with at least 20 percent detections in leachate collected at the sump/wet well within Phases IV-A and IV-B between 2006 and 2017 (semiannual sampling). For both leachate and groundwater average concentration calculations, nondetects were included and managed using the Kaplan-Meir method.

Mean groundwater concentrations were calculated considering groundwater samples collected at each specific monitoring well between 1995 and 2017 (frequency varying over time). Field duplicate samples were not included in average calculations.

a-b-c. EALs identified with an "a" are based on drinking water concerns; EALs identified with a "b" are based on aquatic ecotoxicity concerns; EALs identified with a "c" are based on gross contamination concerns.

Colors in groundwater concentration and leachate/groundwater contrast are only to help visualization.

μg/L = microgram(s) per liter
C/I = commercial industrial sites
Conc. = concentration
DWT = drinking water threatened
EAL = HDOH environmental action level (Fall 2017 risk-based; C/I; >150m SW; DWT EAL)
HDOH = State of Hawaii Department of Health
MAX = maximum contrast (that is, constituent is detected in leachate but not in groundwater)
MCL = maximum contaminant level (SDWA, Primary and Secondary Drinking Water Regulations)
mg/L = milligram(s) per liter
NA = not available (that is, no limit available or mean value not calculated because number of detections is lower than 20 percent).
NC = not calculated
ND = not detected
SDWA = Safe Drinking Water Act
SW = surface water
TDS = total dissolved solids
TOC = total organic carbon
UPL = upper prediction limit (CH2M, 2016)

TABLE 2-6

Compost Leachate Analytical Results

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

		Downgradient (Compliance) Well MW-2		Compost Phase 1 Leachate 3/14/2018		Landfill Phases IV-A and IV-B Leachate
Constituent	**Unit**	**Mean Concentration (2008-2017)**	**Trend**	**Concentration**	**Contrast**	**Mean Concentration (2006-2017)**
Alkalinity, Total (as CaCO3)	mg/L	221	Decreasing	NA	NA	1424
Ammonia	mg/L	0.06	No Trend	NA	NA	13.5
Antimony	mg/L	0.008	No Trend	<0.015	NA	NA
Arsenic	mg/L	NA	NA	0.418	NA	NA
Barium	mg/L	0.005	No Trend	0.439	87.8	0.408
Beryllium	mg/L	NA	NA	<0.01	NA	NA
Boron	mg/L	NA	NA	4.79	NA	NA
Bromide	mg/L	NA	NA	1300	NA	NA
Cadmium	mg/L	NA	NA	0.00809	NA	NA
Calcium	**mg/L**	**24.3**	**Increasing**	**912**	**37.5**	69
Chloride	**mg/L**	**308**	**Increasing**	**3600**	**11.7**	751
Chromium	mg/L	0.005	No Trend	0.0838	16.8	0.009
Cobalt	mg/L	NA	NA	0.0997	NA	NA
Copper	mg/L	0.005	No Trend	0.671	134	0.025
Iron	mg/L	0.066	No Trend	59.6	903	5.67
Lead	mg/L	0.005	No Trend	0.0147	NA	NA
Magnesium	**mg/L**	**41.7**	**Increasing**	**764**	**18.3**	302
Manganese	mg/L	0.004	No Trend	7.85	1963	NA
Nickel	**mg/L**	**0.009**	**Increasing**	**0.187**	**20.8**	0.021
Nitrate-N	**mg/L**	**9.88**	**Increasing**	**0.27**	**0.03**	0.125
Potassium	**mg/L**	**15.5**	**Increasing**	**6040**	**390**	37.2
Selenium	mg/L	0.009	No Trend	0.0342	3.8	NA
Silver	mg/L	0.003	No Trend	0.00809	NA	NA
Sodium	**mg/L**	**233**	**Increasing**	**1260**	**5.4**	528
Sulfate	**mg/L**	**53**	**Increasing**	**1000**	**18.9**	9.69
TDS	**mg/L**	**883**	**Increasing**	**23800**	**27.0**	2877
Thallium	mg/L	NA	NA	<0.015	NA	NA
TOC	mg/L	8.55	No Trend	NA	NA	113
Vanadium	mg/L	0.019	No Trend	0.13	6.8	NA
Zinc	mg/L	0.016	Decreasing	1.69	105.6	0.025

Notes:

Statistical trends were evaluated using the Mann Kendall test

Constituents with increasing groundwater concentration trend in well MW-2 are highlighted in red and bold characters.

mg/L = milligram(s) per liter

NA = not applicable (mean not calculated or constituent not analyzed)
ND = not detected
TOC = total organic carbon

TABLE 3-1

Monitoring Well Construction Details

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

							Top of Screen		Bottom of Screen	
Well ID	**Ground Surface Elevation[a] (ft-amsl)**	**Top of Sounding-Tube Elevation[b] (ft-amsl)**	**Total Depth[c] (ft-btoc)**	**Inside Diameter (inches)**	**Casing Stickup (ft)**	**Screen Length (ft)**	**Depth[c] (ft-btoc)**	**Elevation (ft-amsl)**	**Depth[c] (ft-btoc)**	**Elevation (ft-amsl)**
MW-1	301.20	303.32	320.12	4.5	2.12	25	290	13.20	315	-11.80
MW-2	221.27	224.05	240.78	4.5	2.78	20	215	8.27	235	-11.73
MW-3	241.19	243.41	260.51	4.5	2.51	20	235	8.19	255	-11.81
MW-4	288.78	291.28	309.50	4.5	2.50	20	285	5.78	305	-14.22
MW-5	228.03	230.3	248.27	4.5	2.27	20	223	7.03	243	-12.97
MW-6	304.89	307.02	324.13	4.5	2.13	20	298	8.89	318	-11.11
PW	270.4	272.63	301	8	2.23	NA	NA	NA	NA	NA

Notes:

[a] Ground surface elevation from Masa Fujioka & Associates boring logs (Masa Fujioka & Associates, 1995).

[b] Top of sounding-tube elevations surveyed by Control Point Surveying in 2016.

[c] Depth in feet below the top of the well casing (based on construction diagram).

ft = feet
ft-amsl = feet above mean sea level
ft-btoc = feet below top of casing
ID = identification number
MW = monitoring well
NA = not applicable (no screen for PW; well has a open hole in the bottom 20 feet)
PW = production well

TABLE 3-2

Monitoring Well Objectives and Rationale

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Well ID	Location	Monitoring Objective	Rationale
MW-1	Upgradient of closed SWMU Phases I and II	Background monitoring well - Gauge groundwater level and monitor groundwater quality at upgradient/background location on a semiannual schedule.	This well is representative of background groundwater quality and will be used to monitor groundwater entering the site from upgradient locations. Groundwater quality data from this well will be used for alternative source evaluations in case of UPL exceedances at compliance wells.
MW-2	Downgradient of landfill cell Phase III and SWMU Phases I and II	Compliance monitoriong well - Gauge groundwater level and monitor groundwater quality at downgradient/compliance point location on a semiannual schedule.	This well is representative of downgradient groundwater quality and will be used to monitor groundwater leaving the site from closed SWMU Phases I and II, and cell Phase III. Groundwater quality data from this well will be used to evaluate regulatory compliance.
MW-3	Downgradient of SWMU Phases I and II	Compliance monitoriong well - Gauge groundwater level and monitor groundwater quality at downgradient/compliance point location on a semiannual schedule.	This well is representative of downgradient groundwater quality and will be used to monitor groundwater downgradient of closed SWMU Phases I and II. Groundwater quality data from this well will be used to evaluate regulatory compliance.
MW-4	Crossgradient of closed SWMU Phases I and II	Crossgradient/upgradient monitoring well - Gauge groundwater level and monitor groundwater quality at crossgradient/upgradient location on a semiannual schedule.	This well is representative of groundwater quality crossgradient/upgradient of closed SWMU Phases I and II, and will be used to monitor groundwater entering the site from crossgradient/upgradient locations. Groundwater quality data from this well will be used for alternative source evaluations in case of UPL exceedances at compliance wells.
MW-5	Downgradient of SWMU Phases IV-A	Compliance monitoriong well - Gauge groundwater level and monitor groundwater quality at downgradient/compliance point location on a semiannual schedule.	This well is representative of downgradient groundwater quality and will be used to monitor groundwater downgradient of SWMU Phase IV-A. Groundwater quality data from this well will be used to evaluate regulatory compliance.
MW-6	Upgradient of landfill cell Phase VI	Background monitoring well - Gauge groundwater level at upgradient/background location on a semiannual schedule.	This well is representative of background groundwater quality; however, it will not be sampled because of safety concerns (located in proximity of a vertical ledge). Groundwater level at this well will be gauged when possible. Sampling at this well may be reconsidered in the future if landfill Phase VI is developed and used for waste disposal operations.
MW-7	Proposed for future installation downgradient of SWMUs Phase IV-A, V-A, V-B, and V-B Ext.	Future compliance monitoriong well - Gauge groundwater level and monitor groundwater quality at downgradient/compliance point location on a semiannual schedule.	Once installed, this well will be representative of downgradient groundwater quality and will be used to monitor groundwater downgradient of SWMUs Phase IV-A, V-A, V-B, and V-B Ext. Groundwater quality data from this well will be used to evaluate regulatory compliance.

TABLE 3-2

Monitoring Well Objectives and Rationale

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Well ID	Location	Monitoring Objective	Rationale
MW-8	Proposed for future installation downgradient of SWMUs Phase IV-B, V-A, V-B, and V-B Ext.	Future compliance monitoriong well - Gauge groundwater level and monitor groundwater quality at downgradient/compliance point location on a semiannual schedule.	Once installed, this well will be representative of downgradient groundwater quality and will be used to monitor groundwater downgradient of SWMUs Phase IV-B, V-A, V-B, and V-B Ext. Groundwater quality data from this well will be used to evaluate regulatory compliance.
MW-9	Proposed for future installation downgradient of landfill cell Phase III once it is developed and used for waste disposal operations.	Future compliance monitoriong well - Gauge groundwater level and monitor groundwater quality at downgradient/compliance point location on a semiannual schedule.	Once installed, this well will be representative of downgradient groundwater quality and will be strategically located to capture the advective flow zone for a potential release originating from the future sump in Phase III. Groundwater quality data from this well will be used to evaluate regulatory compliance.

Notes:

ID = identification

SWMU = solid waste management unit

UPL = upper predictive limit

TABLE 4-1

Leachate Collection Point Objectives and Rationale

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Loaction ID	Location	Monitoring Objective	Rationale
Manhole 4	At downgradient location within closed SWMU Phases I and II	Monitor leachate level at least once per week and sample leachate semiannually within closed SWMU Phases I and II.	This leachate collection point is installed at the lowest elevation of the bottom of closed SWMU Phases I and II. Leachate levels will be monitored at least once per week for regulatory compliance purpose. Leachate samples will be collected semiannually to evaluate leachate characteristics.
Phase IV-A Wetwell	At downgradient location within SWMU Phase IV-A	Monitor leachate level at least once per week and sample leachate semiannually within SWMU Phase IV-A.	This leachate collection point is installed at the lowest elevation of the lined SWMU Phase IV-A bottom and collects leachate from SWMU IV-A. Leachate levels will be monitored at least once per week for regulatory compliance purpose. Leachate samples will be collected semiannually to evaluate leachate characteristics.
Phase IV-B Sump	At downgradient location within SWMU Phase IV-B	Monitor leachate level at least once per week and sample leachate semiannually within SWMU Phase IV-B.	This leachate collection point is installed at the lowest elevation of the lined SWMU Phase IV-B bottom and collects leachate from SWMUs IV-B and V. Leachate levels will be monitored at least once per week for regulatory compliance purpose. Leachate samples will be collected semiannually to evaluate leachate characteristics.
Future Phase V-B Ext Sump	At downgradient location within closed future SWMU Phases V-B Ext	Monitor leachate level at various frequencies. Sample leachate semiannually within future SWMU Phase V-B Ext.	This leachate collection point will be installed at the lowest elevation of future SWMU Phase V-B Ext. Leachate levels will be monitored once per operational day and after rain events for regulatory compliance until the select waste layer has been completely installed, and a minimum of two times per week thereafter. Leachate samples will be collected semiannually to evaluate leachate characteristics.

Notes:

Lechate level in all leachate monitoring locations will be monitored after storm events.

ID = identification
SWMU = solid waste management unit

TABLE 5-1

Groundwater Analytical Plan

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Constituent Group	Analytical Method
Metals, Cations, and Anions	USEPA 6010 B
Ammonia	SM 4500-NH3 B/C
Chloride	USEPA 300.0
TOC	SM 5310 D
TDS	SM 2540 C
Total Alkalinity	SM 2320 B
BTEX	USEPA 8260 B
HVOCs	USEPA 8260 B

Notes:

BTEX = benzene, toluene, ethylbenzene, and xylenes

HVOC = halogenated volatile organic compound

TDS = total dissolved solids

TOC = total organic carbon

USEPA = U.S. Environmental Protection Agency

TABLE 5-2

Leachate Analytical Plan

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Constituent Group	Analytical Method
VOCs	USEPA 8260 B
SVOCs	USEPA 8270 C
Herbicides	USEPA 8151 A
Organochlorine Pesticides	USEPA 8081 A
PCBs	USEPA 8082
Anions	USEPA 300.0
Dioxins and Furans	USEPA 8280 A
Metals	USEPA 6010 B + 7471 A
Hardness	SM 2340 B
General Chemistry	Various

Notes:

PCB = polychlorinated biphenyl

SVOC = semivolatile organic compound

USEPA = U.S. Environmental Protection Agency

VOC = volatile organic compound

TABLE 6-1

Intrawell Upper Prediction Limits for Detection Monitoring Constituents

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Well	Constituent	Frequency of Detection			Minimum Values		Maximum Values		Summary Statistics						Background	
		No. of Samples	No. of Detects	%	Non-Detect	Detect	Non-Detect	Detect	Mean	Median	Standard Deviation	95th Percentile	99th Percentile	Distribution	UPL	Method
MW-2	Alkalinity	46	46	100.0	NA	230	NA	409	298	290	38.9	387	403	NP	409	NP, Max Value
MW-2	Calcium	47	47	100.0	NA	20.0	NA	28.8	23.2	23.3	1.49	25.0	27.3	Normal	25.9	Parametric
MW-2	Chloride	48	48	100.0	NA	155	NA	270	233	231	25.9	269	270	NP	270	NP, Max Value
MW-2	Iron	48	13	27.1	0.040	0.0631	0.510	0.542	NA	NA	NA	NA	NA	NP	0.542	NP, Max Value
MW-2	Magnesium	48	48	100.0	NA	30.2	NA	44.8	35.3	34.7	2.89	40.1	43.4	NP	44.8	NP, Max Value
MW-2	Potassium	48	48	100.0	NA	12.0	NA	19.4	14.8	14.8	1.71	18.1	19.3	NP	19.4	NP, Max Value
MW-2	Sodium	48	48	100.0	NA	162	NA	257	204	200	19.9	241	251	Normal	240	Parametric
MW-2	Total Dissolved Solids	48	48	100.0	NA	652	NA	970	801	800	69.8	917	959	Normal	928	Parametric
MW-2	Total Organic Carbon	48	34	70.8	1.000	1.10	8.00	59.0	8.12	3.04	11.6	33.2	49.1	Gamma	28.3	Parametric
MW-3	Alkalinity	24	24	100.0	NA	234	NA	280	249	244	14.1	276	279	NP	280	NP, Max Value
MW-3	Calcium	25	25	100.0	NA	19.9	NA	24.6	22.8	22.9	1.05	24.4	24.6	Normal	24.8	Parametric
MW-3	Chloride	27	27	100.0	NA	170	NA	230	196	200	18.6	227	230	Normal	232	Parametric
MW-3	Iron	26	5	19.2	0.040	0.090	0.100	0.195	NA	NA	NA	NA	NA	NP	0.195	NP, Max Value
MW-3	Magnesium	26	26	100.0	NA	27.0	NA	35.2	32.1	32.3	2.03	34.8	35.1	Normal	36.0	Parametric
MW-3	Potassium	25	25	100.0	NA	12.3	NA	15.8	13.8	13.9	0.899	15.0	15.6	Normal	15.6	Parametric
MW-3	Sodium	25	25	100.0	NA	145	NA	188	173	177	11.8	187	188	Normal	196	Parametric
MW-3	Total Dissolved Solids	25	25	100.0	NA	475	NA	750	659	660	53.0	713	742	Normal	762	Parametric
MW-3	Total Organic Carbon	26	19	73.1	0.500	0.670	1.00	31.0	7.83	1.10	10.2	25.8	29.8	NP	31.0	NP, Max Value
MW-5	Alkalinity	24	24	100.0	NA	180	NA	276	245	245	19.4	272	275	Normal	283	Parametric
MW-5	Calcium	25	25	100.0	NA	20.3	NA	23.6	22.0	21.9	0.949	23.4	23.6	Normal	23.8	Parametric
MW-5	Chloride	28	28	100.0	NA	170	NA	240	202	200	19.7	237	240	Normal	240	Parametric
MW-5	Iron	26	8	30.8	0.040	0.051	0.100	0.610	NA	NA	NA	NA	NA	NP	0.610	NP, Max Value
MW-5	Magnesium	26	26	100.0	NA	27.9	NA	35.2	31.9	32.0	2.13	34.8	35.1	Normal	36.0	Parametric
MW-5	Potassium	25	25	100.0	NA	12.7	NA	15.8	14.5	14.6	0.891	15.7	15.8	Normal	16.2	Parametric
MW-5	Sodium	25	25	100.0	NA	138	NA	191	176	180	12.6	189	191	NP	193	Parametric(1)
MW-5	Total Dissolved Solids	25	25	100.0	NA	555	NA	772	677	674	51.3	751	768	Normal	776	Parametric
MW-5	Total Organic Carbon	28	21	75.0	0.500	0.680	1.00	31.0	9.16	1.35	10.7	26.0	29.7	NP	31.0	NP, Max Value

Notes:

(1) Normalized using Tukey's Ladder of Powers transformation with lambda equal to 7.675.

For data containing non-detects, the Kaplan-Meier method was used to compute descriptive statistics with the censoring limit set at the reporting limit.

Upper prediction limits calculated using a target annual sitewide false positive rate (SWFPR) of 10 percent, semiannual sampling, and a one-of-two retesting scheme.

Concentrations given in milligrams per liter.

% = percent

Max = maximum

NA = not applicable

No. = number

NP = nonparametric

UPL = upper prediction limit

Appendix A
Response to Comments

ALAN M. ARAKAWA
Mayor
STEWART STANT
Director
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Deputy Director

MICHAEL RATTE
Solid Waste Division

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COUNTY OF MAUI
DEPARTMENT OF
ENVIRONMENTAL MANAGEMENT
2050 MAIN STREET, SUITE 2B
WAILUKU, MAUI, HAWAII 96793

October 12, 2017

Mr. Steven Y.K. Chang, P.E., Chief
Solid and Hazardous Waste Branch
Department of Health
919 Ala Moana Boulevard, Room 212
Honolulu, Hawaii 96814

Dear Mr. Chang:

SUBJECT: ***Technical Memorandum: Calculation of Upper Prediction Limits, Central Maui Landfill Facility Groundwater Monitoring*** **(October 16, 2016)**
Central Maui Municipal Solid Waste Landfill
Solid Waste Management Permit No. LF-0069-08
RESPONSE TO DOH COMMENT LETTER OF JULY 19, 2017

As requested in your letter of July 19, 2017, this letter provides a written response to your three specific comments and three general comments. Prior to submitting a revised Tech Memo, we respectfully ask for written concurrence from you that our approach to the revision is acceptable to you.

Comment 1. "Methodology for Calculating Upper Prediction Limits (UPLs)," Paragraph 2: The Tech Memo states that when data does not fit a parametric distribution, defaulting to a normal distribution is considered appropriate.

The Unified Guidance discusses basic assumptions for applying prediction limits as tests of groundwater and details six (6) "key points" regarding data requirements for applying prediction limits to groundwater (see Section 18.1.1). Please substantiate that the Central Maui Landfill (CMLF) data satisfy these Unified Guidance requirements, and where appropriate, explain how data that might not meet these requirements was statistically assessed (e.g. for temporal non-stationarity such as trends, or for statistical outliers in background data) or transformed to meet the requirements.

Response:

The Tech Memo will be revised to include documentation verifying that the CMLF background data either satisfy the six key requirements from the Unified Guidance or, if not, describe the measures that have been taken to address any identified issues. The bullets following each requirement briefly describe the methods for testing the background data (these methods will be fully described in the revision).

1. Background and future sample measurements need to be identically and independently distributed

- *Data will be checked for non-zero pairwise correlation*

2. Sample data do not exhibit temporal non-stationarity in the form of trends, autocorrelation, or other seasonal or cyclic variation

- *Time-series plots (visible identification of trends)*
- *Statistical trend tests (Mann-Kendall), as needed to complement time-series plots*

3. For interwell tests (e.g., upgradient-to-downgradient comparisons), sample data do not exhibit non-stationary distributions in the form of significant natural spatial variability

- *If needed, one-way nonparametric ANOVA Kruskal-Wallis test followed by the posthoc Kruskal-Dunn test for multiple comparisons*

4. Background data do not include statistical outliers (a form of non-identical distributions)

- *Probability plots (visual identification of potential outliers)*
- *Mathematical outlier tests (Dixon's or Rosner's depending on sample size)*

5. For parametric prediction limits, background data are normal or can be normalized using a transformation

- *Goodness-of-fit testing and appropriate parametric fit identified*

6. A minimum of 8 background measurements is available; more for non-parametric limits or when accounting for multiple, simultaneous prediction limit tests.

- *Table 1 shows that CMLF background data for each well/parameter exceed the minimum sample size of 8 except for nickel, vanadium, and zinc, which were added in 2014. These data are qualified in the Tech Memo.*

The procedures used to evaluate the six key statistical assumptions are described in the Unified Guidance, specifically Chapter 12 (Identifying Outliers), Chapter 13 (Spatial Variability), Chapter 14 (Temporal Variability), Chapter 15 (Managing Non-Detect Data), and Chapter 17 (ANOVA, Tolerance Limits, and Trend Testing).

Comment 2. "Results – Calculated UPLs for CMLF Wells by Parameter," Paragraph 1: The Tech Memo states that the upper prediction limits (UPLs) were calculated using data collected from 2011 through the first quarter of 2016.

The Unified Guidance (p. 5-4, para. 2) states, "The overall recommendation of the guidance is to establish background sample sizes as large as feasible." This paragraph continues, "Prediction limit...tests can utilize very small future sample sizes per compliance well (in some cases a single initial sample), but require larger background sample sizes to have sufficient power." The guidance also states (p. 5-9, para. 3) that "...all historical data collected from both upgradient and compliance wells can be evaluated for potential inclusion into background."

Based on our understanding of approach to calculating background outlined in the Unified Guidance, the background data used to calculate the prediction limits for the CMLF should be expanded to include as large a sample size as feasible. The need for a larger background sample size is emphasized by the "very small future sample size" utilized at CMLF (see Comment 3. below). The UPLs (CMLF) should be recalculated using background sample sizes as large as feasible as recommended in the Unified Guidance. Please refer to Chapter 5 of the

Unified Guidance, which addresses procedures for establishing and updating background data, as well as Chapter 3 of the Unified Guidance, which discusses the need for any background sample to satisfy the key statistical assumptions (e.g. temporal and spatial stationarity, lack of statistical outliers).

Response:

We agree that larger background sample sizes are desirable, and all historical data collected from both upgradient and compliance wells were initially considered for potential inclusion into background. However, background data collected prior to 2011 were excluded based on the presence of trends and higher variability in the older data. The change in historical groundwater conditions was documented in the 2010 Semi-Annual Groundwater Monitoring Report (URS, 2011). As a result, control limits were not developed for several constituent/well pairs. To be consistent moving forward, our recommendation is to not expand the sample size further, but rather advocate for data quality, which would ultimately result in a more appropriate comparison of current groundwater conditions to background data. With the exception of parameters added since 2014 (nickel, vanadium, and zinc), the background data set constructed with 2011 to first quarter 2016 data includes 12 to 16 observations per well and parameter, exceeding the recommended minimum sample size of eight (Chapter 18, p. 18-6, para. 2 of the Unified Guidance).

The Tech Memo will be revised to more fully describe the rationale for excluding data collected prior to 2011 and why the resultant background data set is considered to satisfy the key statistical assumptions and provide sufficient power to allow for the proposed future comparisons (also see response to Comment #3). We believe selection of the more recent data is consistent with Chapter 5 of the Unified Guidance (p. 5-1, para. 2) where it is stated that "high quality background data is the single most important key to a successful statistical groundwater monitoring program, especially for detection monitoring."

Comment 3. "Results – Calculated UPLs for CMLF Wells by Parameter," Paragraph 3: The Tech Memo states the number of future observations used in the UPL calculations was 1,200, based on the product of the number of wells (6), the number of anticipated monitoring constituents (20), and the number of events over a five-year period (10). The Tech Memo does not include a reference for this equation or explain the rationale for calculating the "number of future observations" in this manner. We understand that the "number of future observations" is denoted as *k* in the Tech Memo and as *m* in the Unified Guidance; this variable is used in the equation for calculating prediction limits that is included in the Tech Memo and in the Unified Guidance (Equation 18.3).

The Unified Guidance indicates that the "number of future observations" *m* is the number of measurements that are directly compared to the UPL during each statistical evaluation event. The guidance (p. 18-8, para. 1) states, "Each of the *m* individual future observations need to be compared to the prediction limit." The guidance also states that "... the prediction interval can be constructed to cover a specified time period of future sampling. Usually this period will coincide with the time between statistical evaluations specified in the site permit (e.g., on a semi-annual or annual basis)." Example 18-1 (p. 18-9) in the Unified Guidance illustrates a case in which *m* could be greater than one (1), such as when quarterly analytical data are statistically analyzed on an annual basis. In this example, *m* is four (4), and the results of four (4) samples collected over a year are compared to the prediction limit.

Statistical evaluation of groundwater monitoring data at CMLF is conducted following each sampling event. As such, we understand that the "number of future observations" (e.g. *k* or *m*) used in the calculation of UPLs at CMLF should be one (1) future observation, where the "observation" is the analytical result for each constituent generated during each sampling event at each well. Thus, please reevaluate the calculation for "number of future observations" presented in the Tech Memo; justify the calculation as it relates to the CMLF and the Unified Guidance; recalculate the UPLs for CMLF; and substantiate how use of UPLs CMLF will control the false positive rate compared to the frequency of such errors typically found when using control limits (CLs).

Response:

We regret the confusion regarding the use of m and k variables. HDOH correctly noted that the k variable in the equation (taken from Equation 18.3 in the Unified Guidance) should be m. This equation was included in the Tech Memo to illustrate a simple UPL calculation, assuming the UPL is applied to only one constituent in a single well. For the CMLF comparisons, multiple tests are performed (multiple wells and multiple constituents), therefore the UPL is calculated using a κ-multiplier, which is used to control the Site-Wide False Positive Rate (SWFPR, see Section 19.2 of the Unified Guidance). The section describing the methodology for calculating UPLs will be revised to detail the equations and assumptions used for the multiple well/multiple constituent calculation, incorporating the κ-multiplier. The simplified example equation will be removed.

The number of future observations in the Tech Memo (1,200 based on 6 wells x 20 constituents x 10 events over a 5-year period) is being used to determine the appropriate κ-multiplier accounting for the anticipated statistical evaluation and recalculation of UPLs (in 5 years). It is anticipated that CMLF data collected between now and 2022 will be compared (for each sample, by well and constituent) to UPLs following each event, but that a comprehensive reevaluation and recalculation of UPLs would only be revisited every 5 years. We believe this is consistent with Unified Guidance Section 18.2.1 (p. 18-2, 3rd para.) where it states that "the number of future observations to be collected (m) need to be specified in advance in order to correctly compute the κ-multiplier from equation [18.1]", and that "m denotes the number of consecutive sampling events being compared to the prediction limit at a given well for a given constituent."

As noted above, we are proposing that the number of future observations remain at 1,200. This is based on the product of the number of wells (6), the number of anticipated monitoring constituents (20), and the number of events over a 5-year period (10, assuming semi-annual monitoring) across the site. Regarding control of false positives, the Unified Guidance recommends prediction limits for detection monitoring for their proven use of retesting strategies and ability to define an exact false positive error rate.

As discussed in Chapter 6 of the Unified Guidance, the statistical performance (i.e., false positive rates and power) of control charts is not well understood. The control limit used to identify potential releases to groundwater is not based on a formula incorporating a desired false positive rate. Unlike prediction limits, the control limit cannot be precisely set to meet a pre-specified SWFPR, unless the behavior of the control chart is modeled via Monte Carlo simulation. The same is true for assessing statistical power. Control charts usually provide less flexibility than prediction limits in designing a statistical monitoring program for a network. The Unified Guidance recommends a 10 percent annual target for false positives, where the overall target design SWFPR is proportionately divided among all relevant tests conducted in an evaluation period (we are proposing 5 years). The Tech Memo will be revised to include justification for the interpretation of "number of future observations" and how UPLs will control the SWFPR compared to the frequency of false positives typically found using controls.

General Comments

1. The Tech Memo provides a general description of the UPL calculation methodology used at CMLF. Please provide a step-by-step description of the methodology used to determine the UPLs for groundwater at the facility to substantiate the procedure used to calculate UPLs at the facility. The description should present the process used to recalculate the limits (formerly CLs) in a similar manner to the process described when the CLs were recalculated in 2010 (see Appendix A of the *Semi-Annual Groundwater Monitoring Report, Central Maui Landfill*, December 2010). The description should include (but not be limited to) the rationale for determining the number of future observations and the selection of background measurements used in the UPL calculations, as well as the procedures for testing for outliers, season effects, trends, nondetected results, and other parameters in the background data used to calculate UPLs.

Response:

The Tech Memo will be revised to include a step-by-step description of the methodology used to calculate the UPLs. Per the response to Comment #2, the revised memorandum will include the rationale for selecting background measurements, including verifying that the background data satisfy the six key requirements from the Unified Guidance (response to Comment #1). Per the response to Comment #3, the memo will detail the equations and assumptions used for the multiple well/multiple constituent calculation (number of future observations).

2. The Tech Memo states in the section titled "Why UPLs?" that the Unified Guidance includes CLs and UPLs for intrawell groundwater comparisons; the Tech Memo states advantages of UPLs. Chapter 6 of the Unified Guidance ("Detection Monitoring Program Design") discusses control charts (p. 6-46, para. 1) and states, "Standard prediction limits allow only point-in-time comparisons between the most recent data [future observations] and background, making long-term trends more difficult to identify." Given this apparent shortcoming of prediction limit methodologies, please clarify how long-term trends in groundwater data from CMLF will be identified and subsequently managed.

Response:

Time-series plots of the detection monitoring constituents in each monitoring well will be included in the groundwater monitoring reports. Formal trend analysis using the Mann-Kendall test will be conducted as needed.

Also please see the response to Comment #3 Results regarding the applicability of UPLs over control charts for the CMLF data.

3. We understand that CMLF is currently in the assessment monitoring program based on exceedances of several constituents above control limits during previous sampling events. Please refer to Hawaii Administrative Rules 11-58.1-16 (e) (2) and the DOH 2002 Guidance regarding (1) the requirement for sampling and analysis of Appendix II constituents on an annual basis once a landfill has entered assessment monitoring due to a verified exceedance, and (2) stipulations for exiting the assessment monitoring program. Please clarify the status of annual assessment monitoring requirements at CMLF based on previous exceedances, including how this issue ties in with the UPLs.

Response:

A brief summary of the work completed since initiation of Assessment Monitoring in March 2012 is provided in the following paragraphs, and will be included as an attachment to the revised Tech Memo. We believe, as documented in the information summarized below and in the reports received by HDOH in 2015 and 2016, that Assessment Monitoring is complete and the ***Detection Monitoring Program*** *has resumed at CMLF.*

Assessment monitoring was initiated in March 2012 after an exceedance of the iron control limit (CL) was confirmed at monitoring well MW-5 in December 2011. The full list of Appendix II chemical constituents was run in March 2012 and resulted in four new constituents (lead, vanadium, chromium, and nickel) detected in groundwater that were not part of the Detection Monitoring Program (URS, 2012). Per the State of Hawaii Department of Health (HDOH) Landfill Groundwater Monitoring Guidance (HDOH, 2002), background levels and new groundwater protection standards for these constituents were established by conducting eight independent monitoring events (between June 2012 and December 2014) and revising the CLs to calculate and adopt new Upper Predictive Limits (UPLs) as approved by the HDOH Solid and Hazardous Waste Branch (SHWB) in 2016 (CH2M, 2016). Chloride was added to the Assessment Monitoring Program in April 2013 because of an exceedance of its CL in MW-3 and MW-4.

In accordance with the 2002 HDOH Landfill Groundwater Monitoring Guidance, the full list Appendix II constituents was analyzed for again in April 2014 for comparison against the original March 2012 results (URS, 2014), and one more time in June 2015, when no additional Appendix II parameters were detected. Based on the results of the April 2014 and June 2015 groundwater monitoring events, when the full Appendix II constituents list was analyzed for, no new Appendix II sampling was deemed necessary and the Detection Monitoring Program has resumed in compliance with the Unified Guidance (Section 4.2) and EPA the Federal Subtitle D regulations. During both events, no constituents other than those pulled into the detection monitoring program (and for which background levels and control limits/UPLs were being evaluated) were detected above their reporting limits.

All constituents detected during Assessment Monitoring were included in the Detection Monitoring Program, and new UPLs were calculated. While new UPLs were being calculated, a site-specific Conceptual Site Model (CSM) (CH2M, February 2016) was submitted to HDOH SHWB. The CSM demonstrated how slight and occasional exceedances of the CLs reported in 2015 for TOC, chloride, nitrate, magnesium, sulfate and sodium were not indicating a statistically significant increase attributable to landfill impacts, but rather to "external" alternative sources such as natural variation, annual rainfall, and irrigation in agricultural area surrounding the site. No exceedances of the newly calculated UPLs were reported for any of the constituents.

As discussed in the CSM and the Groundwater Detection Monitoring Reports submitted to HDOH from December 2014 through 2016, there has not been a clear correlation between leachate and groundwater data, with no increasing trend of concentrations for a group of leachate constituents as would be expected if leachate impacts were occurring. The presence of the same constituents in groundwater at concentrations fluctuating over time, hovering close to, and sometimes slightly exceeding the established CLs at all site wells, including the upgradient (background) wells, are indicative of background aquifer conditions. Additional evidence of no leachate impact includes the following:

- *Predominant constituents and concentration ratios between constituents detected in leachate not aligning well with the types and concentration ratios of constituents present in groundwater, with specific ratios of cations and anions in groundwater differing from the ratios of the same cations and anions in leachate.*

- *Average groundwater concentrations of sulfate and nitrate that are higher than those found in leachate at the site.*

Slight temporal fluctuations in dissolved constituent concentrations are expected to continue to occur in groundwater at the site as a result of contributing factors as influx of irrigation water, annual rainfall, groundwater pumping, and other potential point sources of dissolved constituents.

As recommended in the CSM document and discussed with HDOH during a meeting held at the HDOH SHWB office on January 23, 2015, Maui County recommends that the analytical plan be revised to analyze groundwater samples for a shorter list of constituents based on actual site conditions, targeting those constituents that are routinely detected in leachate at CMLF (including biodegradation by-products of VOCs present in leachate) and that are mobile and less influenced by temporal fluctuation in background concentrations, also considering significant ratios of major ions and inter-well evaluations to assess landfill impacts (as also agreed by HDOH during the January 2015 meeting). This would decrease the number of false-positive results triggering assessment monitoring unnecessarily, while reducing the overall monitoring costs, as recommended in the 2002 HDOH Landfill Groundwater Monitoring Guidance.

We look forward to your comments on our proposed approach to the revision of the UPL Tech Memo. If you have any questions, please contact Elaine Baker, P.E., at 808-270-7872.

Sincerely,

Stewart Stant

Stewart Stant,
Director of Environmental Management

ALAN M. ARAKAWA
Mayor

STEWART STANT
Director

MICHAEL M. MIYAMOTO
Deputy Director

MICHAEL RATTE
Solid Waste Division

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COUNTY OF MAUI
DEPARTMENT OF
ENVIRONMENTAL MANAGEMENT
2050 MAIN STREET, SUITE 2B
WAILUKU, MAUI, HAWAII 96793

October 12, 2017

Mr. Steven Y.K. Chang, P.E., Chief
Solid and Hazardous Waste Branch
Department of Health
919 Ala Moana Boulevard, Room 212
Honolulu, Hawaii 96814

Dear Mr. Chang:

SUBJECT: ***Groundwater Monitoring Plan Modifications to Date, May 31, 2017***
Central Maui Municipal Solid Waste Landfill
Solid Waste Management Permit No LF-0089-08
RESPONSE TO DOH COMMENT LETTER OF JULY 19, 2017

As requested in your letter of July 19, 2017, this letter provides a written response to your comments in that letter. Prior to submitting a revised Groundwater Monitoring Plan, we respectfully ask for written concurrence from you that our approach to the revision is acceptable to you.

"Analytical Plan" Table:

1. "Proposed Revision" Column: In a revised groundwater monitoring plan, please provide reference and rationale for selecting: 1) the past five years of leachate data for comparison to groundwater data (i.e. why five years?); and 2) re-evaluation of the short list of constituents to compare between groundwater and leachate after a minimum of four independent samples are collected from each monitoring well (i.e. why four samples?).

<u>Response:</u>

The State of Hawaii Department of Health (HDOH) Solid and Hazardous Waste Branch (SHWB) 2002 Landfill Groundwater Monitoring Guidance (HDOH SHWB, 2002), Chapter 5, Detection Monitoring Parameters and Schedule, Sections 5.1 and 5.2, recommends that an appropriate alternative short list of groundwater sampling parameters be selected to minimize false-positive results. The guidance describes the recommended approach for selecting an alternative list of site-specific groundwater monitoring parameters based on leachate composition, groundwater geochemistry, and waste composition. The 2002 HDOH Guidance further discusses the effectiveness of a facility's proposed alternative monitoring parameters depending primarily on the amount and quality of site-specific groundwater and leachate data available for use during the selection process. However, no specific *recommendation is given on the minimum number of years or sampling events that should be considered when evaluating leachate composition. Given the lack of specific direction, it is believed that 5 years (or 10 leachate sampling events, considering biannual sampling) would constitute a reasonable time over which a representative leachate average composition could be developed. If HDOH SHWB has different recommendations, the County of Maui is open to considering a different amount of time.*

With respect to the re-evaluation of the short list of constituents, the 2002 HDOH Guidance provides general recommendations to re-evaluate the monitoring parameter list periodically and modify it appropriately based on changes in groundwater or leachate conditions. Re-evaluation every four events was previously proposed to consider seasonal fluctuations and overall/cumulative trends of leachate and groundwater characteristics as part of a conservative annual review (i.e., groundwater monitoring is conducted quarterly at Central Maui Landfill). However, to follow the United States Environmental Protection Agency (USEPA) 2009 Unified Guidance for Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (USEPA, 2009) and allow for the collection of a larger set of data, the County of Maui proposes to review the short list of constituents every 3 years, as recommended in Chapter 6 (Detection Monitoring Program Design), page 6-10 of the 2009 Unified Guidance.

2. "Rationale for the Change" Column: In contrast to the multiplier of two stated in this column, the DOH 2002 Guidance states, " ... the alternative list of inorganic monitoring parameters should include only those parameters that exhibit a sufficiently high (e.g. 5 times or greater in leachate) concentration contrast between the facility's leachate and groundwater." Also, the Conceptual Site Model/for the landfill (dated February 2016; prepared by CH2M; see p. 3-4) states that a minimum contrast of 10 times between leachate and groundwater chemistry concentrations is assumed when selecting the most useful constituents for identifying a release. Please provide reference and rationale for selecting a multiplier of two.

Response:

The 2002 HDOH Guidance referenced in the comment recommends a contrast between leachate and groundwater of 5 times or greater for inorganic parameters in Section 5.1 (Fundamental Concepts). A contrast between leachate and groundwater of 2 times is also referenced for inorganic parameters in Section 5.4 of the same Guidance. A general contrast of 10 is recommended in the site-specific Conceptual Site Model (CSM) document (CH2M, 2016).

The Main Revisions to the Groundwater Monitoring Plan Draft Table submitted to HDOH SHWB was meant to provide an initial, preliminary summary of the main updates proposed to the Groundwater Monitoring Plan for discussion with the regulatory agency. Given the different recommendations on the contrast between leachate and groundwater provided in previous documentation, the sentence "Generally, effective inorganic monitoring parameters should have concentrations in leachate that are at least 2 times higher than in groundwater" from the 2002 HDOH Guidance was referenced in the Draft Table to include all previous recommendations, with the intent to later discuss and reconcile the discrepancies with HDOH, and agree on the appropriate contrast between leachate and groundwater for CMLF detection monitoring. However, the County of Maui confirms the recommendation provided in the CSM document, with a contrast between leachate and groundwater constituents of 10 times, as also recommended in the American Society for Testing and Materials (ASTM) Standard Guide for Optimization of Groundwater Monitoring Constituents for Detection Monitoring Programs for Waste Disposal Facilities (ASTM D7045-17, 2017). To screen analytes and develop an optimized list of Detection Monitoring constituents for sites larger than 0.5 acres (such as the

Central Maui Landfill), the ASTM Standard D7045-17 (Section 6.6.2) recommends to include only leachate analytes detected at concentrations at least 10 times greater than the background prediction limit.

"Monitoring Network" Table

1. This table states that wells MW-2 and MW-5 are "upgradient of the line of compliance." The term "line of compliance" appears to be a concept that was introduced in the *Groundwater and Leachate Monitoring Plan for Central Maui Landfill* (A-Mehr, Inc., dated November 2012; see Figure 16), in which a line connecting the existing and proposed downgradient monitoring wells was called the "proposed point of compliance." This concept seems to have been interpreted as a "line of compliance" as used in this "Monitoring Network" table. Please note that the term "point of compliance" at a municipal solid waste landfill is defined in Hawaii Administrative Rules (HAR) 11-58.1-14(e) as no more than 150 meters from the waste boundary and on land owned by the owner of the landfill unit.

   Well MW-5 is less than 150 meters from the waste boundary of solid waste management unit (SWMU) IV and as such is a valid point-of-compliance well.

   We understand that the placement of well MW-2 was based on plans for future waste disposal at "Phase III" (where composting operations are currently taking place). Well MW-2 is about 260 meters from SWMUs I and II and thus does not serve as the required point of compliance well for closed SWMUs I and II, as discussed in the comments the DOH provided to the County of Maui for the 2011 draft groundwater and leachate monitoring plan prepared by A-Mehr, Inc. (see DOH letter to County of Maui dated July 5, 2012).

   Well MW-3 is located downgradient and within 150 meters of SWMUs I and II (though the well location at the corner of this closed waste area is not optimal relative to the predominant groundwater flow direction and waste boundary, based on the current understanding of the hydraulic gradient at the site). Proposed well MW-8 included in the *Groundwater and Leachate Monitoring Plan for Central Maui Landfill* (November 2012; A-Mehr, Inc.) appears to be close to this 150-meter requirement and thus might serve as a valid "point of compliance" well for SWMUs I and II, depending on final placement.

Response:

We understand that the relevant "point of compliance" is defined in the HAR 11-58.1-14(e) as no more than 150 meters from the waste boundary. In interpreting "no more than 150 meters from the waste boundary" we assumed that a "line of compliance" can be defined as the imaginary line located 150 meters from the most downgradient solid waste management units (SWMUs). When considering each individual SWMU, and given the current understanding of groundwater flow characteristics at the site (see Figure 3 of the December 2016 and March 2017 Detection Monitoring Report for Central Maui Landfill [CH2M, May 2017]), the following considerations can be made:

- *Monitoring wells MW-5 and proposed MW-7 (to be installed within 150 meters of the SWMUs IV/V downgradient boundary) provide optimal coverage for SWMUs IV/V and meet the "point of compliance" requirements of HAR 11.58.1-14(e).*
- *Based on the current and improved understanding of groundwater flow characteristics at the site, monitoring well MW-3 is located immediately downgradient and within 150 meters of the SWMUs I/II downgradient boundary. Although we*

understand that MW-2 is located at greater than 150 meters from SWMU I/II (about 250 meter from the center point of the front edge of the SWMU, and 205 meters from the northernmost corner of the SWMU), we believe that MW-3 provides adequate coverage to capture the bulk of the groundwater advective flow toward northwest to respond to the "point of compliance" requirements of HAR 11.58.1-14(o), and MW-2 would be sufficient to capture lesser groundwater flow toward the north. Recent updated analysis of groundwater levels in monitoring wells and interpreted groundwater flow to account for the influence of tidal fluctuations, as presented in the December 2016 and March 2017 Detection Monitoring Report (CH2M, May 2017), indicate groundwater flows to the northwest beneath SWMU I/II and to the north-northwest beneath SWMU III, which render the originally proposed location of well MW-8 (east of well MW-2) to be cross-gradient, rather than downgradient of SWMUs I/II and III. Thus, well MW-8 at the location proposed in 2012 would not be considered an effective downgradient monitoring location. Recently collected groundwater data (evaluation of tidal influence on groundwater flow and groundwater flow modeling) and the latest design plans for future SWMU III (e.g., leachate collection sump location) should be considered to evaluate if MW-8 is needed, and if so which is the best location based on the current and improved understanding of groundwater flow characteristics at the site. Newly collected groundwater data will be presented to HDOH SHWB in the updated Groundwater Monitoring Plan.

- *Monitoring well MW-2 will also provide adequate coverage downgradient of SWMU III when developed. In the meantime, if accepted as an adequate well (together with well MW-3) to monitor groundwater downgradient of SWMU I/II, well MW-2 will continue to be sampled as part of the Detection Monitoring Program.*

2. The table proposes to remove wells MW-4 and MW-6 from the monitoring network and to use well MW-1 as the sole background (upgradient) well for the SWMUs at the facility. The following should be considered regarding monitoring of background wells at the facility:

   (a) The Unified Guidance (p. 5-8, para. 4) states, "Generally speaking, a single background well will not generate observations that are adequately representative of the underlying aquifer." It continues, "Background observations collected from a single well are typically neither representative nor constitute a large enough sample to construct powerful, accurate statistical tests."

   (b) The *December 2016 and March 2017 Detection Monitoring Report* (dated May 2017) for the Central Maui Landfill states that intrawell analysis will be conducted at the site. The report also states, "At the same time, interwell (between-well) results will be considered for further evaluation of [upper prediction limit] UPL exceedances from intrawell statistical methods to assess if changes in constituent concentrations are occurring sitewide because of naturally occurring fluctuations in background aquifer conditions or if they may be attributable of landfill operations."

   (c) As stated in the "Monitoring Network" table, well MW-6 is upgradient of future Phase VI. Presuming that Phase VI will be developed as a SWMU at the facility, monitoring data from this well will provide background data for groundwater directly upgradient of future Phase VI prior to development of this SWMU.

In addition, the direction of groundwater flow at the landfill has been variable in the past, varying between north and west. At times when the flow is more northerly, well MW-1 is not necessarily representative of background for SWMUs Phase IV, V, and potential future Phase VI.

(d) The *Conceptual Site Model* (CH2M 2016) prepared for the site states that "adequate upgradient coverage of the site is provided by monitoring wells MW-1, MW-4, and MW-6," and the document recommended that all existing site monitoring wells be retained.

Based on the above, we recommend that you retain all three background wells (MW-1, MW-4, and MW-6) in the monitoring network. However, these comments are not intended to dispute nor reduce the importance of worker safety. Assuming engineering and operation controls are not sufficient to ensure worker safety in the collection of samples at well MW-6, we are open to discussion regarding an alternate data collection point.

Response:

A large amount of data has already been collected from the upgradient/background wells MW-1, MW-4, and MW-6 to evaluate background concentrations. Although we agree that well MW-6 could provide useful data if SWMU VI is developed in the future, there is no immediate plan to expand the landfill operations within this portion of the property in the near future. Because of the recent quarrying activities, well MW-6 is now in proximity of an abrupt cliff, which makes it unsafe to sample and could require fall-protection measures for the field crew. To maximize field staff safety, the County of Maui and CH2M recommend to not sample this well while SWMU VI is not used, to later re-evaluate sampling of well MW-6 when SWMU VI may be developed in the future. The well will not be abandoned and may be gauged occasionally to measure groundwater level.

As for well MW-4, although a significant amount of data has already been generated from this and other upgradient wells, we agree that a second background well may be useful as recommended in the Unified Guidance. MW-4 will be retained and will continue to be sampled during Detection Monitoring.

We look forward to your concurrence with our responses to your comments so that we may proceed with the upcoming revision of the groundwater monitoring plan. If you have any questions, please call Elaine Baker, P.E. at 808-270-7872.

Sincerely,

Stewart Stant

Stewart Stant
Director of Environmental Management

Groundwater and Leachate Monitoring Plan, Central Maui Landfill, Puunene, Hawaii

County of Maui Responses to HDOH SHWB Comments
March 2019

Comment No.	Section	Page (Paragraph or Location)	HDOH-SHWB Comment	County of Maui Response
GENERAL COMMENTS (these comments apply to multiple sections in the plan and its appendices)				
1	First occurrence: Section 3.2.1	3-7 (para. 3) and 3-8 (top of page)	It is unclear if total alkalinity is a selected detection monitoring constituent. In Section 3.2.1, total alkalinity is included in the paragraph for a “2 to 9.9” leachate/groundwater contrast and it is not eliminated in this paragraph. However, total alkalinity is not included in the list of selected detection monitoring constituents in this paragraph. Subsequently at the top of page 3-8, total alkalinity is included in the list of detection monitoring constituents under the heading “major leachate indicators.” Please correct the text throughout the Plan to reflect the inclusion of total alkalinity as a constituent with a leachate/groundwater contrast of “2 to 9.9,” or alternatively, include the rationale for why it was discarded in this analysis in Section 3.2.1. This error is perpetuated throughout the Plan, including in Appendix E. Related to this inconsistency, the number of detection monitoring constituents is stated throughout the Plan and Appendix E as “nine;” if total alkalinity is a selected constituent, the number would be “ten.” In addition, the number of detection monitoring constituents affects calculation of the UPLs. Please recalculate the UPLs if total alkalinity is a selected constituent.	**Concur**. Total Alkalinity is retained as detection monitoring constituent and will be added to the list of selected detection monitoring constituents in the 3rd sentence of this paragraph. Please note that the number of detection monitoring constituents does not change because, as discussed in the first and second paragraphs of page 3.8 (after the constituent list) and later in Section 6 and Appendix E, 12 constituents/groups of constituents are retained and are part of the optimized detection constituent list, but UPLs can be calculated only for nine of these 12 constituents. Three of the indicator constituents (ammonia, BTEX, and HVOCs) are not directly incorporated into the formal statistical testing for detection monitoring (i.e., no UPL calculated) because they are rarely, if ever, detected at site compliance monitoring wells. To clarify this, the following changes will be made: 1) In Section 3.2.1, Page 3-8, 1st Paragraph after the list of constituents, the following statement will be added for clarity at the end of the paragraph: *“Thus, of the 12 constituents retained as the site-specific optimized constituents for detection monitoring at the CMLF, nine (calcium, magnesium, potassium, sodium, chloride, iron, TOC, TDS, and total alkalinity) will be statistically evaluated using UPLs because they are reliable indicators selected for formal detection monitoring testing per the Unified Guidance (USEPA, 2009).”* 2) In Section 6.1, Page 6-1, 2nd paragraph, 1st sentence will be revised as follows: *“A thorough evaluation of available data was completed to select the most appropriate statistical approach and calculate UPLs for the optimized list of nine detection monitoring constituents selected for statistical analysis (calcium, magnesium, potassium, sodium, chloride, iron, TOC, TDS, and Total alkalinity), as discussed in Section 3.2.1.”* In addition, in Section 6.1.1, Page 6-2, 1st Paragraph, 1st Complete Sentence, the nine detection monitoring constituents selected for statistical analysis are already clearly stated. 3) In Section 6.1.2, Page 6-4, 3rd Paragraph, 2nd Sentence will be revised to read: "*A UPL was calculated for each of the nine formal detection monitoring constituents selected for statistical analysis at the two downgradient compliance monitoring wells (MW 3 and MW 5) using data collected from June 2008 through September 2017.*" 4) In Appendix E, Section 4, Page 4-3, 3rd Hyphen Bullet, 2nd Sentence, Total Alkalinity will be added to the list of selected detection monitoring constituents. On Page 4-4, 1st Paragraph after the list of constituents, the following statement will be added for clarity at the end of the paragraph: *“Thus, of the 12 constituents retained as the site-specific optimized constituents for detection monitoring at the CMLF, nine (calcium, magnesium, potassium, sodium, chloride, iron, TOC, TDS, and total alkalinity) will be statistically evaluated using UPLs because they are reliable indicators selected for formal detection monitoring testing per the Unified Guidance (USEPA, 2009).”* 5) In Appendix E, Section 8.3, Page 8-3, the first sentence will be changed to: “*A UPL was calculated for each of the nine formal detection monitoring constituents selected for statistical analysis at the two downgradient compliance monitoring wells (MW 3 and MW 5) using data collected from June 2008 through September 2017.*"
SPECIFIC COMMENTS				
SECTION 1				
1	1.4, Exhibit 1	1-3 (left column, top cell)	Landfill permit LF-0074-13, Section G. “Groundwater and Leachate Management,” Item 1 specifies that a groundwater and leachate monitoring plan shall be submitted within 90 days of issuance date of the permit, whereas the text of the Plan states “within 30 days.” Please correct this number of days to reflect the permit conditions.	**Concur**. The text in Section 1.4, Exhibit 1 will be revised as follows: "*Submit a new Groundwater and Leachate Monitoring Plan within 90 days from the issuance of the new Permit.*"
2	1.4, Exhibit 1	1-4 (left column, under “Leachate”)	Please insert the word “analysis” between “quality” and “plan,” to complete the term “construction quality analysis plan.”	**Discuss**. In the Permit, Section B (Construction and Maintenance - MSW Disposal Cells), Item 4, references a "Construction Quality Assurance Plan". We propose to use the word "Assurance" instead of "Analysis" to complete the term "Construction Quality Assurance Plan."
SECTION 2				
3	2	2-1 (para. 1)	The texts states that the January 2015 meeting minutes are included in Appendix B; however, we did not find January 2015 meeting minutes in Appendix B. Please correct this omission.	**Concur.** The January 2015 meeting minutes will be added to Appendix B.
4	2.2	2-2 (para. 5)	The text states there are seven SWMUs existing or currently planned for development at the facility; however, the text subsequently names eight SWMUs. Please correct this so that the numbers of SWMUs coincides in these two sentences.	**Concur.** The text will be revised to say: "There are eight SWMUs existing or currently planned for development at the CMLF facility."
5	2.4.2	2-6 (para. 2)	(1) The text states that “the County discussed results and justified exiting assessment monitoring in the 2015 Detection Monitoring Report.” Based on our review of the referenced 2015 monitoring report, the analytical results were presented in the 2015 report, but no discussion or justification for exiting assessment monitoring was identified in the 2015 report. Please revise the text to accurately describe the contents of the 2015 Detection Monitoring Report. (2) Please note that the “conclusion” section of the 2015 report states: “Constituents detected during the three monitoring events [as part of assessment monitoring] that have previously been verified as present are now included as part of the detection monitoring program.” Please note that including constituents detected during assessment monitoring as part of the detection monitoring program does not satisfy the rules for exiting assessment monitoring outlined in HAR 11-58.1-16(e)(5), nor does it preclude the annual analysis of Appendix II constituents (HAR 11-58.1-16(e)(2))	**Concur/Discuss**. (1) Although Appendix II monitoring results are discussed in Section 4 and Appendix A of the report, presence of constituents associated with background levels is discussed in Sections 4 and 6, and the Conclusions (Section 6) states that the County will continue detection monitoring at the facility, we concur that no specific discussion/justification is provided in the 2015 Report for exiting assessment monitoring. We propose to revise the first sentences of paragraph 2 on page 2-6 as follows: "A summary of Appendix II assessment monitoring results is provided in Table 2-2. Per HAR 11 58.1 16 sections (d)(3)(C) and (e)(7)(B), the County discussed potential sources other than the landfill (such as natural variation) possibly causing the exceedances of the 2010 CLs, which had triggered assessment monitoring in March 2012, in the 2015 Detection Monitoring Report (CH2M, 2016c) and in the final CSM report (CH2M, 2018). After the last Appendix II........" (2) Comment noted. (3) See paragraph above (1) for proposed edits of the referenced section of the Plan. Please note that given the nature of the site and related potential

			as part of the assessment monitoring program. Please bear this in mind if the facility enters assessment monitoring in the future. (We recognize that, with development of the June 2016 UPLs, no constituents exceeded the UPLs in June and December 2016 and thus, no 2016 or subsequent Appendix II sampling was conducted, as the Plan subsequently describes on page 2-6, paragraph 2). (3) Paragraph 2 also states that "the County …demonstrated in the final CSM report…that sources other than the landfill (such as natural variation) caused the exceedances of the 2010 CLs that had triggered assessment monitoring in March 2012." We understand that the purpose of the CSM is stated in Section 2 of Appendix E of the Plan, as follows: "The purpose of the revised CSM was to develop a better understanding of background aquifer conditions and other potential influences on groundwater beneath the site." The Summary section of the revised CSM (Section 5.1, paragraph 7) states: "Based on the likelihood that both natural processes and other non-landfills sources are contributing dissolved constituents to groundwater, and given the absence of clear or consistent lines of evidence indicating leachate effects, it does not appear that leachate from CMLF is impacting underlying groundwater." Based on our review of the revised CSM, the document does not state that sources other than the landfill definitively caused the exceedances that triggered assessment monitoring, as stated in the Plan. Please revise the section of the Plan to reflect the nature of the conclusions stated in the revised CSM.	sources, it would be difficult to state with absolute and definitive certainty that a specific source caused the exceedances that triggered assessment monitoring in March 2012.
6	2.8	2-13 ("Co-Composting of Green Waste and Biosolids")	The text states that biosolids are mixed with green waste and "grease trap waste." The co-composting incoming feedstock is a little more extensive than this. The operation accepts mulch, grit, mixed grease and sewage waste, and wastewater and solid by-products from grease separation and biodiesel production. Please revise this statement to accurately reflect the process at the co-composting facility.	**Concur.** The text will be revised as requested.
SECTION 3				
7	3.1.1	3-2 (para. 4)	Under "Compliance Wells," first bullet (MW-2), the Plan states that data from well MW-2 can be statistically evaluated "once the water quality issues believed to be attributed to effects of the nearby Co-composting Area have been resolved and significant statistical trend in concentrations are no longer present." Please describe how the County proposes to (1) assess groundwater data from MW-2 to determine if the effects attributed to the Co-composting Area have been resolved, (2) how the County would determine that significant statistical trends in constituent concentrations are no longer present, and (3) which constituent concentrations at MW-2 would be assessed in this evaluation. Also, please see DOH Comment 19 (under SECTION 6 below).	**Concur/Discuss**. (1) The County would evaluate concentrations to determine if they return to pre-2014 levels detected in well MW-2 prior to permitting of the Co-Composting operations in February 2014. (2) Evaluation of significant statistical concentrations trends in well MW-2 would be performed using the nonparametric Mann-Kendall test that was applied for evaluating the data used to develop the UPLs. (3) The concentrations of the nine constituents selected for statistical evaluation for detection monitoring at the CMLF (calcium, magnesium, potassium, sodium, chloride, iron, TOC, TDS, and Total alkalinity) would be assessed in the evaluation. The evaluation would emphasize those constituents with the most obvious increasing trends, including calcium, chloride, magnesium, potassium, sodium, and TDS, as indicated in the time-series concentration plots in Appendix E, Attachment 2.
8	3.1.2	3-3 (all)	Figure I-11 shows an advective flow path emanating from the Phase IV-A wet well. However, Section 3.1.2 does not address how the monitoring network will detect a potential leachate impact from the Phase IV-A wet well. Please address how the proposed monitoring well network will address a potential leachate release from the Phase IV-A wet well.	**Discuss**. As agreed during the meeting of January 3, 2018 attended by HDOH, County, and CH2M-Jacobs representatives, the proposed monitoring network does not include a well directly downgradient of the solid waste management unit (SWMU) Phase IV-A wet well because the wet well is self-contained, sealed, and gravity-fed, and the presence of an additional monitoring well immediately downgradient of it is not critical (see meeting minutes in Appendix B). As described in the January 3, 2018 meeting minutes, the SWMU Phase IV-A wet well consists of a small capacity (500 gallons) polyethylene tank collecting leachate within a concrete manhole that is double-sealed with an epoxy UV protection coat and an epoxy lining coat to maximize the hydraulic seal of the secondary containment. This wet well is collecting leachate exclusively from SWMU Phase IV-A, a relatively small unit (10 acres) that is reaching capacity and will be closed and capped in 1.5 to 2 years. During the January 3, 2018 meeting it was agreed that it would be more beneficial to install a monitoring well (MW-7) downgradient of SWMU Phase IV-B, which includes a much larger capacity (70,000 gallons) sump collecting leachate from a significantly larger area (SWMUs Phase IV-B, Phase V-A, and Phase V-B, for a total of about 32 acres), and one monitoring well near the northwestern corner of the landfill (MW-8). As shown in Figures 3-1 and I-11, monitoring wells MW-7 and MW-8 would provide adequate coverage of groundwater flow from SWMUs Phase IV-B, Phase V-A, Phase V-B, Phase V-B Ext. and most of Phase IV-A, and better overall spatial coverage (spacing of the wells) of the area downgradient of the landfill. Considering the SWMU Phase IV-A wet well and SWMU Phase IV-B sump characteristics described above, placing a well directly downgradient of SWMU Phase IV-A wet well would provide limited additional benefit and ability to detect a release from the landfill, compared to future wells MW-7 and MW-8. Additionally, please consider that the advective flow zones from a hypothetical release point/area in Figure I-11 are simulated using the forward particle tracking tool from MODPATH, which accounts for groundwater flow by advection only. Because other transport mechanisms such as hydraulic dispersion, diffusion, and retardation (sorption/desorption) are not accounted for by the model, it is expected that the actual groundwater particle pathlines generating from a potential source within the landfill (e.g., leachate collection wet well/sump or liner failure) would spread over a much larger and irregular area. Therefore, in the unlikely event that a release occurred within the Phase IV-A wet well, the groundwater impact from the release is expected to be detected in monitoring wells MW-5 or future MW-7. We therefore believe that the locations proposed for the three additional monitoring wells are the most effective in providing adequate and uniform coverage along the line/points of compliance downgradient of the current and future SWMUs. The rationale discussed above as to why no monitoring well is planned immediately downgradient of the SWMU Phase IV-A wet well can be included in Section 3.1.2.
9	3.2	3-4 (para. 1)	The text states that assessment monitoring will be implemented following retesting if a significant statistical increase is indicated that cannot be attributed to other factors besides the landfill through an ASD. Please note that HAR 11-58.1-16(d)(C) includes the other factors besides an ASD that could avert assessment monitoring, including "error in sampling, analysis, statistical evaluation, or natural variation in ground water quality." Please revise the text to clarify these options.	**Concur.** The paragraph will be revised as follows: "*If a significant statistical increase (SSI) is observed for one or more of the detection monitoring constituents through an exceedance of the UPLs confirmed at any of the compliance wells during retesting that cannot be attributed to other factors, including error in sampling, analysis, or statistical evaluation; natural variation in groundwater quality; or outside sources demonstrated through an ASD to be the cause of the SSI Per HAR 11-58.1-16(d)(C, assessment monitoring will be implemented.* "
10	3.2.1	3-5 (para. 3)	In item "2. Concentration contrast," the text states that "The HDOH Landfill Groundwater Monitoring Guidance recommends a contrast of at least 2 for organic constituents and at least 5 for inorganic constituents." This is duplicated in Appendix E, Section 4, page 4-1.	**Concur.** The reference to State guidance will be removed in this section and Appendix E, where leachate-groundwater concentration contrast is discussed.

			Please note that the referenced HDOH document contains conflicting information: Section 5.1 states that "inorganic monitoring parameters should include only those parameters that exhibit a sufficiently high (I.e. 5 times or greater in leachate) concentration contrast between the facility's leachate and groundwater," and Section 5.4 states that "inorganic monitoring parameters should have concentration in leachate which are at least 2 times higher than in groundwater." Thus, both references are relative to inorganic parameters. Because DOH has not resolved this conflict in the DOH guidance, please reference only the USEPA and ASTM guidances with respect to this issue. Please revise the text in Section 3.2.1 and in Appendix E to reflect this correction.	
11	3.2.1	3-7 (para. 3)	Please see the General Comment regarding inclusion of total alkalinity here and at multiple locations within the Plan, including the appendices.	**Concur.** See response to Comment #1.
12	3.2.1	3-9 (Table 3-2)	In the row for "Well ID MW-9," the text states that this well will monitor for groundwater quality downgradient of SWMUs Phase IV-A and Phase V-B Ext. Section 3.1.2, supported by Figure 3-1, indicate that future well MW-9 will be "strategically located to capture the advective flow zone for a potential release originating from the future sump in Phase III." Please reassess these statements and correct Table 3-2 to reflect the intended purpose of future well MW-9.	**Concur.** The rationale for monitoring well MW-9 in Table 3-2 will be revised as follows: "*Once installed, this well will be representative of downgradient groundwater quality and will be strategically located to capture the advective flow zone for a potential release originating from the future sump in Phase III. Groundwater quality data from this well will be used to evaluate regulatory compliance.*"
SECTION 4				
13	4.1	4-1 (para. 3)	The text states that the Phase IV-A wetwell compliance level for leachate is 210 feet amsl. Please note that Permit LF-0074-13 (see Section G Groundwater and Leachate Management, 7. B.) states that the compliance level for the Phase IV-A wetwell (referred to as the "manhole" in the permit) is 207 feet amsl. Please correct the text accordingly.	**Concur.** The bullet discussing leachate compliance level for SWMU Phase IV-A will be revised as follows: "*Leachate from this SWMU is collected via a self-contained concrete wetwell (also referred to as a manhole) that has a compliance level for the leachate of 207 feet amsl.*" Same revision will be made in Section 2.3, Page 2-3, second to last bullet.
SECTION 5				
14	5.1	5-1 (para. 3, 4, and 5)	The "Field Quality Control" section discusses collection of field duplicates, source water blanks, and equipment blanks "where nondedicated equipment is used for sampling." However, Section 3.3.2 states that dedicated groundwater pumps will be used to purge and sample the groundwater monitoring wells, and Section 4.3 states that disposable, single-use bailers will be used to collect leachate samples. Please include a discussion of circumstances under which nondedicated equipment might be used, if that is the intention, and thus, where these field quality control samples would be collected and analyzed.	**Concur.** The reference to nondedicated equipment was erroneously included for the FD sample. The first bullet will be revised as follows: "*A field duplicate (FD) sample will be collected at one compliance monitoring well. The FD sample will be collected together with the parent sample, following the same procedures and analyzing it for the same constituents.*" Also, a footnote will be inserted as a reference at the end of the third bullet as follows: "*Dedicated sampling pumps will be installed in all monitoring wells and source water blank and EB samples should not be necessary. However, nondedicated sampling equipment may be used in the future in the event that dedicated pumps need to be serviced at the time of detection monitoring sample collection. Source water blank and equipment blank samples would be collected only if nondedicated sampling equipment is used during a sampling event.*"
15	5.3	5-3 (Table 5-1)	The table lists USEPA 6020 B as the analytical method for BTEX and HVOCs in groundwater. Please note that USEPA 6020 B is for analysis of metals. Please correct the analytical method that will be used for BTEX and HVOCs in groundwater.	**Concur.** The analytical method USEPA 6020 B was inadvertently referenced erroneously. The table will be revised to reference analytical method USEPA 8260 B for BTEX and HVOCs.
16	5.3	5-3 (Table 5-1)	(1) The table lists USEPA 6020 B as the analytical method for VOCs in leachate. Please note that USEPA 6020 B is for analysis of metals. Please correct the analytical method that will be used for VOCs in leachate. (2) The table lists USEPA 6010 B + 74710 A for hardness. It appears that this is a typographical error and that the latter method is intended to be 7471 A.	**Concur.** The analytical method USEPA 6020 B was inadvertently referenced erroneously in Tables 5-1 and 5-2. The tables will be revised to reference analytical method USEPA 8260 B for VOCs and BTEX. The typographical error in the Table 5-2 will be corrected to indicate method 6010 B + 7471 A for metals (method SM 2340 B is correctly listed for hardness).
17	5.4	5-3 (para. 3 of Section 5.4)	Please see comment above for Section 5.1. If decontamination is used and thus source water blanks are included in Section 5.1, please include the source water blanks in the discussion of field samples in Section 5.4 and in the data quality evaluation.	**Concur.** The first sentence of the third paragraph will be revised as follows: "*The DQE will cover field samples, including normal samples, FD samples, source water blank samples (as needed), EB samples (as needed), and TB samples.*"
SECTION 6 (these comments also apply to similar topics discussed in Appendix E of the Plan)				
18	6.1.1	6-2 (para. 1)	The list of constituents selected for statistical analysis based on leachate/groundwater contrast and listed in Section 3.2.1 includes ten constituents (plus BTEX and HVOCs); that list includes ammonia, which is not included in this Section 6.1.1 list or in the calculation of constituent-well pairs. Please include ammonia in Section 6.1.1 and reassess the constituent-well pairs and any subsequent assessments throughout the Plan related to this topic.	**Discuss.** As discussed in the first paragraph after the optimized constituents list on page 3-8, ammonia is selected as a detection monitoring constituent, but it fits the Unified Guidance definition of "other analytes which may be occasionally or even frequently detected and will be monitored for general groundwater quality information but not tested." As specified in the second paragraph after the optimized list of constituents, ammonia, like BTEX and HVOCs, are not incorporated into the formal statistical testing for detection monitoring because they were rarely, if ever, detected at site compliance wells. Therefore, ammonia will be monitored during detection monitoring, but no UPL is calculated. Thus, the stated number of nine constituents selected for statistical analysis is correct. Please note that Tables 1, 2, and 3 of Appendix G will be revised to include some data from 1995 and 1996 identified as missing during preparation of the Plan.
19	6.1.1	6-3 (para. 2)	The text states: "Because of the different chemical signature [from other wells at the CMLF], increasing trend in concentrations, and associated potential external sources unrelated to waste-landfilling operations at well MW-2, at this time, groundwater quality from well MW-2 is not considered representative for reliably detecting releases from the landfill and it is recommended to not include well MW-2 in the formal statistical testing for detection monitoring at the CMLF." Please note that HAR 11-58.1-16(c)(9) requires statistical analysis of groundwater at the point- of-compliance as part of the detection monitoring program. If trends exist in the data, then calculation of background for such constituents would need to include evaluation and removal of trends from the data prior to conducting statistics, or selecting a background sample that does not include increasing trends. In addition, please note that HAR 11-58.1-16(d)(3)(C) allows for demonstration that a source other than the landfill caused the contamination (e.g. alternate source demonstration, or ASD) if statistically significant increases over background are observed during detection monitoring. While Section 2.8 of the Plan describes potential impacts to groundwater from the co- composting operations, the Plan does not adequately attribute these potential impacts to the increasing trends in constituents observed at well MW-2. Please provide additional evidence to substantiate that	**Concur.** As agreed during a teleconference call held on January 23, 2019 with HDOH SHWB, well MW-2 will be included in the formal statistical testing together with other compliance monitoring wells MW-3 and MW-5 to develop UPLs for detection monitoring at the CMLF. For MW-3 and MW-5, UPLs will be developed using data collected from June 2008 through September 2017. For MW-2, UPLs will be developed using data collected between 1996 and 2011 (i.e., before the concentrations started to increase due to sources other than the landfill).

			impacts from the co-composting operation at Phase II, or other potential alternative sources, are impacting groundwater at MW-2.	
20	6.1.2	6-4 (para. 2)	The text states that the USEPA groundwater protection standards (MCLs) and HDOH EALs for each background data set are included in Table 6-1; however, these standards do not appear to be included in Table 6-1. Please review and correct the table as appropriate.	**Concur.** The last two sentences of the second paragraph on Page 6-4 will be revised as follows: "*Also included in the table are the mean, median, standard deviation, and upper 95th and 99th percentiles. Groundwater protection standards (USEPA maximum contaminant level [MCL] and HDOH environmental action limit [EAL]) are included in Table 2-5.*"
21	6.1.2	6-4 (para. 3)	The text states that Table 6-1 shows that a nonparametric UPL based on the maximum value was used for alkalinity, iron, sodium, and TOC. However, Table 6-1 indicates the nonparametric maximum value was used only for alkalinity, iron, and TOC. Please review and correct the table as appropriate.	**Discuss.** As indicated in the "Distribution" column and "Note 1" of Table 6-1, sodium in well MW-5 has a nonparametric distribution and it was normalized using Tukey's Ladder of Powers transformation to enable calculation of a parametric UPL, while the nonparametric distributions for alkalinity, iron, and TOC could not be transformed to normal distributions enabling calculation of a parametric UPL. Please note that the first sentence of the third paragraph of Section 9 in Appendix E will be revised to read: *"As indicated in Table 11, there are three constituents (alkalinity in well MW-3, iron in wells MW-3 and MW-5, and TOC in wells MW-3 and MW-5) for which the background data were not normally distributed or could not be transformed to fit a normal distribution."*
22	6.2	6-5 (para. 6)	The text states that "…retesting will be conducted within 90 days…" Please describe the minimum time interval between samples, as well as how this minimum time will be established to ensure that separate volumes of groundwater are being sampled.	**Concur.** A minimum time interval of 30 days between samples for retesting will be specified. As discussed in Section 2.6.3, the average linear groundwater velocity calculated for the CMLF ranges from 0.04 ft/day (0.48 in/day) based on monitoring well slug test data to 1.3 ft/day (15.6 in/day) based on production well PW pumping test data, using the Darcy equation (v=Ki/n), as recommended in Chapter 14 of the USEPA Unified Guidance (2009). Considering a diameter for the well+filter pack system of approximately 10 inches, the estimated travel time for a groundwater particle to flow through the complete monitoring well diameter ranges from approximately 21 days to 0.6 days. Note that physical independence does not guarantee statistical independence. As also discussed in the USEPA Unified Guidance (2009), other retardation factors, such as matrix interaction, should be considered in the calculation and the actual time for groundwater to flow through the monitoring well may be greater. Thus, a minimum time interval of 30 days between collection of a detection monitoring sample and a retest sample provides sufficient time to account for these factors so that separate volumes of groundwater are being sampled. This language will be included in Section 6.5 of the text and Section 8.1 of Appendix E.
23	6.2	6-6 (para. 8)	The text states: "If one or more of the 40 CFR 258….., the County will notify the HDOH SHWB…" Please add that the notification to HDOH will occur within 14 days of this finding, as required by HAR 11-58.1-16.	**Concur.** The first sentence of the bullet will be revised as follows: "If one or more of the 40 CFR 258 Appendix II constituents are detected at statistically significant levels above the groundwater protection standards, the County will notify the HDOH SHWB within 14 days, and additional characterization and assessment of corrective measures will start within 90 days in accordance with HAR 11-58.1-16(e)(7)(A)."
Appendix E (these comments also apply to similar topics discussed in Section 6 of the Plan)				
E1	4	4-1 ("Concentration Contrast")	DOH Comment No. 10 above (i.e. Section 3.2.1, page 3-5, paragraph 3, of the main text of the Plan), regarding leachate and groundwater concentration contrast in the HDOH *Landfill Groundwater Monitoring Guidance* (2002), also applies to this section of Appendix E. Please correct as appropriate.	**Concur.** See response to Comment #10, which will be applied here.
E2	4	4-3 (para. 3)	See General Comment No. 1 regarding total alkalinity and the number of detection monitoring constituents (i.e. nine or ten), including how this relates to concentration contrast of constituents in leachate and groundwater. Please confirm the number of detection monitoring constituents and, if the correct number is ten, please recalculate the UPLs accordingly. This comment regarding the inclusion of total alkalinity and the number of detection monitoring constituents (i.e. nine or ten) applies throughout Appendix E.	**Concur.** See response to Comment #1, which will be applied here.
E3	5	5-1 (para. 1)	Please specify what "Group 1" is.	**Concur.** The Unified Guidance (USEPA, 2009), Section 6.2.2, refers to group 1 constituents as "reliable indicators selected for formal detection monitoring testing and contributing to the site-wide false positive rate (SWFPR)". To clarify, the first sentence of Page 4-4 in Appendix E will be revised as follows: "*The major cations and anions and major leachate indicators fit the Unified Guidance (USEPA, 2009) definition of "reliable indicators selected for formal detection monitoring testing and contributing to the site-wide false positive rate (SWFPR)," (Group 1) except for ammonia, which has very low detection frequency.* "
E4	6.3	6-4 (para. 1)	Please correct the reference to the section on spatial variability (i.e. correct section is Section 6.6, not Section 6.5 as stated in the Plan).	**Concur.** Section 6.6 will be referenced.
E5	7	Table 7	Table 7 reports the trend evaluation results for the proposed detection monitoring constituents using the 2008 thru 2017 data. Section 3.2.1 includes ammonia as a detection monitoring constituent; however, Table 7 does not include ammonia. Please evaluate the trends in ammonia at the site wells and revise Table 7 accordingly.	**Discuss.** As discussed in Section 4 of Appendix E, a few of the indicator constituents selected for detection monitoring at CMLF (i.e., ammonia, BTEX, and HVOCs) are not directly incorporated into the formal statistical testing because they are rarely, if ever, detected at site compliance wells. Because ammonia is not part of the formal statistical testing, no trend evaluation is presented for ammonia. See response to Comment #18 for more details.
E6	7	7-2 (para. 1)	The text states: "Although potential sources are still being evaluated, … and the much lower concentrations at other downgradient/compliance wells…". Please include which constituents are being referred to in this sentence.	**Concur.** The first part of the paragraph discusses relatively higher concentrations of metal ions, chloride and TDS in well MW-2. The lower concentrations in downgradient wells MW-3 and MW-5 refer to the same constituents. For clarity, the constituents will be repeated in the second part of the paragraph, which will read: "*Although potential sources are still being evaluated, the absence in well MW-2 of constituents that are present at relatively high concentrations in leachate (such as BTEX and HVOCs), and the much lower concentrations of metal ions, chloride, and TDS at other downgradient/compliance wells (MW-3 and MW-5) located closer to the downgradient edge of closed and active landfill cells (Phase I and II, Phase IV-A, and Phase IV-B), indicate that increasing concentrations of these constituents at well MW-2 are attributable to external sources other than landfill impacts.*"
E7	7	7-2 (para. 2)	See Specific Comment No. 19 above (Section 6.1.1, page 6-3, paragraph 2).	See response to Comment #19.
E8	8.1	8-1 (para. 4)	In Equations (2) and (3), the "T" should be a subscript to the "n."	**Concur.** The formula will be corrected as indicated.
E9	8.1	8-2 (para. 2)	The text states, regarding retesting: "A minimum time interval between samples will be established to ensure that separate volumes of groundwater are being sampled." Please describe how this minimum time interval will be established.	**Concur.** See response to Comment #22, which will also be applied here.
E10	8.4	8-4 (para. 1)	Please note that although the stated HAR reference requires a minimum of four independent samples, the DOH *Landfill Groundwater Monitoring Guidance Document* (Section 6.2.2.2; 2002) requires a minimum of eight independent background samples for the combined Shewart- CUSUM procedures; this is an appropriate minimum for the UPL statistical procedure as well. This is supported by Section 5.2.1 (page 5-3) of the USEPA Unified Guidance, which states: "Four observations from a population are rarely enough to adequately characterize its statistical features," and continues to state that "The Unified Guidance recommends a minimum of at least 8 to 10 independent background observations to be collected before running most statistical tests." Please follow the USEPA Unified Guidance recommendations in this matter.	**Concur.** Please note that the third paragraph in Section 8.4 states the following: "A minimum of four to eight new samples are required to allow a statistical comparison between the new data and the initial background data." The Unified Guidance states that "Four measurements per group should be considered a minimum requirement…" for conducting a two-sample hypothesis test using a parametric test. If a nonparametric test is used, the recommended minimum sample per group size is five. Thus, the statement that a minimum of four to eight new samples are required to allow a statistical comparison meets the minimum requirements specified by EPA in the Unified Guidance. To reduce confusion and consistent with Section 6.1.2, Page 6-5, last paragraph in the main text of the document, the last paragraph of Section 8.4 in Appendix E will be revised as follows: "*Background data will also be updated to calculate the statistical background limits (UPLs) for any new monitoring well that may be installed in the future. Consistent with the Unified Guidance (USEPA, 2009), HAR 11-58.1-16(d)(2), and the HDOH Landfill Guidance (HDOH, 2002) eight*

				independent samples will be collected from each well on a quarterly basis for analysis of the detection monitoring constituents to establish background concentrations."
E11	Table 7		The third column heading is “No. of Detects.” It appears that that the correct column heading should be “Total Samples.”	**Concur.** The heading of the third column will be changed to “No. of Samples”.
Appendix F				
F1		3 (second bullet)	The text states that chromium, lead, nickel, and vanadium are highest at the upgradient/crossgradient wells MW-1, MW-4, and MW-6 and references Table F-2. It appears that the intention might have been to reference Table F-1 (not Table F-2). Please review and correct as appropriate.	**Discuss.** The reference to Table F-2 is correct because this bullet discusses average groundwater concentrations calculated between 1995 and 2017, which are presented in Table F-2. However, we understand that Table F-2 is not fully supportive of the statement in this bullet. The bullet will be revised as follows: "*When looking at groundwater concentrations between 1995 and 2017 for the Appendix II constituents detected during assessment monitoring, nickel and vanadium are the only constituents consistently detected, and concentrations are highest at upgradient/crossgradient wells (that is, noncompliance wells) MW-1, MW-4, and MW-6 (see Table F-2 and Appendix G of the main text). Chromium and lead are rarely detected in groundwater (see Appendix G of the main text). Of the very few detections, the highest concentrations of chromium are detected in upgradient/background well MW-1. Although the highest concentration of lead was detected in compliance monitoring well MW-3, this constituent was only detected in October 1995 (MW-1 and MW-3) and March 2012 (MW-2, MW-3, and MW-5), it was never detected in any of the monitoring wells after 2012 (see Appendix G of the main text), and it is not present in landfill leachate (Table F-2).* "

Appendix B
Meeting Minutes

Meeting with HDOH re. Central Maui Landfill

01-23-15, 9am at Room 212 at HDOH Office

Agenda

General Topics for Discussion:

CH2M HILL role in GWM program

Review of Recent GWM Network

- 2012 GWM Plan
- Element Hydraulic Gradient Evaluation
- Follow up to action items from Element/HDOH meeting on 03-19-14
- Conceptual Site Model Update

HDOH Input/Concerns Regarding Current GWM Program

CH2M HILL Preliminary Input on Current GWM Program

- Previous sampling frequency and triggering Appendix II
- Background concentrations of indicator parameters
- Upgradient-downgradient vs intrawell approaches
- Potential statistical approaches
- Potential alternative source evaluation, aquifer temporal variability

Brief review of past two sampling events

- Reporting frequency

Path forward

Attendees:

Janice Fujimoto (HDOH), Lenelchinotsubo (HDOH)

Marc Dexter (CH2M HILL), Christin Shacat (CH2M HILL)

MINUTES

Follow up to action items from Element/HDOH meeting on 03-19-14

- County has recently gotten conveyance and reallocated additional lots on outside, confirmed that now all wells are within property boundary.

- HDOH expressed concern for new well head locations, HDOH would like to ensure:

  - Adequate coverage downgradient of the leachate sumps

  - Wells being within 150m from the waste edge

- CH agreed to create revised figures that include revised property boundaries, and that identifythe topographic low point for Phases 1+2 (for determining location of future wells). CH may be able to use existing CAD drawings.

- Discussion on abandoning certain wells, reducing monitoring frequencies

- Discussion regarding possibly abandoning MW-6 due the quarrying activities directly around the well that have made it very difficult to safely sample the well. Samplers will now have to be fall protected and adjacent quarrying and excavation have the potential to compromise well integrity. CH confirmedthat Ameron is no longer responsible for replacing this well.

- Concern regarding other activities within the facility property that need to be included/addressed in a revised CSM (including evaluation of other potential point sources of contaminants that could bealternative sources): active quarrying, truck traffic, hydraulic fluid leakage, batch plant activities creating dust, spraying water for dust monitoring and subsequent transport or leaching of contaminants to subsurface, stormwater infiltration (basin near MW-5), green waste activities, ranching/agriculture activities upgradient, etc. Need to include an analysis of surrounding activities that could possibly be contributing contaminants to groundwater in revised CSM.

- CH's current scope does not include a thorough evaluation or determination of alternative sources, only to develop revised CSM, and to make recommendations for future well locations

- Discussed how fractured flow may impact contaminant transport in vadose zone and groundwater, and groundwater flow direction/hydraulic gradient

- HDOH expressed continued concern regarding having representative wells for Phases 1 and 2 as well as Phase 3

- Since Phase 3 is probably not going to happen in the near future, proposed MW-8 might not need to be installed, however, MW-2 and MW-4 should not be abandoned as previously recommended but instead rather kept for possibly sampling them again in the future if conditions change.

- Concerns regarding the inter-well (up-/cross-/downgradient) versus the intra-well approach. HDOH expressed preference for intra-well analysis but acknowledged that use of inter well data may also be useful at this site.

- CH indicated to HDOH that Maui County currently has funding for one (1) well installation in 2017; there was some discussion on if that date may need to be moved up – HDOH to follow up with a recommendation as necessary.

- As indicated in the notes from the last meeting, HDOH recommended to not abandon MW-4 as it could be used for Alternative Source Demonstration (have not gotten an ASD for this site yet, site went straight into assessment monitoring).HDOH prefers to not abandon any wells; CH concurs with not abandoning existing wells at the current time as no benefit would be recognized by the County from abandoning wells. Sampling frequency may be adjusted by well going forward.

- HDOH aware of possibility of some of the pumps not working correctly and possibly being the cause for some of the issues. CH indicated that he County has replaced all damaged or malfunctioning pumps.

- Regarding leachate collection at Phase I&II,since no topographic lowpoint data was available, a manhole-type sump was installed in the approximate location of the low point. Currently themanhole(s) are buried.

Leachate and gas collection done my A-Mehr after RM Towel did Phase 1

- Discussion on Phase I&II, and potential new well location. HDOH recommends that additional MW be located downgradient of Phases 4a and 4b, discussed potential locations. Also noted that County has sufficient property downgradient to install wells.

- 2014 tidal study datawill be used when planning locations ofnew wells.

- CH noted the location of the "proposed production well" with respect to the landfill.

- Based on available information, GW at some Hawaii fractured rock sites moves rather rapidly, VOCs can tend to dissipate more quickly, upstream contents get to site more quickly.

HDOH Input/Concerns Regarding Current GWM Program

- HDOH just received the draft 2012 GWM Plan, which A-Mehr had revised in 2012

CH indicated that the plan may contain sampling procedures or elements that are outdated based on current understanding of site. HDOH indicates that they are open to changes, and that the plan may need to be updated to 2015 regulations and recommendations regarding well replacements, revisions to the CSM, etc.

- CH indicates that the current sampling program appears to be overly complicated, possibly more sampling is done than required/necessary. HDOH indicates that consultant can make recommendations for changes to program, and submit for HDOH review.

- Question regarding what types of statistical analyses are being done and how they are applied.

CH2M HILL Preliminary Input, HDOH Input, and Discussion of Current GWM Program

Previous sampling frequency and triggering Appendix II

- Discussion on full Appendix II list being run multiple times on different wells. Regulations specify that when Appendix II sampling is triggered, you are required to run the full Appendix II list and then again in a year with modified Appendix II sampling in between. Noted that Appendix II is not usually triggered for consecutive sampling rounds.

Recent EPA and statistical studies revealed that false positives are very likely if you have a large number of analytes and related statistical analysis. Therefore it is beneficial to reduce the number of analytes and statistical analysis that you do, and this is also consistent with the Hawaii guidance and Unified guidance documents. HDOH concurred that reduction in number of analytes is an objective of other similar Hawaii landfill GWM programs.

- A plethora of data is available at CMLF, including various control limits. CH indicated that a goal going forward will be to streamline the GWM program to create efficiency and reduce complexity where possible.

- Generally, Poisson prediction limits are not used anymore nowadays throughout the industry, CH is recommending to discontinue the use of Poisson limits for CMLF.

- CH engaged various technical experts including Ken Shump (Groundwater hydrogeologist, Landfill hydrogeology specialist), Larry Hilscher (Statistician), and Brian Schroth (Geochemist specializing in landfill issues)

Background concentrations of indicator parameters

- Lots of indicator compound hits have been recorded (metals, chloride, TOC) that bounce around control limits and laboratory reporting limits. Discussed the potential that the aquifer is evolving, and that changes in concentrations of these indicator compounds may occur naturally over time due to changes in conditions possibly creating false positives.

- HDOH

- Roger Brewer has been engaged regarding heavy metal background concentrations (to determine if "hits" may not be regional background)

Upgradient-downgradient vs intrawell approaches

- Since certain compounds are also detected in upgradient wells, CH recommends to not just use the intrawell approach but rather include surrounding wells to determine what background concentrations exist.

- HDOH prefers the intrawell approach for this site, but not exclusively. When looking at potential ASD issues, OK to use more global approach and use both, intra- and interwell approach. Assure that selected method is defensible.

- HDOH recommends that when re-establishing control limits don't automatically incorporate the next data point, give yourself 5 years to see if there are any trends or changes in data before incorporating the value into the control limit calculations. Use intrawell approach for developing control limits, not interwell.

- CH statistician recommended using ANOVA approach (analysis of variance, one option is a non-parametric test called Wallace test) that evaluates if results from different wells are different from each other, i.e. is there one that stands out. In cases where data is naturally very "spikey" this can help to evaluate if there is an actual statistically significant increase or if we are just seeing smaller site-wide natural variations over time.

- CH indicated that CMLF aquifer is generally still considered a relatively young aquifer, that exists within weathered basalt with naturally occurring iron, manganese, other metals, etc., and that the aquifer may potentially still be evolving. Also noted thatvariability in precipitation over wet and dry season, or due to longer-term weather patterns, may affect the leaching of the metals into groundwater, andgroundwater quality.

- HDOH is open to using other available potential statistical/prediction limit methods besides Poisson, as long as the methods comply with regulation and are defensible.

- HDOH is concerned that adequate methods need to be used to determine if there is an actual problem since there seems to be potential explanations for all the recent exceedances. CH recommends using multiple lines of evidence, trends of increasing concentrations over time, confidence in background values, comparison to surrounding wells. CH noted that it is important to evaluate carefully, so that corrective action is not recommended simply due to natural variation in groundwater quality.

- HDOH expressed concern about landfill gases creating an oxidation/reduction condition causing leaching of metals that are already in soil (either naturally occurring or man-made), and indicates that if present, this condition would be considered as a release from the landfill.

- CH posed the question that if chemicals are indeed released from the landfill, are EALs (under HEER) used to manage risk to public health or evaluate potentially complete pathways? HDOH indicates that HEER EALs do not technically apply under the regulation.

- HDOH: Phases 1 and 2 would still fall under SHW Branch (HEER stopped accepting after 1993), i.e., using solid waste regulation, if demonstrated that release is due to landfill, then corrective actions would have to be undertaken. CH asked what types of corrective actions has HDOH requested for other similar landfill in the past, i.e. groundwater treatment versus less aggressive approaches. HDOH indicates not necessarily groundwater treatment, to their knowledge this has never been requested for a landfill site in the state. Actions can often includemodifying landfill practices – i.e. removing possible sources, limiting the amount of leachate generation, closing portions of the landfill, removal of landfill gas, etc.); no direct example yet for gas impact, could possibly pull more gas if a gas system is onsite.

SHW branch only requires methane monitoring at the perimeter of the landfill, no other specific gas measurements; however, since an active gas system is in place, more parameters are being recorded and that data should be available, quality of the pulled gas, quantity.

2012 GWM Plan

- County can propose revisions to their plan for HDOH's review, HDOH would like to have a rationale or basis for proposed revisions included for evaluation.

Reporting Requirements

- Exceedances above control limits will need to be reported to HDOH within 15 days of when the results are received (not validated). CH indicated that we will not report an exceedance that could result in an NOV or other risk to the client without validating the data, that is our policy. HDOH indicated that because the time necessary to validate data varies, this could be a concern. Thsu they would like an email "heads-up" is sufficient stating that there may be a potential exceedance (without actual concentrations) which still needs to be validated.

- Once data is validated then update HDOH with actual values.

- The current report format is OK for the "Notification report"

- Actual sampling report should include more "big picture", background, recommendation for future monitoring

- Maui County's permit requires quarterly monitoring whereas the regulations require semi-annual sampling. HDOH indicates that the permit supersedes, program needs to be quarterly.

- Per HDOH new permit will also require quarterly sampling.

- Per HDOH, if it is a detection monitoring event, all samples should be analyzed for all the DM parameters. CH noted thatthe County has not been doing DMP quarterly, but rather semi annually, and requested clarification on background of change from quarterly (as per permit) to semi-annual as per the URS program previously coordinated with HDOH.

- Per HDOH, per permit detection monitoring parameters need to be run quarterly.

Per HDOH, most of the larger landfills require quarterly sampling, supposed to be for all DMP.

Central Maui Landfill is the largest operating landfill in the State (as far as daily tonnages), therefore quarterly detection monitoring is warranted.

- CH noted that Oct 2014 was not run for all the DMP, and instead the analyte list followed the program previously developed by URS for quarterly assessment monitoring.

- CH requested clarification on assessment monitoring requirements. HDOH concurred that once and exceedance is detected during DM, verification monitoring needs to be performed during the next sampling event (except VOCs, which should be sooner, but HDOH has allowed it to happen at next quarterly event in some cases).

    - Verification sampling allowed during next quarterly event.

    - Assessment monitoring (AM) is already quarterly, if it was triggered.

    - AM includes DMP

    - If AM is triggered at a certain well for a certain parameter, then it is required to sample that well as well as selecteddowngradient wells at least once a year for the full Appendix II list (and annually thereafter) until it falls outor until hit has been verified, once you have established the background concentrations

    - In addition, it is a requirement that all App. II analytes are runonce a year at all wells once AM is triggered.

- CH reiterated that the goal will be to limit number of analyses so that false positives are kept to a minimum after statistics, Unified guidance and Hawaii guidance provide good support rationale for limiting number of analyses as well.

- CH recommends to reconvene before next sampling event and review proposed list of parameters with HDOH.CH proposes to recommend a list for parameters to be sampled and with justification to HDOH. HDOH concurs.

- HDOH noted that HDOH will only give guidance on the minimum requirements in the regulations, which may not necessarily be sufficient to evaluate all the data and/or determine an alternative source or future monitoring. Operator is responsible to determine additional sampling requirements for things such as ASD.

- HDOH recommends continued leachate sampling to generate data for comparison with GWM data.

- CH will discuss with County to see if we have budget to produce "full-blown" monitoring report every quarter.

Meeting adjourned ~10.50am.

MEETING SUMMARY

Draft Solid Waste Management
Permit No. LF-0074-13

October 11, 2017 Meeting at HDOH SHWB for Central Maui Landfill Draft Permit (No. LF-0074-13)

ATTENDEES:	Lene Ichinotsubo/HDOH SHWB Dawn Garbeil/HDOH SHWB Patrick Tuter/HDOH SHWB Mike Kehano/County of Maui Dept. of Environmental Management Elaine Baker/County of Maui Dept. of Environmental Management Sage Kiyonaga/County of Maui Dept. of Environmental Management James Ewing/County of Maui Dept. of Environmental Management Ali Mehr/A-Mehr, Inc. Sergio Cocchia/CH2M
PREPARED BY:	County of Maui, CH2M, A-Mehr
DATE:	October 12, 2017
PROJECT:	Draft Solid Waste Management Permit No. LF-0074-13, Central Maui Landfill Phases I, II & IV, V, V-B Ext. and Entrance Facility Pulehu Road, Puunene, Maui

Objectives

On October 11, 2017 representatives of State of Hawaii Department of Health (HDOH) Solid and Hazardous Waste Branch (SHWB), County of Maui Department of Environmental Management, A-Mehr (County's consultant for Central Maui Landfill design), and CH2M (County's consultant for Central Maui Landfill groundwater projects) met to discuss conditions of concern included in the Draft Permit and get concurrence before the Permit is finalized and approved by the HDOH SHWB. The meeting was held between 1:30 pm and 3:00 pm at the HDOH SHWB office located at 919 Ala Moana Boulevard in Honolulu.

Summary

Permit conditions of concern relate to groundwater issues (updates of 2012 Groundwater Monitoring Plan and installation of additional monitoring wells) and landfill design/operational items. At the beginning of the meeting, after a brief introduction by Mike Kehano from the County of Maui, Mr. Ali Mehr presented a summary of events that lead to the preparation of the 2012 Groundwater Monitoring Plan and subsequent documents that were prepared by the County of Maui to develop a better understanding of groundwater flow characteristics beneath the landfill.

The following is a summary of the main topics that were discussed during the meeting:

Groundwater

- The liner beneath Phases IV and V is of top quality. If a potential leachate release to groundwater was to occur, that would most likely be from the sump.

- In the past there were a lot of uncertainties on groundwater flow direction mainly due to inaccurate well surveys and groundwater fluctuations due to tidal influence. Groundwater direction ranging from north-northeast to west was reported in reports prior to 2016.
- Studies that helped in developing a better understanding of groundwater flow characteristics following the 2012 Groundwater Monitoring Plan included a new survey of monitoring wells' ground surface and top of casing elevations in 2014, pump replacements in 2014, the development of a Conceptual Site Model (CSM) in 2016, an evaluation of tidal influence on groundwater levels in 2017, and groundwater flow modeling in 2017. The tidal evaluation and groundwater flow modeling have not been submitted to HDOH SHWB yet and will be included in the future update of the Groundwater Monitoring Plan.
- Groundwater at the site has shown fluctuations of some constituents' concentrations (including some metals) from slightly below to slightly above the old control limits. This was possibly due to pumps and background conditions.
- The County of Maui and their consultants expressed some concerns about installing four additional wells within 180 days of Permit issuance, as specified in the Permit's special conditions. The HDOH SHWB pointed out that Permit requirements are based on the documentation that was presented and is currently available to HDOH. Three additional wells were recommended in the 2012 Groundwater Monitoring Plan and two in the 2016 CSM (one of which appeared to be the same as one of those included in the 2012 Groundwater Monitoring Plan).
- The County of Maui confirmed that it is committed to installing MW-7 (located immediately downgradient of Phases IV-A and IV-B) as soon as practicable (when the FY2019 budget will be available). The proposed location is where the advective flow zones from Phases IV and V overlaps. The finalized location will also account for leachate collection sump location and actual field conditions. The final location will be presented in the Updated Groundwater Monitoring Plan and will be approved by HDOH SHWB.
- Before considering the installation of any other additional wells the County would prefer to present newly collected data (tidal evaluation and groundwater flow modeling) in an Updated Groundwater Monitoring Plan that can be submitted to HDOH SHWB no later than 90 days after Permit issuance. This is because the need for and location of additional wells should be based on the latest understanding of groundwater flow characteristics, which has improved significantly since the 2012 Groundwater Monitoring Plan. Based on newly collected data, proposed monitoring wells MW-8 and MW-10 appears to be cross gradient, while MW-9 may be redundant with MW-7. Because of that, and also considering the significant installation costs, a well at those locations would probably add very little to no value to the Groundwater Detection Monitoring Program.
- HDOH SHWB pointed out that MW-10 was proposed in the 2016 CSM as a compliance well downgradient of Phase VI. Since Phase V-B Ext is within Phase VI and construction for Phase V-B Ext is imminent, HDOH would like to have a well installed in that area as soon as possible so that a baseline can be established for future intra-well evaluations. The County of Maui responded that Phase V-B Ext will be lined, with a leachate collection sump planned in the north corner of the cell. If considering the groundwater flow beneath that cell towards northwest, MW-10 at the previously proposed location would not help in detecting a potential release from the sump or the liner of Phase V-B Ext. Although considering the groundwater flow at the site the ideal location of that well appears to be immediately downgradient (i.e., within Phase V-B), the County will conduct additional modeling to evaluate if an alternative location can be found in

the close downgradient locations of the sump that are not within existing landfill cells. Alternatively, MW-7 may be the best options to detect potential releases from Phase V-B Ext.

- To avoid holding up the Permit issuance while waiting to receive and concur on the updated Groundwater Monitoring Plan, the HDOH SHWB agreed to modify Permit language relative to installation of additional monitoring wells to say that monitoring wells MW-7, MW-8, MW-9, and MW-10 may be installed by January 1, 2019 as specified in the Phase V-B Ext Permit application and the 2016 CSM, subject to review and approval of an updated Groundwater Monitoring Plan by HDOH.
- The County shall submit the update Groundwater Monitoring Plan as soon as possible and no later than 90 days of issuance of the Final Solid Waste Management Permit. Among other things, in the updated monitoring plan, the County will present newly collected data (tidal study, groundwater flow modeling, and improved understanding of groundwater flow characteristics) and will identify the need and location for additional wells besides MW-7. Once the update plan is submitted to HDOH, the locations of additional monitoring wells (as needed) will need to be approved by HDOH. The County will schedule the installation of additional monitoring wells as recommended by the County's groundwater consultant and after HDOH approval.

Landfill Design and Operations

- The County requested clarification for a list of draft permit items presented during the meeting (Exhibit A). Due to time constraints, not all items were heard. The County shall work with the Department to reach a concurrence and improve permit documents accordingly.

Action Items

Groundwater

- The County will install monitoring well MW-7 by January 1, 2019.
- The County will submit the update Groundwater Monitoring Plan as soon as possible and no later than 90 days of the issuance of the Final Solid Waste Management Permit.
- The County will schedule the installation of additional monitoring wells as recommended by the County's groundwater consultant and after HDOH approval.

Landfill Design and Operations

- The County shall work with the Department to reach a concurrence for draft permit items indicated in Exhibit A, and improve permit documents accordingly.

EXHIBIT A

1. Emergency operating procedures – Define high wind conditions. Special Condition II, Section A, Item 7.b. (Page 10)

   Draft Permit Reads:
   Emergency Operations. *The permittee shall prepare and implement emergency operating procedures, including those in the Emergency Operating Procedures, provided as Section 13.5, in the February 2017 Operations Plan, and approved subsequent submissions.*

   b. The permittees shall be prepared and implement emergency operating procedures for the minimum following situations:
   iv. High winds conditions

   Clarification Request:
   In addition to general requirements included in Section 13.5.1 (ie prelim assessment, contract emergency response units, etc), Section 13.4 of the Operations Plan describes litter control operational controls (ie wet spray at active area; portable, semi-portable, and property line litter fencing; and in-house and contracted litter collection services). Clarify with DOH if this is sufficiently meets the requirement above.

   Suggested Draft Permit Rewrite:
   None

2. Why increase frequency of random load checks to daily? Special Conditions II, Section C, Item 2c (Page 15)

   Draft Permit Reads:
   The permittee shall implement a Waste Acceptance & Hazardous Waste Exclusion Program as set forth in the Operations Plan for Central Maui Landfill that meets the following conditions, Section C Items 2 to 4. Should there be conflicts between the Operations Plan and the permit or solid waste rules, the latter shall prevail.

   c. The permittee shall conduct random visual surveillance of mixed commercial loads (not inclusive of loads known to only contain single-source-separated materials, such as sludge), at least once per day, to spot check for unacceptable wastes. The permittee shall document findings on the Load Check Data Sheet.

   Clarification Request:
   Though our waste stream changed to include C&D, it accounts for less than 10% of our total tonnage and has the benefit of application screening as well as one C&D dedicated load check per week. The inclusion of C&D to the CML waste stream is negligible, and an increase to the frequency of load checks is not necessary at this time. We request to go back to one MSW plus one C&D load check per week. Should our user population significantly change, we will notify the DOH and suggest a revised load check frequency in accordance with Draft Permit Special Conditions II, Section D, Item 10.

   Suggested Draft Permit Rewrite:
   c. The permittee shall conduct random visual surveillance of mixed commercial loads (not inclusive of loads known to only contain single-source-separated materials, such as sludge), at least ~~once~~ twice per ~~day~~ week (one MSW and one C&D), to spot check for unacceptable wastes. The permittee shall document findings on the Load Check Data Sheet.

3. Why check Phase V-B Extension Sump 1/day? It is oversized for the area of land it will be covering. Why does this differ from the 1/week check of existing sumps? Is this check 1/day or 1/operating day? Special Conditions II, Section G, Item 8d (Page 30)

   Draft Permit Reads:
   Leachate Monitoring. Leachate levels shall be monitored to ensure compliance with the leachate levels specified in Special Conditions II.G.7.b. The levels of leachate shall be measured and recorded as follows or as otherwise approved by the Department:
   d. Phase V-B Ext Sump: Minimum daily

   Clarification Request:
   According to the HELP Model submitted for Phase VB Ext, the peak daily value for the LCRS drainage layer is approximately 12,000 gal. The internal sump in Phase VB will have a capacity of approximately 200,000 gal, or enough capacity for 15 days at peak leachate production before reaching the compliance limit. In order to reduce the potential of reaching the compliance limit, operations shall monitor the sump weekly, and pump the sump down to an appropriate depth where the sump shall have enough capacity for 1 week at peak leachate generation conditions. In the future, the theoretical HELP peak value shall be revised to use actual leachate generation data from Phase VB B Ext to adjust weekly sump capacity.

   Suggested Draft Permit Rewrite:
   Leachate Monitoring. Leachate levels shall be monitored to ensure compliance with the leachate levels specified in Special Conditions II.G.7.b. The levels of leachate shall be measured and recorded as follows or as otherwise approved by the Department:
   d. Phase V-B Ext Sump: Minimum ~~daily~~ weekly

4. Why update the Master Plan every year? Special Conditions II, Section I, Item 2m (Page 34)

   Draft Permit Reads:
   *The **Annual Operating Report** shall include the following information:*
   m. An annual update to the Master Plan shall be included if the remaining disposal capacity is less than 10 years, as described in 2(f) of this section. The Master Plan update shall discuss the timeline to acquire property, submit design and solid waste application, and start and complete construction of planned future expansions.

   Clarification Request:
   Can the requested timeline be included as part of the Annual Operating Report?

   Suggested Draft Permit Rewrite:
   *The **Annual Operating Report** shall include the following information:*
   m. ~~An annual update to the Master Plan shall be included if~~ If the remaining disposal capacity for the facility is less than 10 years, as described in 2(f) of this section, ~~. The Master Plan~~ ~~update~~ the Annual Operating Report shall include a conceptual ~~discuss the~~ timeline to acquire property, submit design and solid waste application, and start and complete construction of planned future expansions.

5. Commercial loads on Pages 35 and 36: What is the intended definition of pickup truck? We currently receive commercial box trucks at the entrance facility. This is safer than having these individuals unload waste at the active face. Special Condition III, Item 1 (Page 36)

Draft Permit Reads:
The entrance facility may only accept, store, and transport household and commercial waste as defined in HAR §11-58.1-03, for disposal. Commercial loads are limited to pick-up truck-sized vehicles that require manual unloading of waste. The entrance facility may accept and temporary store select household-generated recyclables and special waste for recycling, as identified under Special Conditions III, Items 6 and 7. Industrial waste, construction & demolition waste, and waste identified under Special Conditions III, Items 2 and 3 shall not be accepted at the entrance facility. The operations of the facility shall be in accordance with the Central Maui Landfill Entrance Facility Operations Plan revised May 2017, and approved subsequent submissions, unless otherwise specified in these permit conditions.

Clarification Request:
What is the intent in limiting commercial vehicles to "pickup" sized vehicles? Would box (delivery) trucks qualify as a "pickup"?

Suggested Draft Permit Rewrite:
The entrance facility may only accept, store, and transport household and commercial waste as defined in HAR §11-58.1-03, for disposal. Commercial loads are limited to ~~pick-up truck-sized~~ vehicles that require manual unloading of waste. The entrance facility may accept and temporary store select household-generated recyclables and special waste for recycling, as identified under Special Conditions III, Items 6 and 7. Industrial waste, construction & demolition waste, and waste identified under Special Conditions III, Items 2 and 3 shall not be accepted at the entrance facility. The operations of the facility shall be in accordance with the Central Maui Landfill Entrance Facility Operations Plan revised May 2017, and approved subsequent submissions, unless otherwise specified in these permit conditions.

6. Why reduce the number of roll-offs for MSW from eight to five? Special Conditions III, Item 10 (Page 38)

Draft Permit Reads:
The maximum storage capacity for collected household waste, recyclable materials, and special waste is as follows:
a. MSW for disposal: Five 20-cubic yard roll-offs in the self-haul disposal bays only.

Clarification Request:
We request to increase MSW rolloff storage back to 8. These storage areas were identified in Figure 2 and will be managed in accordance with Section 3.7 of the Entrance Facility Ops Plan. In addition, mattresses and furniture are stored adjacent to the UMO storage container at Station 2. The Entrance Facility Ops Plan will be updated to reflect this.

Suggested Draft Permit Rewrite:
The maximum storage capacity for collected household waste, recyclable materials, and special waste is as follows:
a. MSW for disposal: ~~Five~~ Eight 20-cubic yard roll-offs in the self-haul disposal bays only.

7. Is there further justification for covering or not covering at the end of the day on Saturday? This is only a 39 hour span of time versus a 24. Special Conditions III, Item 5 (Page 36)

Draft Permit Reads:
Household and commercial waste for disposal from incoming vehicles shall be unloaded directly into the roll-off containers at the self-haul disposal bays. Commercial vehicles shall be screened in accordance with the screening program described in Special Conditions III Item 4 before offloading. Roll-off containers shall be switched with empty ones when they are filled and shall be transported to the landfill. Household and commercial waste shall not be stored in roll-off containers for period exceeding 24 hours, except roll-off containers that are not full by the end of Saturday's operation may be stored for longer than 24 hours provided they are appropriately covered to prevent rainfall infiltration, vectors, odors, litter, and other nuisances.

Clarification Request:
We request leniency for the requirement to cover partially filled MSW rolloffs stored from Saturday to Monday. Can these rolloffs be stored at Station 2 uncovered during this period?

Suggested Draft Permit Rewrite:
Household and commercial waste for disposal from incoming vehicles shall be unloaded directly into the roll-off containers at the self-haul disposal bays. Commercial vehicles shall be screened in accordance with the screening program described in Special Conditions III Item 4 before offloading. Roll-off containers shall be switched with empty ones when they are filled and shall be transported to the landfill. Household and commercial waste shall not be stored in roll-off containers for period exceeding 24 hours, except roll-off containers that are not full by the end of Saturday's operation may be stored for longer than 24 hours provided that runoff is collected and treated as leachate, and they ~~are appropriately covered to prevent rainfall infiltration~~, do not attract vectors, cause odors, litter, and other nuisances.

8. Why should this ADC not be used at elevations above the perimeter road? Special Conditions II, Section D, Item 14.a (Page 20)

   Clarification Request:
   What concerns does DOH have regarding mulch ADC use above the perimeter road? In our experience with mulch ADC, there should be no issues in utilizing mulch ADC above the road. Mulch ADC is fibrous in nature, improving its resistance to becoming windblown.

9. How close is near in reference to being near the active work face? Special Conditions II, Section D, Item 19.d (Page 23)

   Draft Permit Reads:
   ***Litter Control**. The permittee shall provide measures to minimize free litter in the landfill and prevent its occurrence beyond the property line of the facility. All windblown material on the primary litter fences shall be collected and be properly disposed of by the end of the workday. The measures, at a minimum, shall include:*
   d. Provisions for a truck clean-out area near the active workface that shall be maintained on a daily basis. The truck clean-out area shall have litter control fencing and disposal receptacles for truck clean-out.

   Clarification Request:
   What is the intent of specifying the truck cleanout area proximity to the active workface? Is it to reduce litter tracking?

   Suggested Draft Permit Rewrite:
   None

10. ADC Tarps. We agree to the 2 consecutive day limit utilizing up to 5 tarps.

11. HC&S Low Perm Soil. Follow up on approval status.

12. Updated GW Monitoring Plan within 90-day of Permit issuance. Special Conditions II, Section G, Item 1 (Page 27)

    <u>Draft Permit Reads:</u>
    The permittee shall submit a new Groundwater and Leachate Monitoring Plan within ninety (90) days from the issuance date of this permit. At a minimum, the plan shall discuss the new sump at Phase V-B Ext and the additional groundwater monitoring wells, and comply with HAR 11-58.1-16. The permittee shall implement the existing, Groundwater and Leachate Monitoring Plan, dated 2012 by A-Mehr Inc, as subsequently amended and approved by the Department for Phases I, II, IV and V of the landfill until the Department has approved the new revised plan. The Department may periodically require revisions to the new revised plan.

    <u>Clarification Request:</u>
    Following the meeting on 10.7.17, the County shall continue to coordinate Groundwater Monitoring Plan improvements with the DOH. The updated GWMP will be submitted 90-days from final clarification of DOH comments regarding Plan enhancements.

    <u>Suggested Draft Permit Rewrite:</u>
    The permittee shall submit a new Groundwater and Leachate Monitoring Plan within ninety (90) days from the ~~issuance date of this permit~~ date specified by the Department. At a minimum, the plan shall discuss the new sump at Phase V-B Ext and the additional groundwater monitoring wells, and comply with HAR 11-58.1-16. The permittee shall implement the existing, Groundwater and Leachate Monitoring Plan, dated 2012 by A-Mehr Inc, as subsequently amended and approved by the Department for Phases I, II, IV and V of the landfill until the Department has approved the new revised plan. The Department may periodically require revisions to the new revised plan.

13. Installation of MW 7, 8, 9, and 10 within 180-days of Permit issuance. Special Conditions II, Section G, Item 2 (Page 27)

    <u>Draft Permit Reads:</u>
    Within 180 days after issuance date of this permit, the permittee shall install monitoring wells (MW) 7, 8, and 9 in accordance with the Site Map by A-Mehr Inc on sheet 1 in the February 2017 Phase V-B Ext permit application, and install MW-10 as recommended by the 2016 Conceptual Site Model Figure 8 Groundwater Monitoring Well Network by CH2M Hill prepared February 2016, or as otherwise approved by the Department. The exact installation location of the wells shall be submitted to the Department for review and approval prior to construction.

    <u>Clarification Request:</u>
    With the improved understanding of GW at the CML, the County will install MW-7 by January 9, 2017, MWs-8 and 10 in accordance with the Updated Groundwater Monitoring Plan or 1 year prior to the development of Phase III and Ph VI respectively. MW-9 will be installed in accordance to the Updated Groundwater Monitoring Plan.

Suggested Draft Permit Rewrite:

The permittee shall install monitoring wells (MW) 7 on or before January 1, ~~2017~~ 2018 (note: date corrected after time of meeting). MW 8, and 10 shall be installed 1 year prior to the respective development of Phase III and Phase VI, or in accordance with the Updated Groundwater Monitoring Plan referenced in Section G.1. above. ~~9 in accordance with the Site Map by A-Mehr Inc on sheet 1 in the February 2017 Phase V-B Ext permit application, and install MW-10 as recommended by the 2016 Conceptual Site Model Figure 8 Groundwater Monitoring Well Network by CH2M Hill prepared February 2016, or as otherwise approved by the Department.~~ The exact installation location of the wells shall be submitted to the Department for review and approval prior to construction.

MEETING SUMMARY

January 3, 2018 Meeting at HDOH SHWB for Groundwater Monitoring Central Maui Landfill

ATTENDEES:	Lene Ichinotsubo/HDOH SHWB Dawn Garbeil/HDOH SHWB Elaine Baker/County of Maui Dept. of Environmental Management (via conference call) Sergio Cocchia/CH2M Charles Holbert/CH2M (via conference call)
PREPARED BY:	County of Maui, CH2M
DATE:	January 3, 2018
PROJECT:	Groundwater Monitoring at Central Maui Landfill

Objectives

On January 3, 2018 representatives of the State of Hawaii Department of Health (HDOH) Solid and Hazardous Waste Branch (SHWB), County of Maui Department of Environmental Management, and CH2M (County’s consultant for Central Maui Landfill [CMLF] groundwater projects) met to discuss revisions to the site-specific upper prediction limits (UPLs) and updates to the facility Groundwater Monitoring Plan (GWMP). The meeting was held between 9:00 am and 11:00 am at the HDOH SHWB office located in Pearl City, Oahu.

As required by special conditions included in the Draft Solid Waste Management Permit No. LF-0074-13 for CMLF, updates to the current GWMP (A-Mehr, 2012) are needed within 90 days of the issuance of the permit to include the most recent groundwater data collected at CMLF after 2012. This will allow refinement of the conceptual site model (CSM) for use in evaluating the existing groundwater monitoring network. The updated GWMP will include recommendations on landfill indicator constituents for detection monitoring and on additional monitoring wells needed at the site to provide adequate spatial coverage.

Summary

The following is a summary of the main topics of discussion and concurrence during the meeting:

UPLs Update

- UPLs calculated in 2015-2016 will be revised in accordance with the 2012 USEPA Unified Guidance, including the retesting strategy described in Chapter 19 of the guidance.
- If an exceedance of the revised UPLs occurs, the retesting strategy will involve collection of independent samples to confirm that a significant statistical increase (SSI) is present.
- The statistical evaluation will provide recommendations on background data sample size (e.g., include historical data or just the most recent data) and the retesting strategy by running preliminary calculations and power analyses.

- Future compliance wells planned to be installed at CMLF will not be included in the calculated UPLs. When additional wells are installed and sufficient data are available, the UPLs will be updated. Future potential updates will include a larger number of wells, which could result in different recommendations on the retesting strategy.
- Only compliance wells will be included in the calculated UPLs. Monitoring wells MW-1, MW-4, and MW-6 will not be included and UPLs will not be developed for these wells.
- For constituents selected as landfill indicator parameters that have not been detected in groundwater in the past, and for which a UPL cannot be calculated, detections in two consecutive samples (sample and resample) events will be interpreted as indicative of a potential release (referred to as the Double Quantification rule in Section 6.2.2 of the Unified Guidance).

Groundwater Monitoring Plan Update

- Selection of an appropriate number of detection monitoring constituents will be dictated by the knowledge of waste or waste leachate composition and corresponding groundwater concentrations. The selection will initially consider leachate presence/absence and a leachate/groundwater contrast of 10 times. Up to 8-10 constituents will be considered for the UPL calculation/statistical evaluation to limit the false positive rate while achieving adequate statistical power. Detection monitoring may also include other constituents (e.g., some volatile compounds) that are detected in leachate but not in groundwater, and for which no UPL will be calculated. Because the proposed leachate/groundwater contrast of 10 is only met for 3 of the current detection monitoring constituents (TOC, iron, and magnesium), other evaluation criteria (e.g., leachate characteristics for CMLF or other similar landfills in Hawaii, background groundwater quality, and constituents' mobility) may be considered which will lead to the selection of indicator constituents that have a contrast of less than 10.

- The County will provide additional details in the Updated Groundwater and Leachate Monitoring Plan on the rationale for exiting assessment monitoring after it was triggered in March 2012. HDOH indicated that the Facility needs to comply with HAR 11-58.1-16(e) requirements and analyze for the Appendix II constituents annually while conducting Assessment monitoring. CH2M, on behalf of the County, intends to submit additional data and rationale demonstrating that HAR 11-58.1-16 provisions to exit assessment monitoring are met and/or an alternative source demonstration (ASD) is conducted. The ASD may include comparing leachate and background concentrations to dismiss landfill impacts. The County will include additional data and rationale in the Updated Groundwater and Leachate Monitoring Plan.

- Groundwater modeling will be conducted to evaluate production well impacts and provide recommendations on whether additional compliance monitoring wells are needed at CMLF. Results of modeling and recommendations on the groundwater monitoring network will be included in the updated GWMP. Because the leachate collection system within solid waste management unit (SWMU) Phase IV-A consist of a self-contained wet well that is gravity fed, the presence of an additional monitoring well immediately downgradient of it is not necessary. It may be more beneficial to install a monitoring well downgradient of SWMU Phase IV-B, which includes an actual sump and produces significantly more leachate. Although it could provide some data to evaluate groundwater flow direction, an additional well crossgradient (southwest) of SWMU Phase V-B will not be installed because the installation costs are extremely high compared to the very limited added value it would provide to the detection monitoring program.

- Although they are not compliance wells and will not be included in the calculated UPLs, MW-1 and MW-4 will continue to be sampled during detection monitoring to provide additional data that may be useful to evaluate upgradient and crossgradient concentrations in case of an SSI observed at compliance wells.

- Monitoring well MW-6 will not be sampled in the future because of safety concerns. However, groundwater depth will continue to be gauged during each monitoring event to evaluate groundwater flow direction. Sampling at MW-6 will be re-evaluated if SWMU Phase VI is developed in the future.
- The updated groundwater monitoring plan will include a robust background section to compile and reconcile historical data, CSM relevant data, and more recent groundwater data collected after 2012.
- The use of low-flow sampling methods with dedicated bladder pumps is strongly recommended for groundwater sampling. The county is currently evaluating the replacement of current pumps (grundfos electrical pumps) with bladder pumps capable of low-flow sampling at groundwater depths like those present at CMLF (up to approximately 300 feet below ground surface).

Action Items

- A preliminary statistical evaluation will be provided by the County for HDOH approval prior to the preparation and finalization of a technical memorandum. This evaluation will include results/recommendations on background data sample size, retesting strategy, list of detection monitoring constituents, and other relevant considerations for which approval in advance of UPL finalization/memo preparation may be advisable.
- The County will submit the update Groundwater Monitoring Plan no later than 90 days following issuance of the Final Solid Waste Management Permit.

Appendix C
Landfill Permit

DAVID Y. IGE
GOVERNOR OF HAWAII

VIRGINIA PRESSLER, M.D.
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HI 96801-3378

In reply, please refer to
File

February 26, 2018

S0228LI

DEM	INFO	ACTION
DIRECTOR		
DEPUTY		
PERS		
WWR		
SW	/	/
EP&S		
SECTY		

CERTIFIED MAIL NO. 7016 1370 0001 1215 7596
RETURN RECEIPT REQUESTED

Mr. Stewart Stant, Director
Department of Environmental Management
County of Maui
One Main Plaza, Suite 2B
2050 Main Street
Wailuku, Hawaii 96793

Dear Mr. Stant:

SUBJECT: Solid Waste Management Permit LF-0074-13
Central Maui Landfill Phases I, II & IV, V, V-B Ext. and Entrance Facility
Pulehu Road, Puunene, Maui

This letter is in response to your solid waste permit applications dated October 2013 for renewal, February 2017 for modification to include Phase V-B Extension, and May 2017 for renewal of the transfer station area. The application form from the October 2013 permit application was only used to document request to renew the solid waste management permit. Attachments P1 to P6 and the submitted documents/plans with the February 2017 and May 2017 permit applications were used as a basis for approving the permit applications. The submitted documents included the Master Plan, Closure/Post Closure Plan, Landfill Operations Plan revised February 2017, and an Entrance Facility Operations Plan revised May 2017.

In accordance with Hawaii Revised Statutes, Chapter 342H and Hawaii Administrative Rules Chapter 11-58.1, the Department is issuing Solid Waste Management Permit LF-0074-13 (enclosed) for the closed Phases I and II, the current operation of Phases IV and V, the construction and operation of the new Phase V-B Extension, and the entrance facility at the Central Maui Municipal Solid Waste Landfill. The subject permit expires on February 25, 2023.

The public notice on the subject draft permit was published in *The Maui News* on January 7, 2018. The public notice stated that the Department was accepting comments for 30 days on the draft permit and application. During the public comment period from

January 7, 2018 to February 6, 2018, the Department of Health, Solid and Hazardous Waste Branch did not receive any public comments.

The permittee may appeal to the Director of Health any of the conditions to the subject permit. The appeal must be in writing and submitted to the Director of Health within 20 days after the receipt of this notice.

Hawaii Revised Statutes 342H-14 states that unless the submitted documents and other information secured by the Department from the permittees contain confidential information, such as secret processes or methods of manufacture, they shall be made available for inspection by the public. Please notify the Solid and Hazardous Waste Branch within 20 days of the receipt of this letter if you would like to make a claim of confidentiality. Otherwise, your entire application will be available for public inspection.

If you have any questions, please contact Ms. Lene Ichinotsubo of the Solid and Hazardous Waste Branch at (808) 586-4226.

Sincerely,

JOANNA SETO, P.E., ACTING CHIEF
Environmental Management Division

Enclosure: Solid Waste Management Permit No. LF-0074-13

c: Mr. Sage Kiyonaga, Solid Waste Division, County of Maui

PERMITTEE:
OWNER/OPERATOR:
County of Maui
Pulehu Road
Puunene, Hawaii

PERMIT NUMBER: LF-0074-13
DATE OF ISSUE: February 26, 2018
EXPIRATION DATE: February 25, 2023
COUNTY: Maui
LATITUDE/LONGITUDE: 20 ° 51'N/156° 25'W
PROJECT: Central Maui MSW Landfill
Page 1 of 40

SOLID WASTE MANAGEMENT PERMIT

This solid waste management permit renewal and modification is issued under the provisions of Hawaii Revised Statutes (HRS), Chapter 342H, *Solid Waste Pollution*, and Hawaii Administrative Rules (HAR), Title 11, Chapter 58.1, *Solid Waste Management Control*. The above-named permittee is hereby authorized to maintain existing landfill, Phases I and II, maintain and operate, Phases IV and V, construct and operate the new Phase V-B Extension (Ext), and operate a materials drop-off facility, as shown on the application, additional submittals, and other documents on file with the Department of Health (DOH) as follows:

To Maintain/Construct: (1) A municipal solid waste (MSW) sanitary landfill consisting of approximately 42 acres in Phases I and II, approximately 18 acres in Phase IV (10 acres in Phase IV-A, 8 acres in Phase IV-B), approximately 19 acres in Phase V (Phase V-A and Phase V-B), and approximately 5 acres in Phase V-B Ext. Phases I and II are closed disposal areas constructed and placed in operation prior to 1993, and are not equipped with a bottom liner but do have a leachate collection system. Phase IV-A was constructed with a bottom and side slope composite liner system comprised of a 60-mil HDPE liner on top of a geosynthetic clay liner with a permeability of $5x10^{-9}$ cm/sec or less. Phases IV-B and V were, and Phase V-B Ext will be constructed with a prescribed liner system. Leachate from Phase IV-A is collected via a leachate manhole, leachate from Phases IV-B and V is collected via a sump in Phase IV-B, and leachate from Phase V-B Ext is collected via a sump in Phase V-B Ext.

Phases I and II were closed in 2007 and has a maximum elevation of 375 feet above mean sea level (MSL). Phases IV (Phase IV-A and IV-B) and V (Phase V-A and V-B) have already been constructed and are currently active. The newest expansion, Phase V-B Ext shall be limited to the 4.7-acre area as indicated in the Phase V-B Ext Design Report and Detailed Design Drawings prepared by A-Mehr, Inc., updated February 2017. Phases IV, V, and V-B Ext are contiguous and shall be limited to a maximum elevation of 390 feet above MSL.

Not included in the landfill acreage are areas used for appurtenant uses such as offices, equipment and maintenance facilities, leachate management facilities consisting of a leachate manhole and aboveground tanks, landfill gas management area, transfer station, soil stockpile area, buffer zones, stormwater management system, perimeter road, and parking.

(2) A transfer station, including a self-haul waste drop-off area, recyclables (fiber, plastic, glass and metal) collection and special waste (white goods, used oil, lead acid batteries and tires) collection.

To Operate: (1) An MSW sanitary landfill consisting of approximately 42 acres of closed landfill in Phases I and II (for post-closure care purposes only), approximately 18 acres in Phase IV, approximately 19 acres in Phase V, and approximately 5 acres in Phase V-B Ext.

The peak daily disposal rate for MSW shall not exceed 1200 tons per day. Adequate equipment and personnel to operate the MSW landfill facility shall be maintained. At the nominal operating rate of 800 tons per day, the site shall have a minimum of one bulldozer, one compactor, one water truck and one spotter. Greater than a nominal rate of 800 tons to a peak daily rate of 1200 tons per day will require a minimum of two bulldozers, one compactor, one water truck and two spotters. These requirements shall be met unless otherwise approved by the DOH.

(2) A transfer station, including a self-haul waste drop-off area, recyclables (fiber, plastic, glass and metal) collection and special waste (white goods, used oil, lead acid batteries and tires) collection.

IN ACCORDANCE WITH:
(a) The 'As-Built' drawings for Phases I and II, and The Closure and Post Closure Plan, dated February 2008, and last revised February 2017;
(b) 'As-Built' drawings dated September 1, 2004 for Phases IV-A, February 8, 2007 for IV-B, September 21, 2009 for V-A, and November 11, 2010 for V-B;
(c) the permit application for renewal dated October 2013, and the permit application for modification for Phase V-B Ext dated February 2017;
(d) the revised operations plan dated September 2004 and last revised in February 2017, prepared by A-Mehr, Inc. and submitted by the County of Maui, Department of Environmental Management;
(e) the master plan dated February 2017, prepared by A-Mehr, Inc.;
(f) the transfer station permit application dated May 2017;
(g) the updated Groundwater and Leachate Monitoring Plan dated January 2013 and supplemental reports, Groundwater Well Network Analysis dated February 2014, prepared by Element Environmental, LLC, and Conceptual Site Model dated February 2016, prepared by CH2M Hill;
(h) email correspondence from the County of Maui, regarding groundwater, general permit application questions, and the Entrance Facility that have been compiled into two emails dated August 21, 2017; and
(i) all other engineering plans, 'as built' drawings, and engineering data.

LOCATED AT: Pulehu Road, Puunene, Maui, Hawaii (TMK (2) 3-8-003:019).

SUBJECT TO: HRS 342H; HAR 11-58.1; Standard Conditions I; Special Conditions II; Special Conditions III

Acceptance of this permit constitutes an acknowledgement and agreement that the holder will comply with all rules, regulations, and orders of the DOH and the conditions precedent to the granting of this permit.

This permit supersedes the Solid Waste Management Permit Number LF-0089-08 dated November 1, 2009.

Joanna L Seto

(for) DIRECTOR OF HEALTH
State of Hawaii

The solid waste management facility is subject to HRS Chapter 342H, *Solid Waste Pollution* and HAR Chapter 11-58.1, *Solid Waste Management Control*, and the following conditions:

STANDARD CONDITIONS I:

1. The terms, conditions, requirements, limitations, and restrictions set forth herein are "Permit Conditions" and as such are binding upon the permittee and enforceable pursuant to the authority of HRS Chapter 342H. The DOH will review this permit periodically and may initiate enforcement action for any violation of the "Permit Conditions" by the permittee, its agents, employees, servants, or representatives, contractors or subcontractors. If any term or condition of this permit becomes invalid as a result of a challenge to a portion of this permit the other terms and conditions of this permit shall not be affected and shall remain valid.

2. This permit:

    a. shall not in any manner affect the title of the premises upon which the facility is or will be located;
    b. does not release the permittee from any liability for any loss due to personal injury or property damage caused by, resulting from, or arising out of the design, installation, construction, operation, maintenance, closure or post-closure of this facility;
    c. does not release the permittee from compliance with other applicable statutes and regulations of the state of Hawaii, or with applicable federal or local laws, regulations or ordinances;
    d. in no way implies or suggests that the state of Hawaii, or its officers, agents, or employees assumes any liability, directly or indirectly for any losses due to personal injury or property damage caused by, resulting from, or arising out of the design, construction, operation or maintenance of the facility; and
    e. shall not constitute, nor be construed to be an approval of the design, construction, operation, maintenance, closure and post-closure of the facility beyond the regulatory requirements mandated by HRS 342H and HAR 11-58.1.

3. Issuance of this permit does not preclude the responsibility of the permittee to obtain any and all necessary approvals and permits from the appropriate federal, state, and local agencies, including zoning clearances, prior to the start of operations.

4. Unless the submitted documents and other information secured by the DOH from the permittee contain confidential information, such as secret processes or methods of manufacture, they shall be made available for inspection by the public (HRS 342-14). The permittee shall be responsible for identifying, in writing, the specific information

asserted to be confidential. The DOH shall review the permittee's assertion and determine if confidentiality is indeed warranted.

5. This permit is valid only for the specific processes and operations applied for and indicated in the submitted application and additional submittals on file with the DOH. Any unauthorized deviation from the submitted application, approved drawings, operations manual, additional submittals, or conditions of this permit may constitute grounds for revocation of this permit and enforcement action by the DOH. Should there be any discrepancies between the submitted documents and the permit conditions, the permit conditions shall take precedence. A copy of the submitted application and additional submissions shall be maintained at the facility.

6. This permit is non-transferable whether by operation of law or otherwise, either from one location to another, from one solid waste disposal operation to another, or from one person to another without the written approval of the director [HAR 11-58.1-04(e)(2)].

7. This permit shall be kept at or near the operation site for which the permit is issued and shall be available upon request [HAR 11-58.1-04(f)]. A request for a duplicate permit shall be made in writing to the director within ten (10) days after the destruction, loss, or defacement of this permit. A fee of $50 shall be submitted with the request [HAR 11-58.1-04(h)(3)].

8. The permittee shall at all times properly operate and maintain the facility and systems of treatment and control (and related appurtenances) that are installed or used by the permittee to achieve compliance with the conditions of this permit, as required by DOH rules. The facility shall be designed, constructed and equipped so as to operate without causing a violation of applicable rules and regulations.

9. Incident Notification Requirements: The permittee shall notify the DOH, in writing or facsimile (fax), whenever there are incidents such as fire, explosion, or release of regulated material/waste, which could threaten human health or the environment (i.e. air, soil, or surface and subsurface waters). Initial notification may be by phone or fax and reported within eight hours, whenever possible, and no more than 24 hours. The notification report shall be completed and submitted by an Environmental Compliance Officer or other responsible official within seven (7) calendar days (three (3) calendar days for waste disposal facilities, such as landfills and incinerators) and shall include:

    a. name, address, and telephone number of the owner and operator;
    b. name, address, and telephone number of the facility at which the incident occurred;
    c. date, time and type of incident (i.e., fire, explosion, release, etc.);
    d. name and quantity of material(s) involved;

e. the extent of injuries, if any;
f. an assessment of actual or potential hazards to human health or the environment, where this is applicable;
g. estimated quantity and disposition of recovered and unrecovered material that resulted from the incident;
h. evaluation of the circumstances that led to the incident;
i. steps being taken to prevent, reduce, eliminate, and prevent recurrence, including an implementation schedule; and
j. other information or monitoring as required by the DOH.

Notification requirements for releases only apply to releases of a quantity equal or exceeding the reportable quantity listed in HAR Section 11-451.

10. Noncompliance Notification Requirements. If, for any reason, the permittee does not comply with, or will be unable to comply with, any condition or limitation specified in the permit, the permittee shall notify the DOH verbally within 24 hours followed by a written report within seven (7) calendar days (three (3) calendar days for waste disposal facilities, such as landfills and incinerators) of the verbal notification. The written report shall be completed and submitted by an Environmental Compliance Officer or other responsible official and contain the following information:

a. a description of and the cause of noncompliance;
b. period of noncompliance, including exact dates and times, or, if not corrected, the anticipated duration that the noncompliance is expected to continue;
c. steps that will be taken to correct the area of noncompliance;
d. steps being taken to reduce, eliminate, and prevent recurrence of the noncompliance, including an implementation schedule; and
e. other information or monitoring as required by the DOH.

The permittee may be subject to enforcement action by the DOH, penalties or revocation of this permit.

The use of an electronic fax device or electronic mail (email) for use in written notifications is acceptable. Any data transmission or detailed explanations transmitted shall be accompanied by regular mail submissions. Failure to notify in accordance to this requirement may initiate enforcement action.

11. Monitoring and Recordkeeping Requirements: The permittee shall comply with the following monitoring and recordkeeping requirements:

a. Upon request, the permittee shall furnish all records (i.e. transaction reports, disposal receipts) and plans required by the DOH. The retention period for all transaction reports and disposal receipts shall be a minimum of five (5) years; however, there shall be an indefinite retention period for all records associated with any unresolved enforcement action as determined by the DOH.

b. The permittee shall retain at the facility or other location designated by this permit, records of all monitoring information (including all calibration and maintenance records and all original recordings of monitoring instrumentation), copies of all reports required by this permit, and records of all data used to complete the application for this permit. The retention period shall be for the life of the facility, through closure and post-closure periods, for waste disposal facilities (such as landfills and incinerators).

c. Records of monitoring information shall include:
- The dates, exact place, and time of sampling or measurements;
- The person responsible for performing the sampling or measurements;
- The date(s) analyses were performed;
- The person responsible for performing the analyses;
- Analytical techniques or methods used; and
- Results of such analyses.

12. The permittee shall submit complete and detailed plans and reports on existing solid waste management systems and any proposed addition to, modification of, or alteration of any such systems that affects the facility's operations or procedures, or which could threaten human health and the environment, and contain the information requested by the DOH in the form prescribed by the DOH. Any submission for permit modification shall be submitted in accordance with Standard Condition No. 13. The plans and reports shall be prepared by a competent person acceptable to the DOH, and at the expense of the permittee.

13. Should the permittee decide to modify the permit or continue operation of the solid waste facility beyond the expiration date of the permit, the permittee shall submit a complete permit modification or renewal application at least one year for municipal solid waste landfills prior to the modification or the date of permit expiration. Any submission for permit modification does not affect these permit conditions until such modification becomes final in accordance with HAR §11-58.1-04, or as approved by the DOH.

14. The director may, in accordance with HRS §342H-6, enter and inspect the facility for the purpose of:

    a. investigating an actual or suspected source of solid waste or other pollution;
    b. ascertaining compliance or noncompliance with any rule, regulation, permit condition, or standard promulgated by the DOH; and
    c. conducting tests in connection therewith (including collecting soil, water, air, ash, and any other material or samples).

The permittee, by accepting this permit, specifically agrees to allow authorized DOH personnel, upon presentation of credentials or other documents as may be required by law, access to the premises.

15. The DOH may require the permittee to conduct sampling and testing to determine the degree of pollution, if any, from the solid waste facility (including soil, water, air, ash, and any other materials or samples). If contamination is detected, the permittee shall remediate as necessary to protect public health and the environment.

16. When requested by the DOH, the permittee shall within a reasonable time, as specified by the DOH, furnish any information required by law, which is needed to determine compliance with the permit. If the permittee becomes aware that relevant facts were not submitted or were incorrect in the permit application or in any report to the DOH, such facts or information shall be submitted or corrected promptly. Upon the written request of the permittee, the deadline for submission of information may be extended, if the DOH determines that reasonable justification exists for the extension.

17. If the DOH determines that the permittee has violated or is violating any provision of HRS §342H, HAR §11-58.1, or these permit conditions, the DOH may pursue enforcement action in accordance with HRS §342H-7, *Enforcement*; §342H-9, *Penalties*; §342H-10, *Administrative Penalties*; §342H-11, *Injunctive and other relief*, or any other pertinent rules.

18. The DOH may, on its own motion, modify, suspend, or revoke a permit if, after affording the applicant a hearing in accordance with HRS 91, the DOH determines that any permit condition, rule, or provision of HRS §342H has been violated or that such is in the public interest [HAR §11-58.1-04(d)].

19. If the governor or the director determines that an imminent peril to the public health and safety is, or will be, caused by the disposal of solid waste or any combination of discharges of other waste that requires immediate action, the governor or the director, without a public hearing, may order the permittee to immediately reduce or stop the disposal, discharge, or process, and may take any and all other actions as may be necessary (HRS §342H-8).

SPECIAL CONDITIONS II: MSW Landfill

Section A. General Facility Conditions

1. The **Master Plan** dated February 2017 shall be maintained by the County for planning purposes and be revised on a regular basis of not greater than five-year intervals, or with each new permit application. If the remaining capacity of the landfill is less than 10 years, an update to the Master Plan, identifying status of obtaining additional disposal

capacity shall be incorporated into the Annual Operating Report (AOR) in accordance with Special Conditions II Section I, Item 2m. The Master Plan shall provide information on future landfill capacity requirements in both numerical and graphical presentations with a minimum projection of 20 years and shall include the waste footprints and service lives of the existing Phase IV, V, V-B Ext and any proposed future lateral expansions. The Master Plan shall include the proposed Basis of Design, buffer areas, appurtenant and support facilities. The Master Plan shall address special measures to permanently isolate Phase IV-A from the remaining facility phases.

2. The final maximum elevation of Phases IV (A & B), V (A & B), and V-B Ext shall not exceed 390 feet above MSL and in accordance with Operations Plan for Central Maui Landfill dated February 2017, prepared by A-Mehr, Inc.

3. **Impact Buffer Areas.** The permittee shall rectify any impacts from the site on nearby areas, including any adjacent public roads or environmentally sensitive areas. MSW disposal activities shall not occur within **buffer areas,** a minimum 150 feet from the property line along Pulehu Road, minimum 1000 feet from the property line along any present or future urban area, and minimum 80 feet of any agricultural area as defined in the Operations Plan. The permittee shall incorporate methods to minimize impacts from solid waste activities, including litter, vectors and odors.

4. **Air Criteria.** The permittee is responsible for obtaining permits and maintaining compliance with any state or federal Clean Air regulations, in accordance with HAR 11-58.1-15(e).

5. **Access Control.** The permittee is responsible for providing measures to control public access in accordance with HAR 11-58.1-15(f).

6. The permittee shall provide adequate queuing and storage space such that private self-haul and/or waste delivery vehicles will not queue on Pulehu Road outside of the landfill entrance gate, and as specified in the operations plan.

7. **Emergency Operations.** The permittee shall prepare and implement emergency operating procedures, including those in the Emergency Operating Procedures, provided as Section 13.5, in the February 2017 Operations Plan, and approved subsequent submissions.

    a. The permittee shall provide verbal and written notification of incidents to the DOH, in accordance with Standard Conditions, Item 9 of this permit. Incidents shall also include suspected subsurface fires, and be reported based on any of the notification criteria listed in the Operations Manual.

b. The permittee shall be prepared and implement emergency operating procedures for the minimum following situations:
   i. Fires (including surface, nearby, incoming waste loads, vehicle/equipment, subsurface, etc.),
   ii. Severe storm (2-year, 24-hour storm or greater, or continued rainy conditions over duration of 14 days), including hurricanes,
   iii. Earthquakes and tsunamis,
   iv. High winds conditions,
   v. Hazardous material spills at or above the reportable quantity, and
   vi. Other emergency procedures, and trigger levels, as provided in the emergency operating procedures.

c. The permittee shall assess, monitor, and maintain/repair the landfill after emergencies that may affect the integrity of the landfill, including, but not limited to, the liner system, leachate collection and control system, surface water management system, and any other affected portions of the landfill. If the acceptance and disposal of waste ceases, the permittee shall submit a written evaluation of whether waste acceptance can resume. The evaluation shall be prepared by a professional engineer registered in the state of Hawaii and/or the landfill manager, as appropriate, certifying that the landfill and its associated environmental controls are functional, equivalent or better than required, and that operation of the landfill will not cause a violation of environmental regulations. The evaluation shall also include a description of any findings and corrective actions. The facility may resume acceptance and disposal of waste upon submission of this evaluation to the DOH. The DOH may require additional assessment, monitoring, and corrective actions, as necessary to address the event.

Section B. Construction and Maintenance – MSW Disposal Cells

1. Construction of Phase V-B Ext, or significant modification of the Phases IV-A, IV-B, Phase V-A and/or Phase V-B disposal cells, shall not occur prior to the DOH's approval of the final construction plans and specifications prepared and certified by a professional engineer, registered in the state of Hawaii, with at least five (5) years' experience in designing landfills. Upon approval, construction shall be in conformance with the final construction plans and specifications.

2. The permittee is responsible for obtaining the services of a registered land surveyor who shall provide a minimum second order of accuracy on: triangulation, traverse, leveling and baseline measurements of the base grades, liner grades and key location and elevation points of the leachate collection and sump system as shown on the approved

drawings. The liner contractor and installer prior to liner placement shall certify the base grades in writing.

3. For Phase V-B Ext, the bottom composite liner shall be constructed in accordance with A-Mehr, Inc. drawings, dated February 2017. The bottom liner consists of the following layers (from bottom to top).

    a. Subbase grade shall be prepared to provide a smooth, firm, unyielding, rut-less foundation with well-graded material not to exceed three-fourths inch (0.75 inch).
    b. Low permeability soil liner shall be a minimum of 24 inches thick and constructed with a maximum permeability of 1.0 x 10^{-7} cm/sec for both cell floor and side slope areas.
    c. An 80-mil HDPE geomembrane, textured on both sides.
    d. A 16-ounce per square yard nonwoven geotextile.
    e. 12-inch gravel leachate collection layer on the cell floor not to exceed 1.5-inch in diameter with a minimum hydraulic conductivity of 1.0 x 10^{-2} cm/sec.
    f. A 16-ounce per square yard nonwoven separating geotextile.
    g. Operations layer shall be a minimum 24 inches thick, have a maximum aggregate size of 6 inches. The entire thickness of the drainage layer and operations layer combined shall be a minimum of 36 inches for the cell floor.
    h. The side slope liner consists of:
        i. Subbase grade and low permeability soil liner, as described in 3.a. and 3.b. above;
        ii. An 80-mil HDPE geomembrane, textured on the bottom side, secured with an anchor trench at the top of the slope;
        iii. A 16-ounce per square yard nonwoven geotextile;
        iv. A sacrificial ultraviolet (UV) protective rain cap; and
        v. Operations layer, consisting of a minimum 24 inches of soil, with 100 percent passing a 2-inch sieve.

4. Construction of the composite liner system shall be in accordance with the plans and specifications approved by the DOH. The QA/QC engineer shall observe construction, perform testing as specified in the most recent Technical Specifications and Construction Quality Assurance Plan dated October 2008 and revised in February 2017, and certify that the liner and leachate system comply with the approved plans and specifications, and these permit conditions.

5. Lined side slopes shall not exceed the slope of two to one (horizontal: vertical). Cell floor liner grades shall be a minimum 1% downgrade slope to the collection sump, and a minimum 2% cross slope to the leachate collection trenches as specified in the landfill operations plan, or as approved by the design engineer with concurrence from the DOH.

The liner grades shall prevent accumulation of 30 cm or more of leachate head anywhere on liner system.

6. Installation of any geosynthetic liner shall be performed by an experienced installer who has installed a minimum of 500,000 square feet of similar type liners or shall be performed under the supervision of the manufacturer. An experienced QA/QC landfill inspector with at least five (5) years of experience in landfill CQA, and works under the supervision of a professional engineer, shall observe liner installation and grade elevations. The permittee shall notify the DOH, in writing, at least five (5) days prior to any liner installation work.

7. The leachate collection system shall be installed per the approved plans and drawings. Phases IV-B and V-B Ext sump areas shall be lined with a minimum of two layers of 80-mil high-density polyethylene liner over the minimum 24-inch low permeability earthen liner, as defined in Special Condition II.B.3.b. Three layers of 6-feet by 6-feet by 80-mil HDPE shall be installed directly beneath the sump riser pipe in accordance with the A-Mehr, Inc. drawings, February 2017.

8. The earth berm used to control and manage surface water at the southeastern boundary of Phase V-B Ext shall be constructed such that it is a minimum of 80 feet wide, and 15 feet high, measured from the existing quarry floor as specified in the A-Mehr, Inc. design drawings, February 2017. The berm shall be constructed such that leachate seepage and external stormwater infiltration is minimized. Inspection shall be conducted weekly, and after storm events for erosion. Any deficiencies shall be addressed immediately.

9. The permittee shall retain a professional engineer, with at least five (5) years' experience in designing landfills, and registered in the state of Hawaii, to provide construction quality assurance (CQA) for construction of new lined disposal cells. Upon completion of construction, the professional CQA engineer shall prepare a report for submittal to the DOH at least thirty (30) days prior to proposed placement of the waste in the cell. The CQA Report shall contain, at a minimum, the following:

   a. Documentation of quality assurance/quality control testing procedures.
   b. Summary of field test results demonstrating that the liner and leachate collection systems were constructed as designed, including but not limited to, compaction tests, weld tests.
   c. Summary of results of laboratory analyses, demonstrating that the materials used met design criteria and assumptions, including but not limited to sieve analysis, compaction curves, permeability tests, and interface friction test results for side slopes with comparison between manufacturer specification and field results.
   d. A map of each sector showing panel layouts as installed.

e. Liner inspection reports.
f. Certification that all weld test results and vacuum or pressure testing of all welded seams was visually observed.
g. Certification that the bottom liner and leachate collection system have been installed in accordance with the plans as approved by the DOH.
h. As-built and survey drawings documenting the cell construction, including the location and elevation of base grades, liner system, and leachate collection system.
i. Detailed documentation to show that panels were properly joined to liner in previous constructed sections, and/or the construction of anchor trenches and berms.
j. Identification of any deviations from the construction plan, reason for the deviation and affect on the integrity of the design.

10. No solid waste shall be placed in any new cell or portion thereof until: (1) the professional CQA engineer certifies, by submittal of the report referenced in Special Conditions II.B.9 or a letter containing the certifications required therein, completion of construction in accordance with approved drawings; and (2) the permittee coordinates an inspection of the liner system, leachate collection system, and leachate sump for each new cell or portion thereof by the DOH, with the presence of the design engineer and on-site facility operator. Requests for inspection shall be given at least 21 days in advance of the inspection date.

11. The first layer of solid waste shall consist of a minimum thickness of 5 to 6 feet of select waste that is screened for the removal of objects that can cause puncture or displacement damage. The thickness of the select waste layer shall be determined based on the size/weight of the compactor and shall be defined in the Operation Plan. Material that may cause puncture or displacement damage to the liner shall be removed. Compactor work on the select waste layer shall avoid wheel spinning, twisting or any other activity that may cause damage to the liner. Equipment operation directly on the operations layer shall be prohibited. A record documenting select waste screening and placement shall be maintained at the facility and provided to the DOH with verification by the CQA engineer including photo documentation. An alternate select waste placement may be used if approved by the DOH.

12. Containment systems in Phases IV-B, V (A & B), and V-B Ext shall be constructed and maintained with no deformation to withstand the maximum horizontal acceleration due to the design earthquake (0.36g) for Seismic Zone 2B as defined by the United States Geological Survey. Following any occurrence of an earthquake determined to cause horizontal acceleration at the site equal to or greater than the design event, the permittee shall inspect any exposed liner system to identify and assess any damage that may have occurred. A report of the inspection shall be filed with the DOH within 30 days

following the event, including proposed corrective actions to repair any damage identified by the inspection. A professional engineer registered in the state of Hawaii shall conduct the inspection and prepare the report.

13. Once constructed, the permittee shall maintain the integrity of the liner system and leachate collection system as designed and constructed (inclusive of all landfill phases). In the event that damage has occurred, the permittee shall repair the liner and/or leachate collection system, or implement equivalent or better alternative environmental controls as approved by the DOH.

14. For Phases IV-B, V-A, and V-B, the bottom liner was constructed in accordance with A-Mehr, Inc. drawings, July 2006, June 2008 and September 2009, respectively. The bottom liner consisted of the following layers (from bottom to top).

    a. Prepared subbase grade.
    b. A minimum of 24-inch thick low permeability soil liner, with a maximum permeability of 1.0×10^{-7} cm/sec for both cell floor and side slope areas.
    c. An 80-mil HDPE geomembrane, textured on both sides.
    d. A 16-ounce per square yard nonwoven geotextile.
    e. A 12-inch gravel leachate collection layer, with a maximum 1.5-inch diameter particle size and a minimum hydraulic conductivity of 1.0×10^{-2} cm/sec.
    f. A 16-ounce per square yard nonwoven separating geotextile.
    g. A minimum 24-inch operations layer material, with a maximum aggregate size of 6 inches, and not more than 12 percent passing a No. 200 sieve for the cell floor.
    h. The side slope liner consisted of:
        i. Prepared subbase grade and low permeability soil liner, as described in 14.a. and 14.b. above;
        ii. An 80-mil HDPE geomembrane, textured on the bottom side;
        iii. A 16-ounce per square yard nonwoven geotextile; and
        iv. A minimum 24-inch thick soil operations layer, with 100 percent passing a 2-inch sieve.

15. For Phase IV-A, a portion of the cell floor and side slope liner was repaired in accordance with A-Mehr, Inc. drawings, dated September 2004. The portion of the bottom liner that was repaired as specified in the A-Mehr Drawings, dated July 2004, consisted of the following layers (from bottom to top).

    a. Prepared subbase grade.
    b. A geosynthetic clay liner (GCL).
    c. A 60-mil HDPE geomembrane, textured on both sides.
    d. A 16-ounce per square yard nonwoven geotextile.
    e. A 12-inch gravel leachate collection layer.

f. A 16 ounce per square yard nonwoven separating geotextile.
g. An operations layer with a minimum thickness of 24 inches.
h. The side slope liner consisted of:
    i. Prepared subbase grade and GCL;
    ii. 80-mil HDPE geomembrane, textured on the bottom side;
    iii. 16-ounce per square yard nonwoven geotextile; and
    iv. Minimum 24-inch thick soil operations layer.

16. For the remainder of Phase IV-A, the original bottom liner was constructed in accordance with Parametrix, Inc. drawings, dated June 1998. The cell floor and side slope liner consisted of the following layers (from bottom to top).

    a. Prepared subbase grade.
    b. A cushion layer.
    c. A GCL.
    d. A secondary 60-mil HDPE smooth FML.
    e. A geocomposite drainage layer.
    f. A primary 60-mil HDPE smooth FML.
    g. A 16-ounce per square yard nonwoven geotextile.
    h. An 18-inch thick soil operations layer.

Section C. Acceptance Criteria

1. The permittee is authorized to accept for landfill disposal, solid wastes, as defined in HAR 11-58.1-03, except as further described in this section.

2. The permittee shall implement a Waste Acceptance & Hazardous Waste Exclusion Program as set forth in the Operations Plan for Central Maui Landfill that meets the following conditions, Section C Items 2 to 4. Should there be conflicts between the Operations Plan and the permit or solid waste rules, the latter shall prevail.

    a. The permittee shall make every practicable effort to screen waste and prevent unacceptable waste from entering and being disposed at the landfill.
    b. The permittee shall post a sign on the property that lists unacceptable wastes.
    c. The permittee shall conduct random visual surveillance of mixed commercial loads (not inclusive of loads known to only contain single-source-separated materials, such as sludge), at least six times per week, to spot check for unacceptable wastes. The permittee shall document findings on the Load Check Data Sheet.
    d. The landfill operators at the active workface shall visually screen the contents of each load and remove unacceptable waste.

e. If unacceptable waste is observed, the permittee shall reject the load. If the waste has been unloaded, the permittee shall separate the unacceptable waste, move it away from the active workface, and manage and dispose of it in accordance with applicable regulations.

f. Operators shall receive training on visual surveillance and unacceptable waste handling procedures set forth in the Operations Plan. Training shall be attended at least once per year, or more frequently as needed to ensure compliance with the facility procedures.

g. The permittee shall maintain records of random inspections on the Load Check Data Sheets, and personnel training.

h. Unacceptable waste is defined as:
   i. Regulated hazardous waste, as defined in state hazardous waste regulations;
   ii. Radioactive waste, which shall be managed in accordance with HAR 11-58.1-64;
   iii. Polychlorinated biphenyl (PCB) waste, as defined in 40 CFR Part 761;
   iv. Untreated infectious waste, excluding infectious waste generated within the household, in accordance with HAR 11-58.1-63;
   v. Bulk or non-containerized liquid waste, except as provided in HAR 11-58.1-15(i);
   vi. Containers holding liquid waste, except as provided in HAR 11-58.1-15(i)(2);
   vii. Commercial loads containing greater than 25% greenwaste and household loads containing greater than 50% greenwaste, in accordance with HAR 11-58.1-65(b);
   viii. Scrap automobiles, white goods, and whole motor vehicle tires, in accordance with HAR 11-58.1-65(c);
   ix. Lead acid batteries, in accordance with HRS 342I;
   x. Compressed gas tanks; and
   xi. Other unacceptable wastes listed in the Operations Plan.

3. If unacceptable waste is identified at the landfill, the permittee shall separate the waste, manage, store, transport, and recycle/dispose of it in accordance with the Central Maui Landfill Operations Plan and applicable laws and rules. Unacceptable waste identified at the facility shall not be disposed of at the landfill.

   a. Unacceptable waste shall be transported from the landfill prior to posing a nuisance, health, or safety concern.

   b. Unacceptable waste shall be transported to a permitted solid waste management facility allowed to accept the waste, or appropriate out-of-state recycling/disposal facility.

c. The permittee shall maintain a daily operational log of unacceptable waste turned away from the landfill or separated from disposal, including date, hauler, waste type, estimated quantity, and destination.

d. The permittee shall notify the DOH, in writing, within 24 hours or the next working day of the identification of hazardous or PCB waste. The notification shall include the date and time of incident, origin of the waste, hauler/generator, description and quantity of waste, actions that will be taken to manage the waste at the site, and actions that will be taken to remove the waste from the premises. The permittee shall also provide written notification, including a copy of the associated manifests, within seven (7) days of removal of the waste from the facility.

4. Radioactive wastes shall be managed in accordance with HAR 11-58.1-64. The permittee shall implement the Radioactive Waste Monitoring Program that is provided in Appendix K of the Central Maui Landfill Operations Plan, updated February 2017. In accordance with the program, all incoming loads will be screened with a radiation detector to prevent the acceptance of radioactive wastes. If a radioactive load is identified, the permittee shall complete and submit a Radiation Monitoring Report, documenting the date, time, actions taken, and resolution of the event.

5. The permittee shall implement the Special Waste Acceptance Program provided in the Central Maui Landfill Operations Plan that meets the following conditions listed within this item. Should there be conflicts between the Operations Plan and the permit or solid waste rules, the permit and rules shall prevail. The DOH may require periodic revisions to the plan.

a. The permittee shall pre-approve special wastes, prior to acceptance at the facility.

b. The permittee shall maintain written documentation and implement special handling procedures associated with each type of special waste. The procedures shall be based on the physical, chemical or pertinent characteristics of the special waste.

c. Special waste means any solid waste which, because of its source or physical, chemical, or biological characteristics, requires special consideration for its proper processing or disposal, or both, includes, but is not limited to:
   i. Asbestos.
   ii. Semi-solid wastes including:
      (1) Water separation, car and equipment wash wastes;
      (2) Sewage sludges; and
      (3) Underground storage tank and other sludges.
   iii. Off-specification and outdated products.
   iv. Baghouse dusts.

v. Inorganic filter cakes.
vi. Treated infectious waste.
vii. Dead animals and offal.
viii. Contaminated Materials including:
  (1) Contaminated soils and debris, including: resins and chemical debris, petroleum and other contaminated soils, and petroleum and other contaminated debris;
  (2) Sandblast grits;
  (3) Waste that are toxic in nature, such as insecticides, poisons, or radioactive materials (provided that they are not regulated under another authority such as RCRA Subtitle C, TSCA that requires disposal other than at a permitted MSW landfill); and
  (4) Other solid waste, which may be accepted for disposal such as contaminated industrial/commercial waste and non-TSCA regulated PCB waste, provided such materials are not regulated hazardous waste.
ix. Other special waste listed in the Operations Plan.

d. The permittee shall maintain records of contaminated material approvals and acceptances. The records shall include: acceptance date(s), quantity and description of waste, origin of waste, waste profile sheet/approval manifest; proposed management of contaminated material; and any special management and handling procedures. The record shall be made available to the DOH upon request.

e. Contaminated soils under current DOH Environmental Action Levels (EALs) for commercial/industrial direct-exposure may be stored and used as daily cover at the MSW landfill working face. Contaminated soils that exceed the EALs for unrestricted use shall not be used as intermediate or final cover.

f. Records of all special waste documentation shall be maintained at the facility.

Section D. Operation of the MSW Landfill

1. The peak daily disposal rate for MSW shall not exceed 1200 tons per day. Adequate equipment and personnel to operate the MSW landfill facility shall be maintained. At the nominal operating rate of 800 tons per day, the site shall have a minimum of one bulldozer, one compactor, one water truck and one spotter. Greater than a nominal rate of 800 tons to a peak daily rate of 1200 tons per day requires a minimum of two bulldozers, one compactor, one water truck and two spotters. These requirements shall be met unless otherwise approved by the DOH. The DOH shall be notified if the

average disposal rate for a 12-month period exceeds an 800-ton per day nominal average or the 1200-ton per day peak disposal rate limit.

2. A permanent **sign** shall be posted at the facility entrance identifying the facility, the hours and days of operation, and the name and address of the operator, a telephone number and other pertinent information.

3. An **all-weather access road** shall be maintained into/out of the facility site, through the entrance facility and to/from the working face of the landfill.
4. Provide and maintain **controlled access** to the facility site in the form of fences and gates along the perimeter where natural barriers do not provide a means of controlled access. When natural barriers no longer prove to be an effective means of providing controlled access, then fences and gates shall be provided to meet the requirements of controlled access. All gates shall be kept locked when an attendant is not on duty.

5. Scavenging at the facility by the general public is prohibited.

6. **Operations Personnel Training**. Landfill operations shall be supervised at all times by an individual who has completed a Manager of Landfill Operations training course conducted by the Solid Waste Association of North America or equal as agreed upon by the DOH. Records of such training shall be placed in the facility's operating record and made available upon request.

7. **Program for Regular Training**. The permittee, at a minimum, shall provide training to landfill operators annually. Operators shall be familiar with the Operations Plan by the uses of regular training presentations by supervising staff. Records of such training shall be maintained at the facility and provided to the DOH upon request.

8. The facility shall have a Site Manager and Environmental Compliance Officer, who shall be knowledgeable of state solid waste laws, regulations, these permit conditions and the permit application components including the Operations Plan.

9. The **Operations Plan**, revised February 2017, and approved subsequent revisions shall be implemented. The DOH may periodically require revisions to the Operations Plan. This may include, but is not limited to, revisions based on findings from site inspections that are deemed necessary by the DOH. Any changes to the Operations Plan require approval from the DOH. Depending on the scope of the change, a permit modification may also be required. If there are discrepancies between the Operations Plan and these permit conditions or HAR 11-58.1, the permit conditions or rules shall take precedence.

10. **User Population.** The permittee shall maintain a list of the types of users for operator reference and regulatory review. If the user population changes, the permittee shall

submit a written update of such change. The written update shall propose adjustments to the waste screening and review process, as appropriate to respond to the changes in the user population.

11. **Mud Prevention Program**. The permittee shall provide measures for minimizing the tracking of mud onto public roads from the site. The measures shall include on-site road maintenance and cleaning, a wet-weather disposal area, and a truck or truck wheel cleaning area for vehicles prior to leaving the site. Possible truck or truck wheel cleaning measures that may be implemented include: rumble strip, drive-through tire wash, trash clean out pad, and/or wash pad.

12. **Dust Control Program.** The permittee shall provide measures to control dust from roads and all other areas of the site. The measures shall include road treatments and water sprays to minimize dust generation. Open areas of the landfill that are not to receive waste for a one-year period or more shall be further treated to minimize dust generation and erosion.

13. **Soil Cover Stockpile** stored within the landfill waste footprint shall be limited to a 30-day capacity and shall include stormwater controls. Cover material stored on the MSW landfill shall be placed on top of at least 12 inches of intermediate cover and shall not impede surface water flow. Storage of gravel for roads/wet weather and landfill equipment on the MSW landfill shall also be placed atop at least 12 inches of intermediate cover and shall not impede surface water flow. If the daily cover soil to be stockpiled exceeds unrestricted use EALs, placement of the stockpile should be limited near the workface, where stormwater from the stockpile area will not enter the stormwater system or soil will not disperse from the workface area and onto intermediate cover areas.

14. **Daily Cover** shall be a minimum of six inches of earthen material or an alternative in accordance with HAR 11-58.1-15(b), with no exposed waste. Aggregate size shall be less than 2.5 inches and well-graded (having the representation of all particle sizes less than the specified maximum). Two types of Alternative Daily Cover (ADC) materials have been approved. As specified in your demonstration report, the permittee may implement the following alternatives:

    a. Greenwaste Mulch. Greenwaste mulch shall be less than 6 inches in size, and shall only be used on an active working face that will receive waste on the following day. The top deck and side slope not receiving additional waste shall be covered with soil. The material shall achieve a minimum compacted cover thickness of 10 inches, but shall not exceed 12 inches. This ADC shall not be used in wet weather, or under high wind conditions. Mulch, if stored on the landfill, shall consist of no more than one-week's volume, and shall be stored on

12 inches of intermediate cover in windrows no higher than five feet high and no wider than 12 feet at the base to reduce the potential for fire. Mulch windrows shall be routinely monitored for fire potential and turned as necessary.

b. Compost Rejects. Compost rejects that are larger than the acceptable size for compost (greater than 3/8-inch) may be used as an ADC only on the active work face that will receive waste on the following day. The material shall achieve a minimum compacted cover thickness of 10 inches, but shall not exceed 12 inches. This material shall meet the compost requirements in 40 CFR Part 503 before use. Compost rejects shall not be used in wet weather. Compost rejects shall not be stored at the landfill and shall be transported at the time of daily cover placement.

15. The permittee may submit a written proposal to request the use of an ADC, comprised of alternative materials of an alternative thickness (other than at least six inches of earthen material). Request for the use of additional ADC materials as cover shall be submitted in writing to the DOH at the address listed in Special Conditions II.I.1.

    a. The request shall evaluate the proposed ADC to its specific characteristics and its appropriate use at the facility.
    b. The permittee shall obtain DOH approval prior to commencement of the demonstration project.
    c. The DOH requires demonstration periods in 6-month increments to show that the ADC and its proposed thickness can control disease vectors, fires, odors, nuisance, litter and scavenging without presenting a threat to human health and the environment.
    d. The use of ADC is limited to daily cover use.
    e. The demonstration period shall include oversight by the DOH and at the end of increment period, the permittee shall report the performance of the ADC as to its specific characteristics and appropriate use at the facility.
    f. The permittee shall obtain DOH approval, in writing, prior to commencement of continued use of ADC beyond the demonstration period. The DOH may impose conditions on the use of ADC. Those conditions shall become part of this permit.
    g. The demonstration period or the approved use of an ADC may be rescinded or cancelled by either the DOH or permittee at any time without cause.

16. **Daily Cover-Monitoring-Verification-Program with Recordkeeping**. The permittee, using appropriate personnel shall take digital photos of the workface at the middle of each workday and at the end of each workday, from the same perspective, to demonstrate adequate placement of daily cover. The photos shall be transmitted to the DOH's landfill inspector via email on a daily basis within 12 hours with cell location information. The photos shall be maintained on file at the facility and certified as to its

authenticity by the appropriate personnel. The DOH may require changes to the program at any time including the use of independent third parties.

The Daily Cover Monitoring Verification Program shall include quantitative records of daily waste disposed, approximate cell dimensions and daily soil cover and/or ADC used in tons and cubic yards.

17. **Intermediate cover** is required for all inactive waste areas. Inactive waste areas are areas that do not receive waste within a 30-day period. Intermediate cover shall be a minimum of 12 inches of earthen material including daily cover, and be capable of shedding and directing stormwater to conveyance systems and withstanding traffic. Regardless of the time period since last receiving waste, all areas that have vehicular traffic shall be covered with intermediate cover.

    Intermediate cover shall be maintained on a regular basis including repairs by September 1 of each year for erosion and cracking. Recordkeeping of annual repairs shall be in accordance with Special Conditions II.E.2a. All intermediate slopes and top deck that are not to receive waste for a 1-year period shall be vegetated or have an equivalent plan to minimize infiltration and prevent dust and erosion. Intermediate cover shall shed and direct stormwater to conveyance systems.

    Soil used for intermediate cover shall meet DOH EALs for residential/unrestricted use.

18. **Disease Vector Control.** The permittee shall provide measures to evaluate, prevent and/or control on-site populations of disease vectors and minimize nuisance conditions, and document any associated activities. At a minimum, such measures shall be taken on a monthly basis and shall be implemented as discussed in the Operations Plan. The measures shall meet the requirements of HAR 11-58.1-15(c).

19. **Litter Control.** The permittee shall provide measures to minimize free litter in the landfill and prevent its occurrence beyond the property line of the facility. All windblown material on the primary litter fences shall be collected and be properly disposed of by the end of the workday. The measures, at a minimum, shall include:

    a. The use of portable litter screens which shall be deployed within 100 yards of the active workface.
    b. The use of permanent or semi-permanent litter screens or fences in primary and secondary control positions.
    c. Litter cleanup in the event of a major windstorm or other incident in which litter escapes the normal litter containment systems.

   d. Provisions for a truck clean-out area near the active workface that shall be maintained on a daily basis. The truck clean-out area shall have litter control fencing and disposal receptacles for truck clean-out.
   e. The collection of litter shall be quantified with the number of litter pickers and the number of bags of litter collected on a daily basis.

20. **Asbestos Disposal.** The permittee shall ensure that the disposal of asbestos waste is in accordance with current NESHAP (National Emission Standards for Hazardous Air Pollutants) regulations, 40 CFR Part 61. Asbestos disposals shall be immediately covered on a daily basis with a minimum of 2 feet of cover unless managed in a dedicated disposal area. Disposals in dedicated disposal area shall be identified to the public and covered daily. All disposal locations for asbestos shall be recorded by GPS (global positioning system) for future reference.

21. **Odor Control**. The permittee shall implement procedures for identifying odorous waste received at the landfill, and implement odor control procedures and/or mechanisms to control odor at the landfill. Odor control measures include acceptance standards for the receipt of waste, special handling at the landfill and immediate burial under a minimum of 2 feet of compacted soil. If the selected mechanisms are not adequate, the DOH may require that additional measures be taken.

22. **Dead Animals and Offal**. The permittee shall immediately place a minimum of two feet of compacted soil over any accepted dead animals, offal or odorous waste. The cover soil shall be compacted and be of sufficient thickness (2 feet minimum) to control the release of odors.

23. **Inclement Weather**. A wet weather deck shall be prepared to allow for safe disposal of waste during times of inclement weather.

24. The permittee shall stop accepting waste when the landfill has reached its design capacity or is terminated by any land use permits, whichever comes first, and begin closure actions as delineated in Special Conditions II.H.

25. The permittee shall install and maintain grade survey control markers in sufficient number to demonstrate compliance with final permitted grades when the active phases near disposal capacity.

Section E. Surface Water Management

1. **Surface Water Management**. At a minimum, the permittee shall:

   a. Provide run-on control to prevent flow onto the active portion during peak discharge from a twenty-five-year storm, and run-off control from a twenty-five year 24-hour storm, as provided in HAR 11-58.1-15(g).

   b. Prevent soil erosion and exposure of waste. Surface water that comes into contact with waste material shall be managed as leachate. Should waste become exposed or soil cover materials erode, the permittee shall repair the cover immediately.

   c. Prevent a discharge of pollutants into waters of the United States, or the violation of any requirement of the Clean Water Act or statewide water quality management plan, Title 11 Chapter 54.

   d. Comply with all state and federal requirements related to water quality, as provided in HAR 11-58.1-15(h).

2. **A Surface Water Management Plan** shall be prepared and updated **annually** and filed with the DOH no later than September 1 of each year. The surface water plan shall include the surface water management of all areas in the Central Maui Landfill. It shall contain the following information:

   a. Report of an annual inspection of surface water management features and facilities, together with a description of required maintenance and changes, which shall be completed by September 1 of each year.
   b. Updated drawings showing current topography of the landfill, surface water drainage paths and conveyances, and drainage system modifications planned for the next year in response to waste filling.
   c. All areas with intermediate cover shall be graded to direct surface water away from the workface and towards the surface water collection system.
   d. Engineering calculations documenting the capability of the surface water management system to comply with the run-on and run-off requirements listed under Special Conditions II Section E, Item 1.
   e. Any Storm Water Pollution Prevention Plan or Spill Prevention Control and Countermeasure Plan prepared pursuant to federal requirements under the Clean Water Act.

3. The permittee shall ensure that appropriate drainage as well as static and seismic stability is provided in the landfill design. Based on the submitted design and analysis,

top deck areas of the landfill will have minimum slopes of 2% to 5% to promote drainage. Interim side-slope grades will not exceed 2 horizontal to 1 vertical. Final side slope grades will not exceed 2.5 horizontal to 1 vertical.

4. Stockpiled materials within the landfill waste boundary shall be limited to cover material, and gravel for roads/wet weather pad. The volume of stockpiled soil and gravel shall not exceed a limit of 30 days' capacity and have stormwater controls. Stockpiled soil and gravel shall not exceed permit grades.

Section F. Perimeter Gas Management

1. The permittee shall implement the Perimeter Landfill Gas Management Monitoring Plan for all phases (I, II, IV, V, and V-B Ext) of the landfill, revised August 2012 by A-Mehr, Inc., and approved subsequent revisions. The DOH may periodically require revisions to the new revised plan. The program shall be conducted in accordance with HAR 11-58.1-15(d) and these permit conditions:
   a. The permittee shall monitor the concentration at depths that will minimize the infiltration of and dilution from atmospheric air.
   b. The permittee shall minimize the amount of time that the probe is open prior to recording the gas concentrations.

2. The permittee shall monitor the concentration of gases, including oxygen, methane and carbon dioxide. The permittee shall monitor the concentration of gases in facility structures, including temporary structures, and at the property boundary on a quarterly basis, or other frequency as approved by the DOH. If an exceedance is identified, the permittee may conduct a verification-monitoring event, provided that the verification monitoring is conducted within one (1) hour of the initially detected exceedance. If exceedances or other anomalous condition is identified, the DOH may increase the frequency of monitoring events.
   a. The concentration of methane gas shall not exceed 25% of the lower explosive limit (LEL) for methane in facility structures.
   b. The concentration of methane gas shall not exceed the LEL for methane at the facility property boundary.

3. The permittee shall inspect and maintain the gas monitoring probes. In the event that a probe is unusable, the permittee shall repair the probe or install a new probe prior to the next monitoring event.

a. If the probe is repaired, submit documentation to the DOH indicating the reason for repair, type of repairs completed, and evaluations performed to ensure the probe is acceptable for use.

b. If the probe is replaced:
   - i. The permittee shall update the Perimeter Gas Monitoring Plan to show the new probe location and identification number within thirty (30) days. The update shall also document the reason for replacing the probe.
   - ii. The permittee shall submit an installation report for the new probe within thirty (30) days of completion. The installation report shall include the information specified in Special Conditions II.F.1.
   - iii. The permittee shall abandon the unusable probe, and submit associated documentation.

4. The permittee shall ensure that the field meters are factory calibrated in accordance with manufacturer's specifications. The permittee shall also field calibrate the meters prior to each monitoring event in accordance with the manufacturer's recommendations. The permittee shall conduct monitoring events only with equipment that has been properly calibrated and maintained.

5. The permittee shall submit a report with results within 45 days of each monitoring event. The results shall include the date and time, gas concentrations by volume, barometric pressure, site conditions, name of personnel conducting the monitoring, description of equipment and calibration results, description of monitoring procedure, and identification of any procedures or observations outside of normal conditions.

6. If verification monitoring performed within one (1) hour of the initial exceedance shows concentrations below the limits in Special Conditions II, Section F, Item 2, the permittee shall place results in the operating record and send written notification of the exceedance and verification monitoring results to the DOH within seven (7) days.

7. If combustible gas concentrations exceed the limits in Special Conditions II, Section F, Item 2, and verification monitoring is not performed within one (1) hour of the initial exceedance or verification monitoring confirms the initial exceedance, the permittee shall perform the following.

   a. Immediately take all necessary steps to ensure protection of human health.
   b. Immediately notify the DOH of the exceedance.
   c. Within three (3) days of detection, place in the operating record and submit to the DOH, the type of gas, gas levels detected and a description of the steps taken to protect human health.
   d. Within sixty (60) days of detection, prepare and implement a remediation plan for the combustible gas releases, place a copy of the plan in the operating record,

provide a copy of the plan to the DOH, and notify the DOH that the plan has been implemented.

e. Within thirty (30) days after the remediation plan has been completed, submit a report to the DOH documenting the actions taken, additional monitoring results, and plans to prevent future recurrences.

f. The DOH may modify the reporting and implementation schedule, as necessary to protect human health and the environment.

Section G. Groundwater and Leachate Management

1. If not already submitted by the issuance date of this permit, the permittee shall submit a new Groundwater and Leachate Monitoring Plan within ninety (90) days from the issuance date of this permit. At a minimum, the plan shall discuss the new sump at Phase V-B Ext and the additional groundwater monitoring wells, and comply with HAR 11-58.1-16. The permittee shall implement the existing Groundwater and Leachate Monitoring Plan, dated 2012 by A-Mehr, Inc., as subsequently amended and approved by the DOH for Phases I, II, IV and V of the landfill until the DOH has approved the new revised plan. The DOH may periodically require revisions to the new revised plan.

2. By January 1, 2019, the permittee shall install monitoring wells (MW) 7, 8, and 9 in accordance with the *Site Map* by A-Mehr, Inc. on sheet 1 in the February 2017 Phase V-B Ext permit application, and install MW-10 as recommended by the 2016 Conceptual Site Model *Figure 8 Groundwater Monitoring Well Network* by CH2M Hill prepared February 2016, or as otherwise approved by the DOH. The exact number, and installation location of the wells shall be submitted to the DOH for review and approval prior to construction.

3. Within thirty (30) days of installation of MW-7, 8, 9, and 10, and approved future wells, submit a Well Completion Report for each of the wells, describing subsurface condition, well design, and installation activities, and including as-built drawings (with depths and elevations of all pertinent components of the well, such as top of casing, total depth of well, screened interval, groundwater elevation, and pump intake placement) and locations. Upon well completion, the permittee shall incorporate wells into the groundwater monitoring program.

4. The permittee shall submit a detailed CQA plan, complete with specifications and design drawings to the DOH thirty (30) days prior to the construction and extension of the Phase V-B Ext leachate sump riser pipe. At a minimum, the permittee shall install additional pipes to the riser at the Phase V-B Ext sump as the surrounding waste fill increases in height as depicted in the 'Leachate Sump Detail' drawing on sheet 15 in the 2017 Phase V-B Ext permit application, as prepared in January 2017 by A-Mehr, Inc.

Soil fill shall be placed and compacted around the extended riser pipe such that it does not damage the sump or any of the associated components.

5. The permittee shall also submit a CQA report that is prepared by a professional engineer with the requirements listed in Special Conditions II.B.9 for the Phase V-B Ext sump riser at least thirty (30) days following the construction of each riser extension. The CQA report shall contain, at a minimum:

   a. Documentation and description of any temporary stormwater control measures implemented.
   b. Documentation and as-built drawings for installation, and extension for the Phase V-B Ext Leachate Sump riser pipe with a summary of materials used, the length of pipe used in the extension, compaction results, and surveyed elevation grades. The elevation grades shall be measured at (1) the top of the riser pipe after extension or modification, and (2) the surrounding soil fill that is placed around the riser until construction is complete and final grade has been achieved.
   c. Documentation to show that the extended risers have been properly installed, and the condition of previously installed riser pipes and the sump to ensure no damage has occurred.

6. The permittee shall maintain reasonable access to all groundwater monitoring stations and leachate manholes/sumps required by this permit. To assure that accurate measurements and representative samples are obtained, it shall be the responsibility of the permittee to periodically validate top of casing elevation and maintain the integrity of the monitoring stations and manholes and protect them from destruction or vandalism. If any of these stations/manholes are destroyed, the permittee shall notify the DOH immediately. The notification shall include pertinent information as to the cause, and what steps are being taken to replace the monitoring station/manhole and prevent the recurrence of such problems in the future. If the damage occurred at the leachate manhole/sump, an assessment as to the damage to the leachate collection and containment system shall also be performed and provided to the DOH. If repairs are required, the DOH shall have an opportunity to review and approve the proposed repairs. A Manhole/Well Completion Report shall be sent to the DOH within thirty (30) days of any new or repaired leachate manhole/sump or groundwater well construction.

7. Leachate Management. The permittee shall implement leachate management measures as provided in the Operations Plan including the following:

   a. Stormwater that comes in contact with solid waste shall be treated as leachate. Leachate shall be managed to prevent any entry into the stormwater collection system and any contact with the public.

b. Leachate shall be removed from the landfill in a manner that maintains a maximum depth of 30 centimeters (12 inches) of leachate above any part of the liner outside the sump area in Phases IV-B and V-B Ext. The IV-B sump services Phases IV-B and V. The Phase V-B Ext sump services Phases V-B Ext. The compliance level for the leachate manhole for IV-A is 207 feet above MSL to avoid overflow and maintain an acceptable leachate level within the inner tank. The compliance level for leachate in the IV-B sump is 212 feet above MSL. The compliance level for leachate in the V-B Ext Sump is 228 feet above MSL, or otherwise determined by the DOH based on as-built drawings of the liner and sump in V-B Ext. The compliance level for leachate in the Phase I and II manholes is one-foot of leachate in the manhole.

c. Leachate from IV-A manhole and IV-B sump shall be pumped to on-site storage tanks having a minimum total capacity of 30,000 gallons for temporary storage, currently consisting of eight 4,000-gallon tanks. Storage tanks shall be double lined or be located within a secondary containment structure with capacity to hold the contents of the largest storage tank. Leachate shall be removed from the storage tanks and managed in accordance with Special Conditions II.G.7.f. Leachate from Phase IV-A manhole shall be pumped via an automated pump that is triggered by a high level sensor. Leachate removal from the IV-B sump shall be through its own dedicated and automated pump and plumbing system. Leachate removal from the V-B Ext and Phases I and II will be directly into pumper trucks. The permittee shall follow the automated and/or manual fill pump procedures specified in the Operations Plan dated February 2017, or as otherwise approved by the DOH.

d. The permittee shall inspect the leachate storage tanks servicing Phase IV-A, IV-B, V-A, and V-B daily to ensure that the tanks and plumbing system are operational, and repair if leaking. At a minimum, leachate shall be pumped and removed from the tank(s) when more than 10,000 gallons are present, and removed at a rate to ensure that no more than 10,000 gallons are present at the end of each operational day. Maintain daily operational records on the inspections and maintenance of the tanks, volume of leachate in the tank, the volume of leachate removed, and disposition of leachate. Any leachate pumped and removed from Phases I and II and from Phase V-B Ext shall also be recorded as to date, volume pumped and disposition of leachate.

e. The permittee shall manage leachate removed from storage tanks or sumps in one or more of the following ways:

   i. Not more than 2,000 gallons per day may be spread at the active disposal face when the active disposal face is located above the liner system of

Phase IV-A. Leachate application shall be done by a water truck using methods that ensure leachate does not come in contact with site personnel or the public, and is only used to aid litter control and waste compaction. Leachate placement shall not promote infiltration.

ii. Leachate may be reintroduced to refuse in Phase IV-B or Phase V-A/B by spreading at the active face for litter control and aid to waste compaction, or outside the active face using vertical injection wells or infiltration trenches. Leachate shall not be recirculated and/or reintroduced in Phase V-B Ext by any means aside from using as litter control as specified in Special Condition II.G.7.e., unless approved by the DOH. Methods used for leachate reintroduction shall be approved by the DOH and shall not allow leachate to be released from the site or exposed to the public or site personnel. The automated and manual control procedures for leachate recirculation described within the Leachate Management Section of the Operations Plan dated May 2017 shall be implemented, unless otherwise approved by the DOH.

iii. Leachate may be transported to a public wastewater treatment facility. Permittee shall maintain a list of one or more qualified and properly licensed third-party contractors to remove and transport leachate from the temporary storage tanks or directly from the leachate sumps, to supplement any leachate transport capability of the permittee. The combined pumping and transport capability of the permittee and contractors shall be not less than 20,000 gallons per day.

f. The permittee shall maintain daily records of leachate monitoring and pumping and management activities, and shall report results in the Annual Operating Report as provided in Special Conditions II.I.2.e.

8. Leachate Monitoring. Leachate levels shall be monitored to ensure compliance with the leachate levels specified in Special Conditions II.G.7.b. The levels of leachate shall be measured and recorded as follows or as otherwise approved by the DOH:

a. Closed landfill Phases I and II (according to the county, only Manhole 4 remains accessible): Minimum once per week.
b. Phase IV-A Leachate Manhole: Minimum once per week.
c. Phase IV-B Leachate Sump: Minimum once per week.
d. Phase V-B Ext Sump: Minimum once per operational day, and after rain events until the select waste layer has been completely installed; minimum two (2) times per week thereafter. Based on data, the DOH may revise the monitoring frequency.

e. All leachate collection points shall be monitored after storm events.

f. If an exceedance occurs, leachate level measurements shall be performed before and after leachate pumping on a daily basis until the level has remained within the allowable limit for a period of one week.

g. All monitoring activities and measured levels shall be recorded and maintained by the permittee.

Leachate and Groundwater Sampling

9. All groundwater and leachate analyses shall be submitted to the DOH within 45 days of sampling and analysis.

10. A sample of leachate shall be collected from each collection point or sump on a minimum semi-annual basis for constituent analysis, or as otherwise approved by the DOH. Leachate samples shall be analyzed for parameters listed in 40 CFR Part 258, Appendix II and major leachate indicators including cations/anions per the Hawaii Landfill Groundwater Monitoring Guidance Document, unless an alternate parameter list has been approved by the DOH.

11. Groundwater sampling for all monitoring wells shall be performed on a quarterly basis unless otherwise approved by the DOH.

12. The permittee shall measure groundwater elevations from each monitoring well prior groundwater sampling and within a reasonable time period in order to estimate groundwater flow direction.

13. The permittee shall sample and analyze groundwater in accordance with the Groundwater and Leachate Monitoring Plan, dated 2012 by A-Mehr, Inc., approved subsequent revisions, and requirements of HAR 1-58.1-16 unless an alternate detection parameter program has been approved by the DOH. The permittee shall request and receive approval from the DOH before implementing any changes to the groundwater analyte list.

14. All sample collection, handling, management, and analysis shall be conducted in accordance with EPA SW-846, *Test Methods for Evaluating Solid Waste*.

15. Each sample shall be properly collected, identified, contained, and preserved. The name and signature of the person who collected the sample shall be included in the records. A chain of custody shall be maintained from the time of sample collection through the final analysis and disposition.

16. Sample analysis shall be conducted by an independent third party with appropriate credentials and performed at the expense of the permittee.

17. The permittee shall provide statistical analysis and documentation in each groundwater and leachate report that adequately supports each assumption, position, and/or conclusion. This shall include, but is not limited to:

    a. Step-by-step methodology for determining and/or updating baseline statistics.
    b. Methodology and statistical data for evaluating monitoring data.
    c. Methodology and historical analysis for determining trends or spikes.
    d. Methodology and statistical data for describing changes or additions to the parameter monitoring list.

18. The permittee shall compare and provide a detailed description of the results obtained from both leachate and groundwater analyses to determine if there is a correlation that may indicate issues with leachate infiltrating into the groundwater, or if these results are independent.

Section H. Closure and Post-Closure

1. The permittee shall maintain and implement the Closure and Post-Closure Plan dated October 2008 and revised February 2017 for all phases unless otherwise approved by the DOH or required by HAR Chapter 11-58.1, and these permit conditions. Should there be discrepancies between these documents, the HAR and these conditions will take precedence.

2. At a minimum, the Closure and Post-Closure Plan and the Financial Assurance report shall be revised every five (5) years or earlier if facility plans are updated and/or changed. This is not withstanding the requirement to make adjustments for inflation on an annual basis. Revisions to the plan shall be prepared in accordance with HAR 11-58.1-17, "Closure and Post-Closure Care," and HAR 11-58.1-18, "Financial Assurance." The Closure Plan and all revisions shall be prepared and certified by a professional engineer, with at least five (5) years' experience in designing landfills, and registered in the state of Hawaii. The Closure Plan shall identify all buffer areas.

3. Two years prior to the final receipt of waste at the facility, the permittee shall submit a final closure and post-closure plan, prepared by a professional engineer registered in the state of Hawaii. The final closure plan shall contain detailed engineering drawings, plans and specifications for construction of closure cap, surface water management improvements and other elements of final closure. The final post-closure plan shall include all maintenance and monitoring requirements based on HAR 11-58.1-17 and the

design/construction of the closure. If an alternative final cover design will be used, a test plot demonstrating compliance with regulations may be required.

4. The permittee shall begin closure activities within 30 days after the date on which the facility receives the known final receipt of waste, unless the DOH grants an extension of time pursuant to HAR 11.58.1-17(a)(6). Closure activities shall be completed within

   180 days following the beginning of closure unless the DOH grants an extension of time pursuant to HAR 11.58.1-17(a)(7).

5. The permittee shall retain a professional engineer registered in the state of Hawaii for the supervision of the closure construction, and upon the completion, the engineer shall submit a summary report to the DOH as to the complete conformity to the plans and specifications as approved. This summary report shall be submitted within 60 days after closure activities are completed. The summary report shall include a documented control program of the closure cap construction, and the quality assurance/quality control testing procedures, laboratory analyses, and engineer's certification of construction and conformity to the approved designs and to HAR Chapter 11-58.1-17.

6. Following completion of any closure construction, the permittee shall submit a copy of the notation on the deed to the landfill property in accordance with HAR 11-58.1-17; and implement post-closure care as provided in the approved post-closure plan in accordance with HAR 11-58.1-17. The DOH may periodically require revisions to the plan.

7. The permittee shall maintain and submit evidence that HAR 11-58.1-18, Financial Assurance, is satisfied on an annual basis.

Section I. Recordkeeping and Reporting

1. By July 31 of each year, the permittee shall submit an AOR, using June 30 of each year as the year-end to:

   Solid and Hazardous Waste Branch
   Environmental Management Division
   Hawaii Department of Health
   P.O. Box 3378
   Honolulu, Hawaii 96801-3378
   Fax No. (808) 586-7509

2. The AOR shall include the following information:

   a. Types of solid waste received (MSW, greenwaste, industrial/commercial, tires, wood, metals, containers of 20 gallons or larger capacity, asbestos, and other special wastes).
   b. Quantities of solid wastes received by type with totals using an appropriate unit of measure.
   c. The average daily disposal rate on a yearly basis.
   d. Quantities of semi-solid liquid waste (tons) received and how it is handled or disposed.
   e. Quantities of leachate (gallons) generated and how it was handled or disposed. If requested by the DOH, the permittee shall also provide water balance estimates of leachate generation using the most recent EPA HELP model using climatic information collected in accordance with Special Conditions II.I.4. Annual rain data for the site on a daily basis shall be provided with this analysis.
   f. Volume of airspace filled during the reporting year, airspace filled during previous years, and airspace remaining in each phase in both cubic yards and years shall be provided. The information shall be provided in both numerical and graphical presentations.
   g. An annual topographic survey and an isopach drawing (depicting the vertical difference between the permitted final grades and existing site elevations) of the site as prepared by a land surveyor registered in the state of Hawaii or an approved alternate method. Any exceedance of permit grades shall be identified and the DOH shall be notified by the use of a Non-Compliance Report. This survey shall clearly show the horizontal and vertical dimensions of the landfill area.
   h. A Sequencing Plan, including a drawing, identifying the cell areas to be filled in the coming year including identification of the wet weather areas. The cell areas and wet weather area capacity shall be provided using an appropriate unit of measure.
   i. Final fill areas, intermediate fill areas, and future unused fill areas shall be identified for the projected year.
   j. A soil-balance report of the past year and coming projected year reported separately. The soil daily cover and intermediate cover including erosion replacement soil shall be reported separately. The source and type of soil shall be recorded separately for daily cover and intermediate cover. The soil-balance report for the past year shall be based on records of actual use in a daily, weekly and monthly basis. Any incomplete/non-application of daily cover shall be identified. Current soil use records shall be maintained at the facility for review.
   k. After closure of any portion of the landfill, a summary of post-closure care and maintenance activities conducted at the closed landfill phases.

l. A copy of the detailed written estimates and documentation of financial assurance.
m. If the remaining disposal capacity for the facility is less than 10 years, as described in 2(f) of this section, the AOR shall include an updated timeline to acquire property, submit design and solid waste application, and start and complete construction of planned future expansions.

3. **Recordkeeping Requirements.** The permittee shall maintain records in accordance with HAR 11-58.1-15(j), Standard Conditions, Item 11, and the conditions of this permit. Records shall include the following list and any other recordkeeping requirements set forth in this permit:

a. Impact buffer area identification within operations plan drawings (Special Conditions II, Section A, Item 3)
b. Load Check Data Sheet (Special Conditions II, Section C Item 2g)
c. Daily log of unacceptable waste (Special Conditions II, Section C Item 3c)
d. Radiation Monitoring Report (Special Conditions II, Section C Item 4)
e. Special Waste Acceptance Program records (Special Conditions II, Section C Item 5b and 5d)
f. Training records (Special Conditions II, Section D Item 6 and 7)
g. Daily Cover-Monitoring-Verification-Program (Special Conditions II, Section D Item 16)
h. Litter control (Special Conditions II, Section D Item 19e)
i. Asbestos disposal locations (Special Conditions II, Section D Item 20)
j. Annual surface water management plan (Special Conditions II, Section E Item 2)
k. Landfill gas monitoring records (Special Conditions II, Section F Item 1)
l. Leachate monitoring records (Special Conditions II, Section G Items 7d, 7f, and 8)
m. Financial assurance requirements (Special Conditions II, Section H Item 7)
n. Climatic information (Special Conditions II, Section I Item 4)

4. **Climatic Information.** Climate information shall be collected on a daily basis and shall include information on rainfall, solar radiation, evaporation, wind speed and direction, humidity, temperature, and other applicable meteorological data, as applicable, for use in modeling evapotranspiration and leachate generation with the HELP Model at the landfill and evaluating litter/odor control. The permittee shall also monitor and record daily wind speed and direction at the active workface of the MSW landfill. The permittee shall minimize any weather equipment downtimes. In the event that the equipment is not operational, the permittee shall maintain a record of the affected date(s), reason, and actions taken. Data shall be provided to the DOH upon request.

SPECIAL CONDITIONS III: ENTRANCE FACILITY—WASTE TRANSFER AND RECYCLING OPERATIONS

1. The entrance facility may only accept, store, and transport household and commercial waste as defined in HAR §11-58.1-03, for disposal. Commercial loads are limited to vehicles that require manual unloading of waste. The entrance facility may accept and temporary store select household-generated recyclables and special waste for recycling, as identified under Special Conditions III, Items 6 and 7. Industrial waste, construction & demolition waste, and waste identified under Special Conditions III, Items 2 and 3 shall not be accepted at the entrance facility. The operations of the facility shall be in accordance with the Central Maui Landfill Entrance Facility Operations Plan revised May 2017, and approved subsequent submissions, unless otherwise specified in these permit conditions.

2. No regulated hazardous waste as defined in state hazardous waste regulations, and PCB waste as defined in 40 CFR Part 761 shall be accepted at the entrance facility.

3. No infectious waste from commercial sources as defined by HAR Chapter 11-104.1, shall be accepted at the entrance facility.

4. The permittee shall implement a screening program at the entrance to ensure that only acceptable solid wastes enter the entrance facility. If the entrance facility inadvertently accepts unacceptable wastes or receives unacceptable wastes at the landfill disposal area of Central Maui Landfill, the permittee shall properly manage and dispose of the unacceptable materials, in accordance with applicable federal, state, and local laws and regulations prior to causing a nuisance, health or environmental threat.

5. Household and commercial waste for disposal from incoming vehicles shall be unloaded directly into the roll-off containers at the self-haul disposal bays. Commercial vehicles shall be screened in accordance with the screening program described in Special Conditions III, Item 4 before offloading. Roll-off containers shall be switched with empty ones when they are filled and shall be transported to the landfill. Household and commercial waste shall not be stored in roll-off containers for period exceeding 24 hours, except roll-off containers that are not full by the end of Saturday's operation may be stored for longer than 24 hours provided containers are appropriately covered (such as before an expected rain event), and runoff is collected and treated as leachate—to prevent vectors, odors, litter, and other nuisances.

6. Acceptance of household-generated source-separated waste materials for recycling shall be limited to fiber materials (including cardboard, newspaper, and paper bags), plastic bottles and bags, glass containers, metal (aluminum, bi-metal, and steel) containers, and scrap metals unless otherwise specified under Special Conditions III,

Item 7. The accepted materials listed in this condition shall be free of fluids and/or contaminants that may cause harm to human health or the environment (i.e., paints, oils, solvents, etc.). Leaded glass such as lead crystals shall not be accepted. The accepted materials for recycling shall be stored in a safe and orderly manner in the designated drop-off containers indicated in the site plan in Figure 2A of the Entrance Operations Manual submitted May 16, 2017, and transported to DOH-permitted recycling facilities. Measures shall be taken to control windblown litter, insects, odors, and vectors.

7. The permittee may accept additional types of recyclable materials, if an updated site plan and operation plan addressing nuisance controls, storage method and location, site holding capacity, removal frequency is submitted and approved by the DOH prior to accepting additional recyclables. Upon approval of the updated site plan and operation plan, the plan shall become part of this permit. The DOH may impose additional conditions for this added activity.

8. Acceptance of special waste shall be limited to used motor oil, scrap tires, white goods, and batteries, from residential sources. The special waste shall be stored in a safe and orderly manner at the designated areas/containers indicated in the site plan in Figure 2A of the Entrance Operations Manual submitted May 16, 2017, and transported to DOH-permitted/approved facilities before creating a nuisance, health, safety, or environmental hazard. Measures shall be taken to prevent and respond to fires, and to control nuisance and environmental impact (spills, leaks, and emissions).

   a. Used motor oil collection, storage, transport, and recordkeeping should be managed in accordance with HAR §11-279, *Standards for The Management of Used Oil*. In accordance with the Entrance Facility Operations Plan, revised May 2017, used motor oil will be stored in a locked shipping container.

   b. The permittee shall comply with the tire disposal requirements specified under HRS 342 I for Used Motor Vehicle Tire Recovery. Tire storage must be free of all contaminants such as oil, grease, gasoline, diesel, etc. that could create fire hazards. Tires must be stored in a manner so that they minimize the accumulation of water and creation of a vector problem. Tires shall only be transported to a DOH-permitted recycling or tire processing facility, or out of state recycling facility.

   c. White goods that enter the facility shall be unloaded properly, stored in an upright position at the designated area, and transported to a permitted facility for refrigerant removal and processing. Refrigerant containing items shall not be pushed into a scrap metal roll-off container unless refrigerant is removed and verified by an EPA certified personnel. Measures shall be taken to prevent the release of CFCs from refrigerant containing items into the atmosphere during storage and transport. Federal regulations prohibit venting of CFCs into the atmosphere.

d. Batteries shall be placed in a locked, covered, leak-proof container. The permittee shall comply with the disposal, collection, and recycling requirements specified under HRS 342I Lead Acid Battery Recycling. Releases that occur shall be removed immediately and disposed of accordingly. Cracked or leaking batteries must be containerized and managed separately, in accordance with applicable regulations. Battery storage shall be limited to the floor in the container and shall be removed from the site, at least on a monthly basis.

9. If special waste requires processing at the site, such as refrigerant removal and mercury switch and/or mercury thermostat removal from the white goods, an operations plan for special waste processing shall be submitted for DOH review and approval, at least 60 days prior to processing. Upon approval of the revised plan, the plan shall become part of this permit. Depending on the nature of the processing, a permit modification may be required.

10. The maximum storage capacity for collected household waste, recyclable materials, and special waste is as follows:

    a. MSW for disposal: Five 20-cubic yard roll-offs (in use) in the self-haul disposal bays only
    b. Recyclables: Four 20-cubic yard roll-offs or compactors below grade
    Five 20-cubic yard roll-offs at grade
    c. Special Waste:
        i. White goods: 25 pieces in the designated area
        ii. Used oil: Eight 55-gallon drums in the designated area
        iii. Used tires: One 20-cubic yard roll-off container below grade
        iv. Batteries: One 20-cubic yard container

11. An all-weather access road shall be maintained into and within the entrance facility.

12. The facility shall be supervised, secured, and have a permanent sign posted at the facility entrance identifying the facility, the name and address of the operator, a contact in case of an emergency, the hours and days of operation, and the waste accepted or not accepted.

13. Scavenging at the facility by the general public is prohibited.

14. Adequate measures shall be prepared to prevent standing water, and to control stormwater run-on and run-off.

15. Adequate measures shall be implemented to collect generated leachate. Any collected leachate shall be properly managed and disposed of prior to creating a nuisance, health or environmental threat. Records shall be maintained as to the quantity and management of all collected leachates.

16. Suitable means shall be provided to prevent and control fires, including the implementation of Fire Prevention and Control Plan and Hazardous Material Spill Response Plan. All incidents shall be reported to the DOH and records of incidents shall be maintained for five (5) years.

17. Suitable means shall be provided to prevent solid waste from scattering; control litter, odors, insects, and vectors; and minimize nuisance conditions.

18. All solid waste passing through this facility shall be collected, treated, recycled, or disposed of at a permitted solid waste management disposal and/or recycling facility.

19. Operational records shall be maintained and shall include a daily log of type and volume of solid waste received, waste screening, waste transported, and the disposal/recycling destination of the solid waste.

20. An annual report shall be prepared and submitted to the DOH reviewing the past year's operations and detailing the total tonnage of each type of material collected at the entrance facility, processed, recycled, transferred, and disposed from the previous fiscal year (July 1 to June 30) by July 31 of each year using the address provided in Special Conditions II, Section I, Item 1. The report shall also include a summary of incidents outside of normal operations.

    The permittee may choose to submit a separate annual report for the entrance facility, or combine with the annual report requirements listed in Special Condition II, Section I.

21. The annual report for the entrance facility shall include the following information:

    a. Quantities of solid waste received by type including destination for disposal.
    b. Quantities (in gallons) of liquid waste (leachate) generated and method of management disposal.
    c. Quantities of materials recycled from the waste stream by type and destination.

    An estimate in gross values of tons, cubic yards, or quantity count, as appropriate, is sufficient.

22. The permittee shall comply with the recordkeeping requirements relating to used motor vehicle tires as provided under HRS Chapter 342 I. The statute requires facilities that

accept used tires to submit a summary of the following information by July 31 of each year:

a. date of receipt of used tires;
b. quantity of used tires received; and
c. record of shipment indicating:
    i. ultimate destination of the used tires;
    ii. identification of the transporter;
    iii. date of shipment; and
    iv. quantity of tires shipped.

23. If the permittee terminates the facility operation (or faces lease termination or eviction), the permittee shall perform necessary closure activities including, but not limited to, the removal of all remaining solid waste and performing appropriate site assessments and remedial activities. The permittee shall notify the DOH in writing at least within ninety (90) calendar days prior to the facility's closure [HAR §11-58. 1-04(e)(3)J. The written notification shall include an updated closure plan, which should accomplish the following objectives:

a. Provide an assessment of the site's present and future threat to public health and the environment due to contaminants possibly left on-site from the facility's operation.
b. Provide a plan of action to minimize or mitigate any threats to public health and the environment due to contaminants possibly left on-site by the facility's operation.
c. Provide a schedule to implement the plan of action.

Upon DOH approval of the closure plan, the permittee shall implement the plan in accordance with the approved implementation schedule.

Appendix D
Leachate Data

Appendix D
Leachate Concentrations from Phase IV-A and Phase IV-B Collection Points

	PHASE IV-A																	
Date	03/24/06	07/05/06	02/27/08	03/22/10	09/28/10	03/16/11	09/28/11	03/29/12	09/25/12	03/14/13	09/25/13	03/10/14	07/29/14	03/30/15	4/19/2016	11/2/2016	6/19/2017	11/14/2017
Total Dissolved Solids (TDS)	3,100	1,870	3,160	1,988	3,402	1,800	2,800	2,600	3,400	3,300	3,070	3,290	3,598	3,100	3,500	3,800	3,700	4,308
Total Organic Carbon (TOC)	980	250	70	55.5	85.0	33	83	83	470	91	87.0	62.0	106	13	110	130	120	177
Total Alkalinity (as CaCO3)	1,020	1,450	2,300	1,540	1,216	1,400	1,700	1,800	1,800	1,800	1,897.5	1,710	1,696	1,700	1,700	1,800	2,000	187
Alkalinity - Bicarbonate (as CaCO3)	NA	NA	NA	NA	14,725	1,400	1,700	1,800	1,800	1,800	2,313.5	2,080.9	2,065.9	1,700	1,700	1,800	NA	228.4
Alkalinity - Carbonate (as CaCO3)	NA	NA	NA	NA	56.2	NA	<2.0	<20	<20	<20	<0.5	2.9	1.9	<4	<4	<4	<4	<0.5
Nitrogen, Ammonia	7.24	22.0	5.99	6.72	8.51	10.3	8.1	6.9	8.3	12	15.3	18.7	24.7	16	29	49	59	24.9
Nitrate - Nitrite	2.44	<0.25	0.987	0.48	1.23	<0.05	<0.05	<0.05	<0.05	<0.050	1.10	0.030	0.034	NA	<0.05	NA	NA	0.029
Nitrate	<0.25	<0.05	NA	NA	NA	<0.05	<0.05	<0.05	<0.05	<0.05	1.1	0.03	0.034	NA	NA	NA	NA	NA
Chlorine (Total Residual)	0.2	<2	0.16	<0.02	0.10	0.0246	0.0235	0.0580	<0.0100	0.0660	0.245	0.426	0.418	0.0960	<0.1	<0.1	<0.1	0.55
Iron	10.1	6.18	11.9	1.01	0.986	11	4.7	4.5	3.4	4	3.5	4.1	3.7	3.6	2.8	3.9	3.7	1.671
Magnesium	180	176	430	224	334	200	410	350	370	380	342	420	476	380	410	400	380	477
Sodium	339	360	634	339	639	350	590	500	610	580	574	625	679	570	680	730	650	925
Calcium	170	117	41.9	37.3	40.2	47	27	25	23	22	23.7	23.2	17.34	18	18	20	20	29.4
Potassium	53.2	62.8	32.5	21.1	30.6	24	30	25	29	28	26.9	29.8	33.8	29	43	54	52	68.9
Sulfate (SO4)	129	28.8	<200	<2	<2	1.7	1.5	<5.0	<2.5	<2.5	<2	1.68	1.24	84	<2.5	<5	<5	<1
Chloride	235	220	690	370	1,040	280	590	590	800	1,000	975	822	919	720	1,100	1,300	1,200	1,388
Acetone	208	902	42.6	<10.0	10.4	<25.0	27.9	38	18	16	<10.0	<10.0	<10.0	<10	<20	<20	<20	156
Barium	0.354	0.184	1.90	0.191	0.758	0.22	0.45	0.44	0.47	0.480	0.55	0.51	0.54	0.42	0.57	0.61	0.59	0.784
Benzene	2.35	<1	<1	<10	<1	<5	7	6	4.3	0.98	2.3	2.1	<2	3.2	<2	<2	4	3
Chromium	0.0122	<0.01	<0.01	NA	0.056	<0.005	<0.005	<0.005	<0.005	<0.005	0.018	0.025	0.038	<0.005	<0.025	<0.005	<0.005	0.004
Copper	0.0118	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	0.02	0.03	0.03	0.072	0.19	0.046	0.018	<0.05	0.012	0.011	0.016
p-Dichlorobenzene	2.49	<1.0	<1.0	<1.0	<1.0	<5.0	2.61	2.4	2.7	<2.0	2.0	<5.0	<2.0	2.4	2.2	2.0	4.8	<15
1,1-Dichlorethane	8.62	<1.0	<1.0	<1.0	<1.0	<5.0	<2.0	<2.0	<2.0	<1.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-Dichloroethane	2.00	<0.5	<0.5	0.830	<0.5	5.35	<2.0	<2.0	<2.0	<0.5	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
cis-1,2-Dichloroethylene	NA	NA	NA	NA	<1.00	<5.00	<2.00	<2.0	<2.0	<1.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	5.4	2.8
Ethylbenzene	6.13	<1.0	<1.0	<1.0	<1.0	<5.0	<2.0	<2.0	<2.0	<1.0	<2.0	<2.0	<2.0	13	<2.0	<2.0	20	ND
Lead	0.00533	<0.005	<0.05	<0.001	<0.01	<0.005	0.02	0.0053	0.005	0.0073	<0.01	<0.01	<0.011	<0.005	<0.03	<0.005	<0.005	0.001
Methyl Ethyl Ketone (MEK or 2-Butanone)	467	1,220	36.2	<5.0	<5.0	<25.0	<10.0	<10.0	<10.0	<10.0	<2.0	<2.0	<2.0	<10.0	<10.0	<10.0	<10.0	<10.0
Nickel	0.0184	0.0136	<0.01	<0.02	0.019	<0.01	<0.01	<0.01	0.014	0.014	0.028	0.018	0.022	0.011	0.025	0.027	0.026	0.047
Selenium	0.013	<0.01	<0.1	<0.01	<0.01	0.017	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.011	<0.01	<0.1	<0.01	<0.01	0.002
Toluene	62.8	10.4	<1.0	<1.0	<1.0	<5.0	<2.0	<2.0	<2.0	1.2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	16	3.1
Vanadium	NA	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.011	<0.01	<0.02	<0.01	<0.01	0.005
Vinyl Chloride	<0.5	<0.5	1.40	1.02	<0.5	2.36	6.18	<5.0	<5.0	2.2	5.9	2.9	<2.0	<5.0	<5.0	<5.0	<5.0	<0.2
Xylenes	33.9	<0.5	2.46	7.76	1.38	<5.0	23.80	12.00	9.00	7.90	3.20	<5.0	2.12	2.20	3.90	3.40	32	37
Zinc	0.0455	<0.02	<0.02	0.042	<0.02	<0.02	0.044	0.026	0.031	0.021	0.035	0.053	0.032	0.029	<0.04	<0.02	<0.02	0.047

Notes:

NA = not analyzed
<xx = not detected (where 'xx' indicates the reporting limit)

Appendix D

Leachate Concentrations from Phase IV-A and Phase IV-B Collection Points

	PHASE IV-B																
Date	01/22/09	12/21/09	06/23/10	12/15/10	06/21/11	12/22/11	06/19/12	12/18/12	06/20/13	12/18/13	05/14/14	12/18/14	06/30/15	11/16/15	04/19/16	11/02/16	5/9/2017
Total Dissolved Solids (TDS)	2,360	2,750	1,942	1,370	2,130	2,180	1,900	2,300	2,400	2,411	2,424	2,900	3,100	3,900	3,900	4,100	3,200
Total Organic Carbon (TOC)	29	72.5	3.6	27.0	34.0	48	35	43	48	31	49	39	74	100	94	130	100
Total Alkalinity (as CaCO3)	333	1,860	1,246	774	1,500	1,300	1,100	1,400	1,500	106.6	1,188	1,100	1,400	1,600	1,400	1,600	1,700
Alkalinity - Bicarbonate (as CaCO3)	NA	NA	1,518.6	314.4	1,500	1,300	1,100	1,400	1,500	133.7	1,446.9	1,100	1,400	1,600	1,400	1,600	1,700
Alkalinity - Carbonate (as CaCO3)	NA	NA	0.9	<2	<2.0	<2	<20	<20	<20	<0.5	1.4	<4	<4	<4	<4	<4	<4
Nitrogen, Ammonia	0.56	5.12	7.84	9.46	8.01	7.3	6.5	8.4	7.6	7.7	8.1	7.3	8.2	9.5	8.5	17	NA
Nitrate - Nitrite	0.42	0.618	0.47	0.429	NA	<0.05	0.06	<0.05	<0.05	0.61	0.034	NA	NA	<0.05	<0.005	NA	NA
Nitrate	NA	NA	NA	NA	<0.05	<0.05	0.05	<0.05	<0.05	0.61	0.034	0.033	NA	NA	NA	NA	NA
Chlorine (Total Residual)	0.05	<0.02	<0.02	0.02	0.125	0.022	0.063	0.076	0.078	0.22	0.248	0.032	0.078	<0.1	<0.1	<0.1	<0.1
Iron	3.10	0.962	2.34	3.317	14	7.8	9.7	18	23	1.7	1.9	5.6	3	4.1	6.4	4.3	4.5
Magnesium	211	341	153	88.8	190	210	190	260	220	207	224	270	290	370	330	390	290
Sodium	402	470	267	192	340	450	320	460	420	435	433	590	520	670	630	740	780
Calcium	72.1	40.2	74.4	49.5	120	120	110	130	120	92.6	92.9	96	120	130	110	130	87
Potassium	21.6	21.5	25.5	<20.0	27	36	29	34	36	34	37.9	43	43	51	49	63	57
Sulfate (SO4)	5.0	13.5	<2	30.0	0.59	<1.0	<1.0	<5	<2.5	<2	1.96	<2.5	<2.5	<100	<2.5	<5	2.6
Chloride	515	470	330	170	350	550	460	570	580	727.6	676	900	910	1,200	1,100	1,600	930
Acetone	<10.0	<10.0	<10.0	187	12	<10.0	<10.0	16	<10	<10	<10	29	<10	<20	<20	<20	<20
Barium	0.205	NA	0.118	0.079	0.274	0.2	0.18	0.24	0.25	0.16	0.199	0.23	0.24	0.31	0.28	0.37	0.32
Benzene	<1	3.73	<1.0	1.68	2	<2.0	<2.0	<2.0	0.76	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.9
Chromium	<0.1	NA	0.026	<0.02	<0.01	<0.005	<0.005	<0.005	<0.005	0.21	<0.01	<0.005	<0.005	<0.005	<0.025	<0.005	<0.005
Copper	<0.01	<0.02	<0.02	<0.02	<0.01	0.012	<0.01	0.015	0.016	0.041	0.04	0.039	0.023	<0.01	<0.05	0.041	0.022
p-Dichlorobenzene	<1.0	1.35	<1.0	<1.0	<2.0	<2.0	<2.0	<2.0	<2.0	<5.0	5.7	2.2	<2.0	<2.0	<2.0	<2.0	2.3
1,1-Dichlorethane	<1.0	<1.0	1.4	<1.0	1.6	<2.	<2.0	<2.0	1.4	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-Dichloroethane	1.28	1.3	3.84	8.58	8.8	<2.0	<2.0	5.2	7.7	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
cis-1,2-Dichloroethylene	NA	NA	4.81	8.54	<1.0	2.12	<2.0	2.6	1.6	<2.0	<2.0	<2.0	<2.0	2.6	<2.0	<2.0	<2.0
Ethylbenzene	1.67	2.62	2.82	3.52	4.8	<2.0	<2.0	<2.0	<1.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	12
Lead	<0.05	NA	<0.02	<0.02	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	<0.005	<0.005	<0.005	<0.03	<0.005	<0.005
Methyl Ethyl Ketone (MEK or 2-Butanone)	<5.0	12.5	<5.0	66.8	<10.0	<10.0	<10.0	<10.0	<10.0	<2.0	<2.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Nickel	0.016	<0.02	<0.02	<0.02	<0.01	0.011	<0.01	0.018	0.012	0.027	0.02	0.035	0.03	0.039	0.042	0.051	0.037
Selenium	<0.1	NA	<0.02	<0.02	<0.01	<0.01	0.017	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.01	<0.01
Toluene	<1.0	5.47	2.24	14	4.7	<2.0	<2.0	<2.0	<1.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	9.5
Vanadium	NA	NA	0.027	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	0.01
Vinyl Chloride	1.710	2.29	<0.5	<0.5	<5.0	<1.0	<5.0	<5.0	1	<2.0	<2.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Xylenes	3.85	12.4	<1.00	10.6	9.5	3.19	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	15
Zinc	0.021	0.057	<0.02	<0.02	<0.01	0.02	<0.02	0.024	<0.02	0.024	0.031	0.061	0.02	<0.02	<0.04	0.05	<0.02

Notes:

NA = not analyzed

<xx = not detected (where 'xx' indicates the reporting limit)

Appendix E

Calculation of Upper Prediction Limits for Central Maui Landfill Facility Groundwater Detection Monitoring

Calculation of Upper Prediction Limits for Central Maui Landfill Facility Groundwater Detection Monitoring

Prepared for

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Department of Environmental Management
Solid Waste Division

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March 2019

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Acronyms and Abbreviations

ACF	autocorrelation function
ANOVA	analysis of variance
ASTM	ASTM International
BTEX	benzene, toluene, ethylbenzene, and xylenes
$CaCO_3$	calcium carbonate
CFR	*Code of Federal Regulations*
CH2M	CH2M HILL Engineers, Inc.
CMLF	Central Maui Landfill Facility
County	County of Maui
CSM	conceptual site model
HAR	Hawaii Administrative Rules
HDOH	State of Hawaii Department of Health
HVOC	halogenated volatile organic compound
IQR	interquartile range
KM	Kaplan-Meier
MAD	median absolute deviation
MAX	maximum
MLE	maximum likelihood
MW	monitoring well
N	nitrate
NA	not applicable
PC	principal component
PCA	principal component analysis
QA/QC	quality assurance/quality control
Q-Q	quantile–quantile
RCRA	Resource Conservation and Recovery Act
RL	reporting limit
ROS	regression on order statistics
SHWB	Solid and Hazardous Waste Branch
SWFPR	site-wide false positive rate
SWMU	solid waste management unit
TDS	total dissolved solids
TOC	total organic carbon
UPL	upper prediction limit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

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1 Introduction

This document has been prepared by CH2M HILL Engineers, Inc. (CH2M), a wholly owned direct subsidiary of Jacobs,[1] for the County of Maui (County) to provide revised background values based on upper prediction limits (UPLs) for statistical evaluation of groundwater monitoring data for the detection monitoring program at the Central Maui Landfill Facility (CMLF). Before developing the revised background values, a statistical review of historical groundwater monitoring data collected at the CMLF was conducted to examine the statistical properties of the data for use in determining background. This review was conducted using historical analytical data supplied by the County, as well as recent analytical data collected by CH2M for the County after October 2014 from the wells (three upgradient and three downgradient) that comprise the current groundwater monitoring network at the CMLF (Figure 1). Based on the current understanding of groundwater flow characteristics at the CMLF, monitoring wells MW-1 and MW-6 are located upgradient and are considered representative of background aquifer conditions, well MW-4 is located crossgradient/upgradient, and wells MW-2, MW-3, and MW-5 are located downgradient of the facility and represent the compliance monitoring well network.

The intent of this document is to present the results of the statistical data review and to facilitate concurrence from the State of Hawaii Department of Health (HDOH) on the compliance monitoring well network, constituents proposed for detection monitoring, and the UPLs developed for those constituents (where applicable).

Project background and data preparation, including management of duplicate data, non-detects, and data qualifiers, are discussed in Sections 2 and 3, respectively. The need and rationale for the selection of an effective and optimized list of constituents for the CMLF monitoring program are presented in Section 4. Temporal variability of data that lead to the selection of a subset of data to establish background concentrations for the CMLF is discussed in Section 5. Sections 6 and 7 present the methods that were used to evaluate the data against the common statistical assumptions, while the development of the UPLs and report conclusions are provided in Sections 8 and 9, respectively. Technical discussions throughout this report are supported by tables and graphical representations that are provided at the end of this report.

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[1] CH2M was acquired by Jacobs in December 2017. For consistency, work performed by Jacobs for this project will be attributed to CH2M, and any references will be provided under the name used at the time.

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2 Background

A revised conceptual site model (CSM) for the CMLF was provided to HDOH initially in February 2016 (CH2M, 2016a) and was incorporated into the final CSM report provided to HDOH in January 2018 (CH2M, 2018). The purpose of the revised CSM was to develop a better understanding of background aquifer conditions and other potential influences on groundwater beneath the site. The CSM demonstrated that multiple factors unrelated to the landfill contribute to both short- and long-term changes in dissolved constituent concentrations in groundwater underlying the site. These include (1) naturally occurring concentrations of metals in soil and basalt within the aquifer and (2) potential migration of dissolved constituents originating from sources other than the landfill, including historic agricultural activities and seawater intrusion.

In June 2016, on behalf of the County's Solid Waste Division, CH2M requested and obtained approval from HDOH to re-evaluate the statistical control-chart limits for the detection monitoring program at the site, based on the revised CSM. As part of that evaluation, CH2M reviewed regulatory requirements and state guidance documents (HDOH, 2002), as well as the *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance* (Unified Guidance) (USEPA, 2009).

Upon consideration of the dynamic conditions occurring in groundwater at the CMLF, the use of prediction limits is considered more suitable than control-chart limits for detection monitoring and to reach appropriate technical conclusions regarding groundwater concentration stability and trends going forward.

After receiving concurrence from HDOH on an approach that was generally consistent with the Unified Guidance, a technical memorandum describing the statistical method applied and the calculated UPLs was submitted by the County to HDOH in October 2016 (CH2M, 2016b). After review of the document, HDOH provided comments in July 2017 (HDOH, 2017). During the regulatory review process, which included two meetings with HDOH in October 2017 and January 2018, it was agreed the UPL calculations would be revised following full compliance with the Unified Guidance (USEPA, 2009). This report provides the results of the statistical data review and corresponding UPL calculations based on this agreed-upon approach.

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3 Data Preparation

This section describes the methods used to process and prepare the data for statistical evaluation.

3.1 Managing Duplicate Data

Duplicate groundwater samples have been collected at the CMLF for quality assurance and quality control (QA/QC) purposes. For statistical analysis of parameters with duplicate groundwater sample results, only the parent sample was used for statistical comparisons. Although duplicate sample results can provide valuable information about the level of measurement variability attributable to sampling or analytical techniques, they should not be used as separate observations in estimating background. Averaging the parent sample and duplicate sample results may provide a more accurate representation of the constituent concentration for that time, but doing so would reduce the sample variability. The Unified Guidance (USEPA, 2009) reports that the variability in means of two correlated measurements is approximately 30 percent less than the variability associated with two single independent measurements. If a data set consists of a mixture of single measurements and field duplicates, the variability of the averaged values will be less than the variability of the single measurements. This causes background variability to be underestimated, which may result in higher false positive rates.

3.2 Managing Non-detect Data

EPA's ProUCL Version 5.1 Technical Guide (USEPA, 2015) discourages imputation of censored, or non-detect observations with an arbitrary value (e.g., one-half the reporting limit [RL]). For data sets consisting of non-detects with multiple RLs, several estimation methods are available, including the maximum likelihood (MLE) method, the Kaplan-Meier (KM) method, bootstrap methods, regression on order statistics (ROS) methods, and substitution methods. For the evaluation of the CMLF groundwater and leachate data, the KM method (Helsel, 2005; Singh et al., 2006; Kaplan and Meier, 1958) was used to compute descriptive statistics with the censoring limit set at the RL.

The KM estimator is a nonparametric procedure originally devised to estimate survival probabilities for right-censored samples (Kaplan and Meier, 1958), such as in medical studies. Because it is nonparametric, there is no requirement that the underlying population be normal or transformable to normality. However, in adapting the technique to left-censored data (i.e., samples containing non-detects), the Unified Guidance recommends that the KM procedure be used to estimate the mean and variance of a normal or normalized distribution for use in parametric statistical tests.

The KM method assumes that all detected and non-detect data arise from the same population, but that non-detect values have been censored at their RLs. The method involves initially fitting a left-censored sample to a known distribution to create an estimate of the population mean and standard deviation adjusted for data censoring, based on the fitted distributional model. A partial ranking of the data is used, accounting for the non-detects and assigning explicit ranks to each of the detected values. These detected values can then be graphed on a censored probability plot and fitted against a known distribution. The technique estimates the approximate proportion of concentrations below each observed level by sorting and ordering the distinct sample values, although the exact concentrations of non-detects are unknown. The KM estimator for left-censored data thus depends on a series of conditional probabilities, where the frequency of lower concentrations depends on how many larger concentrations have already been observed. The result is an estimate of the cumulative distribution function for each distinct concentration level in the sample.

Practitioners (Helsel, 2005; Singh et al., 2006) and the Unified Guidance (USEPA, 2009) recommend the use of the KM method when dealing with environmental data sets containing multiple censored observations. The details of the various estimation methods including the KM method can be found in U.S. Environmental Protection Agency (USEPA) (2015), Singh et al. (2006), and Helsel (2005).

3.3 Data Qualifiers

Estimated concentrations (constituent concentrations denoted with the “J” qualifier) for groundwater and leachate were treated as qualified detected concentrations for the purposes of statistical analysis. No data rejected through analytical data validation were identified in the data set; therefore, no data were rejected from the data set used for statistical evaluation.

4 Indicator Constituents Selection

State (Hawaii Administrative Rules [HAR] 11-58.1) and federal (40 *Code of Federal Regulations* [CFR] 258) regulations require municipal solid waste landfills to routinely monitor for numerous constituents included in Appendix I of 40 CFR 258 (15 heavy metals and the full list of volatile organic compounds [VOCs]). However, USEPA has provided authorized states, such as Hawaii, the flexibility to approve alternative lists of site-specific monitoring (indicator) constituents (40 CFR 258.54 (a) (1) and (2)). This flexibility and authority for the State of Hawaii to approve an alternative and optimized indicator constituents list is captured in HAR 11-58.1-16 (d) (1) (A) and (B).

Many of the Appendix I constituents are not considered effective in detecting potential releases from the CMLF because of their absence in leachate and/or very low mobility. Therefore, a site-specific indicator constituent list was developed for the detection monitoring program at the CMLF. Federal (USEPA Unified Guidance [USEPA, 2009]) and ASTM International (ASTM, 2017) guidance documents, together with site-specific information (leachate and groundwater characteristics), were considered in developing an optimized list of indicator constituents for the CMLF. The indicator constituent selection process included the following basic principles and steps:

1. **Leachate composition**. Based on analytical results of samples collected at leachate monitoring points within CMLF solid waste management units (SWMUs) Phase IV-A and Phase IV-B over the 2006-2017 monitoring period, leachate mean concentrations were calculated.[2] Constituents with less than 20 percent detections were considered not representative of the average leachate composition and not carried further in the selection process.
2. **Concentration contrast**. Sufficient contrast is generally assumed when the leachate concentration is consistently and sufficiently higher than the concentration in groundwater to account for the effects of dilution and attenuation. For screening constituents and developing an optimized primary constituents list, a concentration contrast of 10 is considered conservative by USEPA, which identifies typical contrast factors between 10 and 20 (USEPA, 1996). The ASTM guidance (ASTM, 2017) recommends a contrast of 10 times for a source area greater than 0.5 acre. Therefore, a contrast of 10 was initially used in the selection process to be consistent with USEPA and ASTM guidance. If insufficient contrast exists for a specific constituent (i.e., leachate average concentration approximately the same or lower than groundwater average concentration), then the specific constituent was eliminated from further consideration for compliance monitoring.
3. **Redundancy**. Constituents with the same physical and chemical characteristics were minimized where possible, giving preference to those that are more effectively detected in groundwater.
4. **Constituent physical and chemical characteristics**. Preference was given to constituents that have higher mobility, detectability, and persistence, which make them more effective indicators to detect a potential release from the landfill.

Leachate data from 11 years of monitoring (2006-2017) conducted at wet well IV-A and sump IV-B (see Figure 1) were evaluated against groundwater data collected at compliance monitoring wells MW-2, MW-3, and MW-5 between 1995 and 2017, to identify an optimized list of constituents for detection monitoring at the CMLF. The results of the selection process are discussed below. As summarized in Table 1, from the first two steps of the selection process, the following was found:

- A total of 25 leachate constituents were carried to the second step. The constituents 1,1-dichloroethane, carbonate alkalinity, lead, methyl ethyl ketone, selenium, and vanadium were discarded because of detection

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[2] Since leachate monitoring started in 2006, no leachate was ever observed at the collection system present at the lowest point of the unlined subgrade of closed SWMU Phase I and II. Leachate mean concentrations were therefore calculated considering only samples collected at the leachate collection points within SWMUs Phase IV-A and Phase IV-B.

frequencies in leachate lower than 20 percent. Acetone and chlorine residual were also discarded because the former is considered a typical laboratory contaminant, while the latter is typically not monitored in groundwater.

- Alkalinity and nitrate (as N) have been reported inconsistently in the past, as described below. They were carried over to the second step and further evaluated based on the following assumptions:
  - Alkalinity – Alkalinity in leachate has been reported as carbonate (as $CaCO_3$), bicarbonate (as $CaCO_3$), and total alkalinity (as $CaCO_3$). Alkalinity in groundwater has been reported interchangeably as bicarbonate alkalinity (as $CaCO_3$) and total alkalinity (as $CaCO_3$). Starting in December 2014, total alkalinity (as $CaCO_3$) has consistently been reported. From leachate and groundwater historical results, when bicarbonate and total alkalinity were reported separately, it is evident that at acidic and neutral pH conditions found in the CMLF leachate and groundwater, total alkalinity and bicarbonate alkalinity are equivalent and can be used interchangeably. Available literature confirms this assumption. The United States Geological Survey (USGS) *Study and Interpretation of the Chemical Characteristics of Natural Waters* (USGS, 1985) discusses the main components of alkalinity in natural waters (including groundwater) and their relationships with pH. The USGS (1985) document confirms that the main alkalinity components in natural waters are carbonate and bicarbonate, and shows that carbonate is present only at pH greater than 8.3. At the pH values observed in the CMLF groundwater (e.g., average pH of 7.1 at compliance wells MW-3 and MW-5), alkalinity can be attributed entirely to dissolved bicarbonate. Therefore, “total alkalinity (as $CaCO_3$)” and “bicarbonate alkalinity (as $CaCO_3$)” can be considered the same constituent. To calculate alkalinity average concentrations, total alkalinity was used for leachate and groundwater data.
  - Nitrate-nitrite. This constituent has been reported interchangeably as “nitrate” and “nitrate-nitrite” in leachate. In groundwater, it was reported as “nitrate (as N)” before 2015, after which it was reported as “nitrate-nitrite (as N)”. As discussed in the literature (U.S. Department of Health and Human Services, 2017), and confirmed by leachate data with “nitrate” and “nitrate-nitrite” almost always reported at the same concentration, nitrite is easily oxidized to nitrate, and nitrate is the compound predominantly found in groundwater. Therefore, “nitrate-nitrite (as N)” and “nitrate (as N)” were considered the same constituent for purposes of calculating representative nitrate concentrations in groundwater at site compliance wells.
- For the 25 leachate constituents carried over from step 1, the leachate/groundwater concentration contrast was calculated considering the average concentrations over the entire monitoring periods (2006-2017 for leachate and 1995-2017 for groundwater). Concentration contrast was calculated using the following formula:

$$\text{Concentration contrast} = \frac{\text{Mean historical leachate concentration in wet well IV-A and sump IV-B combined}}{\text{Mean historical groundwater concentration at MW-X}}$$

  As discussed in detail below, only five constituents have a contrast higher than 10, the value recommended by USEPA and ASTM; as a result, the threshold contrast to further evaluate constituents was lowered. From the first two steps of the selection process, constituents with a leachate/groundwater concentration contrast higher than 2, the value recommended by HDOH for organic constituents, were further evaluated to develop a site-specific, optimized constituents list for detection monitoring at the CMLF. A detailed discussion on leachate/groundwater contrast and constituents selection follows:

  - **Maximum** - Benzene, toluene, ethylbenzene, and xylenes (BTEX); 1,4-dichlorobenzene, 1,2-dichloroethane, cis-1,2-dichloroethylene, and vinyl chloride (halogenated volatile organic compounds [HVOCs]) have been detected in leachate with average concentrations ranging from 1.2 to 55 milligrams per liter. These constituents were not detected in groundwater at any of the compliance wells between 1995 and 2017. Ammonia (in well MW-5), barium (in well MW-5), chromium (in wells MW-2 and MW-5), copper (in well MW-5), and nickel (in well MW-3) were either not detected in groundwater or had less than 10 percent detection frequencies, which did not allow a calculation of mean groundwater concentration. The contrast for these constituents that are detected in leachate but not detected in groundwater is identified in the Leachate/Groundwater Contrast portion of Table 1 as maximum (“MAX”) for constituents with no detections in groundwater, and as not applicable ("NA") for those groundwater constituents with detection frequencies of less than 20 percent that did not allow a reasonable estimate of the average concentrations. Ammonia, BTEX, and HVOCs are therefore carried over and selected as detection monitoring constituents. Based on the relatively wide range of or low detection frequencies for barium (0 to 47 percent), chromium (0 to 12 percent), copper (0 to 33 percent), and nickel (4 to 100 percent) in the monitoring wells and in consideration of their physical-chemical characteristics, lack of mobility in groundwater relative to other constituents, and frequent presence as background in Hawaiian aquifers, these metals are discarded from further consideration as indicator constituents.

- **100 to 200** - Ammonia (in wells MW-2 and MW-3) and barium (in well MW-2) have a contrast greater than 100, with less than 50 percent detection frequency in groundwater at compliance wells. As previously discussed, ammonia is selected as detection monitoring constituent, while barium is discarded.
- **10 to 99** – Barium (in well MW-3), iron, and total organic carbon (TOC) have a contrast between 10 and 100. Of these, barium and iron have less than 50 percent detection frequency in groundwater at compliance wells, while TOC has between 71 and 79 percent detection frequency. Iron and TOC are selected as detection monitoring constituents, while barium is discarded because of its physical-chemical characteristics and presence as background in Hawaiian aquifers.
- **2 to 9.9** - Total alkalinity, calcium, chloride, chromium (in well MW-3), copper (in wells MW-2 and MW-3), magnesium (in wells MW-2 and MW-5), potassium, sodium, and total dissolved solids (TDS) have a contrast between 2 and 10. Of these, chromium and copper have less than 50 percent detection frequency in groundwater at compliance wells, while other constituents have a 100 percent rate of detection. Of these, calcium, chloride, magnesium, potassium, sodium, TDS, and total alkalinity are selected as detection monitoring constituents, while chromium and copper are discarded because of their physical-chemical characteristics and presence as background in Hawaiian aquifers.
- **1 to 1.9** - Nickel (in well MW-2) and zinc (in wells MW-3 and MW-5) have a contrast between 1 and 1.9. Nickel in well MW-2 has only 32 percent detection frequency in groundwater at compliance wells, while the zinc detection frequencies in wells MW-3 and MW-5 are greater than 50 percent. These constituents are discarded because of the low leachate/groundwater concentration contrast.
- **Less than 1** - Mean concentrations of nitrate, sulfate, and zinc (in well MW-2) are higher in groundwater than leachate (i.e., contrast less than 1), with detection frequencies in groundwater at compliance wells that are greater than 50 percent. These constituents are therefore discarded because of the low leachate/groundwater concentration contrast.

As discussed above, some constituents commonly used as indicator parameters at landfills, such as nitrate and sulfate, were not carried over in the selection process because average concentrations in groundwater at the CMLF (including in upgradient/background monitoring wells) are higher than in leachate. In summary, the following constituents are retained and will be part of the site-specific, optimized constituents list used for detection monitoring at the CMLF:

- Major cations and anions
  - Calcium
  - Magnesium
  - Potassium
  - Sodium
- Major leachate indicators
  - Ammonia
  - Chloride

  - Iron
  - TOC
  - TDS
  - Total alkalinity
- Organic constituents
  - BTEX
  - HVOCs (including 1,4-dichlorobenzene, 1,2-dichloroethane, cis-1,2-dichloroethylene, and vinyl chloride)

The major cations and anions and major leachate indicators fit the Unified Guidance (USEPA, 2009) definition of "*reliable indicators selected for formal detection monitoring testing and contributing to the site-wide false positive rate (SWFPR)*" (Group 1) except for ammonia, which has very low detection frequency. Ammonia fits in the second group specified in the Unified Guidance as "*other analytes which may be occasionally or even frequently detected and will be monitored for general groundwater quality information but not tested.*" The hazardous constituents BTEX and HVOCs fit in the third group of constituents specified in the Unified Guidance as "*those meeting the 'never detected' criteria.*" Therefore, of the 12 constituents retained as the site-specific optimized constituents for detection monitoring at the CMLF, 9 (calcium, magnesium, potassium, sodium, chloride, iron, TOC, TDS, and total alkalinity) will be statistically evaluated using UPLs because they are reliable indicators selected for formal detection monitoring testing per the Unified Guidance (USEPA, 2009).

Despite the relatively low leachate/groundwater contrast, some constituents, such as chloride, potassium, and TDS were retained and included in the detection monitoring list because they are typical landfill leachate indicator constituents and support development of a sufficient number of indicator constituents consistent with the Unified Guidance (USEPA, 2009) to calculate the revised UPLs. A few of the indicator constituents indicated above (i.e., ammonia, BTEX, and HVOCs) are not directly incorporated into the formal statistical testing for detection monitoring because they are rarely, if ever, detected at site compliance wells.

By limiting the statistically-evaluated constituents to the most useful indicators, the overall number of statistical tests can be reduced to help meet the cumulative annual SWFPR of 10 percent recommended in the Unified Guidance (USEPA, 2009). The Unified Guidance (USEPA, 2009) recommends a comprehensive detection monitoring program design, based on two key performance characteristics: adequate statistical power and a low predetermined SWFPR. The SWFPR is measured on a site-wide basis and partitioned among the total number of annual statistical tests. The total number of statistical tests depends on the number of monitoring constituents, compliance wells, and periodic evaluations. Fewer tests imply a lower single-test false negative error rate, and therefore an improvement in statistical power.

5 Data Timeframe Selection

Table 2 presents summary statistics for concentrations of the nine proposed indicator constituents selected for statistical analysis (Group 1) collected between October 1995 and September 2017 from the two upgradient wells (MW-1 and MW-6), one crossgradient/upgradient well (MW-4), and three downgradient wells (MW-2, MW-3, and MW-5). The statistics include the total number of samples and detected results, frequency of detection, minimum and maximum concentrations for detected and non-detected observations, the last (most recent) sample result, and the mean and standard deviation.

Results of trend testing using the Mann-Kendall test also are included in Table 2. The Mann-Kendall test is a nonparametric procedure that does not require the underlying data to follow a specific distribution. The Mann-Kendall test is based on the idea that a lack of trend should correspond to a time series plot fluctuating randomly about a constant mean level, with no visually apparent upward or downward pattern (USEPA, 2009). The test compares the relative magnitudes of sample data rather than the data values. Non-detects were used by assigning them a common value that was less than the smallest measured value in the data set (Gilbert, 1987; USEPA, 2009). Positive values of the Mann-Kendall test statistic (S) indicate an increase in constituent concentrations over time, whereas negative values indicate a decrease in constituent concentrations over time. The strength of the trend is proportional to the magnitude of the Mann-Kendall statistics (i.e., the larger the absolute value of the statistics, the stronger the evidence for a real increasing or decreasing trend).

The calculated probability (p-value) for the Mann-Kendall test provided in Table 2 represents the probability that any observed trend would occur purely by chance (given the variability and sample size of the data set). A significance level of 0.05, corresponding to a confidence level of 95 percent, was used for comparisons with this probability and the resulting decision is reported (i.e., only p-values less than 0.05 indicate a statistically significant trend). The result could be a significantly increasing or decreasing trend or a nonsignificant result (no trend). It should be noted that a nonsignificant result does not necessarily demonstrate that there is no trend. Rather, it is a statement that the evidence available is not sufficient to conclude that there is a trend at the specified confidence level.

Of 54 constituent-well pairs (obtained multiplying the six monitoring wells present at the site, times the nine constituents selected for statistical analysis) evaluated with the Mann-Kendall test, there were 38 instances (70.4 percent) with a significant calculated trend, 17 of them representing significantly decreasing trends and 21 representing significantly increasing trends. Results of the trend analyses indicate concentrations of alkalinity between 1995 and 2017 are statistically decreasing and concentrations of chloride and magnesium are statistically increasing in the upgradient and downgradient wells. Concentrations of calcium, iron, potassium, sodium, and TDS across the site exhibit a mixture of increasing, decreasing, or no trend; TOC concentrations at all the monitoring wells exhibited no trend.

Overlapping and individual time series plots showing the temporal behavior of the proposed detection monitoring indicator constituents are provided in Attachments 1 and 2, respectively. The parallel plots are comprised of single constituent data from all six monitoring wells plotted over time, where the data are color-coded by well name. These plots allow for comparisons of constituent concentrations between all wells and can be useful for identifying potentially significant temporal components of variability. For example, seasonal fluctuations will show up in the time series plot as a pattern of parallel traces, in which the individual wells will tend to rise and fall together across the sequence of sampling dates. The time series plots support the results of the trend analysis and suggest higher variability in data collected before approximately 2008.

The time series plots show a slight general increase in concentrations of chloride, magnesium, potassium, and sodium at all monitoring wells after 2010, with decreasing concentrations after approximately 2015. The only exception is monitoring well MW-2, where concentrations have continued to increase after 2015. The temporary increase in these ion concentrations at all monitoring wells (including background wells) between 2010 and 2015 could have been caused by a drought period recorded at the Puunene Weather Station between 2008 and 2013.[3] Reduced precipitation over an extended period resulted in decreasing aquifer recharge, with thinning of the freshwater lens. This may have caused rising of the freshwater/seawater transition zone (seawater intrusion), with increasing concentrations of ion constituents in groundwater. This temporary change in concentrations also at upgradient monitoring wells indicate that the episodic increase was likely caused by natural variation, rather than landfill-related releases to groundwater.

Based on the significantly higher variability in data collected before approximately 2008, background concentrations for wells MW-3 and MW-5 at the CMLF have been established using data collected from June 2008 through September 2017. Background concentrations for well MW-2 have been established using data collected from February 1996 through December 2011. These timeframes provide a minimum of 10 years of groundwater monitoring data at the CMLF. Because detection monitoring tests involve comparisons of compliance point data against background, background must represent current natural conditions. If natural groundwater conditions have changed over time, historical background measurements may not reflect current natural conditions. In this case, older background data should be discarded in favor of more recent measurements for constructing an appropriate comparison. Older background data are being used for well MW-2 because of the temporal trends in constituent concentrations observed in this well starting in January 2012.

The remaining sections of this document present a statistical evaluation conducted on the groundwater monitoring data collected at the CMLF during the two time periods listed above, and document that the data meet the required performance standards.

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[3] As shown by the total annual precipitation data provided by the Western Regional Climate Center, average rainfall between 2008 and 2013 was 8.9 inches per year, versus an average calculated between 1950 and 2016 of 18.1 inches per year (https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?hi8543).

6 Univariate Statistical Evaluation

An objective of any background investigation for sites including landfills is the development of a background data set that is representative of background conditions for an area and, therefore, may be used to distinguish background concentrations in an environmental medium from site-related contamination. In addition, a background data set should be robust for purposes of performing the statistical tests used to differentiate background concentrations from site-related contamination. It is assumed for most statistical analyses that the data from a given population are independent and identically distributed. If this basic assumption is not satisfied, statistical conclusions and test results may be invalid.

This section describes the methods that were used to evaluate the data against the common statistical assumptions, and to process and prepare the background groundwater data for statistical evaluation. A stepwise approach consistent with the Unified Guidance (USEPA, 2009) was used for evaluating the groundwater monitoring data to determine its suitability for statistical analysis. These steps include data compilation, exploratory analysis and descriptive statistics, statistical outlier detection, evaluation of data independence and stationarity, and testing for parametric behavior. Unless stated differently, statistical tests conducted during the exploratory data evaluation stage were performed using a significance level of 5 percent. If the calculated probability from a test is below this significance level, a conclusion is drawn to reject the null hypothesis and instead determine that a significant test result exists. A significance level of 5 percent typically is used to provide strong evidence against the null hypothesis. Using this significance level, there is a probability that 5 percent (0.05) of the cases would be significant simply from random variability (false positives).

Whenever possible, statistical results are supplemented with formalized graphical displays. Graphical displays provide added insight (e.g., presence of outliers, data distributions and patterns, mixture populations, and visual comparison of two or more groups) into data sets that are not possible to visualize and understand by reviewing descriptive and test statistics and tabulated data. Graphical representation of the analysis is provided in attachments to this report, as referenced in the discussion below.

Statistical plotting methods include scatterplots, box-and-whisker plots, histograms, and probability plots. Box-and-whisker plots show the central tendency, degree of symmetry, range of variation, and potential outliers of a data set. The upper value of the box represents the 75th percentile for the data and the lower value of the box is the 25th percentile for the data. Thus, 50 percent of the data fall within the box. The top of the whisker represents the 75th percentile plus 1.5 times the interquartile range (IQR), where the IQR is the 75th percentile minus the 25th percentile. The bottom of the whisker is the 25th percentile minus 1.5 times the IQR. Any value outside of this range is considered a potential statistical outlier, which is represented by a dot on the plot.

The outlying concentrations of box-and-whisker plots only serve the definition of falling relatively far from the middle 50 percent of the data. If the data are drawn from a highly skewed distribution, or a symmetrical one with long tails, multiple outliers of this type are expected. Although it is common vernacular to refer to these points as outliers, they should not be confused with the outlier definitions described below in the evaluation of outliers.

Normal probability plots show the ordered sample results versus the corresponding quantiles of a theoretical data distribution, such as the normal distribution, and is described as a quantile–quantile, or Q–Q, plot (e.g., normal Q-Q plot). Since quantiles are associated with cumulative probabilities, Q–Q plots are also referred to as probability plots. A normal probability plot is used to evaluate the normality of the distribution of a variable (i.e., whether, and to what extent, the distribution of the variable follows the normal distribution). If the data are not normally distributed, they will deviate systematically from a straight line. Variability in the data will cause the data to scatter randomly around this line, but the data will still appear to follow a single straight line. Outliers may also be evident in this plot.

6.1 Evaluation of Outliers

The groundwater data were visually inspected for potential outliers using graphical presentations of the data as previously described. Statistical outliers were formally evaluated using Dixon's (1953) and Rosner's (1983) outlier tests. Dixon's test is valid for data sets with up to 25 members, while Rosner's test is recommended for larger data sets (USEPA, 2009). Both Dixon's and Rosner's tests assume that the data values (aside from those being tested as potential outliers) are normally distributed. Because environmental data tend to be right-skewed, a test that relies on an assumption of a normal distribution may identify a relatively large number of statistical outliers. These statistical outliers were further evaluated using nonparametric methods, including IQR and median absolute deviation (MAD) scores (Wilcox, 2010).

A list of statistical outliers identified at the 5 percent significance level is presented in Table 3. Statistical outliers include alkalinity in the three upgradient (MW-1, MW-4, and MW-6) and three downgradient wells (MW-2, MW-3, and MW-5); calcium, iron, and magnesium in MW-2; potassium in MW-1 and MW-6; sodium in MW-5; TDS in MW-2, MW-3, and MW-4; and TOC in MW-2. Graphical presentations of the data, including box-and-whisker plots, histograms, and probability plots, are provided in Attachment 3. As previously discussed, probability plots are useful when identifying statistical outliers.

The presence of statistical outliers by itself is not sufficient reason to exclude those observations from the background data set. The Unified Guidance (USEPA, 2009) recommends that statistical outliers generally not be removed unless some basis for a likely error or discrepancy can be identified. Such possible errors or discrepancies could include data recording errors, unusual sampling and laboratory procedures or conditions, inconsistent sample turbidity, and values significantly outside the historical ranges of background data. Because extreme outliers can adversely affect the results of statistical calculations, it may be advisable at times to remove high-magnitude outliers in background even if the reasons for these apparently extreme observations are not known.

Except for total alkalinity, no suitable reasons could be identified to exclude the statistical outliers from further calculations. The total alkalinity outliers were approximately five times lower than the next lowest measurement in each well and were associated with a single sampling event that occurred in December 2011. These total alkalinity values also exhibited IQR and MAD scores indicative of extreme observations, as shown in the outlier plots included as Attachment 4. In these plots, observations are identified as potential outliers if their value exceeds either three times the IQR (shown as the blue dashed line in the plots) or five times the MAD (shown as the red dashed line). Inspection of the probability plots in Attachment 3 also indicate that the total alkalinity values associated with the December 2011 sampling event are far removed from the remaining sample population. Because the December 2011 total alkalinity results are associated with a single sampling event and the results appear to be extreme observations, they were excluded from further calculations. Total alkalinity in a sample collected during December 2001 also was excluded from the final background data set for MW-2.

6.2 Temporal Independence

Background data should be statistically independent. This means that each measurement should be randomly representative of the target population and its value should not be influenced by any other measurement (i.e., each measurement should be independent of every other measurement). While samples of independent data exhibit no pairwise correlation, non-independent or dependent data do exhibit some form of pairwise correlation. It is important to note that dependent measurements exhibit less variability than independent measurements, which leads to an underestimation of the population variance and an increase in the false positive rate.

The rank von Neumann Ratio test was used to test the background data for serial correlation. The rank von Neumann Ratio test is a nonparametric alternative to the sample autocorrelation function and is used to test for first-order temporal autocorrelation in a single data series, as described in the Unified Guidance (USEPA, 2009). The test is based on the idea that a truly independent series of data will vary in an unpredictable fashion as the list is examined sequentially. The first order or lag-1 autocorrelation will be approximately zero. By contrast, the first-order autocorrelation in dependent data will tend to be positive (or negative), implying that lag 1 data pairs in the series will tend to be more similar (or dissimilar) in magnitude than would be expected by chance.

The sample autocorrelation function (ACF) also was used to evaluate serial correlation in the data. The ACF is a valuable visual tool for assessing different types of autocorrelation (Chatfield, 2004). An autocorrelation plot is designed to show whether the elements of a time series are positively correlated, negatively correlated, or independent of each other. A test of significant autocorrelation at the 95 percent significance level was made by examining the sample autocorrelation function to see if any coefficients exceeded the approximate upper and lower confidence limits (USEPA, 2009).

The results of the lag-1 autocorrelation rank von Neumann Ratio test for serial correlation are provided in Table 4. The test results indicate that, except for iron and TDS, concentrations of the proposed detection monitoring constituents generally exhibit pairwise correlation (p-value less than 0.05). Concentrations of iron in the six monitoring wells were mostly non-detect and therefore were not analyzed for serial correlation using the rank von Neumann Ratio test. Autocorrelation plots for each constituent-well combination are provided in Attachment 5. The vertical lines on the plot correspond to increasing number of lags, where the height of each line shows the value of the ACF for that lag. Each line that rises above or falls below the 95 percent significance level, which is represented by the dashed blue lines, is considered statistically significant. This means the line has a value that is significantly different from zero, indicating evidence of autocorrelation in the data.

In general, the data exhibit a large ACF value at the first lag, followed by another one or two significantly nonzero ACF values at subsequent lags. Successive measurements in time series from groundwater monitoring are often correlated with one another, especially when the groundwater is so slow-moving and wells are being sampled on closely-spaced sampling events. This means that pairs of consecutive measurements taken in a series will be positively correlated, exhibiting a stronger similarity in concentration levels than expected from pairs collected at random times. Only strong correlations are likely to substantially impact the results of further statistical testing. Measurable correlation among consecutive sample pairs generally indicates the need for decreasing the sampling frequency.

6.3 Temporal Variability

A stationary statistical distribution is one whose population characteristics do not change over time or space. A nonstationary distribution infers that either the mean, variance, or both is changing over time in any given well, or the means and variances differ at distinct locations. The effects of nonstationarity are commonly observed as spatial variability, the existence of trends or seasonal variation, or other forms of temporal variation. Temporal variability exists when the distribution of measurements varies with the times at which sampling or analytical measurement occurs.

The Unified Guidance (USEPA, 2009) distinguishes temporal variations from trends or seasonal effects by the lack of a regular or identifiable pattern. This can be observed as a temporary shift in concentration levels that is similar in magnitude and direction at multiple wells. Three common examples of temporal factors include (1) an irregular, but consistent shift of average concentrations over time, (2) cyclical seasonal patterns, or (3) parallel upward or downward trends. These can occur in both upgradient and downgradient well data.

A nonparametric analysis of variance (ANOVA) method, the Kruskal-Wallis test, was applied to the data to test for temporal variability. This test considers multiple monitoring well data sets for individual sampling events as the relevant statistical factor. While the parametric ANOVA method is a statistical procedure used to determine whether there are statistically significant differences in mean concentrations among a group, the Kruskal-Wallis method tests for differences among average population ranks equivalent to the medians. Under the null hypothesis of no difference in concentrations among the groups, the observations are assumed to arise from identical distributions with equal population variances. When the calculated probability (p-value) is greater than or equal to the common significance level of 0.05, the null hypothesis of no significant difference between the groups is assumed.

Results of the temporal variability analysis using the Kruskal-Wallis test are presented in Table 5. Except for calcium and chloride, which have p-values greater than the significance level of 0.05, the formal detection monitoring constituents exhibit temporal dependence. This temporal dependence can be seen in the parallel movement (i.e., when several wells exhibit the same pattern of up-and-down fluctuations over time) on the time series plots included as Attachment 6. Common water quality indicators like cations and anions, pH, TDS, and specific conductance generally exhibit various kinds of within- and between-well temporal variation (USEPA, 2009). Dependence may also be exhibited spatially across a well field, where wells located more closely in space and screened in the same hydrostratigraphic zone generally show greater similarity in concentration patterns than wells that are farther apart.

When a significant temporal dependence or correlation is identified across a group of wells using one-way ANOVA for temporal effects, results of the ANOVA can be used to create stationary adjusted data. The adjusted data can then be used in subsequent statistical procedures. The key requirement to correct for a temporal effect using ANOVA is that the same effect must be present in all wells to which the adjustment is applied. The monitoring well network at the CMLF exhibit significant spatial variability (see Section 6.6) and thus, adjustment of the data is not advisable because of the tendency to skew or bias measurements at wells with no observable temporal dependence.

Variance estimates of dependent, positively autocorrelated data are likely to be biased low. However, the characteristics of the groundwater population at the CMLF are based on sample measurements collected over 10 years of groundwater monitoring. Using a long temporal record (10 years), such as the case herein, provides an evaluation of the full range of concentrations and an accurate estimate of total variability in groundwater concentrations.

6.4 Seasonality

The nonparametric Kruskal-Wallis test also was used to test the data for seasonality. Based on evaluation of precipitation data for Maui, it was assumed samples collected during the months from May through October represented the “dry” season and the remaining months were assumed to represent the “wet” season. Results of the seasonality analysis using the Kruskal-Wallis test are presented in Table 6. The data do not indicate the presence of statistically significant seasonal variation.

6.5 Secular Trend Analysis

A secular trend at a well location indicates that the mean is not stationary but is changing over time. Secular trend analysis was performed using the nonparametric Mann-Kendall test. The results for the Mann-Kendall test for each constituent and well are shown in Table 7. The table includes the calculated probability for the test, which represents the probability that any observed trend would occur purely by chance (given the variability and sample size of the data set). A significance level of 0.05 was used for comparisons with this probability and the resulting decisions are reported as significantly increasing or decreasing trends or a nonsignificant result (no trend).

Of 63 cases evaluated with the Mann-Kendall test, there were 21 cases (33.3 percent) with a significant calculated trend, 8 of them representing significantly decreasing trends and 13 significantly increasing trends. For groundwater monitoring data collected from MW-2 during 1996 through 2011, two constituents (alkalinity and calcium) exhibit decreasing trends in concentrations over time. For groundwater monitoring data collected from downgradient compliance wells during 2008 through 2017, there are 11 constituent-well pairs that exhibit statistically significant trends in concentrations over time. Of these 11 cases, 7 cases are associated with well MW-2. However, as discussed in Section 5, background concentrations for well MW-2 have been established using data collected from 1996 through 2011 because of the temporal trends in constituent concentrations observed in this well starting in January 2012. For the remaining two downgradient compliance wells MW-3 and MW-5, there are 4 cases with a significant calculated trend. Except for iron in MW-5, the calculated probabilities for these 4 cases are generally close to the 0.05 significance level. The significance level for iron in MW-5 indicates a strong decreasing trend, but the data set only contains eight detected concentrations out of 26 samples (detection frequency of 30.8 percent). The significance level of 0.05 suggests one could find significant trends in about 5 percent of the cases from purely random data. Therefore, the significant trends in the downgradient wells MW-3 and MW-5 may simply be consistent with noise expected when applying this test. Compared to the trend analysis results shown in Table 2 for the entire monitoring record, concentrations of the proposed detection monitoring constituents in wells MW-3 and MW-5 from June 2008 through 2017 and in well MW-2 from 1996 through 2011 are more stable and support development of background concentrations.

6.6 Spatial Variability

Spatial variability refers to statistically identifiable differences in mean and variance levels across the well field. In the absence of any spatial variation, it is expected that each constituent in the monitoring well network should have the same population mean and variance. The Kruskal-Wallis test was used to check the data for spatial variability using the monitoring wells as the relevant statistical factor. The calculated probabilities from the test were compared with a significance level of 0.05. When the probability is below this level, a significant difference between the central tendency of at least one of the wells and the other multiple well groups is suggested. Note that this comparison only indicates significant differences between wells, but does not indicate which well-pair(s) are different. For cases with a significant difference, a post-hoc test (multiple comparison test) was employed to determine which wells, if any, exhibit a significant difference in constituent concentrations.

Table 8 presents results of the spatial variability analysis using the Kruskal-Wallis test. The results indicate that, except for iron and TOC, the formal detection monitoring constituents exhibit significant spatial variation. Concentrations of calcium, chloride, magnesium, potassium, sodium, and TDS are generally higher in well MW-2 than the other monitoring wells. For alkalinity, concentrations are higher in well MW-6. This is shown graphically in the overlapping time series plots included as Attachment 6.

6.7 Distribution Goodness-of-Fit Testing

Determining the nature of the underlying population from which samples are drawn is important as it governs whether a parametric test procedure can be employed in subsequent statistical analyses. The ability to apply parametric statistical tests conveys higher statistical power, a lower false-positive error rate, and more confident conclusions overall.

Goodness-of-fit tests were performed to determine the probability that the data set for each constituent-well combination could have come from the tested distribution. Because a data set can pass a goodness-of-fit test for more than one distribution, the following hierarchy was used to choose a parametric distribution with which to calculate the statistics:

- Normal distribution assumed – data pass the test for normality
- Gamma distribution assumed – data fail the test for normality but passes the test for the gamma distribution
- Lognormal distribution assumed – data are neither normal nor gamma but pass the test for lognormality
- Nonparametric methods used – data fail the test for all three distributions

USEPA (2015) warns that use of a parametric lognormal distribution on a lognormally distributed data set may yield impractically large background values, especially when the standard deviation of the log-transformed data becomes greater than 1.0 for small data sets (less than 30 to 50 measurements). Because environmental data sets typically can be modeled by a gamma distribution, gamma distribution limits were given preference over lognormal distribution limits, where appropriate.

The results of the goodness-of-fit testing are provided in Table 9. The probability values (p-values) for the Anderson-Darling and Kolmogorov-Smirnov goodness-of-fit tests for a gamma distribution were computed based on the simulated critical values given in USEPA's ProUCL Version 5.1 software (USEPA, 2015). Most of the constituent-well data can be assumed to follow a normal distribution. The exceptions are iron and TOC across the entire monitoring well network. In the case of iron, the high percentage of non-detects makes fitting a distribution impracticable. For TOC, an attempt was made to transform the data to meet the normality assumption; however, no transformation could be identified.

7 Development of Upper Prediction Limits

Prediction intervals can be used for both inter- and intrawell comparisons. At sites where natural geochemical differences in groundwater quality exist between monitoring locations, the probability increases that statistically significant differences reported between upgradient and downgradient locations are the result of spatial or hydrogeologic variability rather than the facility. This is the case for the CMLF and consequently, intrawell UPLs will be used to minimize the likelihood that spatial variability will contribute to invalid statistical limits. For intrawell comparisons, the background data set is taken from each compliance monitoring well, as discussed in the Unified Guidance (USEPA, 2009). Well-specific UPLs are therefore developed for compliance monitoring wells MW-2, MW-3, and MW-5. New compliance data for each well will be compared to earlier background data from that well.

7.1 Parametric Upper Prediction Limit

For background data that are normally distributed or can be transformed to fit a normal distribution, the intrawell parametric UPL was calculated using the following equation:

$$UPL = \overline{x} + Ks \qquad (1)$$

where:

$\overline{x}$ = mean concentration of the background data set
s = standard deviation of the background data set
K = multiplier based on the characteristics of the site and the statistical test

The K-multipliers were computed using the EnvStats (Millard, 2013) library run within the R language and environment for statistical computing (R Core Team, 2014). The Unified Guidance (EPA, 2009) includes R-code files for calculating exact K-multipliers and per-test false positive error rates. The exact K-multipliers were then verified using the K-multiplier tables in Appendix D of the Unified Guidance. Values for K were chosen to maintain the annual SWFPR at 10 percent, as recommended in the Unified Guidance (USEPA, 2009), and are dependent upon the following:

- Number of compliance wells (assumed to be three: MW-2, MW-3, and MW-5)
- Number of constituents being evaluated (assumed to be nine per Section 4)
- Size of the background data set (ranges from 24 to 28 for wells MW-3 and MW-5 and from 46 to 48 for well MW-2)
- Number of statistical evaluations performed per year (assumed to be two for semiannual sampling)
- Retesting strategy

In general, the false positive rate increases in direct proportion to the number of comparisons being made, so a larger number of comparisons will increase the probability that a release will be indicated even though no release has occurred. Several options are available for limiting the SWFPR of a facility where multiple comparisons are made: (1) limit the number of comparisons, (2) decrease the per-test false positive rate, or (3) allow retesting in cases where statistical exceedances are noted. As discussed in Section 4, the number of comparisons will be constrained by limiting the number of constituents that are statistically analyzed on a semiannual basis.

The Unified Guidance (USEPA, 2009) recommends that detection monitoring programs be developed using a SWFPR of 10 percent over a 1-year period of testing. Using this criterion, the yearly SWFPR is fixed at 10 percent, and as such, the semiannual SWFPR is fixed at 5 percent. The magnitude of the per-test significance level (α_{test}) varies with the number of statistical tests required per semiannual evaluation. A cumulative false positive error rate α_{cum} is calculated as the probability of at least one statistically significant outcome for a total number of tests n_T in a calendar year at a single false positive error rate α_{test} using the properties of the Binomial distribution:

$$\alpha_{cum} = 1 - (1 - \alpha_{test})^{n_T} \qquad (2)$$

By rearranging to solve for α_{test} and substituting the 10 percent design SWFPR for α_{cum}, the needed per-test false positive error rate is calculated as:

$$\alpha_{test} = 1 - (0.9)^{1/n_T} \tag{3}$$

Design of the retesting strategy is based on an assessment of its ability to meet the power standards provided in the Unified Guidance (USEPA, 2009). In addition to specifying the annual SWFPR, the Unified Guidance (USEPA, 2009) also requires facilities to achieve adequate statistical power to detect a release, should one occur. More specifically, the Unified Guidance (USEPA,2009) recommends a power of approximately 55 percent to 60 percent when concentration levels are 3 standard deviations above the background mean, or approximately 80 percent to 85 percent power at 4 standard deviations above the background mean.

Results of the power analysis for the intrawell parametric UPLs are shown in Table 10, as are the K-multipliers calculated for each background sample size. Sample sizes range from 24 to 28 for wells MW-3 and MW-5 and from 46 to 48 for well MW-2. As shown in Table 10, a one-of-two retesting strategy meets the minimum required power requirements as specified in the Unified Guidance (USEPA, 2009) and is appropriate to verify that an apparent detection exceeds background. The per-test significance level (alpha) is achieved based on how parametric prediction limits are developed. This is not necessarily the case for nonparametric prediction limits, which are discussed in the following section.

For the one-of-two retesting strategy, when the prediction limit analyses indicate an initial exceedance, one discrete verification resample from the indicating well(s) will be collected within 90 days and before the next semiannual scheduled sampling event. For the test to be valid, the resample needs to be statistically independent which requires that sufficient time elapse between the initial sample and resample. A minimum time interval between samples is established to ensure that separate volumes of groundwater are being sampled. Semiannual detection monitoring sampling with retesting (as needed) within 90 days (but not earlier than 30 days)[4] of a background exceedance is believed adequate considering the site-specific pumping test-based groundwater seepage velocity between 14 feet per year (4 meters per year) and 478 feet per year (146 meters per year) estimated for the aquifer beneath the CMLF. This means that groundwater within the aquifer beneath the CMLF would travel a short distance between subsequent detection monitoring events, and migration of contamination caused by potential landfill impacts would be further slowed by physical and biochemical processes (see Section 2.6.3 of the Groundwater and Leachate Monitoring Plan for more details on groundwater seepage velocity).

7.2 Nonparametric Upper Prediction Limit

Nonparametric prediction limits were considered when the background data were not normally distributed or could not be transformed to fit a normal distribution. A nonparametric UPL was constructed by setting the limit as a large order statistic selected from the background data (e.g., the maximum or second-largest background value). Unlike parametric limits, the confidence level for nonparametric limits is not adjustable, but is fixed. To increase the confidence level, the number of future values to be predicted needs to be decreased or the number of background observations increased.

The confidence probability for a prediction limit on one future measurement is equal to:

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[4] A minimum time interval between samples of 30 days is estimated using Darcy's equation (v=Ki/n), as recommended in Chapter 14 of the USEPA Unified Guidance. Using slug test data to estimate hydraulic conductivity (k) (geometric mean of 60 feet per day), an average hydraulic gradient (i) of $9.7\text{x}10^{-5}$ feet per foot, and an effective porosity (n) of 0.15, a linear velocity of 0.039 feet per day (or 0.47 inch per day) is estimated. Considering a diameter for the well+filter pack system of approximately 10 inches, approximately 21 days are estimated for a groundwater particle to flow through the complete monitoring well diameter. As also discussed in the USEPA Unified Guidance, other retardation factors, such as matrix interaction, should be considered in the calculation and the actual time for groundwater to flow through the monitoring well may be greater. To account for retardation factors, the geometric mean hydraulic conductivity from slug test (which evaluate near-well aquifer properties and sometimes underestimate k) was considered and the minimum time interval between samples is rounded to 30 days.

$$(1-\alpha) = j/(n+1) \tag{4}$$

where:

α = false positive rate
n = sample size
j = rank of the prediction limit value

If the background maximum is taken as the UPL, the confidence level thus becomes n/(n+1). Davis and McNichols (1999) developed a general formula to determine the confidence probability when the j^{th} order statistic is taken as the UPL:

$$(1-\alpha) = \frac{(j+m-1)\cdot(j+m-2)\ldots\ldots\ldots\ldots\cdot(j+1)\cdot j}{(n+m)\cdot(n+m-1)\ldots\ldots\ldots\ldots\cdot(n+2)\cdot(n+1)} \tag{5}$$

To construct a prediction interval with sufficiently high confidence, more background observations are needed for a nonparametric prediction limit compared to a parametric-based limit. Parametric prediction intervals do not require as many background measurements because the form of the underlying distribution is assumed to be known.

Table 10 presents the achievable significance levels (alpha) and power ratings for nonparametric prediction limits using a one-of-two retesting strategy with a 10 percent SWFPR, three compliance wells, nine detection monitoring constituents selected for statistical analysis, semiannual sampling, and a background size between 24 and 48; the larger background size is associated with well MW-2. As shown in Table 10, a one-of-two retesting strategy meets the minimum required power requirements as specified in the Unified Guidance (USEPA, 2009) and is appropriate to verify that an apparent detection exceeds background. The per-test significance level (alpha) is achieved for the larger background sample size of 46 to 48, which is associated with well MW-2. For the smaller background sample size of 24 to 28, the per-test significance level (alpha) is not achieved. This results in a slightly higher false positive rate for the nonparametric prediction limits developed for wells MW-3 and MW-5 than targeted based on a 10 percent SWFPR.

7.3 Calculated Upper Prediction Limits

A UPL was calculated for each of the nine formal detection monitoring constituents selected for statistical analysis at the three downgradient compliance monitoring wells (MW-2, MW 3, and MW 5). For wells MW-3 and MW-5, UPLs were developed using data collected from June 2008 through September 2017. For well MW-2, UPLs were developed using data collected between 1996 and 2011. Table 11 presents the UPLs and supporting summary statistics, including the number of detects, the number of analyses, the percentage (frequency) of detection, minimum and maximum detected values, minimum and maximum detection limits for non-detects, and the distributional assumption. Also included in the table are the mean, median, standard deviation, and upper 95th and 99th percentiles of each background data set. A graphical comparison of the calculated UPLs to each corresponding background data set is provided in Attachment 7.

7.4 Updating Background

The basic assumption in detection monitoring is that the facility is not impacting groundwater unless statistically demonstrated otherwise. For intrawell testing, statistical comparisons are made over time in a single well to identify significant changes in groundwater quality that may be caused by the facility. Appropriate and representative background data is the most important factor to a successful statistical groundwater monitoring program. Representative background data show numerical characteristics closely matching those arising from the site-specific aquifer being evaluated. Background data must also be appropriate to the statistical test. All detection monitoring tests involve comparisons of compliance point data against the established background limits. Due to temporal changes in ambient groundwater quality, background data should not be regarded as a single fixed quantity. If natural groundwater conditions change over time during the collection of compliance point data, comparisons against previously established background may not be appropriate.

While updating background data, it is important to monitor and understand changes in the hydrogeologic conditions (e.g., changes in groundwater elevation because of rising water levels, groundwater mounding, changes in groundwater gradients and direction, or migration of groundwater constituents from other locations or offsite). Changes that occur in parallel between compliance point and upgradient wells may signal sitewide aquifer changes in groundwater quality not specifically attributable to the facility. If hydrogeology changes, then background data should be updated to match the latest conditions.

The Unified Guidance (USEPA, 2009) recommends that background data should be updated periodically so compliance samples can be tested against data that best represent the current background conditions.
A minimum of four to eight new samples are required to allow a statistical comparison between the new data and the initial background data. Using this principle with semiannual sampling, the UPL values at the CMLF should be updated at least every 4 years assuming no confirmed release is identified. In cases when a release is confirmed, the background will not be updated; instead, appropriate regulatory action at the site should be taken. While updating background, the set of new observations will be statistically compared to the existing background data, as appropriate. If the data are found to be comparable, then the new data will be combined with the existing background data set to recompute the statistical background limits (UPLs). If the data are shown to be different, then the data will be reviewed to evaluate the cause of the difference. In the absence of evidence of a release, more recent data should be considered more representative of present-day groundwater conditions and used for background.

Background data will also be updated to calculate the statistical background limits (UPLs) for any new monitoring well that will be installed in the future. Consistent with the Unified Guidance (USEPA, 2009), HAR 11-58.1-16(d)(2), and the HDOH landfill guidance (HDOH, 2002), eight independent samples will be collected from each well on a quarterly basis for analysis of the detection monitoring constituents to establish background concentrations.

8 Conclusions

The background monitoring data set was explored statistically. Extreme outliers were identified and removed. The final data set after this review was evaluated against the statistical methods per the Unified Guidance (USEPA, 2009). Background data used to develop the UPLs that are listed in Table 11 generally satisfy the following key statistical assumptions:

- Statistical independence of background measurements
- Temporal stationarity
- Lack of statistical outliers
- Correct distribution assumptions of background when a parametric statistical approach was selected
- Minimum background measurements

The background data exhibited significant natural spatial variability, and intrawell UPLs were therefore calculated for each compliance well. Although the data did exhibit temporal nonstationarity in the form of weak secular trends and autocorrelation, the characteristics of the groundwater population at the CMLF are based on sample measurements collected over a minimum of 10 years of groundwater monitoring. Using a 10-year-long temporal record provides an evaluation of the full range of background concentrations and an accurate estimate of total variability in groundwater concentrations. However, it is noted that variance estimates of dependent, positively autocorrelated data are likely to be biased low, which may result in the underestimation of the UPLs and an increase in the false positive rate. Table 12 compares the calculated UPLs to previously used background control limits at the CMLF. In general, the UPLs are similar to the 2005 and 2010 control limits, but lower than the control limits developed in 2000.

As indicated in Table 11, there are several constituents for which the background data were not normally distributed or could not be transformed to fit a normal distribution. For these cases, a nonparametric UPL based on the maximum value (NP, Max Value) was used. For the remaining constituent-well pairs, UPLs were calculated based on a parametric method, and the KM approach was used for each calculated UPL when the data included non-detects. The final background sample sizes meet the minimum required power requirements as specified in the Unified Guidance (USEPA, 2009) and are appropriate to verify that an apparent detection exceeds background. The per-test significance level (alpha) is not achieved for UPLs developed using a nonparametric method with a background sample size of between 24 and 28. This results in a slightly higher false positive rate for the nonparametric UPLs developed for MW-3 and MW-5 than targeted based on a 10 percent SWFPR.

The Unified Guidance (USEPA, 2009) recommends that prediction limits be combined with retesting for maintaining a low SWFPR while providing high statistical power. As mentioned in Section 7, a one-of-two retesting strategy will be used to verify an apparent detection that exceeds the background values. With this retesting approach, an apparent statistically significant exceedance cannot be confirmed or denied until the results of the resampling event have been obtained. If the initial result does not exceed the UPL, then no resampling is needed. If the initial result does exceed the UPL, then a resample will be collected before the next regularly scheduled sampling event at the monitoring well and for the constituent exceeding the UPL.

In conclusion, the UPLs listed in Table 11 can be used for comparison to determine whether future concentrations from a well are consistent with previous concentrations at the same well. Given the dynamic influences in groundwater at the site, it is expected that use of the UPL approach will result in a more defensible and reliable indication of true changes in groundwater conditions compared to other statistical methods, which will provide decision makers (CMLF and HDOH) a better basis for risk management.

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9 References

ASTM International (ASTM). 2017. *Standard Guide for Optimization of Groundwater Monitoring Constituents for Detection Monitoring Programs for Waste Disposal Facilities*. ASTM Standard D7045-17.

CH2M HILL (CH2M). 2016a. *Conceptual Site Model, Central Maui Landfill, Puunene, Hawaii.* Prepared for The County of Maui, Department of Environmental Management, Solid Waste Division. February.

CH2M HILL (CH2M). 2016b. *Calculation of Upper Prediction Limits, Central Maui Landfill Facility Groundwater Monitoring*. Technical Memorandum. Prepared for Kevin Kihara, Hawaii Department of Health, Solid and Hazardous Waste Branch. October 16.

CH2M HILL (CH2M). 2018. *Conceptual Site Model, Central Maui Landfill, Puunene, Hawaii.* Prepared for The County of Maui, Department of Environmental Management, Solid Waste Division. January.

Chatfield, C. 2004. *The Analysis of Time Series: An Introduction*. 6th Edition. Boca Raton, FL. Chapman and Hall.

Code of Federal Regulations (CFR), Title 40, Part 258 (Subtitle D)

Davis, C.B. and R.B. McNichols. 1999. "Simultaneous Nonparametric Prediction Limits." *Technometrics*, 41, 89-101.

Dixon, W.J. 1953. "Processing Data for Outliers." *Biometrics*, 9, 74-89.

Gilbert, Richard O. 1987. *Statistical Methods for Environmental Pollution Monitoring*.

Hawaii Administrative Rules (HAR), Title 11, Chapter 58.1, Subchapter 2 Solid Waste Disposal Facilities.

Helsel, D.R. 2005. *Nondetects and Data Analysis. Statistics for Censored Environmental Data*. John Wiley and Sons, NY.

Johnson, R.A. and D. Wichern. 2007. *Applied Multivariate Statistical Analysis*. 6th Edition. Prentice Hall

Jolliffe, I.T. 1986. *Principal Component Analysis*. Springer-Verlag, New York, New York.

Kaplan, E.L. and O. Meier. 1958. Nonparametric Estimation from Incomplete Observations. *Journal of the American Statistical Association*, Vol. 53. 457-481.

Millard, S.P. 2013. *EnvStats: An R Package for Environmental Statistics*. Springer, NY.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

Rosner, B. 1983. "On the Detection of Many Outliers." *Technometrics*, 17, 221-227.

Singh, A., R. Maichle, and S. Lee. 2006. *On the Computation of a 95% Upper Confidence Limit of the Unknown Population Mean Based Upon Data Sets with Below Detection Limit Observations*. EPA/600/R-06/022, March.

State of Hawaii Department of Health (HDOH). 2002. *State of Hawaii Landfill Groundwater Monitoring Guidance Document*. Version 1.8. Solid and Hazardous Waste Branch (SHWB). September.

State of Hawaii Department of Health (HDOH). 2017. *Re: Technical Memorandum: Calculation of Upper Prediction Limits, Central Maui Landfill Facility Groundwater Monitoring (October 16, 2016), Central Maui Municipal Solid Waste Landfill, Solid Waste Management Permit No. LF-0089-08.* Letter to Mr. Stewart Stant, Director, Department of Environmental Management, County of Maui. July 19.

U.S. Department of Health and Human Services. 2017. *Public Health Service Agency for Toxic Substances and Disease Registry, Toxicological Profile for Nitrate and Nitrite*. July.

U.S. Environmental Protection Agency (USEPA). 1996. *Soil Screening Guidance: Technical Background Document.* Office of Solid Waste and Emergency Response. EPA/540/R95/128. May.

U.S. Environmental Protection Agency (USEPA). 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*. EPA 530/R-09-007. Office of Research and Development. March.

U.S. Environmental Protection Agency (USEPA). 2015. *ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations*. EPA/600/R-07/041. Office of Research and Development. October.

United States Geological Survey (USGS). 1985. *Study and Interpretation of the Chemical Characteristics of Natural Waters.*

Western Regional Climate Center (WRCC). Climate data for Puunene 396, Hawaii (518543), Period of Record: 10/01/1949 to 05/31/2016. https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?hi8543.

Wilcox, Rand R. 2010. *Fundamentals of Modern Statistical Methods*. March.

Tables

Table 1

Summary Statistics and Leachate/Groundwater Contrast

Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

Constituent	Conc. Unit	Action Level								Leachate Concentration				Mean Groundwater Concentration												Leachate/Groundwater Contrast					
		UPL						MCL	EAL	Detections (percent)	MIN	MAX	Mean	Upgradient/Crossgradient Wells						Downgradient (Compliance) Wells						Upgradient/Crossgradient Wells			Downgradient (Compliance) Wells		
		MW-1	MW-2	MW-3	MW-4	MW-5	MW-6							MW-1		MW-4		MW-6		MW-2		MW-3		MW-5		MW-1	MW-4	MW-6	MW-2	MW-3	MW-5
														Conc.	Detection Frequency (percent)	Conc.	Detection Frequency (percent)	Conc.	Detection Frequency (percent)	Conc.	Detection Frequency (percent)	Conc.	Detection Frequency (percent)	Conc.	Detection Frequency (percent)						
Total Alkalinity (as CaCO3)*	mg/L	550	501	560	485	557	595	NA	NA	100	107	2300	1424	269	100	247	100	273	100	274	100	247	100	261	100	5	5.8	5.2	5.2	5.8	5.5
Ammonia	mg/L	NC	NC	NC	NC	NC	NC	NA	NA	100	0.56	59	13.5	0.064	32	NA	15.4	ND	0	0.135	47	0.087	37	NA	8	211	NC	MAX	100	155	NC
Nitrate-N**	mg/L	10.2	25.9	10.3	9.35	10.4	9.56	10	NA	39	0.03	1.1	0.125	18.9	99	4.6	98	4.86	98	24	99	22.6	99	4.98	98	0	0.0	0.0	0.01	0.01	0.03
Barium	mg/L	NC	NC	NC	NC	NC	NC	2	2	100	0.079	1.9	0.408	0.005	33	ND	0	ND	0	0.004	47	0.005	35	ND	0	82	MAX	MAX	102	82	MAX
Benzene	µg/L	NC	NC	NC	NC	NC	NC	0.005	0.005[a]	43	0.76	7	1.91	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Calcium	mg/L	29.5	38.6	27.7	29.3	27.9	26.1	NA	NA	100	17.3	170	69	20.4	100	22.5	100	18.2	100	23.6	100	23.5	100	22.3	100	3	3.1	3.8	2.9	2.9	3.1
Chloride	mg/L	287	505	282	318	304	216	250	NA	100	170	1600	751	185	100	205	100	161	100	259	100	180	100	192	100	4	3.7	4.7	2.9	4.2	3.9
Chromium	mg/L	NC	NC	NC	NC	NC	NC	0.1	0.016[b]	24	0.004	0.056	0.009	NA	8	NA	5	ND	0	ND	0	0.004	12	ND	0	NC	NC	MAX	MAX	2.3	MAX
Copper	mg/L	NC	NC	NC	NC	NC	NC	1.3	0.0029[b]	57	0.011	0.19	0.025	0.005	22	ND	0	ND	0	0.004	33	0.006	17	ND	0	5	MAX	MAX	6.3	4.2	MAX
1,4-Dichlorobenzene	µg/L	NC	NC	NC	NC	NC	NC	0.075	0.005[c]	37	1.35	5.7	1.72	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
1,2-Dichloroethane	µg/L	NC	NC	NC	NC	NC	NC	0.005	0.005[a]	28.6	0.83	8.8	1.8	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
cis-1,2-Dichloroethylene	µg/L	NC	NC	NC	NC	NC	NC	0.07	0.07[a]	28	1.6	8.54	1.88	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Ethylbenzene	µg/L	NC	NC	NC	NC	NC	NC	0.7	0.03[a]	26	1.67	20	2.71	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Iron	mg/L	NC	0.215	NC	0.126	0.959	0.73	0.3	NA	100	0.962	23	5.67	0.052	10	0.078	43	0.079	33	0.079	23	0.062	19	0.108	48	109	73	72	72	91	53
Magnesium	mg/L	47.6	72.9	40.7	48.6	42	43.8	NA	NA	100	88.8	477	302	30.8	100	33.2	100	29.1	100	37.5	100	30.8	100	31.3	100	10	9.1	10	8.1	10	9.6
Nickel	mg/L	NC	0.0298	NC	0.367	0.246	0.148	NA	0.005[b]	71	0.011	0.051	0.021	NA	7	0.219	100	0.11	100	0.013	32	NA	4	0.178	100	NC	0.1	0.2	1.6	NC	0.12
Potassium	mg/L	20.9	25.1	18.5	18.8	18.3	20.8	NA	NA	97	21.1	68.9	37.2	13.8	100	13.8	100	13.6	100	15.1	100	13.6	100	14.5	100	3	2.7	2.7	2.5	2.7	2.6
Sodium	mg/L	242	379	217	239	219	221	NA	NA	100	192	925	528	175	100	174	100	168	100	216	100	168	100	174	100	3	3.0	3.1	2.4	3.1	3.0
Sulfate	mg/L	74.1	300	75.3	96.6	75.2	69	250	NA	37	0.59	129	9.69	26.1	93	29.4	98	24.2	98	42.6	96	26.1	94	29	98	0	0.3	0.4	0.23	0.37	0.33
Total Dissolved Solids	mg/L	975	1400	1080	1080	1050	945	500	NA	100	1370	4308	2877	739	100	672	100	631	100	840	100	677	100	675.6	100	4	4.3	4.6	3.4	4.2	4.3
Total Organic Carbon	mg/L	76.3	69.3	76	67.4	76.3	80.6	NA	NA	100	3.6	980	113	8.1	76	5.79	71	7.1	77	8.85	79	8.69	73	8.68	71	14	20	16	13	13	13
Toluene	µg/L	NC	NC	NC	NC	NC	NC	1	0.04[c]	29	1.2	62.8	4.44	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Vinyl Chloride	µg/L	NC	NC	NC	NC	NC	NC	0.002	0.002	29	1.0	6.18	1.29	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Xylenes	µg/L	NC	NC	NC	NC	NC	NC	10	0.02[c]	60	1.38	37	7.11	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Zinc	mg/L	0.0983	0.184	0.239	0.196	0.162	0.0769	5	0.022[b]	57	0.02	0.061	0.025	0.027	40	0.015	39	0.018	62	0.029	55	0.025	55	0.021	62	1	1.7	1.4	0.86	1.0	1.2

Note:

This table includes only constituents with at least 20 percent detections in leachate collected at the sump/wet well within Phases IV-A and IV-B between 2006 and 2017 (semiannual sampling). For both leachate and groundwater average concentratio calculations, non detects were included and managed using the Kaplan-Meir method

Mean groundwater concentrations were calculated considering groundwater samples collected at each specific monitoring well between 1995 and 2017 (frequency varying over time). Field duplicate samples were not included in average calculation

a-b-c. EALs identified with an "a" are based on drinking water concerns; EALs identified with a "b" are based on aquatic ecotoxicity concerns; EALs identified with a "c" are based on gross contamination concerns

* Alkalinity in groundwater was reported as bicarbonate alkalinity (as CaCO3) until 10/2014 and as total alkalinity (as CaCO3) after 12/2014. For leachate concentrations both total and bicarbonate alkalinity were reported and were in most cases the same. Leachate data and literature show that at pH levels observe at the site, bicarbonate alkalinity is equivalent to total alkalinity because other carbonate (the other major alkalinity in natural waters) is stable only at higher pH values. When both toal and bicarbonate alkalinity were available (and they were in most cases the same), only total alkalinity was considere

** Nitrogen in groundwater was reported as "nitrate (as N)" until 12/2014. After 12/2014 "nitrate-nitrite (as N)" was reported; because nitrite is unstable and easily oxidized to nitrate, nitrate is the compound predominantly found in groundwater (U.S. Department of Health and Human Services, 2017) Therefore, concentrations of nitrogen reported as “nitrate-nitrite (as N)” and “nitrate (as N)" are generally the same

µg/L = microgram(s) per liter
C/I = commercial industrial sites
Conc. = concentration
DWT = drinking water threatened
EAL = HDOH environmental action level (risk-based; C/I; greater than 150 meters from SW; DWT
HDOH = State of Hawaii Department of Health
MAX = maximum contrast (i.e., constituent is detected in leachate but not in groundwater
MCL = maximum contaminant level (Safe Drinking Water Act, Primary and Secondary Drinking Water Regulations
mg/L = milligram(s) per liter
NA = not available (that is, no limit available or mean value not calculated because number of detections is lower than 20 percent)
NC = not calculated
ND = not detected
SW = surface water
UPL = upper prediction limit (CH2M, 2016b)

Table 2

Summary Statistics for Proposed Detection Monitoring Constituents (1995-2017)

Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

		Frequency of Detection			Minimum Values		Maximum Values						Mann-Kendall Test		
Well	Constituent	Total Samples	Detect Results	Detect Freq. (%)	Non-Detect (mg/L)	Detect (mg/L)	Non-Detect (mg/L)	Detect (mg/L)	Mean (mg/L)	Std Dev (mg/L)	Last Result (mg/L)	Last Sample Date	MK Test Statistic (S)	MK p-value	MK Trend Result
MW-1	Alkalinity	65	65	100	NA	220	NA	362	269	32.5	242	Sep-17	-1169	0.000	Decreasing
MW-2	Alkalinity	66	66	100	NA	193	NA	409	274	51.8	208	Sep-17	-1522	0.000	Decreasing
MW-3	Alkalinity	66	66	100	NA	234	NA	379	278	32.0	252	Sep-17	-1261	0.000	Decreasing
MW-4	Alkalinity	40	40	100	NA	206	NA	327	247	36.6	225	Sep-17	-549	0.000	Decreasing
MW-5	Alkalinity	39	39	100	NA	180	NA	306	261	26.3	256	Sep-17	-423	0.000	Decreasing
MW-6	Alkalinity	40	40	100	NA	251	NA	299	273	14.9	257	Sep-17	-535	0.000	Decreasing
MW-1	Calcium	66	66	100	NA	17.0	NA	23.5	20.4	1.32	18.2	Sep-17	100	0.291	No Trend
MW-2	Calcium	67	67	100	NA	20.0	NA	28.8	23.6	1.95	26.5	Sep-17	457	0.007	Increasing
MW-3	Calcium	67	67	100	NA	19.9	NA	27.5	23.5	1.54	19.9	Sep-17	-892	0.000	Decreasing
MW-4	Calcium	41	41	100	NA	18.3	NA	27.8	22.5	2.29	18.3	Sep-17	-426	0.000	Decreasing
MW-5	Calcium	41	41	100	NA	20.0	NA	24.8	22.3	1.25	20.3	Sep-17	-246	0.003	Decreasing
MW-6	Calcium	41	41	100	NA	16.4	NA	21.0	18.2	1.09	16.5	Sep-17	171	0.028	Increasing
MW-1	Chloride	69	69	100	NA	132	NA	230	185	20.7	170	Sep-17	854	0.000	Increasing
MW-2	Chloride	70	70	100	NA	155	NA	390	259	53.5	390	Sep-17	1359	0.000	Increasing
MW-3	Chloride	69	69	100	NA	132	NA	230	180	20.5	180	Sep-17	790	0.000	Increasing
MW-4	Chloride	44	44	100	NA	170	NA	250	205	24.4	170	Sep-17	372	0.000	Increasing
MW-5	Chloride	44	44	100	NA	160	NA	240	192	21.1	180	Sep-17	411	0.000	Increasing
MW-6	Chloride	43	43	100	NA	140	NA	190	161	11.1	140	Sep-17	291	0.001	Increasing
MW-1	Iron	68	7	10.3	0.040	0.089	0.300	0.270	0.052	0.038	<0.1	Sep-17	-202	0.022	Decreasing
MW-2	Iron	69	16	23.2	0.040	0.063	0.510	0.542	0.079	0.091	<0.1	Sep-17	-191	0.091	No Trend
MW-3	Iron	69	13	18.8	0.040	0.062	0.300	0.270	0.062	0.044	<0.1	Sep-17	-144	0.138	No Trend
MW-4	Iron	42	18	42.9	0.050	0.051	0.100	0.235	0.078	0.040	<0.1	Sep-17	-251	0.001	Decreasing
MW-5	Iron	42	20	47.6	0.040	0.051	0.100	0.610	0.108	0.114	<0.1	Sep-17	-302	0.000	Decreasing
MW-6	Iron	42	14	33.3	0.040	0.050	0.100	0.527	0.079	0.096	<0.1	Sep-17	-133	0.044	Decreasing
MW-1	Magnesium	69	69	100	NA	21.0	NA	37.2	30.8	2.94	31.5	Sep-17	1190	0.000	Increasing
MW-2	Magnesium	69	69	100	NA	29.0	NA	50.3	37.5	5.55	47.4	Sep-17	1130	0.000	Increasing
MW-3	Magnesium	69	69	100	NA	25.0	NA	35.2	30.8	2.23	30.4	Sep-17	782	0.000	Increasing
MW-4	Magnesium	42	42	100	NA	28.8	NA	38.8	33.2	2.46	30.4	Sep-17	201	0.015	Increasing
MW-5	Magnesium	42	42	100	NA	27.7	NA	35.2	31.3	2.03	30.3	Sep-17	255	0.003	Increasing
MW-6	Magnesium	42	42	100	NA	25.7	NA	34.6	29.1	2.27	27.6	Sep-17	270	0.002	Increasing
MW-1	Potassium	67	67	100	NA	9.80	NA	24.0	13.8	1.88	12.6	Sep-17	509	0.003	Increasing
MW-2	Potassium	68	68	100	NA	11.0	NA	19.4	15.1	1.78	16.4	Sep-17	683	0.000	Increasing
MW-3	Potassium	68	68	100	NA	9.50	NA	21.0	13.6	1.71	12.3	Sep-17	485	0.005	Increasing
MW-4	Potassium	41	41	100	NA	11.5	NA	16.0	13.8	1.15	12.3	Sep-17	-35	0.351	No Trend
MW-5	Potassium	41	41	100	NA	12.0	NA	16.3	14.5	1.03	13.5	Sep-17	-68	0.225	No Trend
MW-6	Potassium	41	41	100	NA	11.7	NA	16.8	13.6	1.09	12.7	Sep-17	122	0.087	No Trend
MW-1	Sodium	67	67	100	NA	151	NA	230	175	12.8	163	Sep-17	207	0.132	No Trend
MW-2	Sodium	68	68	100	NA	162	NA	280	216	27.5	265	Sep-17	704	0.000	Increasing
MW-3	Sodium	68	68	100	NA	144	NA	225	168	12.7	163	Sep-17	383	0.021	Increasing
MW-4	Sodium	41	41	100	NA	140	NA	236	174	17.4	158	Sep-17	90	0.158	No Trend
MW-5	Sodium	41	41	100	NA	138	NA	234	174	15.4	170	Sep-17	210	0.009	Increasing
MW-6	Sodium	41	41	100	NA	140	NA	240	168	15.8	154	Sep-17	143	0.055	No Trend
MW-1	Total Dissolved Solids	67	67	100	NA	585	NA	4,910	739	520	645	Sep-17	-378	0.021	Decreasing
MW-2	Total Dissolved Solids	68	68	100	NA	652	NA	1,400	840	121	955	Sep-17	513	0.003	Increasing
MW-3	Total Dissolved Solids	68	68	100	NA	475	NA	1,300	677	86.7	610	Sep-17	-443	0.010	Decreasing
MW-4	Total Dissolved Solids	41	41	100	NA	500	NA	770	672	48.7	575	Sep-17	-215	0.008	Decreasing
MW-5	Total Dissolved Solids	40	40	100	NA	538	NA	772	676	51.8	635	Sep-17	-68	0.217	No Trend

Table 2

Summary Statistics for Proposed Detection Monitoring Constituents (1995-2017)

Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

		Frequency of Detection			Minimum Values		Maximum Values						Mann-Kendall Test		
Well	Constituent	Total Samples	Detect Results	Detect Freq. (%)	Non-Detect (mg/L)	Detect (mg/L)	Non-Detect (mg/L)	Detect (mg/L)	Mean (mg/L)	Std Dev (mg/L)	Last Result (mg/L)	Last Sample Date	MK Test Statistic (S)	MK p-value	MK Trend Result
MW-6	Total Dissolved Solids	41	41	100	NA	475	NA	821	631	52.1	535	Sep-17	-199	0.013	Decreasing
MW-1	Total Organic Carbon	70	53	75.7	0.500	0.560	8.00	55.0	8.06	11.0	0.820	Sep-17	65	0.372	No Trend
MW-2	Total Organic Carbon	70	55	78.6	1.00	1.10	8.00	59.0	8.85	11.1	3.10	Sep-17	159	0.210	No Trend
MW-3	Total Organic Carbon	69	50	72.5	0.500	0.670	8.00	37.0	8.69	10.3	0.670	Sep-17	-147	0.222	No Trend
MW-4	Total Organic Carbon	42	30	71.4	0.500	0.620	25.0	30.0	5.79	7.30	0.650	Sep-17	-74	0.211	No Trend
MW-5	Total Organic Carbon	44	31	70.5	0.500	0.680	1.00	47.0	8.68	11.1	0.770	Sep-17	24	0.407	No Trend
MW-6	Total Organic Carbon	43	33	76.7	0.500	0.550	1.00	32.0	7.14	9.39	<0.5	Sep-17	-6	0.479	No Trend

Notes:

< = less than
"---" = not applicable
% = percent
Freq. = frequency
mg/L = milligram(s) per liter
MK = Mann-Kendall

p-value = probability value ($p < 0.05$ indicates significant test result)
Std Dev = standard deviation
Trend analysis performed using Mann Kendall single-tailed test at 0.05 significance level.
Nondetects were assigned a common value less than the smallest measured value in the data set for the Mann-Kendall test.
Summary statistics calculated using Kaplan-Meier method for non-detects.

Table 3

Statistical Outlier Detection Results

Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

Well	Constituent	Sample Date	Result (mg/L)	Next Closest Value (mg/L)	IQR Score	MAD Score	Determined to be an actual outlier?
Data collected from well MW-2 during 1996 through 2011							
MW-2	Alkalinity	Dec-11	42.0	193	6.90	9.29	Yes
MW-2	Alkalinity	Dec-01	27.9	42.0	7.32	9.82	Yes
MW-2	Calcium	Jun-98	28.8	28.3	2.40	3.60	No
MW-2	Magnesium	Jun-04	44.8	41.9	2.77	4.68	No
MW-2	Total Organic Carbon	Apr-96	59.0	38.0	4.98	16.63	No
MW-2	Total Organic Carbon	Sep-99	38.0	33.9	2.85	10.47	No
MW-2	Total Organic Carbon	Mar-00	33.9	32.0	2.43	9.27	No
MW-2	Total Organic Carbon	Dec-99	32.0	26.2	2.24	8.71	No
MW-2	Total Organic Carbon	Jun-00	26.2	17.0	1.65	7.01	No
Data collected from all wells during 2008 through 2017							
MW-1	Alkalinity	Jun-09	294	274	4.00	5.23	No
MW-1	Alkalinity	Dec-11	44.0	219	14.2	15.9	Yes
MW-2	Alkalinity	Dec-11	42.0	193	6.23	10.5	Yes
MW-3	Alkalinity	Dec-11	44.0	234	12.2	16.9	Yes
MW-4	Alkalinity	Dec-11	44.0	206	11.4	19.2	Yes
MW-5	Alkalinity	Dec-11	42.0	224	12.3	17.0	Yes
MW-5	Alkalinity	Dec-10	180	224	3.63	5.40	No
MW-6	Alkalinity	Dec-11	50.0	251	22.3	31.6	Yes
MW-2	Iron	Jun-10	0.463	0.110	2.65	18.6	No
MW-1	Potassium	Jun-15	16.8	15.3	2.89	4.89	No
MW-6	Potassium	Jun-15	16.8	15.0	1.18	2.06	No
MW-5	Sodium	Jun-09	138	156	2.13	3.54	No
MW-2	Total Dissolved Solids	Mar-17	1,280	1,020	2.28	3.95	No
MW-3	Total Dissolved Solids	Sep-15	475	610	2.38	3.57	No
MW-4	Total Dissolved Solids	Sep-15	500	575	2.10	2.84	No

Notes:

IQR = interquartile range

MAD = median absolute deviation

mg/L = milligram(s) per liter

For the purpose of the identification of statistical outliers, non-detects were not considered.

Statistical outliers identified at a significance level of 0.05.

Table 4

Results of Serial Correlation Analysis (2008 - 2017)

Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

Well	Constituent	No. of Detects	No. of NDs	p-value	Conclusion
MW-1	Alkalinity	24	0	0.000	significant
MW-2	Alkalinity	24	0	0.000	significant
MW-3	Alkalinity	24	0	0.001	significant
MW-4	Alkalinity	23	0	0.000	significant
MW-5	Alkalinity	24	0	0.020	significant
MW-6	Alkalinity	23	0	0.154	not significant
MW-1	Calcium	25	0	0.131	not significant
MW-2	Calcium	25	0	0.000	significant
MW-3	Calcium	25	0	0.165	not significant
MW-4	Calcium	24	0	0.008	significant
MW-5	Calcium	25	0	0.070	not significant
MW-6	Calcium	24	0	0.014	significant
MW-1	Chloride	28	0	0.000	significant
MW-2	Chloride	27	0	0.000	significant
MW-3	Chloride	27	0	0.000	significant
MW-4	Chloride	27	0	0.000	significant
MW-5	Chloride	28	0	0.000	significant
MW-6	Chloride	26	0	0.000	significant
MW-1	Iron	26	25	NA	NA
MW-2	Iron	26	22	NA	NA
MW-3	Iron	26	21	NA	NA
MW-4	Iron	25	18	NA	NA
MW-5	Iron	26	18	NA	NA
MW-6	Iron	25	19	NA	NA
MW-1	Magnesium	27	0	0.000	significant
MW-2	Magnesium	26	0	0.000	significant
MW-3	Magnesium	26	0	0.000	significant
MW-4	Magnesium	25	0	0.003	significant
MW-5	Magnesium	26	0	0.000	significant
MW-6	Magnesium	25	0	0.000	significant
MW-1	Potassium	25	0	0.015	significant
MW-2	Potassium	25	0	0.000	significant
MW-3	Potassium	25	0	0.016	significant
MW-4	Potassium	24	0	0.008	significant
MW-5	Potassium	25	0	0.003	significant
MW-6	Potassium	24	0	0.001	significant
MW-1	Sodium	25	0	0.007	significant
MW-2	Sodium	25	0	0.000	significant
MW-3	Sodium	25	0	0.001	significant
MW-4	Sodium	24	0	0.000	significant
MW-5	Sodium	25	0	0.003	significant
MW-6	Sodium	24	0	0.015	significant
MW-1	Total Dissolved Solids	25	0	0.771	not significant
MW-2	Total Dissolved Solids	25	0	0.008	significant
MW-3	Total Dissolved Solids	25	0	0.953	not significant
MW-4	Total Dissolved Solids	24	0	0.481	not significant
MW-5	Total Dissolved Solids	25	0	0.420	not significant
MW-6	Total Dissolved Solids	24	0	0.341	not significant
MW-1	Total Organic Carbon	21	7	0.008	significant
MW-2	Total Organic Carbon	23	4	0.002	significant
MW-3	Total Organic Carbon	19	7	0.020	significant
MW-4	Total Organic Carbon	16	9	0.047	significant
MW-5	Total Organic Carbon	21	7	0.005	significant
MW-6	Total Organic Carbon	20	6	0.005	significant

Notes:

NA = not applicable

NDs = non-detects

No. = number

p-value = probability value for the rank von Neumann Ratio test ($p < 0.05$ indicates significant test result).

Table 5

Results of Temporal Variability Analysis (2008 - 2017)

Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

Constituent	No. of Detects	No. of NDs	KW p-value	Conclusion
Alkalinity	142	0	0.002	significant
Calcium	148	0	0.270	not significant
Chloride	163	0	0.135	not significant
Iron	31	123	0.002	significant
Magnesium	155	0	0.000	significant
Potassium	148	0	0.000	significant
Sodium	148	0	0.000	significant
Total Dissolved Solids	148	0	0.008	significant
Total Organic Carbon	120	40	0.000	significant

Notes:

KW = Kruskal-Wallis
NDs = non-detects
No. = number
p-value = probability value ($p < 0.05$ indicates significant test result)

Table 6

Results of Seasonaility Analysis (2008 - 2017)

Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

Re	No. of Detects	No. of NDs	KW p-value	Conclusion
Alkalinity	142	0	0.335	not significant
Calcium	148	0	0.925	not significant
Chloride	163	0	0.541	not significant
Iron	31	123	0.261	not significant
Magnesium	155	0	0.856	not significant
Potassium	148	0	0.418	not significant
Sodium	148	0	0.090	not significant
Total Dissolved Solids	148	0	0.497	not significant
Total Organic Carbon	120	40	0.852	not significant

Notes:

KW = Kruskal-Wallis
NDs = non-detects
No. = number
p-value = probability value ($p < 0.05$ indicates significant test result)

Table 7
Trend Evaluation Results
Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

Well	Constituent	No. of Samples	No. of NDs	MK Test Statistic (S)	MK p-value	MK Trend Result
Data collected from well MW-2 during 1996 through 2011						
MW-2	Alkalinity	46	0	-717	0.000	Decreasing
MW-2	Calcium	47	0	-270	0.007	Decreasing
MW-2	Chloride	48	0	184	0.051	No Trend
MW-2	Iron	48	35	105	0.118	No Trend
MW-2	Magnesium	48	0	77	0.249	No Trend
MW-2	Potassium	48	0	60	0.300	No Trend
MW-2	Sodium	48	0	-62	0.294	No Trend
MW-2	Total Dissolved Solids	48	0	-119	0.147	No Trend
MW-2	Total Organic Carbon	48	14	-174	0.059	No Trend
Data collected from all wells during 2008 through 2017						
MW-1	Alkalinity	24	0	-47	0.126	No Trend
MW-2	Alkalinity	24	0	-159	0.000	Decreasing
MW-3	Alkalinity	24	0	-41	0.160	No Trend
MW-4	Alkalinity	23	0	-86	0.012	Decreasing
MW-5	Alkalinity	24	0	-18	0.336	No Trend
MW-6	Alkalinity	23	0	-104	0.003	Decreasing
MW-1	Calcium	25	0	64	0.071	No Trend
MW-2	Calcium	25	0	163	0.000	Increasing
MW-3	Calcium	25	0	-77	0.038	Decreasing
MW-4	Calcium	24	0	-21	0.312	No Trend
MW-5	Calcium	25	0	-10	0.418	No Trend
MW-6	Calcium	24	0	30	0.238	No Trend
MW-1	Chloride	28	0	52	0.153	No Trend
MW-2	Chloride	27	0	287	0.000	Increasing
MW-3	Chloride	27	0	15	0.384	No Trend
MW-4	Chloride	27	0	71	0.070	No Trend
MW-5	Chloride	28	0	-6	0.460	No Trend
MW-6	Chloride	26	0	45	0.156	No Trend
MW-1	Iron	26	25	11	0.414	No Trend
MW-2	Iron	26	22	-50	0.142	No Trend
MW-3	Iron	26	21	-21	0.331	No Trend
MW-4	Iron	25	18	-141	0.000	Decreasing
MW-5	Iron	26	18	-118	0.005	Decreasing
MW-6	Iron	25	19	-63	0.075	No Trend
MW-1	Magnesium	27	0	120	0.007	Increasing
MW-2	Magnesium	26	0	212	0.000	Increasing
MW-3	Magnesium	26	0	79	0.043	Increasing
MW-4	Magnesium	25	0	62	0.077	No Trend
MW-5	Magnesium	26	0	91	0.024	Increasing
MW-6	Magnesium	25	0	98	0.012	Increasing
MW-1	Potassium	25	0	115	0.004	Increasing
MW-2	Potassium	25	0	168	0.000	Increasing
MW-3	Potassium	25	0	20	0.328	No Trend
MW-4	Potassium	24	0	34	0.206	No Trend
MW-5	Potassium	25	0	42	0.168	No Trend
MW-6	Potassium	24	0	82	0.022	Increasing
MW-1	Sodium	25	0	69	0.057	No Trend
MW-2	Sodium	25	0	200	0.000	Increasing
MW-3	Sodium	25	0	0	0.509	No Trend
MW-4	Sodium	24	0	60	0.072	No Trend
MW-5	Sodium	25	0	50	0.128	No Trend
MW-6	Sodium	24	0	82	0.022	Increasing
MW-1	Total Dissolved Solids	25	0	-42	0.168	No Trend
MW-2	Total Dissolved Solids	25	0	125	0.002	Increasing
MW-3	Total Dissolved Solids	25	0	-70	0.053	No Trend
MW-4	Total Dissolved Solids	24	0	-34	0.206	No Trend
MW-5	Total Dissolved Solids	25	0	-69	0.056	No Trend
MW-6	Total Dissolved Solids	24	0	-39	0.172	No Trend
MW-1	Total Organic Carbon	21	7	-1	0.500	No Trend
MW-2	Total Organic Carbon	23	4	66	0.087	No Trend
MW-3	Total Organic Carbon	19	7	10	0.420	No Trend
MW-4	Total Organic Carbon	16	9	25	0.283	No Trend
MW-5	Total Organic Carbon	21	7	-16	0.382	No Trend
MW-6	Total Organic Carbon	20	6	-22	0.320	No Trend

Notes:
MK = Mann-Kendall
NDs = non-detects
No. = number
p-value = probability value ($p < 0.05$ indicates significant test result)
Trend analysis performed using Mann Kendall single-tailed test at 0.05 significance level.

Table 8
Results of Spatial Variability Analysis (2008 - 2017)
Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

Constituent	No. of Detects	No. of NDs	KW p-value	Conclusion	Post-hoc Test for Multiple Comparisons (list of spatially different pairs)
Alkalinity	142	0	0.000	significant	MW-1-MW-6; MW-2-MW-3; MW-2-MW-5; MW-2-MW-6; MW-3-MW-4; MW-4-MW-5 MW-4-MW-6
Calcium	148	0	0.000	significant	MW-1-MW-2; MW-1-MW-3; MW-2-MW-4 MW-2-MW-6; MW-3-MW-4; MW-3-MW-6 MW-4-MW-6; MW-5-MW-6
Chloride	163	0	0.000	significant	MW-1-MW-2; MW-1-MW-6; MW-2-MW-3 MW-2-MW-4; MW-2-MW-5; MW-2-MW-6 MW-3-MW-6; MW-4-MW-6; MW-5-MW-6
Iron	31	123	0.202	not significant	NA
Magnesium	155	0	0.000	significant	MW-1-MW-2; MW-1-MW-6; MW-2-MW-3 MW-2-MW-4; MW-2-MW-5; MW-2-MW-6 MW-4-MW-6
Potassium	148	0	0.000	significant	MW-1-MW-2; MW-2-MW-3; MW-2-MW-4 MW-2-MW-6
Sodium	148	0	0.000	significant	MW-1-MW-2; MW-2-MW-3; MW-2-MW-4 MW-2-MW-5; MW-2-MW-6
Total Dissolved Solids	148	0	0.000	significant	MW-1-MW-2; MW-1-MW-6; MW-2-MW-3 MW-2-MW-4; MW-2-MW-5; MW-2-MW-6 MW-5-MW-6
Total Organic Carbon	120	40	0.417	not significant	NA

Notes:
KW = Kruskal-Wallis
NA = not applicable
NDs = non detects
No. = number
p-value = probability value ($p < 0.05$ indicates significant test result)

Table 9

Results of Goodness-of-Fit Tests

Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

Well	Constituent	Total Samples	Detect Results	Shapiro-Wilk p-value Normal	Lilliefor p-value Normal	Shapiro-Wilk p-value Lognormal	Lilliefor p-value Lognormal	Anderson-Darling p-value Gamma	Kolmogorov-Smirnov p-value Gamma	Assumed Distribution
Data collected from well MW-2 during 1996 through 2011										
MW-2	Alkalinity	46	46	0.000	0.001	0.007	0.009	< 0.01	< 0.01	NP
MW-2	Calcium	47	47	0.026	0.481	0.124	0.640	>= 0.10	>= 0.10	Normal
MW-2	Chloride	48	48	0.008	0.012	0.000	0.001	< 0.01	< 0.01	NP
MW-2	Iron	48	13	0.005	0.024	0.277	0.449	0.05 <= p < 0.10	>= 0.10	Gamma
MW-2	Magnesium	48	48	0.004	0.002	0.029	0.009	< 0.01	< 0.01	NP
MW-2	Potassium	48	48	0.004	0.002	0.040	0.018	0.01 <= p < 0.05	< 0.01	NP
MW-2	Sodium	48	48	0.027	0.090	0.127	0.260	0.01 <= p < 0.05	>= 0.10	Normal
MW-2	Total Dissolved Solids	48	48	0.770	0.497	0.834	0.648	>= 0.10	>= 0.10	Normal
MW-2	Total Organic Carbon	48	34	0.000	0.000	0.021	0.017	0.01 <= p < 0.05	>= 0.10	Gamma
Data collected from all wells during 2008 through 2017										
MW-1	Alkalinity	24	24	0.001	0.001	0.003	0.003	< 0.01	< 0.01	NP
MW-2	Alkalinity	24	24	0.024	0.007	0.051	0.014	0.01 <= p < 0.05	0.01 <= p < 0.05	Lognormal
MW-3	Alkalinity	24	24	0.002	0.015	0.004	0.022	< 0.01	0.01 <= p < 0.05	NP
MW-4	Alkalinity	23	23	0.000	0.010	0.001	0.020	< 0.01	0.01 <= p < 0.05	NP
MW-5	Alkalinity	24	24	0.006	0.181	0.001	0.066	0.01 <= p < 0.05	>= 0.10	Normal
MW-6	Alkalinity	23	23	0.015	0.010	0.021	0.013	0.01 <= p < 0.05	0.01 <= p < 0.05	NP
MW-1	Calcium	25	25	0.826	0.746	0.842	0.604	>= 0.10	>= 0.10	Normal
MW-2	Calcium	25	25	0.120	0.052	0.132	0.053	>= 0.10	0.01 <= p < 0.05	Normal
MW-3	Calcium	25	25	0.387	0.562	0.211	0.429	>= 0.10	>= 0.10	Normal
MW-4	Calcium	24	24	0.224	0.325	0.224	0.366	>= 0.10	>= 0.10	Normal
MW-5	Calcium	25	25	0.390	0.315	0.399	0.324	>= 0.10	>= 0.10	Normal
MW-6	Calcium	24	24	0.409	0.261	0.317	0.157	>= 0.10	>= 0.10	Normal
MW-1	Chloride	28	28	0.046	0.041	0.045	0.022	0.01 <= p < 0.05	0.01 <= p < 0.05	NP
MW-2	Chloride	27	27	0.036	0.045	0.022	0.030	< 0.01	0.01 <= p < 0.05	NP
MW-3	Chloride	27	27	0.101	0.172	0.107	0.182	>= 0.10	>= 0.10	Normal
MW-4	Chloride	27	27	0.019	0.031	0.015	0.020	< 0.01	0.01 <= p < 0.05	NP
MW-5	Chloride	28	28	0.081	0.065	0.139	0.089	>= 0.10	0.05 <= p < 0.10	Normal
MW-6	Chloride	26	26	0.131	0.018	0.123	0.011	0.01 <= p < 0.05	0.01 <= p < 0.05	Normal
MW-1	Iron	26	1	NA	NA	NA	NA	NA	NA	NP
MW-2	Iron	26	4	0.008	NA	0.049	NA	NA	NA	NP
MW-3	Iron	26	5	0.724	0.538	0.474	0.363	>= 0.10	>= 0.10	NP
MW-4	Iron	25	7	0.703	0.454	0.456	0.266	>= 0.10	>= 0.10	NP
MW-5	Iron	26	8	0.007	0.017	0.230	0.558	0.05 <= p < 0.10	>= 0.10	NP
MW-6	Iron	25	6	0.060	0.051	0.288	0.450	>= 0.10	>= 0.10	NP
MW-1	Magnesium	27	27	0.122	0.528	0.130	0.498	>= 0.10	>= 0.10	Normal
MW-2	Magnesium	26	26	0.009	0.095	0.009	0.134	0.01 <= p < 0.05	>= 0.10	Normal
MW-3	Magnesium	26	26	0.357	0.434	0.216	0.407	>= 0.10	>= 0.10	Normal
MW-4	Magnesium	25	25	0.437	0.337	0.384	0.204	>= 0.10	>= 0.10	Normal
MW-5	Magnesium	26	26	0.369	0.835	0.352	0.840	>= 0.10	>= 0.10	Normal
MW-6	Magnesium	25	25	0.234	0.320	0.190	0.173	>= 0.10	>= 0.10	Normal
MW-1	Potassium	25	25	0.161	0.042	0.356	0.084	>= 0.10	0.05 <= p < 0.10	Normal
MW-2	Potassium	25	25	0.262	0.314	0.529	0.539	>= 0.10	>= 0.10	Normal
MW-3	Potassium	25	25	0.804	0.785	0.776	0.615	>= 0.10	>= 0.10	Normal
MW-4	Potassium	24	24	0.056	0.062	0.055	0.056	0.01 <= p < 0.05	0.01 <= p < 0.05	Normal
MW-5	Potassium	25	25	0.185	0.058	0.132	0.050	0.05 <= p < 0.10	0.01 <= p < 0.05	Normal
MW-6	Potassium	24	24	0.419	0.580	0.553	0.598	>= 0.10	>= 0.10	Normal
MW-1	Sodium	25	25	0.834	0.792	0.858	0.667	>= 0.10	>= 0.10	Normal
MW-2	Sodium	25	25	0.383	0.375	0.240	0.427	>= 0.10	>= 0.10	Normal
MW-3	Sodium	25	25	0.046	0.093	0.022	0.068	0.01 <= p < 0.05	0.05 <= p < 0.10	Normal
MW-4	Sodium	24	24	0.148	0.284	0.095	0.313	>= 0.10	>= 0.10	Normal
MW-5	Sodium	25	25	0.019	0.046	0.005	0.027	0.01 <= p < 0.05	0.01 <= p < 0.05	NP
MW-6	Sodium	24	24	0.463	0.170	0.239	0.108	>= 0.10	>= 0.10	Normal
MW-1	Total Dissolved Solids	25	25	0.595	0.417	0.681	0.499	>= 0.10	>= 0.10	Normal
MW-2	Total Dissolved Solids	25	25	0.001	0.051	0.010	0.068	0.01 <= p < 0.05	0.05 <= p < 0.10	Normal
MW-3	Total Dissolved Solids	25	25	0.005	0.270	0.000	0.118	0.01 <= p < 0.05	>= 0.10	Normal
MW-4	Total Dissolved Solids	24	24	0.336	0.509	0.074	0.287	>= 0.10	>= 0.10	Normal
MW-5	Total Dissolved Solids	25	25	0.755	0.747	0.483	0.669	>= 0.10	>= 0.10	Normal
MW-6	Total Dissolved Solids	24	24	0.002	0.061	0.001	0.029	< 0.01	0.01 <= p < 0.05	Normal
MW-1	Total Organic Carbon	28	21	0.001	0.001	0.002	0.002	< 0.01	< 0.01	NP
MW-2	Total Organic Carbon	27	23	0.000	0.000	0.003	0.001	< 0.01	< 0.01	NP
MW-3	Total Organic Carbon	26	19	0.001	0.001	0.002	0.003	< 0.01	< 0.01	NP
MW-4	Total Organic Carbon	25	16	0.007	0.010	0.005	0.006	< 0.01	< 0.01	NP
MW-5	Total Organic Carbon	28	21	0.001	0.019	0.002	0.033	< 0.01	0.01 <= p < 0.05	NP
MW-6	Total Organic Carbon	26	20	0.001	0.000	0.005	0.003	< 0.01	0.01 <= p < 0.05	NP

Notes:

> = greater than

>= = greater than or equal to

< = less than

<= = less than or equal to

NP = nonparametric

p-value = probability value (p < 0.05 indicates significant test result)

The p-values for the Anderson-Darling and Kolmogorov-Smirnov goodness-of-fit tests for a gamma distribution were computed based on the simulated critical values given in USEPA's ProUCL Version 5.1 software.

Table 10

Intrawell Upper Prediction Limit Power Analysis

Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

No. of Samples	Retesting Rule	K Multiplier	Order Statistic	Target Alpha	Actual Alpha	Alpha Achieved	Power at 3 SD	Power at 4 SD	Power Rating
Parametric Prediction Limits									
24	1-of-2	1.94	NA	0.00389	0.00389	Yes	0.906	0.996	Good
25	1-of-2	1.93	NA	0.00389	0.00389	Yes	0.909	0.996	Good
26	1-of-2	1.92	NA	0.00389	0.00389	Yes	0.912	0.997	Good
27	1-of-2	1.91	NA	0.00389	0.00389	Yes	0.915	0.997	Good
28	1-of-2	1.90	NA	0.00389	0.00389	Yes	0.917	0.997	Good
46	1-of-2	1.82	NA	0.00389	0.00389	Yes	0.940	0.999	Good
47	1-of-2	1.82	NA	0.00389	0.00389	Yes	0.941	0.999	Good
48	1-of-2	1.82	NA	0.00389	0.00389	Yes	0.941	0.999	Good
Nonparametric Predicton Limits									
24	1-of-2	NA	Max	0.00389	0.00611	No	0.904	0.996	Good
26	1-of-2	NA	Max	0.00389	0.00525	No	0.897	0.995	Good
28	1-of-2	NA	Max	0.00389	0.00457	No	0.890	0.995	Good
46	1-of-2	NA	Max	0.00389	0.00177	Yes	0.835	0.991	Good
47	1-of-2	NA	Max	0.00389	0.00170	Yes	0.833	0.991	Good
48	1-of-2	NA	Max	0.00389	0.00163	Yes	0.830	0.991	Good

Notes:

Max = maximum

No. = number

SD = standard deviations

Target alpha represents the per-test significance level based on an annual site-wide false positive rate (SWFPR) of 10 percent.

The Unified Guidance (USPEA, 2009) recommends at least 55 to 60 percent annual power for detecting a 3 standard deviation increase and at least 80 to 85 percent annual power for detecting a 4 standard deviation increase above the true background mean.

Table 11

Intrawell Upper Prediction Limits for Proposed Detection Monitoring Constituents

Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

Well	Constituent	Frequency of Detection			Minimum Values		Maximum Values		Summary Statistics						Background	
		No. of Samples	No. of Detects	%	Non-Detect	Detect	Non-Detect	Detect	Mean	Median	Standard Deviation	95th Percentile	99th Percentile	Distribution	UPL	Method
MW-2	Alkalinity	46	46	100.0	NA	230	NA	409	298	290	38.9	387	403	NP	409	NP, Max Value
MW-2	Calcium	47	47	100.0	NA	20.0	NA	28.8	23.2	23.3	1.49	25.0	27.3	Normal	25.9	Parametric
MW-2	Chloride	48	48	100.0	NA	155	NA	270	233	231	25.9	269	270	NP	270	NP, Max Value
MW-2	Iron	48	13	27.1	0.040	0.0631	0.510	0.542	NA	NA	NA	NA	NA	NP	0.542	NP, Max Value
MW-2	Magnesium	48	48	100.0	NA	30.2	NA	44.8	35.3	34.7	2.89	40.1	43.4	NP	44.8	NP, Max Value
MW-2	Potassium	48	48	100.0	NA	12.0	NA	19.4	14.8	14.8	1.71	18.1	19.3	NP	19.4	NP, Max Value
MW-2	Sodium	48	48	100.0	NA	162	NA	257	204	200	19.9	241	251	Normal	240	Parametric
MW-2	Total Dissolved Solids	48	48	100.0	NA	652	NA	970	801	800	69.8	917	959	Normal	928	Parametric
MW-2	Total Organic Carbon	48	34	70.8	1.000	1.10	8.00	59.0	8.12	3.04	11.6	33.2	49.1	Gamma	28.3	Parametric
MW-3	Alkalinity	24	24	100.0	NA	234	NA	280	249	244	14.1	276	279	NP	280	NP, Max Value
MW-3	Calcium	25	25	100.0	NA	19.9	NA	24.6	22.8	22.9	1.05	24.4	24.6	Normal	24.8	Parametric
MW-3	Chloride	27	27	100.0	NA	170	NA	230	196	200	18.6	227	230	Normal	232	Parametric
MW-3	Iron	26	5	19.2	0.040	0.090	0.100	0.195	NA	NA	NA	NA	NA	NP	0.195	NP, Max Value
MW-3	Magnesium	26	26	100.0	NA	27.0	NA	35.2	32.1	32.3	2.03	34.8	35.1	Normal	36.0	Parametric
MW-3	Potassium	25	25	100.0	NA	12.3	NA	15.8	13.8	13.9	0.899	15.0	15.6	Normal	15.6	Parametric
MW-3	Sodium	25	25	100.0	NA	145	NA	188	173	177	11.8	187	188	Normal	196	Parametric
MW-3	Total Dissolved Solids	25	25	100.0	NA	475	NA	750	659	660	53.0	713	742	Normal	762	Parametric
MW-3	Total Organic Carbon	26	19	73.1	0.500	0.670	1.00	31.0	7.83	1.10	10.2	25.8	29.8	NP	31.0	NP, Max Value
MW-5	Alkalinity	24	24	100.0	NA	180	NA	276	245	245	19.4	272	275	Normal	283	Parametric
MW-5	Calcium	25	25	100.0	NA	20.3	NA	23.6	22.0	21.9	0.949	23.4	23.6	Normal	23.8	Parametric
MW-5	Chloride	28	28	100.0	NA	170	NA	240	202	200	19.7	237	240	Normal	240	Parametric
MW-5	Iron	26	8	30.8	0.040	0.051	0.100	0.610	NA	NA	NA	NA	NA	NP	0.610	NP, Max Value
MW-5	Magnesium	26	26	100.0	NA	27.9	NA	35.2	31.9	32.0	2.13	34.8	35.1	Normal	36.0	Parametric
MW-5	Potassium	25	25	100.0	NA	12.7	NA	15.8	14.5	14.6	0.891	15.7	15.8	Normal	16.2	Parametric
MW-5	Sodium	25	25	100.0	NA	138	NA	191	176	180	12.6	189	191	NP	193	Parametric(1)
MW-5	Total Dissolved Solids	25	25	100.0	NA	555	NA	772	677	674	51.3	751	768	Normal	776	Parametric
MW-5	Total Organic Carbon	28	21	75.0	0.500	0.680	1.00	31.0	9.16	1.35	10.7	26.0	29.7	NP	31.0	NP, Max Value

Notes:

% = percent

Max = maximum

NA = not applicable

No. = number

NP = nonparametric

UPL = upper prediciton limit

Concentrations given in milligrams-per-liter (mg/L).

(1) Normalized using Tukey's Ladder of Powers transformation with lambda equal to 7.675.

For data containing non-detects, the Kaplan-Meier method was used to compute descriptive statistics with the censoring limit set at the reporting limit.

Upper prediction limits calculated using a target annual site-wide false positive rate (SWFPR) of 10 percent, semi-annual sampling, and a 1-of-2 retesting scheme.

Table 12

Comparison of 2018 Upper Prediction Limits to Historical Background Limits

Calculation of Upper Prediction Limits, Central Maui Landfill, Puunene, Maui, Hawaii

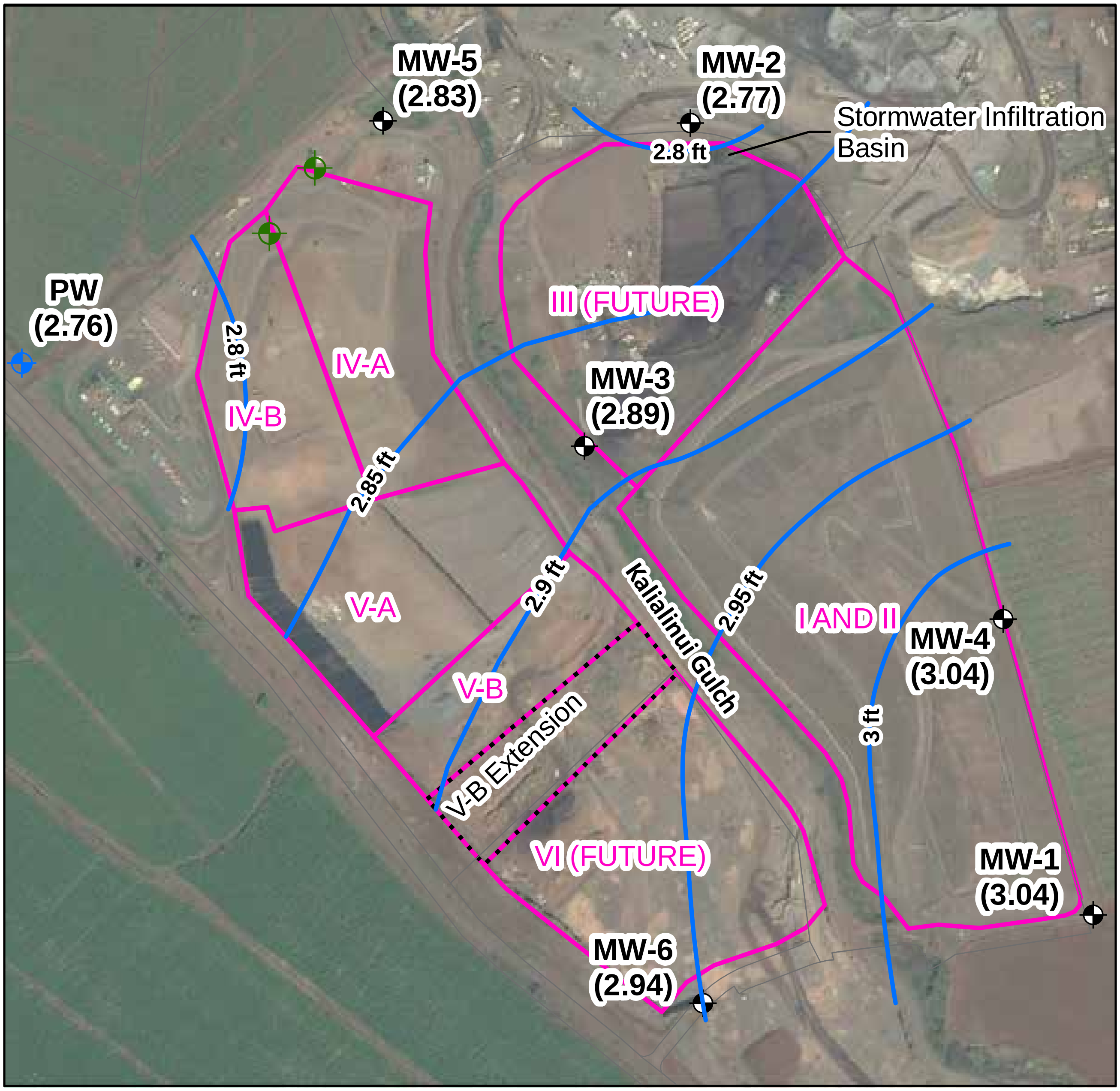
Well	**Analyte**	**Historical Background Control Limits**				**2018 Limits**
		2000 Upper Control Limits	**2005 Upper Control Limits**	**2010 Upper Control Limits**	**2010 Poisson Prediction Limits**	**Upper Prediction Limit**
MW-2	Alkalinity	518	ND	ND	ND	409
MW-2	Calcium	32.1	27.9	ND	ND	25.9
MW-2	Chloride	323	305	ND	ND	270
MW-2	Iron	0.447	0.530	0.290	ND	0.542
MW-2	Magnesium	49.7	46.5	45.7	ND	44.8
MW-2	Potassium	20.3	ND	21.7	ND	19.4
MW-2	Sodium	288	264	272	ND	240
MW-2	Total Dissolved Solids	1,450	1,108	1,075	ND	928
MW-2	Total Organic Carbon	79.8	ND	29.7	ND	28.3
MW-3	Alkalinity	461	ND	ND	ND	280
MW-3	Calcium	31.8	ND	ND	ND	24.8
MW-3	Chloride	236	ND	211	NC	232
MW-3	Iron	0.359	ND	ND	0.520	0.195
MW-3	Magnesium	39.8	36.1	36.4	ND	36.0
MW-3	Potassium	22.5	ND	ND	ND	15.6
MW-3	Sodium	204	198	199	ND	196
MW-3	Total Dissolved Solids	1,472	796	ND	ND	762
MW-3	Total Organic Carbon	66.6	55.0	49.4	ND	31.0
MW-5	Alkalinity	327	335	ND	ND	283
MW-5	Calcium	26.5	27.1	ND	ND	23.8
MW-5	Chloride	210	207	ND	ND	240
MW-5	Iron	0.255	ND	0.330	ND	0.610
MW-5	Magnesium	34.0	35.8	ND	ND	36.0
MW-5	Potassium	18.4	ND	ND	ND	16.2
MW-5	Sodium	184	203	206	ND	193
MW-5	Total Dissolved Solids	803	ND	882	ND	776
MW-5	Total Organic Carbon	27.8	70.2	24.8	ND	31.0

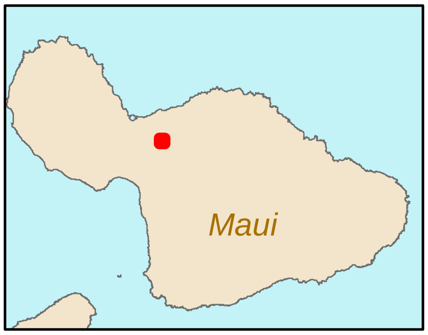
Notes:

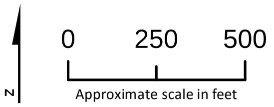
ND = not determined

Concentrations given in milligrams per liter.

Figures







LEGEND

- ▭ SWMU/Landfill Cell
- ⬚ SWMU Currently Under Construction
- ⊕ Existing Monitoring Well
- ⊕ Production Well
- ⊕ Leachate Collection Point (Sump or Well)
- — Inferred Groundwater Potentiometric Contour

Notes:
- Average hydraulic gradient = 1.44E-04 foot/foot
- Average seepage velocity = 14 feet/year to 478 feet/year
- Hourly measurements from 2013 continuous synoptic water level measurements (Element, 2014). Groundwater flow characteristics have been modeled using the software Surfer 8.0.
- This figure represents the average groundwater equipotential lines and the horizontal hydraulic gradient during the 71-hour period (between 8/22/2013, 00:00 hours and 8/24/2013, 23:00 hours). The average hydraulic gradient has been estimated using groundwater elevations between monitoring wells MW-4 and MW-2, and MW-4 and PW.

ACRONYMS:
ft = feet (above mean sea level)
SWMU: Solid Waste Management Unit

FIGURE 1
Groundwater Contour Map
Calculation of Upper
Prediction Limits
Central Maui Landfill
Puunene, Maui, Hawaii

ch2m:

\\NALA\PROJ\GIS_LIBRARY\MAUI LANDFILL\MXDS\PREDICTION LIMITS\FIGURE1_GROUNDWATER_CONTOUR.MXD AR055181 4/18/2018 12:11:27 PM

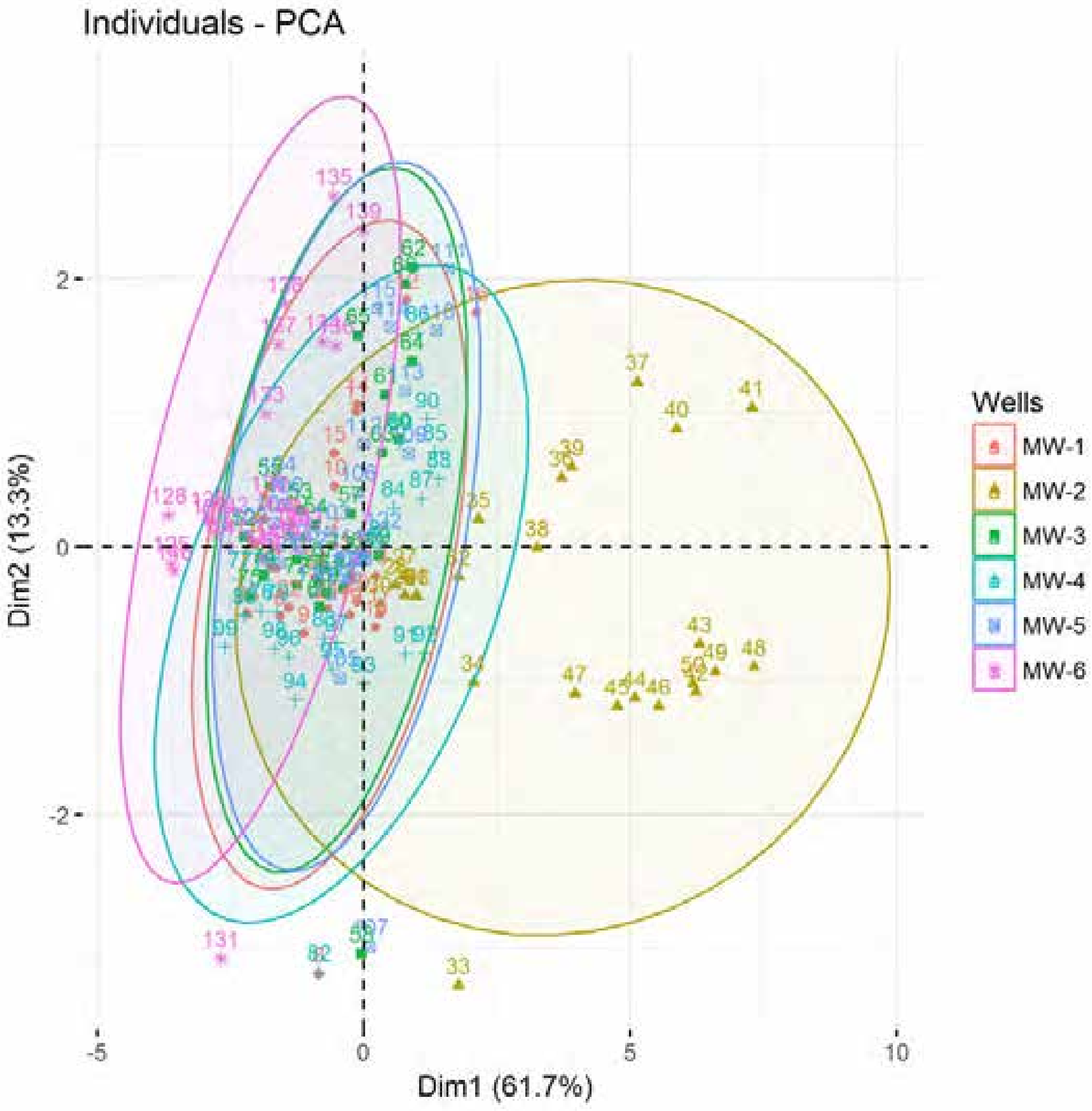
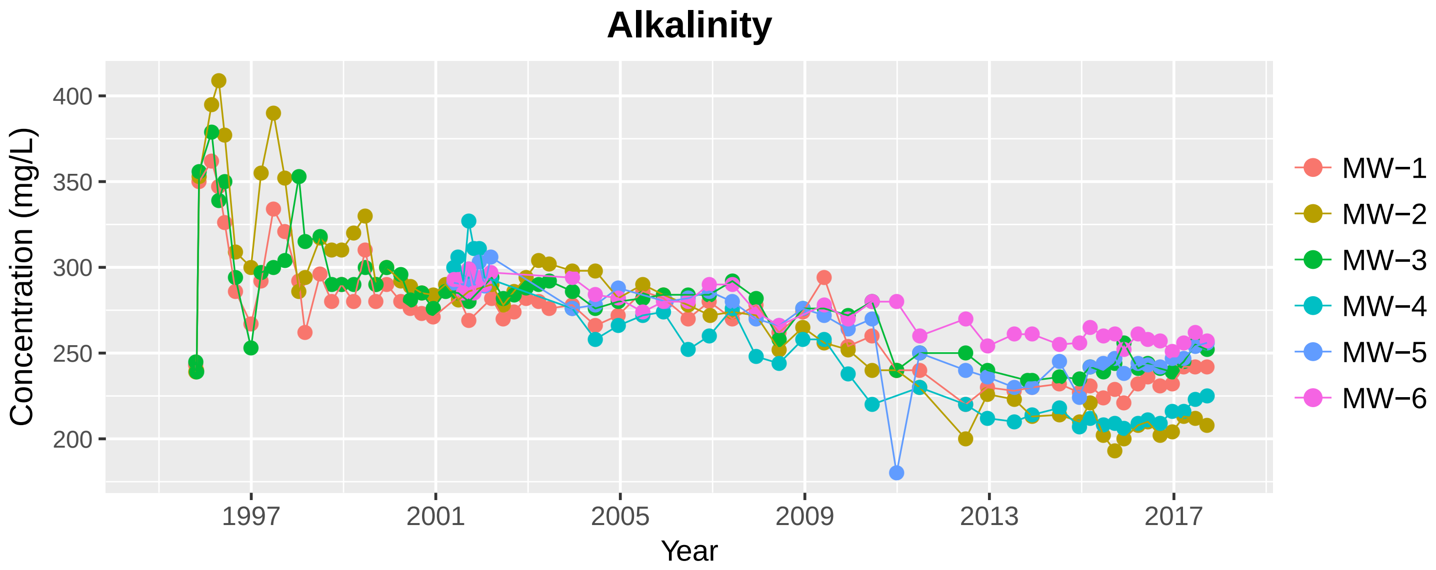


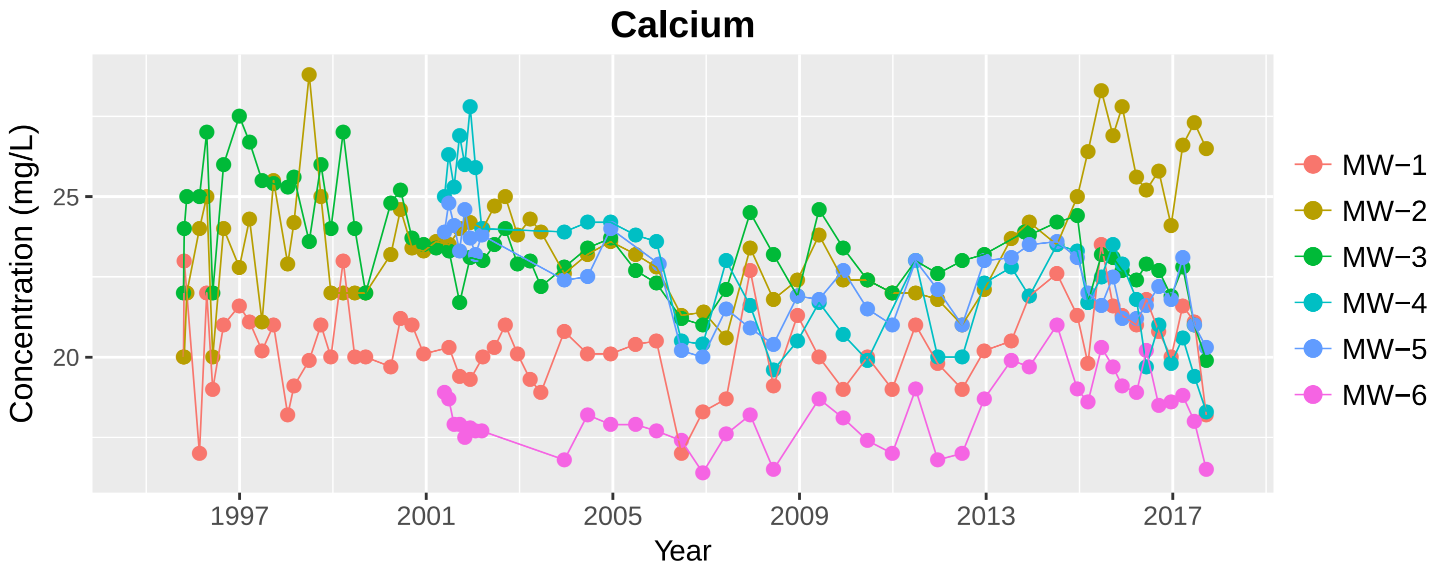
FIGURE 2
PCA Individuals Plot with Well-Specific 95%
Bivariate Confidence Ellipses
(numbers correspond to the sample number)
Calculation of Upper
Prediction Limits
Central Maui Landfill
Puunene, Maui, Hawaii

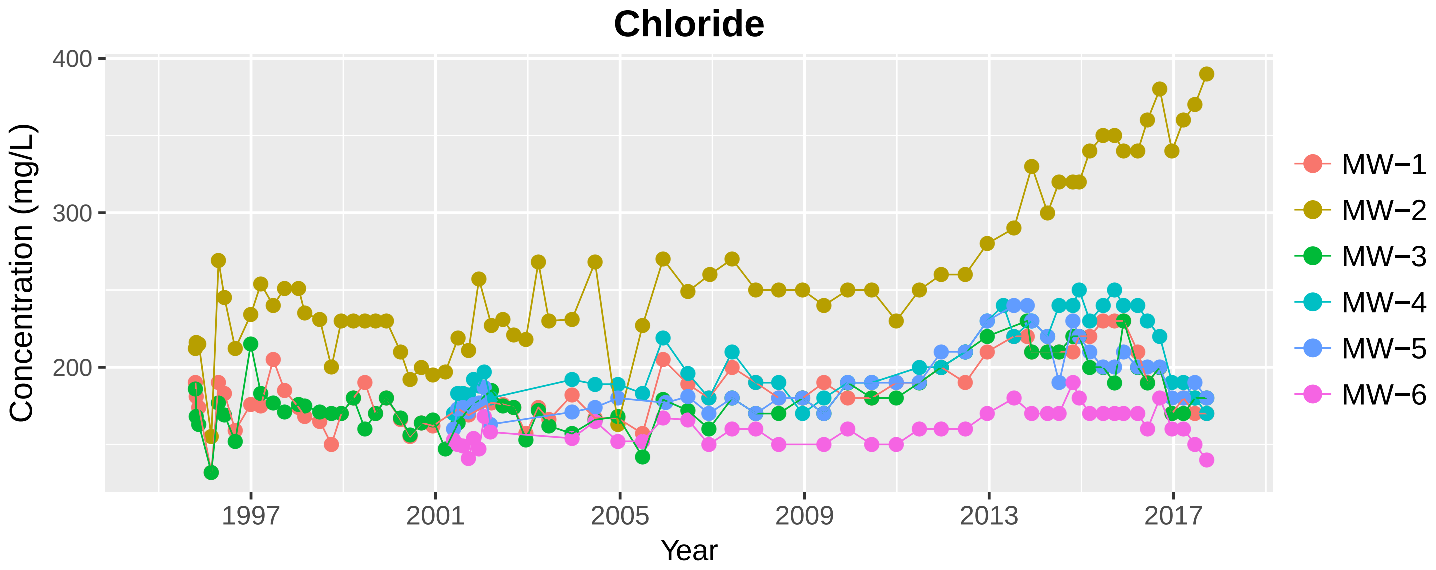
Attachment 1

Overlapping Time Series Constituent Concentration Plots (1995-2017)

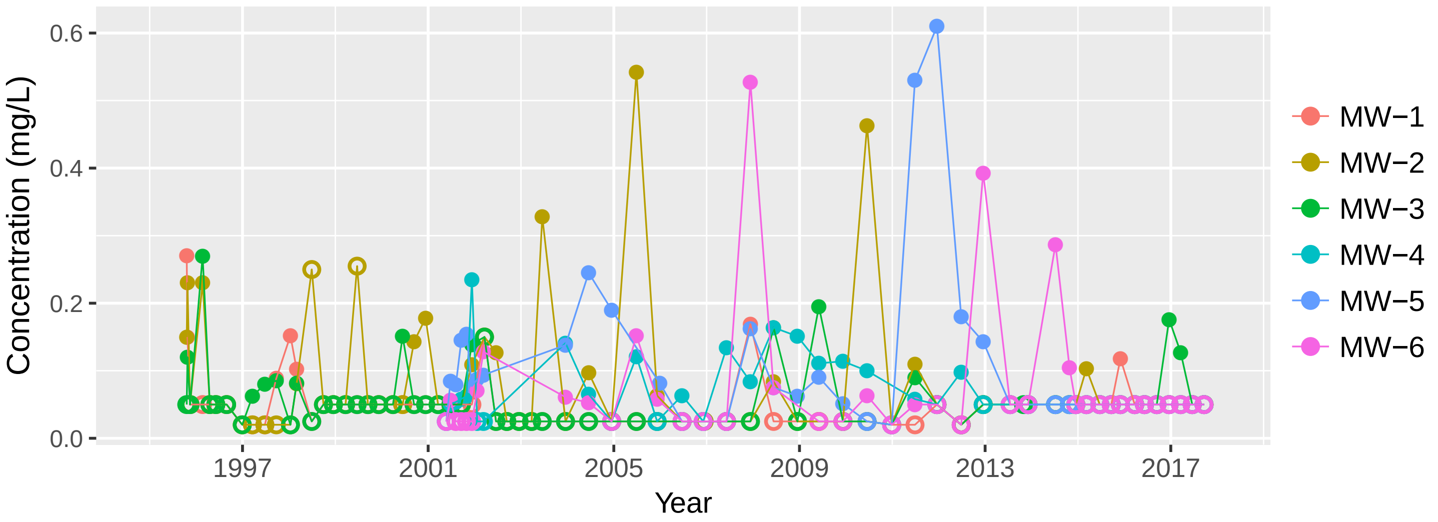
Overlapping Time Series Plots
(Nondetects plotted using open symbols at one−half the RL)

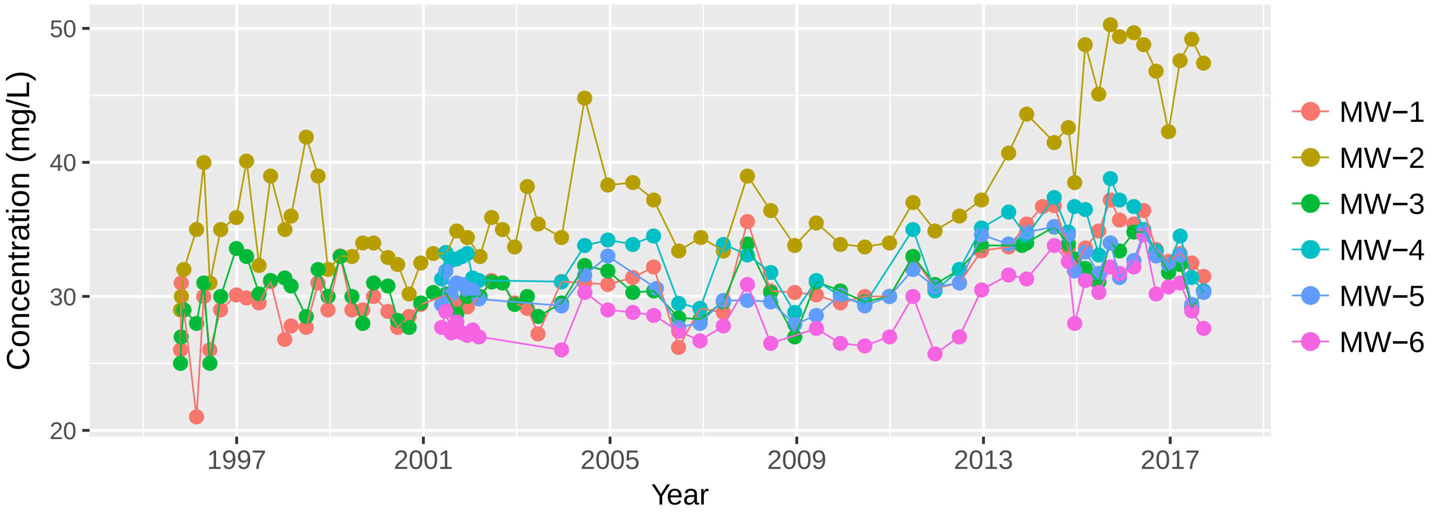


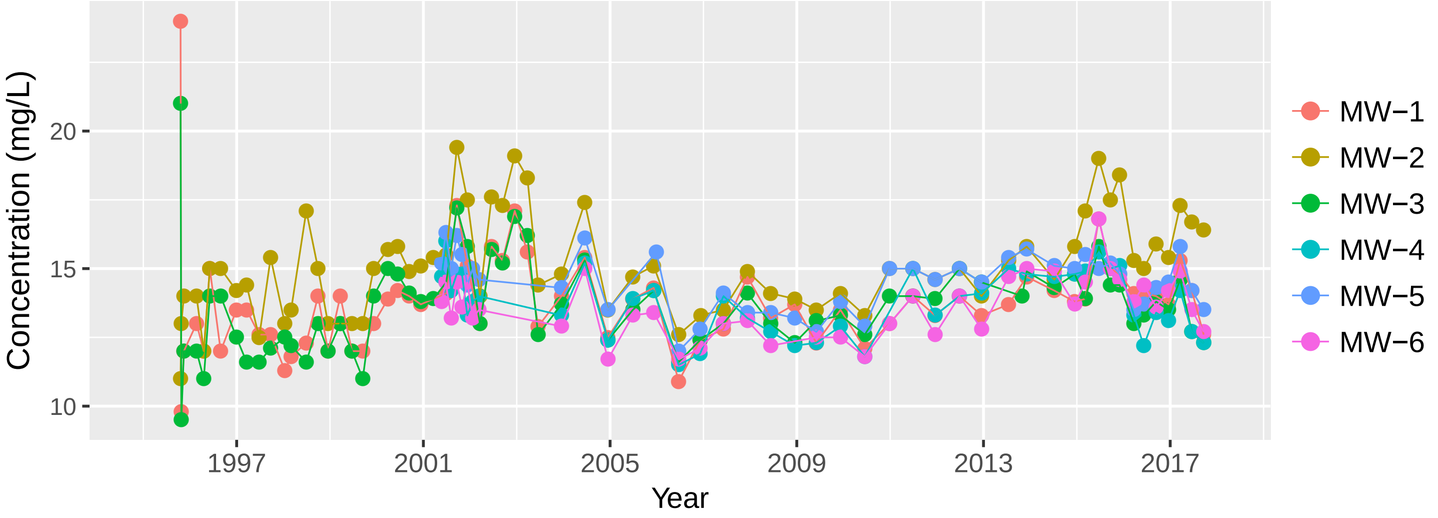




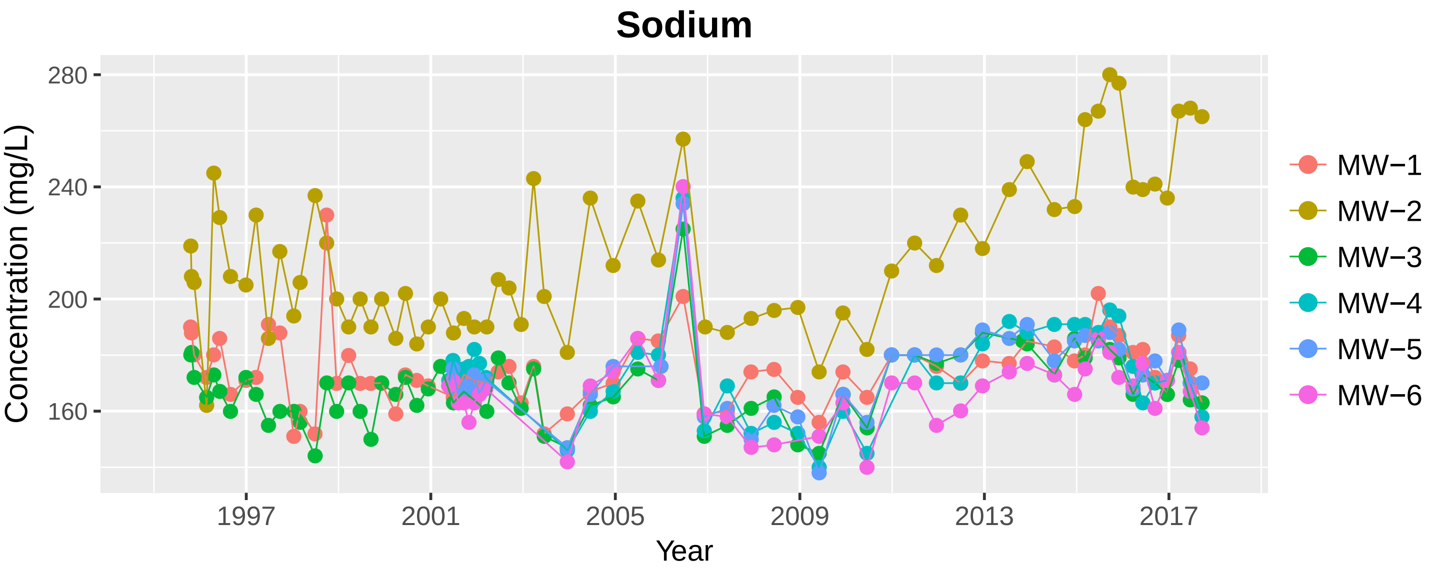
Overlapping Time Series Plots
(Nondetects plotted using open symbols at one−half the RL)
Page 2 of 3

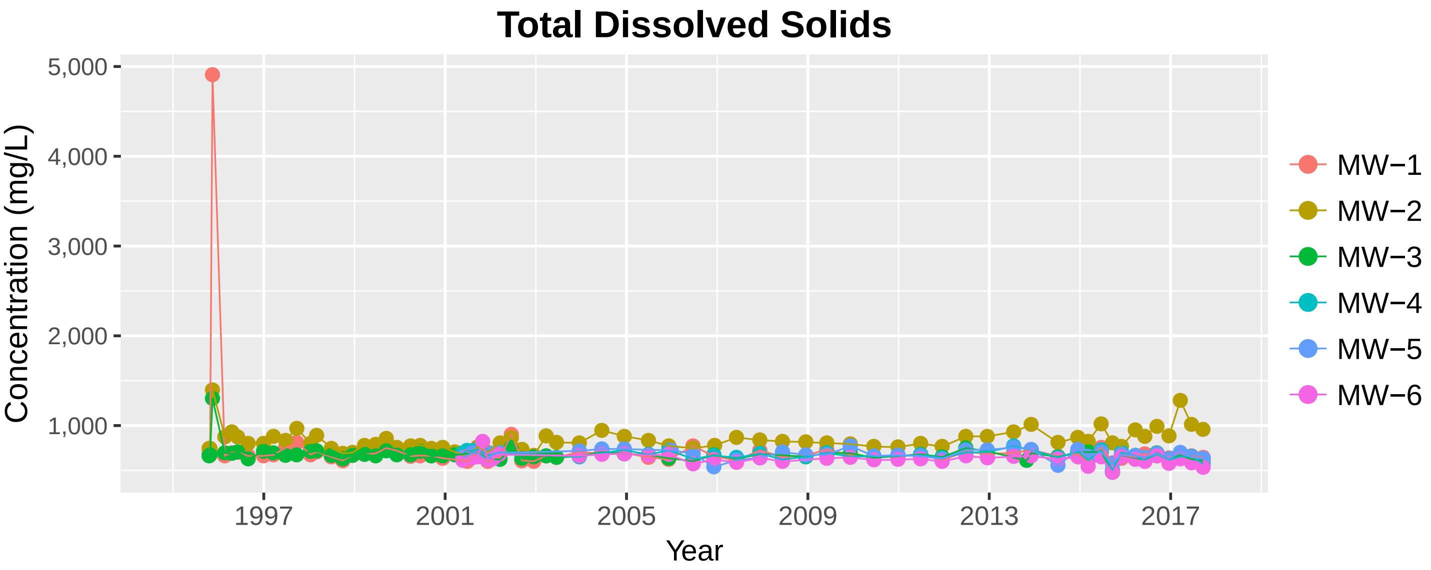

Iron

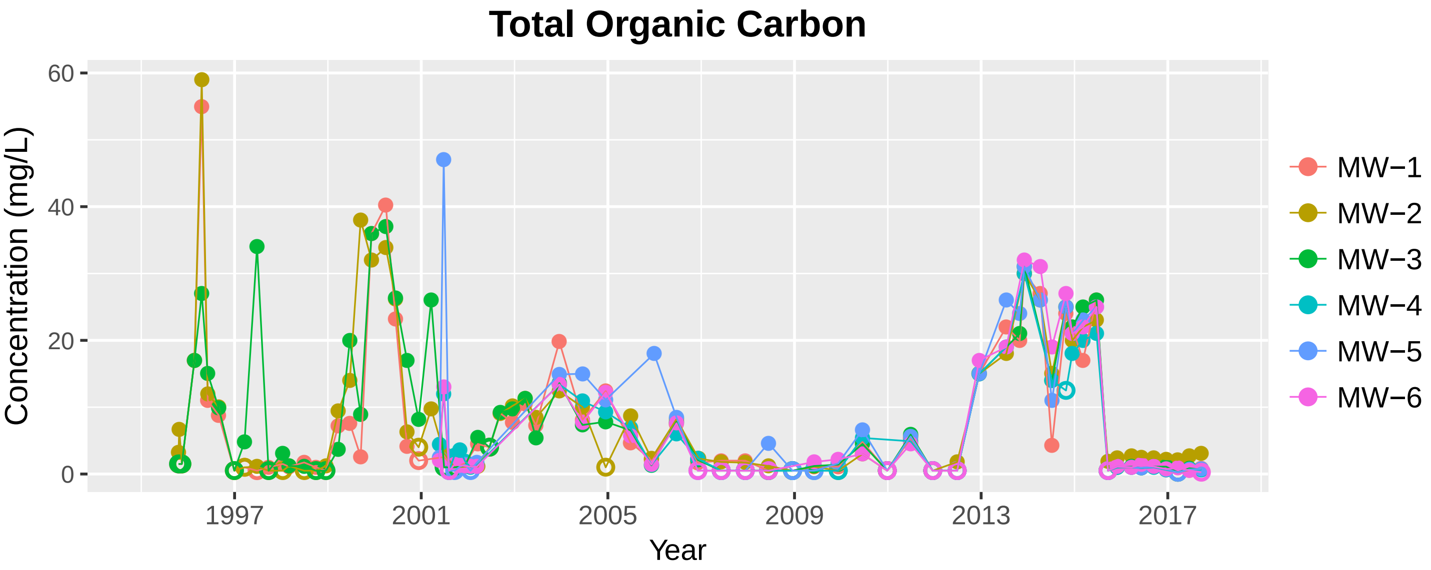

Magnesium


Potassium

Overlapping Time Series Plots
(Nondetects plotted using open symbols at one−half the RL)
Page 3 of 3





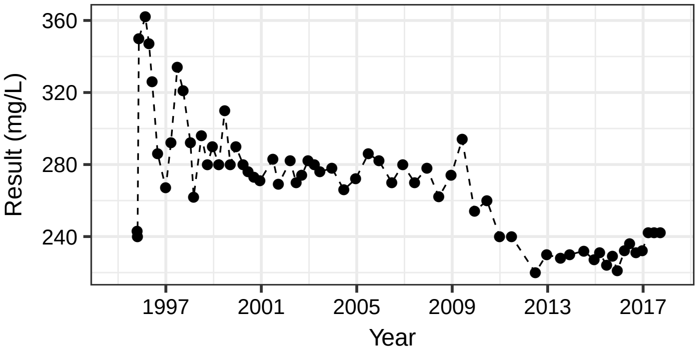


Attachment 2

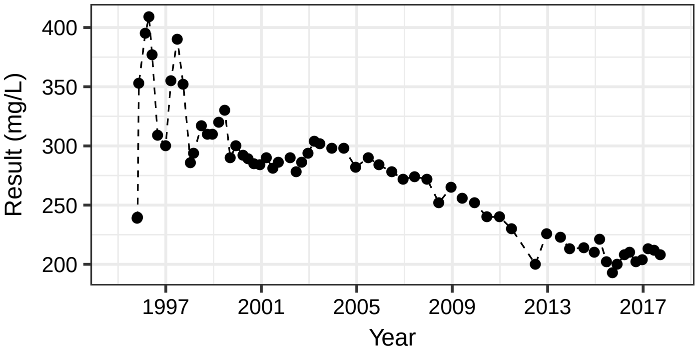
Time Series Constituent Concentration Plots (1995-2017)

Time Series Plots
(Nondetects plotted using open symbols at one−half the RL)
Page 1 of 7

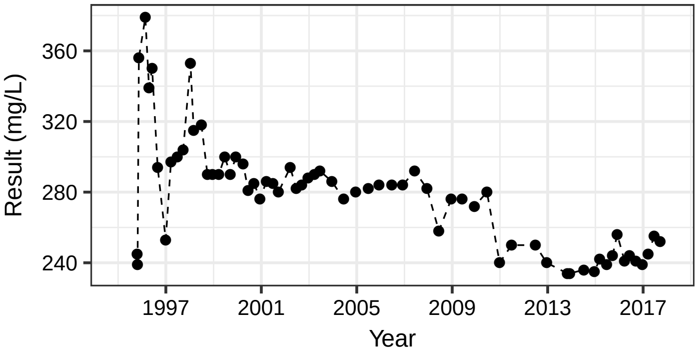
Alkalinity
MW−1



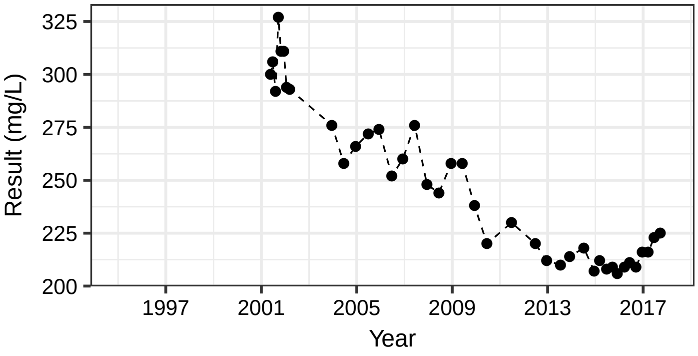
Alkalinity
MW−2



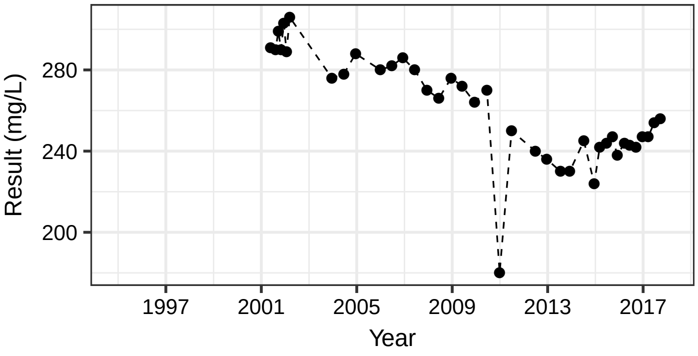
Alkalinity
MW−3



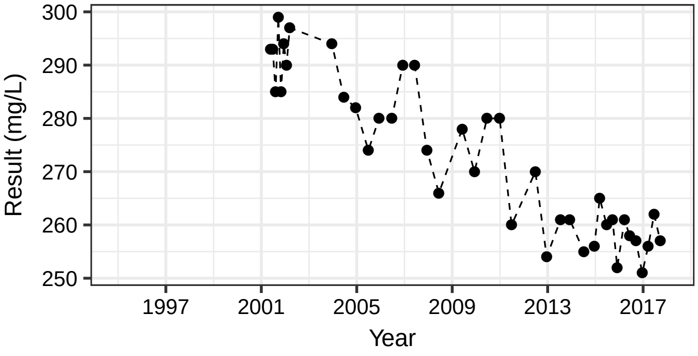
Alkalinity
MW−4



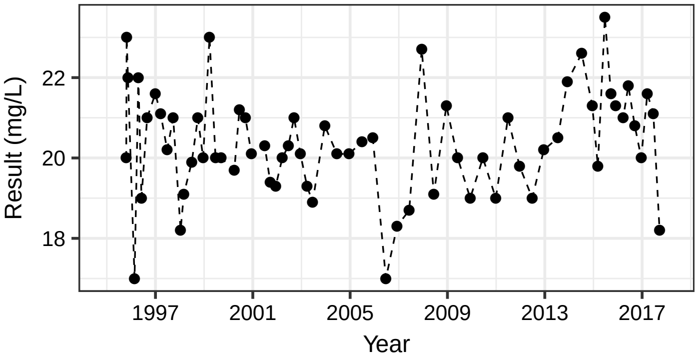
Alkalinity
MW−5



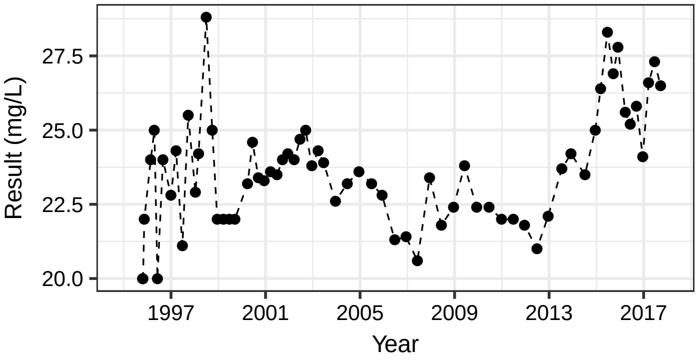
Alkalinity
MW−6



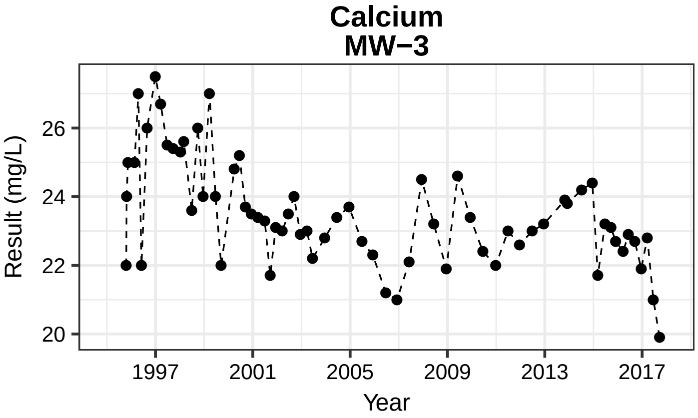
Calcium
MW−1

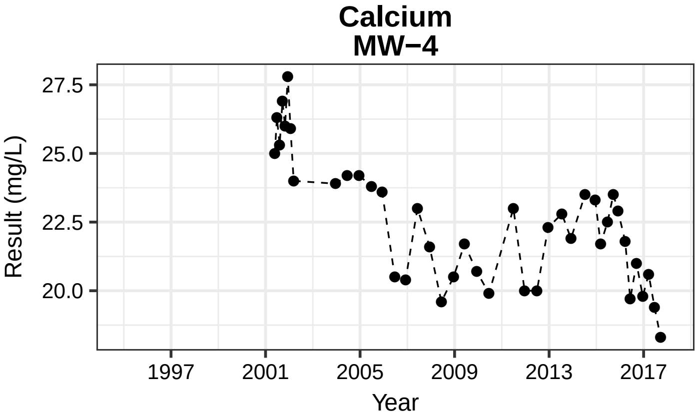


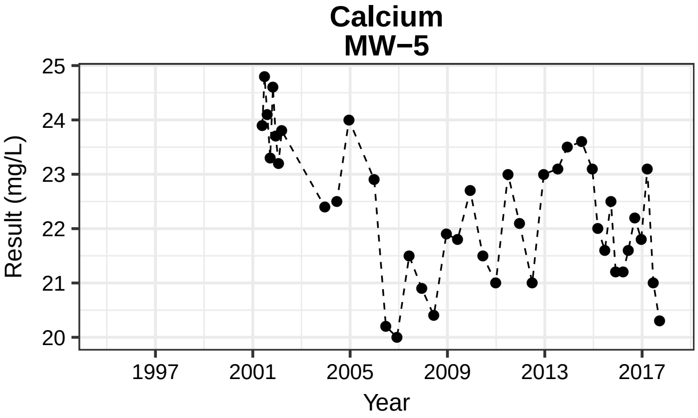
Calcium
MW−2

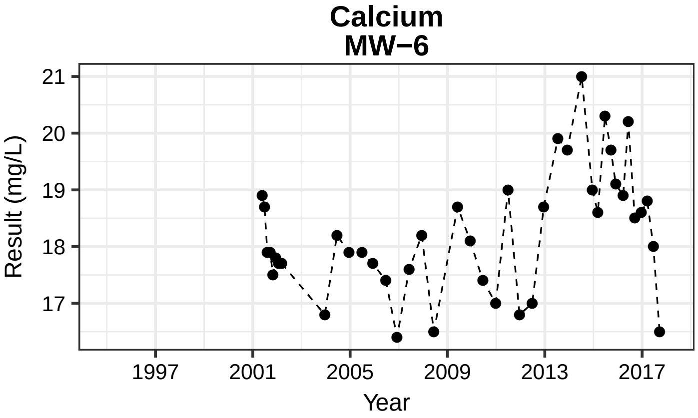


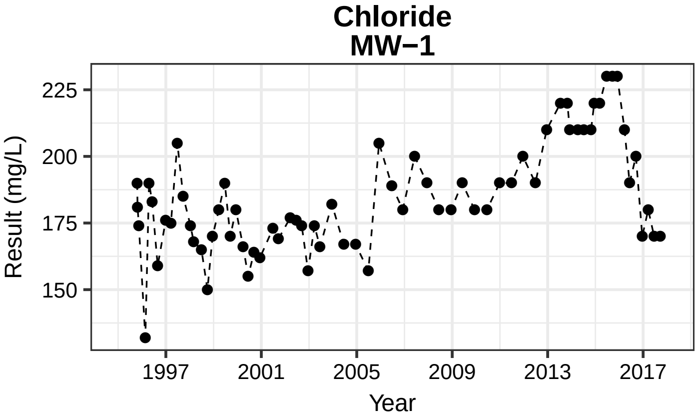
Time Series Plots
(Nondetects plotted using open symbols at one−half the RL)
Page 2 of 7

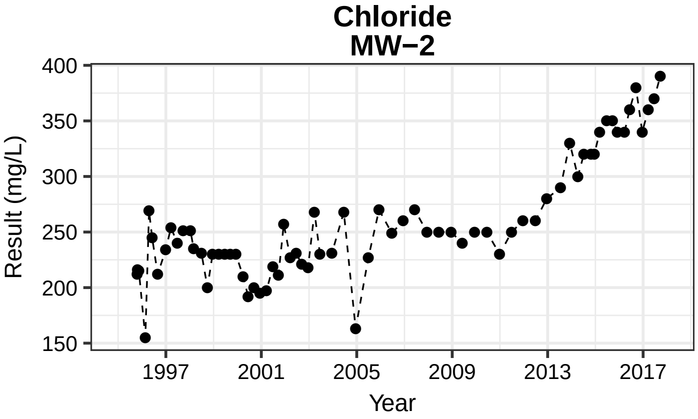


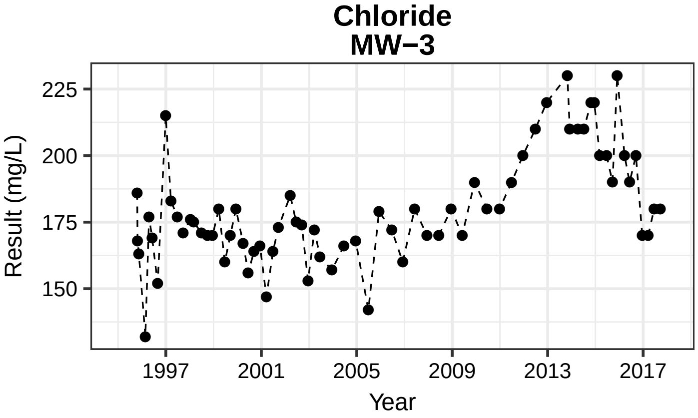


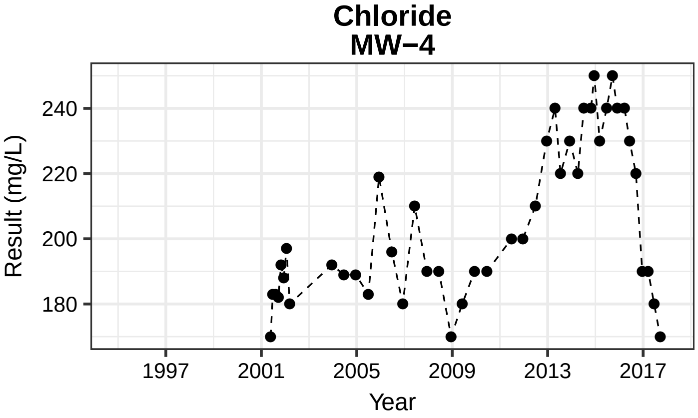




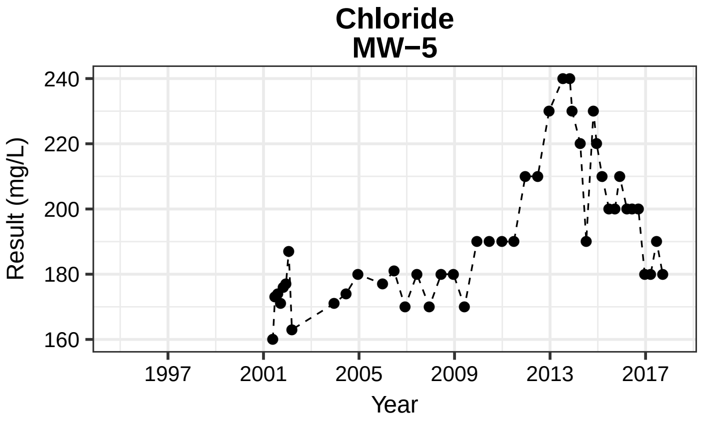


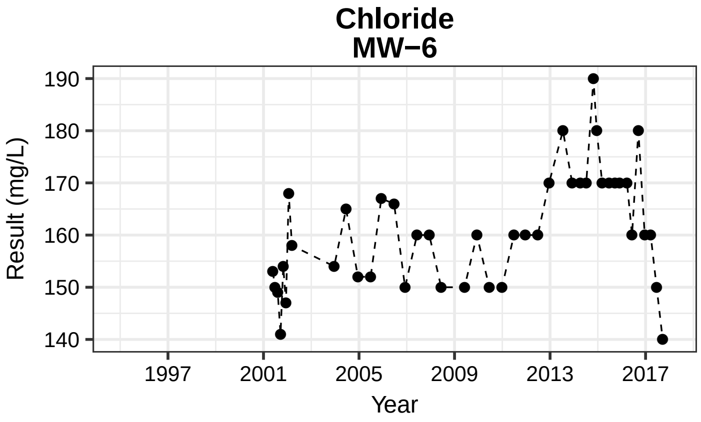


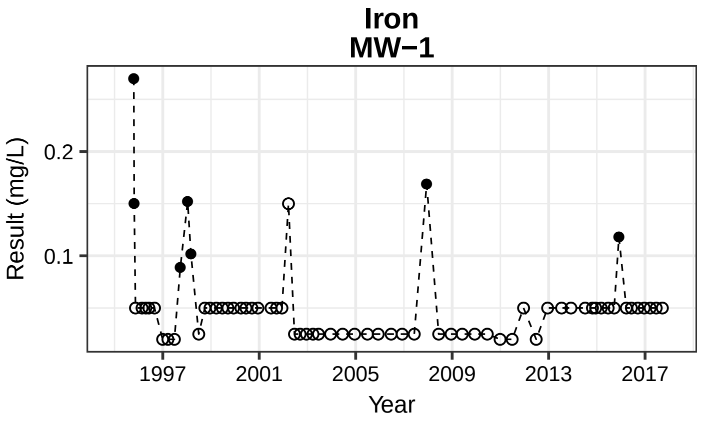


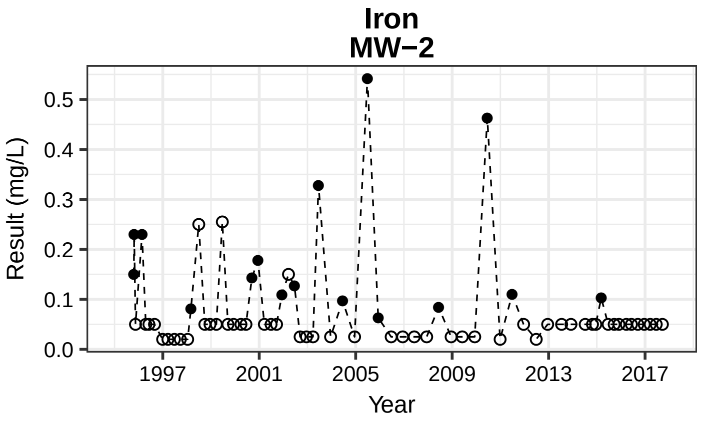


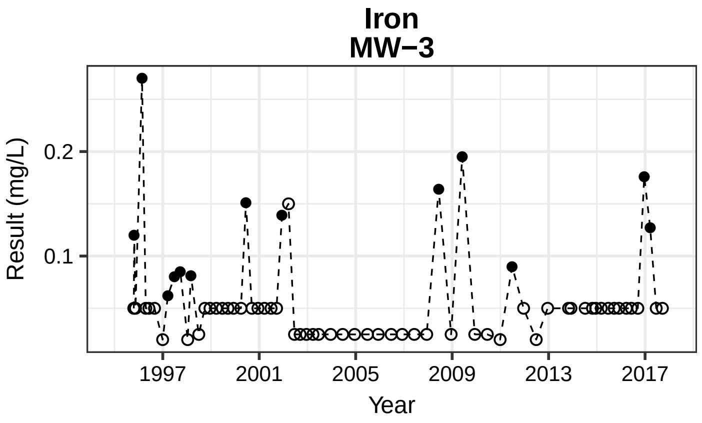
Time Series Plots
(Nondetects plotted using open symbols at one−half the RL)
Page 3 of 7

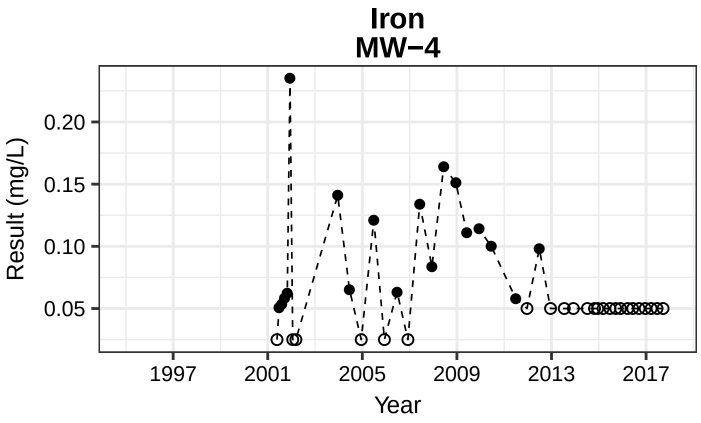


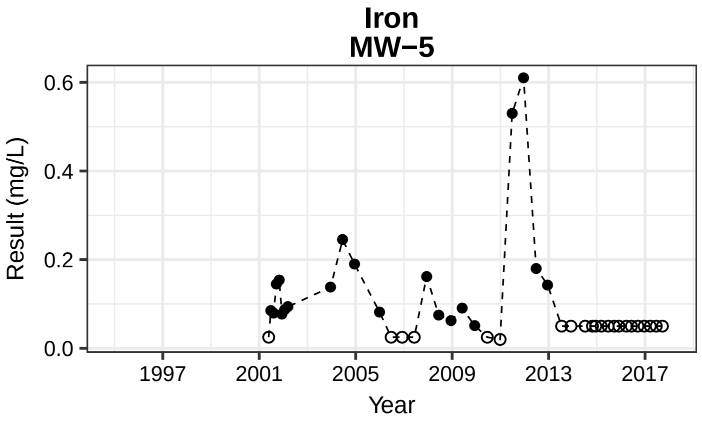


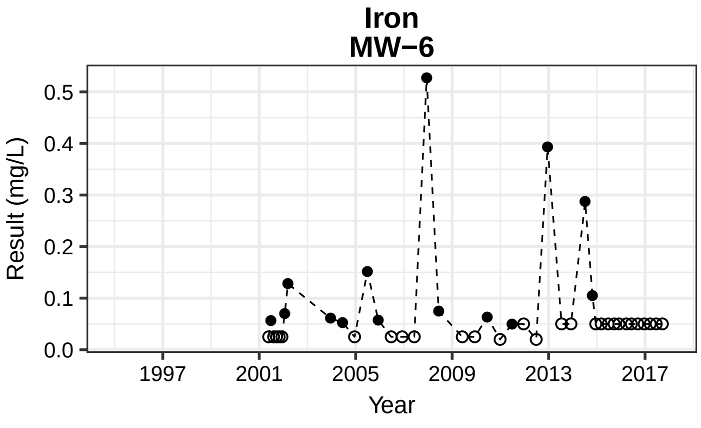








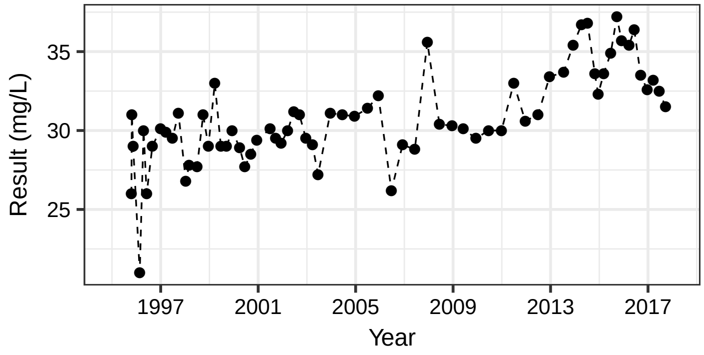




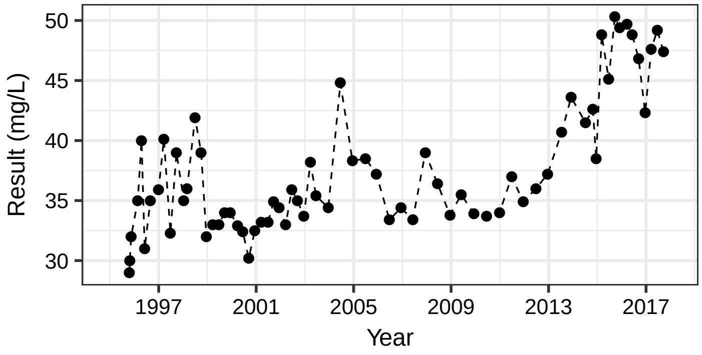
Time Series Plots

(Nondetects plotted using open symbols at one−half the RL)

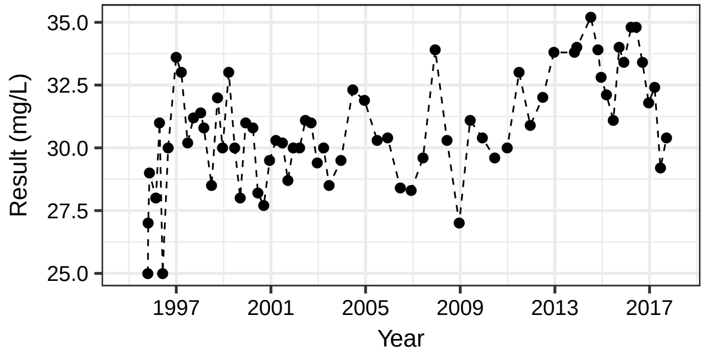
Page 4 of 7



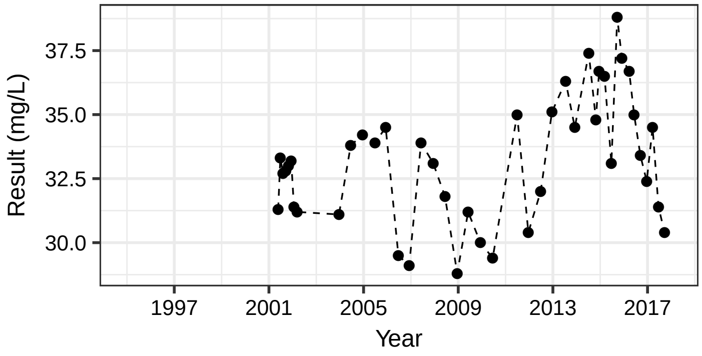
Magnesium
MW−1



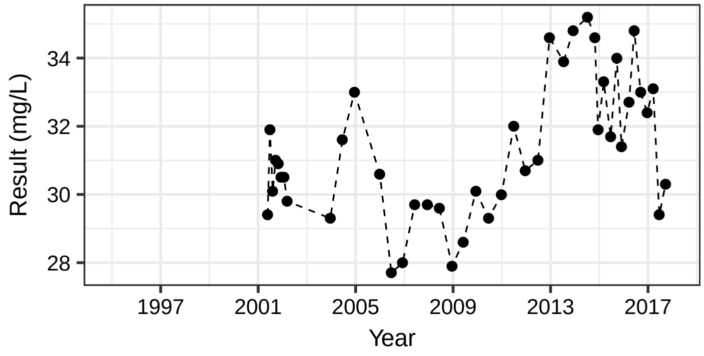
Magnesium
MW−2



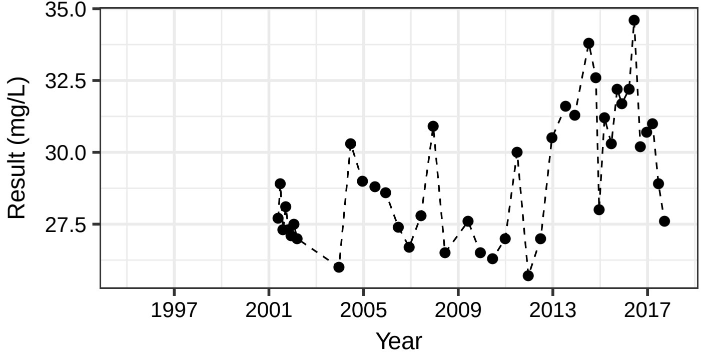
Magnesium
MW−3



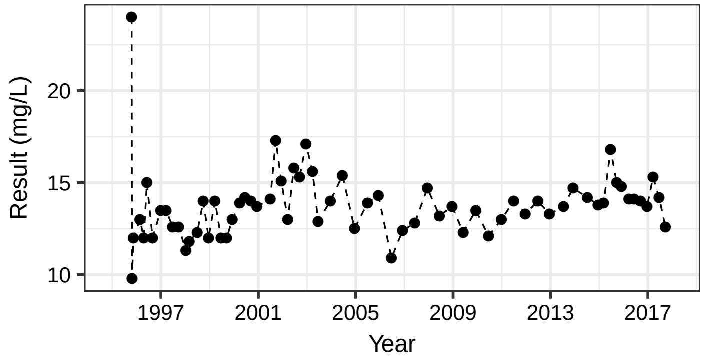
Magnesium
MW−4



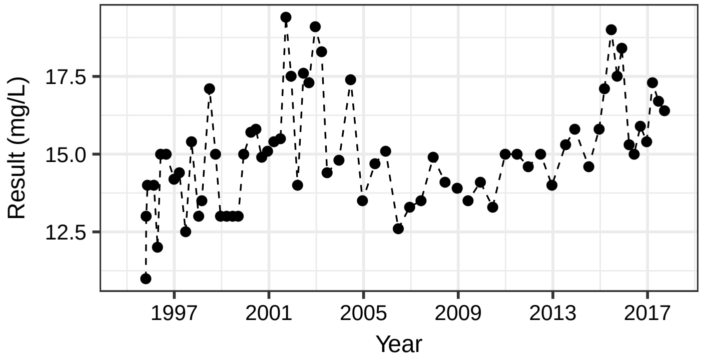
Magnesium
MW−5



Magnesium
MW−6



Potassium
MW−1



Potassium
MW−2

Time Series Plots

(Nondetects plotted using open symbols at one−half the RL)

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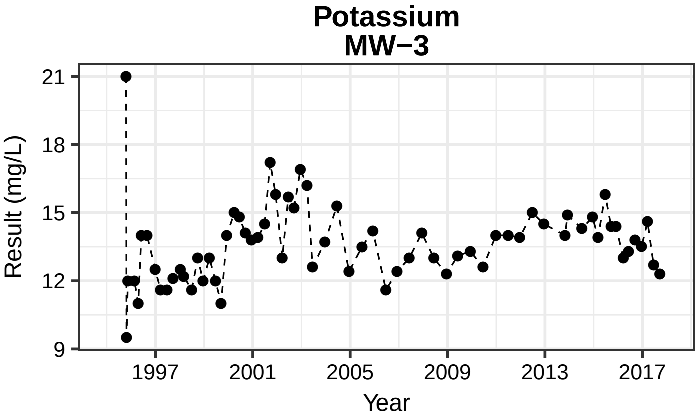
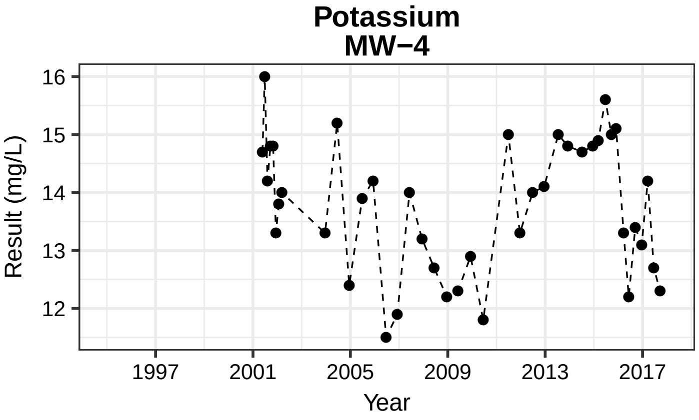
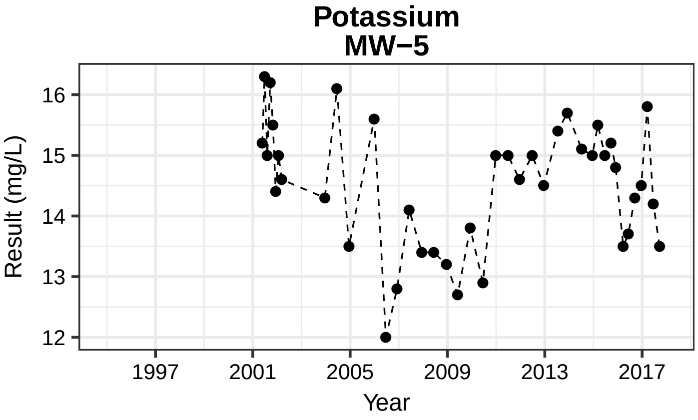
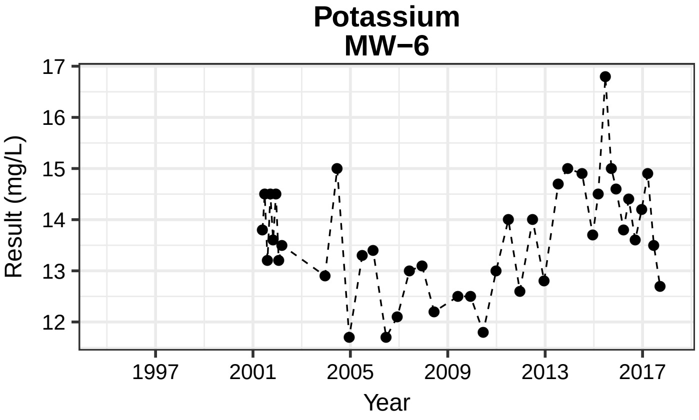
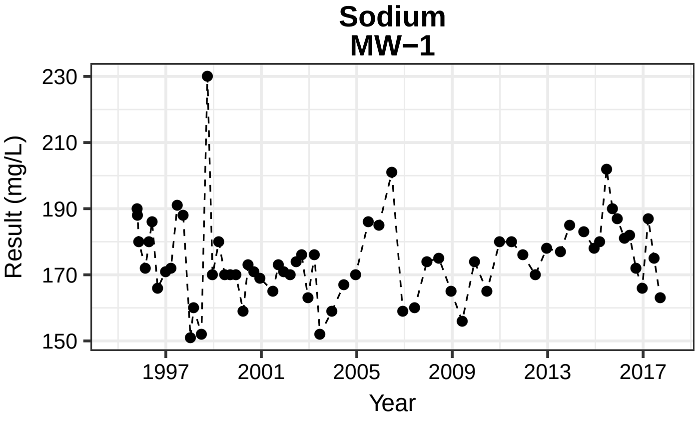
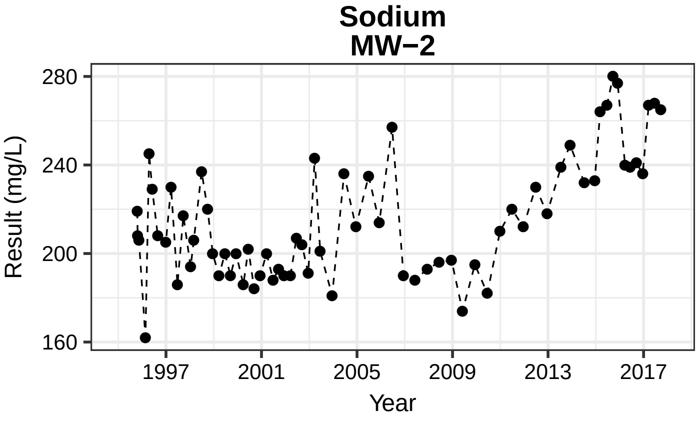

Potassium MW−3

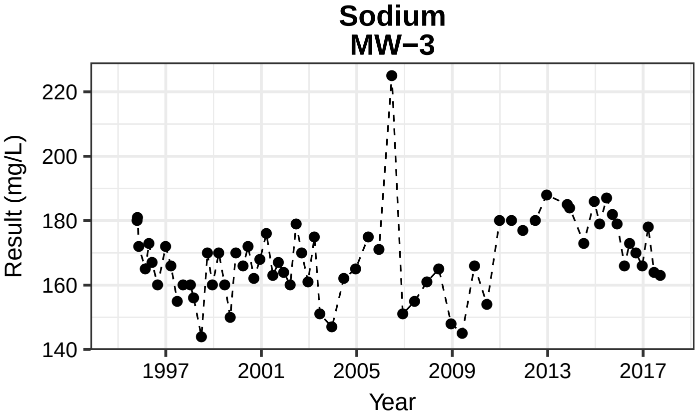

Potassium MW−4

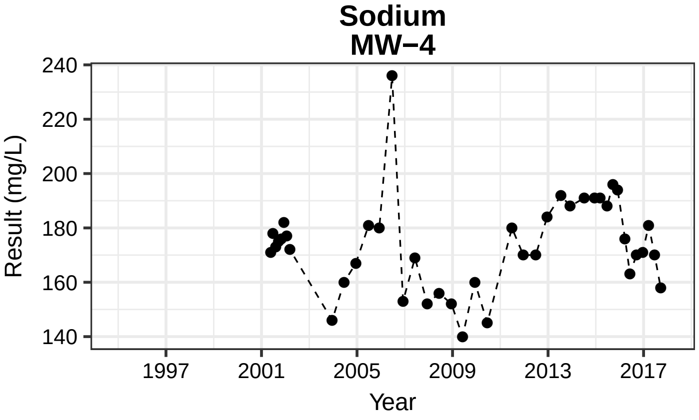

Potassium MW−5


Potassium MW−6


Sodium MW−1


Sodium MW−2


Sodium MW−3


Sodium MW−4

Time Series Plots
(Nondetects plotted using open symbols at one−half the RL)
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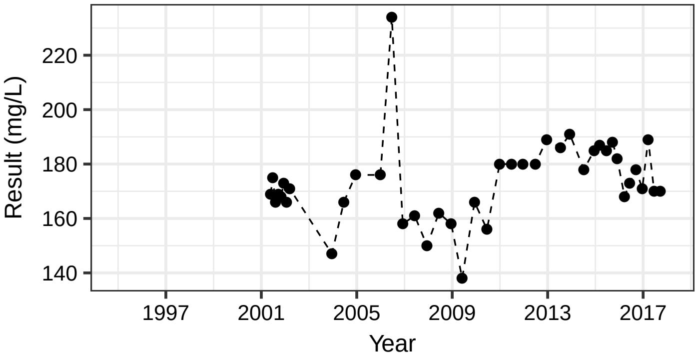
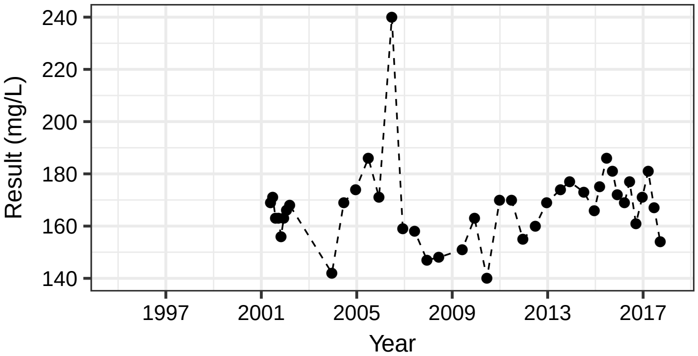
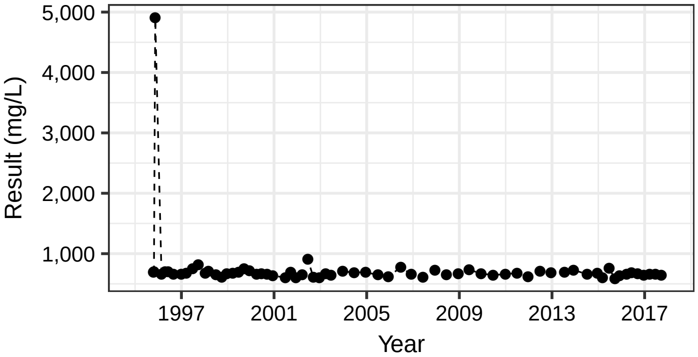
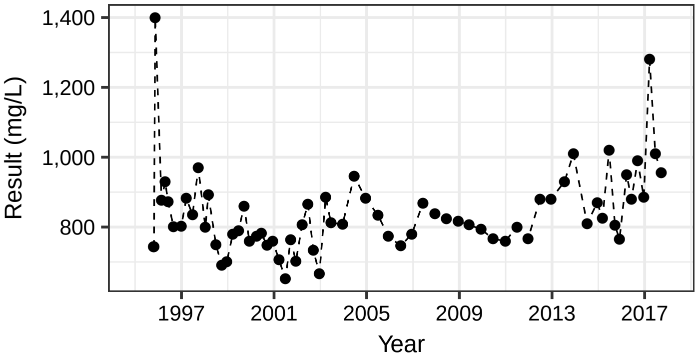
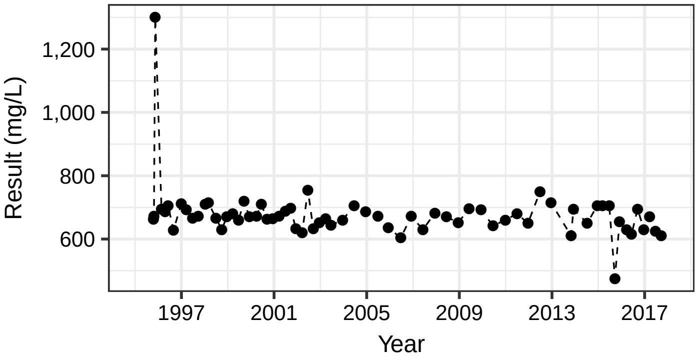
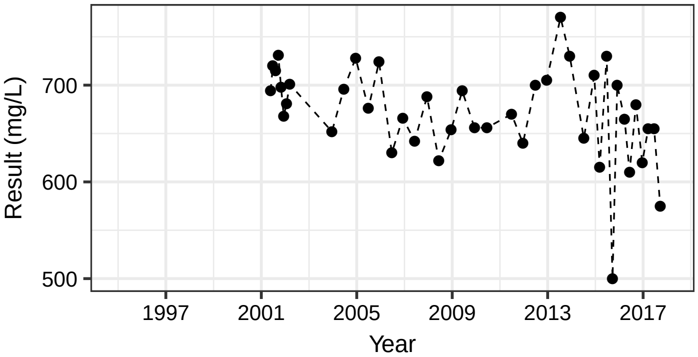

Sodium
MW−5

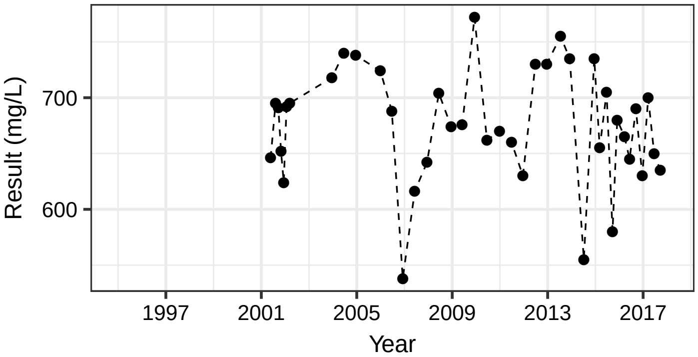

Sodium
MW−6

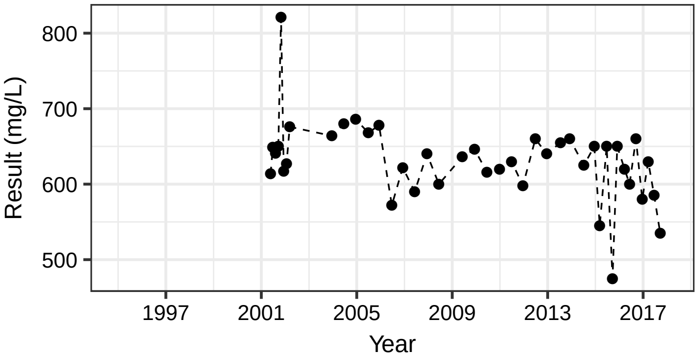

Total Dissolved Solids
MW−1


Total Dissolved Solids
MW−2


Total Dissolved Solids
MW−3


Total Dissolved Solids
MW−4


Total Dissolved Solids
MW−5


Total Dissolved Solids
MW−6

Time Series Plots
(Nondetects plotted using open symbols at one−half the RL)
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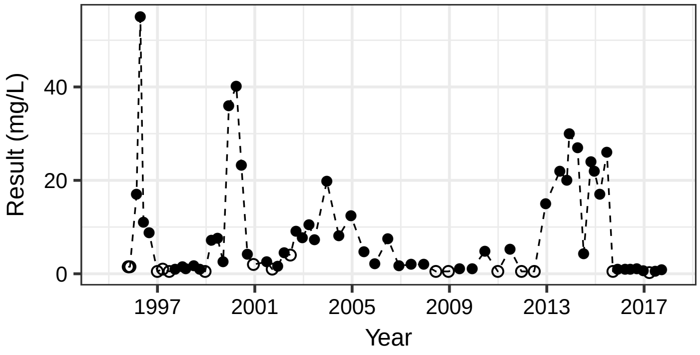
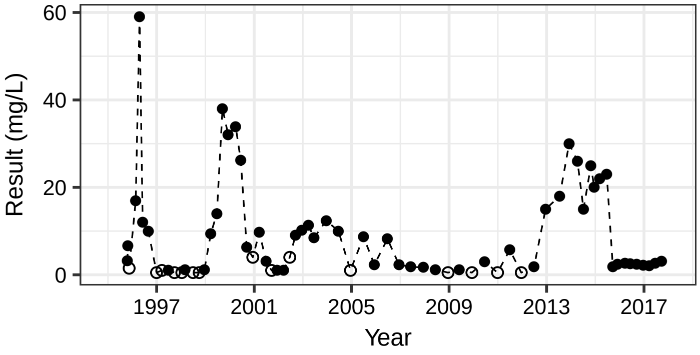
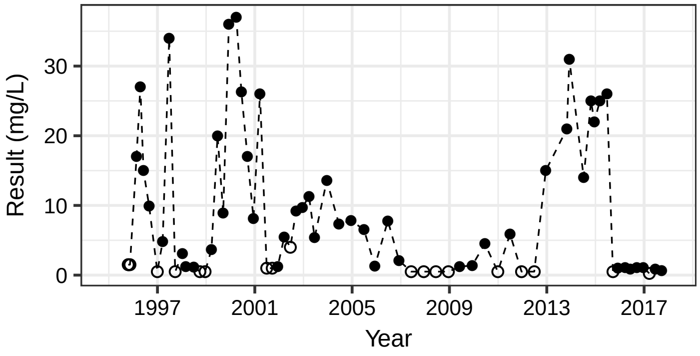
Total Organic Carbon
MW−1



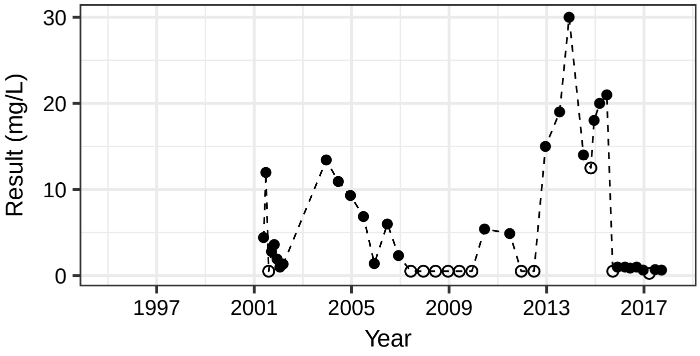
Total Organic Carbon
MW−2



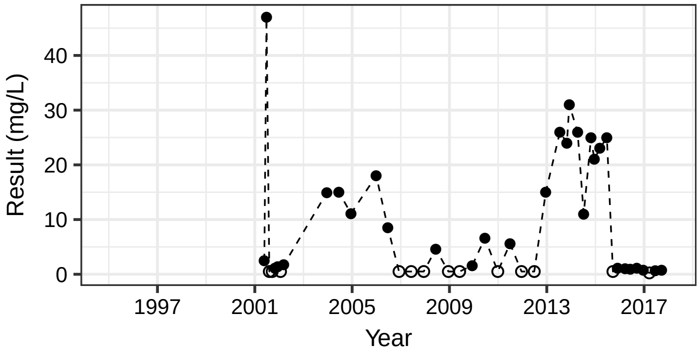
Total Organic Carbon
MW−3



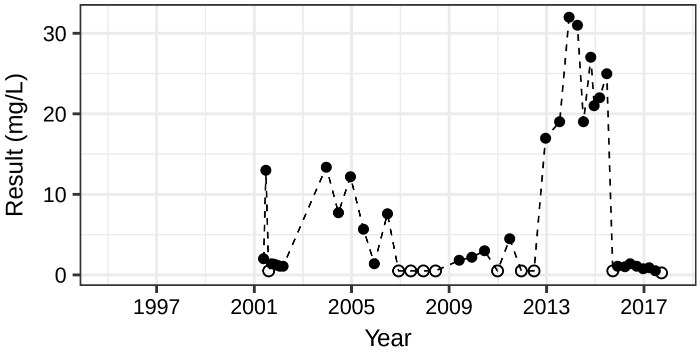
Total Organic Carbon
MW−4



Total Organic Carbon
MW−5



Total Organic Carbon
MW−6



Attachment 3
Box-and-Whisker Plots, Histograms, and Probability Plots

Combined Plots
(Nondetects assumed equal to one−half the RL)
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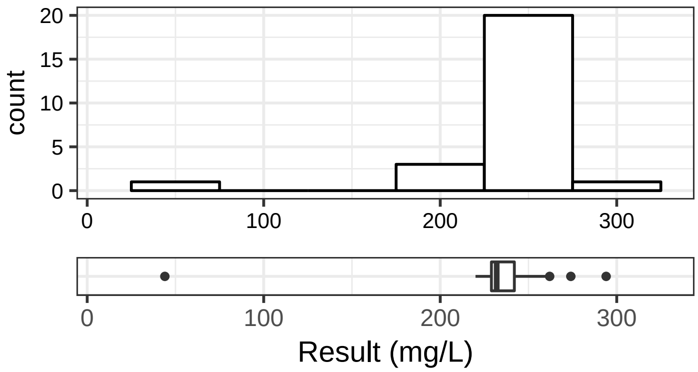
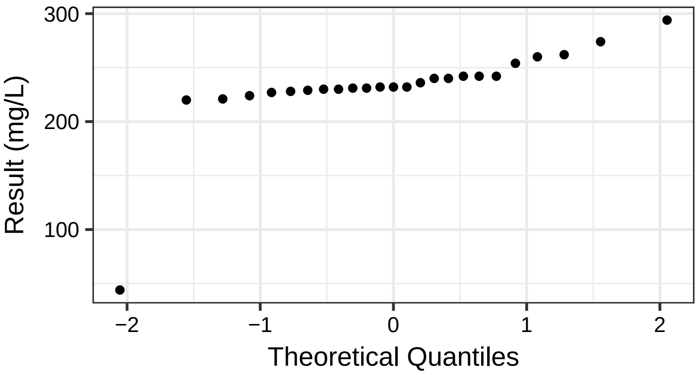
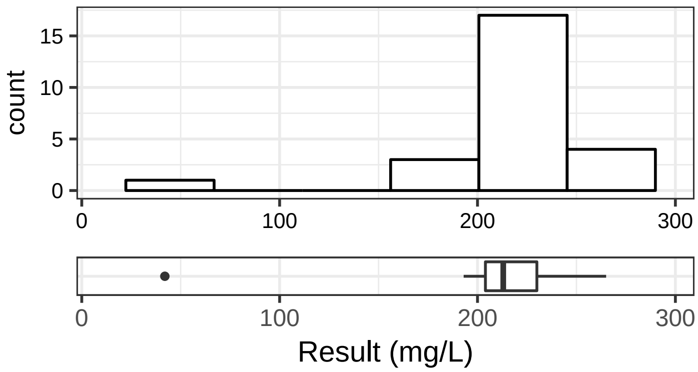
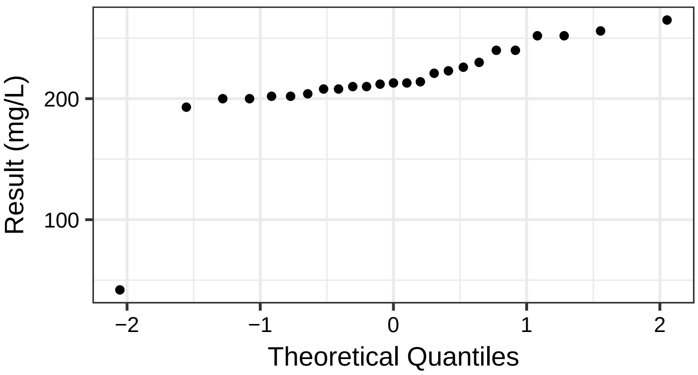
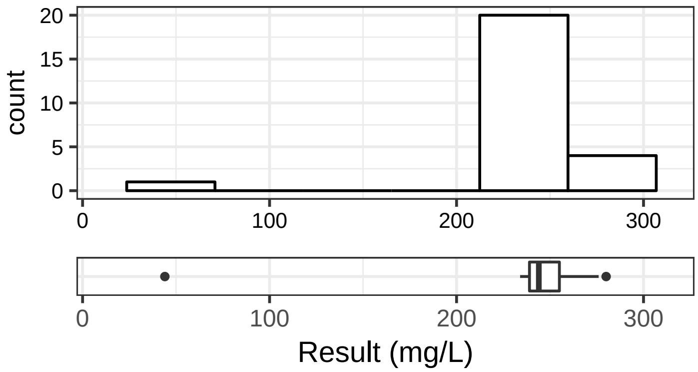
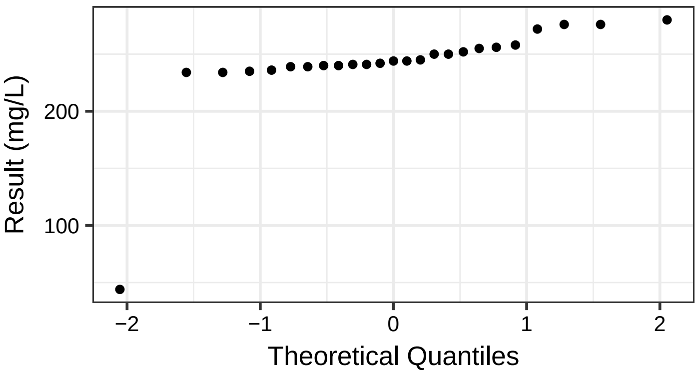

Alkalinity in MW−1

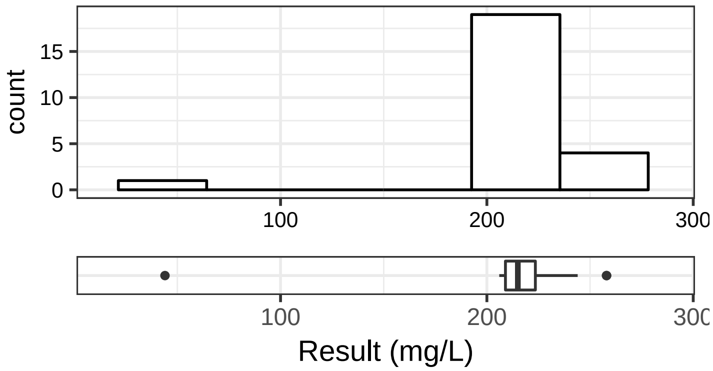

Alkalinity in MW−1

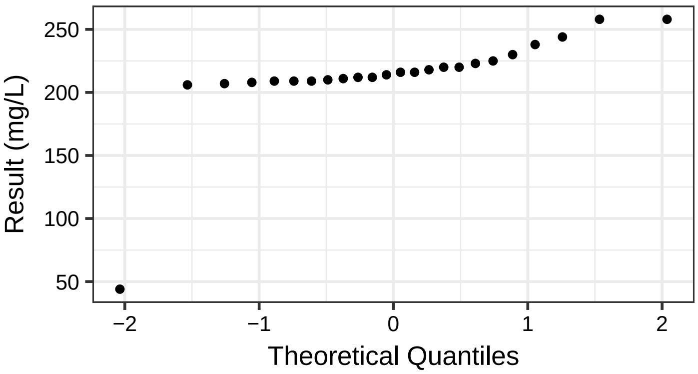

Alkalinity in MW−2


Alkalinity in MW−2


Alkalinity in MW−3

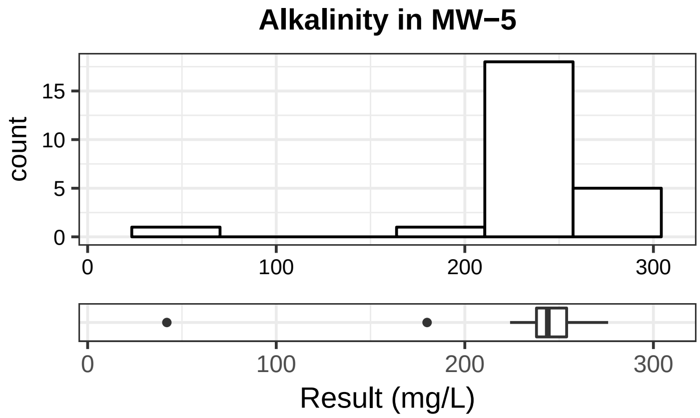

Alkalinity in MW−3

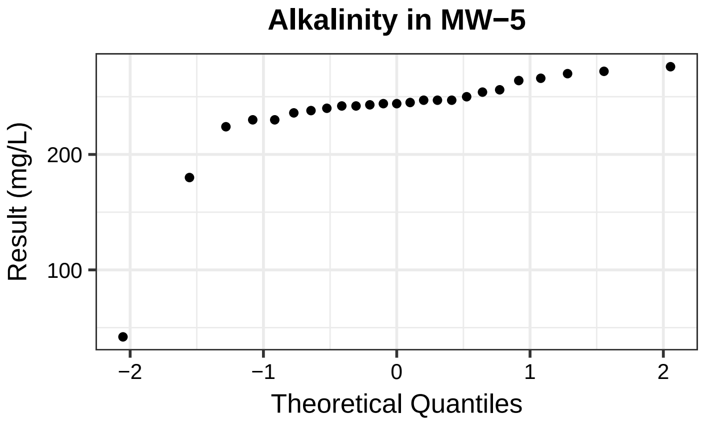

Alkalinity in MW−4

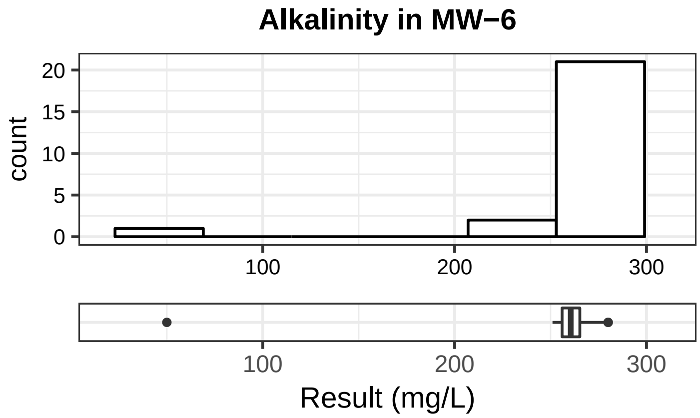

Alkalinity in MW−4

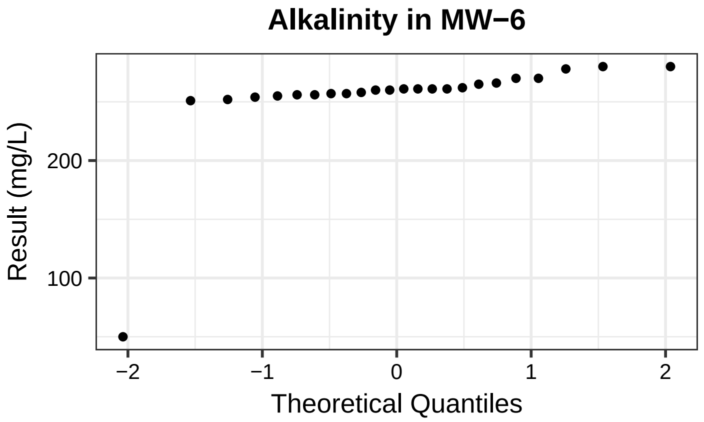
Combined Plots

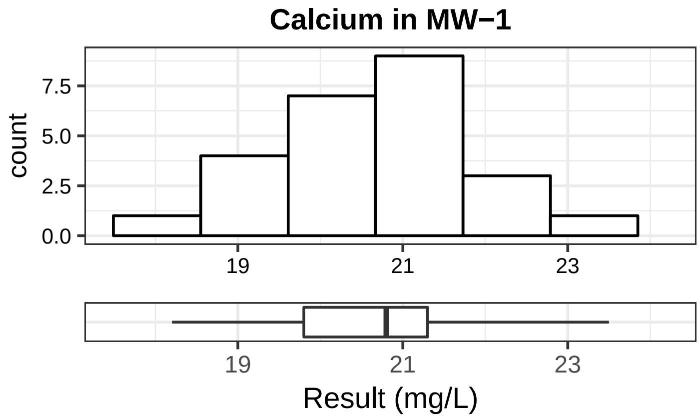
(Nondetects assumed equal to one−half the RL)

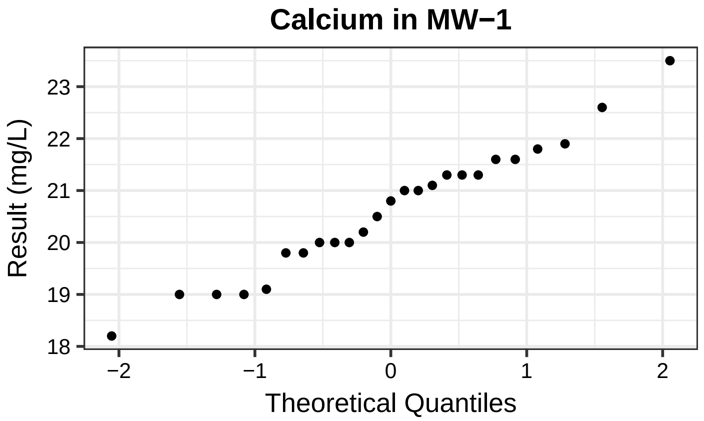

Alkalinity in MW−5

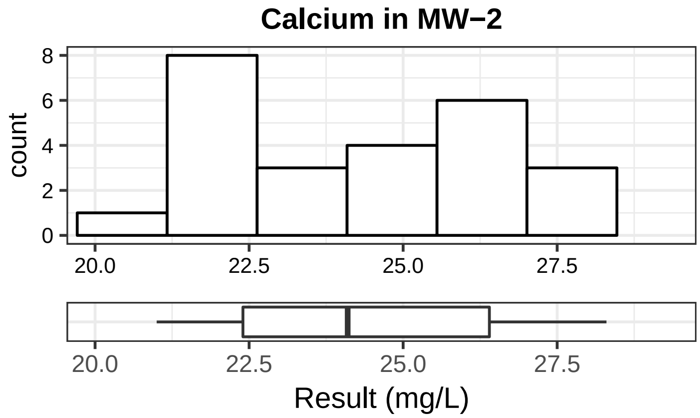

Alkalinity in MW−5

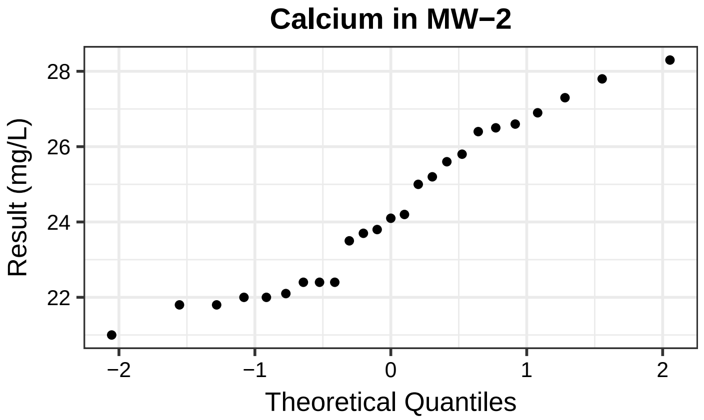

Alkalinity in MW−6


Alkalinity in MW−6


Calcium in MW−1


Calcium in MW−1

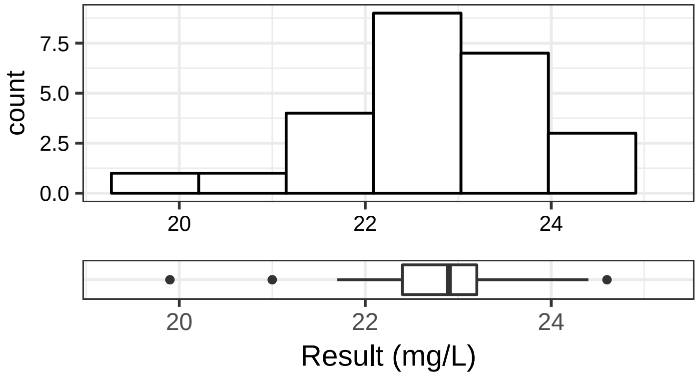

Calcium in MW−2


Calcium in MW−2

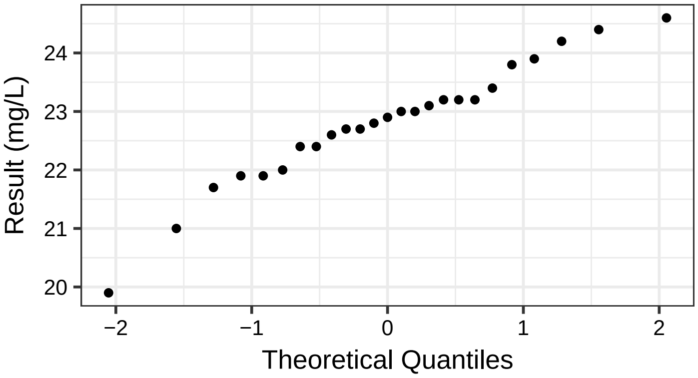
Combined Plots

(Nondetects assumed equal to one−half the RL)

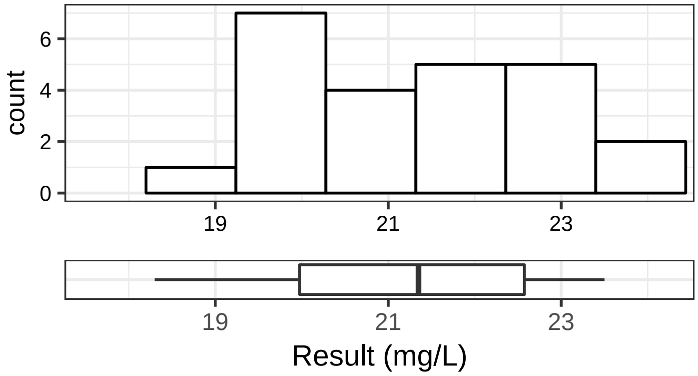
Calcium in MW−3



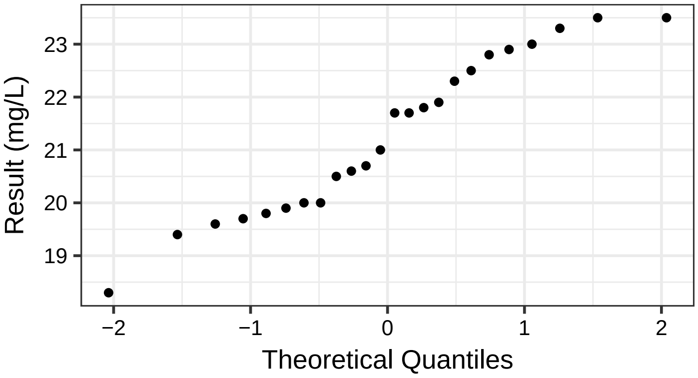
Calcium in MW−3



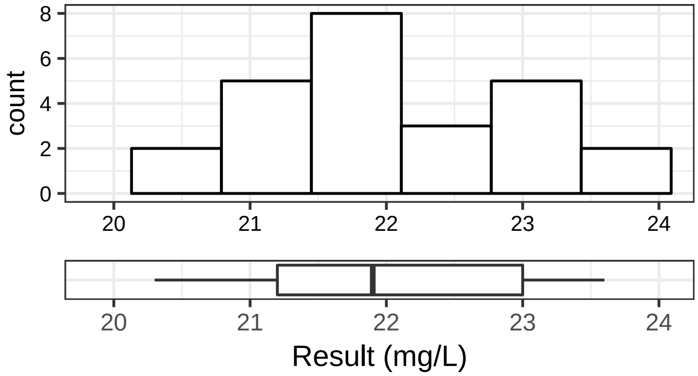
Calcium in MW−4



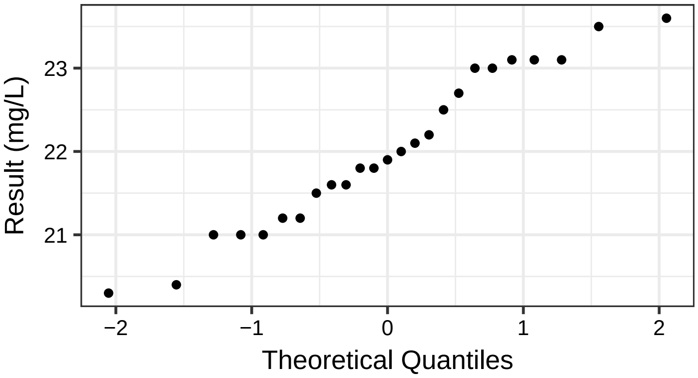
Calcium in MW−4



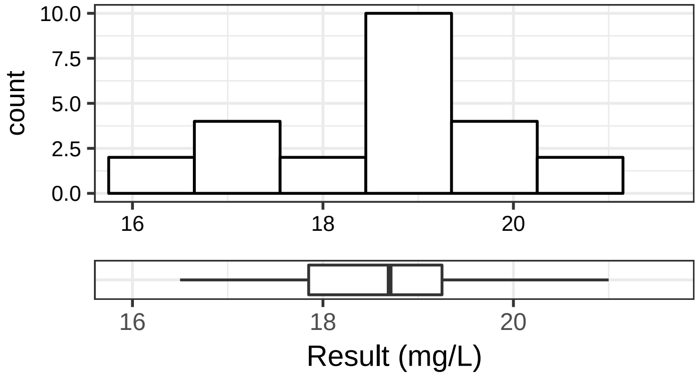
Calcium in MW−5



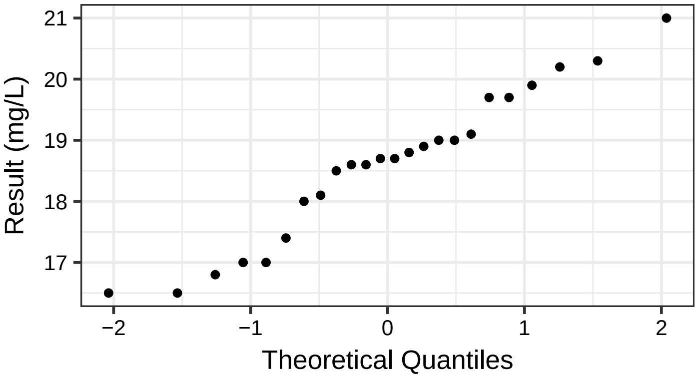
Calcium in MW−5



Calcium in MW−6



Calcium in MW−6



Combined Plots
(Nondetects assumed equal to one−half the RL)
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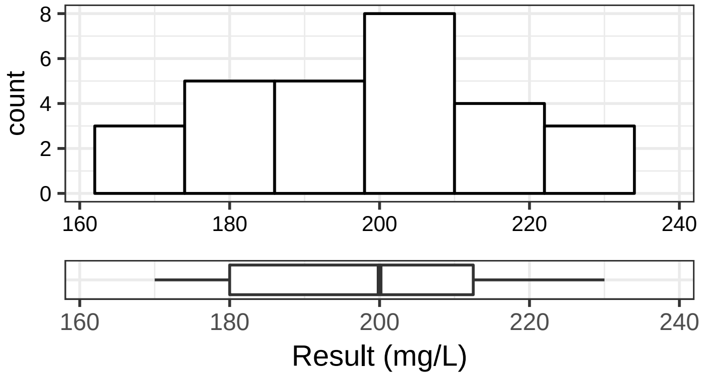
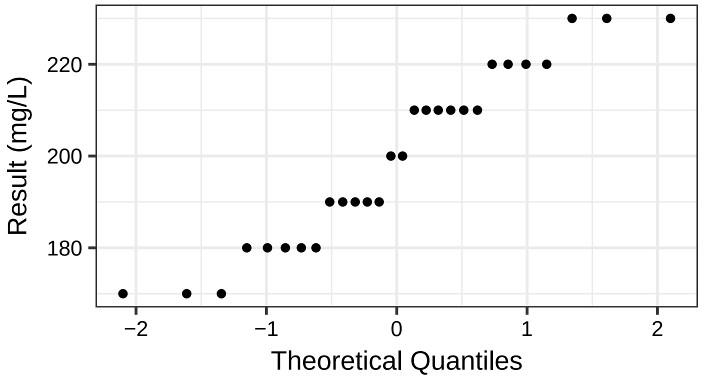
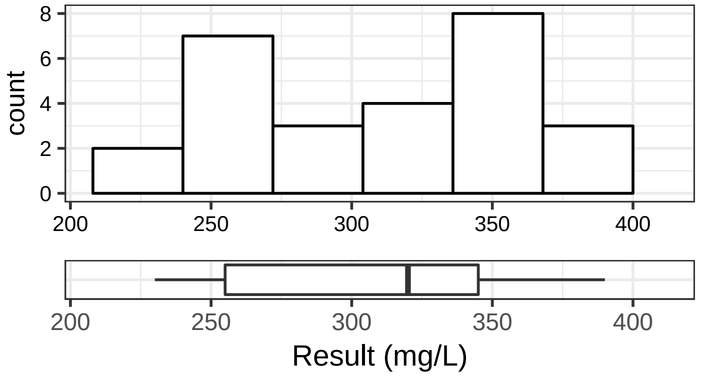
Chloride in MW−1



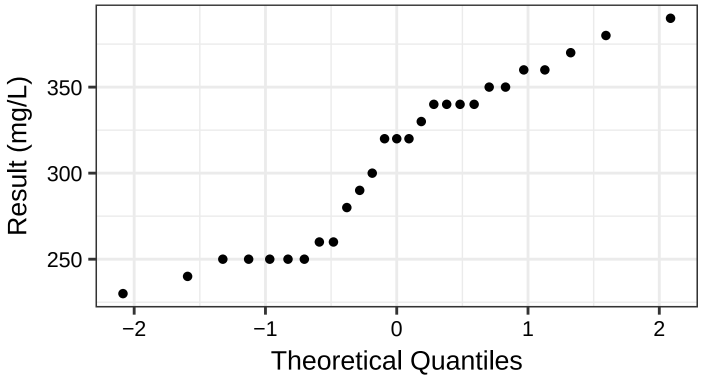
Chloride in MW−1



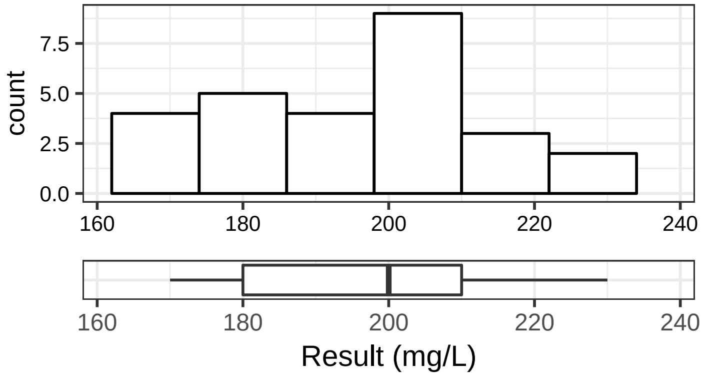
Chloride in MW−2



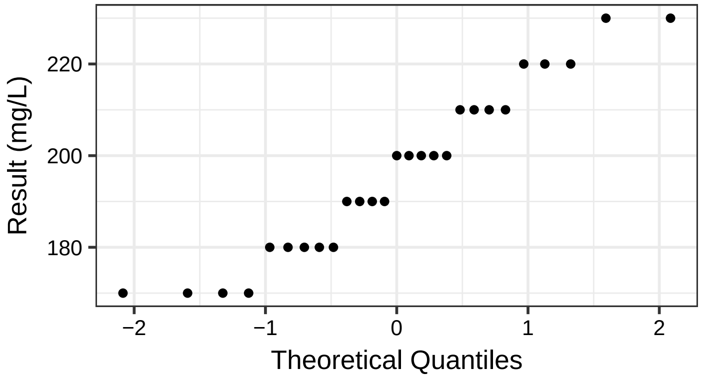
Chloride in MW−2



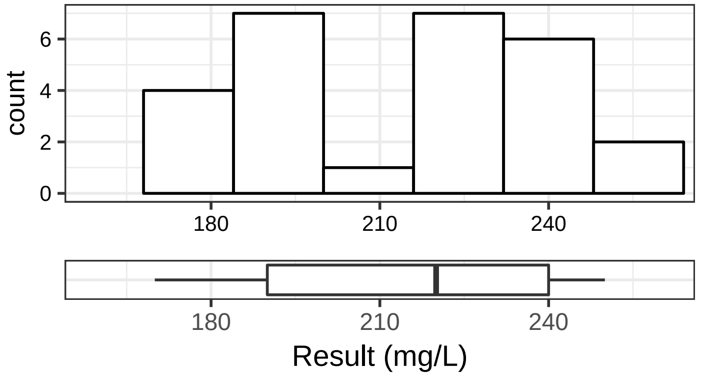
Chloride in MW−3



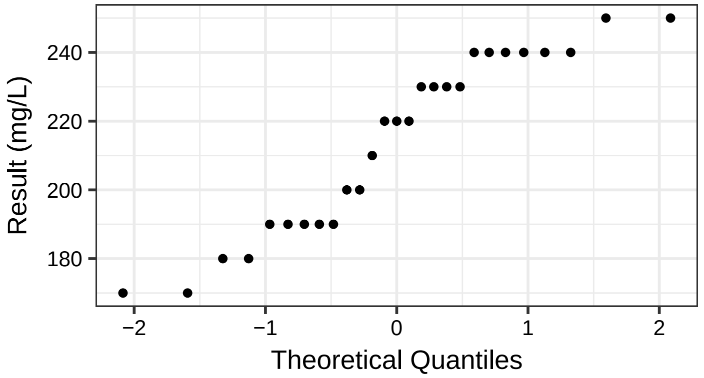
Chloride in MW−3



Chloride in MW−4

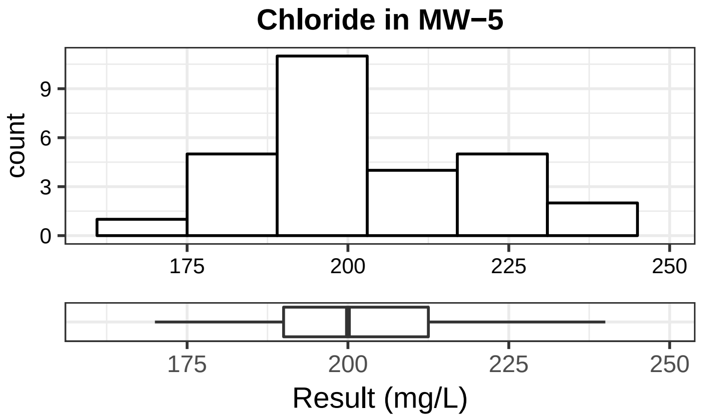


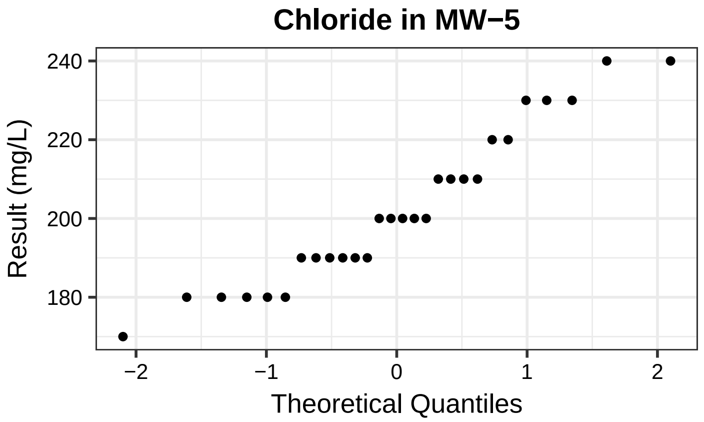
Chloride in MW−4

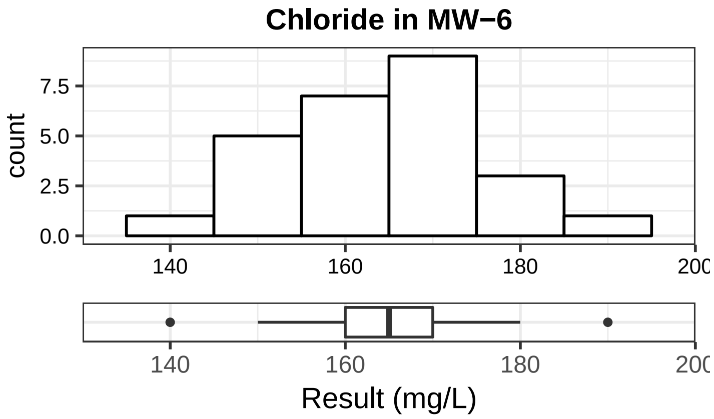


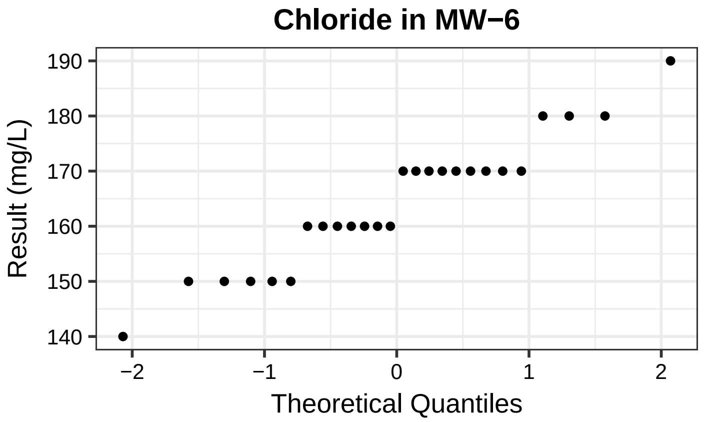
Combined Plots

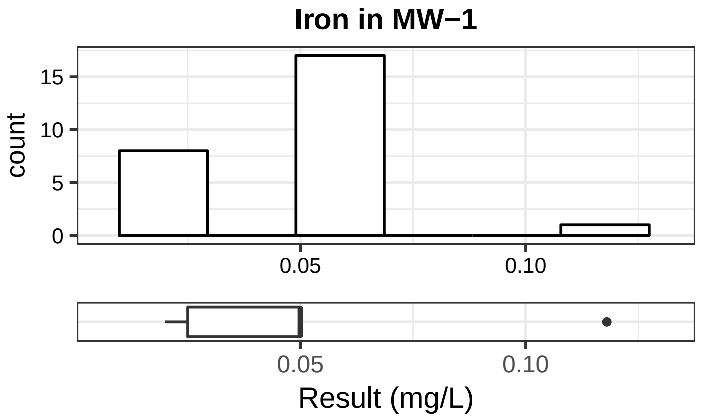
(Nondetects assumed equal to one−half the RL)

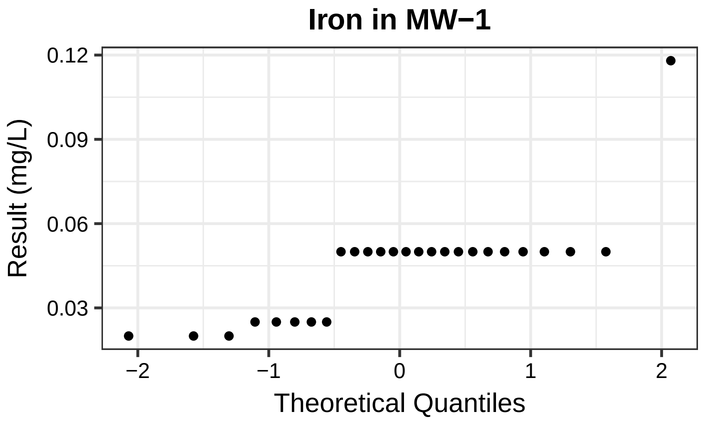


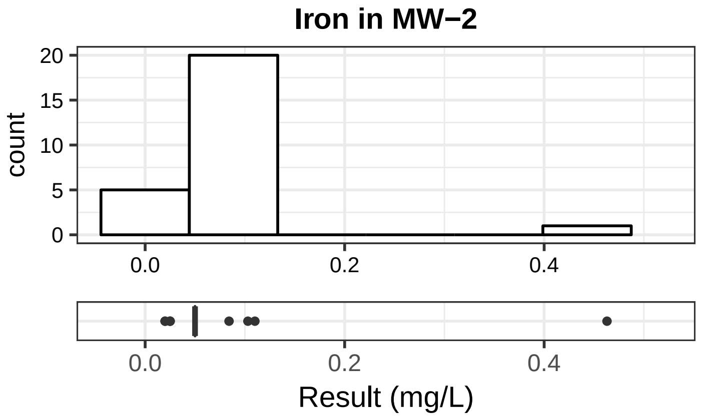


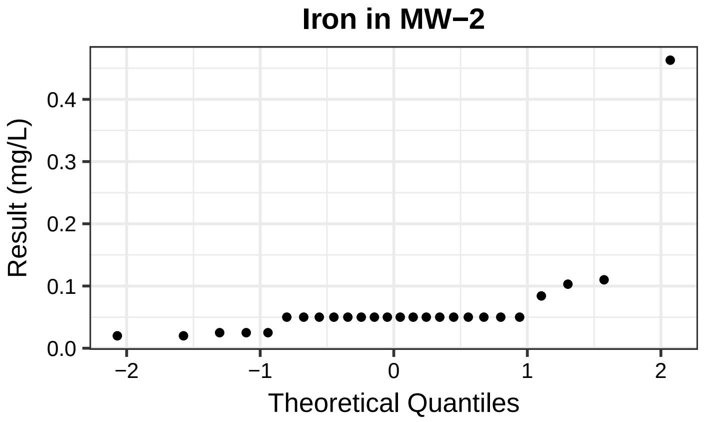












Combined Plots
(Nondetects assumed equal to one−half the RL)
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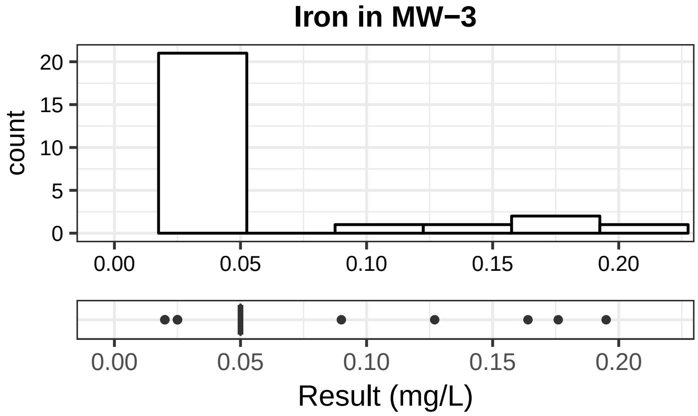

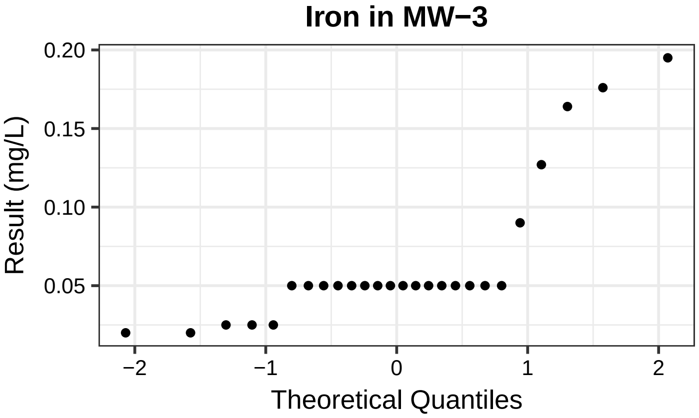

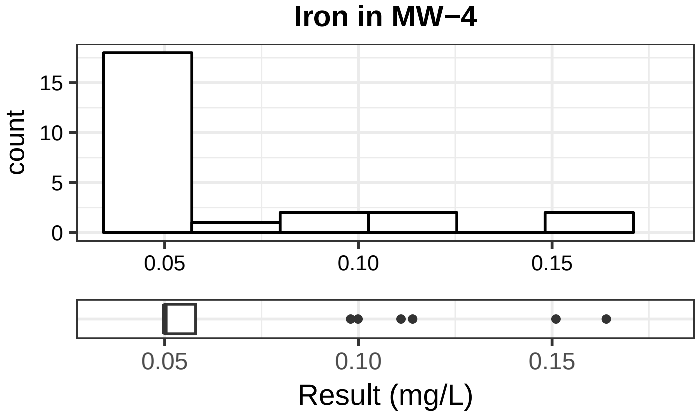

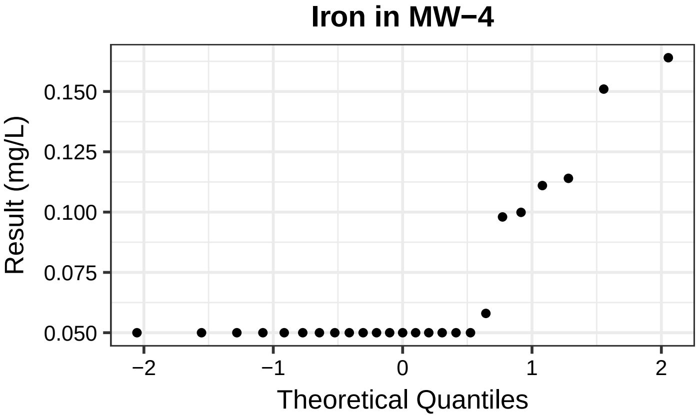

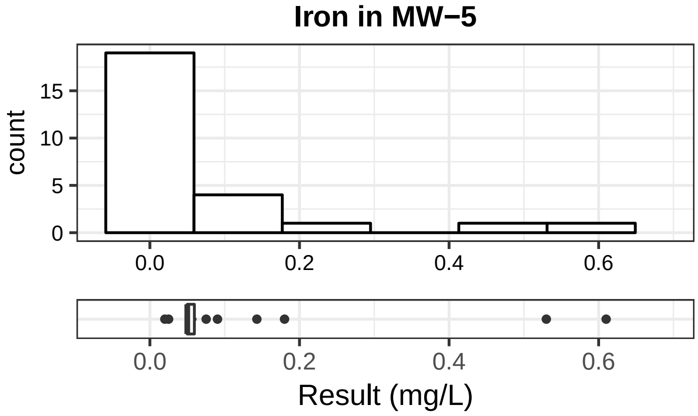

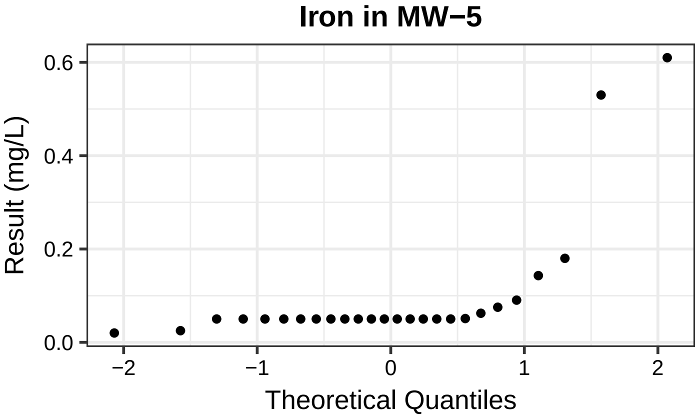

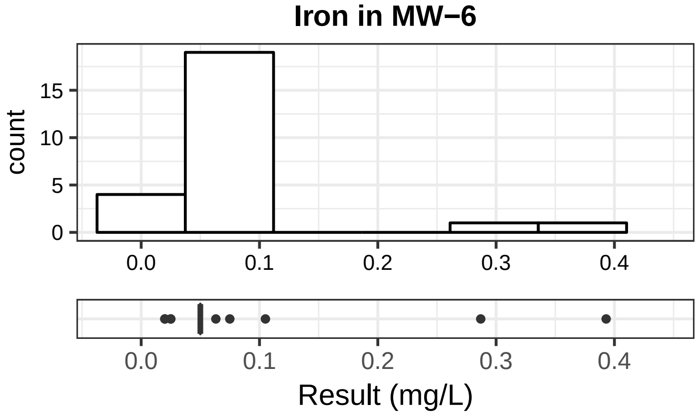

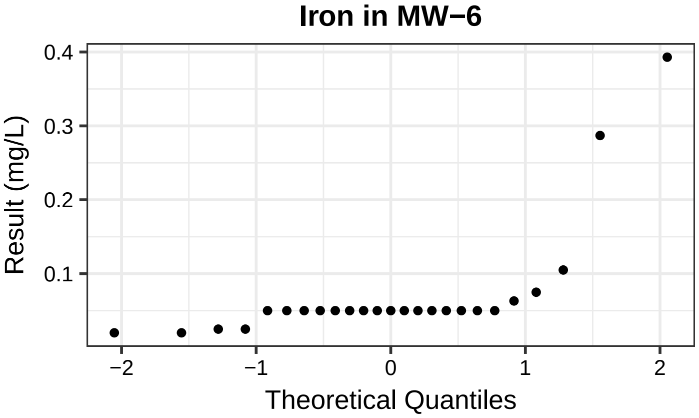

Combined Plots

(Nondetects assumed equal to one−half the RL)

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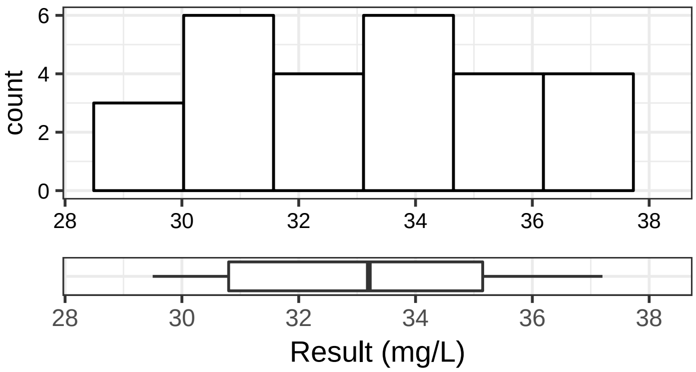
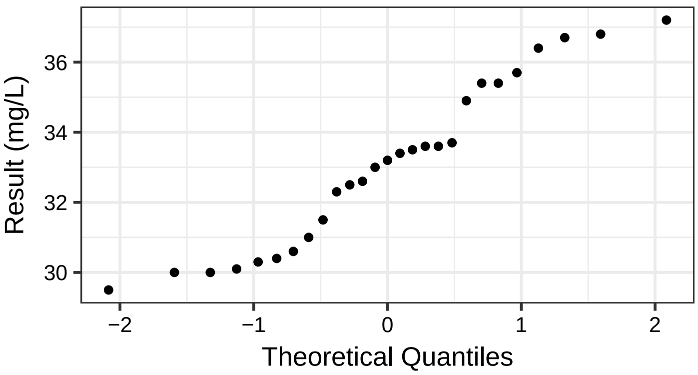
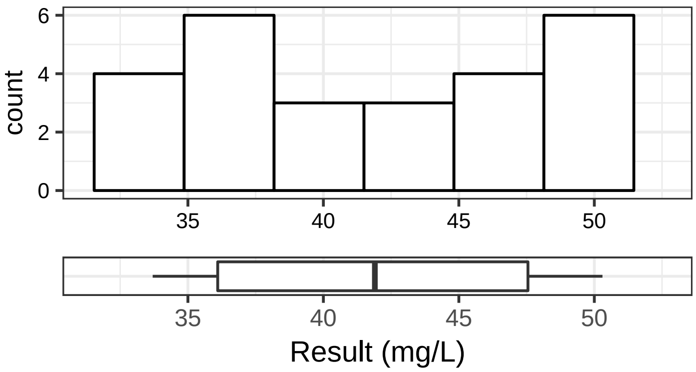
Magnesium in MW−1



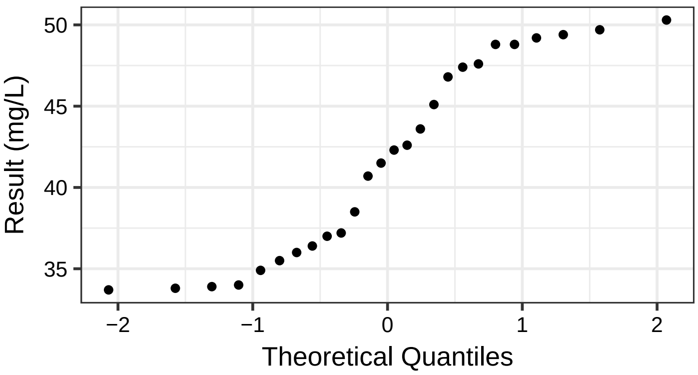
Magnesium in MW−1



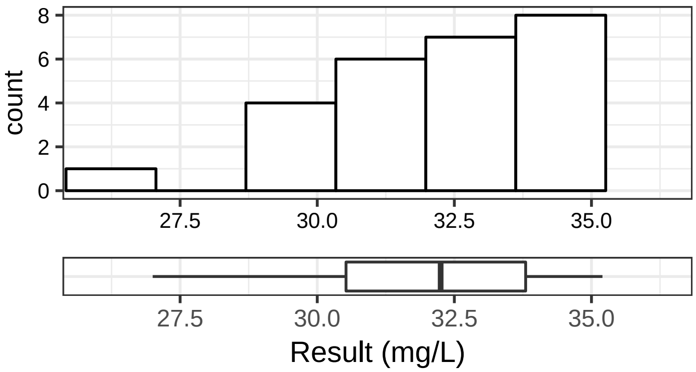
Magnesium in MW−2



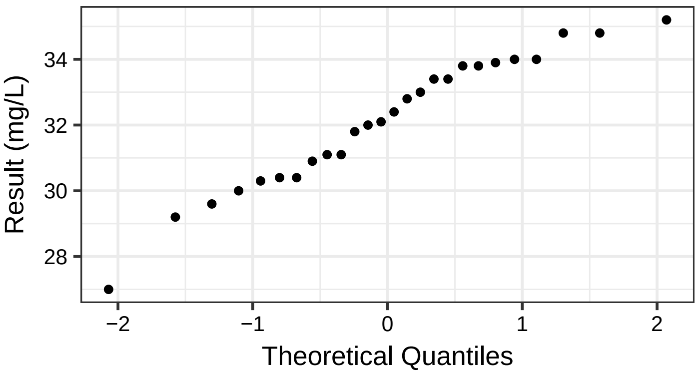
Magnesium in MW−2



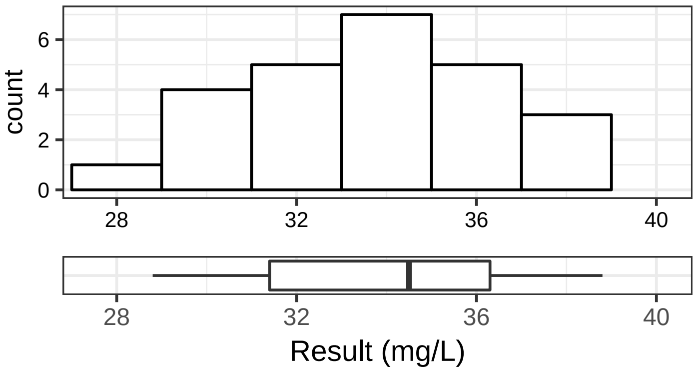
Magnesium in MW−3



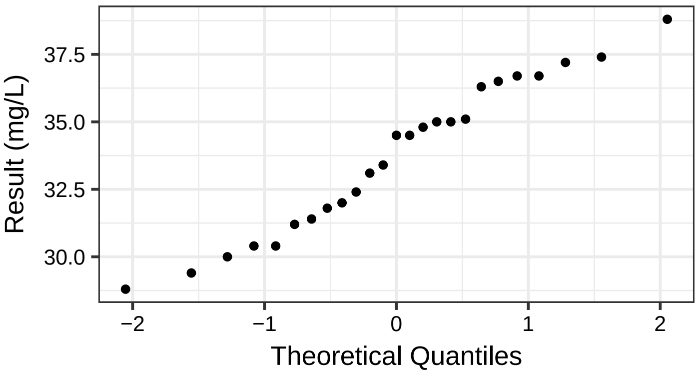
Magnesium in MW−3

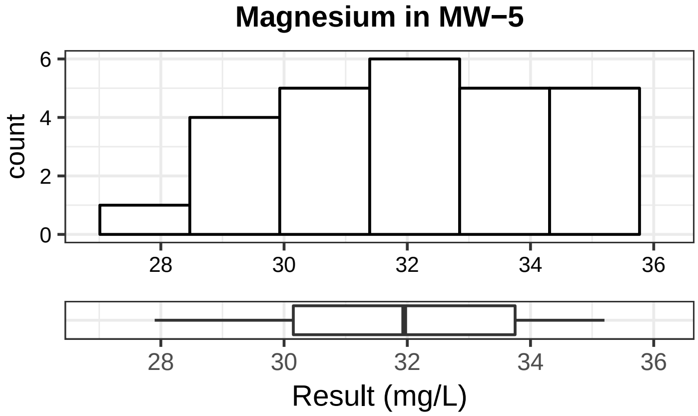


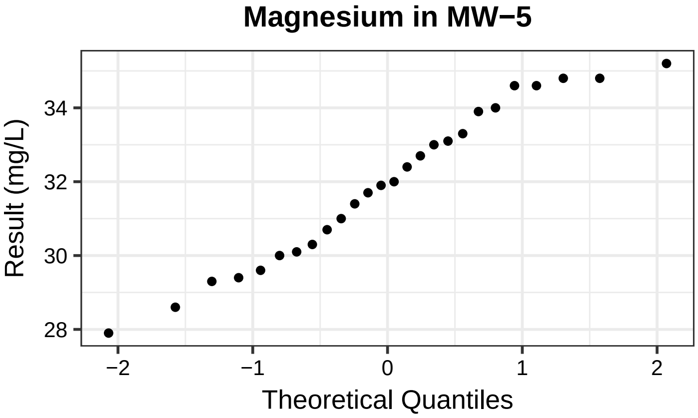
Magnesium in MW−4

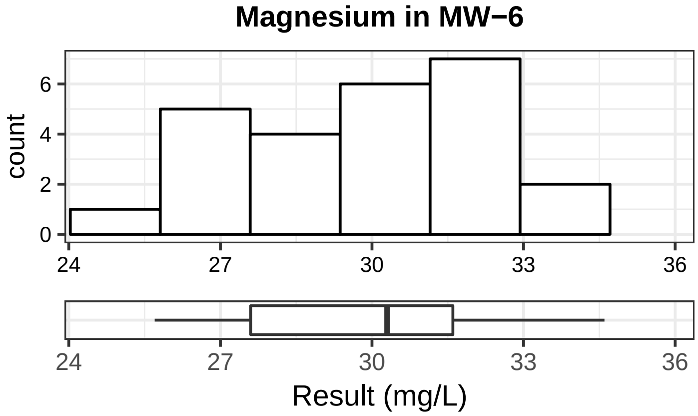


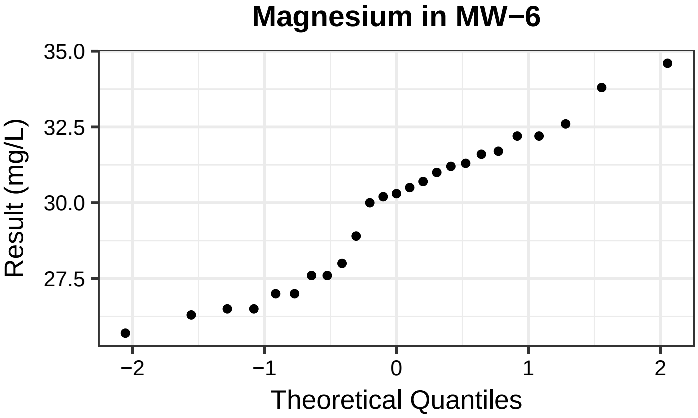
Magnesium in MW−4

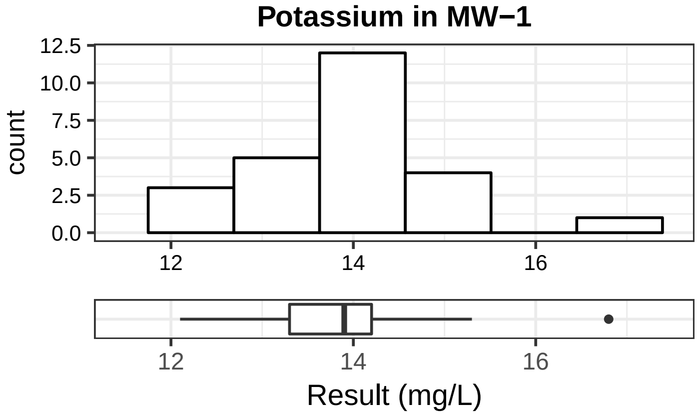


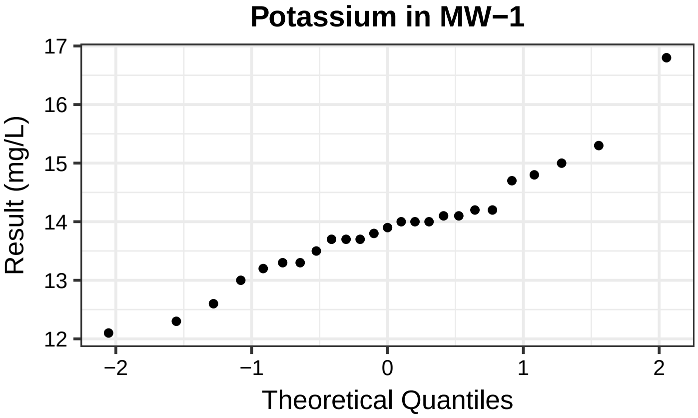

Magnesium in MW−5

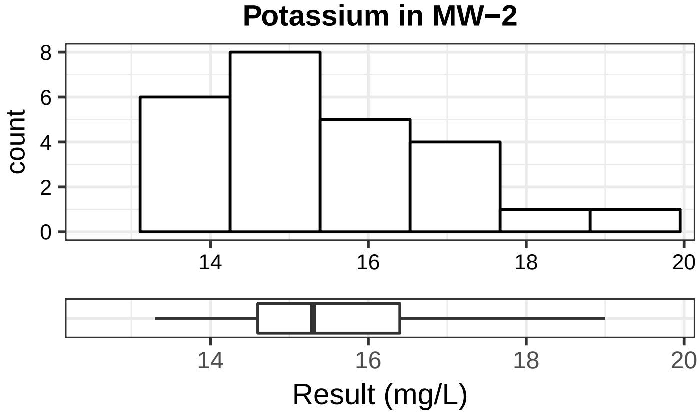

Magnesium in MW−5

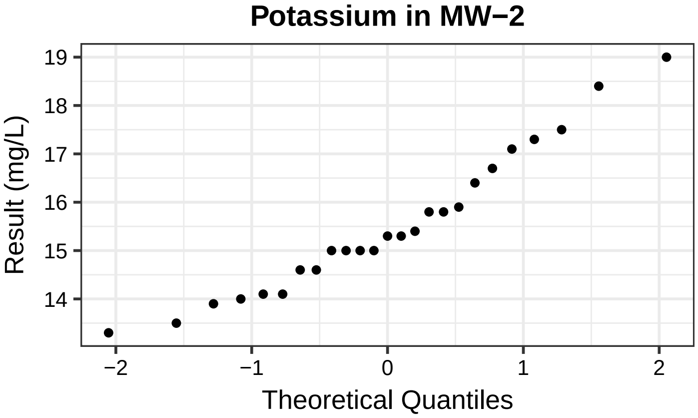

Magnesium in MW−6


Magnesium in MW−6


Potassium in MW−1

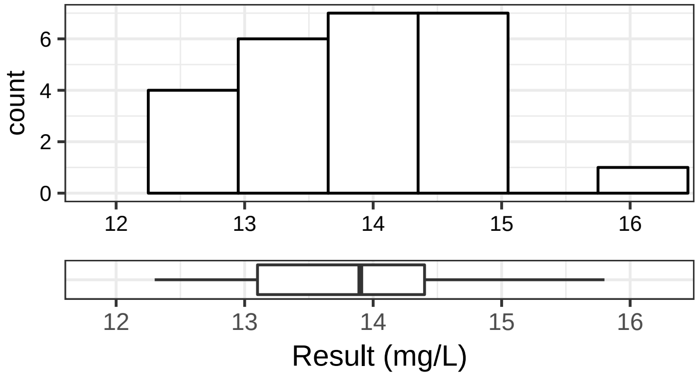

Potassium in MW−1


Potassium in MW−2

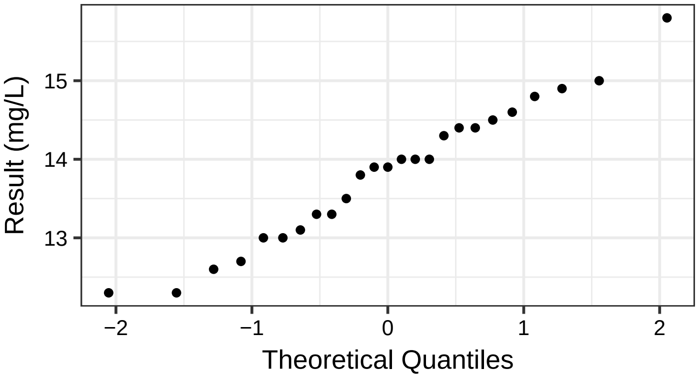

Potassium in MW−2

Combined Plots
(Nondetects assumed equal to one−half the RL)

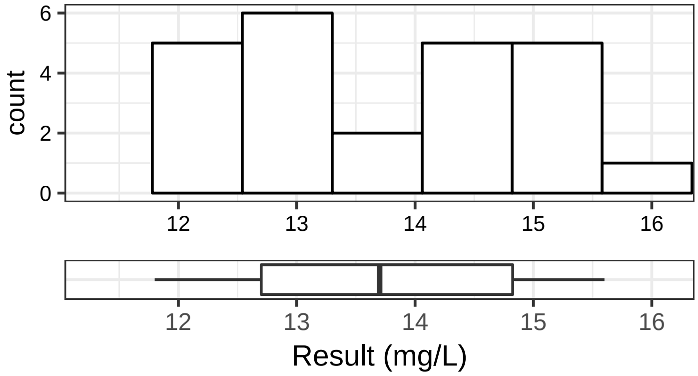
Potassium in MW−3



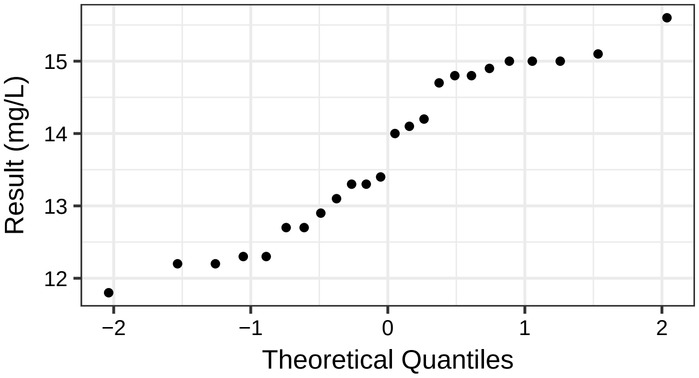
Potassium in MW−3



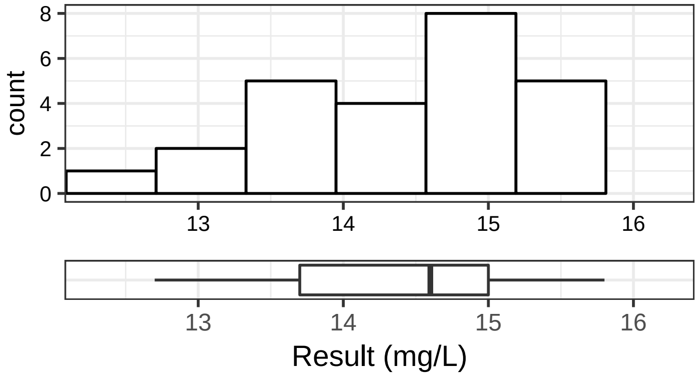
Potassium in MW−4



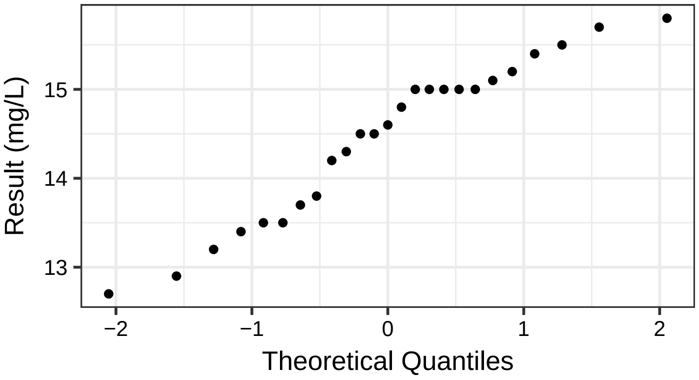
Potassium in MW−4



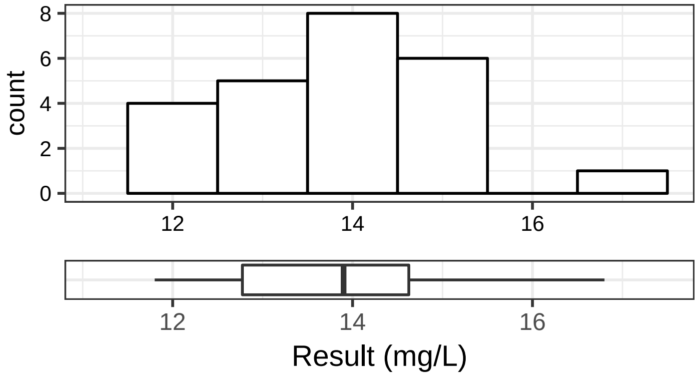
Potassium in MW−5



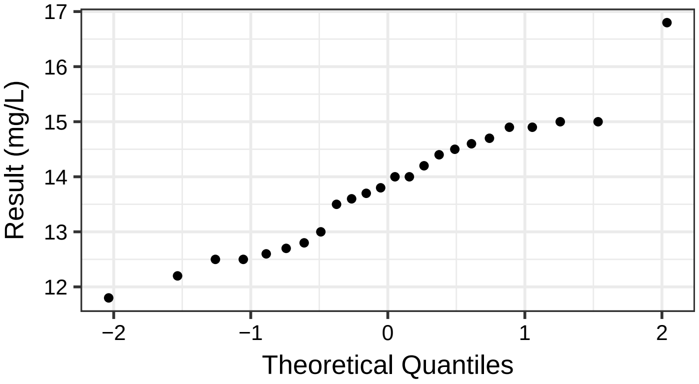
Potassium in MW−5



Potassium in MW−6



Potassium in MW−6



Combined Plots
(Nondetects assumed equal to one−half the RL)
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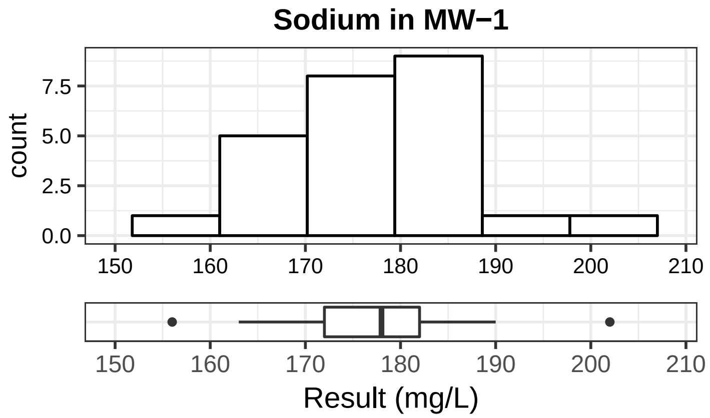
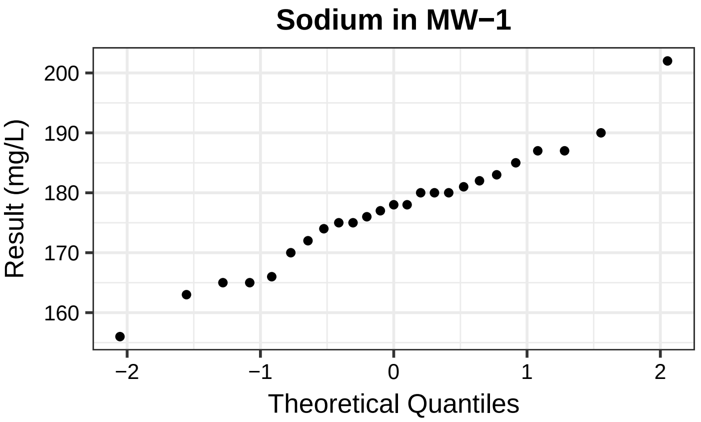
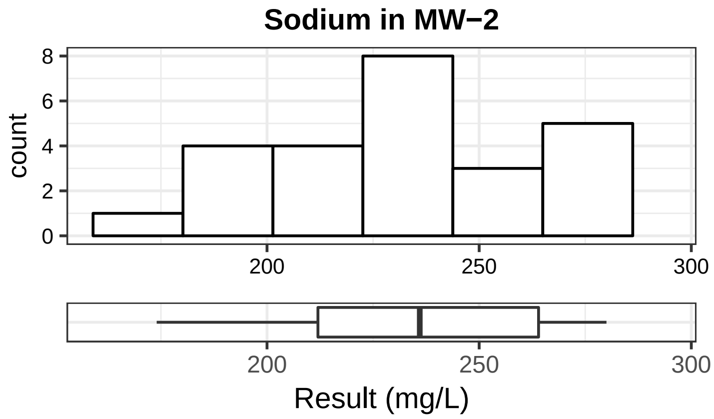
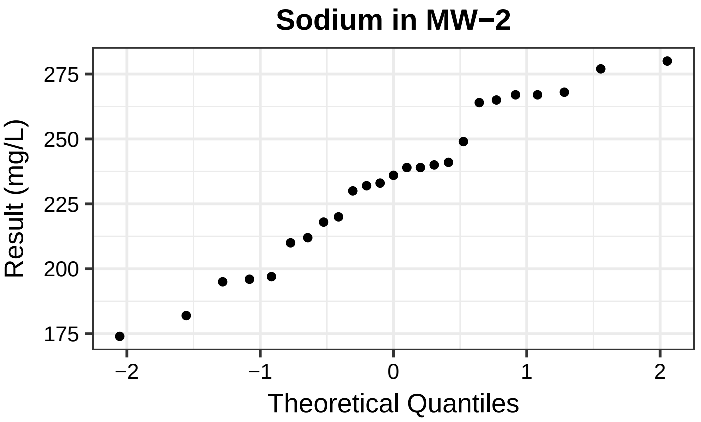
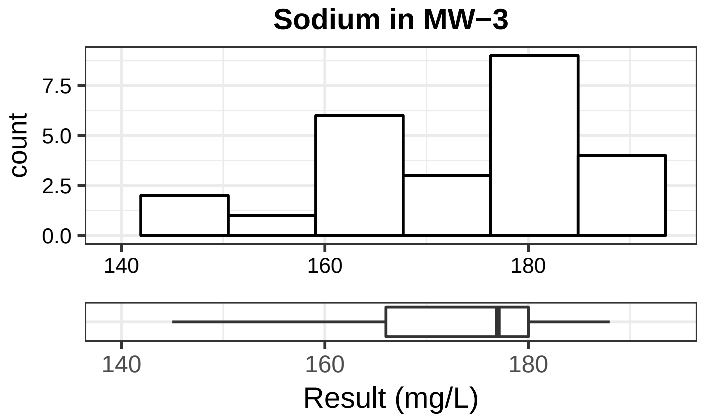
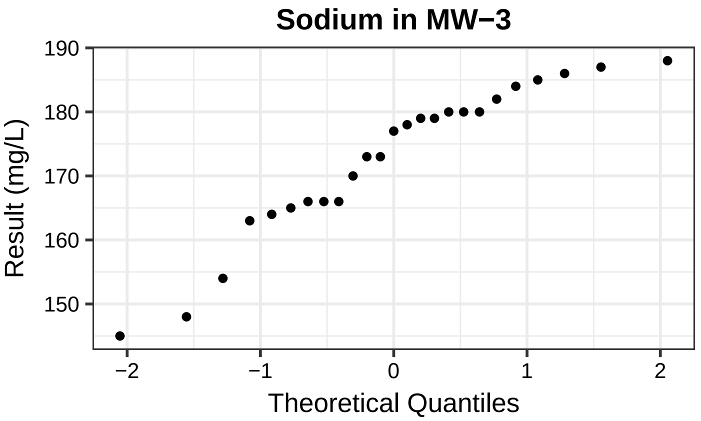


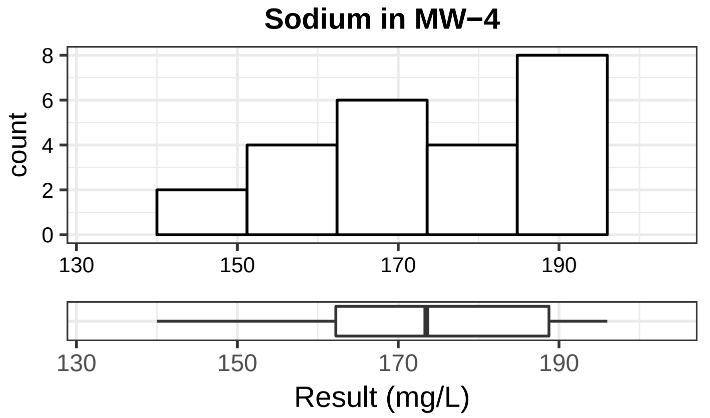


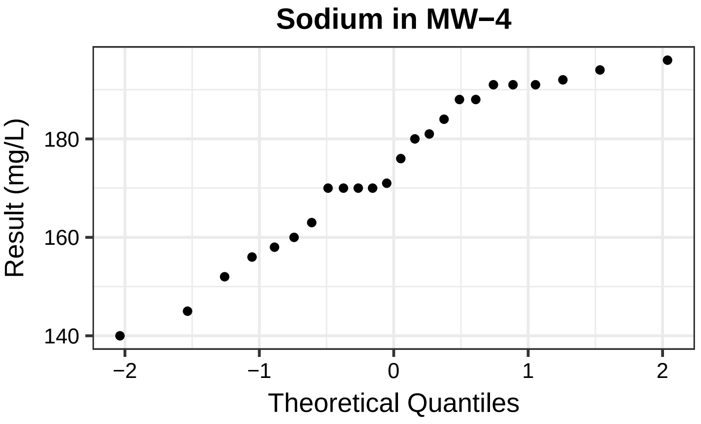


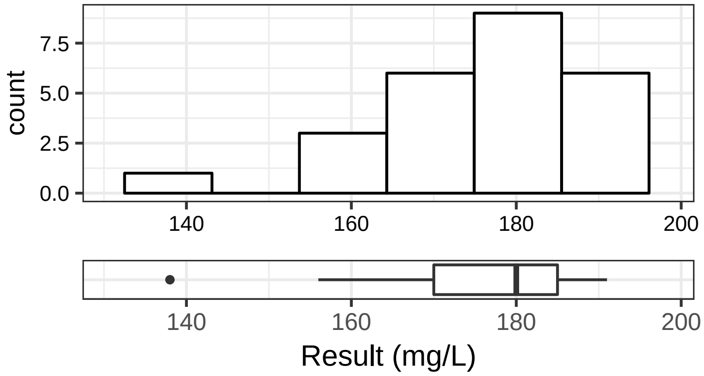


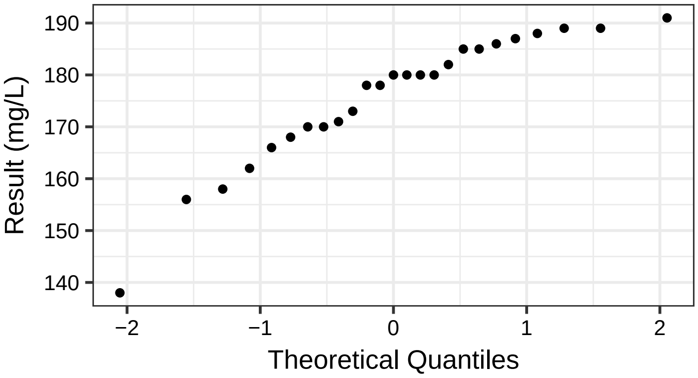


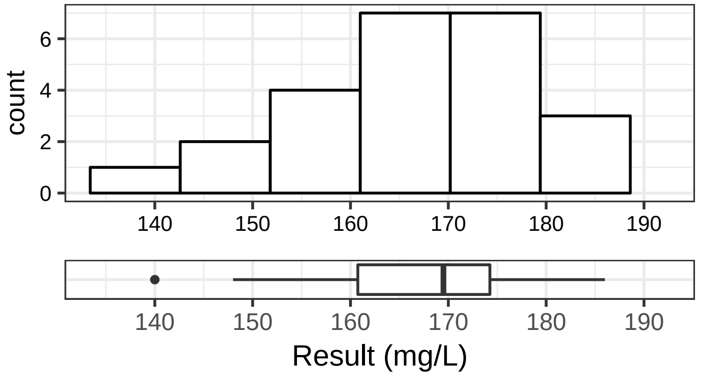


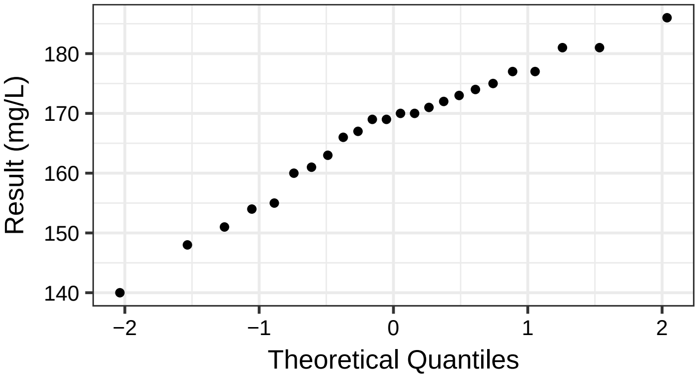


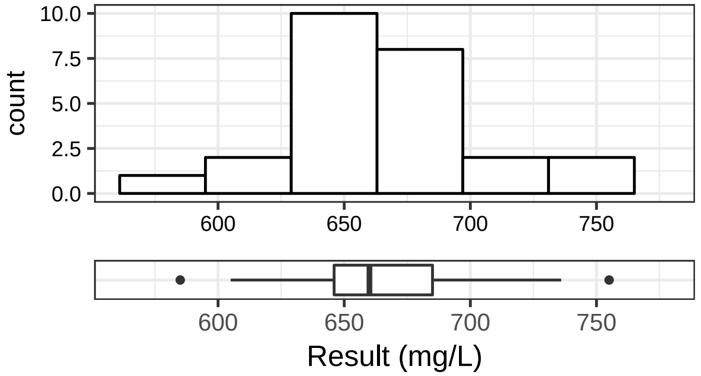


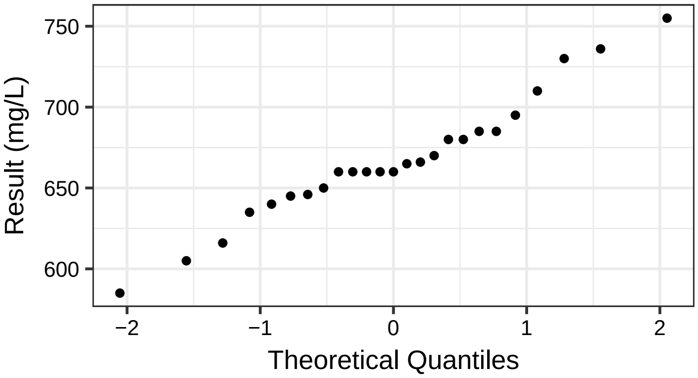

Sodium in MW−5

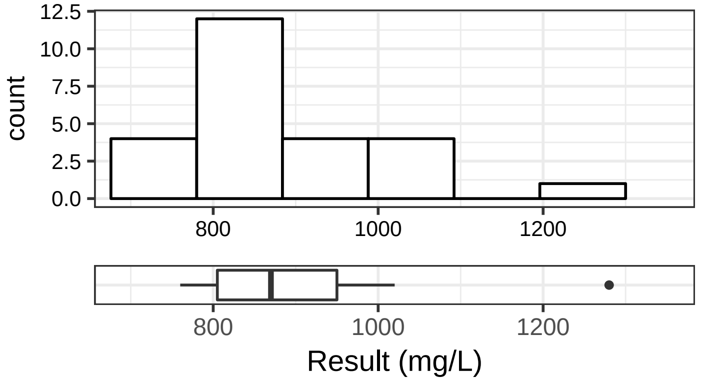

Sodium in MW−5

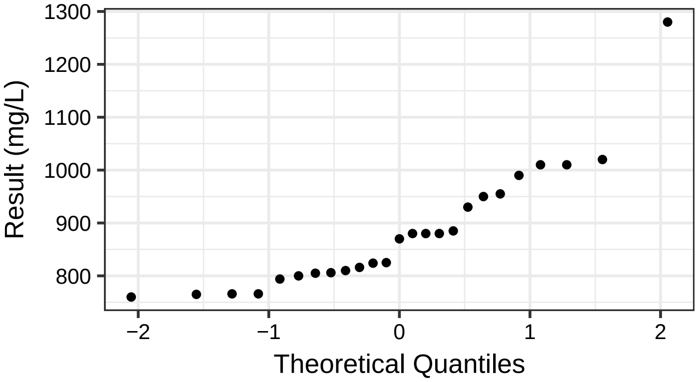

Sodium in MW−6


Sodium in MW−6

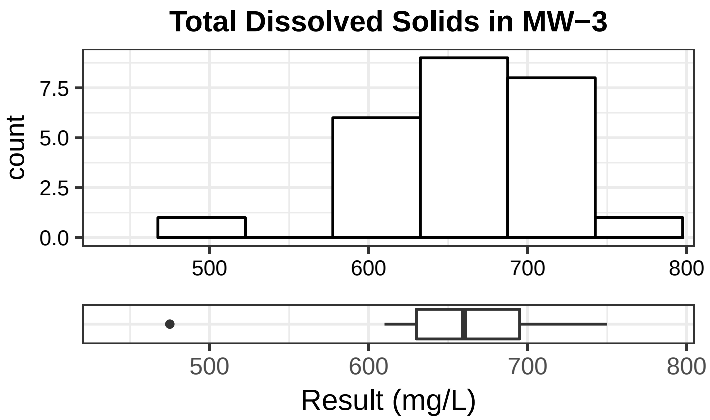

Total Dissolved Solids in MW−1

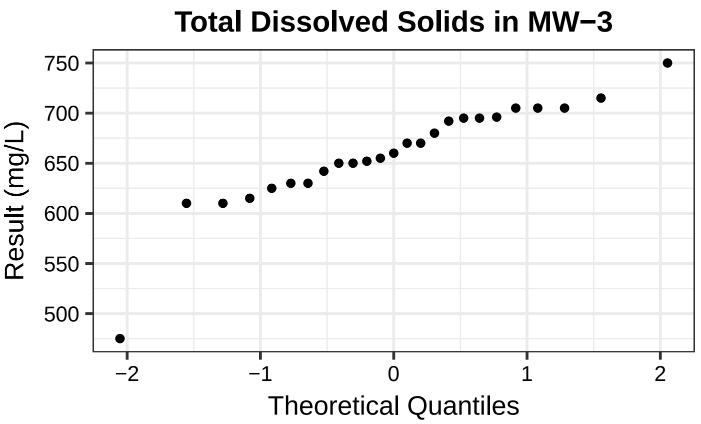

Total Dissolved Solids in MW−1

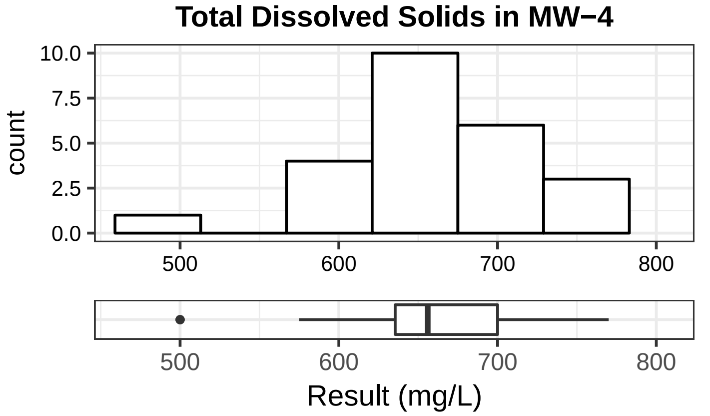

Total Dissolved Solids in MW−2

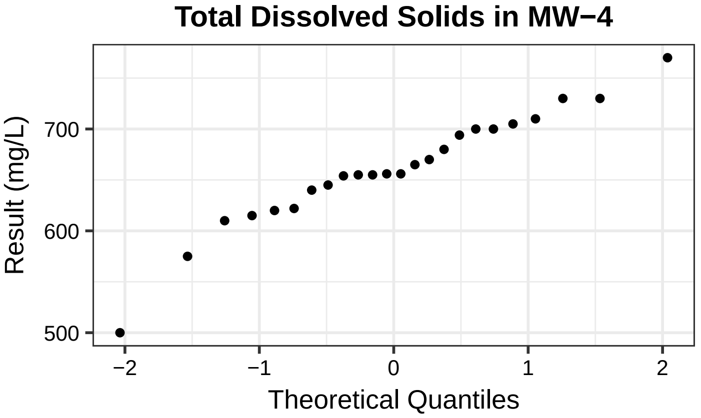

Total Dissolved Solids in MW−2

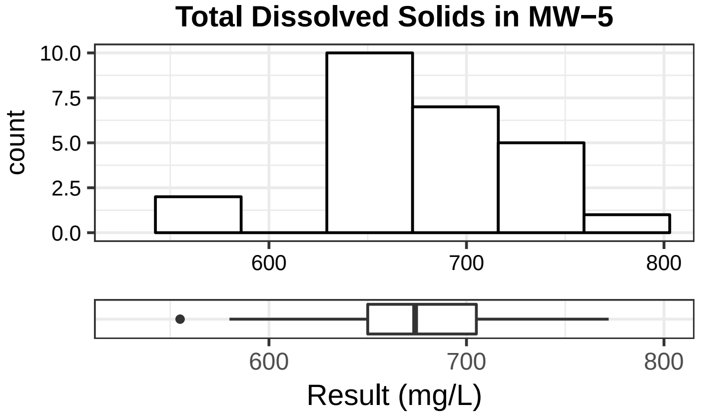
Combined Plots
(Nondetects assumed equal to one−half the RL)

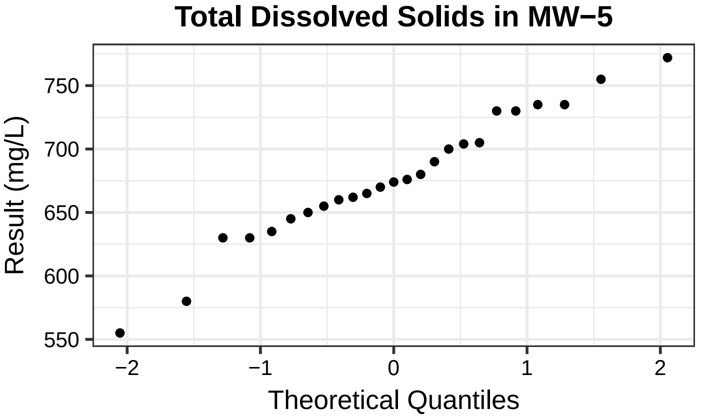

Total Dissolved Solids in MW−3

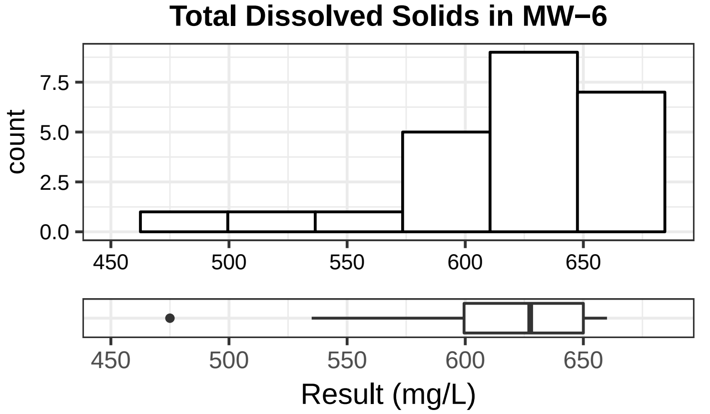

Total Dissolved Solids in MW−3

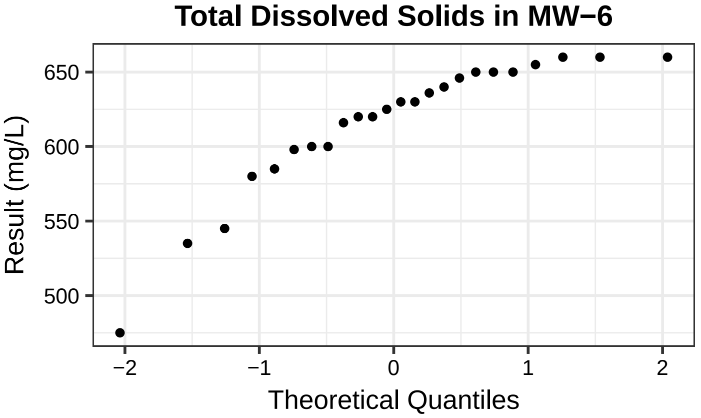

Total Dissolved Solids in MW−4


Total Dissolved Solids in MW−4


Total Dissolved Solids in MW−5


Total Dissolved Solids in MW−5


Total Dissolved Solids in MW−6


Total Dissolved Solids in MW−6

Combined Plots
(Nondetects assumed equal to one−half the RL)
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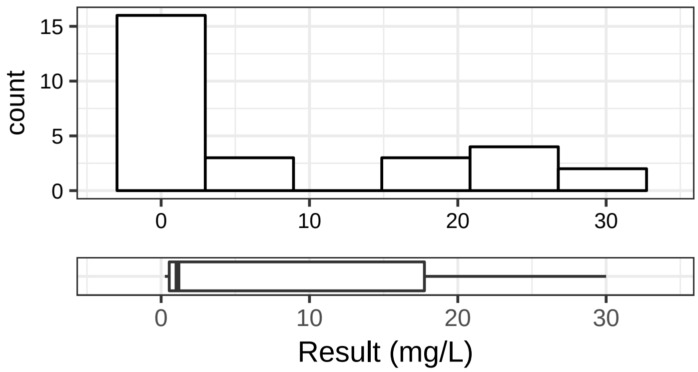
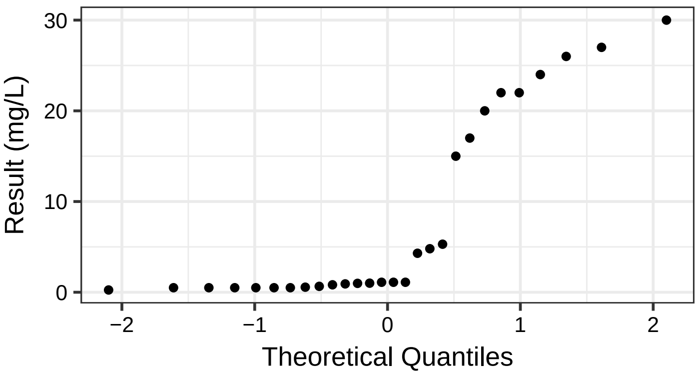
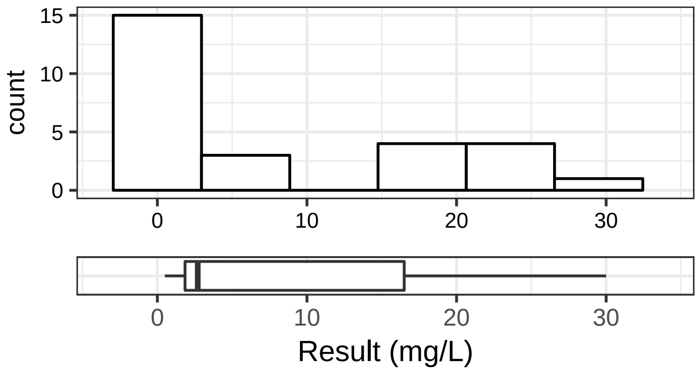
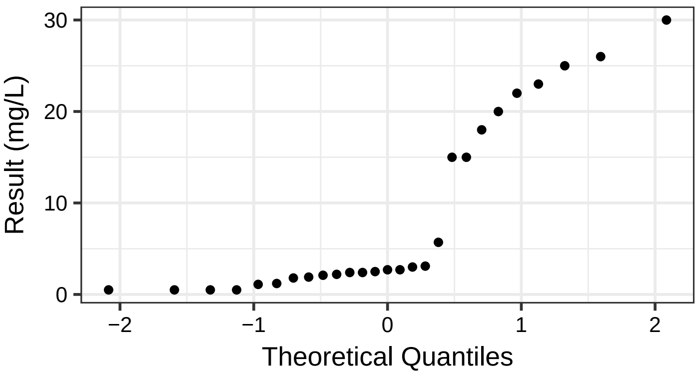
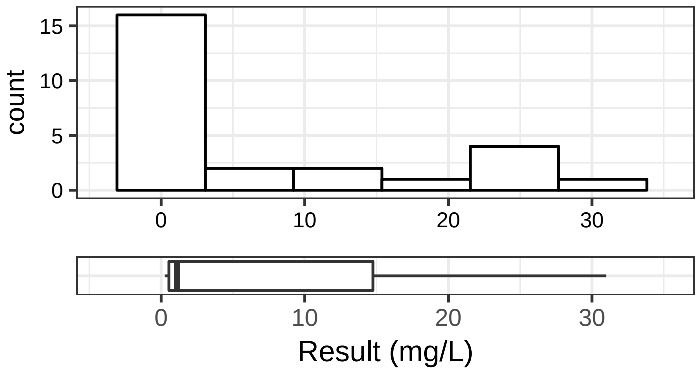
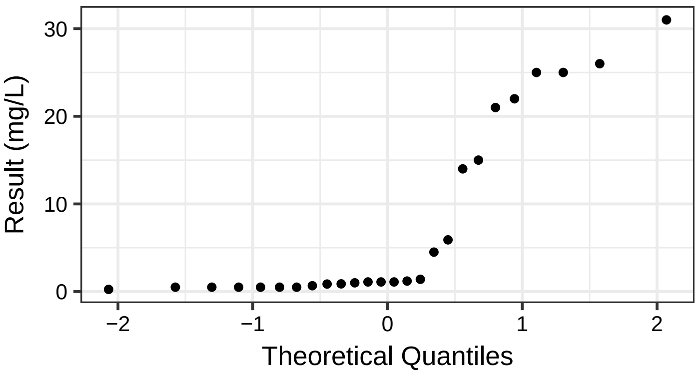

Total Organic Carbon in MW−1

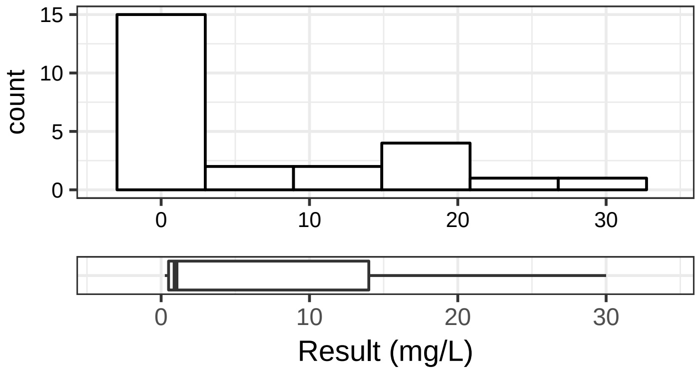

Total Organic Carbon in MW−1

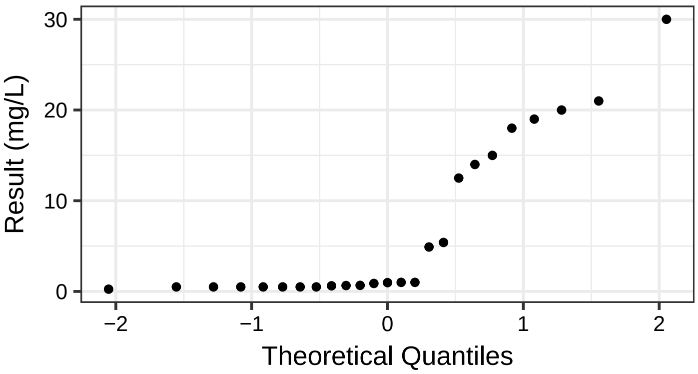

Total Organic Carbon in MW−2


Total Organic Carbon in MW−2


Total Organic Carbon in MW−3

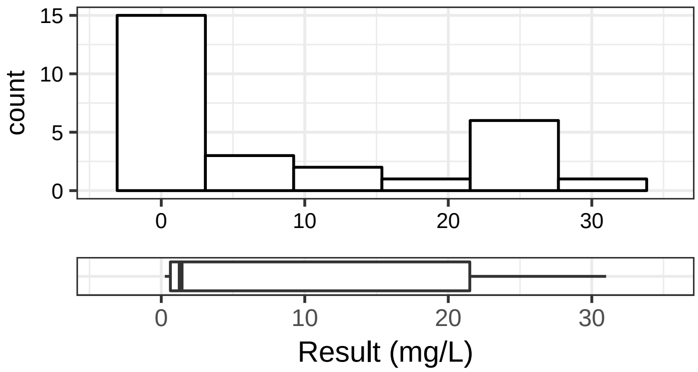

Total Organic Carbon in MW−3


Total Organic Carbon in MW−4

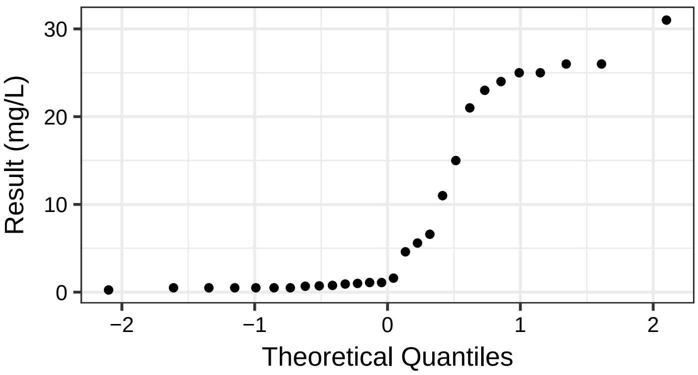

Total Organic Carbon in MW−4

Combined Plots
(Nondetects assumed equal to one−half the RL)

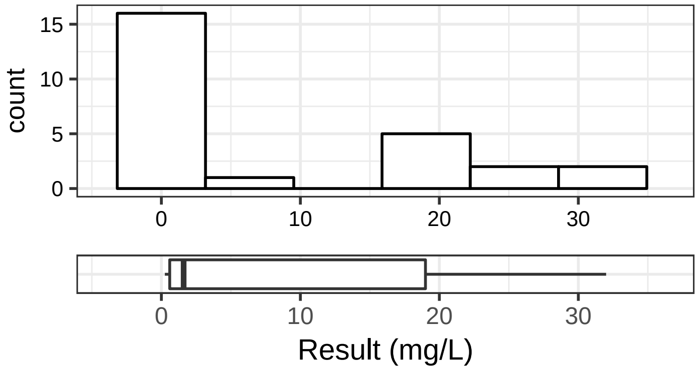
Total Organic Carbon in MW−5



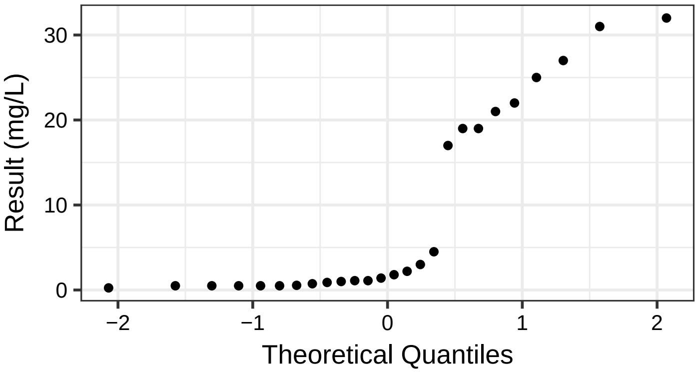
Total Organic Carbon in MW−5



Total Organic Carbon in MW−6



Total Organic Carbon in MW−6

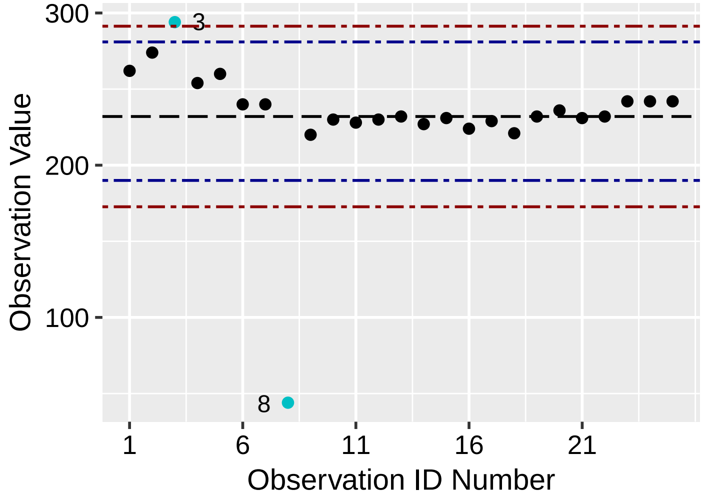


Attachment 4

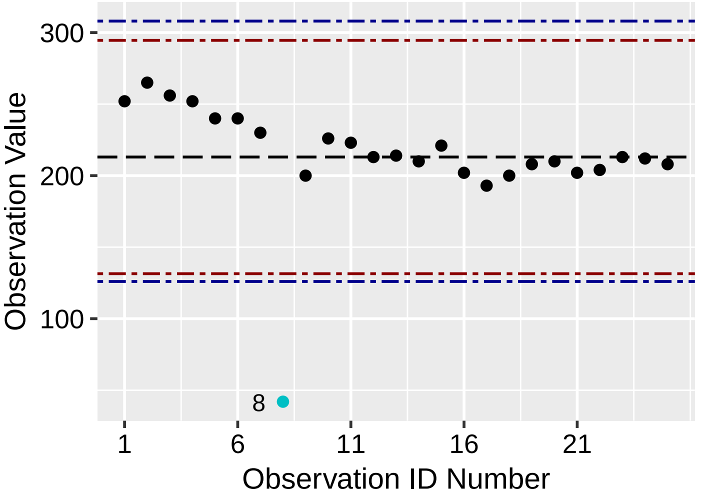
Outlier Plots (2008-2017)

Interquartile Range (IQR) and Median Absolute Deviation (MAD) Outlier Plots
(lines represent median value [black], MAD limits [red], and IQR limits [blue])
Page 1 of 9

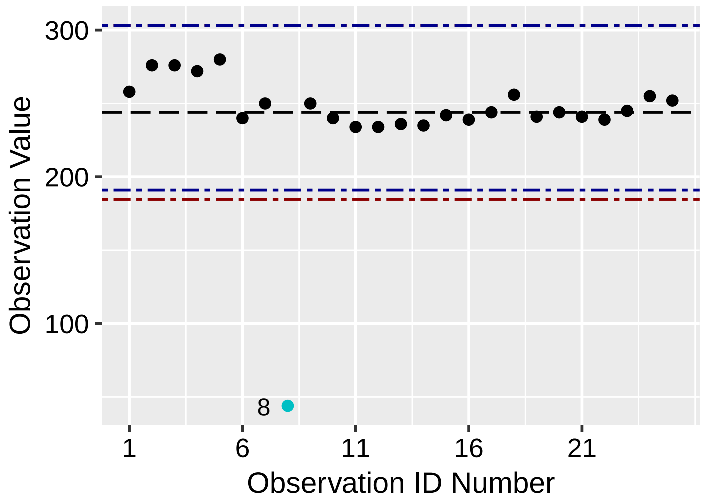
Alkalinity in MW−1
Statistical outliers detected = 2



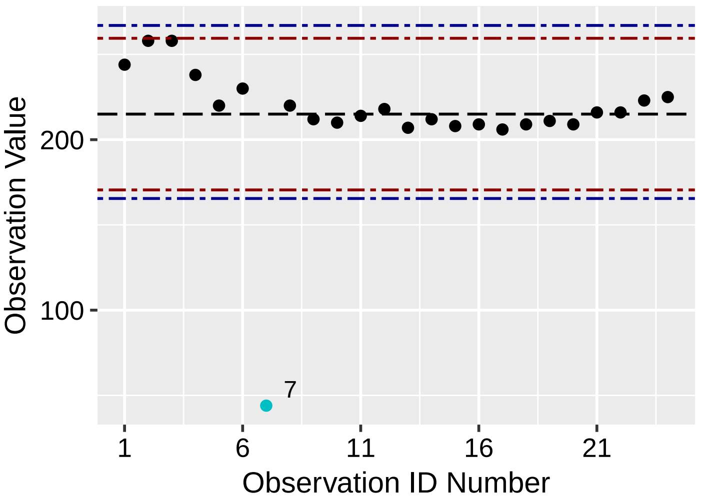
Alkalinity in MW−2
Statistical outliers detected = 1



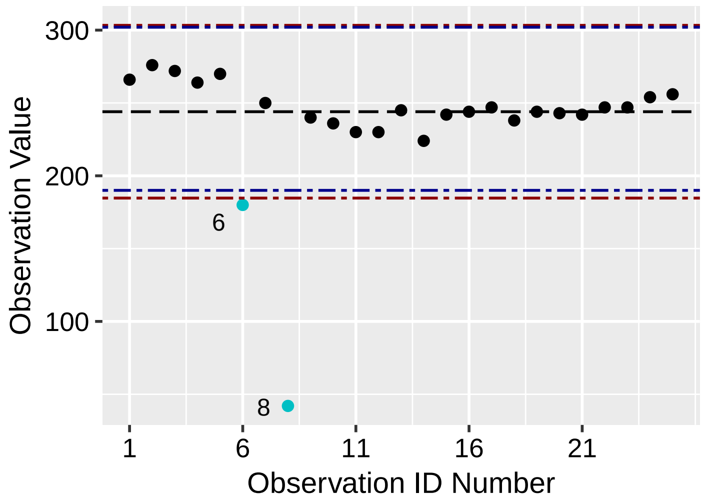
Alkalinity in MW−3
Statistical outliers detected = 1



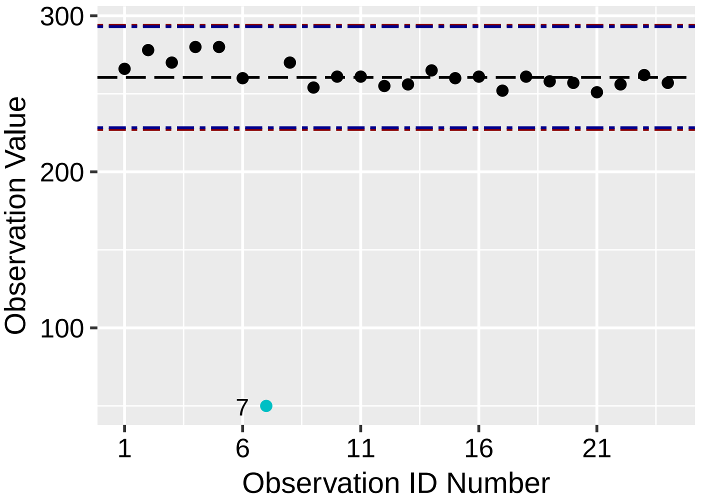
Alkalinity in MW−4
Statistical outliers detected = 1



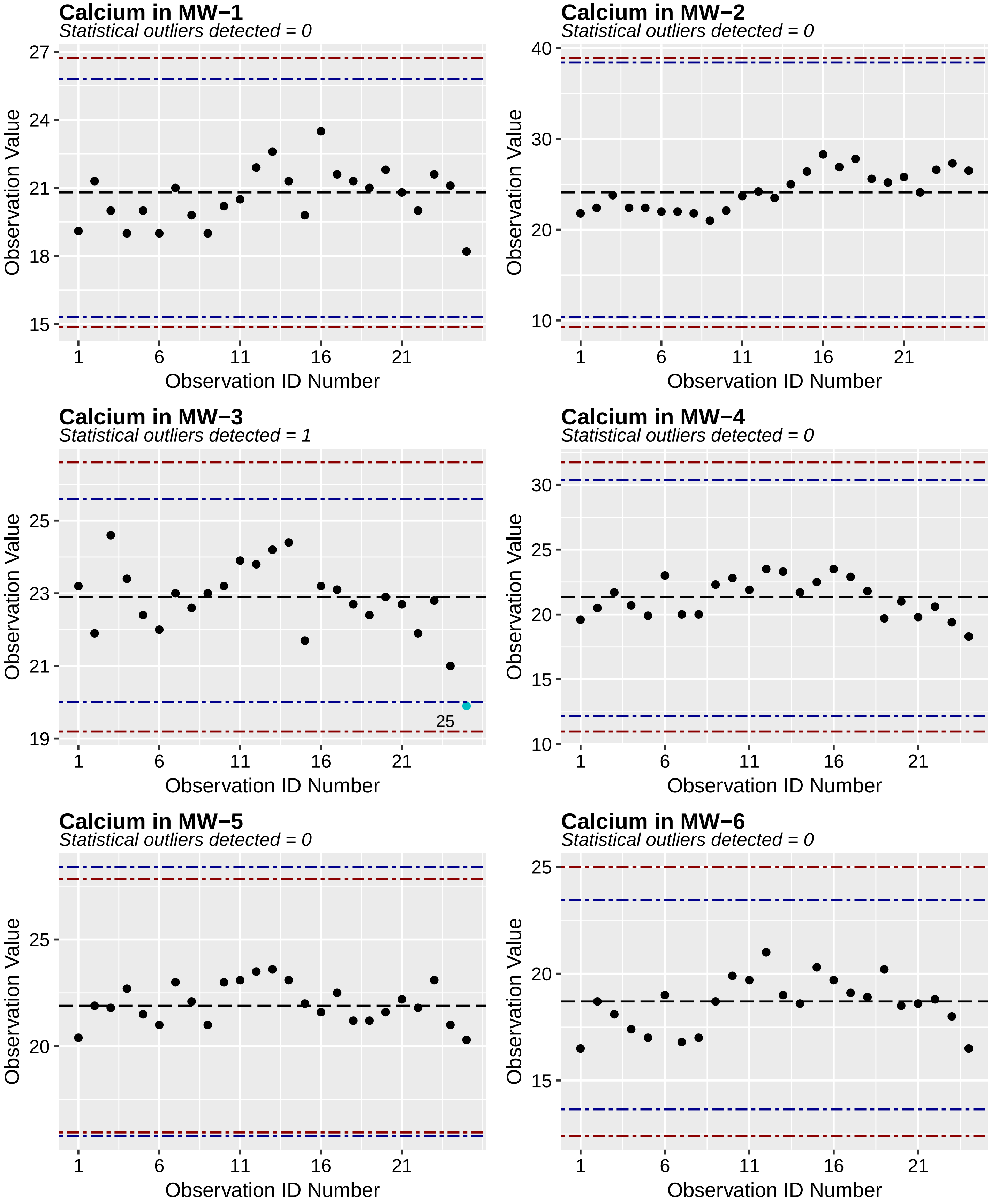
Alkalinity in MW−5
Statistical outliers detected = 2



Alkalinity in MW−6
Statistical outliers detected = 1

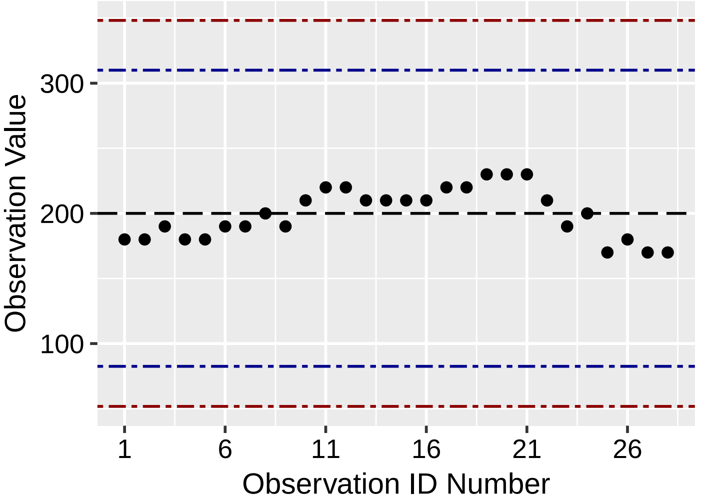


Interquartile Range (IQR) and Median Absolute Deviation (MAD) Outlier Plots
(lines represent median value [black], MAD limits [red], and IQR limits [blue])

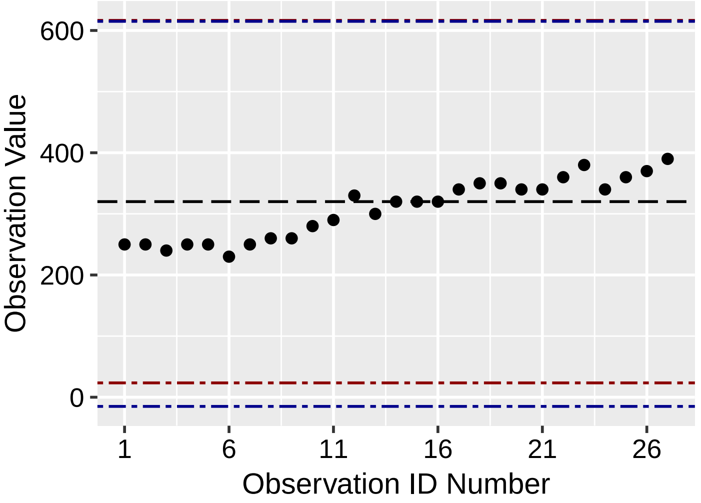


Interquartile Range (IQR) and Median Absolute Deviation (MAD) Outlier Plots
(lines represent median value [black], MAD limits [red], and IQR limits [blue])
Page 3 of 9

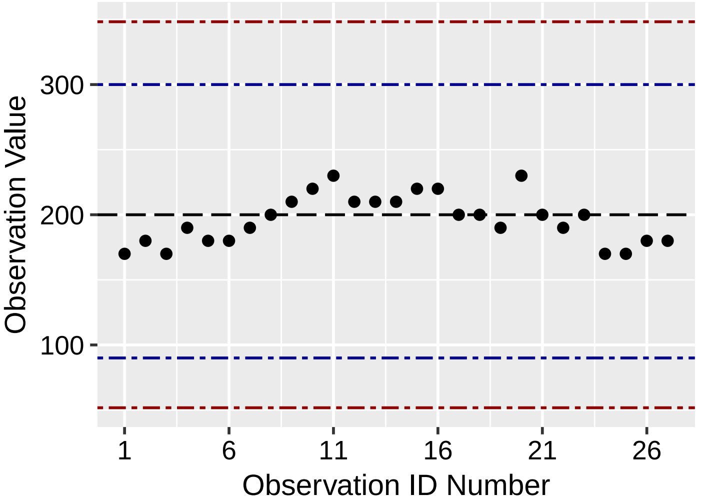
Chloride in MW−1
Statistical outliers detected = 0



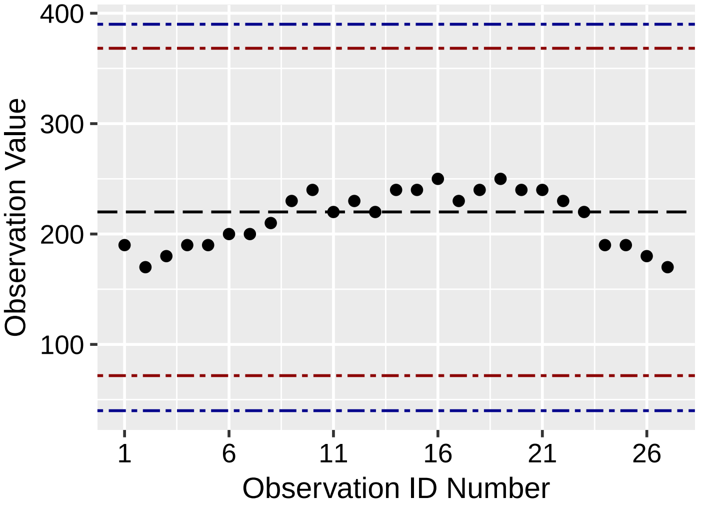
Chloride in MW−2
Statistical outliers detected = 0



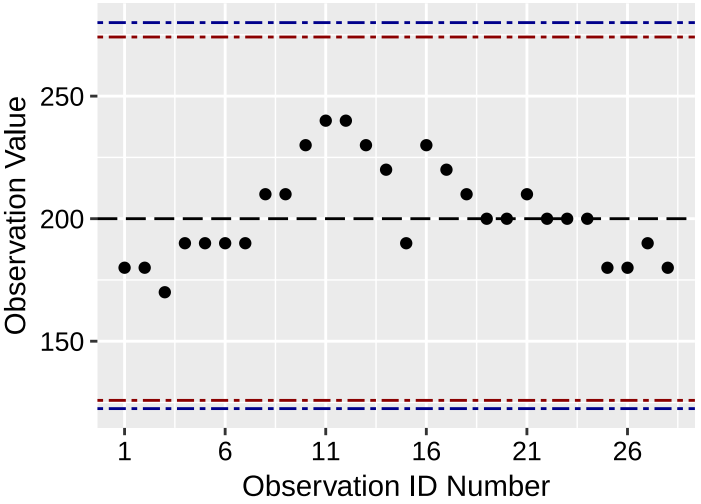
Chloride in MW−3
Statistical outliers detected = 0



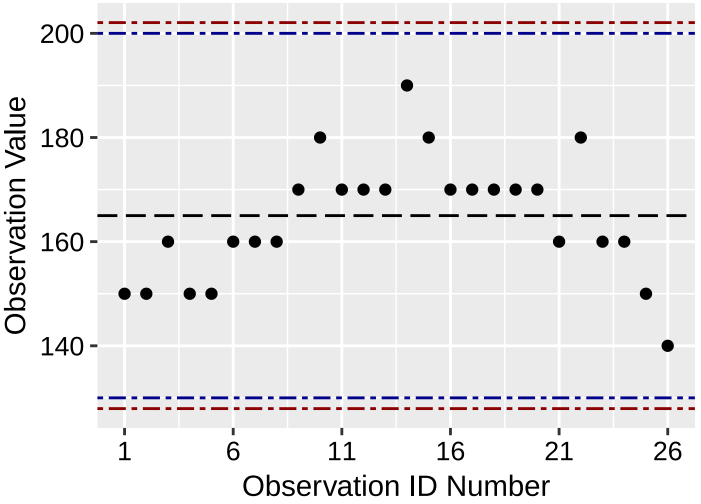
Chloride in MW−4
Statistical outliers detected = 0



Chloride in MW−5
Statistical outliers detected = 0

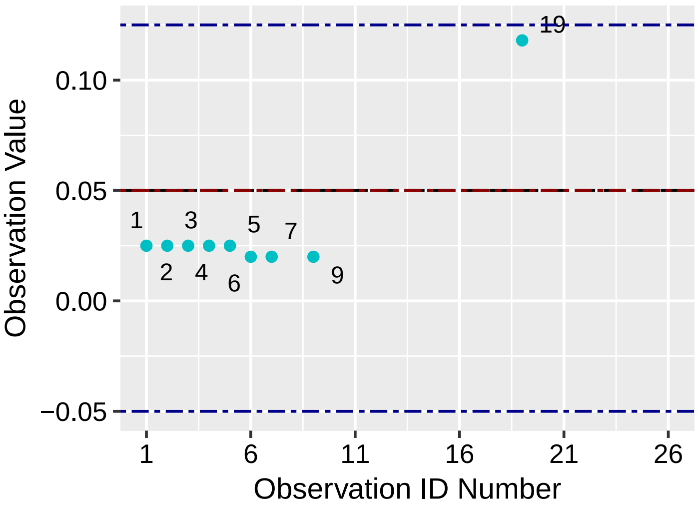


Chloride in MW−6
Statistical outliers detected = 0

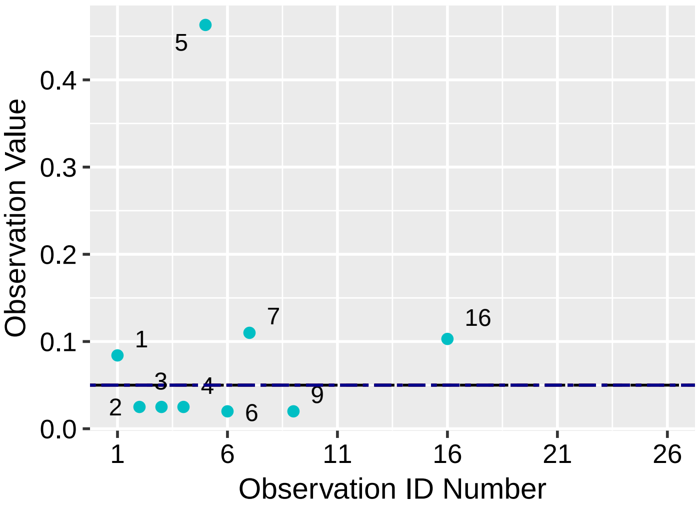


Interquartile Range (IQR) and Median Absolute Deviation (MAD) Outlier Plots
(lines represent median value [black], MAD limits [red], and IQR limits [blue])

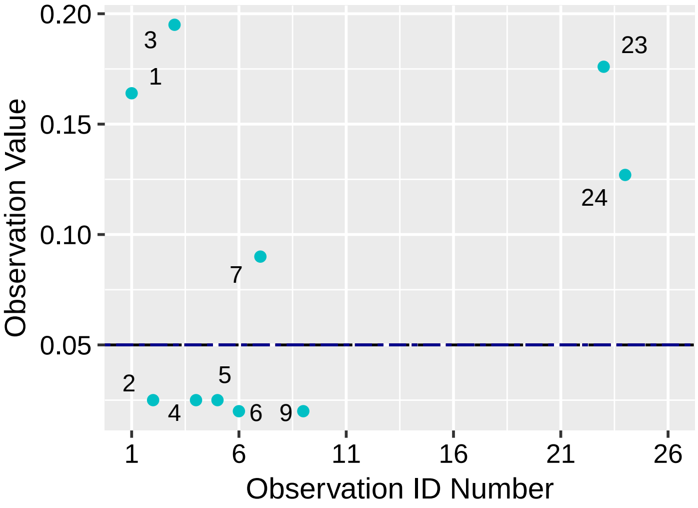
Iron in MW−1
Statistical outliers detected = 9



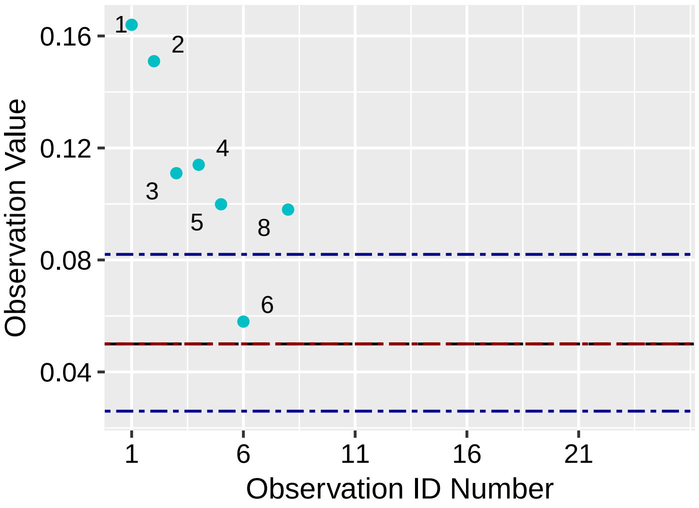
Iron in MW−2
Statistical outliers detected = 9



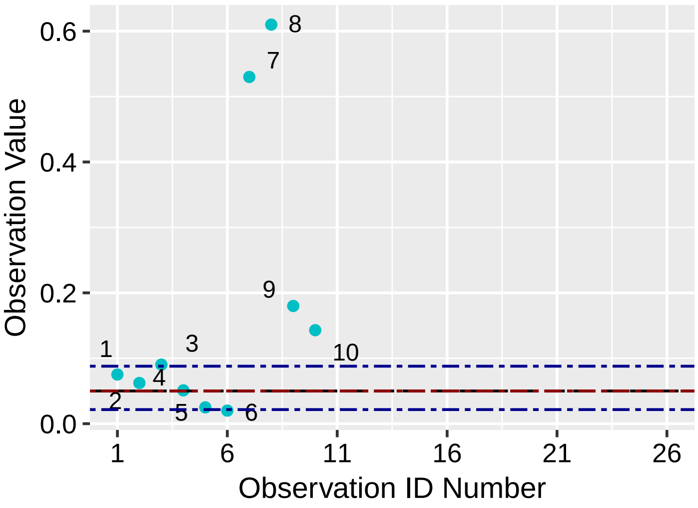
Iron in MW−3
Statistical outliers detected = 10



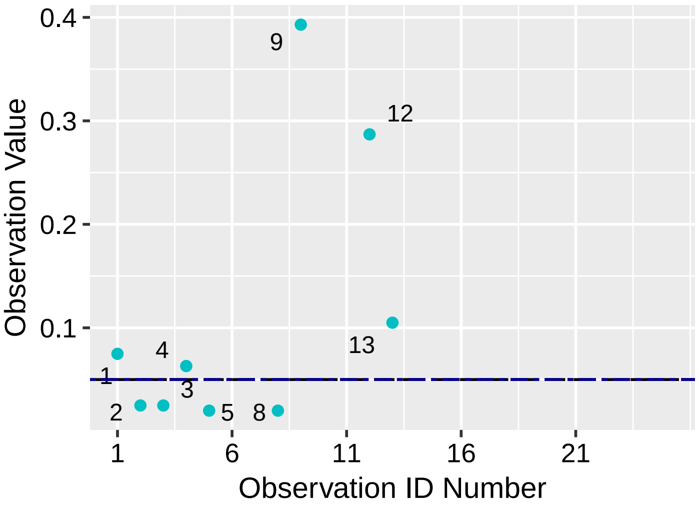
Iron in MW−4
Statistical outliers detected = 7



Iron in MW−5
Statistical outliers detected = 10

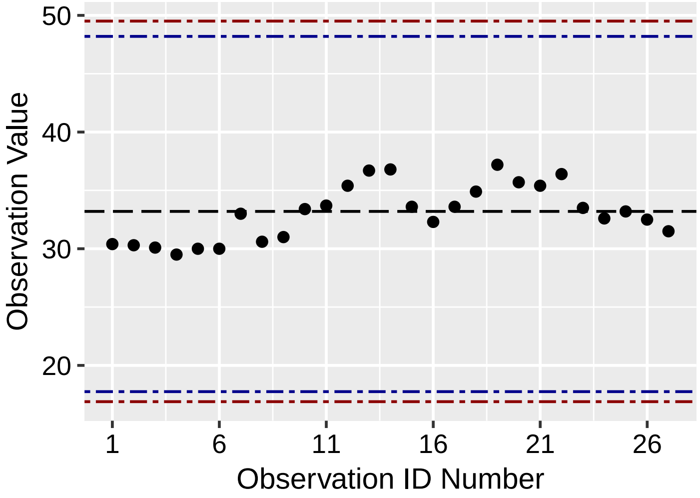


Iron in MW−6
Statistical outliers detected = 9

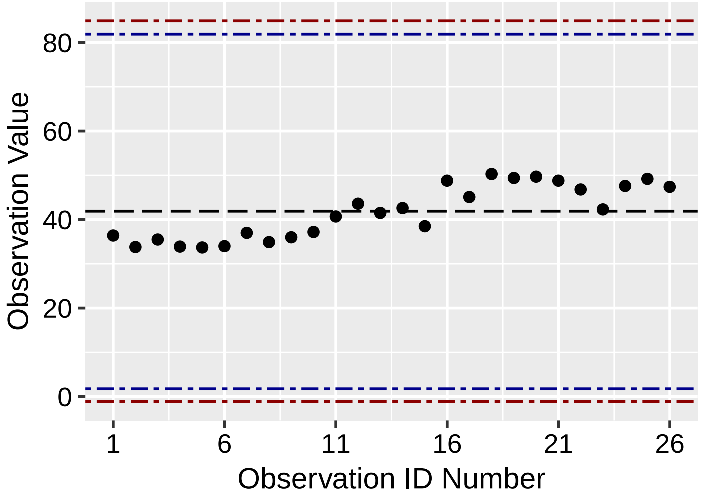


Interquartile Range (IQR) and Median Absolute Deviation (MAD) Outlier Plots
(lines represent median value [black], MAD limits [red], and IQR limits [blue])
Page 5 of 9

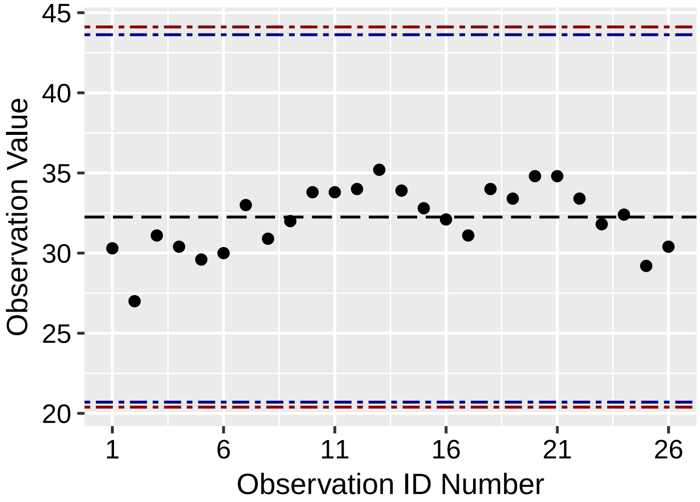
Magnesium in MW−1
Statistical outliers detected = 0



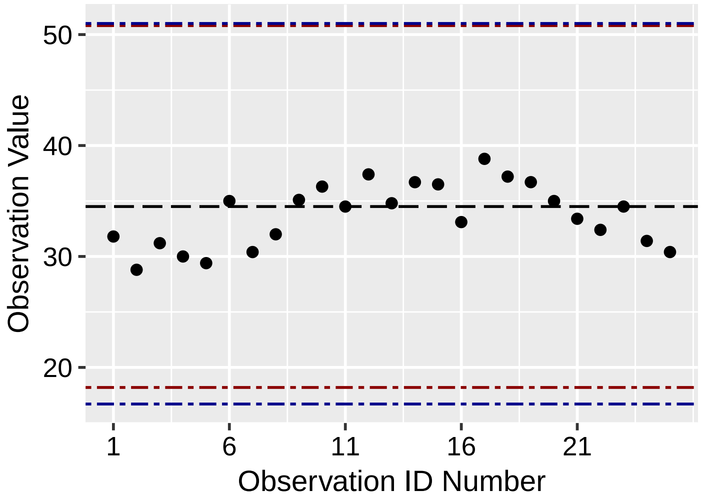
Magnesium in MW−2
Statistical outliers detected = 0



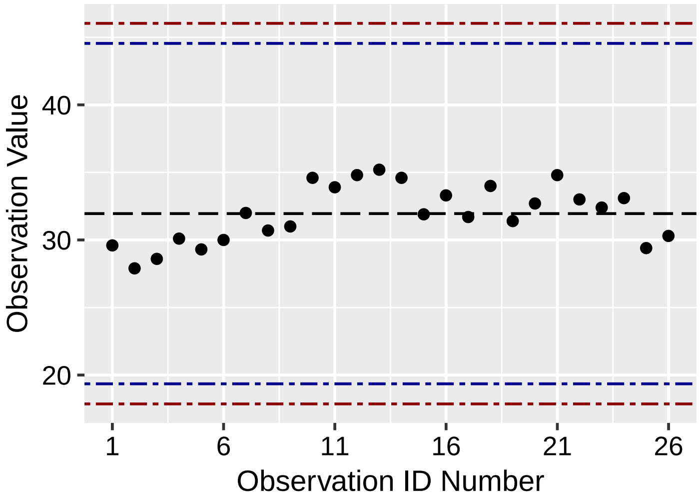
Magnesium in MW−3
Statistical outliers detected = 0



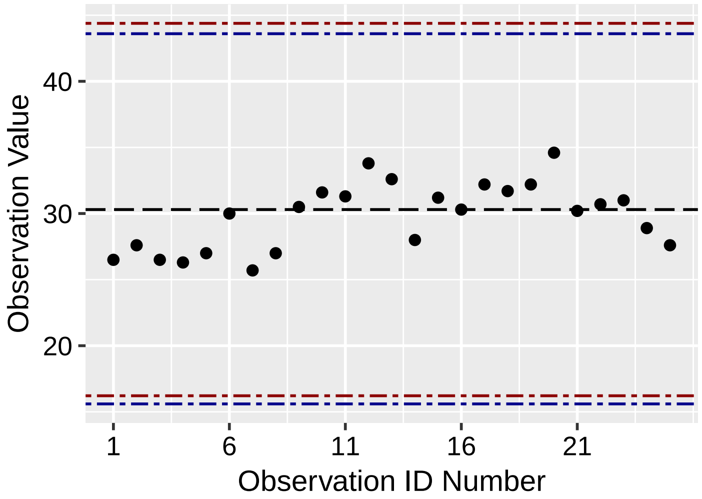
Magnesium in MW−4
Statistical outliers detected = 0



Magnesium in MW−5
Statistical outliers detected = 0

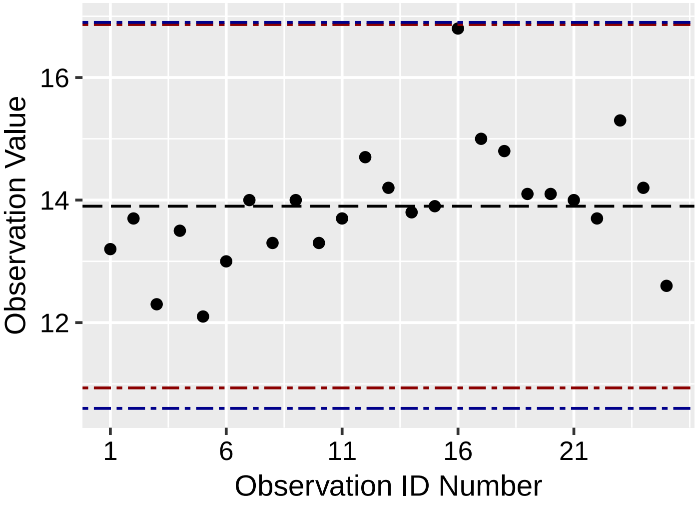


Magnesium in MW−6
Statistical outliers detected = 0

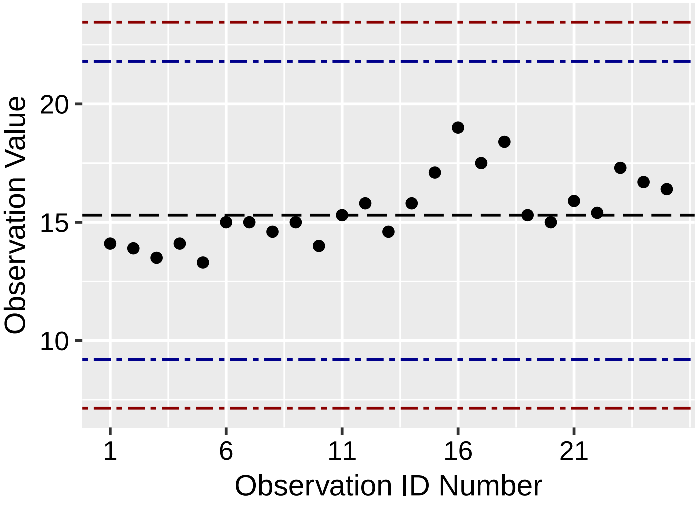


Interquartile Range (IQR) and Median Absolute Deviation (MAD) Outlier Plots
(lines represent median value [black], MAD limits [red], and IQR limits [blue])

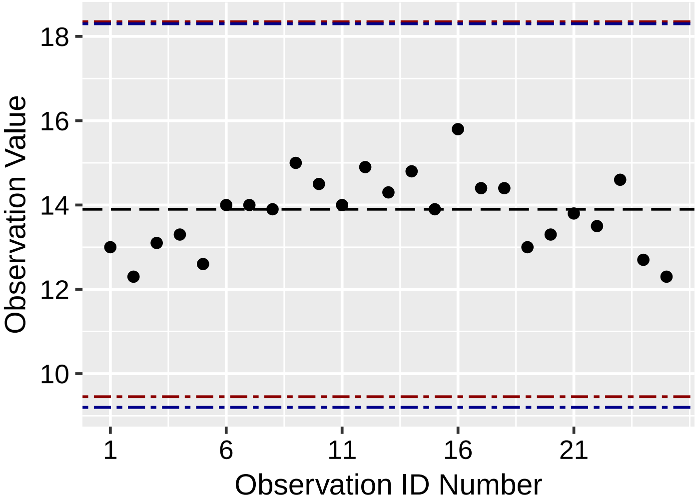
Potassium in MW−1
Statistical outliers detected = 0



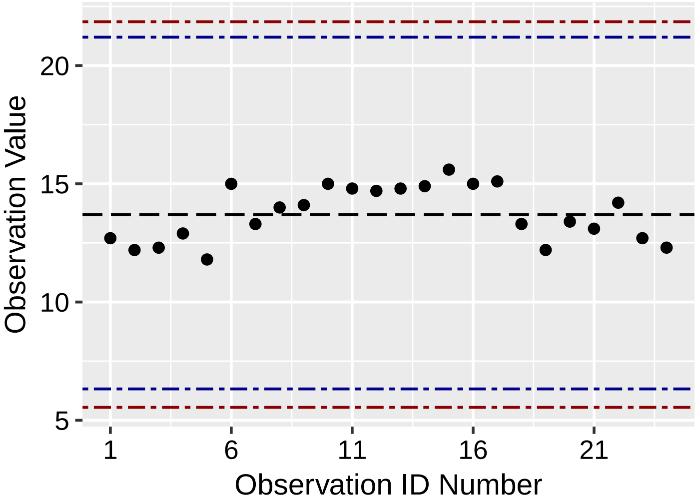
Potassium in MW−2
Statistical outliers detected = 0



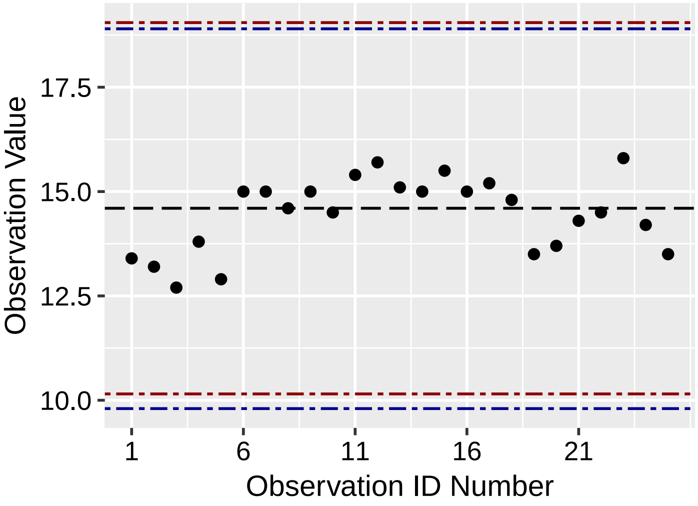
Potassium in MW−3
Statistical outliers detected = 0



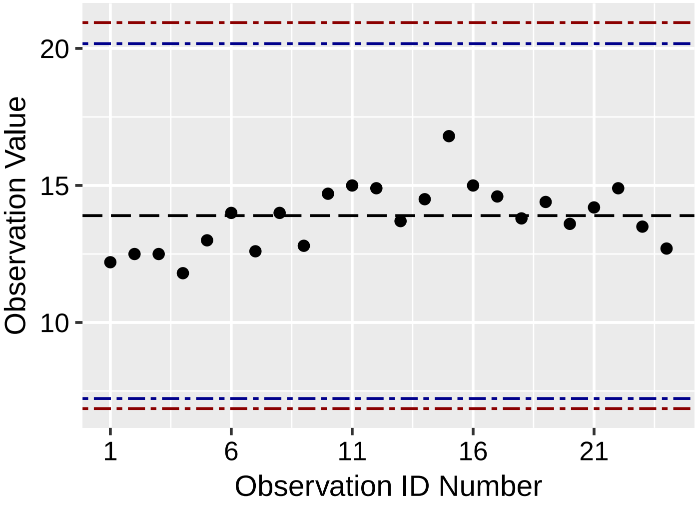
Potassium in MW−4
Statistical outliers detected = 0



Potassium in MW−5
Statistical outliers detected = 0



Potassium in MW−6
Statistical outliers detected = 0



Interquartile Range (IQR) and Median Absolute Deviation (MAD) Outlier Plots
(lines represent median value [black], MAD limits [red], and IQR limits [blue])
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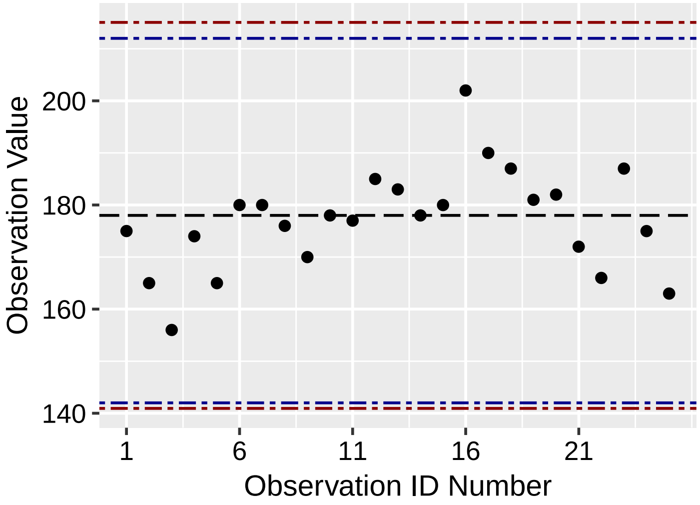
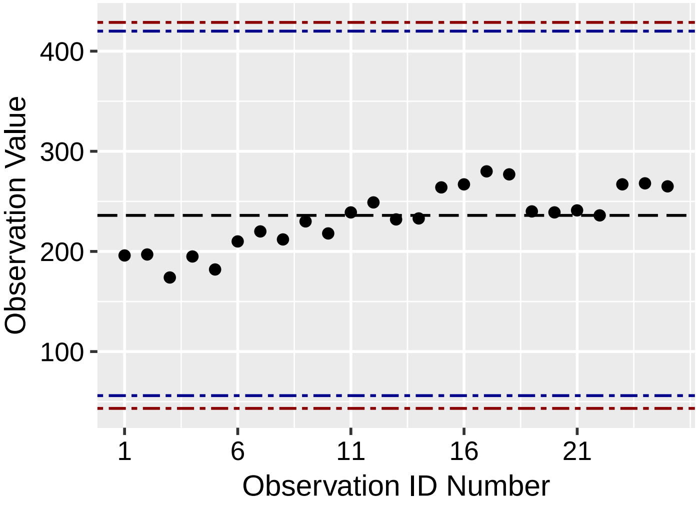
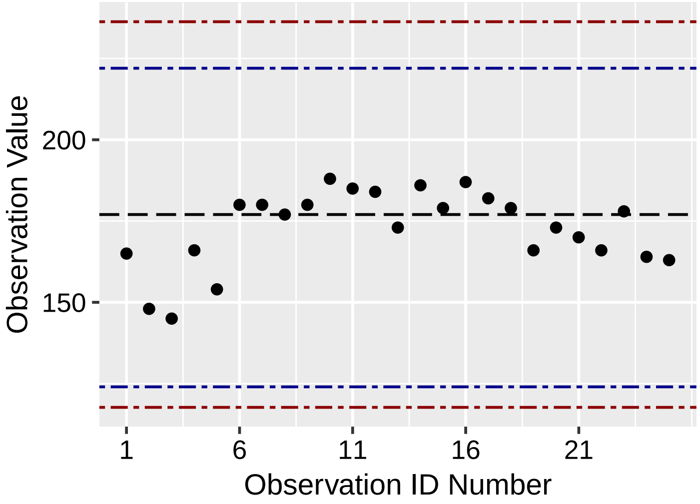
Sodium in MW−1
Statistical outliers detected = 0



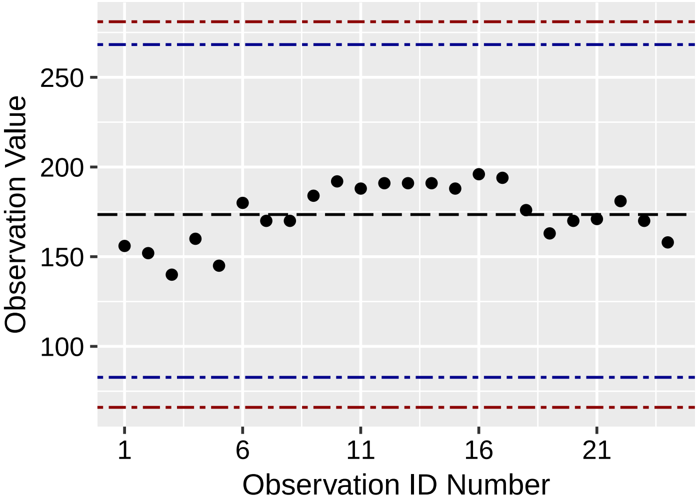
Sodium in MW−2
Statistical outliers detected = 0



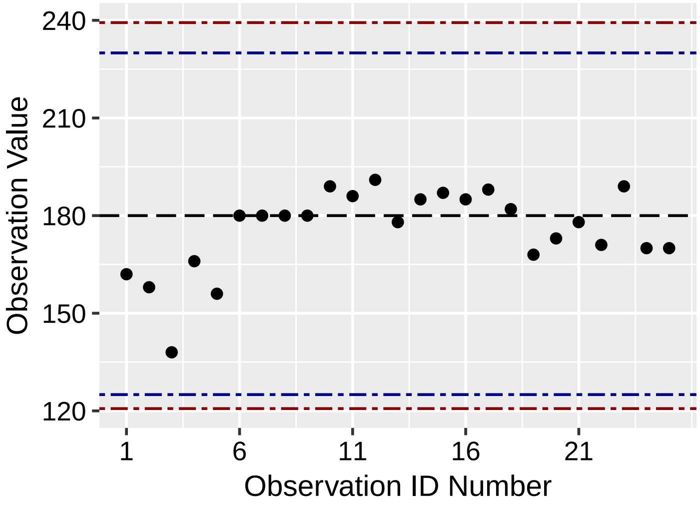
Sodium in MW−3
Statistical outliers detected = 0



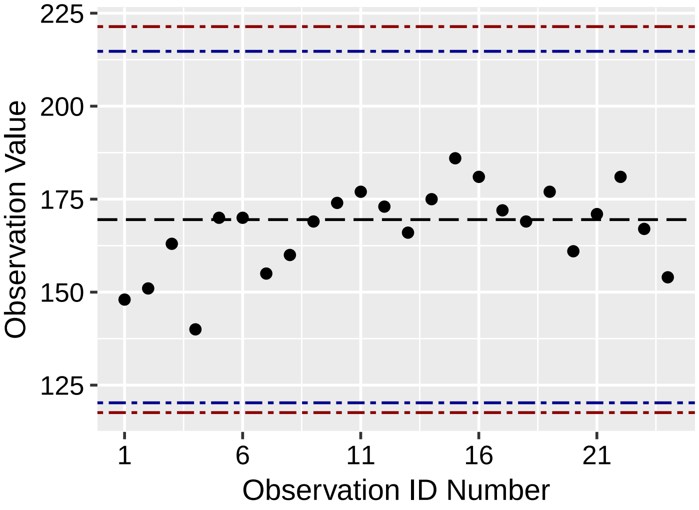
Sodium in MW−4
Statistical outliers detected = 0



Sodium in MW−5
Statistical outliers detected = 0

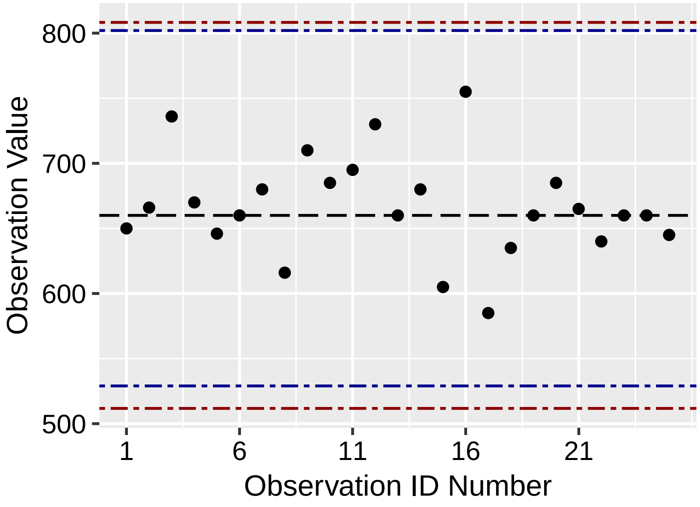


Sodium in MW−6
Statistical outliers detected = 0

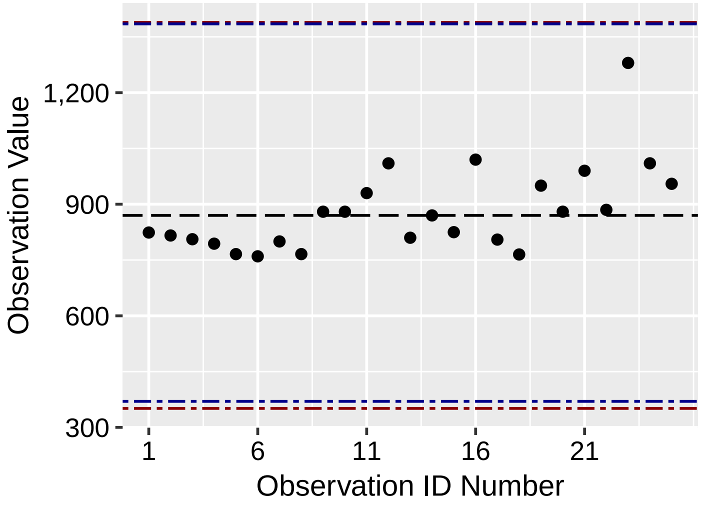


Interquartile Range (IQR) and Median Absolute Deviation (MAD) Outlier Plots
(lines represent median value [black], MAD limits [red], and IQR limits [blue])

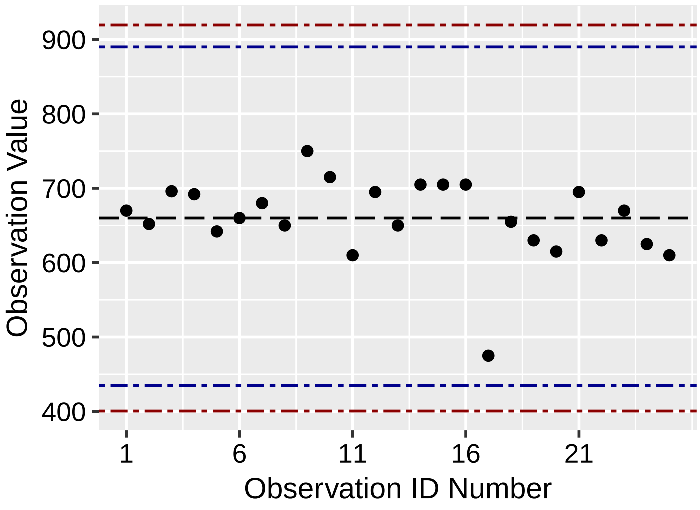
Total Dissolved Solids in MW−1
Statistical outliers detected = 0



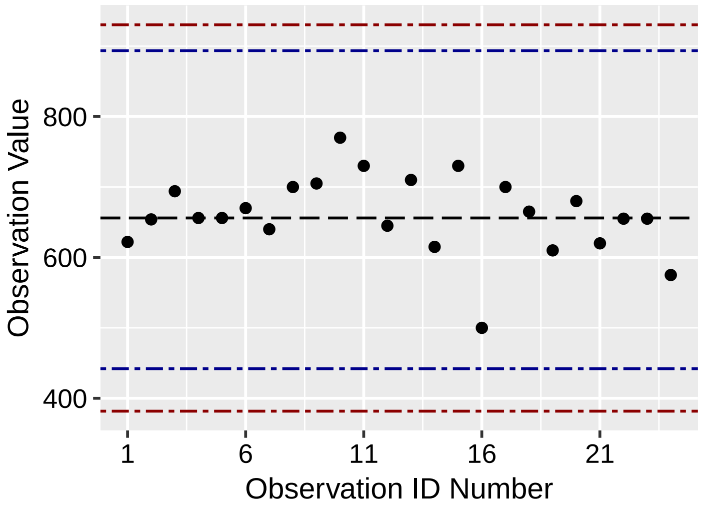
Total Dissolved Solids in MW−2
Statistical outliers detected = 0



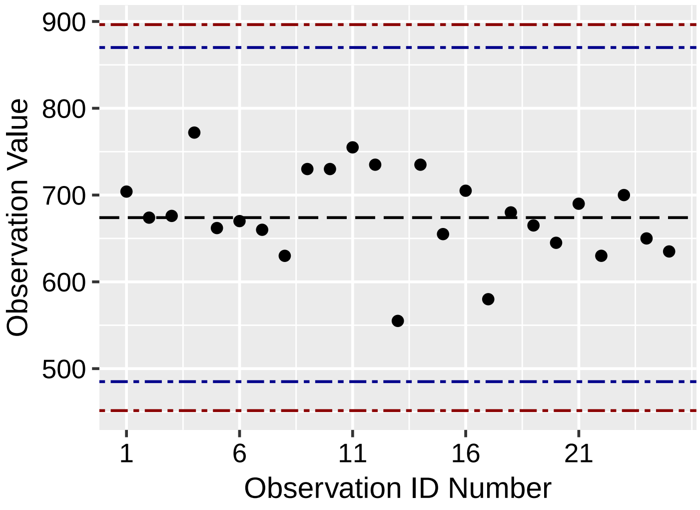
Total Dissolved Solids in MW−3
Statistical outliers detected = 0



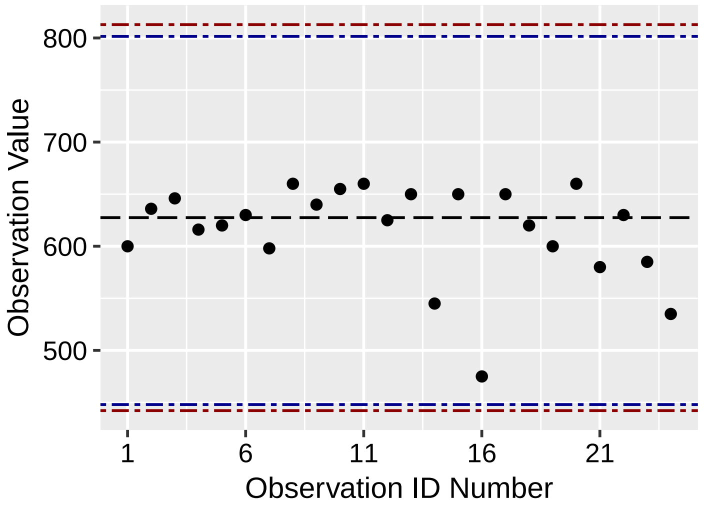
Total Dissolved Solids in MW−4
Statistical outliers detected = 0



Total Dissolved Solids in MW−5
Statistical outliers detected = 0



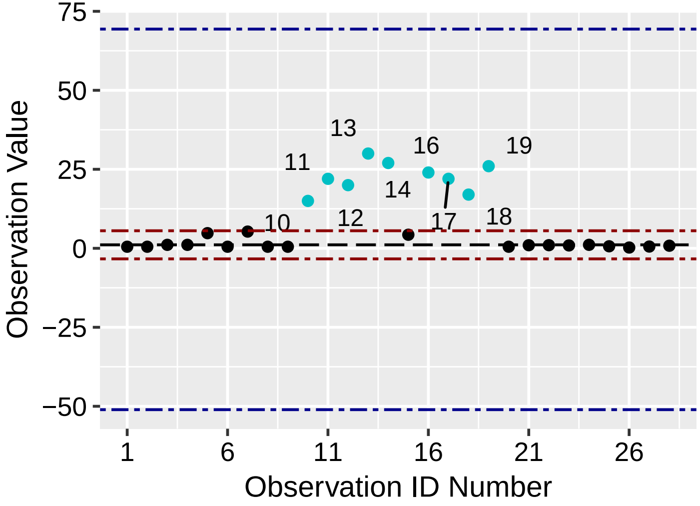
Total Dissolved Solids in MW−6
Statistical outliers detected = 0



Interquartile Range (IQR) and Median Absolute Deviation (MAD) Outlier Plots
(lines represent median value [black], MAD limits [red], and IQR limits [blue])

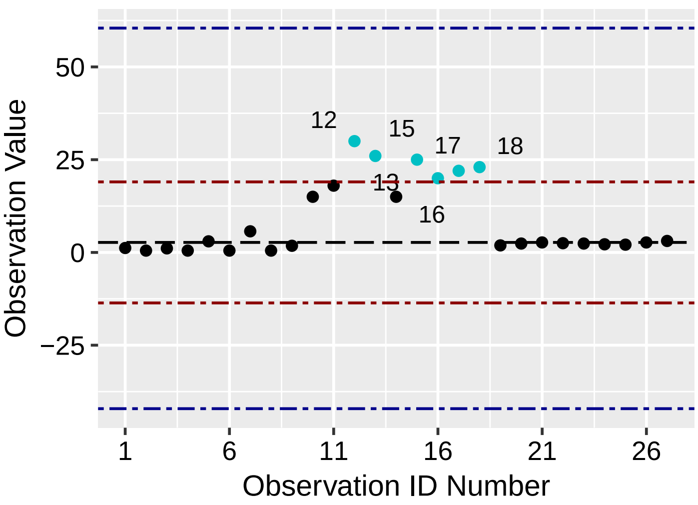
Total Organic Carbon in MW−1

Statistical outliers detected = 9



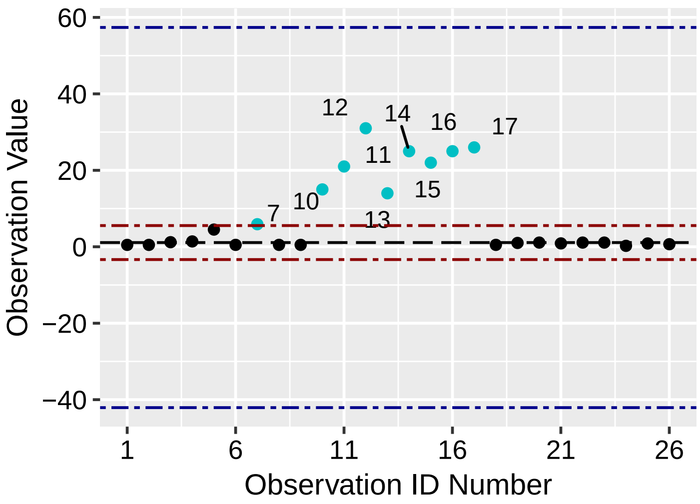
Total Organic Carbon in MW−2

Statistical outliers detected = 6



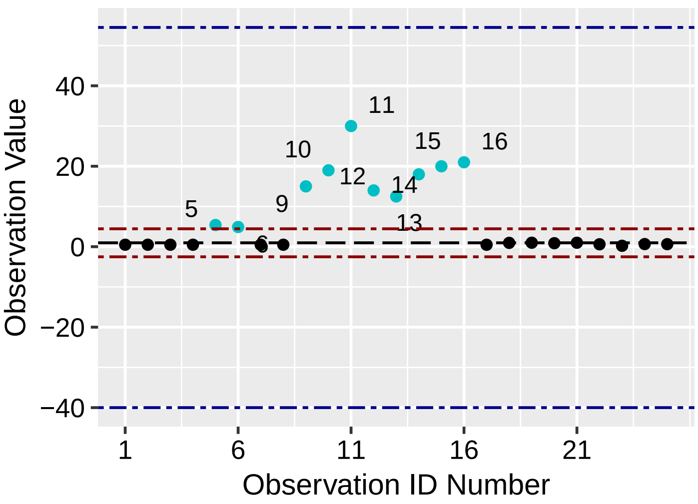
Total Organic Carbon in MW−3

Statistical outliers detected = 9



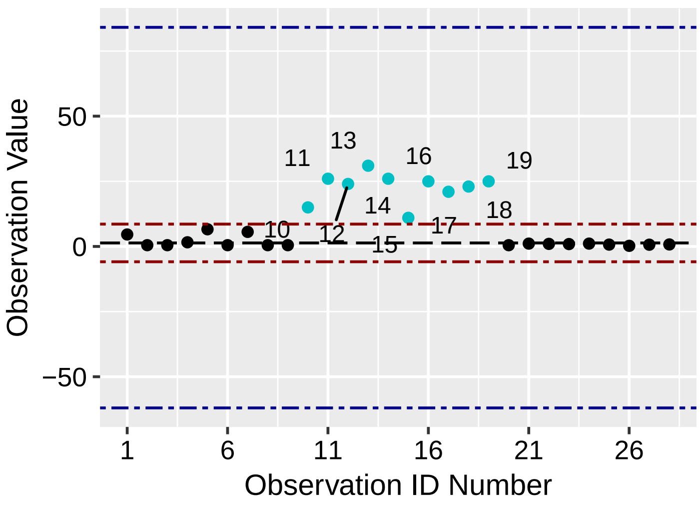
Total Organic Carbon in MW−4

Statistical outliers detected = 10



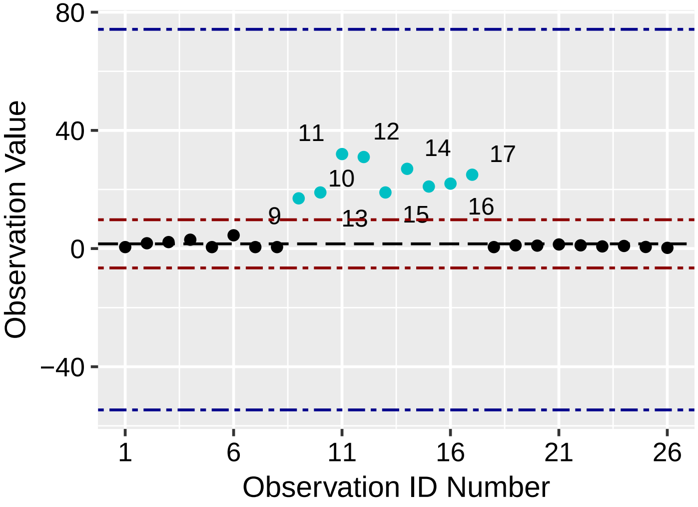
Total Organic Carbon in MW−5

Statistical outliers detected = 10



Total Organic Carbon in MW−6

Statistical outliers detected = 9



Attachment 5
Autocorrelation Plots (2008-2017)

Autocorrelation Plots

(95% confidence limits plotted as horizontal lines)

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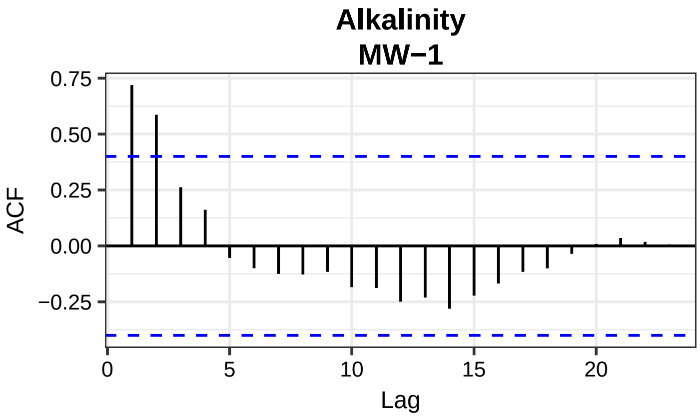

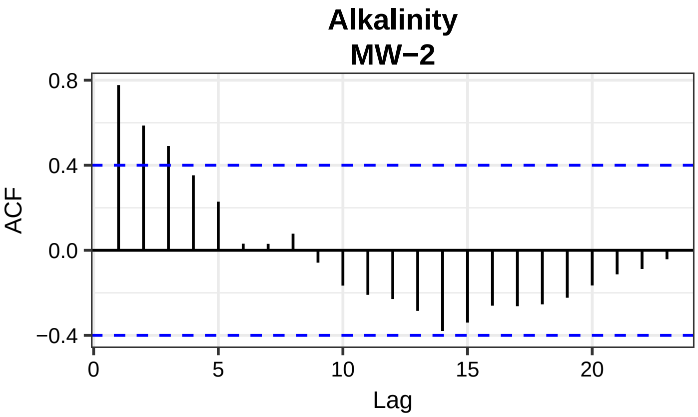

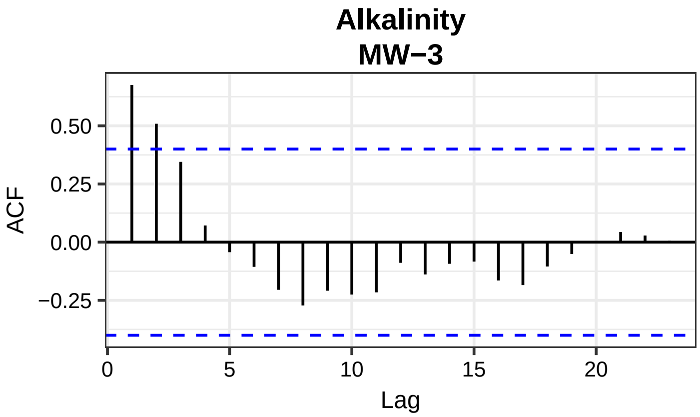

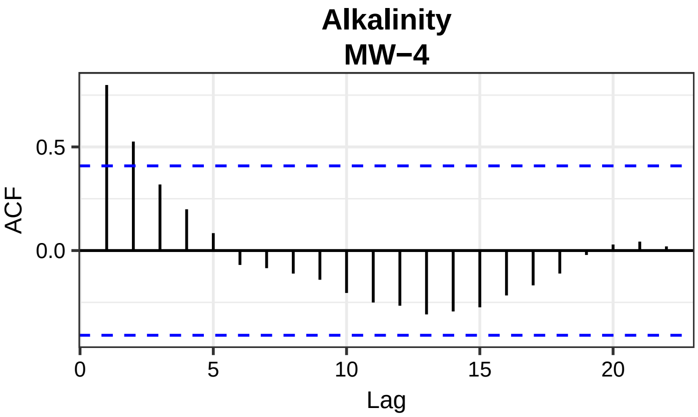

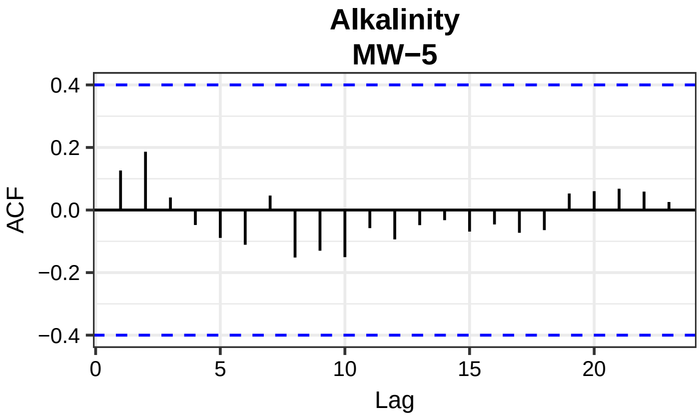

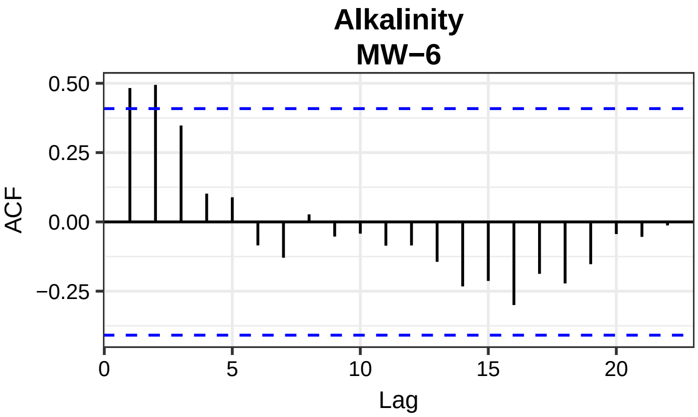

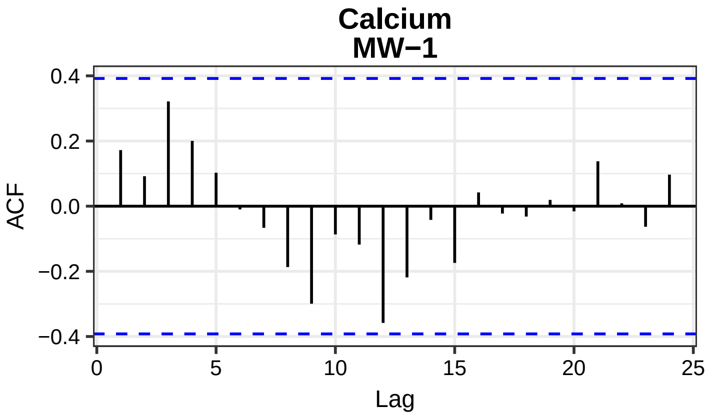

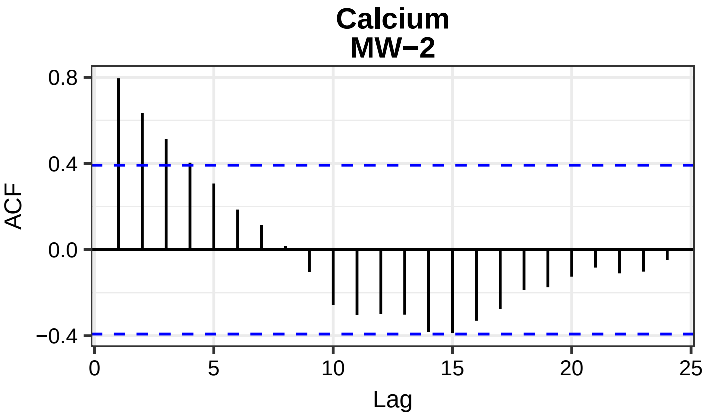

Autocorrelation Plots
(95% confidence limits plotted as horizontal lines)
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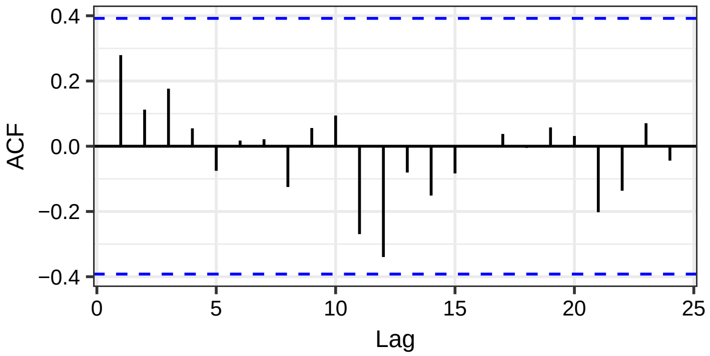
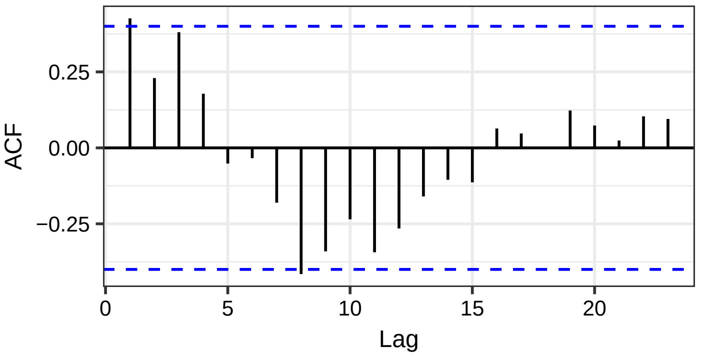
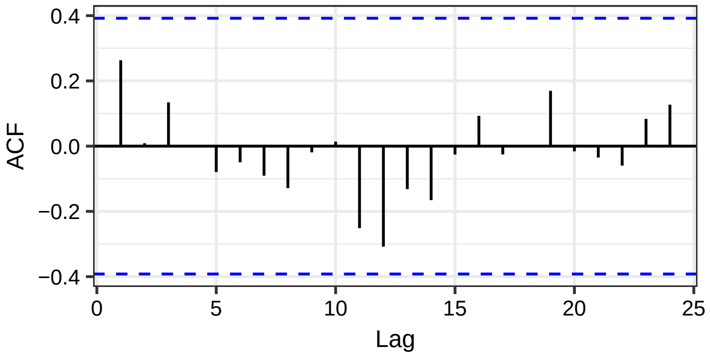
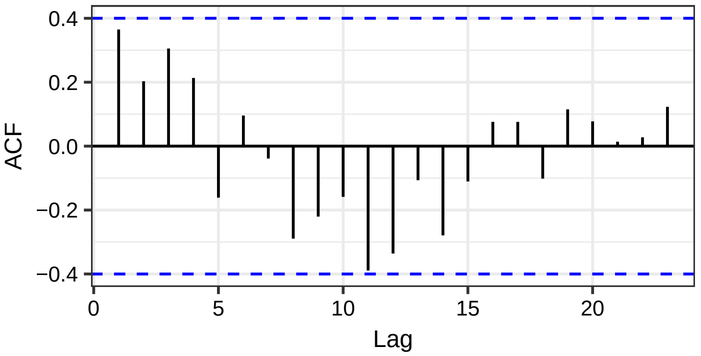
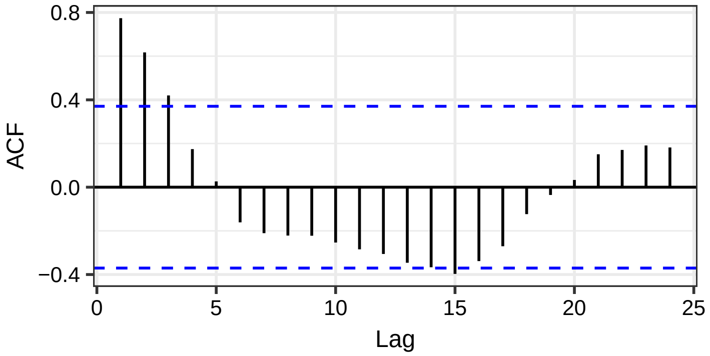
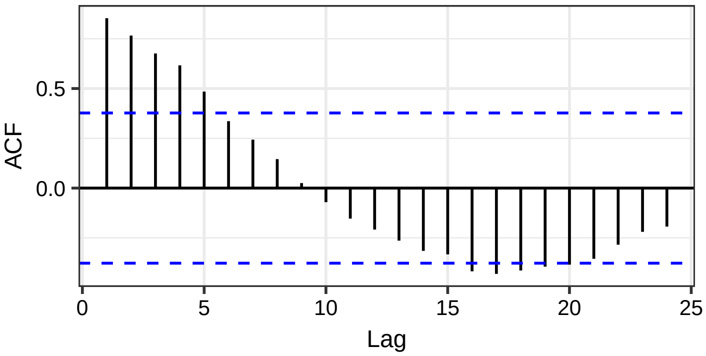

Calcium
MW−3

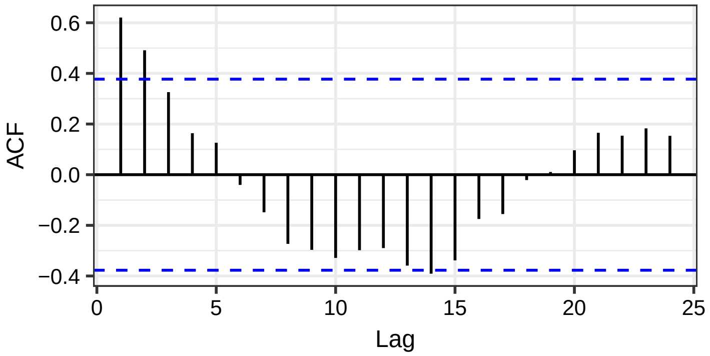

Calcium
MW−4

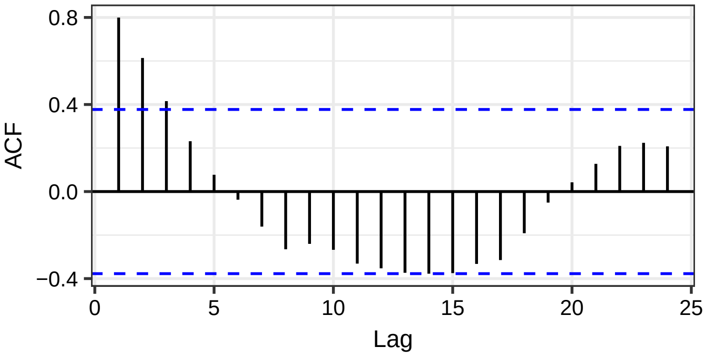

Calcium
MW−5


Calcium
MW−6


Chloride
MW−1

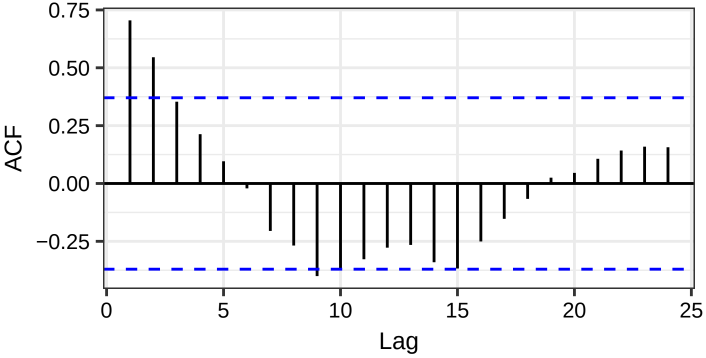

Chloride
MW−2


Chloride
MW−3

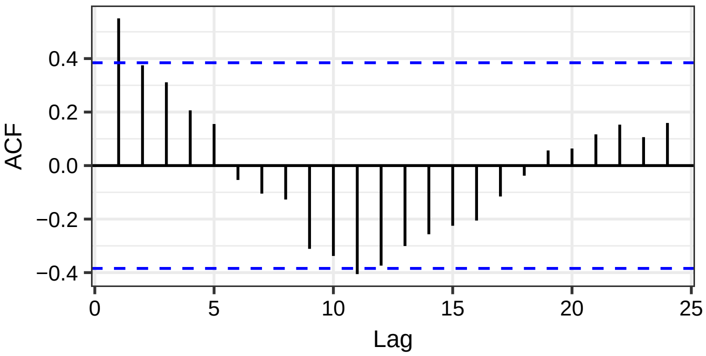

Chloride
MW−4

Autocorrelation Plots
(95% confidence limits plotted as horizontal lines)
Page 3 of 7

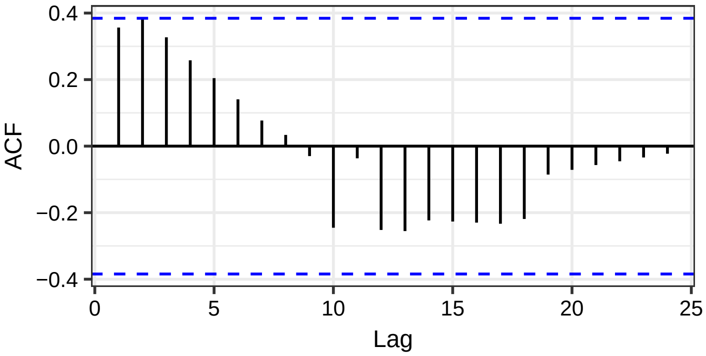
Chloride
MW−5



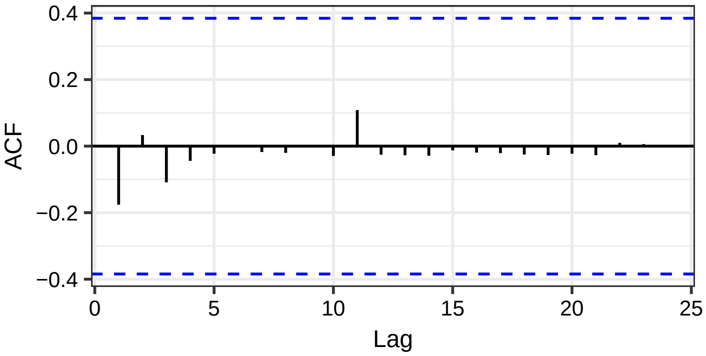
Chloride
MW−6



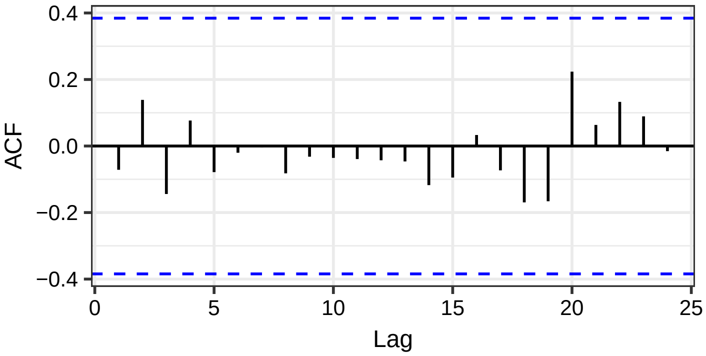
Iron
MW−1



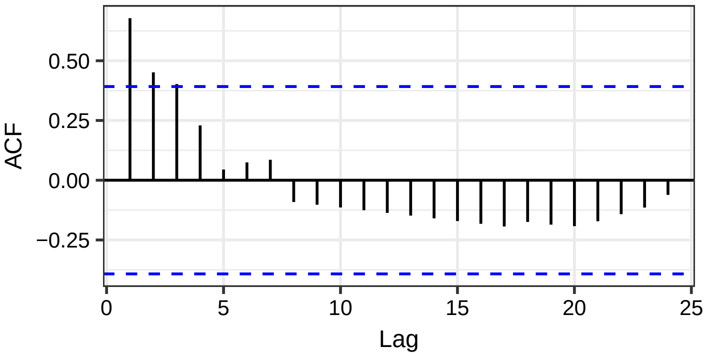
Iron
MW−2



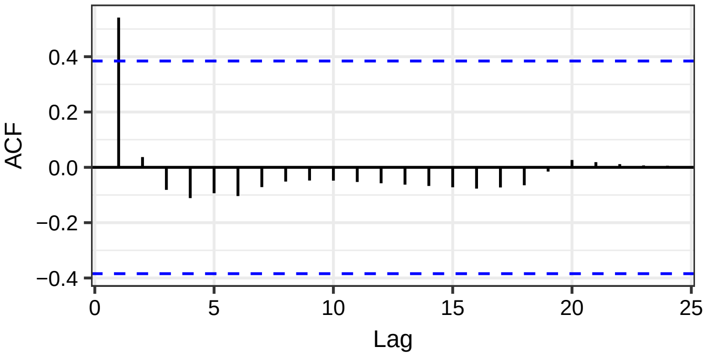
Iron
MW−3



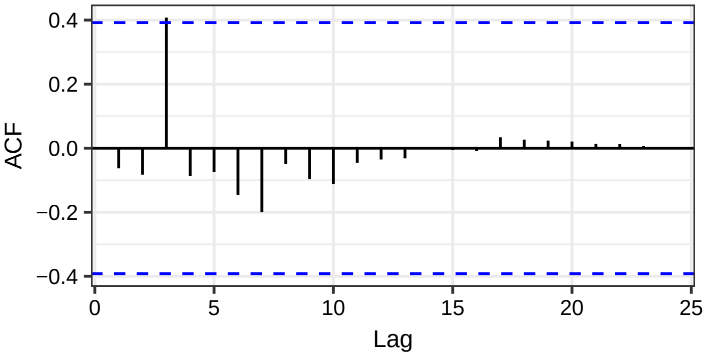
Iron
MW−4



Iron
MW−5

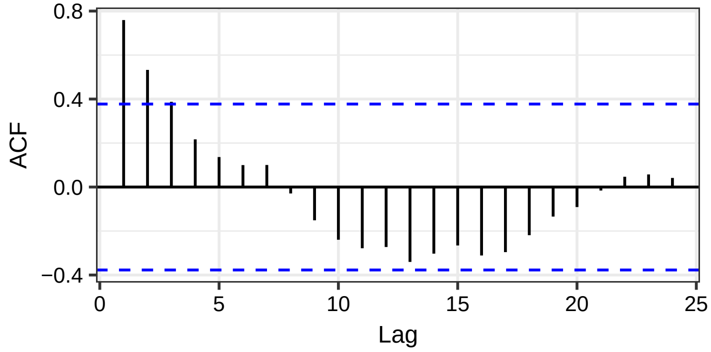


Iron
MW−6

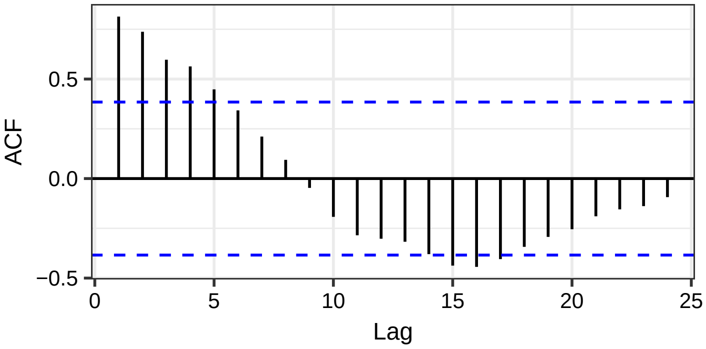


Autocorrelation Plots
(95% confidence limits plotted as horizontal lines)
Page 4 of 7

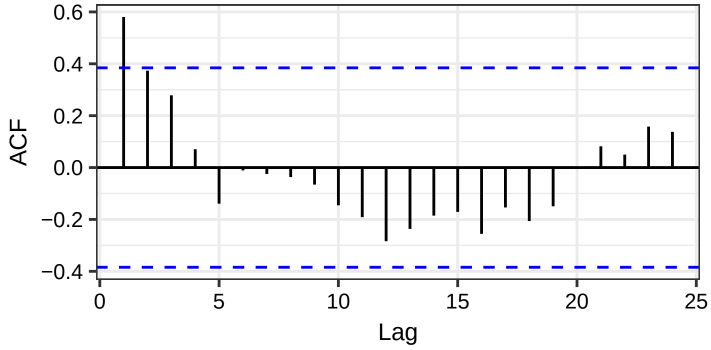
Magnesium
MW−1



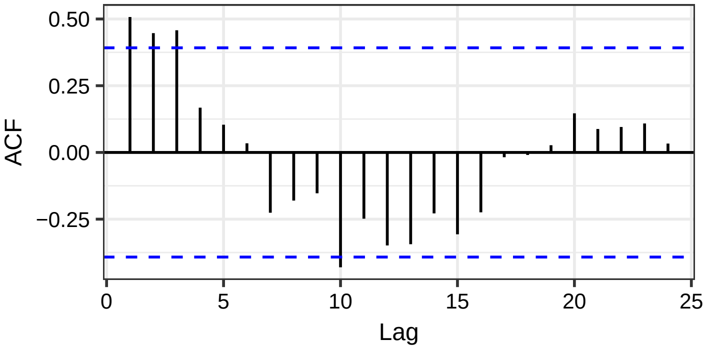
Magnesium
MW−2



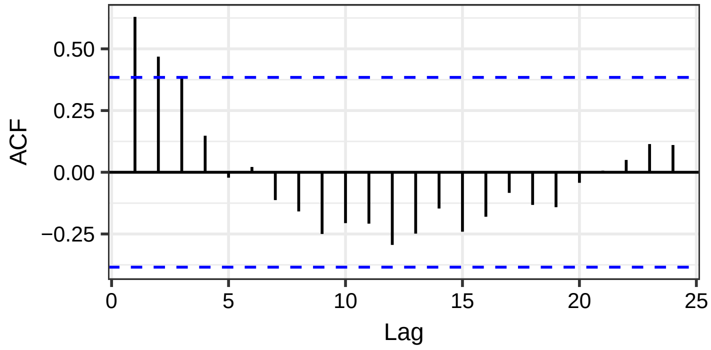
Magnesium
MW−3



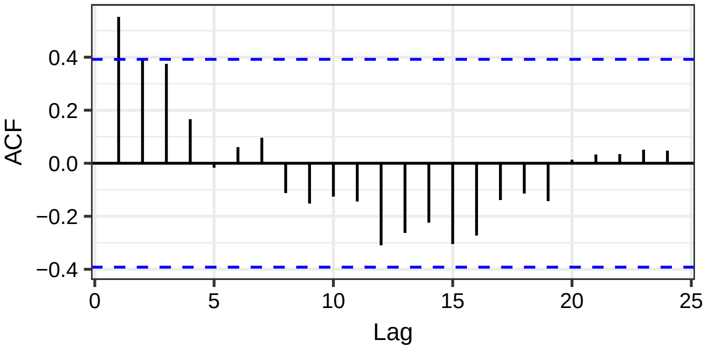
Magnesium
MW−4



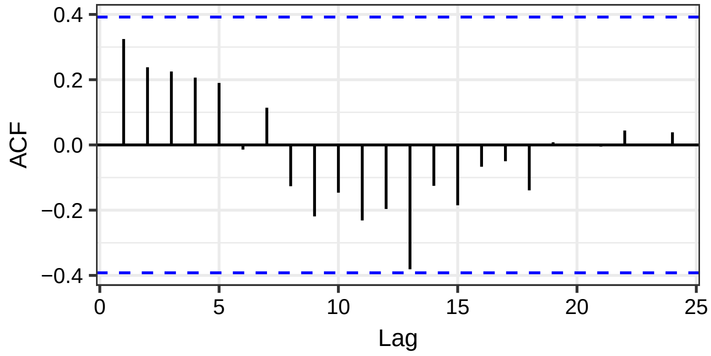
Magnesium
MW−5



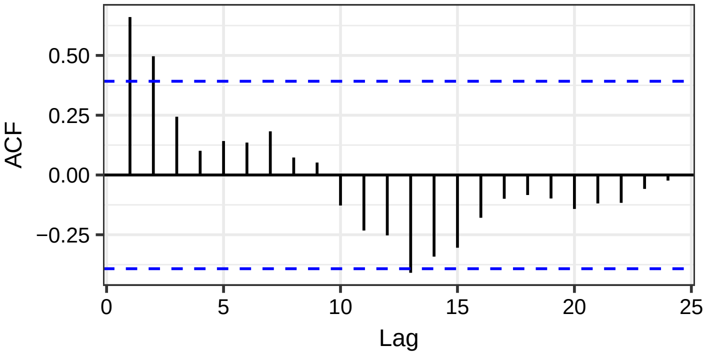
Magnesium
MW−6



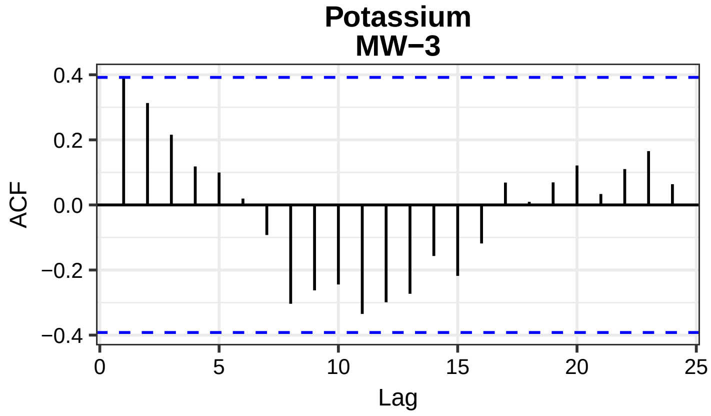
Potassium
MW−1

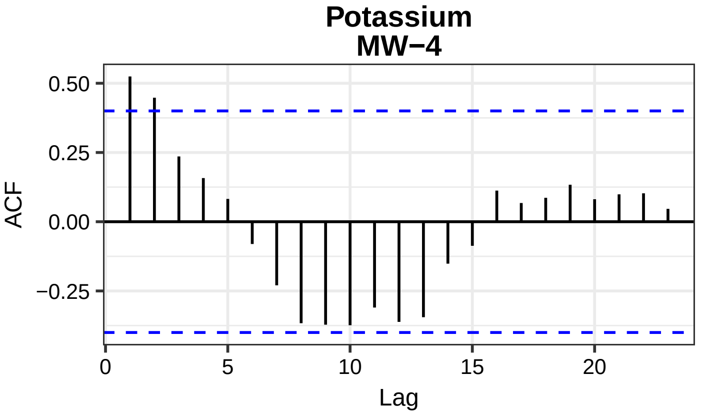


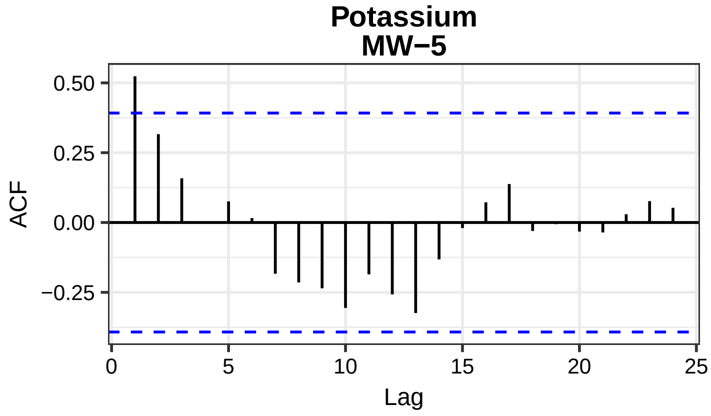
Potassium
MW−2

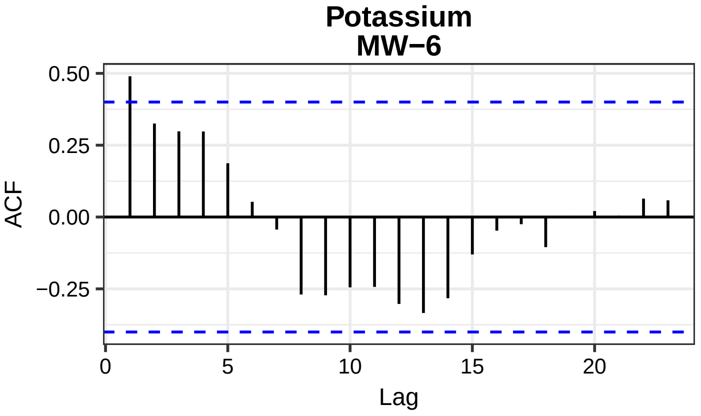


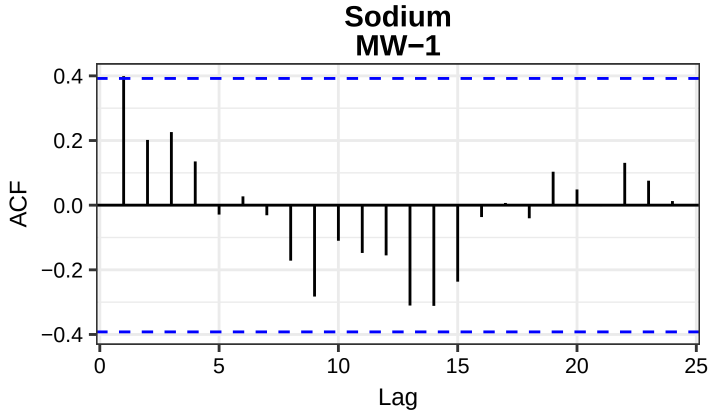
Autocorrelation Plots
(95% confidence limits plotted as horizontal lines)

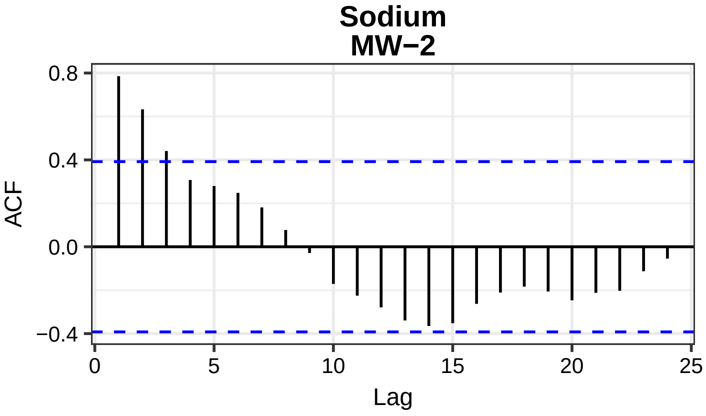


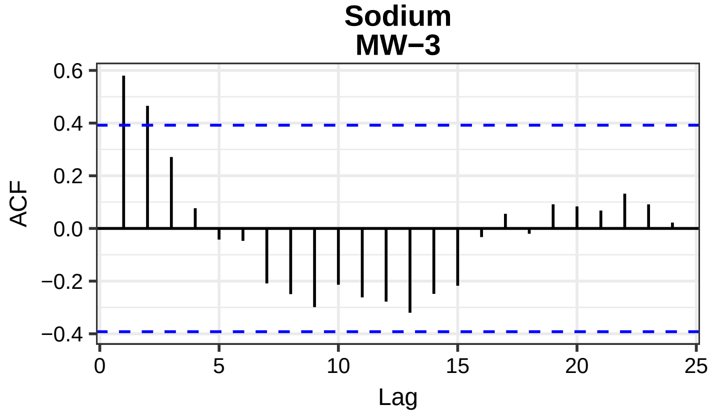


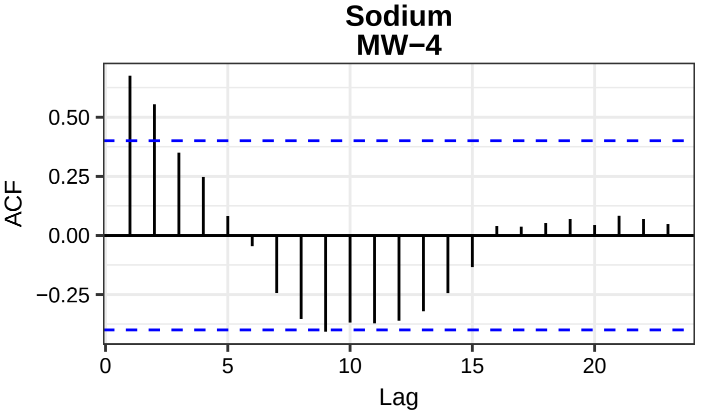












Autocorrelation Plots

(95% confidence limits plotted as horizontal lines)

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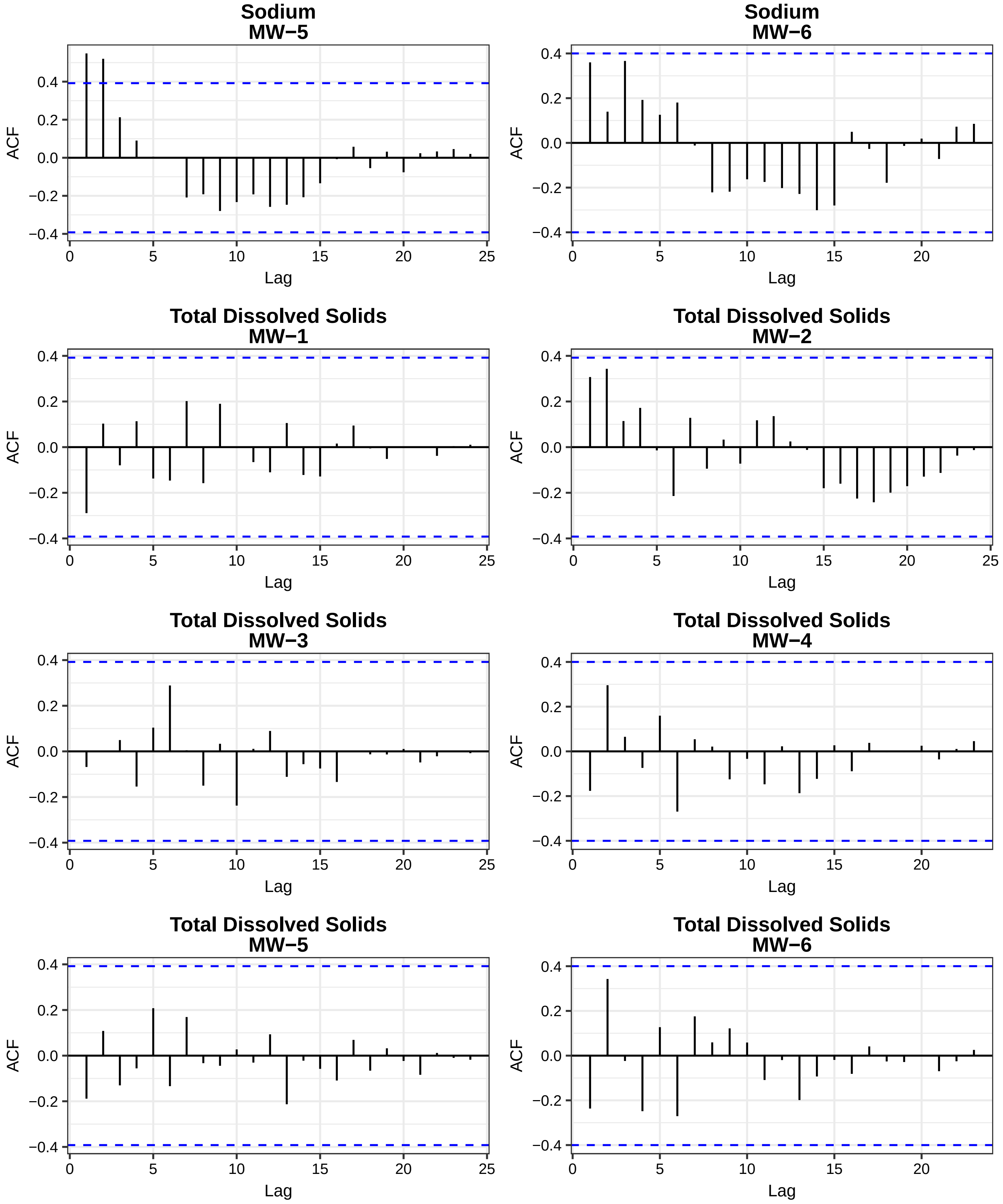
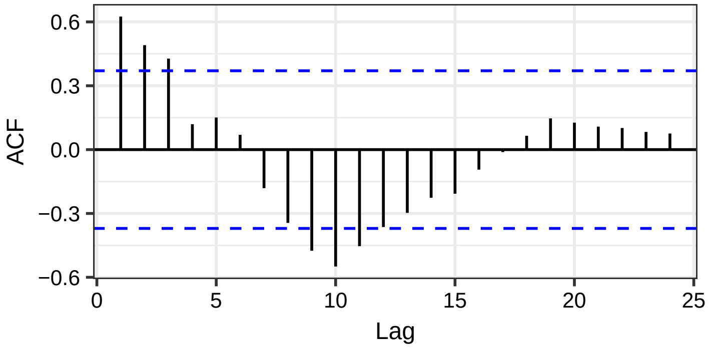
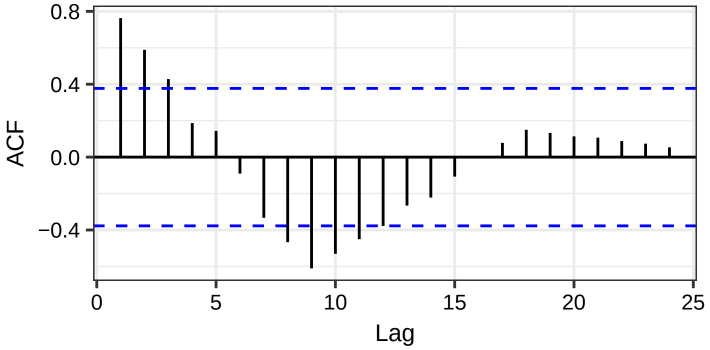
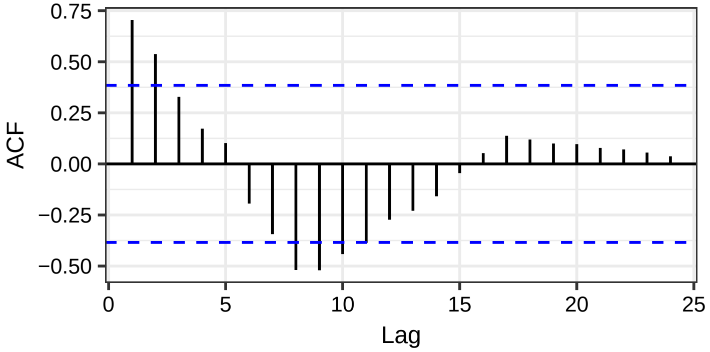
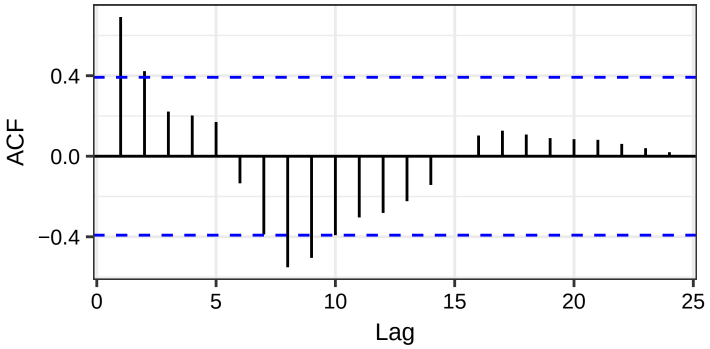


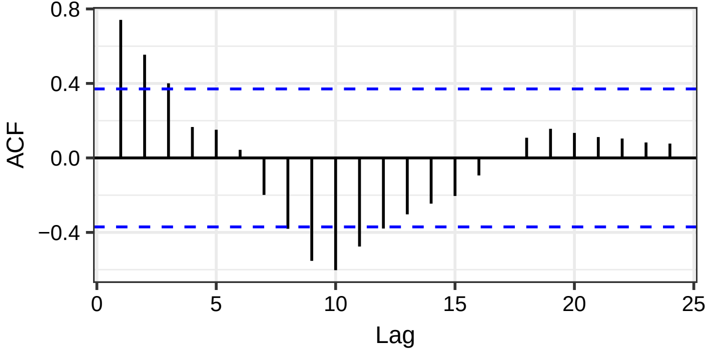
Autocorrelation Plots
(95% confidence limits plotted as horizontal lines)
Page 7 of 7

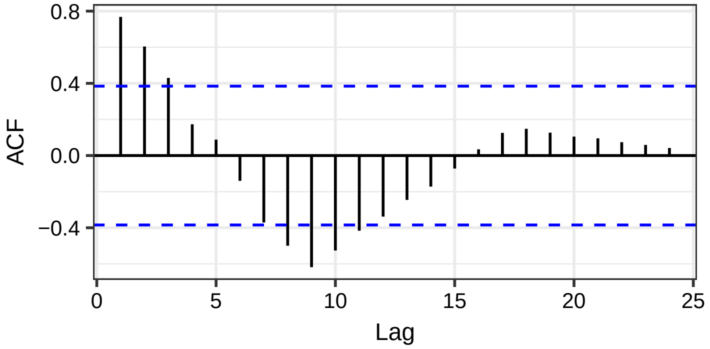

Total Organic Carbon
MW−1


Total Organic Carbon
MW−2


Total Organic Carbon
MW−3

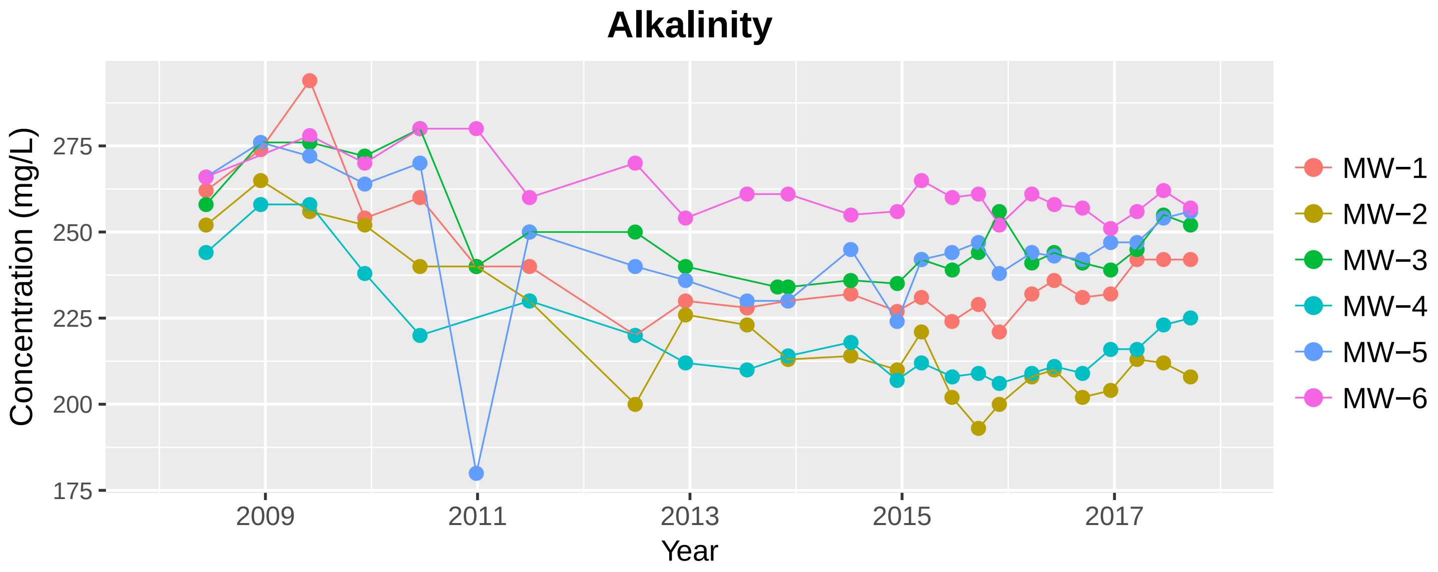

Total Organic Carbon
MW−4

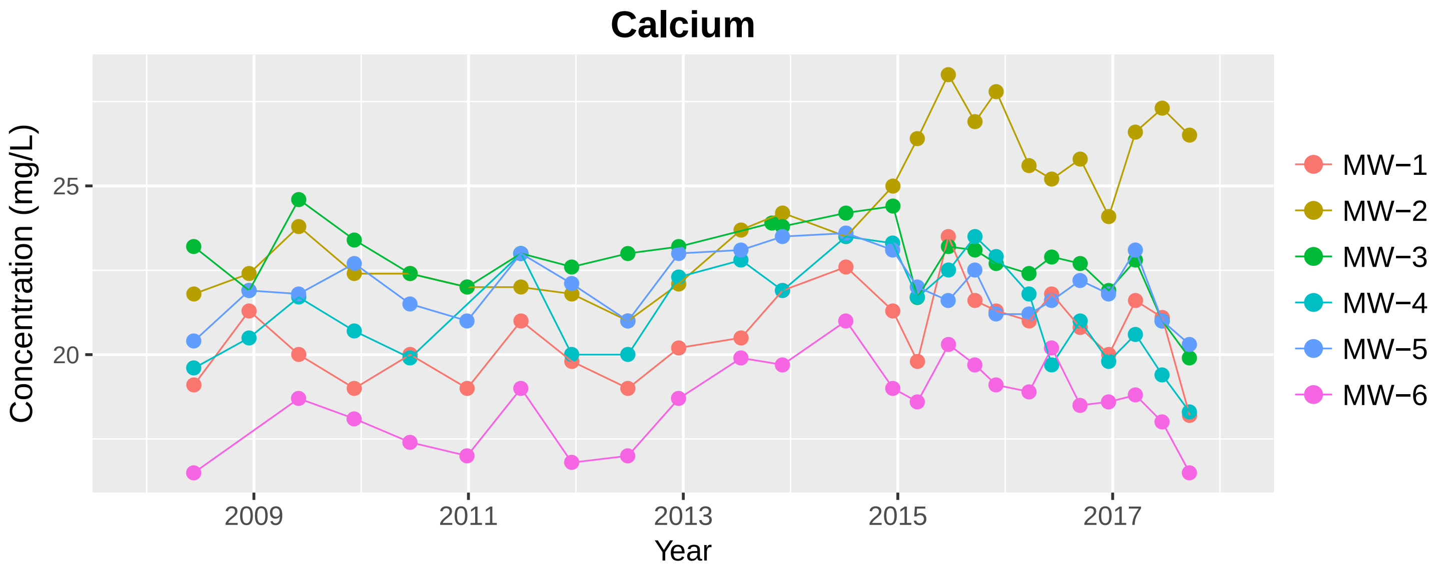

Total Organic Carbon
MW−5

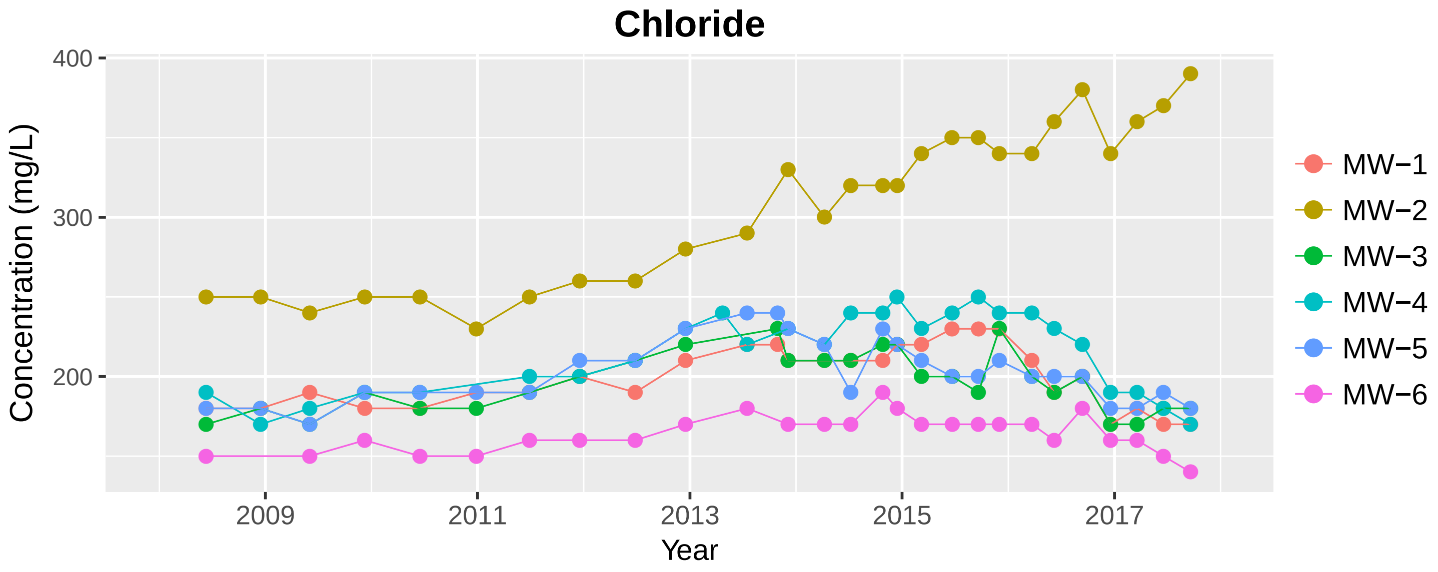

Total Organic Carbon
MW−6

Attachment 6
Overlapping Time Series Plots (2008-2017)

Overlapping Time Series Plots
(Nondetects plotted using open symbols at one−half the RL)
Page 1 of 3

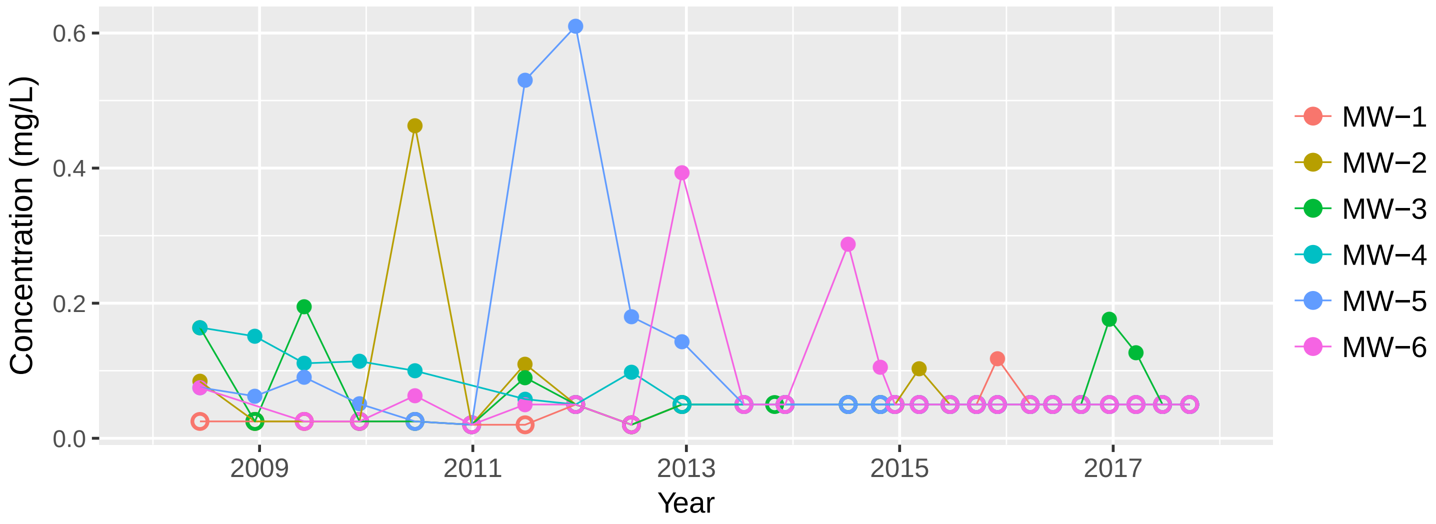




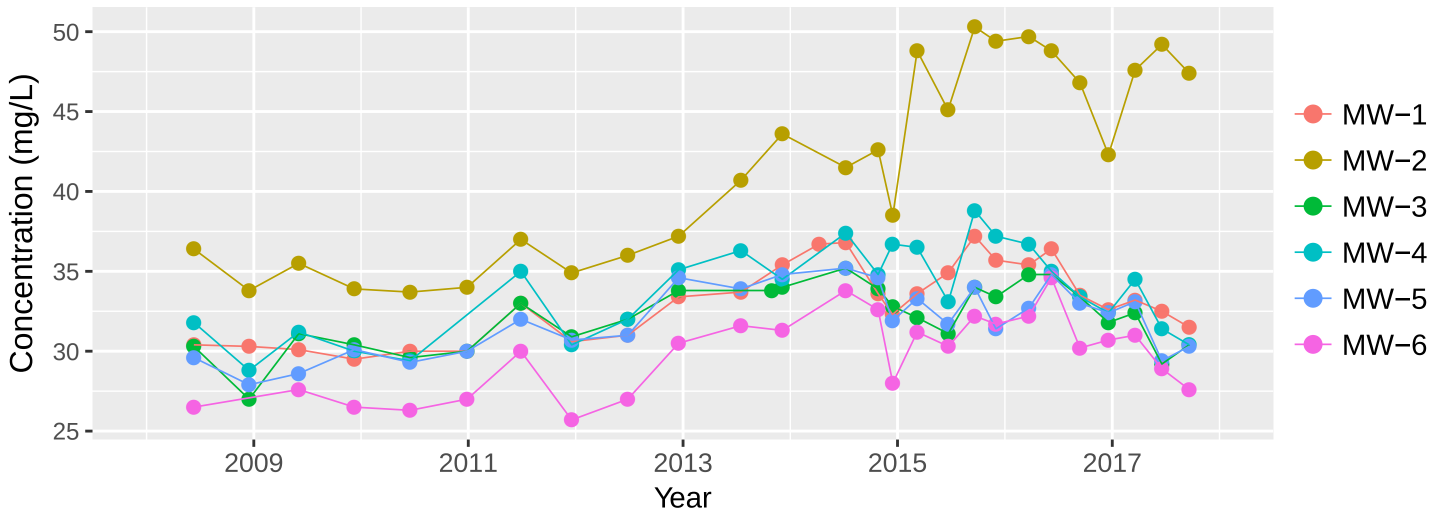


Overlapping Time Series Plots
(Nondetects plotted using open symbols at one−half the RL)
Page 2 of 3

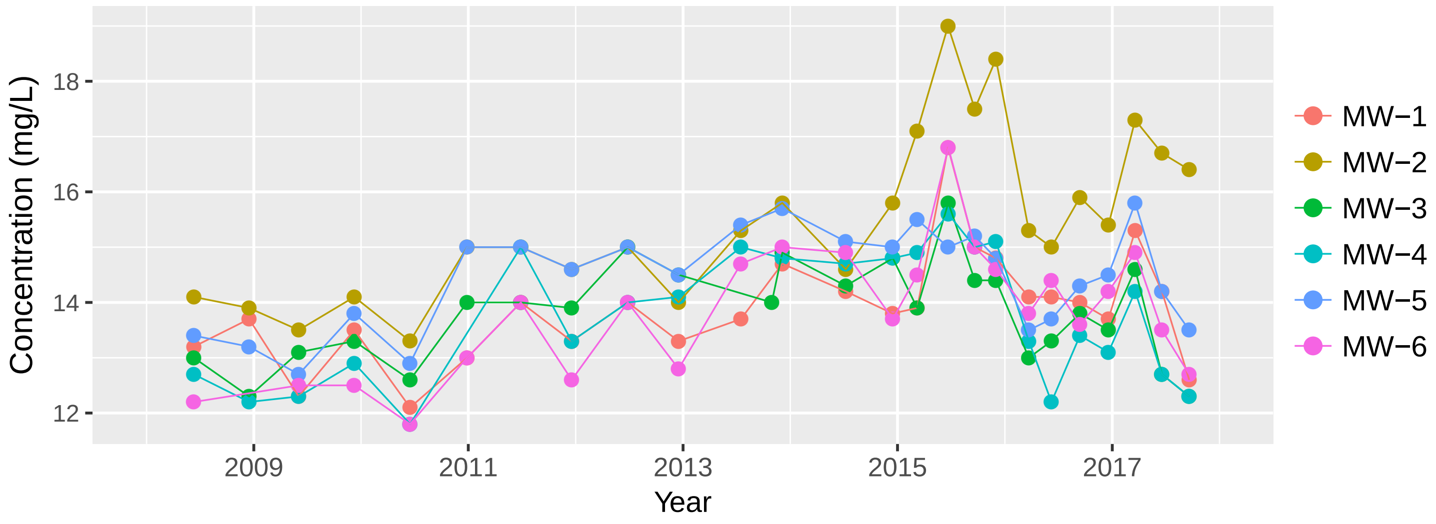
Iron



Magnesium

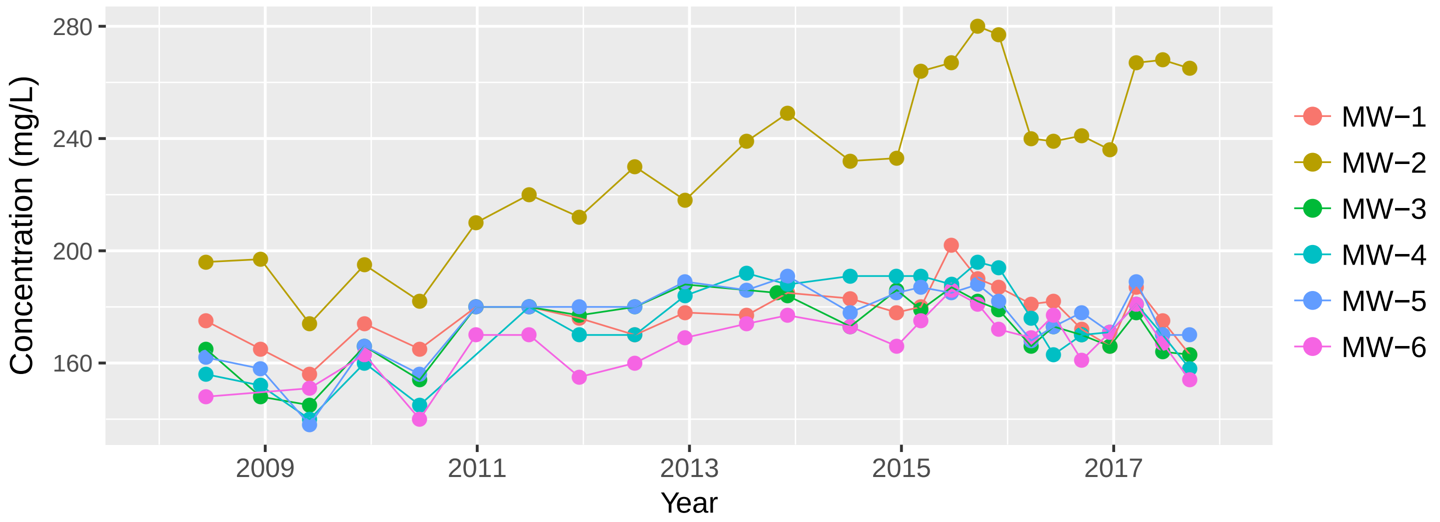


Potassium

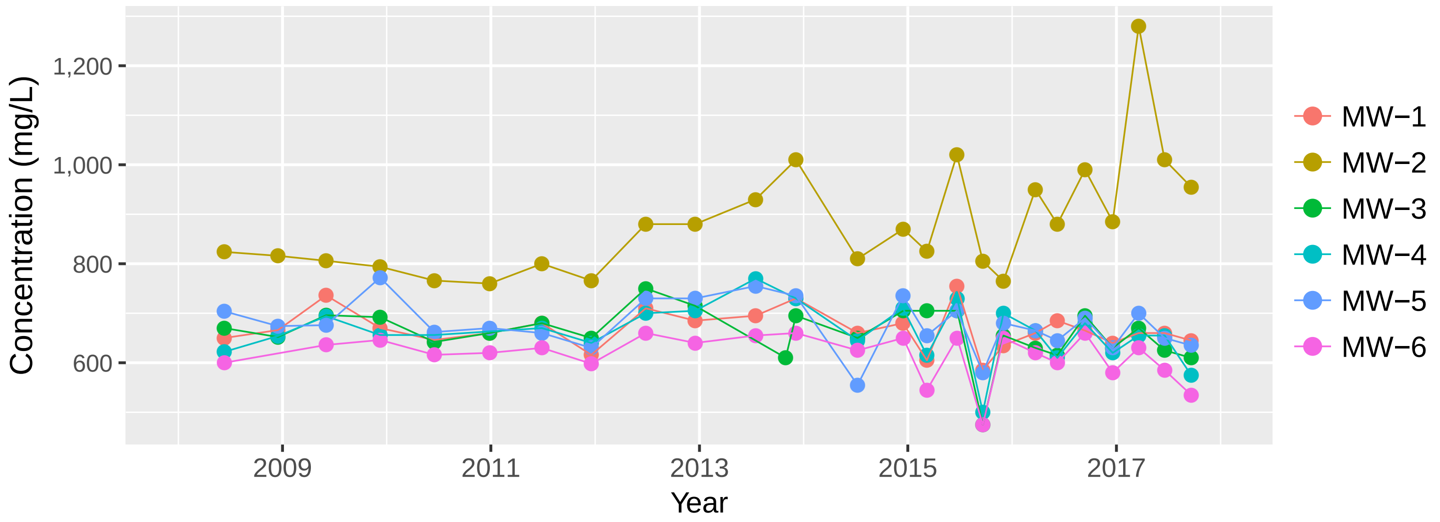


Overlapping Time Series Plots
(Nondetects plotted using open symbols at one−half the RL)
Page 3 of 3

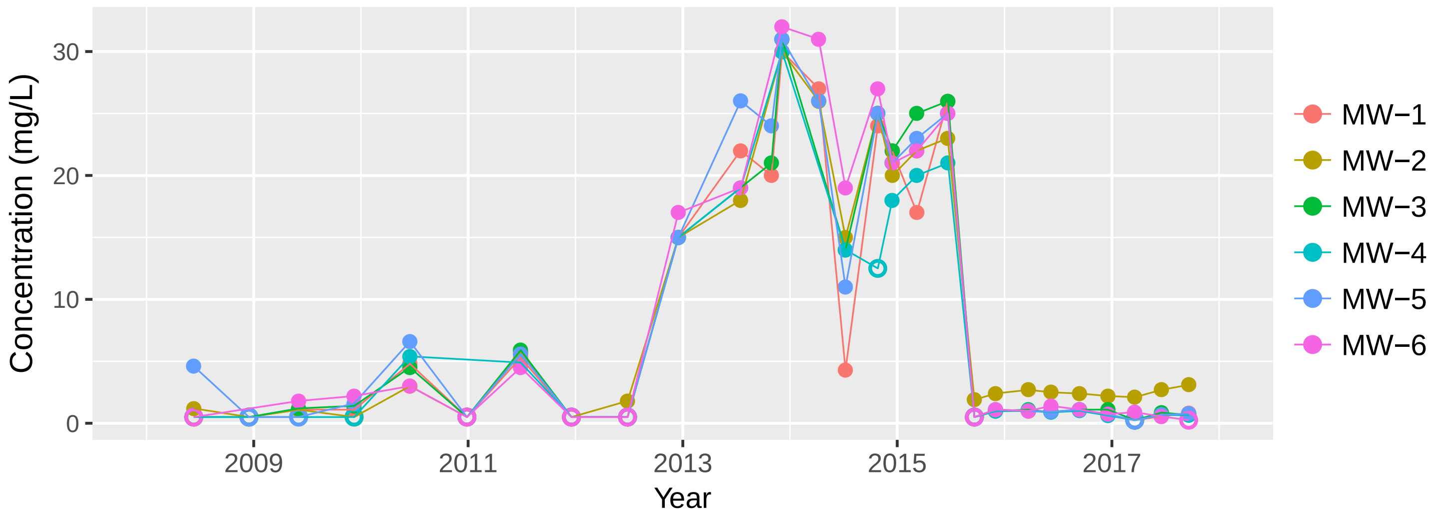
Sodium



Total Dissolved Solids



Total Organic Carbon

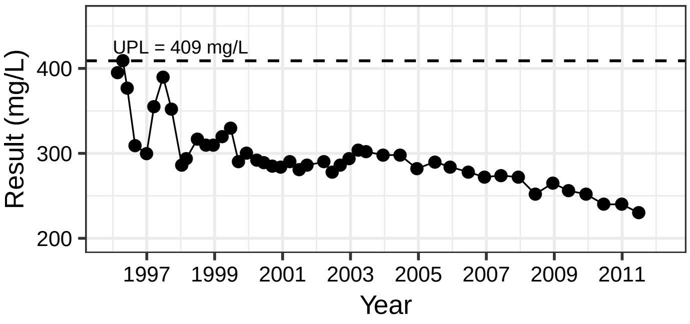


Attachment 7

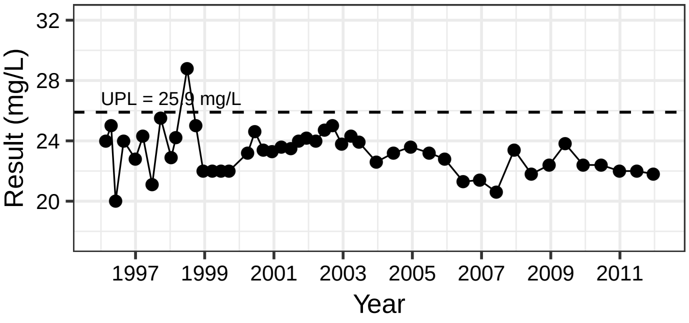
Time Series Plots Comparing Calculated UPLs to Corresponding Background Data

UPL Time Series Plots for MW−2
(nondetects plotted using open symbols at one−half the RL)
Page 1 of 2

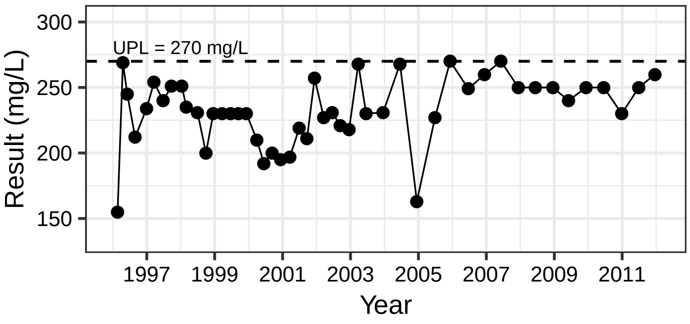
Alkalinity in MW−2



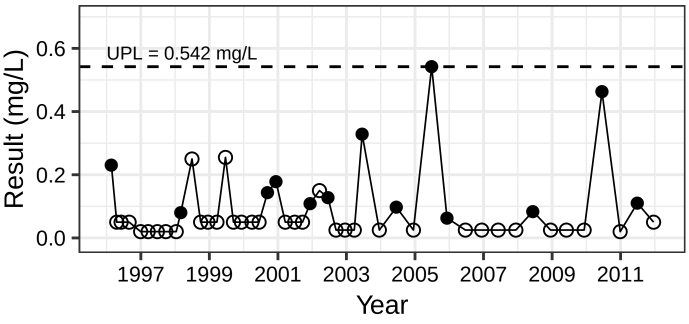
Calcium in MW−2



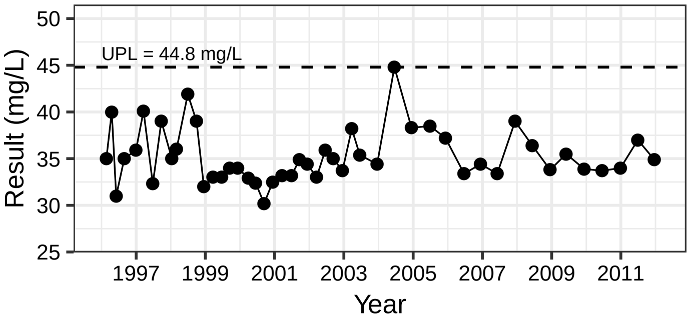
Chloride in MW−2



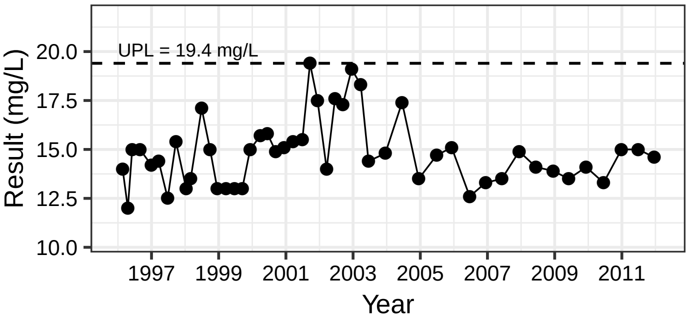
Iron in MW−2



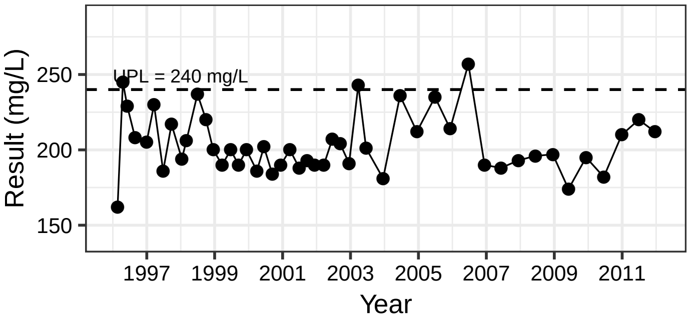
Magnesium in MW−2



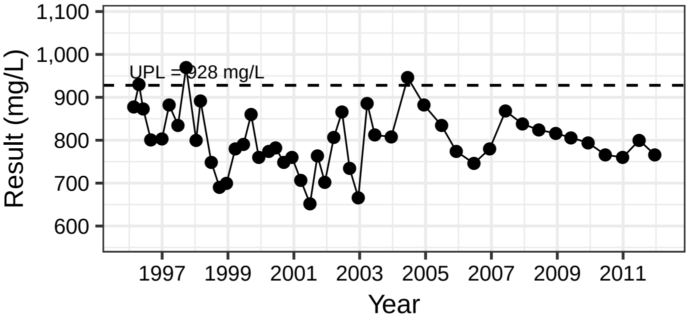
Potassium in MW−2



Sodium in MW−2

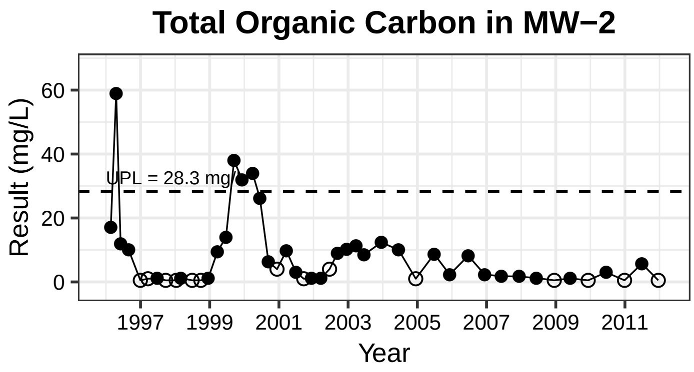


Total Dissolved Solids in MW−2



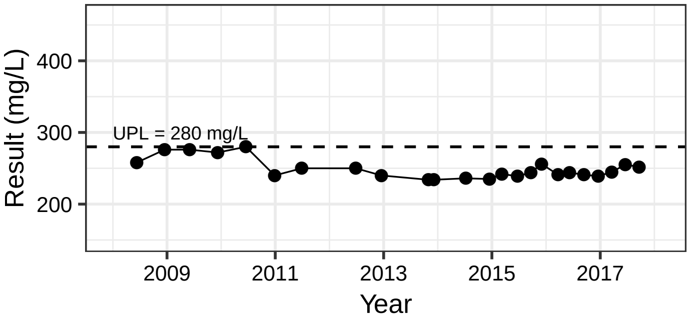
UPL Time Series Plots for MW−2

(nondetects plotted using open symbols at one−half the RL)

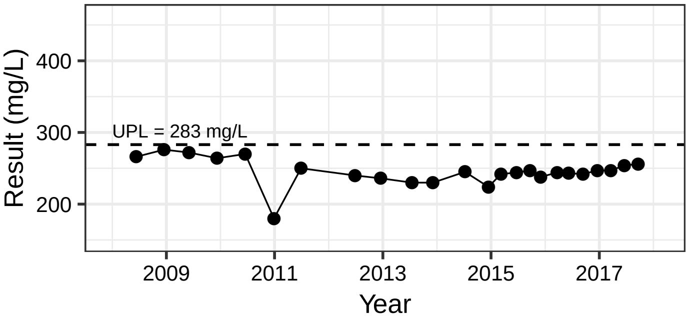


UPL Time Series Plots for MW−3 and MW−5
(nondetects plotted using open symbols at one−half the RL)
Page 1 of 3

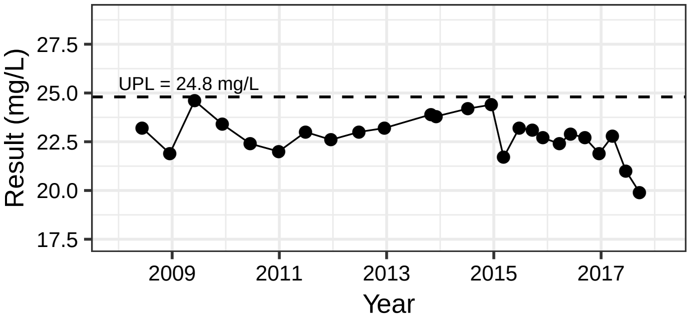
Alkalinity in MW−3



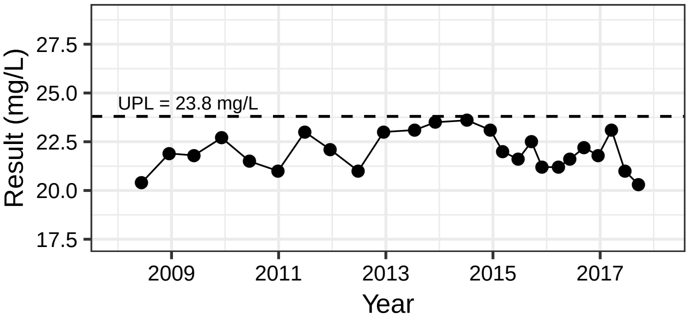
Alkalinity in MW−5



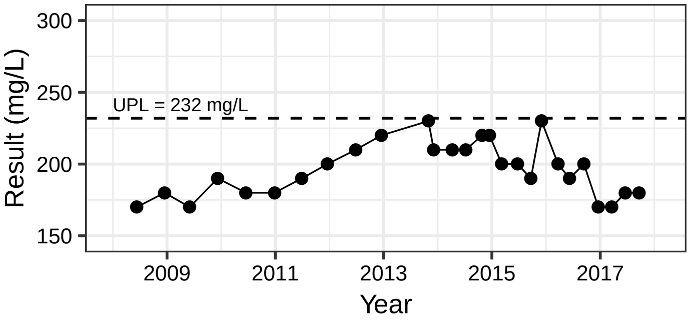
Calcium in MW−3



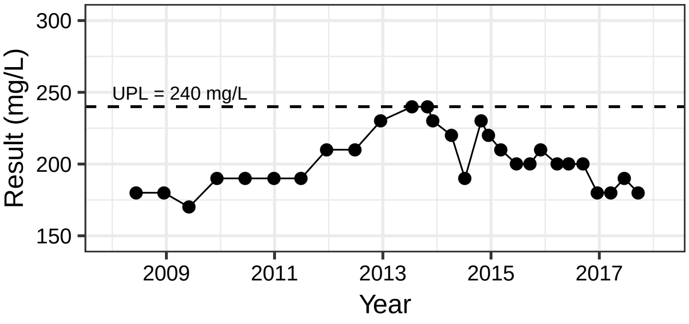
Calcium in MW−5



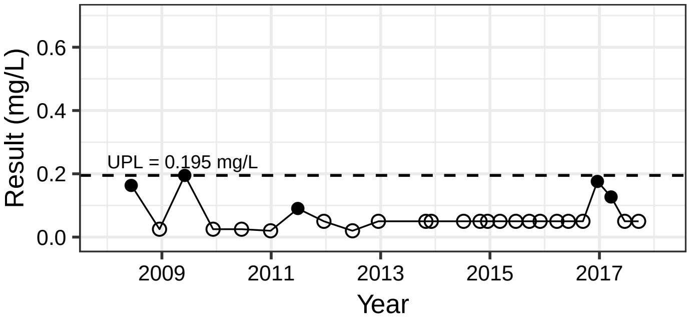
Chloride in MW−3



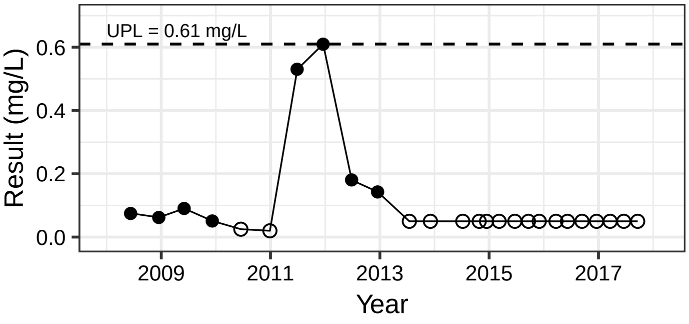
Chloride in MW−5



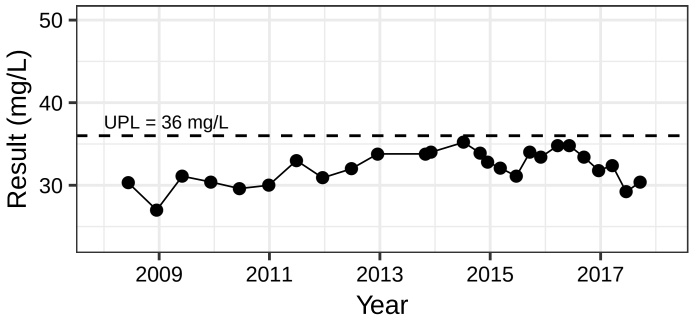
Iron in MW−3

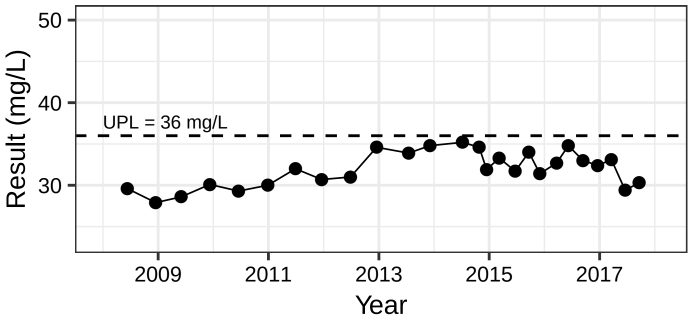


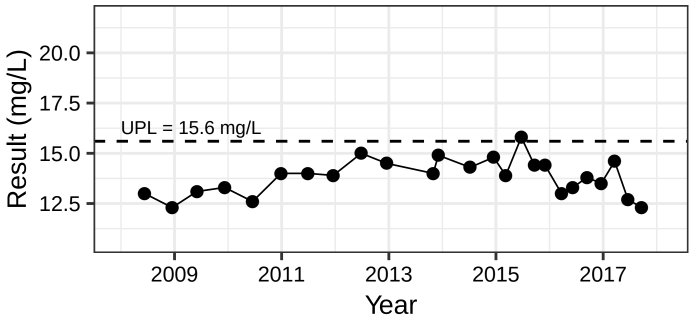
Iron in MW−5

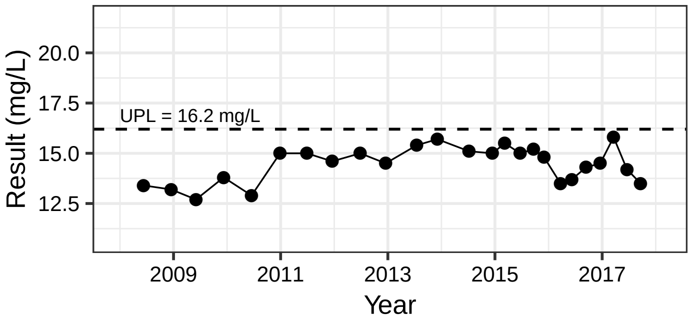


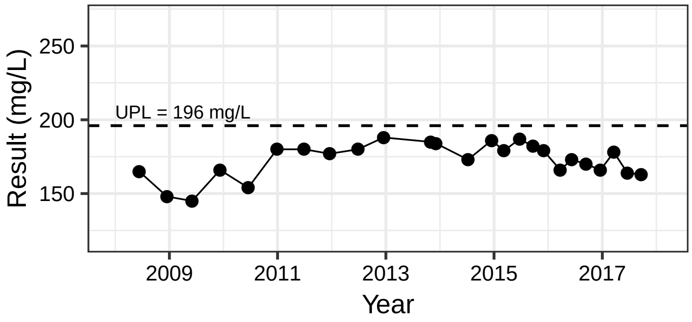
UPL Time Series Plots for MW−3 and MW−5
(nondetects plotted using open symbols at one−half the RL)
Page 2 of 3

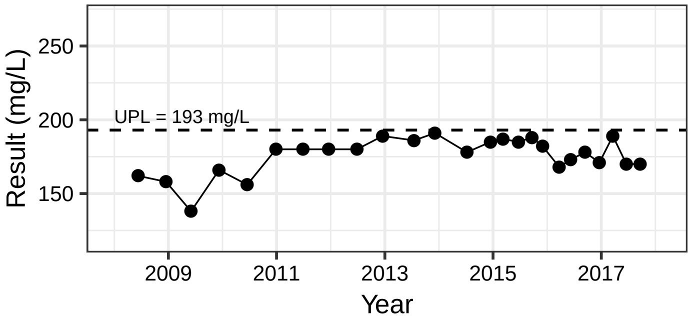

Magnesium in MW−3

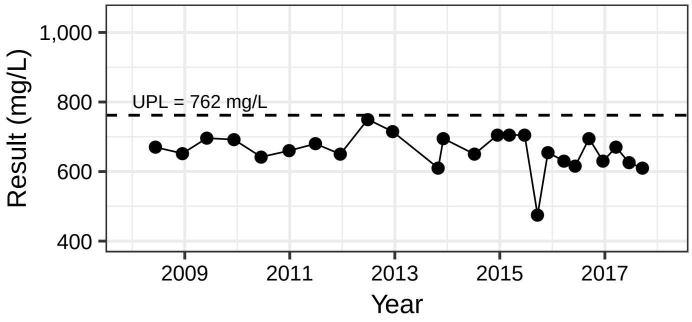

Magnesium in MW−5

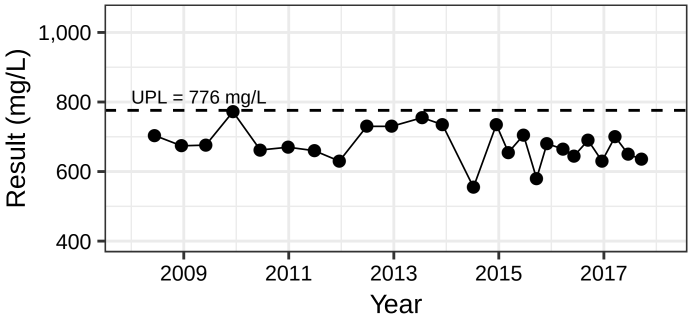

Potassium in MW−3


Potassium in MW−5


Sodium in MW−3


Sodium in MW−5


Total Dissolved Solids in MW−3


Total Dissolved Solids in MW−5

UPL Time Series Plots for MW−3 and MW−5
(nondetects plotted using open symbols at one−half the RL)

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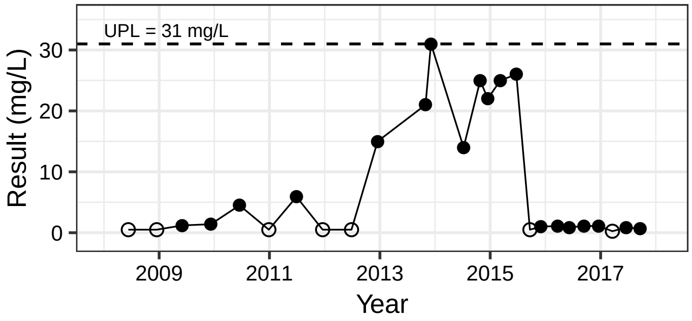
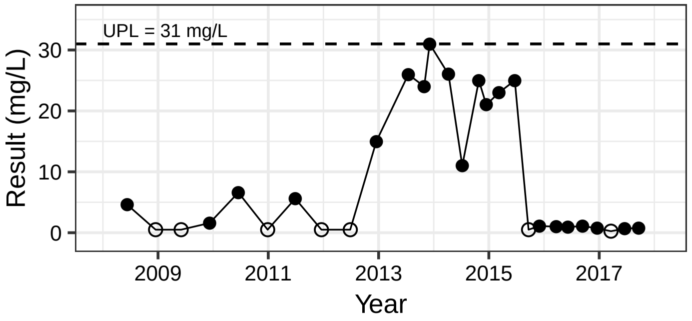

Total Organic Carbon in MW−3


Total Organic Carbon in MW−5

Appendix F

Assessment Monitoring at Central Maui Landfill

Technical Memorandum

Assessment Monitoring at Central Maui Landfill

PREPARED FOR: Elaine Baker, County of Maui
PREPARED BY: CH2M
DATE: February 8, 2018

Introduction

This technical memorandum was prepared by CH2M HILL Engineers Inc. (CH2M) on behalf of the County of Maui (County) in response to State of Hawaii Department of Health (HDOH) Solid and Hazardous Waste Branch (SHWB) comments on recent documents submitted by the County for their Central Maui Landfill (CMLF) Groundwater Monitoring Program.

On January 3, 2018, representatives of the HDOH SHWB, the County, and CH2M met to discuss revisions to the site-specific upper prediction limits (UPLs) and updates to the facility Groundwater Monitoring Plan. The meeting was held between 9 am and 11 am at the HDOH SHWB office in Pearl City, Oahu. One of the concerns expressed by HDOH SHWB in the response to comments to a UPLs memorandum prepared by CH2M for the County (CH2M, 2016a) was related to assessment monitoring conducted at the CMLF between 2012 and 2015. The response to comments table and updated UPL report are provided as Appendixes A and H, respectively, of the main *Groundwater and Leachate Monitoring Plan, Central Maui Landfill, Puunene, Maui* (Groundwater and Leachate Monitoring Plan).

During the January meeting, the HDOH SHWB requested that the County provide additional details in the Updated Groundwater and Leachate Monitoring Plan on the rationale for exiting assessment monitoring in 2015. HDOH indicated that the facility needs to comply with Hawaii Administrative Rules (HAR) 11-58.1-16(e) and perform annual testing for the Appendix II constituents while conducting assessment. CH2M, on behalf of the County, prepared this memorandum to address HDOH concerns by providing additional data and explanation to demonstrate that HAR 11-58.1-16 provisions to exit assessment monitoring are being met and that sources other than the landfill produced sporadic detections of four Appendix II metals.

Assessment Monitoring

Assessment monitoring was initiated in March 2012 after an exceedance of the iron control limit (CL) applicable at that time was confirmed at monitoring well MW-5 in December 2011. In compliance with HAR 11.58.1-16, the full list of Appendix II constituents was run in March 2012 for samples collected at the three downgradient/compliance monitoring wells MW-2, MW-3, and MW-5. Analysis of Appendix II parameters resulted in four new constituents (chromium, lead, nickel, and vanadium) detected in groundwater that were not part of the Detection Monitoring Program (URS, 2012). Per HAR 11.58.1-16 requirements, background levels for these constituents were established by conducting eight independent monitoring events and revising the CLs to calculate and adopt the new UPLs. Quarterly sampling to establish background levels started in June 2012 and extended to December 2014 because chromium was temporarily dropped from the analytical testing plan between July and December 2013 due to non-detects at all wells during the first four sampling events (June 2012-April 2013). This constituent was then reintroduced in April 2014, when its detection was confirmed at monitoring well MW-4 during metals testing, resulting in eight background samples for dissolved chromium as of December 2014 (see Attachment 1).

Although lead has not been detected during the entire Assessment Monitoring Program in any of the six wells, and nickel has never been detected in MW-1, MW-2, or MW-3, there have been historical detections of both lead and nickel in leachate samples collected from Phases IVA and IVB (i.e., down-gradient locations). Therefore, both constituents were retained in the Assessment Monitoring Program (URS, 2014b).

Assessment monitoring with complete Appendix II sampling was also initiated at the following upgradient/ crossgradient monitoring wells:

- Upgradient/crossgradient monitoring well MW-4 in July 2013, for an exceedance of the chloride CL in December 2012 that was confirmed in April 2013. The July 2013 analysis of Appendix II constituents at MW-4 resulted in no detections.
- Upgradient monitoring well MW-1 in July 2014, for a confirmed exceedance of the magnesium CL in April 2014 (URS 2014b). The July 2014 analysis of Appendix II constituents at MW-1 resulted in detections of zinc and vanadium, which were already being monitored at downgradient wells as part of the Appendix II assessment monitoring started in March 2012.

In compliance with HAR 11.58.1-16 (e)(2) and (e)(4)(C), while background values for the detected Appendix II constituents were being established and CLs were being revised to calculate UPLs, analysis of the full list of Appendix II constituents was repeated at different wells with different schedules for comparison against the original Appendix II sampling results (URS, 2014a and 2014b). A schedule summary for the complete Appendix II constituent testing follows:

- MW-1 – July 2014 and June 2015;
- MW-2 – March 2012, April 2014, and June 2015;
- MW-3 – March 2012, April 2014, and June 2015;
- MW-4 – July 2013, October 2013, December 2013, and June 2015;
- MW-5 – March 2012, April 2014, and June 2015; and
- MW-6 – June 2015.

No additional Appendix II parameters were detected during these sampling events, except for zinc at wells MW-2, MW-3, and MW-5 in April 2014 and 3&4-methylphenol at well MW-4 in October 2013. While zinc was verified to be present during subsequent Appendix II sampling and was added to the assessment monitoring constituents list to establish background concentrations, 3&4-methylphenol (detected only once in MW-4) was not added to the Assessment Monitoring Program because the detection was not confirmed during the December 2013 sampling (URS, 2014a). Total chromium, total nickel, and total vanadium were also detected in MW-4 in October 2013 and confirmed above the reporting limit in December 2013. These constituents were therefore kept in the Assessment Monitoring Program, but later dropped in 2014 because HDOH agreed metals in groundwater were almost entirely in dissolved state (URS, 2014b). A summary of Appendix II assessment monitoring results is provided in Table F-1.

As summarized in Table F-1, when comparing Appendix II constituent results from June 2015 to previous Appendix II monitoring results (including March 2012), the following are observed:

- Chromium was not detected at any of the monitoring wells in June 2015.
- Lead was not detected at any of the monitoring wells in June 2015.
- Nickel was detected in June 2015 only at monitoring wells MW-4 and MW-5, but concentrations were significantly lower than previous Appendix II monitoring events.
- Vanadium was detected at all monitoring wells in June 2015, but concentrations were lower than previous Appendix II monitoring events at all wells except for upgradient monitoring well MW-1, where a slight increase was observed between July 2014 and June 2015.

- Zinc was detected at all monitoring wells in June 2015; concentrations were lower than previous Appendix II monitoring events at all wells except for wells MW-4 and MW-5, where higher concentrations were observed.

Justification to Exit Assessment Monitoring

Per HAR 11-58.1-16 sections (d)(3)(C) and (e)(5), the County discussed exiting assessment monitoring in the 2015 Detection Monitoring Report (CH2M, 2016b) and demonstrated in the Conceptual Site Model report (CH2M, 2018) that sources other than the landfill (such as natural variation) caused the exceedances of the 2010 CLs that had triggered assessment monitoring in March 2012. No additional Appendix II sampling was necessary in 2016 (after the last Appendix II sampling was conducted in June 2015), because the detected Appendix II constituents were either not detected or did not exceed the newly calculated UPLs during the June and September 2016 monitoring events. Therefore, the detection monitoring program resumed in compliance with HAR 11.58.1-16 sections (e)(5), the U.S. Environmental Protection Agency (USEPA) Unified Guidance Section 4.2 (USEPA, 2009), and the USEPA Federal Subtitle D regulations. The following discussion further demonstrates that the presence in groundwater of the Appendix II constituents detected during assessment monitoring was from a source other than the landfill (e.g., natural variation):

- As shown in Table F-1, the assessment monitoring Appendix II constituents in groundwater (except for zinc) were either not detected or were detected at concentrations in groundwater that were higher than the average leachate concentrations calculated for leachate collection locations IV-A and IV-B between 2006 and 2017 (overall average). Concentrations in groundwater were also higher than the leachate average concentrations calculated considering only the years before assessment monitoring was triggered (between 2006 and 2011 [see Appendices C and E for historical leachate and groundwater concentrations, respectively]).
- When looking at groundwater concentrations between 1995 and 2017 for the Appendix II constituents detected during assessment monitoring, nickel and vanadium are the only constituents consistently detected, and concentrations are highest at upgradient/crossgradient wells (that is, noncompliance wells) MW-1, MW-4, and MW-6 (see Table F-2 and Appendix G of the main text). Chromium and lead are rarely detected in groundwater (see Appendix G of the main text). Of the very few detections, the highest concentrations of chromium are detected in upgradient/background well MW-1. Although the highest concentration of lead was detected in compliance monitoring well MW-3, this constituent was only detected in October 1995 (MW-1 and MW-3) and March 2012 (MW-2, MW-3, and MW-5), it was never detected in any of the monitoring wells after 2012 (see Appendix G of the main text), and it is not present in landfill leachate (Table F-2).
- As shown in Table F-1, during Appendix II assessment monitoring conducted at wells MW-1, MW-2, MW-3, and MW-5, zinc was detected at concentrations in groundwater ranging from slightly below (0.011 milligram per liter [mg/L]) to slightly above (0.033 mg/L) the overall (2006-2017) average zinc concentration in leachate (0.025 mg/L). These zinc groundwater concentrations also fluctuated around the average zinc concentration of 0.023 mg/L calculated for leachate during the period before Assessment Monitoring was triggered (2006-2011).

  Historically, zinc concentrations in groundwater at upgradient/background wells (MW-1 and MW-6) have often been detected during assessment and detection monitoring at concentrations above the average zinc concentration in leachate, with the highest groundwater concentration (0.0755 mg/L detected in MW-1 in March 2017) that is above the highest concentration ever detected in leachate (0.061 mg/L in December 2014).

  Also, as shown in Table F-2, the zinc average concentration in groundwater at upgradient/background wells is up to 0.024 mg/L, which is basically the same as the average zinc concentrations calculated for leachate (0.025 mg/L) and for the downgradient/compliance wells (up to 0.026 mg/L in MW-2).

- Considering the zinc data and the depth of groundwater of 200 to 250 feet beneath the bottom of the landfill, it is very unlikely that the landfill is the source of the zinc concentrations detected in groundwater to date (including the period of the Appendix II Assessment Monitoring).
- New UPLs were calculated and adopted in June 2016 for those constituents included in the Detection and Assessment Monitoring Programs. No exceedances of the newly adopted UPLs have been reported to date. Therefore, in accordance with HAR 11.58.1-16(e)(5), it was confirmed that no additional Appendix II constituent sampling was necessary in 2016.

The data above provide multiple lines of evidence that the presence in groundwater of the Appendix II constituents detected during assessment monitoring was not from landfill impact. In particular, concentrations in groundwater higher than in leachate and concentrations in upgradient/background wells higher than in downgradient wells, indicate that the Appendix II constituents detected in groundwater during assessment monitoring are from a natural source.

In support of these conclusions, there are studies documenting the ubiquitous presence of metals (such as vanadium, zinc, chromium, and nickel) in volcanic rock aquifers in Hawaii. Among these are the United States Geological Survey (USGS) National Water Information System (NWIS), with groundwater analytical data for metals and other constituents, and the Hawaiian Islands Soil Metal Background Evaluation (AECOM, 2012).

The USGS NWIS includes groundwater quality data for the Island of Maui; zinc is typically present in groundwater throughout the Island of Maui, with concentrations up to at least 0.33 and 0.02 mg/L for total and dissolved zinc, respectively (https://nwis.waterdata.usgs.gov/nwis). These concentrations are similar to those found in groundwater at the CMLF site.

An investigation completed by AECOM in 2012 (AECOM, 2012) evaluated metal concentrations in soils on the seven main Hawaiian islands. As an example, during this study, vanadium was detected in 100 percent of the 141 soil samples analyzed during this investigation, with concentrations ranging from 0.25 to 1,090 milligrams per kilogram (mg/kg). The two samples collected nearest to the CMLF (about 3 miles north of the site) had concentrations of 149 and 162.5 mg/kg (Figure F-1).

Zinc was also detected in 100 percent of the 125 soil samples analyzed during the 2012 AECOM study, with concentrations ranging from 3.57 to 1,200 mg/kg. The two samples collected nearest to the CMLF (about 3 miles north of the site) had concentrations of 153 and 349 mg/kg (Figure F-2).

Other Appendix II metal constituents detected in groundwater during assessment monitoring also resulted in 100 percent detections in soil during the AECOM 2012 study. Because of this, it is considered very likely that at least a portion of the dissolved metals typically present in groundwater beneath the facility is derived through dissolution of naturally occurring metals in the basalt that comprises the aquifer matrix.

It is therefore concluded that the Appendix II constituents detected in groundwater during assessment monitoring were from sources other than the landfill, and it was appropriate to exit assessment monitoring and return to detection monitoring.

References

AECOM. 2012. *Hawaiian Islands Soil Metal Background Evaluation Report. May.*

CH2M HILL (CH2M). 2016a. *Calculation of Upper Prediction Limits, Central Maui Landfill Facility Groundwater Monitoring*. Technical Memorandum. Prepared for Kevin Kihara, Hawaii Department of Health, Solid and Hazardous Waste Branch. October 16.

CH2M HILL (CH2M). 2016b. *March, June, and September 2015 Detection Monitoring Report*, Central Maui Landfill, Puunene, Hawaii. May

CH2M HILL (CH2M). 2018. *Conceptual Site Model, Central Maui Landfill, Puunene, Hawaii.* Final. Prepared for The County of Maui, Department of Environmental Management, Solid Waste Division. January.

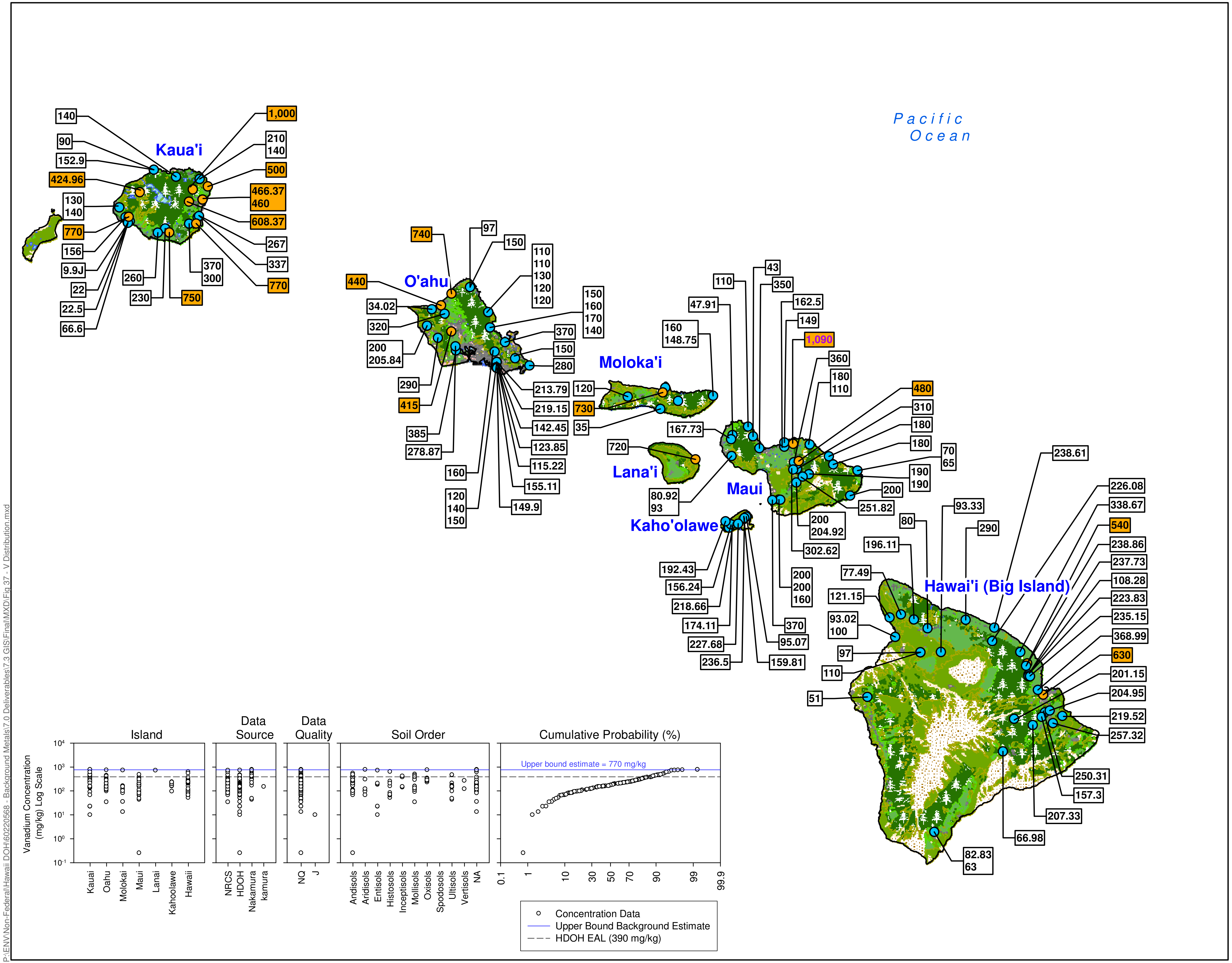
URS. 2012. *2012 Groundwater Assessment Monitoring Report, Central Maui Landfill, March 2012.* May.

URS. 2014a. *Semiannual Groundwater Monitoring Report, Central Maui Landfill, December 2013.* February.

URS. 2014b. *Semiannual Groundwater Monitoring Report, Central Maui Landfill, July 2014.* October.

U.S. Environmental Protection Agency (USEPA). 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities—Unified Guidance*. EPA 530/R-09-007. Office of Research and Development. March.

Figures



LEGEND

Vanadium Location and Concentration (mg/kg)

- ● 0 - 390
- ● 390 - 1,090

Landuse

🟥	Residential, Commercial and Services
■	Industrial & Other Built-up Urban Land
🟩	Agricultural Land
🟩	Rangeland
🟩	Forest Land
🟦	Water
▨	Wetland
▨	Barren Land

NOTES

1. Map projection: Hawaii State Plane Zone3, NAD83.
2. mg/kg: milligram/kilogram
   J: Estimated analyte concentration
3. Concentration highlighted in purple represents maximum value in the dataset.
4. Orange-shaded callout box represents concentration above the EAL.
   EAL for Vanadium = 390 mg/kg (Residential Direct Exposure Soil Action Levels [HDOH 2011])
5. Cumulative probability and univariate plots shown include filtered data with outliers removed.

AECOM

N

0 20 40 80 Miles

Vanadium Sample Location and Concentration Distribution Hawaiian Islands Soil Metal Background Evaluation Report

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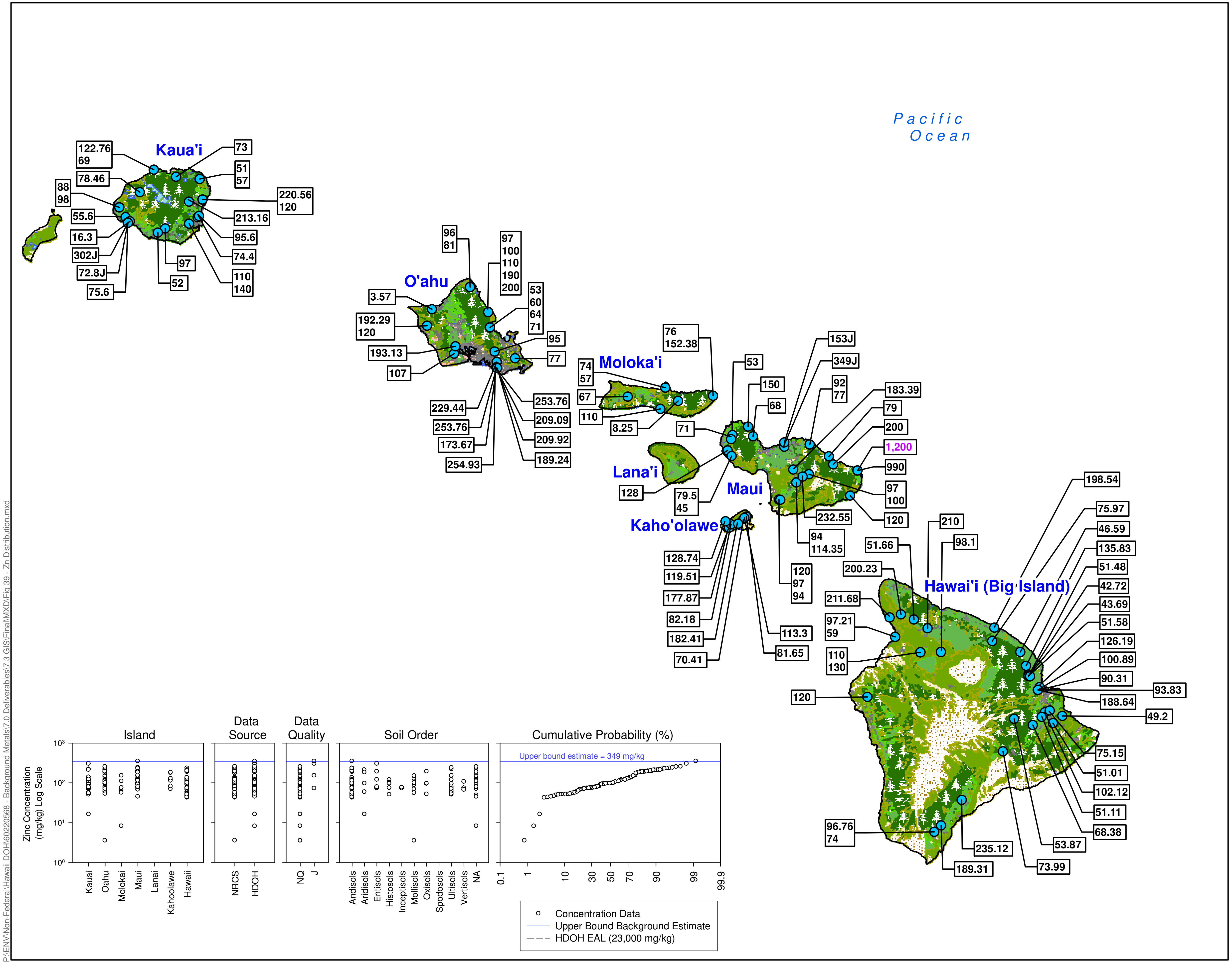

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LEGEND

Zinc Location and Concentration (mg/kg)

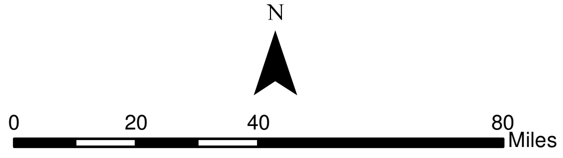
● 0 - 1,200

Landuse

- 🟥 Residential, Commercial and Services
- ▨ Industrial & Other Built-up Urban Land
- 🟩 Agricultural Land
- 🟩 Rangeland
- 🟩 Forest Land
- 🟦 Water
- ▨ Wetland
- ▨ Barren Land

NOTES

1. Map projection: Hawaii State Plane Zone3, NAD83.
2. mg/kg: milligram/kilogram
   J: Estimated analyte concentration
3. Concentration highlighted in purple represents maximum value in the dataset.
4. EAL for Zinc = 23,000 mg/kg (Residential Direct Exposure Soil Action Levels [HDOH 2011])
5. Cumulative probability and univariate plots shown include filtered data with outliers removed.



Zinc Sample Location and
Concentration Distribution
Hawaiian Islands Soil Metal
Background Evaluation Report

Tables

TABLE F-1

Appendix II Constituent Detections

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Constituent	Unit	Monitoring Well	2016 UPL (Effective June 2016)	MCL	EAL	Leachate Average Concentration (2006-2017)	Leachate Average Concentration (2006-2011)	Assessment Monitoring Appendix II Concentrations						
								3/20/2012	7/17/2013	10/30/2013	12/5/2013	4/9/2014	7/9/2014	6/22/2015
Chromium	mg/L	MW-1	NC	0.1	0.016[a]	0.016	0.016	NA	NA	NA	NA	NA	ND (0.01)	ND (0.01)
		MW-2	NC					ND (0.005)	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-3	NC					ND (0.005)	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-4	NC					NA	NA	0.150	0.0375	NA	NA	ND (0.01)
		MW-5	NC					0.054	NA	NA	NA	0.0144	NA	ND (0.01)
Lead	mg/L	MW-1	NC	0.015	0.015[a]	0.006	0.009	NA	NA	NA	NA	NA	ND (0.01)	ND (0.01)
		MW-2	NC					0.018	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-3	NC					0.020	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-4	NC					NA	NA	ND (0.01)	ND (0.01)	NA	NA	ND (0.01)
		MW-5	NC					0.018	NA	NA	NA	ND (0.01)	NA	ND (0.01)
Nickel	mg/L	MW-1	NC	NA	0.005[a]	0.020	0.011	NA	NA	NA	NA	NA	ND (0.01)	ND (0.01)
		MW-2	0.0298					ND (0.01)	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-3	NC					ND (0.01)	NA	NA	NA	ND (0.01)	NA	ND (0.01)
		MW-4	0.367					NA	NA	0.249	0.251	NA	NA	0.163
		MW-5	0.246					0.300	NA	NA	NA	0.204	NA	0.0522
Vanadium	mg/L	MW-1	0.0349	NA	0.09[a]	0.010	0.011	NA	NA	NA	NA	NA	0.0208	0.0216
		MW-2	0.0349					0.021	NA	NA	NA	0.0211	NA	0.0178
		MW-3	0.0291					0.020	NA	NA	NA	0.0213	NA	0.0187
		MW-4	0.0329					NA	NA	0.0224	0.0192	NA	NA	0.0173
		MW-5	0.0266					0.025	NA	NA	NA	0.0187	NA	0.0185
Zinc	mg/L	MW-1	0.0983	5	0.022[a]	0.025	0.023	NA	NA	NA	NA	NA	0.0299	0.0112
		MW-2	0.184					ND (0.02)	NA	NA	NA	0.0270	NA	0.012
		MW-3	0.239					ND (0.02)	NA	NA	NA	0.0329	NA	0.0106
		MW-4	0.196					NA	NA	ND (0.01)	NA	NA	NA	0.0214
		MW-5	0.162					ND (0.02)	NA	NA	NA	0.0159	NA	0.0254

Note:

Appendix II metals are total concentrations.
Concentrations on 6/22/2015 are dissolved.
a - EAL based on drinking water concerns.

C/I = commercial industrial sites
DWT = drinking water threatened
EAL = HDOH environmental action level (risk-based; C/I; >150m SW; DWT)
HDOH = State of Hawaii Department of Health
MCL = maximum contaminant level (SDWA, Primary and Secondary Drinking Water Regulations)
mg/L = milligram(s) per liter

NA = not available or not analyzed
NC = not calculated (because the constituent was mostly ND)
ND = not detected (reporting limit indicated in paranthesis)
SDWA = Safe Drinking Water Act
SW = surface water

TABLE F-2

Summary Statistics and Leachate/Groundwater Contrast

Groundwater and Leachate Monitoring Plan

Central Maui Landfill, Puunene, Maui

Constituent	Conc. Unit	Action Level								Leachate Concentration				Mean Groundwater Concentration												Leachate/Groundwater Contrast					
		UPL						MCL	EAL	Detections (percent)	MIN	MAX	Mean	Upgradient/Crossgradient Wells						Downgradient (Compliance) Wells						Upgradient/Crossgradient Wells			Downgradient (Compliance) Wells		
		MW-1	MW-2	MW-3	MW-4	MW-5	MW-6							MW-1		MW-4		MW-6		MW-2		MW-3		MW-5		MW-1	MW-4	MW-6	MW-2	MW-3	MW-5
														Conc.	Detections (percent)	Conc.	Detections (percent)	Conc.	Detections (percent)	Conc.	Detections (percent)	Conc.	Detections (percent)	Conc.	Detections (percent)						
Alkalinity, total (as CaCO3)[1]	mg/L	550	501	560	485	557	595	NA	NA	100	107	2300	1424	269	100	247	100	273	100	274	100	247	100	261	100	5.3	5.8	5.2	5.2	5.8	5.5
Ammonia	mg/L	NC	NC	NC	NC	NC	NC	NA	NA	100	0.56	59	13.5	0.064	32	NA	15.4	ND	0	0.135	47	0.087	37	NA	8	211	NC	MAX	100	155	NC
Barium	mg/L	NC	NC	NC	NC	NC	NC	2	0.22[b]	100	0.079	1.9	0.408	0.005	33	ND	0	ND	0	0.004	47	0.005	35	ND	0	82	MAX	MAX	102	82	MAX
Benzene	µg/L	NC	NC	NC	NC	NC	NC	5	5[a]	43	0.76	7	1.91	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Calcium	mg/L	29.5	38.6	27.7	29.3	27.9	26.1	NA	NA	100	17.3	170	69	20.4	100	22.5	100	18.2	100	23.6	100	23.5	100	22.3	100	3.4	3.1	3.8	2.9	2.9	3.1
Chloride	mg/L	287	505	282	318	304	216	250	NA	100	170	1600	751	185	100	205	100	161	100	259	100	180	100	192	100	4.1	3.7	4.7	2.9	4.2	3.9
Chromium	mg/L	NC	NC	NC	NC	NC	NC	0.1	0.011[b]	24	0.004	0.056	0.009	NA	8	NA	5	ND	0	ND	0	0.004	12	ND	0	NC	NC	MAX	MAX	2.3	MAX
Copper	mg/L	NC	NC	NC	NC	NC	NC	1.3	0.0029[b]	57	0.011	0.19	0.025	0.005	22	ND	0	ND	0	0.004	33	0.006	17	ND	0	5.0	MAX	MAX	6.3	4.2	MAX
1,4-Dichlorobenzene	µg/L	NC	NC	NC	NC	NC	NC	75	5[c]	37	1.35	5.7	1.72	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
1,2-Dichloroethane	µg/L	NC	NC	NC	NC	NC	NC	5	5[a]	28.6	0.83	8.8	1.8	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
cis-1,2-Dichloroethylene	µg/L	NC	NC	NC	NC	NC	NC	70	70[a]	28	1.6	8.54	1.88	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Ethylbenzene	µg/L	NC	NC	NC	NC	NC	NC	700	7.3[b]	26	1.67	20	2.71	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Iron	mg/L	NC	0.215	NC	0.126	0.959	0.73	0.3	NA	100	0.962	23	5.67	0.052	10	0.078	43	0.079	33	0.079	23	0.062	19	0.108	48	109	73	72	72	91	53
Magnesium	mg/L	47.6	72.9	40.7	48.6	42	43.8	NA	NA	100	88.8	477	302	30.8	100	33.2	100	29.1	100	37.5	100	30.8	100	31.3	100	10	9.1	10	8.1	10	9.6
Nickel	mg/L	NC	0.0298	NC	0.367	0.246	0.148	NA	0.005[b]	71	0.011	0.051	0.021	NA	7	0.219	100	0.11	100	0.013	32	NA	4	0.178	100	NC	0.10	0.19	1.6	NC	0.12
Nitrate-N[2]	mg/L	10.2	25.9	10.3	9.35	10.4	9.56	10	NA	39	0.03	1.1	0.125	18.9	99	4.6	98	4.86	98	24	99	22.6	99	4.98	98	0.01	0.03	0.03	0.01	0.01	0.03
Potassium	mg/L	20.9	25.1	18.5	18.8	18.3	20.8	NA	NA	97	21.1	68.9	37.2	13.8	100	13.8	100	13.6	100	15.1	100	13.6	100	14.5	100	2.7	2.7	2.7	2.5	2.7	2.6
Sodium	mg/L	242	379	217	239	219	221	NA	NA	100	192	925	528	175	100	174	100	168	100	216	100	168	100	174	100	3.0	3.0	3.1	2.4	3.1	3.0
Sulfate	mg/L	74.1	300	75.3	96.6	75.2	69	250	NA	37	0.59	129	9.69	26.1	93	29.4	98	24.2	98	42.6	96	26.1	94	29	98	0.37	0.33	0.40	0.23	0.37	0.33
TDS	mg/L	975	1400	1080	1080	1050	945	500	NA	100	1370	4308	2877	739	100	672	100	631	100	840	100	677	100	675.6	100	3.9	4.3	4.6	3.4	4.2	4.3
TOC	mg/L	76.3	69.3	76	67.4	76.3	80.6	NA	NA	100	3.6	980	113	8.1	76	5.79	71	7.1	77	8.85	79	8.69	73	8.68	71	14	20	16	13	13	13
Toluene	µg/L	NC	NC	NC	NC	NC	NC	0.001	0.0098[b]	29	1.2	62.8	4.44	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Vinyl Chloride	µg/L	NC	NC	NC	NC	NC	NC	2	2[a]	29	1.0	6.18	1.29	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Xylenes	µg/L	NC	NC	NC	NC	NC	NC	0.01	0.0013[b]	60	1.38	37	7.11	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0	MAX	MAX	MAX	MAX	MAX	MAX
Zinc	mg/L	0.0983	0.184	0.239	0.196	0.162	0.0769	5	0.022[b]	57	0.02	0.061	0.025	0.027	40	0.015	39	0.018	62	0.029	55	0.025	55	0.021	62	0.93	1.7	1.4	0.86	1.0	1.2

Note:

[1] Alkalinity in groundwater was reported as bicarbonate alkalinity (as CaCO3) until 10/2014 and as total alkalinity (as CaCO3) after 12/2014. For leachate concentrations both total and bicarbonate alkalinity were reported and were in most cases the same. Leachate data and literature show that at pH levels observed at the site, bicarbonate alkalinity is equivalent to total alkalinity because other carbonate (the other major alkalinity in natural waters) is stable only at higher pH values. When both toal and bicarbonate alkalinity were available (and they were in most cases the same), only total alkalinity was considered.

[2] Nitrogen in groundwater was reported as "nitrate (as N)" until 12/2014. After 12/2014 "nitrate-nitrite (as N)" was reported; because nitrite is unstable and easily oxidized to nitrate, nitrate is the compound predominantly found in groundwater (US Department of Health and Human Services, 2017). Therefore concentrations of nitrogen reported as “nitrate-nitrite (as N)” and “nitrate (as N)" are generally the same.

This table includes only constituents with at least 20 percent detections in leachate collected at the sump/wet well within Phases IV-A and IV-B between 2006 and 2017 (semiannual sampling). For both leachate and groundwater average concentration calculations, nondetects were included and managed using the Kaplan-Meir method.

Mean groundwater concentrations were calculated considering groundwater samples collected at each specific monitoring well between 1995 and 2017 (frequency varying over time). Field duplicate samples were not included in average calculations.

a-b-c. EALs identified with an "a" are based on drinking water concerns; EALs identified with a "b" are based on aquatic ecotoxicity concerns; EALs identified with a "c" are based on gross contamination concerns.

Colors in groundwater concentration and leachate/groundwater contrast are only to help visualization.

µg/L = microgram(s) per liter
C/I = commercial industrial sites
Conc. = concentration
DWT = drinking water threatened
EAL = HDOH environmental action level (Fall 2017 risk-based; C/I; >150m SW; DWT EAL)
HDOH = State of Hawaii Department of Health
MAX = maximum contrast (that is, constituent is detected in leachate but not in groundwater)
MCL = maximum contaminant level (SDWA, Primary and Secondary Drinking Water Regulations)
mg/L = milligram(s) per liter
NA = not available (that is, no limit available or mean value not calculated because number of detections is lower than 20 percent).
NC = not calculated
ND = not detected
SDWA = Safe Drinking Water Act
SW = surface water
TDS = total dissolved solids
TOC = total organic carbon
UPL = upper prediction limit (CH2M, 2016)

Attachment 1

Summary of Assessment Monitoring Analytical Results

TABLE 8
SUMMARY OF ASSESSMENT MONITORING ANALYTICAL RESULTS
CENTRAL MAUI LANDFILL

WELL NUMBER	UNITS	MW-1	MW-1	MW-1	MW-1	MW-1	MW-1	MW-1	MW-1	MW-1	MW-2	MW-7
DATE		6/27/2012	10/17/2012	12/17/2012	4/24/2013	7/17/2013	10/30/2013	12/5/2013	4/9/2014	7/9/2014	6/27/2012	6/27/2012
ANALYTE												Duplicate of MW-2
FIELD PARAMETERS												
Static Water Level	feet, msl	3.01	3.06	3.18	2.80	2.93	2.96	3.09	3.30	3.22	2.47	NA
Well Depth	feet, bgs	314	314	314	314	314	314	314	314	314	235	NA
pH	pH units	7.95	7.3	7.27	7.42	7.19	6.67	7.57	7.29	7.29	7.82	NA
Temperature	degree C	23.76	24.43	23.02	24.39	24.07	23.64	23.59	23.93	24.15	23.24	NA
Turbidity	NTU	2.7	1.1	0.0	0.0	1.21	0.0	0.0	1.16	1.03	0.0	NA
Specific Conductivity	uS/cm	1120	997	1230	1250	1226	2840	1250	1277	1190	1440	NA
Salinity	%	0.03	0.05	0.06	0.06	0.06	0.15	0.06	0.064	0.059	0.04	NA
Dissolved Oxygen	mg/L	7.63	6.72	7.90	6.83	6.29	7.75	8.42	7.28	7.87	7.32	NA
INORGANIC AND CONVENTIONAL PARAMETERS												
Chromium[1] (Dissolved)	mg/L	ND (0.0050)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--	--	ND(<0.0100)	ND(<0.0100)	ND (0.0050)	ND (0.0050)
Chromium (Total)	mg/L	--	--	--	--	--	--	--	ND(<0.0100)	ND(<0.0100)	--	--
Lead (Dissolved)	mg/L	ND (0.0050)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND (0.0050)	ND (0.0050)
Lead (Total)	mg/L	--	--	--	--	--	--	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--
Nickel (Dissolved)	mg/L	ND (0.010)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND (0.010)	ND (0.010)
Nickel (Total)	mg/L	--	--	--	--	--	--	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--
Vanadium (Dissolved)	mg/L	ND (0.010)	0.0204	0.0200	0.0205	0.0198	0.0200	0.0203	0.0227	0.0210	ND (0.010)	ND (0.010)
Vanadium (Total)	mg/L	--	--	--	--	--	--	0.0194	0.0225	0.0208	--	--
Chloride[2]	mg/L	--	--	--	--	220	220	210	210	210	--	--

Notes:

-- : constituent not analyzed

mg/L: milligrams per liter

MW: monitoring well

NA: not applicable

ND (XX): not detected (reporting limit)

URS, 2013. Letter - *Groundwater Monitoring Verification Sample Notification, Central Maui Landfill* . June 20.

[1] Chromium was removed from the assessment monitoring program on June 20, 2013 (URS, 2013), but reentered the program on December 5, 2014 (URS, 2014)

[2] Chloride entered the assessment monitoring program on 10/30/2013 (URS, 2013).

[3] MW-3 was not sampled on 7/17/2013 due to pump malfunction in the field.

TABLE 8
SUMMARY OF ASSESSMENT MONITORING ANALYTICAL RESULTS
CENTRAL MAUI LANDFILL

WELL NUMBER	UNITS	MW-2	MW-7	MW-2	MW-7	MW-2	MW-7	MW-2	MW-7	MW-2	MW-7
DATE		10/17/2012	10/17/2012	12/17/2012	12/17/2012	4/24/2013	4/24/2013	7/17/2013	7/17/2013	10/30/2013	10/30/2013
ANALYTE			Duplicate of MW-2		Duplicate of MW-2		Duplicate of MW-2		Duplicate of MW-2		Duplicate of MW-2
FIELD PARAMETERS											
Static Water Level	feet, msl	2.52	NA	2.72	NA	2.27	NA	2.45	NA	2.39	NA
Well Depth	feet, bgs	235	NA	235	NA	235	NA	235	NA	235	NA
pH	pH units	7.21	NA	7.28	NA	7.26	NA	7.19	NA	6.43	NA
Temperature	degree C	24.45	NA	22.86	NA	24.08	NA	23.80	NA	23.30	NA
Turbidity	NTU	0.3	NA	0.0	NA	0.0	NA	1.04	NA	0.0	NA
Specific Conductivity	uS/cm	1370	NA	1540	NA	1620	NA	1579	NA	3820	NA
Salinity	%	0.07	NA	0.08	NA	0.08	NA	0.079	NA	0.20	NA
Dissolved Oxygen	mg/L	5.96	NA	8.60	NA	7.75	NA	6.80	NA	7.67	NA
INORGANIC AND CONVENTIONAL PARAMETERS											
Chromium[1] (Dissolved)	mg/L	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--	--	--
Chromium (Total)	mg/L	--	--	--	--	--	--	--	--	--	--
Lead (Dissolved)	mg/L	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)
Lead (Total)	mg/L	--	--	--	--	--	--	--	--	--	--
Nickel (Dissolved)	mg/L	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)
Nickel (Total)	mg/L	--	--	--	--	--	--	--	--	--	--
Vanadium (Dissolved)	mg/L	0.0197	0.0200	0.0189	0.0202	0.0201	0.0202	0.0199	0.0204	0.0186	0.0190
Vanadium (Total)	mg/L	--	--	--	--	--	--	--	--	--	--
Chloride[2]	mg/L	--	--	--	--	--	--	290	280	330	330

Notes:

-- : constituent not analyzed

mg/L: milligrams per liter

MW: monitoring well

NA: not applicable

ND (XX): not detected (reporting limit)

URS, 2013. Letter - *Groundwater Monitoring Verification Sample Notification, Central Maui Landfill* . June 20.

[1] Chromium was removed from the assessment monitoring program on June 20, 2013 (URS, 2013), but reentered the program on December 5, 2014 (URS, 2014)

[2] Chloride entered the assessment monitoring program on 10/30/2013 (URS, 2013).

[3] MW-3 was not sampled on 7/17/2013 due to pump malfunction in the field.

TABLE 8
SUMMARY OF ASSESSMENT MONITORING ANALYTICAL RESULTS
CENTRAL MAUI LANDFILL

WELL NUMBER	UNITS	MW-2	MW-7	MW-2	MW-7	MW-2	MW-7	MW-3	MW-3	MW-3	MW-3	MW-3
DATE		12/5/2013	12/5/2013	4/9/2014	4/9/2014	7/9/2014	7/9/2014	6/27/2012	10/17/2012	12/17/2012	4/24/2013	7/17/2013 [3]
ANALYTE			Duplicate of MW-2		Duplicate of MW-2		Duplicate of MW-2					
FIELD PARAMETERS												
Static Water Level	feet, msl	2.65	NA	2.8	NA	2.74	NA	2.60	2.60	2.83	2.38	2.51
Well Depth	feet, bgs	235	NA	235	NA	235	NA	256.8	256.8	256.8	256.8	256.8
pH	pH units	7.40	NA	7.25	NA	7.09	NA	7.94	7.27	7.21	7.21	7.03
Temperature	degree C	23.08	NA	23.81	NA	24.13	NA	23.70	24.52	22.87	24.15	24.04
Turbidity	NTU	0.0	NA	0.63	NA	1.1	NA	1.4	0.9	5.4	0.0	1.69
Specific Conductivity	uS/cm	1690	NA	1707	NA	1580	NA	1180	1190	1300	1330	1281
Salinity	%	0.09	NA	0.086	NA	0.079	NA	0.03	0.06	0.06	0.07	0.06
Dissolved Oxygen	mg/L	8.44	NA	6.66	NA	8.16	NA	8.40	8.76	8.57	7.54	6.61
INORGANIC AND CONVENTIONAL PARAMETERS												
Chromium[1] (Dissolved)	mg/L	--	--	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND (0.0050)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--
Chromium (Total)	mg/L	--	--	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--	--	--	--
Lead (Dissolved)	mg/L	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND (0.0050)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--
Lead (Total)	mg/L	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--	--	--	--
Nickel (Dissolved)	mg/L	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND (0.010)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--
Nickel (Total)	mg/L	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--	--	--	--
Vanadium (Dissolved)	mg/L	0.0187	0.0191	0.0218	0.0216	0.0189	0.0197	ND (0.010)	0.0196	0.0188	0.0191	--
Vanadium (Total)	mg/L	0.0192	0.0193	0.0211	0.0208	0.0199	0.0197	--	--	--	--	--
Chloride[2]	mg/L	330	310	300	320	320	300	--	--	--	--	--

Notes:

-- : constituent not analyzed

mg/L: milligrams per liter

MW: monitoring well

NA: not applicable

ND (XX): not detected (reporting limit)

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[2] Chloride entered the assessment monitoring program on 10/30/2013 (URS, 2013).

[3] MW-3 was not sampled on 7/17/2013 due to pump malfunction in the field.

TABLE 8
SUMMARY OF ASSESSMENT MONITORING ANALYTICAL RESULTS
CENTRAL MAUI LANDFILL

WELL NUMBER	UNITS	MW-3	MW-3	MW-3	MW-3	MW-4	MW-4	MW-4	MW-4	MW-4	MW-4	MW-4
DATE		10/30/2013	12/5/2013	4/9/2014	7/9/2014	6/27/2012	10/17/2012	12/17/2012	4/24/2013	7/17/2013	10/30/2013	12/5/2013
ANALYTE												
FIELD PARAMETERS												
Static Water Level	feet, msl	2.26	2.46	2.67	2.58	2.81	2.83	2.99	2.56	2.73	2.69	2.91
Well Depth	feet, bgs	256.8	256.8	256.8	256.8	299.03	299.03	299.03	299.03	299.03	299.03	299.03
pH	pH units	6.45	7.49	7.17	7.14	7.87	7.28	7.51	7.26	7.04	6.44	7.45
Temperature	degree C	23.59	23.26	24.03	24.12	24.01	24.49	23.33	24.73	24.19	23.98	24.02
Turbidity	NTU	0.0	0.0	1.03	0.90	14.3	14.1	28.4	1.0	17.6	4.2	3.5
Specific Conductivity	uS/cm	2930	1270	1284	1213	1140	1130	1280	1310	1305	2870	1270
Salinity	%	0.15	0.06	0.064	0.060	0.03	0.06	0.06	0.06	0.07	0.15	0.06
Dissolved Oxygen	mg/L	7.82	7.35	6.65	6.54	8.68	7.94	7.89	7.48	5.81	7.11	8.17
INORGANIC AND CONVENTIONAL PARAMETERS												
Chromium[1] (Dissolved)	mg/L	--	--	ND(<0.0100)	ND(<0.0100)	0.0052	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--	ND(<0.0100)
Chromium (Total)	mg/L	--	--	ND(<0.0100)	ND(<0.0100)	--	--	--	--	--	0.150	0.0375
Lead (Dissolved)	mg/L	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND (0.0050)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)
Lead (Total)	mg/L	--	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--	--	--	--	ND(<0.0100)	ND(<0.0100)
Nickel (Dissolved)	mg/L	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	0.26	0.233	0.244	0.247	0.231	0.246	0.305
Nickel (Total)	mg/L	--	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--	--	--	--	0.249	0.251
Vanadium (Dissolved)	mg/L	0.0181	0.0190	0.0210	0.0196	ND (0.010)	0.0193	0.0187	0.0190	0.0188	0.0193	0.0181
Vanadium (Total)	mg/L	--	0.0191	0.0213	0.0202	--	--	--	--	--	0.0224	0.0192
Chloride[2]	mg/L	230	210	210	210	--	--	--	--	220	240	230

Notes:

-- : constituent not analyzed

mg/L: milligrams per liter

MW: monitoring well

NA: not applicable

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[2] Chloride entered the assessment monitoring program on 10/30/2013 (URS, 2013).

[3] MW-3 was not sampled on 7/17/2013 due to pump malfunction in the field.

TABLE 8
SUMMARY OF ASSESSMENT MONITORING ANALYTICAL RESULTS
CENTRAL MAUI LANDFILL

WELL NUMBER	UNITS	MW-4	MW-4	MW-5	MW-5	MW-5	MW-5	MW-5	MW-5	MW-5	MW-5	MW-5
DATE		4/9/2014	7/9/2014	6/27/2012	10/17/2012	12/17/2012	4/24/2013	7/17/2013	10/30/2013	12/5/2013	4/9/2014	7/9/2014
ANALYTE												
FIELD PARAMETERS												
Static Water Level	feet, msl	3.06	2.99	2.53	2.60	2.75	2.28	2.38	2.41	2.73	2.82	2.73
Well Depth	feet, bgs	299.03	299.03	237.51	237.51	237.51	237.51	237.51	237.51	237.51	237.51	237.51
pH	pH units	7.18	7.13	7.85	7.22	7.17	7.30	7.04	6.54	7.47	7.13	7.11
Temperature	degree C	24.17	24.31	23.23	23.95	22.64	23.89	23.65	25.53	23.20	23.55	23.82
Turbidity	NTU	24.6	14.3	10.1	15.5	16.6	3.0	7.62	1.0	0.0	2.01	3.48
Specific Conductivity	uS/cm	1285	1233	1170	1150	1320	1310	1300	3000	1290	1309	1210
Salinity	%	0.064	0.061	0.03	0.06	0.07	0.07	0.065	0.16	0.06	0.065	0.060
Dissolved Oxygen	mg/L	5.45	7.45	8.82	9.15	7.41	7.72	6.20	7.12	8.84	6.97	7.32
INORGANIC AND CONVENTIONAL PARAMETERS												
Chromium[1] (Dissolved)	mg/L	ND(<0.0100)	ND(<0.0100)	ND (0.0050)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--	--	ND(<0.0100)	ND(<0.0100)
Chromium (Total)	mg/L	0.0949	0.0569	--	--	--	--	--	--	--	0.0144	ND(<0.0100)
Lead (Dissolved)	mg/L	ND(<0.0100)	ND(<0.0100)	ND (0.0050)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)
Lead (Total)	mg/L	ND(<0.0100)	ND(<0.0100)	--	--	--	--	--	--	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)
Nickel (Dissolved)	mg/L	0.282	0.236	0.36	0.475	0.382	0.386	0.234	0.268	0.193	0.220	0.183
Nickel (Total)	mg/L	0.314	0.260	--	--	--	--	--	--	0.256	0.204	0.249
Vanadium (Dissolved)	mg/L	0.0203	0.0193	ND (0.010)	0.0152	0.0148	0.0147	0.0160	0.0156	0.0171	0.0188	0.0167
Vanadium (Total)	mg/L	0.0251	0.0215	--	--	--	--	--	--	0.0162	0.0187	0.0175
Chloride[2]	mg/L	220	240	--	--	--	--	240	240	230	220	190

Notes:

-- : constituent not analyzed

mg/L: milligrams per liter

MW: monitoring well

NA: not applicable

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[1] Chromium was removed from the assessment monitoring program on June 20, 2013 (URS, 2013), but reentered the program on December 5, 2014 (URS, 2014)

[2] Chloride entered the assessment monitoring program on 10/30/2013 (URS, 2013).

[3] MW-3 was not sampled on 7/17/2013 due to pump malfunction in the field.

TABLE 8
SUMMARY OF ASSESSMENT MONITORING ANALYTICAL RESULTS
CENTRAL MAUI LANDFILL

WELL NUMBER	UNITS	MW-6	MW-6	MW-6	MW-6	MW-6	MW-6	MW-6	MW-6	MW-6
DATE		6/27/2012	10/17/2012	12/17/2012	4/24/2013	7/17/2013	10/30/2013	12/5/2013	4/9/2014	7/9/2014
ANALYTE										
FIELD PARAMETERS										
Static Water Level	feet, msl	2.79	2.84	2.97	2.55	2.71	2.72	2.91	3.08	3.00
Well Depth	feet, bgs	314.09	314.09	314.09	314.09	314.09	314.09	314.09	314.09	314.09
pH	pH units	8.00	7.4	7.32	7.52	7.22	6.69	7.60	7.31	7.35
Temperature	degree C	22.76	23.84	22.35	23.86	23.50	23.08	22.75	23.43	23.58
Turbidity	NTU	10.2	8.0	4.6	0.5	10.8	3.8	0.0	5.76	3.94
Specific Conductivity	uS/cm	1040	918	1160	1150	1142	2630	1170	1192	1113
Salinity	%	0.03	0.05	0.06	0.06	0.057	0.14	0.06	0.059	0.055
Dissolved Oxygen	mg/L	8.41	8.69	8.02	7.63	7.83	8.69	8.34	6.80	7.55
INORGANIC AND CONVENTIONAL PARAMETERS										
Chromium[1] (Dissolved)	mg/L	ND (0.0050)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	--	--	--	ND(<0.0100)	ND(<0.0100)
Chromium (Total)	mg/L	--	--	--	--	--	--	--	0.0440	0.0220
Lead (Dissolved)	mg/L	ND (0.0050)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)
Lead (Total)	mg/L	--	--	--	--	--	--	ND(<0.0100)	ND(<0.0100)	ND(<0.0100)
Nickel (Dissolved)	mg/L	0.10	0.108	0.0922	0.0932	0.0762	0.0689	0.0830	0.0919	0.0885
Nickel (Total)	mg/L	--	--	--	--	--	--	0.0764	0.0977	0.0919
Vanadium (Dissolved)	mg/L	ND (0.010)	0.0235	0.0215	0.0231	0.0231	0.0234	0.0228	0.0254	0.0236
Vanadium (Total)	mg/L	--	--	--	--	--	--	0.0233	0.0277	0.0250
Chloride[2]	mg/L	--	--	--	--	180	180	170	170	170

Notes:

-- : constituent not analyzed

mg/L: milligrams per liter

MW: monitoring well

NA: not applicable

ND (XX): not detected (reporting limit)

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[3] MW-3 was not sampled on 7/17/2013 due to pump malfunction in the field.

Appendix G
Groundwater Data

Table G-1

Summary of Field and Analytical Results: MW-1

Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2000 Upper Shewhart-Cusum Control Limits**	**2005 Upper Shewhart-Cusum Control Limits**	**2010 Upper Shewhart-Cusum Control Limits**	**2010 Poisson Prediction Limits**	**2016 Upper Predictive Limits**	**MW-1 10/20/1995**	**MW-1 10/26/1995**	**MW-1 11/15/1995**	**MW-1 11/15/1995 Duplicate**	**MW-1 2/22/1996**	**MW-1 4/19/1996**	**MW-1 6/5/1996**	**MW-1 8/29/1996**	**MW-1 12/30/1996**	**MW-1 3/20/1997**	**MW-1 6/26/1997**	**MW-1 9/24/1997**	**MW-1 1/13/1998**	**MW-1 3/3/1998**	**MW-1 6/30/1998**
FIELD PARAMETERS																					
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	NC	3.69	3.24	3.39		3.38	3.58	3.08	3.29	-16.89	4.11	NA	NA	NA	NA	8.76[2]
Well Depth	feet, btoc	NC	NC	NC	NC	NC	320.12	320.12	320.12		320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12
pH	pH units	NC	NC	NC	NC	NC	NA	7.4	7.4		7.6	7.8	7.5	7.2	7.6	7.8	7.0	6.8	7.4	7.3	7.12
Temperature	degree C	NC	NC	NC	NC	NC	NA	25.0	25.0		24.0	25.0	26.0	26.0	24.3	25.0	25.0	25.0	26.3	24.6	24.5
Turbidity	NTU	NC	NC	NC	NC	NC	NA	4.80	1.82		1.98	2.86	0.45	0.47	7.20	7.17	9	10	1	1	10
Specific Conductivity	µS/cm	NC	NC	NC	NC	NC	NA	900	800		600	790	700	360	1174	873	1210	820	1070	960	1060
Salinity	%	NC	NC	NC	NC	NC	NA	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.04
Dissolved Oxygen	mg/L	NC	NC	NC	NC	NC	NA	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA	7.78	4.96	5.69
INORGANIC AND CONVENTIONAL PARAMETERS																					
Ammonia (as N)	mg/L	NC	NC	NC	NC	NC	0.12	0.14	0.12	0.11	0.1	0.16	0.18	ND (0.03)	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	74.21	tbd	20.72	NC	76.3	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	17	55	11	8.8	ND (1)	ND (2)	ND (1)	1	1.5	1.1	1.73
Nitrate-N	mg/L	6.48	6.77	6.90	NC	10.2	5.1	3.9	4.6	4.6	4.3	4.7	5	4.8	5.0	4.51	6.4/5.7[1]	4.93	5.03	5.1	4.51
Chloride	mg/L	240.21	tbd	tbd	tbd	287	190	181	174	174	132	190	183	159	176	175	205	185	174	168	165
Sulfate	mg/L	78.04	tbd	tbd	tbd	74.1	39	59	35	35	30	31	31	34	32.2	32	31.6	31.8	25.5	29.1	26.7
Alkalinity	mg/L	440.82	tbd	tbd	tbd	550	243	240	350	330	362	347	326	286	267	292	334	321	292	262	296
Total Dissolved Solids	mg/L	4661.46	934.74	865.53	NC	975	690	702	**4910**	**729**	664	699	704	661	662	674	752	816	677	707	651
Antimony	mg/L	NC	NC	NC	NC	NC	0.009	0.009	0.007	0.006	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	26.93	23.97	tbd	tbd	29.5	20	23	22	22	17	22	19	21	21.6	21.1	20.2	21	18.2	19.1	19.9
Magnesium	mg/L	38.97	35.38	35.39	NC	47.6	26	31	29	28	21	30	26	29	30.1	29.9	29.5	31.1	26.8	27.8	27.7
Iron	mg/L	0.385	NC	NC	0.49	NC	0.27	0.15	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.040)	ND (0.040)	ND (0.040)	0.0888	0.152	0.102	ND (0.05)
Manganese	mg/L	0.149	NC	NC	0.21	NC	0.15	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.007)	ND (0.007)	ND (0.007)	ND (0.007)	0.00883	ND (0.007)	0.00906
Potassium	mg/L	24.55	tbd	19.28	NC	20.9	**24**	9.8	12	12	13	12	15	12	13.5	13.5	12.6	12.6	11.3	11.8	12.3
Selenium	mg/L	NC	NC	NC	NC	NC	0.006	0.006	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	0.006	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NC	0.004	0.004	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	246.2	208.64	213.17	NC	242	190	188	180	180	172	180	186	166	171	172	191	188	151	160	152
VOLATILE ORGANIC PARAMETERS																					
EPA Test Method 8260	mg/L	NC	NC	NC	NC	NC	ND (0.005)	ND (0.005)	NA	NA	NA	NA	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.001)
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	NC	NA	NA	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NC	NA	NA	ND (0.001)	ND (0.001)	ND (0.0005)	ND (0.0005)	ND (0.0005)	0.0028	NA	NA	NA	NA	NA	NA	NA
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	ND (0.0005)	ND (0.0005)	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	ND (0.0005)	0.0031	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																					
Chromium	mg/L	NC	NC	NC	NC	NC	0.009	0.008	ND (0.003)	ND (0.003)	ND (0.003)	ND (0.003)	ND (0.003)	ND (0.003)	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NC	0.011	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	TBD	0.003	ND (0.003)	ND (0.003)	ND (0.003)	ND (0.003)	ND (0.003)	0.008	ND (0.003)	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	0.0349	0.028	0.023	0.019	0.019	NA	0.021	0.022	0.022	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	0.0983	0.019	0.11	0.022	0.014	ND (0.01)	ND (0.01)	0.15	0.013	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius

% = percent

µS/cm = microsiemen(s) per centimeter

amsl = above mean sea level

bgs = below ground surface

CUSUM = cumulative summation

EPA = U.S. Environmental Protection Agency

ft = feet

J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011), or the parameter was analyzed outside of its associated holding time (12/17/2012)

mg/L = milligram(s) per liter

msl = mean sea level

MW = monitoring well

NA = not analyzed or measured

NC = not calculated

ND (XX) = not detected (reporting limit)

NTU = nephelometric turbidity units

PVC = polyvinyl chloride

tbd = to be determined

Baseline data collected 10/20/95 through 8/29/96. Post-Baseline data collected 12/30/96 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Nitrate analysis conducted by two different laboratories using the same method (6/26/97).

[2] Wells were reconditioned, but not resurveyed (6/30/98). Historical well elevation data for 8-inch casing at 303.23 feet above msl was used to determine static water level.

[3] 1.684 correction factor used for portion of missing tape and stretch factor for measurements over 175 feet (6/22/99 through 12/9/99).

[4] MW-1 pump was repaired and PVC piping position adjusted, well was not professionally surveyed (6/29/01).

[5] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 303.45 feet above msl (9/20/01), applicable for groundwater elevation calculations until 7/2014.
Potentiometric surfaces have been recalculated (303.38 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[6] VOC detected is toluene (6/29/01). VOCs have no control limits, as any detection triggers verification sampling.

[7] Water quality meter could not be calibrated for dissolved oxygen, results are not accurate (3/20/02 and 3/26/03).

[8] Water quality meter could not be calibrated for pH, results are not accurate (6/17/04).

[9] Values were revised from previous report due to amended laboratory report (6/28/05).

[10] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[11] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[12] Corrected well depths (ft bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-1
Summary of Field and Analytical Results: MW-1
Central Maui Landfill

WELL NUMBER DATE ANALYTE	**Units**	**2000 Upper Shewhart-Cusum Control Limits**	**2005 Upper Shewhart-Cusum Control Limits**	**2010 Upper Shewhart-Cusum Control Limits**	**2010 Poisson Prediction Limits**	**MW-1 9/30/1998**	**MW-1 12/17/1998**	**MW-1 3/23/99**	**MW-1 6/22/99**	**MW-1 9/15/1999**	**MW-1 12/9/1999**	**MW-1 3/30/2000**	**MW-1 6/14/2000**	**MW-1 9/12/2000**	**MW-1 12/12/2000**	**MW-1 3/20/2001**	**MW-1 6/29/2001**	**MW-1 9/20/2001**	**MW-1 12/11/2001**
FIELD PARAMETERS																			
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	1.84	2.48	3.17	2.75[3]	3.17[3]	2.96[3]	2.74	2.56	2.32	2.50	3.03	2.21[4]	2.84[6]	3.27
Well Depth	feet, btoc	NC	NC	NC	NC	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12
pH	pH units	NC	NC	NC	NC	7.22	7.13	6.69	7.03	7.28	7.18	7.37	7.50	7.61	7.36	NA	7.34	7.54	7.30
Temperature	degree C	NC	NC	NC	NC	24.2	24.5	24.1	24.4	25	24.3	24.1	24.2	24.2	24.2	NA	24.7	24.2	23.8
Turbidity	NTU	NC	NC	NC	NC	10	9	10	7	5	5	-10	9	10	5	NA	10	0	0
Specific Conductivity	µS/cm	NC	NC	NC	NC	1180	967	1160	1110	1090	1100	1430	903	1160	1040	NA	866	933	1000
Salinity	%	NC	NC	NC	NC	0.05	0.04	0.05	0.05	0.04	0.04	0.06	0.03	0.05	0.04	NA	0.03	0.04	0.04
Dissolved Oxygen	mg/L	NC	NC	NC	NC	4.98	5.09	6.33	5.40	4.35	5.76	5.19	5.28	6.16	5.81	NA	9.68	6.28	6.50
INORGANIC AND CONVENTIONAL PARAMETERS																			
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	74.21	tbd	20.72	NC	1.0	ND (1)	7.2	7.6	2.6	36	40.2	23.2	4.17	ND (4.00)	NA	2.54	ND (2.00)	1.60
Nitrate-N	mg/L	6.48	6.77	6.90	NC	5.0	4.5	4.5	NA	4.4	4.5	**924**	5.74 / 5.22	4.42	4.16	NA	5.40	4.44	4.56
Chloride	mg/L	240.21	tbd	tbd	tbd	150	170	180	190	170	180	166	155	164	162	NA	173	169	87.9
Sulfate	mg/L	78.04	tbd	tbd	tbd	27	31	34	27	ND (0.02)	31	25.4	15.3	ND (10.0)	32.1	NA	ND (50.0)	22.5	ND (20.0)
Alkalinity	mg/L	440.82	tbd	tbd	tbd	280	290	280	310	280	290	280	276	273	271	NA	283	269	27.7
Total Dissolved Solids	mg/L	4661.46	934.74	865.53	NC	610	670	680	690	750	720	660	666	662	638	NA	602	696	602
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	26.93	23.97	tbd	tbd	21	20	23	20	20	NA	19.7	21.2	21.0	20.1	NA	20.3	19.4	19.3
Magnesium	mg/L	38.97	35.38	35.39	NC	31	29	33	29	29	30	28.9	27.7	28.5	29.4	NA	30.1	29.5	29.2
Iron	mg/L	0.385	NC	NC	0.49	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	NA	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.149	NC	NC	0.21	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	NA	ND (0.05)	ND (0.05)	ND (0.05)
Potassium	mg/L	24.55	tbd	19.28	NC	14	12	14	12	12	13	13.9	14.2	14.0	13.7	NA	14.1	17.3	15.1
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	246.2	208.64	213.17	NC	**230**	170	180	170	170	170	159	173	171	169	NA	165.0	173.0	171.0
VOLATILE ORGANIC PARAMETERS																			
EPA Test Method 8260	mg/L	NC	NC	NC	NC	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005-0.01)	ND (0.005)	ND(0.005-0.01)	ND (0.005-0.01)	ND (0.005-0.01)	ND (0.002-0.01)	ND (0.002-0.01)	NA	**0.0146**[5]	ND (<0.00652)	ND (0.002-0.01)
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																			
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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ft = feet
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011), or the parameter was analyzed outside of its associated holding time (12/17/2012)
mg/L = milligram(s) per liter
msl = mean sea level
MW = monitoring well
NA = not analyzed or measured
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined

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Central Maui Landfill

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FIELD PARAMETERS																		
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	3.13	2.84	3.12	2.98	3.05	2.94	3.15	3.64	3.20	2.91	3.28	4.74	2.64
Well Depth	feet, btoc	NC	NC	NC	NC	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12
pH	pH units	NC	NC	NC	NC	6.86	6.89	6.83	6.62	6.69	6.43	7.29	8.83 [8]	7.47	7.28	7.31	7.51	7.25
Temperature	degree C	NC	NC	NC	NC	23.7	23.9	24.3	23.9	22.8	23.7	23.7	24.3	23.80	24.30	25.85	23.91	24.5
Turbidity	NTU	NC	NC	NC	NC	6	3	3	3	1	4	2	3	8.70	2.50	0	0	0.0
Specific Conductivity	µS/cm	NC	NC	NC	NC	937	1190	1110	1370	932	1130	970	1160	1100	1200	1190	1190	1160
Salinity	%	NC	NC	NC	NC	0.04	0.04	0.05	0.06	0.04	0.05	0.04	0.05	0.10	0.10	0.05	0.05	0.05
Dissolved Oxygen	mg/L	NC	NC	NC	NC	0.35 [7]	6.00	6.05	6.25	0.08 [7]	5.96	6.91	6.44	12.57	8.64	5.97	7.39	5.31
INORGANIC AND CONVENTIONAL PARAMETERS																		
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	74.21	tbd	20.72	NC	4.50	ND (8.00)	9.08	7.71	10.5	7.28	19.8	8.1	12.4	4.69 [9]	2.1	7.5	1.7
Nitrate-N	mg/L	6.48	6.77	6.90	NC	4.25	4.90	4.74	4.75	4.94	4.69	4.62	5.5	4.81	4.20	5.25	4.46	3.80
Chloride	mg/L	240.21	tbd	tbd	tbd	177	176	174	157	174	166	182	167	167	157	205	189	180
Sulfate	mg/L	78.04	tbd	tbd	tbd	24	25.0	23.9	25.7	24.3	24.2	24.6	27.5	23.1	23.8	23.8	23.2	23
Alkalinity	mg/L	440.82	tbd	tbd	tbd	282	270	274	282	280	276	278	266	272	286	282	270	280
Total Dissolved Solids	mg/L	4661.46	934.74	865.53	NC	648	**904**	610	602	666	646	706	688	692	648	622	772	660
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	26.93	23.97	tbd	tbd	20.0	20.3	21.0	20.1	19.3	18.9	20.8	20.1	20.1	20.4	20.5	17.0	18.3
Magnesium	mg/L	38.97	35.38	35.39	NC	30.0	31.2	31.0	29.5	29.1	27.2	31.1	31.0	30.9	31.4	32.2	26.2	29.1
Iron	mg/L	0.385	NC	NC	0.49	ND (0.3)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
Manganese	mg/L	0.149	NC	NC	0.21	ND (0.01)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	24.55	tbd	19.28	NC	13.0	15.8	15.3	17.1	15.6	12.9	14.0	15.4	12.5	13.9	14.3	10.9	12.4
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	246.2	208.64	213.17	NC	170.0	174.0	176.0	163.0	176.0	152.0	159.0	167.0	170.0	186.0	185.0	201.0	159.0
VOLATILE ORGANIC PARAMETERS																		
EPA Test Method 8260	mg/L	NC	NC	NC	NC	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																		
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

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°C = degrees Celsius

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MW = monitoring well

NA = not analyzed or measured

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Potentiometric surfaces have been recalculated (303.38 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

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[11] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[12] Corrected well depths (ft bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-1

Summary of Field and Analytical Results: MW-1

Central Maui Landfill

WELL NUMBER DATE ANALYTE	Units	2000 Upper Shewhart-Cusum Control Limits	2005 Upper Shewhart-Cusum Control Limits	2010 Upper Shewhart-Cusum Control Limits	2010 Poisson Prediction Limits	MW-1 6/7/2007	MW-1 12/12/2007	MW-1 6/11/2008	MW-1 12/16/2008	MW-1 6/3/2009	MW-1 12/9/2009	MW-1 6/17/2010	MW-1 12/28/2010	MW-1 6/29/2011	MW-1 12/19/2011	MW-1 6/27/2012
FIELD PARAMETERS																
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	2.67	2.85	2.89	2.18	2.60	2.89	1.65	3.47	3.10	3.11	3.01
Well Depth	feet, btoc	NC	NC	NC	NC	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12
pH	pH units	NC	NC	NC	NC	6.76	7.16	7.32	7.48	6.93	7.19	7.34	7.14	7.33	7.45	7.95
Temperature	degree C	NC	NC	NC	NC	24.5	24.09	24.31	24.1	23.59	24.06	24.24	25.89	25.55	23.46	23.76
Turbidity	NTU	NC	NC	NC	NC	--[10]	0.0	0.0	3	1.2	--[10]	21.4	1.1	0.0	3.9	2.7
Specific Conductivity	µS/cm	NC	NC	NC	NC	1300	1200	1210	1260	1258	1200	1134	1160	1220	1200	1120
Salinity	%	NC	NC	NC	NC	0.1	0.05	0.06	0.1	0.063	0.03	0.056	0.0006	0.06	0.03	0.03
Dissolved Oxygen	mg/L	NC	NC	NC	NC	6.10	8.27	6.68	6.08	8.65	8.05	8.37	6.38	7.66	9.86	7.63
INORGANIC AND CONVENTIONAL PARAMETERS																
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA
Total Organic Carbon	mg/L	74.21	tbd	20.72	NC	2.0	2.0	ND (1.0)	ND (1.0)	1.1	1.1	4.8	ND (1.0)	5.3	NA	ND (1.0)
Nitrate-N	mg/L	6.48	6.77	6.90	NC	4.43	4.56	5.45	4.41 [11]	5.27	4.58	5.93	**15.2**	5.02 / 5.24	NA	5.41
Chloride	mg/L	240.21	tbd	tbd	tbd	200	190	180	180	190	180	180	190	190	NA	200 J
Sulfate	mg/L	78.04	tbd	tbd	tbd	26	24	24	22	26	27	25	25	29	NA	28
Alkalinity	mg/L	440.82	tbd	tbd	tbd	270	278	262	274	294	254	260	240	240	NA	44 J
Total Dissolved Solids	mg/L	4661.46	934.74	865.53	NC	610	726	650	666	736	670	646	660	680	NA	616
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA
Calcium	mg/L	26.93	23.97	tbd	tbd	18.7	22.7	19.1	21.3	20.0	19	20	19	21	NA	19.8
Magnesium	mg/L	38.97	35.38	35.39	NC	28.8	**35.6**	30.4	30.3	30.1	29.5	30	30	33	NA	30.6
Iron	mg/L	0.385	NC	NC	0.49	ND (0.05)	0.169	ND (0.0500)	ND (0.0500)	ND (0.0500)	ND (0.0500)	ND (0.0500)	ND (0.040)	ND (0.040)	NA	ND (0.10)
Manganese	mg/L	0.149	NC	NC	0.21	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.00500)	ND (0.00500)	ND (0.00500)	ND (0.007) [12]	ND (0.020)	NA	ND (0.0050)
Potassium	mg/L	24.55	tbd	19.28	NC	12.8	14.7	13.2	13.7	12.3	13.5	12.1	13	14	NA	13.3
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA
Sodium	mg/L	246.2	208.64	213.17	NC	160.0	174.0	175	165	156	174	165	180	180	NA	176
VOLATILE ORGANIC PARAMETERS																
EPA Test Method 8260	mg/L	NC	NC	NC	NC	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.00050-0.010)	ND (0.00050-0.020)	NA	ND (0.0010 - 0.0020)
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND (0.01)	ND (0.005)
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND (0.01)	ND (0.005)
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND (0.01)	ND (0.01)
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0204	ND (0.01)
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

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NA = not analyzed or measured

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Table G-1

Summary of Field and Analytical Results: MW-1

Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2000 Upper Shewhart-Cusum Control Limits**	**2005 Upper Shewhart-Cusum Control Limits**	**2010 Upper Shewhart-Cusum Control Limits**	**2010 Poisson Prediction Limits**	**MW-1** **10/17/2012**	**MW-1** **12/17/2012**	**MW-1** **4/24/2013**	**MW-1** **7/17/2013**	**MW-1** **10/30/2013**	**MW-1** **12/5/2013**	**MW-1** **4/9/2014**	**MW-1** **7/9/2014**	**MW-1** **10/27/2014**	**MW-1** **12/15/2014**	**MW-1** **3/9/2015**	**MW-1** **6/22/2015**	**MW-1** **9/21/2015**
FIELD PARAMETERS																		
Groundwater Elevation	feet, amsl	NC	NC	NC	NC		3.18		2.93	2.96	3.09	3.30	3.22	3.11	3.19	3.4	3.43	3.47
Well Depth	feet, btoc	NC	NC	NC	NC		320.12		320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12
pH	pH units	NC	NC	NC	NC		7.27		7.19	6.67	7.57	7.29	7.29	7.34	7.29	7.45	7.24	7.09
Temperature	degree C	NC	NC	NC	NC		23.02		24.07	23.64	23.59	23.93	24.15	24.1	24.02	23.9	24.1	24.2
Turbidity	NTU	NC	NC	NC	NC		0.0		1.21	0.0	0.0	1.16	1.03	0.51	0.47	0.62	0.85	0.43
Specific Conductivity	µS/cm	NC	NC	NC	NC		1230		1226	2840	1250	1277	1190	1025	1186	1190	1020	1240
Salinity	%	NC	NC	NC	NC		0.06		0.06	0.15	0.06	0.064	0.059	0.059	0.051	0.059	0.05	0.063
Dissolved Oxygen	mg/L	NC	NC	NC	NC		7.90		6.29	7.75	8.42	7.28	7.87	6.09	7.14	7.05	6.19	6.89
INORGANIC AND CONVENTIONAL PARAMETERS																		
Ammonia (as N)	mg/L	NC	NC	NC	NC		NA	NA	NA	NA	NA	NA		NA	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Total Organic Carbon	mg/L	74.21	tbd	20.72	NC	NA	ND (1.0)	15	**22**	20	**30**	**27**	4.3	**24**	**22**	17	**26**	ND (1)
Nitrate-N	mg/L	6.48	6.77	6.90	NC	NA	5.07	4.2 J	4.9 J	NA	5.0 J	NA	5.3 BU	NA	5.7	5.5	4.9	5.5
Chloride	mg/L	240.21	tbd	tbd	tbd	NA	190	210	220	220	210	210	210	210	220	220	230	230
Sulfate	mg/L	78.04	tbd	tbd	tbd	NA	26	13	30	NA	31	NA	28	NA	30	46	27	29
Alkalinity	mg/L	440.82	tbd	tbd	tbd	NA	220	230	228	NA	230	NA	232	NA	227	231	224	229
Total Dissolved Solids	mg/L	4661.46	934.74	865.53	NC	NA	710	685	695	NA	730	NA	660	NA	680	605	755	585
Antimony	mg/L	NC	NC	NC	NC		NA	NA	NA	NA	NA	NA	ND (0.015)	NA	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Calcium	mg/L	26.93	23.97	tbd	tbd	NA	19	20.2	20.5	NA	21.9	NA	22.6	NA	21.3	19.8	23.5	21.6
Magnesium	mg/L	38.97	35.38	35.39	NC	NA	31	33.4	33.7	NA	**35.4**	**36.7**	**36.8**	33.6	32.3	33.6	34.9	**37.2**
Iron	mg/L	0.385	NC	NC	0.49	NA	ND (0.040)	ND (0.100)	ND (0.100)	NA	ND (0.100)	NA	ND (0.100)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.149	NC	NC	0.21	NA	ND (0.020)	ND (0.00500)	ND (0.00500)	NA	ND (0.00500)	NA	ND (0.00500)	NA	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	24.55	tbd	19.28	NC	NA	14	13.3	13.7	NA	14.7	NA	14.2	NA	13.8	13.9	16.8	15
Selenium	mg/L	NC	NC	NC	NC		NA	NA	NA	NA	NA	NA	ND (0.015)	NA	ND (0.015)	ND (0.015)	ND (0.015)	0.0184
Silver	mg/L	NC	NC	NC	NC		NA	NA	NA	NA	NA	NA	ND (0.005)	NA	ND (0.005)	ND (0.005)	0.0054	ND (0.005)
Sodium	mg/L	246.2	208.64	213.17	NC	NA	170	178	177	NA	185	NA	183	NA	178	180	202	190
VOLATILE ORGANIC PARAMETERS																		
EPA Test Method 8260	mg/L	NC	NC	NC	NC	NA	ND (0.0010 - 0.150)	ND (0.00050 - 0.10)	ND (0.00050 - 0.020)	NA	ND (0.00050 - 0.050)	NA	ND (0.00050 - 0.050)	NA	ND	ND	ND	ND
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND
ADDITIONAL ANALYTES (Assessment/Verification)																		
Chromium	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	NA	NA	NA	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Vanadium	mg/L	NC	NC	NC	NC	0.0204	0.02	0.0205	0.0198	0.02	0.0203	0.0227	0.021	0.0206	0.0191	0.0197	0.0198	0.0212
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	ND (0.01)	0.0231	ND (0.01)	ND (0.01)	0.0173

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[12] Corrected well depths (ft bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-1

Summary of Field and Analytical Results: MW-1

Central Maui Landfill

WELL NUMBER DATE ANALYTE	Units	2000 Upper Shewhart-Cusum Control Limits	2005 Upper Shewhart-Cusum Control Limits	2010 Upper Shewhart-Cusum Control Limits	2010 Poisson Prediction Limits	MW-1 12/2/2015	MW-1 3/23/2016	MW-1 6/8/2016	MW-1 9/13/2016	MW-1 12/19/2016	MW-1 3/20/2017	MW-1 6/19/2017	MW-1 9/20/2017	MW-1 12/18/2017	MW-1 3/12/2018
FIELD PARAMETERS															
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	3.52	3.33	3.40	3.33	3.33	3.24	3.18	3.29	3.34	2.92
Well Depth	feet, btoc	NC	NC	NC	NC	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12	320.12
pH	pH units	NC	NC	NC	NC	7.27	7.22	6.65	7.26	6.7	7.07	7.21	7.02	7.66	7.12
Temperature	degree C	NC	NC	NC	NC	24.12	23.6	24.21	22.9	24.14	24.09	19.12	23.17	24.00	22.90
Turbidity	NTU	NC	NC	NC	NC	0.35	0.72	0.5	0.61	3.75	1.87	0	0	0.0	0.0
Specific Conductivity	µS/cm	NC	NC	NC	NC	1243	1196	1221	1170	1240	1164	0.93	1.18	1100	1130
Salinity	%	NC	NC	NC	NC	0.062	0.059	0.061	0.058	0.062	0.058	0	0.06	0.05	0.06
Dissolved Oxygen	mg/L	NC	NC	NC	NC	5.75	7.46	7.04	8.40	8.49	7.51	11.18	9.78	9.50	7.10
INORGANIC AND CONVENTIONAL PARAMETERS															
Ammonia (as N)	mg/L	NC	NC	NC	NC	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Total Organic Carbon	mg/L	74.21	tbd	20.72	NC	0.98	1	0.92	1.1	0.65	ND (0.50)	0.56	0.82	ND (0.50)	ND (0.50)
Nitrate-N	mg/L	6.48	6.77	6.90	NC	5.8	5.6	5.9	6.1	4.5	5.0	5.0	5.7	6.5	3.0
Chloride	mg/L	240.21	tbd	tbd	tbd	230	210	190	200	170	180	170	170	170	170
Sulfate	mg/L	78.04	tbd	tbd	tbd	ND (0.1)	25	26	24	23	24	24	23	23	24
Alkalinity	mg/L	440.82	tbd	tbd	tbd	221	232	236	231	232	242	242	242	250	240
Total Dissolved Solids	mg/L	4661.46	934.74	865.53	NC	635	660	685	665	640	660	660	645	610	610
Antimony	mg/L	NC	NC	NC	NC	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	0.0444
Calcium	mg/L	26.93	23.97	tbd	tbd	21.3	21	21.8	20.8	20.0	21.6	21.1	18.2	19.1	19.8
Magnesium	mg/L	38.97	35.38	35.39	NC	**35.7**	**35.4**	36.4	33.5	32.6	33.2	32.5	31.5	31.4	31.5
Iron	mg/L	0.385	NC	NC	0.49	0.118	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.149	NC	NC	0.21	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND	ND	ND (0.005)	ND (0.005)
Potassium	mg/L	24.55	tbd	19.28	NC	14.8	14.1	14.1	14.0	13.7	15.3	14.2	12.6	13.1	13.7
Selenium	mg/L	NC	NC	NC	NC	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Silver	mg/L	NC	NC	NC	NC	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Sodium	mg/L	246.2	208.64	213.17	NC	187	181	182	172	166	187	175	163	162	174
VOLATILE ORGANIC PARAMETERS															
EPA Test Method 8260	mg/L	NC	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	mg/L	NC	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	mg/L	NC	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ADDITIONAL ANALYTES (Assessment/Verification)															
Chromium	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Vanadium	mg/L	NC	NC	NC	NC	0.0215	0.0208	0.0235	0.0223	0.021	0.0221	0.0233	0.0215	0.0218	0.0225
Zinc	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	0.0755	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius

% = percent

µS/cm = microsiemen(s) per centimeter

amsl = above mean sea level

bgs = below ground surface

CUSUM = cumulative summation

EPA = U.S. Environmental Protection Agency

ft = feet

J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011), or the parameter was analyzed outside of its associated holding time (12/17/2012)

mg/L = milligram(s) per liter

msl = mean sea level

MW = monitoring well

NA = not analyzed or measured

NC = not calculated

ND (XX) = not detected (reporting limit)

NTU = nephelometric turbidity units

PVC = polyvinyl chloride

tbd = to be determined

Baseline data collected 10/20/95 through 8/29/96. Post-Baseline data collected 12/30/96 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Nitrate analysis conducted by two different laboratories using the same method (6/26/97).

[2] Wells were reconditioned, but not resurveyed (6/30/98). Historical well elevation data for 8-inch casing at 303.23 feet above msl was used to determine static water level

[3] 1.684 correction factor used for portion of missing tape and stretch factor for measurements over 175 feet (6/22/99 through 12/9/99).

[4] MW-1 pump was repaired and PVC piping position adjusted, well was not professionally surveyed (6/29/01).

[5] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 303.45 feet above msl (9/20/01), applicable for groundwater elevati
Potentiometric surfaces have been recalculated (303.38 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014

[6] VOC detected is toluene (6/29/01). VOCs have no control limits, as any detection triggers verification sampling.

[7] Water quality meter could not be calibrated for dissolved oxygen, results are not accurate (3/20/02 and 3/26/03).

[8] Water quality meter could not be calibrated for pH, results are not accurate (6/17/04).

[9] Values were revised from previous report due to amended laboratory report (6/28/05).

[10] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[11] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[12] Corrected well depths (ft bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-2
Summary of Field and Analytical Results: MW-2
Central Maui Landfill

WELL NUMBER	**Units**	**2000**	**2005**	**2010**	**2010**	**2016**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**
DATE							**10/20/1995**	**10/26/1995**	**11/15/1995**	**11/15/1995**	**2/22/1996**	**4/19/1996**	**6/5/1996**	**8/29/1996**	**12/30/1996**	**3/20/1997**	**6/26/1997**	**9/24/1997**	**1/13/1998**	**3/3/1998**
ANALYTE		**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Poisson Prediction Limits**	**Upper Predictive Limits**				**Duplicate**										
FIELD PARAMETERS																				
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	NC	3.44	2.99	3.10		3.08	3.28	2.75	2.99	-17.45	3.76	NA	NA	NA	NA
Well Depth	feet, btoc	NC	NC	NC	NC	NC	240.78	240.78	240.78		240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78
pH	pH units	NC	NC	NC	NC	NC	7.4	7.4	7.5		7.2	7.3	7.4	7.3	7.8	7.6	7.1	6.9	7.4	7.03
Temperature	degree C	NC	NC	NC	NC	NC	26	26	24.9		24	25	25	26	22.9	24.6	24.0	24.6	23.9	23.8
Turbidity	NTU	NC	NC	NC	NC	NC	7.2	8.7	6.1		2.48	4.13	0.43	1.8	2.5	0.81	1	10	3	2
Specific Conductivity	µS/cm	NC	NC	NC	NC	NC	850	1000	910		800	800	650	420	1375	1177	1360	1530	1410	1290
Salinity	%	NC	NC	NC	NC	NC	NA	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved Oxygen	mg/L	NC	NC	NC	NC	NC	NA	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA	5.17	NA
INORGANIC AND CONVENTIONAL PARAMETERS																				
Ammonia (as N)	mg/L	NC	NC	NC	NC	NC	0.11	0.66	0.15	0.11	0.16	0.11	0.17	0.09	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	79.76	tbd	29.68	NC	69.3	3.2	6.7	ND (3.0)	ND (3.0)	17	**59**	12	10	ND (1)	ND (2)	1.1	ND(1)	ND(1)	1.2
Nitrate-N	mg/L	8.52	11.51	tbd	tbd	25.9	3.3	4	4.5	4.6	4.6	5.2	4.9	4.8	5.4	5.64	6.8/5.52[1]	5.29	6.02	6
Chloride	mg/L	323.46	305.23	tbd	tbd	505	212	216	215	213	155	269	245	212	234	254	240	251	251	235
Sulfate	mg/L	100.36	73.32	71.99	NC	300	71	63	38	37	38	42	39	40	39.7	45.7	40	39.7	33.9	38.2
Alkalinity	mg/L	518.39	tbd	tbd	tbd	501	239	240	353	350	395	409	377	309	300	355	390	352	286	294
Total Dissolved Solids	mg/L	1450.14	1107.86	1,074.88	NC	1400	744	744	**1400**	**746**	877	930	873	801	803	882	835	970	800	892
Antimony	mg/L	NC	NC	NC	NC	NC	0.011	0.018	0.008	0.009	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	NA	NA	NA	NA	NA	NA
Calcium	mg/L	32.1	27.88	tbd	tbd	38.6	20	20	22	22	24	25	20	24	22.8	24.3	21.1	25.5	22.9	24.2
Magnesium	mg/L	49.7	46.49	45.68	NC	72.9	29	30	32	32	35	40	31	35	35.9	40.1	32.3	39	35	36
Iron	mg/L	0.447	0.53	0.29	NC	NC	0.15	0.23	ND (0.10)	ND (0.10)	0.23	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.040)	ND (0.040)	ND (0.040)	ND (0.040)	ND (0.040)	0.0806
Manganese	mg/L	0.095	NC	NC	0.21	NC	ND (0.05)	0.07	ND (0.05)	ND (0.05)	0.06	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.007)	ND(0.007)	ND(0.007)	ND (0.007)	ND (0.007)	ND (0.007)
Potassium	mg/L	20.25	tbd	21.66	NC	25.1	11	13	14	14	14	12	15	15	14.2	14.4	12.5	15.4	13	13.5
Selenium	mg/L	NC	NC	NC	NC	NC	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	0.011	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NC	ND (0.001)	0.002	0.18	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	NA	NA	NA	NA	NA	NA
Sodium	mg/L	288.36	264.23	272.14	NC	379	219	208	206	202	162	245	229	208	205	230	186	217	194	206
VOLATILE ORGANIC PARAMETERS																				
EPA Test Method 8260	mg/L	NC	NC	NC	NC	NC	ND (0.005)	ND (0.005)	NA	NA	NA	NA	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	NC	NA	NA	ND (0.001)	ND (0.001)	ND (0.0005)	ND (0.0005)	ND (0.0005)	ND (0.0005)	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NC	NA	NA	ND (0.001)	ND (0.001)	ND (0.0005)	ND (0.0005)	ND (0.0005)	0.0016	NA	NA	NA	NA	NA	NA
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	ND (0.0005)	ND (0.0005)	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	ND (0.0005)	0.0032	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																				
Chromium	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	0.0298	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	0.0349	NA	0.021	0.018	0.018	NA	0.016	0.017	0.02	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	0.184	NA	0.11	0.022	0.014	ND (0.01)	ND (0.01)	0.15	0.013	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius

% = percent

µS/cm = microsiemen(s) per centimeter

amsl = above mean sea level

bgs = below ground surface

CUSUM = cumulative summation

Duplicate = the duplicate sample collected for MW-2 is referred to as "MW-4" up through 2003 and "MW-7"

after 2003 in the semiannual reports for Central Maui Landfill

EPA = U.S. Environmental Protection Agency

J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),

of its associated holding time (12/17/2012), or the parameter was analyzed outside

mg/L = milligram(s) per liter

MW = monitoring well

NA = not analyzed or measured

NC = not calculated

ND (XX) = not detected (reporting limit)

NTU = nephelometric turbidity units

PVC = polyvinyl chloride

tbd = to be determined

TOC = top of casing

Baseline data collected 10/20/95 through 8/29/96. Post-Baseline data collected 12/30/96 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Nitrate analysis conducted by two different laboratories using same method (6/26/97).

[2] Wells were reconditioned, but not resurveyed (6/30/98). Historical well elevation data for 8-inch casing at 223.41 feet above msl was used to determine static water level.

[3] 1.684 feet correction factor used for portion of missing tape and stretch factor for measurements over 175 feet (6/22/99 through 12/9/99).

[4] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 223.06 feet above mean sea level (msl) (9/20/01), applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (223.96 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[5] Well reconditioned, but not resurveyed (3/20/02). 8-inch TOC surveyed elevation (224.02 feet above msl) used with sounding tube TOC field measurement (223.81 feet above msl).

[6] Water quality meter could not be calibrated for dissolved oxygen, results are not accurate (3/20/02 and 3/26/03).

[7] Values were revised from previous report due to amended laboratory report (6/28/05).

[8] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[9] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[10] Corrected well depths (ft bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-2

Summary of Field and Analytical Results: MW-2

Central Maui Landfill

WELL NUMBER	**Units**	**2000**	**2005**	**2010**	**2010**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**	**MW-2**
DATE **ANALYTE**		**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Poisson Prediction Limits**	**6/30/1998**	**9/30/1998**	**12/17/1998**	**3/23/1999**	**6/22/1999**	**9/15/1999**	**12/9/1999**	**3/30/2000**	**6/14/2000**	**9/12/2000**	**12/12/2000**	**3/20/2001**	**6/29/2001**	**9/20/2001**
FIELD PARAMETERS																			
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	3.26[2]	1.59	3.32	3.35	2.92[3]	3.35[3]	3.16[3]	2.84	2.65	2.13	2.36	2.85	1.89	2.46[4]
Well Depth	feet, btoc	NC	NC	NC	NC	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78
pH	pH units	NC	NC	NC	NC	6.98	7.09	7.05	6.78	6.88	7.06	7.40	7.09	7.20	7.36	6.94	7.15	7.18	7.29
Temperature	degree C	NC	NC	NC	NC	24.1	24	23.8	23.3	23.9	24.1	24.0	23.9	23.8	23.8	23.5	23.8	23.8	23.8
Turbidity	NTU	NC	NC	NC	NC	10	10	9	10	10	10	1	-10	54	10	1	0	10	2
Specific Conductivity	µS/cm	NC	NC	NC	NC	1290	1310	1200	1400	1330	1310	1320	1680	1310	1330	1210	1310	1270	1330
Salinity	%	NC	NC	NC	NC	0.05	0.06	0.05	0.05	0.06	0.06	0.06	0.07	0.06	0.06	0.05	0.05	0.05	0.06
Dissolved Oxygen	mg/L	NC	NC	NC	NC	5.5	4.14	5.15	5.64	5.40	3.54	5.31	4.51	4.46	5.27	4.85	5.45	4.3	5.45
INORGANIC AND CONVENTIONAL PARAMETERS																			
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	79.76	tbd	29.68	NC	ND (1)	ND (1)	1.2	9.4	14	**38**	**32**	**33.9**	26.2	6.29	ND (8.0)	9.74	3.08	ND (2.00)
Nitrate-N	mg/L	8.52	11.51	tbd	tbd	5.07	5.20	4.8	5.3	NA	5.2	4.8	1120	6.39 / 6.53	5.06	4.47	3.00	5.71	5.03
Chloride	mg/L	323.46	305.23	tbd	tbd	231	200	230	230	230	230	230	210	192	200	195	197	219	211
Sulfate	mg/L	100.36	73.32	71.99	NC	37.1	31.0	40	45	33	ND (0.02)	39	30.4	22.6	ND (10.0)	37.2	29.1	ND (50.0)	27.4
Alkalinity	mg/L	518.39	tbd	tbd	tbd	317	310	310	320	330	290	300	292	289	285	284	290	281	286
Total Dissolved Solids	mg/L	1450.14	1107.86	1,074.88	NC	749	690	700	780	790	860	760	774	782	748	760	706	652	764
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	32.1	27.88	tbd	tbd	28.8	25	22	22	22	22	NA	23.2	24.6	23.4	23.3	23.6	23.5	24.0
Magnesium	mg/L	49.7	46.49	45.68	NC	41.9	39	32	33	33	34	34	32.9	32.4	30.2	32.5	33.2	33.2	34.9
Iron	mg/L	0.447	0.53	0.29	NC	ND (0.5)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.51)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.143	0.178	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.095	NC	NC	0.21	0.00577	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
Potassium	mg/L	20.25	tbd	21.66	NC	17.1	15	13	13	13	13	15	15.7	15.8	14.9	15.1	15.4	15.5	19.4
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	288.36	264.23	272.14	NC	237	220	200	190	200	190	200	186	202	184	190	200	188	193.0
VOLATILE ORGANIC PARAMETERS																			
EPA Test Method 8260	mg/L	NC	NC	NC	NC	ND (0.001)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND(0.005-0.01)	ND(0.005-0.01)	ND(0.005-0.01)	ND(0.002-0.01)	ND(0.002-0.01)	ND(0.002-0.01)	ND(0.002-0.01)	ND (<0.0071)
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																			
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius

% = percent

µS/cm = microsiemen(s) per centimeter

amsl = above mean sea level

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CUSUM = cumulative summation

Duplicate = the duplicate sample collected for MW-2 is referred to as "MW-4" up through 2003 and "MW-7"

after 2003 in the semiannual reports for Central Maui Landfill

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J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),

of its associated holding time (12/17/2012), or the parameter was analyzed outside

mg/L = milligram(s) per liter

MW = monitoring well

NA = not analyzed or measured

NC = not calculated

ND (XX) = not detected (reporting limit)

NTU = nephelometric turbidity units

PVC = polyvinyl chloride

tbd = to be determined

TOC = top of casing

Baseline data collected 10/20/95 through 8/29/96. Post-Baseline data collected 12/30/96 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Nitrate analysis conducted by two different laboratories using same method (6/26/97).

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[3] 1.684 feet correction factor used for portion of missing tape and stretch factor for measurements over 175 feet (6/22/99 through 12/9/99).

[4] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 223.06 feet above mean sea level (msl) (9/20/01), applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (223.96 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

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[9] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[10] Corrected well depths (ft bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-2
Summary of Field and Analytical Results: MW-2
Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2000 Upper Shewhart-Cusum Control Limits**	**2005 Upper Shewhart-Cusum Control Limits**	**2010 Upper Shewhart-Cusum Control Limits**	**2010 Poisson Prediction Limits**	**MW-2 12/11/2001**	**MW-2 3/20/2002**	**MW-2 6/19/2002**	**MW-2 9/12/2002**	**MW-2 12/17/2002**	**MW-2 3/26/2003**	**MW-2 6/18/2003**	**MW-2 12/18/2003**	**MW-2 6/17/2004**	**MW-2 12/15/2004**	**MW-2 6/28/2005**	**MW-2 12/8/2005**	**MW-2 6/22/2006**
FIELD PARAMETERS																		
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	2.90	2.8[5]	2.52	2.81	2.66	2.75	2.6	2.83	3.25	2.90	2.53	2.90	2.01
Well Depth	feet, btoc	NC	NC	NC	NC	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78
pH	pH units	NC	NC	NC	NC	7.18	6.75	6.56	6.68	6.3	6.52	6.19	6.83	7.33	7.00	6.88	7.21	7.35
Temperature	degree C	NC	NC	NC	NC	23.6	23.5	23.3	23.8	23.8	23.0	23.8	23.9	25.1	23.60	23.9	25.53	23.70
Turbidity	NTU	NC	NC	NC	NC	0	0	2	4	4	1	5	3	60	0.00	1.2	0	0
Specific Conductivity	µS/cm	NC	NC	NC	NC	936	1340	1340	1330	1300	1540	1470	1160	1680	1500	1630	1430	1500
Salinity	%	NC	NC	NC	NC	0.04	0.06	0.06	0.06	0.06	0.07	0.06	0.05	0.07	0.10	0.10	0.07	0.07
Dissolved Oxygen	mg/L	NC	NC	NC	NC	5.45	0.17[6]	5.63	6.15	6.15	0.08[6]	5.52	6.17	7.87	10.78	6.94	7.30	6.80
INORGANIC AND CONVENTIONAL PARAMETERS																		
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	79.76	tbd	29.68	NC	1.10	1.10	ND (8.00)	9.02	10.2	11.3	8.46	12.4	10.0	ND (2.0)	8.7[7]	2.3	8.2
Nitrate-N	mg/L	8.52	11.51	tbd	tbd	4.99	4.82	5.95	5.64	5.5	7.17	6.58	5.90	11.3	7.50	7.9	7.92	6.92
Chloride	mg/L	323.46	305.23	tbd	tbd	257	227	231	221	218	268	230	231	268	163	227	270	249
Sulfate	mg/L	100.36	73.32	71.99	NC	33.7	38	34.0	31.5	34	40.2	38.4	33.2	43.2	38.60	38.2	35.9	34.0
Alkalinity	mg/L	518.39	tbd	tbd	tbd	27.9	290	278	286	294	304	302	298	298	282	290	284	278
Total Dissolved Solids	mg/L	1450.14	1107.86	1,074.88	NC	702	806	866	734	666	886	812	808	946	882	834	774	746
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	32.1	27.88	tbd	tbd	24.2	24.0	24.7	25.0	23.8	24.3	23.9	22.6	23.2	23.6	23.2	22.8	21.3
Magnesium	mg/L	49.7	46.49	45.68	NC	34.4	33.0	35.9	35.0	33.7	38.2	35.4	34.4	44.8	38.3	38.5	37.2	33.4
Iron	mg/L	0.447	0.53	0.29	NC	0.109	ND (0.3)	0.127	ND (0.05)	ND (0.05)	ND (0.05)	**0.328**	ND (0.05)	0.0971	ND (0.05)	**0.542**	0.0631 / ND (<0.05)	ND (0.05)
Manganese	mg/L	0.095	NC	NC	0.21	ND (0.05)	ND (0.01)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	0.0105	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	20.25	tbd	21.66	NC	17.5	14.0	17.6	17.3	19.1	18.3	14.4	14.8	17.4	13.5	14.7	15.1	12.6
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	288.36	264.23	272.14	NC	190.0	190.0	207.0	204.0	191.0	243.0	201.0	181.0	236.0	212.0	235.0	214.0	257.0
VOLATILE ORGANIC PARAMETERS																		
EPA Test Method 8260	mg/L	NC	NC	NC	NC	ND(0.002-0.01)	ND(0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																		
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.
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°C = degrees Celsius
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EPA = U.S. Environmental Protection Agency
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),
of its associated holding time (12/17/2012), or the parameter was analyzed outside
mg/L = milligram(s) per liter
MW = monitoring well
NA = not analyzed or measured
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined
TOC = top of casing

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[4] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 223.06 feet above mean sea level (msl) (9/20/01), applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (223.96 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[5] Well reconditioned, but not resurveyed (3/20/02). 8-inch TOC surveyed elevation (224.02 feet above msl) used with sounding tube TOC field measurement (223.81 feet above msl).

[6] Water quality meter could not be calibrated for dissolved oxygen, results are not accurate (3/20/02 and 3/26/03).

[7] Values were revised from previous report due to amended laboratory report (6/28/05).

[8] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[9] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[10] Corrected well depths (ft bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-2
Summary of Field and Analytical Results: MW-2
Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2000 Upper Shewhart-Cusum Control Limits**	**2005 Upper Shewhart-Cusum Control Limits**	**2010 Upper Shewhart-Cusum Control Limits**	**2010 Poisson Prediction Limits**	**MW-2 12/13/2006**	**MW-2 6/7/2007**	**MW-2 12/12/2007**	**MW-2 6/11/2008**	**MW-2 12/16/2008**	**MW-2 6/3/2009**	**MW-2 12/9/2009**	**MW-2 6/17/2010**	**MW-2 12/28/2010**	**MW-2 6/29/2011**	**MW-2 12/19/2011**
FIELD PARAMETERS																
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	2.28	2.26	3.18	1.76	2.47	2.13	2.48	1.16	3.01	2.61	2.66
Well Depth	feet, btoc	NC	NC	NC	NC	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78
pH	pH units	NC	NC	NC	NC	7.20	5.68	7.05	7.19	7.35	6.94	7.14	7.18	7.13	7.24	7.32
Temperature	degree C	NC	NC	NC	NC	24.3	24.2	23.85	24.00	23.9	23.1	24.40	23.82	25.64	25.24	23.42
Turbidity	NTU	NC	NC	NC	NC	4.1	--[8]	0.0	0.0	1	0.8	--[8]	14	0.0	0.0	1.4
Specific Conductivity	µS/cm	NC	NC	NC	NC	1460	1700	1460	1540	1530	1414	1500	1370	1360	1490	1420
Salinity	%	NC	NC	NC	NC	0.07	0.1	0.07	0.07	0.1	0.071	0.05	0.068	0.7	0.07	0.04
Dissolved Oxygen	mg/L	NC	NC	NC	NC	5.06	8.08	7.63	6.14	5.39	8.02	9.68	7.55	5.86	7.44	9.64
INORGANIC AND CONVENTIONAL PARAMETERS																
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	79.76	tbd	29.68	NC	2.3	1.8	1.7	1.2	ND (1.0)	1.1	ND (1.0)	3.0	ND (1.0)	5.7	ND (1.0)
Nitrate-N	mg/L	8.52	11.51	tbd	tbd	7.45	8.93	8.46	9.67	7.25	8.33	6.73	8.42	11.8	9.03	8.83
Chloride	mg/L	323.46	305.23	tbd	tbd	260	270	250	250	250	240	250	250	230	250	260
Sulfate	mg/L	100.36	73.32	71.99	NC	38	44	36	38	35	37	40	37	40	42	46
Alkalinity	mg/L	518.39	tbd	tbd	tbd	272	274	272	252	265	256	252	240	240	230	42 J
Total Dissolved Solids	mg/L	1450.14	1107.86	1,074.88	NC	780	868	838	824	816	806	794	766	760	800	766
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	32.1	27.88	tbd	tbd	21.4	20.6	23.4	21.8	22.4	23.8	22.4	22.4	22	22	21.8
Magnesium	mg/L	49.7	46.49	45.68	NC	34.4	33.4	39.0	36.4	33.8	35.5	33.9	33.7	34	37	34.9
Iron	mg/L	0.447	0.53	0.29	NC	ND (0.05)	ND (0.05)	ND (0.05)	0.0841	ND (0.05)	ND (0.0500)	ND (0.0500)	**0.463**	ND (0.040)	0.11	ND (0.10)
Manganese	mg/L	0.095	NC	NC	0.21	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.00500)	ND (0.00500)	0.0146	ND (0.007) [10]	ND (0.020)	ND (0.0050)
Potassium	mg/L	20.25	tbd	21.66	NC	13.3	13.5	14.9	14.1	13.9	13.5	14.1	13.3	15	15	14.6
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	288.36	264.23	272.14	NC	190.0	188.0	193	196	197	174	195	182	210	220	212
VOLATILE ORGANIC PARAMETERS																
EPA Test Method 8260	mg/L	NC	NC	NC	NC	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.00050-0.010)	ND (0.00050-0.020)	ND (0.0010 - 0.0020)
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

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Potentiometric surfaces have been recalculated (223.96 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

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Summary of Field and Analytical Results: MW-2
Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2000 Upper Shewhart-Cusum Control Limits**	**2005 Upper Shewhart-Cusum Control Limits**	**2010 Upper Shewhart-Cusum Control Limits**	**2010 Poisson Prediction Limits**	**MW-2 3/20/2012**	**MW-2 6/27/2012**	**MW-2 10/17/2012**	**MW-2 12/17/2012**	**MW-2 4/24/2013**	**MW-2 7/17/2013**	**MW-2 10/30/2013**	**MW-2 12/5/2013**	**MW-2 4/9/2014**	**MW-2 7/9/2014**	**MW-2 10/27/2014**
FIELD PARAMETERS																
Groundwater Elevation	feet, amsl	NC	NC	NC	NC		2.47		2.72		2.45		2.65	2.8	2.74	2.87
Well Depth	feet, btoc	NC	NC	NC	NC		240.78		240.78		240.78		240.78	240.78	240.78	240.78
pH	pH units	NC	NC	NC	NC		7.82		7.28		7.19		7.40	7.25	7.09	7.18
Temperature	degree C	NC	NC	NC	NC		23.24		22.86		23.80		23.08	23.81	24.13	24
Turbidity	NTU	NC	NC	NC	NC		0.0		0.0		1.04		0.0	0.63	1.1	0.47
Specific Conductivity	µS/cm	NC	NC	NC	NC		1440		1540		1579		1690	1707	1580	1395
Salinity	%	NC	NC	NC	NC		0.04		0.08		0.079		0.09	0.086	0.079	0.07
Dissolved Oxygen	mg/L	NC	NC	NC	NC		7.32		8.60		6.80		8.44	6.66	8.16	7.26
INORGANIC AND CONVENTIONAL PARAMETERS																
Ammonia (as N)	mg/L	NC	NC	NC	NC		NA		NA		NA		NA	NA	NA	NA
Total Organic Carbon	mg/L	79.76	tbd	29.68	NC	NA	1.8	NA	15	NA	18	NA	**30**	26	15	25
Nitrate-N	mg/L	8.52	11.51	tbd	tbd	NA	10.2	NA	7.9 J	NA	11 J	NA	13 J	NA	12 BU	NA
Chloride	mg/L	323.46	305.23	tbd	tbd	NA	260	NA	280	NA	290	NA	330	300	320	320
Sulfate	mg/L	100.36	73.32	71.99	NC	NA	46	NA	27	NA	46	NA	58	NA	48 J	NA
Alkalinity	mg/L	518.39	tbd	tbd	tbd	NA	200	NA	226	NA	223	NA	213	NA	214	NA
Total Dissolved Solids	mg/L	1450.14	1107.86	1,074.88	NC	NA	880	NA	880	NA	930	NA	1010	NA	810	NA
Antimony	mg/L	NC	NC	NC	NC		NA		NA		NA		NA	NA	NA	NA
Calcium	mg/L	32.1	27.88	tbd	tbd	NA	21	NA	22.1	NA	23.7	NA	24.2	NA	23.5	NA
Magnesium	mg/L	49.7	46.49	45.68	NC	NA	36	NA	37.2	NA	40.7	NA	43.6	NA	41.5	42.6
Iron	mg/L	0.447	0.53	0.29	NC	NA	ND (0.040)	NA	ND (0.100)	NA	ND (0.100)	NA	ND (0.100)	NA	ND (0.100)	ND (0.1)
Manganese	mg/L	0.095	NC	NC	0.21	NA	ND(0.020)	NA	ND (0.00500)	NA	ND (0.00500)	NA	ND (0.00500)	NA	ND (0.00500)	NA
Potassium	mg/L	20.25	tbd	21.66	NC	NA	15	NA	14.0	NA	15.3	NA	15.8	NA	14.6	NA
Selenium	mg/L	NC	NC	NC	NC		NA		NA		NA		NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC		NA		NA		NA		NA	NA	NA	NA
Sodium	mg/L	288.36	264.23	272.14	NC	NA	230	NA	218	NA	239	NA	249	NA	232	NA
VOLATILE ORGANIC PARAMETERS																
EPA Test Method 8260	mg/L	NC	NC	NC	NC	NA	ND (0.0010 - 0.150)	NA	ND (0.00050 - 0.10)	NA	ND (0.00050 - 0.020)	NA	ND (0.00050 - 0.050)	ND (0.00050 - 0.050)	ND (0.00050 - 0.050)	NA
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																
Chromium	mg/L	NC	NC	NC	NC	ND (0.005)	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.01)	NA	NA	NA	ND (0.01)	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	0.018	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Vanadium	mg/L	NC	NC	NC	NC	0.021	ND (0.01)	0.0197	0.0189	0.0201	0.0199	0.0186	0.0187	0.0218	0.0189	0.0186
Zinc	mg/L	NC	NC	NC	NC	ND (0.02)	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0512

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius

% = percent

µS/cm = microsiemen(s) per centimeter

amsl = above mean sea level

bgs = below ground surface

CUSUM = cumulative summation

Duplicate = the duplicate sample collected for MW-2 is referred to as "MW-4" up through 2003 and "MW-7"

after 2003 in the semiannual reports for Central Maui Landfill

EPA = U.S. Environmental Protection Agency

J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),

of its associated holding time (12/17/2012), or the parameter was analyzed outside

mg/L = milligram(s) per liter

MW = monitoring well

NA = not analyzed or measured

NC = not calculated

ND (XX) = not detected (reporting limit)

NTU = nephelometric turbidity units

PVC = polyvinyl chloride

tbd = to be determined

TOC = top of casing

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Nitrate analysis conducted by two different laboratories using same method (6/26/97).

[2] Wells were reconditioned, but not resurveyed (6/30/98). Historical well elevation data for 8-inch casing at 223.41 feet above msl was used to determine static water level.

[3] 1.684 feet correction factor used for portion of missing tape and stretch factor for measurements over 175 feet (6/22/99 through 12/9/99).

[4] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 223.06 feet above mean sea level (msl) (9/20/01), applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (223.96 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[5] Well reconditioned, but not resurveyed (3/20/02). 8-inch TOC surveyed elevation (224.02 feet above msl) used with sounding tube TOC field measurement (223.81 feet above msl).

[6] Water quality meter could not be calibrated for dissolved oxygen, results are not accurate (3/20/02 and 3/26/03).

[7] Values were revised from previous report due to amended laboratory report (6/28/05).

[8] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[9] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[10] Corrected well depths (ft bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-2
Summary of Field and Analytical Results: MW-2
Central Maui Landfill

WELL NUMBER DATE ANALYTE	Units	2000 Upper Shewhart-Cusum Control Limits	2005 Upper Shewhart-Cusum Control Limits	2010 Upper Shewhart-Cusum Control Limits	2010 Poisson Prediction Limits	MW-2 12/16/2104	MW-2 3/9/2015	MW-2 6/22/2015	MW-2 9/21/2015	MW-2 12/2/2015	MW-2 3/23/2016	MW-2 6/8/2016	MW-2 9/13/2016	MW-2 12/19/2016	MW-2 3/20/2017	MW-2 6/19/2017	MW-2 9/20/2017	MW-2 12/18/2017	MW-2 3/12/2018
FIELD PARAMETERS																			
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	2.91	3.17	3.15	3.19	3.34	3.06	3.23	3.22	3.33	3.15	3.1	3.2	3.23	2.85
Well Depth	feet, btoc	NC	NC	NC	NC	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78	240.78
pH	pH units	NC	NC	NC	NC	7.19	7.09	7.09	7.07	7.14	7.04	6.67	7.12	6.59	6.84	7.74	6.97	7.46	6.90
Temperature	degree C	NC	NC	NC	NC	23.99	23.8	23.9	24	22.87	23.5	24.18	22.9	24.11	24.05	19.18	27.17	22.89	23.03
Turbidity	NTU	NC	NC	NC	NC	0.53	0.34	0.48	0.14	0.29	0.79	0.3	0.39	0.2	1.01	0	0	0	0
Specific Conductivity	µS/cm	NC	NC	NC	NC	1669	1710	1450	1780	1731	1711	1789	1710	1240	1740	1.71	1.7	1790	1700
Salinity	%	NC	NC	NC	NC	0.084	0.086	0.073	0.092	0.088	0.087	0.08	0.086	0.092	0.088	0	0.09	0.09	0.09
Dissolved Oxygen	mg/L	NC	NC	NC	NC	7.3	6.64	7.48	6.39	5.17	7.84	6.3	8.09	7.16	6.97	10.01	7.63	8.05	6.55
INORGANIC AND CONVENTIONAL PARAMETERS																			
Ammonia (as N)	mg/L	NC	NC	NC	NC	ND (0.1)	0.11	ND (0.1)	ND (0.1)	0.11	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.11
Total Organic Carbon	mg/L	79.76	tbd	29.68	NC	20	22	23	1.9	2.4	2.7	2.5	2.4	2.2	2.1	2.7	3.1	2.4	2.0
Nitrate-N	mg/L	8.52	11.51	tbd	tbd	10	15	6.9	14	11	10	11	13.0	8.7	11.0	11.0	12.0	13	5.2
Chloride	mg/L	323.46	305.23	tbd	tbd	320	340	350	350	340	340	360	380.0	340.0	360.0	370.0	390.0	370.0	340.0
Sulfate	mg/L	100.36	73.32	71.99	NC	42	**190**	58	59	51	53	55	54	49	56	59	60	58 J	54 J
Alkalinity	mg/L	518.39	tbd	tbd	tbd	210	221	202	193	200	208	210	202	204	213	212	208	227	220
Total Dissolved Solids	mg/L	1450.14	1107.86	1,074.88	NC	870	825	1020	805	765	950	880	990	885	1280	1010	955	920	910
Antimony	mg/L	NC	NC	NC	NC	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	0.0215
Calcium	mg/L	32.1	27.88	tbd	tbd	25	26.4	28.3	26.9	27.8	25.6	25.2	25.8	24.1	26.6	27.3	26.5	26.6	24.1
Magnesium	mg/L	49.7	46.49	45.68	NC	38.5	**48.8**	45.1	**50.3**	**49.4**	**49.7**	48.8	46.8	42.3	47.6	49.2	47.4	46.7	44.8
Iron	mg/L	0.447	0.53	0.29	NC	ND (0.1)	0.103	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.095	NC	NC	0.21	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	20.25	tbd	21.66	NC	15.8	17.1	19	17.5	18.4	15.3	15.0	15.9	15.4	17.3	16.7	16.4	15.9 J	15.2
Selenium	mg/L	NC	NC	NC	NC	ND (0.015)	ND (0.015)	ND (0.015)	0.0191	0.0173	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Silver	mg/L	NC	NC	NC	NC	ND (0.005)	ND (0.005)	0.0054	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Sodium	mg/L	288.36	264.23	272.14	NC	233	264	267	**280**	**277**	240	239	241	236	267	268	265	260	242
VOLATILE ORGANIC PARAMETERS																			
EPA Test Method 8260	mg/L	NC	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
EPA Test Method 601, 602	mg/L	NC	NC	NC	NC	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
EPA Test Method 524.2	mg/L	NC	NC	NC	NC	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ADDITIONAL ANALYTES (Assessment/Verification)																			
Chromium	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	0.0104	0.0166	0.0127	0.0183	0.0244	0.0218	0.0210	0.0228	0.0187
Vanadium	mg/L	NC	NC	NC	NC	0.0172	0.0193	0.0178	0.0189	0.0215	0.0195	0.0209	0.0190	0.0181	0.0204	0.0201	0.0185	0.0179	0.0195
Zinc	mg/L	NC	NC	NC	NC	0.0156	0.0212	0.0118	0.0385	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	0.0284	ND (0.01)	ND (0.01)	0.0129 B	ND (0.01)

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.
2016 Upper Predictive Limits are used on events past June 2016.
°C = degrees Celsius
% = percent
µS/cm = microsiemen(s) per centimeter
amsl = above mean sea level
bgs = below ground surface
CUSUM = cumulative summation
Duplicate = the duplicate sample collected for MW-2 is referred to as "MW-4" up through 2003 and "MW-7"
after 2003 in the semiannual reports for Central Maui Landfill
EPA = U.S. Environmental Protection Agency
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),
of its associated holding time (12/17/2012), or the parameter was analyzed outside
mg/L = milligram(s) per liter
MW = monitoring well
NA = not analyzed or measured
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined
TOC = top of casing

Baseline data collected 10/20/95 through 8/29/96. Post-Baseline data collected 12/30/96 through present.
Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Nitrate analysis conducted by two different laboratories using same method (6/26/97).

[2] Wells were reconditioned, but not resurveyed (6/30/98). Historical well elevation data for 8-inch casing at 223.41 feet above msl was used to determine static water level.

[3] 1.684 feet correction factor used for portion of missing tape and stretch factor for measurements over 175 feet (6/22/99 through 12/9/99).

[4] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 223.06 feet above mean sea level (msl) (9/20/01), applicable for groundwater elevation calculations until 7/2014.
Potentiometric surfaces have been recalculated (223.96 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[5] Well reconditioned, but not resurveyed (3/20/02). 8-inch TOC surveyed elevation (224.02 feet above msl) used with sounding tube TOC field measurement (223.81 feet above msl).

[6] Water quality meter could not be calibrated for dissolved oxygen, results are not accurate (3/20/02 and 3/26/03).

[7] Values were revised from previous report due to amended laboratory report (6/28/05).

[8] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[9] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[10] Corrected well depths (ft bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-3
Summary of Field and Analytical Results: MW-3
Central Maui Landfill

WELL NUMBER	Units	2000	2005	2010	2010	2016	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3
DATE		**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Poisson Prediction Limits**	**Upper Predictive Limits**	**10/20/1995**	**10/26/1995**	**11/15/1995**	**11/15/1995**	**2/22/1996**	**4/19/1996**	**6/5/1996**	**8/29/1996**	**12/30/1996**	**3/20/1997**	**6/26/1997**	**9/24/1997**	**1/13/1998**	**3/3/1998**	**6/30/1998**	**9/30/1998**	**12/17/1998**	**3/23/1999**	**6/22/1999**
ANALYTE										**Duplicate**															
FIELD PARAMETERS																									
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	NC	3.49	3.09	3.21	3.21	3.21	3.40	2.86	3.08	4.05	3.95	- -	- -	NA	NA	4.36 [2]	3.82	3.78	3.84	3.42 [3]
Well Depth	feet, btoc	NC	NC	NC	NC	NC	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51
pH	pH units	NC	NC	NC	NC	NC	NA	7.4	7.5	7.1	7.2	7.2	7.4	7.1	7.8	7.8	6.84	6.74	6.95	7.03	6.81	6.95	6.83	6.61	6.89
Temperature	degree C	NC	NC	NC	NC	NC	NA	24	24.9	25.2	25	26	26	26	23.2	25.6	24.2	24.6	23.9	24	24.1	24.5	24	23.7	23.9
Turbidity	NTU	NC	NC	NC	NC	NC	NA	3.3	2.3	2.1	1.5	1.74	1.34	0.48	3.5	7.59	4	10	3	3	10	10	10	10	5
Specific Conductivity	µS/cm	NC	NC	NC	NC	NC	NA	850	800	800	650	680	580	360	1215	953	1060	1180	1120	1000	1070	1110	963	1190	1120
Salinity	%	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.04	0.05	0.04	0.06	0.05
Dissolved Oxygen	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.24	NA	5.06	9.02	4.96	4.58	5.51
INORGANIC AND CONVENTIONAL PARAMETERS																									
Ammonia (as N)	mg/L	NC	NC	NC	NC	NC	0.09	0.15	0.09	0.12	0.09	0.06	0.14	0.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	66.63	54.95	49.43	NC	76	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	17	27	15	9.9	ND (1)	4.8	34	ND (1)	3.1	1.2	1.17	ND (1)	ND (1)	3.7	20
Nitrate-N	mg/L	6.09	6.61	tbd	tbd	10.3	4.5	3.6	4.2	4.3	3.9	4.3	4.4	4.5	4.6	4.03	5.4/4.48[1]	4.2	4.82	4.86	4.33	4.0	4.5	4.2	NA
Chloride	mg/L	235.56	tbd	210.60	NC	282	186	168	163	164	132	177	169	152	**215**	183	177	171	176	175	171	170	170	180	160
Sulfate	mg/L	73.2	tbd	tbd	tbd	75.3	36	52	32	33	29	35	28	31	35	31.8	27.6	30	26.5	28	26.9	24	31	34	24
Alkalinity	mg/L	461.44	tbd	tbd	tbd	560	245	239	356	350	379	339	350	294	253	297	300	304	353	315	318	290	290	290	300
Total Dissolved Solids	mg/L	1471.58	795.99	tbd	tbd	1080	662	672	1300	1240	695	687	705	628	711	693	666	672	710	715	666	630	670	680	660
Antimony	mg/L	NC	NC	NC	NC	NC	0.048	0.007	0.01	0.008	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	31.8	tbd	tbd	tbd	27.7	22	24	25	24	25	27	22	26	27.5	26.7	25.5	25.4	25.3	25.6	23.6	26	24	27	24
Magnesium	mg/L	39.77	36.14	36.35	NC	40.7	25	27	29	29	28	31	25	30	33.6	33	30.2	31.2	31.4	30.8	28.5	32	30	33	30
Iron	mg/L	0.359	NC	NC	0.52	NC	ND (0.10)	0.12	ND (0.10)	ND (0.10)	0.27	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.040)	0.0622	0.0802	0.0852	ND (0.040)	0.0813	ND (0.05)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.064	NC	NC	0.21	NC	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.007)	ND (0.007)	ND (0.007)	ND (0.007)	ND (0.007)	ND (0.007)	ND (0.005)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
Potassium	mg/L	22.48	tbd	tbd	tbd	18.5	21	9.5	12	12	12	11	14	14	12.5	11.6	11.6	12.1	12.5	12.2	11.6	13	12	13	12
Selenium	mg/L	NC	NC	NC	NC	NC	ND (0.005)	ND (0.005)	0.011	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	0.011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NC	ND (0.001)	ND (0.001)	0.009	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	203.99	197.63	199.41	NC	217	180	181	172	170	165	173	167	160	172	166	155	160	160	156	144	170	160	170	160
VOLATILE ORGANIC PARAMETERS																									
EPA 8260	mg/L	NC	NC	NC	NC	NC	ND (0.005)	ND (0.005)	NA	NA	NA	NA	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.001)	ND (0.0005)	ND (0.005)	ND (0.005)	ND (0.01)
EPA 601, 602	mg/L	NC	NC	NC	NC	NC	NA	NA	ND (0.001)	ND (0.001)	ND (0.0005)	ND (0.0005)	ND (0.0005)	ND (0.0005)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NC	NA	NA	ND (0.001)	ND (0.001)	ND (0.0005)	ND (0.0005)	ND (0.0005)	0.0012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA 524.2	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	ND (0.0005)	ND (0.0005)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	ND (0.0005)	0.0032	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																									
Chromium	mg/L	NC	NC	NC	NC	NC	0.003	0.006	0.004	0.006	ND (0.003)	ND (0.003)	ND (0.003)	ND (0.003)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NC	0.005	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	TBD	ND (0.003)	ND (0.003)	0.033	ND (0.003)	ND (0.003)	ND (0.003)	NA	ND (0.003)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	0.0291	0.019	0.018	0.005	0.017	NA	0.015	0.018	0.019	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	0.239	0.019	0.03	0.14	0.015	ND (0.01)	ND (0.01)	0.034	ND (0.01)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius
°C = degrees Celsius
% = percent
µS/cm = microsiemen(s) per centimeter
amsl = above mean sea level
bgs = below ground surface
CUSUM = cumulative summation
EPA = U.S. Environmental Protection Agency
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),
or the parameter was analyzed outside of its associated holding time (12/17/2012)
mg/L = milligram(s) per liter
msl = mean sea level
MW = monitoring well
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined
VOC = volatile organic compound

Baseline data collected 10/20/95 through 8/29/96. Post-Baseline data collected 12/30/96 through present.
Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Nitrate analysis conducted by two different laboratories using the same method (6/26/97).

[2] Wells were reconditioned, but not resurveyed (6/30/98). Historical well elevation data for 8-inch casing at 244.01 feet above msl was used to determine static water level.

[3] 1.684 correction factor used for portion of missing tape and stretch factor for measurements over 175 feet (6/22/99 through 12/9/99).

[4] VOC detected is carbon disulfide (6/14/00). VOCs have no control limits, as any detection triggers verification sampling.

[5] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 243.17 feet above msl (9/20/01), applicable for groundwater elevation calculations until 7/2014.
Potentiometric surfaces have been recalculated (243.70 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[6] VOC detected is 2-butanone (12/11/01). VOCs have no control limits, as any detection triggers verification sampling.

[7] Water quality meter could not be calibrated for dissolved oxygen, results are not accurate (3/20/02 and 3/26/03).

[8] Values were revised from previous report due to amended laboratory report (6/28/05).

[9] VOC detected is Carbon Disulfide (6/22/06). VOCs have no control limits, as any detection triggers verification sampling.

[10] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[11] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[12] Manganese was not detected above the method detection limit of 0.007 mg/L.

[13] VOC detected is toluene (10/30/13). VOCs have no control limits, as any detection triggers verification sampling.

[14] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-3
Summary of Field and Analytical Results: MW-3
Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2000 Upper Shewhart-Cusum Control Limits**	**2005 Upper Shewhart-Cusum Control Limits**	**2010 Upper Shewhart-Cusum Control Limits**	**2010 Poisson Prediction Limits**	**MW-3 9/15/1999**	**MW-3 12/9/1999**	**MW-3 3/30/2000**	**MW-3 6/14/2000**	**MW-3 9/12/2000**	**MW-3 12/12/2000**	**MW-3 3/20/2001**	**MW-3 6/29/2001**	**MW-3 9/20/2001**	**MW-3 12/11/2001**	**MW-3 3/20/2002**	**MW-3 6/19/2002**	**MW-3 9/12/2002**	**MW-3 12/17/2002**	**MW-3 3/26/2003**	**MW-3 6/18/2003**
FIELD PARAMETERS																					
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	2.87 [3]	3.71 [3]	3.4	3.2	3.02	3.19	3.92	2.23	2.56 [5]	3.01	2.85	2.57	2.84	2.71	2.8	2.65
Well Depth	feet, btoc	NC	NC	NC	NC	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51
pH	pH units	NC	NC	NC	NC	7.03	7.32	7.04	7.10	7.33	6.91	7.06	7.17	7.35	7.22	6.74	6.75	6.75	6.32	6.52	6.35
Temperature	degree C	NC	NC	NC	NC	24.4	24.1	24.0	24.0	23.8	23.6	24.15	24.1	23.9	23.8	23.6	23.6	23.5	23.4	23.5	23.8
Turbidity	NTU	NC	NC	NC	NC	10	2	-10	6	10	0	0	10	5	0	10	3	2	19	4	2
Specific Conductivity	µS/cm	NC	NC	NC	NC	1110	1110	1460	919	1180	871	925	1090	940	807	935	1120	1130	915	1130	1110
Salinity	%	NC	NC	NC	NC	0.05	0.05	0.06	0.04	0.05	0.03	0.04	0.04	0.04	0.03	0.04	0.05	0.05	0.04	0.05	0.05
Dissolved Oxygen	mg/L	NC	NC	NC	NC	4.35	5.46	4.95	4.90	5.97	5.78	6.24	4.96	5.99	6.50	0.06 [7]	5.86	6.05	6.05	0.16 [7]	5.91
INORGANIC AND CONVENTIONAL PARAMETERS																					
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	66.63	54.95	49.43	NC	8.9	36	37.0	26.3	17.0	8.13	26.0	ND (2.00)	ND (2.00)	1.24	5.50	ND (8.00)	9.19	9.71	11.3	5.38
Nitrate-N	mg/L	6.09	6.61	tbd	tbd	4.2	4.5	1190	5.72 / 6.17	4.77 / 4.76	4.11	3.26	5.31	4.13	4.61	4.16	4.88	4.73	4.73	4.9	4.67
Chloride	mg/L	235.56	tbd	210.60	NC	170	180	167	156	164	166	147	164	173	87.6	185	175	174	153	172	162
Sulfate	mg/L	73.2	tbd	tbd	tbd	ND (0.02)	33	25.2	15.6	ND (10.0)	31.6	24.9	ND (50.0)	21.0	27.5	29	24.7	23.3	24.0	23.6	23.3
Alkalinity	mg/L	461.44	tbd	tbd	tbd	290	300	296	281	285	276	286	285	280	27.9	294	282	284	288	290	292
Total Dissolved Solids	mg/L	1471.58	795.99	tbd	tbd	720	670	672	710	662	664	672	688	698	632	620	754	632	652	664	644
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	31.8	tbd	tbd	tbd	22	NA	24.8	25.2	23.7	23.5	23.4	23.3	21.7	23.1	23.0	23.5	24.0	22.9	23.0	22.2
Magnesium	mg/L	39.77	36.14	36.35	NC	28	31	30.8	28.2	27.7	29.5	30.3	30.2	28.7	30.0	30.0	31.1	31.0	29.4	30.0	28.5
Iron	mg/L	0.359	NC	NC	0.52	ND (0.1)	ND (0.1)	ND (0.1)	0.151	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.139	ND (0.3)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
Manganese	mg/L	0.064	NC	NC	0.21	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.01)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	22.48	tbd	tbd	tbd	11	14.0	15.0	14.8	14.1	13.8	13.9	14.5	17.2	15.8	13.0	15.7	15.2	16.9	16.2	12.6
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	203.99	197.63	199.41	NC	150	170	166	172	162	168.0	176.0	163.0	167.0	164.0	160.0	179.0	170.0	161.0	175.0	151.0
VOLATILE ORGANIC PARAMETERS																					
EPA 8260	mg/L	NC	NC	NC	NC	ND (0.005)	ND(0.005-0.01)	ND(0.005-0.01)	**0.0438** [4]	ND(0.002-0.01)	ND(0.002-0.01)	ND(0.002-0.01)	ND(0.002-0.01)	ND (<0.00683)	**0.0138** [6]	ND(0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)	ND (0.002-0.02)
EPA 601, 602	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA 524.2	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																					
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

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°C = degrees Celsius
% = percent
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EPA = U.S. Environmental Protection Agency
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),
or the parameter was analyzed outside of its associated holding time (12/17/2012)
mg/L = milligram(s) per liter
msl = mean sea level
MW = monitoring well
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined
VOC = volatile organic compound

Baseline data collected 10/20/95 through 8/29/96. Post-Baseline data collected 12/30/96 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Nitrate analysis conducted by two different laboratories using the same method (6/26/97).

[2] Wells were reconditioned, but not resurveyed (6/30/98). Historical well elevation data for 8-inch casing at 244.01 feet above msl was used to determine static water level.

[3] 1.684 correction factor used for portion of missing tape and stretch factor for measurements over 175 feet (6/22/99 through 12/9/99).

[4] VOC detected is carbon disulfide (6/14/00). VOCs have no control limits, as any detection triggers verification sampling.

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[6] VOC detected is 2-butanone (12/11/01). VOCs have no control limits, as any detection triggers verification sampling.

[7] Water quality meter could not be calibrated for dissolved oxygen, results are not accurate (3/20/02 and 3/26/03).

[8] Values were revised from previous report due to amended laboratory report (6/28/05).

[9] VOC detected is Carbon Disulfide (6/22/06). VOCs have no control limits, as any detection triggers verification sampling.

[10] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[11] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[12] Manganese was not detected above the method detection limit of 0.007 mg/L.

[13] VOC detected is toluene (10/30/13). VOCs have no control limits, as any detection triggers verification sampling.

[14] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-3
Summary of Field and Analytical Results: MW-3
Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2000** **Upper Shewhart-Cusum Control Limits**	**2005** **Upper Shewhart-Cusum Control Limits**	**2010** **Upper Shewhart-Cusum Control Limits**	**2010** **Poisson Prediction Limits**	**MW-3** **12/18/2003**	**MW-3** **6/17/2004**	**MW-3** **12/15/2004**	**MW-3** **6/28/2005**	**MW-3** **12/8/2005**	**MW-3** **6/22/2006**	**MW-3** **12/6/2006**	**MW-3** **6/7/2007**	**MW-3** **12/12/2007**	**MW-3** **6/11/2008**	**MW-3** **12/16/2008**	**MW-3** **6/3/2009**	**MW-3** **12/9/2009**	**MW-3** **6/17/2010**
FIELD PARAMETERS																			
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	2.87	3.31	2.94	2.58	2.96	2.11	2.31	2.31	2.52	2.54	2.56	2.18	2.54	1.26
Well Depth	feet, btoc	NC	NC	NC	NC	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51
pH	pH units	NC	NC	NC	NC	7.19	7.14	7.36	7.13	7.29	7.42	7.19	6.30	7.14	7.23	7.44	6.79	7.22	7.26
Temperature	degree C	NC	NC	NC	NC	23.6	24.2	23.7	24.0	25.57	23.83	24.0	24.2	23.90	24.2	24.0	23.3	24.51	23.99
Turbidity	NTU	NC	NC	NC	NC	2	38	0	2.9	4.1	0.0	2.3	--[10]	0.0	0.0	2	0.3	--[10]	18.5
Specific Conductivity	µS/cm	NC	NC	NC	NC	930	1150	1200	1210	1130	1190	1100	1300	1140	1230	1250	1154	1180	1140
Salinity	%	NC	NC	NC	NC	0.04	0.05	0.10	0.10	0.05	0.05	0.05	0.1	0.05	0.1	0.1	0.057	0.03	0.057
Dissolved Oxygen	mg/L	NC	NC	NC	NC	6.76	7.04	13.80	7.87	7.42	7.07	5.49	6.97	8.02	6.84	6.33	8.78	7.40	7.93
INORGANIC AND CONVENTIONAL PARAMETERS																			
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	66.63	54.95	49.43	NC	13.6	7.34	7.82	6.53 [8]	1.3	7.8	2.1	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	1.2	1.4	4.5
Nitrate-N	mg/L	6.09	6.61	tbd	tbd	4.73	5.28	4.89	4.12	5.03	4.72	4.10	4.75	8.88	5.89	4.07 [11]	5.39	4.77	5.77
Chloride	mg/L	235.56	tbd	210.60	NC	157	166	168	142	179	172	160	180	170	170	180	170	190	180
Sulfate	mg/L	73.2	tbd	tbd	tbd	23.9	28.0	22.0	22.3	22.7	22.8	23.0	27	23	24	21	25	28	26
Alkalinity	mg/L	461.44	tbd	tbd	tbd	286	276	280	282	284	284	284	292	282	258	276	276	272	280
Total Dissolved Solids	mg/L	1471.58	795.99	tbd	tbd	660	706	686	672	636	604	672	630	682	670	652	696	692	642
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	31.8	tbd	tbd	tbd	22.8	23.4	23.7	22.7	22.3	21.2	21.0	22.1	24.5	23.2	21.9	24.6	23.4	22.4
Magnesium	mg/L	39.77	36.14	36.35	NC	29.5	32.3	31.9	30.3	30.4	28.4	28.3	29.6	33.9	30.3	27.0	31.1	30.4	29.6
Iron	mg/L	0.359	NC	NC	0.52	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	0.164	ND (0.05)	0.195	ND (0.0500)	ND (0.0500)
Manganese	mg/L	0.064	NC	NC	0.21	0.00851	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	0.0054	ND (0.005)	ND (0.00500)	ND (0.00500)	ND (0.00500)
Potassium	mg/L	22.48	tbd	tbd	tbd	13.7	15.3	12.4	13.5	14.2	11.6	12.4	13.0	14.1	13.0	12.3	13.1	13.3	12.6
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	203.99	197.63	199.41	NC	147.0	162.0	165.0	175.0	171.0	**225.0**	151.0 / 150.0	155.0	161.0	165.0	148	145	166	154
VOLATILE ORGANIC PARAMETERS																			
EPA 8260	mg/L	NC	NC	NC	NC	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	**0.00699** [9]	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)	ND (0.002-0.025)
EPA 601, 602	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA 524.2	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																			
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius
°C = degrees Celsius
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J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),
or the parameter was analyzed outside of its associated holding time (12/17/2012)
mg/L = milligram(s) per liter
msl = mean sea level
MW = monitoring well
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined
VOC = volatile organic compound

Baseline data collected 10/20/95 through 8/29/96. Post-Baseline data collected 12/30/96 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Nitrate analysis conducted by two different laboratories using the same method (6/26/97).

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[3] 1.684 correction factor used for portion of missing tape and stretch factor for measurements over 175 feet (6/22/99 through 12/9/99).

[4] VOC detected is carbon disulfide (6/14/00). VOCs have no control limits, as any detection triggers verification sampling.

[5] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 243.17 feet above msl (9/20/01), applicable for groundwater elevation calculations until 7/2014.
Potentiometric surfaces have been recalculated (243.70 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[6] VOC detected is 2-butanone (12/11/01). VOCs have no control limits, as any detection triggers verification sampling.

[7] Water quality meter could not be calibrated for dissolved oxygen, results are not accurate (3/20/02 and 3/26/03).

[8] Values were revised from previous report due to amended laboratory report (6/28/05).

[9] VOC detected is Carbon Disulfide (6/22/06). VOCs have no control limits, as any detection triggers verification sampling.

[10] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[11] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[12] Manganese was not detected above the method detection limit of 0.007 mg/L.

[13] VOC detected is toluene (10/30/13). VOCs have no control limits, as any detection triggers verification sampling.

[14] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-3
Summary of Field and Analytical Results: MW-3
Central Maui Landfill

WELL NUMBER	**Units**	**2000**	**2005**	**2010**	**2010**	**MW-3**	**MW-3**	**MW-3**	**MW-3**	**MW-3**	**MW-3**	**MW-3**	**MW-3**	**MW-3**	**MW-3**	**MW-3**	**MW-3**
DATE		**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Poisson Prediction Limits**	**12/28/2010**	**6/29/2011**	**12/19/2011**	**3/20/2012**	**6/27/2012**	**10/17/2012**	**12/17/2012**	**4/24/2013**	**10/30/2013**	**12/5/2013**	**4/9/2014**	**7/9/2014**
ANALYTE																	
FIELD PARAMETERS																	
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	3.08	2.77	2.72		2.60		2.83		2.26	2.46	2.67	2.58
Well Depth	feet, btoc	NC	NC	NC	NC	260.51	260.51	260.51		260.51		260.51		260.51	260.51	260.51	260.51
pH	pH units	NC	NC	NC	NC	7.14	7.23	7.36		7.94		7.21		6.45	7.49	7.17	7.14
Temperature	degree C	NC	NC	NC	NC	25.74	25.39	23.60		23.70		22.87		23.59	23.26	24.03	24.12
Turbidity	NTU	NC	NC	NC	NC	0.0	0.0	0.7		1.4		5.4		0.0	0.0	1.03	0.90
Specific Conductivity	µS/cm	NC	NC	NC	NC	1150	1230	1190		1180		1300		2930	1270	1284	1213
Salinity	%	NC	NC	NC	NC	0.60	0.06	0.03		0.03		0.06		0.15	0.06	0.064	0.060
Dissolved Oxygen	mg/L	NC	NC	NC	NC	3.45	7.92	10.11		8.40		8.57		7.82	7.35	6.65	6.54
INORGANIC AND CONVENTIONAL PARAMETERS																	
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA		NA		NA		NA	NA	NA	NA
Total Organic Carbon	mg/L	66.63	54.95	49.43	NC	ND (1.0)	5.9	ND (1.0)	NA	ND (1.0)	NA	15	NA	21	31	NA	14
Nitrate-N	mg/L	6.09	6.61	tbd	tbd	11.3	5.28	5.75	NA	5.88	NA	4.4 J	NA	5.7 J	4.9 J	NA	5.6 BU
Chloride	mg/L	235.56	tbd	210.60	NC	180	190	200	NA	210	NA	**220**	NA	**230**	210	210	210
Sulfate	mg/L	73.2	tbd	tbd	tbd	25	27	34	NA	27	NA	15	NA	35	33	NA	28
Alkalinity	mg/L	461.44	tbd	tbd	tbd	240	250	44 J	NA	250	NA	240	NA	234	234	NA	236
Total Dissolved Solids	mg/L	1471.58	795.99	tbd	tbd	660	680	650	NA	750	NA	715	NA	610	695	NA	650
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA		NA		NA		NA	NA	NA	NA
Calcium	mg/L	31.8	tbd	tbd	tbd	22	23	22.6	NA	23	NA	23.2	NA	23.9	23.8	NA	24.2
Magnesium	mg/L	39.77	36.14	36.35	NC	30	33	30.9	NA	32	NA	33.8	NA	33.8	34.0	NA	35.2
Iron	mg/L	0.359	NC	NC	0.52	ND (0.040)	0.090	ND (0.10)	NA	ND (0.040)	NA	ND (0.100)	NA	ND (0.100)	ND (0.100)	NA	ND (0.1)
Manganese	mg/L	0.064	NC	NC	0.21	ND (0.007) [12]	ND (0.020)	ND (0.0050)	NA	ND (0.020)	NA	ND (0.00500)	NA	ND (0.00500)	ND (0.00500)	NA	ND (0.00500)
Potassium	mg/L	22.48	tbd	tbd	tbd	14	14	13.9	NA	15	NA	14.5	NA	14.0	14.9	NA	14.3
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA		NA		NA		NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	203.99	197.63	199.41	NC	180	180	177		180		188		185	184	NA	173
VOLATILE ORGANIC PARAMETERS																	
EPA 8260	mg/L	NC	NC	NC	NC	ND (0.00050-0.010)	ND (0.00050-0.020)	ND (0.0010 - 0.0020)	NA	ND (0.0010 - 0.150)	NA	ND (0.00050 - 0.10)	NA	**0.0062** [13]	ND (0.00050 - 0.050)	ND (0.00050 - 0.050)	ND (0.00050 - 0.050)
EPA 601, 602	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA 524.2	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ADDITIONAL ANALYTES (Assessment/Verification)																	
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	ND (0.005)	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.01)	NA	NA	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	0.02	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	0.02	ND (0.01)	0.0196	0.0188	0.0191	0.0181	0.019	0.021	0.0196
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	ND (0.02)	NA	NA	NA	NA	NA	NA	NA	NA

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Central Maui Landfill

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DATE		Upper Shewhart-Cusum Control Limits	Upper Shewhart-Cusum Control Limits	Upper Shewhart-Cusum Control Limits	Poisson Prediction Limits	10/27/2014	12/16/2014	3/9/2015	6/23/2015	9/21/2015	12/2/2015	3/23/2016	6/8/2016	9/13/2016	12/19/2016	3/20/2017	6/19/2017	9/20/2017	12/18/2017	3/12/2018
ANALYTE																				
FIELD PARAMETERS																				
Groundwater Elevation	feet, amsl	NC	NC	NC	NC	3.11	3.18	3.47	3.46	3.51	3.66	3.46	3.01	3.28	3.31	3.28	3.26	3.36	3.46	3.11
Well Depth	feet, btoc	NC	NC	NC	NC	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51	260.51
pH	pH units	NC	NC	NC	NC	7.16	7.16	7.46	7.15	7.17	7.13	7.09	6.69	7.14	6.55	6.91	7.7	6.98	7.46	6.82
Temperature	degree C	NC	NC	NC	NC	24.19	24.2	23.9	23.9	24	23.89	23.5	24.08	22.8	24.07	24.16	21.08	23.34	23.06	22.91
Turbidity	NTU	NC	NC	NC	NC	0.58	0.25	0.63	0.16	0.36	0.17	0.87	0.2	0.54	0.19	0.55	0	0	0.0	0.0
Specific Conductivity	µS/cm	NC	NC	NC	NC	1054	1211	1180	1040	1170	1144	1175	1209	1160	1240	1165	0.872	1.16	1130	1090
Salinity	%	NC	NC	NC	NC	0.052	0.06	0.086	0.055	0.059	0.06	0.058	0.06	0.058	0.062	0.058	0	0.06	0.06	0.05
Dissolved Oxygen	mg/L	NC	NC	NC	NC	7.41	5.31	6.74	8.11	6.76	5.96	7.3	7.11	8.46	7.96	7.38	9.26	8.55	8.05	6.76
INORGANIC AND CONVENTIONAL PARAMETERS																				
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Total Organic Carbon	mg/L	66.63	54.95	49.43	NC	25	22	25	26	ND (1)	1	1.1	0.88	1.1	1.1	ND (0.5)	0.86	0.67	0.51	0.65
Nitrate-N	mg/L	6.09	6.61	tbd	tbd	NA	5.7	5.7	5.4	5.5	5.8	4.3	5.0	6.2	4.4	5.1	4.4	4.8	5.4	2.9
Chloride	mg/L	235.56	tbd	210.60	NC	**220**	**220**	200	200	190	**230**	200	190	200	170	170	180	180	190	150
Sulfate	mg/L	73.2	tbd	tbd	tbd	NA	31	48	25	26	ND (0.1)	24	26	24	23	24	23	23	22	23
Alkalinity	mg/L	461.44	tbd	tbd	tbd	NA	235	242	239	244	256	241	244	241	239	245	255	252	264	250
Total Dissolved Solids	mg/L	1471.58	795.99	tbd	tbd	NA	705	705	705	475	655	630	615	695	630	670	625	610	595	575
Antimony	mg/L	NC	NC	NC	NC	NA	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Calcium	mg/L	31.8	tbd	tbd	tbd	NA	24.4	21.7	23.2	23.1	22.7	22.4	22.9	22.7	21.9	22.8	21	19.9	21.6	20.1
Magnesium	mg/L	39.77	36.14	36.35	NC	33.9	32.8	32.1	31.1	34	33.4	34.8	34.8	33.4	31.8	32.4	29.2	30.4	30.9	29.3
Iron	mg/L	0.359	NC	NC	0.52	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.176	0.127	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.064	NC	NC	0.21	NA	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	22.48	tbd	tbd	tbd	NA	14.8	13.9	15.8	14.4	14.4	13	13.3	13.8	13.5	14.6	12.7	12.3	13.2	12.7
Selenium	mg/L	NC	NC	NC	NC	NA	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Silver	mg/L	NC	NC	NC	NC	NA	ND (0.005)	ND (0.005)	0.00561	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Sodium	mg/L	203.99	197.63	199.41	NC	NA	186	179	187	182	179	166	173	170	166	178	164	163	170	165
VOLATILE ORGANIC PARAMETERS																				
EPA 8260	mg/L	NC	NC	NC	NC	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
EPA 601, 602	mg/L	NC	NC	NC	NC	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
EPA 524.2	mg/L	NC	NC	NC	NC	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	mg/L	NC	NC	NC	NC	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ADDITIONAL ANALYTES (Assessment/Verification)																				
Chromium	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Vanadium	mg/L	NC	NC	NC	NC	0.0197	0.019	0.019	0.0187	0.0209	0.0205	0.020	0.0211	0.0189	0.0199	0.0204	0.0199	0.0207	0.0191	0.021
Zinc	mg/L	NC	NC	NC	NC	0.0688	0.0296	ND (0.01)	0.0106	0.0371	ND (0.01)	0.014	ND (0.01)	ND (0.01)	ND (0.01)	0.0106	ND (0.01)	0.0252	ND (0.01)	ND (0.01)

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[1] Nitrate analysis conducted by two different laboratories using the same method (6/26/97).

[2] Wells were reconditioned, but not resurveyed (6/30/98). Historical well elevation data for 8-inch casing at 244.01 feet above msl was used to determine static water level.

[3] 1.684 correction factor used for portion of missing tape and stretch factor for measurements over 175 feet (6/22/99 through 12/9/99).

[4] VOC detected is carbon disulfide (6/14/00). VOCs have no control limits, as any detection triggers verification sampling.

[5] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 243.17 feet above msl (9/20/01), applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (243.70 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[6] VOC detected is 2-butanone (12/11/01). VOCs have no control limits, as any detection triggers verification sampling.

[7] Water quality meter could not be calibrated for dissolved oxygen, results are not accurate (3/20/02 and 3/26/03).

[8] Values were revised from previous report due to amended laboratory report (6/28/05).

[9] VOC detected is Carbon Disulfide (6/22/06). VOCs have no control limits, as any detection triggers verification sampling.

[10] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[11] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[12] Manganese was not detected above the method detection limit of 0.007 mg/L.

[13] VOC detected is toluene (10/30/13). VOCs have no control limits, as any detection triggers verification sampling.

[14] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-4
Summary of Field and Analytical Results: MW-4
Central Maui Landfill

WELL NUMBER	**Units**	**2002**	**2005**	**2010**	**2010**	**2016**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**
DATE		**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Poisson Prediction Limits**	**Upper Predictive Limits**	**5/24/2001**	**6/26/2001**	**8/7/2001**	**9/19/2001**	**10/30/2001**	**12/11/2001**	**1/22/2002**	**3/12/2002**	**12/18/2003**	**6/17/2004**
ANALYTE																
FIELD PARAMETERS																
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	NC	3.01	3.02	3.04	3.06	3.12	3.49	3.36	3.30	3.17	3.51
Well Depth	feet, btoc	NC	NC	NC	NC	NC	309.5	309.5	309.5	309.5	309.5	309.5	309.5	309.5	309.5	309.5
pH	pH units	NC	NC	NC	NC	NC	7.55	7.51	7.52	7.53	7.40	7.40	7.26	7.23	7.16	7.12
Temperature	degree C	NC	NC	NC	NC	NC	23.33	23.33	23.89	22.78	25.00	23.89	25.56	23.33	23.8	24.3
Turbidity	NTU	NC	NC	NC	NC	NC	2.1	1.9	2.0	7.2	1.7	1.3	1.2	0	51	322
Specific Conductivity	µS/cm	NC	NC	NC	NC	NC	1190	1230	1210	1220	1200	1180	1280	1230	940	1160
Salinity	%	NC	NC	NC	NC	NC	--	--	--	--	--	--	--	--	0.04	0.05
Dissolved Oxygen	mg/L	NC	NC	NC	NC	NC	--	--	--	--	--	--	--	--	5.53	7.03
INORGANIC AND CONVENTIONAL PARAMETERS																
Ammonia (as N)	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	19.9	24.43	tbd	tbd	67.4	4.4	12	ND(1.0)	2.8	3.6	1.9	1.0	1.3	13.4	10.9
Nitrate-N	mg/L	6.7	7.04	7.06	NC	9.35	5.4	4.7	4.8	5.0	5.6	5.0	5.6	4.9	5.13	5.15
Chloride	mg/L	221	213.92	222.66	NC	318	170	183	183	182	192	188	197	180	192	189
Sulfate	mg/L	61.9	tbd	tbd	tbd	96.6	50	34	34	32.6	37.3	37.5	37.7	37	25.6	31.0
Alkalinity	mg/L	358	tbd	tbd	tbd	485	300	306	292	327	311	311	294	293	276	258
Total Dissolved Solids	mg/L	794	794.34	tbd	tbd	1080	694	720	715	731	698	668	681	701	652	696
Antimony	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	31.18	tbd	tbd	tbd	29.3	25.0	26.3	25.3	26.9	26.0	27.8	25.9	24.0	23.9	24.2
Magnesium	mg/L	36.42	37.18	39.09	NC	48.6	31.3	33.3	32.7	32.8	33.0	33.2	31.4	31.2	31.1	33.8
Iron	mg/L	0.381	0.33	tbd	tbd	NC	ND(0.05)	0.0507	0.0536	0.0582	0.0623	0.235	ND(0.05)	ND(0.05)	0.141	0.0652
Manganese	mg/L	0.0789	0.12	0.10	NC	NC	0.01	0.0204	0.0221	0.05	0.0176	0.0145	0.0114	0.0095	0.0302	0.0187
Potassium	mg/L	18.15	18.08	tbd	tbd	18.8	14.7	16.0	14.2	14.8	14.8	13.3	13.8	14.0	13.3	15.2
Selenium	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	191.6	211.7	tbd	tbd	239	171	178	173	175	176	182	177	172	146	160
VOLATILE ORGANIC PARAMETERS																
EPA 8260	mg/L	NC	NC	NC	NC	NC	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.002-0.025)	ND(0.002-0.025)
ADDITIONAL ANALYTES (Assessment/Verification)																
Chromium	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	0.367	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	0.0329	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	0.196	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.
2016 Upper Predictive Limits are used on events past June 2016.
°C = degrees Celsius
% = percent
µS/cm = microsiemen(s) per centimeter
amsl = above mean sea level
bgs = below ground surface
CUSUM = cumulative summation
EPA = U.S. Environmental Protection Agency
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),
or the parameter was analyzed outside of its associated holding time (12/17/2012)
mg/L = milligram(s) per liter
msl = mean sea level
MW = monitoring well
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined

Baseline data collected 5/24/01 through 3/12/02. Post-Baseline data collected 12/18/03 through present.
Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 291.22 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (291.32 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Values were revised from previous report due to amended laboratory report (6/28/05).

[3] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[4] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[5] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-4
Summary of Field and Analytical Results: MW-4
Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2002 Upper Shewhart-Cusum Control Limits**	**2005 Upper Shewhart-Cusum Control Limits**	**2010 Upper Shewhart-Cusum Control Limits**	**2010 Poisson Prediction Limits**	**MW-4** **12/15/2004**	**MW-4** **6/28/2005**	**MW-4** **12/8/2005**	**MW-4** **6/22/2006**	**MW-4** **12/6/2006**	**MW-4** **6/7/2007**	**MW-4** **12/12/2007**	**MW-4** **6/11/2008**	**MW-4** **12/16/2008**	**MW-4** **6/3/2009**	**MW-4** **12/9/2009**
FIELD PARAMETERS																
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	3.11	2.79	3.13	2.29	2.51	2.50	2.68	2.71	1.98	2.37	2.71
Well Depth	feet, btoc	NC	NC	NC	NC	309.5	309.5	309.5	309.5	309.5	309.5	309.5	309.5	309.5	309.5	309.5
pH	pH units	NC	NC	NC	NC	7.29	7.02	7.19	7.34	7.06	6.28	7.03	7.06	7.31	6.85	7.21
Temperature	degree C	NC	NC	NC	NC	23.6	24.2	25.73	23.93	23.9	24.3	23.96	24.08	23.9	23.3	24.93
Turbidity	NTU	NC	NC	NC	NC	121	532	79.2	159.0	55.4	--[3]	88.3	92.5	70	67.7	--[3]
Specific Conductivity	µS/cm	NC	NC	NC	NC	1200	1240	1200	1220	1210	1400	1170	1230	1260	1157	1190
Salinity	%	NC	NC	NC	NC	0.10	0.10	0.05	0.06	0.06	0.1	0.05	0.06	0.1	0.058	0.03
Dissolved Oxygen	mg/L	NC	NC	NC	NC	11.70	7.25	6.73	6.49	4.68	6.07	7.19	6.49	5.22	7.20	9.95
INORGANIC AND CONVENTIONAL PARAMETERS																
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	19.9	24.43	tbd	tbd	9.29	6.86 [2]	1.4	6.0	2.3	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Nitrate-N	mg/L	6.7	7.04	7.06	NC	4.37	3.75	4.67	4.22	3.55	3.81	4.86	5.01	4.22 [4]	4.73	4.26
Chloride	mg/L	221	213.92	222.66	NC	189	183	219	196	180	210	190	190	170	180	190
Sulfate	mg/L	61.9	tbd	tbd	tbd	25.2	24.8	25.7	25.2	23	27	25	25	20	25	31
Alkalinity	mg/L	358	tbd	tbd	tbd	266	272	274	252	260	276	248	244	258	258	238
Total Dissolved Solids	mg/L	794	794.34	tbd	tbd	728	676	724	630	666	642	688	622	654	694	656
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	31.18	tbd	tbd	tbd	24.2	23.8	23.6	20.5	20.4	23.0	21.6	19.6	20.5	21.7	20.7
Magnesium	mg/L	36.42	37.18	39.09	NC	34.2	33.9	34.5	29.5	29.1	33.9	33.1	31.8	28.8	31.2	30
Iron	mg/L	0.381	0.33	tbd	tbd	ND(0.05)	0.121	ND(0.05)	0.0633	ND(0.05)	0.134	0.0837	0.164	0.151	0.111	0.114
Manganese	mg/L	0.0789	0.12	0.10	NC	0.0161	0.0225	0.0159	0.0156	0.0119	0.0332	0.0123	0.0124	0.0072	0.0138	0.0172
Potassium	mg/L	18.15	18.08	tbd	tbd	12.4	13.9	14.2	11.5	11.9	14.0	13.2	12.7	12.2	12.3	12.9
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	191.6	211.7	tbd	tbd	167	181	180	236	153 / 147	169	152	156	152	140	160
VOLATILE ORGANIC PARAMETERS																
EPA 8260	mg/L	NC	NC	NC	NC	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)
ADDITIONAL ANALYTES (Assessment/Verification)																
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.
2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius
% = percent
µS/cm = microsiemen(s) per centimeter
amsl = above mean sea level
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CUSUM = cumulative summation
EPA = U.S. Environmental Protection Agency
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011), or the parameter was analyzed outside of its associated holding time (12/17/2012)
mg/L = milligram(s) per liter
msl = mean sea level
MW = monitoring well
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined

Baseline data collected 5/24/01 through 3/12/02. Post-Baseline data collected 12/18/03 through present.
Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 291.22 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (291.32 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Values were revised from previous report due to amended laboratory report (6/28/05).

[3] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[4] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[5] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-4

Summary of Field and Analytical Results: MW-4

Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2002 Upper Shewhart-Cusum Control Limits**	**2005 Upper Shewhart-Cusum Control Limits**	**2010 Upper Shewhart-Cusum Control Limits**	**2010 Poisson Prediction Limits**	**MW-4** **6/17/2010**	**MW-4 [5]** **12/28/2010**	**MW-4** **6/29/2011**	**MW-4** **12/19/2011**	**MW-4** **6/27/2012**	**MW-4** **10/17/2012**	**MW-4** **12/17/2012**	**MW-4** **4/24/2013**	**MW-4** **7/17/2013**
FIELD PARAMETERS														
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	2.14	3.30	2.92	2.93	2.81		2.99	2.56	2.73
Well Depth	feet, btoc	NC	NC	NC	NC	309.5	309.5	309.5	309.5	309.5		309.5	309.5	309.5
pH	pH units	NC	NC	NC	NC	7.21	--	7.17	7.31	7.87		7.51	7.26	7.04
Temperature	degree C	NC	NC	NC	NC	25.26	--	25.84	23.52	24.01		23.33	24.73	24.19
Turbidity	NTU	NC	NC	NC	NC	168.4	--	0.0	11.8	14.3		28.4	1.0	17.6
Specific Conductivity	µS/cm	NC	NC	NC	NC	1123	--	1230	1190	1140		1280	1310	1305
Salinity	%	NC	NC	NC	NC	0.056	--	0.06	0.03	0.03		0.06	0.06	0.07
Dissolved Oxygen	mg/L	NC	NC	NC	NC	8.45	--	7.63	9.27	8.68		7.89	7.48	5.81
INORGANIC AND CONVENTIONAL PARAMETERS														
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA		NA	NA	NA
Total Organic Carbon	mg/L	19.9	24.43	tbd	tbd	5.4	--	4.9	ND (1.0)	ND (1.0)	NA	15	NA	19
Nitrate-N	mg/L	6.7	7.04	7.06	NC	5.40	--	4.90	5.04	4.81	NA	3.6 J	NA	4.5 J
Chloride	mg/L	221	213.92	222.66	NC	190	--	200	200	210	NA	**230**	**240**	220
Sulfate	mg/L	61.9	tbd	tbd	tbd	28	--	27	31	28	NA	19	NA	34
Alkalinity	mg/L	358	tbd	tbd	tbd	220	--	230	44 J	220	NA	212	NA	210
Total Dissolved Solids	mg/L	794	794.34	tbd	tbd	656	--	670	640	700	NA	705	NA	770
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA		NA	NA	NA
Calcium	mg/L	31.18	tbd	tbd	tbd	19.9	--	23	20.0	20	NA	22.3	NA	22.8
Magnesium	mg/L	36.42	37.18	39.09	NC	29.4	--	35	30.4	32	NA	35.1	NA	36.3
Iron	mg/L	0.381	0.33	tbd	tbd	0.0999	--	0.058	ND (0.10)	0.098	NA	ND (0.100)	NA	ND (0.100)
Manganese	mg/L	0.0789	0.12	0.10	NC	0.018	--	ND (0.020)	0.0087	ND (0.040)	NA	0.00951	NA	0.00633
Potassium	mg/L	18.15	18.08	tbd	tbd	11.8	--	15	13.3	14	NA	14.1	NA	15.0
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA		NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA		NA	NA	NA
Sodium	mg/L	191.6	211.7	tbd	tbd	145	--	180	170	170	NA	184	NA	192
VOLATILE ORGANIC PARAMETERS														
EPA 8260	mg/L	NC	NC	NC	NC	ND(0.002-0.025)	--	ND (0.00050-0.020)	ND (0.0010 - 0.0020)	ND (0.0010 - 0.150)	NA	ND (0.00050 - 0.10)	NA	ND (0.00050 - 0.020)
ADDITIONAL ANALYTES (Assessment/Verification)														
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	0.0052	ND (0.01)	ND (0.01)	ND (0.01)	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	0.26	0.233	0.244	0.247	0.231
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	ND (0.01)	0.0193	0.0187	0.019	0.0188
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius

% = percent

µS/cm = microsiemen(s) per centimeter

amsl = above mean sea level

bgs = below ground surface

CUSUM = cumulative summation

EPA = U.S. Environmental Protection Agency

J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011), or the parameter was analyzed outside of its associated holding time (12/17/2012)

mg/L = milligram(s) per liter

msl = mean sea level

MW = monitoring well

NC = not calculated

ND (XX) = not detected (reporting limit)

NTU = nephelometric turbidity units

PVC = polyvinyl chloride

tbd = to be determined

Baseline data collected 5/24/01 through 3/12/02. Post-Baseline data collected 12/18/03 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 291.22 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (291.32 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Values were revised from previous report due to amended laboratory report (6/28/05).

[3] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[4] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[5] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-4

Summary of Field and Analytical Results: MW-4

Central Maui Landfill

WELL NUMBER	**Units**	**2002**	**2005**	**2010**	**2010**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**	**MW-4**
DATE		**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Poisson Prediction Limits**	**10/30/2013**	**12/5/2013**	**4/9/2014**	**7/9/2014**	**10/27/2014**	**12/15/2014**	**3/9/2015**	**6/23/2015**	**9/21/2015**	**12/2/2015**	**3/23/2016**
ANALYTE																
FIELD PARAMETERS																
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC		2.91	3.06	2.99	3.04	3.1	3.37	3.35	3.4	3.55	3.28
Well Depth	feet, btoc	NC	NC	NC	NC		309.5	309.5	309.5	309.5	309.5	309.5	309.5	309.5	309.5	309.5
pH	pH units	NC	NC	NC	NC		7.45	7.18	7.13	7.19	7.18	7.33	7.12	7	7.04	7.05
Temperature	degree C	NC	NC	NC	NC		24.02	24.17	24.31	24.2	24.15	23.9	24	24.2	24.03	23.6
Turbidity	NTU	NC	NC	NC	NC		3.5	24.6	14.3	9.5	2.25	5.09	3.04	3.01	3.32	4.38
Specific Conductivity	µS/cm	NC	NC	NC	NC		1270	1285	1233	1066	1221	1220	1090	1280	1282	1224
Salinity	%	NC	NC	NC	NC		0.06	0.064	0.061	0.053	0.061	0.061	0.054	0.065	0.064	0.061
Dissolved Oxygen	mg/L	NC	NC	NC	NC		8.17	5.45	7.45	6.13	4.44	5.91	7.24	5.68	5.22	6.21
INORGANIC AND CONVENTIONAL PARAMETERS																
Ammonia (as N)	mg/L	NC	NC	NC	NC		ND (0.1)	NA	NA	NA	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.11	ND (0.1)
Total Organic Carbon	mg/L	19.9	24.43	tbd	tbd	NA	30	NA	14	ND (25)	18	20	21	ND (1)	0.97	1
Nitrate-N	mg/L	6.7	7.04	7.06	NC	NA	4.4 J	NA	4.8 BU	NA	5.1	5.1	3.6	5.5	4.9	4.2
Chloride	mg/L	221	213.92	222.66	NC	**240**	**230**	220	**240**	**240**	**250**	**230**	**240**	**250**	**240**	**240**
Sulfate	mg/L	61.9	tbd	tbd	tbd	NA	37	NA	32	NA	31	65	29	31	ND (0.1)	28
Alkalinity	mg/L	358	tbd	tbd	tbd	NA	214	NA	218	NA	207	212	208	209	206	209
Total Dissolved Solids	mg/L	794	794.34	tbd	tbd	NA	730	NA	645	NA	710	615	730	500	700	665
Antimony	mg/L	NC	NC	NC	NC		ND (0.015)	NA	NA	NA	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Calcium	mg/L	31.18	tbd	tbd	tbd	NA	21.9	NA	23.5	NA	23.3	21.7	22.5	23.5	22.9	21.8
Magnesium	mg/L	36.42	37.18	39.09	NC	NA	34.5	NA	37.4	34.8	36.7	36.5	33.1	38.8	37.2	36.7
Iron	mg/L	0.381	0.33	tbd	tbd	NA	ND (0.100)	NA	ND (0.100)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.0789	0.12	0.10	NC	NA	0.0109	NA	0.00837	NA	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	18.15	18.08	tbd	tbd	NA	14.8	NA	14.7	NA	14.8	14.9	15.6	15	15.1	13.3
Selenium	mg/L	NC	NC	NC	NC		ND (0.015)	NA	NA	NA	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Silver	mg/L	NC	NC	NC	NC		ND (0.005)	NA	NA	NA	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Sodium	mg/L	191.6	211.7	tbd	tbd	NA	188	NA	191	NA	191	191	188	196	194	176
VOLATILE ORGANIC PARAMETERS																
EPA 8260	mg/L	NC	NC	NC	NC	NA	ND (0.00050 - 0.050)	ND (0.00050 - 0.050)	ND (0.00050 - 0.050)	NA	ND	ND	ND	ND	ND	ND
ADDITIONAL ANALYTES (Assessment/Verification)																
Chromium	mg/L	NC	NC	NC	NC	NA	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	0.246	0.305	0.282	0.236	0.208	0.198	0.192	0.163	0.202	0.195	0.217
Vanadium	mg/L	NC	NC	NC	NC	0.0193	0.0181	0.0203	0.0193	0.0193	0.0212	0.0198	0.0173	0.0203	0.0206	0.0199
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	ND (0.01)	0.0165	0.0589	0.0214	0.0127	ND (0.01)	ND (0.01)

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius

% = percent

µS/cm = microsiemen(s) per centimeter

amsl = above mean sea level

bgs = below ground surface

CUSUM = cumulative summation

EPA = U.S. Environmental Protection Agency

J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011), or the parameter was analyzed outside of its associated holding time (12/17/2012)

mg/L = milligram(s) per liter

msl = mean sea level

MW = monitoring well

NC = not calculated

ND (XX) = not detected (reporting limit)

NTU = nephelometric turbidity units

PVC = polyvinyl chloride

tbd = to be determined

Baseline data collected 5/24/01 through 3/12/02. Post-Baseline data collected 12/18/03 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 291.22 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (291.32 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Values were revised from previous report due to amended laboratory report (6/28/05).

[3] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[4] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[5] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-4
Summary of Field and Analytical Results: MW-4
Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2002 Upper Shewhart-Cusum Control Limits**	**2005 Upper Shewhart-Cusum Control Limits**	**2010 Upper Shewhart-Cusum Control Limits**	**2010 Poisson Prediction Limits**	**MW-4 6/8/2016**	**MW-4 9/13/2016**	**MW-4 12/19/2016**	**MW-4 3/20/2017**	**MW-4 6/19/2017**	**MW-4 9/20/2017**	**MW-4 12/18/2017**	**MW-4 3/12/2018**
FIELD PARAMETERS													
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	3.41	3.37	3.32	3.24	3.19	3.3	3.33	2.94
Well Depth	feet, btoc	NC	NC	NC	NC	309.5	309.5	309.5	309.5	309.5	309.5	309.5	309.5
pH	pH units	NC	NC	NC	NC	6.12	7.12	6.6	6.9	7.8	7.06	7.56	6.94
Temperature	degree C	NC	NC	NC	NC	24.26	22.9	24.19	24.31	19.71	24.2	23.11	23.01
Turbidity	NTU	NC	NC	NC	NC	2.5	2.83	8.3	5	0.8	1	0.0	0.0
Specific Conductivity	µS/cm	NC	NC	NC	NC	1242	1180	1240	1156	0.906	1.12	1100	1100
Salinity	%	NC	NC	NC	NC	0.062	0.058	0.062	0.57	0	0.06	0.05	0.05
Dissolved Oxygen	mg/L	NC	NC	NC	NC	6.29	7.08	8.19	6.89	8.93	7.15	6.53	6.18
INORGANIC AND CONVENTIONAL PARAMETERS													
Ammonia (as N)	mg/L	NC	NC	NC	NC	ND (0.1)	0.14	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Total Organic Carbon	mg/L	19.9	24.43	tbd	tbd	0.88	1.0	0.62	ND (0.5)	0.67	0.65	ND (0.5)	0.89
Nitrate-N	mg/L	6.7	7.04	7.06	NC	4.6	5.0	3.6	4.2	4.6	4.9	6.1	3.1
Chloride	mg/L	221	213.92	222.66	NC	230	220	190	190	180	170	170	170
Sulfate	mg/L	61.9	tbd	tbd	tbd	28	26	24	25	24	23	22	24
Alkalinity	mg/L	358	tbd	tbd	tbd	211	209	216	216	223	225	236	230
Total Dissolved Solids	mg/L	794	794.34	tbd	tbd	610	680	620	655	655	575	595	555
Antimony	mg/L	NC	NC	NC	NC	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Calcium	mg/L	31.18	tbd	tbd	tbd	19.7	21.0	19.8	20.6	19.4	18.3	18.7	19.4
Magnesium	mg/L	36.42	37.18	39.09	NC	35.0	33.4	32.4	34.5	31.4	30.4	31.4	30.9
Iron	mg/L	0.381	0.33	tbd	tbd	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.0789	0.12	0.10	NC	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	18.15	18.08	tbd	tbd	12.2	13.4	13.1	14.2	12.7	12.3	12.5	12.8
Selenium	mg/L	NC	NC	NC	NC	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Silver	mg/L	NC	NC	NC	NC	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Sodium	mg/L	191.6	211.7	tbd	tbd	163	170	171	181	170	158	166	159
VOLATILE ORGANIC PARAMETERS													
EPA 8260	mg/L	NC	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND
ADDITIONAL ANALYTES (Assessment/Verification)													
Chromium	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	0.206	0.190	0.193	0.198	0.193	0.179	0.193	0.189
Vanadium	mg/L	NC	NC	NC	NC	0.0194	0.0188	0.0197	0.0227	0.021	0.0218	0.0203	0.0211
Zinc	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	0.0107	ND (0.01)	ND (0.01)	0.0840 B	ND (0.01)

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.
2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius
% = percent
µS/cm = microsiemen(s) per centimeter
amsl = above mean sea level
bgs = below ground surface
CUSUM = cumulative summation
EPA = U.S. Environmental Protection Agency
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011), or the parameter was analyzed outside of its associated holding time (12/17/2012)
mg/L = milligram(s) per liter
msl = mean sea level
MW = monitoring well
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined

Baseline data collected 5/24/01 through 3/12/02. Post-Baseline data collected 12/18/03 through present.
Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 291.22 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (291.32 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Values were revised from previous report due to amended laboratory report (6/28/05).

[3] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[4] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[5] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-5

Summary of Field and Analytical Results: MW-5

Central Maui Landfill

WELL NUMBER	**Units**	**2002**	**2005**	**2010**	**2010**	**2016**	**MW-5**	**MW-5**	**MW-5**	**MW-5**	**MW-5**	**MW-5**	**MW-5**	**MW-5**	**MW-5**	**MW-5**	**MW-5**
DATE		**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Poisson Prediction Limits**	**Upper Predictive Limits**	**5/24/2001**	**6/26/2001**	**8/7/2001**	**9/19/2001**	**10/30/2001**	**12/11/2001**	**1/22/2002**	**3/12/2002**	**12/18/2003**	**6/17/2004**	**12/15/2004**
ANALYTE																	
FIELD PARAMETERS																	
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	NC	ZX	2.69	2.76	2.75	2.84	3.21	3.09	3.03	2.81	3.23	2.84
Well Depth	feet, btoc	NC	NC	NC	NC	NC	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27
pH	pH units	NC	NC	NC	NC	NC	7.56	7.55	7.53	7.60	7.45	7.48	7.24	7.25	7.19	6.86	7.31
Temperature	degree C	NC	NC	NC	NC	NC	23.89	23.33	23.89	23.89	23.89	23.33	25.00	23.33	23.2	23.8	23.4
Turbidity	NTU	NC	NC	NC	NC	NC	1.2	1.5	2.0	0	1.13	0.3	0	1.7	6	7	266
Specific Conductivity	µS/cm	NC	NC	NC	NC	NC	1160	1150	1150	1130	1140	1140	1210	1210	970	1180	1200
Salinity	%	NC	NC	NC	NC	NC	--	--	--	--	--	--	--	--	0.04	0.05	0.1
Dissolved Oxygen	mg/L	NC	NC	NC	NC	NC	--	--	--	--	--	--	--	--	6.25	7.16	10.75
INORGANIC AND CONVENTIONAL PARAMETERS																	
Ammonia (as N)	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	27.79	70.2	24.78	NC	76.3	2.5	**47**	ND(1.0)	ND(1.0)	1.1	1.4	ND(1.0)	1.7	14.9	7.08 / 15.0	11.1
Nitrate-N	mg/L	7.1	6.85	6.80	NC	10.4	4.7	4.3	4.8	5.1	5.3	5.1	5.9	5.00	4.74	5.20	4.75
Chloride	mg/L	210	206.59	tbd	tbd	304	160	173	174	171	176	177	187	163	171	174	180
Sulfate	mg/L	64	65.59	tbd	tbd	75.2	50	33	33	30.6	34.3	35	38.7	38.8	25.2	31.0	24.5
Alkalinity	mg/L	327	334.53	tbd	tbd	557	291	1740	290	299	290	303	289	306	276	278	288
Total Dissolved Solids	mg/L	803	tbd	881.67	NC	1050	646	**2260**	695	691	652	624	692	695	718	740	738
Antimony	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	26.47	27.1	tbd	tbd	27.9	23.9	24.8	24.1	23.3	24.6	23.7	23.2	23.8	22.4	22.5	24.0
Magnesium	mg/L	34.01	35.77	tbd	tbd	42	29.4	31.9	30.1	31.0	30.9	30.5	30.5	29.8	29.3	31.6	33.0
Iron	mg/L	0.255	tbd	0.33	NC	NC	ND(0.05)	0.0848	0.0794	0.145	0.154	0.0773	0.0873	0.0938	0.138	0.245	0.190
Manganese	mg/L	0.0395	tbd	tbd	tbd	NC	0.0263	0.0212	0.0176	0.207	0.0162	0.011	0.017	0.0191	0.0202	0.00756	0.0109
Potassium	mg/L	18.38	tbd	tbd	tbd	18.3	15.2	16.3	15.0	16.2	15.5	14.4	15.0	14.6	14.3	16.1	13.5
Selenium	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	184.04	202.72	206.14	NC	219	169	175	166	169	168	173	166	171	147	166	176
VOLATILE ORGANIC PARAMETERS																	
EPA 8260	mg/L	NC	NC	NC	NC	NC	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)
ADDITIONAL ANALYTES (Assessment/Verification)																	
Chromium	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	0.246	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	0.0266	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	0.162	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.
2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius
% = percent
µS/cm = microsiemen(s) per centimeter
amsl = above mean sea level
bgs = below ground surface
CUSUM = cumulative summation
EPA = U.S. Environmental Protection Agency
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),
or the parameter was analyzed outside of its associated holding time (12/17/2012)
mg/L = milligram(s) per liter
msl = mean sea level
MW = monitoring well
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined
VOC = volatile organic compound

Baseline data collected 5/24/01 through 3/12/02. Post-Baseline data collected 12/18/03 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 230.11 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (230.26 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[3] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[4] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-5

Summary of Field and Analytical Results: MW-5

Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2002** **Upper Shewhart-Cusum Control Limits**	**2005** **Upper Shewhart-Cusum Control Limits**	**2010** **Upper Shewhart-Cusum Control Limits**	**2010** **Poisson Prediction Limits**	**MW-5** **6/28/2005**	**MW-5** **12/29/2005**	**MW-5** **6/22/2006**	**MW-5** **12/6/2006**	**MW-5** **6/7/2007**	**MW-5** **12/12/2007**	**MW-5** **6/11/2008**	**MW-5** **12/16/2008**	**MW-5** **6/3/2009**	**MW-5** **12/9/2009**	**MW-5** **6/17/2010**
FIELD PARAMETERS																
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	2.50	2.9	2.03	2.20	2.25	3.20	1.73	1.75	2.10	2.47	1.14
Well Depth	feet, btoc	NC	NC	NC	NC	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27
pH	pH units	NC	NC	NC	NC	--	6.9	7.43	7.21	5.26	7.02	7.21	7.26	6.82	7.35	7.24
Temperature	degree C	NC	NC	NC	NC	--	23.34	23.52	23.8	24.0	23.62	23.92	23.7	23.05	24.02	23.64
Turbidity	NTU	NC	NC	NC	NC	--	1	9.6	27.1	--[2]	5.1	6.5	50	65.7	--[2]	28.5
Specific Conductivity	µS/cm	NC	NC	NC	NC	--	1290	1220	1150	1300	1150	1200	1280	1151	1230	1155
Salinity	%	NC	NC	NC	NC	--	0.06	0.06	0.05	0.1	0.05	0.05	0.1	0.057	0.04	0.057
Dissolved Oxygen	mg/L	NC	NC	NC	NC	--	7.72	6.47	4.84	5.55	8.04	6.24	4.45	6.87	10.33	8.53
INORGANIC AND CONVENTIONAL PARAMETERS																
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	27.79	70.2	24.78	NC	--	18	8.5	ND (1.0)	ND (1.0)	ND (1.0)	4.6	ND (1.0)	ND (1.0)	1.6	6.6
Nitrate-N	mg/L	7.1	6.85	6.80	NC	--	4.87	4.37	3.70	4.33	4.76	5.40	4.31 [3]	4.88	4.74	5.49
Chloride	mg/L	210	206.59	tbd	tbd	--	177	181	170	180	170	180	180	170	190	190
Sulfate	mg/L	64	65.59	tbd	tbd	--	25.0	25.1	24.0	28	25	26	23	25	38	27
Alkalinity	mg/L	327	334.53	tbd	tbd	--	280	282	286	280	270	266	276	272	264	270
Total Dissolved Solids	mg/L	803	tbd	881.67	NC	--	724	688	538	616	642	704	674	676	772	662
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	26.47	27.1	tbd	tbd	--	22.9	20.2	20.0	21.5	20.9	20.4	21.9	21.8	22.7	21.5
Magnesium	mg/L	34.01	35.77	tbd	tbd	--	30.6	27.7	28.0	29.7	29.7	29.6	27.9	28.6	30.1	29.3
Iron	mg/L	0.255	tbd	0.33	NC	--	0.0814	ND (0.05)	ND (0.05)	ND (0.05)	0.162	0.0752	0.0623	0.0904	0.0510	ND(0.0500)
Manganese	mg/L	0.0395	tbd	tbd	tbd	--	0.0095	0.00832	0.00900	0.00837	0.00935	0.00920	ND (0.005)	0.0117	0.00608	0.00564
Potassium	mg/L	18.38	tbd	tbd	tbd	--	15.6	12.0	12.8	14.1	13.4	13.4	13.2	12.7	13.8	12.9
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	184.04	202.72	206.14	NC	--	176	**234**	158 / 154	161	150	162	158	138	166	156
VOLATILE ORGANIC PARAMETERS																
EPA 8260	mg/L	NC	NC	NC	NC	--	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)
ADDITIONAL ANALYTES (Assessment/Verification)																
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius

% = percent

µS/cm = microsiemen(s) per centimeter

amsl = above mean sea level

bgs = below ground surface

CUSUM = cumulative summation

EPA = U.S. Environmental Protection Agency

J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),
or the parameter was analyzed outside of its associated holding time (12/17/2012)

mg/L = milligram(s) per liter

msl = mean sea level

MW = monitoring well

NC = not calculated

ND (XX) = not detected (reporting limit)

NTU = nephelometric turbidity units

PVC = polyvinyl chloride

tbd = to be determined

VOC = volatile organic compound

Baseline data collected 5/24/01 through 3/12/02. Post-Baseline data collected 12/18/03 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 230.11 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (230.26 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[3] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[4] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-5

Summary of Field and Analytical Results: MW-5

Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2002** **Upper Shewhart-Cusum Control Limits**	**2005** **Upper Shewhart-Cusum Control Limits**	**2010** **Upper Shewhart-Cusum Control Limits**	**2010** **Poisson Prediction Limits**	**MW-5** **12/28/2010**	**MW-5** **6/29/2011**	**MW-5** **12/19/2011**	**MW-5** **3/20/2012**	**MW-5** **6/27/2012**	**MW-5** **10/17/2012**	**MW-5** **12/17/2012**	**MW-5** **4/24/2013**	**MW-5** **7/17/2013**	**MW-5** **10/30/2013**
FIELD PARAMETERS															
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	3.07	2.65	2.66		2.53		2.75		2.38	2.41
Well Depth	feet, btoc	NC	NC	NC	NC	248.27	248.27	248.27		248.27		248.27		248.27	248.27
pH	pH units	NC	NC	NC	NC	7.14	7.26	7.34		7.85		7.17		7.04	6.54
Temperature	degree C	NC	NC	NC	NC	25.56	25.54	23.32		23.23		22.64		23.65	25.53
Turbidity	NTU	NC	NC	NC	NC	0.8	22.3	14.6		10.1		16.6		7.62	1.0
Specific Conductivity	µS/cm	NC	NC	NC	NC	1170	1200	1190		1170		1320		1300	3000
Salinity	%	NC	NC	NC	NC	0.60	0.06	0.03		0.03		0.07		0.065	0.16
Dissolved Oxygen	mg/L	NC	NC	NC	NC	3.49	8.56	10.26		8.82		7.41		6.20	7.12
INORGANIC AND CONVENTIONAL PARAMETERS															
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA		NA		NA		NA	NA
Total Organic Carbon	mg/L	27.79	70.2	24.78	NC	ND (1.0)	5.6	ND (1.0)	NA	ND (1.0)	NA	15	NA	**26**	24
Nitrate-N	mg/L	7.1	6.85	6.80	NC	**11.0**	5.26 / 5.25	5.50	NA	5.47	NA	4.1 J	NA	4.8 J	NA
Chloride	mg/L	210	206.59	tbd	tbd	190	190	210	NA	210	NA	230	NA	240	240
Sulfate	mg/L	64	65.59	tbd	tbd	27	31	33	NA	32	NA	17	NA	35	NA
Alkalinity	mg/L	327	334.53	tbd	tbd	180	250	42 J	NA	240	NA	236	NA	230	NA
Total Dissolved Solids	mg/L	803	tbd	881.67	NC	670	660	630	NA	730	NA	730	NA	755	NA
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA		NA		NA		NA	NA
Calcium	mg/L	26.47	27.1	tbd	tbd	21	23	22.1	NA	21	NA	23.0	NA	23.1	NA
Magnesium	mg/L	34.01	35.77	tbd	tbd	30	32	30.7	NA	31	NA	34.6	NA	33.9	NA
Iron	mg/L	0.255	tbd	0.33	NC	ND(0.040)	**0.53**	**0.15 / 0.61**	NA	0.18	NA	0.143	NA	ND (0.100)	NA
Manganese	mg/L	0.0395	tbd	tbd	tbd	ND(0.007) [4]	ND (0.020)	0.0090	NA	ND (0.020)	NA	0.0129	NA	0.00531	NA
Potassium	mg/L	18.38	tbd	tbd	tbd	15	15	14.6	NA	15	NA	14.5	NA	15.4	NA
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA		NA		NA		NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA		NA		NA		NA	NA
Sodium	mg/L	184.04	202.72	206.14	NC	180	180	180	NA	180	NA	189	NA	186	NA
VOLATILE ORGANIC PARAMETERS															
EPA 8260	mg/L	NC	NC	NC	NC	ND (0.00050-0.010)	ND (0.00050-0.020)	ND (0.0010 - 0.0020)	NA	ND (0.0010 - 0.150)	NA	ND (0.00050 - 0.10)	NA	ND (0.00050 - 0.020)	NA
ADDITIONAL ANALYTES (Assessment/Verification)															
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	0.054	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.01)	NA	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	0.018	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	0.3	0.36	0.475	0.382	0.386	0.234	0.268
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	0.025	ND (0.01)	0.0152	0.0148	0.0147	0.016	0.0156
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	ND (0.02)	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.
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°C = degrees Celsius
% = percent
µS/cm = microsiemen(s) per centimeter
amsl = above mean sea level
bgs = below ground surface
CUSUM = cumulative summation
EPA = U.S. Environmental Protection Agency
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011),
or the parameter was analyzed outside of its associated holding time (12/17/2012)
mg/L = milligram(s) per liter
msl = mean sea level
MW = monitoring well
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined
VOC = volatile organic compound

Baseline data collected 5/24/01 through 3/12/02. Post-Baseline data collected 12/18/03 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 230.11 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (230.26 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[3] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[4] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-5
Summary of Field and Analytical Results: MW-5
Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2002** **Upper Shewhart-Cusum Control Limits**	**2005** **Upper Shewhart-Cusum Control Limits**	**2010** **Upper Shewhart-Cusum Control Limits**	**2010** **Poisson Prediction Limits**	**MW-5** **12/5/2013**	**MW-5** **4/9/2014**	**MW-5** **7/9/2014**	**MW-5** **10/27/2014**	**MW-5** **12/16/2014**	**MW-5** **3/9/2015**	**MW-5** **6/22/2015**	**MW-5** **9/21/2015**	**MW-5** **12/2/2015**	**MW-5** **3/23/2016**	**MW-5** **6/8/2016**	**MW-5** **9/13/2016**	**MW-5** **12/19/2016**
FIELD PARAMETERS																		
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	2.73	2.82	2.73	2.87	2.93	3.23	3.17	3.22	3.37	3.11	3.26	3.21	3.22
Well Depth	feet, btoc	NC	NC	NC	NC	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27	248.27
pH	pH units	NC	NC	NC	NC	7.47	7.13	7.11	7.15	7.13	7.15	7.09	7.09	7.08	7.03	6.45	7.05	6.47
Temperature	degree C	NC	NC	NC	NC	23.20	23.55	23.82	23.85	23.88	23.6	23.7	23.7	23.61	23.2	23.79	22.5	23.73
Turbidity	NTU	NC	NC	NC	NC	0.0	2.01	3.48	1.05	0.62	0.62	0.88	0.78	1.18	1.09	1.2	1.09	1.7
Specific Conductivity	µS/cm	NC	NC	NC	NC	1290	1309	1210	1066	1225	1200	990	1180	1202	1178	1217	1180	1270
Salinity	%	NC	NC	NC	NC	0.06	0.065	0.060	0.053	0.061	0.059	0.049	0.06	0.06	0.059	0.061	0.059	0.063
Dissolved Oxygen	mg/L	NC	NC	NC	NC	8.84	6.97	7.32	91.9	5.86	6.64	5.53	6.41	5.91	6.43	6.29	8.31	7.55
INORGANIC AND CONVENTIONAL PARAMETERS																		
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.11	ND (0.1)
Total Organic Carbon	mg/L	27.79	70.2	24.78	NC	**31**	**26**	11	**25**	21	23	**25**	ND (1)	1.1	1	0.93	1.10	0.72
Nitrate-N	mg/L	7.1	6.85	6.80	NC	4.6 J	NA	5.0 BU	NA	5.7	5.7	3.5	5.5	5.4	4.5	7.0	5.6	3.8
Chloride	mg/L	210	206.59	tbd	tbd	230	220	190	230	220	210	200	200	210	200	200	200	180
Sulfate	mg/L	64	65.59	tbd	tbd	36	NA	31	NA	31	49	26	27	ND (0.1)	25	26	26	24
Alkalinity	mg/L	327	334.53	tbd	tbd	230	NA	245	NA	224	242	244	247	238	244	243	242	247
Total Dissolved Solids	mg/L	803	tbd	881.67	NC	735	NA	555	NA	735	655	705	580	680	665	645	690	630
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Calcium	mg/L	26.47	27.1	tbd	tbd	23.5	NA	23.6	NA	23.1	22	21.6	22.5	21.2	21.2	21.6	22.2	21.8
Magnesium	mg/L	34.01	35.77	tbd	tbd	34.8	NA	35.2	34.6	31.9	33.3	31.7	34	31.4	32.7	34.8	33	32.4
Iron	mg/L	0.255	tbd	0.33	NC	ND (0.100)	NA	ND (0.100)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.0395	tbd	tbd	tbd	0.00506	NA	0.00688	NA	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	18.38	tbd	tbd	tbd	15.7	NA	15.1	NA	15	15.5	15	15.2	14.8	13.5	13.7	14.3	14.5
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	ND (0.015)	ND (0.015)	ND (0.015)	0.0193	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	ND (0.005)	ND (0.005)	0.00507	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Sodium	mg/L	184.04	202.72	206.14	NC	191	NA	178	NA	185	187	185	188	182	168	173	178	171
VOLATILE ORGANIC PARAMETERS																		
EPA 8260	mg/L	NC	NC	NC	NC	ND (0.00050 - 0.050)	ND (0.00050 - 0.050)	ND (0.00050 - 0.050)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
ADDITIONAL ANALYTES (Assessment/Verification)																		
Chromium	mg/L	NC	NC	NC	NC	NA	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	NA	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	0.193	0.22	0.183	0.103	0.0956	0.0827	0.0522	0.0723	0.08	0.0852	0.109	0.105	0.121
Vanadium	mg/L	NC	NC	NC	NC	0.0171	0.0188	0.0167	0.0187	0.0166	0.0186	0.0185	0.0189	0.018	0.0187	0.0202	0.0192	0.0182
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	0.0151	0.0396	0.0113	0.0254	0.0407	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	0.0411

Notes:

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Table G-5
Summary of Field and Analytical Results: MW-5
Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2002** **Upper Shewhart-Cusum Control Limits**	**2005** **Upper Shewhart-Cusum Control Limits**	**2010** **Upper Shewhart-Cusum Control Limits**	**2010** **Poisson Prediction Limits**	**MW-5** **3/20/2017**	**MW-5** **6/19/2017**	**MW-5** **9/20/2017**	**MW-5** **12/18/2017**	**MW-5** **12/18/2017** **Duplicate**	**MW-5** **3/12/2018**	**MW-5** **3/12/2018** **Duplicate**
FIELD PARAMETERS												
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	3.16	3.11	3.2	3.26	3.26	2.88	2.88
Well Depth	feet, btoc	NC	NC	NC	NC	248.27	248.27	248.27	248.27	248.27	248.27	248.27
pH	pH units	NC	NC	NC	NC	6.8	7.5	6.86	7.39	7.39	6.16	6.16
Temperature	degree C	NC	NC	NC	NC	23.85	19.38	24.15	27.74	27.74	22.44	22.44
Turbidity	NTU	NC	NC	NC	NC	0.55	0.1	0.1	0.0	0.0	0.0	0.0
Specific Conductivity	µS/cm	NC	NC	NC	NC	1187	0.911	1.14	1160	1160	1160	1160
Salinity	%	NC	NC	NC	NC	0.059	0	0.06	0.06	0.06	0.06	0.06
Dissolved Oxygen	mg/L	NC	NC	NC	NC	7.35	9.42	8.4	7.4	7.4	6.71	6.71
INORGANIC AND CONVENTIONAL PARAMETERS												
Ammonia (as N)	mg/L	NC	NC	NC	NC	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.14
Total Organic Carbon	mg/L	27.79	70.2	24.78	NC	ND (0.5)	0.68	0.77	ND (0.5)	ND (0.5)	0.54	0.54
Nitrate-N	mg/L	7.1	6.85	6.80	NC	4.9	5.0	4.2	4.7	6.3	3.4	3.5
Chloride	mg/L	210	206.59	tbd	tbd	180	190	180	180	180	170	170
Sulfate	mg/L	64	65.59	tbd	tbd	26	24	24	24	24	25	26
Alkalinity	mg/L	327	334.53	tbd	tbd	247	254	256	263	266	254	250
Total Dissolved Solids	mg/L	803	tbd	881.67	NC	700	650	635	630	580	645	585
Antimony	mg/L	NC	NC	NC	NC	0.0287	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Calcium	mg/L	26.47	27.1	tbd	tbd	23.1	21	20.3	20.1	21	20.7	21.6
Magnesium	mg/L	34.01	35.77	tbd	tbd	33.1	29.4	30.3	29.5	30.7	30.8	31.2
Iron	mg/L	0.255	tbd	0.33	NC	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.0395	tbd	tbd	tbd	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	18.38	tbd	tbd	tbd	15.8	14.2	13.5	13.3	13.9	13.8	14
Selenium	mg/L	NC	NC	NC	NC	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Silver	mg/L	NC	NC	NC	NC	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Sodium	mg/L	184.04	202.72	206.14	NC	189	170	170	167	171	173	174
VOLATILE ORGANIC PARAMETERS												
EPA 8260	mg/L	NC	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND
ADDITIONAL ANALYTES (Assessment/Verification)												
Chromium	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	0.118	0.0935	0.107	0.086	0.090	0.084	0.086
Vanadium	mg/L	NC	NC	NC	NC	0.0201	0.0191	0.0191	0.0180	0.0181	0.0189	0.0193
Zinc	mg/L	NC	NC	NC	NC	0.0271	ND (0.01)	0.0196	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)

Notes:

Bold = exceedance of control limits. Any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.
2016 Upper Predictive Limits are used on events past June 2016.
°C = degrees Celsius
% = percent
µS/cm = microsiemen(s) per centimeter
amsl = above mean sea level
bgs = below ground surface
CUSUM = cumulative summation
EPA = U.S. Environmental Protection Agency
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011), or the parameter was analyzed outside of its associated holding time (12/17/2012)
mg/L = milligram(s) per liter
msl = mean sea level
MW = monitoring well
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined
VOC = volatile organic compound

Baseline data collected 5/24/01 through 3/12/02. Post-Baseline data collected 12/18/03 through present.
Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 230.11 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces have been recalculated (230.26 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

[3] Indicated concentration represents total Nitrate-Nitrite (12/16/08).

[4] Corrected well depths (feet bgs) were re-calculated in 4/30/15 based on original installation logs and used for data post 8/2014.

Table G-6

Summary of Field and Analytical Results: MW-6

Central Maui Landfill

WELL NUMBER	Units	2002	2005	2010	2010	2016	MW-6	MW-6	MW-6	MW-6	MW-6	MW-6	MW-6	MW-6	MW-6	MW-6
DATE		**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Poisson Prediction Limits**	**Upper Predictive Limits**	**5/24/2001**	**6/26/2001**	**8/7/2001**	**9/19/2001**	**10/30/2001**	**12/11/2001**	**1/22/2002**	**3/12/2002**	**12/18/2003**	**6/17/2004**
ANALYTE																
FIELD PARAMETERS																
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	NC	3.12	3.05	3.11	3.13	3.12	3.5	3.4	3.36	3.11	3.57
Well Depth	feet, btoc	NC	NC	NC	NC	NC	324.13	324.13	324.13	324.13	324.13	324.13	324.13	324.13	324.13	324.13
pH	pH units	NC	NC	NC	NC	NC	7.64	7.55	7.58	7.51	7.51	7.61	7.28	7.41	7.26	9.66 [2]
Temperature	degree C	NC	NC	NC	NC	NC	23.89	23.33	23.89	24.44	24.44	23.33	24.44	23.89	23.5	23.6
Turbidity	NTU	NC	NC	NC	NC	NC	1.1	1.9	0.8	0	0	1.1	0.4	0	2	6
Specific Conductivity	µS/cm	NC	NC	NC	NC	NC	1040	1100	1070	1030	1030	1060	1130	1240	1110	1190
Salinity	ppt	NC	NC	NC	NC	NC	--	--	--	--	--	--	--	--	0.04	0.05
Dissolved Oxygen	mg/L	NC	NC	NC	NC	NC	--	--	--	--	--	--	--	--	6.00	7.81
INORGANIC AND CONVENTIONAL PARAMETERS																
Ammonia (as N)	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	21.63	25.71	20.88	NC	80.6	2	13	ND(1.0)	1.4	1.3	1.2	1.1	1.1	13.4	7.72
Nitrate-N	mg/L	7.1	6.91	6.85	NC	9.56	5.04	4.6	4.5	4.8	5.8	4.8	5.6	4.9	4.43	5.09
Chloride	mg/L	188	183.1	183.60	NC	216	153	150	149	141.0	154	147	168	158	154	165
Sulfate	mg/L	44.7	49.91	tbd	tbd	69	33	29	29	27.9	32.1	30.7	36.1	34.6	21.8	28.7
Alkalinity	mg/L	314	318.15	tbd	tbd	595	293	293	285	299	285	294	290	297	294	284
Total Dissolved Solids	mg/L	965	tbd	762.10	NC	945	614	649	641	650	**821**	617	627	676	664	680
Antimony	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	20.29	20.06	tbd	tbd	26.1	18.9	18.7	17.9	17.9	17.5	17.8	17.7	17.7	16.8	18.2
Magnesium	mg/L	30.43	32.56	32.74	NC	43.8	27.7	28.9	27.3	28.1	27.3	27.1	27.5	27.0	26.0	30.3
Iron	mg/L	0.185	0.23	0.19	NC	NC	ND(0.05)	0.0566	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	0.0702	0.128	0.0609	0.0526
Manganese	mg/L	0.176	tbd	0.03	NC	NC	ND(0.005)	ND(0.005)	0.005	ND(0.005)	ND(0.005)	ND(0.005)	ND(0.005)	ND(0.005)	0.0119	0.00965
Potassium	mg/L	16.43	17.25	tbd	tbd	20.8	13.8	14.5	13.2	14.5	13.6	14.5	13.2	13.5	12.9	15.0
Selenium	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	186.04	207.85	207.24	NC	221	169	171	163	163	156	163	166	168	142	169
VOLATILE ORGANIC PARAMETERS																
EPA 8260	mg/L	NC	NC	NC	NC	NC	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.005-0.1)	ND(0.002-0.025)	ND(0.002-0.025)
ADDITIONAL ANALYTES (Assessment/Verification)																
Chromium	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	0.148	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	0.0363	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	0.0769	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. For any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius

% = percent

µS/cm = microsiemen(s) per centimeter

amsl = above mean sea level

bgs = below ground surface

CUSUM = cumulative summation

EPA = U.S. Environmental Protection Agency

J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011), or the parameter was analyzed outside of its associated holding time (12/17/2012)

mg/L = milligram(s) per liter

msl = mean sea level

MW = monitoring well

NC = not calculated

ND (XX) = not detected (reporting limit)

NTU = nephelometric turbidity units

PVC = polyvinyl chloride

tbd = to be determined

VOC = volatile organic compound

Baseline data collected 5/24/01 through 3/12/02. Post-baseline data collected 12/18/03 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 307.03 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces were recalculated (307.06 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Water quality meter could not be calibrated for pH; results are not accurate (6/17/04).

[3] Values were revised from previous report due to amended laboratory report (6/28/05).

[4] VOC detected is carbon disulfide (6/22/06). VOCs have no control limits, as any detection triggers verification sampling.

[5] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

Table G-6
Summary of Field and Analytical Results: MW-6
Central Maui Landfill

WELL NUMBER	**Units**	**2002**	**2005**	**2010**	**2010**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**
DATE		**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Poisson Prediction Limits**	**12/15/2004**	**6/28/2005**	**12/8/2005**	**6/22/2006**	**12/6/2006**	**6/7/2007**	**12/12/2007**	**6/11/2008**	**12/16/2008**	**6/3/2009**	**12/9/2009**
ANALYTE																
FIELD PARAMETERS																
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	3.14	2.83	3.19	2.31	2.55	2.53	3.42	2.72	2.13	2.37	2.69
Well Depth	feet, btoc	NC	NC	NC	NC	324.13	324.13	324.13	324.13	324.13	324.13	324.13	324.13	324.13	324.13	324.13
pH	pH units	NC	NC	NC	NC	7.44	7.10	7.26	7.14	6.94	6.49	6.95	7.20	--	7.16	6.99
Temperature	degree C	NC	NC	NC	NC	23.5	24.0	25.98	24.07	24.5	24.6	24.62	24.68	--	23.4	24.31
Turbidity	NTU	NC	NC	NC	NC	34.2	137.0	105	122	36.5	--[5]	4.6	28.4	--	16.7	--[5]
Specific Conductivity	µS/cm	NC	NC	NC	NC	1100	1200	1080	1170	1170	1200	1110	1150	--	1071	1150
Salinity	ppt	NC	NC	NC	NC	0.10	0.10	0.05	0.05	0.05	0.1	0.05	0.05	--	0.053	0.03
Dissolved Oxygen	mg/L	NC	NC	NC	NC	11.74	5.22	6.01	6.42	5.16	6.25	7.01	6.60	--	9.10	10.34
INORGANIC AND CONVENTIONAL PARAMETERS																
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	21.63	25.71	20.88	NC	12.20	5.68 [3]	1.4	7.6	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	--	1.8	2.2
Nitrate-N	mg/L	7.1	6.91	6.85	NC	4.58	3.86	5.04	4.29	3.85	4.28	4.88	5.35	--	4.64	3.85
Chloride	mg/L	188	183.1	183.60	NC	152	152	167	166	150	160	160	150	--	150	160
Sulfate	mg/L	44.7	49.91	tbd	tbd	19.6	21.2	21.7	22.6	22.0	23	21	21	--	22	44
Alkalinity	mg/L	314	318.15	tbd	tbd	282	274	280	280	290	290	274	266	--	278	270
Total Dissolved Solids	mg/L	965	tbd	762.10	NC	686	668	678	572	622	590	640	600	--	636	646
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L	20.29	20.06	tbd	tbd	17.9	17.9	17.7	17.4	16.4	17.6	18.2	16.5	--	18.7	18.1
Magnesium	mg/L	30.43	32.56	32.74	NC	29.0	28.8	28.6	27.4	26.7	27.8	30.9	26.5	--	27.6	26.5
Iron	mg/L	0.185	0.23	0.19	NC	ND(0.05)	0.152	0.0576	ND (0.05)	ND (0.05)	ND (0.05)	**0.527**	0.0749	--	ND (0.0500)	ND (0.0500)
Manganese	mg/L	0.176	tbd	0.03	NC	0.00937	0.019	0.0116	0.0158	0.00977	0.00844	0.0262	0.00856	--	0.00599	0.00774
Potassium	mg/L	16.43	17.25	tbd	tbd	11.7	13.3	13.4	11.7	12.1	13.0	13.1	12.2	--	12.5	12.5
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L	186.04	207.85	207.24	NC	174	186	171	**240**	159 / 159	158	147	148	--	151	163
VOLATILE ORGANIC PARAMETERS																
EPA 8260	mg/L	NC	NC	NC	NC	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	**0.0054** [4]	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	ND(0.002-0.025)	--	ND(0.002-0.025)	ND(0.002-0.025)
ADDITIONAL ANALYTES (Assessment/Verification)																
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. For any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.
2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius
% = percent
µS/cm = microsiemen(s) per centimeter
amsl = above mean sea level
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CUSUM = cumulative summation
EPA = U.S. Environmental Protection Agency
J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011), or the parameter was analyzed outside of its associated holding time (12/17/2012)
mg/L = milligram(s) per liter
msl = mean sea level
MW = monitoring well
NC = not calculated
ND (XX) = not detected (reporting limit)
NTU = nephelometric turbidity units
PVC = polyvinyl chloride
tbd = to be determined
VOC = volatile organic compound

Baseline data collected 5/24/01 through 3/12/02. Post-baseline data collected 12/18/03 through present.
Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 307.03 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces were recalculated (307.06 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Water quality meter could not be calibrated for pH; results are not accurate (6/17/04).

[3] Values were revised from previous report due to amended laboratory report (6/28/05).

[4] VOC detected is carbon disulfide (6/22/06). VOCs have no control limits, as any detection triggers verification sampling.

[5] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

Table G-6
Summary of Field and Analytical Results: MW-6
Central Maui Landfill

WELL NUMBER	**Units**	**2002**	**2005**	**2010**	**2010**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**	**MW-6**
DATE		**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Upper Shewhart-Cusum Control Limits**	**Poisson Prediction Limits**	**6/17/2010**	**12/28/2010**	**6/29/2011**	**12/19/2011**	**6/27/2012**	**10/17/2012**	**12/17/2012**	**4/24/2013**	**7/17/2013**
ANALYTE														
FIELD PARAMETERS														
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	2.14	3.27	2.85	2.91	2.79		2.97		2.71
Well Depth	feet, btoc	NC	NC	NC	NC	324.13	324.13	324.13	324.13	324.13		324.13		324.13
pH	pH units	NC	NC	NC	NC	7.34	7.22	7.34	7.44	8.00		7.32		7.22
Temperature	degree C	NC	NC	NC	NC	23.46	25.48	25.01	23.04	22.76		22.35		23.50
Turbidity	NTU	NC	NC	NC	NC	70.4	0.3	50.7	73.1	10.2		4.6		10.8
Specific Conductivity	µS/cm	NC	NC	NC	NC	1057	1	1130	1080	1040		1160		1142
Salinity	ppt	NC	NC	NC	NC	0.052	0.50	0.06	0.03	0.03		0.06		0.057
Dissolved Oxygen	mg/L	NC	NC	NC	NC	7.94	3.06	8.32	9.70	8.41		8.02		7.83
INORGANIC AND CONVENTIONAL PARAMETERS														
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L	21.63	25.71	20.88	NC	3.0	ND (1.0)	4.5	ND (1.0)	ND (1.0)		17		19
Nitrate-N	mg/L	7.1	6.91	6.85	NC	5.03	**15.5**	4.62 / 4.61	4.90	4.87	NA	3.7 J	NA	4.2 J
Chloride	mg/L	188	183.1	183.60	NC	150	150	160	160	160	NA	170	NA	180
Sulfate	mg/L	44.7	49.91	tbd	tbd	22	20	26	21	26	NA	14	NA	19
Alkalinity	mg/L	314	318.15	tbd	tbd	280	280	260	50 J	270	NA	254	NA	261
Total Dissolved Solids	mg/L	965	tbd	762.10	NC	616	620	630	598	660	NA	640	NA	655
Antimony	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA		NA		NA
Calcium	mg/L	20.29	20.06	tbd	tbd	17.4	17	19	16.8	17	NA	18.7	NA	19.9
Magnesium	mg/L	30.43	32.56	32.74	NC	26.3	27	30	25.7	27	NA	30.5	NA	31.6
Iron	mg/L	0.185	0.23	0.19	NC	0.0631	ND(0.040)	0.050	ND (0.10)	ND (0.040)	NA	**0.393**	NA	ND (0.100)
Manganese	mg/L	0.176	tbd	0.03	NC	0.00789	ND(0.007) [6]	ND (0.020)	0.012	ND (0.020)	NA	0.0125	NA	ND (0.00500)
Potassium	mg/L	16.43	17.25	tbd	tbd	11.8	13	14	12.6	14	NA	12.8	NA	14.7
Selenium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA		NA		NA
Silver	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA		NA		NA
Sodium	mg/L	186.04	207.85	207.24	NC	140	170	170	155	160	NA	169	NA	174
VOLATILE ORGANIC PARAMETERS														
EPA 8260	mg/L	NC	NC	NC	NC	ND(0.002-0.025)	ND (0.00050-0.010)	ND (0.00050-0.020)	ND (0.0010 - 0.0020)	ND (0.0010 - 0.150)	NA	ND (0.00050 - 0.10)	NA	ND (0.00050 - 0.020)
ADDITIONAL ANALYTES (Assessment/Verification)														
Chromium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.01)	NA
Lead	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	0.1	0.108	0.0922	0.0932	0.0762
Vanadium	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	ND (0.01)	0.0235	0.0215	0.0231	0.0231
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Bold = exceedance of control limits. For any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.
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°C = degrees Celsius
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mg/L = milligram(s) per liter
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VOC = volatile organic compound

Baseline data collected 5/24/01 through 3/12/02. Post-baseline data collected 12/18/03 through present.
Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 307.03 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces were recalculated (307.06 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Water quality meter could not be calibrated for pH; results are not accurate (6/17/04).

[3] Values were revised from previous report due to amended laboratory report (6/28/05).

[4] VOC detected is carbon disulfide (6/22/06). VOCs have no control limits, as any detection triggers verification sampling.

[5] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

Table G-6

Summary of Field and Analytical Results: MW-6

Central Maui Landfill

WELL NUMBER DATE ANALYTE	Units	2002 Upper Shewhart-Cusum Control Limits	2005 Upper Shewhart-Cusum Control Limits	2010 Upper Shewhart-Cusum Control Limits	2010 Poisson Prediction Limits	MW-6 10/30/2013	MW-6 12/5/2013	MW-6 4/9/2014	MW-6 7/9/2014	MW-6 10/27/2014	MW-6 12/16/2014	MW-6 3/9/2015	MW-6 6/23/2015	MW-6 9/21/2015	MW-6 12/2/2015	MW-6 3/23/2016
FIELD PARAMETERS																
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC		2.91	3.08	3.00	2.46	3.05	3.31	3.31	3.36	4.06	3.24
Well Depth	feet, btoc	NC	NC	NC	NC		324.13	324.13	324.13	324.13	324.13	324.13	324.13	324.13	324.13	324.13
pH	pH units	NC	NC	NC	NC		7.60	7.31	7.35	7.37	7.34	7.06	7.27	7.24	7.34	7.16
Temperature	degree C	NC	NC	NC	NC		22.75	23.43	23.58	23.81	22.69	23.5	23.8	24.1	23.64	23.1
Turbidity	NTU	NC	NC	NC	NC		0.0	5.76	3.94	1.36	1.24	1.1	0.85	0.75	0.81	6.11
Specific Conductivity	µS/cm	NC	NC	NC	NC		1170	1192	1113	969	1189	1110	1000	1120	1134	1104
Salinity	ppt	NC	NC	NC	NC		0.06	0.059	0.055	0.048	0.059	0.055	0.049	0.056	0.056	0.055
Dissolved Oxygen	mg/L	NC	NC	NC	NC		8.34	6.80	7.55	7.48	5.25	6.56	7.61	7.2	5.56	7.9
INORGANIC AND CONVENTIONAL PARAMETERS																
Ammonia (as N)	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	NA	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Total Organic Carbon	mg/L	21.63	25.71	20.88	NC		**32**	**31**	19	**27**	**21**	**22**	**25**	ND (1)	1.1	1
Nitrate-N	mg/L	7.1	6.91	6.85	NC	NA	4.4 J	NA	5.1 BU	NA	5.4	5.1	3.3	5.3	5.3	5.1
Chloride	mg/L	188	183.1	183.60	NC	NA	170	170	170	**190**	180	170	170	170	170	170
Sulfate	mg/L	44.7	49.91	tbd	tbd	NA	27	NA	25	NA	25	46	21	23	ND (0.1)	21
Alkalinity	mg/L	314	318.15	tbd	tbd	NA	261	NA	255	NA	256	265	260	261	252	261
Total Dissolved Solids	mg/L	965	tbd	762.10	NC	NA	660	NA	625	NA	650	545	650	475	650	620
Antimony	mg/L	NC	NC	NC	NC		NA	NA	NA	NA	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Calcium	mg/L	20.29	20.06	tbd	tbd	NA	19.7	NA	21.0	NA	19	18.6	20.3	19.7	19.1	18.9
Magnesium	mg/L	30.43	32.56	32.74	NC	NA	31.3	NA	**33.8**	32.6	28	31.2	30.3	32.2	31.7	32.2
Iron	mg/L	0.185	0.23	0.19	NC	NA	ND (0.100)	NA	**0.287**	0.105	ND (0.100)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Manganese	mg/L	0.176	tbd	0.03	NC	NA	0.00587	NA	0.0156	NA	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	16.43	17.25	tbd	tbd	NA	15.0	NA	14.9	NA	13.7	14.5	16.8	15	14.6	13.8
Selenium	mg/L	NC	NC	NC	NC		NA	NA	NA	NA	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Silver	mg/L	NC	NC	NC	NC		NA	NA	NA	NA	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Sodium	mg/L	186.04	207.85	207.24	NC	NA	177	NA	173	NA	166	175	186	181	172	169
VOLATILE ORGANIC PARAMETERS																
EPA 8260	mg/L	NC	NC	NC	NC	NA	ND (0.00050 - 0.050)	NC	ND (0.00050 - 0.050)	NA	ND	ND	ND	ND	ND	ND
ADDITIONAL ANALYTES (Assessment/Verification)																
Chromium	mg/L	NC	NC	NC	NC	NA	NA	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	0.0689	0.083	0.0919	0.0885	0.0719	0.0486	0.0569	0.0494	0.0506	0.0432	0.0582
Vanadium	mg/L	NC	NC	NC	NC	0.0234	0.0228	0.0254	0.0236	0.0245	0.0216	0.0236	0.0235	0.0248	0.0246	0.0248
Zinc	mg/L	NC	NC	NC	NC	NA	NA	NA	NA	0.0208	0.0132	0.0107	ND (0.01)	0.0209	ND (0.01)	0.0184

Notes:

Bold = exceedance of control limits. For any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.

2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius

% = percent

µS/cm = microsiemen(s) per centimeter

amsl = above mean sea level

bgs = below ground surface

CUSUM = cumulative summation

EPA = U.S. Environmental Protection Agency

J = value is estimated due to the associated method blank containing the target analyte at a reportable level (12/19/2011), or the parameter was analyzed outside of its associated holding time (12/17/2012)

mg/L = milligram(s) per liter

msl = mean sea level

MW = monitoring well

NC = not calculated

ND (XX) = not detected (reporting limit)

NTU = nephelometric turbidity units

PVC = polyvinyl chloride

tbd = to be determined

VOC = volatile organic compound

Baseline data collected 5/24/01 through 3/12/02. Post-baseline data collected 12/18/03 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 307.03 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces were recalculated (307.06 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Water quality meter could not be calibrated for pH; results are not accurate (6/17/04).

[3] Values were revised from previous report due to amended laboratory report (6/28/05).

[4] VOC detected is carbon disulfide (6/22/06). VOCs have no control limits, as any detection triggers verification sampling.

[5] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

Table G-6

Summary of Field and Analytical Results: MW-6

Central Maui Landfill

WELL NUMBER **DATE** **ANALYTE**	**Units**	**2002** **Upper Shewhart-Cusum Control Limits**	**2005** **Upper Shewhart-Cusum Control Limits**	**2010** **Upper Shewhart-Cusum Control Limits**	**2010** **Poisson Prediction Limits**	**MW-6** **6/8/2016**	**MW-6** **9/13/2016**	**MW-6** **12/19/2016**	**MW-6** **3/20/2017**	**MW-6** **6/19/2017**	**MW-6** **9/20/2017**	**MW-6** **12/18/2017**	**MW-6** **3/12/2018**
FIELD PARAMETERS													
Groundwater Elevation [1]	feet, amsl	NC	NC	NC	NC	3.28	3.24	3.25	3.18	3.14	3.22	3.28	2.88
Well Depth	feet, btoc	NC	NC	NC	NC	324.13	324.13	324.13	324.13	324.13	324.13	324.13	324.13
pH	pH units	NC	NC	NC	NC	7.04	7.24	6.65	7.05	7.5	7.15	7.56	6.75
Temperature	degree C	NC	NC	NC	NC	23.77	22.5	23.74	23.75	19.38	23.74	22.66	22.46
Turbidity	NTU	NC	NC	NC	NC	1.8	1.48	0.7	1.91	0.1	0.3	0.0	0.0
Specific Conductivity	µS/cm	NC	NC	NC	NC	1130	1080	1150	1076	0.911	1.04	1010	982
Salinity	ppt	NC	NC	NC	NC	0.056	0.054	0.057	0.053	0	0.05	0.05	0.05
Dissolved Oxygen	mg/L	NC	NC	NC	NC	8.82	8.81	6.9	7.61	9.42	10.38	8.89	6.98
INORGANIC AND CONVENTIONAL PARAMETERS													
Ammonia (as N)	mg/L	NC	NC	NC	NC	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Total Organic Carbon	mg/L	21.63	25.71	20.88	NC	1.4	1.1	0.74	0.89	0.55	ND (0.5)	0.78	ND (0.50)
Nitrate-N	mg/L	7.1	6.91	6.85	NC	4.4	5.3	3.6	4.5	4.4	5	5.5	3.2
Chloride	mg/L	188	183.1	183.60	NC	160	180	160	160	150	140	140	140
Sulfate	mg/L	44.7	49.91	tbd	tbd	21	20	19	20	18	18	17	18
Alkalinity	mg/L	314	318.15	tbd	tbd	258	257	251	256	262	257	267	252
Total Dissolved Solids	mg/L	965	tbd	762.10	NC	600	660	580	630	585	535	555	580
Antimony	mg/L	NC	NC	NC	NC	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Calcium	mg/L	20.29	20.06	tbd	tbd	20.2	18.5	18.6	18.8	18	16.5	16.4	15.8
Magnesium	mg/L	30.43	32.56	32.74	NC	34.6	30.2	30.7	31.0	28.9	27.6	26.5	25.9
Iron	mg/L	0.185	0.23	0.19	NC	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.124	ND (0.1)
Manganese	mg/L	0.176	tbd	0.03	NC	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Potassium	mg/L	16.43	17.25	tbd	tbd	14.4	13.6	14.2	14.9	13.5	12.7	12.7	12.4
Selenium	mg/L	NC	NC	NC	NC	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Silver	mg/L	NC	NC	NC	NC	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Sodium	mg/L	186.04	207.85	207.24	NC	177	161	171	181	167	154	155	151
VOLATILE ORGANIC PARAMETERS													
EPA 8260	mg/L	NC	NC	NC	NC	ND	ND	ND	ND	ND	ND	ND	ND
ADDITIONAL ANALYTES (Assessment/Verification)													
Chromium	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Lead	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Nickel	mg/L	NC	NC	NC	NC	0.0711	0.0625	0.0672	0.0773	0.0634	0.0646	0.0601	0.0591
Vanadium	mg/L	NC	NC	NC	NC	0.0274	0.0221	0.0249	0.0266	0.0263	0.0266	0.0242	0.0252
Zinc	mg/L	NC	NC	NC	NC	ND (0.01)	ND (0.01)	0.0162	0.0364	ND (0.01)	0.0457	ND (0.01)	ND (0.01)

Notes:

Bold = exceedance of control limits. For any date before June 2016, 2010 Upper Shewhart-Cusum Control Limits were used.
2016 Upper Predictive Limits are used on events past June 2016.

°C = degrees Celsius

% = percent

µS/cm = microsiemen(s) per centimeter

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PVC = polyvinyl chloride

tbd = to be determined

VOC = volatile organic compound

Baseline data collected 5/24/01 through 3/12/02. Post-baseline data collected 12/18/03 through present.

Records with 2 values indicate original and duplicate verification sample results (original / verification).

[1] Surveyed measurement point from 1-inch PVC sounding tube for calculated potentiometric surface is 307.03 feet above msl, applicable for groundwater elevation calculations until 7/2014. Potentiometric surfaces were recalculated (307.06 feet above msl) during a survey performed in 2013 and are used to calculate groundwater elevations post 8/2014.

[2] Water quality meter could not be calibrated for pH; results are not accurate (6/17/04).

[3] Values were revised from previous report due to amended laboratory report (6/28/05).

[4] VOC detected is carbon disulfide (6/22/06). VOCs have no control limits, as any detection triggers verification sampling.

[5] Turbidity sensor in water quality meter was not operating (6/7/07 and 12/9/09).

Appendix H
Evaluation of Tidal Effect on Groundwater Flow, Central Maui Landfill

Appendix H
Evaluation of Tidal Effect on Groundwater Flow, Central Maui Landfill

H.1 Introduction

Element Environmental LLC conducted continuous monitoring of water levels at the Central Maui Landfill Facility (CMLF) between August 15 and October 16, 2013 (Element, 2013), using Solinst transducers deployed in the six monitoring wells and the the newly installed production well (PW). The continuous groundwater levels measured by Element in 2013 clearly showed the harmonic tidal fluctuation (Figure H-1) typical of sites located close to the coast in Hawaii, with two high water levels (mean high water [MHW] and mean higher high water [MHHW]) that alternate with two low water levels (mean low water [MLW] and mean lower low water [MLLW]) during each tidal cycle. [1] Anomalous static (one-time) groundwater elevations and inconsistent groundwater maps are frequent at these sites, unless continuous readings are taken and tidal evaluations are made.

The continuous groundwater levels measured by Element in 2013 were therefore processed by CH2M HILL (CH2M) using a method developed by Serfes (Serfes, 1991) to evaluate the influence of tidal fluctuations on groundwater flow characteristics and provide a net groundwater flow direction and gradient for the CMLF site. This additional evaluation refines the conceptual site model (CSM) for the site.

At any point where groundwater tidally fluctuates (as is the case at the CMLF), the magnitude and direction of the hydraulic gradient fluctuate about the mean or regional hydraulic gradient. The net effect of these fluctuations on groundwater flow can be determined using the mean groundwater elevations and the mean hydraulic gradient. As part of the tidal effect evaluation, groundwater levels measured by Element in 2013 were processed by CH2M using the Serfes method to evaluate the influence of tidal fluctuations on groundwater flow characteristics and provide a net groundwater flow direction and gradient for the CMLF site. This method (Serfes, 1991) is used to evaluate groundwater flow in coastal aquifers and allows the removal of the lunar tidal influence to estimate the net groundwater flow direction.

A summary of methods and findings for the tidal evaluation is provided in the following sections, along with specific conclusions.

H.2 Data Processing and Interpretation

Data downloaded from the monitoring stations, together with tidal information obtained from the National Oceanic and Atmospheric Administration (NOAA) Kahului Harbor Station (NOAA Station ID 1615680) were evaluated to determine the influence of tidal fluctuations on groundwater movement beneath the CMLF site.

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[1] The tidal cycle typical of the Hawaiian Islands is characterized by a mixed pattern, with two high and two low tides of unequal amplitude. The MHHW is followed by MLW, MHW, and MLLW in a cyclical daily pattern.

A representative 71-hour subset of the data collected by Element in 2013 was selected for evaluation of both tidal influences and groundwater flow conditions.[2] The 71-hour subset of data (hereafter referred to as the 71-hour period) was chosen based on maximum tidal fluctuations. The intent was to select a subset of data that represented a large range of tidal fluctuation during the 2-month data collection period. After examination of the entire continuous water level dataset, the 71-hour period was selected from August 22, 2013, at 00:00 hours to August 24, 2013, at 23:00 hours. The NOAA tidal gauging station subset of data was filtered to use only the data measurements collected every 1 hour, concurrent with the 1-hour measurements obtained from the Element 2013 dataset. Lag times and mean groundwater elevations were calculated using this subset of data, as described in the following sections.

H.3 Lag Times

Lag times between the NOAA station and each of the monitoring wells were calculated as the time difference of each higher high (or lower low) tide within the 71-hour period between each monitoring station and the NOAA station. Lag times between the earliest and the latest monitoring well were also calculated for each higher high (or lower low) tide. Lag time data have an accuracy of ±1 hour.

Estimated lag times between the NOAA tidal gauging station and the monitoring wells as well as the relative lag times between the wells where the tide was observed first and last are presented in Table H-1. Transmission of pressure waves generated by fluctuating pressure heads in the ocean is generally faster and less dampened deeper in the aquifer and in areas of higher permeability. As indicated in Table H-1, the fastest responses to tidal fluctuations were constantly recorded in PW (in some instances, also MW-3 or MW-5), where the tidal pressure waves were observed from 2 to 3 hours earlier compared to the monitoring wells screened at shallower depths (approximately 20 feet shallower).

Average lag times between wells (that is, the time between tidal pressure waves observed at the first and the last well) were approximately the same at high and low tide (2.5 hours). Faster responses to tidal fluctuations in the monitoring wells were generally observed in MW-3, while the slowest responses were generally recorded in MW-4 and MW-6, which are the farthest from the ocean, together with MW 1.

H.4 Tidal Efficiency

The tidal efficiency of a well, which is defined as the ratio of the amplitudes of the plotted groundwater table and tidal elevations, provides one method for directly comparing the influence of tidal fluctuations on groundwater elevations between measurement points (hydrographs provide a graphical comparison of the same information).

To evaluate tidal influences, hourly water level data from site wells (MW-1 through MW-6 and PW) were compared to levels observed at the NOAA station during the 71-hour period. The tidal efficiency factors (TEFs) were calculated as the ratio of the standard deviations of the two sets of readings. This method, developed by Erskine, uses hourly observations during the 71-hour period rather than just the peak readings, therefore reducing the effect of individual reading errors potentially occurring during the test (Erskine, 1991).

Tidal efficiencies relative to the NOAA tidal gauging station were calculated at the seven wells that were part of the tidal evaluation network, as shown in Table H-2. Tidal efficiencies ranged between 5 (wells MW-1 and MW-3) and 8 percent (MW-4, MW-5, and MW-6) during the 71-hour period. Table H-2 shows that TEFs do not correlate well with relative lag times between monitoring wells. Wells with

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[2] A 71-hour period was selected for evaluation because the method used to calculate mean groundwater elevations is based on 71 hourly readings.

faster responses (PW, MW-3, and MW-5) and locations closer to the ocean would be expected to have higher TEFs. Greater distance from the ocean, different basalt fracture geometry, and slightly different lithology/permeabililty in the immediate vicinity of the wells may be the cause of these anomalies.

H.5 Mean Water Elevations and Groundwater Flow

Mean groundwater elevations were calculated adopting a method described by Serfes (1991), which is used to filter diurnal and semi-diurnal lunar and solar harmonics from 71 hourly water level measurements. This method uses moving averages, with different sequences of means, to yield a filtered mean level for the median time of the 71-hour period.

Figure H-2 represents the net mean effect of groundwater fluctuations caused by tidal pressure wave propagation during the 71-hour period. Based on the 71-hour mean groundwater elevations, an average hydraulic gradient ranging from 1.4×10^{-4} feet per foot (feet/foot) (in eastern portion of the site) and 5.8×10^{-5} feet/foot (in the western portion of the site) is estimated for the uppermost, basal aquifer beneath CMLF.

The net groundwater flow during the 71-hour period was toward the north-northwest, which is consistent with the regional groundwater flow (oceanward). The highest groundwater elevation was recorded in monitoring wells MW-1 and MW-4 (3.04 feet above mean sea level [amsl]), while the lowest (2.76 feet amsl) was observed in the production well PW.

H.6 Tidal Evaluation Conclusions

A site-specific tidal evaluation was conducted at the CMLF to estimate the mean groundwater flow direction and hydraulic gradient in the uppermost basal aquifer and to evaluate the influence of tidal fluctuation on groundwater movement at the site. Continuous groundwater monitoring was conducted at seven wells by Element in 2013. A 71-hour period between August 22, 2013 (at 00:00 hours) and August 24, 2013 (at 23:00 hours), was selected and filtered from the Element dataset. After data acquisition, mean water elevations were calculated and groundwater flow conditions assessed based on observations made during the 71-hour period and adopting the Serfes filtering method (Serfes, 1991). Based on the data collected as part of this evaluation, the following general conclusions have been reached:

- Groundwater beneath CMLF is tidally influenced and characterized by the harmonic tidal fluctuation typical of sites located close to the coast in Hawaii, with two high water levels (MHW and MHHW) and two low water levels (MLW and MLLW). Groundwater level fluctuations recorded in the 71-hour period were up to approximately 0.24 feet, which is significant considering the relatively flat groundwater gradient at the site.
- MW-1 and MW-3 are much less influenced by tidal fluctuation (possibly because of fracture geometry, distance from the ocean, or both), which could explain anomalies observed when taking static manual groundwater level measurements.
- Average groundwater level at the production well is basically the same as MW-2 and similar to MW-5. Significant differences observed when taking static manual groundwater level measurements at these wells are therefore attributed to the effect of tidal fluctuation on groundwater elevations and flow.
- Lag time between wells onsite can be significant (average of 3 hours, ± 1 hour), which could also explain anomalous groundwater elevations observed when taking static manual groundwater level measurements.
- The lag time between the ocean and the site is 4 to 6 hours, ± 1 hour.

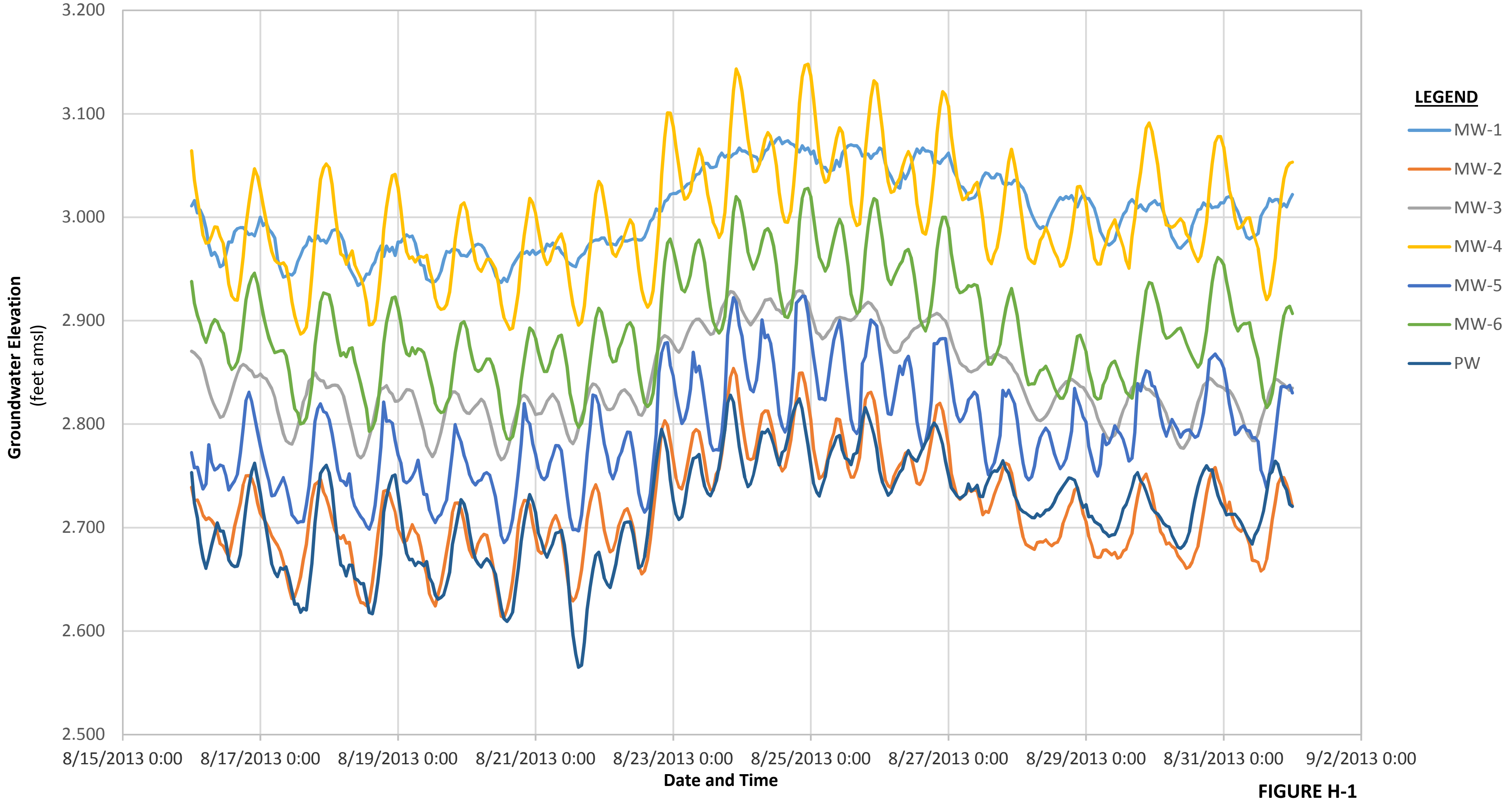
- The net groundwater flow estimated for the CMLF site is toward the north-northwest, consistent with the regional flow.
- The combination of groundwater level fluctuations, low hydraulic gradient, and significant lag time between monitoring wells at the site, together with the nature of the aquifer (fractured basalt, with potentially different fracture geometry resulting in different ways each well communicate with the aquifer), is the most plausible explanation of anomalous groundwater elevations recorded when taking static (one-time) groundwater readings in site wells. The tidal pressure wave is observed at each well at different times (with significant lag times), which causes anomalous groundwater elevations because of fluctuating groundwater levels (with the low hydraulic gradient typical of CMLF, even a fluctuation of a few inches can cause significant anomalies). The anomalous static groundwater elevations often result in inconsistent groundwater flow direction modeled in groundwater flow maps for the site.

H.7 References

Erskine. 1991. “The Effect of Tidal Fluctuation on a Coastal Aquifer in the UK.” *Groundwater*, vol. 29, no. 4, July-August 1991.

Serfes. 1991. “Determining the Mean Hydraulic Gradient of Groundwater Affected by Tidal Fluctuations.” *Groundwater*, vol. 29, no. 4, July-August 1991.

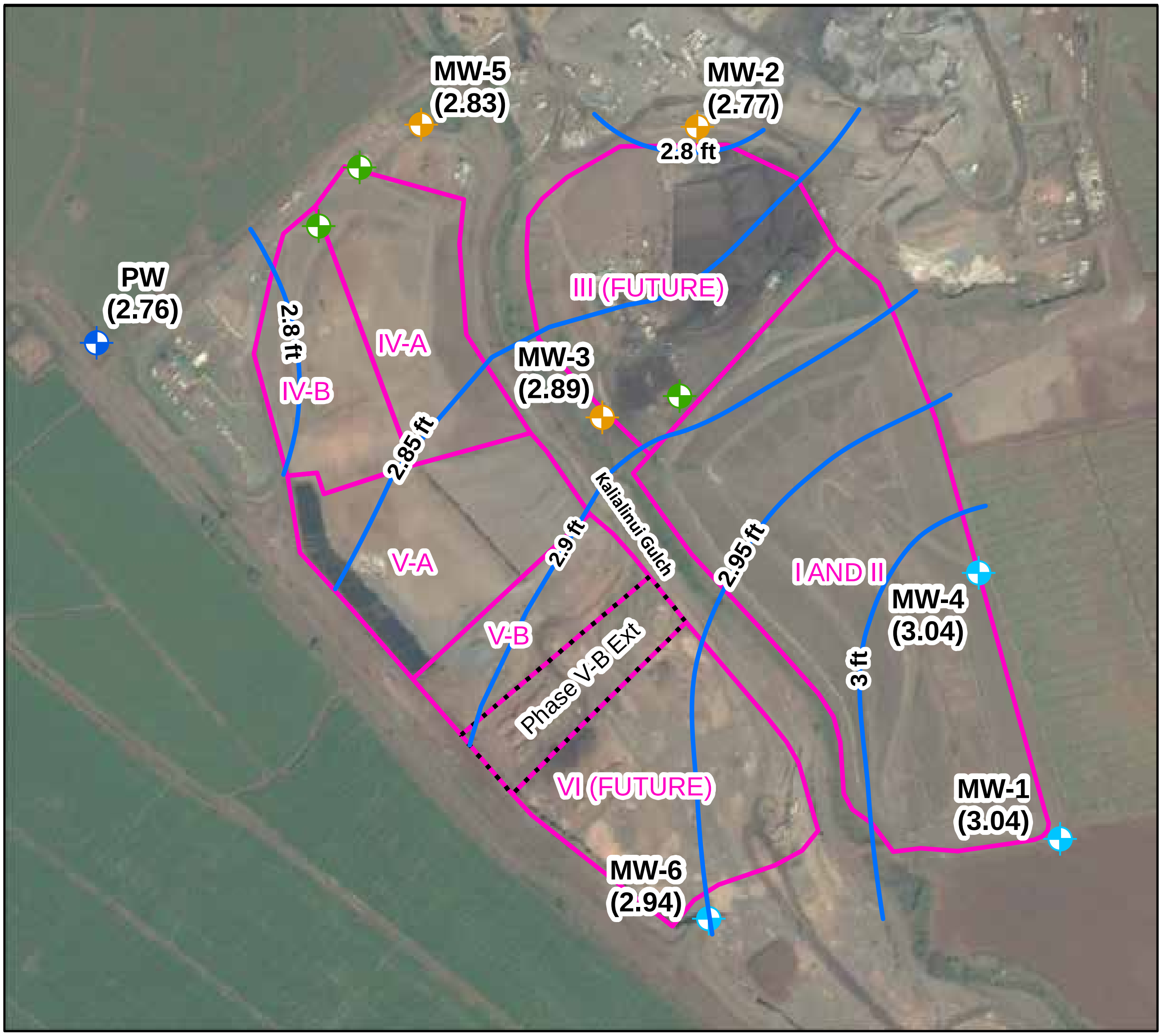
Figures

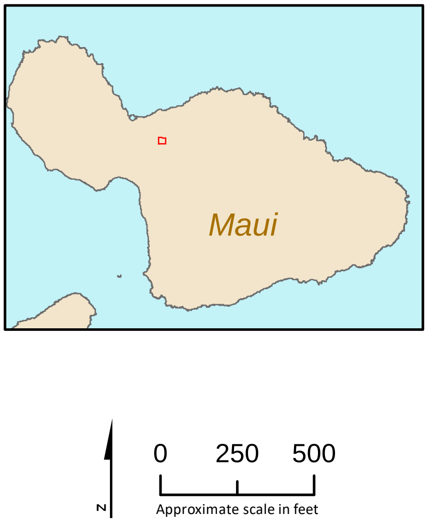


<u>Notes</u>: Element Environmental LLC conducted continuous monitoring of water levels at the site between August 15, 2013 and October 16, 2013 (Element, 2013)

amsl = above mean sea level

FIGURE H-1
Harmonic Tidal Fluctuations
Evaluation of Tidal Effect on
Groundwater Flow
Central Maui Landfill
Puunene, Maui





Notes:

- Average hydraulic gradient = 1.0 E-04 foot/foot
- Seepage velocity = 14 feet/year to 478 feet/year
- Hourly measurements from 2013 continuous synoptic water level measurements (Element, 2014). Groundwater flow characteristics have been modeled using the software Surfer 8.0.
- This figure represents the average groundwater equipotential lines and the horizontal hydraulic gradient during the 71-hour period (between 8/22/2013, 00:00 hours and 8/24/2013, 23:00 hours). The average hydraulic gradient has been estimated using groundwater elevations between monitoring wells MW-4 and MW-2, and MW-4 and PW.
- Groundwater elevations (indicated along contour lines and in parenthesis for each well) are in feet above mean sea level.

ACRONYMS:

ft = feet (above mean sea level)

LEGEND

EXISTING MONITORING LOCATIONS

⊕ Compliance Monitoring Well

⊕ Upgradient/Crossgradient Monitoring Well

⊕ Production Well

⊕ Leachate Collection Point (Sump or Wet Well)

▭ Landfill Phase Boundary

⬚ Landfill Phase Currently Under Construction

— Inferred Groundwater Potentiometric Contour

FIGURE H-2
71-Hour Mean Groundwater Contour Map
Evaluation of Tidal Effect on Groundwater Flow
Central Maui Landfill
Puunene, Maui

ch2m

Tables

TABLE H-1

Tidal Evaluation Lag Times

Central Maui Landfill, Puunene, Maui

Tide Event	Tide Observation		Lag Time		
	Earliest Well	**Latest Well**	**Earliest Well - Latest Well** (hours)	**Earliest Well - NOAA** (hours)	**Latest Well - NOAA** (hours)
Peak 1	MW-3	MW-4, MW-6, PW	2	4	6
Trough 2	PW	MW-4, MW-6	3	3	6
Peak 2	PW	MW-6	3	4	7
Trough 3	MW-3, PW	MW-4, MW-6	2	4	6
Peak 3	MW-5	MW-4, MW-6, PW	2	3	5
Trough 4	MW-3, PW	MW-4, MW-6	3	3	6
Peak 4	MW-3, PW	MW-4, MW-6	2	5	7
Trough 5	PW	MW-4, MW-5, MW-6	2	3	5
Peak 5	MW-5	MW-3	3	3	6
Trough 6	PW	MW-4, MW-6	3	3	6
Peak 6	MW-2, MW-3, PW	MW-4, MW-6	3	4	7
		Average at High Tide	2.5	3.8	6.3
		Average at Low Tide	2.6	3.2	5.8

Notes:

NOAA Station # 1615680 located at Kahului Harbor, approximately 3.8 miles from the site.

NOAA = National Oceanic and Atmospheric Administration

TABLE H-2

71-Hour Mean Groundwater Elevations and Tidal Efficiencies

Central Maui Landfill, Puunene, Maui

Monitoring Well ID	**Approximate Distance from Ocean** (feet)	**71-Hour Filtered Mean Water Elevation** (feet amsl)	**Average Relative Tidal Efficiency** (percent)	**Standard Deviations**
MW-1	19,356	3.04	5	0.036
MW-2	16,611	2.77	7	0.052
MW-3	17,203	2.89	5	0.038
MW-4	18,436	3.04	8	0.059
MW-5	15,937	2.83	8	0.056
MW-6	18,882	2.94	8	0.054
PW	15,950	2.76	7	0.049
NOAA	0	1.42	100	0.697

Notes:

Data collected from August 22, 2013, 00:00, through August 24, 2013, 23:00.

amsl = above mean sea level

ID = identification

Appendix I

Groundwater Flow Modeling for the Central Maui Landfill

Technical Memorandum

TECHNICAL MEMORANDUM

Groundwater Flow Modeling for the Central Maui Landfill

PREPARED FOR:	County of Maui
COPY TO:	File
PREPARED BY:	Kerang Sun/SCO
DATE:	May 2018

1.0 Introduction

This technical memorandum describes groundwater flow modeling activities performed for the Central Maui Landfill Facility (CMLF) located in Puunene, Maui, Hawaii. The CMLF is owned and operated by the Solid Waste Division of the County of Maui (County) Department of Environmental Management.

Groundwater modeling evaluated possible influence on groundwater flow conditions of daily pumping at the production well (PW). The PW was installed by the County to supply water for dust control and irrigation activities at the CMLF. The modeling may also assess the adequacy of the CMLF monitoring well network for detection monitoring and help to optimize the location of any additional monitoring wells.

2.0 Site Hydrogeologic Conditions

2.1 Regional Hydrogeology

The CMLF is located on the eastern side of the isthmus between West Maui and Haleakala, approximately 3 miles from the Pacific Ocean coastline at Kahului (Figure I-1). The aquifer underlying the CMLF is part of the Paia aquifer system, which is in turn part of the larger Central aquifer sector on Maui. The flank lava flows of the Kula and Honomanu series underlying the CMLF generally dip to the northwest. Groundwater in the area occurs in the lava flow deposits referred to as the basal aquifer. The basal aquifer is unconfined, with net groundwater flow toward north-northwest, consistent with the general direction of deposition of the lava flows (CH2M, 2016). Figure I-1 shows a regional groundwater contour map for Central Maui published online by the United States Geological Survey (USGS). The contour map is based on water levels measured on May 17, 2005, and confirms a northwest groundwater flow direction at regional scale.

2.2 Local Hydrogeology

Findings from previous site investigations indicate that the uppermost aquifer beneath the landfill is a basal aquifer consisting of fractured basalt. Six groundwater monitoring wells (MW-1 through MW-6) comprise the CMLF detection monitoring network (Figure I-2), with a static water level ranging from approximately 300 feet below ground surface (bgs) in the southern part of the landfill (wells MW-1 and MW-6) to approximately 220 feet bgs in the northern part of the landfill (wells MW-2 and MW-5). Groundwater elevations are typically between 3 and 3.2 feet above mean sea level (amsl) in the upgradient, southeastern portion of the CMLF (well MW-1) and approximately 2.7 feet amsl in the downgradient, northern portion of the site (wells MW-2 and MW-5). The hydraulic gradient is relatively flat and generally toward the north-northwest (CH2M, 2016), consistent with the regional groundwater flow direction (Figure I-1). Hydrogeologic studies of transient groundwater conditions indicate groundwater is influenced by tidal fluctuations, with tidal pressure wave amplitude and time varying among the wells. Groundwater elevation data from a 3-month transducer monitoring study of site wells in 2013 (Element, 2013) were used to calculate mean groundwater elevations. Figure I-2 depicts the net effect on groundwater level and hydraulic gradient fluctuations from the tidal pressure waves, and shows the net groundwater flow based on mean groundwater elevations from a representative 71-hour subset of the continuous logging. The 71-hour subset of data (from August 22, 2013, at 0000 hours to August 24, 2013, at 2300 hours) and the corresponding National Oceanic and Atmospheric Administration (NOAA) tidal gauging station subset of data were filtered to use only the measurements collected every hour. Rolling averages were calculated using a method developed by Serfes (Serfes, 1991). This method filters diurnal and semidiurnal lunar and solar harmonics from 71 hourly water level measurements to evaluate groundwater flow in coastal aquifers and estimate the net groundwater flow direction. The groundwater contour map of Figure I-2 reflects a head loss of 0.1 feet over a distance of approximately 1,000 feet, yielding an average hydraulic gradient of approximately 1.0E-4 feet per foot (feet/foot).

Aquifer slug tests conducted on wells MW-1, MW-2, and MW-3, yielded hydraulic conductivity values ranging from 8.5 to 19 feet per day (feet/day) (CH2M, 2016). Slug tests conducted on wells MW-4, MW-5, and MW-6 yielded hydraulic conductivity values of 52, 380 and 240 feet/day, respectively, considerably larger than the values calculated from MW-1, MW-2 and MW-3 slug tests (CH2M, 2016). A step drawdown test was performed on PW to assess the well specific capacity after well development, followed by a 24-hour constant rate pumping test. The long term test had a pumping rate of 160 gallons per minute (gpm), with a drawdown of 0.36 feet for most of the test (WWS, 2012).

The constant rate pumping test indicates that the basal aquifer is highly conductive with a specific capacity of approximately 440 gpm per foot and a hydraulic conductivity between approximately 1,500 and 2,560 feet/day (456 and 780 meters per day), estimated using specific capacity and hydraulic conductivity relationships discussed by Rotzoll and El-Kadi (Rotzoll and El-Kadi, 2008). The relatively flat hydraulic gradient (1.0E-4 feet/foot) observed at the site also suggests a highly conductive aquifer. Slug tests evaluate near-well aquifer properties and can underestimate hydraulic conductivity; many previous studies report estimated hydraulic conductivity from slug tests orders of magnitude lower than that estimated from pumping tests in the same formation (Bradbury and Muldoon, 1990; Rayne, 1993; Rovey and Cherkauer, 1995). Therefore, hydraulic conductivity may be substantially higher than that derived from the slug tests. The value derived from the PW pumping test data is probably more accurate.

3.0 Groundwater Modeling

A finite-difference numerical groundwater flow model was developed using MODFLOW-SURFACT (HGL, 2008) in conjunction with the Groundwater Vistas Version 6.0 (GW-Vistas 6.0) (ESI, 2011) pre- and post-processing software package as the primary graphical user interface. The model was constructed based on the understanding of the regional and local hydrogeology and calibrated under both steady-state and transient (variable with time) conditions. The calibrated model was used to simulate groundwater flow conditions for the CMLF to evaluate the effect of pumping at PW on groundwater levels at the monitoring wells.

3.1 Model Setup

The model domain and boundary conditions were chosen based on the general groundwater flow conditions at the CMLF (Figure I-3). The active model domain is a rectangular area of approximately 20,000 by 15,000 feet, considerably larger than the CMLF, which is located at the center of the domain. The southwest and northeast boundaries are oriented parallel to the general groundwater flow direction, and are modeled as no-flow boundaries. The upgradient and downgradient boundaries are perpendicular to the general groundwater flow direction, and are modeled as constant head boundaries with assigned constant head values of 4 and 2 feet amsl, respectively.

A single model layer was used to represent the basal aquifer with a uniform bottom elevation of -100 feet below mean sea level, resulting in a saturated thickness of the aquifer ranging from 102 to 104 feet. The entire model domain consisted of 29,455 uniform and discrete cells, 100 by 100 feet.

3.2 Model Calibration

The groundwater flow model was calibrated under both steady-state and transient conditions. Steady-state calibration used the water levels measured at the six monitoring wells and PW between August 22 and 24, 2013 (corrected to remove influence from tidal fluctuations), as calibration targets (Figure I-2). The initial steady-state calibration used the automated parameter estimation package, PEST, a widely used model-independent parameter optimizer (WNC, 2010), which resulted in a perfect match between the observed and calibrated water levels for all the wells. The pilot point approach provided by PEST was used with a total of 71 pilot points distributed throughout the model domain to calibrate the horizontal hydraulic conductivity field, while the anisotropy ratio (horizontal:vertical) was set at 100:1. Figure I-4 shows the distribution of the 71 pilot points used for the PEST model calibration.

The model was further calibrated under transient conditions by simulating a 24-hour constant-rate pumping test at PW with a pumping rate of 160 gpm. The goal of the transient calibration was to match the observed drawdown of 0.36 feet at the end of the 24 hours (WWS, 2012). The hydraulic conductivity field resulting from the initial steady-state calibration was adjusted to match the observed drawdown of 0.36 feet. After adjusting the hydraulic conductivity field, the steady-state calibration was checked to evaluate whether the model still simulated the observed flow condition (Table I-1). Therefore, the steady-state and transient model calibrations were iterated until the model was capable of replicating both the steady-state flow condition and the observed drawdown during the 24-hour pumping test at PW.

Table I-1 summarizes the final results of the steady-state calibration. The normalized percent Root-Mean-Squared error (%RMS) is 6.19 percent, which is below the industry standard of 10 percent for a good calibration, suggesting that the model calibration was successful (ESI, 2011). The final calibrated model matched the observed drawdown of 0.36 feet at PW.

Table I-1. Summary of Steady-State Model Calibration

ID	Observed Water level (feet)	Simulated Water Level (feet)	Residual (feet)
MW-1	3.04	3.03	-0.01
MW-2	2.77	2.78	0.01
MW-3	2.89	2.87	-0.02
MW-4	3.04	3.02	-0.02
MW-5	2.83	2.8	-0.03
MW-6	2.94	2.95	0.01
PW	2.76	2.77	0.01
Summary Statistics			
Range of Observed Water Levels (feet)			0.28
Mean Residual (feet)			-0.007
RMS (feet)			0.017
RMS normalized by Range of Observed Water Levels (RMS%)			6.19%

Note:
ID = identification

Figure I-5 shows the groundwater contours simulated by the groundwater model under the steady-state condition. The 71-Hour Mean Groundwater Contour Map based on mean water levels corrected to remove tidal influence (Figure I-2) and the model-simulated groundwater contour map (Figure I-5) show good agreement. This indicates that the 71-hour groundwater elevation contours on Figure I-2 represent average groundwater flow conditions at the CMLF. The north to northwesterly groundwater flow indicated by the groundwater contour patterns on Figures I-2 and I-5 are consistent with the northwesterly regional groundwater flow direction from USGS (Figure I-1). Figure I-6 shows the model-simulated drawdown contours under the transient condition for the 24-hour constant pumping test at PW and the model-simulated reverse particle path lines (released at and tracked backward from PW) when it is pumping at 160 gpm.

3.3 Simulating Daily Pumping at Production Well PW

To assess the potential impact of the daily pumping activity at PW, the calibrated model simulated a scenario of daily pumping at PW at 160 gpm for 75 minutes to fill the water storage tank with a capacity of 12,000 gallons. Figure I-7 shows the model-simulated drawdown contours at the end of the 75-minute pumping period. Figure I-8 shows the model-simulated hydrographs of water levels over time at PW and the six monitoring wells. Both figures indicate that the daily pumping activities at PW have little impact on groundwater flow at the CMLF. In addition, the modeling calculates a maximum drawdown of 0.06 feet at production well PW caused by the 75 minutes of pumping; the drawdown is estimated to fully recover within 180 minutes (3 hours).

3.4 Simulating Future Daily Pumping at Production Well PW

The County of Maui plans to expand the existing CMLF Facility to include landfill diversion activities. The total daily water demand combining the demand for the existing landfill operation (21,500 gallons per day [gallons/day] average) and the demand of the expansion project (117,000 gallons/day) is estimated to be 138,500 gallons/day in the future (A-Mehr, 2017). The calibrated model was also used to simulate a scenario of daily pumping at the PW at 160 gpm for 866 minutes (or approximately 14 hours) to meet the future water demand.

Figure I-9 shows the model-simulated drawdown contours at the end of the 75-minute pumping period. Figure I-10 shows the model-simulated hydrographs of water levels over time at PW and the six monitoring wells. Both figures indicate that the projected future daily pumping at PW has little impact on groundwater flow at the CMLF. The modeling calculates a maximum drawdown of 0.09 feet at PW caused by 14 hours of pumping; the drawdown recovers 24 hours after pumping stops.

4.0 Particle Tracking Analyses

Forward particle tracking analysis was done with the calibrated groundwater flow model. This analysis evaluates the effectiveness of the existing groundwater monitoring well network for detecting a potential release from the CMLF, and to assist in locating additional monitoring well or wells (should they be necessary). The particle path lines were generated by running MODPATH in the GW-Vistas 6.0 platform (ESI, 2011).

This simulation assumes a potential release within Phases III, IV, and V of the CMLF, with potentially contaminated groundwater particles released along the middle portion of each cell, as shown on Figure I-11. The simulation also included a scenario of a potential release from leachate collection wet well IV-A and leachate sump IV-B, and future leachate collection sumps III and V-B Ext. The model calculates the trajectories of the particles as they move downgradient, resulting in groundwater advective flow zones that represent the primary migration pathways of potential plumes. Particle tracking analysis only accounts for transport by advection; other transport processes such as hydraulic dispersion and diffusion are ignored. Simulated groundwater advective flow zones represent the expected migration pathways of a release.

Figure I-11 indicates that MW-2 can detect a potential release from the Phase III cell. The figure also suggests that the current monitoring network is insufficient to detect a potential release from Phases IV and V and from future leachate collection sump III. Based on the particle tracking analysis, two additional compliance wells are recommended downgradient of Phase IV, between PW and MW-5, and one additional compliance well is recommended downgradient of leachate collection sump III when SWMU Phase III is developed.

5.0 References

A-Mehr, Inc. (A-Mehr). 2017. *Preliminary Engineering Report for Central Maui Landfill Integrated Solid Waste Management Facility Extension Area*. Prepared for County of Maui, Department of Environmental Management, Solid Waste Division. May.

Bradbury, K.R. and M.A. Muldoon. 1990. “Hydraulic conductivity determinations in lithified glacial and fluvial materials.” In *Groundwater and Vadose Monitoring.* Ed. D.M. Nielsen and A.I., Johnson. P. 138-152. ASTM STP 1053.

CH2M HILL (CH2M). 2016. *Conceptual Site Model, Central Maui Landfill, Puunene, Hawaii*. February.

Element Environmental, LLC (Element). 2013. *Synoptic Water Level Data for Central Maui Landfill.* Excel Spreadsheet.

Environmental Simulations, Inc. (ESI). 2011. *Guide to Using Groundwater Vistas, Version 6*. Reinholds, Pennsylvania.

Hydrogeologic Inc. (HGL). 2008. *MOD-HMS/MODFLOW-SURFACT ver. 4.0 User’s manual. A Comprehensive MODFLOW-Based Hydrologic Modeling System*.

Rayne, R.W. 1993. “Variability of hydraulic conductivity in sandy till: The effects of scale and method.” Ph.D. diss., Department of Geology and Geophysics, University of Wisconsin at Madison, Madison, Wisconsin.

Rotzoll, K., and A.I. El-Kadi. 2008. “Estimating Hydraulic Conductivity from Specific Capacity for Hawaii Aquifers, USA.” *Hydrogeology Journal,* August 2008.

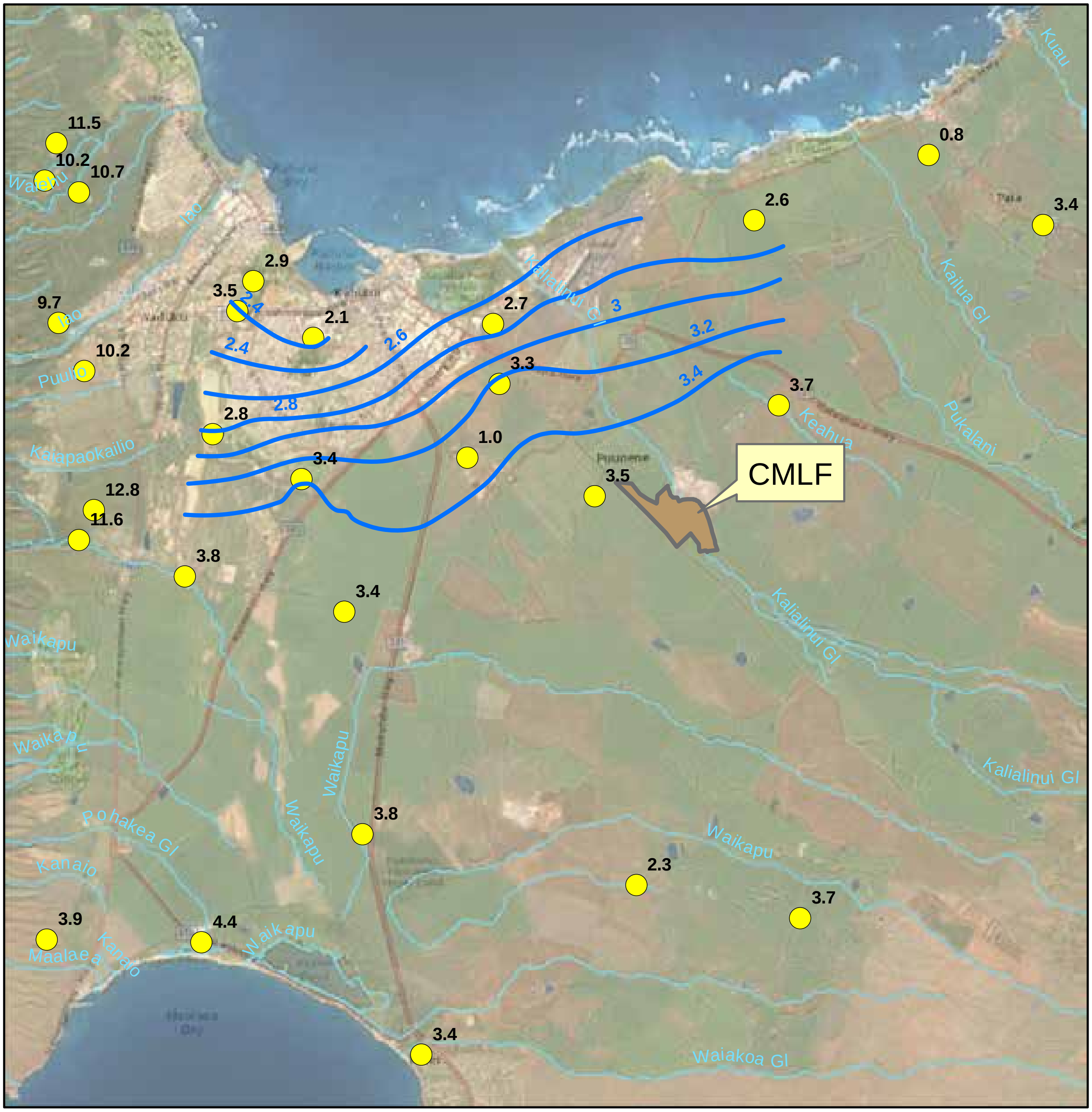
Rovey, C.W. II, and D.S. Cherkauer. 1995. “Scale dependence of hydraulic conductivity measurements.” *Groundwater* 33, no. 5: 769-780.

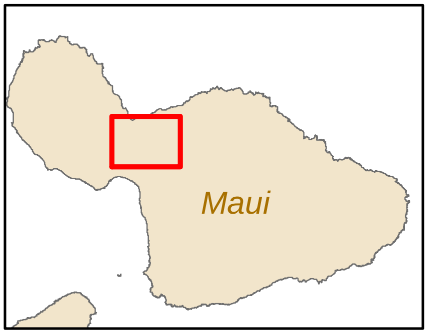
Serfes. 1991. *Determining the Mean Hydraulic Gradient of Groundwater Affected by Tidal Fluctuations. Groundwater*, vol. 29, no. 4, July-August 1991.

Waimea Water Services (WWS). 2012. *Owner’s Well Report, Puunene Solid Water Well (State Well No. 5125-07).* December 21.

Watermark Numerical Computing (WNC). 2010. *PEST, Model-Independent Parameter Estimation*, 5th edition.

Figures



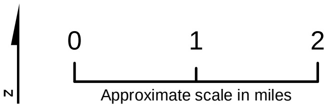


LEGEND

● U.S. Geological Survey Groundwater Monitoring Well

— Stream

— U.S. Geological Survey Groundwater Elevation Contour selection



Note:
- Central Maui area groundwater levels May 17, 2005 (7:00 a.m. to 2:30 p.m.)
- Water level next to well symbol is in feet above mean sea level (rounded to nearest tenth of a foot)
- Base modified from U.S. Geological Survey National Hydrography Dataset. Relief from U.S. Geological Survey digital elevation models 1:24,000

FIGURE I-1
Regional Groundwater Contours
Central Maui Landfill Groundwater Modeling
Puunene, Maui, Hawaii

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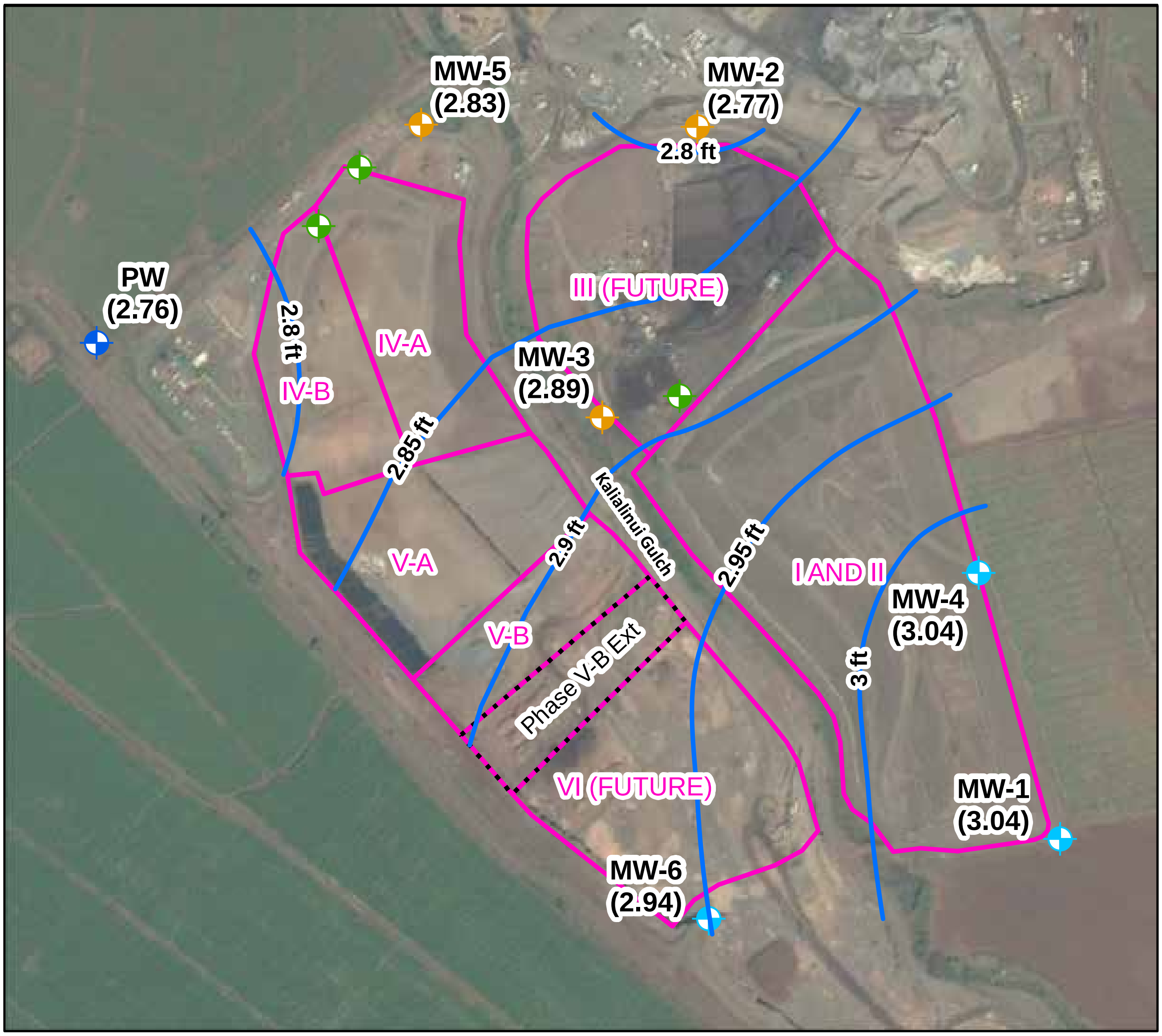

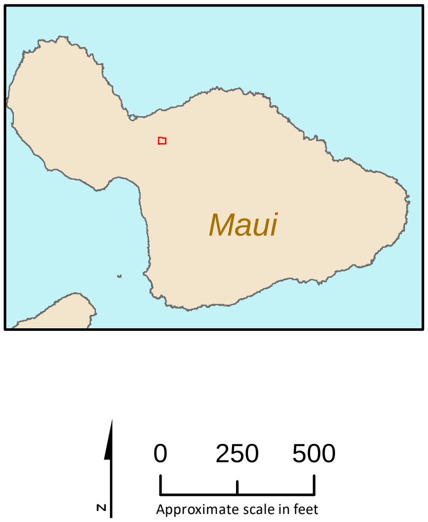

Notes:
- Average hydraulic gradient = 1.0 E-04 foot/foot
- Seepage velocity = 14 feet/year to 478 feet/year
- Hourly measurements from 2013 continuous synoptic water level measurements (Element, 2014). Groundwater flow characteristics have been modeled using the software Surfer 8.0.
- This figure represents the average groundwater equipotential lines and the horizontal hydraulic gradient during the 71-hour period (between 8/22/2013, 00:00 hours and 8/24/2013, 23:00 hours). The average hydraulic gradient has been estimated using groundwater elevations between monitoring wells MW-4 and MW-2, and MW-4 and PW.
- Groundwater elevations (indicated along contour lines and in parenthesis for each well) are in feet above mean sea level.

ACRONYMS:
ft = feet (above mean sea level)

LEGEND

EXISTING MONITORING LOCATIONS

⊕ Compliance Monitoring Well

⊕ Upgradient/Crossgradient Monitoring Well

⊕ Production Well

⊕ Leachate Collection Point (Sump or Wet Well)

▭ Landfill Phase Boundary

⋯ Landfill Phase Currently Under Construction

— Inferred Groundwater Potentiometric Contour

FIGURE I-2
71-Hour Mean Groundwater Contour Map
Central Maui Landfill
Puunene, Maui

LEGEND

- ⊕ Existing Monitoring Well
- ⊕ Production Well
- ━ Constant Head Boundary
- ▨ Landfill Boundary
- ☐ Model Grid

N

0 0.5 1

Approximate scale in miles

FIGURE I-3
Model Domain and Boundary
Central Maui Landfill Modeling
Puunene, Maui, Hawaii

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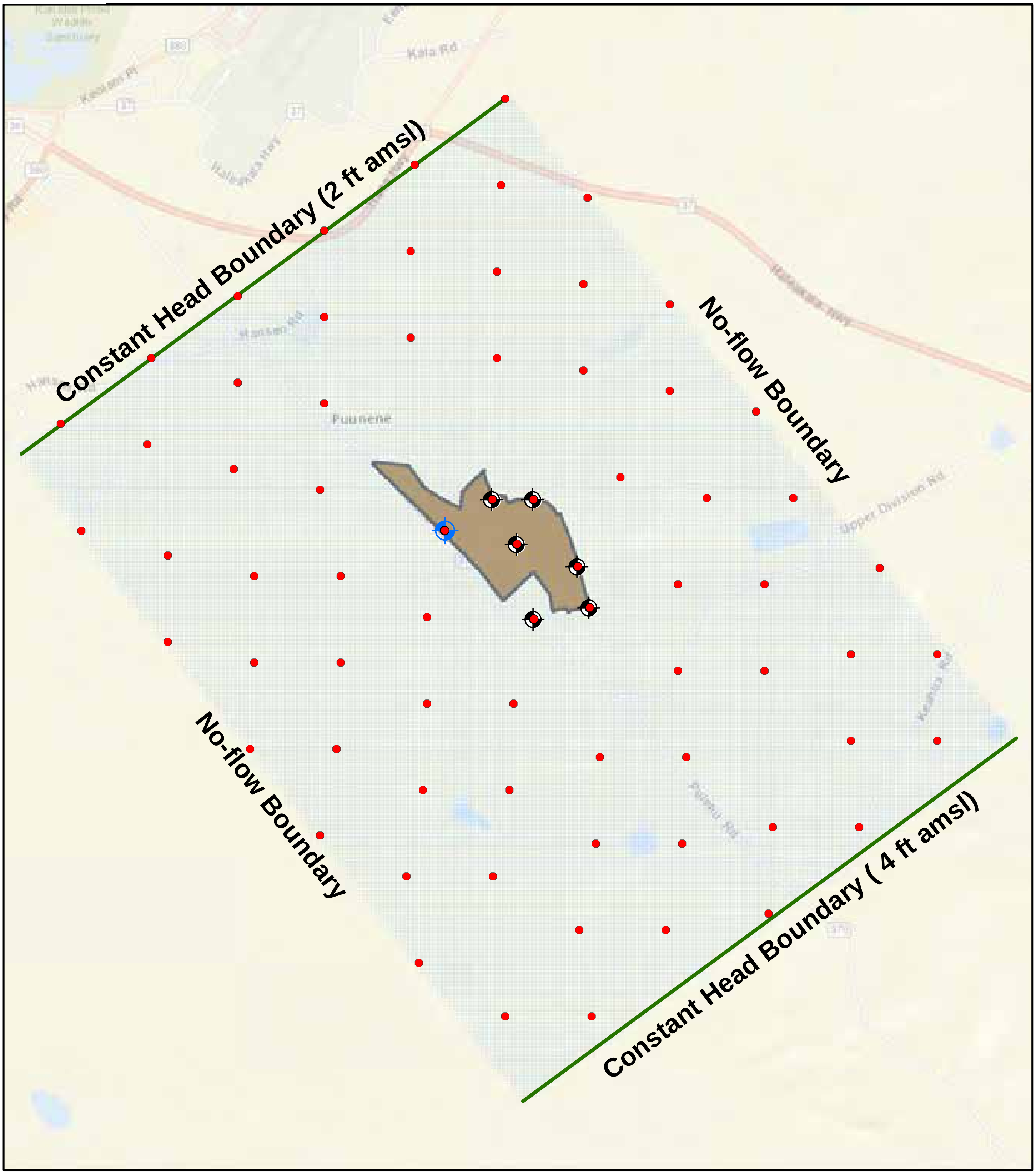

LEGEND

⊕ Existing Monitoring Well

⊕ Production Well

— Constant Head Boundary

▨ Landfill Boundary

☐ Model Grid

● PEST Pilot Points for Horizontal Hydraylic Conductivity

N

0 0.5 1

Approximate scale in miles

FIGURE I-4

PEST Pilot Point Distribution

Central Maui Landfill Modeling

Puunene, Maui, Hawaii

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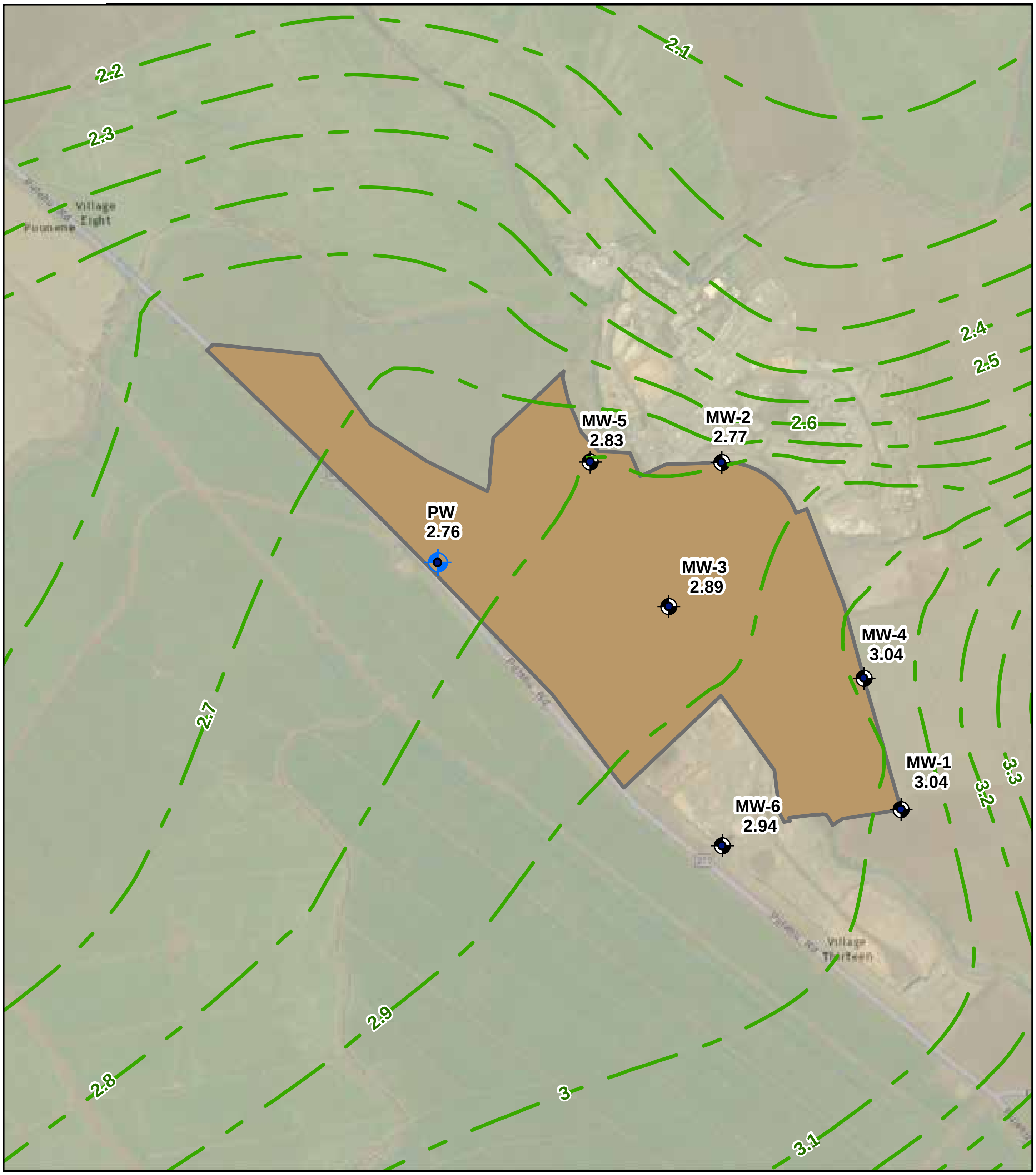

LEGEND

- Simulated groundwater level contours (ft)
- Existing Monitoring Well
- Production Well

FIGURE I-5
Simulated Steady-State Groundwater Contours

Central Maui Landfill Modeling

Puunene, Maui, Hawaii

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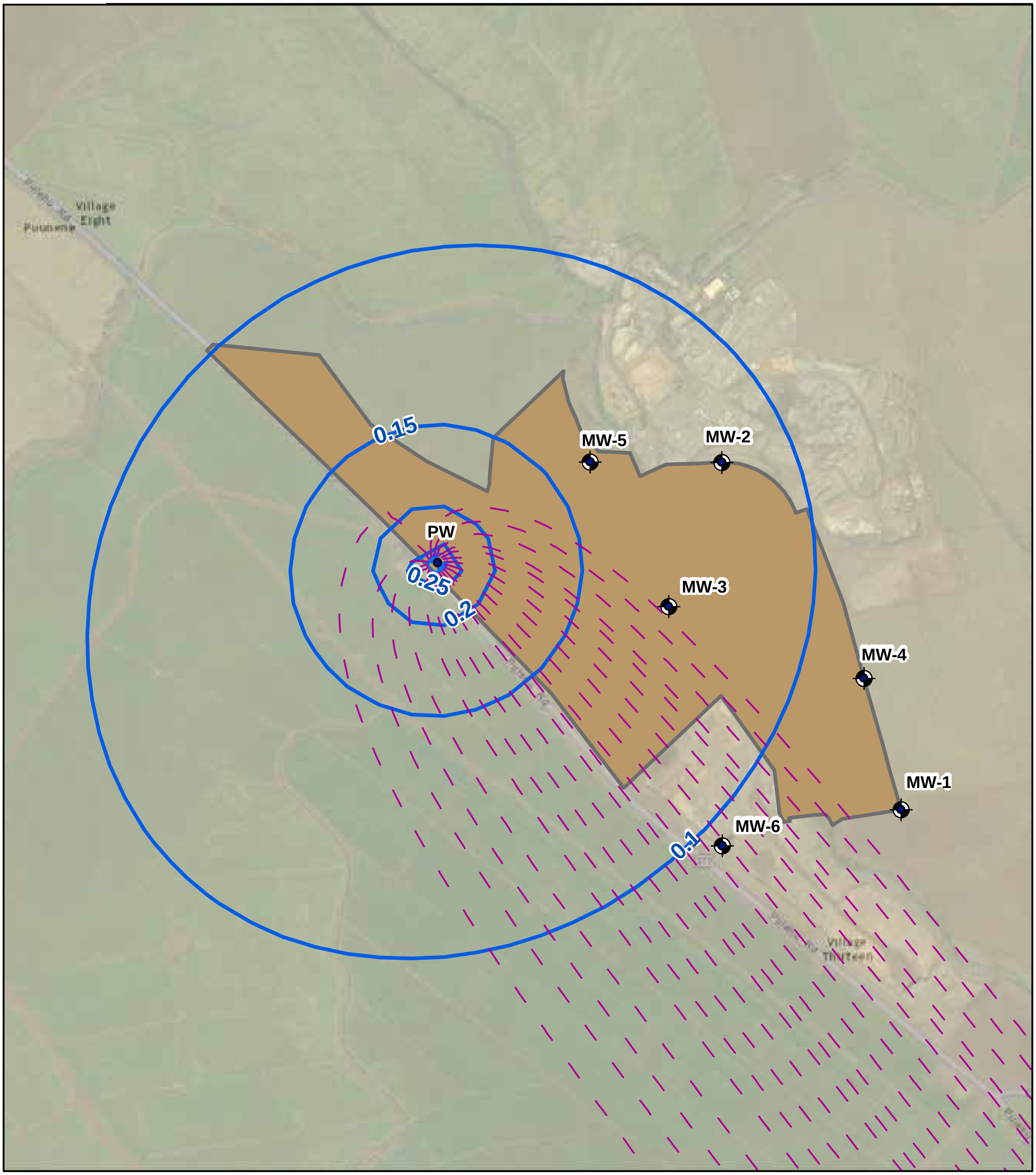

N

0 0.125 0.25

Approximate scale in miles

LEGEND

▬	Simulated drawdownl contours (ft)
–	Simulated backward particle pathlines
⊕	Existing Monitoring Well
⊕	Production Well

FIGURE I-6
Simulated Drawdown Contours and Backward Particle Pathlines

Central Maui Landfill Modeling

Puunene, Maui, Hawaii

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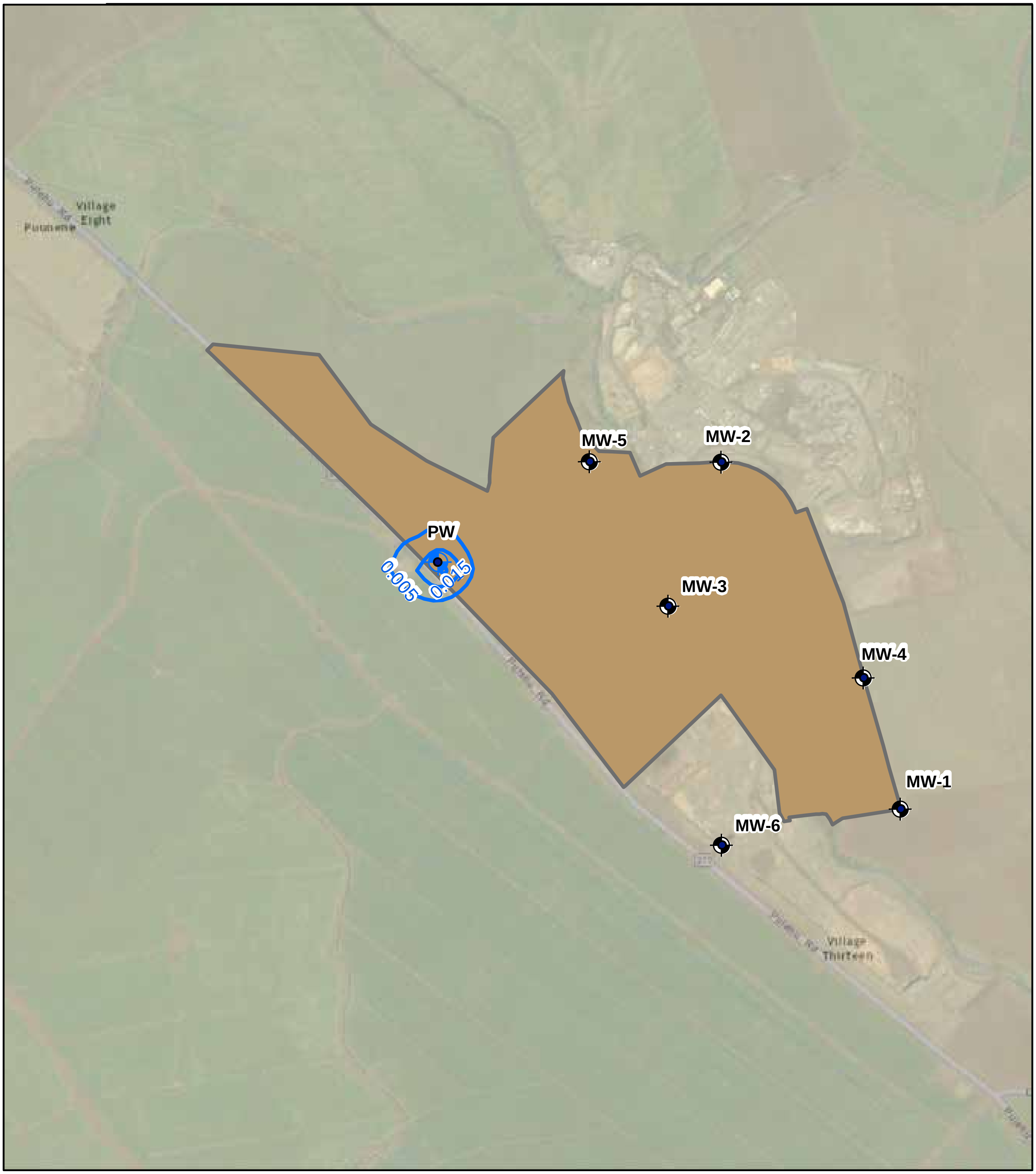

N

0 0.125 0.25

Approximate scale in miles

LEGEND

▬ Simulated drawdownl contours (ft)

⊕ Existing Monitoring Well

⊕ Production Well

FIGURE I-7
Simulated Drawdown Contours
PW Daily Pumping
Central Maui Landfill Modeling
Puunene, Maui, Hawaii

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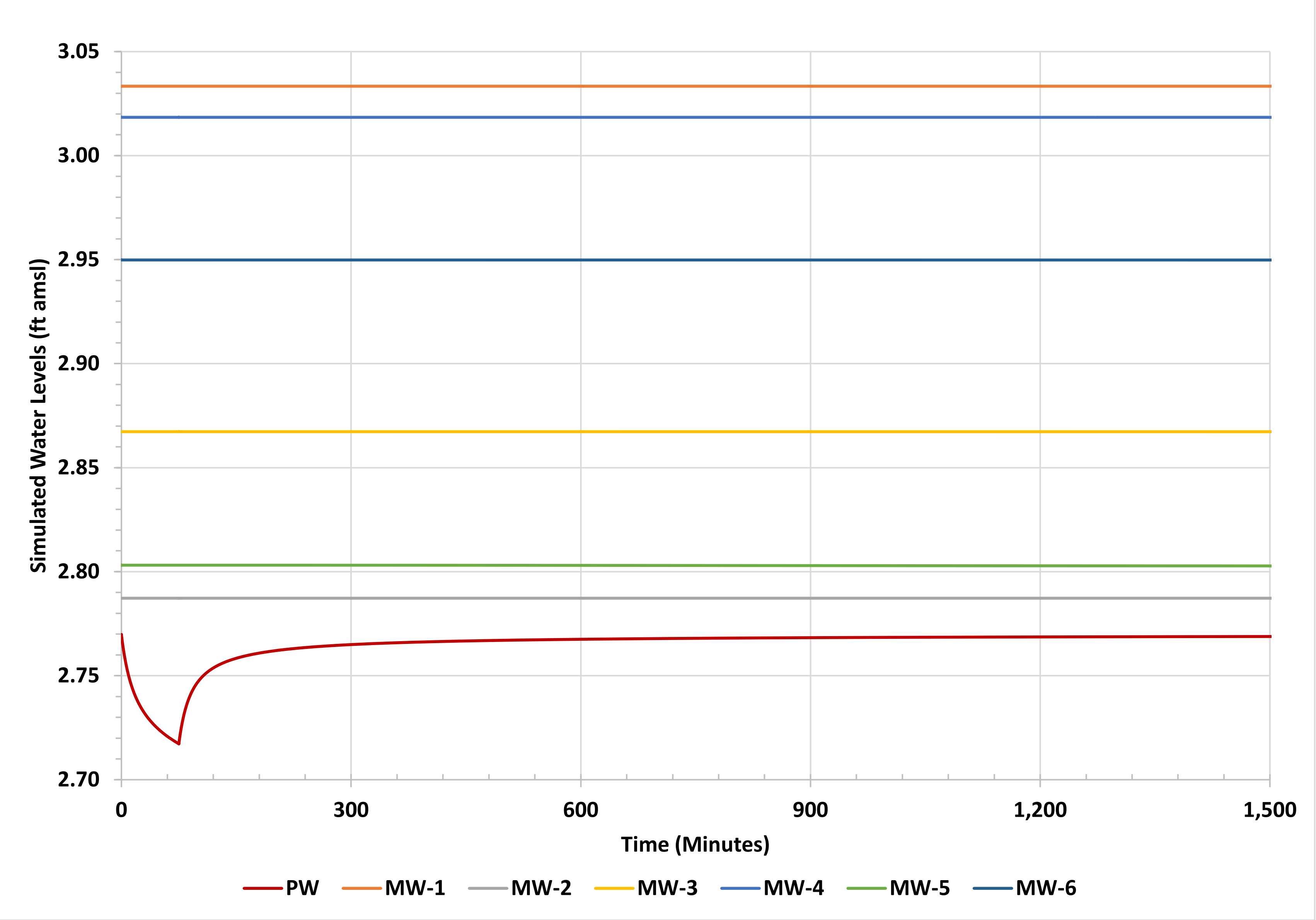
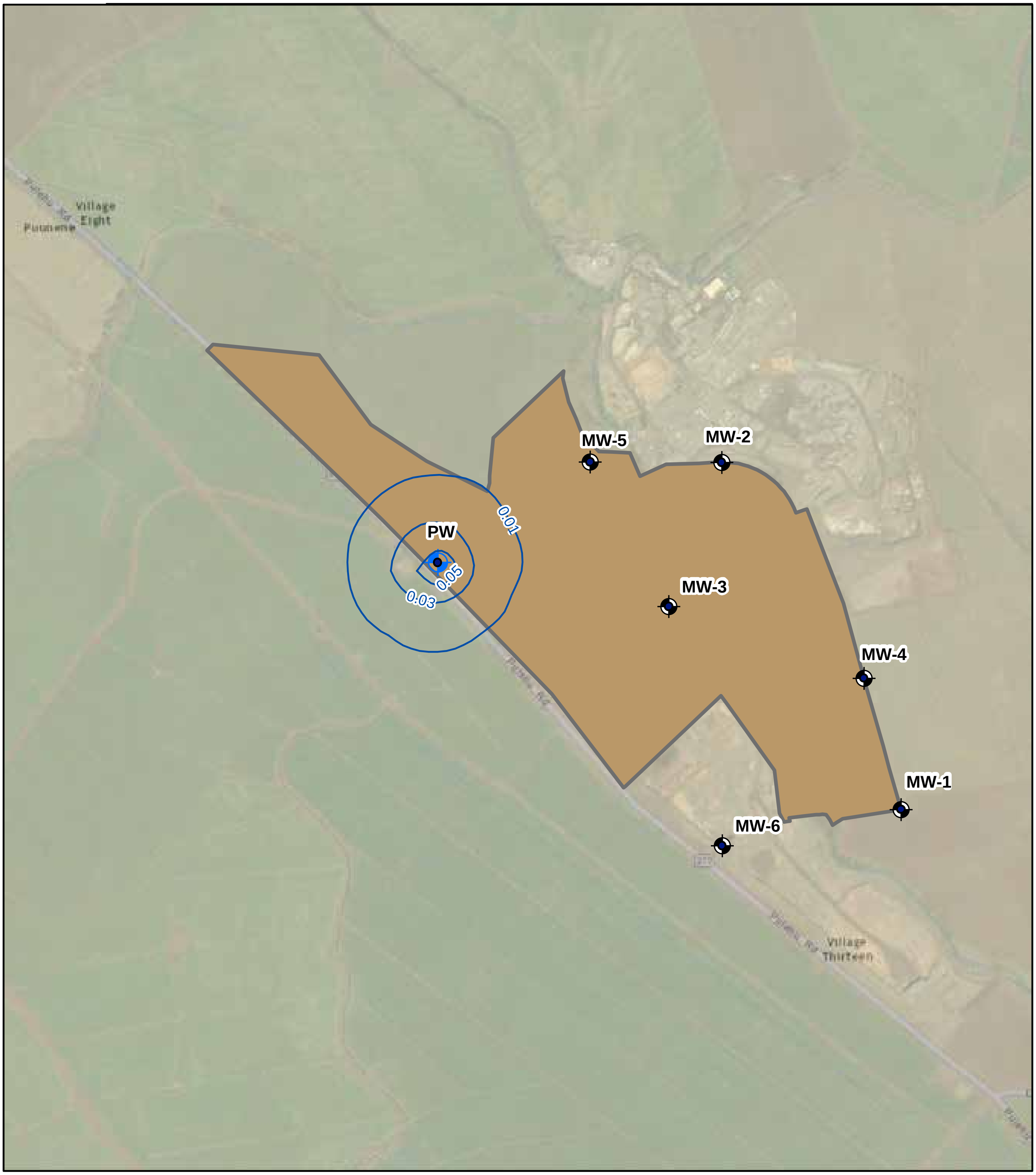


FIGURE I-8
Simulated Hydrographs during Daily Pumping
Central Maui Landfill Groundwater Modeling
Puunene, Maui, Hawaii



N

0 0.125 0.25

Approximate scale in miles

LEGEND

Simulated drawdownl contours (ft)

Existing Monitoring Well

Production Well

FIGURE I-9

Simulated Drawdown Contours

Future PW Daily Pumping

Central Maui Landfill Modeling

Puunene, Maui, Hawaii

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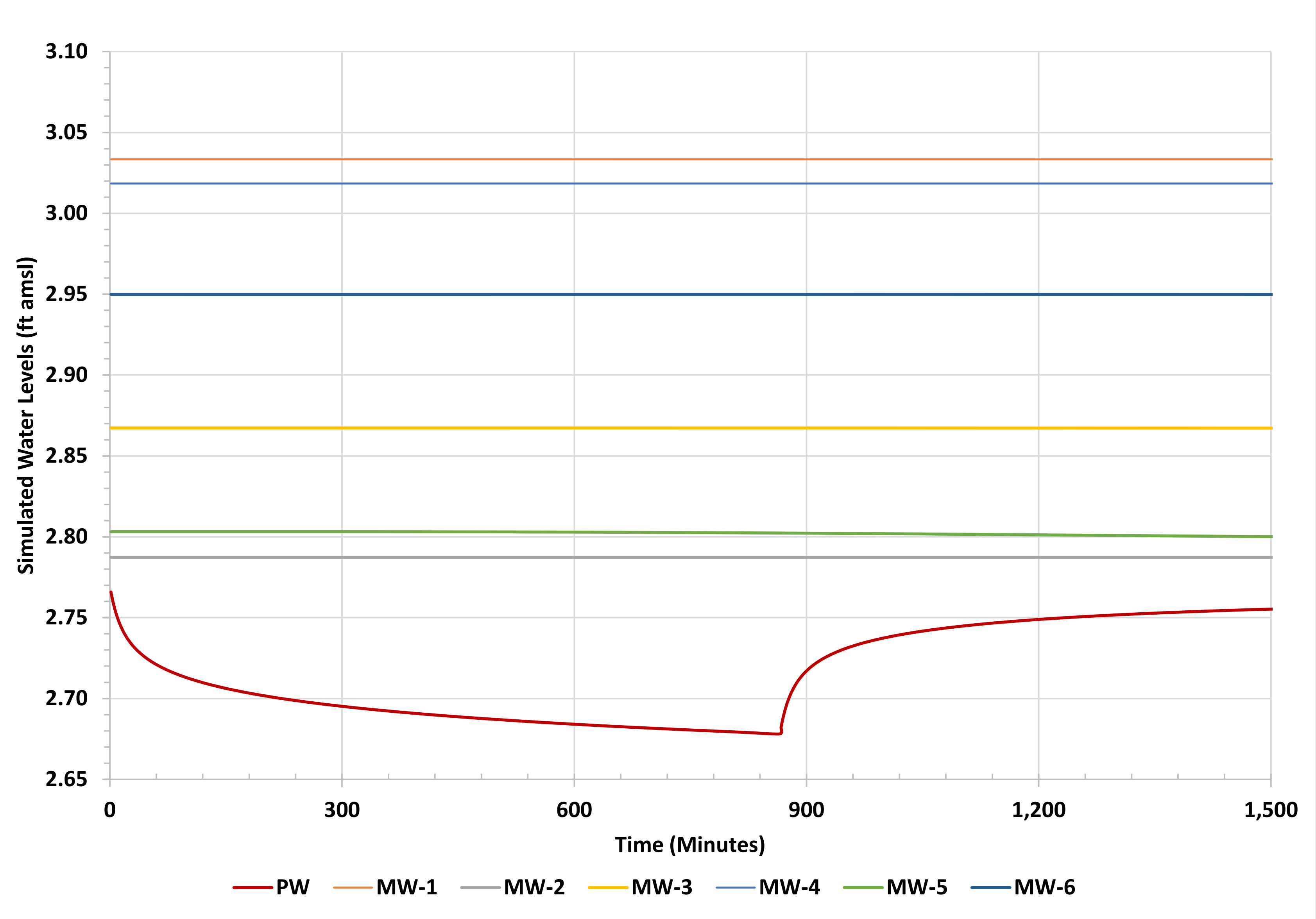
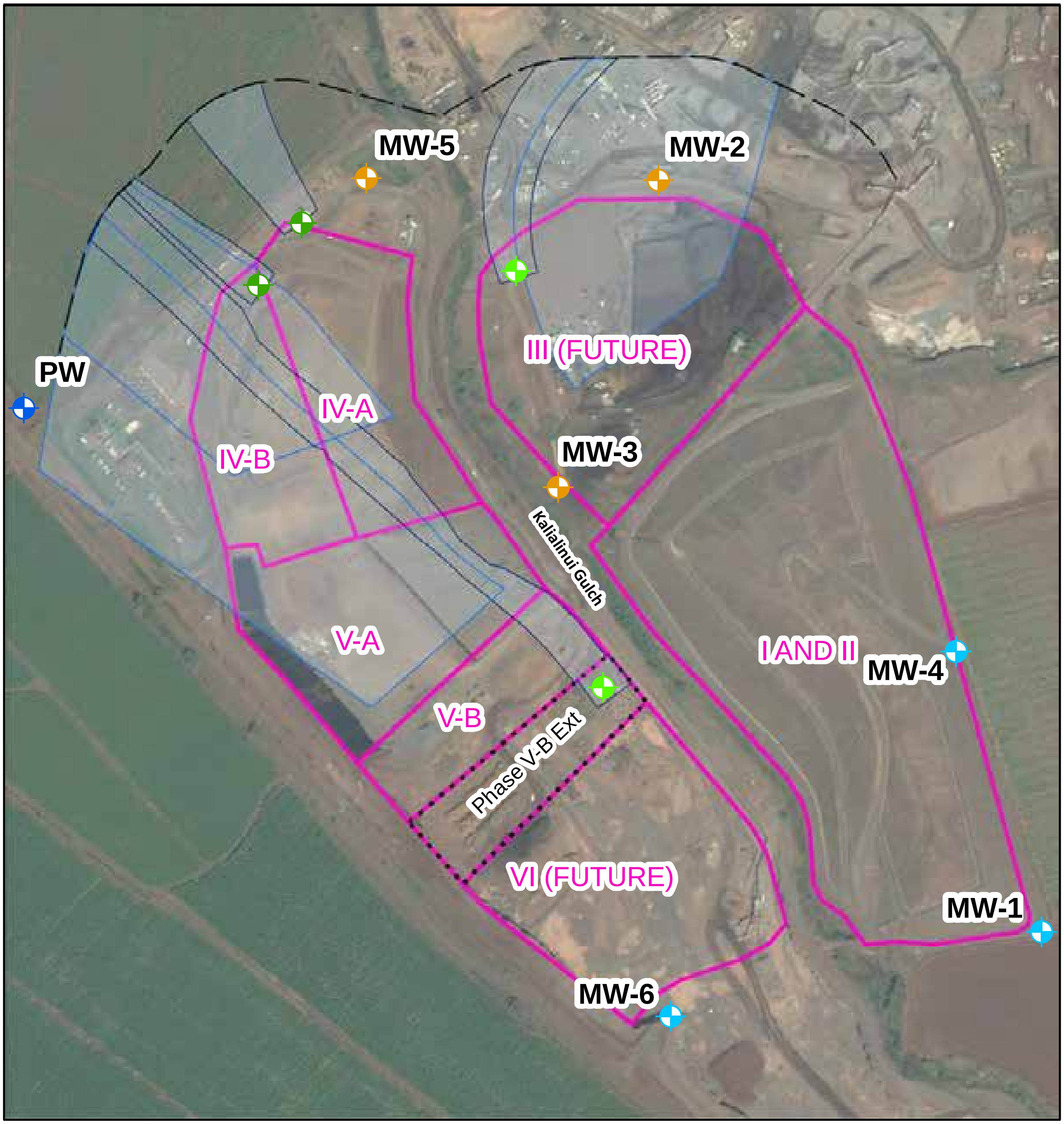


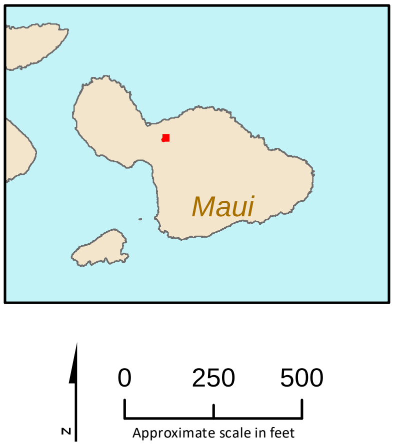
FIGURE I-10

Simulated Hydrographs under Future Pumping Condition

Central Maui Landfill Groundwater Modeling

Puunene, Maui, Hawaii





LEGEND

EXISTING MONITORING LOCATIONS

- ⊕ Compliance Monitoring Well
- ⊕ Upgradient/Crossgradient Monitoring Well
- ⊕ Production Well
- ⊕ Leachate Collection Point (Sump or Wet Well)

FUTURE MONITORING LOCATIONS

- ⊕ Future Leachate Collection Point (Sump or Wet Well)
- ▭ Groundwater Advective Flow
- ▭ Landfill Phase Boundary
- ⬚ Landfill Phase Currently Under Construction

FIGURE I-11 Simulated Groundwater Flow Paths
Central Maui Landfill
Groundwater Modeling
Puunene, Maui, Hawaii

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