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Rainfall, Discharge, and Water-Quality Data During Stormwater Monitoring, July 1, 2008, to June 30, 2009: Halawa Stream Drainage Basin and the H-1 Storm Drain, Oahu, Hawaii

By Todd K. Presley and Marcael T.J. Jamison

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Flow rate		
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8$$

Vertical coordinate information is referenced relative to mean sea level.

Horizontal coordinate information is referenced to Old Hawaiian Datum (Figure 1) or NAD 83 (Figure 2).

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (μg/L).

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Abstract

Storm runoff water-quality samples were collected as part of the State of Hawaii Department of Transportation Stormwater Monitoring Program. The program is designed to assess the effects of highway runoff and urban runoff on Halawa Stream, and to assess the effects from the H-1 storm drain on Manoa Stream. For this program, rainfall data were collected at three stations, continuous discharge data at five stations, and water-quality data at six stations, which include the five continuous discharge stations. This report summarizes rainfall, discharge, and water-quality data collected between July 1, 2008, and June 30, 2009.

Within the Halawa Stream drainage area, three storms (October 25 and December 11, 2008, and February 3, 2009) were sampled during July 1, 2008, to June 30, 2009. A total of 43 environmental samples were collected during these three storms. During the storm of October 25, 2009, 31 samples were collected and analyzed individually for metals only. The other 12 samples from the other two storms were analyzed for some or all of the following analytes: total suspended solids, total dissolved solids, nutrients, chemical oxygen demand, and selected trace metals (cadmium, chromium, copper, lead, and zinc). Additionally, grab samples were analyzed for some or all of the following analytes: oil and grease, total petroleum hydrocarbons, fecal coliform, and biological oxygen demand. Some grab and composite samples were analyzed for only a partial list of these analytes, either because samples could not be delivered to the laboratory in a timely manner, or an insufficient volume of sample was collected by the automatic samplers. Two quality-assurance/quality-control samples were collected after cleaning automatic sampler lines to verify that the sampling lines were not contaminated.

Four environmental samples were collected at the H-1 Storm Drain during July 1, 2008, to June 30, 2009. An oil and grease sample and a composite sample were collected during the storm on November 15, 2008, and two composite samples were collected during the January 11, 2009, storm. All samples at this site were collected using an automatic sampler. Samples were analyzed for some or all of the following analytes: total suspended solids, nutrients, oil and grease, total petroleum hydrocarbons, and selected trace metals (cadmium, chromium, copper, lead, nickel, and zinc). One quality-assurance/quality-control sample was collected after cleaning automatic sampler lines to verify that the sampling lines were not contaminated.

During the storm of January 11, 2009, the two composite samples collected at H-1 Storm Drain were collected about three hours apart. Higher constituent concentrations were detected in the first

composite sample relative to the second composite sample, although the average discharge was higher during the period when the second sample was collected.

INTRODUCTION

The State of Hawaii Department of Transportation (DOT) Stormwater Monitoring Program Plan (State of Hawaii Department of Transportation Highways Division, 2008) was implemented on January 1, 2001, to monitor the Halawa Stream drainage basin, Oahu, Hawaii. The Stormwater Monitoring Program Plan was designed to fulfill part of the permit requirements for the National Pollutant Discharge Elimination System program and is revised yearly. The Stormwater Monitoring Program Plan requires the collection of rainfall, discharge, and water-quality data at selected stations in the Halawa Stream drainage basin.

In 2005, additional monitoring of a storm drain that collects runoff from the H-1 Freeway was implemented to fulfill requirements, outlined by the United States Environmental Protection Agency (USEPA), related to Total Maximum Daily Loads (TMDL) for total nitrogen and total phosphorous (U.S. Environmental Protection Agency, Region 9, and Hawaii Department of Health, 2002) for discharges into Manoa Stream. Rainfall, discharge, and water-quality data were collected at this site starting in 2006.

This report summarizes water-quality data collected by the U.S. Geological Survey (USGS) as part of the Stormwater Monitoring Program Plan. This report also presents rainfall and discharge data collected from July 1, 2008, to June 30, 2009, for stations within the Halawa Stream drainage area and for a storm drain of the H-1 Freeway (hereinafter referred to as the H-1 storm drain) that discharges into Manoa Stream. Descriptions of the sampling techniques are included with the water-quality data. Quality-assurance/quality-control (QA/QC) samples were collected concurrently with storm samples and during routine cleaning of the sampling equipment between storms. Water-quality data for the QA/QC samples are not published in this report, but are available upon request from the USGS Pacific Islands Water Science Center in Honolulu, Hawaii.

Within the Halawa Stream drainage area, three storms (October 25 and December 11, 2008, and February 3, 2009) were sampled during July 1, 2008, to June 30, 2009. A total of 43 environmental samples were collected during these three storms within the Halawa Stream drainage area. Of the 43 samples, 31 samples were collected during the storm of October 25, 2008, and analyzed individually for metals only. QA/QC samples included two artificial blank water samples, collected on May 20, 2009, to check isolated parts of the sampling equipment for possible contamination.

At the H-1 Storm Drain, four environmental samples were collected during July 1, 2008, to June 30, 2009. One QA/QC sample was collected after cleaning automatic sampler lines to check for contamination.

DATA-COLLECTION NETWORK

Stream-stage, stream-discharge, rainfall, and water-quality data were collected at selected stations in the Halawa Stream drainage basin (fig. 1). Rainfall data were collected at two stations, 212428157511201, North Halawa Valley rain gage at H-3 tunnel portal (abbreviated to Tunnel rain gage) and 212304157542201, North Halawa rain gage near Honolulu (abbreviated to Xeriscape garden rain gage). Rainfall data have been collected at the Tunnel and Xeriscape garden rain gages since July

1998 and May 1983, respectively. The Tunnel and Xeriscape garden rain gages were improved by installing tipping-bucket rain gage devices, which in turn drain into the existing measurement equipment for comparison. Tipping-bucket rain gages are more sensitive to low rainfall, and are better for measuring rainfall intensity. The Tunnel rain gage was improved on November 20, 2008, and the Xeriscape garden rain gage was improved on October 30, 2008.

Continuous discharge data were collected at four stations in North Halawa Valley. The sampling site 212356157531801, North Halawa Stream at Bridge 8 near Halawa (abbreviated to Bridge 8) was upgraded and equipped for continuous stream stage and discharge measurement, and data collection started on January 30, 2009. The station number for this site was changed to a stream-gage station number, 16225900. Discharge data have been collected since 1998 at station 212353157533001, North Halawa Valley Highway Storm Drain C near Aiea (abbreviated Storm drain C). Stream discharge data have been collected since 1983 at station 16226200, North Halawa Stream near Honolulu (abbreviated to Xeriscape garden), and since 2001 at station 16226400, North Halawa Stream at Quarantine Station (abbreviated to Quarantine). The gage at the Quarantine site was destroyed on December 7, 2003, and rebuilt in June 2005.

Discharge data have been collected since April 6, 2006, at station 211722157485601, H-1 Storm Drain at Kapiolani Boulevard, Oahu, HI (abbreviated to H-1 storm drain). The location of the H-1 storm drain is shown on figure 2. Rainfall data were collected at station 211722157485602, State Key Number 711.7 H-1 Rain Gage at Kapiolani Boulevard, Oahu, HI, (abbreviated to H-1 rain gage). The H-1 rain gage is located on the roof of the H-1 storm drain gage house.

Rainfall and discharge data were collected using variable sampling intervals depending on rainfall or discharge rates. Discharge data from Bridge 8, Storm drain C, and Xeriscape garden stations were transferred to the USGS National Water Information System (NWIS) database every half-hour by digital cell phone telemetry, and data from the Quarantine station were transferred hourly by satellite telemetry. Discharge and rainfall data from the H-1 storm drain are transferred to the NWIS database hourly by satellite telemetry.

Recent data can be viewed at <http://hi.water.usgs.gov/> under “Real-Time Data (from NWISWeb)” by selecting “Streamflow” or “Rainfall” and then selecting the appropriate USGS station numbers. Historical rainfall and streamflow data can be accessed through the website <http://hi.water.usgs.gov/> under “Historical Data (from NWISWeb)” by selecting “Streamflow” or “Rainfall” and then selecting “Daily Data” and then entering the appropriate USGS station numbers.

In the Halawa Stream drainage basin, water-quality data were collected at five stations (fig. 1): Bridge 8, Storm drain C, Xeriscape garden, Quarantine, and 16227100, Halawa Stream below H-1 (abbreviated to Stadium). The Bridge 8 station is about 0.75 miles (mi) upstream from the discharge point of Storm drain C on North Halawa Stream. Storm drain C collects runoff from an approximately 4-mi length of freeway starting at the leeward tunnel portal and extending to mid-valley and discharges directly to North Halawa Stream (fig. 1). The Xeriscape garden station is directly upstream from a light-industrial area near North Halawa Stream, and about 0.75 mi downstream of the discharge point of Storm drain C. The Quarantine station is about 1 mi downstream of Xeriscape garden and near the downstream end of the light-industrial area that borders the North Halawa Stream. The Stadium station is about 1.5 mi downstream of the Quarantine station, downstream from the confluence of North and South Halawa Streams, downstream from the crossing of H-1 freeway, and directly upstream from the mouth at Pearl Harbor.

The H-1 storm drain collects runoff from about 1.3 mi of freeway, flowing southeast to northwest (fig 2.). Part of the neighborhood adjacent to the freeway also drains into the drainage system connected to the storm drain. The H-1 storm drain discharges into Manoa Stream near the intersection

of King Street and Kapiolani Boulevard, under the viaducts of the freeway and onramp. The discharge point of the storm drain is along a sloping wall about 10 ft higher than the bed of Manoa stream, about 0.1 mi downstream of the confluence of Palolo and Manoa Streams. The H-1 storm drain station is located directly above the discharge point of the drain.

Automatic samplers for collection of water-quality samples are installed at three sites in the Halawa Stream drainage basin and the H-1 storm drain. The automatic sampler from the Quarantine station was moved to the Bridge 8 station as part of the revisions to the DOT Stormwater Monitoring Program Plan for 2009. The automatic sampler at Bridge 8 was operational on May 17, 2009. The gaging stations Storm drain C and Xeriscape garden were equipped with automatic samplers during July 1, 2008, to June 30, 2009. The automatic sampler at the Quarantine station was operational during July 1, 2008, to January 23, 2009.

Water-quality data that have been collected at stations Storm drain C (1998-present), Xeriscape garden (1983-present), and Stadium (1988-present) by the USGS as part of the H-3 freeway construction monitoring study, as well as water-quality data collected for this study and data collected at the H-1 storm drain (2006-present), can be viewed at the website <http://hi.water.usgs.gov/> under “Historical Data (from NWISWeb)” by selecting “Water Quality” and then selecting either “Field/lab samples” or “Daily Data” and then entering the appropriate USGS station numbers.

WATER-QUALITY SAMPLING TECHNIQUES

Water-quality samples include: grab samples collected manually, grab samples collected by an automatic sampler, time-composite samples collected by an automatic sampler, and flow-weighted composite samples collected by an automatic sampler. Each grab and composite sample is assigned a median sampling time based on the start and finish time of the grab sampling process, or the times of collection of the samples used for the grab or composite sample from the automatic sampler.

Sampling Requirements

The DOT Stormwater Monitoring Program Plan states that water-quality samples will be collected at least once per quarter during periods of storm runoff from each of the five water-quality monitoring stations in the Halawa area (fig. 1) and the H-1 storm drain (fig. 2). Also, if a storm does not occur during a quarter, no samples will be collected.

The DOT Stormwater Monitoring Program Plan states that efforts must be made to sample all five Halawa-area water-quality monitoring stations during the same storm. For the Halawa area, a complete set of samples for a storm consists of five grab samples (one from each of the five stations), three flow-weighted composite samples (one each from Storm drain C, Xeriscape garden, and Quarantine stations), and one QA/QC sample. However, some storms are brief and do not produce adequate runoff to sample all five stations and collect all samples. In practice, storms were sampled as thoroughly as possible and analyzed for as many constituents as practical. For the H-1 storm drain, only one flow-weighted composite sample per storm is required.

Storm Criteria

The USEPA Storm Water Sampling Guidance Manual (U.S. Environmental Protection Agency, Office of Water, 1993) provides criteria for stormwater sampling. The first criterion requires at least 0.1 in. of accumulated rainfall within a storm. Rainfall accumulations exceeded 0.1 in. at the Tunnel rain gage and Xeriscape garden rain gage when stormwater sampling was conducted. The second criterion

requires that samples be collected only for storms preceded by at least 72 hours of dry weather. The second criterion would prevent sampling of most storms on North Halawa Stream because the Halawa Stream drainage basin, as well as many other parts of Oahu, receives tradewind showers almost daily. Many of the samples collected in the past do not meet the second criterion.

In practice, criteria used to initiate sampling of the stream and storm drain were based on the rate of rainfall accumulation and the rise of stage in Storm drain C, Xeriscape garden, Quarantine, and H-1 storm drain stations. Each automatic sampler is triggered at a station-specific, stream-stage threshold determined after investigating the relation between rainfall and runoff.

Sample Collection

Grab samples were collected only from the sites in the Halawa Stream drainage basin. In general, grab samples were collected manually using isokinetic, depth-integrating samplers and equal-width increment (EWI) or single vertical sampling techniques (Wilde and others, 1998). Samplers are made of high-density polyethylene (HDPE) that collect water in an isokinetic manner, in which water enters the sampler at the same velocity as the stream at the sampling point.

The EWI sampling technique utilizes evenly spaced sampling increments along the cross section of the stream, with equal vertical transit rates of the isokinetic sampler for all increments. Because the transit rates are equal for each increment, the volume of each subsample collected at each increment is proportional to the discharge at that increment. Sub-samples are combined in a HDPE churn. An EWI sample is practical to collect where depths are greater than 0.5 ft and the stream is wadeable, or where bridges or cable ways are available. If it is not practical or safe to collect an EWI sample, an alternative is to sample at the centroid of flow. At such times, a grab sample was collected with the isokinetic sampler at the estimated centroid of flow at a single vertical section. Subsamples from the single-vertical technique also were combined in a HDPE churn. During storms, flow in North Halawa Stream generally is thought to be well mixed, although sampling to determine the extent of mixing has not been done.

Automatic samplers collect water from a fixed point in the stream channel after predetermined stage thresholds are met. The automatic samplers have a capacity of 24, 1-liter bottles. When the first threshold has been met, the automatic samplers are programmed to collect water samples every 2 minutes for the first 5 samples, and then every 15 minutes for the remaining 19 samples. The first stage thresholds for the samplers correspond to discharges of about 24, 5.2, 36, and 55 ft³/s for Bridge 8, Storm drain C, Xeriscape garden, and Quarantine stations, respectively. To enable collection of a sufficient volume of water in each sample during storms with quick rising and falling stream stages, or high overall flow, a second set of stage thresholds, corresponding to higher discharges, is used to trigger the samplers to sample every 7 minutes. These higher stage thresholds correspond to discharges of 168, 44, 84 and 110 ft³/s for Bridge 8, Storm drain C, Xeriscape garden, and Quarantine stations, respectively. At the H-1 storm drain, the stage thresholds correspond to discharges of 2.4 ft³/s for the first threshold and 56 ft³/s for the second threshold.

The automatic samplers are set up with “bottles” that are actually bags held in bottle-like frames. The bags are either reusable and made of teflon that can be cleaned, or disposable and made of low density polyethylene (LDPE). The teflon bags are positioned in the first three slots of the sampler, and the LDPE bags are positioned in the remaining 21 slots. Water samples collected in the teflon bags are sometimes analyzed for oil and grease (O+G) and total petroleum hydrocarbons (TPH). The main limitations of using water collected in the teflon bags for O+G and TPH analyses are that: (1) analyses for these constituents requires that the samples be chilled prior to analysis and analyzed within a certain time after collection, known as the “holding time,” and (2) these constituents may adhere to tubing lines

used to collect the sample. Fecal coliform (FC) and biological oxygen demand (BOD) samples are not collected by this method because the holding times for these constituents would likely be exceeded, and because the teflon bags are not sterilized for fecal coliform analysis. Holding times for nutrient analyses also may be exceeded.

Time-composite samples and flow-weighted composite samples are created by combining, in a HDPE churn, all or part of the samples collected by the automatic samplers. A time-composite sample is created by combining the entire contents of bottles with no weighting proportional to stream discharge. Time-composite samples are created when only a few bottles are filled or partially filled, when multiple discharge peaks are separated by time gaps of an hour or more, or when the combined volume of the sample collected in the bottles is low. A flow-weighted composite sample is created by combining specific volumes of water from each sample, the amount being proportional to the volume of stream discharge between sample collection times. Flow-weighted composite samples are collected over time periods that sometimes last several hours, whereas time-composite samples are usually collected over shorter time periods.

Grab, time-composite, or flow-weighted composite samples were created from the samples collected by the automatic sampler depending on (1) the temporal distribution of discharge over the duration of the storm, (2) the discharge at the time the site was visited to collect a grab sample, (3) site analytical requirements, (4) the number of sample bottles filled, and (5) the volume of sample collected in each bottle. Situations in which the storm samples deviate from the sampling requirements, outlined in the sampling plan, occurred when there were multiple peaks in discharge, when stream discharge had decreased too much after a storm to collect a grab sample, or when a small discharge peak was followed by a much larger discharge peak. When discharge was too low to sample at the time of visit, the first five samples from the automatic sampler, which are collected over about two minutes each, may be used to create a grab sample, and would represent a “first flush” type sample collected during the first peak of discharge for the storm. Because of the variability in discharge, one or a few hours may have separated groups of samples collected by the automatic sampler. In these cases, samples may have been grouped and analyzed separately as flow-weighted composite samples or time-composite samples.

The H-1 storm drain has unique requirements relative to the Halawa sites; only composite samples (no grab samples) are analyzed, although samples from the first two bottles are used for O+G and TPH analyses. In practice, due to the short duration of the peaks, and multitude of peaks associated with each storm at the H-1 storm drain, the composite samples are most often time-composite samples rather than flow-weighted samples.

At sites with automatic samplers, individual samples collected by the automatic samplers were sometimes analyzed separately for metals only. This type of sample is called a “discrete” sample because it is not combined with samples from other bottles, and represents the runoff composition at the time the sample was taken. Discrete samples allow for evaluation of how constituent concentrations vary with changes in discharge during the storm.

Determination of Discharge for Samples

At Bridge 8, Storm drain C, Xeriscape garden, Quarantine and H1 storm drain, discharge associated with each sample was determined using a stage-discharge rating created for the station, or by direct measurement using a current meter. Stage-discharge ratings were developed using direct measurements of stage and discharge, and the results from hydraulic models that were verified by measurements at each site. USGS practices for making discharge measurements and stage-discharge ratings can be found in Rantz and others (1982).

At the Storm drain C site, rapid changes in discharge and the nature of the flow in the 5-foot-diameter pipe make accurate measurements challenging. Analytical means of determining flow are also challenging due to the geometry of the drain and the disrupted flow in the concrete box where the sampling orifice and bubbler line (where gage height is measured) are located. Upon review, the stage-discharge relation for this site was modified starting in 2007. For a common gage height, discharge values for data collected after July 1, 2007, are about twice or even greater than values using the previous stage-discharge relation.

At the Quarantine site, deposition, scouring of the stream bed, and damage to the concrete control resulted in stage-discharge ratings that varied throughout the year. The rating for this gage has many adjustments resulting in poor estimates of discharge at any given time.

At the Stadium station, the wide and curving concrete-lined channel and shallow and swift streamflow preclude development of an accurate discharge rating. When possible, discharge at this station was measured using a current meter. At higher flows, discharge was measured either by using float-measurement techniques, a radar gun, or using a flow meter suspended by cable. The float-measurement technique involves timing floating objects over a known distance to determine water velocity. The radar gun measures surface velocity at multiple points in the cross section. In both techniques, the area of the cross section was estimated using measured water depths and surveyed dimensions of the channel.

An average discharge value was calculated for each composite sample. The average-discharge value was equal to the total volume of water that flowed by the gaging station during sample collection, divided by the total elapsed time required to collect the samples. To determine the volume of water that passed the station for each sample, the discharge at the time of sample collection was multiplied by the elapsed time. The elapsed time is computed by taking the difference between the times of the samples taken before and after the sample in question and dividing by two. To compute the elapsed time of the first and last samples, the difference between the time of the sample and next/previous sample is divided by two. These volumes were summed, and the total volume was divided by the total elapsed time.

Measured, stage-discharge rating, and averaged discharge values are reported to appropriate numbers of significant figures. These discharge values and the corresponding values of constituent concentrations are used to compute loads. Reported discharge values and the calculation of loads are discussed in appendix A. Table 1 shows the number of significant figures for the range of discharge values, and table 2 shows the conversion factors for computing loads from constituent concentration and discharge.

Sample Processing, Analysis, and Quality Assurance / Quality Control

USGS water-quality sampling methods (Wilde and others, 1998) were followed to prevent possible contamination during sample processing. Both grab and composite samples were processed using churns to mix and suspend sediment while delivering the sample to specific bottles for the various constituent analyses. The time assigned to each grab and composite sample is the median time of the sample collection.

As required by the DOT Stormwater Monitoring Program Plan, each composite and grab sample was analyzed for temperature, pH, specific conductance, total suspended solids (TSS), nutrients, and selected trace metals (cadmium, chromium, copper, lead, and zinc). In addition, chemical oxygen demand (COD) and total dissolved solids (TDS) analyses are performed only for Halawa samples, and nickel analyses are performed only for H-1 storm drain samples. Grab samples also were analyzed for O+G, TPH, FC, and BOD. Analyses for O+G and TPH also were performed for samples from the H-1

storm drain. USGS personnel made field measurements of temperature, pH, and specific conductance when collecting grab samples.

FC and BOD analyses were performed by Aecos Incorporated, a private laboratory on Oahu. QA/QC practices for FC and BOD were performed by Aecos Incorporated, but are not published here. For storm sampling that occurred on a weekend or holiday, or late in the day, no FC or BOD samples were collected because Aecos Incorporated was closed and holding times for these constituents would be exceeded. O+G and TPH were analyzed at the Test America Laboratories facility in Denver, Colorado.

All other analyses, including laboratory analyses of pH and specific conductance, were performed at the USGS National Water Quality Laboratory (USGS NWQL) in Denver, Colorado. The methods used for analyses of all water-quality constituents and quality-control practices at the USGS NWQL are documented in Friedman and Erdmann (1982), Fishman and Friedman (1989), Pritt and Raese (1992), Patton and Truitt (1992), Fishman (1993), Hoffman and others (1996), Garbarino and Struzeski (1998), and Garbarino and others (2006). Data values published in this report with “less-than” symbols are below the minimum reporting level. Minimum reporting levels for each of the analyzed properties and constituents are determined by the USGS NWQL and have changed through time as methods and equipment improved, or if the criteria used to set the minimum reporting levels changed. The calculated values organic nitrogen and total nitrogen do not have minimum reporting levels. More information about minimum reporting levels and how they are determined by the USGS NWQL can be found in Childress and others (1999).

A duplicate sample, field or laboratory, is required by the Stormwater Monitoring Program Plan for each storm sample. A field duplicate grab sample is a sample that is collected concurrently with the grab sample, or split from a single, larger volume grab sample. The analytical results of the two samples are used to verify the sampling method. A laboratory duplicate is a sample that is split into two equal parts during sample processing and the results are used to verify the precision of the laboratory.

During the period between storms, nondedicated and nondisposable equipment, such as churns, isokinetic samplers, and teflon automatic-sampler bottle liners, were cleaned following procedures in Wilde and others (1998).

As a check of the sampler intake lines and bags, inorganic blank water (IBW), free of inorganic constituents, was passed through the automatic sampler and collected as ‘field-blank’ samples. The intake lines were cleaned following procedures in Wilde and others (1998) prior to the collection of the field-blank samples. The IBW field-blank samples were analyzed for the same inorganic constituents as the storm samples.

HALAWA STREAM DRAINAGE BASIN

Rainfall and Discharge Data

Hydrographs of daily rainfall and daily mean discharge for the period of July 1, 2008, through June 30, 2009 are shown in figure 3. During this period, a total of 121.3 in. of rain was recorded at the Tunnel rain gage, and 40.2 in. of rain was recorded at Xeriscape garden rain gage, although 7 days of record were missing at Xeriscape garden. The highest recorded daily rainfall totals were 6.52 at the Tunnel rain gage on March 9, 2009, and 4.28 in. at the Xeriscape garden rain gage on December 11, 2008.

Continuous recording of gage height and discharge began at Bridge 8 on January 30, 2009. During January 30 to June 30, 2009, there were 65 days of zero flow. The longest continuous period of

zero flow was 58 days from May 4 to June 30, 2009. The highest daily mean discharge was 68 ft³/s on March 14, 2009. The highest instantaneous discharge was 867 ft³/s at 08:18 on March 14, 2009.

North Halawa Stream and Storm drain C flow intermittently. Storm drain C had zero flow for 115 days during July 1, 2008, to June 30, 2009, and the longest continuous period of zero flow was 9 days during April 30 to May 8, 2009. The highest daily mean discharge at Storm drain C was 12 ft³/s on December 11, 2008, and the highest instantaneous discharge was 116 ft³/s at 10:34 on February 12, and at 07:30 on March 14, 2009.

Xeriscape garden had zero flow for 137 days, and the longest continuous period of zero flow was 32 days from July 1 to August 1, 2008. The highest daily mean discharge was 174 ft³/s on December 11, 2008, and the highest instantaneous discharge was 1,320 ft³/s at 08:25 on March 14, 2009.

For the Quarantine station, the site had zero flow for 251 days during July 1, 2008, to June 30, 2009. The longest continuous period of zero daily mean discharge at this station was 106 days from July 1 to October 14, 2008. The highest daily mean discharge was 166 ft³/s, on December 11, 2008. The highest instantaneous discharge was estimated at 1,170 ft³/s at 08:45 on March 14, 2009.

Stormwater Sampling: Conditions and Results

During the period July 1, 2008, through June 30, 2009, about 12 storms created sufficient runoff to trigger the automatic samplers at the predetermined thresholds at Xeriscape garden and Quarantine station. Of these storms, three were sampled: October 25, 2008, December 11, 2008, and February 3, 2009.

The number of storms sufficient to trigger the automatic sampler at Storm drain C was much larger, because small amounts of rainfall collected on the freeway cause runoff to enter the storm drain. Although these storms had sufficient runoff to trigger the samplers, some of the storms were either of very short duration and could not be adequately sampled, or rainfall caused small antecedent runoff peaks, which is in conflict with USEPA guidelines requiring 72 hours of antecedent dry conditions.

Third Quarter 2008 – July 1 to September 30, 2008

Hydrographs of discharge during the third quarter 2008 for Storm drain C, Xeriscape garden, and Quarantine stations are shown in figure 4. No storms of sufficient flow triggered the automatic samplers within the North Halawa Stream during the third quarter 2008, and no samples were collected. The greatest measured instantaneous discharge in North Halawa Stream during the quarter was 7.0 ft³/s at Xeriscape garden on September 12, 2008. There was no flow at the Quarantine station during the third quarter 2008.

Fourth Quarter 2008 –October 1 to December 31, 2008

Hydrographs showing discharge during the fourth quarter 2008 for Storm drain C, Xeriscape garden, and Quarantine stations are shown in figures 5-13. Of the approximately seven storms during this quarter, two were sampled. Two storms were sampled during the fourth quarter, on October 25, 2008, and December 11, 2008. Only Storm drain C, Xeriscape garden, and Quarantine station were sampled. All samples for these storms were collected by the automatic samplers.

Storm of October 25, 2008

Rainfall totals at the Tunnel rain gage during October 24 and 25 were 0.3 and 4.0 in., respectively, although zero rainfall was recorded at the Xeriscape garden rain gage for both of these

days. The rainfall caused sufficient runoff to trigger the automatic samplers at Storm drain C, Xeriscape garden, and Quarantine stations. Because the sites were not visited until the day following the storm, the holding times for nutrient analyses may have been exceeded and samples were only analyzed for metals. The small volume of sample necessary for metals analyses provided an opportunity to process the samples individually as discrete samples. A total of 31 samples were analyzed for cadmium, chromium, copper, lead, and zinc. Hydrographs of discharge at Storm drain C, Xeriscape garden, and Quarantine stations during October 1 to December 31, 2007, and sample collection times during the storm of October 25, are shown in figures 5, 7, and 9. Discharge, pH and specific-conductance values from laboratory measurements, metal concentrations, and constituent loads associated with the samples are shown on table 3 in appendix B.

Storm drain C. --The automatic sampler filled 13 bottles during 02:39 to 12:10 on October 25, 2008. Bottles 5 and 12 had insufficient volume for sample processing. The remaining 11 samples were processed for metals analyses. Discharge associated with each sample (fig. 5) was calculated using the gage height recorded at the time each sample was collected and the stage-discharge rating created for the station. The flow associated with the first sample was 7.2 ft³/s, the lowest flow associated with a sample was 4.4 ft³/s, the highest flow associated with a sample was 8.4 ft³/s, and the overall peak flow during the sample collection period was 11 ft³/s.

Figure 6 shows discharge and the concentrations of chromium, lead, copper and zinc relative to time. Cadmium concentrations were either estimated or lower than detection levels for 8 of the 11 samples and were not plotted. The highest concentrations of metals (fig. 6) were in the first or second samples collected during the storm.

Xeriscape Garden. --The automatic sampler filled 24 bottles from 07:29 to 10:17 on October 25, 2008. Ten samples were selected for metals analyses, distributed relative to time over the period between the first and last sample collected by the automatic sampler (fig. 7). Discharge associated with each sample was calculated using the gage height recorded at the time each sample was collected and the stage-discharge rating created for the station. Flow associated with the samples was between 81 and 122 ft³/s.

Figure 8 shows discharge and the concentrations of chromium, lead, copper, and zinc relative to time. Cadmium concentrations were either estimated or lower than detection levels for 8 of the 10 samples and were not plotted. The highest concentrations of chromium, lead, copper, and zinc (fig. 8) were in the second sample collected during the storm.

Quarantine. -- The automatic sampler filled 24 bottles from 08:02 to 12:41 on October 25, 2008. Ten samples were selected for metals analyses, distributed relative to time over the period between the first and last sample collected by the automatic sampler (fig. 9). Discharge associated with each sample was calculated using the gage height recorded at the time each sample was collected and the stage-discharge rating created for the station. Flow associated with the samples was lowest (76 ft³/s) at 08:02 and highest (123 ft³/s) at 11:55.

Figure 10 shows discharge and the concentrations of chromium, lead, copper and zinc relative to time. Cadmium concentrations were either estimated or lower than detection levels for 6 of the 10 samples and were not plotted. However, the highest cadmium concentration for the storm from the three sites was the first sample collected at this site, with a concentration of 0.22 µg/l. The highest concentrations of chromium, lead, copper, and zinc (fig. 10) were either in the first or last samples collected during the storm, depending on the constituent.

Storm of December 11, 2008

Rainfall totals at the Tunnel rain gage during December 10 and 11, 2008, were 0.2 and 6.2 in., respectively, and rainfall totals at the Xeriscape garden rain gage for the same days were 0.1 and 4.3 in., respectively. The rainfall caused runoff that was sufficient for a storm sample to be collected. Many of the USGS stormwater-sampling personnel were off-island during December 11, and as a result, only three composite samples (Storm drain C, Xeriscape garden, and Quarantine station) and O+G and TPH grab samples (Storm drain C) were collected for this storm. Discharge and sample times from the automatic sampler are shown in figures 11, 12, and 13. Samples were analyzed for all constituents listed in the Stormwater Monitoring Program Plan (State of Hawaii Department of Transportation Highways Division, 2008) for composite samples. Discharge, pH and specific-conductance values from laboratory measurements, constituent concentrations, and average loads for the composite samples are shown on table 3 in appendix B. The USGS NWQL reported an insufficient sample volume for analysis of TDS for Storm drain C and Xeriscape garden.

Storm Drain C. –Twenty-four bottles were filled by the automatic sampler during 05:10 to 09:28 December 11, 2008 (fig. 11). The first bottle filled by the sampler was used for an oil and grease and total petroleum hydrocarbons sample. The remaining 23 samples were combined as a composite sample. The discharge at the time of the first sample was 5.8 ft³/s, and the range of discharge associated with the remaining 23 samples was 9.9 to 115 ft³/s. The time-weighted average flow for the composite sample was estimated at 45 ft³/s. Peak discharge for this storm was estimated at 115 ft³/s at 07:26 on December 11, 2008.

Xeriscape Garden. –Twenty-four bottles were filled by the automatic sampler during 06:34 to 09:07 on December 11, 2008 (fig. 12). Water from all 24 bottles was used to create a composite sample. The flow ranged from 52 ft³/s to 740 ft³/s during the sample-collection period. The peak discharge during the storm was 792 ft³/s at 08:38. The composite sample collected water during the early part of the storm through the peak. The time-weighted average discharge associated with the composite sample was 437 ft³/s.

Quarantine. –Twenty-four bottles were filled by the automatic sampler during 06:01 to 09:24 on December 11, 2008 (fig. 13). Water from all 24 bottles was used to create a composite sample. The flow ranged from 57 ft³/s to 765 ft³/s during the sample-collection period. The peak discharge was 810 ft³/s at 08:42. The composite sample collected water during the early part of the storm through the peak. The time-weighted average discharge associated with the composite sample was 386 ft³/s.

First Quarter 2009 – January 1 to March 31, 2009

Hydrographs showing discharge during the first quarter 2009 for Bridge 8, Storm drain C, Xeriscape, and Quarantine stations are shown in figures 14, 15, 16, and 17. Of the approximately five storms, one storm was sampled this quarter. A storm on February 3, 2009, was sampled at all five sites. A storm with higher rainfall and discharge occurred on March 14, 2009, although this storm was not sampled because a storm had already been sampled during the quarter.

Storm of February 3, 2009

The tunnel rain gage collected about 0.63 in. of rainfall on February 2 and 3.34 in. of rainfall on February 3, and the Xeriscape rain gage collected about 0.15 in. of rainfall on February 2 and 0.37 in. of rainfall on February 3. This rainfall produced sufficient runoff to trigger the automatic samplers. Hydrographs showing discharge during the storm of February 3, 2009, for Bridge 8, Storm drain C, Xeriscape garden, and Quarantine stations are shown in figures 14, 15, 16, and 17.

Grab samples were collected at all five sites. FC and BOD samples were not collected because the storm occurred late in the day; by the time sampling was completed it was too late to arrange sample analysis at the AECOS laboratory. O+G and TPH grab samples were collected at all sites. No duplicate grab sample was collected for this storm. Composite samples were collected at Storm drain C and Xeriscape garden. The sampler at Bridge 8 was not operational at the time of sampling. The samples from the automatic sampler at Xeriscape garden were collected over two separate time intervals, thus two composite samples were created. Beginning and ending composite sample-collection times are displayed on the hydrographs in figures 15, 16, and 17. Discharge, pH and specific-conductance values from laboratory measurements, constituent concentrations, loads for the grab samples, and average loads for the composite samples are shown on table 3 in appendix B.

Bridge 8. – The grab sample was collected using the EWI method and an isokinetic, depth-integrating sampler at 17:28 on February 3, 2009. The sampling cross section was about 24 feet wide; it was sampled at 1-ft intervals, and was located about 15 feet upstream of the gage. Discharge was an estimated $18 \text{ ft}^3/\text{s}$ (fig. 14) and was determined by using the gage height measured at the time of the sample and the stage-discharge rating created for the station. O+G, and TPH bottles were filled at the site.

Storm Drain C. – A grab sample was collected by dipping the churn into the flow inside the storm drain. The sample was collected at 16:32 on February 3, 2009. Discharge associated with the sample was calculated using the gage height recorded at the time of the sample and the stage-discharge rating created for the station. Discharge was estimated at $3.1 \text{ ft}^3/\text{s}$. O+G and TPH samples were collected by dipping the sample bottles into the flow.

The automatic sampler filled 19 bottles on February 3, 2009. Prior to the bottles filled on February 3, five bottles were filled by discharge that occurred on January 26, February 1 and 2. The sampler lines were not cleaned between the fifth sample collected on February 2 and subsequent 19 samples collected on February 3. Sixteen samples were combined as a flow weighted composite sample (fig. 15). The last three bottles were filled over 4 hours later, and were not used for the composite sample. The time-weighted average discharge for the composite sample was estimated at $8.9 \text{ ft}^3/\text{s}$.

Xeriscape Garden. –A grab sample was collected about 40 ft upstream of the gage at 18:27, February 3, 2009. The sampling cross section was 14 ft wide and was sampled at 3-ft intervals at 5 different locations. A dipped bottle was used to collect the sample, and subsamples were combined in a churn. Discharge for the sample was estimated using the gage height recorded at the time of the sample and the stage-discharge rating created for the station. The discharge was estimated at $42 \text{ ft}^3/\text{s}$ (fig. 16). O+G and TPH samples were collected by dipping the sample bottles.

Twenty-four bottles were filled by the automatic sampler during 6:03 to 14:44 on February 3, 2009. The sample times were grouped during two different time periods: 8 bottles were filled during 06:03 to 07:00, and 16 bottles were filled during 11:45 to 14:44. Two composite samples were processed according to these two time periods: the first 8 samples were combined for the first composite sample, and the remaining 16 samples were combined for the second composite sample. The time-weighted average discharge associated with the first composite sample was $45 \text{ ft}^3/\text{s}$ and for the second composite sample was $77 \text{ ft}^3/\text{s}$.

Quarantine. --A grab sample was collected at the gage at 17:48, February 3, 2009. The discharge associated with the grab sample, $33 \text{ ft}^3/\text{s}$, was estimated using the gage height recorded at the time of the sample and the stage-discharge rating created for the station (fig. 17). The stream was sampled using the EWI method. The stream width was 17 ft, and it was sampled every foot using an isokinetic, depth-integrating sampler. O+G and TPH samples were collected by dipping the sample bottles.

Stadium. --A grab sample was collected along a cross section located near the staff plate at 16:44 on February 3, 2009. The width of the sampling section was 52 feet wide, and the section was sampled every foot using the EWI method. O+G and TPH samples were collected by dipping the sample bottles.

Discharge was not measured due to time constraints. Instead, discharge was estimated using the gage height observed at the site (1.00 ft) and averaging the discharge values of similar gage heights of previous samples (0.94 ft on October 28, 2001, and March 2, 2006). The discharge was estimated at 45 ft³/s.

Second Quarter 2009 – April 1 to June 30, 2009

Hydrographs showing discharge for Storm drain C, Bridge 8, Xeriscape, and Quarantine stations are shown in figure 18. No storms were sampled during the second quarter 2009. Only one storm on April 23-24, 2009, created sufficient flow to trigger the automatic samplers at the sites. However, rainfall during the days prior to the storm created low flow in the streams, which conflicts with the 72-hour antecedent dry-weather period required for collecting a sample. Zero flow occurred at Bridge 8 and Quarantine sites after May 3 and April 26, 2009, respectively, and zero flow was detected at Xeriscape after May 12, 2009, except during May 28-29 and June 26-28, 2009.

Quality Assurance

Field and laboratory quality-assurance procedures were implemented as described in the DOT Storm Water Monitoring Program Plan (State of Hawaii Department of Transportation Highways Division, 2008). Two QA/QC samples were analyzed during July 1, 2008 to June 30, 2009: one inorganic-blank-water (IBW) sample was collected at Bridge 8 and one at Storm drain C on May 20, 2009. IBW blank samples were collected after cleaning the sampler intake lines to check the effectiveness of the cleaning procedures and possible contamination. Results for the blank samples are not published in this report, but are available from the USGS Pacific Islands Water Science Center upon request.

All grab-sample-collection equipment was cleaned prior to use. Automatic sampler intake lines were cleaned once during the year at Bridge 8, seven times at Storm drain C, six times at Xeriscape garden, and five times at the Quarantine site. Possible contamination of the sampling lines may have occurred at the Storm drain C site prior to the February 3, 2009, sample, because the automatic sampler was triggered by prior rainfall on January 26 and February 2, 2009. The potential for contamination is reduced because the automatic sampler conducts a rinse cycle prior to collecting every sample. The rinse cycle routine is as follows: (1) sample line is first purged by air, (2) water is pumped up the line to a sensor located before the pump, (3) water is purged out, and (4) the sample is then collected. Thus, the rinse cycle conditions the intake lines with sample water prior to sample collection, reducing possible contamination from water pumped during earlier storms and from previously pumped samples during the same storm.

H-1 STORM DRAIN

Rainfall and Discharge Data

Hydrographs of daily rainfall and daily mean discharge for the period of July 1, 2008, through June 30, 2009, are shown in figure 19 for the H-1 rain gage and the H-1 storm drain station. The rainfall and discharge data logger for the site furnished complete record except for the following dates: August

13, August 31 to September 3, and September 12 to October 20, 2008. Total rainfall at the H-1 rain gage was 24.4 in. during July 1, 2008, through June 30, 2009, but this does not include estimates for the days with missing record. The highest recorded daily rainfall, the highest daily mean discharge and the highest instantaneous discharge were all recorded on December 11, 2008. The highest recorded daily rainfall was 4.72 in., the highest daily mean discharge was 7.3 ft³/s and the highest instantaneous discharge was 80 ft³/s at 09:55. Sixty-one days had zero flow, and the longest period of zero flow was 12 days: from January 22 through February 2, 2009.

Stormwater Sampling: Conditions and Results

During the period July 1, 2008, through June 30, 2009, the flashy nature of the H-1 storm drain created many discharge peaks high enough to sample. About 12 peaks over the year had sufficient flow to trigger the automatic sampler, and most of these peaks occurred during October 2008 to March 2009. The period from July 1 to September 30, 2008, had one storm that generated enough runoff to trigger the sampler, and the period from April 1 to June 30, 2009, had two storms that generated enough runoff to trigger the sampler. Funding was not available for sampling for part of the year (late January to early April). For the period July 1, 2008, through June 30, 2009, four samples were collected during two storms.

Third Quarter 2008 – July 1 to September 30, 2008

The hydrograph of discharge (fig. 20) for third quarter 2008 shows only one discharge peak that was high enough to trigger the sampler on July 19, 2008. No samples were collected during the quarter.

Fourth Quarter 2008 –October 1 to December 31, 2008

Hydrographs of discharge and sampled storms during fourth quarter 2008 are shown in figure 21. Six storms during the quarter produced sufficient flow to trigger the sampler. Two samples were collected on November 15, 2008.

Storm of November 15, 2008

Total rainfall on November 15, 2008, was 0.16 in., causing enough runoff on the freeway to trigger the automatic sampler at the gage. The peak discharge on November 15, 2008, was 6.0 ft³/s at 05:20. Eight bottles were filled by the automatic sampler (fig. 21). The first two samples were used for O+G and TPH analyses. The average time of the sample was 05:18, and the average discharge associated with this sample was 4.9 ft³/s. The remaining six samples were processed and combined as a time-weighted composite sample. The composite sample was analyzed for all composite-sample-analysis constituents. The average time of the sample was 05:30, and the time-weighted discharge associated with the sample was 5.1 ft³/s. Discharge, pH and specific-conductance values from laboratory measurements, constituent concentrations, and average loads for the composite samples are shown on table 4 in appendix B.

First Quarter 2009 – January 1 to March 31, 2009

Hydrographs showing discharge and the storms sampled during January 1 to March 31, 2009, are shown in figure 22. Storms during January 1-2, January 11, February 12, and March 14 had sufficient discharge to trigger the automatic samplers. Only the storm of January 11 was sampled.

Storm of January 11, 2009

The rain gage at the H-1 storm drain recorded a total of 1.14 in. of rain on January 11. Two peaks of discharge occurred during this storm, one peak at 01:00 was recorded at 23 ft³/s and a second peak at 03:45 at 37 ft³/s. Ten bottles, associated with the two peaks in discharge, were filled by the automatic sampler during 00:47 to 04:25 on January 11, 2009. The 10 samples were processed into 2 time-composite samples: the first combining 7 samples with fill times from 00:47 to 01:17, and the second combining 3 samples with fill times from 03:27 to 04:25, January 11, 2009. The time-weighted average discharge associated with the first composite sample was 10 ft³/s, and the time-weighted average discharge associated with the second was 18 ft³/s. Discharge pH and specific-conductance values from laboratory measurements, constituent concentrations, and average loads for the time-composite samples are shown on table 4 in appendix B.

Second Quarter 2009 – April 1 to June 30, 2009

Two storms caused runoff sufficient to trigger the automatic sampler at the H-1 storm drain during second quarter 2009; April 6 and 11, 2009 (fig. 23). No samples were collected during the quarter.

Quality Assurance

Field and laboratory quality-assurance procedures were implemented as described in the DOT Storm Water Monitoring Program Plan (State of Hawaii Department of Transportation Highways Division, 2008). One QA/QC sample was collected during July 1, 2008 to June 30, 2009. An inorganic-blank-water (IBW) sample was collected at the H-1 storm drain on August 11, 2008. IBW blank samples were collected after cleaning the sampler intake lines to check the effectiveness of the cleaning procedures and possible contamination. IBW was run through the sampling apparatus, collected, and processed similar to an environmental sample. The IBW blank sample was analyzed for total suspended solids, metals, and nutrients at the USGS NWQL. Complete results for the blank samples are not published in this report, but are available from the USGS Pacific Islands Water Science Center upon request. Zinc commonly has been detected in IBW blank samples from this site. The sample of August 11, 2008, had a zinc concentration of 27.5 µg/L. Although this value is higher than similar analyses at Halawa sites (estimates of 1.0 and 1.1 µg/L at Storm drain C and Bridge 8, respectively), the value is lower than environmental samples at this site, which ranged from 139 to 405 µg/L.

To reduce the possibility of contamination, the sampling lines were cleaned four times at the H-1 storm drain; two of the cleanings, on November 10, 2008, and January 9, 2009, were just prior to sampling. In addition, the potential for contamination of the sampler intake line is further reduced because the automatic sampler conducts a rinse cycle prior to collecting every sample.

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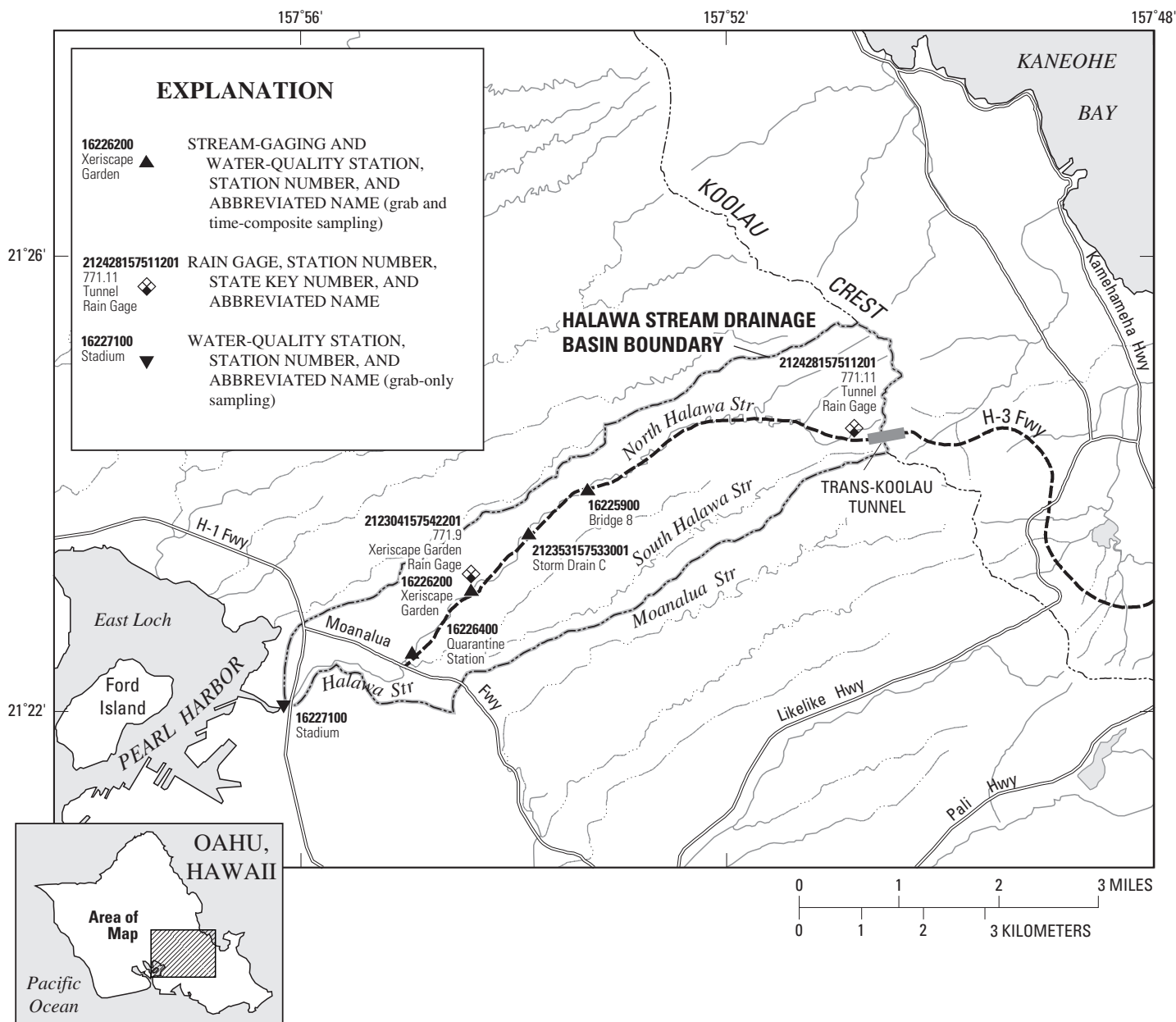


Figure 1. Stream-gaging stations, rain gages, and water-quality sampling stations in the Halawa drainage basin, Oahu, Hawaii.

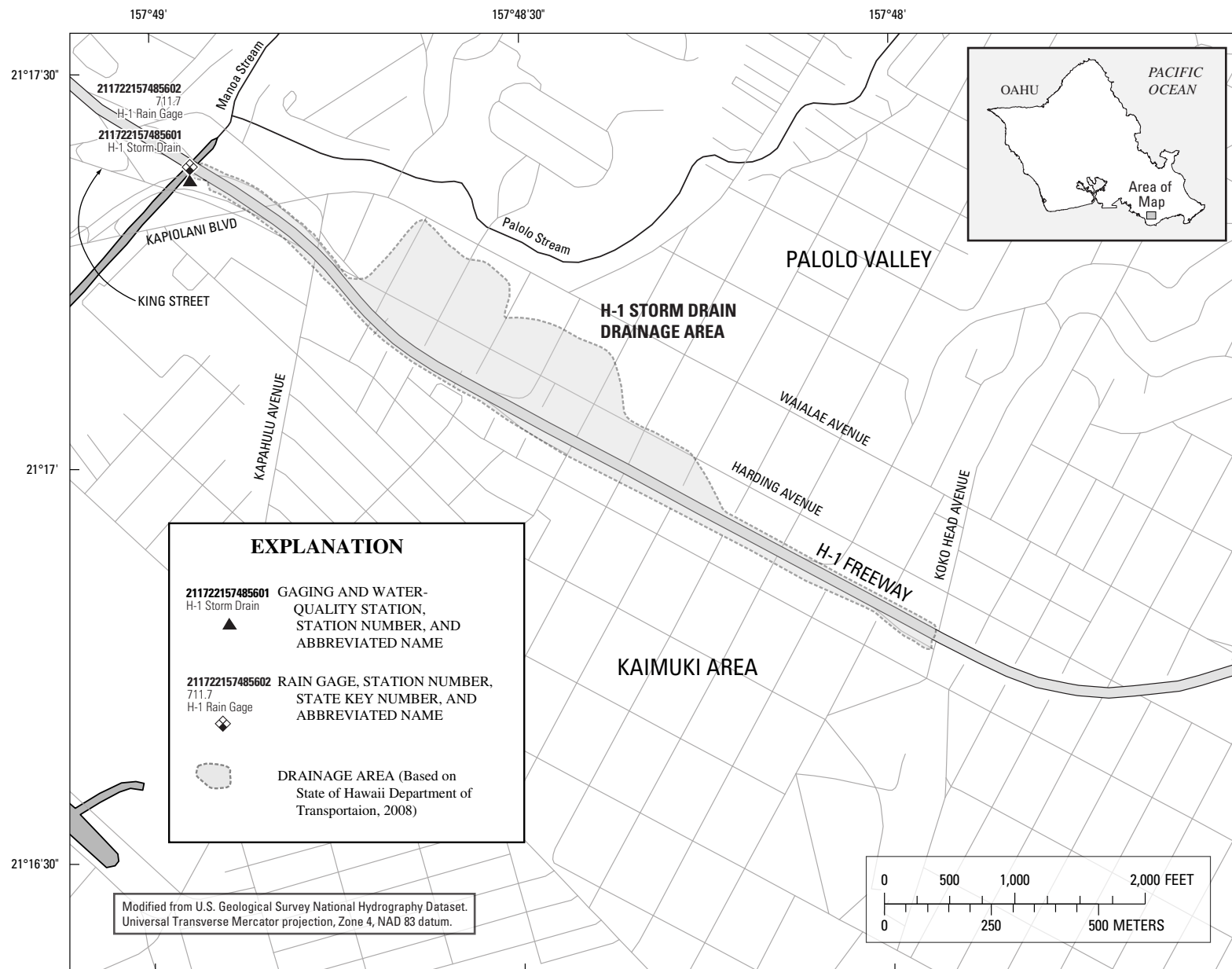


Figure 2. Drainage area of the H-1 storm drain and locations of the H-1 rain gage and H-1 storm drain gage and sampling site, Oahu, Hawaii.

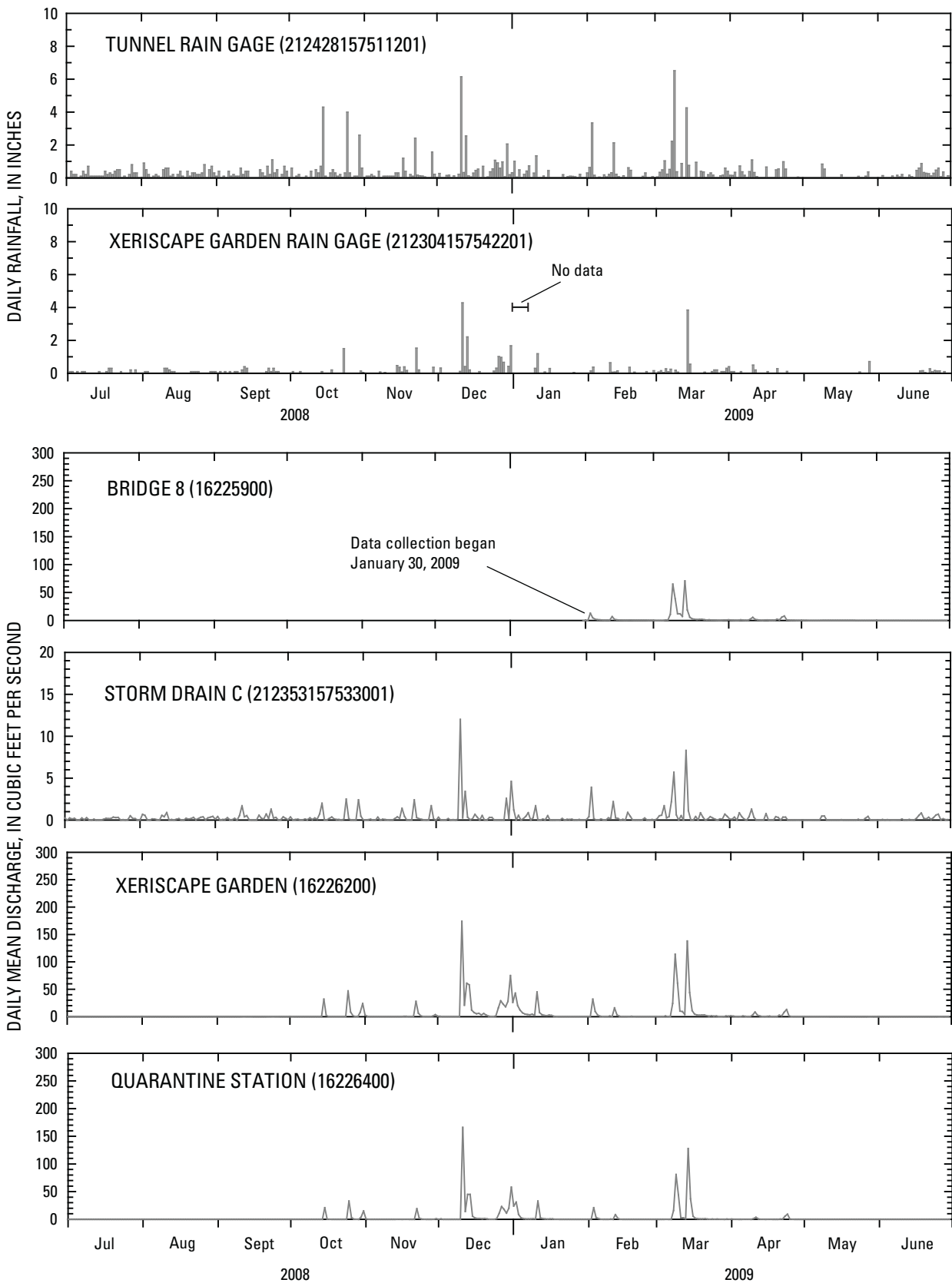


Figure 3. Rainfall and discharge for stations within the Halawa Stream drainage basin, Oahu, Hawaii, for July 1, 2008, to June 30, 2009.

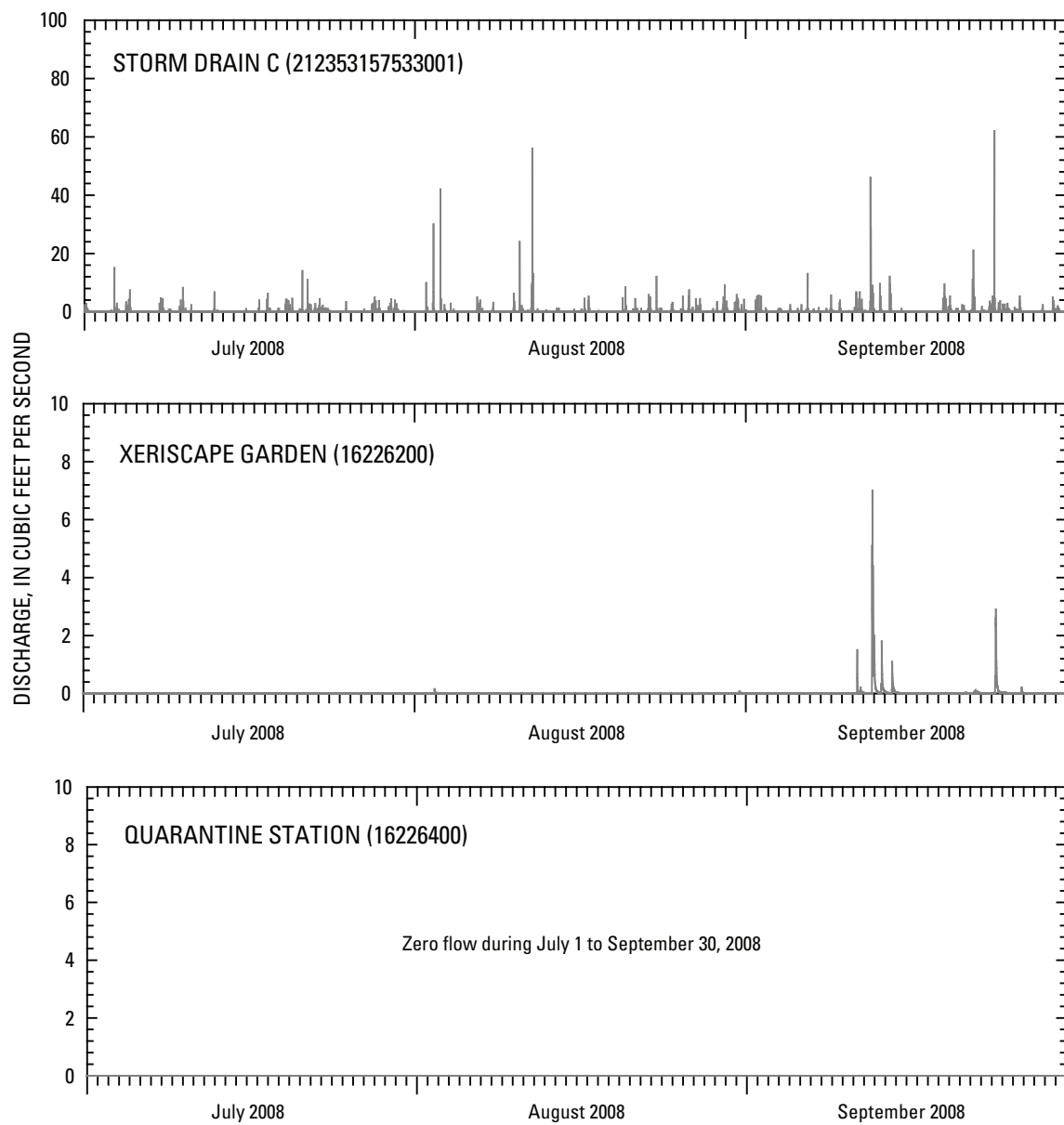


Figure 4. Discharge at Storm Drain C (212353157533001), and stream discharge at Xeriscape garden (16226200) and Quarantine station (16226400) for July 1 to September 30, 2008, Oahu, Hawaii.

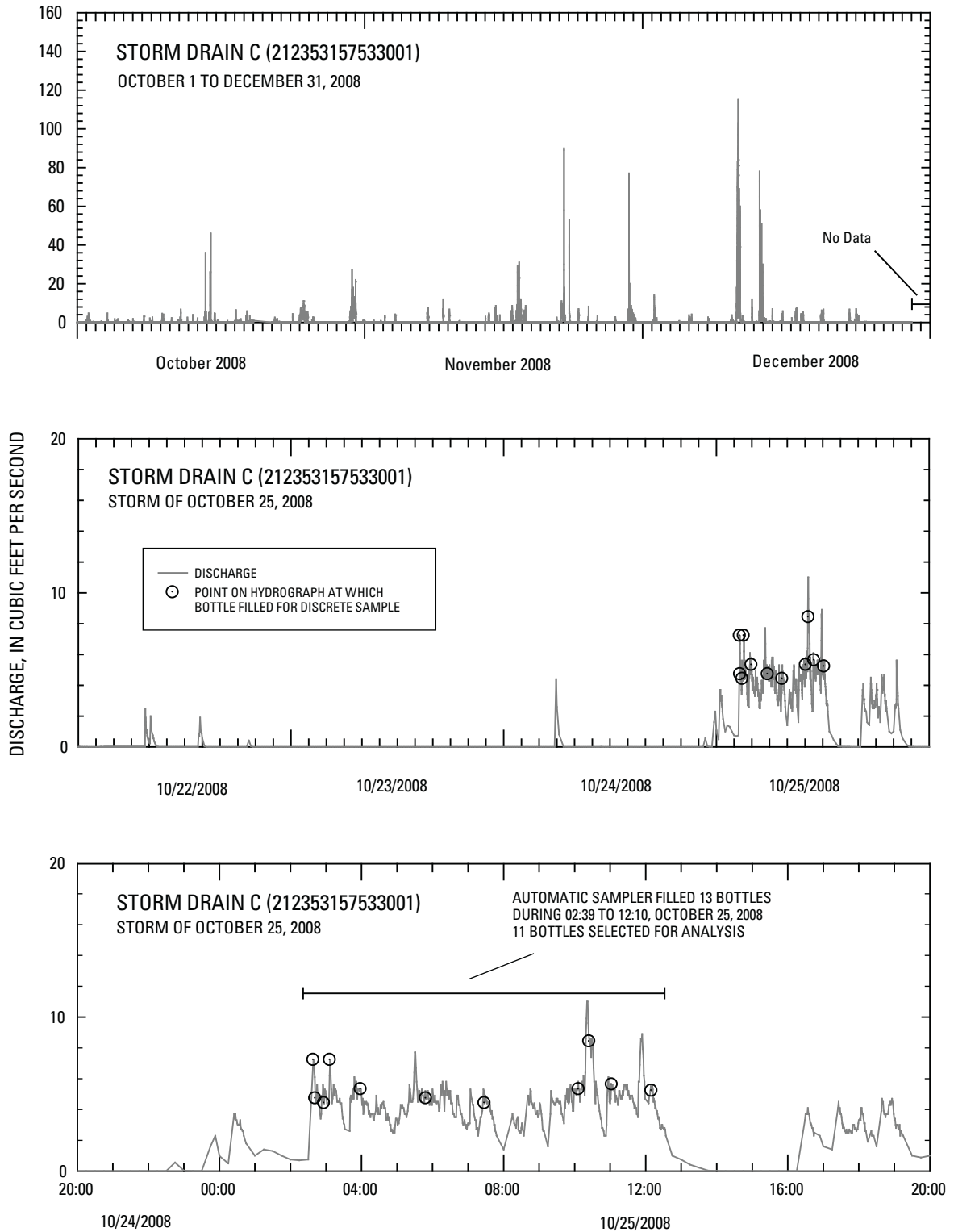


Figure 5. Stream discharge at Storm drain C (212353157533001) for October 1 to December 31, 2008; detail of October 22-25, 2008; and detail of 24-hour period from 20:00 October 24 to 20:00 October 25, 2008, Oahu, Hawaii.

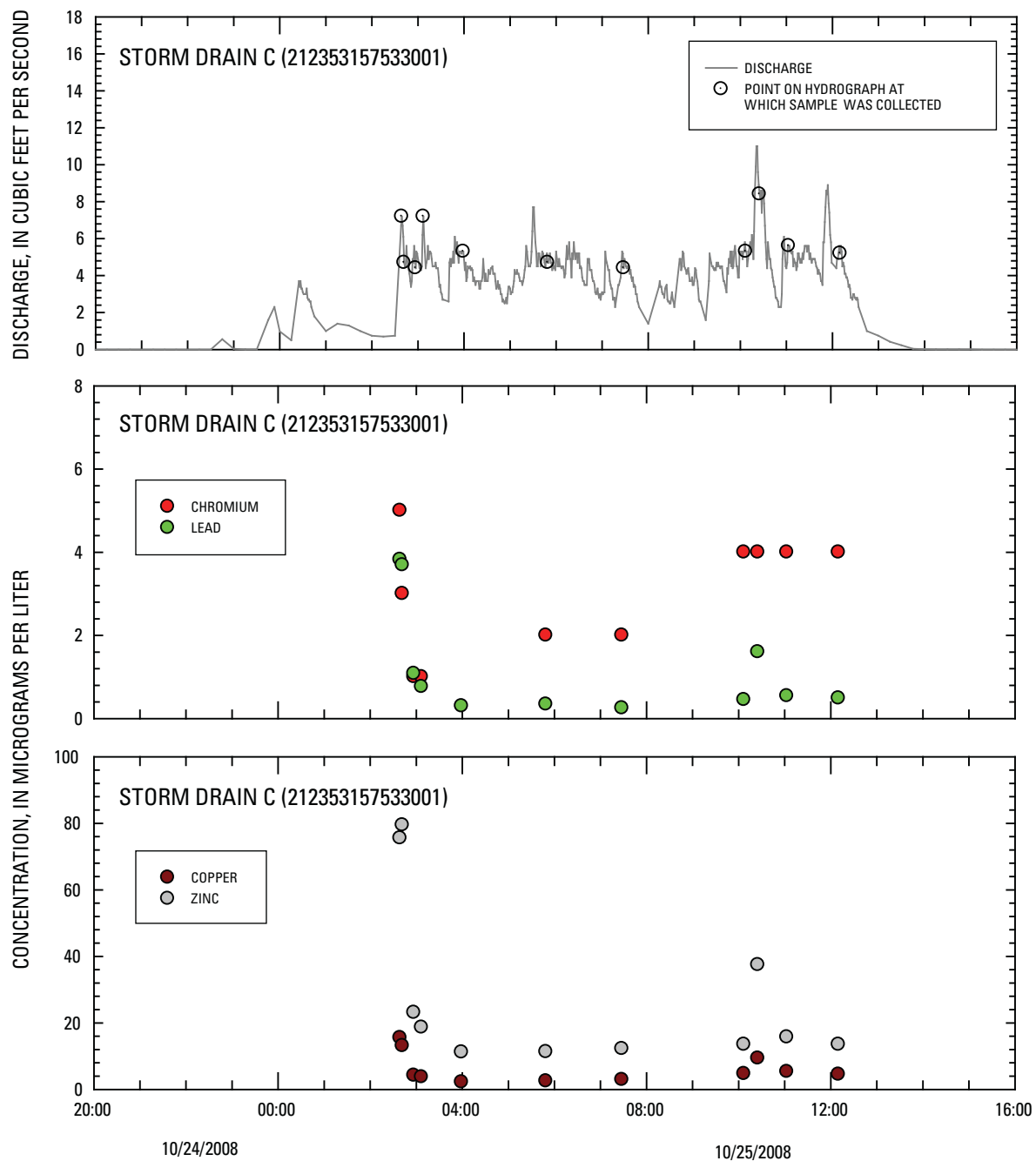


Figure 6. Discharge and concentrations of chromium, lead, copper, and zinc at Storm drain C (212353157533001) during storm of October 25, 2008, Oahu, Hawaii.

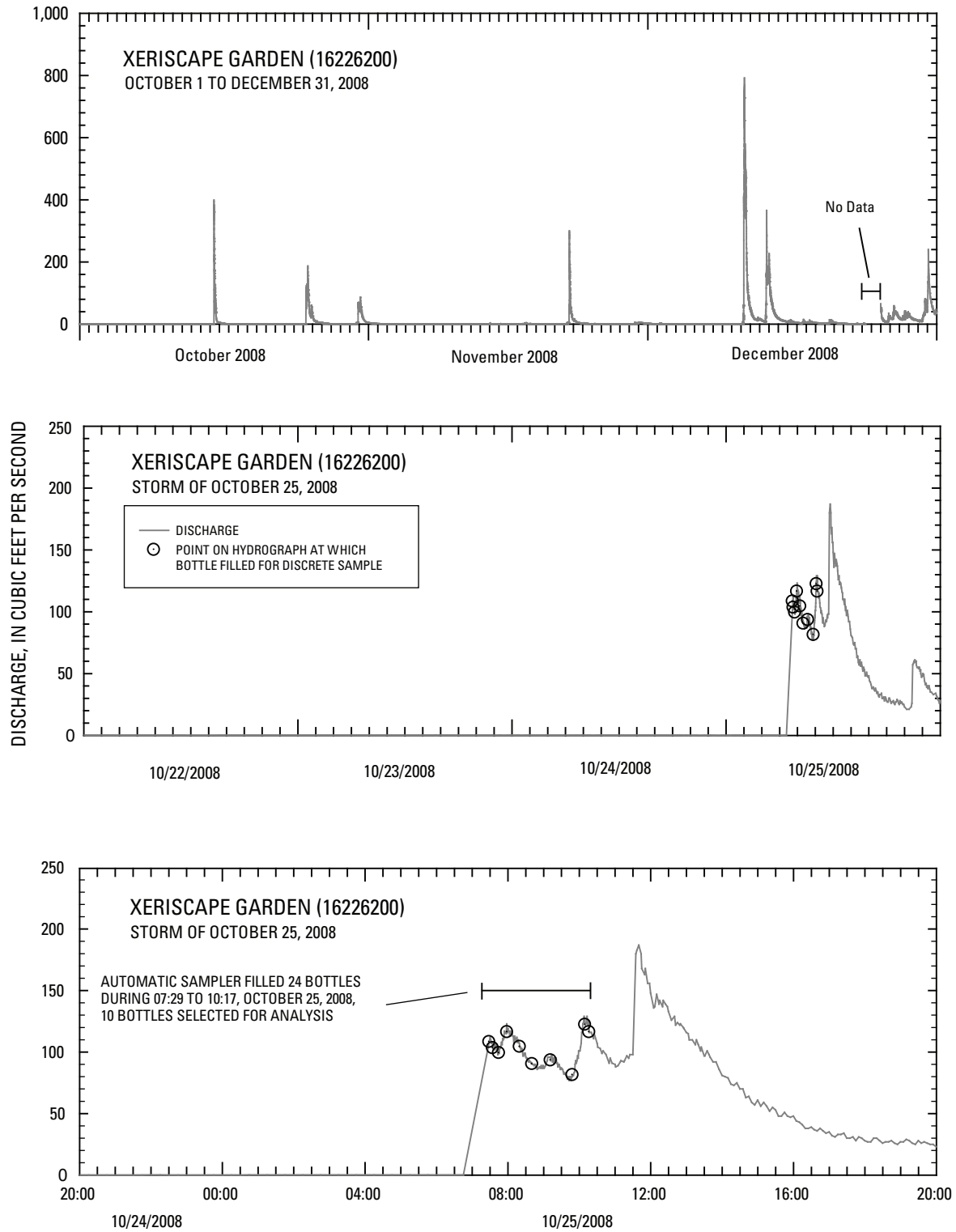


Figure 7. Stream discharge at Xeriscape garden station (16226200) for October 1 to December 31, 2008; detail of October 22-25, 2008; and detail of 24-hour period from 20:00 October 24 to 20:00 October 25, 2008, Oahu, Hawaii.

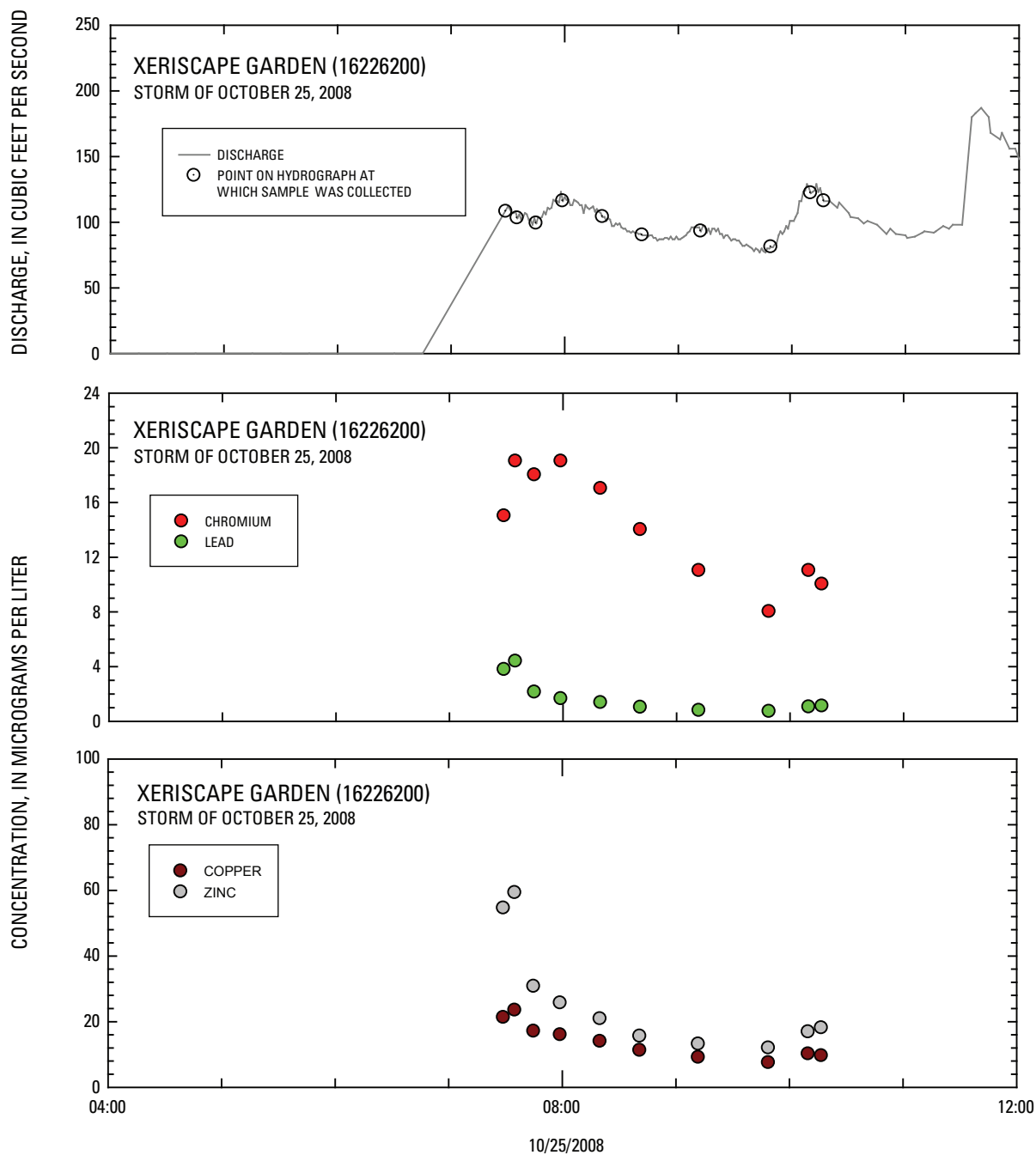


Figure 8. Discharge and concentrations of chromium, lead, copper, and zinc at Xeriscape garden (16226200) during storm of October 25, 2008, Oahu, Hawaii.

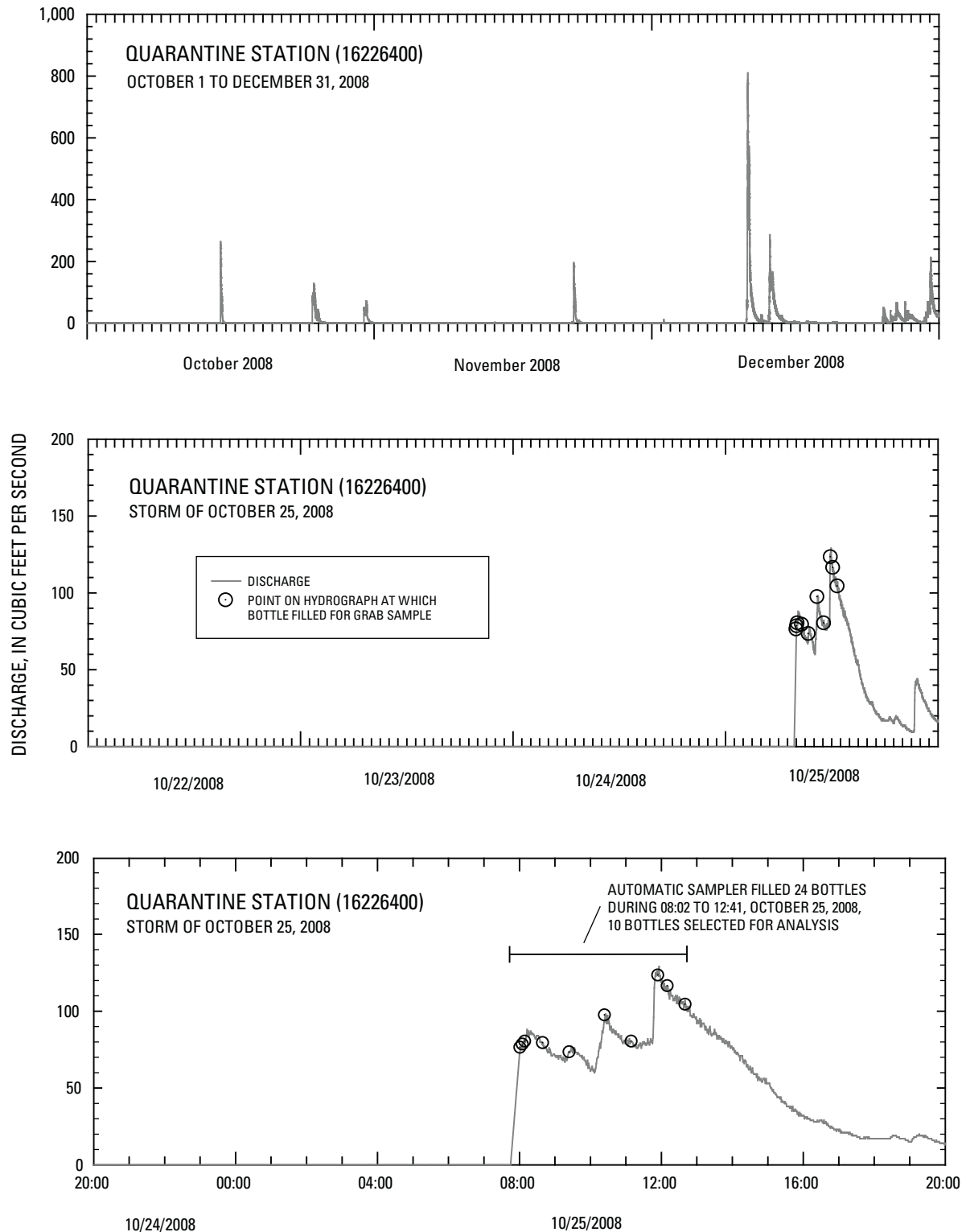


Figure 9. Stream discharge at Quarantine station (16226400) for October 1 to December 31, 2008; detail of October 22-25, 2008; and detail of 24-hour period from 20:00 October 24 to 20:00 October 25, 2008, Oahu, Hawaii.

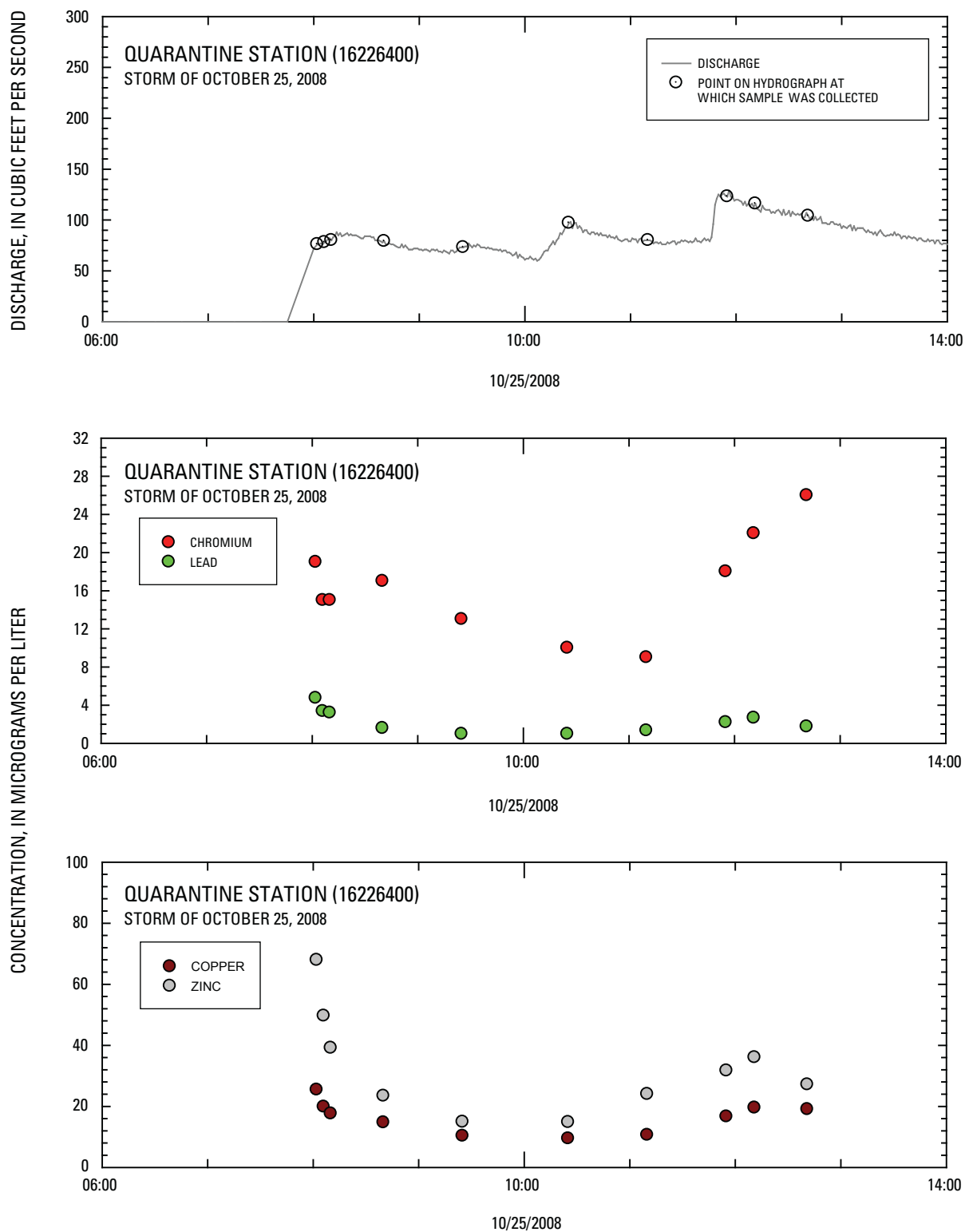


Figure 10. Discharge and concentrations of chromium, lead, copper, and zinc at Quarantine station (16226400) during storm of October 25, 2008, Oahu, Hawaii.

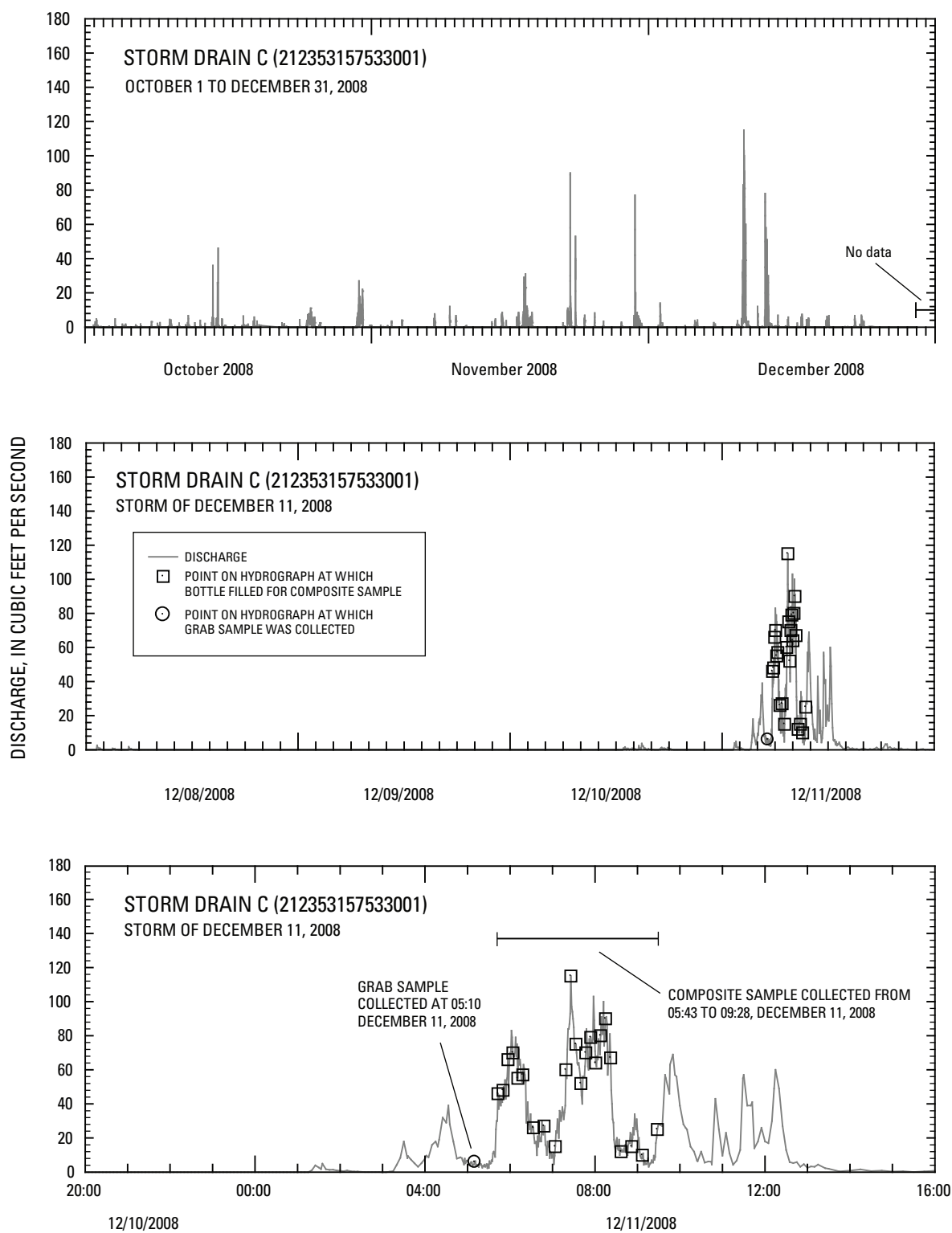


Figure 11. Stream discharge at Storm drain C (212353157533001) for October 1 to December 31, 2008; detail of December 8-11, 2008; and detail of 20-hour period from 20:00 December 10 to 16:00 December 11, 2008, Oahu, Hawaii.

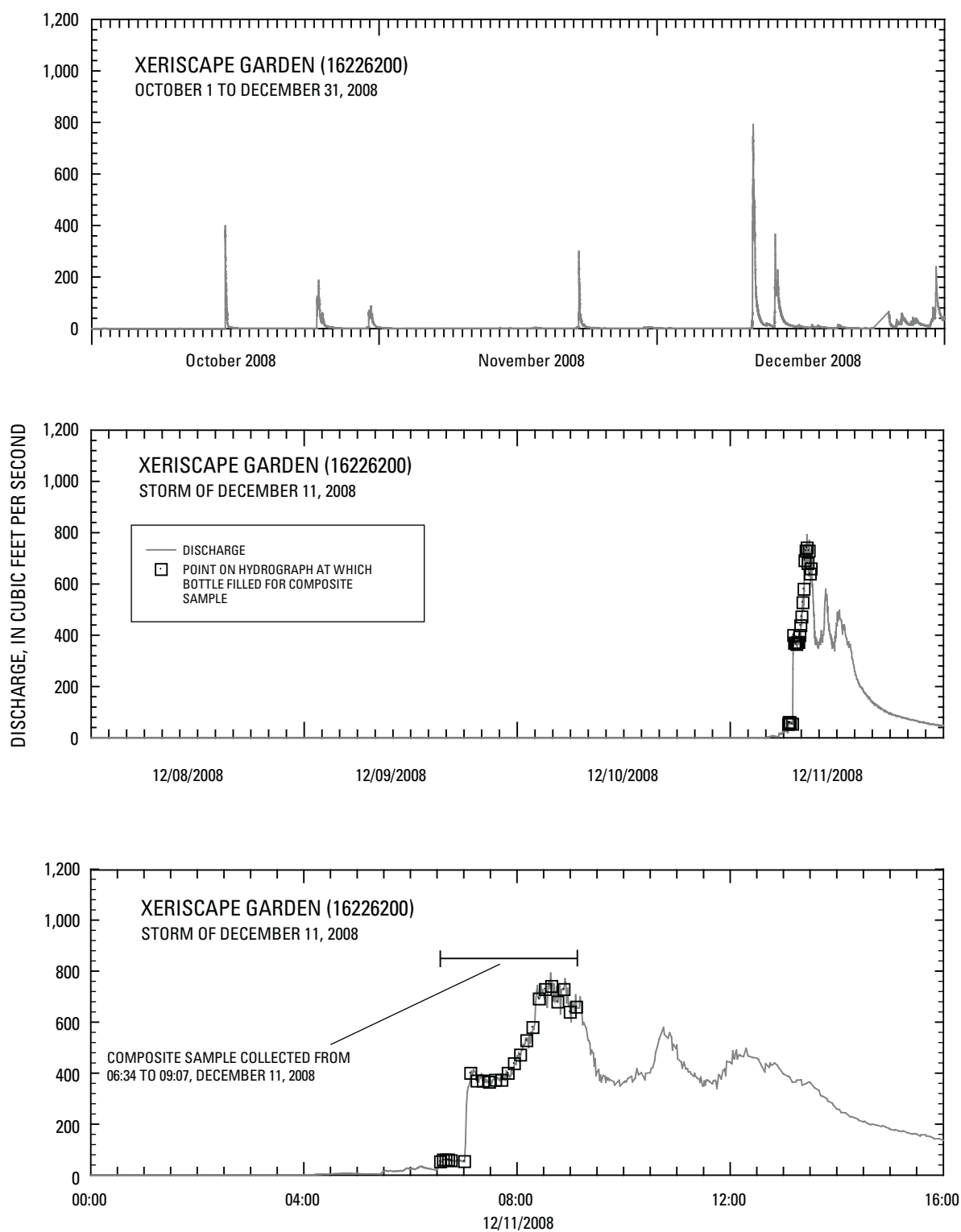


Figure 12. Stream discharge at Xeriscape garden station (16226200) for October 1 to December 31, 2008; detail of December 8-11, 2008; and detail of 16-hour period from 00:00 to 16:00 December 11, 2008, Oahu, Hawaii.

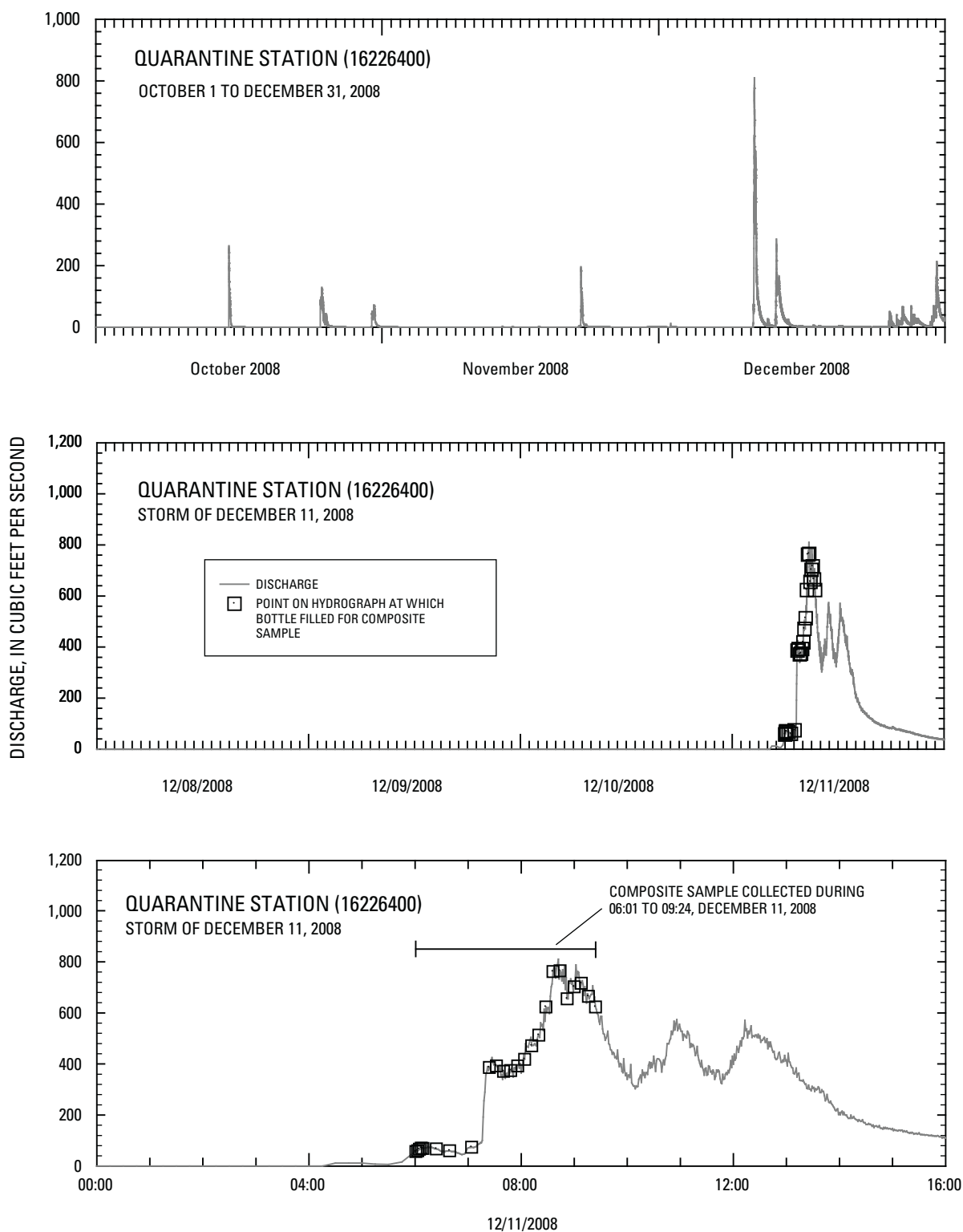


Figure 13. Stream discharge at Quarantine station (16226400) for October 1 to December 31, 2008; detail of December 8-11, 2008; and detail of 16-hour period from 00:00 to 16:00 December 11, 2008, Oahu, Hawaii.

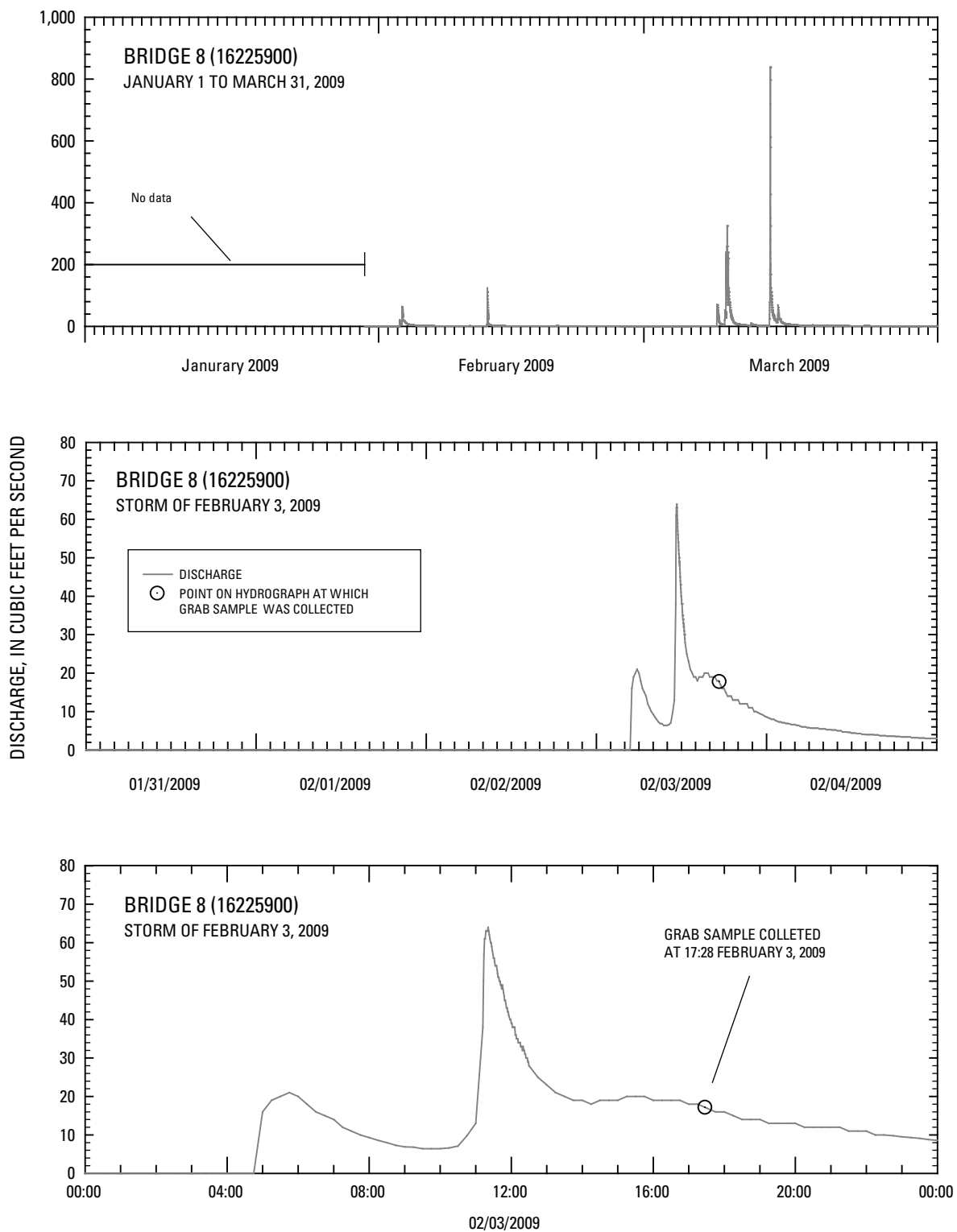


Figure 14. Stream discharge at Bridge 8 (16225900) for January 1 to March 31, 2009; detail of January 31 to February 4, 2009; and detail of 24-hour period from 00:00 February 3 to 00:00 February 4, 2009, Oahu, Hawaii.

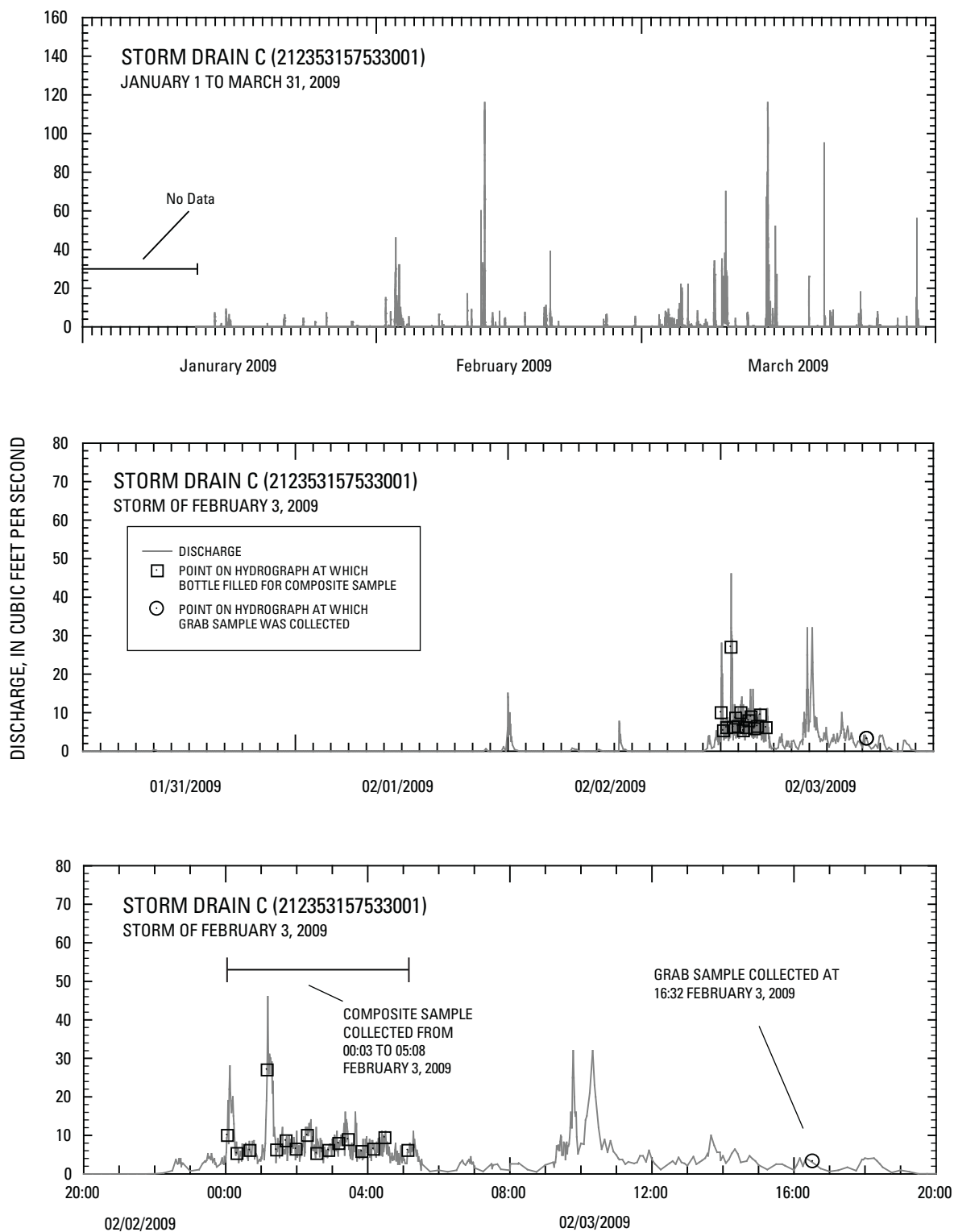


Figure 15. Stream discharge at Storm drain C (212353157533001) for January 1 to March 31, 2009; detail of January 31 to February 3, 2009; and detail of 24-hour period from 20:00 February 2 to 20:00 February 3, 2009, Oahu, Hawaii.

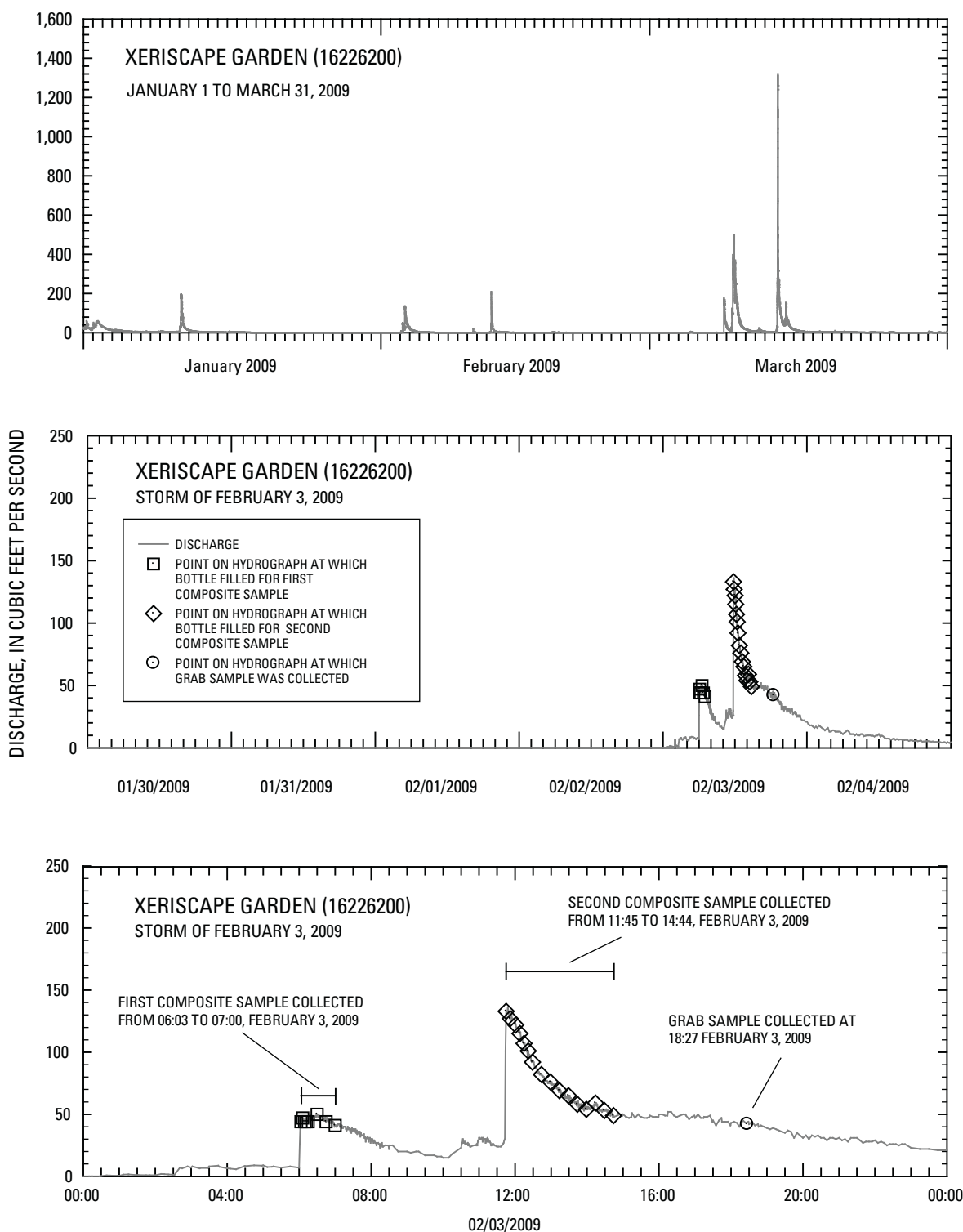


Figure 16. Stream discharge at Xeriscape garden station (16226200) for January 1 to March 31, 2009; detail of January 30 to February 4, 2009; and detail of 24-hour period from 00:00 February 3 to 00:00 February 4, 2009, Oahu, Hawaii.

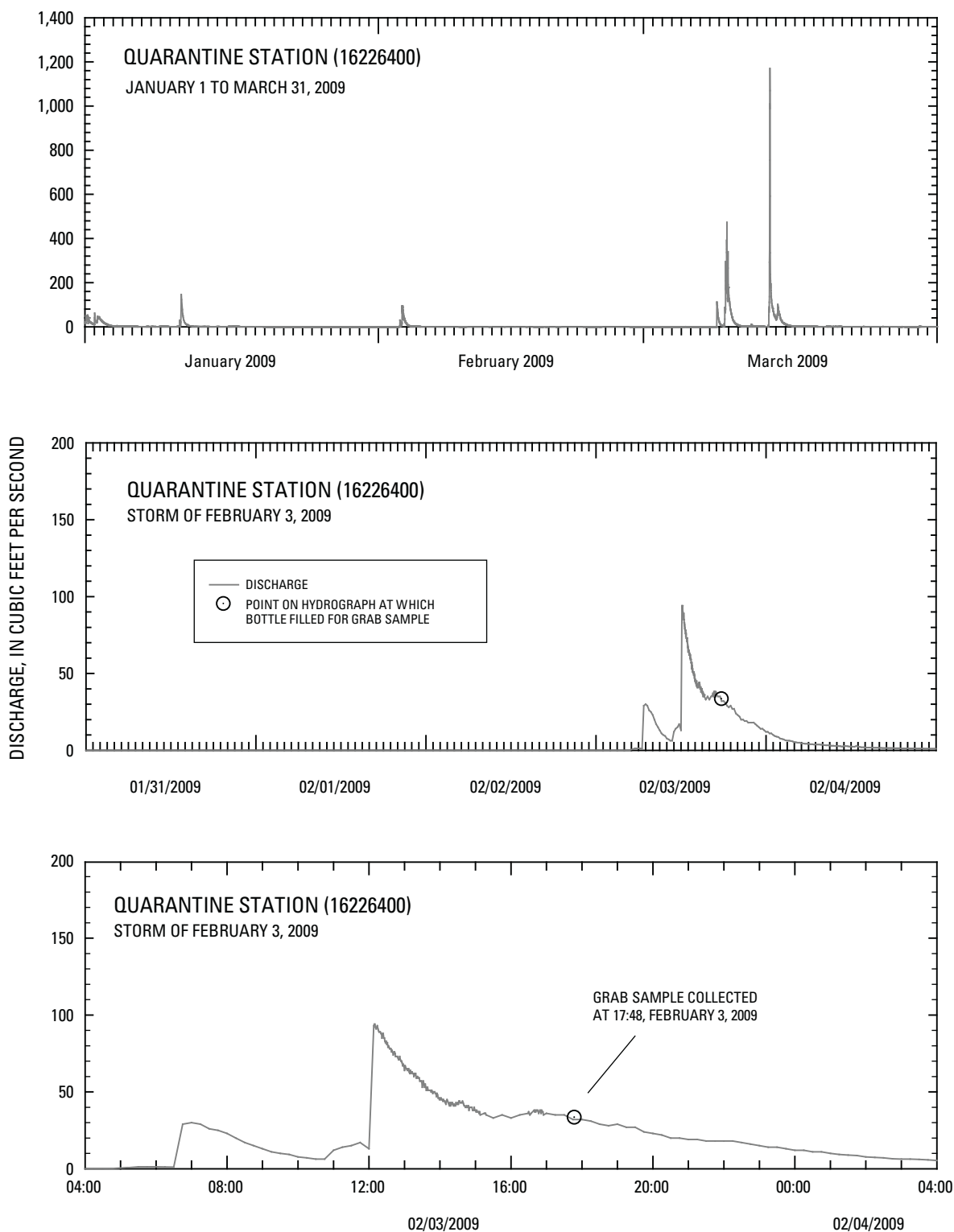


Figure 17. Stream discharge at Quarantine station (16226400) for January 1 to March 31, 2009; detail of January 30 to February 4, 2009; and detail of 24-hour period from 04:00 February 3 to 04:00 February 4, 2009, Oahu, Hawaii.

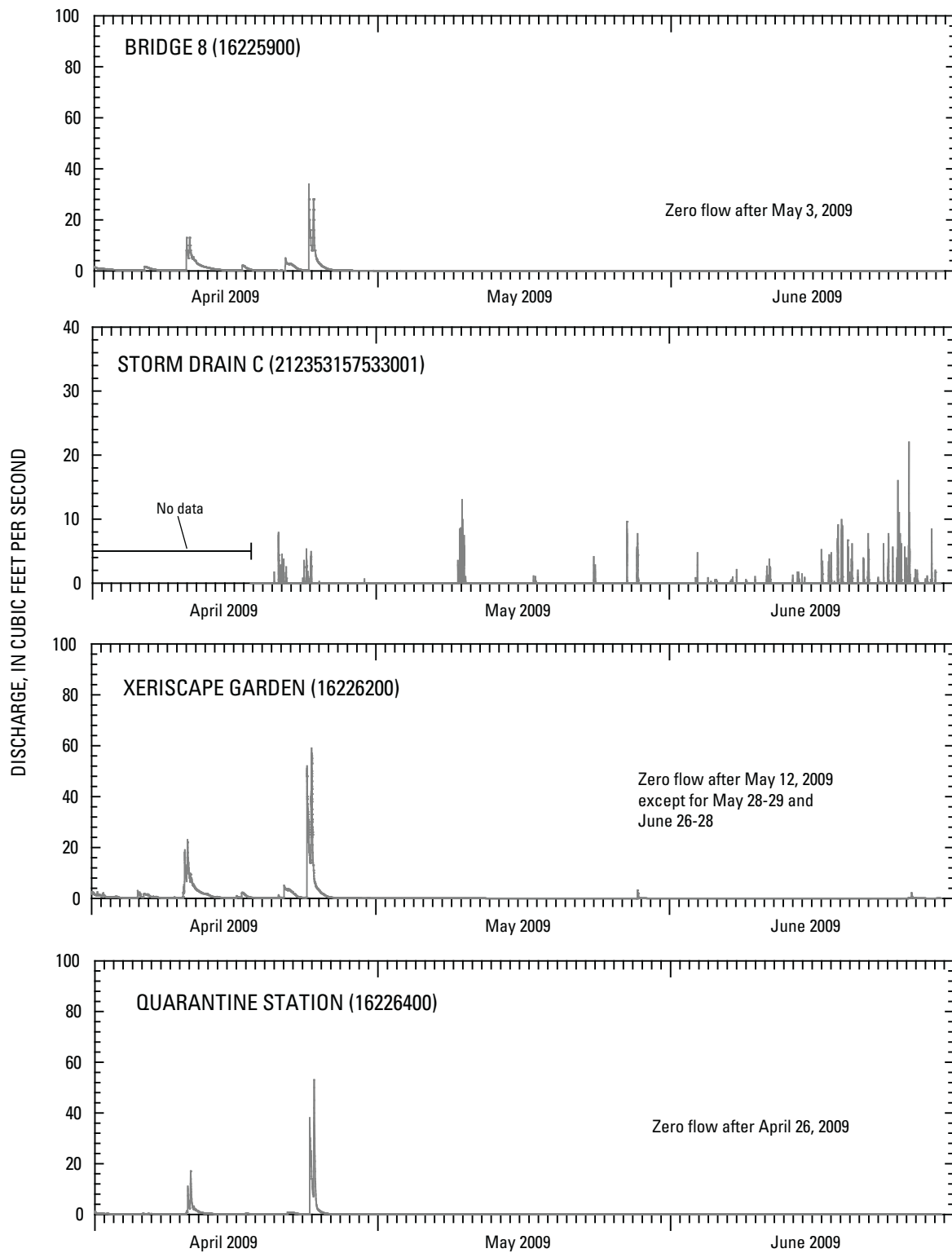


Figure 18. Discharge at Storm Drain C (212353157533001) and stream discharge at Bridge 8 (16225900), Xeriscape garden (16226200), and Quarantine station (16226400) for April 1 to June 30, 2009, Oahu, Hawaii.

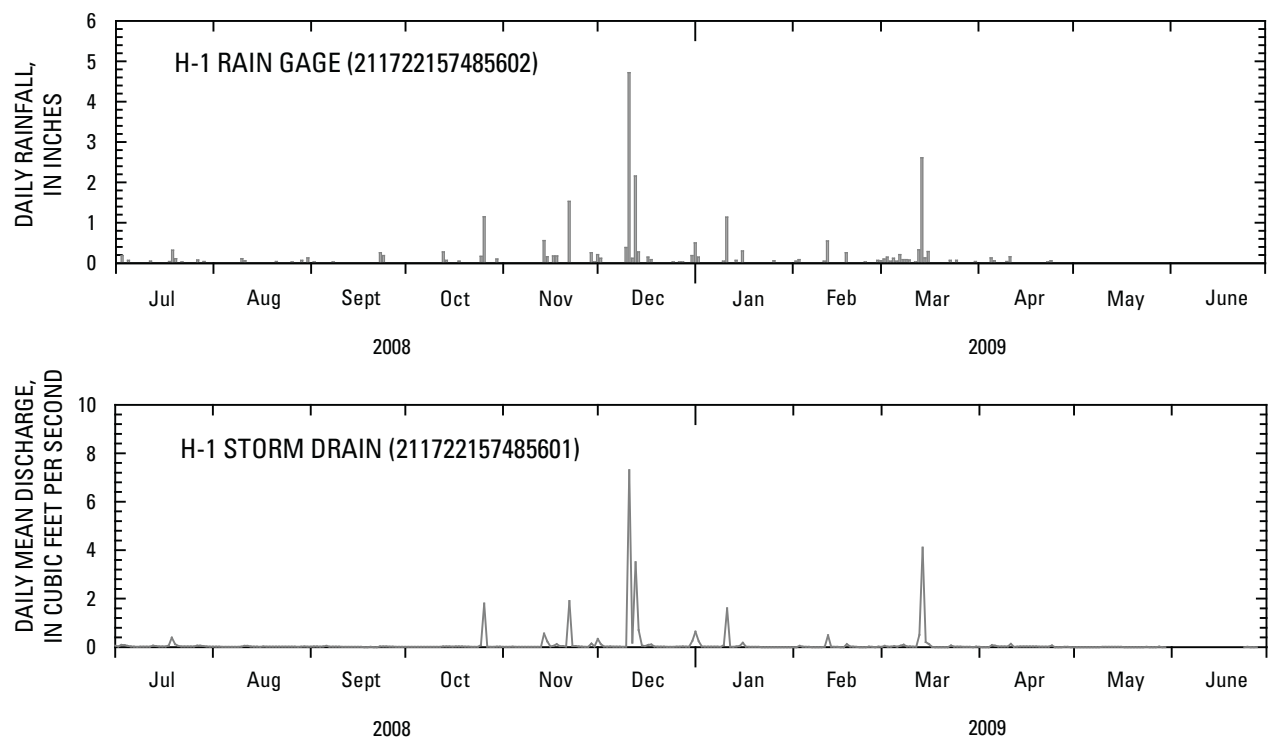


Figure 19. Rainfall and discharge for H-1 rain gage and H-1 storm drain within the Ala Wai Canal watershed, July 1, 2008, to June 30, 2009, Oahu, Hawaii.

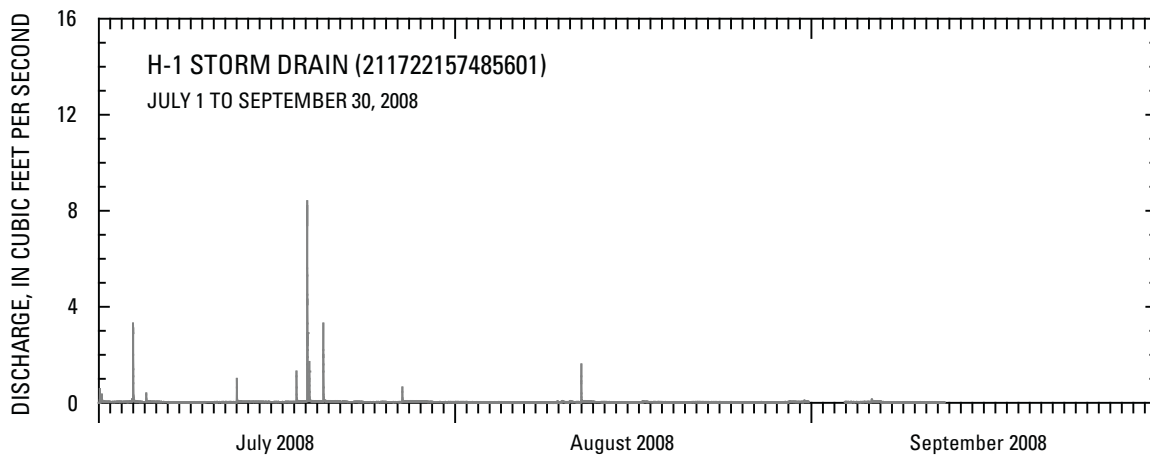


Figure 20. Discharge at H-1 storm drain (211722157485601) for July 1 to September 30, 2008, Oahu, Hawaii.

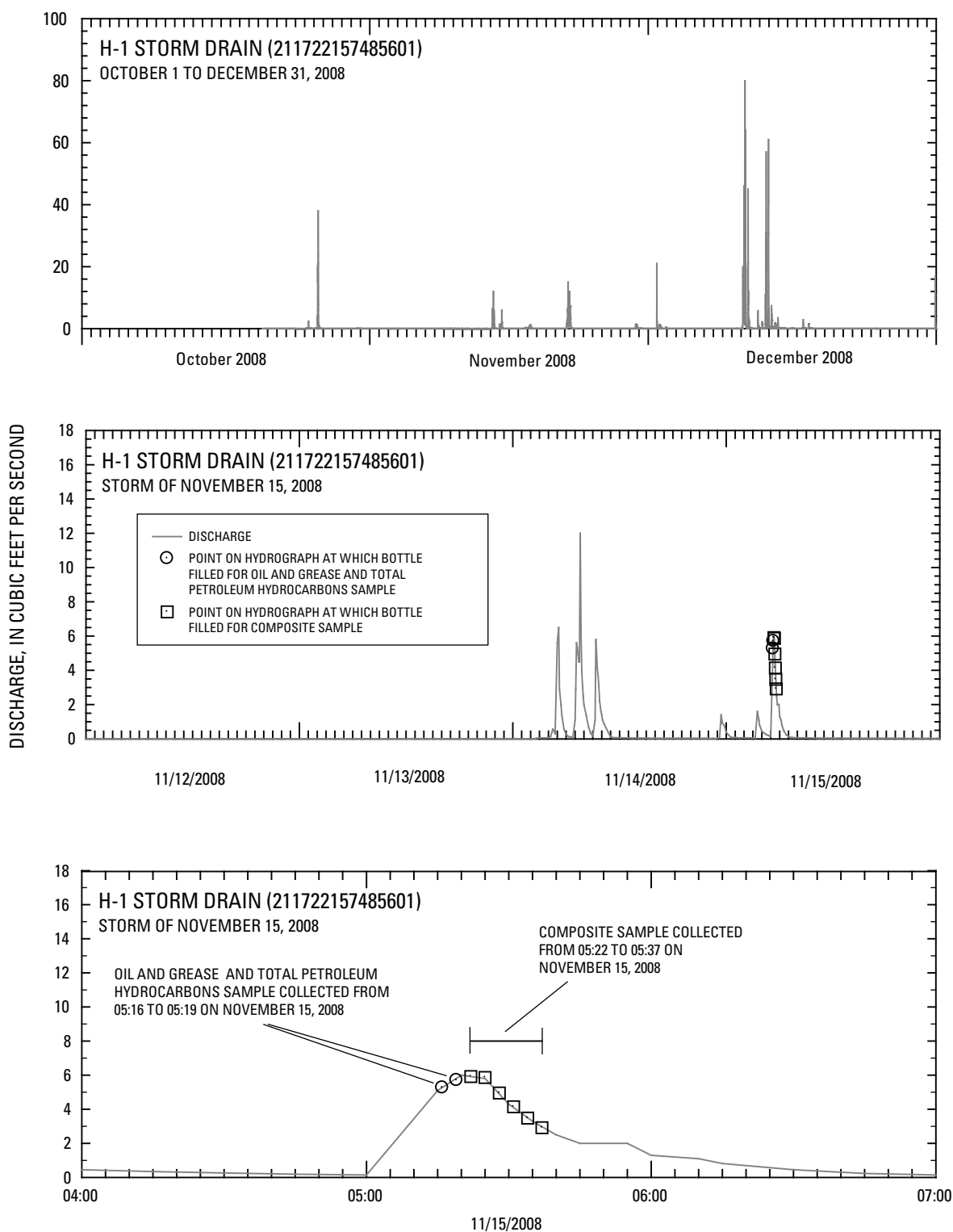


Figure 21. Discharge at H-1 storm drain (211722157485601) for October 1 to December 31, 2008; detail of 4-day period from November 12 to November 15, 2008; and detail of 3-hour period from 04:00 to 07:00 November 15, 2008, Oahu, Hawaii.

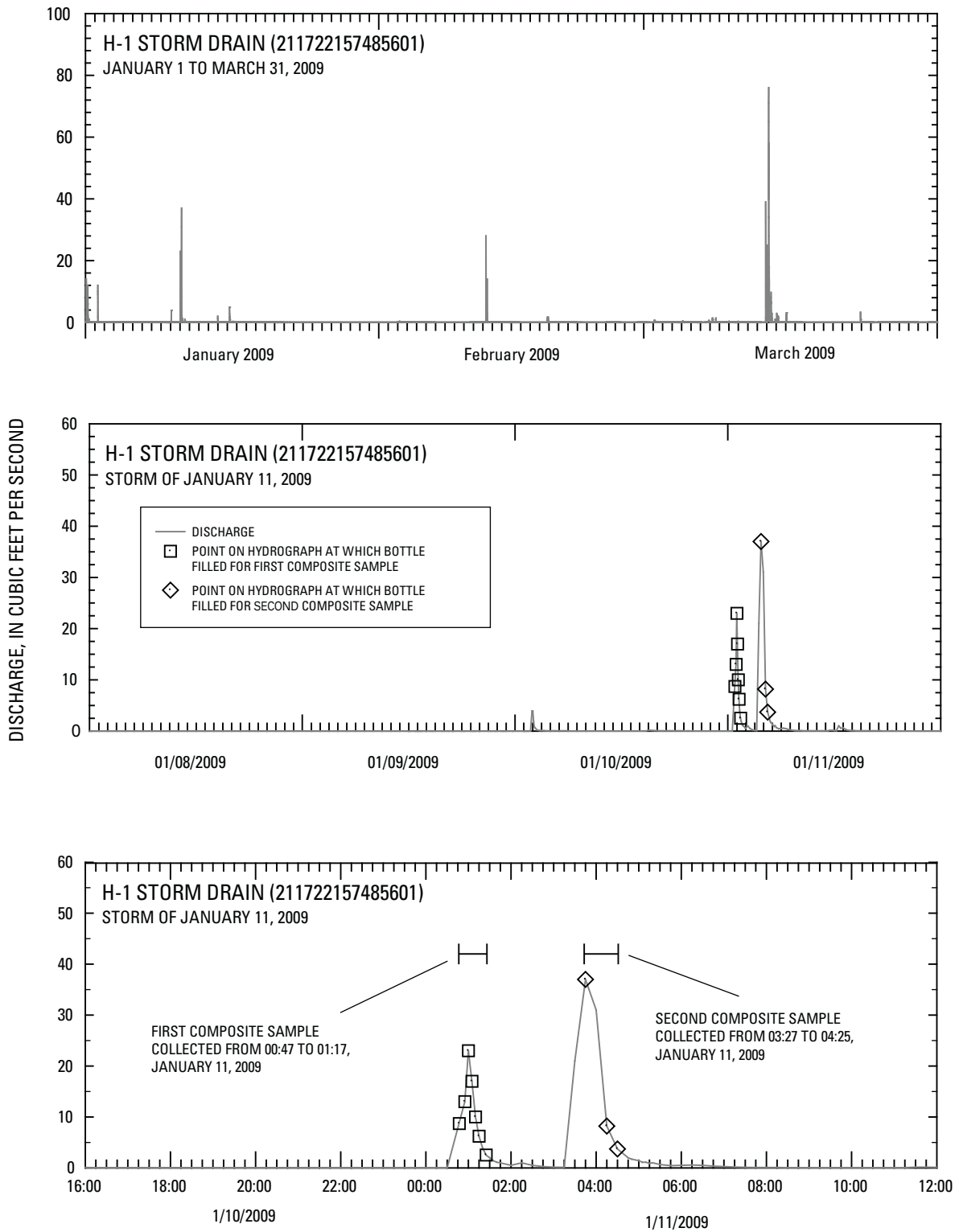


Figure 22. Discharge at H-1 storm drain (211722157485601) for January 1 to March 31, 2009; detail of 4-day period from January 8 to 11, 2009; and detail of 20-hour period from 16:00 January 10 to 12:00 January 11, 2009, Oahu, Hawaii.

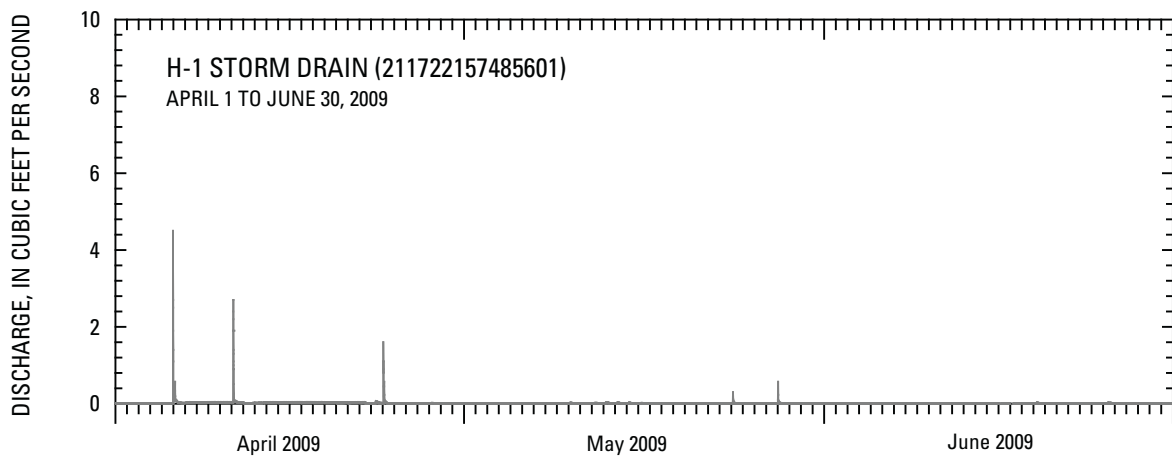


Figure 23. Discharge at H-1 storm drain (211722157485601) for April 1 to June 30, 2009, Oahu, Hawaii.

Appendix A: Discharge-Reporting and Load-Calculation Methods

This appendix further defines the methods used for reporting discharge data and constituent-concentration data and the methods for calculating constituent loads. Discharge and water-quality-data values are rounded off to the number of significant figures that best describe the precision of the measurement.

Discharge data.--Table 1 shows the number of significant figures and rounding limits for the range of discharges used in this study. Discharges measured by current meter or float-measurement techniques follow guidelines for measured discharges. Discharges determined by discharge rating or by averaging follow guidelines for daily mean discharges (Sauer, 2002). Measured discharges may have more significant figures because they are considered more precise than averaged discharges.

Table 1. Significant figures and rounding limits for measured, discharge-rating, and averaged discharges
[ft³/s, cubic feet per second; <, actual value is less than shown; ≥, actual value is greater than or equal to value shown]

Range of discharge (ft ³ /s)	Measured discharge		Discharge-rating and averaged discharges	
	Significant figures	Rounding limit	Significant figures	Rounding limit
<0.10	2	thousandths	1	hundredths
≥ 0.10 and <1.0	2	hundredths	2	hundredths
≥ 1.0 and < 10	3	hundredths	2	tenths
≥ 10 and < 100	3	tenths	2	units
≥ 100	3	variable	3	variable

Calculation of loads.--Table 2 shows the conversion factors used for determining constituent loads. Constituent loads for all analyses are reported as pounds per day (lbs/day) except for fecal coliform, which is reported as billion colonies per day. All loads are the product of constituent concentration multiplied by associated discharge and the appropriate conversion factor (equation 1). Concentrations are reported in milligrams per liter (mg/L) or micrograms per liter (µg/L), except for fecal coliform, which is reported in most probable number (of colonies) per 100 milliliters (MPN/100 mL).

Since the values of concentrations are multiplied by the discharge, a significant-figure rule applies for cases where the number of significant figures for each value is different by at least two figures. In these cases, the value with the greater number of significant figures is rounded off to contain one more significant figure than the value with the lesser number of significant figures, prior to multiplying the values. The load value is reported with the number of significant figures of the value (concentration or discharge) with the least number of significant figures. This significant-figure rule is not applied to the conversion factor, which has four significant figures.

$$Q(C)K = L \quad (1)$$

Where Q = discharge (ft³/s)

C = constituent concentration (mg/L, µg/L or MPN/100ml)

K = conversion factor

L = constituent load (lbs/day or billion colonies per day)

Table 2. Conversion factors for computing daily loads from constituent concentration and discharge.

[mg/L, milligrams per liter; µg/L, micrograms per liter; MPN/100mL, most probable number (of colonies) per 100 milliliters; lbs/day, pounds per day]

Unit of concentration	Conversion factor ^a	Load unit
mg/L	5.394	lbs/day
µg/L	0.005394	lbs/day
MPN/100mL	0.02447	billion colonies per day

^aAll conversion factors are based on discharge in cubic feet per second.

Appendix B: Physical Properties, Concentrations, and Loads for All Samples Collected from Halawa Stream Drainage Basin and H-1 Storm Drain During the Period from July 1, 2008, to June 30, 2009, Oahu, Hawaii

Table 3. Physical properties, concentrations, and loads for all samples collected from Halawa Stream drainage basin during the period from July 1, 2008, to June 30, 2009, Oahu, Hawaii

[h:h:mm, hours and minutes; Instant., value of instantaneous discharge; Avg., value of average discharge for composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; M, presence of material verified but not quantified; N, nitrogen; μS/cm, microsiemens per centimeter; °C, degrees Celsius; ft³/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; μg/L, micrograms per liter; ND, not detected]

Station name	Date	Median time (hh:mm)	Sample type	Discharge (ft ³ /s)		pH, lab reported to nearest 0.1	Specific conductance (µS/cm at 25°C) reported to nearest whole number	Temperature (°C) reported to nearest 0.1 °C	Total suspended solids		Total dissolved solids		Total nitrogen ^a		Organic nitrogen ^b		
				Instant.	Avg.				Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	
Storm of October 25, 2008																	
Storm drain	October 25, 2008	02:39	Discrete	#7.2		7.0	98	--	--	--	--	--	--	--	--	--	
Storm drain	October 25, 2008	02:42	Discrete	#4.7		7.3	72	--	--	--	--	--	--	--	--	--	
Storm drain	October 25, 2008	02:57	Discrete	#4.4		7.6	61	--	--	--	--	--	--	--	--	--	
Storm drain	October 25, 2008	03:07	Discrete	#7.2		7.7	59	--	--	--	--	--	--	--	--	--	
Storm drain	October 25, 2008	03:59	Discrete	#5.3		7.8	49	--	--	--	--	--	--	--	--	--	
Storm drain	October 25, 2008	05:49	Discrete	#4.7		7.8	51	--	--	--	--	--	--	--	--	--	
Storm drain	October 25, 2008	07:28	Discrete	#4.4		7.8	54	--	--	--	--	--	--	--	--	--	
Storm drain	October 25, 2008	10:07	Discrete	#5.3		7.8	49	--	--	--	--	--	--	--	--	--	
Storm drain	October 25, 2008	10:25	Discrete	#8.4		7.8	45	--	--	--	--	--	--	--	--	--	
Storm drain	October 25, 2008	11:03	Discrete	#5.6		7.8	45	--	--	--	--	--	--	--	--	--	
Storm drain	October 25, 2008	12:10	Discrete	#5.2		7.9	44	--	--	--	--	--	--	--	--	--	
Xeriscape	October 25, 2008	07:29	Discrete	#108		7.7	78	--	--	--	--	--	--	--	--	--	
Xeriscape	October 25, 2008	07:35	Discrete	#103		7.6	79	--	--	--	--	--	--	--	--	--	
Xeriscape	October 25, 2008	07:45	Discrete	#99		7.6	75	--	--	--	--	--	--	--	--	--	
Xeriscape	October 25, 2008	07:59	Discrete	#116		7.5	67	--	--	--	--	--	--	--	--	--	
Xeriscape	October 25, 2008	08:20	Discrete	#104		7.5	59	--	--	--	--	--	--	--	--	--	
Xeriscape	October 25, 2008	08:41	Discrete	#90		7.5	55	--	--	--	--	--	--	--	--	--	
Xeriscape	October 25, 2008	09:12	Discrete	#93		7.6	54	--	--	--	--	--	--	--	--	--	
Xeriscape	October 25, 2008	09:49	Discrete	#81		7.6	53	--	--	--	--	--	--	--	--	--	
Xeriscape	October 25, 2008	10:10	Discrete	#122		8.5	51	--	--	--	--	--	--	--	--	--	
Xeriscape	October 25, 2008	10:17	Discrete	#116		8.0	52	--	--	--	--	--	--	--	--	--	
Quarantine	October 25, 2008	08:02	Discrete	#76		7.4	132	--	--	--	--	--	--	--	--	--	
Quarantine	October 25, 2008	08:06	Discrete	#78		7.5	95	--	--	--	--	--	--	--	--	--	
Quarantine	October 25, 2008	08:10	Discrete	#80		7.5	79	--	--	--	--	--	--	--	--	--	
Quarantine	October 25, 2008	08:40	Discrete	#79		7.7	69	--	--	--	--	--	--	--	--	--	
Quarantine	October 25, 2008	09:25	Discrete	#73		7.6	61	--	--	--	--	--	--	--	--	--	
Quarantine	October 25, 2008	10:25	Discrete	#97		7.5	57	--	--	--	--	--	--	--	--	--	
Quarantine	October 25, 2008	11:10	Discrete	#80		7.5	59	--	--	--	--	--	--	--	--	--	
Quarantine	October 25, 2008	11:55	Discrete	#122		7.4	57	--	--	--	--	--	--	--	--	--	
Quarantine	October 25, 2008	12:11	Discrete	#116		6.5	55	--	--	--	--	--	--	--	--	--	
Quarantine	October 25, 2008	12:41	Discrete	#104		6.9	55	--	--	--	--	--	--	--	--	--	
Storm of December 11, 2008																	
Storm drain	December 11, 2008	05:10	Grab	#5.8		--	--	--	--	--	--	--	--	--	--	--	
Storm drain	December 11, 2008	07:35	Composite		#45	8.0	42	--	< 15	< 3,600	--	--	e 0.25	e 61	0.19	46	
Xeriscape	December 11, 2008	07:55	Composite		#437	7.5	79	--	1,220	2,880,000	--	--	8.40	19,800	≤ 8.2	≤ 19,000	
Quarantine	December 11, 2008	07:43	Composite		#386	7.3	89	--	1,160	2,420,000	50	110,000	6.40	13,300	≤ 6.1	≤ 13,000	
Storm of February 3, 2009																	
Bridge 8	February 3, 2009	17:28	Grab	#18		7.6	133	18.7	< 15	< 1,500	76	7,400	0.39	38	≤ 0.28	≤ 27	
Storm drain	February 3, 2009	02:35	Composite		#8.9	7.7	88	--	< 15	< 720	49	2,400	0.34	16	0.23	11	
Storm drain	February 3, 2009	16:32	Grab	#3.1		7.8	188	--	18	300	105	1,700	0.49	8.2	≤ 0.37	≤ 6.2	
Xeriscape	February 3, 2009	06:32	Composite		#45	7.5	111	--	72	17,000	57	14,000	1.03	240	e 0.873	e 210	
Xeriscape	February 3, 2009	13:15	Composite		#77	7.5	114	--	165	66,000	71	29,000	1.71	710	≤ 1.6	≤ 660	
Xeriscape	February 3, 2009	18:27	Grab	#42		7.7	139	18.8	< 15	< 3,400	90	20,000	0.40	91	e 0.28	e 63	
Quarantine	February 3, 2009	17:48	Grab	#33		7.7	141	19.0	17	3,030	90	16,000	0.47	84	≤ 0.35	< 62	
Stadium	February 3, 2009	16:44	Grab	#45		7.6	167	19.6	36	8,700	97	24,000	0.68	170	e 0.53	e 130	

Table 3. Physical properties, concentrations, and loads for all samples collected from Halawa Stream drainage basin during the period from July 1, 2008, to June 30, 2009, Oahu, Hawaii--Continued

[hh:mm, hours and minutes; Instant., value of instantaneous discharge; Avg., value of average discharge for composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; M, presence of material verified but not quantified; N, nitrogen; µS/cm, microsiemens per centimeter; °C, degrees Celsius; ft³/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; µg/L, micrograms per liter; ND, not detected]

Station name	Date	Median time (hh:mm)	Sample type	Ammonia dissolved		Nitrogen, total organic + ammonia		Nitrogen, nitrite + nitrate dissolved		Phosphorus dissolved		Total phosphorus		Chemical oxygen demand	
				Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc (mg/L)	Load (lbs/day)
Storm of October 25, 2008															
Storm drain	October 25, 2008	02:39	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm drain	October 25, 2008	02:42	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm drain	October 25, 2008	02:57	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm drain	October 25, 2008	03:07	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm drain	October 25, 2008	03:59	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm drain	October 25, 2008	05:49	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm drain	October 25, 2008	07:28	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm drain	October 25, 2008	10:07	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm drain	October 25, 2008	10:25	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm drain	October 25, 2008	11:03	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm drain	October 25, 2008	12:10	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Xeriscape	October 25, 2008	07:29	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Xeriscape	October 25, 2008	07:35	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Xeriscape	October 25, 2008	07:45	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Xeriscape	October 25, 2008	07:59	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Xeriscape	October 25, 2008	08:20	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Xeriscape	October 25, 2008	08:41	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Xeriscape	October 25, 2008	09:12	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Xeriscape	October 25, 2008	09:49	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Xeriscape	October 25, 2008	10:10	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Xeriscape	October 25, 2008	10:17	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Quarantine	October 25, 2008	08:02	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Quarantine	October 25, 2008	08:06	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Quarantine	October 25, 2008	08:10	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Quarantine	October 25, 2008	08:40	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Quarantine	October 25, 2008	09:25	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Quarantine	October 25, 2008	10:25	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Quarantine	October 25, 2008	11:10	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Quarantine	October 25, 2008	11:55	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Quarantine	October 25, 2008	12:11	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Quarantine	October 25, 2008	12:41	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm of December 11, 2008															
Storm drain	December 11, 2008	05:10	Grab	--	--	--	--	--	--	--	--	--	--	--	--
Storm drain	December 11, 2008	07:35	Composite	0.020	4.9	0.21	51	e0.04	e9.7	< 0.04	< 10	0.05	10	10	2,000
Xeriscape	December 11, 2008	07:55	Composite	< 0.020	< 47	8.2	19,000	0.20	470	e0.02	e50	1.66	3,910	320	750,000
Quarantine	December 11, 2008	07:43	Composite	< 0.020	< 42	6.1	13,000	0.30	620	e0.04	e80	1.36	2,830	250	520,000
Storm of February 3, 2009															
Bridge 8	February 3, 2009	17:28	Grab	< 0.020	< 1.9	0.28	27	0.11	11	< 0.04	< 4	e0.04	e4	< 10	< 1,000
Storm drain	February 3, 2009	02:35	Composite	0.046	2.2	0.28	13	0.06	3	< 0.04	< 2	e0.03	e1	< 10	< 500
Storm drain	February 3, 2009	16:32	Grab	< 0.020	< 0.33	0.37	6.2	0.12	2	< 0.04	< 0.7	0.06	1	30	500
Xeriscape	February 3, 2009	06:32	Composite	e0.017	e4.1	0.89	220	0.14	34	< 0.04	< 10	0.14	34	30	7,000
Xeriscape	February 3, 2009	13:15	Composite	< 0.020	< 8.3	1.6	660	0.11	46	< 0.04	< 20	0.27	110	70	30,000
Xeriscape	February 3, 2009	18:27	Grab	e0.010	e2.3	0.29	66	0.11	25	< 0.04	< 9	e0.03	e7	10	2,000
Quarantine	February 3, 2009	17:48	Grab	< 0.020	< 3.6	0.35	62	0.12	21	< 0.04	< 7	0.05	9	20	4,000
Stadium	February 3, 2009	16:44	Grab	e0.011	e2.7	0.54	130	0.14	34	< 0.04	< 10	0.08	20	20	5,000

Table 3. Physical properties, concentrations, and loads for all samples collected from Halawa Stream drainage basin during the period from July 1, 2008, to June 30, 2009, Oahu, Hawaii--Continued

[h:mm, hours and minutes; Instant., value of instantaneous discharge; Avg., value of average discharge for composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; M, presence of material verified but not quantified; N, nitrogen; μS/cm, microsiemens per centimeter; °C, degrees Celsius; ft³/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; μg/L, micrograms per liter; ND, not detected]

Station name	Date	Median time (hh:mm)	Sample type	Total cadmium		Total chromium		Total copper		Total lead		Total zinc		Oil and grease ^e		Total petroleum hydrocarbons ^e	
				Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)
Storm of October 25, 2008																	
Storm drain	October 25, 2008	02:39	Grab	0.08	0.003	5	0.2	15.5	0.60	3.82	0.15	75.5	2.9	--	--	--	--
Storm drain	October 25, 2008	02:42	Grab	0.08	0.002	3	0.1	13.1	0.33	3.69	0.09	79.4	2.0	--	--	--	--
Storm drain	October 25, 2008	02:57	Grab	0.09	0.002	1	0.02	4.2	0.10	1.08	0.026	23.1	0.55	--	--	--	--
Storm drain	October 25, 2008	03:07	Grab	< 0.06	< 0.002	1	0.04	e3.7	e0.14	0.76	0.030	18.6	0.72	--	--	--	--
Storm drain	October 25, 2008	03:59	Grab	< 0.06	< 0.002	M	--	e2.2	e0.063	0.30	0.0086	11.2	0.32	--	--	--	--
Storm drain	October 25, 2008	05:49	Grab	e0.05	e0.001	2	0.05	e2.5	e0.063	0.34	0.0086	11.3	0.29	--	--	--	--
Storm drain	October 25, 2008	07:28	Grab	< 0.06	< 0.001	2	0.05	e2.9	e0.069	0.25	0.0059	12.2	0.29	--	--	--	--
Storm drain	October 25, 2008	10:07	Grab	< 0.06	< 0.002	4	0.1	4.7	0.13	0.45	0.013	13.5	0.39	--	--	--	--
Storm drain	October 25, 2008	10:25	Grab	e0.04	e0.002	4	0.2	9.3	0.42	1.60	0.072	37.4	1.7	--	--	--	--
Storm drain	October 25, 2008	11:03	Grab	< 0.06	< 0.002	4	0.1	5.3	0.16	0.54	0.016	15.7	0.47	--	--	--	--
Storm drain	October 25, 2008	12:10	Grab	< 0.06	< 0.002	4	0.1	4.5	0.13	0.49	0.014	13.5	0.38	--	--	--	--
Xeriscape	October 25, 2008	07:29	Grab	0.09	0.05	15	8.9	21.2	12.4	3.77	2.20	54.5	31.7	--	--	--	--
Xeriscape	October 25, 2008	07:35	Grab	0.08	0.04	19	10.	23.4	13.0	4.37	2.43	59.2	32.9	--	--	--	--
Xeriscape	October 25, 2008	07:45	Grab	e0.05	e0.03	18	9.6	17.0	9.1	2.12	1.1	30.7	16	--	--	--	--
Xeriscape	October 25, 2008	07:59	Grab	e0.05	e0.03	19	12	15.9	9.95	1.63	1.02	25.6	16.0	--	--	--	--
Xeriscape	October 25, 2008	08:20	Grab	e0.04	e0.02	17	9.5	13.9	7.80	1.34	0.752	20.8	11.7	--	--	--	--
Xeriscape	October 25, 2008	08:41	Grab	< 0.06	< 0.03	14	6.8	11.2	5.4	1.01	0.49	15.5	7.5	--	--	--	--
Xeriscape	October 25, 2008	09:12	Grab	< 0.06	< 0.03	11	5.5	9.0	4.5	0.78	0.39	13.1	6.6	--	--	--	--
Xeriscape	October 25, 2008	09:49	Grab	< 0.06	< 0.03	8	3	7.4	3.2	0.70	0.31	11.9	5.2	--	--	--	--
Xeriscape	October 25, 2008	10:10	Grab	e0.04	e0.03	11	7.1	10.1	6.65	1.03	0.678	16.8	11.3	--	--	--	--
Xeriscape	October 25, 2008	10:17	Grab	e0.04	e0.03	10	6.5	9.5	5.9	1.09	0.682	18.0	12	--	--	--	--
Quarantine	October 25, 2008	08:02	Grab	0.22	0.090	19	7.8	25.4	10	4.74	1.9	67.9	28	--	--	--	--
Quarantine	October 25, 2008	08:06	Grab	0.08	0.03	15	6.3	19.8	8.3	3.36	1.4	49.6	21	--	--	--	--
Quarantine	October 25, 2008	08:10	Grab	0.08	0.03	15	6.5	17.6	7.6	3.19	1.4	39.1	17	--	--	--	--
Quarantine	October 25, 2008	08:40	Grab	e0.05	e0.02	17	7.2	14.7	6.3	1.58	0.67	23.4	10	--	--	--	--
Quarantine	October 25, 2008	09:25	Grab	e0.04	e0.02	13	5.1	10.3	4.1	0.98	0.39	14.9	5.9	--	--	--	--
Quarantine	October 25, 2008	10:25	Grab	< 0.06	< 0.03	10	5.2	9.4	4.9	0.98	0.51	14.8	7.7	--	--	--	--
Quarantine	October 25, 2008	11:10	Grab	< 0.06	< 0.03	9	4	10.6	4.6	1.32	0.57	24	10	--	--	--	--
Quarantine	October 25, 2008	11:55	Grab	e0.05	e0.03	18	12	16.6	10.9	2.20	1.45	31.7	20.9	--	--	--	--
Quarantine	October 25, 2008	12:11	Grab	0.07	0.04	22	14	19.5	12.2	2.66	1.66	36.0	22.5	--	--	--	--
Quarantine	October 25, 2008	12:41	Grab	e0.06	e0.03	26	15	19.0	10.7	1.74	0.976	27.1	15.2	--	--	--	--
Storm of December 11, 2008																	
Storm drain	December 11, 2008	05:10	Grab	--	--	--	--	--	--	--	--	--	--	5.5	170	--	--
Storm drain	December 11, 2008	07:35	Composite	0.07	0.02	5	1	7.9	1.9	2.70	0.66	39.2	9.5	--	--	--	--
Xeriscape	December 11, 2008	07:55	Composite	0.34	0.80	112	264	85.5	202	9.73	22.9	109	257	--	--	--	--
Quarantine	December 11, 2008	07:43	Composite	0.26	0.54	94	200	76.2	159	10.1	21.0	102	212	--	--	--	--
Storm of February 3, 2009																	
Bridge 8	February 3, 2009	17:28	Grab	< 0.06	< 0.01	2	0.2	e2.1	e0.20	0.11	0.011	2.3	0.22	e3.6	e350	ND	--
Storm drain	February 3, 2009	02:35	Composite	e0.04	e0.002	2	0.1	6.9	0.33	1.92	0.092	38.2	1.8	--	--	--	--
Storm drain	February 3, 2009	16:32	Grab	0.11	0.0018	7	0.1	15.0	0.25	3.09	0.052	85.0	1.4	e6.3	e110	6.0	100
Xeriscape	February 3, 2009	06:32	Composite	0.08	0.02	7	2	9.9	2.4	1.58	0.38	48.9	12	--	--	--	--
Xeriscape	February 3, 2009	13:15	Composite	0.07	0.03	15	6.2	15.9	6.6	2.17	0.90	37.3	15	--	--	--	--
Xeriscape	February 3, 2009	18:27	Grab	< 0.06	< 0.01	3	0.7	e2.9	e0.66	0.26	0.059	9.4	2.1	e4.9	e1,100	ND	--
Quarantine	February 3, 2009	17:48	Grab	< 0.06	< 0.01	3	0.5	e3.2	e0.57	0.36	0.064	9.8	1.7	e4.9	e870	ND	--
Stadium	February 3, 2009	16:44	Grab	< 0.06	< 0.01	4	1	4.7	1.1	0.60	0.15	13.0	3.2	e4.8	e1,200	ND	--

^a Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl), to nitrogen, nitrite + nitrate, dissolved. If the concentration value of nitrogen, nitrite + nitrate dissolved, is estimated and below the minimum reporting level, the concentration value of total nitrogen is reported as the sum of the values shown for nitrogen, total organic + ammonia and nitrogen, nitrite + nitrate dissolved, and noted as estimated.

^b Organic nitrogen is calculated by subtracting nitrogen ammonia, dissolved, from total organic + ammonia (Kjeldahl). If the concentration value of nitrogen ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen. If the concentration value of nitrogen ammonia, dissolved is estimated and below the minimum reporting level, the concentration value of organic nitrogen is reported as the difference between the values shown for nitrogen, total organic + ammonia (Kjeldahl), and nitrogen ammonia, dissolved, and noted as estimated.

^c Oil and grease and Total petroleum hydrocarbons are analyzed at the Test America Laboratory in Arvada, Colorado.

Table 4. Physical properties, concentrations, and loads for all samples collected from H-1 Storm Drain during the period from July 1, 2008, to June 30, 2009, Oahu, Hawaii

[hh:mm, hours and minutes; Avg., value of average discharge for time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads, loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; N, nitrogen; #, discharge value from streamflow rating, all others are measured; e, value is estimated; --, not analyzed or measured; μS/cm, microsiemens per centimeter; °C, degrees Celsius; ft³/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; μg/L, micrograms per liter]

Date	Time	Sample type	Discharge	pH, lab (Std. Units)	Specific conductance (μS/cm at 25°C) reporting to nearest whole number	Total suspended solids		Total nitrogen ^a		Organic nitrogen ^b		Ammonia dissolved	
						Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)
			Avg. (ft3/s)										
Storm of November 15, 2008													
November 15, 2008	0518	Grab	# 4.9	--	--	--	--	--	--	--	--	--	--
November 15, 2008	0530	Composite	# 5.1	7.1	76	69	1,900	0.98	27	0.79	22	0.050	1.4
Storm of January 11, 2009													
January 11, 2009	0102	Composite	# 10	7.2	90	186	10,000	2.4	130	≤ 2.10	≤ 110	<0.020	<1.1
January 11, 2009	0357	Composite	# 18	7.3	50	79	7,700	0.88	85	0.71	69	0.051	5.0

Table 4. Physical properties, concentrations, and loads for all samples collected from H-1 Storm Drain during the period from July 1, 2008, to June 30, 2009, Oahu, Hawaii--Continued

[hh:mm, hours and minutes; Avg., value of average discharge for time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads,

loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; N, nitrogen; #, discharge value from streamflow rating, all others are measured; e, value is estimated;

--, not analyzed or measured; µS/cm, microsiemens per centimeter; °C, degrees Celsius; ft³/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; µg/L, micrograms per liter]

Date	Time	Sample type	Nitrogen, total organic + ammonia		Nitrogen, nitrite + nitrate dissolved		Phosphorus dissolved		Total phosphorus		Total cadmium		Total chromium	
			Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L as N)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)
Storm of November 15, 2008														
November 15, 2008	0518	Grab	--	--	--	--	--	--	--	--	--	--	--	--
November 15, 2008	0530	Composite	0.84	23	0.14	3.9	0.09	2	0.26	7.2	0.22	0.0061	9	0.2
Storm of January 11, 2009														
January 11, 2009	0102	Composite	2.1	110	0.28	15	0.15	8.1	0.73	39	0.55	0.030	25	1.3
January 11, 2009	0357	Composite	0.76	74	0.12	12	0.09	9	0.31	30	0.23	0.022	10	0.97

Table 4. Physical properties, concentrations, and loads for all samples collected from H-1 Storm Drain during the period from July 1, 2008, to June 30, 2009, Oahu, Hawaii--Continued

[hh:mm, hours and minutes; Avg., value of average discharge for time-composite samples; Conc., concentration; Load, computed from concentration value and discharge value for each sample, loads associated with grab samples are instantaneous loads,

loads associated with composite samples are average loads; <, actual value is less than the value shown; ≤, actual value is less than or equal to the value shown; N, nitrogen; #, discharge value from streamflow rating, all others are measured; e, value is estimated;

--, not analyzed or measured; μS/cm, microsiemens per centimeter; °C, degrees Celsius; ft³/s, cubic feet per second; mg/L, milligrams per liter; lbs/day, pounds per day; μg/L, micrograms per liter]

Date	Time	Sample type	Total copper		Total lead		Total nickel		Total zinc		Oil and grease		Total petroleum hydrocarbons	
			Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (µg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)	Conc. (mg/L)	Load (lbs/day)
Storm of November 15, 2008														
November 15, 2008	0518	Grab	--	--	--	--	--	--	--	--	12	320	e22	e580
November 15, 2008	0530	Composite	44.9	1.2	33.8	0.93	9.8	0.27	160	4.4	--	--	--	--
Storm of January 11, 2009														
January 11, 2009	0102	Composite	197	11	95.9	5.2	34.3	1.9	405	22	--	--	--	--
January 11, 2009	0357	Composite	60.9	5.9	44.1	4.3	13.1	1.3	139	13	--	--	--	--

^a Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl), to nitrogen, nitrite + nitrate, dissolved.

^b Organic nitrogen is calculated by subtracting nitrogen ammonia, dissolved, from total organic + ammonia (Kjeldahl). If the concentration value of nitrogen ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen.