Appendix I2: Implementation and Monitoring Plan for North Fork Kaukonahua Stream, 2015

IMPLEMENTATION AND MONITORING PLAN FOR NORTH FORK KAUKONAHUA STREAM WASTELOAD ALLOCATION FOR THE CITY AND COUNTY OF HONOLULU MUNICIPAL SEPARATE STORM SEWER SYSTEM NPDES PERMIT NO. HI S000002

June 2012
Revised June 2013
Revised June 2015

Prepared by
City and County of Honolulu
Department of Environmental Services
Kapolei, Hawaii

E Mālama I Ka Wai Ola
Protect our waters...
FOR LIFE

Transmittal Letter

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Appendix A – Summary of Water Quality Sampling, January 2012 – January 2013

Appendix B – Event Mean Concentration Computations

Appendix C – Downspout Disconnection Field Survey

Acronyms

BMP	Best Management Practice
CB	Catch Basin
City/CCH	City and County of Honolulu
CSM	Collection System Maintenance Division
CY	Calendar Year
DFM	City and County of Honolulu, Department of Facility Maintenance
DOH	State of Hawaii, Department of Health
EMC	Event Mean Concentration
ENV	City and County of Honolulu, Department of Environmental Services
EPA	United States Environmental Protection Agency
FDCI	Flow Duration Curve Interval
FY	Fiscal Year
GH	Good Housekeeping
GRP	Grouted Rubble Paving
I&M Plan	Implementation and Monitoring Plan
MS4	Municipal Separate Storm Sewer System
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
OM	Organic Matter
Permit	NPDES Permit No. HI S000002
PM	Particulate Matter
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TSS	Total Suspended Solids
USGS	United States Geological Survey
WLA	Wasteload Allocation
WQ	Water Quality

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Executive Summary

The State of Hawaii, Department of Health (DOH) developed and established Total Maximum Daily Loads for the North and South Forks of Kaukonahua Stream (i.e., Upper Kaukonahua Stream). The DOH further defined Wasteload Allocations (WLAs) for the City and County of Honolulu (City or CCH) for the North Fork of Kaukonahua Stream with the goal of wasteload reductions for turbidity in the wet and dry seasons and total nitrogen (TN) in the wet season.

This implementation and monitoring plan was developed to comply with the terms of the National Pollutant Discharge Elimination System Permit No. HI S000002 (Permit) for the City's municipal separate storm sewer system (MS4). The Permit requires that the City identify specific activities targeted to reducing turbidity and TN discharges in the North Fork of Upper Kaukonahua Stream Watershed.

The City conducted water quality monitoring for TN and Total Suspended Solids (a surrogate for turbidity) at two representative residential subcatchments within the watershed between January 2012 and January 2013. The results of the year-long water quality sampling were used to recalculate the existing pollutant and nutrient loads from the City's MS4 for the wet and dry seasons. Furthermore, based on discussions with DOH representatives, it was determined that the City's load reduction goals should be based on the seasonal "elevated" flow duration curve interval (FDCI), as defined by the TMDL report; demonstration of daily compliance is not required. Based on this methodology, the resulting load reduction goals are as follows:

Table ES-1: Turbidity Load Reduction Summary

	Wet Season Elevated FDCI	Dry Season Elevated FDCI
CCH WLA (NTU-tons/day)	0.069	0.025
CCH Existing Load (NTU-tons/day)	0.058	0.011
Load Reduction Required (NTU-tons/day)	0	0
Number of Days in Elevated FDCI (days)	18.10	18.40
Seasonal Load Reduction (NTU-lb/season)	0	0

Table ES-2: Total Nitrogen Load Reduction Summary

	Wet Season Elevated FDCI
CCH WLA (lb/day)	44.1
CCH Existing Load (lb/day)	45.5
Load Reduction Required (lb/day)	1.4
Number of Days in Elevated FDCI (days)	18.10
Seasonal Load Reduction (lb/season)	25

Based on this analysis which has received DOH concurrence, the City will implement Best Management Practices targeted at removing 25 lbs of TN in the wet season from the Upper Kaukonahua watershed. Specific reduction goals for turbidity are not applicable, as the monitoring data has indicated that the

City's discharge is below the WLA. However, good housekeeping activities proposed for TN removal will also reduce turbidity loadings.

The City will implement a variety of Best Management Practices (BMPs) to reduce pollutant loads in the watershed. These activities include:

- Public outreach efforts informing homeowners of how their actions affect water quality in the North Fork Kaukonahua Stream;
- Public outreach efforts targeted to specific homeowners who could make improvements around their homes such as disconnecting roof drains;
- Implementing a schedule for routine street sweeping;
- Maintenance of Grandview Pump Station; and
- Inspection and cleaning of drainage structures and conveyances as necessary.

The combination of these efforts is expected to remove pollutants, namely TN, from the waste stream and ultimately achieve the targeted WLA. Based on historical collections, it is anticipated that street sweeping three times during the wet season and monthly grounds maintenance site visits at Grandview Pump Station will collect sediment and organic matter in sufficient quantity to meet the seasonal TN reduction goal. If additional activities (ex. additional street sweeping cycle and/or drain cleaning) are required to meet the target reductions, the City will implement them as necessary on a season-by-season basis. The following table provides a summary of the estimated pollutant load reductions for each of the City's BMPs.

Table ES-3: Summary of BMP Activities and Quantitative Reductions

	Turbidity Reduction (NTU-lbs/season)		**TN Reduction (lbs/season)**
	Wet Season	Dry Season	Wet Season
Downspout Disconnect	*	*	*
Homeowner Outreach/Volunteer Cleanup	*	*	*
Street Sweeping	not calculated	0	9
Grounds Maintenance at Grandview Pump Station	not calculated	0	18
Storm Drain Maintenance	**	**	**
TOTAL	not calculated	0	27
REDUCTIONS REQUIRED	none	none	25

* The City will conduct a public education and outreach program to all homeowners within the watershed; however, due to difficulty in quantifying pollutant load reductions due to behavior changes, no homeowner contribution is assumed for accounting purposes at this time.

**Cleaning of storm drains and drainage structures will be implemented only if collections from other activities are less than anticipated and the City needs additional reductions to meet the load reduction goals for a particular season. Storm drain cleaning may also be done in lieu of additional street sweeping activities based on scheduling and equipment availability.

The final compliance deadline is December 31, 2018.

1.0 Introduction

The National Pollutant Discharge Elimination System (NPDES) Permit No. HI S000002 (Permit) issued by the State of Hawaii, Department of Health (DOH) to the City and County of Honolulu (City or CCH) for their municipal separate storm sewer system (MS4) became effective February 16, 2015. It stipulates that the City develop an updated WLA implementation and monitoring plan (I&M Plan) for the North Fork of Upper Kaukonahua Stream by the end of Fiscal Year 2015 (FY15). For the purpose of complying with the foregoing requirement, the City is submitting this revised I&M Plan for the North Fork of Upper Kaukonahua Stream.

The DOH developed and established Total Maximum Daily Loads (TMDLs) for the North and South Forks of Kaukonahua Stream (i.e., Upper Kaukonahua Stream) in its technical report *Total Maximum Daily Loads (TMDLs) for the North and South Forks of Kaukonahua Stream, Oahu, Hawaii* (DOH, September 2009). The DOH further defined Wasteload Allocations (WLAs) for the City and County of Honolulu (City or CCH) and the U.S. Navy for the North Fork of Kaukonahua Stream with the goal of wasteload reductions for Total Nitrogen (TN) and turbidity. This I&M Plan will address specific City activities targeted at reducing turbidity and Total Nitrogen discharges in the Upper Kaukonahua Stream watershed as necessary to comply with the TMDLs and the City's WLA. The monitoring plan specifies activity tracking necessary to demonstrate efforts by the City to comply with the urban source WLAs.

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2.0 Upper Kaukonahua Watershed

The Kaukonahua watershed is the second largest on Oahu, encompassing nearly 37 square miles (23,500 acres). It is bordered by Poamoho watershed to the North; Punaluu and Kahana watersheds to the East; and Waikele watershed to the South (see Figure 1). The eastern fringes of the basin drain the leeward face of the Koolau Mountain Range towards central Oahu and ultimately to Kaiaka Bay on the North Shore. Kaiaka Bay has long been identified as a water quality limited segment and is currently listed under the State's Section 303(d) as a water body in which water quality is impaired by excessive nutrients and turbidity. In addition, there have been numerous public complaints regarding nuisance odors, poor agricultural water quality, and overall concern for water quality in Kaiaka Bay.

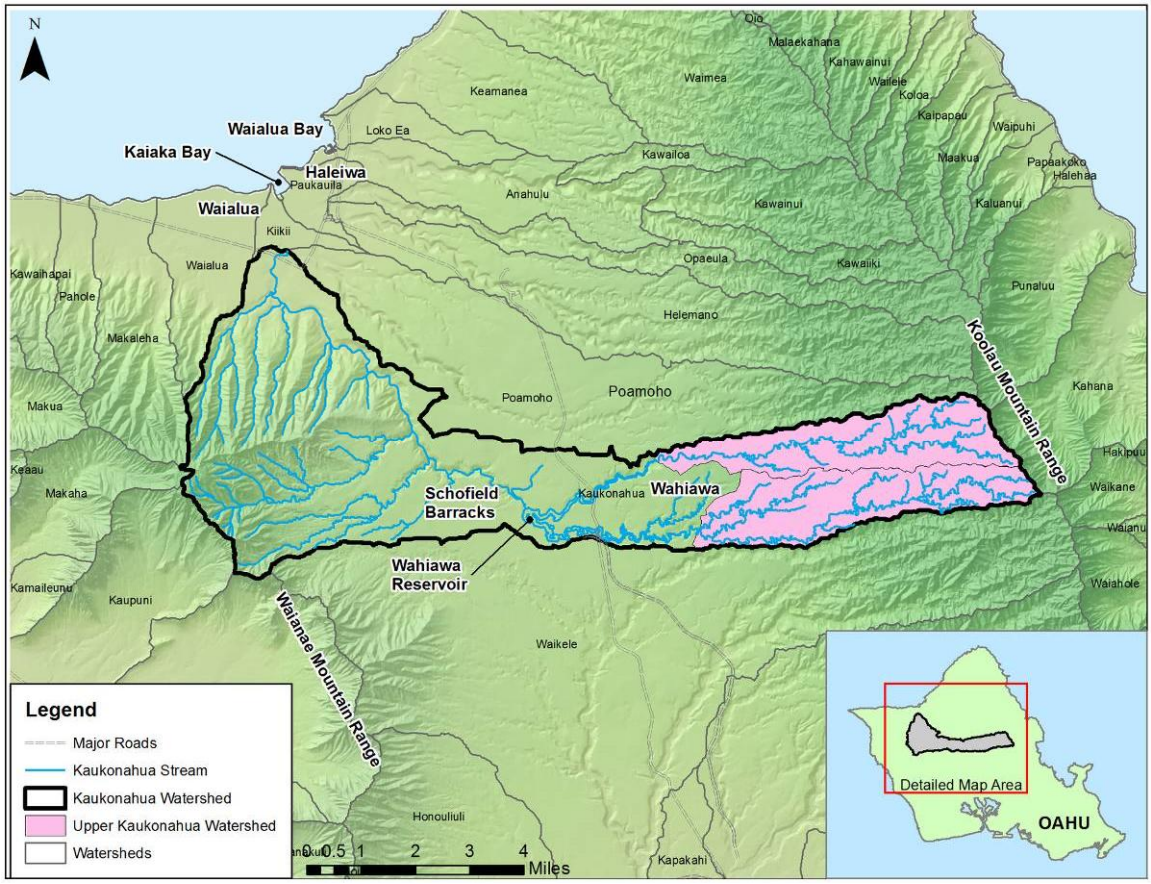

Figure 1: Kaukonahua Stream Watershed

Wahiawa Reservoir, also referred to as Lake Wilson, is the largest freshwater impoundment in the State with a storage capacity of three billion gallons. The reservoir receives urban stormwater from municipal drainage systems, runoff from surrounding agricultural, military, and urban lands, and treated sewage effluent from Wahiawa Wastewater Treatment Plant. Due to uncertainties associated with the reservoir, the DOH has opted for an incremental TMDL development with the first phase targeting the area upstream of the reservoir. This includes the two main tributaries – the North and South Forks of Kaukonahua Stream. Collectively, the two sub-basins occupy nearly 12 square miles (7,511 acres) of the upper watershed and is the focus of this I&M Plan (see Figure 2).

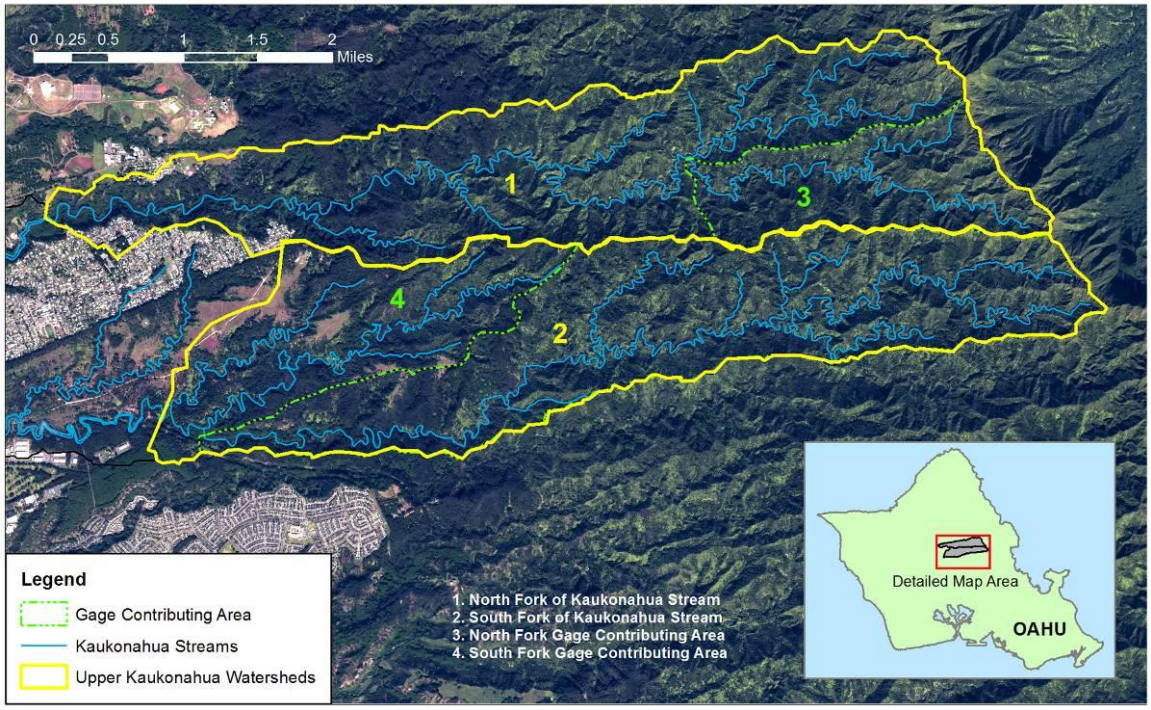

Figure 2: Upper Kaukonahua Stream Aerial Photo

Land use varies within the study area from conservation to agricultural to urban and includes a critical habitat for the endangered Oahu *'elepaio*, a multi-use state forest reserve, heavily used military training areas and support facilities, and small clusters of agricultural and residential lands.

Within the North Fork sub-basin, the City regulates 77 acres (2.1%) of the total 3,651 acres. The U.S. Navy regulates 43 acres of urban area and 20 acres of military training area for the Stryker Brigade for a total of 1.7% of the North Fork sub-basin. Neither the City nor the U.S. Navy has allocations in the South Fork sub-basin which encompasses 3,860 acres, including the East Range of Schofield Barracks. See Table 1 and Figures 3 and 4.

Table 1: Zoning in Upper Kaukonahua Watershed

Zoning[1]	Total Acres	Percent of Total
Restricted Agriculture	102	1.4%
Military and Federal	391	5.2%
Preservation	6,941	92.4%
Residential (CCH MS4)	77	1.0%
Total	7,511	100%

[1]Modified from DOH TMDL Report, Table 1-6.

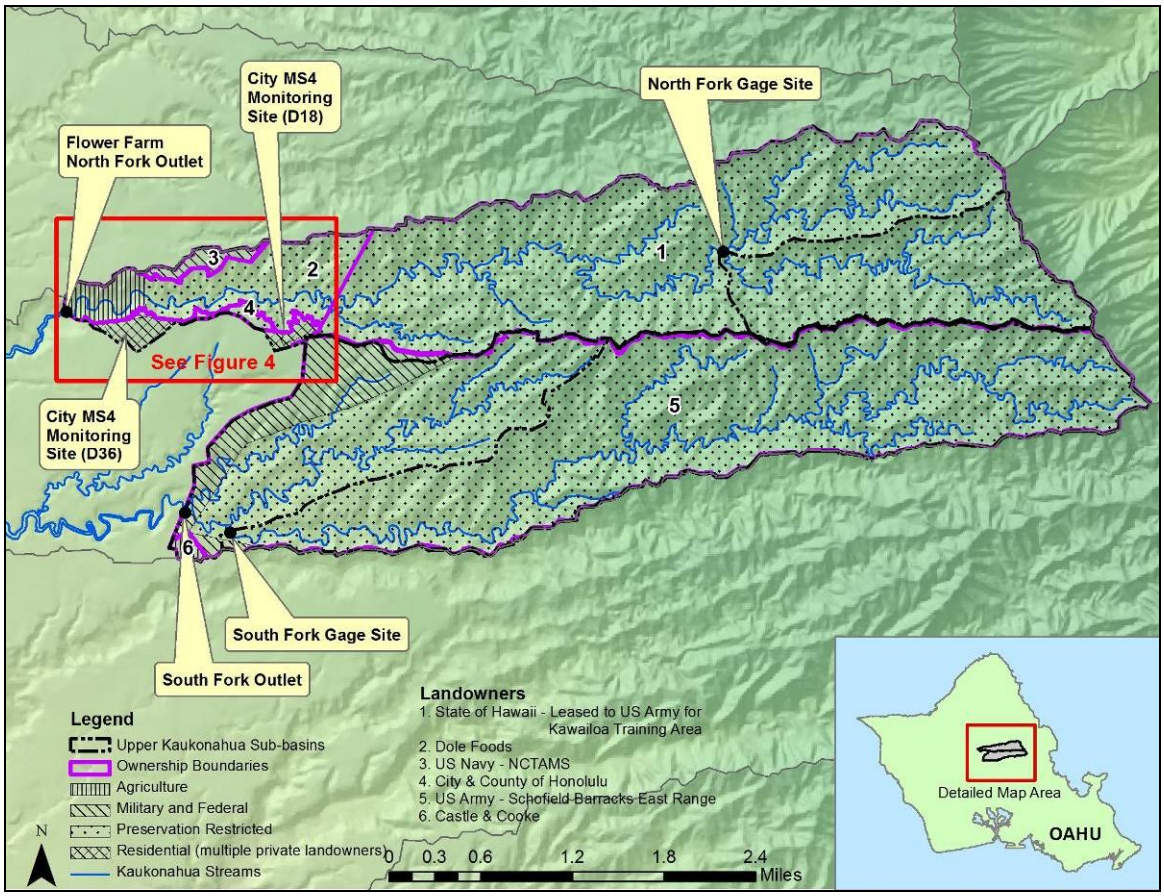

Figure 3: Upper Kaukonahua Watershed Land Ownership

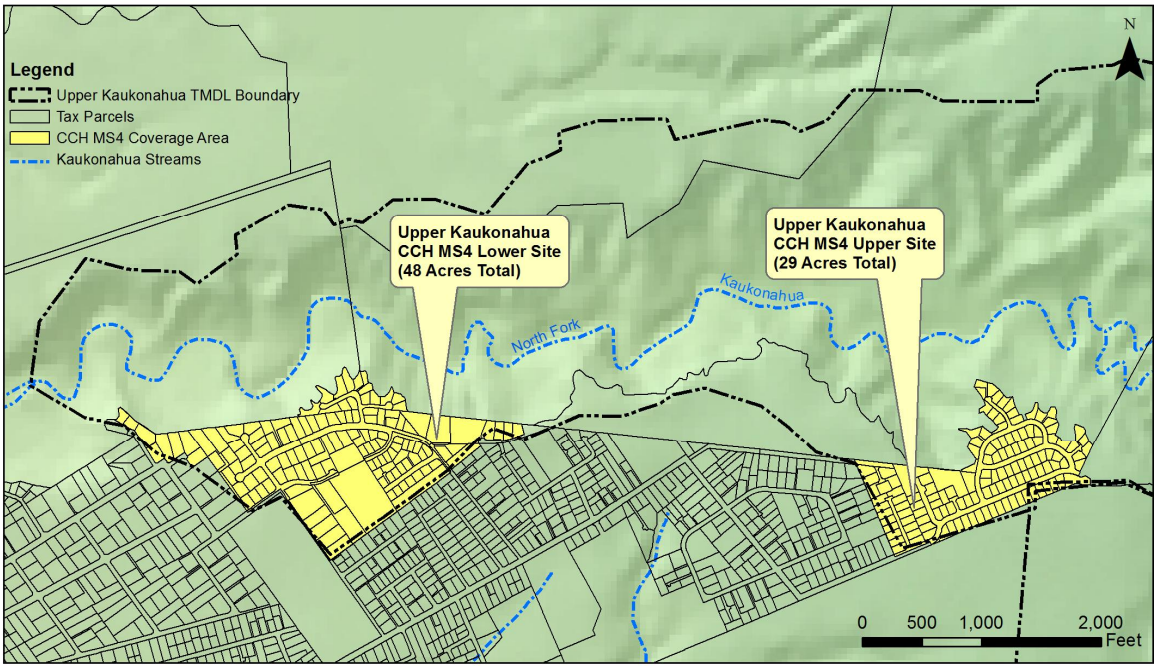

Figure 4: Detail of City MS4 Coverage Area in Upper Kaukonahua

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3.0 TMDLs and WLAs for Upper Kaukonahua Stream Watershed

TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards and is an allocation of that load among the various sources of that pollutant. The DOH developed and the United States Environmental Protection Agency (EPA) approved TMDLs for the North and South Forks of Kaukonahua Stream in 2010 that consist of turbidity and TN. These TMDLs are further allocated between various point and non-point sources for both the wet and dry seasons for three flow intervals (high, elevated, and stable) based on a modified load-duration curve. Non-point sources of pollutants for streams in the Upper Kaukonahua watershed include landscape-level processes in forested mountain environments, agricultural activity, construction, urban runoff, and disturbance from military training activities. Point sources include the U.S. Navy's Large MS4 Permit (HI S000006) and the City's Large MS4 Permit (HI S000002).

The consolidated wet and dry season WLAs for North Fork of Kaukonahua Stream assigned to the City Department of Environmental Services (ENV) Large MS4 are presented in Tables 2 and 3 (from Table 4-4, DOH, September 2009). The wet season is defined as the period between November 1st and April 30th for a total of 181 days. The dry season is defined as the period between May 1st and October 31st for a total of 184 days.

Table 2: CCH MS4 – Turbidity WLA (NTU-tons/day)

Wet Season			Dry Season		
Flow Duration Curve Interval[1]			Flow Duration Curve Interval[1]		
High	Elevated	Stable	High	Elevated	Stable
0.393	0.069	0.002	0.076	0.025	0.0006

Note: Nephelometric Turbidity Units (NTU)
[1]Curve Intervals are 0-4% flow duration (High), 4-20% flow duration (Elevated), and 20-100% flow duration (Stable)

Table 3: CCH MS4 – Total Nitrogen WLA (lbs/day)

Wet Season		
Flow Duration Curve Interval[1]		
High	Elevated	Stable
349	44.1	1.79

[1]Curve Intervals as noted in Table 2 above

3.1 Existing Seasonal Loads

The DOH TMDL report assigned existing load concentrations to the City's MS4 based on the urban land use category for base flow and storm flow intervals. The existing pollutant concentrations for storm flows were derived from EPA's Nationwide Urban Runoff Program (1983) for TSS and US Department of Agriculture (Natural Resource Conservation Service) data for TN. The DOH TMDL report did not distinguish between wet season and dry season pollutant concentrations, nor did it make a distinction between elevated and high flow duration interval concentrations.

In an effort to validate the existing pollutant load concentration assumptions in the DOH TMDL report, the City implemented a water quality monitoring program in January 2012 to measure TSS and TN concentrations at two representative residential subcatchments within the watershed (see sites D36 and D18 in Figure 3). The purpose of this effort was to collect local, site-specific data to develop event mean concentrations (EMCs) for storm flows of various intensities. This dataset is considered more applicable and representative of current, local conditions as opposed to the national dataset with monitoring stations

located across the US mainland. This methodology is consistent with 40 CFR 130.7(c)(1)(i) which states, "site specific information should be used wherever possible" in developing TMDLs. A summary of the City's water quality sampling program is provided in Appendix A.

A total of six months of dry season storm flows and six months of wet season storm flows were collected between January 2012 and January 2013. Six wet season events (stable, elevated, and high flow intervals) were recorded along with nine dry season events (elevated and high flow intervals). EMCs were calculated for each event by summing the rising limb, peak, and falling limb pollutant loads divided by the total flow volume. An average flow-weighted EMC was then calculated for each seasonal flow interval where valid data was collected. The resulting pollutant concentrations are shown in Tables 4 and 5 below. The pollutant concentrations referenced in the DOH TMDL report are also included in these tables for comparison purposes. Supporting calculations for the City's flow-weighted EMCs are provided in Appendix B.

Table 4: CCH MS4 – Existing TSS Pollutant Concentration (mg/L)

Source	Wet Season			Dry Season		
	Flow Duration Curve Interval			Flow Duration Curve Interval		
	High	Elevated	Stable	High	Elevated	Stable
DOH TMDL Report	101[1]		9[2]	101[1]		9[2]
CCH WQ Monitoring Data (flow-weighted EMC)	111.1	41.6	6.3	15.6	16.3	- [3]

[1]Table 4-1 Data Source: EPA Nationwide Urban Runoff Program, 1983
[2]Table 4-1 Data Source: Based on data from Chattahoochee River, 1993-1998
[3]Baseflow water quality data during the dry season was not collected

Table 5: CCH MS4 – Existing TN Pollutant Concentration (mg/L)

Source	Wet Season			Dry Season		
	Flow Duration Curve Interval			Flow Duration Curve Interval		
	High	Elevated	Stable	High	Elevated	Stable
DOH TMDL Report	3[1]		2[2]	3[1]		2[2]
CCH WQ Monitoring Data (flow-weighted EMC)	1.73	1.04	0.93	0.83	1.06	- [3]

[1]Table 4-1 Data Source: US Department of Agriculture, NRCS, 1999
[2]Table 4-1 Data Source: USGS National Water Quality Assessment Program, 1999
[3]Baseflow water quality data during the dry season was not collected

3.2 Loading Factors and Load Reduction Goals

Based on the flow-weighted EMC data computed for the two Upper Kaukonahua sites, a process consistent with the DOH TMDL report was repeated to calculate revised pollutant loading factors for urban land use. Tables 6 and 7 below summarize the revised loading factors for turbidity and TN. Loading factors were not explicitly provided in the DOH TMDL report but were back-calculated from the existing loading rates and concentrations. These values are also provided in Tables 6 and 7 for comparison purposes. It should be noted that existing pollutant load concentrations for agriculture and conservation land use were unchanged from the original assumptions in the DOH TMDL report.

Table 6: Urban Land Use Loading Factors for Turbidity

Source	Wet Season			Dry Season		
	Flow Duration Curve Interval			Flow Duration Curve Interval		
	High	Elevated	Stable	High	Elevated	Stable
DOH TMDL Report[1]	0.047	0.047	0.034	0.047	0.047	0.034
CCH WQ Monitoring Data (flow-weighted EMC)	0.051	0.020	0.024	0.008	0.008	- [2]

[1]Loading factors were not explicitly stated in the DOH TMDL report, so values were back-calculated from the existing loads and concentrations
[2]No baseflow data collected

Table 7: Urban Land Use Loading Factors for TN

Source	Wet Season		
	Flow Duration Curve Interval		
	High	Elevated	Stable
DOH TMDL Report[1]	0.511	0.511	0.268
CCH WQ Monitoring Data (flow-weighted EMC)	0.421	0.304	0.145

[1]Loading factors were not explicitly stated in the DOH TMDL report, so values were back-calculated from the existing loads and concentrations

These modified urban land use loading factors for turbidity and TN were then used to recalculate the City's existing load and subsequent load reductions in a manner consistent with the original TMDL calculations.

Per discussions with DOH, the City's load reduction goals and compliance with the WLAs shall be based on the seasonal elevated flow interval, as defined by the DOH TMDL report, and the modified urban land use loading factors described in Tables 6 and 7. The rationale to comply with only the elevated flow interval criteria is based on the premise that discharges from the MS4 occurred in excess of 10% of the time during TMDL development. Therefore, the City will demonstrate compliance with the WLA by removing the defined amount of pollutants as described in Tables 8 and 9 below. Tables 8 and 9 summarize the resulting target pollutant load reduction goals for the elevated flow interval by season.

Table 8: CCH MS4 – WLA, Existing Loads, and Load Reductions for Turbidity

	Wet Season Elevated FDCI	Dry Season Elevated FDCI
CCH WLA (NTU-tons/day)	0.069	0.025
CCH Existing Load (NTU-tons/day)	0.058	0.011
Load Reduction Required (NTU-tons/day)	0	0
Number of Days in Elevated FDCI (days)*	18.10	18.40
Seasonal Load Reduction (NTU-lb/season)	0	0

*12% (elevated) – 2% (high) = 10% of total days in season

Table 9: CCH MS4 – WLA, Existing Loads, and Load Reductions for TN

	Wet Season Elevated FDCI
CCH WLA (lb/day)	44.1
CCH Existing Load (lb/day)	45.5
Load Reduction Required (lb/day)	1.4
Number of Days in Elevated FDCI (days)*	18.10
Seasonal Load Reduction (lb/season)	25

*12% (elevated) – 2% (high) = 10% of total days in season

Based on the above computations which have been reviewed and concurred by DOH, the City's implementation plan will target reductions in TN loadings by 25 lb during the wet season. Since the actual monitoring data indicates that the City's current discharge for turbidity is below its WLA for both the wet and dry seasons, turbidity reductions are not applicable (see Table 8).

It should be noted that the City is preparing to appeal to the State Department of Health to revise the TMDL/WLA calculations to incorporate site-specific information where appropriate per 40 CFR 130.7(c)(1)(i) with the modifications described in this section.

3.3 Use of TSS as a surrogate for Turbidity

The DOH TMDL report stated that many streams exhibit a fairly strong correlation between TSS and Turbidity. For Upper Kaukonahua Watershed in particular, the report cited very high correlation values for storm flows ($R^2 > 0.9$), but low correlation for baseline flows ($R^2 < 0.1$) (DOH, 2009). References to TSS as a surrogate for turbidity in the following sections are used to quantify reductions for BMPs that report typical TSS reductions, but do not estimate turbidity reductions. This method is considered to be conservative since turbidity is affected by particles sizes larger than those that contribute to TSS and can also be affected by other mitigating factors including color.

Although compliance with turbidity reductions is not required, the following sections provide computations for estimated turbidity reductions based on the selected activities. These computations are provided for information only and will not be used for compliance purposes.

4.0 Proposed Best Management Practice Implementation and Monitoring Plan

The City will implement various Best Management Practices (BMPs) to reduce pollutants, particularly TN, from entering the stream. The aggregate effect of these individual activities is expected to reduce the pollutants in the City's stormwater discharge to below the target WLA. This TMDL Implementation Plan identifies specific activities with the goal of reducing pollutants, improving water quality, and increasing the stream's ability to support aquatic habitat. While ultimately the attainment of the Upper Kaukonahua TMDL requires all stakeholders, including the major landowners and land operators, to participate in pollution reduction efforts, the City proposes to implement the following BMPs to reduce point source loads from the City's streets and facilities.

- Community Involvement and Outreach/Education
- Pollution Prevention and Good Housekeeping

4.1 Community Involvement and Outreach/Education

Outreach efforts which educate the general public to effect changes in their behavior can result in significant reductions of pollutants that would otherwise enter the storm drain system and receiving waters.

4.1.1 Downspout Disconnection

Building rooftops are impervious surfaces, similar to paved streets and parking lots that accumulate debris, chemicals, fine sediment, nutrients or other pollutants that could adversely affect water quality if the runoff is discharged untreated. Connected downspouts discharge rooftop runoff either directly to the storm drain system or to impervious surfaces. In both cases, there is little to no treatment of stormwater runoff before it reaches the stream system. Most of the nitrogen contained in stormwater is in the form of dissolved nitrate. Since the nitrogen is not in solid form, removal through plant uptake has been shown to be much more effective than filtration methods.

Downspout disconnection can help reduce runoff volume, rate, and accumulated rooftop pollutants introduced to local streams by allowing runoff water to pass through the initial plant uptake process as well as the secondary infiltration process rather than discharging directly to the storm drainage system. Disconnected downspouts typically drain to pervious areas such as yards and lawns, rain barrels, or rain gardens, all of which allow rooftop runoff to enter treatment prior to discharge.

A survey of the 259 residential properties in Upper Kaukonahua to assess the potential for downspout disconnection was performed on May 2, 2012. The results of the survey are provided in Table 10.

Table 10: Survey of Properties for Potential Downspout Disconnection

Roof / Gutter / Downspout Condition	Number
Roofs with no gutters	73
Roofs with gutters with direct connection to storm drainage system	27
Disconnected roof gutters that drain to impervious surfaces	89
Disconnected roof gutters that drain to pervious surfaces	70
TOTAL PROPERTIES SURVEYED	259

Based on the results, there is a potential for 116 houses to implement downspout disconnection or redirection as there is a direct or indirect connection to the storm drainage system. These properties have been identified in Appendix C. In addition, these lots were identified to have at least 10 feet of pervious area available for infiltration down gradient of the disconnected downspout or sufficient room to accommodate a rain barrel installation.

Figure 5: Typical Example of Connected Downspout

Figure 6: Typical Example of Disconnected Downspout Draining to Impervious Surfaces

The City will prepare an informational mailer to targeted homeowners educating them on the benefits of downspout disconnection. The mailer will specify the benefits of such activity and provide homeowners with resources for additional information.

Pollutant reductions for downspout disconnection are calculated based on the pollutant load received from the total rooftop drainage area (A_{IMP}) suitable for disconnection and the anticipated removal efficiency of the selected BMP. The equation used to estimate TN and turbidity load reductions for downspout disconnection is expressed as follows:

Load Reduction [lb/yr] = LR * A_{IMP} * P * PP * RE * C, where:

LR = Loading rate for urban land use (NY State Stormwater Management Design Manual) (1.5 mg/L for TN; 19 mg/L for TSS)

A_{IMP} = impervious rooftop drainage area recommended for disconnection (estimated from Google Earth images) (10 Acres)

P = Average precipitation totals for calendar years 1990-2007 (26.6 in/yr during the dry season, 38.8 in/yr during the wet season)

PP = Percent of Residents who Participate (%)

RE = Removal Efficiency for Specific BMP Type (open channel removal rate of 81% for TSS and 56% for TN per National Pollutant Removal Performance Database, Center of Watershed Protection [CWP], 2007)

C = Conversion Factor, 0.2266

Table 11 provides a summary of the estimated load reductions in TN and turbidity from this activity based on varying participation rates.

Table 11: Downspout Disconnection Anticipated Load Reduction

Percent Participation	# of Houses	Wet Season		Dry Season	
		TSS (lb/season)	TN (lb/season)	TSS (lb/season)	TN (lb/season)
5%	5	58	3.16	40	2.17
10%	12	139	7.58	95	5.21
15%	17	198	10.79	136	7.41
20%	23	267	14.59	184	10.03
25%	29	337	18.40	232	12.64
30%	35	407	22.50	279	15.25
35%	41	477	26.01	327	17.87

While downspout disconnection is a meaningful and tangible homeowner contribution to reducing pollutants in the waste stream, this activity has not been included in the accounting of turbidity or TN load reductions from the City's MS4 due to uncertainty in the participation rate. If, however, it is determined, based on photographic evidence, that a significant number of homeowners have taken action, reduction contributions from this activity will be used to offset other activities such as street sweeping. Hypothetically speaking, if 41 of the 116 houses identified were to disconnect their roof drain downspouts, the TN load reduction goal of 25 lb during the wet season will be estimated to have been met, and therefore, it is also assumed that the City's WLA is also being met. In this case, other load reduction activities in the watershed would cease.

4.1.2 Homeowner Outreach/Volunteer Cleanup

Raising awareness among homeowners about some of the common activities around their homes that can negatively affect water quality can invoke a behavior change. This shift in behavior is a primary citizen-based strategy that can yield significant positive results and water quality improvements.

The City partnered with Leilehua High School staff and students to conduct an outreach effort on March 30, 2013 to characterize the state of the neighborhood and identify potential aspects for improvement. The City is currently evaluating the data and will continue to explore opportunities to encourage beneficial behavioral changes among the residents.

Since the effects of public participation on storm water discharges is often unreliable and difficult to quantify, the anticipated removal rates from this activity have not been included in the calculations to quantify TN load reductions. However, if a methodology is developed to quantify the homeowner/volunteer group contribution in removal of TN (i.e., volume of material removed and debris composition), it will be applied in a manner similar to that of street sweeping described below.

4.2 Pollution Prevention and Good Housekeeping

The City currently implements a host of pollution prevention and good housekeeping (GH) practices across the island. Collectively, these programs are a key element in the diversion of trash, sediment, and nutrients from entering the storm drain system and discharging to receiving waters. The City will implement the following plan to expand its maintenance operations in the Upper Kaukonahua watershed for the upcoming 2016 fiscal year (FY16).

4.2.1 Street Sweeping

The Wahiawa-Mililani Baseyard of the City Department of Facility Maintenance (DFM) currently maintains the City's streets and facilities within the Upper Kaukonahua Watershed area. Beginning in 2013, DFM started routine street sweeping in the Upper Kaukonahua neighborhoods every other month during the wet season. The baseyard currently has no mechanical street sweepers and relies on a combination of manual street sweeping and the use of a mechanical street sweeper on loan from the Pearl City baseyard.

A street sweeping pilot study was initiated in May 2013 to determine baseline conditions. During the baseline study, the total volume of debris removed from the roadside area was estimated by spreading the collected material into a rectangle of uniform thickness and measuring the dimensions to calculate the volume. In addition, the percent composition of the debris collected (gravel + sand + sediment, green waste, and trash) was visually estimated. The raw data summarizing the estimated removal quantity and debris composition are presented in Table 12 below.

Table 12: Summary of Street Sweeping Baseline Data Collection

Date	Season	Quantity Collected (CY) [1]	Debris Composition (%)[2]		
			Trash	Gravel/Sand Sediment	Green Waste
5/22/13	Dry	3	0-1	60-70	14-30
11/4/13	Wet	1.23	0-1	39-60	40-60
1/24/14	Wet	0.89	0	60	40
3/10/14	Wet	1.57	0-1	20-84	15-80
11/12/14	Wet	0.3	0	50	50
1/7/15	Wet	1.30	0	50	50
2/18/15	Wet	1.11	0	25	75

[1]Quantity estimated by spreading out the material collected into a uniform thickness and measuring length x width x depth
[2]Debris composition percentages estimated based on visual assessment

Particulate matter (PM) consisting of road sediment/sand/gravel were randomly sampled from the material collected and taken to the University of Hawaii at Manoa Agricultural Diagnostic Service Center for nitrogen analysis. The nitrogen content of the samples varied from 0.09% to 0.87% of total weight with an average concentration of 0.0034 lb-N/lb-PM.

Organic matter (OM) was also extracted from the material collected and taken to the University of Hawaii at Manoa Agricultural Diagnostic Service Center for nitrogen analysis. The nitrogen content of the samples varied from 0.54% to 1.35% of the total weight. The average nitrogen content of all OM collected was 0.0086 lb-N/lb-OM.

EPA bulk density conversion factors were determined for "gravel" + "sand" + "soil" (for sediment) and "compost" (for green waste) (www.epa.gov/osw/conserve/smm/wastewise/pubs/conversions.pdf).

The measured concentrations along with the bulk density conversion factors were used to compute the estimated removal quantity of TN according to the following equation:

TN Load Reduction [lb/sweep] = $(V_{TOTAL} * F_{G+S+S} * W_{G+S+S} * N_{PM}) + (V_{TOTAL} * F_{OM} * W_{COMPOST} * N_{OM})$, where:

V_{TOTAL} = Total volume of material collected (CY)

F_{G+S+S} = Estimated fraction of gravel + sand + sediment by volume based on visual assessment (%)

F_{OM} = Estimated fraction of organic material by volume based on visual assessment (%)

W_{G+S+S} = Average bulk density conversion factor for gravel, sand, and sediment (2,466 lbs/CY)

$W_{COMPOST}$ = Bulk density conversion factor for green waste (360 lbs/CY)

N_{PM} = Nitrogen content of particulate matter (gravel, sand, and sediment) (lb-N/lb-PM)

N_{OM} = Nitrogen content of organic matter (green waste) (lb-N/lb-OM)

A summary of the computations is provided in Table 13.

Table 13: Summary of Street Sweeping Pilot Study Load Reductions

Date	Qty (CY)	Material Collected	Bulk Density (lb/CY)	Concentration (lb/lb)	Qty Removed (lb/sweep)
				TN	TN
5/22/13	3	Gravel+Sand+Sediment	2,466	0.0009-0.0027	1.86
		Green Waste	360	0.0089	
11/4/13	1.23	Gravel+Sand+Sediment	2,466	0.0013-0.0034	2.37
		Green Waste	360	0.0060-0.0094	
1/24/14	0.89	Gravel+Sand+Sediment	2,466	0.0041	1.73
		Green Waste	360	0.0135	
3/10/14	1.57	Gravel+Sand+Sediment	2,466	0.0025-0.0087	3.94
		Green Waste	360	0.0071-0.0111	
11/12/14	0.30	Gravel+Sand+Sediment	2,466	0.0044	1.99
		Green Waste	360	0.0072	
1/7/15	1.30	Gravel+Sand+Sediment	2,466	0.0027	6.18
		Green Waste	360	0.0080	
2/18/15	1.11	Gravel+Sand+Sediment	2,466	0.0034	3.95
		Green Waste	360	0.0054	

The street sweeping pilot study will continue through the end of calendar year 2016 (CY16). Throughout this period, the total volume of material collected and the estimated debris composition will be tracked for each street sweeping cycle. In addition, laboratory analysis for the nutrient content of the particulate fraction and organic fraction of the material collected from street sweeping will be conducted.

Based on the data collected thus far, it is estimated that each monthly street sweeping cycle is anticipated to reduce TN loadings by 3-4 lbs. On average, 2-3 lbs of TN is removed per cubic yard of street sweeping debris collected.

This activity will occur approximately three times during the wet season. In the event the street sweeping equipment is out of commission for an extended period of time, the baseyard will borrow equipment from another baseyard to ensure the removal from this activity is sufficient to meet the City's WLA.

The seasonal removal quantity will be measured based on the City's fiscal year which begins on July 1st of each year. Data collected from each street sweeping cycle will be tallied and the running total will be measured against seasonal metrics to determine if collections are on target to meet the TN reduction goal for the season. If, at any time, the actual collections fall short of the estimates and it appears that routine street sweeping operations scheduled for the remainder of the season are not sufficient to meet the reduction goals, additional activities including drain cleaning will be conducted.

4.2.2 Grandview Wastewater Pump Station

The Grandview Pump Station, located at the end of Nonohe Place in Wahiawa Heights, is operated and maintained by the Collection System Maintenance Division (CSM) of the ENV. The site is unmanned

and closed at all times except during routine inspection and maintenance which occurs twice a week. The facility consists of approximately 0.162 acres (7,045 square feet) and includes an asphalt concrete driveway as well as the gated paved parking area and pump station building.

The pump station is located in an area of lush vegetation surrounded by mature trees including fast-growing species such as albizia and eucalyptus. If unmaintained, the decaying leaves could present a potential source of nitrogen loading to the surrounding area. As such, the City performs regular monthly maintenance on the property grounds. Based on previous maintenance collection efforts, it is estimated that approximately 3-4 lbs of TN are removed during each monthly site maintenance visit. Debris composition was estimated by the site supervisor based on visual assessment of the material collected. Bulk density conversions and pollutant concentrations were assumed to be similar to the street sweeping collections.

4.2.3 Maintenance of Storm Drainage System

Within the Upper Kaukonahua watershed, the City currently maintains 35 inlets (catch basins and grated inlets), 12 manholes, and nearly 5,500 linear feet of ditches and reinforced concrete drainage pipe ranging in diameter between 18” and 36”. The City routinely inspects its drainage facilities once every five years (once per permit term) and cleans all structures that are at least 50% full. Cleaning is performed more frequently if complaints are received. The City will continue this routine maintenance through the end of the permit term (2020).

An initial storm drain system cleaning was conducted between 7/25/12 and 8/1/12 to determine baseline conditions. Only drainage structures were inspected and cleaned during this effort; drainlines were not included in the inspection. During this study, 4 cubic yards of debris consisting of gravel, sediment, green waste, and trash were removed from the drainage structures. The collections were separated by the “Upper” area (mauka of Grand View Place) and “Lower” area (vicinity of Dole Road and Kilea Place). The raw data summarizing the estimated removal quantity and debris composition are presented in Table 14 below.

Table 14: Summary of Drain Cleaning Baseline Data Collection

Location	Date	Quantity Collected (CY) [1]	Debris Composition (%)[1,2]			
			Trash	Gravel	Sediment	Green Waste
Upper Area	7/25/12	1	0	65	15	20
Upper Area	7/26/12	1	0	65	15	20
Lower Area	7/31/12	1	20	40	20	20
Lower Area	8/1/12	1	20	40	20	20

[1]Quantity and debris composition percentages estimated by street sweeper operator based on visual assessment
[2]Operator combined percentage of “Dirt & Gravel” together; this was segregated into sediment and gravel by estimating similar proportions to material collected during street sweeping operations.

Bulk density conversions and pollutant concentrations for the material removed from the drainage structures were assumed to be similar to the street sweeping collections for the applicable Upper and Lower areas. Table 15 below summarizes the anticipated load reduction from this activity. The calculations are similar to those presented for street sweeping.

Table 15: Summary of Drain Cleaning Load Reductions

Date	Qty (CY)	Material Collected	Bulk Density (lb/CY)	Concentration (lb/lb)	Qty Removed (lb/sweep)
				TN	TN
7/25/12	1	Gravel+Sand+Sediment	2,466	0.0009	2.4
		Green Waste	360	0.0089	
7/26/12	1	Gravel+Sand+Sediment	2,466	0.0009	24
		Green Waste	360	0.0089	
7/31/12	1	Gravel+Sand+Sediment	2,466	0.0027	4.6
		Green Waste	360	0.0089	
8/1/12	1	Gravel+Sand+Sediment	2,466	0.0027	4.6
		Green Waste	360	0.0089	

Based on the estimated removal rate and the nutrient analysis, it is estimated that the maintenance cleaning of the drainage structures will result in TN reductions of approximately 14.1 lb/cleaning cycle. On average, 3.5 lbs of TN are removed with each CY of debris removed from the drainage system. This activity will occur once a permit term unless the collective efforts of the street sweeping and Grandview Pump Station site maintenance do not adequately account for the necessary TN removal quantities within a particular wet season.

The City also owns nine outfalls within the watershed boundary. Field investigations and an evaluation of six of the nine outfalls were conducted. In general, the outfall channels are hardened with concrete or GRP for a short distance beyond the outlet (varies from approximately 5 feet to 30 feet). Due to the steep topography and lush vegetation, the conditions at the end of the channels are not readily visible. It was determined that there was insufficient room at any of the sites to implement any type of downstream improvements that would yield beneficial results. In addition, the adverse topography would make access for construction and maintenance extremely difficult. For these reasons, no outfall improvements are proposed for the Upper Kaukonahua area.

4.3 Permanent BMP

It is not anticipated that permanent BMPs will be required to meet the nutrient load reductions; however, if it becomes necessary to further reduce pollutant loads, the City will consider permanent BMP options which include retrofitting outfalls with sediment capture devices and/or installing catch basin inserts in strategic locations. The decision to implement permanent BMPs will be made after the results of FY17 debris collection data is compiled and analyzed. If required, a revised I&M Plan will be submitted to the DOH by the end of FY18. Additional details on the implementation timeline are provided in Section 5.0.

4.4 Summary of BMP Activities

The following table summarizes the estimated effectiveness of the various BMP activities to be implemented by the City.

Table 16: Summary of BMP Activities and Quantitative Reductions

	Turbidity Reduction (NTU-lbs/season)		TN Reduction (lbs/season)
	Wet Season	Dry Season	Wet Season
Downspout Disconnect	*	*	*
Homeowner Outreach/Volunteer Cleanup	*	*	*
Street Sweeping	not calculated	0	9
Grounds Maintenance at Grandview Pump Station	not calculated	0	18
Storm Drain Maintenance	**	**	**
TOTAL	not calculated	0	27
REDUCTIONS REQUIRED	none	none	25

* The City will conduct a public education and outreach program to all homeowners within the watershed; however, due to difficulty in quantifying pollutant load reductions due to behavior changes, no homeowner contribution is assumed for accounting purposes at this time.

** Cleaning of storm drains and drainage structures will be implemented only if collections from other activities are less than anticipated and the City needs additional reductions to meet the load reduction goals for a particular season. Storm drain cleaning may also be done in lieu of additional street sweeping activities based on scheduling and equipment availability.

4.5 Summary of Activities to be Tracked

The City will meet the TN load reduction goal of 25 lbs during the wet season by employing a combination of street sweeping and monthly site maintenance at the Grandview Pump Station grounds.

The City intends to continue routine street sweeping within the residential areas of the Upper Kaukonahua watershed indefinitely. The quantity of material collected, the debris composition, and the laboratory analysis of the particulate and organic matter will continue through the end of the street sweeping pilot study (December 2016). At the conclusion of the pilot study, laboratory analysis for the nutrient content of the collected material will cease and the three years of data will be averaged to determine estimated removal rates going forward. The quantification of the material removed and estimation of debris composition will continue until the end of FY17. After that date, the City will utilize the historical data to determine the basic level of street sweeping activities necessary to meet the pollutant load reduction goal and ultimately the City's WLA.

The City also intends to track the material removed at the Grandview Pump Station grounds. The quantity of material collected and debris composition will be measured for each site visit through FY17. Laboratory analysis for nutrient content of the collected material will be conducted twice during the compliance period since the composition of the vegetation is expected to be rather consistent. After FY17, the City will utilize the historical data to determine the basic level of grounds maintenance necessary to meet the pollutant load reduction goal and ultimately the City's WLA.

If the combination of all of the proposed activities results in less collections than required, the City will reevaluate the program. Depending on the findings, this may result in implementing additional program elements, including identifying opportunities for permanent BMP development.

If, at any time, it is determined that homeowners have disconnected roof drain downspouts, the changes will be photo documented, and the applicable load reductions will be applied to the seasonal tally. Depending on the level of homeowner participation for this activity, other BMP activities will be reduced to offset the load reduction contribution by the homeowners.

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5.0 Compliance Schedule

The achievement of the City's WLA for the Upper Kaukonahua Watershed will occur over a period of three and a half years with a final compliance deadline of December 31, 2018. Based on historical collections, it is anticipated that street sweeping three times during the wet season and monthly grounds maintenance at Grandview Pump Station will collect sediment and organic matter in sufficient quantity to meet the TN reduction goal.

If it is determined that significantly more activities are required to meet the target reductions and the City is unable to meet the WLA by the compliance deadline, the City will work with the appropriate agency to reevaluate the program. Depending on the findings, this may result in implementing additional program elements or reevaluating the current conditions to determine if the characteristics of the MS4 discharges have changed. In accordance with these modifications, the City will submit a revised I&M Plan in FY18 and request a modification to the final compliance deadline. The revised plan will outline the additional activities the City plans to implement to achieve the WLA and include a timeline for implementation. The proposed implementation schedule is shown in the following table.

Table 17: Schedule of Compliance

Due No Later Than:	Milestone / Deliverable
June 30, 2015	• Submit updated I&M Plan per Part F.3.a • Continue 3-yr street sweeping pilot study (quantity of material collected, debris composition, and TN analysis)
June 30, 2016	• Continue 3-yr street sweeping pilot study (quantity of material collected, debris composition, and TN analysis)
December 31, 2016	• Complete street sweeping pilot study (TN analysis) • Continue numerical tracking of GH activities (quantity of material collected and debris composition)
June 30, 2017	• Complete numerical tracking of GH activities (quantity of material collected and debris composition)
December 31, 2017	• Submit street sweeping pilot study report and provide summary of street sweeping material analyzed during pilot study
June 30, 2018	• Complete analysis of GH numerical tracking data to determine basic level of activities necessary, and • If additional activities are required, submit revised I&M Plan which outlines additional activities to be implemented[1]
December 31, 2018	FINAL COMPLIANCE DEADLINE • Submit final report detailing how compliance with WLA reductions was achieved and will be maintained

[1]Other activities are defined as other municipal and public participation maintenance activities such as drain cleaning, volunteer cleanups, regulatory compliance and enforcement policies, homeowner involvement, downspout disconnections, structural retrofits and other structural BMP measures

After the final compliance deadline, the City's compliance will be based on fulfilling the basic level of activities determined to be necessary to meet the pollutant load reduction.

Ultimately, it is the City's goal to contribute to good stewardship of the land and ensure that water quality in and around the island of Oahu is safe and useable for all intended purposes. These activities are proposed to aid in achieving this goal.

6.0 References

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APPENDIX A:

CITY AND COUNTY OF HONOLULU
DEPARTMENT OF ENVIRONMENTAL SERVICES
SUMMARY OF WATER QUALITY SAMPLING
JANUARY 2012 – JANUARY 2013

1.0 Site Selection

The yellow shaded areas in Figure 1 below illustrate residential properties serviced by the City's MS4 infrastructure. The boundary of the watershed transects upper Wahiawa Heights and divides the neighborhood into two separate drainages, both of which feed into the North Fork of Kaukonahua Stream several hundred feet below. One representative outfall was selected for water quality monitoring purposes in each area. Since the City's MS4 coverage consists entirely of single family residential properties and City streets in this watershed, both monitoring locations were selected to collect samples from this urban land use.

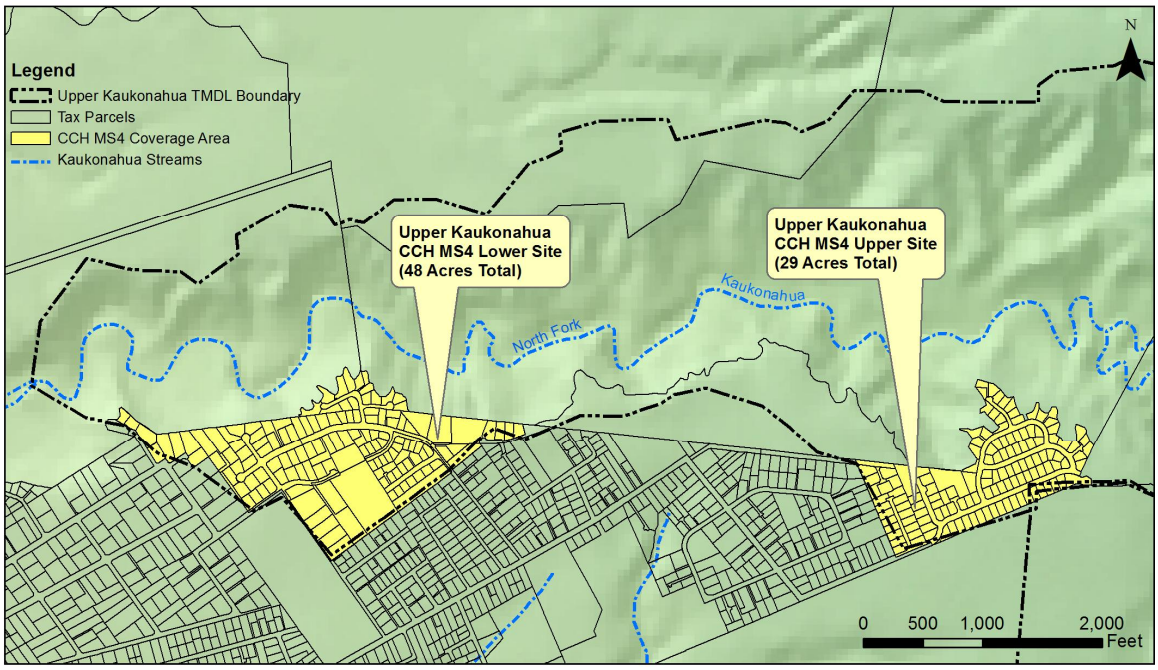

Figure 1: Upper Kaukonahua Watershed CCH MS4 Coverage Area

1.1 Dole Road Monitoring Site

The lower monitoring site (D36) is located at the outfall of a 36" diameter pipe at the end of the Dole Road cul-de-sac (158˚0.422' W, 21˚30.555' N) (see Figure 2). The site is accessible through a 10' wide easement in favor of the City and County of Honolulu along 194 Dole Road. The catchment area is approximately 8 acres and incorporates runoff from approximately 30 house lots and 1,800 linear feet of asphalt paved roadway. Runoff generally sheet flows to the road where it enters the sub-surface storm drains through curb inlet structures.

The drain outlet consists of a 10' x 7' concrete pad with vertical wingwalls with no flare (see Figure 3). A 14" lip at the downstream end of the structure restricts flow with two 6" wide cutouts for low flow conditions. A baffle is located about 4' downstream of the pipe outlet to dissipate the energy before exiting to the steep, forested hillslopes of the North Fork Valley. The outfall is located approximately 240 feet above the North Fork of Kaukonahua Stream.

As evidenced in Figure 4, upon first inspection of the site, the basin was full of sand, gravel, and debris. Both low flow outlets were occluded with vegetation and the outlet did not appear to be maintained for some time.

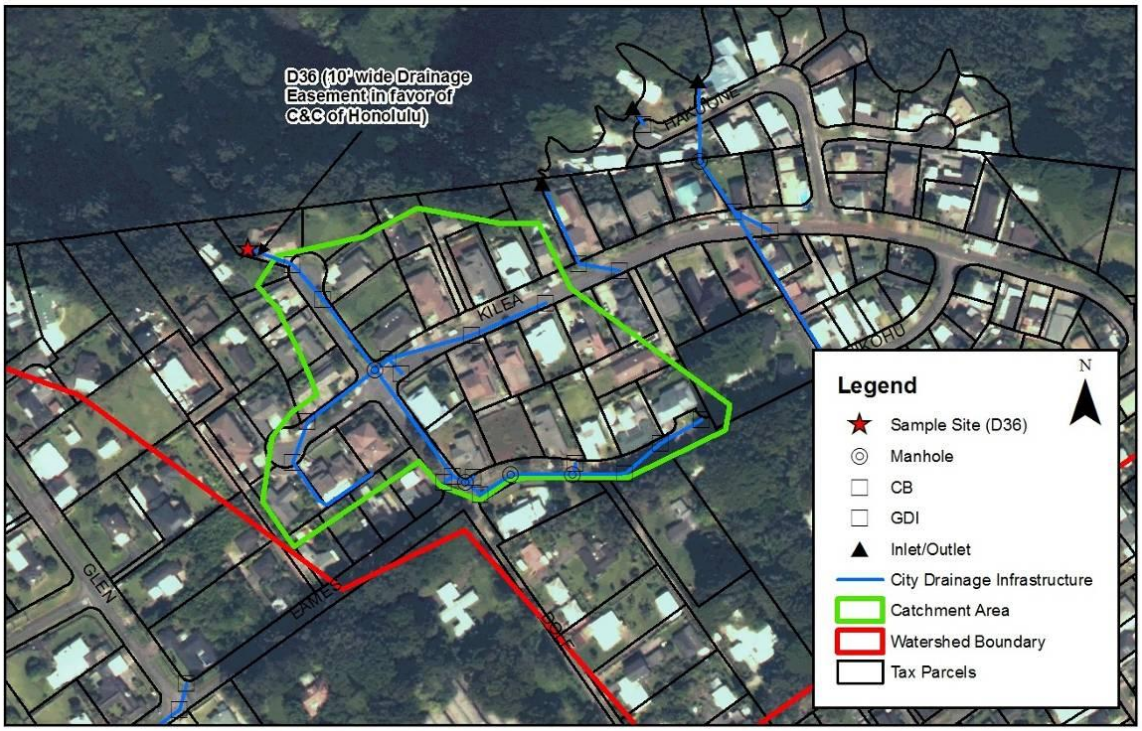

Figure 2: Dole Road Monitoring Location and Catchment Area (D36)

Figure 3: Concrete Outlet Structure and Energy Dissipater

Figure 4: Downstream Condition at Initial Site Inspection

1.2 Nonohe Street Monitoring Site

The upper monitoring site (D18) is located in a catch basin (CB) fronting 2623 Nonohe Street (157˚59.295' W, 21˚30.579' N) (see Figure 5). The catchment area is approximately 3.98 acres and collects runoff from about 24 house lots and 1,500 linear feet of asphalt paved roadway. Runoff from roofs, lawns, and driveways sheet flow along the curb and gutter into a single catch basin (see Figures 6 and 7). The drainage structure is a 48" x 46" wide concrete box that is approximately 4' deep. The concrete box is drained by an 18" diameter pipe with a slope of approximately -1°. An outlet structure is located approximately 60 feet downstream of the CB, but is not visible or accessible from the public right-of-way.

Figure 5: Nonohe Street Monitoring Location and Catchment Area (D18)

Figure 6: Nonohe Street View of Sampling Location

Figure 7: Grab Sample Attempt on 01/26/12

2.0 Precipitation Monitoring

Due to the typically erratic temporal rainfall patterns characteristic of Hawaii, it was determined that an on-site rain gage close to the water sample collection station would be beneficial in providing information that would assist with the interpretation of the stormwater quality data and provide a better understanding of the rainfall-runoff relationship. For this reason, a 6-inch diameter tipping bucket rain gage was installed on May 10, 2012 on a carport at 2631 Nonohe Street (see Figures 8 and 9). The data collected

from this station was supplemented with information from the National Weather Service Gage (Wheeler Airfield (H102) – WAFH1) to determine precipitation patterns.

Figure 8: 6-inch Diameter Tipping Bucket Rain Gage

Figure 9: Rain Gage Installed in Unobstructed Location at 2631 Nonohe Street

3.0 Water Quality Monitoring Methodology

The objective of the monitoring plan for the two Upper Kaukonahua sites was to develop event mean concentration runoff values for typical City land uses unique to a location and precipitation pattern. In addition, small, medium, and large storm events were targeted to provide a good representative distribution of samples within the stable, elevated, and high flow intervals as defined in the DOH TMDL report.

3.1 Equipment

On March 6th and 7th, 2012, 12-bottle capacity (750 mL) automated ISCO samplers (model number ISCO 3700) were installed at each site (See Figures 10 and 11).

Figure 10: Sampling Equipment Installed in CB at Nonohe St.

Figure 11: Sampling Equipment Installed at Dole Road

Flow depth sensors (Schlumberger DIVER 701-10m) were also installed in the drainage pipes to estimate runoff volumes based on the physical dimensions of the drainage pipe (see Figure 12).

Figure 12: Flow Depth Sensor (Pressure Transducer)

Figure 13: Intake Tube

3.2 Sampling Procedures and Field Methods

Most of the samples were collected via the automatic ISCO samplers, supplemented occasionally with grab samples taken at the beginning or end of storm periods. The automatic ISCO samplers were programmed to collect up to 12 discrete samples at select time intervals which varied between 15 and 120 minutes, depending on the perceived intensity and likely duration of the storm event.

All ISCO samplers were typically serviced within 24 hours of the actual sample time. During servicing, all sample bottles were collected and transported to AECOS laboratories in Kaneohe where they were photographed, composited, and analyzed. All manual grab samples were immediately placed on ice after collection. Several of the automatic samples collected were also chilled immediately upon collection, although most were not chilled until arrival at AECOS laboratories.

When a sufficient number of discrete samples were collected, three samples were typically composited and submitted for analysis. Each 3-bottle composite generally represented the first flush, peak, and falling limb portions of the given storm event.

The laboratory ensured that samples were analyzed within the designated hold time. If samples were submitted beyond the hold time, they were either not analyzed or a notation was made on the analysis report.

3.3 Parameters

Each composite sample was analyzed for TSS, Turbidity, TN, Nitrate + Nitrite ($NO_3 + NO_2$), Total Phosphorous (TP) and dissolved metals (lead, copper, zinc).

4.0 Results

A total of 219 discrete water samples were collected from the two samples sites via grab samples and automatic ISCO samplers from 13 rainfall events between January 2012 and January 2013. The discrete samples were compiled into 69 composite samples for analysis. Table 1 provides a summary of the storm events collected, including the estimated event flow volumes. Tables 2 and 3 provide a summary of the laboratory analyses of the composited samples performed by AECOS, Inc.

Table 1: Event Summary Table (D18 and D36)

Storm Event	Event Date	Rain (in.)	Rain duration (h:mm)	Rain Source	Rain Runoff Volume (liters)	Pipe Flow Volume (liters)	Flow Source	No. Samples Collected	No. Samples Analyzed
D18									
1	1/17/2012	1.73	4:36	Wheeler	422,840	22,478	Manual	4	2
2	3/7/2012	0.00	1:00	Wheeler	0	0	Diver	2	1
3	3/9/2012	0.14	5:10	Wheeler	33,635	6,349	Diver	12	2
4	3/10/2012	-	-	Wheeler	-	-	Diver	-	-
5	4/22/2012-4/23/2012	0.81	4:30	Wheeler	197,005	23,463	Diver	12	3
6	5/3/2012	0.46	4:40	Wheeler	111,661	27,976	Diver	11	2
7	5/23/2012 - 5/24/2012	-	-	Wheeler	-	-	Diver	-	-
8	6/19/2012	0.2	7:20	Oceanit	48,782	15,176	Diver	5	3
9	6/22/2012-6/23/2012	0.25	4:30	Oceanit	60,977	17,462	Diver	12	3
10	6/25/2012	0.52	6:10	Oceanit	126,832	45,218	Diver	12	3
11	7/5/2012	1.17	11:40	Oceanit	285,373	100,839	Diver	12	3
12	7/5/2012 (QA)	n/a	n/a	n/a	n/a	n/a	n/a	2	2
13	7/15/2012-7/17/2012	0.4	14:40	Oceanit	97,563	35,431	Diver	10	3
14	1/3/2013-1/6/2013	3.20	44:15	Oceanit	780,507	337,808	Diver	21	5
D36									
1	1/17/2012	1.43	4:31	Wheeler	739,513	225,532	Manual	4	2
2	3/7/2012	-	-	Wheeler	-	-	Diver	-	-
3	3/9/2012	-	-	Wheeler	-	-	Diver	1 (sediment)	1 (sediment)
4	3/10/2012	0.70	14:10	Wheeler	361,353	304,814	Diver	7	1
5	4/22/2012-4/23/2012	0.67	6:30	Wheeler	344,546	5,860	Diver	12	3
6	5/3/2012	-	-	Wheeler	-	-	Diver	-	-
7	5/23/2012 - 5/24/2012	0.52	50:20	Wheeler	308,074	510	Diver	12	6
8	6/19/2012	0.06	2:20	Oceanit	32,016	2,391	Diver	3	3
9	6/22/2012-6/23/2012	0.14	4:50	Oceanit	74,704	8,792	Diver	12	3
10	6/25/2012	0.32	8:00	Oceanit	167,195	26,971	Diver	12	3
11	7/5/2012	0.75	9:00	Oceanit	384,192	119,353	Diver	12	3
12	7/5/2012 (QA)	n/a	n/a	n/a	n/a	n/a	n/a	2	2
13	7/15/2012-7/17/2012	0.44	29:50	Oceanit	227,669	29,840	Diver	12	5
14	1/3/2013-1/6/2013	3.07	76:00	Oceanit	1,583,013	613,090	Diver	16	6

Table 2: Water Quality Data Summary at D36 (Dole Road Outfall)

AECOS Sample Results Summary								Site:	D36
	Sample	Turbidity (NTU)	TSS (mg/L)	Nitrate + Nitrite (μg/L)	Total Nitrogen (μg/L)	Total Phosphorus (μg/L)	Copper (μg/L)	Lead (μg/L)	Zinc (μg/L)
	2	16.8	10	91	671	65	6.8	<4.0	7.8
	4	22.6	8.7	139	799	80	7.4	<4.0	7.4
	6	24.4	52.5	57	1180	115	13.8	<4.0	17.1
1/17/2012	8	21	6.8	115	695	58	8.6	<4.0	6
3/10/2012	1-7 comp	6.64**	6.6**	88	770	29	6.4	<4.0	9.9
	2, 3, 4 comp	8.39	8.6	156	1070	42	28.2	<4.0	9.4
	5, 6, 7, 8, 9 comp	4.86	4	167	920	33	16	<4.0	4.9
4/22/2012	10, 11, 12 comp	4.04	4.6	71	700	40	13.3	<4.0	5.2
	10	7.58	23	577	2200	96	17.1	0.47	12.2
	11	10.2	13	460	1490	113	19.3	0.872	11.7
6/19/2012	12	13	9.5	463	1420	117	20.1	1.25	14.9
	1-4 comp		11	552	1710	100	21.1	<4.0	9
	5-8 comp		2.2	259	1020	74	13.9	<4.0	3.9
6/23/2012	9-12 comp		1.4	189	850	60	13.2	<4.0	3.9
	3-5 comp	5.09	3.6	266	1020	64	16.2	<4.0	6.1
	6-9 comp	3.85	2.4	68	770	47	8	<4.0	4.1
6/25/2012	10-12 comp	3.8	3.4	55	700	40	7.6	<4.0	4.1
	1-3 comp	25.1	76.5	150	2030	144	15.8	<4.0	7.2
	4-8 comp	9.3	13	60	720	107	12.5	<4.0	12.4
7/5/2012	9-12 comp	4.46	6.3	39[J]	740	43	6.2	<4.0	7.5
7/5/2012	Grab	6.22	7	54	770	43	15.5	<4.0	6
(QA/QC)	Grab Chilled	7.26	8.5	39[J]	790	49	39.2	7.5[J]	90.5
	1-2 comp	8.18	23	471	1660	87	19.9	<4.0	15.7
	3-5 comp	4.39	6.7	153	980	66	9.4	<4.0	6.8
	6-7 comp	6.1	4.7	99	920	44	10.8	<4.0	4.8
	8-10 comp	5.75	5.3	77	760	51	9	<4.0	6
7/15/2012	11-12 comp	0.5	0.8	20[J]	34[J]	<4.0	1.7	<4.0	1.0[J]
	1A-2A comp	6.46	4.3	148	1270	84	18.1	<4.0	8.6
	1-5 comp	4.19	3.6	53	960	47	7.1	<4.0	8.9
1/3/2013-1	7-11 comp	4.4	3.4	66	790	37	7.7	<4.0	5.5
	1-2 comp	32.2	14	268	1280	99	14.4	<4.0	9.5
	3-4 comp	29.8	21	2240	3400	98	14.7	<4.0	11.1
1/3/2013-2	5-6 comp	275	163	452	1890	290	29.1	6.1[J]	26.1

** Samplers not serviced within 12-hours of collection and samples analyzed beyond the analytical holding time for Turbidity and TSS.

[J]Parameter was detected below the detection limit

Table 3: Water Quality Data Summary at D18 (Nonohe Street Catch Basin)

AECOS Sample Results Summary								Site:	D18
	Sample	Turbidity (NTU)	TSS (mg/L)	Nitrate + Nitrite (ug/L)	Total Nitrogen (ug/L)	Total Phosphorus (ug/L)	Copper (ug/L)	Lead (ug/L)	Zinc (ug/L)
1/17/2012	1	42.4	11	230	1170	147	7	<4.0	34.5
	3, 5, 7 comp	60.4	18	196	1130	78	11.1	<4.0	19.2
3/9/2012	1, 3, 4 comp	63.8	41	53	750	152	11.3	<4.0	49.5
	6-8, 10-12 comp	60.7	44.7	51	980	157	10.6	<4.0	24.9
4/22/2012	1, 2, 3 comp	11	8	131	970	24	14.7	<4.0	18
	4, 5, 6, 7, 8 comp	6.36	3.8	349	1010	14	6.8	<4.0	12.8
	9, 10, 11, 12 comp	6.49	4.8	70	820	17	9.3	<4.0	8.1
5/3/2012	1-4 comp	2.65**	4.6**	166	1150	13	<0.8	<4.0	1.5 [1]
	6-12 comp	6.40**	3.6**	117	990	5 [1]	4.9	<4.0	8.2
6/19/2012	8-9 comp	7.3	16	122	1010	52	14.3	0.492	23.1
	10-11 comp	4.12	13	54	1160	48	8	0.243	15.5
	12	20	38	75	1410	117	17.9	0.925	26.3
6/23/2012	1-4 comp		24.4	47[J]	780	78	13.2	<4.0	22.6
	5-8 comp		3	25[J]	650	28	7.6	<4.0	11.7
	9-12 comp		4.2	26[J]	690	26	6.9	<4.0	14.8
6/25/2012	3-5 comp	7.99	18	23[J]	860	38	9.2	<4.0	16.7
	6-9 comp	7	5.8	82	510	27	4.7	<4.0	10.5
	10-12 comp	11.4	3.8	65	540	21	5.2	<4.0	10.9
7/5/2012	1-3 comp	15.2	70	42[J]	1160	142	26.8	<4.0	46
	4-8 comp	15.6	8	72	600	57	5.1	<4.0	16.7
	9-12 comp	24.4	14	94	650	61	5.3	<4.0	17.9
7/5/2012 (QA/QC)	Grab	33.2	12	12[J]	770	75	9.5	<4.0	23
	Grab Chilled	37.2	27	<9	740	77	12.3	<4.0	31.4
7/15/2012	3-6 comp	6.8	5.2	42	880	28	18.3	<4.0	13.1
	7-9 comp	9.03	21	117	1000	68	9.9	<4.0	21.6
	10-12 comp	15	29	116	910	71	13.9	<4.0	25.9
1/3/2013-1	1A-1DA comp	25.7	8	24[J]	1070	30	5.6	<4.0	14.7
	1-5 comp	20.7	6.6	22[J]	680	28	5.7	<4.0	22
	6-11 comp	20.3	15	24[J]	680	29	5.6	<4.0	29.1
1/3/2013-2	1-3 comp	36.8**	145	32[J]	2190	321	27.8	<4.0	86.7
	4-9 comp	68.0**	154	52	2080	334	37.3	7.1[J]	121

** Samplers not serviced within 12-hours of collection and samples analyzed beyond the analytical holding time for Turbidity and TSS.

[J]Parameter was detected below the detection limit

5.0 Loading Estimates

Oceanit Laboratories, Inc. further calculated pollutant loadings for each event from the pollutant concentrations and the flow volume. The pollutant concentrations were obtained from the AECOS laboratory analysis based on Standard Methods. Flow volumes estimates were calculated from the flow depth measurements typically derived from pressure transducers. Tables 4 and 5 provide a summary of the calculated event loads for each pollutant.

Table 4: Summary of Event Pollutant Loads (D18)

Event Date	TSS (g)	TN (g)	TP (g)	NO_3+NO_2 (g)	Cu (g)	Pb (g)	Zn (g)
1/17/12	359	25.7	2.20	4.63	0.22	0.09	0.53
3/7/12	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3/9/12	275	5.7	0.99	0.33	0.07	0.03	0.21
4/22/12-4/23/12	120	21.3	0.41	3.96	0.22	0.09	0.27
5/3/12	105	28.4	0.17	3.48	0.12	0.11	0.20
6/19/12	422	20	1.34	1.11	0.22	0.01	0.34
6/22/12-6/23/12	197	12.4	0.80	0.58	0.16	0.07	0.29
6/25/12	326	26.5	1.20	2.90	0.26	0.09	0.53
7/5/12	1,781.63	69.06	6.83	8.29	0.74	0.20	2.05
7/15/12-7/17/12	501.01	32.70	1.69	2.76	0.53	0.07	0.63
1/3/13-1/6/13	40,441	607.16	88.78	13.90	9.51	1.64	31.02

Table 5: Summary of Event Pollutant Loads (D36)

Event Date	TSS (g)	TN (g)	TP (g)	NO_3+NO_2 (g)	Cu (g)	Pb (g)	Zn (g)
1/17/12	10,894	255.3	24.86	13.80	2.97	0.90	3.65
3/7/12	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3/10/12	2,012	234.7	8.84	26.82	1.95	1.22	3.02
4/22/12-4/23/12	27	4.1	0.23	0.42	0.08	0.02	0.03
6/19/12	30	3.68	0.27	1.14	0.05	0.00	0.03
6/22/12-6/23/12	57	11.6	0.73	3.41	0.15	0.04	0.06
6/25/12	78	20.7	1.24	2.22	0.23	0.05	0.12
7/5/12	2,621.26	116.52	10.16	8.06	1.23	0.24	1.10
7/15/12-7/17/12	255.91	29.88	1.78	5.38	0.33	0.06	0.22
1/3/13-1/6/13	3,842	569.49	33.23	73.85	5.85	1.23	4.10

APPENDIX B:

CITY AND COUNTY OF HONOLULU
DEPARTMENT OF ENVIRONMENTAL SERVICES
EVENT MEAN CONCENTRATION COMPUTATIONS

UPPER KAUKONAHUA END-OF-PIPE WATER QUALITY SAMPLING (JAN. 2012 - JAN. 2013)											
				Event	Flow	TSS			TN		
Sampling	Location	Season	Interval[1]	Precip[2]	Vol[3]	Load[4]	EMC	Flow-Weighted	Load[4]	EMC	Flow-Weighted
Date				(in)	(l)	(g)	(mg/L)	EMC (mg/L)	(g)	(mg/L)	EMC (mg/L)
1/17/12	Upper	wet	elevated	1.73	44,956	359	7.99	41.60	25.7	0.57	1.04
1/17/12	Lower	wet	elevated	1.44	225,532	10894	48.30		255.3	1.13	
3/7/12	Upper	*									
3/9/12	Upper	wet	high	0.14	6,349	275	43.31	111.08	5.7	0.90	1.73
3/10/12	Lower	*									
4/22/12	Upper	wet	high	0.81	23,463	120	5.11		21.3	0.91	
4/22/12	Lower	*									
5/3/12	Upper	*									
5/22/12	Lower	*									
6/19/12	Upper	dry	elevated	0.2	15,176	422	27.81	16.32	20	1.32	1.06
6/19/12	Lower	*									
6/22/12	Upper	dry	elevated	0.25	17,461	197	11.28		12.4	0.71	
6/22/12	Lower	dry	elevated	0.14	8,791	57	6.48		11.6	1.32	
6/25/12	Upper	dry	high	0.52	45,217	326	7.21	15.56	26.5	0.59	0.83
6/25/12	Lower	dry	high	0.32	26,970	78	2.89		20.7	0.77	
7/5/12	Upper	dry	high	1.17	100,839	1781.63	17.67		69.06	0.68	
7/5/12	Lower	dry	high	0.75	119,353	2621	21.96		116.5	0.98	
7/16/12	Upper	dry	high	0.4	35,430	501.01	14.14		32.7	0.92	
7/16/12	Lower	dry	high	0.44	29,840	256	8.58		29.9	1.00	
1/3/13	Upper	wet	high	3.2	337,808	40441	119.72	combine w/ above	607.16	1.80	combine w/ above
1/3/13	Lower	wet	stable	3.07	613,090	3842	6.27	6.27	569.5	0.93	0.93
	Wet Season - High Flow Interval (3 events)							111.1			1.73
	Wet Season - Elevated Flow Interval (2 events)							41.6			1.04
	Wet Season - Stable Flow Interval (1 event)							6.3			0.93
	Dry Season - High Flow Interval (6 events)							15.6			0.83
	Dry Season - Elevated Flow Interval (3 events)							16.3			1.06
	Dry Season - Stable Flow Interval (0 events)							n/a			n/a

Footnotes and References:

*Excluded from EMC calculation due to lack of precipitation data or lab analysis was performed beyond hold time

[1]See DOH TMDL Report Appendix D-2 and USGS NF Kaukonahua continuous stream gage site for stream flow corresponding to collection date/time

[2]Estimated/measured by Oceanit Laboratories, Inc. via on-site rain gage mounted at 2642 Nonohe Street and Wheeler AAF rain gage (WAFH1)

[3]Estimated by Oceanit Laboratories, Inc. based on measured flow depths in the pipe via pressure transducers

[4]Computed by Oceanit Laboratories, Inc., where Loading Rate = Pollutant Concentration * Volume of storm water conveyed

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NORTH FORK GAGE SITE (Flow Intervals from TMDL Report Appendix D-2)

	WET SEASON SAMPLE DATES	Wet Season		Dry Season		DRY SEASON SAMPLE DATES
		Flow Interval	Flow (cfs)	Flow Interval	Flow (cfs)	
HIGH (0 - 4%)		**0.0012%**	3070	**0.0012%**	1330	
	3/9/2012 →	**0.135%**	399	**0.135%**	286	
		0.270%	284	**0.270%**	195.7	
		0.56%	221	**0.56%**	152.4	← 7/5/2012
		1%	152	**1%**	111.6	
	1/3/2013 →	**2%**	104	**2%**	83.6	← 6/25/2012
	4/22/2012 →	**4%**	69.3	**4%**	55.4	← 7/16/2012
ELEVATED (4% - 20%)		**5%**	58.9	**5%**	48.8	← 6/22/2012
		10%	33.3	**10%**	30	← 6/19/2012
	1/17/2012 →	**12%**	28.9	**12%**	25.3	
		15%	22.8	**15%**	20.2	
		20%	17	**20%**	15.2	
STABLE (20% - 100%)		**25%**	13.5	**25%**	12.6	
		30%	11.4	**30%**	10.6	
		35%	9.25	**35%**	8.83	
		40%	7.82	**40%**	7.64	
		45%	6.56	**45%**	6.6	
		50%	5.65	**50%**	6.03	
		55%	4.95	**55%**	5.35	
		60%	4.43	**60%**	4.79	
		65%	3.8	**65%**	4.32	
		70%	3.42	**70%**	3.74	
		75%	3.13	**75%**	3.18	
		80%	2.81	**80%**	2.78	
		85%	2.42	**85%**	2.34	
		90%	2.17	**90%**	1.96	
	~~1/17/2012~~ →	**95%**	1.9	**95%**	1.6	
		96.333%	1.81	**96.333%**	1.52	
		97.185%	1.73	**97.185%**	1.42	
		98%	1.61	**98%**	1.3	
		99%	1.5	**99%**	1.15	
		99.865%	1.13	**99.865%**	0.52	
		100%	0.7	**100%**	0	

Real Time Stream Flow Data (USGS 16200000 NF Kaukonahua Str abv RB, nr Wahiawa, Oahu, HI)
http://nwis.waterdata.usgs.gov/hi/nwis/uv?cb_00060=on&cb_00065=on&format=gif_default&period=&begin_date=2012-07-04&end_date=2012-07-17&site_no=16200000

Flow interval was assumed, streamflow was inconsistent with observed rainfall at site

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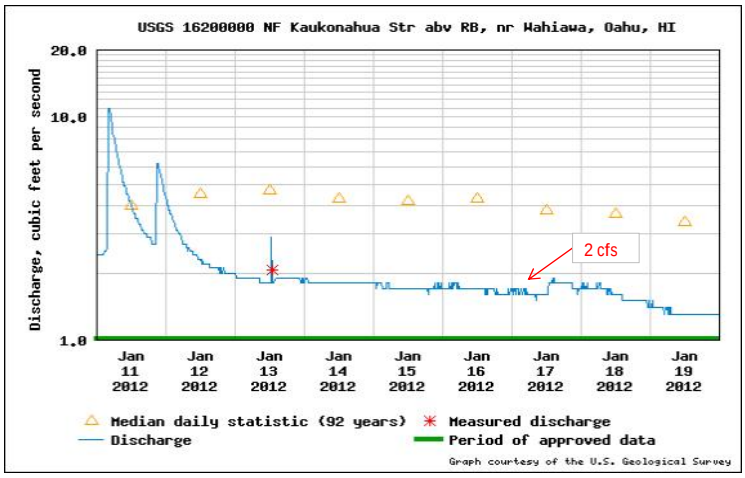
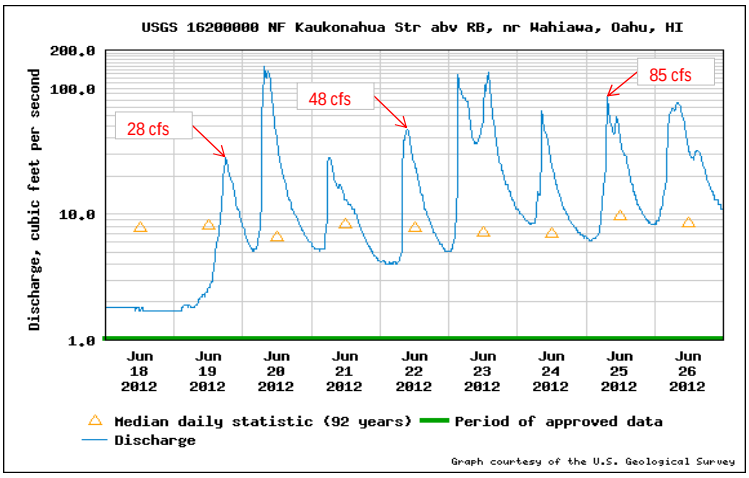
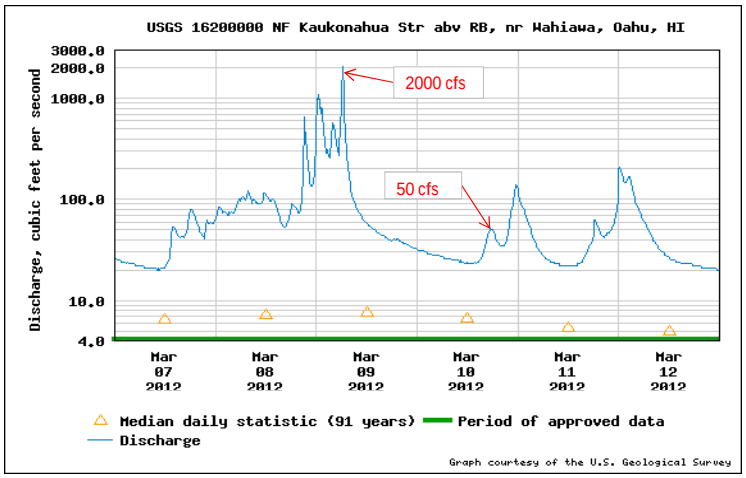
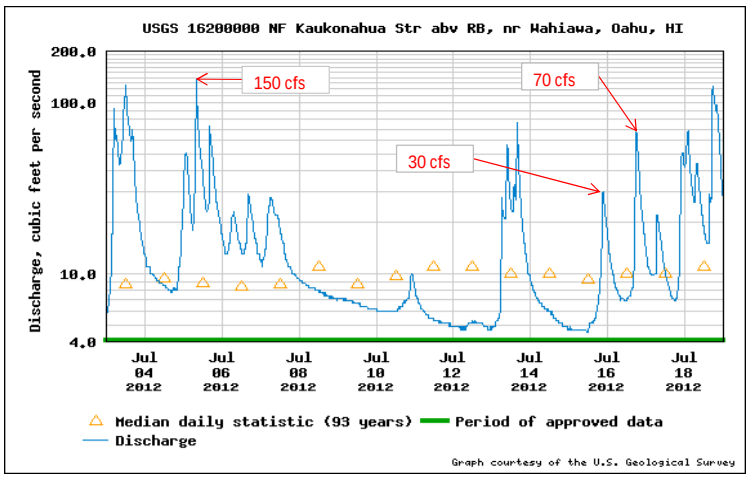
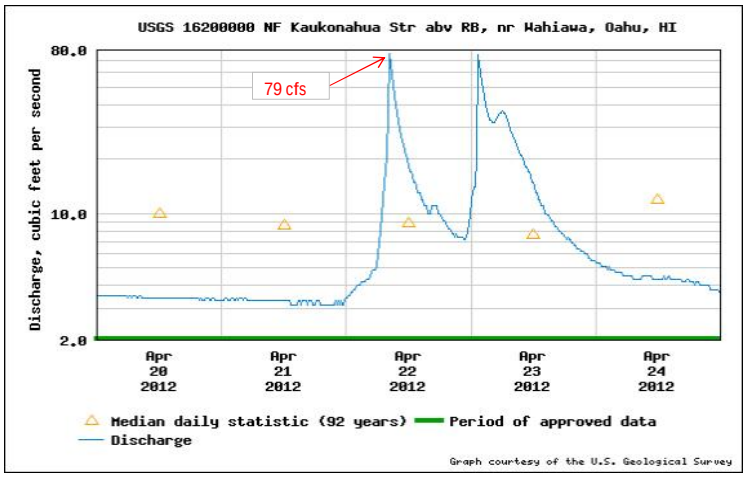
Stream Flow at USGS Site 16200000 NF Kaukonahua Stream

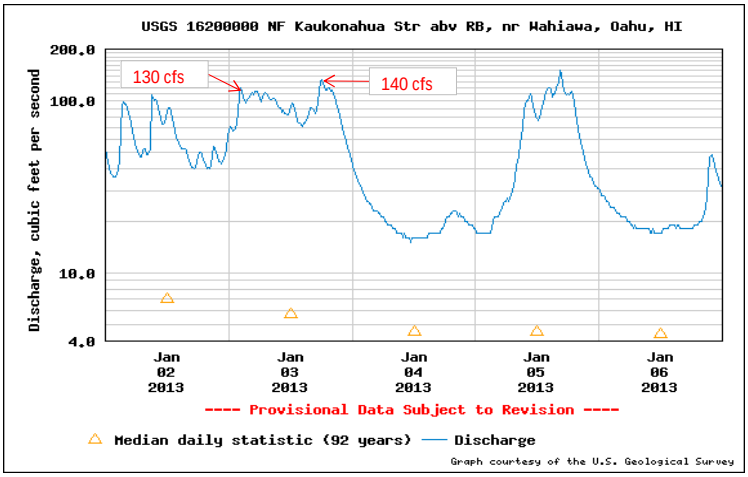












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APPENDIX C:

CITY AND COUNTY OF HONOLULU
DEPARTMENT OF ENVIRONMENTAL SERVICES
DOWNSPOUT DISCONNECTION FIELD SURVEY
(MAY 2012)

Legend
Upper Kaukonahua Watershed Boundary
Disconnected roof gutters that drain to impervious surfaces
Roofs with gutters with direction connection to storm drainage system
N
0 50 100 200 300 400
Feet
71002016
71002012
75019016
75019040
75013026
75013028
75013030
75013022
75013018
75013020
75013019
75013015
75013036
75013040
75022022
75022019
75022018
75022050
75022051
75022052
75022054
75022049
75022048
75022047
75022056
75022055
75022026
75022015
75022014
75022011
75022008
75022009
75022005
75022003
75022033
75022036
75022039
75023026
75023023
75023022
75023021
75023009
75023010
75023020
75023019
75023016
75023018
75014079
KANOELEHUA PL
NAHENAHE PL
GLEN AVE
EAMES ST
ROYAL PALM DR
KILEA PL
HAKUONE PL
HAKUONE ST
KINIKOHU ST
KINIPOPO ST
DOLE RD
KIEKIE PL
KOENA WAY
LIHI WAY
KALIKO DR

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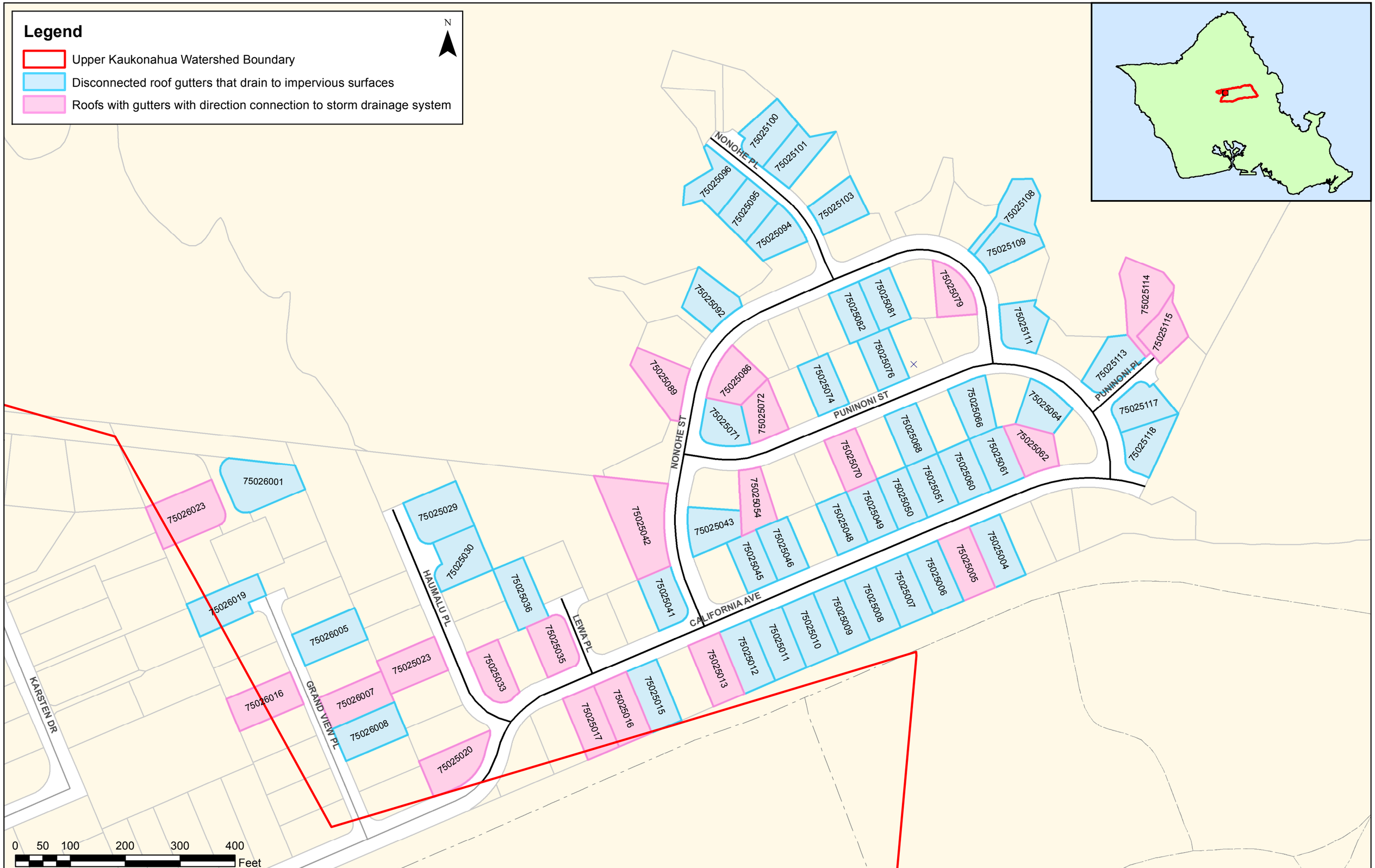
Legend
Upper Kaukonahua Watershed Boundary
Disconnected roof gutters that drain to impervious surfaces
Roofs with gutters with direction connection to storm drainage system
N
NONOHE PL
NONOHE ST
PUNINONI ST
PUNINONI PL
CALIFORNIA AVE
HAUMALU PL
LEWA PL
GRAND VIEW PL
KARSTEN DR
75025100
75025101
75025096
75025095
75025094
75025103
75025108
75025109
75025092
75025079
75025081
75025082
75025076
75025111
75025114
75025115
75025113
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75025072
75025071
75025074
75025066
75025064
75025062
75025117
75025118
75025068
75025070
75025061
75025060
75025051
75025050
75025049
75025048
75025054
75025043
75025046
75025045
75025042
75025041
75025029
75025030
75025036
75025035
75025033
75026001
75026023
75026019
75026005
75025023
75026016
75026007
75026008
75025020
75025017
75025016
75025015
75025013
75025012
75025011
75025010
75025009
75025008
75025007
75025006
75025005
75025004
0 50 100 200 300 400
Feet

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