Sierra Nevada Network Lake Monitoring Protocol
Standard Operating Procedure 10. Hydrological Sampling Methods

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Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Contents

1. Introduction

The purpose of this standard operating procedure (SOP) is to provide standardized guidance on outlet site data logger set up, lake outflow measurements, data download, and routine visits to the outlet site. This SOP is designed to be used in conjunction with the manufacturers' manuals. Portions are adapted from the San Francisco Bay Area Network Stream Flow Monitoring Protocol SOP's (Fong 2007), the USGS Measurement and Computation of Streamflow by (S.E. Rantz et al. 1982), and the Water Measurement Manual (US Department of the Interior Bureau of Reclamation 2001). This SOP should be used in conjunction with SOP 2 (Safety), SOP 4 (QAPP), SOP 6 (Chain-of-Custody), and SOP (Equipment Disinfection).

2. Equipment Checklists

2.1. Lake Outlet Flow - Routine Visit

- Digital Camera
- Notebook and pencil
- Leveloader and spare 9V battery
- Direct/Optical Read Cable (Y-cable)

2.2. Stream Flow Measurement

2.2.1. Current Meter Method

- Current meter and stopwatch if needed
- Routine visit equipment
- Waders
- Meter tape
- 2 tent stakes to secure tape across outlet

2.2.2. Salt Slug Injection Method

- Routine visit equipment
- Collapsible bucket(s)
- 2 watches
- Conductivity meter
- Salt concentrate solution or:
- Salt
- Graduated cylinder

2.2.3. Rhodamine Slug Injection Method

- Routine visit equipment

- Collapsible bucket(s)
- 2 watches
- Flourometer
- Rhodamine concentrate solution

2.3. Data logger on site set up (per site)

In addition to routine visit list:

- Protective 1” perforated pipe threaded both ends
- Perforated inner pipe or rubber gasket (if needed to keep data logger secure in protective pipe)
- 2 screw end caps per pipe section
- 1 Solinst 3001 LT Levelogger Gold M5/F15.
- 3 hose clamps
- 4 sections rebar (cut to length)
- Screw driver for hose clamps
- 5 lb mallet
- Laser level or survey equipment

3. Stream Flow Measurement

Sierra Nevada Network (SIEN) is using the current meter method and the slug injection method. The current meter method is the method of first choice. However, if a suitable cross-section cannot be found, a slug injection methods is used. The current meter proposed for use is the SonTek FlowTracker handheld acoustic Doppler velocimeter (ADV). Salt (NaCl) or Rhodamine will be used as the tracer for slug injections. Method choice will be further assessed during the first field season to decide if another method (allowable in designated wilderness) is more appropriate. SIEN anticipates returning once per month, from May through October, to establish the rating curve. If possible SIEN field crews will return more frequently and at specific flows. The network recognizes the importance of a staff gage. Because the lakes being sampled are in wilderness, the network is attempting to limit equipment by surveying the data logger level relation to nearby landmarks (rock outcrops, etc.) to substitute for the installation of a standard staff gage. The distance between outflow water surface and the fixed reference heights will be used to gage.

3.1. Current Meter Method

1. Select a current meter. The outlet depth should be known and the correct current meter chosen for the site to get the most accurate reading.
2. Maintain and calibrate the current meter prior to going into the field per the instruction manual.
3. Select a monitoring method (depending on depth).

   a. Two point method measure at .2 and .8 of the depth. Compute the mean of the two measurements.
   b. .6 depth method measure at .6 below surface.
   c. Three point method measure at .2, .6, and .8 of the depth. Mean velocity is computed using the average of the .2 and the .8 depth readings, and averaging that with the .6 depth rating.
   d. Surface velocity method (float), volumetric, or an optical current meter.
4. Select a cross section that is safe to work. Find a cross section that is:
   a. Part of a straight reach.
   b. Primarily flowing parallel (avoid eddies, and areas of high turbulence).
   c. At a spot along the streambed that is relatively uniform and without obstructions.
   d. Located near the level logger to avoid other inputs.
5. Document the site on the field data sheet (see attached blank field sheet).
   a. Site Name.
   b. Personnel Names.
   c. Date.
   d. Time.
   e. Digital Photo.
   f. GPS the location.
6. Measure the stream width at the cross section.
   a. String measuring tape line at right angle to flow across the cross section.
      i. Secure measuring tape at both ends.
      ii. The initial point or Point 0 is at the secured starting end of the measuring tape.
      iii. Document the distance from the Point 0 to the water edge. This is Point 1.
      iv. Document the distance to the farthest edge. This will be the last subsection point.
   b. Document the stream width in the notes.
7. Divide the stream into sections.
   a. 25 to 30 subsections where no subsection has more than 5% of the flow is the ideal.
   b. No subsection should have more than 10 percent of the discharge.
   c. The spacing of the subsections should not necessarily be equal. In deeper and faster flowing areas, the subsections should be narrower.
   d. If the stream width is less than 5 feet, cross section widths are 0.5 feet.

e. If the stream width is between 5 and 10 feet, the minimum number of cross sections is 10.

f. Document the subsection points as measurements from Point 0 (Starting with 2 remember Point 1 is the water edge and the last point will be the far side of the outlet).

8. Measure at subsection points the stream depth and the velocity at the depths called for in from the chosen method.

    a. Wade to a safe position at the subsection point (distance from Point 0).

    b. Stand in a position that least affects the flow.

        i. In small outflows stand out of the water if it is safe (on a log spanning the cross section, etc.).

        ii. In stream, stand at least 1.5 feet from the rod and face the bank, so the water flows against the side of the leg.

    c. Measure and record depth of stream bottom.

    d. Place the meter at the correct depth for velocity measure.

    e. Point into the current.

    f. Wait for the meter to adjust to the stream velocity.

    g. Record the reading.

    h. Repeat steps a through g until all points are taken.

3.2. Tracer Method

Either table salt (NaCl) or Rhodamine tracer dye will be used to estimate flow using the slug tracer method.

1. Determine the tracer to be used (salt or Rhodamine).
2. Determine tracer application amount.

    a. Salt (Moore 2005)

        i. Use a concentration of no greater than 1 kg salt per 6 L.

        ii. The amount injected should raise the electrical conductivity of the stream 100-200% from the background.

    b. Rhodamine

        i. Use an injected amount that when mixed with the stream will have the lowest concentration that can be accurately detected by the fluorometer. Use the MstockCalc.xls spreadsheet to calculate rhodamine water tracer (Rwt) weight and concentrations. (MstockCalc.xls is located on the SEKI network:

3. Select channel reach for measurement.

    a. Injection site is ideally upstream of a stream constriction where there is good mixing, and has no pools below the constriction.

b. The mixing length should be at least 25 stream widths (Moore 2005).

c. Reach should have as few pools as possible.

d. The reach should end at a good location for measurements (see set up of meter).

4. Set up meter.

    a. Salt – conductivity meter

        i. Place probe in the main part of the flow.

        ii. Avoid eddies.

        iii. Place the probe in a fixed location for the measurement.

        iv. This location should not be downstream of a tributary or area of discharge.

        v. The location of the meter should be in the best spot possible to allow the recorder to read the display and watch easily, and write in the notebook the readings.

        vi. Allow meter to equilibrate with stream water (this is the baseline reading).

    b. Rhodamine – fluorometer

        i. Place the fluorometer in the main part of the flow.

        ii. Avoid eddies.

        iii. Place the fluorometer in a fixed location for the measurement.

        iv. This location should not be downstream of a tributary or area of discharge.

        v. The location of the meter should be in the best spot possible to allow the recorder to read the display and watch easily, and write in the notebook the readings.

        vi. Allow meter to equilibrate with stream water (this is the baseline reading).

5. One person will inject the tracer, the second person will record the passage of the slug.

6. Injection and recording.

    a. At the meter station should be a watch with seconds, the properly set up meter, notebook (or datasheet) with time pre-written in 5 second increments, and pencil.

    b. At the injection station should be the injection concentrate, and a watch with seconds (or be in the line of sight of the recorder).

    c. At a predetermined time or when a signal is given from the person recording, the slug should be dumped into the stream in the well mixed area at the top of the reach.

    d. At the predetermined time, the person recording starts documenting the meter reading, and continues recording the meter reading every 5 seconds until the slug has passed (the reading has returned to baseline).

4. Data logger Setup

The data logger used in this protocol is the Solinst 3001 LT Levelogger Gold. For troubleshooting, and additional instructions see the user manuals (Solinst 2007a, 2007b).

The leveloader must have the clock synchronized in the office. Datalogger electronic setup can be done either in the office or on site. The setup can be done with a computer that has the Solinst software or with the handheld Solinst leveloader. Program the levelogger with the following parameters:

1. Time – synchronize leveloader and levelogger.
2. Instrument Number.
3. Location.
4. Sampling Rate (15 minute intervals).
5. Sampling Type (Linear)
6. Altitude (Set at site with leveloader)

Once the lake sampling site is reached, the location for deployment of the levelogger (using a pressure transducer to measure level) must be determined.

1. Site selection: Since the pressure transducer measures the pressure of the column of water above the sensor, a site is wanted where the in stream flow pressure is as constant as possible. Think about the forces acting in the stream in that location. Choose a location downstream of outlet that is:
    a. Representative of the outflow channel, the channel slope, and the bottom surface roughness.
    b. The least turbulent flow that is still representative of the stream reach.
    c. Away from areas of surcharging from additional inputs.
    d. Away from obstacles (such as trees) that could cause hydraulic jump.
    e. Not necessarily the deepest spot, but is below the lowest expected water line.
    f. Not in a location that will readily catch debris that can impede the data logger or catch on the tether line.
2. Site setup
    a. Check that the data logger is in the protective perforated pipe.
    b. Find a location in the bed of the stream where rebar can be pounded into the bed.
    c. In lower flow outlets, less rebar may be needed to secure the data logger (because monitoring is in designated wilderness, use as few sections of rebar as needed to adequately secure).
    d. Using the mallet, pound 1 rebar straight down into the bed. If possible this rebar should be pounded deep enough into the stream to be at the same level as the top of the perforated pipe.

e. Pound 3 remaining rebar into the stream bed to form a tripod support.

f. Secure the perforated pipe with the data logger vertical to the upright rebar.

g. Secure the perforated pipe with a hose clamp to the 3 rebar (2 hose clamps may be necessary).

h. Establish by surveying accurately the height of the top of the data logger perforated pipe and the upright rebar to 2 reference locations. Reference locations are determined at the site and are intended to help eliminate a standard staffing gauge.

3. Site documentation

   a. Sketch a rough map of the lake and note the deployment site.

   b. Record location with GPS.

   c. Take a digital image of the site

   d. Document

      i. Site Name

      ii. Personnel Names

      iii. Date

      iv. Time

      v. Manual water depth measurement.

      vi. Equipment condition description

      vii. Actions taken

5. Routine Visit

1. Site documentation

   a. Take a digital photo.

   b. Document

      i. Site name.

      ii. Personnel names.

      iii. Date.

      iv. Time.

      v. Manual water depth measurement (or staff gage height).

      vi. Equipment condition description.

      vii. Actions taken.

2. Download data refer to the Solinst user manuals at: http://www.solinst.com/Downloads/downmain.html.

   a. Remove the data logger from the outlet.

b. Remove the data logger from the protective pipe.

c. Turn leveloader on.

d. Attach the direct read cable to the leveloader and the levelogger.

e. Highlight “Connect to Logger” press the button for OK.

f. Highlight “Data from Levelogger” press the button for OK.

g. Press the button for Save Log.

h. To erase the data just saved from the levelogger, highlight “Restart Levelogger” press the button for OK.

i. Highlight “Start Logging” press the button for Select.

j. The next screen will say “All Data will be erased and cannot recover!! Continue?” press the button for OK.

3. Check data and function of datalogger.
    a. Highlight “Info from Levelogger” and press the button for OK.
    b. Scroll down to “Logger Status” it should say “Started”.
4. Put levelogger back in protective pipe.
5. Return levelogger to outlet site.
6. Refer to SOPs 15 and 16 for data processing procedures.

6. References

Fong, D. 2007. San Francisco Bay Area Network (SFAN) stream flow monitoring protocol V2.82. Natural Resource Report NPS/SFAN/NRR 2007. National Park Service, Fort Collins, Colorado.

Moore, R. D. 2005. Introduction to salt dilution gauging for streamflow measurements Part III: Slug injection using salt in solution. Streamline Watershed Management Bulletin 8(2) . Kamloops, BC, Canada. FORREX – Forest Research Extension Partnership.

Rantz, S. E. et al. 1982. Measurement and computation of streamflow: Volume 1. Measurement of stage and discharge. US Geological Survey Water Supply Paper 2175. Washington DC. US Government Printing Office. 284 p.

Solinst 2007a. Leveloader Gold User Guide. Available at: http://www.solinst.com/Downloads/downmain.html (Accessed 2007).

Solinst 2007b. Levelogger Gold Software Version 3.1.1 User Guide. Available at: http://www.solinst.com/Downloads/downmain.html (Accessed 2007).

US Department of the Interior Bureau of Reclamation. 2001. Water measurement manual: A Water Resources Technical publication. 2001 Edition. US Government Printing Office, Washington D.C. Available on line at: http://www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/ (Accessed 2007).

SIEN Field Data Sheet for Current Meter Measurements

Station Name: _____

Station ID: _____

Date:_____ Time:_____ PST

Field Crew:_____

Field Conditions:_____

Station (ft)	Depth (ft)	Velocity (ft/s)	Mean Velocity	Cumulative Q
