NEON USER GUIDE TO SECCHI DEPTH AND DEPTH PROFILE (DP1.20252.001 AND DP1.20254.001)

PREPARED BY	ORGANIZATION
Caren Scott	AQU
Stephanie Parker	AQU
Kaelin M Cawley	AQU

CHANGE RECORD

REVISION	DATE	DESCRIPTION OF CHANGE
A	05/19/2017	Initial Release
B	05/26/2020	Included general statement about usage of neonUtilities R package and statement about possible location changes. Update lake sensor location names in diagrams.
C	03/08/2022	Updated section 4.3 Data Revision with latest information regarding data release
D	04/17/2025	Adding calculations and rationale built into the field data collection app for fields upperMetalimnionDepth, lowerMetalimnionDepths, upper-MetalimnionDepth2 and lowerMetalimnionDepth2. Added information about the new neonUtilities Python package.

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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 dry weights of litter functional groups from a single collection event 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 products Secchi Depth (measurement of water clarity) and Depth Profile at specific depths (the depth profile of water temperature, conductivity and dissolved oxygen) at lakes and rivers, and associated metadata from input data. This document also provides details relevant to the publication of the data products via the NEON data portal, with additional detail available in the files, NEON Data Variables for Secchi Depth (DP1.20252.001) (AD[06]) and NEON Data Variables for Depth Profile (DP1.20254.001) (AD[07]), 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 in the field pertaining to AOS Protocol and Procedure: Secchi Disk and Depth Profile Sampling in Lakes and Non-wadeable Streams (AD[07]). The raw data that are processed in this document are detailed in the files, NEON Raw Data Validation for Secchi Depth (DP0.20252.001) (AD[04]) and NEON Raw Data Validation for Depth Profile (DP0.20254.001) (AD[05]), 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., '20252') 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.000913	TOS Science Design for Spatial Sampling
AD[03]	NEON.DOC.002652	NEON Data Products Catalog
AD[04]	Available with data download	NEON Raw Data Validation for Secchi Depth (DP0.20252.001)
AD[05]	Available with data download	NEON Raw Data Validation for Depth Profile (DP0.20254.001)
AD[06]	Available with data download	NEON Data Variables for Secchi Depth (DP1.20252.001)
AD[07]	Available with data download	NEON Data Variables for Depth Profile (DP1.20254.001)
AD[06]	NEON.DOC.001152	Aquatic Sampling Strategy
AD[07]	NEON.DOC.002792	AOS Protocol and Procedure: Secchi Disk and Depth Profile Sampling in Lakes and Non-wadeable Streams
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[05]	Available with data download	Categorical Codes csv

2.2 Acronyms

Acronym	Definition
DO	Dissolved oxygen
USEPA	U.S. Environmental Protection Agency

3 DATA PRODUCT DESCRIPTION

Aquatic communities and water quality are highly dependent on water clarity and temperature. Secchi depth is often used as a quick measurement of productivity as it measures the depth to which light penetrates and can indicate a lake is either oligotrophic (low-nutrient) or eutrophic (high-nutrient). In lakes, light penetration is typically limited by phytoplankton growth (although turbidity also limits light penetration in some lakes).

Depth or vertical temperature profiles indicate whether or not the lake or river is thermally stratified, where the body of water is separated into two or more layers based on temperature. Typically, in a thermally stratified system, the top layer of water is warmer (epilimnion) while the lower layer is colder (hypolimnion). The area separating the two layers is known as the thermocline. The thermocline occurs when the rate of decreasing temperature with increasing depth is greatest, where there is a change of greater than 1 degree C per 1.0 m change in depth (USEPA 2012). Thermal stratification can dramatically change the water chemistry and biology of each layer. If the lake or river is thermally stratified, samples may be taken at multiple depths to capture the conditions of each layer in the associated protocols.

3.1 Spatial Sampling Design

Secchi and depth profile data are measured at all lake and river sites at the buoy location. In lakes, the buoy is located at the deepest part of the main basin, while in rivers, the buoy is located in a deep area outside of the navigable channel.

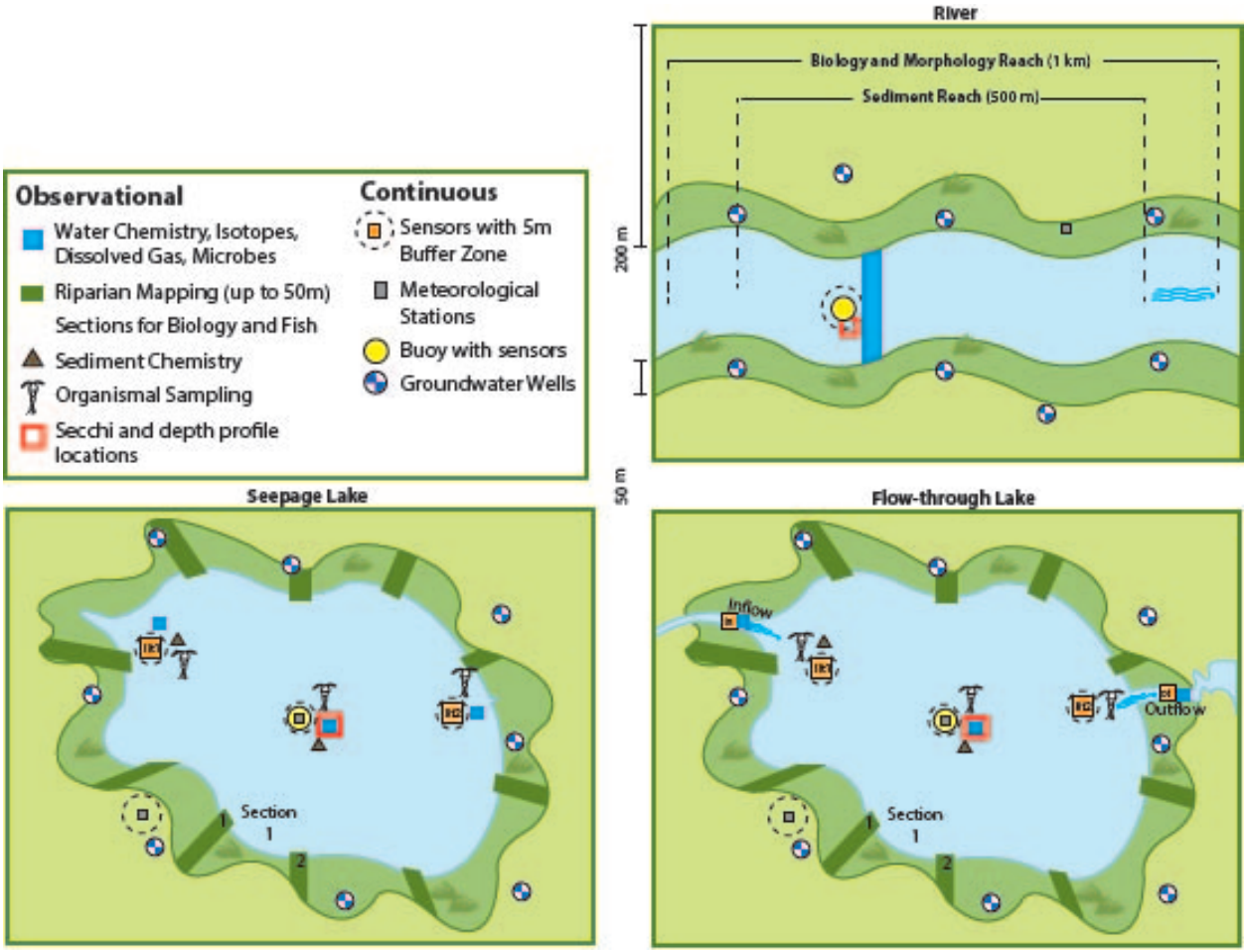

Figure 1: A generic site layout for lakes and rivers with Secchi depth and vertical profile sampling locations (red boxes).

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/

3.2 Temporal Sampling Design

Depth profiles will be measured every time techs sample for water chemistry, surface microbes, phytoplankton, zooplankton and sediment chemistry, even under ice. Secchi data are collected only during only when ice is not present.

3.3 Variables Reported

All variables reported from the field or laboratory technician (L0 data) are listed in the files, NEON Raw Data Validation for Secchi Depth (DP0.20252.001) (AD[04]) and NEON Raw Data Validation for Depth Profile (DP0.20254.001) (AD[05]). All variables reported in the published data (L1 data) are also provided separately in the files, NEON Data Variables for Secchi Depth (DP1.20252.001) (AD[06]) and NEON Data Variables for Depth Profile (DP1.20254.001) (AD[07]).

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.

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

3.4 Spatial Resolution and Extent

The finest spatial resolution at which Secchi and depth profile data will be tracked is per station (1 stationID per site). Each surface Secchi and/or depth profile sample will be representative of the site level (i.e., siteID).

Overall, this results in a spatial hierarchy of:

stationID (ID of sampling location within the site) -> **siteID** (ID of NEON site) -> **domainID** (ID of a NEON domain)

3.5 Temporal Resolution and Extent

The finest temporal resolution that Secchi and/or depth profile data will be tracked is at the level of an individual sample in a sampling bout (i.e., date-YYYYMMDD).

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. Code to stack files across months is available here: (LINK TBD)

3.6 Associated Data Streams

eventID is a linking variable that can tie measurements of Secchi Depth and Depth Profile to each other. Depth Profile data can also be linked to continuous temperature measurements from the temperature chain attached to the buoy (DP1.20264.001).

3.7 Product Instances

The total number of bouts per year is expected to be 18 per lake site (12 associated with surface water chemistry and surface microbes, 3 associated with phytoplankton and zooplankton, and 3 associated with sediment chemistry) and 32 per river site (26 associated with surface water chemistry-12 of which will also include surface microbes, 3 associated with phytoplankton and zooplankton, and 3 associated with sediment chemistry).

3.8 Data Relationships

The protocol dictates that profile measurements are recorded from the surface of the water down, starting at 0.5 m and recording every 0.5 m. The header information (location, date, recordedBy etc) is recorded once in dep_profileHeader. Each record in dep_profileHeader can therefore have one or more child records (profile measurements in dep_profileData) associated with it, depending on the depth of the lake. These two tables (dep_profileHeader and dep_profileData) can be joined using the **eventID** field. Duplicates and/or missing data may exist where protocol and/or data entry abberations have occurred; users should check data carefully for anomalies before joining tables.

dep_profileHeader.csv - > one record expected per namedLocation per collectDate (day of year, UTC) combination

dep_profileData.csv - > one record expected per depth per namedLocation per collectDate (day of year, UTC) combination

Data downloaded from the NEON Data Portal are provided in separate data files for each site and month requested. The neonUtilities package in R and the neonutilities package in Python contain functions to merge these files across sites and months into a single file for each table. The neonUtilities R 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. The neonutilities package in Python is available on the Python Package Index (PyPi; https://pypi.org/project/neonutilities/) and can be installed using pip. For instructions on using the package in either language 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.

3.9 Special Considerations

Calculations to determine **thermalStratification**, **upperMetalimnionDepth**, **lowerMetalimnionDepth**, **upperMetalimnionDepth2** and **lowerMetalimnionDepth2** occur in the field data collection app for DP1.20254.001. Those calculations are outlined here:

1. At each sampling depth, the field app creates a table of depth, previous depth, water temperature, depth difference, and terature difference, and populates a stratification = true/false field dependin on whether or not the temperature change per meter is greater than or less than 1 °C.
2. The app “cleans” the table created if there are >3 rows to only include layers that are at least 1/3 of the **maxDepth**. This step removes small layers that may be in unstratified portions of the metalimnion or shallow stratified layers at the bottom of the water column.
3. The water column is “not stratified” if there is only one row where the “stratified” column == *FALSE*.

4. The water column is “completely stratified” if there is only one row where the “stratified” column = *TRUE*. This occurs in shallow lakes whether there is usually only a 1 °C throughout the entire depth of the water column.
5. The water column is “stratified” if there is more than one row in the cleaned table. From there, it pulls out the uppermost depth with stratification = TRUE (**upperMetalimnionDepth**) and the lower depth from the next row (**lowerMetalimnionDepth**) to indicte the depths of the thermocline. If there is not a next row, the app defaults to the **maxDepth**.
6. If there is another set of rows where stratification = TRUE, the app also pulls out the top depth (**upperMetalimnionDepth2**) and lower depth (**lowerMetalimnionDepth2**) to indicate that there is a second thermocline.

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 or web user interface (UI). 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. 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 documents NEON Raw Data Validation for Secchi Depth (DP0.20252.001) (AD[04]) and NEON Raw Data Validation for Depth Profile (DP0.20254.001) (AD[05]), 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 ([AD[11]).

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.

1. **samplingImpractical** captures scenarios where attempts at measurements and/or sample collection were made. If **samplingImpractical** is set to “other” additional **remarks** are required.
2. When ice is present at a lake or river secchi readings are not collected and an abbreviated depth profile are collected. The App accommodates this with a **Ice Present?** field that changes the requirements for an entry depending on the selection.
3. If a lake is clear to the bottom the **Euphotic Depth** is set to the **Maximum Depth** and the **Secchi Mean Depth** is set to NULL.
4. Following entry of the depth profile measurements, the app calculated the stratification status of the water body. A water body is stratified if there is a change of 1 or more °C per meter.
5. In a non-stratied water body, the upper segment depth is the surface (i.e. 0 m) and the lower segment depth is the maximum depth.
6. In a stratified water body, the first segment is the epilimnion and upper segment 1 depth is the surface (i.e. 0 m) and the lower segment 1 depth is the top of the metalimnion. The metalimnion is the region where the temperaturee change is at least 1 °C per meter. The second segment is the

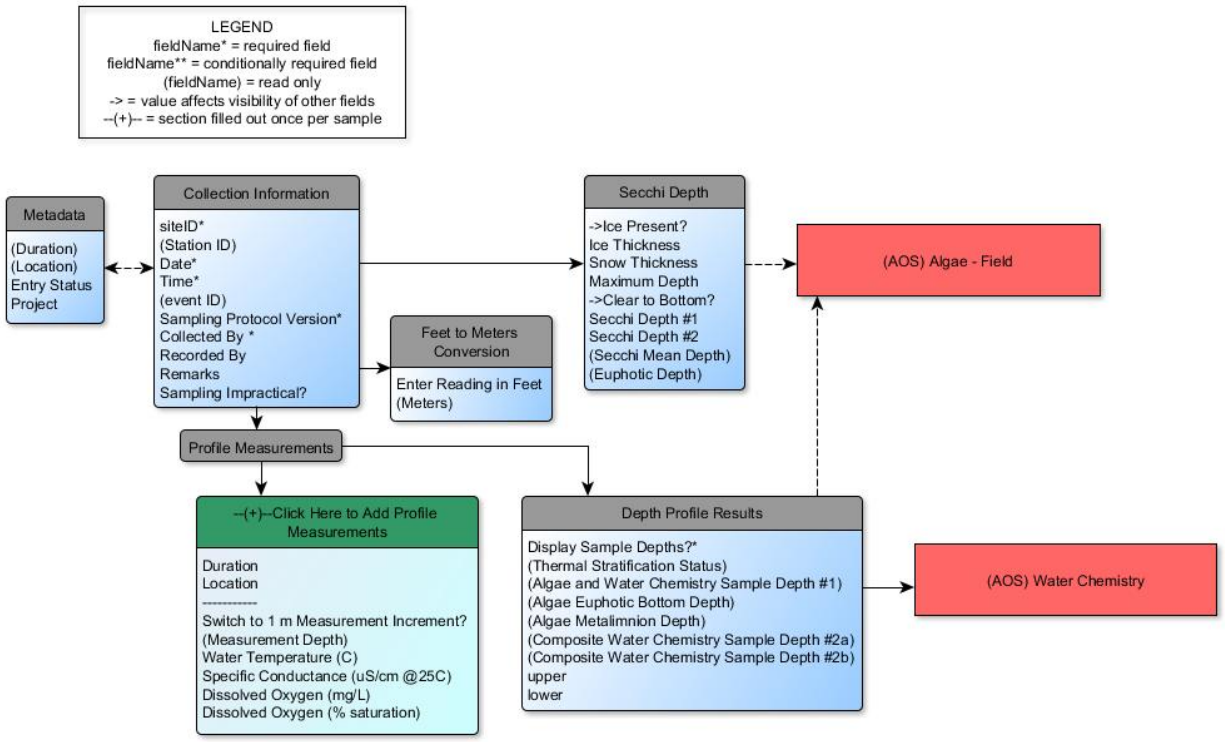

Figure 2: Schematic of the applications used by field technicians to enter secchi depth and depth profile field data

hypolimnion and upper segment 2 depth is the bottom of the metalimnion and the lower segment 2 depth is the max depth. These values are passed to the Water Chemistry app where the data is stored with additional measurements and samples.

7. The app calculates sample depths for water chemistry and algae samples. In non-stratified water bodies, algae samples are collected at 0.5 m and 0.5 m above the **Euphotic Depth**, water chemsitry samples are collected at 0.5 m. In a stratified water body, algae samples are collected at 0.5 m and at the mid-point of the metalimnion, water chemistry samples are collected at 0.5 m and at the midpoint of the hypolimnion. If the hypolimnion is at least 2 m in depth a composite sample from two points in the hypolimnion is collected. These sample depths are linked to the Algae and Water Chemistry apps.

4.2 Automated Data Processing Steps

Following data entry into a mobile application of 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. Annually, NEON releases a static version of all or almost all data products, annotated with digital object identifiers (DOIs). The first data Release was made in 2021. 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 Issue Log section of the data product landing page 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. There are currently no dataQF codes in use in this data product.

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)