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| <i>Title:</i> NEON User Guide to Dissolved gases in surface water (DP1.20097.001) | <i>Date:</i> 12/23/2020 |
| <i>Author:</i> Kaelin M. Cawley | <i>Revision:</i> B |

NEON USER GUIDE TO DISSOLVED GASES IN SURFACE WATER (DP1.20097.001)

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CHANGE RECORD

| REVISION | DATE | DESCRIPTION OF CHANGE |
|-----------------|-------------|--|
| A | 06/27/2017 | Initial Release |
| B | 07/06/2020 | Included general statement about usage of neonUtilities R package and statement about possible location changes. Updated taxonomy information. |



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1 DESCRIPTION

1.1 Purpose

This document provides an overview of the data included in this NEON Level 1 data product, the quality controlled product generated from raw Level 0 data, and associated metadata. In the NEON data products framework, the raw data collected in the field, for example the specific conductance of water, are considered the lowest level (Level 0). Raw data that have been quality checked via the steps detailed herein, as well as simple metrics that emerge from the raw data are considered Level 1 data products.

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 L1 data creation.

1.2 Scope

This document describes the steps needed to generate the L1 data product Dissolved gases in surface water, the concentrations of carbon dioxide, nitrous oxide, and methane in surface water samples. This document also provides details relevant to the publication of the data products via the NEON data portal, with additional detail available in the file NEON Data Variables for Dissolved gases in surface water (DP1.20097.001) (AD[05]), provided in the download package for this data product.

This document describes the process for ingesting and performing automated quality assurance and control procedures on the data collected and analyzed following AOS Protocol and Procedure: Surface Water Dissolved Gas Sampling (AD[06]). The raw data that are processed in this document are detailed in the file NEON Raw Data Validation for Dissolved gases in surface water, Level 0 (DP0.20097.001) (AD[04]), provided in the download package for this data product. Please note that raw data products (denoted by 'DP0') may not always have the same numbers (e.g., '20093') as the corresponding L1 data product.



2 RELATED DOCUMENTS AND ACRONYMS

2.1 Associated Documents

| | | |
|--------|-------------------------------|--|
| AD[01] | NEON.DOC.000001 | NEON Observatory Design (NOD) Requirements |
| AD[02] | NEON.DOC.001152 | NEON Aquatic Sampling Strategy |
| AD[03] | NEON.DOC.002652 | NEON Level 1, Level 2 and Level 3 Data Products Catalog |
| AD[04] | Available with data download | Validation csv |
| AD[05] | Available with data download | Variables csv |
| AD[06] | NEON.DOC.001199 | AOS Protocol and Procedure: Surface Water Dissolved Gas Sampling |
| AD[07] | NEON.DOC.002905 | AOS Protocol and Procedure: Water Chemistry Sampling in Surface Waters and Groundwater |
| AD[08] | NEON.DOC.000008 | NEON Acronym List |
| AD[09] | NEON.DOC.000243 | NEON Glossary of Terms |
| AD[10] | NEON.DOC.004825 | NEON Algorithm Theoretical Basis Document: OS Generic Transitions |
| AD[11] | Available on NEON data portal | NEON Ingest Conversion Language Function Library |
| AD[12] | Available on NEON data portal | NEON Ingest Conversion Language |
| AD[13] | Available with data download | Categorical Codes csv |

2.2 Acronyms

| Acronym | Definition |
|------------------|---|
| MDR | mobile data recorder |
| ppmv | parts per million on a volumetric basis |
| CO ₂ | carbon dioxide |
| N ₂ O | nitrous oxide |
| CH ₄ | methane |



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3 DATA PRODUCT DESCRIPTION

The Dissolved gases in surface water (DP1.20097.001) data product provides carbon dioxide (CO₂), nitrous oxide (N₂O), and methane (CH₄) concentrations in reference air and water equilibrated air samples collected using AOS Protocol and Procedure: Surface Water Dissolved Gas Sampling (AD[06]). Field samples are collected from wadeable streams, non-wadeable rivers, and lakes, with sampling strategies specific to the type of water body and described briefly below. Barometric pressure from a handheld sensor, along with temperature and specific conductance of the water subsample for dissolved gas analysis, are also provided so that concentrations of dissolved gases in the original water body can be determined using Henry's law equilibrium constants. These procedures implement the guidelines and requirements described in the NEON Aquatic Sampling Strategy (AD[02]). Gas concentrations are reported at the spatial resolution of a single water sample, collected from a unique named Location within a sampled water body. The temporal resolution is that of a single collection date.

Measurements of surface water dissolved gases can provide valuable information for scientists, managers and decision makers regarding potential water quality responses to natural and anthropogenic changes. For example, supersaturation and undersaturation of pCO₂ in freshwaters may result from nutrient loading, point and non-point pollution sources, and groundwater inputs. Dissolved gas measurements can also provide insight into how changes in the surrounding landscape may influence aquatic ecosystem structure and function, enabling stakeholders to answer questions such as: How do increased nitrogen inputs influence stream denitrification? How are increases in CO₂ affecting the biological communities? Measuring long-term trends in concentrations of dissolved gases in surface water is part of the overall NEON biogeochemistry goal to understand how major nutrient and carbon fluxes within and across air, land and water systems change over 30 years.

3.1 Spatial Sampling Design

In wadeable streams, grab sampling in the thalweg is used to obtain water samples for dissolved gas analysis, assuming the stream channel is completely mixed and gradients in dissolved gases with water depth are minimal (Figure 1a). In rivers, a grab sample is collected from the thalweg at 0.5 m depth - unless the river is stratified, in which case a 0.5 m epilimnion sample plus an integrated hypolimnion sample are collected (Figure 1b). In streams and rivers, samples are collected immediately downstream of the most downstream sensor set, S2 or buoy, so that sensor measurements can be validated with water chemistry samples.

In lakes, at the buoy location, samples are taken from variable depths dependent on the degree of lake stratification (Figure 1c and 1d), acknowledging that exchange and movement of dissolved gases may be limited due to density differences. In lakes with a true inflow and outflow, samples are collected near lake buoy, inflow, and outflow sensor infrastructure (Figure 1d). Refer to AOS Protocol and Procedure: Water Chemistry Sampling in Surface Waters and Groundwater (AD[07]) for further details regarding field sampling.

As much as possible, sampling occurs in the same locations over the lifetime of the Observatory. However, over time some sampling locations may become impossible to sample, due to disturbance or other local changes. When this occurs, the location and its location ID are retired. A location may also shift to slightly different coordinates. Refer to the locations endpoint of the NEON API for details about locations that



have been moved or retired: <https://data.neonscience.org/data-api/endpoints/locations/>

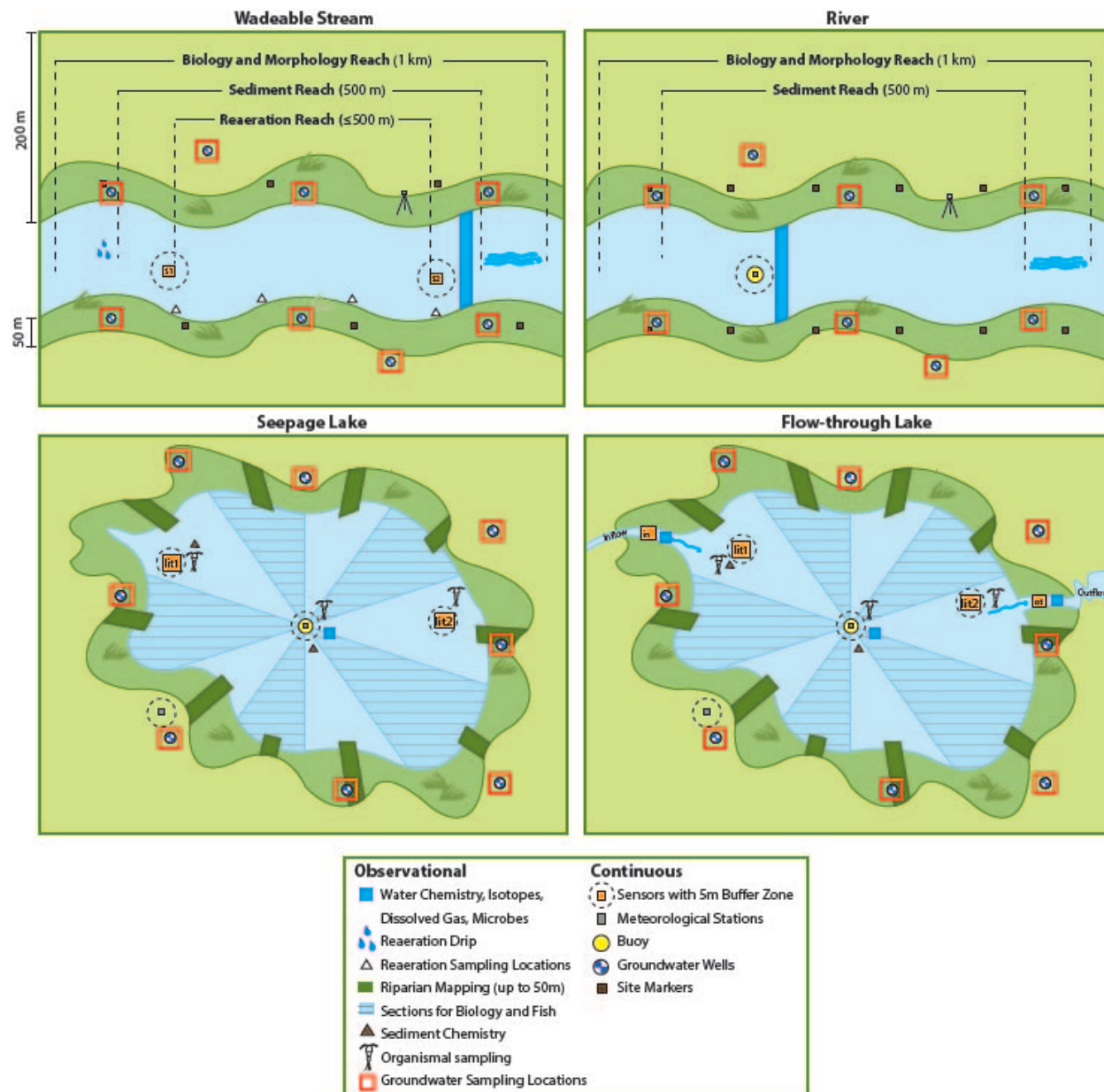


Figure 1: Summary of sampling locations for dissolved gas in water.

3.2 Temporal Sampling Design

For streams, sampling occurs up to 26 times per year, which is monthly with 14 flow-weighted samples guided by historical stream discharge data. Lakes are sampled 12 times per year, approximately monthly and during shoulder seasons to capture ice-on/ice-off and lake turnover events. The specific dates chosen



for sampling depend upon environmental conditions at each NEON site and are outlined in site-specific sampling design documents for each Domain. Dissolved gas sampling will be conducted at the same time as other parameters such as surface water chemistry, stable isotopes, and surface water microbes.

Water subsamples for dissolved gas analysis are collected in syringes and are either immediately processed or stored in buckets of lake water while samples are collected from other stations at a given site. Once samples are collected from all stations at a site, a known volume of the water sample will be equilibrated with a known volume of ambient air by shaking the mixture for 5 minutes (Figure 2). A sample of ambient “reference” air will also be collected immediately prior to water and air equilibration. The reference air and water equilibrated air are injected into evacuated vials which are stored upside down in water-filled centrifuge tubes for transport to an external laboratory facility for analysis of CO₂, CH₄, and N₂O concentration, which is reported as parts per million on a volumetric basis (ppmv).

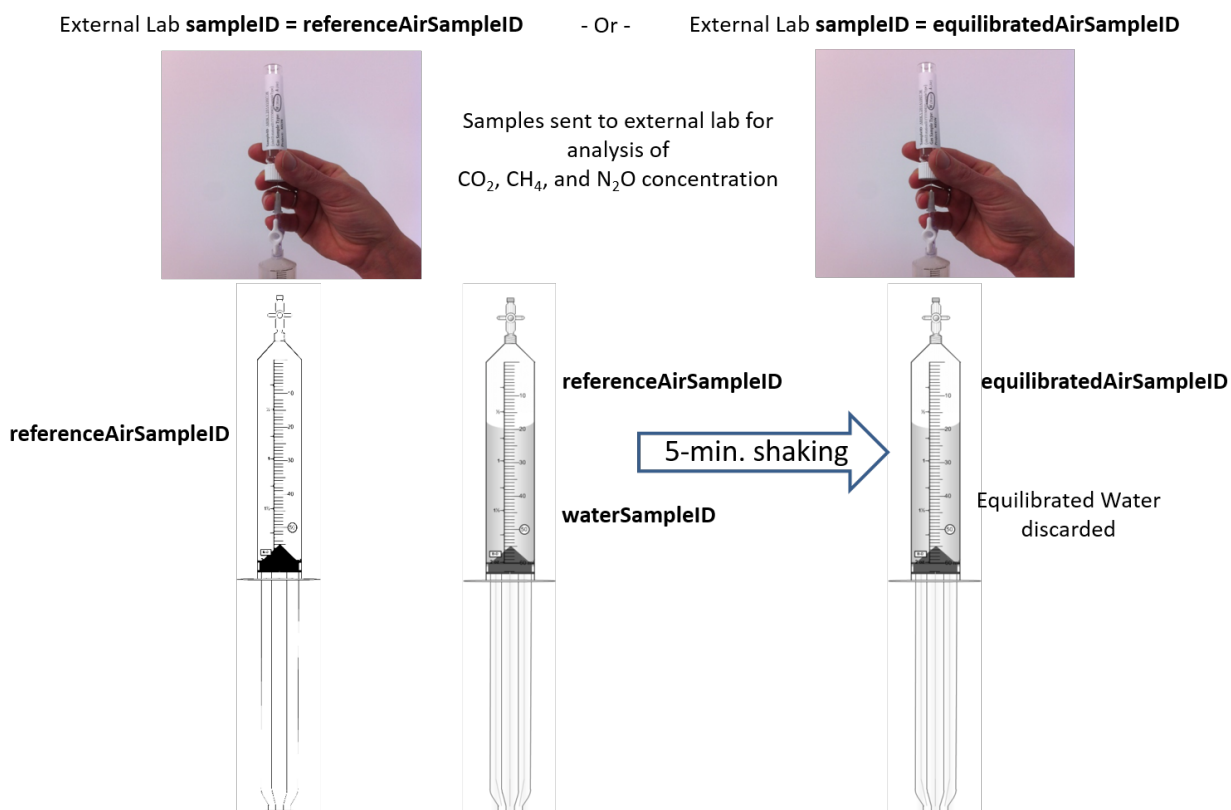


Figure 2: Diagram illustrating sample collection and field processing

3.3 Sampling Design Changes

- Seepage lakes are no longer sampled at their littoral1 and littoral2 locations, implemented 2018



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3.4 Laboratory Quality Assurance and Uncertainty

NEON field procedures for collection of dissolved gas samples follow widely adopted community methods and all NEON technicians conducting this work receive proper training. For external laboratory analyses, facilities have been chosen for their use of analytical methods widely adopted by the aquatic chemistry community. Labs report the method detection limit, along with long-term analytical precision and uncertainty of standards analyzed as unknowns, for each gas species in a summary file. This allows users to interpret and model the dissolved gas data in the context of its uncertainty range. Contracted external facilities upload this summary file (sdg_externalLabSummaryData) when they begin work for NEON, then again once per year or whenever their information changes (for example, a new instrument is acquired or a change is detected in analytical precision). Additionally, NEON's Calibration/Validation department has regular procedures for auditing the quality assurance of external laboratories and their reports are available to data users.

3.5 Variables Reported

All variables reported from the field technician or laboratory (L0 data) are listed in the file NEON Raw Data Validation for Dissolved gases in surface water, Level 0 (DP0.20097.001) (AD[04]). All variables reported in the published data (L1 data) are also provided separately in the file, NEON Data Variables for Dissolved gases in surface water (DP1.20097.001) (AD[05]).

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 Earth Gravitational Model 96 (EGM96) for its reference gravitational ellipsoid. Latitudes and longitudes are denoted in decimal notation to six decimal places, with longitudes indicated as negative west of the Greenwich meridian.

Some variables described in this document may be for NEON internal use only and will not appear in downloaded data.

3.6 Spatial Resolution and Extent

The finest resolution at which dissolved gas spatial data are reported is a single sample collected from a unique namedLocation. Overall, this results in a spatial hierarchy of:

waterSampleID (unique ID given to the individual water sample) → **namedLocation** (ID of the sampling location) → **siteID** (ID of NEON site) → **domainID** (ID of a NEON domain).

StationID in wadeable and non-wadeable (i.e. rivers) streams is indicated as 'ss', and stationIDs for lakes are designated as 'c0', and 'c1','c2', and 'c3', as needed (if center is stratified), with 'c1' being the top layer. As of July 2019, Toolik Lake (TOOK), also collects surface water samples at the inflow and outflow, where 'in' and 'ot' designations are used to indicate inflow and outflow sampling locations.

Prior to January 2018, samples were also collected at two littoral locations designated as 'in' and 'ot'.



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The basic spatial data included in the data downloaded include the latitude, longitude, and elevation of the namedLocation where sampling occurred, plus associated uncertainty due to GPS error. Shapefiles of all NEON Aquatic Observation System sampling locations can be found in the Document Library: <http://data.neonscience.org/documents>. If for some reason samples cannot be taken at the designated stations, the coordinates for the center of the site will be returned. In this case, the actual coordinates of the sampling location are recorded in the **altLocation**, **altLatitude** and **altLongitude** fields.

3.7 Temporal Resolution and Extent

The finest resolution at which dissolved gas temporal data are reported is the **collectDate**, a single date on which water samples were collected. The total number of sampling events per year is expected to be 26 per wadeable and non-wadeable stream and 12 per lake.

The NEON Data Portal currently provides data in monthly files for query and download efficiency. Queries including any part of a month will return data from the entire month. All queries, regardless of the date range specified, will include a copy of `sdg_externalLabSummaryData`, which provides summary information from the external lab about method detection limits, equipment used, and precision and accuracy. Code to stack files across months is available here: <https://github.com/NEONScience/NEON-utilities>

3.8 Associated Data Streams

The ‘super parent’ sample of the data from the Dissolved gases in surface water product is shared with several other related data products. **siteID**, **namedLocation** and **collectDate** (or **parentSampleID** of the `xxx_fieldSuperParent` table in each data product) are the linking variables that tie samples and their associated metadata to those found in the Chemical properties of surface water (DP1.20093.001), Stable isotope concentrations in surface waters (DP1.20206.001), and Surface water microbe cell count (DP1.20138.001.001) data products.

3.9 Product Instances

The NEON Observatory contains 34 aquatic sites, consisting of 24 wadeable streams, 3 non-wadeable streams (rivers), and 7 lakes.

Dissolved gas sampling yields one unique equilibrated air sample per namedLocation per sampling event. There will be up to 26 sampling events per year in wadeable streams and rivers and up to 12 sampling events in lakes. Thus in wadable streams and rivers, there will be up to 52 unique sample records per site per year, and lakes will yield 24-72 records per year, depending on stratification. Observatory-wide, this will yield a total of 1572-1908 records per year.

NOTE: Replicate samples may be taken of a small percentage of our samples. If replicate samples are taken, there will be one unique sample per **replicateNumber** per namedLocation per sampling event, and the sample ID(s) of the replicate sample(s) will have the **replicateNumber** appended to the end.

3.10 Data Relationships

Each `siteID x namedLocation` combination is sampled at least once per event (one record expected per `parentSampleID` in `sdg_fieldSuperParent`). A record from `sdg_fieldSuperParent` may have zero or one

child records in `sdg_fieldData`, depending on whether a water sample was successfully collected. In the event that a water sample cannot be taken, a record will still be created in `sdg_fieldSuperParent`, and `sdg_fieldSuperParent.sampleImpractical` will be something other than blank, but there will be no corresponding record in `sdg_fieldData`. Each record from `sdg_fieldData` is expected to have one child record in `sdg_fieldDataProc`, which is a mixture of a water sample created in `sdg_fieldData` and reference air sample created in `sdg_fieldDataAir`. Each record from `sdg_fieldDataProc` and `sdg_fieldDataAir` is expected to have one child record in `sdg_externalLabData`. However, duplicates and/or missing data may exist where protocol and/or data entry aberrations have occurred; *users should check data carefully for anomalies before joining tables.*

`sdg_fieldSuperParent.csv` -> One record expected per parentSampleID.

`sdg_fieldData.csv` -> One record expected per parentSampleID per collectDate (day of year, local time), generates a single waterSampleID to be used in dissolved gas equilibration procedure

`sdg_fieldDataAir.csv` -> One referenceAirSampleID record expected per namedLocation x collectDate combination

`sdg_fieldDataProc.csv` -> One record expected per waterSampleID, generates a single equilibratedAirSampleID

`sdg_externalLabData.csv` -> One record expected per equilibratedAirSampleID and referenceAirSampleID, associated with external laboratory gas species concentration measurements

`sdg_externalLabSummaryData.csv` -> One record expected per laboratoryName x analyte x method x labSpecificStartDate combination. Can use corresponding variables in externalLabData tables to associate sample data with relevant uncertainty values and method detection limits

sampleIDs and **sampleBarcodes** will be generated for each sampling event. After field processing and shipment to external labs are complete, any physical sample that remains will be discarded.

Data downloaded from the NEON Data Portal are provided in separate data files for each site and month requested. The `neonUtilities` R package contains functions to merge these files across sites and months into a single file for each table described above. The `neonUtilities` package is available from the Comprehensive R Archive Network (CRAN; <https://cran.r-project.org/web/packages/neonUtilities/index.html>) and can be installed using the `install.packages()` function in R. For instructions on using `neonUtilities` to merge NEON data files, see the Download and Explore NEON Data tutorial on the NEON website: <https://www.neonscience.org/download-explore-neon-data>

3.11 Special Considerations

For users interested in calculating dissolved gas concentrations in surface water, solubility levels at the time of sampling, or percent saturation for the dissolved gases, see the Appendix and references cited therein. The information provided in these references is outside the scope of the basic QA/QC of L0 data used to create this L1 data product. However, the field and laboratory methods chosen were designed to enable these calculations by data users, thus a discussion of them is provided. NEON does maintain the `neonDissGas` R package, that can be found in the NEON-dissolved-gas GitHub repository (<https://github.com>)

om/NEONScience/NEON-dissolved-gas) that contains functions to make some of the calculations outlined in the Appendix.

4 DATA QUALITY

4.1 Data Entry Constraint and Validation

Many quality control measures are implemented at the point of data entry within a mobile data entry application (field data) and web user interface (UI, lab data). For example, data formats are constrained and data values controlled through the provision of dropdown options, which reduces the number of processing steps necessary to prepare the raw data for publication (Figure 3). An additional set of constraints are implemented during the process of ingest into the NEON database. The product-specific data constraint and validation requirements built into data entry applications and database ingest are described in the document NEON Raw Data Validation for Dissolved gases in surface water, Level 0 (DP0.20097.001), provided with every download of this data product. Contained within this file is a field named 'entryValidationRulesForm', which describes syntactically the validation rules for each field built into the data entry application. Data entry constraints are described in NiCl syntax in the validation file provided with every data download, and the NiCl language is described in NEON's Ingest Conversion Language (NICL) specifications ([AD11]).

Data collected prior to 2017 were processed using a paper-based workflow that did not implement the full suite of quality control features associated with the interactive digital workflow.

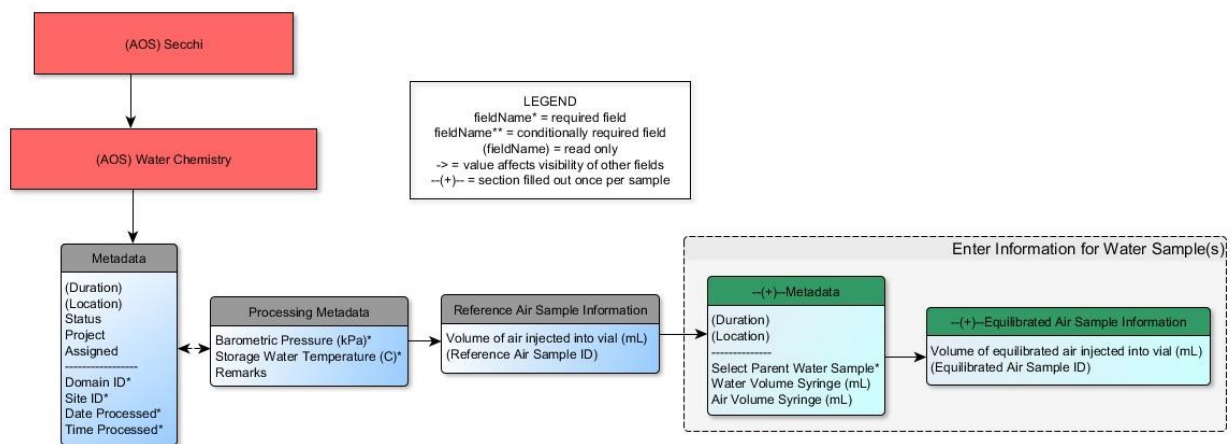


Figure 3: Diagram illustrating the mobile data entry application

4.2 Automated Data Processing Steps

Following data entry into a mobile application or web user interface, the steps used to process the data through to publication on the NEON Data Portal are detailed in the NEON Algorithm Theoretical Basis Document: OS Generic Transitions (AD[10]).

4.3 Data Revision

All data are provisional until a numbered version is released; the first release of a static version of NEON data, annotated with a globally unique identifier, is planned to take place in 2020. During the provisional period, QA/QC is an active process, as opposed to a discrete activity performed once, and records are updated on a rolling basis as a result of scheduled tests or feedback from data users. The Change Log section of the data product readme, provided with every data download, contains a history of major known errors and revisions.

4.4 Quality Flagging

The **dataQF** field in each data record is a quality flag for known errors applying to the record. Please see the *Special Considerations* section of this document for a list of known errors that may be present in the data, and below for an explanation of **dataQF** codes specific to this product.

Table 1: Descriptions of the dataQF codes for quality flagging

| fieldName | value | definition |
|-----------|------------|---|
| dataQF | legacyData | Data recorded using a paper-based workflow that did not implement the full suite of quality control features associated with the interactive digital workflow |

Records of land management activities, disturbances, and other incidents of ecological note that may have a potential impact are found in the Site Management and Event Reporting data product (DP1.10111.001)

4.5 Analytical Facility Data Quality

Data analyses conducted for dissolved gas in surface water conform to the current data quality standards used by practitioners. On at least an annual basis a QAQC summary file is reported that contains a description of the method, method detection limit, precision, and measurement uncertainty associated with a specific time range and analyte. This is published in the **sdg_externalLabSummaryData** table in the expanded download package. In the **sdg_externalLabData** table, as part of the basic download package, a run detection limit and precision are also published. The run detection limit and precision may be different from the method detection limit and precision since they are based on the specific standards and settings used for a specific run rather than the method as a whole.

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6 APPENDIX

Notes about calculating dissolved gas concentrations in surface water from reference air and equilibrated air gas concentrations. **ConcentrationCO₂_{gas}**, **ConcentrationCH₄_{gas}** and **ConcentrationCN₂O_{gas}** are the external laboratory concentrations for the **equilibratedAir** sample and **ConcentrationCO₂_{air}**, **ConcentrationCH₄_{air}** and **ConcentrationN₂O_{air}** are the external laboratory concentrations for the **referenceAir** sample.

- For all gasses:

- The gas constant, R, is:

$$R = 8.3122598 \text{ L kPa K}^{-1} \text{ mol}^{-1}$$

- Temperature adjusted Henry's Law Constant is:

$$H(T) = H_0 e^{\frac{d \ln(H)}{d(\frac{1}{T})} (\frac{1}{T} - \frac{1}{T_0})}$$

- Dissolved gas concentration in water is:

$$C_w = \frac{\text{mol}_{gas\text{wat}}}{\text{vol}_{H_2O}} = \frac{\text{mol}_{gas\text{aireq}} + \text{mol}_{gas\text{wateq}} - \text{mol}_{gas\text{air}}}{\text{vol}_{H_2O}}$$

- where, Totalmol_{gas}

$$\text{Totalmol}_{gas} = \text{mol}_{gas\text{air}} + \text{mol}_{gas\text{wat}} = \text{mol}_{gas\text{aireq}} + \text{mol}_{gas\text{wateq}}$$

- Where, mol_{gas}aireq

$$\text{mol}_{gas\text{aireq}} = \frac{\text{ppmv}_{aireq} \cdot 10^{-6} \cdot BP \cdot \text{vol}_{aireq}}{RT}$$

- Where, mol_{gas}air

$$\text{mol}_{gas\text{air}} = \frac{\text{ppmv}_{air} \cdot 10^{-6} \cdot BP \cdot \text{vol}_{air}}{RT}$$

- Where, mol_{gas}wateq

$$\text{mol}_{gas\text{wateq}} = H(T) \cdot \text{ppmv}_{aireq} \cdot 10^{-6} \cdot BP \cdot \text{vol}_{H_2O}$$

- Calculate dissolved carbon dioxide (CO₂) concentration.



- a. The Henry's Law constant used is (Sander, 2015):

$$H_0 = 3.3 \cdot 10^{-4} \text{ mol m}^{-3} \text{ Pa}^{-1}$$

- b. The temperature relationship is:

$$\frac{d \ln(H)}{d\left(\frac{1}{T}\right)} = 2400 \text{ K}$$

- c. The overall equation is:

$$C_{CO_2} = \text{ptBarometricPressure} \cdot 10^{-6} \cdot \left[\frac{(\text{gasVolumeSyringe})(\text{concentrationCO2gas} - \text{concentrationCO2air})}{R \cdot (\text{storageWaterTemp} + 273.15) \cdot \text{waterVolumeSyringe}} + 3.3 \cdot 10^{-4} e^{\left(2400 \left(\frac{1}{\text{storageWaterTemp} + 273.15} - \frac{1}{298.15}\right)\right)} \cdot \text{concentrationCO2gas} \right]$$

3. Calculate dissolved nitrous oxide concentration.

- a. The Henry's Law constant used is (Sander, 2015):

$$H_0 = 2.4 \cdot 10^{-4} \text{ mol m}^{-3} \text{ Pa}^{-1}$$

- b. The temperature relationship is:

$$\frac{d \ln(H)}{d\left(\frac{1}{T}\right)} = 2700 \text{ K}$$

- c. The overall equation is:

$$C_{N_2O} = \text{ptBarometricPressure} \cdot 10^{-6} \cdot \left[\frac{(\text{gasVolumeSyringe})(\text{concentrationN2Ogas} - \text{concentrationN2Oair})}{R \cdot (\text{storageWaterTemp} + 273.15) \cdot \text{waterVolumeSyringe}} + 2.4 \cdot 10^{-4} e^{\left(2700 \left(\frac{1}{\text{storageWaterTemp} + 273.15} - \frac{1}{298.15}\right)\right)} \cdot \text{concentrationN2Ogas} \right]$$

4. Calculate dissolved methane concentration.

- a. The Henry's Law constant used is (Sander, 2015):

$$H_0 = 1.4 \cdot 10^{-4} \text{ mol m}^{-3} \text{ Pa}^{-1}$$

- b. The temperature relationship is:

$$\frac{d \ln(H)}{d\left(\frac{1}{T}\right)} = 1900 \text{ K}$$

- c. The overall equation is:

$$C_{CH_4} = \text{ptBarometricPressure} \cdot 10^{-6} \cdot \left[\frac{(\text{gasVolumeSyringe})(\text{concentrationCH4gas} - \text{concentrationCH4air})}{R \cdot (\text{storageWaterTemp} + 273.15) \cdot \text{waterVolumeSyringe}} + 1.4 \cdot 10^{-4} e^{\left(1900 \left(\frac{1}{\text{storageWaterTemp} + 273.15} - \frac{1}{298.15}\right)\right)} \cdot \text{concentrationCH4gas} \right]$$

6.1 Using sensor data for barometric pressure

Barometric pressure measured by the handheld devices published here are accurate +/- 0.0667 kPa (5 mmHg). Meteorological station data collected by sensors deployed at NEON Aquatic Sites often have reported uncertainty that is an order of magnitude lower. Therefore, if an application requires more precise estimates of dissolved gas concentrations, consider downloading barometric pressure sensor data from the NEON data portal (data.neonscience.org) and calculating dissolved gas concentrations using those values.

6.2 Accounting for salinity in dissolved gas concentrations

The NEON Aquatic Sites are comprised of freshwater lakes, yet some lakes occasionally have specific conductance values that indicate salinity could be significant when calculating dissolved gas concentrations. Based on data collected to date, it is estimated that these elevated specific conductance values could result in up to a 2% difference in calculated dissolved gas concentrations with and without salinity-based adjustments to Henry's Law or Bunsen coefficients.

Salinity for freshwater environments can be determined from the concentration of dissolved solutes and used along with Bunsen coefficients to calculate dissolved gas concentrations using reference air and equilibrated gas concentrations. The salinity of freshwater environments can vary depending on the composition of dissolved ions and therefore the salinity and conductivity need to be calculated for a given water body. The Chemical properties of surface water (DP1.20093.001) data product includes concentrations of dissolved ions for each NEON water body. Bunsen coefficients and their relationships with temperature and salinity for CO₂ can be found in Weiss, 1974, those for methane can be found in Yamamoto et al., 1976, and values for nitrous oxide can be found in Weiss and Price, 1980.