NEON USER GUIDE TO CONTINUOUS DISCHARGE (DP4.00130.001)

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CHANGE RECORD

REVISION	DATE	DESCRIPTION OF CHANGE
A	01/11/2018	Initial Release
B	03/01/2021	Major updates to workflow including added input tables, added data relationships, migration of gauge-pressure relationship data from being transitioned in IS to being transitioned in OS, updates to gauge and TROLL offset calculation, updates to flow series calculation, updates to systematic uncertainty propagation, and added information about including lake inflow and outflow locations in this data product.
C	01/25/2022	Updated to include details of how TOMB Continuous discharge is produced and fix typos.
D	05/15/2023	General textual updates throughout, added information on the inclusion of data from the Discharge field collection (DP1.20048.001) data product and science review flags from the Elevation of surface water (DP1.20016.001) data product in L4 processing, added information about continuous discharge active periods, updated algorithm implementation steps within the docker containers to match current processing workflow, added detail on data entry validation, data revision, provisional data status, regression coefficients, uncertainty, and quality flagging.
D.1	08/24/2023	Added table in 'Special Considerations' section detailing the variables sufficient to plot continuous discharge, stage, associated discharge and stage uncertainties, and final quality flags associated with the discharge data.
E	04/02/2024	Updated to detail new L4 discharge input data table structure, added information about inactive provisional data, updated NEON logo.
F	05/28/2025	Removed 'Algorithm Theoretical Basis' and associated sections (now published in NEON.DOC.005403), added information regarding newly-published tables for periods of corrected data, updated referenes to L0 raw pressure data inputs to be L1 water column height data inputs.
G	02/06/2026	Updated to include information about the new 15-minute resolution table, first published in RELEASE-2026.

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1 DESCRIPTION

1.1 Purpose

This document provides an overview of the data included in this NEON L4 data product, which is generated from L4 and L1 OS data, L1 IS data, and associated metadata. In the NEON data products framework, the raw data collected in the field (i.e. staff gauge measurements from a single collection event or pressure transducer readouts at 1 min interval) are considered the lowest level (L0). Raw data that have been quality checked and simple metrics that emerge from the raw data are considered L1 data products. Level 4 data products rely on inputs of any level data, often from multiple input products, and may involve calculations that use data collected over a range of spatial or temporal scales.

The text herein provides a discussion of measurement theory and implementation, data product provenance, quality assurance and control methods used, and approximations and/or assumptions made during L4 data creation.

1.2 Scope

This document describes the steps needed to generate the L4 Continuous discharge (DP4.00130.001) data product and associated metadata from input data and calculations. This document also provides details relevant to the publication of the data product via the NEON data portal, with additional detail available in AD[03], provided in the download package for this data product. For information on the data products that are used as inputs for this data product, see the following: for water column height data, AD[06]; for gauge height, AD[07] and AD[08]; for discharge field collection, AD[09] and AD[10]; for stage-discharge rating curve, AD[11]; for USGS streamflow data, AD[17]. Documents are available for download with the respective L1 or L4 data package or from the USGS website. Please note that raw or lower level source data products (denoted by 'DP0') may not always have the same numbers (e.g., '20048') as the corresponding L1 or L4 data product.

This document does not describe, in detail, the theory of measurement, custom algorithms, or data correction methods. That information can be found in the NEON Algorithm Theoretical Basis Document (ATBD): Stage-discharge rating curves and continuous discharge (AD[05]).

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Associated Documents

AD[01]	NEON.DOC.000001	NEON Observatory Design (NOD) Requirements
AD[02]	NEON.DOC.002652	NEON Level 1, Level 2 and Level 3 Data Products Catalog
AD[03]	DP4.00130.001_variables.csv	NEON Data Variables for Continuous Discharge (DP4.00130.001)
AD[04]	NEON.DOC.001152	NEON Aquatic Sampling Strategy
AD[05]	NEON.DOC.005403	NEON Algorithm Theoretical Basis Document (ATBD): Stage-discharge rating curves and continuous discharge
AD[06]	NEON.DOC.001198	NEON Algorithm Theoretical Basis Document (ATBD): Surface Water Elevation
AD[07]	NEON_gaugeHeight_userGuide.pdf	NEON User Guide to Gauge Height (DP1.20267.001)
AD[08]	DP0.20267.001.validation.csv	NEON Data Validations for Gauge Height (DP1.20267.001)
AD[09]	NEON_fieldDischarge_userGuide.pdf	NEON User Guide to Discharge Field Collection (DP1.20048.001)
AD[10]	DP0.20048.001.validation.csv	NEON Data Validations for Discharge Field Collection (DP1.20048.001)
AD[11]	NEON_ratingCurve_userGuide.pdf	NEON User Guide to Stage-Discharge Rating Curves (DP1.00133.001)
AD[12]	NEON.DOC.000008	NEON Acronym List
AD[13]	NEON.DOC.000243	NEON Glossary of Terms
AD[14]	NEON.DOC.000927	NEON Calibration and Sensor Uncertainty Values
AD[15]	NEON.DOC.001113	Algorithm Theoretical Basis Document: Quality Flags and Quality Metrics for TIS Data Products
AD[16]	NEON.DOC.011081	Algorithm Theoretical Basis Document: QA/QC Plausibility Testing
AD[17]	https://doi.org/10.3133/wsp2175	Measurement and Computation of Streamflow Testing

2.2 Acronyms

Acronym	Definition
AOS	Aquatic Observational System
API	Application Programming Interface
BaM	Bayesian Modeling
BaRatinAGE	Bayesian Rating Curve Advanced Graphical Environment
CI	Confidence Interval
DPID	Data Product Identification Code
GUI	Graphical User Interface
hr	hour
IS	Instrumental Systems
kg	Kilogram
kPa	Kilopascal
L	Liter
L0	Level Zero (Unprocessed) Data
L1	Level One (Processed) Data
L4	Level Four (Derived and Processed) Data
m	Meter
MCMC	Markov Chain Monte Carlo
min	Minute
OS	Observational Systems
Pa	Pascal
Q	Discharge
QAQC	Quality Assurance Quality Checking
s	Second
S1	Aquatic Sensor Set One
S2	Aquatic Sensor Set Two
SRF	Science Review Flag
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
wk	Week
WY	Water Year (October 1 to September 30)

3 DATA PRODUCT DESCRIPTION

The Continuous discharge (DP4.00130.001) data product provides calculated stage, discharge and associated uncertainty values at stream, river, and lake inflow/outflow locations, except for the TOMB site in D08. Continuous discharge and stage data are derived from once per minute pressure readings, empirical gauge heights, pre-developed gauge height-water column height regressions, and stage-discharge rating curves. Data at the TOMB site are published at the same frequency as input USGS data.

3.1 Spatial Sampling Design

Continuous discharge is developed at the site level (except for Toolik Lake, where two stations have continuous discharge produced at the inflow and outflow to the lake) using data collected near either sensor set #1 or sensor set #2, whichever is closer to the staff gauge in wadeable streams, at the near shore sensor set (i.e. sensor set #1) at large rivers, or at sensor sets located at the inflow and outflow locations of Toolik Lake. TOMB continuous discharge data are produced using USGS data and a relationship between empirical readings collected by NEON and the contemporaneous USGS flow readings.

The geospatial information related to the input data is published as part of the data product package, including standard fields such as **siteID** (four character NEON site code), **horizontalPosition** (three digit code for the sensor set; e.g., S1 = 101/131, S2 = 102/132), and **namedLocation** (four character NEON site code, or staff gauge named location [SITE.AOS.gauge]). See AD[03] for more details on metadata and geolocation fields included in each table available in this data product.

As much as possible, sampling occurs in the same locations over the lifetime of the Observatory. However, some sampling locations may become impossible to sample over time, due to disturbance or other local changes. When this occurs, the location and its location ID are retired. A location may also shift to different coordinates. Refer to the locations endpoint of the NEON API for details about sampling locations that have been moved or retired: https://data.neonscience.org/data-api/endpoints/locations/.

Data in sdrc_gaugePressureRelationship, csd_continuousDischarge, and csd_15_min use staff gauge offset values to correct data following changes in the physical location of infrastructure. Offsets are calculated using information derived from the NEON geolocation database (Table 1). The processes for calculating offsets in both staff gauge and pressure transducer infrastructure is the same:

1. A total reference elevation is calculated for a location as the sum of its **elevation** above sea level (m) and **zOffset** (m) (vertical correction needed in order for the location to be relatable to previous locations).
2. The total reference elevation for the initial location is subtracted from each subsequent location to obtain the offset value for each subsequent location.
3. Every staff gauge record between the start date and end date of a specific location will have the appropriate offset applied.

3.2 Temporal Sampling Design

During active periods, one record is created in csd_continuousDischarge per min or csd_15_min per 15 min regardless of whether the pressure transducer was producing data. An active period is defined as a period of time where a sensor is installed and data are expected. In the case of Continuous discharge,

active periods can be adjusted due to seasonal conditions (e.g. at OKSR at TOOK where pressure transducers are installed year round but do not log data during the winter due to power limitations). However, for some situations (e.g. a high flow event disrupts the pressure transducer causing to it stop collecting measurements for > 1 calendar month), an active period may be adjusted to avoid producing data files with no usable data. For timestamps when the pressure transducer is not collecting measurements within an active period, records in csd_continuousDischarge or csd_15_min are produced containing the timestamp, applicable flags, and metadata, but no stage or discharge timeseries data. Some NEON sites are seasonal due to climate or logistical constraints. Records will not be processed and published at seasonal sites when sensors are intentionally deactivated or removed from the site.

3.3 Variables Reported

All variables reported in the published data (L4 data) are provided separately in the file, NEON Data Variables for Continuous Discharge (DP4.00130.001) (AD[03]). Some variables described in this document may be for NEON internal use only and will not appear in downloaded data.

Field names have been standardized with Darwin Core terms (http://rs.tdwg.org/dwc/; accessed 16 February 2014), the Global Biodiversity Information Facility vocabularies (http://rs.gbif.org/vocabulary/gbif/; accessed 16 February 2014), the VegCore data dictionary (https://projects.nceas.ucsb.edu/nceas/projects/bien/wiki/VegCore; accessed 16 February 2014), where applicable. NEON AOS spatial data employs the World Geodetic System 1984 (WGS84) for its fundamental reference datum and Geoid12A geoid model for its vertical reference surface. Latitudes and longitudes are denoted in decimal notation to six decimal places, with longitudes indicated as negative west of the Greenwich meridian.

3.4 Spatial Resolution and Extent

The finest spatial resolution at which data are reported is a site, except at Toolik Lake (TOOK) where data are published from both the lake inflow and the lake outflow.

3.5 Temporal Resolution and Extent

Water column height data are collected at a 1 min resolution (AD[06]). The 1 min resolution is retained in the csd_continuousDischarge table. Water column height is averaged to a 15-min resolution in the csd_15_min table.

The csd_continuousDischargeUSGS table is published at the resolution provided by the USGS (approximately 1 hour resolution).

The csd_gaugePressureRelationship table retains the temporal resolution of the input L1 data products (AD[07], AD[11]).

Records in the csd_gaugeWaterColumnRegression and csd_dischargeRegressionUSGS tables are published at the end date of each developed regression.

Tables associated with data correction are not published at a regular temporal resolution. Records in csd_dataGapToFillMethodMapping will be published with an end date corresponding to the end of a distinct date range identified for data correction. Records in csd_constantBiasShift will be published with an

end date corresponding to the end of a shifted period of record. Records in csd_gapFillingRegression will be published with an end date corresponding to the end of a period of record used to develop a regression used for data correction. See AD[05] for more information on data correction methods and temporal extent.

3.6 Associated Data Streams

All data and geolocation variables derived from sources outside this L4 data product are listed in Table 1 and Table 2.

Table 1: List of geolocation inputs for Continuous Discharge.

Data Source	field	contents
NEON geolocation database	active period startDate	SITE.AOS.continuous.discharge
NEON geolocation database	active period endDate	SITE.AOS.continuous.discharge
NEON geolocation database	location startDate	SITE.AOS.gauge SITE.AOS.discharge
NEON geolocation database	location endDate	SITE.AOS.gauge SITE.AOS.discharge
NEON geolocation database	location elevation	SITE.AOS.gauge SITE.AOS.discharge
NEON geolocation database	location zOffset	SITE.AOS.gauge SITE.AOS.discharge

Table 2: For each derived data table in this data product, all NEON input tables and data sources are listed with the data product in which they are published on the NEON Data Portal.

Continuous Discharge Table	Data Product	DPID	Input Table/Data Source
sdrc_gaugePressureRelationship	Continuous discharge	DP4.00130.001	csd_gaugeWaterColumnRegression
sdrc_gaugePressureRelationship	Gauge height	DP1.20267.001	gag_fieldData
sdrc_gaugePressureRelationship	Discharge field collection	DP1.20048.001	dsc_fieldData
sdrc_gaugePressureRelationship	Elevation of surface water	DP1.20016.001	EOS_1_min
csd_continuousDischarge csd_15_min	Stage-discharge rating curves	DP4.00133.001	sdrc_curveIdentification
csd_continuousDischarge csd_15_min	Continuous discharge	DP4.00130.001	csd_gaugeWaterColumnRegression
csd_continuousDischarge csd_15_min	Elevation of surface water	DP1.20016.001	EOS_1_min
csd_continuousDischarge csd_15_min	Stage-discharge rating curves	DP4.00133.001	sdrc_controlInfo
csd_continuousDischarge csd_15_min	Stage-discharge rating curves	DP4.00133.001	sdrc_priorParameters
csd_continuousDischarge csd_15_min	Continuous discharge	DP4.00130.001	sdrc_gaugePressureRelationship
csd_continuousDischarge csd_15_min	Stage-discharge rating curves	DP4.00133.001	sdrc_stageDischargeCurveInfo
csd_continuousDischarge csd_15_min	Stage-discharge rating curves	DP4.00133.001	sdrc_sampledParameters
csd_continuousDischarge csd_15_min	Stage-discharge rating curves	DP4.00133.001	sdrc_gaugeDischargeMeas
csd_continuousDischargeUSGS	Continuous discharge	DP4.00130.001	sdrc_dischargeRegressionUSGS

3.7 Product Instances

The NEON Observatory contains 24 wadeable streams, 3 large rivers, and 1 lake site containing an inflow and an outflow where discharge is measured.

At each site or location, this data product yields a maximum of 104 gauge and mean pressure readings per year (~2 per wk) in the sdrc_gaugePressureRelationship table, 525,600 records per year (~1 per min) in the csd_continuousDischarge table, 35,040 records per year (~1 per 15 min) in the csd_15_min table, and 8,760 records per year (~1 per hr) in the csd_continuousDischargeUSGS.

3.8 Data Relationships for All Sites Except TOMB

csd_15_min - > One record expected per 15 min during active periods regardless of available water column height data. Inactive periods will contain gaps in data.

csd_continuousDischarge - > One record expected per min during active periods regardless of available water column height data. Inactive periods will contain gaps in data.

- For a given site, beginning with RELEASE-2026, no two time periods will contain data in both of the csd_continuousDischarge and csd_15_min tables. Across all sites, the period back to the beginning of WY 2022 (2021-10-01) was converted from csd_continuousDischarge to csd_15_min, corrected, and published in RELEASE-2026. All provisional data post-RELEASE-2026 is now being aggregated to a 15-minute temporal resolution before BaM modeling and pubished in csd_15_min. The csd_continuousDischarge table is not published for any records after 2021-10-01, starting with RELEASE-2026. For most sites, data pre-dating WY 2022 will continue to be published, un-corrected, in the csd_continuousDischarge table. Over time, NEON staff will review and correct pre-WY 2022 time periods as time allows. See Section 4.2 for more information on when specific site-years were converted from csd_continuousDischarge to csd_15_min tables.
- A tutorial entitled *Introduction to the NEON Continuous Discharge Data Product* is available to aid users in creating a continuous timeseries of stage and discharge by merging two disparate tables. The tutorial is coded in both R and Python programming langauges. Visit the tutorial library in the NEON Learning Hub to access the tutorial, or follow this link: https://www.neonscience.org/resources/learning-hub/tutorials/continuous-discharge-intro

csd_gaugeWaterColumnRegression - > One record expected per unique gauge height - water column height linear regression. Each record in this table will contain a unique identifier as the **regressionID** variable.

- Records in this table can be linked to csd_continuousDischarge, csd_15_min, sdrc_gaugePressureRelationship via **regressionID**.

sdrc_gaugePressureRelationship - > One record expected per unique gauging event that can be paired with water column height data. The number of total unique input gauging events may differ from the number of records in sdrc_gaugePressureRelationship for a given site and water year because a gauging will not be processed into sdrc_gaugePressureRelationship if no water column height data are present within 15-min of the gauging collect date. Missing water column height data may be a result of a site-level issue (e.g., sensor malfunction or power failure), a quality flag applied to the timeseries, or a linear interpolation correction method (AD[05]) applied to the timeseries.

- Records in this table can be linked to csd_gaugeWaterColumnRegression via **regressionID**.
- Records in this table can be linked to csd_continuousDischarge and csd_15_min via **regressionID** and date ranges.

3.8.1 Data Relationships for Corrected Data

Beginning with RELEASE-2026, data corrections were applied to csd_15_min for distinct time periods. See AD[05] for details on the data correction process, methods, and timeline. Up to three tables can be published during time periods when data were corrected, with the following relationships:

csd_dataGapToFillMethodMapping - > One record expected per data gap. A data gap is defined as a period of missing record or a period of record flagged for correction (AD[05]). Unique records in this table are identified by combinations of **namedLocation**x**endDate**x**gapFilledDataStream** and can be linked to csd_15_min by matching **siteID** and date ranges.

csd_constantBiasShift - > One record expected per period of record shifted. Unique records in this table are identified by combinations of **namedLocation**x**endDate**x**gapFilledDataStream** and can be linked to csd_15_min by matching **siteID** and date ranges.

csd_gapFillingRegression - > One record expected per unique regression developed for correcting data at a site. Every record in this table will contain a unique identifier as the **gapFillRegressionID** variable. **gapFillRegressionID** can be used to link csd_gapFillingRegression and csd_dataGapToFillMethodMapping data when csd_dataGapToFillMethodMapping:**gapFillMethod** is 'transducer', 'conductivity', or 'usgs'.

3.9 Data Relationships for TOMB

Continuous discharge at one NEON site is not developed using the Bayesian model. At D08 TOMB (located on the Tombigbee River in southwest Alabama) a downstream lock and and dam system operated by the United States Army Corp of Engineers highly influences the stage-discharge relationship at the NEON site. Publicly available discharge data collected by the USGS at the dam are thus utilized to publish continuous discharge. The csd_continuousDischargeUSGS table represents the data published in this manner. The csd_dischargeRegressionUSGS table contains input data for csd_continuousDischargeUSGS and describes the fit between empirical NEON discharge measurements and published USGS discharge data. **usgsRegressionRegID** can be used to link csd_continuousDischargeUSGS and csd_dischargeRegressionUSGS data.

csd_continuousDischargeUSGS - > Approximately one record per hour that contains USGS discharge and associated uncertainty based on the fit of USGS data with corresponding discharge measurements collected at the adjacent NEON site.

csd_dischargeRegressionUSGS - > One record expected per unique NEON discharge - USGS discharge linear regression developed at a site. Every record in this table will contain a unique identifier as the **usgsRegressionRegID** variable.

4 DATA QUALITY

4.1 Data Entry Constraint and Validation

Many quality control measures are implemented at the point of data entry (i.e., the L1 data that are used as an input for this data product) within a mobile data entry application or web user interface. See AD[08] and AD[10] for more details.

In this L4 data product, L1 input data are subject to additional constraint and validation in the form of manual review of the stage-discharge relationship and gauge-water column height regressions by NEON scientists. When a rating curve is developed, gaugings published in DP1.20048.001 may be excluded if they are determined to be outliers due to human error (i.e., transcription error), contain quality flags in the L1 data product (See AD[09] for information on L1 quality flags), or report temporary hydrologic conditions at the discharge cross-section (information found in dsc_fieldData:**dscTempHydroCond**). When gauge-water column height regressions are developed, NEON scientists review the quality of both the L1 gauge height and L1 water column height data. If the L1 gauge height is determined to be in error, the **initialStageHeight** and **endStageHeight** values will be deleted from gag_fieldData in DP1.20267.001 (see AD[07] and AD[08]). If water column height data are determined to be invalid, a science review flag will be added to the affected time range in DP1.20016.001, which will programatically exclude associated gaugings from further processing (see Section 3.8 of this document).

4.2 Provisional Data and Data Revisions

At the end of a water year, NEON will provide corrected and gap-filled continuous discharge data within six months. While this data is corrected, it remains Provisional until the next release, which occurs in January of the following year when a static, versioned data release with digital object identifiers (DOIs) is published. Throughout the course of the water year, Provisional, uncorrected continuous discharge data are provided monthly, a process similar to that of other national stream monitoring networks such as the USGS. Users should always reference values in the data download package that stipulate whether data are Provisional vs. Released, and whether data correction and gap-filling methods have been applied. The Issue Log has the most up-to-date information and contains a history of changes and known errors. This data product was first included in RELEASE-2022, the second NEON data release.

Site-Years Converted from 1-min to 15-min Resolution: In RELEASE-2026, and in all subsequent releases, continuous discharge data beginning in WY 2022 (2021-10-01) are corrected, aggregated to a 15-min temporal resolution, and published in the csd_15_min table. NEON staff will work to correct and update the temporal resolution to 15-min for pre-WY 2022 records as time allows. See (Table 3) for information on site-years prior to WY 2022 that have been corrected and updated to 15-min averaging.

Table 3: Site-Years that have been corrected and updated to a 15-min temporal resolution prior to WY 2022 along with the associated Data Release.

Data Release	Site-Year
RELEASE-2026	BIGC-WY2021

Publication Timeline and Annual Reprocessing: Throughout the year, Provisional csd_15_min and csd_continuousDischargeUSGS data are automatically published using input data (Table 2) from the previous water year. Note that these Provisional data are not fully QAQC'ed. At the end of each water year, NEON scientists develop, review, and publish all the input data (e.g. stage discharge rating curves, stage models, etc.) for each site or location for that water year. Once the rating curves for the complete water year have been developed, csd_15_min and csd_continuousDischargeUSGS data are reprocessed and re-published for inclusion in the next data Release.

Due to this data processing schedule, the difference between Provisional and Released data is larger in Continuous discharge (DP4.00130.001) than in most NEON data products. Provisional data in csd_15_min can be inaccurate if calibration factors, geolocation data, or the physical conditions of the site (e.g. discharge cross-section morphology) have changed relative to input data from the previous water year. Most Provisional data issues of this nature will not be addressed until annual reprocessing occurs at the end of a water year.

Provisional data may be made inactive, and therefore not published, if the morphological and hydrologic regimes become vastly different than that used to develop the models used to estimate Provisional stage and discharge (e.g., new surveys of the staff gauge and/or discharge cross section required due to major flow event, rating curve shift, or issues with the instrument infrastructure). If users observe a site where Provisional data are not available (i.e., recent, unpublished months), please review the issue log where inactive provisional date ranges are reported.

In csd_continuousDischargeUSGS, the **usgsValueQualCode** field reports USGS Instantaneous and Daily Data-Value Qualification Codes included in the data downloaded from the *dataRetrieval* R package (P = Provisional, A = Approved; De Cicco et al., 2022). Data users should be aware of the USGS Provisional Data Statement (https://waterdata.usgs.gov/provisional-data-statement/) when working with Provisional data in csd_continuousDischargeUSGS.

Users are encouraged to check the curveID and regressionID associated with continuous discharge and stage data, respectively, in order to determine which rating curve or stage model coefficients were applied to calculate the value. Users should also check the issue log of this data product for any major Provisional data quality issues that cannot be resolved until annual reprocessing at the end of a water year. If a user's research requires the use of Provisional data (i.e., for near real-time hydrologic forecasting), users can contact NEON scientists (https://www.neonscience.org/about/contact-us) for more information on the validity and potential use of Provisional data in this data product.

4.3 Uncertainty

One of the benefits of using BaM and MCMC sampling is that there are a large number of realizations from the posterior distribution, which can be used to quantify uncertainty associated with the maximum likelihood posterior parameters (BaRatin statistical model documentation and Le Coz et al., 2014). NEON publishes both the parametric and remnant (structural) error based off of 500 realizations from the posterior distribution.

Note that the uncertainty published in the basic download package of this data product is expanded uncertainty, i.e. multiplied by a factor of 1.96 to cover two standard deviations, or, the 95% confidence interval. When using the BaRatin GUI tool, the uncertainty should be represented the same way as NEON

publishes it. Note that for the BaM executable, uncertainty is represented as one standard deviation. These values are also published in this data product as part of the expanded download package. The 1 standard deviation uncertainty from the expanded download package should be used when writing out NEON data and configurations.

For TOMB data, the standard error of the regression between NEON empirical discharge readings and USGS discharge data are used to calculate the 95% confidence intervals (2 standard deviations) associated with the discharge prediction.

4.4 Quality Flagging

For the quality flags in the csd_continuousDischarge and csd_15_min tables, see the descriptions in AD[13] and AD[14] for more details on the automated quality flagging associated with instrument data.

A general overview of the Science Review Flag is also described in AD[13]. In this data product, **dischargeFinalQFSciRvw** contains science review flags in the csd_continuousDischarge, csd_15_min, and csd_continuousDischargeUSGS tables. Most science review flags in this data product will be assigned at the end of a water year during annual review and reprocessing for a site. During annual review, NEON scientists will assess periods of erratic or erroneous sensor data and apply science review flagging as needed. Situations in which continuous discharge may be flagged include, but are not limited to, ice periods (flow over ice, ice pinching sensor housing, etc.), sensor instability within the housing, sensor biofouling, or an exposed sensor during baseflow or dry periods. Peak flows in csd_continuousDischarge may also receive a science review flag if **maxpostDischarge** far exceeds the highest empirical gauging in the associated stage-discharge rating curve (**curveID**) or the predicted flow appears implausible given historic data.

In the csd_continuousDischargeUSGS table, the **usgsValueQualCode** field reports USGS Instantaneous and Daily Data-Value Qualification Codes included in the data downloaded from the *dataRetrieval* R package (De Cicco et al., 2022). In addition to reporting the Provisional status of the data, this field also reports any codes that relate to data quality (e.g., *e* for discharge values that are edited or estimated; more information on USGS data quality codes can be found at https://help.waterdata.usgs.gov/codes-and-parameters/instantaneous-value-qualification-code-uv_rmk_cd).

5 REFERENCES

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