LISST-SL



Operating Manual

Version 2.2

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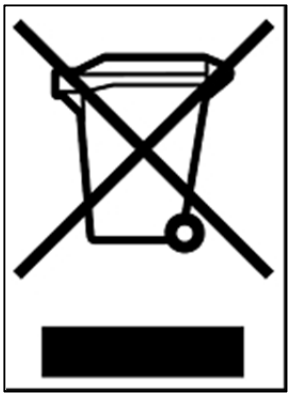
Technical assistance

To obtain technical assistance please contact your local distributor.
A list can be found on http://www.SequoiaSci.com/contact/international.aspx?SectionName=contact
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Please be sure to include the instrument serial number with any correspondence.

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Waste Electrical and Electronic Equipment

Smaltimento di apparecchiature elettriche ed elettroniche da rottamare

Contents

1. Introduction 1

1.1. The LISST-SL sensor 1
1.2. The Topside Control Box (TCB) 2
1.3. The B-Reel 3
1.4. The Laser Diffraction Principle 3
1.4.1 Background Files, and "VIEW RINGS" 4
1.4.2 Attenuation 4
1.4.3 Background 4
1.5. General Precautions 4
1.6. Operational Limits 5

2. Contents and Technical Specifications 7

2.1. Parameters Displayed on TCB 8
2.2. Operating Specifications 8
2.3. Datalogger Specifications 8
2.4. Power 8
2.5. Physical Dimensions – LISST-SL 8
2.6. Physical Dimensions – TCB 9
2.7. Datafiles and their Contents 9
2.8. Size Ranges 9

3. Learning the LISST-SL System 11

3.1. Basics 11
3.2. LISST-SL Sensor 11
3.3. B-Reel 11
3.4. The Touch Panel Display 12
3.4.1 Main Menu 12
3.4.2 Setup Menu 12
3.4.3 Set Clock 12
3.4.4 Calibration 13
3.5. Understanding the Background File 15
3.5.1 Laser Power and Laser Reference 15
3.5.2 Alignment 15
3.5.3 Dirty Windows 15
3.5.4 Turbid or bubble-filled water 16
3.5.5 Scintillation 16
3.5.6 Noise Test 16
3.6. Measure and Acquire Data 16
3.6.1 Battery Charging 18
3.6.2 Data Download from TCB 18

4. Using the LISST-SL System in a Laboratory 19

4.1. First Assembly and Test in Laboratory 19
4.2. System Integration 19
4.2.1 Form a loop for the pump 19
4.2.2 Purge the pitot tube 20
4.2.3 Obtain background 20
4.2.4 Instrument Health Check 21
4.2.5 Check if Pitot Tube is free of air 21
4.2.6 Collecting Lab Test Data 21
4.2.7 Temporary Storage 22
4.2.8 Draining Turbid Water 22

5. Field Deployment 23

5.1. Preparing for a Field Experiment 23
5.1.1 Pack list 23
5.1.2 Getting set up on the bridge 23
5.1.3 Prepare for an in-situ background file collection 23
5.1.4 Collecting Data 24
5.1.5 Shutting Down 25
5.1.6 Clean up 25

6. Software Installation and Viewing Data 27
6.1. Overview 27
6.2. Software Installation 27
6.3. Learning the Software 27
6.3.1 Batch File Processing 30
6.3.2 Settings 31
6.4. Formats of Results file 32
6.5. Presenting Results 32
7. Handling, Cleaning & Maintenance and Storage 33
7.1. Handling 33
7.2. Cleaning & Maintenance 33
7.3. Storage 34
8. FAQ's 35
Appendix A File names, File Formats, and Size Classes 37
Appendix B Purging the Pitot System 39
Appendix C Cleaning the Optics 40
Appendix D Detailed Accessories List 41
Appendix E 5-pin Connector and B-Reel Cable Termination 43
Appendix F Warranty 44
Appendix G MY NOTES 46

1. Introduction

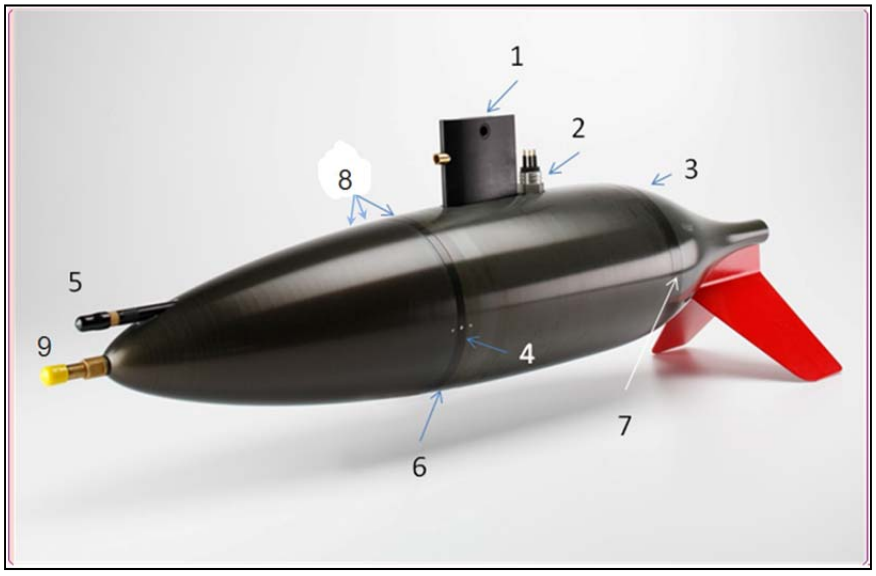
Dear LISST-SL Customer:

Thank you for purchasing the LISST-SL iso-kinetic sediment grain-size analyzer! It is a sophisticated sediment sensor for use from bridges and it provides all the data you need for computation of river discharge and sediment flux in a river: River velocity, sediment concentration, particle size distribution, depth, and water temperature.

In the shipment you will find 2(3) main items which comprise the LISST-SL Instrument System. These are: the LISST-SL submersible sensor, a Topside Control Box (TCB), and a B-reel if you ordered one. If you did not order a B-reel, you will need to procure one from one of many vendors in the US. Also included is Windows software for downloading and processing raw data. A full list of items shipped to you appears in Chapter 2, Contents and Technical Specifications.

Sequoia Scientific, Inc. thanks you for choosing one of our products. We strive to make our instruments rugged, reliable, and simple to operate. If you should have any difficulties, questions, or suggestions, please feel free to contact us: info@sequoiasci.com

1.1. The LISST-SL sensor



1) Cable Attachment Point
2) Underwater Connector (to B-Reel)
3) Exit point for intake flow
4) Dots for aligning mechanical parts
5) Pitot-tube velocity sensor
6) Front bulkhead
7) Rear bulkhead
8) Purging holes
9) Intake nozzle

The main system is the streamlined submersible LISST-SL sensor. The sensor is the entire streamlined instrument which enters the water. This is only a sensor; it needs power to operate, and it has no data storage capacity. It must be connected to the TCB at all times (See Section 1.3).

The LISST-SL sensor contains the laser optics and electronics, used to detect the light scattered off of the particles, and an iso-kinetic pump. Whenever power is applied to the LISST-SL from the TCB, a dedicated microprocessor inside the LISST-SL begins operation. It senses current velocity, turns on and controls operation of the internal pump to match current velocity (i.e. in iso-kinetic mode), and immediately begins transmitting data to the TCB. The LISST-SL will continue to transmit data regardless of whether the TCB is capturing it or not. In this regard, it is a 'dumb' sensor: The LISST-SL needs the TCB for power. The TCB executes the user commands, e.g. capturing a background scattering file, or capturing river data.

At the top of the LISST-SL sensor is the cable attachment point (1), which is hidden in a streamlined black 'housing' that looks like the sail of a submarine.

Immediately behind it is the underwater connector (2) to which the cable from the B-reel will be connected [see Appendix F for connector pin outs].

The exit point for the intake flow (3) is behind the underwater connector.

Three dots are shown (4), for aligning the nose, the front bulkhead, and the mid-section of the LISST-SL. A hole on the far side in this image, exactly behind the mark (4), and on the bulkhead is a static pressure port. Depth of the instrument below water surface

is sensed through 2 small holes on the side of the bulkhead ('static port'), connected to a pressure sensor.

The pitot-tube velocity sensor (5) is the smaller of the 2 nozzles protruding from the front of the sensor. To prevent large sediment grains from entering the pitot tube, a 35 µm metal screen is fitted behind the conical opening. Whenever not in use, KEEP THE PITOT TUBE COVERED with the plastic cap provided with the shipment. Not doing so may dry up the passage to the pitot pressure sensor and introduce bubbles. We will describe separately how to identify if bubbles are present in the pitot tube and how to remove bubbles.

Note that the front (6) and rear (7) bulkheads are identified on the photo. Not shown in this photo is the bleed port. The bleed port is a screw on the top surface of the nose section, ahead of the front bulkhead.

The hole at the top (8) of the bulkhead is to purge air. Over years of operation, sediment may accumulate in the static ports. You may use the top static port to inject water and blow out the sediment. The three radial holes in the bulkhead are connected to a common cavity that is applying the static pressure for the flow velocity and the pressure for the depth sensor. Temperature is sensed in the water passage, within the instrument. On the nose is an intake nozzle (9) on the instrument axis.

A large fin (not shown in this photo, see page 27) is provided to stabilize the LISST-SL Sensor and point it into the flow. The downward pointing fin enters water first, immediately spinning the instrument and pointing it into the flow. During deployment the LISST-SL will sway in the river current. This is because of turbulent eddies in the river, causing the instantaneous flow direction to veer; the instrument follows this instantaneous direction.

1.2. The Topside Control Box (TCB)



1) Communication port and battery recharge connector
2) On/Off button
3) Touch-panel display
4) TCB-to-B-Reel / -LISST-SL connector
5) Pen and stylus
6) Quick guide (2-sided)

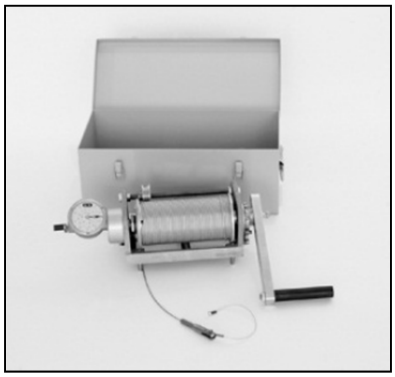
Control of the system is from the TCB, which contains a powerful 25V 19.2A-hr Lithium-ion battery, a computer and data logger system that is controlled via the touch-panel display. The TCB battery powers the LISST-SL sensor, the computer within the TCB, and the touch-screen. All communication with the LISST-SL is via the menus on the touch-panel display. Two separate cables (not shown) are provided; one for communication with a computer, the other to recharge the battery.

Once the TCB – B-reel – LISST-SL system is connected together, operations involve these 3 simple steps, which are described in detail in chapter 5:

1 Verify that the pitot tube is free of air bubbles.
2 Acquire a background datafile; this contains measurements of scattering from optics on to the detectors and some other parameters.
3 Capture river /stream data.

YOU CAN ONLY CHARGE THE BATTERY WHEN THE TCB POWER IS TURNED OFF.

1.3. The B-Reel



This is an essential part of the system. It has 50m of strong cable wrapped on a barrel and a handle to manually operate it as a winch.

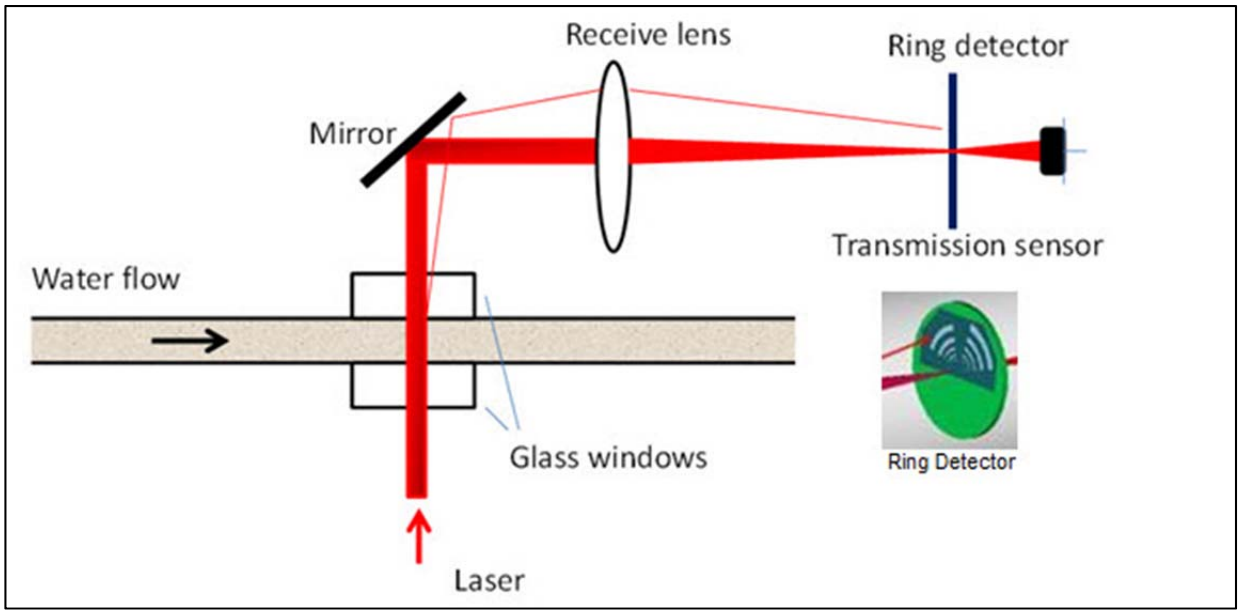
The B-reel serves a dual purpose: it is used to lower the LISST-SL sensor from the bridge, and also provides electrical connection between the sensor and the TCB.

The B-reel cable has a river side end, which splits into a Y. One end of the Y is tied to the lifting point on the LISST-SL, and the other end is a female submersible connector, which is connected to the LISST-SL underwater electrical connector.

The other end of the cable is permanently attached to slip-rings, which are permanently fastened to the rotating barrel of the B-reel. The slip rings connect to 2 terminal posts. A provided cable is used to connect to these terminal posts and to the LISST-SL TCB..

If you ordered the B-reel from Sequoia, the river end termination is done by us. See Appendix F for connector type and wiring instructions.

1.4. The Laser Diffraction Principle



The measurement of sediment size distribution and concentration in the LISST-SL is based on the principle of laser diffraction Because some of the terminology in this manual refers to principles and components of laser diffraction, a brief explanation is offered here.

Inside the LISST-SL, the river water passes between a pair of parallel glass windows (see diagram above). A laser beam crosses these windows. Light scattered by particles in this laser beam is collected by a receive lens, and is sensed by 32 ring-shaped detectors, each one covering a small, distinct angle sub-range.

From these 32 measurements, 32 solutions are obtained using methods of linear algebra. These 32 solutions are the *concentration* of sediments in 32 size classes. The sum of all these represents the *total suspended sediment concentration*. A full description of this method is available in several publications. For more detail, we invite the reader to review the Application Note 'How LISST instruments measure the size distribution and concentration of particles' on our website (http://sequoiasci.com/Articles/ArticlePage.aspx?pageId=119).

1.4.1 Background Files, and "*VIEW RINGS*"

In this manual, you will frequently read about ring detectors (sometimes just 'rings'). It is important to understand what this means. We therefore offer a brief description of instrument optics.

In the figure above, a laser beam illuminates particles in water, flowing between two water-tight glass windows. [For a cut-out cross-section of the instrument, see figure at end of this chapter]. The particles scatter light (one example ray is shown as a thin line). A receive lens collects this light and focuses it onto the focal plane of the lens. A special detector is placed on the lens' focal plane. It consists of 32 concentric rings of silicon (hence the term '**rings**' or '**ring detector'**).

At the center of the rings is a 75 μm diameter hole. The laser beam passes through this hole and is detected with a silicon photodiode (transmission sensor). In this manner, the 'rings' measure light scattered out of the laser beam, while the power of the beam that passes through the central hole is the beam 'transmission' measurement.

1.4.2 Attenuation

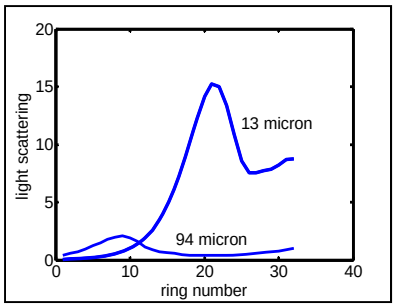
This is the **attenuation** suffered by the laser as well as by the scattered light as it passes through water. This measurement of attenuation is used to *de-attenuate* the measured scattered light on the ring detectors. *The attenuation is not used to estimate sediment concentration.*

1.4.3 Background

It is important that you understand the significance of the patterns of light on the rings. The total amount of light on rings is a combination of a '**Background'** and light scattered by particles.

The Background arises from imperfections and micro-scratches on optical windows. This Background is very carefully measured to create a **Background File**. The background is subtracted from the total signal on the rings to compute the scattering from particles alone.

The background changes due to age, or due to particle deposition on windows. **HENCE, IT IS NECESSARY TO MEASURE THE BACKGROUND BEFORE EVERY EXPERIMENT.**



To understand the importance of the Background, it is important to understand the nature of light scattering by particles. For this purpose, the light scattering patterns on the rings for *equal concentrations* of large (94 microns), and small particles (13 microns) are shown on the figure to the left.

Note that for a given volume or mass concentration, small particles produce a lot more scattered light than large particles (the relationship is inverse with size). Also, the main peak of scattering occurs at small rings for large particles, and vice versa; i.e. here too, there is an inverse relationship between the particle size and the ring where its maximum scattering occurs. Viewed another way, light on small rings is interpreted as the presence of large particles, and vice versa

This last point is very important. It follows that an error in the measurement of the background on the small rings is equivalent to a large error in the amount of large particles.

A similar error on the outer rings would amount to a smaller error of the small particles. For this reason, the **strongest emphasis is placed on getting extremely good measurements of background light on the smallest rings.** This is why we repeatedly emphasize maintaining clean optics and low, stable values of background scattering on the inner rings. See also **Error! Reference source not found.** on background scattering.

1.5. General Precautions

The LISST-SL instrument is a precision opto-electronic device. ***AVOID SHOCK AND VIBRATION***. See also chapter 7.

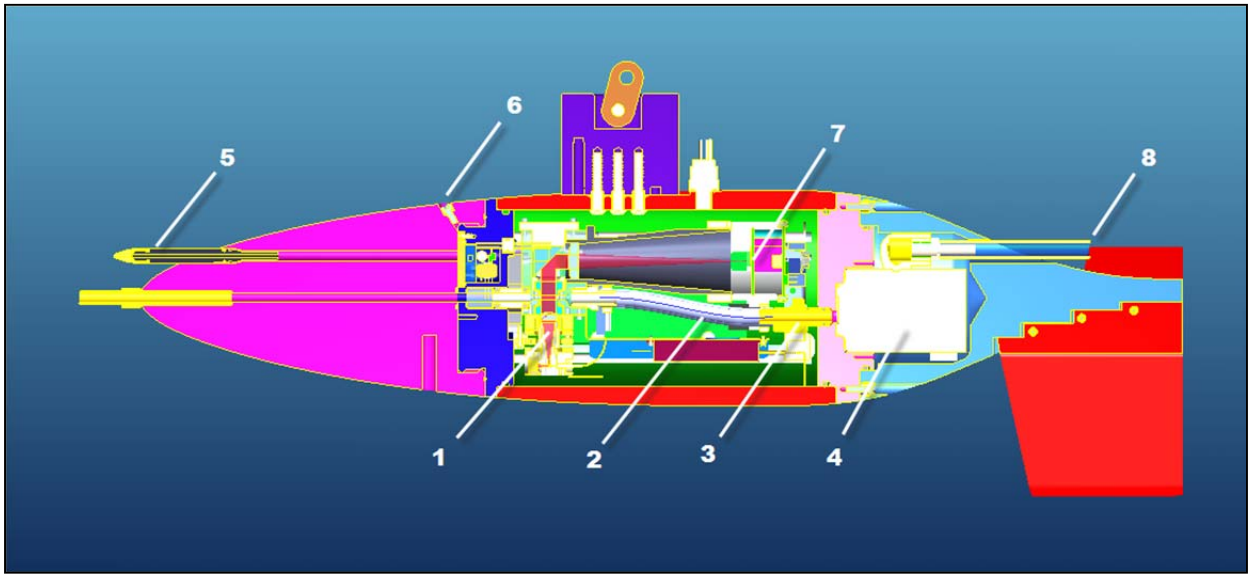
1.6. Operational Limits

While working in extreme conditions of water turbidity, you should note that there are limits on both the lower and upper concentrations at which the instrument will work:

At the lower end, too few particles can lead to very weak scattering on the ring detectors. A guide for water turbidity is the *optical transmission* measured across the test cell. The optical transmission is the ratio of laser power transmitted through the cell, to its value in clean particle-free water. This defines the lower concentration limit of operations. Although with care, you may be able to operate and get meaningful data at transmission as high as 99.8%, the instrument is designed to produce good data at transmissions below about 98%.

In contrast, at the high turbidity end, when too many sediment particles are present in the laser beam, multiple scattering degrades results. Multiple scattering grows with decreasing transmission. As a practical matter, we suggest that at transmission below about 30%, accuracy may degrade. These limits are worth remembering while you interpret your field measurements.

An approximate estimate for operating limits: from about 10mg/l to about 2,000 mg/l. Above the highest specified concentration (i.e. transmission below 30%) the data can still be used all the way down to a transmission of 10%. The error in concentration and size distribution will simply increase at these low transmissions. For example, for a single size particle measurement, we have seen an error of about 10% in concentration at a transmission reaching 10%. In other words, the data at transmissions below 30% are still usable, though with awareness that the errors (bias) is growing. Please visit our website for articles on this topic.



A cut-out cross-sectional view of the LISST-SL.

The laser beam (1) can be seen traveling from bottom to top, like the figure shown on page 4. The water passage is marked as (2). The ring detector is (7), the temperature sensing thermistor is in a fitting (3). The pump is marked as (4) and the water exhaust port is marked as (8). The pitot tube is marked as (5) and the bleed port is marked as (6).

2. Contents and Technical Specifications



In the box(es) [Photographs of all items are included in Appendix D]:

LISST-SL Sensor	Topside Control Box (TCB)
5-pin impulse plug and Sleeve (attached to –SL)	3-Pin Impulse Plug (Attached to TCB)
Pin Clips (2)	Quick Reference Guide (in TCB)
Foam Instrument Stands (2)	Sensor toTCB Cable
LISST-SL Tail	TCB to B-Reel Cable
Tail Fin Screws	Communications Cable
Filter Disks, 35 Micron (Pitot Tube)	25.2V Lithium Battery Charger
Filter Cartridge, 0.2 Micron (Lab Use)	B-Reel (if ordered)
Filter, Modified, 0.8/0.2 Micron (Field Use)	Flexible Tubing, 1 meter (3)
Nose Wrench	Funnels (2)

Hex Tool Kit	Hose Pinch Clamps (3)
Cleaning Patches	Tube Adapters, ½" x 3/8"
Tweezers	Tube Adapters, 3/8 x 3/8"
O-ring Pick	Rubber Bands
Plastic Caps (Pitot Tube / Sampling Tube)	Red Taper Plugs
Ship Disk for Instrument System	ISO Coarse Sediment
O-ring kit [sizes 2-007,009,011,013,046]	Syringes(2)
LISST-SL Manual	

2.1. Parameters Displayed on TCB

- Particle Concentration [mg/l]
- Mean Particle Size computed as Sauter Mean Diameter [µm]
- Optical Transmission
- Depth of instrument [m or ft]
- Temperature of water [°C]
- Water velocity in the river [m/s or ft/s]
- Pump drive voltage and current
- State of Charge of the Battery

2.2. Operating Specifications

- Sediment Concentration: 10-2000 mg/l (nominal) [Depends on grain size]. NOTE: Silt Density is assumed to be 2.65. [for other values, you will need to adjust the density as follows: first divide by 2.65 then multiply by new density].
- Size Ranges: 1.9 – 381 µm for randomly shaped grains (versus spheres). See Appendix A for details.
- Size Resolution: 32 log spaced size classes [each size is 1.1809 times previous].
- Optical Transmission: 0 – 100%. Useful range: 30 – 98%.
- Depth of operation: 0 – 30 m (100ft).
- Operating Temperature: 0 – 40^0C (32 – 104^0F)
- River velocity: 0 – 3 m/s, or 0 –10 ft/s;
- Isokinetic control range: 0.5 – 3 m/s, or 1.5 – 10 ft/sec. [Pump minimum speed is set to a low value to prevent sediment accumulation within it].
- Power consumption: 24V, 2.5Amp (with pump full on)

2.3. Datalogger Specifications

- 128 MB storage capacity; corresponding to at least 100,000 size distributions and associated sample information [over 20 hours operation.]
- Expandable to 4 GB.
- RS232 Interface

2.4. Power

- Battery – Rechargeable Lithium-ion battery pack. 24V x 19.2 A-hr inside TCB.
- Battery life on bridge: 8 Hours, nominal. [**WILL NOT CHARGE WHILE TCB IS IN USE**]
- Battery Alarm – sounding sound when ½-hour life left on battery.
- AC battery charger (120/240VAC)
- Recharge time: 8 hours.

2.5. Physical Dimensions – LISST-SL

- Length: 76.2 cm

- Diameter: 19.8 cm
- Tail width: 58.4 cm
- Total height with tail mounted: 25.4 cm
- Weight in air: 16 kg (35 lbs)
- Weight submerged: 7 kg (15 lbs)

2.6. Physical Dimensions – TCB

- Length: 44.5 cm
- Width: 29.2 cm
- Height: 17.8 cm
- Height with lid fully open: 43.2 cm
- Weight: 9 lkg

2.7. Datafiles and their Contents

All files have the same filename format and are named as either Rdddhhmm or Zdddhhmm, where ddd is the day of the year, hh is the hour of the day, and mm is the minute of the hour.

Data files start with the letter R. The Background file start with the letter Z. Appendix A contains a more detailed description of all the files.

Z0641443.ASC	Background scatter file, to be used for processing *.dat* file. See Appendix A for order of variables. The background should be taken immediately prior to every data run (see Chapter 3). It also zeros out any depth sensor drift and atmospheric pressure changes to yield the correct water depth. The background is subtracted before computing sediment concentration and size distribution.
R0641443.TXT	Text file with details of all related files below. Contains date and time stamp of when the measurement was started, instrument serial number, firmware version in TCB, name of file with Concentration and Mean Size; name of Raw Scattering data binary file; associated background file (Z***,asc above) , and units.
R0641443.CSV	Comma-separated file, saves data displayed on TCB during data collection. Contains Date, Time, Depth, Velocity, Mean Size, TSS, Temperature, Optical Transmission, Pump state (1 = ON, 0 = OFF), and Battery Voltage.
R0641443.DAT	Binary data file, 50 variables per record. See Appendix A to see order of variables (needed if processing data in MATLAB).
R0641443.PSD	Particle Size Distribution, from post-processing *.dat* file. It is a binary file, only used by the VIEW PSD FILE function on the PC software.
R0641443.ASC	This file is produced after processing the .dat file. It is an ASCII file containing size distribution and other variables. See Appendix A for order of variables.

2.8. Size Ranges

There are 32 size ranges (also called size bins) logarithmically placed from 1.9 – 381 µm. The table below shows the lower and upper limit and median size of each size bin in µm.

	Sizes (microns)						
Size Bin #	Lower	Upper	Median	Size Bin #	Lower	Upper	Median
1	1.90	2.25	2.07	17	26.9	31.8	29.2
2	2.25	2.65	2.44	18	31.8	37.5	34.5
3	2.65	3.13	2.88	19	37.5	44.2	40.7
4	3.13	3.69	3.40	20	44.2	52.2	48.0
5	3.69	4.35	4.01	21	52.2	61.6	56.7
6	4.35	5.14	4.73	22	61.6	72.7	66.9
7	5.14	6.06	5.58	23	72.7	85.7	78.9
8	6.06	7.15	6.59	24	85.7	101	93.1
9	7.15	8.44	7.77	25	101	119	110
10	8.44	9.96	9.17	26	119	141	130

11	9.96	11.8	10.8	27	141	166	153
12	11.8	13.9	12.8	28	166	196	181
13	13.9	16.4	15.1	29	196	232	213
14	16.4	19.3	17.8	30	232	273	252
15	19.3	22.8	21.0	31	273	322	297
16	22.8	26.9	24.8	32	322	381	350

3. Learning the LISST-SL System

3.1. Basics

The LISST-SL sensor, whenever powered, immediately begins to adjust the internal pump to iso-kinetic operation and starts transmitting data to the TCB. Iso-kinetic means when water is taken into the LISST-SL at a velocity matching the river velocity. The power to the LISST-SL comes from the TCB, and operation and data collection is managed by the TCB also, using the touch-screen display. In Chapter 1, we described the LISST-SL sensor and familiarized you with the component systems that are visible.



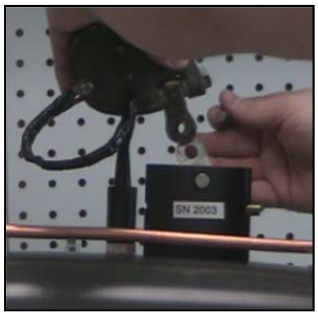
For the purposes of this manual, we will assume that the user has a bridge-top cart to which the B-reel would be mounted. The user will also need to locate a place to position the Topside Control Box.

3.2. LISST-SL Sensor



The LISST-SL is shipped to you with caps on the intake and pitot tube openings, and on the underwater connector**.** Remove all for use, but keep them covered when in storage. A flexible tube is also attached to the water exit end.

3.3. B-Reel



Recall from Chapter 1 that the B-reel is a battery-powered or manually operated winch, with a strong steel cable. The cable has a conductor at center which makes the cable a 2-conductor wire. The free end of the cable is terminated to connect to the lifting point and to the electrical connector on the LISST-SL. For quick tests, it is not essential to have the B-reel between the LISST-SL and the TCB. A short cable is provided so that you may directly connect the LISST-SL to the TCB.

The electrical termination of the steel cable should always be protected from shorts. If you did not purchase the B-reel from Sequoia, you will need to terminate the free end of the steel cable. The pin-outs for wiring are in Appendix E.

3.4. The Touch Panel Display

3.4.1 Main Menu

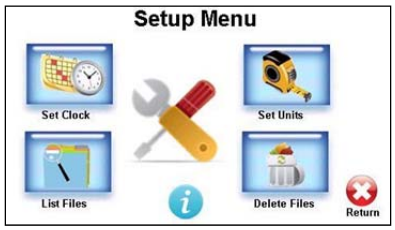


When you turn on the TCB (see chapter 1.2) the LISST-SL Main Menu display appears. The main menu is where you make the key selections: CALIBRATE, MEASURE and SETUP.

The CALIBRATE button is used to collect a Background Scatter file. The MEASURE button is to operate the instrument to collect data. The SETUP button is used to change settings such as the clock, units etc.

Note that all operations on the touch panel display are also graphically shown on the Quick Reference Sheet attached to the inside of the lid of the TCB.

3.4.2 Setup Menu



Start by verifying that the clock and units are correct. Press the SETUP button to go to the Setup Menu where you have 4 choices: Set Clock, Set Units, List existing files, Delete existing files.

The CANCEL button takes you back to the MAIN MENU.

The button will display an info panel summarizing the current settings for the LISST-SL. Press the Done button to return to the Setup Menu.

The button leads you to an option to set pump speed. Leave it on Auto. For some laboratory work, e.g. to blast the water channel at high velocity for cleaning or for blowing out sediment in the system, choose MAX power.

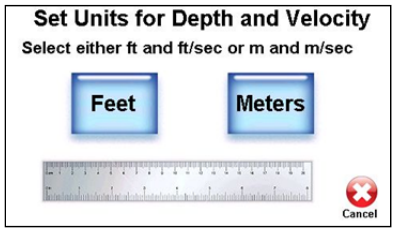
Press cancel to return to Main Menu.

3.4.3 Set Clock



Press the SET CLOCK button. A new menu will open and guide you to set the current time. Use the key pad to set the date and time in the displayed format. Please note that the date format is mm/dd/yy, and that the time format is 24 hour format hh:mm:ss.

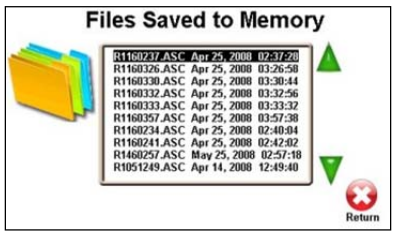
Once you have set up the clock and date, press the SET CLOCK button at the bottom of the screen. Press the CANCEL button, to go back to the Setup Menu without making any changes to the clock.



Press the SET UNITS button to set the units of the display, e.g. British units (feet and feet/second) or SI units (m and m/s). Temperature is always only displayed in ^{o}C.

Simply press the FEET or METERS button to set the units.

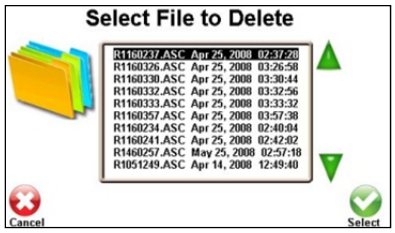
To return to the Setup Menu without making any selections, press the CANCEL button.



The LIST FILES button displays the files saved to the TCB data logger. The list only shows the .ASC files, although all associated files have also been saved (see chapter 2.7 for a detailed description of all file extensions and formats).

There are no options to change the list of files saved.

Press CANCEL to return to the SETUP menu.



The DELETE FILES button opens a window with a list of all saved files. Select the file that you wish to delete. You may select only one file at a time to delete by using the stylus and pressing the file name.

When you have made a selection, press the SELECT button.

Press CANCEL to return to the SETUP menu without selecting or deleting any files.



The next panel shows all the files with the same root name that will be deleted. Select YES to delete the files and return to the SETUP menu. Select NO to return to the Setup Menu without deleting any files. To delete more than one file at a time, you must use the Windows program provided separately for your PC.

CAUTION: ONCE THE FILES ARE DELETED, THEY CANNOT BE RECOVERED.

3.4.4 **Calibration**

The calibrate function records a Background scatter file. This file contains measurements of light scattered from imperfections of optics on the 32 ring detectors. A few other parameters are also stored.

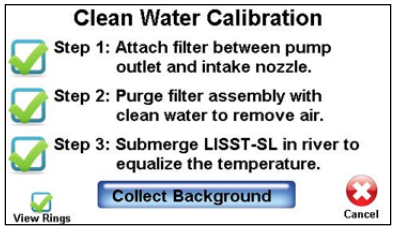
YOU MUST NEVER SKIP THE CALIBRATE STEP.

THE BACKGROUND FILE IS CRITICAL TO THE QUALITY OF DATA YOU WILL OBTAIN WITH THE MEASURE FUNCTION.

Preparing the LISST-SL sensor for the Calibrate step is described in the next sections. Here we describe TCB operation only.



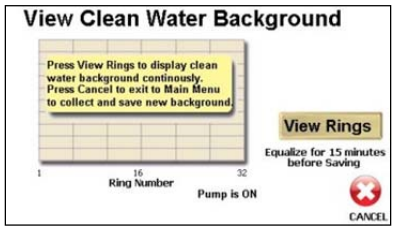
From the Main Menu, press the CALIBRATE button to obtain a background scatter file.



The Clean Water Calibration menu opens.

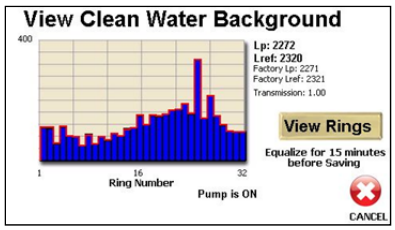
It reminds the user to perform 3 steps to prepare the LISST-SL instrument for acquiring a background file. These steps are fairly intuitive, but will be described in more detail in the chapters 4 and 5.

For now, simply check all 3 boxes and then tap the View Rings check box twice. The first time you will set a check mark in it, the 2nd time it opens up a new window, enabling you to view your current background scattering pattern in comparison to its ideal, factory value.



REMEMBER THAT THE QUALITY OF THE BACKGROUND IS EVERYTHING FOR A SUCCESSFUL DATA RUN.

Press the View Rings button on the screen again. This will open a new screen showing a regular update of the background about once every 2 seconds.



A good background can only be obtained if the rings display is steady, with minimal or no change. If there are bubbles or particles in the water, the rings display will show variability. This is NOT a good situation to capture a background file.

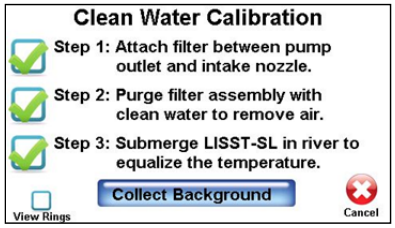
If you see variability, remove bubbles from the system, and remove particles (attach a filter to the intake). Then repeat.

WHEN THE VIEW RINGS DISPLAY UPDATES WITH MINIMAL VARIABILITY, YOU ARE READY TO CAPTURE A BACKGROUND.

Press Cancel to go back to the Main Menu.

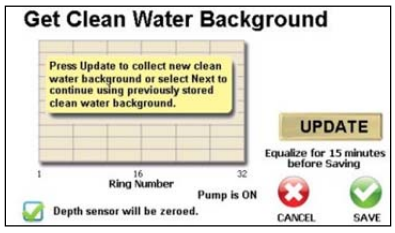


Again choose Calibrate.



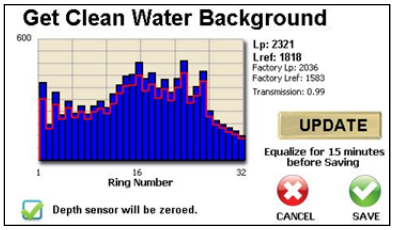
On the Clean Water Calibration screen, check the check boxes marked 1-3, but DO NOT check the View Rings button.

Instead, press the Collect Background button.



The Get Clean Water Background screen will open.

Press the UPDATE button to capture an updated background.

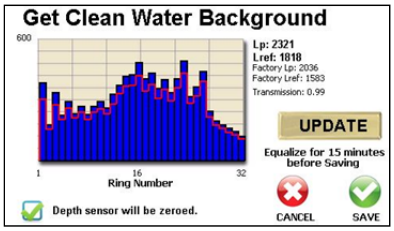


After averaging 20 samples (roughly 40 seconds), the display will show your new background data, and the factory values (red line). Ideally, the two should be very similar, as in the picture on the left.

You may save the new background file by pressing the SAVE button at bottom right of the frame. The file will be saved and the Main Menu will appear. Note that the file is named automatically by the TCB. The format is described in chapter 2.7.

NOTE: If you now list all the files on your TCB, you will **not** see this new file. However, when you download files with the windows software on your PC, this file, beginning with the letter Z will be visible. This file will be used to subtract background light scattering from the sediment in the next step.

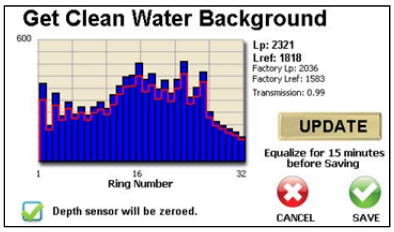
3.5. Understanding the Background File



OTHER THAN THE DATA FILE, THE SINGLE MOST IMPORTANT FILE IS THE BACKGROUND FILE.

When you update the background file, the display shows a set of blue bars, which is the current (NEW) background scattering on the rings of the detector. The red line is the factory value. Over time, due to sand-blasting of windows or simply due to fouling, your background will become slightly higher than factory.

3.5.1 Laser Power and Laser Reference



Note the two variables Lp (2321) and Lref (1818), with their factory values (2036 and 1583, respectively). Lp refers to the laser power (in digital counts only), transmitted through water and through the small hole at center of the ring detector. Lref is the laser emitted power.

In clean water, the ratio Lp/Lref should be nearly identical to factory value with less than 3% variability. In the example on the left the current Lp/Lref is 1.277 (2321/1818) while the factory Lp/Lref is 1.286 (2036/1583). The difference is only 0.7%, which is very acceptable.

Slightly higher values may occur; that is acceptable. Lower values of Lp/Lref than the factory value suggests:

1) Misalignment
2) Dirty Windows
3) Turbid or bubble-filled water, or
4) Scintillation due to temperature differences between the instrument and the water.

3.5.2 Alignment

If the Background scattering pattern you capture has a shape that is very similar to the factory value, with the ratio Lp/Lref within 3% of the factory value, the optics are in excellent shape. Accept the Background file and proceed.

If the optics become mis-aligned the inner rings (rings 1-6 in particular) will become higher, but only ALTERNATE rings will be higher (e.g., 1, 3, 5). This is usually accompanied by a much lower Lp/Lref ratio, typically below 90% of the factory Lp/Lref ratio.

3.5.3 Dirty Windows

Dirty windows will add light on the middle rings. In this case, your Background scattering pattern will be higher in the middle rings than the factory scattering, and the Lp/Lref ratio will typically decline.

Try cleaning the windows with the window cleaning tool three (3) times. If it does not change, minor scratches on the window may have developed due to sand grains blasting the windows. It may be OK to proceed, after checking for noise (chapter 3.5.6).

3.5.4 **Turbid or bubble-filled water**

If the background shows elevated scattering on all rings, and the Lp/Lref ratio is lower, then the water is probably too turbid to be used for background scattering. Replace or flush out the filter on the intake nozzle.

If there are bubbles in the water, the inner rings (all of them, not just alternating rings) will show elevated values and the Lp/Lref ratio is lower. Check that the filter is fitting tight.

3.5.5 **Scintillation**

Scintillation is the scattering of light by turbulent eddies with temperature differences between water and instrument. The identifier for this is that ALL INNER RINGS increase in magnitude, not just alternate ones (which indicate misalignment).

Let the instrument come to water temperature. It is for this reason that you are advised you to make a Background measurement in the river with a 30 minute dip period.

3.5.6 **Noise Test**

If the instrument is not misaligned, the optics are clean, but the background is still higher than factory, the question becomes: can I go further? The answer is yes if the new background is stable. If it is not stable, this will add noise to the measurement.

To test for noise, capture a background. Then switch to the MEASURE mode WITH THE SAME WATER RUNNING THROUGH THE INSTRUMENT.

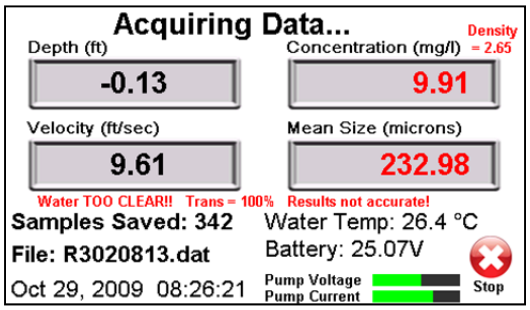
In this case, the instrument should see no sediment. The outputs on the touch-screen should be small and fluctuating numbers. This is the instrument noise. Now you can judge if the noise level is acceptable. In turbid rivers, a noise of 5 mg/l may be acceptable. In cleaner waters, you may tolerate only 1 mg/l or even less. In our experience, this number is often less than 1 mg/l. This noise is the most vital criterion for accepting a background measurement.

In the end, it is noise on your measurement that determines your confidence in the data.

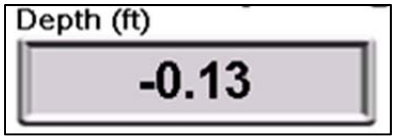
3.6. Measure and Acquire Data



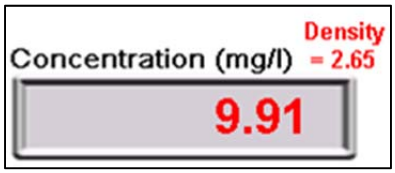
This button is meant to take you to data collection. After familiarizing you, we will show you how to test your new background file first, and then how to capture real data in the next chapter.



Pressing the MEASURE button from the Main Menu takes you to a panel that is titled Acquiring Data. This panel shows the current instrument depth, sediment concentration in water, a mean sediment size, water temperature, river velocity, number of samples saved, filename, battery voltage and the pump drive voltage and current drain. The display is mostly self-explanatory.

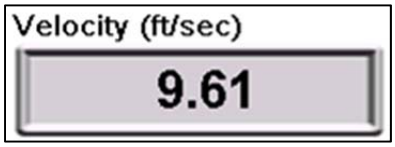


The depth panel tells you the depth of the instrument below the surface, *regardless of the wire angle.* If the background was acquired recently, the depth should show a small value if the LISST-SL is in the lab, or held just below water surface in a river.

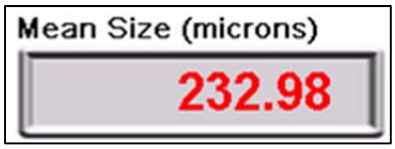


The sediment concentration is displayed in units of mg/l.

This display assumes a mass density of 2.65 g/ml. If you believe the mass density to be different, a correction will need to be applied to your final processed results.

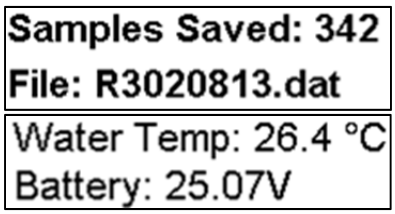


In field use, the velocity display will fluctuate with the passage of turbulent eddies, and also due to the movement of the cable itself. However, unreasonable fluctuations may be due to bubbles in the pitot tube. See Appendix B for instructions on how to remove bubbles.



The Mean Size on the display is calculated as the Sauter Mean Diameter using a simplified method and is not an exact match to the mean size you will get when you process the RAW data on your PC after downloading.

In extremely clear waters, this number may be erratic. With increasing turbidity, this number becomes stable.



Note also that the display shows the number of samples saved in the data file, the filename, the date and time, the water temperature, and the battery voltage.

The TCB is programmed to give you a sound alert when the battery voltage drops to 21.5V. At this time, there is about 20 minutes of life left on the battery. If you do not shut down, the instrument will itself shut down when battery drops to 20V.



Pump supply voltage and current are displayed in a crude semi-quantitative way. The purpose of this is to help you identify if the pump is operating. Do not try to interpret this display in a quantitative way. Digital data on pump voltage and current are saved in data files.

To stop data acquisition, press the STOP button.

3.6.1 **Battery Charging**



ONLY charge the battery inside the TCB using the charger provided to by Sequoia. Lithium battery manufacturers do not recommend charging the batteries unattended for long periods of time. Limit charging to overnight or while attended. The charger indicates the batteries are fully charged with a Green LED and will automatically cut off. The LED is Red when it is charging.

Charging Lithium batteries requires 'smart' chargers. If you attempt to charge the battery with some other charger, your warranty will be voided. The battery charger has a connector that mates to the charging connector on the TCB panel.

NOTE: THE BATTERY CANNOT BE CHARGED WITH THE TCB IN USE. IF ATTEMPTED, THE CHARGING IS DISABLED, BUT THE TCB WILL FUNCTION NORMALLY.

3.6.2 **Data Download from TCB**



A serial communication cable is provided with the LISST-SL. The TCB end of this cable is identical to the charging cable.

Only one function can be carried out at a time: battery charging or data download.



When the data download cable is connected to the TCB and power is turned on, the graphic on the left briefly appears on the TCB screen.

The graphic disappears when the Windows software is launched on the PC, see Chapter VI.

4. Using the LISST-SL System in a Laboratory

4.1. First Assembly and Test in Laboratory

Now that you have become familiar with the subsystems, LISST-SL sensor, the B-reel, and the TCB, it is time to do a test assembly in the laboratory.

For this test, make sure the instrument has been at room temperature for at least 4 hours, and that the water you use is also at room temperature. Temperature differences between the instrument and water can cause scintillation of the laser beam and invent large particles.

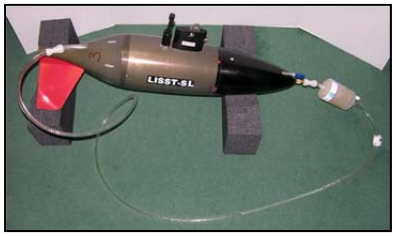
4.2. System Integration

It is important that the pump in the LISST-SL does not run dry for prolonged periods of time. You should either form a loop from the nose of the SL to the tail to circulate water or submerge the LISST-SL for laboratory testing.

4.2.1 **Form a loop for the pump**



- Put a pinch clamp on a meter length of tubing.
- Attach a funnel to one end and the inline 0.2um filter inlet on the other end of the tubing.
- Use the bleed port on the 0.2µm filter to fill the filter and the tubing.
- Keep a full column of water from the filter to the funnel (no air). Use the pinch clamp to control the volume of water in the tube.
- Attach the filter outlet to the sampling tube with a short length of tubing to the sampling tube.



- Tilt the LISST-SL slightly so the nose is lower than the tail.
- Fill the LISST-SL until water comes out of the tail.
- Close the pinch clamp so the water does not drain out of the tube.
- Remove the funnel and attach the end of the tube to the tail outlet.
- Release the pinch clamp.

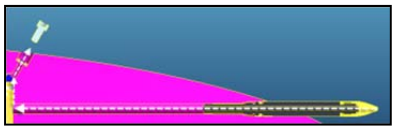
4.2.2 **Purge the pitot tube**



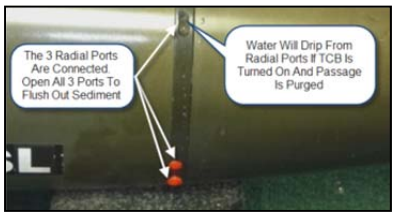
- Inspect the pitot filter screen. Clean or replace it as necessary.
- Put a pinch clamp on another meter length of tubing.
- Attach a funnel to one end of the tubing and attach the other end to the pitot tube.



- Remove the bleed port screw on top of the LISST-SL nose cone.
- Keep the funnel above the top to the LISST-SL and continue filling the funnel with water as it purges all the air out of the LISST-SL nose cavity.
- Water will drain out of the bleed port.
- Use the hose pinch clamp to stop the flow before the funnel drains but after the LISST-SL nose cavity is purged.
- Fill the funnel assembly with more water and install the bleed port screw.
- There should be no air in the tubing.
- Keep the funnel above the top to the LISST-SL and turn the TCB on. For best results, support the funnel about 1 meter above the LISST-SL.
- The pump will turn on and water will circulate through the 0.2um filter and sample tube

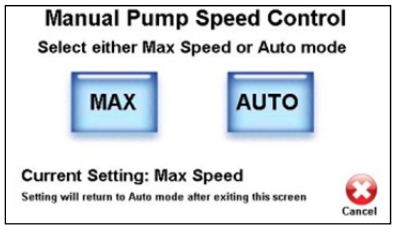


The diagram to the left shows the pitot tube bleed passage.



- The 3 radial ports are connected internally.
- Use a syringe to fill the passages connecting the 3 radial ports.
- Put plugs in the two side ports and fill the top port.
- The water displacement is very small, but it should bead up, and spill out of the top port.
- This purge may take 15 minutes the first time the instrument is purged.
- After the water displacement is observed, plug the last radial port with the plastic plug.
- Cover the plugs with a large rubber band so they do not fall out.
- Place a plastic cap over the pitot tube.

Shortly after turning on power at the TCB, the microprocessor in the LISST-SL will turn on the pump within it. You will be able to see water moving in the tubing. You will be able to hear the pump. Wait for bubbles to escape.



If needed, use the Manual Pump Speed Control under the Setup Menu to help bubbles along.

4.2.3 **Obtain background**

Press the CALIBRATE button. Follow the procedures as explained in the chapter 3.4.4. Check off the 3 boxes, and then also check the View Rings button. At the next frame, press View Rings button again. In the background collection mode, the pump runs at full power. If the rings view is steady, cancel out, and re-enter the Background mode.

Press Update to capture a new Background file following procedure described in the introduction to the TCB. It will be named automatically. The new background is shown in contrast to factory values.

4.2.4 Instrument Health Check

Perform a background scatter health check as described in chapter 3.5 and then a noise test as described in chapter 3.5.6.

4.2.5 Check if Pitot Tube is free of air

Air in the pitot system can cause faulty operation of the iso-kinetic pump controller. The simplest test is as follows:

- Set up a head on the pitot tube as in the last test.
- Apply 10 cm (0.328 ft) of head.
- Turn on the TCB and go directly to MEASURE.
- Observe the indicated velocity on the display. It should be fairly steady. Its magnitude should also be consistent with the formula:

  Velocity (ft/sec) = 8 $\sqrt{H}$ fps (H in feet); 8*sqrt(0.328ft) = 4.5 ft/s.

  Or,

  Velocity (m/sec) = 4.43 $\sqrt{H}$ m/s (H in meters); 4.43*sqrt(0.1m) = 1.4 m/s

- If the numbers show more than 10% variability, try again.
- If the variability persists, you may need to purge air from the pitot tube. This procedure is described in Appendix B.

4.2.6 Collecting Lab Test Data

This step also serves as a practice run for field tests. Begin with power switch off at the TCB. It is assumed that you have just acquired a good background file.

- Fill a 1-liter beaker with 1 liter of clean water and add about 500 mg of coarse sediment (say 20-100 micron).
- Put the beaker on a magnetic table and set up a small magnetic stir bar so that the sediment won't settle out. Stir vigorously.
- Connect one water-filled flexible tube (1/4-inch inner diameter (ID), or 6 mm ID) with a pinch clamp to the intake of the LISST-SL.
- Connect a second tube to the exit of the SL (at top, behind the 6-pin connector). Send the free end of this tube to a drain.



- Finally, to simulate a dynamic hydraulic head of 10 cm or more, connect a tube to the pitot intake, fill with water, and raise it. See photo.
- Turn on power at the TCB. The pump will start pumping and water will recirculate.
- From the MAIN MENU press the MEASURE button on the panel.
- After several samples, open the pinch valve to the beaker. The instrument will display the measured mean grain size, concentration, and a velocity. These are your test data. With this method, only 5 to 10 samples will be valid before air bubbles will be sucked into the inlet tube to produce erroneous data.
- Compare the displayed velocity from a computed value; it is related to the head H on the pitot tube, as $(2gH)^{1/2}$ where g is 9.81 m/s^2 or 32 ft/s^2 and H is in corresponding units.

A recirculating method of sampling can be implemented by sending the drain line back to the beaker. Data accuracy will suffer due to sediment settling in or releasing from the pump cavity and bubbles being introduced from the pump. These effects can be minimized, but the best results will be obtained from a well-mixed single pass-through.

Download data from the instrument to your PC and process it. See Chapter 6.

4.2.7 **Temporary Storage**

Turn off power on the TCB. You can now store the instrument.

4.2.8 **Draining Turbid Water**

TO AVOID FOULING THE INTERNAL WINDOWS ALWAYS DRAIN ALL TURBID WATER OUT OF THE SYSTEM BEFORE STORAGE.

A simple way to do this is to remove the intake tube from the turbid water tank and put it in a clean water tank. Turn on TCB power, and select Calibrate. The pump will run full power. Pump a few liters of clean water through. You may add a little bleach to prevent algae growth in the water passage and pump.

TO PREVENT AIR FROM ENTERING THE PITOT TUBE, COVER THE PITOT OPENING WITH A PLASTIC CAP.

5. Field Deployment

5.1. Preparing for a Field Experiment

If you have gone through a Laboratory instrument system health check, you are mostly prepared for a field test. (Field assembly can be minimized by leaving all exterior plumbing attached, filled with water and tested before taking the instrument to the testing site.)

The only difference is that you will collect an *in-situ* background file. This is to make fine corrections related to temperature and to remove atmospheric pressure changes from depth data. The in-situ background file is collected with filtered river water passing through the instrument with a modified 0.2/0.8 micron filter (provided).

Because temperature differences between the LISST-SL and river water can cause scintillation of laser beam in water, and 'invent' large particles, the in-situ background is collected after bringing the LISST-SL to river water temperature. A 30-minute submergence is recommended for the LISST-SL to reach river temperature.

5.1.1 Pack list

You must pack the following items:

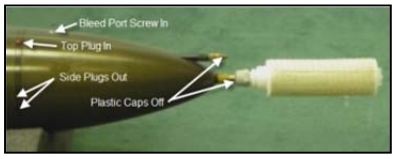
- LISST-SL
- Topside Controller Box
- B-reel
- A platform for the B-reel.
- Gallon of filtered clear water
- A customized 0.2/0.8 micron filter cartridge, provided by Sequoia.
- Cable to connect TCB to B-reel.
- Termination on the B-reel to connect to the –SL [this is provided by Sequoia if you purchased the B-reel through us.]
- Carry the rest of the accessories supplied to you as these may come in handy as well.

5.1.2 Getting set up on the bridge

CHECK FOR AIR IN PITOT-TUBE.

The best indicator is that the velocity numbers show erratic values if there is air. See also Appendix B. If air is present, follow the purge procedure in Appendix B.

5.1.3 Prepare for an *in-situ* background file collection

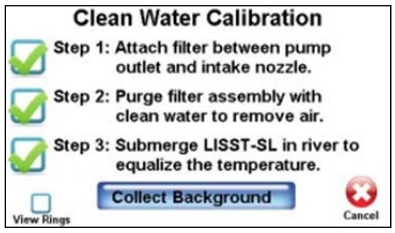


- Make sure you have cleaned the water passage. It is a good idea to use the Cleaning Rod (see photos in Appendix E) to clean windows a few times. After each cleaning, check the background each time. When backgrounds look similar, proceed next.
- Attach the customized 0.2/0.8 micron filter to the nose of the LISST-SL by sliding it directly over the sampling inlet tube.
- Mount the B-reel on its platform.
- Place the TCB on the platform in a safe secure place.

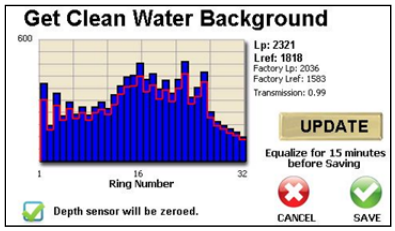


- Connect power cable from TCB to the slip ring on the B-reel.
- Connect the LISST-SL underwater connector to the termination of the B-reel.
- Remove the plastic cap on the pitot tube and the two red tapered plugs on the side of the nose.
- Attach the hook to raise the tail of the LISST-SL above the nose 10 degrees as it hangs from the B-Reel cable.
- Lower the instrument in water. Hold just below the surface.
- Tie off the platform to the bridge rail or otherwise secure the system to prevent accidents.
- Turn on TCB power.
- Press the SETUP button, set clock and units as desired. Return to MAIN MENU.
- Select SETUP then select the TOOLS button.
- The Manual pump speed control option will be displayed.
- Toggle between Max and Auto four times leaving the pump on Max for the final selection. The instrument takes 2-3 seconds to update. This should take about 20 seconds.
- Leave the pump on Max for 30* minutes with the LISST-SL in the water just below the surface. This is the temperature equilibration time and the depth that will be defined as zero.

- ***For very clear water (less than ~50mg/L), longer temperature equilibration time than half-hour is recommended; up to an hour for best results.**



- Once the temperature equilibration time has passed, select CANCEL, RETURN and then CALIBRATE.
- Perform Steps 1-3 are done and check them off.
- Press the COLLECT BACKGROUND button.



- Check the DEPTH SENSOR WILL BE ZEROED box.
- Press UPDATE. When data looks favorable compared to factory values, press SAVE.
- When finished, press CANCEL button to go back to MAIN MENU.
- Test your background: with the instrument still in river with the filter etc. connected, use the MEASURE button to view Concentration. If it is in the range of approximately 1 mg/l, the background is good.
- Cancel, and stop the instrument.
- Pull up the LISST-SL to remove the filter and release the tail hook.

5.1.4 **Collecting Data**



After the background has been collected, and the filter and tail hook removed you can start collecting data. Lower the instrument in the river. Turn on power on TCB, then press MEASURE. The LISST-SL will immediately start sending data up the B-Reel to the TCB.

To stop data collection, press the STOP button at bottom right of the ACQUIRING DATA screen. When you press the STOP button, the files that have been created during the measurement will be closed.

You may move to a different location of the river cross-section and collect more data by pressing the MEASURE button on the MAIN MENU again. It is not necessary to collect another background measurement if you are just moving across the transect to another profiling position.

If the Battery Low alarm sounds, quickly finish your work and prepare to shut down.

5.1.5 **Shutting Down**

When you have finished your measurements, turn off the power at the TCB, then pull up the instrument, and promptly put the plastic cap on the pitot tube.

NOTE: WHILE DISASSEMBLING EQUIPMENT ALWAYS FIRST TURN OFF POWER AT THE TCB TO AVOID ELECTRICAL SHORTS.

5.1.6 **Clean up**

Wash the exterior of the instrument and connector area with fresh water.

Use a syringe filled with clean water to blow sediment out of the 3 radial static pressure ports.

Attach a clean water tube to the intake of the LISST-SL and wash out the internal surfaces with a strong flow of water. Keep the optics path filled with water to prevent water spots from forming on the windows.

If you are planning to store the instrument for a long duration (more than a few days) see chapter 7.

6. Software Installation and Viewing Data

6.1. Overview

Every time the MEASURING button is pressed, a number of data files are created. These were described in Chapter 2.7. To recap, the following files are produced:

Rdddhhmm.TXT Text file with details of all related files below. Contains 'memory' of when created, instrument serial number, firmware version in TSB, name of file with Concentration and Mean Size; name of Raw Scattering data binary file; associated background file (Z***,asc below) , and units

Zdddhhmm.ASC Background scatter file, used for processing *.dat* file.

Rdddhhmm.CSV Comma-separated file, saves data displayed on TCB during data collection. Contains Date, Time, Depth, Velocity, Mean Size, TSS, Temperature, Optical Transmission, Pump state (1 =ON, 0=OFF), and Battery Voltage.

Rdddhhmm.DAT Binary data file, 50 variables per record. See Appendix A to see order of variables (needed if processing data in Matlab).

The **Particle Size Distribution,** which contains the 32-bin size distributions are created , from post-processing *.dat* file through the Windows software. These Particle Size Distribution files have the name Rdddhhmm.psd. See Appendix A for order of variables in the *.psd* files.

You will notice that so far, even including a field test, no PC use was required. The Windows Software provided by Sequoia is needed only to process the .dat binary data file.

You will only process one file: the *.dat* file on your PC. This is the raw binary data file. Processing this file takes some time, hence it is done on a PC. It produces the size distribution file, *.psd* . To process the file, you will need 2 other files: the background saved with this file, and the ringarea file (provided with the software). The software always needs calibration parameters of the instrument which are included in the *.ini* file. In the next step, you will load software on your PC.

6.2. Software Installation

Load the CD supplied to you with the instrument, and type setup when ready. The software will be installed in a folder selected by you. Create a short-cut to the executable program on your desktop.

6.3. Learning the Software

The LISST-SL software is needed to

- Offload data from the TCB
- Process the .DAT binary datafiles stored on the TCB into ASCII files of the full size distribution for viewing in Excel or other spreadsheets ASCII files (.ASC format)
- View the resulting particle size distribution files (.PSD). The .PSD file is also a binary file. It is only useful for viewing the results using the LISST-SL software on your PC.
- Perform batch processing of multiple .DAT files in one operation.



Connect the TCB to your PC using the serial cable and turn on the TCB power. Launch the LISST-SL software. The Quick Start Menu window on the left will show, with 3 possible selections: OFFLOAD DATA, PROCESS RAW DATA, and VIEW PSD FILE.



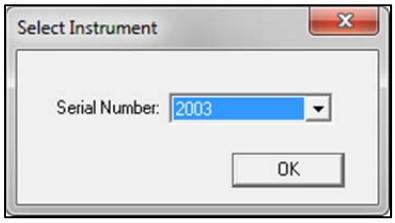
Click the OFFLOAD DATA button and select the file(s) you want to offload. Use the CTRL button on your PC to select multiple files. Then select a destination folder on your PC. If the LISST-SL software is already running, choose the Quick Launch button under the File menu option. Then select Offload Data button.

This completes the download process. You may select another file to download the same way.

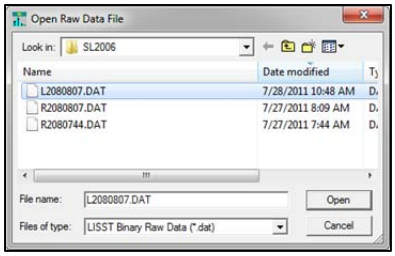


After downloading data, or directly from the Quick Launch button, press the PROCESS RAW DATA button.

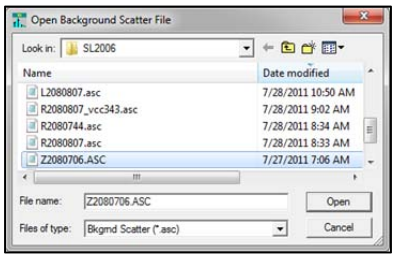
The processing typically takes a few seconds to a few tens of seconds, depending on file size. Two files are created during processing; a binary .PSD file and an ASCII .ASC file.



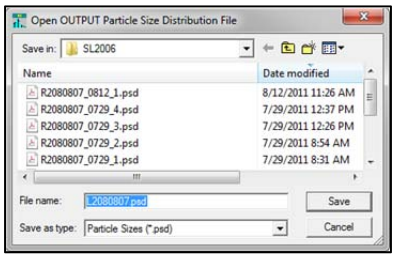
You will be prompted to select the instrument serial number from the drop down menu.



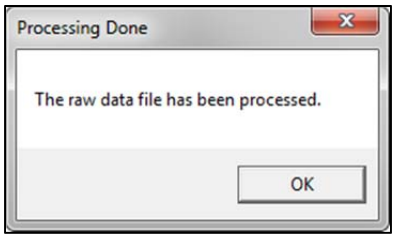
Next, select the Raw Data File (.DAT) format to open. You can only select one file at the time.



Next, select the Background Scatter File that you obtained before the deployment of the LISST-SL.



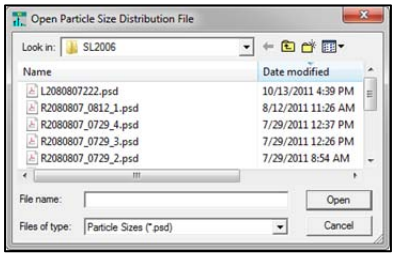
Select the output file name for your .PSD file. The selected .DAT file will be processed and saved as soon as you click the Save button.



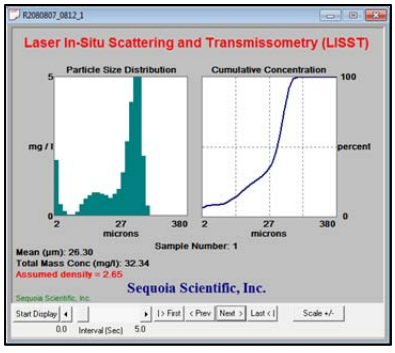
A dialog box will inform you that processing has been completed. Click the OK button.



Press the VIEW PSD FILE button from the main menu.



Select the .PSD file to view.



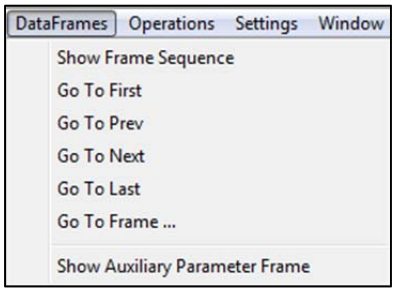
The file will open up in a window as shown. The size distribution is displayed in the left frame, the cumulative size distribution is displayed in the right frame. The mean size, and total mass concentration of the sediment for this measurement is displayed below the size distribution plot.

Click the Next button to scroll through the measurements one by one.

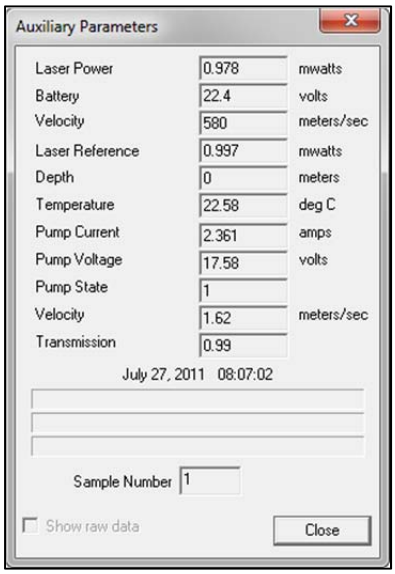
The Last button will take you to the last measurement in the file

Clicking the Start Display button will play the size distributions as a movie.

The scale on the ordinate (y-axis) of the size distribution can be adjusted at any time using the Scale button.



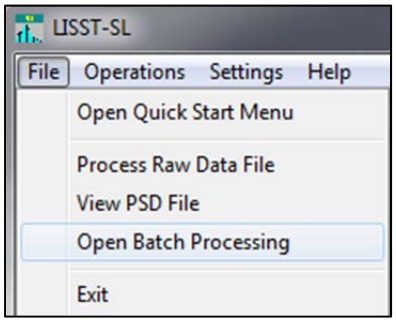
You can also move forward and backward in the file if you click the DataFrames Menu.



In the DataFrames Menu, click Show Auxiliary Parameter Frame to display a second frame with auxiliary data such as velocity, battery voltage, temperature etc.

6.3.1 **Batch File Processing**

Because the LISST-SL created a file every time the Measurement button on the TCB is pushed, it is possible to generate many files very quickly. Using the Batch processing allows the user to process all these .DAT files in one operation.



To open Batch Processing click File | Open Batch Processing



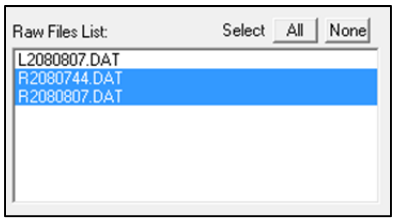
The Batch Process window opens up.

First select the Instrument Serial Number from the drop down menu.



Then select

1) the location of the Background File you want to use for processing
2) the location of the Raw Files (.DAT files) you want to process, and
3) the Output Files folder.



All files with a .DAT extension in the Raw Files Directory are now listed in the Raw Files list. Select the files you want to process by clicking them.

If you want to select and process all files, press the All button. Press the None button to unselect all selected files.

In the example on the left, one of the files is a LISST-100X file (L2080807.DAT), which we do not want to process. If you have selected All Files, simply unselect the file(s) you do not want to process by clicking them once they are highlighted.

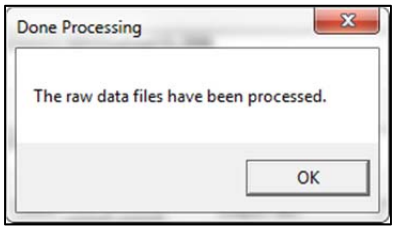


The Output Files window will show a list of the files with a .PSD and .ASC extension that already exists in the Output Files Directory. In this example, no files are present.

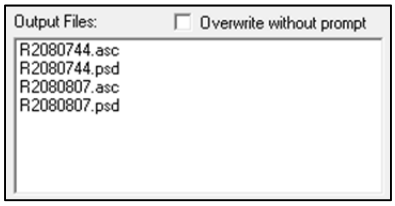
If you check the Overwrite without prompt box, existing files will be overwritten without warning. If you leave it unchecked, you will have to approve the overwrite for each individual file that is being overwritten.



When you are happy with your selections, press the Process Raw Files button.



When the batch processing has been completed, a status message will appear. Press the OK button.

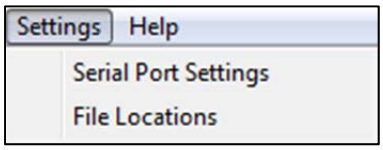


Note that the Output Files window has now been updated with the processed .ASC and .PSD files.

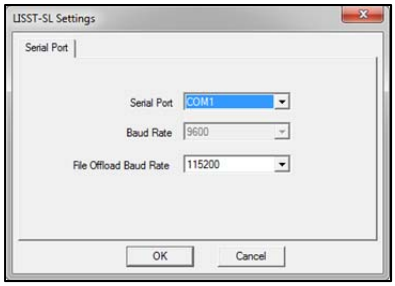


Close down the batch processing window using the Close button

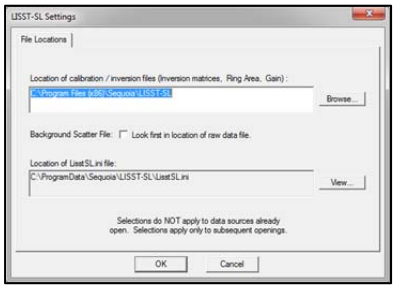
6.3.2 **Settings**



The Settings Menu has two options: Serial Port Settings and File Locations



Click the Serial Port Settings to select the correct Serial Port that the TCB is connected to. The LISST-SL software will automatically detect which ports are available for connection.



Click the File Locations to verify the location of the calibration files needed by the software. This is helpful for troubleshooting. Clicking the View button will open up the LisstSL.ini file, which shows calibration constants for your instrument.

6.4. Formats of Results file

The formats of all files, (.txt, .csv, and .asc) are provided in Appendix A.

6.5. Presenting Results

Sequoia Scientific, Inc. does not provide software for you to prepare your reports. You may load the *.CSV* and/or .ASC files into any plotting software for report preparation. If using Excel, note that the .CSV file is a comma-separated-variable file.

7. Handling, Cleaning & Maintenance and Storage

7.1. Handling

When handling the instrument, at all times please remember that the LISST-SL is a high-precision optical instrument. Treat it as you would treat an expensive camera.

Avoid mechanical shocks and impact to the LISST-SL or the TCB as this may cause misalignment of the optical parts, or damage to electronic assemblies.

Avoid scratching the touch panel display.

7.2. Cleaning & Maintenance

For lubrication of the underwater connector and the TCB connector, use ONLY silicone spray such as, e.g. 3M Silicone Lubricant.

DO NOT USE O-RING GREASE TO LUBRICATE THE CONNECTOR AND PINS – grease may build up in the connector on the B-reel and over time hinder communication to the LISST-SL.

Clean the LISST-SL body with fresh water each time after use, and before storage.

It is a good idea to connect a hose to the intake and run tap water through the system. This removes any sediment grains that may have accumulated in the pump.

Remove the pitot tube cap and clean the screen. Put the cap back on.

Remove the red tapered plug form the top static port. Flush water through all three static ports. Replace the tapered plug and put a rubber band around the sensor over the ports.

Clean the panel of the TCB using only a soft cloth. Never apply abrasives or abrasive surfaces to the touch panel. It scratches easily.

Do not use abrasive cleaners.

NEVER use solvents such as toluene or acetone for cleaning the TCB. If you do so the warranty will be immediately voided!

For cleaning of the windows inside the test section of the LISST-SL, see Appendix C.

7.3. Storage

IF PREPARING TO STORE THE INSTRUMENT SYSTEM FOR A LONG DURATION, IT IS A GOOD IDEA TO RUN CHLORINATED WATER THROUGH THE SYSTEM TO PREVENT BIOLOGICAL GROWTH ON INTERNAL SURFACES. STORE THE FILTER PROVIDED FOR BACKGROUND FILE COLLECTIONS IN A CHLORINATED WATER SOLUTION.

Put plastic caps on the intake and pitot tube openings. Place the LISST-SL on its foam stands or inside the shipping box.

Before storage, be sure to turn off power on the TCB.

Extended storage may cause weakening of the battery.

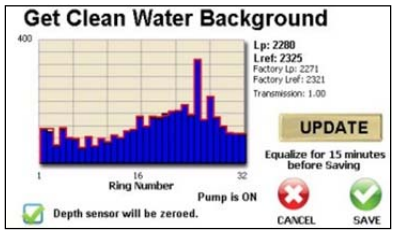
You should recharge the battery before use if the TCB has not been used for long (month or more).

A 5 pin Impulse plug and sleeve is provided to protect the connector on the LISST-SL when the sensor is not in use. The 3 pin Impulse plug should be put on the TCB connector and the rubber cover put on the communications connector to keep the connections dry and clean.

8. FAQ's

How do I evaluate the background measurement?

Upon obtaining a background, the red line shows the factory background and the blue bars show the current background. If they are close, all is well and good.



Increased scattering on the middle rings results from just one source: dirt or fine scratches on the windows. Try cleaning the windows a few times until they are acceptable.

If you see increase in the inner-most rings, i.e. rings 1-8 the explanation is more complex. Read descriptions of alignment and scintillation in Section 3.5.

In the end, what really matters is that the instrument is reasonably aligned, and that the background be STABLE. Try to MEASURE with the clean water that you used for Background. If the displayed concentration is small (<5mg/l), you may use the instrument, knowing that that is the noise floor.

Does the LISST-SL take into account the irregular shape of the natural sediment grains?

Yes. This was published in a study by Sequoia Scientific, Inc. scientists. The paper can be downloaded from our website here: http://www.sequoiasci.com/graphics/upload/pdf/library/technicalpapers/Agrawal_et_al_2008.pdf.

The LISST-SL software that processes raw data files incorporates irregular particle shape.

Does the LISST-SL require any calibration?

No. All that is required is that the user makes a background measurement before a sample is taken. This is in order to evaluate the state and cleanliness of the optical system. If this is good (e.g. the current background measurement is close to the factory background, see FAQ above) the instrument will deliver good data.

Drifts in laser power output are taken care of by the data processing software.

What happens if there are particle present outside of the size range covered by my LISST-SL?

This is a more complex question. Very briefly, the presence of sediment particles outside the size range covered by the instrument will cause some additional scattering on the inner- or outermost rings of the ring detector. In turn, this increased scattering will be interpreted as particle volume, so that the net effect is to increase the particle volume in the smallest and/or largest size classes.

Typically, the effect can be seen if there is a significant amount of particles outside the size range, so that a rising tail will appear in the coarse and/or fine end of the size spectrum.

Does the instrument measure NTU, FTU or any other turbidity units?

No. All laser diffraction based instruments measure the volume distribution of the suspended particles. This may or may not be related to NTU.

Can the LISST-SL be cross-calibrated with NTU's

No. The calibration of the NTU unit itself is based on a specific size of particles. With changing grain size, NTU itself changes, and it is meaningless to do a cross-calibration.

Can I overcharge the rechargeable battery inside the instrument?

If you charge the battery with the power adaptor supplied by Sequoia as part of the instrument you cannot overcharge the battery.

Do you have an FAQ not answered here?
Try the FAQ webpage on our website (http://www.SequoiaSci.com/faq/?SectionName=faq)!
Otherwise contact us at info@sequoiasci.com

Appendix A File names, File Formats, and Size Classes

lisstsl.ini — File provided on the CD accompanying the instrument. Contains calibration data for the instrument.

InstrumentData.txt — File containing information about the instrument used by the software during processing. The format is [SNSN, Instrument Type, unused value, Mass Conversion Constant, X]. For serial number 2005, the InstrumentData.txt file looks as follows:

2005, C, 8192, 1169, x

Factory_zsc_SNSN.asc — File containing the Background data on the instrument in format identical to the Background file (see later in this Appendix). SNSN refers to instrument serial number.

Ringarea_SNSN.asc — A file used by the data processing program. It applies geometrical factors to raw data. Also used in processing data in MATLAB. SNSN refers to instrument serial number.

Rdddhhmm.TXT — Text File created during sampling with the LISST-SL. Contains information settings, date and time for file creation, firmware version and the name of the background file used to partially process the data on board the instrument. The typical content is shown below.

LISST-SL Data File
Created on: Thursday, March 04, 2010 12:31:36 Day: 063
LISST-SL Serial number = 2005
Firmware Version 2.200 Mar 1 2010 16:45:31

Concentration and Mean Size Data in file: R0631231.csv
Raw Scattering Data in binary file: R0631231.dat
Background file used for Calculations: Z0620631.asc
Units for Depth are Feet. Unit for Velocity are Feet/sec.

Rdddhhmm.CSV — Comma-separated file (opens in MS Excel), saves data displayed on TCB during data collection:

Element #	Description
1	Date (mm/dd/yyyy)
2	Time (hh:mm:ss)
3	Depth (m or ft)
4	Velocity (m/s or ft/s)
5	Sauter Mean Size (µm)
6	Total Concentration (mg/l)
7	Temperature (°C)
8	Optical Transmission (%)
9	Pump State
10	Battery Voltage (V)

Rdddhhmm.DAT — Binary data file, 50 2-byte variables per record. All values are digital counts, and therefore are uncalibrated. Each .DAT file also contains a 200 byte header. The description of the 50 values is below.

Element #	Description
1-32	Raw ring counts x 10
33-36	Reserved for future use
37	Raw Laser Power
38	Raw Battery Voltage
39	Raw Differential Pressure
40	Raw Laser Reference
41	Raw Depth
42	Raw Temperature
43	YYMM
44	DDHH
45	MMSS

46	Raw Pump Current
47	Raw Pump Voltage
48	Pump State
49	Unused (set to 0 [zero])
50	Unused (set to 0 [zero])

Zdddhhmm.ASC — Background file. The format is identical to the .dat file, shown above.

Rdddhhmm.PSD — Particle Size Distribution, from post-processing *.dat* file. It is a binary file, only used by the VIEW PSD FILE function on the PC software.

Rdddhhmm.ASC — This is an ASCII file, for use with user's plotting software or report preparation. It contains the FULL size distribution from the instrument.

Element #	Description
1	Date (mm/dd/yyyy)
2	Time (hh:mm:ss)
3-34	Concentration (mg/l)
35	Laser Transmission (mW)
36	TCB Battery Voltage (V)
37	Differential Pressure (digital counts)
38	Laser Reference (mW)
39	Depth (m or ft)
40	Temperature (°C)
41	Pump Current (A)
42	Pump Voltage (V)
43	Pump State
44	Velocity (m/s or ft/s)
45	Optical Transmission (%)
46	Beam Attenuation (m^{-1})

Appendix B Purging the Pitot System

In order to purge the Pitot System, you need the O-ring pick, a 35µm filter disk for the Pitot nozzle, a tweezer, a syringe filled with clean, particle-free water (Milli-Q, de-ionized, steam distilled or bottled water), flexible tubing with hose pinch clamps, a funnel, and an Allen wrench (see Appendix D). Then watch the Video on Sequioa's YouTube channel named 'LISST-SL Appendix B: Purging the Pitot System.

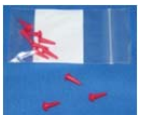
The direct link to Sequoia's YouTube channel is http://www.youtube.com/user/SequoiaScientific

Appendix C Cleaning the Optics

In order to purge the Pitot System, clean the LISST-SL optics you need a tweezer, the cleaning rod, cleaning solution, cleaning patches and a syringe filled with clean, particle-free water (Milli-Q, de-ionized, steam distilled or bottled water) (see Appendix D). Then watch the Video on Sequioa's YouTube channel named 'LISST-SL Appendix C: Cleaning The Optics'.

The direct link to Sequoia's YouTube channel is http://www.youtube.com/user/SequoiaScientific

Appendix D Detailed Accessories List

			
TCB Battery Charger (Used Only with TCB Power Off)	SL to TCB Cable Used in Lab Testing (Without B-reel)	TCB to B-Reel Cable	Communications Cable (For Data Download Only)
			
5 Pin Impulse Plug and Sleeve (Protection of SL Underwater Connector in Transit or Storage)	3 pin Impulse Plug	Nose Wrench (Used to Remove Nose Section)	Tweezers
			
O-ring Pick	Tool Kit	Tail Fin Screws	Bleed Port Screws with O-rings
			
Cleaning Rod to Clean Glass Windows Without Removing Nose Cone	Cleaning Patches (Insert at Cleaning End of Cleaning Rod)	Cleaning Solution	Syringes
			
ISO Coarse Sediment	Pins and Clips	Red Taper Plugs (for Plugging Pressure Sensor Ports)	Rubber Bands (to Cover Pressure Ports)
			
Plastic Caps for Pitot Tube and Sampling Tube	¼" ID Flexible Tubing	½" x 3//8" Tube Adapter	3/8" x 3/8" Tube Adapter
			

Hose Pinch Clamps	Funnels	Spare O-rings	Customized 0.2/0.8 Micron Nose Filter with Tube Adapter
			
35µm Filter Disks for Pitot Nozzle	0.2µm Filter Assembly (Backgrounds in Lab)	LISST-SL Tail Fin	Foam Instrument Stands

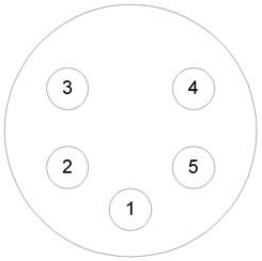
Appendix E 5-pin Connector and B-Reel Cable Termination

Connector Manufacturer: Teledyne-Impulse Enterprise, Inc. San Diego, CA, USA

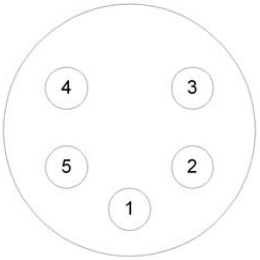
Connector Part Number (Bulkhead): MCBH-5-MP Stainless Steel

Mating Cable Part Number: MCIL-5-FS

Connector Pin #	Use
1	Power /Signal Ground
2	Power In (+24VDC)
3	Test Point 1
4	Test Point 2
5	Test Point 3

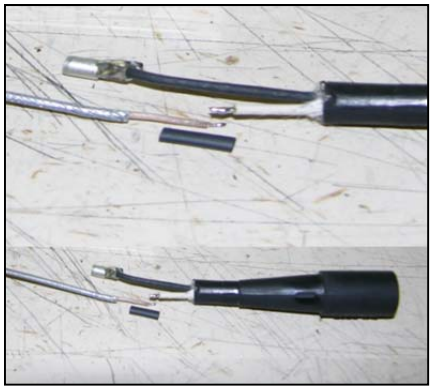


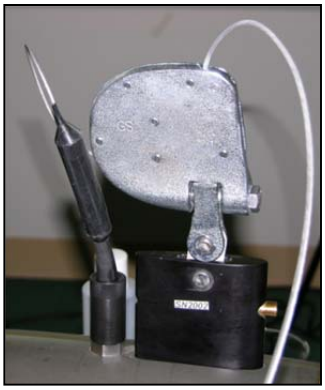
Bulkhead Endview



Cable Endview

The inner wire on the B-Reel steel cable is the Power In for the LISST-SL. The Signal Ground is the outer jacket of the steel cable. Appropriate sealing and potting compounds should be used to maintain a waterproof isolated connection to the Power In. The wires for the Test Points are not used, and should be terminated and sealed. The text and illustrations below describe the wiring details for this connector. If you have purchased your B-Reel from Sequoia together with the LISST-SL, the cable will already be appropriately terminated.





Appendix F Warranty

STATEMENT OF LIMITED WARRANTY AND LIABILITY

This Statement of Limited Warranty applies to all Sequoia Scientific, Inc. (“SEQUOIA”) products ("Products"). Any additional or different terms, including any terms in any purchase order, will be of no effect unless agreed to in writing by an authorized representative of SEQUOIA as reflected in a written SEQUOIA quotation.

1. Limited Warranty
SEQUOIA warrants that upon delivery by SEQUOIA (a) the Products will be free from defects in materials and workmanship, (b) the Products will perform substantially in accordance with SEQUOIA's applicable specifications, and (c) any Products (or components or parts thereof) that are manufactured by SEQUOIA do not infringe any U.S. patent or copyright.

2. Correction of Non-Compliance
If, during the twelve months after delivery (the “Warranty Period”), any Product does not comply with the warranties set forth in 1(a) and 1(b) above, SEQUOIA will, at its option, either (a) repair the Product, (b) replace the Product, or (c) refund the purchase price paid by Customer to SEQUOIA for the Product; provided that Customer gives SEQUOIA written notice of the noncompliance within the Warranty Period and ships the Product to SEQUOIA within one month after the end of the Warranty Period. As to any Product repaired or replaced by SEQUOIA, the Warranty Period will end upon the later of the end of the original Warranty Period or 90 days after SEQUOIA's delivery of the repaired or replacement Product to Customer. Any Product, component, part or other item replaced by SEQUOIA becomes the property of SEQUOIA. SEQUOIA may use refurbished components in the repair of Products supplied hereunder.

SEQUOIA's warranties shall be void and not apply if the Product has been subjected to misuse or alteration or repaired by a party not approved by SEQUOIA or the serial number on a product (if applicable) has been altered or defaced. SEQUOIA shall not be liable for normal wear and tear (such as replacement of consumables), nor for defects or failure caused by maintenance, misuse, negligence or failure resulting from non-compliance with SEQUOIA’s specifications, operating or maintenance manuals.

3. Infringement Indemnification
If any Product does not comply with the warranty set forth in 1(c) above, SEQUOIA will defend and indemnify Customer against any third-party claim asserted in any proceeding against Customer based on this noncompliance; provided that Customer gives SEQUOIA prompt written notice of the claim, SEQUOIA has exclusive control over the defense and settlement of the claim, Customer provides such assistance as SEQUOIA may request in connection with the defense and settlement of the claim (in which event SEQUOIA will reimburse the reasonable out-of-pocket costs incurred by Customer to provide such assistance), Customer does not settle the claim without the prior written consent of SEQUOIA and, upon SEQUOIA's request, Customer returns the Non-Complying Product to SEQUOIA for modification, replacement or a refund of the purchase price paid by Customer to SEQUOIA for the Non-Complying Product, less a reasonable allowance for Customer's use prior to return.

4. Exclusive Warranties
THE WARRANTIES SET FORTH IN PARAGRAPH 1 ABOVE ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED. SEQUOIA DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED (INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, AND ANY IMPLIED WARRANTY ARISING FROM COURSE OF PERFORMANCE, COURSE OF DEALING, OR USAGE OF TRADE) OTHER THAN THOSE SPECIFICALLY SET FORTH IN PARAGRAPH 1.

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SEQUOIA will not be liable for any indirect, incidental, special or consequential damages, any cover, or any loss of revenue, profit, data or use.

7. Limitations of Liability
SEQUOIA's liability (whether in contract, tort, or otherwise; and notwithstanding any fault, negligence, strict liability or product liability) with regard to any Product (including, but not limited to, any breach of or default by SEQUOIA) will in no event exceed the purchase price paid by Customer to SEQUOIA for such Product. Further, SEQUOIA will not be liable for, or be in breach of or default on account of, any delay or failure to perform as a result of any cause, condition or circumstance beyond SEQUOIA's reasonable control.

8. Indemnification by Customer
Customer acknowledges that the Products are designed and manufactured for use in non-critical, monitoring situations. If Customer chooses to purchase a Product or Products for use in applications that could result in damages in excess of the price of

the Product if the Product does not operate properly or otherwise fails, Customer acknowledges and agrees that it is Customer's responsibility to provide for redundancy and/or other safety or back-up measures sufficient to assure that failure of a Product(s) will not cause such damages. Customer agrees that it will defend and hold SEQUOIA harmless from any and all claims and costs (including but not limited to attorney's fees and other costs of defense against such claims) in excess of the price of the Products arising directly or indirectly from such Customer's use of the Products. Such indemnification is a critical part of the consideration being provided by Customer (over and above the price paid for the Product(s)) for the right to use the Products for such purposes and Customer shall not use a Product or Products for such purposes if it is unwilling or unable to provide such indemnification.

9. Statute of Limitations
Customer will not commence any action based on breach of warranty with respect to any Product more than 18 months after SEQUOIA's delivery of such Product.

10. Software
The Products may include or be delivered with certain computer programs, databases or other software that is proprietary to SEQUOIA. SEQUOIA hereby grants Customer a nonexclusive license to use such software solely for the purpose of operating Products. Customer will not: use any such software for any other purpose; modify, adapt, translate, or create derivative works based on any such software; or disassemble, decompile or reverse engineer any such software. No title to or ownership of any software or intellectual property rights are transferred to Customer.

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12. Controlling Document
In the event of any conflict or inconsistency between any provision of this Statement of Limited Warranty and any other provision of the Order, the provision of this Statement of Limited Warranty will control.

13. Controlling Law
This Statement of Limited Warranty will be governed by the laws of the State of Washington without reference to its rules relating to choice of law for the purpose of applying another jurisdiction's law. The U.N. Convention on Contracts for the International Sale of Goods will not apply.

Appendix G MY NOTES