BOARD OF WATER SUPPLY

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June 2, 2017

Mr. Bob Pallarino
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and

Mr. Steven Chang, P.E.
DOH Red Hill Project Coordinator
State of Hawaii
Department of Health
P.O. Box 3378
Honolulu, Hawaii 96801-3378

Dear Messrs. Pallarino and Chang:

Subject: Draft Synoptic Water Level Study Work Plan, Halawa Area, Oahu, Hawaii, Prepared by the United States Geological Survey (USGS) Pacific Islands Water Science Center Dated May 5, 2017

Thank you for the opportunity to review the subject work plan. We have the following comments to offer.

1. The work plan should include monitoring of the water levels in Halawa Shaft and near Moanalua Wells in order to define the difference in water levels between Red Hill and these water supply points. BWS Moanalua Wells Pump No. 3 does not currently operate and a transducer may be placed in this well to monitor water levels in the Moanalua Wells area.

2. The water levels and pumping rates at Aiea Halawa Shaft should be recorded because it was a major pumping point in Halawa Valley during 2016 according to Commission on Water Resources Management (CWRM) records.

3. We feel the monitoring period is too short to capture seasonal changes in pumping rates and recharge rates. The monitoring plan should extend for at least one year with quarterly interruptions for groundwater sample collection for those wells currently being sampled by the Navy.

4. The Board of Water Supply (BWS) has reviewed the graph showing the proposed groundwater withdrawal rates from Halawa Shaft and Moanalua Wells for the study period. The BWS is prepared to pump Halawa Shaft at a typical rate (10 million gallons per day [mgd]) and a high rate of 14 mgd during the Work Plan's proposed time period subject to our operational schedule and needs at the time of the test. Likewise, the BWS is also prepared to pump BWS Moanalua Wells at a typical rate of 2.5 mgd and a high rate of 5 mgd during the Work Plan's proposed time period subject to our operational schedule and needs at that time. Please contact Erwin Kawata at 808-748-5080 to coordinate BWS pumping operations. The Work Plan does not specify the typical and high rates of pumping for both Halawa Shaft and Moanalua Wells. Please provide further clarification.

5. Has the Navy committed to the pumpage study and at what typical and high rates will they pump Red Hill Shaft? Depending on what the withdrawal rates will be at Red Hill Shaft, this may require an adjustment to the withdrawal rates for Halawa Shaft and Moanalua Wells during the study period. Please clarify.

6. Page 1, Equipment, states that "groundwater levels will be manually measured…prior to deploying the pressure transducer and immediately following removal of the pressure transducer". Meanwhile, Page 2, Quality Assurance / Quality Control, states that "the current plan is to use separate sets of equipment in each well to avoid well cross-contamination issues…therefore, no on-site cleaning will be necessary". How many separate, cleaned and calibrated water level measuring tapes will be used for this study? The BWS assumes only some of the wells will be measured and outfitted each day, until the entire list of wells is outfitted. Please clarify.

7. Page 3, Monitoring Plan, acknowledges that two of the monitoring wells are already being monitored by BWS (Halawa T-45 and Manaiki T-24). Similar to the last synoptic water level survey, the BWS prefers to not install additional monitoring equipment in these wells. The BWS has alerted our Hydrology-Geology staff to make sure that the existing water level dataloggers are configured for 10-minute data collection intervals, in preparation for this study. The BWS has also alerted our Hydrology-Geology staff to avoid conductivity logging of the Kaamilo, USGS Halawa, or Moanalua Deep Monitoring Wells

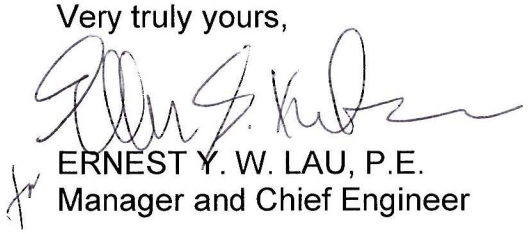
during the study. The USGS will have pressure transducers installed in them, and these should not be disturbed until USGS retrieves them.

8. Figure 1 can be misleading in terms of well ownership. The BWS recommends including well owner information in parentheses, next to well IDs on Figure 1, or a separate figure showing well ownership.

9. Is the draft Work Plan going through legal review? Perhaps additional language is needed (e.g. all parties involved provide data or access to wells in a timely manner, USGS is the final reviewer and reporter of compiled water level data, etc.).

If you have any questions, please feel free to contact Erwin Kawata at 808-748-5080.

Very truly yours,



for ERNEST Y. W. LAU, P.E.
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DRAFT Synoptic Water Level Study Work Plan
Hālawa Area, Oʻahu, Hawaiʻi
U.S. Geological Survey, Pacific Islands Water Science Center
May 5, 2017

Introduction

Improving the understanding of the groundwater-flow system in the Hālawa area, Oʻahu, Hawaiʻi, is critical to evaluating the potential fate of contaminants that could be introduced to the groundwater body and the potential for these contaminants to affect the quality of water withdrawn by existing production wells in the area. Monitoring groundwater-level responses to changes in the spatial and temporal distributions of withdrawals provides data that can be used to better understand and estimate aquifer hydraulic properties. These groundwater-level responses also provide insight into the potential presence of barriers of geologic origin, including volcanic dikes or valley-filling sedimentary deposits and underlying weathered basalt, which could have an important role in controlling the rate and direction of groundwater flow. Data collected as part of this monitoring effort will be useful for calibrating numerical groundwater models that are designed to simulate groundwater flow in the Hālawa area.

Purpose and Scope

The purpose of the continuous water-level monitoring is to provide data that will lead to an improved understanding of the groundwater-flow system in the Hālawa area. Groundwater levels will be monitored in 21 wells (fig. 1) over a three-month period to document spatial and temporal variations in groundwater levels under typical and controlled withdrawal conditions. An attempt will be made to coordinate controlled withdrawal conditions designed to provide data that can be used to interpret the short-term, aquifer-wide response of the aquifer to withdrawals. Groundwater-level data collected as part of this effort will be made publicly available online through the National Water Information System (NWIS) database.

Equipment

The equipment for this monitoring effort consists of (1) water-level measuring tapes, and (2) pressure transducers. Groundwater levels will be manually measured, with either an electric tape or a steel tape marked with chalk, prior to deploying the pressure transducer and immediately following removal of the pressure transducer. The pressure transducer will be connected to a 15- to 25-foot length of vented polyurethane communication cable, which will be suspended from the top of the well with a stainless-steel cable.

Pressure transducers will be installed in wells as needed (three actively monitored wells already are equipped with groundwater-level monitoring equipment). Vented pressure transducers with an accuracy of 0.01 foot will be used to monitor groundwater levels in wells without existing groundwater-level monitoring equipment and also in wells with existing equipment that may not be of sufficient accuracy. In some small-diameter wells, use of non-vented pressure transducers of lower accuracy may be necessary because of the possible need to maintain a seal on the well, which may preclude the

option of leaving the vented parts of the equipment outside the well. Four barometers will be installed at two selected locations within the Red Hill tunnel and also two locations outside the facility. Data from the barometers are needed for (1) correcting groundwater-level data from non-vented pressure transducers such that the data reflect the effects of groundwater-level changes only, and (2) understanding the semidiurnal and longer-term changes in groundwater levels associated with barometric-pressure variations.

Quality Assurance/Quality Control

All pressure transducers (each having a temperature sensor) used for this monitoring effort will be tested by the U.S. Geological Survey (USGS) at the Pacific Islands Water Science Center (PIWSC) laboratory prior to use. The accuracy of the temperature sensors will be evaluated in the laboratory using a National Institute of Standards and Technology (NIST) certified thermometer as a reference. Each temperature sensor will be checked for accuracy at five different temperatures within the temperature range of about 10°C to 30°C, which spans the range of groundwater temperatures in the Hālawa area. The pressure sensors will be evaluated in the laboratory for linearity over the depth range of interest using a static water column. In addition, an in-well calibration will determine the slope of the pressure-depth relation under representative ambient groundwater conditions. The pressure-depth relation will be used to determine the magnitude of groundwater-level changes recorded in the well.

Manual groundwater-level measurements using calibrated steel or electric tapes will be made immediately prior to deployment of equipment and immediately following any removal of equipment from the well. The manual groundwater-level measurements will reflect the best available measuring-point altitudes of each well (generally the altitude at the top of the well casing), and these manual measurements will be used to ensure consistency with the recorded groundwater levels. Manual groundwater-level measurements will be made following standard PIWSC protocol, which requires that a check measurement be made by the field personnel immediately following the initial measurement.

All equipment that contacts water in the well will be cleaned in the PIWSC laboratory prior to use in the field to ensure that the equipment is not a source of contaminants that could affect ambient concentrations of constituents. In the PIWSC laboratory, equipment will be soaked and scrubbed using a 0.1- to 2-percent solution of non-phosphate detergent, followed by a tap-water rinse to remove the detergent solution, and then a deionized-water rinse. If necessary, the wetted parts of the tape also will be cleaned with an appropriate solvent to avoid introducing contaminants to or causing cross-contamination between wells. Equipment will be stored in clean, disposable plastic bags for storage and transport prior to use. The current plan is to use separate sets of equipment in each well to avoid well cross-contamination issues; therefore, on-site cleaning will be unnecessary. Thus, no investigative-derived waste will be generated on site.

Monitoring Requirements

All existing water-sampling equipment in wells will need to be removed from the well at least one week prior to planned installation of groundwater-level monitoring equipment. The removal of sampling equipment is necessary to allow access for PIWSC equipment, ensuring the accurate measurement of

groundwater levels. Furthermore, moisture on the inside of the well casing, caused by removal of sampling equipment, will hinder accurate measurement of groundwater levels, and early removal of the sampling equipment will allow some of this moisture to drain. The planned date of installation of groundwater-level monitoring equipment will be scheduled in coordination with the U.S. Navy (USN) and other affected parties. Access to wells in the USN Red Hill facility for reconnaissance and data collection will be required from the USN. All field work will be conducted by trained USGS personnel and scheduled on week days (Monday through Friday) during the hours of 7:00 a.m. to 5:00 p.m., in coordination with the USN.

Monitoring Plan

Groundwater levels will be monitored for a period of three months in 21 wells in the Hālawa area (fig. 1) and will be recorded at 10-minute intervals. Details of the monitoring plan are provided below.

Groundwater levels will be monitored during a three-month period within the June to September, 2017 time frame. The starting date of monitoring is dependent on (1) identification of monitoring-equipment requirements by USGS, (2) USGS receipt and testing of the monitoring equipment that will be purchased by the USN, and (3) coordination of groundwater-withdrawal schedules with the Honolulu Board of Water Supply (HBWS) and USN. In general, withdrawal scenarios that are potentially achievable, minimally disruptive, and meaningful (covering a range of hydrologic conditions) could be considered and include: (1) withdrawing water from Hālawa Shaft at a high rate while Red Hill Shaft is off, (2) withdrawing water from Red Hill Shaft at a high rate while Hālawa Shaft is withdrawing water at typical and steady rate, and (3) withdrawing water from the Moanalua wells at a high rate while both Hālawa Shaft and Red Hill Shaft withdraw water at typical, steady rates (fig. 2). The desired duration of each scenario is on the order of seven to ten days, although practical considerations related to water demand, storage capacity, or equipment limitations may constrain the duration. Ideally, withdrawals from other wells in the vicinity of the Hālawa area would be maintained at steady rates during the three-month period, although water-demand considerations may make this difficult to achieve in practice.

Groundwater levels will be monitored in 21 existing wells in the Hālawa area (fig. 1), provided access or safety considerations do not preclude monitoring of wells. The 21 wells include three wells that are actively being monitored for groundwater levels; two are being monitored by HBWS and one is being monitored by the Hawaii Commission on Water Resource Management (CWRM). Data requirements will be discussed with HBWS and CWRM to evaluate whether additional monitoring equipment is necessary, and if so, whether installation of additional equipment would be possible. A reconnaissance of wells within the USN Red Hill facility will be needed to determine the appropriate type of equipment to use and how the equipment will be secured at the top of the well.

Groundwater levels will be recorded using a ten-minute recording interval. The 10-minute recording interval is designed to (1) provide data of sufficient temporal resolution to estimate regional-scale aquifer properties (not local properties near individual wells), (2) understand how groundwater levels are affected by semidiurnal changes in barometric pressure, and (3) manage the effort required to process and check data in a timely manner. A higher-frequency recording interval may be useful for

understanding early-time responses to withdrawals from ideal vertical wells of known diameter and with known vertical distribution of inflow. However, because of uncertainties related to the geometry of the infiltration tunnels in the Red Hill area and the spatial and temporal distributions of inflows along the lengths of the infiltration tunnels under prevailing withdrawal conditions, collection of higher-frequency data and analysis of early-time data (collected within the first ten minutes following a change in withdrawal rate) are unlikely to result in reliable estimates of aquifer properties. The longer-term (hourly to daily) response to changes in withdrawal conditions will provide more reliable regional estimates of aquifer hydraulic properties.

Critical Data Need

Information on withdrawal rates is critical to properly evaluate the hydrologic response of the groundwater system to changes in withdrawals. Withdrawal rates recorded using a ten-minute recording interval (or more frequent) are needed from all large production wells near the Hālawa area. These data are typically available from supervisory control and data acquisition (SCADA) systems, and will be requested from appropriate agencies for the benefit of all stakeholders.

Data Archiving and Access

All groundwater-level data collected for this monitoring effort will be made publicly available through the National Water Information System (NWIS) database. Preliminary data will be made publicly available as soon as possible (within about 30-45 days following completion of data collection) and will require a standard USGS check and review process before being approved and released as final data through NWIS. All data will be approved and released as final data through NWIS prior to the end of 2017.

Reporting

A draft report documenting the data collected during the monitoring period will be prepared within 60 days following the completion of the monitoring. The non-interpretive report will be provided to subject matter experts for comment (two-week comment period) and also will follow the standard USGS review, approval, and publication process. The final report is expected to be published and made available on the internet by March 2018.

Coordination

Successful completion of the monitoring will require coordination among the USN, HBWS, CWRM, U.S. Army, private land owners, and USGS. The following is a list of items that will need to be addressed prior to and possibly during the monitoring effort.

1. USGS will coordinate access to monitor wells with individual well and land owners.
2. USGS will communicate with USN, HBWS, and the U.S. Army about the need to remove existing water-sampling equipment from wells to allow groundwater-level monitoring equipment to be installed. Groundwater-level monitoring will be scheduled during the period between quarterly

water-sampling dates to avoid interruption of the groundwater-level record and issues caused by wetting the inside of the casing.

3. USGS will identify wells in which installation of vented pressure transducers is problematic. This mainly is expected to be a potential issue associated with small-diameter wells in the Red Hill tunnel.
4. USGS will communicate with HBWS and CWRM on whether existing groundwater-level monitoring equipment in wells can be used to meet monitoring objectives.
5. USGS will communicate with USN on the equipment that needs to be purchased once the monitoring needs have been fully identified.
6. USGS will communicate the desire for USN and HBWS to retain and share their SCADA withdrawal data from relevant production wells in the Hālawa area.
7. Coordination and cooperation between USN and HBWS will be needed to develop meaningful and achievable withdrawal schedules from high-capacity production wells that are capable of causing measurable regional groundwater-level changes in the aquifer.

Schedule

Table 1. Proposed schedule of tasks related to Red Hill groundwater-level monitoring, 2017—18.

	2017								2018		
Task	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Coordination	x	x									
Equipment acquisition	x	x									
Equipment testing	x	x									
Equipment deployment		x	x								
Monitoring		x	x	x	x						
Equipment removal					x						
Data processing and release						x	x	x			
Report draft						x	x				
Report review and release							x	x	x	x	x

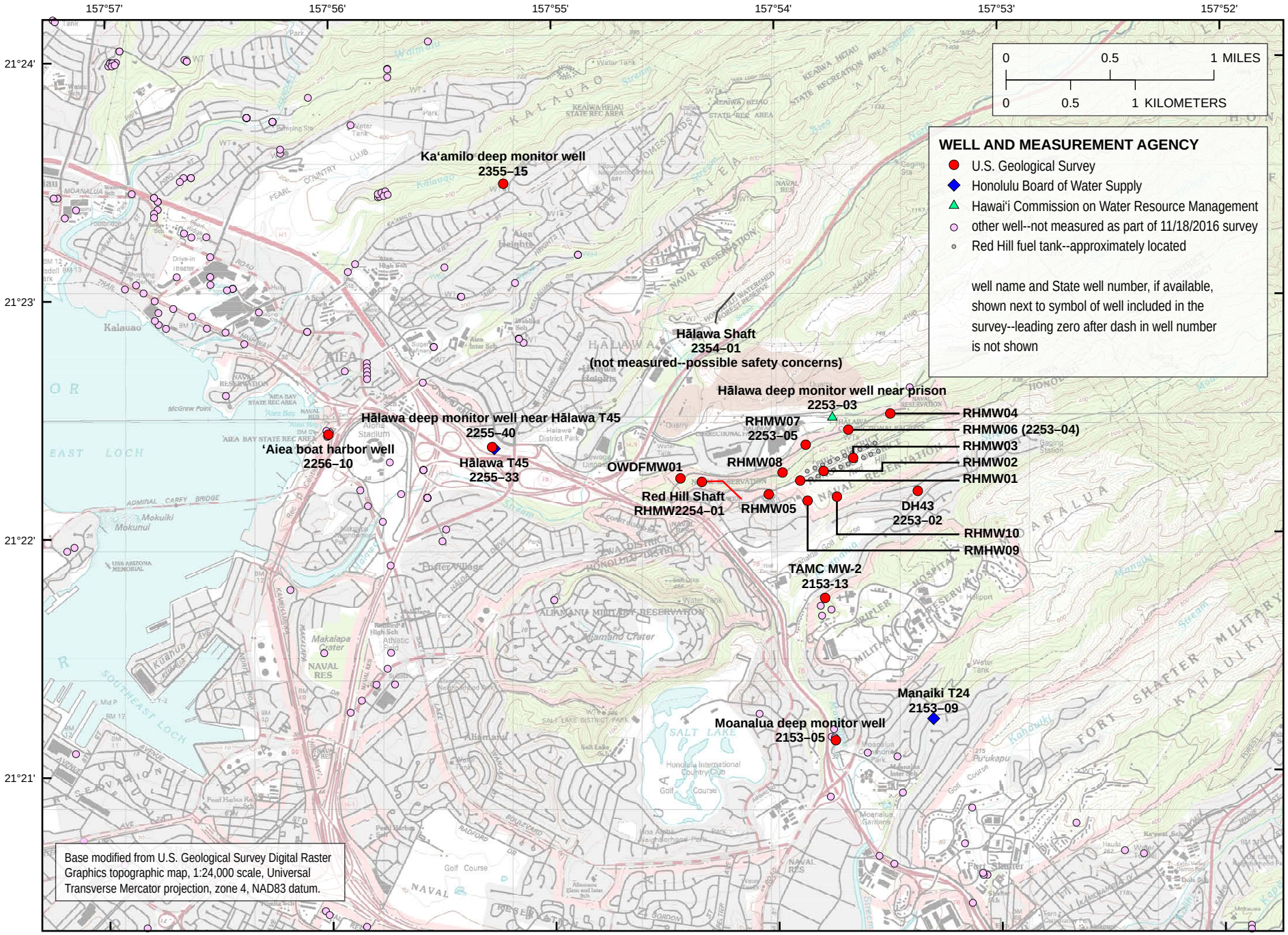

Figure 1. Proposed wells to be monitored during a three-month period of 2017, Hālawa area, O'ahu, Hawai'i.

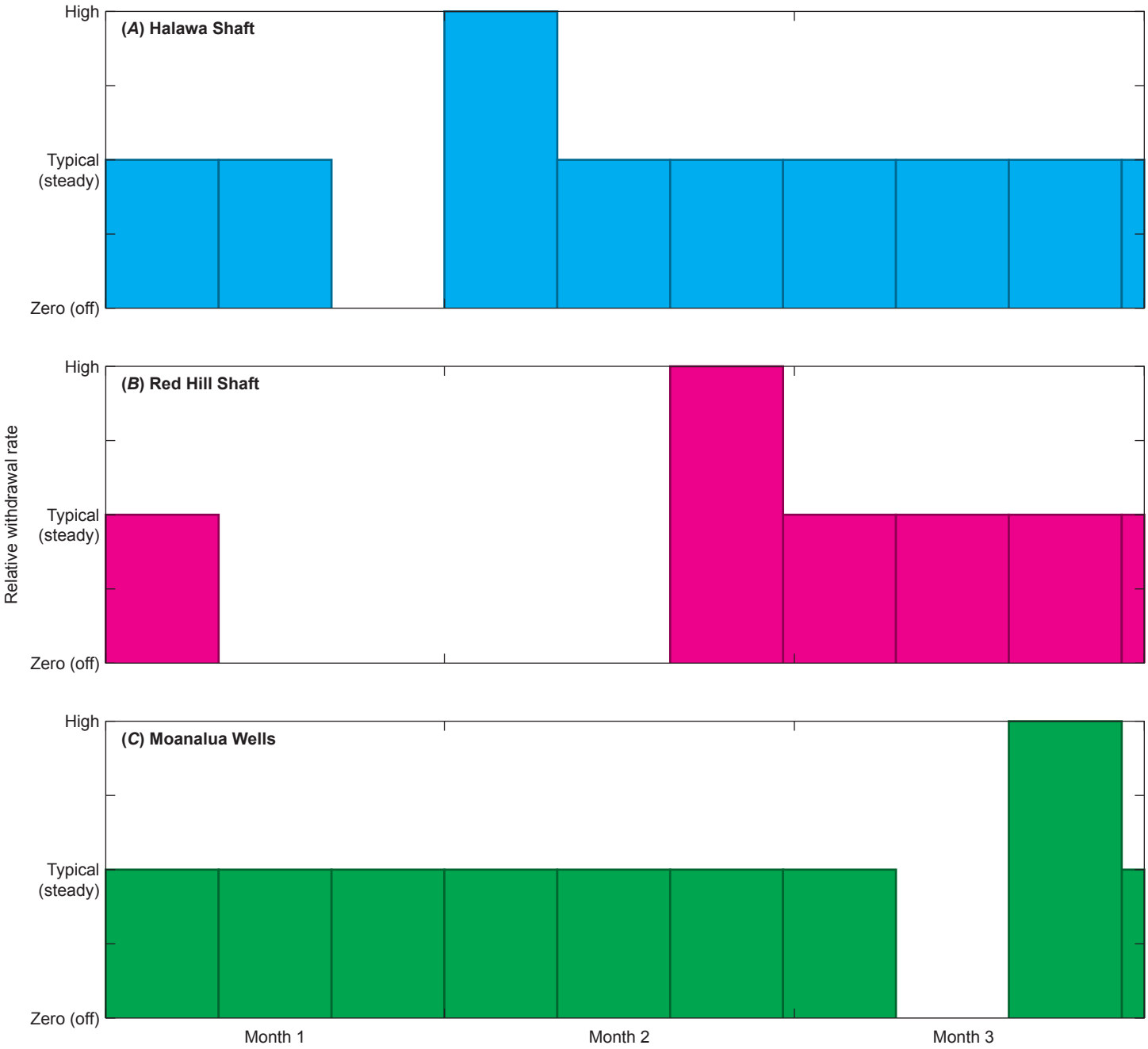

Figure 2. Proposed withdrawal rates from (***A***) Halawa Shaft, (***B***) Red Hill Shaft, and (***C***) Moanalua Wells during a three-month monitoring period, 2017.