Lake RMN Protocol Document.
Secchi Depth Transparency (SDT) (12/28/2022)

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Why measure water clarity/Secchi depth?

Secchi depth transparency (SDT) is a measurement of surface water clarity, which affects light penetration. It is an indicator of trophic status and overall lake health that it is easy to measure and relates directly to the aesthetic perceptions of the general public (MPCA 2018). Many lakes have long-term SDT records. SDT provides important information about primary production, plant species composition and thermal stratification (low water transparency restricts transfer of thermal energy to deeper waters) (Read and Rose 2013, Schmid et al. 2014, Rose et al. 2016, Richardson et al. 2017). SDT can be used to track trends in phytoplankton biomass and suspended sediment loading from agricultural and urban runoff and shoreline erosion (Elias et al. 2015).

1 Level of effort

The RMN framework allows for different levels of effort to maximize participation. Table 1 contains a 'menu' of options for SDT measurements, divided into three levels of participation: 'minimum', 'target' and 'better'. If resources permit, participants are encouraged to collect data at the 'target' or 'better' levels, since these levels of effort increase the number of ways in which the data can be used and improve the likelihood of detecting trends over shorter time periods (e.g., monthly measurements have much stronger trend detection power than annual measurements). Table 1 is intended to provide a basic framework; there may be participation levels that fall in-between those suggested in this table.

Table 1. Secchi depth divided into three levels of participation: 'minimum', 'target' and 'better'. Participants are encouraged to collect data at the 'target' or 'better' levels. Higher levels of effort increase the likelihood of detecting trends over shorter time periods and increase the number of ways in which the data can be used. Note that there may be participation levels that fall in-between those suggested in this table.

Sampling location	Level of participation		
	Minimum	Target	Better
Deepest point	1X/year during summer (July 24-August 7*)	Spring turnover + 3X/year during summer (15 July – 15 Sept); one of the 3 visits should occur during the July 24-Aug 7 time period	Monthly to weekly during open water season**

* While efforts should be made to sample during this time period whenever possible, situations may arise where people need to monitor during the week before or after. Those data will still be used but will be flagged.

**More frequent measurements provide greater statistical power for analyses (Smeltzer et al. 1989), which means there is a higher likelihood of correctly detecting subtle changes over shorter time periods.

2 Protocols

The use of consistent and comparable methods is very important for the RMNs, as different methodologies may introduce analytical constraints and contribute to variability, which reduces the sensitivity of indicators and increases trend detection times.

Time period
If possible, at least one SDT measurement should be taken between July 24-August 7, with the intent of coordinating the timing of at least one set of regional measurements. While efforts should be made to sample during this time period whenever possible, situations may arise where people need to monitor during the week before or after. Those data will still be used but will be flagged.

The July 24-August 7 time period is when lake temperatures are typically warmest and chlorophyll-a tends to reach its annual maximum. This is also a time when the lake is likely to be stratified (if it stratifies at all) and dissolved oxygen is likely lowest in the hypolimnion. Many lake monitoring programs typically sample around this time.

A shown in Table 1, additional measurements are encouraged, with the target being three measurements during the July 15 – September 15 time period and one measurement during spring turnover. If monthly to weekly measurements during open water season are possible, these higher frequency measurements will improve the likelihood of detecting trends over shorter time periods (Smeltzer et al. 1989).

Steps

1. Motor or paddle to the deepest part of the lake. Measurements should be taken from this same location each visit.
2. Anchor your boat if helpful to prevent drifting during measurement.
3. Record the bottom depth on the field data sheet.
4. Take off sunglasses.
5. Take the SDT reading on the shady side of the boat, using a black and white 20-cm (8-inch) diameter Secchi disk with a surveyor grade tape measure or non-stretch line (marked in meters) and, if available, a view scope.
6. Use either of the techniques below.[1] For both, determine depth to the nearest 0.05 m if the Secchi depth is <1.0 m. Otherwise, determine depths to the nearest 0.1 m. Note if the Secchi disk is still visible at the bottom of the lake.
    a. With view scope[2] (if available, see text box) –
        i. View the disk through the scope, slowly lower the Secchi disk until you can no longer see it (no white glow.) Then, raise it until it is visible again and lower it one more time, very slowly, stopping when it disappears. Hold the Secchi disk and tape steady, remove your face from the scope and mask and place the scope safely inside the boat. Pinch the meter tape where it meets the water and record that depth onto the Field Data Sheet.
    b. Without view scope –

[1] Maine DEP has done comparisons between these two approaches and the measurements came within 1-centimeter of each other (Linda Bacon, ME DEP, personal communication).
[2] This method is used by Maine's lake monitoring programs.

i. Slowly lower the disk until it disappears. Record the depth.
ii. Slowly raise the disk until it reappears. Record the depth.
iii. Calculate the midpoint between depth of disappearance and reappearance. This is the Secchi depth result.

Quality Assurance/Quality Control (QA/QC)
Field duplicates should be collected at a rate of 10%. If there are two observers in the boat, both people should make independent Secchi disk observations and record both readings. The second reading should be listed as a duplicate.

Keys to accurate and comparable SDT measurements at RMN lakes:

- **Anchor the boat** - always do this! If the boat moves while taking the reading, and the disk does not hang vertically, the reading will not be accurate. If you drift from the deepest spot while taking the measurement, pull up the anchor, move back to the deep spot, re-deploy the anchor and take the measurements over again.
- **Use a black and white 20-cm (8-inch) diameter Secchi disk** – this helps us standardize equipment across RMN lakes.
- **Keep your disk clean** – the observer needs to be able to clearly see its whiteness (and blackness).
- **Weather** - take the reading on a clear and calm day if possible (to avoid wave disturbances).
- **Time of day** – take the readings when the sun is most directly overhead (generally between 10:00 am (1000 hours) and 3:00 pm (1500 hours)). This will minimize the influence of the sun's altitude. Readings taken in the early morning or late afternoon can be markedly lower than a midday reading.
- **Take off your sunglasses** (this affects observer vision characteristics). If wearing prescription sunglasses, temporarily replace them with regular clear lens prescription glasses.
- **Take the measurement from the shady site of the boat** - the shade reduces glare and can improve the readings up to 3ft. (~1 meter.)
- **Considering using a view scope –** this helps standardize readings under different conditions (see text box).
- **Use a surveyor grade tape measure or non-stretch line –** stretching in the line affects the accuracy of readings.

Disclaimer: we expect participating entities to follow their own approved safety protocols and thus do not provide any here.

What if this differs from your normal monitoring procedures?
If possible, take two sets of measurements – one using your normal protocols (that are consistent with your long-term data record; we want your long-term record to stay intact) and one using the RMN protocols. The use of a view scope is encouraged when possible. If you haven't used a view scope in the past, we recommend taking one set of measurements with the view scope, and one using protocols that are consistent with your long-term record. Retain both sets of readings for comparison.

Why use a view scope?
The scope helps standardize readings in different conditions. It allows the monitor to see more deeply and clearly into the water by reducing glare and cutting down on wave disturbances. Using a scope can maximize the depth of SDT reading and minimize the effects of varying cloud covers, wave movements and wind velocities.

ME DEP has done numerous side-by-side measurements (with and without view scopes) and found definite differences when it was wavy or when there was strong glare from the sun (the non-scope readings were much shallower, sometimes by as much as a meter). They performed a paired t-test between readings taken without a scope and with an Aqua-Scope II (4" diameter, with mask and slanted glass) and found a highly significant difference between methods ($p<0.001$). Readings were nearly identical in calm conditions without too much sun (Jeremy Deeds, personal communication).

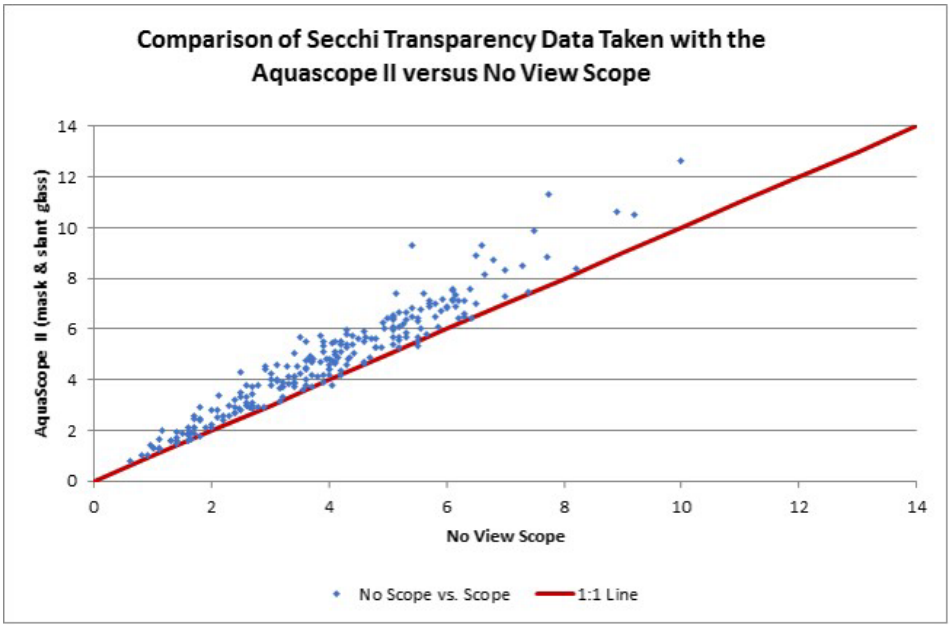

Figure 1. Scatterplot of measurements taken with and without a view scope, with a 1:1 line. The view scope readings were consistently higher (the mean percent difference for scope readings vs. non-scope readings was +21.3%). This figure was provided by Jeremy Deeds and Linda Bacon from ME DEP.

3 Equipment

Table 2 and Figure 2 contain information on basic equipment needs (Secchi disk, measuring line, view scope), considerations and estimated costs. This assumes you have access to a boat and anchor, a GPS unit for locating the sampling location and safety gear.

Table 2. Basic equipment needs and estimated costs (3/30/2018)

Equipment	Specifications	Considerations	Estimated Costs*
Secchi disk	Diameter of 20cm (8 inches), with standard pattern of two white and two black quadrants and a bottom weight (approx. 1.5 lbs)	Not too light and not too heavy (in windy conditions or if it is too deep to anchor, light disks don't sink well and heavy disks can tear the measuring tape or break the line)	Generally $35-50
Measuring line	Use a line that does not stretch; units should be in meters	People have had good success with open reel fiberglass measuring tapes used in conjunction with the transparency disk (Figure 2 shows a tape that has been modified to attach to the Secchi depth). Other people use marked line, which should be non-stretching.	Modified tapes run from $30 (15-meter) to $40 (30-meter) (Figure 2)
View scope	Several possibilities (tilted vs. flat, 4" vs 6")	Slanted (or tilted) lens have advantages over flat lens because they eliminate both surface glare as well as internal reflection. With tilted lens, it is not necessary to have one's face in contact with the view mask in order to eliminate unwanted reflection. If you wear glasses, the 6" version may be better than the 4" because the 6"can accommodate eyeglasses.	Tilted can range from $69 (4") to $129 (6")

*http://www.watermonitoringequip.com/pages/lake.html


Figure 2. Example of a disk/tape measure set-up (left) and view scopes (right). The tape has been modified with a stainless steel quick link to attach to the Secchi disk eyebolt (http://www.watermonitoringequip.com/pages/lake.html).

4 Field forms

At a minimum, RMN SDT field forms should contain the following information:

- Lake name and RMN SiteID
- Date
- Time
- Person taking the measurements (include contact information)
- Latitude and longitude where measurement is taken
- If not taken from a boat, note what type of platform the measurement was taken from
    - Dock
    - Bridge
    - Wading
    - Other
- Measurements (preferably in meters)
    - If the Secchi depth is <1.0 m, record depths to the nearest 0.05 m. Otherwise, record depths to the nearest 0.1 m.
- Time of observation (military time is preferred)
- Confirm that sunglasses were removed
- Confirm that measurements were taken from the shady side of the boat (or make a note if there wasn't a shady side)
- Was the disk resting on the bottom? Yes or no
- Type of disk
    - Black and white 20-cm (8-inch) diameter
    - If 'Other', please describe
- Did you use a view scope? Yes or no
- If yes, what type of scope?
    - Open tube or tube with a bottom
    - Mask or no mask

- Flat glass or tilted lens
- Size - 4”, 6” diameter, other
- Light conditions
    - 1 = bright, distinct shadows
    - 2 = cloudy-bright, no shadows
    - 3 = heavily overcast
- Condition of water surface
    - Calm = completely calm
    - Light = smooth or rippled to small wavelets
    - Gentle = large wavelets, crests begin to break, few whitecaps
    - Moderate = small waves, frequent whitecaps
    - Fresh = moderate crested waves, many whitecaps
    - Strong = large waves, white foam crest everywhere, wind blown spray (too dangerous for monitoring!)

5 Data management

RMN partners will be custodians and owners of their data. The goal is to upload the SDT data to the Water Quality Portal/Water Quality Exchange (WQX), where it can be accessed by other regional partners.

There are three options for uploading SDT data into WQX:

1) Standard web-based application (WQX Web) that uses Microsoft Excel spreadsheets.
2) Create a custom submission application using WQX XML schema through Exchange Network Nodes or Node Clients
3) Via a third-party system such as The Ambient Water Quality Monitoring System (AWQMS) (proprietary) and Lake Observer[3] (https://www.lakeobserver.org/) (free). Users have the option of pushing the data to WQX through these platforms. The North American Lake Management Society (NALMS) website may also be an option - https://www.nalms.org/secchidipin/explore-the-data/

6 Helpful Resources

With view scope –

- Maine Volunteer Lake Monitoring Program Secchi Simulator – https://www.mainevlmp.org/secchi-simulator/

Without view scope –

- Secchi Dip-In YouTube video on how to take a Secchi measurement - https://www.youtube.com/watch?v=xiRT2j54Y2U

[3] The Lake Observer option offers both a mobile phone app (for Apple or Android platforms) as well as a computer (online) interface. Users have the option of pushing the data to WQX through Lake Observer. Training videos are available on the Lake Observer website.

- NALMS website - https://www.nalms.org/secchidipin/explore-the-data/

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