Wisconsin DNR – Lake Level Monitoring
Surveyor Protocol

EGAD#3200-2018-44

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I. Project Background

This project will engage volunteers with the Citizen Lake Monitoring Network (CLMN) and other local partnerships to monitor inland lake levels in Wisconsin and is coordinated by the Wisconsin Department of Natural Resources (WDNR). Regional CLMN coordinators will oversee the water level monitoring program in their region, with support from county staff and central office monitoring and SWIMS staff. Water level measurements will be attained from a staff gauge installed near shore that is surveyed each spring and fall. A staff gauge is a graduated measuring instrument made out of enameled steel. The gauge is placed in the lake bed to show the elevation of the water surface and can be visually read from the shore or by boat. The elevation of the staff gauge is calibrated by referencing the numbered height on the gauge to the surveyed elevation of permanent reference marks on land at the time of installation (Harrelson et al., 1994). Surveying the staff gauge each year is essential as it enables water level readings to be linked across years.

Staff gauges are often mounted on permanent structures such as a bridge piling or weir, but for this project, most staff gauges will be attached to fence posts and sunk into the lake bottom (Elias et al., 2008). Staff gauges should be installed and surveyed in the spring each year (April or ice-out) and surveyed again before they are removed in October or November to prevent ice damage. Staff gauges need to be resurveyed and referenced to the same reference mark each year upon installation (Kenney, 2010). A permit from the WDNR is not necessary if the staff gauge is being used for WDNR purposes, is placed outside a navigation zone, and is visually unobtrusive.

Staff gauge installation and the surveying of the staff gauge should not be undertaken by volunteers unless they are professionally trained. The WDNR will provide training on the proper surveying/installation methods to potential surveying staff including: counties, North Lakeland Discovery Center (NLDC), the Natural Resources Conservation Service (NRCS), UW-Extension (UWEX), WDNR, US Forest Service (USFS), and consulting firms. All project consultants will need to be trained using these protocols prior to installing and surveying staff gauges.

II. Equipment

Listed below is the necessary equipment for installing and surveying the staff gauge:

- Staff Gauge (Figure 1A)
  - WaterMark® Style "A" Stream Gauge - 0-3.33 ft. (Forestry Suppliers)
  - Style "A" Stream Gauge, 0-3.33 ft. (Ben Meadows)
- Wooden Gauge Board (nominally 1 in. x 8 in. x 4 ft. size)
  - Good materials include: oak or pressure-treated wood
- Metal fence post (U-style, 2-3 in. wide, 8 ft. tall) (Figure 1B)
  - 8 ft. x 3.00 lbs/ft. Steel U Channel Post (Gopher Signs)
- '12x1' flathead stainless steel screws to attach gauge to wood
- Stainless steel screws to attach wood to fence post
  - 3.5 in. x 5/16 in. hex bolt and 5/16 in. hex nut
  - Flat washer and lock washer
- Stainless steel 2.5 in. lag bolt for '0' marker
- Extra stainless steel bolts/nuts, washers

A

B

Figure 1. Staff gauge equipment

- WDNR Contact Information Card (to be affixed to the staff gauge)
- Builder's level, screwdriver, wrench/socket, crescent wrench
- Fencepost pounder and maul
- GPS and Digital Camera
- Surveying equipment (auto level or laser level, tripod, stadia rod, survey nails)
- Staff gauge installation and calibration data sheet(s)
- Calculator, clipboard, and pencil
- Waders or hip boots
- AIS decontamination/cleaning equipment

III. Choosing an Installation Location

First, determine the location where the staff gauge will be installed. In order to be able to monitor the staff gauge throughout the field season, the gauge needs to be installed at a depth that can accommodate a large change in water level, but still be near shore for accessibility. The staff gauge needs to be placed in areas away from general use navigation zones, but still be visible from land (binoculars can be used if monitoring from land or dock) or accessible by boat. **Coordinate placement/orientation of the gauge with the lake level volunteer** and/or lake association to ensure that the volunteer can efficiently monitor (i.e. facing a dock, toward shore, near volunteer's property). Do not install a staff gauge too close to shore if the lake bottom remains shallow over a long distance, as the gauge may come out of the water when levels are low (USACE Fact Sheet 2015).

It is strongly encouraged to place the staff gauge in the lake adjacent to public land. If the staff gauge is adjacent to private land, please ensure that you have a written agreement ("Release of Claims") for staff to access the property during the monitoring season without trespassing issues. Whenever possible, place the staff gauge near an existing elevation bench mark for ease of surveying.

Although a permit is not needed for staff gauges involved in a WDNR project, the staff gauge must not be a material obstruction to navigation or detrimental to the public interest.

IV. Staff Gauge Installation

Once your installation site is selected, please use the following steps to properly install the staff gauge in the lake bottom:

1. Check to make sure a heavy stainless steel lag bolt is installed at the '0.00' line on the staff gauge to set the leveling rod on when surveying the gauge and check that enough of the bolt is showing to provide room for the leveling rod to rest on.

2. Place the wooden board at the top of the fence post so that most of the post can be driven into the sediment. Attach the wooden board to the fence post using a single bolt at the bottom of the board. Wait until after you pound the post into the lake bed to attach the bolt at the top of the board.
    a. Prior to installation, you may also want to drill additional holes into the fence post to allow for the proper spacing of bolts when securing the wooden board to the post.
3. With the staff gauge attached as described above, carry the gauge and fence post out to a water depth of ~3 ft.
4. From there, pound the post down until the gauge reads ~2 feet.
    a. Be sure to drive the fence post or pipe several feet into the ground so that the gauge will stay stable through high water or bad weather. The staff gauge installer should not be able to move the post with their hands when it is properly installed.
    b. The sign post should be as straight as possible (use a builder's level to help determine straightness), so that when the wooden board and staff gauge are securely attached to the post, both can be properly surveyed using the survey equipment.
    c. If the gauge has builder's level's attached, they may be used to make sure the gauge is vertical, however, judging verticality by eye will also achieve sufficient accuracy.
5. Once the post is set, fasten the top of the board onto the post using stainless steel bolts.
6. Record the x,y location of the staff gauge with a GPS and take photographs of it from the shore.

V. Establishing Reference Marks and Surveying the Staff Gauge

To determine the water surface elevation, the staff gauge needs to be leveled and tied into a surveying reference mark (a fixed object that can be referred to each year). All reference marks should be very stable and permanent to ensure consistent measurements from one year to the next. Reference marks can be: a mark on bridges or other permanent structures, a steel rod driven into a firm soil base, chiseled squares in concrete, file marks in bridge rails, or a cross or circle on a prominent point on a boulder in close proximity to the installation site (U.S. EPA, 2014). A nail in a tree should only be used as a last resort as trees can grow substantially and cover the nails over the years. Please contact your CLMN regional coordinator if you have any questions about suitable reference marks for this program.

The purpose of surveying the staff gauge to reference marks is to obtain a consistent lake level record across years even though the staff gauge is removed each winter. It will also allow for corrections if the staff gauge gets bumped. Therefore, knowing the absolute elevation of each reference mark is unnecessary. The reference marks can be assigned a relative elevation to be used as part of the elevation calculations described below.

Bench marks are permanent structures with known elevation (vertical coordinates). If possible, one of the reference marks used should be a formal survey bench mark. Existing bench marks that are tied to datums (e.g., NAVD88) can be found here: http://www.sco.wisc.edu/controlfinder/controlfinder.html. Make sure that the vertical elevation is listed for the bench mark of interest. Bathymetric lake maps are available at http://dnr.wi.gov/lakes/documents/LakeMaps.aspx. Many of these maps show the location of WDNR bench marks (many with an arbitrarily assigned elevation of 100 ft.). Depending on the age of the map, the benchmarks shown may not still be present.

If the reference marks do not have known vertical elevations, the water level cannot be tied to mean sea level. To ensure the longevity of these records, we recommend obtaining the mean sea level of your reference marks using a real-time-kinematic GPS (RTK-GPS). This process should be done for one reference mark when a lake group, the county, or the WDNR initiates water level monitoring. The other reference marks will be surveyed to the known elevation. A survey using the RTK-GPS should be replicated on the 11th year of the monitoring program and every 10 years thereafter. Please contact professionals with the proper equipment (e.g., NRCS) to tie your reference marks to mean sea level.

Surveying equipment, including a tripod, a leveling instrument, and a stadia rod, will be used to survey the staff gauge into the reference marks. The survey equipment needs to be properly calibrated to survey reference marks and staff gauges for this program. Because the accuracy of the survey affects the accuracy of all water level readings, the surveying process needs to be *duplicated* on the day of installation in order to minimize error.

During the survey process (establishing reference marks, leveling survey equipment, surveying the reference marks and staff gauge), use the surveying data sheet to record all required documentation.

Please use the following steps to properly survey the staff gauge at the monitoring location:

1. Before beginning the survey, establish three different reference marks (RM) along the lakeshore to calibrate the staff gauge. *These reference marks must be used as part of all future lake level monitoring activities at this location unless the reference mark is damaged or removed.*
    a. Record the location of each reference mark with a GPS and take pictures of the reference mark and surrounding area. Be sure to include identifying features in the photo.

Reference Mark and Staff Gauge Information

Reference Mark #1 (RM1) Reference Mark Type: _____

Latitude: _____ Longitude: _____ Mean Sea Level Yes ☐ No ☐ Elevation: _____ Photograph ☐

Location Description: _____

_____

    b. Sketch the locations of the reference marks in relation to the location of the staff gauge (Figure 4). By clearly documenting both the location of the reference marks and any relevant site features, it will be easy to locate them for subsequent surveys.

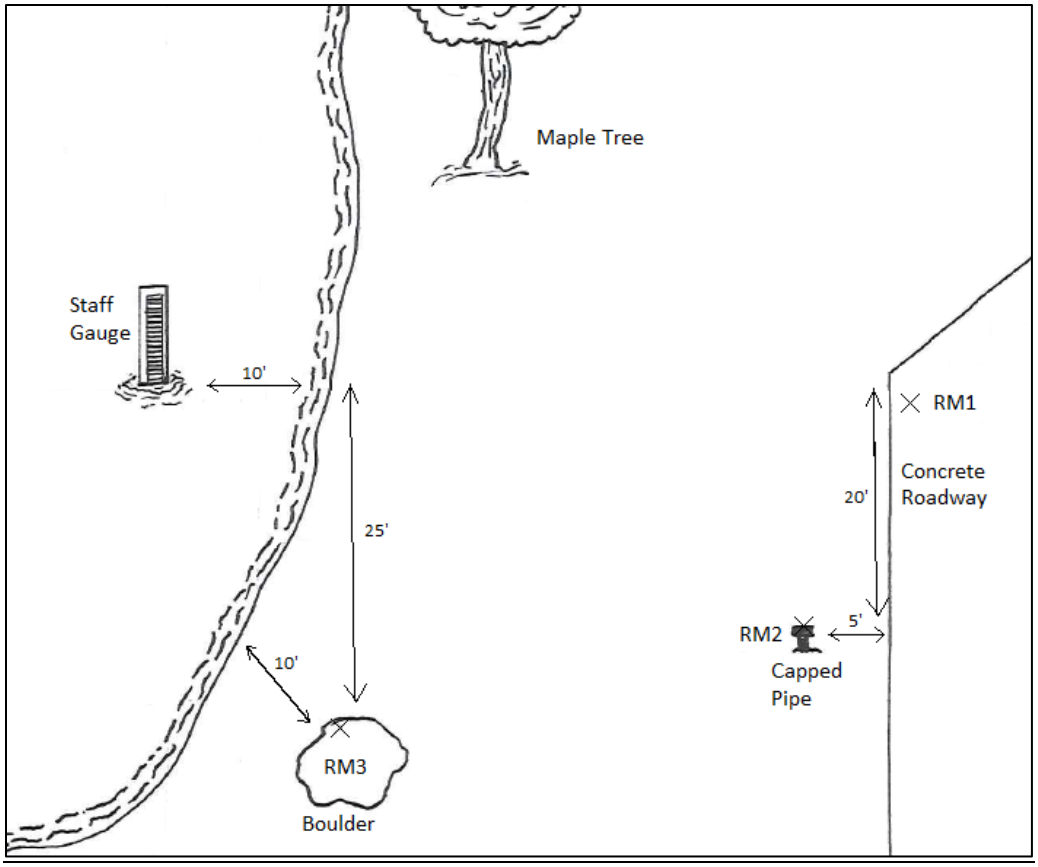


Figure 4. Diagram of the survey site

2. If the vertical elevation of the first reference mark is known, record that elevation on the data sheet (either it is a pre-existing bench mark with known elevation or you obtained the elevation with a RTK-GPS unit). If not, assign an arbitrary elevation of 100 ft. to RM 1 and record the elevation on the datasheet (see Appendix B).

3. Set up the tripod for **Survey Stage 1** in a centralized location where the staff gauge and reference marks are visible and attach the leveling instrument (Figure 5). Be sure to follow the levelling procedures for the auto level before continuing with the survey.

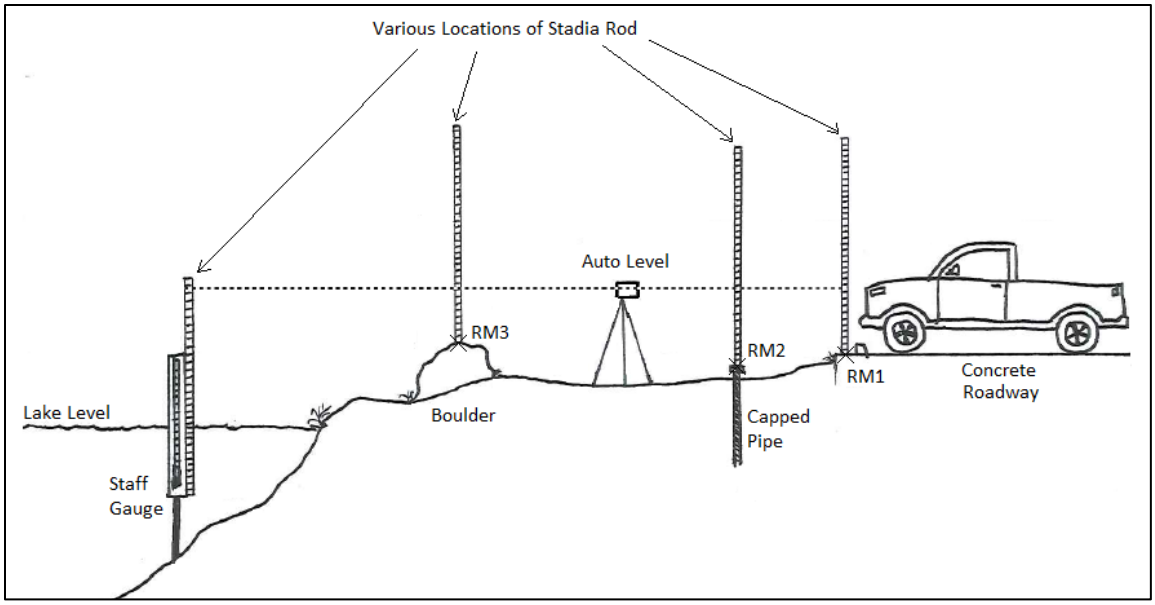


Figure 5. Various locations of reference marks with an auto level and stadia rod

4. Have a partner place the stadia rod on the first reference mark (RM1). Then read the height of the rod through the instrument (intersection of the cross-hair with the marks on the stadia rod). This reading is called your back sight reading, BS (Figure 6). Record it as BS1 on the data sheet.
    a. The number read from the rod is added to the given elevation of the reference mark and is called the height of the instrument, HI (HI = 'Known or Assigned Elevation' + BS).

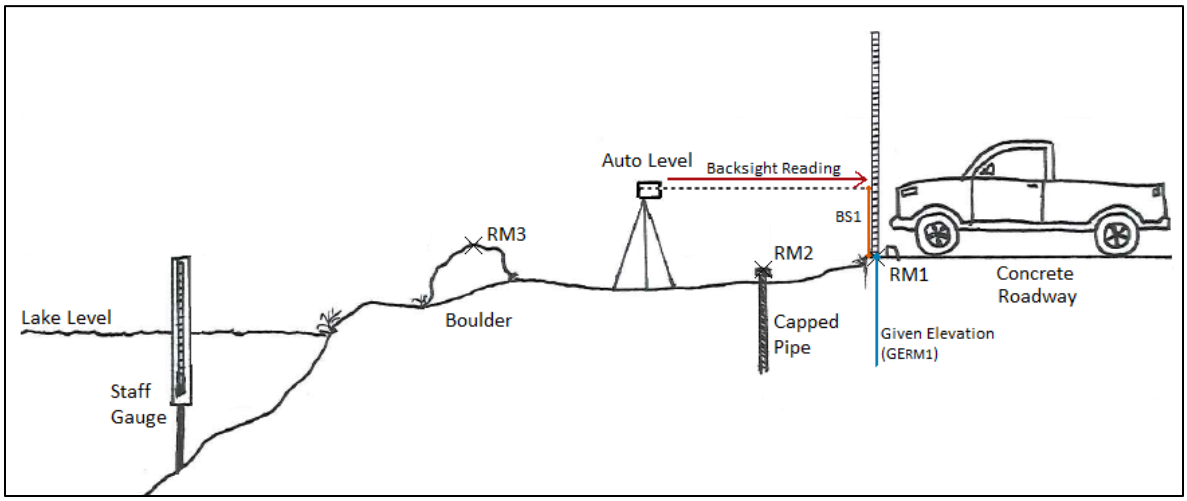


Figure 6. Back sight reading (BS) of a reference mark (RM) with an auto level and stadia rod

5. Record the HI1 value on the data sheet.

Date: _____ Time: _____ AM/PM Check one: Install ☐ Midseason ☐ Removal ☐

Survey Stage 1 - Instrument at first height*

	Reference Mark 1		Fore sight (FS1)	Calculated Elevation (CE1)
Given Elevation (GE_{RM1})	_____			
Back sight 1 (BS1)	+ _____			
Height of Instrument (HI1)	☐	- Staff Gauge	_____	= ☐
	HI1	- Ref Mark 2	_____	= ☐
	HI1	- Ref Mark 3	_____	= ☐

Survey Equations:
$HI1 = GE_{RM1} + BS1$
$CE1 = HI1 - FS1$

6. Place the rod on the heavy stainless steel lag bolt at '0.00' marker of the staff gauge and read the rod through the survey instrument. This is called your foresight (FS) reading (Figure 7).

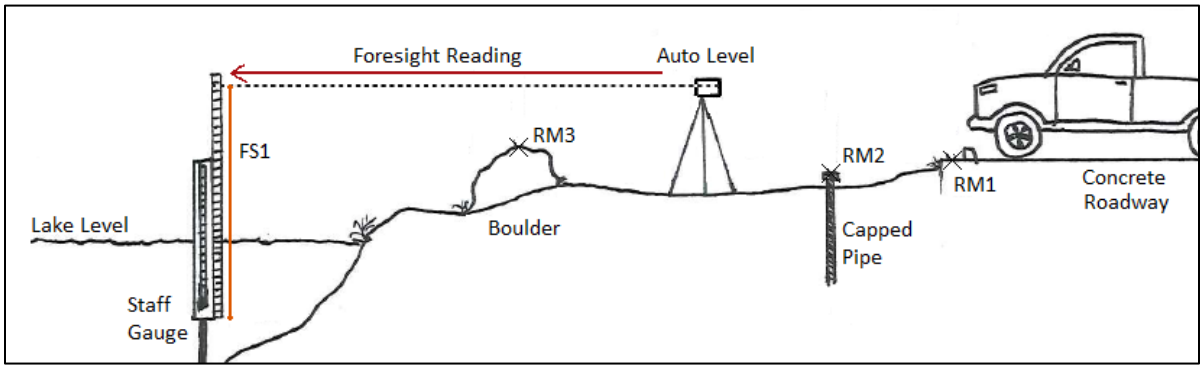


Figure 7. Foresight reading (FS) of a staff gauge with an auto level and stadia rod

7. Record the FS and calculated elevation value for the staff gauge on the data sheet.
   The elevation of the staff gauge = HI – FS.

8. Obtain foresight readings for all additional reference marks in your survey (RM2 and RM3) by repeating steps 6 through 8.

Date: _____ Time: _____ AM/PM Check one: Install ☐ Midseason ☐ Removal ☐

Survey Stage 1 - Instrument at first height*

	Reference Mark 1		Fore sight (FS1)	Calculated Elevation (CE1)
Given Elevation (GE_{RM1})	_____			
Back sight 1 (BS1)	+ _____			
Height of Instrument (HI1)	☐	- Staff Gauge	_____	= ☐
	HI1	- Ref Mark 2	_____	= ☐
	HI1	- Ref Mark 3	_____	= ☐

Survey Equations:
$HI1 = GE_{RM1} + BS1$
$CE1 = HI1 - FS1$

9. For quality assurance, re-set the surveying equipment at a new spot for **Survey Stage 2** with a different elevation and survey the staff gauge to three reference marks a second time. We will now repeat the survey process in reverse (Figure 8). Record data under "Survey Stage 2 – Reset instrument at different height".

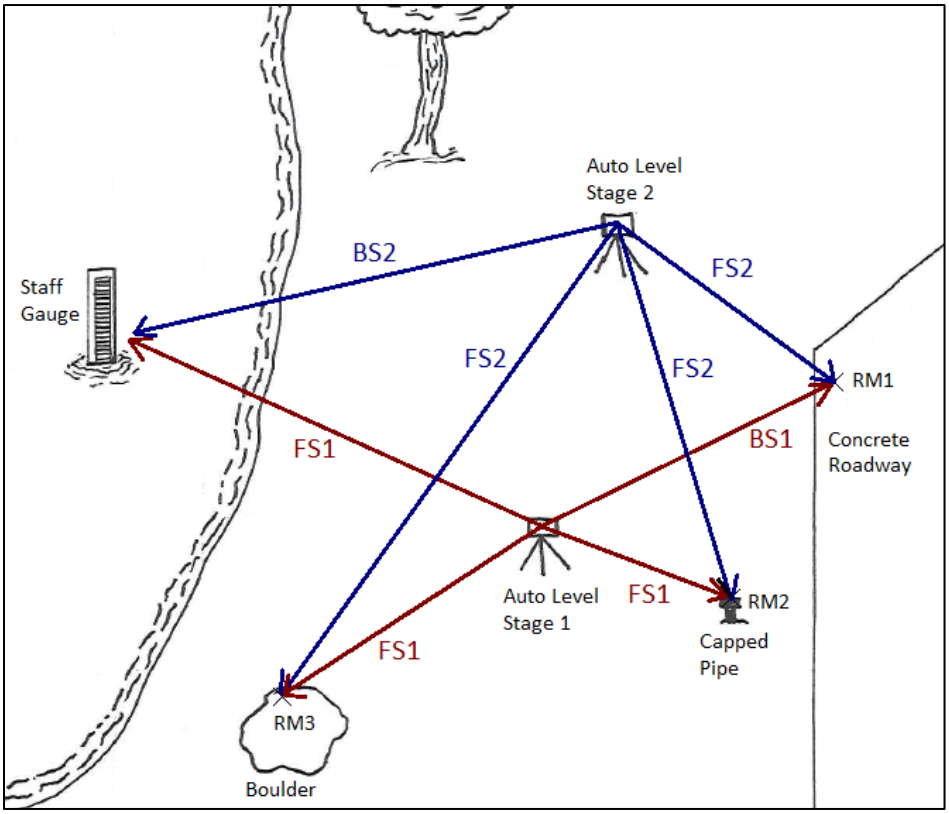


Figure 8. Back sight (BS) and fore sight (FS) readings of reference marks (RM) and staff gauge using an auto level at different locations during stage 1 and stage 2 surveys

10. Transfer the Calculated Elevation 1 of the Staff Gauge from Survey Stage 1 down to the Calculated Elevation 1 blank under Survey Stage 2.

11. Place the stadia rod on the staff gauge and take a reading through the instrument. Record as Back sight 2 (BS2) under the Staff Gauge column.

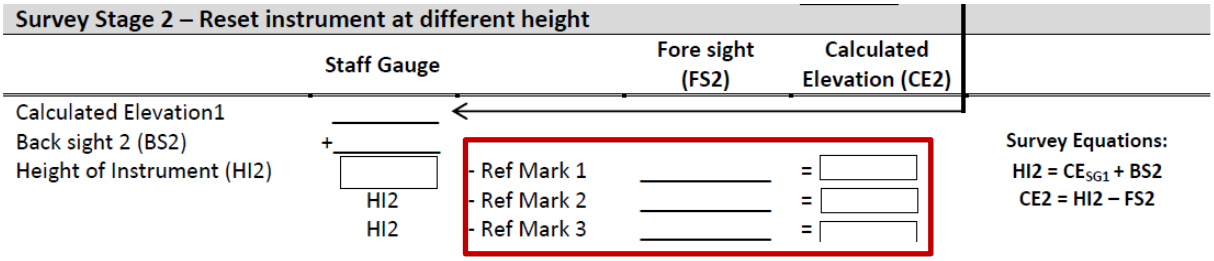
Survey Stage 2 – Reset instrument at different height

	Staff Gauge		Fore sight (FS2)	Calculated Elevation (CE2)
Calculated Elevation1	_____			
Back sight 2 (BS2)	+ _____			
Height of Instrument (HI2)		- Ref Mark 1	_____	=
~~HI2~~		- Ref Mark 2	_____	=
HI2		- Ref Mark 3	_____	=

Survey Equations:
HI2 = CE_{SG1} + BS2
CE2 = HI2 – FS2

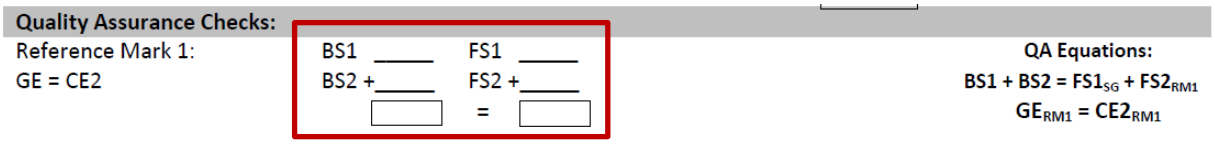
12. The Height of Instrument 2 is the sum of Calculated Elevation 1 of the staff gauge and back sight 2 of the staff gauge.

13. Now take foresight readings of all three reference marks.



14. The calculated elevations 2 equal the second height of instrument minus the second foresight reading of each reference mark.

15. Ensure that the calculated elevations of the reference marks and staff gauge were within 0.01 feet of one another in survey stage 1 and survey stage 2 by completing some **Quality Assurance Checks**.
    a. The given elevation of reference mark 1 should equal the calculated elevation 2 of reference mark 1.
    b. The sum of the back sights 1 (reference mark 1) and back sight 2 (staff gauge) should equal the sum of foresight 1 (staff gauge) and foresight 2 (reference mark 1).



    c. If the 2 quality assurance checks above are not met, repeat the survey.

    d. If the quality assurance checks are met, accept the calculated elevations from survey stage 1 and use these values for the remainder of the season and for comparing lake levels between years.

16. Upon completing the survey, take a water level reading and record it on the data sheet.

Lake Level Reading: _____ ft

VI. Mid-Season Resurveying of the Staff Gauge

During the field season, large storm events or human tampering could move the gauge, introducing error to lake level readings for the remainder of the summer. It is not the responsibility of the installer to check on the gauge throughout the monitoring season. CLMN volunteers will be trained to monitor the stability and placement of the staff gauge.

If the volunteer or local coordinator notices that the staff gauge moved at any point during the field season, the staff gauge and reference marks need to be resurveyed following the procedures laid out in **Section V. Establishing Reference Marks and Surveying the Staff Gauge.** If the gauge is still within 0.01

ft. of the original survey (survey results should be documented in SWIMS or be made available in hard copy format), then staff gauge monitoring can continue as is. However, if the gauge moved more than 0.01 ft. since the original survey was conducted, follow this procedure to resurvey the gauge:

1. Reposition the gauge so that it is vertical. If necessary, remove the fencepost and gauge, repair, and reinstall in the lake bed.
2. Resurvey the staff gauge and three reference marks and fill out the datasheet accordingly.
3. Take a water level reading off of the staff gauge.
4. Enter the newly collected survey and water level information into the Surface Water Integrated Monitoring System (SWIMS) database.
5. Be sure that lake level readings after this date are tied to the mid-season survey information, not the original survey conducted at the time of the spring installation.
6. Contact the CLMN regional coordinator if you have any questions about this process.

VII. Staff Gauge Removal

At the conclusion of the field season, the staff gauge will need to be resurveyed (using the same reference marks established in the spring) and then removed from the lake and stored for the winter. Please follow the aforementioned surveying protocol described in **Section IV. Establishing Reference Marks and Surveying the Staff Gauge** for more information about the proper surveying methods.

Upon removing the staff gauge from the lake, perform a quick visual inspection of the gauge plate, wooden board, and fence post. Remove any mud, debris, organic materials, or animals attached to the gauge plate, board or fence post. Thoroughly inspect the area between the board and the fence as invasive rusty crayfish have been found living in this gap. The board may need to be removed from the fence post to clean this area and prevent transportation of invasive species. Determine if the bolts need to be replaced and if the fence post is straight. Be sure to note on the data sheet what maintenance is recommended for the staff gauge during the offseason.

Once fieldwork is concluded for the season, the staff gauge can be stored locally with the volunteer, surveyor, or the local coordinator for further maintenance (if required).

VIII. Aquatic Invasive Species

Wisconsin has various laws in place to prevent the introduction and control the spread of aquatic invasive species (AIS) and diseases in Wisconsin. Please observe the regulations in NR 40.

The laws under NR 40 for aquatic invasive species:

1. Prohibit the transportation of any vehicle, including boats and trailers, on a public highway with aquatic plants or aquatic animals attached.
2. Require removal of aquatic plants and aquatic animals and draining of all water from any vehicles or equipment immediately upon removal from the water and before leaving any boat launch or parking area.
3. Prohibit the placing of any boat, vehicle or equipment into waters of the state (statewide) if they have any aquatic plants or aquatic animals attached.

When exiting the lake, please be sure to take the following steps to prevent the spread of AIS:

1. INSPECT your boat, trailer, and equipment.
2. REMOVE any attached aquatic plants or animals (before launching, after loading, and before transporting on a public highway).
3. DRAIN all water from boats, motors and all equipment.

Please go to http://dnr.wi.gov/lakes/invasives/ for more information about invasive species in the state of Wisconsin or contact your regional AIS coordinator (http://dnr.wi.gov/lakes/invasives/topics.aspx). For more information on the invasive species rule (NR40), go to https://dnr.wi.gov/topic/invasives/classification.html.

IX. Equipment Upkeep

Surveying equipment should be properly calibrated before being used as part of the WDNR's lake level monitoring program the following spring. Please review the calibration instructions associated with your leveling equipment to ensure your equipment is properly maintained during the off season.

After the staff gauge has been removed from the lake, detach the wooden board from the fence post and evaluate it for any necessary repairs. You do not need to remove the gauge from the wooden board in preparation for winter storage. Clean both the gauge and the fence post with a scrub brush before storing for the winter, making sure to remove and rinse off any mud, plant material, mussels, or other visible organic material that is attached to the gauge and/or fence post. Pay particular attention to any holes or crevices in the equipment during the cleaning process. Use baking soda to help clean gauge plates that are especially dirty.

X. Data Management

Staff gauge survey information must be collected following the protocol listed above. Proper record keeping in the field is integral to the success of this program as the survey data (reference mark coordinates) will be used to link lake level data across years and compile long-term records.

After the survey is complete, you should possess the following documents:

- Survey Calibration Data Sheet (complete)
- Photographs of the three reference marks and the staff gauge
- GPS x,y coordinates of the three reference marks and the staff gauge
- Site Diagram including the location of the staff gauge and the three reference marks
- Mean sea level for primary reference mark

When entering the data and uploading photographs to SWIMS, please use the following directions.

Before entering data, you must obtain a Wisconsin Access Management System (WAMS) ID by following the instructions at http://dnr.wi.gov/topic/surfacewater/swims/SWIMS_UI_XML/pdf/How%20to%20Get%20a%20WAMS%20User%20Id%20and%20Password.pdf

Then email the SWIMS database coordinator and ask to be added to the lake level calibration project for your lake. Current contact information can be found at the bottom of this webpage: http://dnr.wi.gov/topic/surfacewater/swims/

To enter data into SWIMS, the proper architecture must be set up, including:

- A project to house the volunteer's lake level readings
  - "Citizen Water Level Monitoring - *Lake Name* - *County Name*"
- A subproject to house the survey data (this is the project you must have access to)
  - "Citizen Water Level Monitoring - *Lake Name* - Calibration"
- A station to associate the data with (x and y coordinates of the location of the staff gauge)

The project and station for the staff gauge should already exist, and once your ID has been given permission to enter information in the appropriate project, you may begin. If any of the above do not exist, WDNR central office SWIMS staff may assist.

If you have moved the staff gauge from previous years, and the two records are not linked to a common benchmark, a new station must be created (adding the year to the end of the station name).

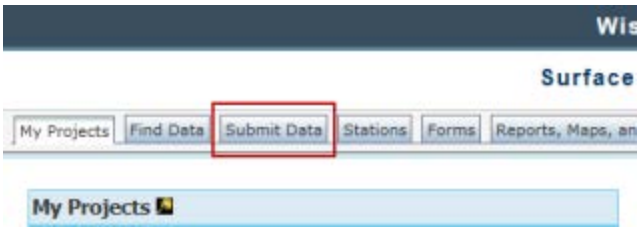
For more help documentation on SWIMS, see http://dnr.wi.gov/topic/surfacewater/swims/helpdocs.html.

Entering metadata into SWIMS:

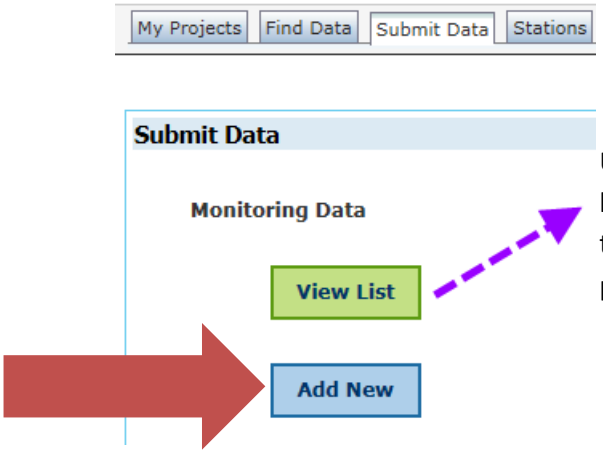
** When entering survey data into SWIMS, please keep in mind that all '0' values will be recorded as data points which could lead to misinterpretation of the results down the line. If you did not measure it, please leave the data entry screen blank and do not enter a '0' value.

1. Open Internet Explorer and log into the SWIMS database (https://dnrx.wisconsin.gov/swims) with your WAMS ID and password.

2. Click on the 'Submit Data' tab at the top of the screen.

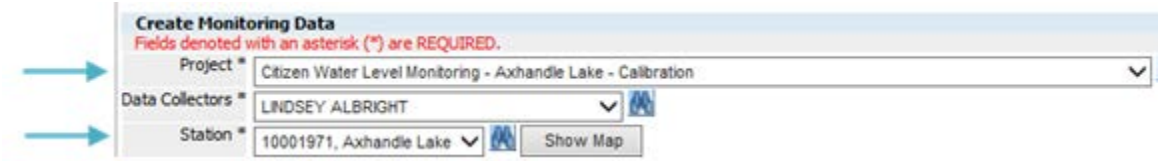


3. Click the 'Add New' link in the second box on the screen.



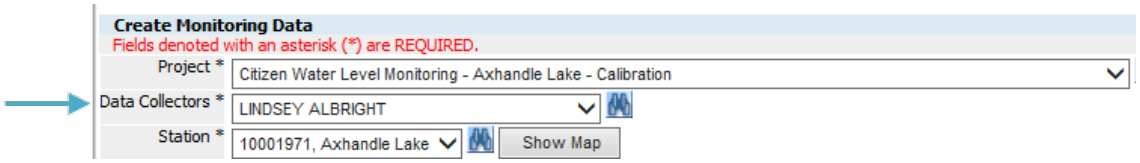
Use the 'View List' link in the top box to view and edit previously entered .

4. Select the **Project** and then the **Station**

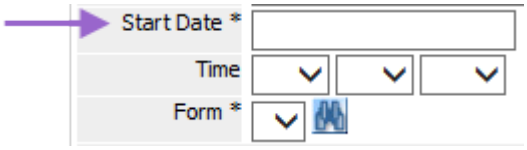


   a. From the **Project** dropdown menu, select the correct monitoring project for the lake. The project is called '**Citizen Water Level Monitoring – *LAKE* – Calibration'**.
   b. Select the station you wish to enter data for from the Station dropdown menu.
   c. If your monitoring location is not listed in the Station dropdown menu, please do not enter your lake level data at this time, but instead contact the CLMN coordinator to get your SWIMS account assigned to the correct station(s).

5. Select yourself from the list of **Data Collectors**.

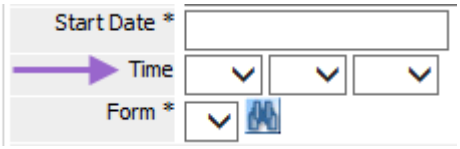


6. Click the 'Select Date' button to enter the **Start Date**.



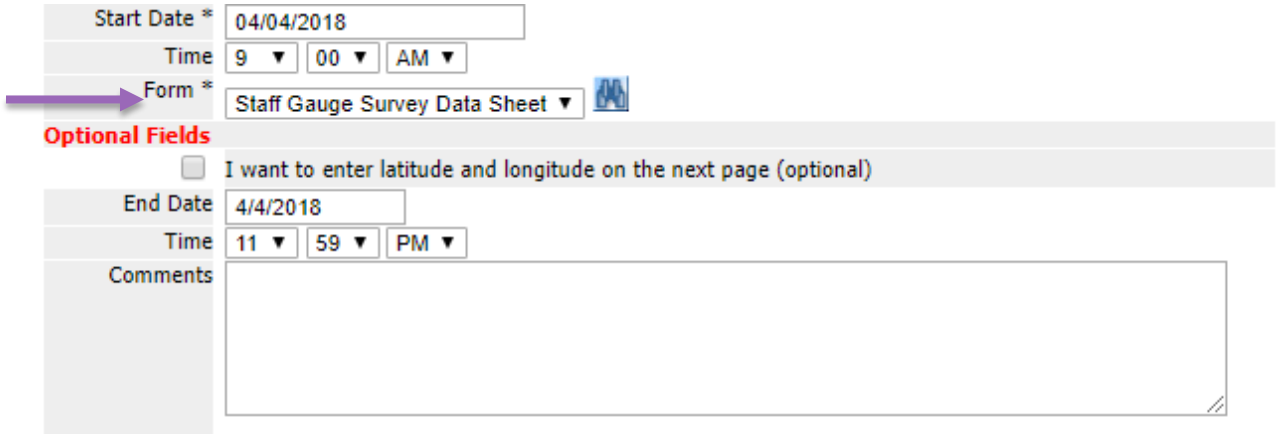
a. The monitoring date must be entered in the mm/dd/yyyy format

7. Enter the **Time** that you started your data collection work.



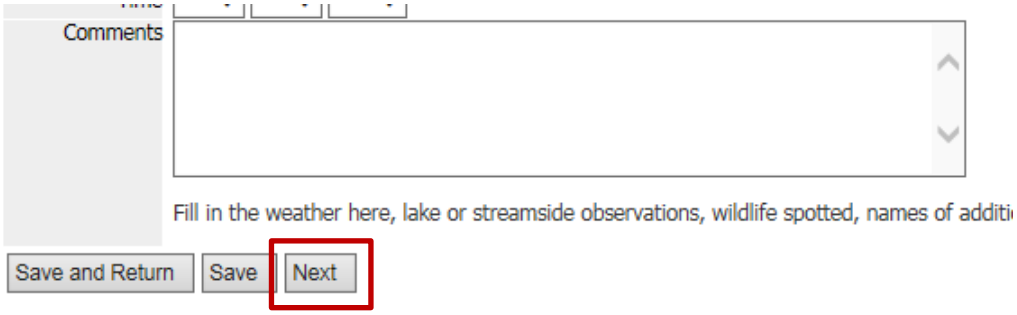
a. SWIMS requires the start time information (enter AM or PM) for all monitoring data.

8. Select the **Staff Gauge Calibration Data Sheet** form if it is not selected already.



9. You can ignore the optional fields. It is not necessary to enter this information.
10. Add any **Comments** you recorded from your field data sheet and then click **Next** to go to the field work data entry screen.

a. **Record all maintenance issues** with the staff gauge, wooden board, and sign post into the comments area



11. For **Reference Marks 1, 2, and 3** fill in the following information from the datasheet:

Staff Gauge Survey Data Sheet			
	Parameter	**Result**	**Units**
Reference mark 1	Reference Mark Type		
	Latitude		
	Longitude		
	Mean Sea Level?		
	Mean Sea Level Elevation		FEET
	Photograph?		
	Location Description		

    a. **Mean Sea Level**: 'Yes' or 'No' options depending on if the RTK-GPS survey was conducted for the reference mark.
    b. **Mean Sea Level Elevation**: the only unit option is 'Feet'.
    c. **Photograph**: 'Yes' or 'No' options. The process for uploading photographs is detailed below.

12. For the **Staff Gauge** fill in the following information from the datasheet:

Staff Gauge	Latitude		
	Longitude		
	Mean Sea Level?		
	Mean Sea Level Elevation		FEET
	Photograph?		
	Location Description		

    a. **Mean Sea Level**: 'Yes' or 'No' options depending on if the RTK-GPS survey was conducted for the reference mark.
    b. **Mean Sea Level Elevation**: the only unit option is 'Feet'.
    c. **Photograph**: 'Yes' or 'No' options.

13. **Record the survey information from Survey Stage 1** for each reference mark and the staff gauge:

Survey	Check one:		
Survey Stage 1	Ref Mark 1 - Given Elevation (GE RM1)		FEET
	Ref Mark 1 - Back site 1 (BS1)		FEET
	Ref Mark 1 - Height of instrument (HI1)		FEET
	Staff Gauge Foresight (FS1)		FEET
	Ref Mark 2 Foresight (FS1)		FEET
	Ref Mark 3 Foresight (FS1)		FEET
	Staff Gauge - Calculated Elevation (CE1)		FEET
	Ref Mark 2 - Calculated Elevation (CE1)		FEET
	Ref Mark 3 - Calculated Elevation (CE1)		FEET

    a. **RM1** – back sight measurement
    b. **RM2** – foresight measurement
    c. **RM3** – foresight measurement
    d. **Staff gauge** – foresight measurement
    e. If you did not measure it, please leave it blank. Entering a '0' value as a placeholder is still considered a data value and will be recorded as such in the database.

14. **Record the survey information from Survey Stage 2** for each reference mark and the staff gauge:

Survey Stage 2	Staff Gauge - Calculated Elevation1 (CE1)			FEET
	Staff Gauge - Backsight 2 (BS2)			FEET
	Staff Gauge - Height of Instrument (HI2)			FEET
	Ref Mark 1 - Foresight (FS2)			FEET
	Ref Mark 2 - Foresight (FS2)			FEET
	Ref Mark 3 - Foresight (FS2)			FEET
	Ref Mark 1 - Calculated Elevation (CE2)			FEET
	Ref Mark 2 - Calculated Elevation (CE2)			FEET
	Ref Mark 3 - Calculated Elevation (CE2)			FEET

    a. **Staff gauge** – back sight measurement
    b. **RM1** – foresight measurement
    c. **RM2** – foresight measurement
    d. **RM3** – foresight measurement
    e. If you did not measure it, please leave it blank. Entering a '0' value as a placeholder is still considered a data value and will be recorded as such in the database.

15. **Record the lake level reading** at the time of survey:

Lake Level Reading	Lake level reading			FEET

Next Date | Next Station | Save | Save and Return to List

16. Once you finish entering data, select one of the following options:

Next Date | Next Station | Save and Return to List

    a. Click **Next Date** to enter more lake level data for the same site. If you have data for several dates at the same site, choose this option.
    b. Choose **Next Station** to enter data for a different site on the same date.
    c. Click **Save and Return to List** to enter data for other sites. If you choose this option, you will see a list of all your entered data.

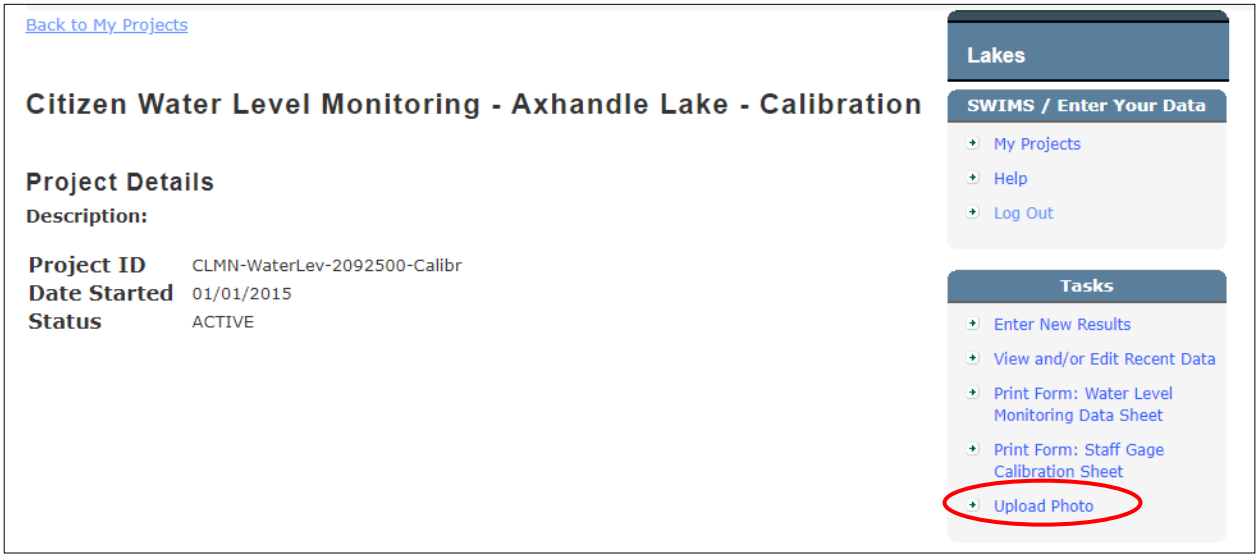
Uploading photographs and other documents to SWIMS:

It is recommended to upload photos of each reference mark and the location of the staff gauge. Volunteers can use your photos to see if the staff gauge has moved. It can also be helpful to upload a scan of your data sheet or site sketch.

1. Return to the list of projects you see when you first log on to SWIMS, and click "More" on the project you with to add a photograph to.

2. Look on the right-hand side of the page under “Tasks”, and click “Upload Photo”.
3. Choose a logical and descriptive “Document Title”, and “Document Type”. It is not necessary to include your name or a date, but it can be helpful to include a description.

Please contact the CLMN coordinator if you have any questions about or issues with the data entry



process in SWIMS.

XI. Quality Assurance and Quality Control

Field Quality Assurance and Quality Control

On the day of installation, the survey of the staff gauge and reference marks should be replicated. After completing the first survey (Stage 1), re-set the survey equipment at a new location and survey all three reference marks and the staff gauge again (Stage 2). The two readings must agree within 0.01 ft. or the survey must be completed for a third time. Use the first of the two readings to define lake levels for the season.

Surveyors are not responsible for checking the verticalness of the staff gauge during the field season unless requested to do so by the local or statewide coordinator. Volunteers will be trained to evaluate the verticalness of the gauge using the mini levels on the board.

Data Entry Quality Assurance and Quality Control

Please double-check the information that you are entering into the SWIMS database. The results from the survey will be used to define lake levels for the remainder of the season and create a long-term lake level record. Accurate information is integral to the success of the program.

XII. References

Elias, J. E, R. Axler, and E. Ruzycki. 2008. Water quality monitoring protocol for inland lakes. Version 1.0. National Park Service, Great Lakes Inventory and Monitoring Network. Natural Resources Technical Report NPS/MWR/GLKN/NRTR—2008/109. National Park Service, Fort Collins, Colorado.

Harrelson, C. C, C. L. Rawlins, J. P. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Kenney, T.A. 2010. Levels at gaging stations: U.S. Geological Survey Techniques and Methods 3-A19.

Lipe, J. Step-By-Step Instructions for Leveling a Staff Gauge (accessed 2/10/2015)

North Lakeland Discovery Center. 2013. Lake Level Staff Gauge Monitoring Guide for Coordinator.

U.S. Army Corps of Engineers Fact Sheet (accessed 2/4/2015)
http://www.nwo.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/2034/Article/487672/staff-gauge-setup-instructions.aspx

U.S. EPA. 2014. Best Practices for Continuous Monitoring of Temperature and Flow in Wadeable Streams (Final Report). U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. Washington D.C. EPA/600/R-13/170F.

Glossary

Back sight Reading (BS): a reading on the stadia rod, to the nearest 1/100th foot, taken when looking through the instrument (level) back toward a point of known elevation. It is used to establish the height of instrument

Bench Mark (BM): a permanent marker with known survey control of vertical and (or) horizontal coordinates in an established geodetic system, such as the North American Vertical Datum of 1988. Bench marks used during survey activities are often established by the United States Geological Survey (USGS). Common bench marks include a bronze tablet set in concrete or an "X" or "+" etched in concrete, rock, or some other permanent structure. At secluded locations, a Reference Mark (RM) is often used in place of a bench mark.

Engineer's Level: a surveying instrument consisting of a minimum of a telescopic sight and a sensitive leveling device to make the line of sight horizontal

Foresight Reading (FS): a reading on the stadia rod, to the nearest 1/100th foot, taken when looking through the instrument (level) forward toward a point of unknown elevation (staff gauge)

Gauge Datum: the zero elevation reference surface at a gaging station to which all gauges are set

Height of Instrument (HI): the elevation of the horizontal line of sight (crosshairs), or viewing elevation of the level

Reference Mark (RM): a permanent marker, typically an "X" or "+" sign etched in concrete, a bolt, or other "permanent" feature whose elevation above a set datum is known. A Reference Mark can be used to check and make sure that all gauges and reference points are properly set to gauge datum.

Stadia rod: a survey tool used when running levels at gaging stations or staff gauges. Used in conjunction with the engineer's level to read the elevations of bench marks, reference marks, and establish the height of unknown location(s).

Staff Gauge: a graduated measuring instrument that can be visually read from the shore or by boat

*Glossary terms and definitions from Kenney 2010 and Lipe (accessed 2/10/2015).

Mathematical Equations for Surveying:

- Height of Instrument (HI) = Reference Mark (RM) + Back sight Reading (BS)
- Elevation of Staff Gauge = Height of Instrument (HI) – Foresight Reading (FS)

Appendix A. Staff Gauge Surveying Field Instructions (text only)

1. Before beginning the survey, establish three different reference marks (RM) along the lakeshore to calibrate the staff gauge.
    a. Record the location of each reference mark with a GPS and take pictures of the reference mark and surrounding area.
    b. Sketch the locations of the reference marks in relation to the location of the staff gauge.
2. If the vertical elevation of the first reference mark is known, record that elevation on the data sheet. If not, assign an arbitrary elevation of 100 ft. to RM1.
3. Set up the tripod for **Survey Stage 1** in a centralized location where the staff gauge and reference marks are visible and attach the leveling instrument.
4. Have a partner place the stadia rod on the first reference mark (RM1). Then read the height of the rod through the instrument (intersection of the cross-hair with the marks on the stadia rod). This reading is called your back sight reading, BS. Record it as BS1 on the data sheet.
    a. The number read from the rod is added to the given elevation of the reference mark and is called the height of the instrument, HI (HI = 'Known or Assigned Elevation' + BS).
5. Record the HI1 value on the data sheet.
6. Place the rod on the heavy stainless steel lag bolt at '0.00' marker of the staff gauge and read the rod through the survey instrument. This is called your foresight (FS) reading.
7. Record the FS and calculated elevation value for the staff gauge on the data sheet.
    a. The elevation of the staff gauge = HI – FS.
8. Obtain foresight readings for all additional reference marks in your survey (RM2 and RM3) by repeating steps 6 through 8.
9. For quality assurance, re-set the surveying equipment at a new spot for **Survey Stage 2** with a different elevation and survey the staff gauge to three reference marks a second time. Record data under "Survey Stage 2 – Reset instrument at different height".
10. Transfer the Calculated Elevation 1 of the Staff Gauge from Survey Stage 1 down to the Calculated Elevation 1 blank under Survey Stage 2.
11. Place the stadia rod on the staff gauge and take a reading through the instrument. Record as Back sight 2 (BS2) under the Staff Gauge column.
12. The Height of Instrument 2 is the sum of Calculated Elevation 1 of the staff gauge and back sight 2 of the staff gauge.
13. Now take foresight readings of all three reference marks.
14. The calculated elevations 2 equal the second height of instrument minus the second foresight reading of each reference mark.
15. Ensure that the calculated elevations of the reference marks and staff gauge were within 0.01 feet of one another in survey stage 1 and survey stage 2 by completing some **Quality Assurance Checks**.
    a. The given elevation of reference mark 1 should equal the calculated elevation 2 of reference mark 1.
    b. The sum of the back sights 1 (reference mark 1) and back sight 2 (staff gauge) should equal the sum of foresight 1 (staff gauge) and foresight 2 (reference mark 1).
    c. If the 2 quality assurance checks above are not met, repeat the survey.
    d. If the quality assurance checks are met, accept the calculated elevations from survey stage 1 and use these values for the remainder of the season and for comparing lake levels between years.
16. Upon completing the survey, take a water level reading and record it on the data sheet.

Appendix B. Staff Gauge Calibration Data Sheet

Wisconsin DNR – Lake Level Monitoring

Staff Gauge Survey Data Sheet

Lake Information

Lake Name _____ County _____

Data Collectors

Primary Data Collector _____ Email _____ Phone No. (___) ___-____

Additional Data Collector(s) _____

Reference Mark and Staff Gauge Information

Reference Mark #1 (RM1) Reference Mark Type: _____

Latitude: _____ Longitude: _____ Mean Sea Level Yes ☐ No ☐ Elevation: _____ Photograph ☐

Location Description: _____

Reference Mark #2 (RM2) Reference Mark Type: _____

Latitude: _____ Longitude: _____ Mean Sea Level Yes ☐ No ☐ Elevation: _____ Photograph ☐

Location Description: _____

Reference Mark #3 (RM3) Reference Mark Type: _____

Latitude: _____ Longitude: _____ Mean Sea Level Yes ☐ No ☐ Elevation: _____ Photograph ☐

Location Description: _____

Staff Gauge

Latitude: _____ Longitude: _____ Mean Sea Level Yes ☐ No ☐ Elevation: _____ Photograph ☐

Location Description: _____

Date: _____ Time: _____ AM/PM Check one: Install ☐ Midseason ☐ Removal ☐

Survey Stage 1 - Instrument at first height*

	Reference Mark 1		Fore sight (FS1)	Calculated Elevation (CE1)
Given Elevation (GE_{RM1})	_____			
Back sight 1 (BS1)	+ _____			
Height of Instrument (HI1)	☐	- Staff Gauge	_____	= ☐
	HI1	- Ref Mark 2	_____	= ☐
	HI1	- Ref Mark 3	_____	= ☐

Survey Equations:
$HI1 = GE_{RM1} + BS1$
$CE1 = HI1 - FS1$

Survey Stage 2 – Reset instrument at different height

	Staff Gauge		Fore sight (FS2)	Calculated Elevation (CE2)
Calculated Elevation1	_____			
Back sight 2 (BS2)	+ _____			
Height of Instrument (HI2)	☐	- Ref Mark 1	_____	= ☐
	HI2	- Ref Mark 2	_____	= ☐
	HI2	- Ref Mark 3	_____	= ☐

Survey Equations:
$HI2 = CE_{SG1} + BS2$
$CE2 = HI2 - FS2$

Quality Assurance Checks:

Reference Mark 1: BS1 _____ FS1 _____

GE = CE2 BS2 + _____ FS2 + _____

☐ = ☐

QA Equations:
$BS1 + BS2 = FS1_{SG} + FS2_{RM1}$
$GE_{RM1} = CE2_{RM1}$

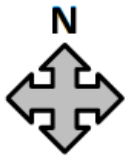
*Accept Survey Stage 1 if QA checks within 0.01 ft. Use calculated elevations 1 for the rest of the season unless the gauge moves.

Lake Level Reading: _____ ft

Wisconsin DNR – Lake Level Monitoring

Staff Gauge Survey Data Sheet

Site Diagram (including Staff Gauge and Reference Marks)



Notes

Data Management

Survey Data uploaded to SWIMS?	Yes ☐ No ☐	Date: _____	Name: _____
Photographs uploaded to SWIMS?	Yes ☐ No ☐	Date: _____	Name: _____
Data Sheet scan uploaded to SWIMS?	Yes ☐ No ☐	Date: _____	Name: _____

Equipment Maintenance

Replace bolts/screws on staff gauge?	Yes ☐ No ☐	Date: _____	Name: _____
Replace gauge plate on staff gauge?	Yes ☐ No ☐	Date: _____	Name: _____
Replace post or wooden board?	Yes ☐ No ☐	Date: _____	Name: _____