



Streamflow Monitoring

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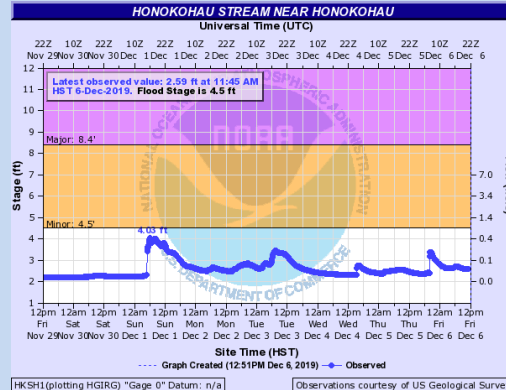
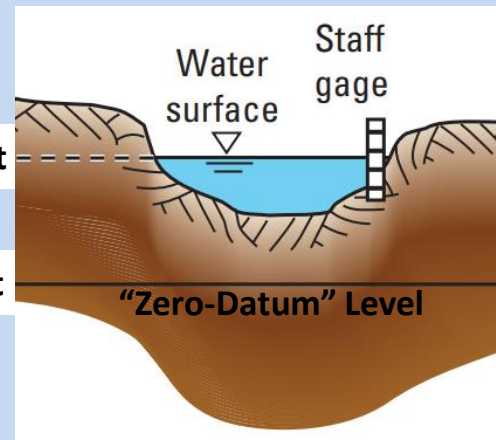
Streamflow Monitoring

Outline of presentation

- What are stream stage and streamflow?
- How are stream stage and streamflow measured?
- What is a stream gage?
- How to find USGS water data on the internet
- Limitations of provisional real-time data
- How USGS quality-assures data
- Details about some of the stream gages in this area

What is Stream Stage?

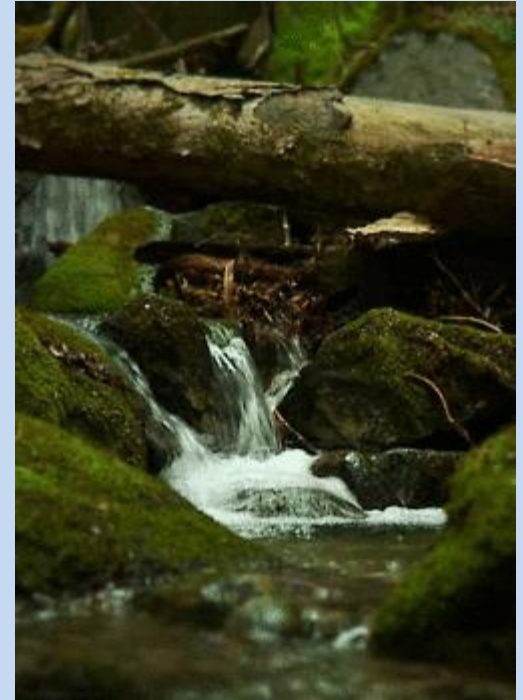
- The height of the water surface of a stream above a “local datum” at the station, usually measured in feet
- The level where the local datum equals zero is generally just below the bed of the stream, so stage is often roughly the stream depth at the station
- The National Weather Service bases flood levels and flood warnings on stream stage, often measured and provided by USGS



What is Streamflow?

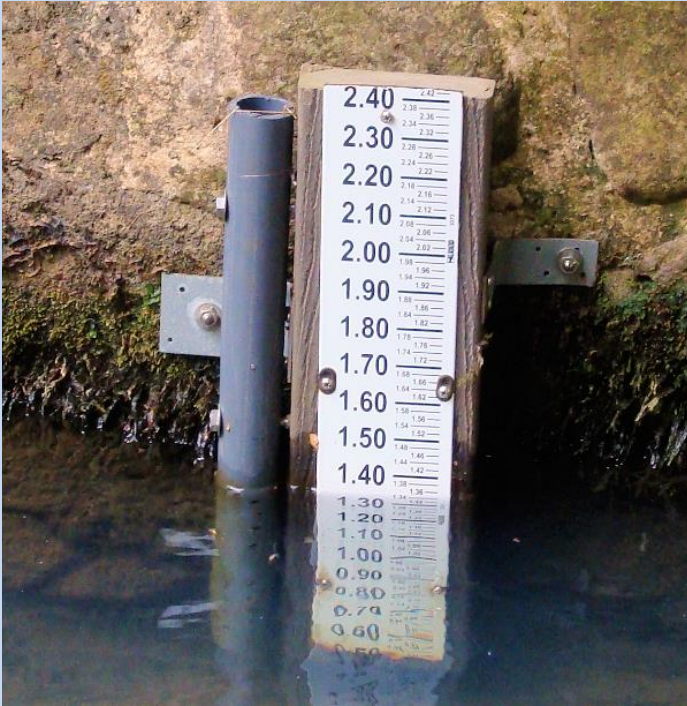
- Also called “Discharge”
- Volume of water passing through the width of a stream at a location in a specific amount of time
- Usually reported in million gallons per day (mgd) or cubic feet per second (cfs)
 - USGS reports flow in cfs
 - 1 mgd = 1.55 cfs | 1 cfs = 0.65 mgd
- The State of Hawai‘i establishes Interim Instream Flow Standards (IIFS) in specific locations to protect the public interest in the waters of the state

Location	Interim Instream Flow Standard
Kaua‘ula Stream below ditch	3.36 mgd (5.2 cfs)
Wailuku River at Īao Valley Road	10.0 mgd (15.5 cfs)



Terms to Remember

Stream Stage



(in feet)

Stream flow



(in cfs or mgd)

Streamflow Monitoring

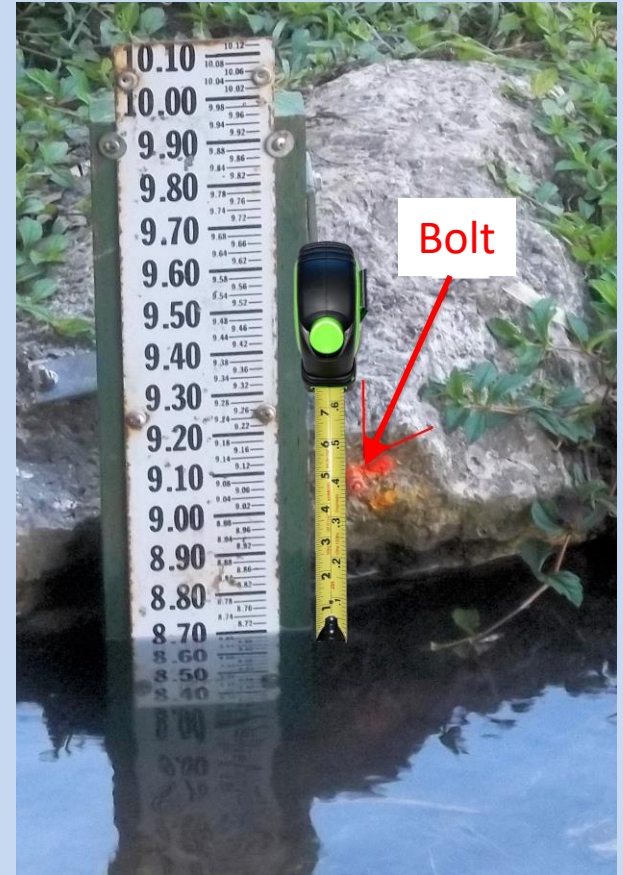
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How is Stream Stage measured?

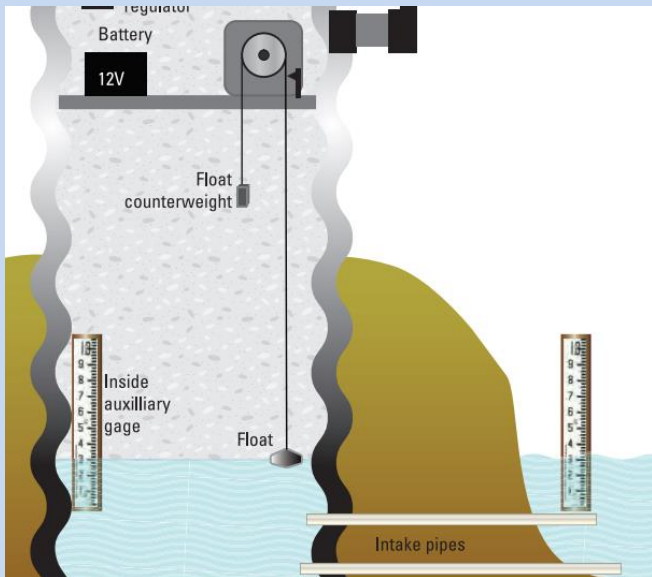
Manually

- Read directly from a “staff plate”
- Measured with a ruler from a point with a known elevation, down to the water surface (bolt at 9.09 feet – 0.40 feet = 8.69 feet)
- These methods are accurate, but require a person to visit the station



How is Stream Stage measured? *Automatically and Continuously*

Method 1: Float and pulley system



*USGS Station on Hālaulani Stream near
Kīlauea, Kaua'i*

How is Stream Stage measured? *Automatically and Continuously*

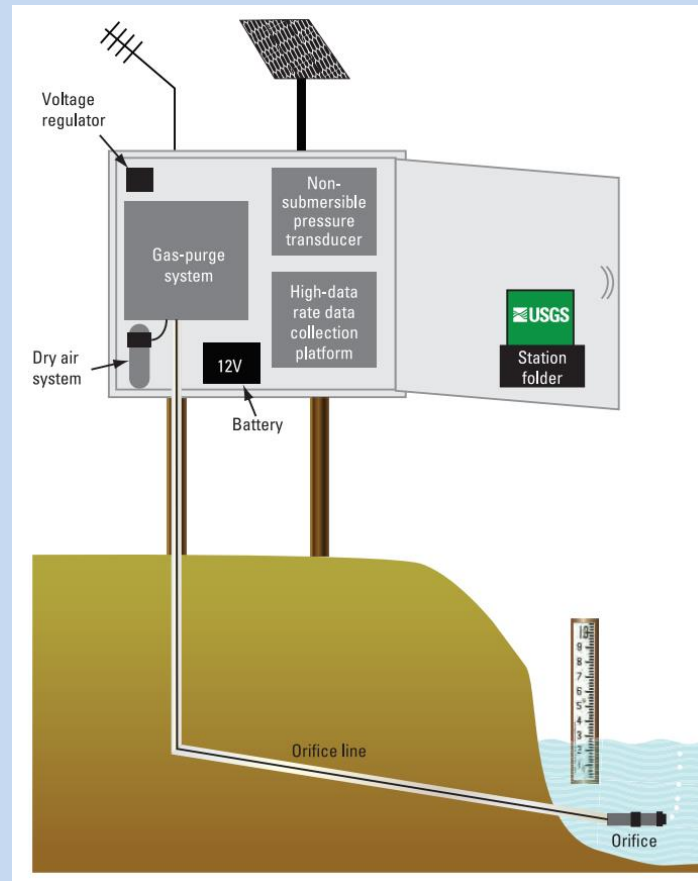
Method 2: Pressure sensors



USGS Station on Wailuku River at
Kepaniwai Park, Maui

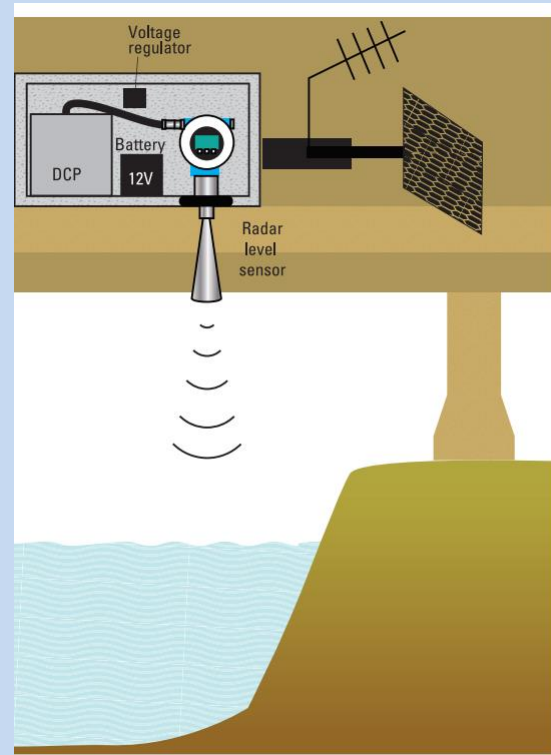


USGS Station on Hanakāpī'ai
Stream, Kaua'i



How is Stream Stage measured? *Automatically and Continuously*

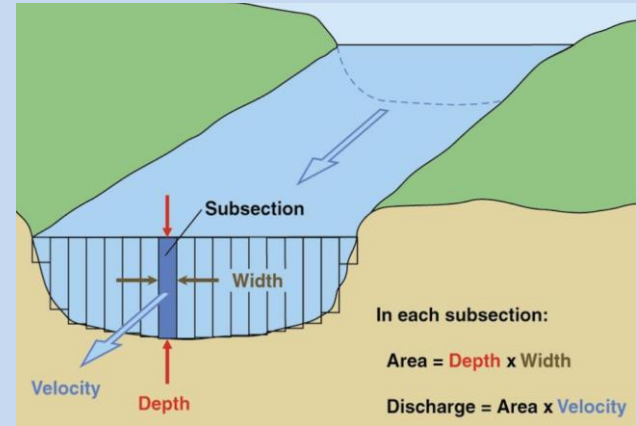
Method 3: Radar sensor



How is Streamflow measured?

Manually

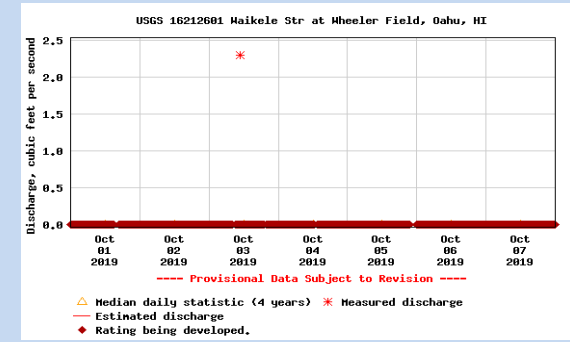
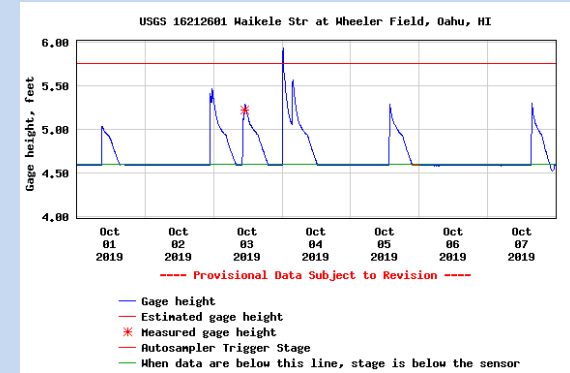
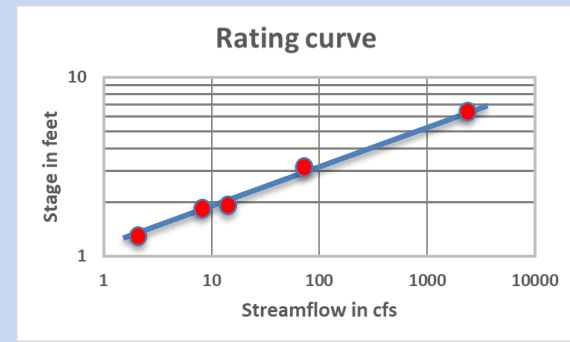
- Measuring tape is stretched across the stream
- A hydrographer wades in the stream and divides the width into about 25 “sub-sections”
- The width and depth of each subsection are measured
- The average water velocity in each subsection is measured with a velocity meter
- The flow in each sub-section is $\text{Width} \times \text{Depth} \times \text{Velocity}$
- The total flow in the stream is the flow in all of the sub-sections added together



How is Streamflow measured?

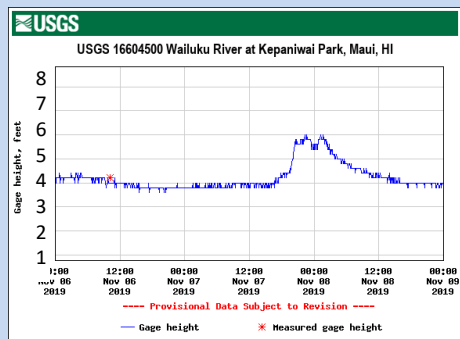
Automatically and Continuously

- Streamflow cannot be “measured” continuously
- We compute a continuous streamflow record using stage and a “rating curve”
- After a gage is installed, we start making manual streamflow measurements
- We need to make several measurements, covering a range of flows, which usually takes 4–12 months
- Once we have sufficient measurements, we determine the relation between stage and flow (the rating curve), and start computing streamflow in real-time
- Following the installation of a new gage, the USGS website will only report stage and not streamflow until the rating curve is developed

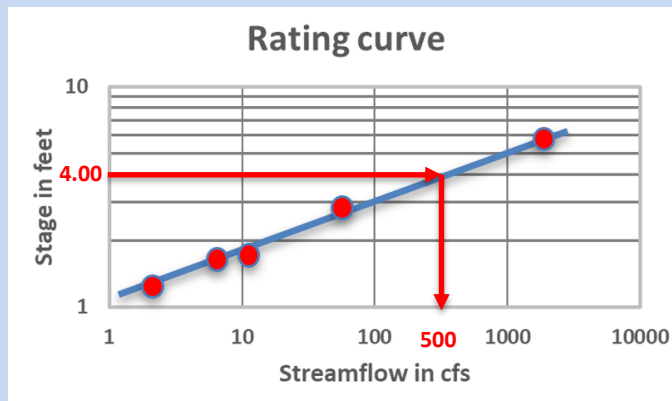


How is Streamflow measured?

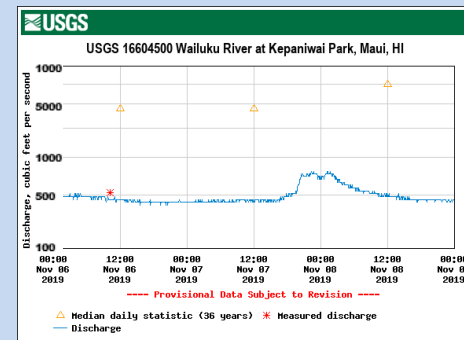
Automatically and Continuously



Measure stage
continuously
(in feet)



Convert stage to flow using a
“Rating curve”
(calibrated with recent manual
measurements)



Result is continuous
streamflow record
(in cfs)

Streamflow Monitoring

Outline of presentation

- What are stream stage and streamflow?
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- **What is a stream gage?**
- How to find USGS water data on the internet
- Limitations of provisional real-time data
- How USGS quality-assures data
- Details about some of the stream gages in this area

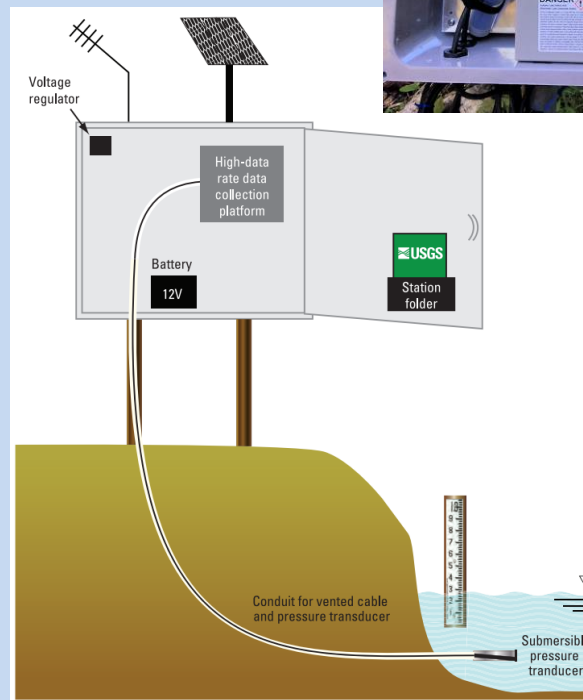
What is a “Stream Gage”?

Monitoring station that:

- Measures stream stage continuously using an electronic sensor
- Records and transmits those stages to the USGS using a small computer with a built-in radio
- Uses a small battery that is charged with a solar panel for power
- Has “reference points” and sometimes “staff plates” for manually measuring stage



Use of product/trade names does not imply endorsement



Important details about USGS Stream Gages

Process for their establishment

- A group (often a governmental agency) has a need and funding for a stream gage in a particular location
- If the data from the gage can be used to meet the USGS's mission of:
 - providing reliable scientific information to describe and understand the Earth
 - minimizing loss of life and property from natural disasters
 - managing water resources

then we generally move forward with siting the gage and obtaining needed permissions to install it



Kepuni Gulch, Maui

Important details about USGS Stream Gages

Why they are located where they are

- The purpose of a stream gage is the primary factor considered when deciding where to place it
- Other factors that may affect siting
 - Monitoring flow above or below diversions
 - Flood warning
 - Monitoring for regulatory compliance
 - Landowner, environmental, or other requirements
 - Accessibility to locations (legal and physical)
 - Tributary inflows or diversions from streams
 - Channel shape and stability
 - Pools are best
 - Channel reaches full of boulders or material that shifts during medium to high flows are poor



Wailuku River Basin, Maui



He'eia Stream, O'ahu

Important details about Stream Gages

How they are installed

- Stream is visited, site is selected, and then an installation plan is developed
- Extensive permitting process can take a year or more (right-of-entry, environmental, cultural-historical considerations)
- Installation of station
 - Pour a small cement pad on the ground above the expected peak-flood level
 - Mount a stand on the pad
 - Attach instruments, shelter, antenna, and solar panel
 - Run bubble tube or sensor with cable in flexible conduit from the shelter to the stream along the surface of the ground



Important details about Stream Gages

How they are maintained

- **USGS generally visits the stations every 8 weeks, or sooner if:**
 - **An urgent repair is needed**
 - **Conditions warrant an unscheduled streamflow measurement (high flow or obvious calibration problem)**
- **Visits generally include:**
 - **Manual measurements of stage and streamflow, so both data sets can be calibrated**
 - **Trimming of vegetation to maintain access**
 - **Maintenance of instruments and shelter (paint, change batteries, repair/replace equipment)**
 - **Periodic surveying to verify reference points and staff plates**



USGS surveying at La Sa Fua River, Guam

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USGS Water Data on the Internet

Where to find it

- usgs.gov/piwsc
- Can also Google “USGS water Hawaii”

USGS Current Water Data for Hawaii

<https://waterdata.usgs.gov/nwis>

Daily Streamflow Conditions. Select a site to retrieve data and station information. Stream gage levels in Hawaii, relative to 30 year average.

USGS
science in a changing world

Pacific Islands Water Science Center

Pacific Islands Quick Links

Current (real-time) conditions
Water data

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National Water Information System: Web Interface

USGS Water Resources (Default Area)

Click to hide News Bulletins

- Introducing The Next Generation of USGS Water Data for the Nation
- Full News

USGS Current Water Data for Hawaii

Click to hide state-specific text

Predefined displays: Introduction

Daily Streamflow Conditions

Select a site to retrieve data and station information.

Tuesday, December 10, 2019 10:16:11

Pacific Islands Streamflow Current Conditions

Pacific Islands Precipitation Current Conditions

Pacific Islands Reservoir Current Conditions

Pacific Islands Groundwater Current Conditions

All Pacific Islands Current Condition sites

Current data typically are recorded at 15- to 60-minute intervals, stored onsite, and then transmitted to USGS offices every 1 to 4 hours, depending on the data relay technique used. Recording and transmission times may be more frequent during critical events. Data from current sites are relayed to USGS offices via satellite, telephone, and/or radio telemetry and are available for viewing within minutes of arrival.

All real-time data are **provisional and subject to revision**.

Build Current Conditions Table

Build Time Series

Explanation

- 90th percentile
- 75th - 90th percentile
- 25th - 75th percentile
- 10th - 25th percentile
- 10th percentile
- Low
- Not ranked

The colored dots on this map depict streamflow conditions as a **gageplus**, which is computed from the period of record for the current day of the year. Only stations with at least 30 years of record are used.

The **gray circles** indicate other stations that were not ranked in percentiles either because they have fewer than 30 years of record or because they report parameters other than streamflow. Some stations, for example, measure stage only.

Current Conditions for Hawaii: Streamflow -- 82 site(s) found

PROVISIONAL DATA SUBJECT TO REVISION

Streamflow in Hawaii is monitored in cooperation with State, County, and other Federal agencies.

Predefined displays: Streamflow Data

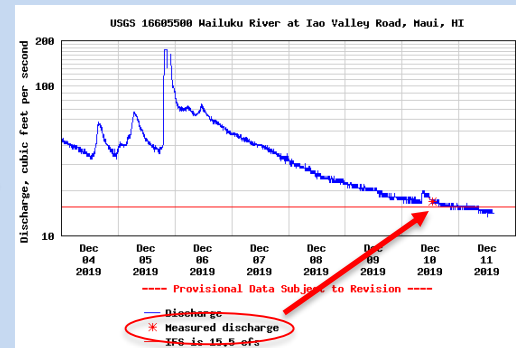
Group table by: and county

Select sites by number or name: 82

Show map on a map

Customize table to display other current-condition parameters

Station Number	Station name	Date/Time	Gage height, feet	Discharge, cfs	Long-term median flow, 12/10
16010000	Kawaikoi Stream nr Waimea, Kauai, HI	12/10 15:20 HST	2.15	7.18	20.0
16019000	Waialeale Str at alt 3,820 ft nr Waimea, Kauai, HI (backup)	12/10 15:55 HST	0.95	2.05	12.0
16031000	Waimea River near Waimea, Kauai, HI	12/10 14:40 HST	0.93	---	---
16033000	Waimea River near Waimea, Kauai, HI	12/10 15:30 HST	6.27	43.2	39.0
16036000	2-Makalele River nr Waimea, Kauai, HI	12/10 15:00 HST	4.59	52.7	49.0
16040000	2-Hanalepe Riv b/w Manuahi Str nr Eleele, Kauai, HI	12/10 15:30 HST	1.78	71.8	43.0
16060000	SF Waialua River nr Lihue, Kauai, HI	12/10 15:45 HST	2.89	88.8	63.0
16058000	EB of Np Waialua River nr Lihue, Kauai, HI	12/10 15:15 HST	0.50	35.9	33.0
16071500	Left Branch Opaekea Str nr Kapaa, Kauai, HI	12/10 15:45 HST	1.04	3.54	2.40
16094150	Ka Loko Reservoir near Kilauea, Kauai, HI	12/10 15:45 HST	20.80	---	---



Manual calibration measurements, show up as red stars (*)

USGS Water Data on the Internet

What data are available

- **Types**

- **Stream stage and flow**
- **Reservoir stage (not currently on Maui)**
- **Rainfall**
- **Groundwater level**
- **Water temperature**
- **Water specific conductance**
- **Water-quality samples**
- **Many other types for historical data**

- **Places**

- **15 stations with real-time data on Maui**
- **100 stations with real-time data across Hawai'i**
- **Thousands of historical stations across Hawai'i**



Active USGS real-time hydrologic monitoring stations

Streamflow Monitoring

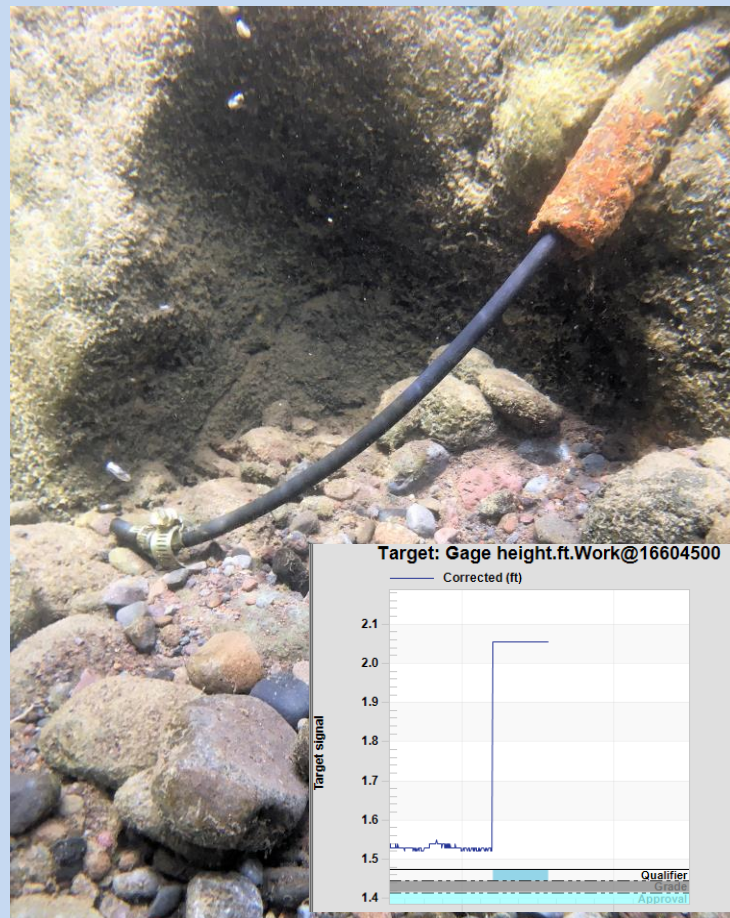
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USGS Water Data on the Internet

Potential issues with real-time stage data

- Current stage values are generally accurate
- Readings from sensors that use pressure to measure stage are more susceptible to problems, which include:
 - Being moved
 - Being buried or plugged by low-permeability material
 - Gas leaks (gas-purge systems)
 - Temperature or air-pressure compensation issues

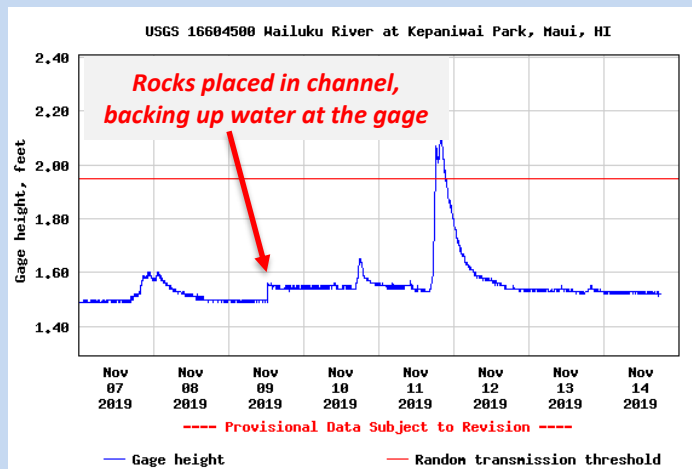


Stage sensor “bubble-line” moved out of its protective pipe deeper in the stream, causing the reported stage to rise

USGS Water Data on the Internet

Potential issues with real-time streamflow data

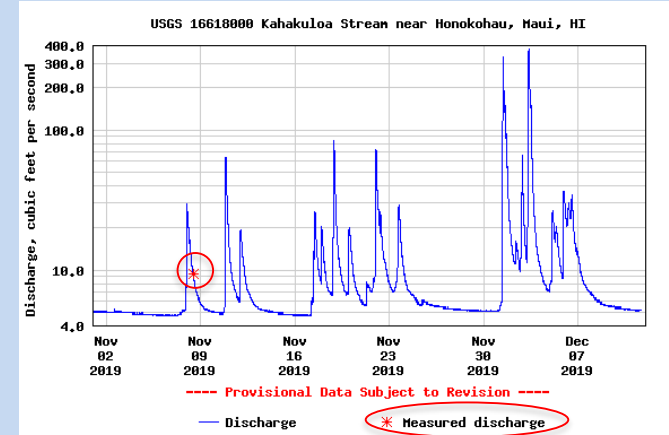
- Reporting accurate current values of streamflow is very challenging, and data can have errors
- Changes to the shape of the stream channel near a gage can throw the rating curve out of calibration
- Common sources of channel changes that affect the accuracy of current (real-time) streamflow data are:
 - Flow moving rocks or vegetation in the channel
 - People moving rocks in the stream
 - Changing vegetation growth in the stream
 - Trees or other debris falling in the channel



USGS Water Data on the Internet

Potential issues with real-time streamflow data

- The longer it has been since a manual measurement was made (*), the more likely it is that the reported streamflow is in error due to a rating curve that is out of calibration
- Stage errors (though uncommon) will cause errors in the computed streamflow data
- Data errors are corrected after manual measurements of flow are made, calibrations and other adjustments are applied, and the records are thoroughly analyzed and reviewed

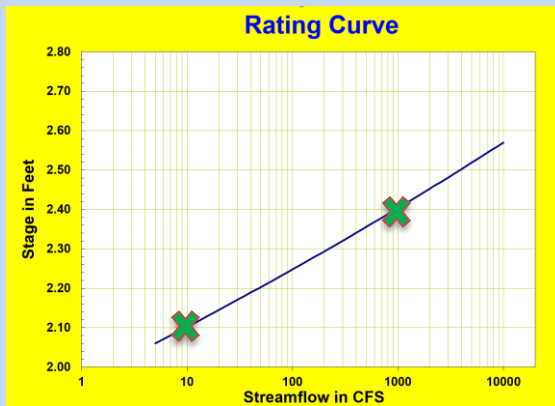
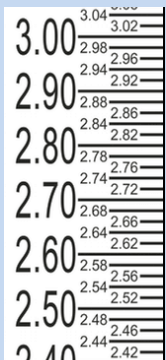


Last manual calibration measurement was 34 days ago

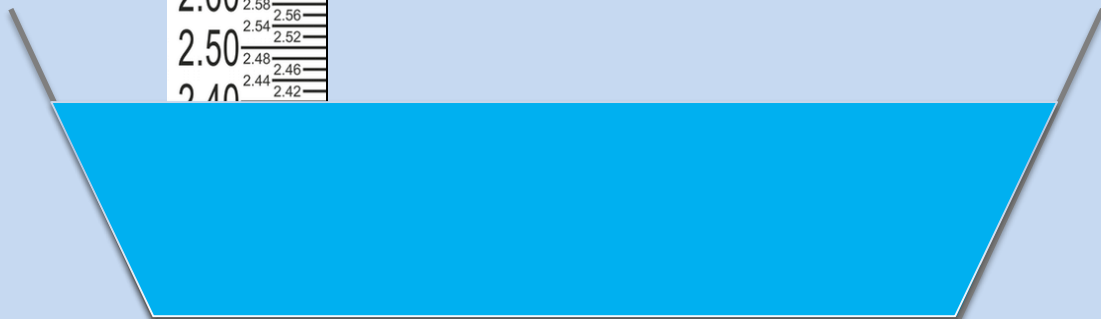


Fallen tree in Waikāne Stream, O'ahu

Rating "Shifts" Stable channels



Stable natural stream channel at Wailuku River near Pi'ihonua, Island of Hawaii



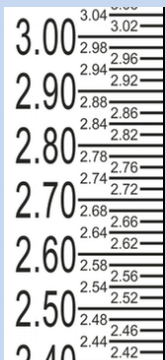
FLOW = 1,000 cfs



Stable concrete-lined stream channel at Kahoma Stream, Lahaina, Maui

Rating "Shifts"

Unstable channels



*Stream channel with variable amounts of vegetation
Alakahi Stream, Island of Hawai'i*



FLOW = 1,000 cfs



*Unstable stream channel full of loose, shifting rocks
Waihe'e Stream, Maui*

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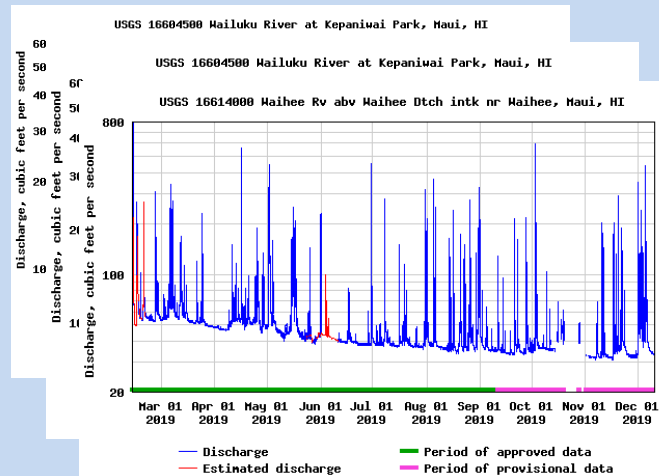
USGS Water Data on the Internet

How data are quality-assured

- Recent provisional data are evaluated weekday mornings by USGS staff for potential issues
- Data that are considered to have issues are removed or hidden until they can be corrected or estimated
- After calibration measurements are made on site, staff make any needed adjustments to the data
- An experienced scientist reviews the data, and “approves” the data when the record is determined to be accurate
- Annually, data are reviewed again by an independent senior scientist



USGS staff reviewing data



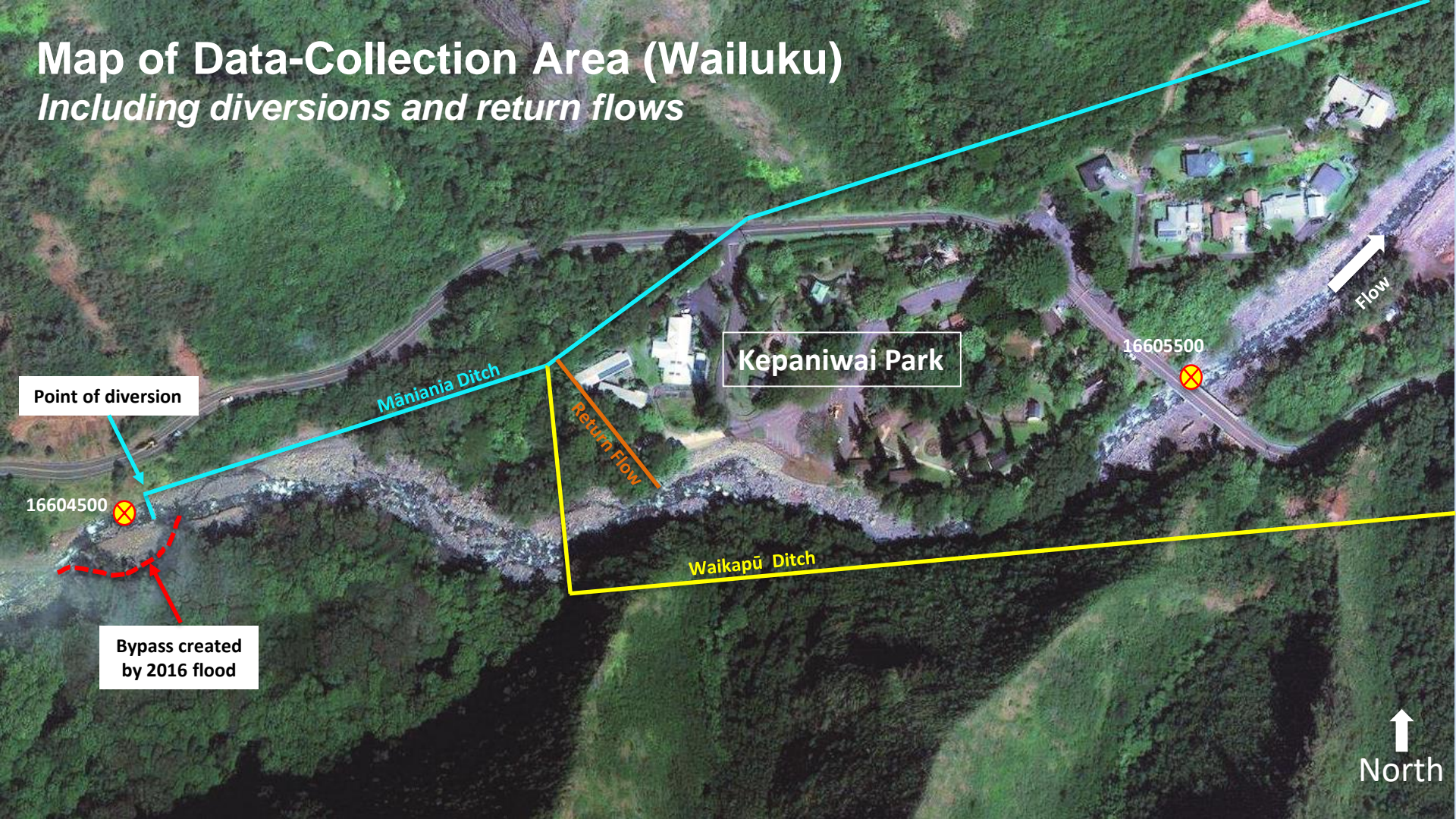
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Map of Data-Collection Area (Wailuku)

Including diversions and return flows



Point of diversion

16604500

Māniana Ditch

Return Flow

Waikapū Ditch

Kepaniwai Park

16605500

Flow

Bypass created by 2016 flood

North

Upstream Gage

16604500 “at Kepaniwai Park”

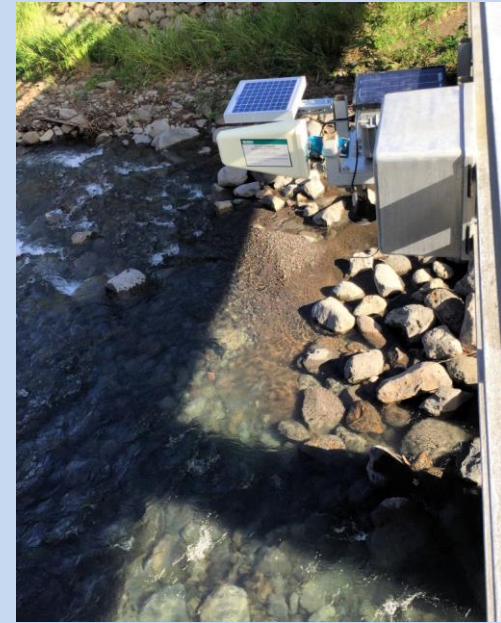
- Current (real-time) stage and flow above the diversion
- Operation began May 1, 1983
- Destroyed by flood September 13, 2016
- Reinstalled on Oct. 3, 2019 with sensor in the same location, but instrument shelter ~50 feet higher
- Stage sensor is a “bubbling” pressure transducer
- Discharge reported includes flow in the main (north) and bypass (south) channels



Downstream Gage

16605500 “at ‘Īao Valley Road”

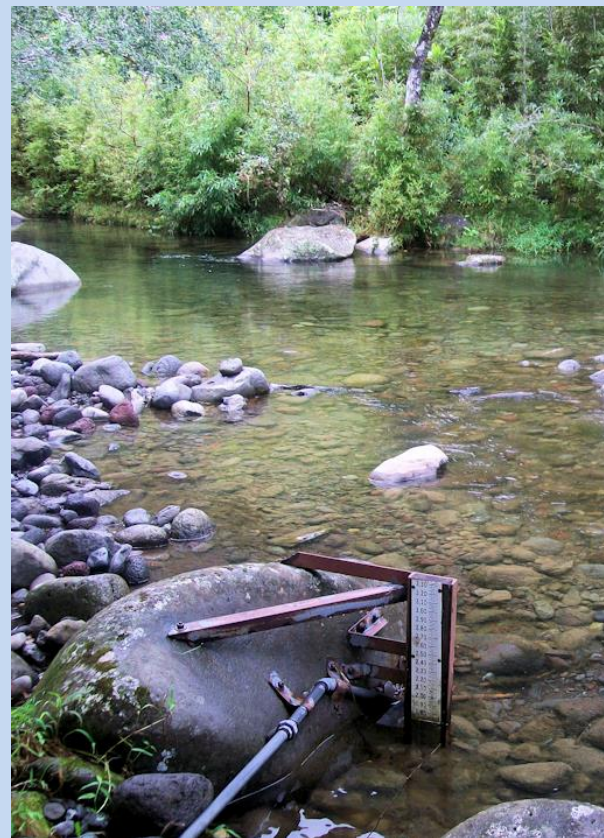
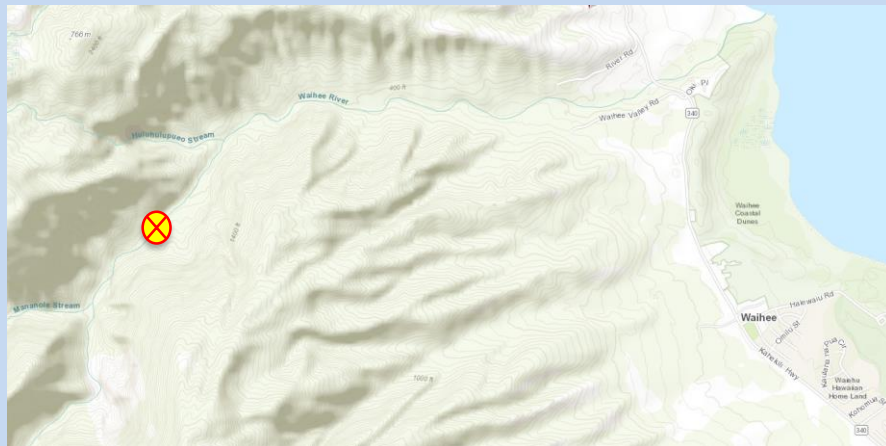
- Current (real-time) stage and flow below the diversion
- Gage began operating on April 13, 2017
- Continuous discharge record began Oct 1, 2019 (online beginning Nov 7)
- Stage sensor uses radar waves
- All instrumentation and equipment for the gage is mounted to the bridge



Waihe'e River Gage

16614000 "above Waihe'e Ditch Intake, near Waihe'e"

- Current (real-time) stage and flow above the Waihe'e Ditch Intake
- Located about 0.5 miles upstream of the mouth of Huluhulupueo Stream, and 3.0 miles from the ocean
- Gage began operating in November 1983



ANY QUESTIONS?

Feel free to email me if you have questions

Brian Loving

bloving@usgs.gov

Civil No. 19-1-0019-01 (JPC)

Defendant A&B/EMI's Exhibit AB-77

FOR IDENTIFICATION _____

RECEIVED IN EVIDENCE _____

CLERK _____