AquaVISION Colloidal Borescope

Installation and Operation Manual

Rev 11/04/2014 Part #22070014

Table of Contents

AquaVISION Environmental LLC.

Colloidal Borescope System Users Guide

AquaLITE Version

Please complete and return all registration cards for the computer and frame grabber upon delivery of the AquaVISION Env., Llc .Colloidal Borescope System.

For technical support concerning the Colloidal Borescope or software, contact your local AquaVISION Env., Llc. Colloidal Borescope distributor or the manufacturer directly at:

GEOTECH ENVIRONMENTAL EQUIPMENT, INC.
2650 East 40th Avenue
Denver, Colorado 80205
303-320-4764
1-800-833-7958

For computer or frame grabber related issues, contact the technical support group for the appropriate vendor. (Enclosed with your Colloidal Borescope System).

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AquaVISION Env., Llc. software package contains a number of options all of which are described in this document. Which of these options is actually present in your installation of AquaLITE may depend upon the type of contract under which the software was acquired. If you have any questions about the presence or absence of a particular option, please contact AquaVISION Env., Llc.

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DOCUMENTATION CONVENTIONS

This uses the following conventions to present information:

A note icon indicates **NOTE** information. Notes provide additional or supplementary information about an activity or concept.

Section 1: Initial Equipment Setup and Testing

Operating and Maintenance Manual

General Description:

The colloidal borescope is an integrated high resolution flux gate compass and a high magnification colloid imaging camera.

Accidental spills and leaks associated with normal operations have resulted in significant sub-surface contamination at many facilities. The Colloidal Borescope offers an improved methodology for assessing contaminant transport potential. Data acquired with the instrument may be used to quantify heterogeneities and dispersion – parameters necessary to estimate the extent and magnitude of underlying contaminants define exposure routes and assess risks.

In addition to a high magnification image of colloidal particles suspended in the borehole, the colloidal borescope also provides magnetic heading information. The heading of the camera top (picture top of the displayed video image) is digitally displayed with the AquaLITE Software where the groundwater analysis can be determined.

By plotting the trajectory and speed of a colloidal particle across the screen with the AquaLITE Software, the relative flow direction can be determined. The compass display can then be used to determine the magnetic heading of the picture top, and from this the actual trajectory of the colloidal particle can be determined. The horizontal speed of the particle (and thus the flow speed) can be determined by software.

The camera housing and light head are made of stainless steel, and are sealed for underwater use to 1000 foot depths.

Installation and Operation

When you receive the colloidal borescope, unpack it carefully and inspect for any shipping damage. Please contact AquaVISION Environmental LLC if any damage is noted.

Operational Check:

After unpacking, an operational check should be made prior to installation or field use of the colloidal borescope. The following procedure is recommended:

1. Make sure the power cord to the controller is **NOT** plugged into the 120 VAC power source, and the control unit is turned off.
2. Connect the control cable to the camera and to the controller. Before plugging the underwater connector into the camera, make sure the O-ring is properly located in the camera bulkhead connector, and one is around the plug body of the mating connector. Also make sure the O-rings and sealing surfaces are clean and lightly lubricated with silicon grease or other O-ring lubricant
3. Connect the power cord of the controller to 120 VAC. Connect the video monitor, and turn on the controller.
4. The video screen should be white, and the colloidal back light should be on. Place a small object (pencil tip, piece of paper, etc.) approximately midway between the light head and the camera. A magnified, silhouetted image should be observed on the monitor.
5. Hold the borescope with the light head down and rotate the unit. Observe the compass display on the monitor to make sure it changes smoothly and corresponds to the angular position of the borescope.

Operation:

The colloidal borescope is intended for operation in vertical boreholes with the light head downward. Normally, the camera is suspended by the cable, which contains a Kevlar strength member with a tensile rating of 426 pounds. For most applications, the camera should be used with a centering device to minimize abrasion of the camera and light head, and to provide optimum fluid flow conditions.

With the controller unplugged and the power switch turned off, connect the cable to the controller and to the camera. Turn on the camera and operate the control functions before beginning the operation.

When the borescope is lowered in position, adjust the light for optimum contrast and observation of the maximum number of colloidal particles. In relatively clear water, the best results will be obtained with the light at a low setting.

Use the AquaLITE Software to determine groundwater direction and velocity as outlined in the following section.

Always use a grounding wire attached to the power supply if inserted into a stainless steel or metal cased well.

Maintenance:

Maintenance for the camera and light head is limited to cleaning and maintenance of the O-ring seals, and cleaning the housing and window.

To avoid scratching the windows, they should only be cleaned with mild soap and water. During cleaning, flush the windows with clean water then use a small amount of mild soap on your finger to gently clean the windows. Allow to air-dry or gently dry with a soft cloth or lens tissue.

The O-rings in the housing and light head should be inspected on a yearly basis, and should be replaced if any damage is noted, or if they appear to be flattened or deformed in any way. During replacement, the O-rings, O-ring grooves, and mating surfaces should always be clean, and should be lubricated with silicon grease or other O-ring lubricant before assembly.

The light head uses an LED with a very long lifetime and should not require regular maintenance. If replacement is necessary, the lamp assembly should be replaced as a complete unit. This is accomplished by first removing the retaining ring on the light housing, and withdrawing the end closure by inserting a ¼-20 bolt for use as a puller. The lamp assembly can then be taken out by removing an internal retaining ring and unsoldering the leads to the lamp.

After replacing of the lamp circuit, check the O-ring seal and mating surfaces for cleanliness, and for any nicks or scratches. Replace the O-ring if damaged. Lubricate the O-ring and mating surfaces with a light coating of O-ring lubricant, install the O-ring, and replace the end closure and retaining ring.

If repair or replacement of other components is necessary, please contact AquaVISION Env. LLC, or Geotech Environmental Inc.
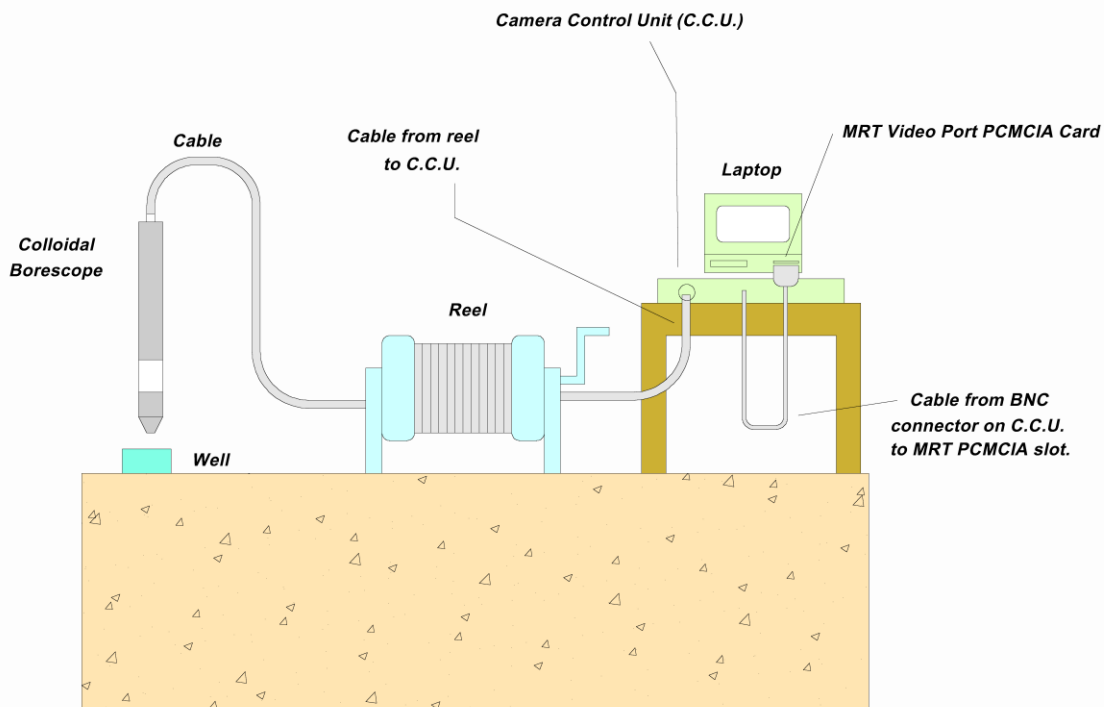
Specifications:

Applications:	2" (5.8 cm) or larger well diameter
Maximum operating depth:	1000' (305 m)
Maximum water pressure:	1200 PSI (82 bar), or 3000' (915m) water column
AC power requirements*	90-240V AC, 47 to 63 Hz. 7 Watts. Service requirement < 1 amp
DC power requirements*:	10 to 16 VDC @ < 1 amp
Probe size:	21.25" (54 cm) L x 1.75" (4.5 cm) OD
Probe weight:	5 lbs. (2.5 kg)
Probe housing material:	300 series stainless steel
Window materials:	Sapphire
Camera control unit size:	3.98" W (10 cm) x 7.89" (20 cm) L x 3.16" (8 cm) H
Camera control unit weight:	2 lbs. (907 g)
Cable size:	.32" (81 cm) OD (Customer specified length from 100' to 1000' / 30.5 m to 305 m)
Cable jacket material:	Urethane (composite cable material ROHS compliant)
Electrical component material:	Non ROHS compliant, dispose of properly
Operating temperature range:	-10 to 45°C (14-113° F)
Camera Field of View:	2.7 to 2 mm
Depth of focus:	.2 mm

(*Not including laptop or PC)

Connector Wiring:

CONTROL BOX CONNECTOR	WIRE PURPOSE
A	Coax center conductor
B	Coax Shield
C	Camera V-
D	Compass out
E	Compass in
F	Compass V-
G	Compass V+
H	Camera V+
J	LED V-
K	LED V+
L	Drain

Figure A: Equipment Setup

Note: Turn on power only after all connections have been made!

A certification program should be complete prior to using the Colloidal Borescope system.

After complete assembly of all equipment, plug all power cords into an approved 110 power outlet or appropriate power source. If using a Power Inverter, always use a grounding wire from the inverter to the well or grounding rod (not the vehicle)! Surge protectors should be used for all power connections. Turn on power to computer, monitors and Camera Control Unit.

All power indicator lights and the red back lighting lamp for the Colloidal Borescope should be ON.

Check for video image on Colloidal Borescope Monitor/T.V. by simply inserting fingertip or similar object under the Colloidal Borescope lens. A magnified black and white image of the object should be visible on the monitor.

Be sure to remove pigtail from cable reel when rinsing or lowering instrument.

Section 2: Software Use

The basic principle of Colloidal Borescope and Software:

Naturally occurring colloids exist in groundwater and by definition are neutrally buoyant. Therefore, colloids being carried by the natural groundwater can be observed /measured and a groundwater velocity and direction obtained. AquaVISION Env., Llc. Colloidal Borescope has a ~130X magnification accompanied by a flux-gate compass contained in stainless steel housing. Data from the Colloidal Borescope is transferred to the surface by high strength electrical cable where AquaLITE takes these magnified images and digitizes them at a pre-selected time (frames). The first digitized image is compared to the second image and numerical algorithms determine the best match for all colloids. A vector line is then drawn between the matched particles and the distance and direction are added to a file. This data can be graphed and incorporated into various modeling packages, groundwater formulas and general reports. This software has various parameters that can enhance the video signal and ability to track particles. Like all software, the more you use it, the better and easier it becomes to operate.

The AquaLITE Software was developed for standard Windows users. All menu items are described below and are simple to operate.

Photos provided by Oak Ridge National Laboratory

When the Colloidal Borescope is inserted into a monitoring well, it directly measures the movement of colloids.

Software Requirements:

- Pentium based laptop computer with an available PCMCIA slot or Express card slot.
- Windows 98or higher, Windows NT 4.0 or higher.
- At least 8 MB of free hard disk space in the Windows Drive.
- At least 13 MB of free hard disk space.
- At least 12 MB of RAM, 32 MB is recommended.

To Install the Quatech USB Adapter Drivers (from AquaLITE CD-ROM):

1. Follow the instructions described in the Quatech Driver Installation Guide

To Install the VCE Software (from AquaLITE CD-ROM):

1. From the Start/Run command, type in the drive letter and \VCE\Setup then Enter (i.e., D:\VCE\setup.exe where D:\ is the drive letter of your CD-ROM) or from explorer, double-click on the D:\VCE\ Setup.exe from your CD-ROM.
2. Follow the instructions on the screen.
3. Insert VCE PCMCI Card
4. Follow "Found New Hardware" instructions.
5. When prompted for the driver location, Browse the CD.
6. Find folder "VCE\Drivers", inside it find folder for your system.
7. NT users, please read "Readme" file in the Drivers/NT folder.

To Install the VCE-PRO Software (from AquaLITE CD-ROM):

1. Follow the instructions described in the VCE PRO Quick Start Guide

To Install the AquaLITE Software:

Exit any open programs, including those that run automatically at startup.

Insert the AquaLITE software CD-ROM into the computer's CD_ROM drive (or insert diskette labeled Setup into the diskette drive).

From the Start/Run command, type in the drive letter and Setup then Enter (i.e., *D:\setup.exe* where D:/ is the drive letter of your CD-ROM) or from explorer, double-click on the Setup.exe from your CD-ROM.

Follow the instructions on the screen.

For AquaLITE v. 7.3 and newer:

Before using the Video Preview or Tracking functions for the first time you must perform the following steps to initialize the VCE Video Configuration:

- Start a "New File" – Enter Well Configuration information – click OK. Save the file.
- From the menu, select Configuration -> Video -> Configuration (or press F5).
- Ignore the error message that says "VCE Capture Card Registry Data Not Available". Click OK.
- Click the "Auto Crop" button.
- Click the "Close" button.
- From the menu, select Configuration -> Video -> Save Configuration (or press F6)
- Close the File.

General Layout of Screen:

The general layout of the AquaVISION AquaLITE Colloidal Borescope Software has a menu bar (top), two video windows (left) and a status screen (right). The menu bar will be discussed in detail below. The lower video window (or the preview window) allows the user to see video image of the colloids moving in the well, as it appears magnified 130 times.
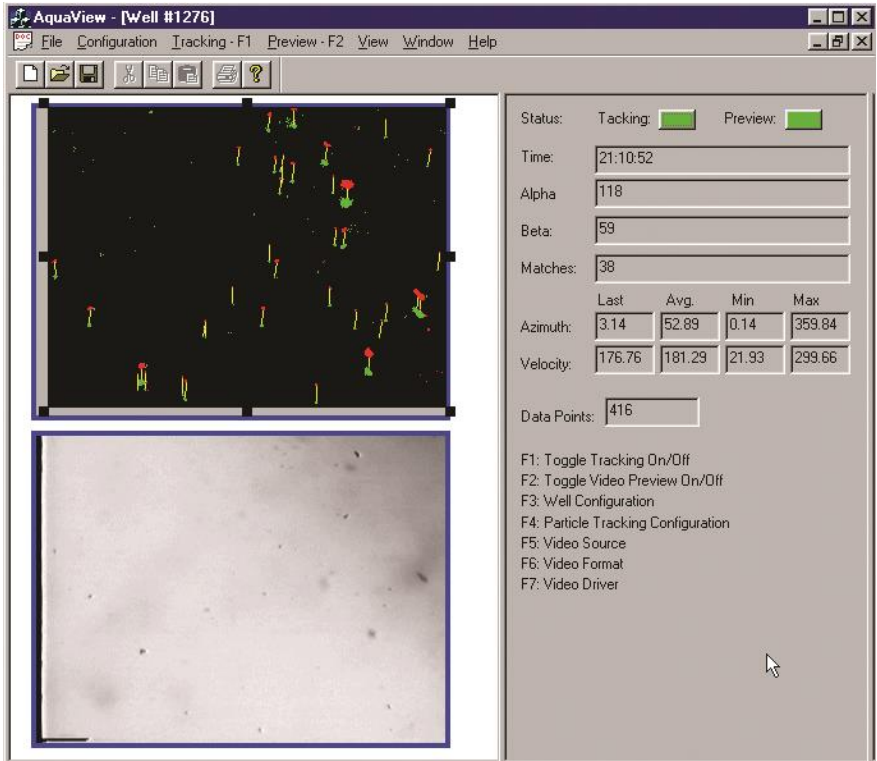
The upper video window or tracking window is a digitized version of the lower preview window. This upper displays the particle grabbing and matching process. The Alpha or first particle is represented by a green cluster (these colors can be modified in the configuration menu), the Beta or second particle is represented by a blue cluster and the "particle vector" is represented by a yellow line connecting the alpha and beta clusters. After all matched particles have been analyzed; the data will be averaged and added to the file specified in the File-Save section.
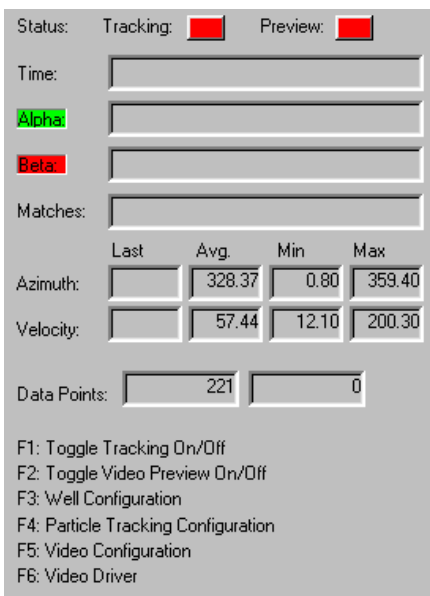
The status screen on the right details the incoming data. The Tracking and Preview buttons (red off/green on) allows the user to visually see if these two parameters are on or off. The data values described above are entered in the "Last", "Avg.", "Min" and "Max" boxes and are displayed for easy reference. Other boxes include the time (Elapsed time) and data points (number of averaged data points).

The following text is a general overview of the menu bars and sub menus.

When software is first initiated, agreement to the software terms and limitations is required. Software will not work without consent.

The next screen will ask which Video Grabber card is being used. Determine if you are using the MRT Video Port Professional or the IMPERX Video Capture Essentials. Enter the data. This information can be changed at any time under the file menu.

Software must be re-started after changing video card.

Compass Configuration:

File – Compass – View/Configure Compass

The newer colloidal borescope models come with an automatic compass feature that allows the software to read the compass automatically. If you are using the new model (contact AquaVISION to determine) then click the automatic button. Software should start reading compass output. Turn borescope around to determine if compass reading are accurate with top of camera toward north.

Older system users must click the F5 button manually and enter the compass reading from the TV screen.
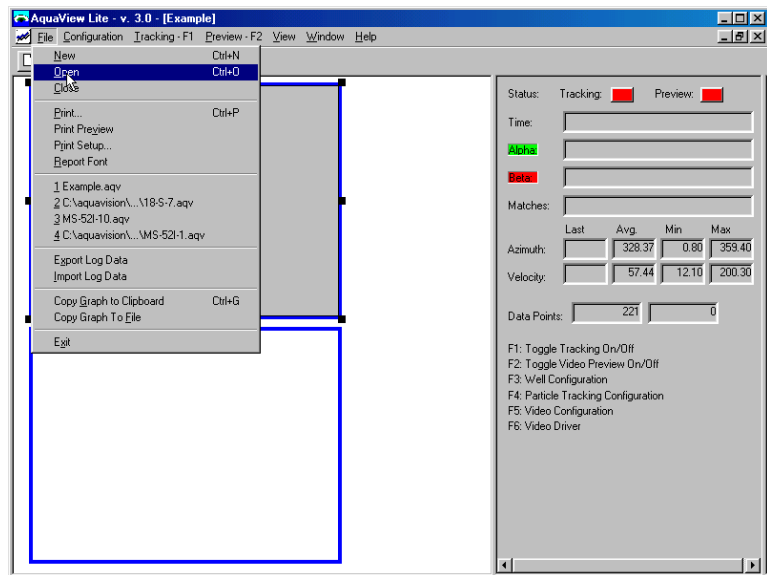
File Field: New, Open, and Print Setup

Start a new file:

> **File-Open-New**

Enter the following:

> **Well Name**: Alpha numeric field, specific to the well of interest.

> **Depth**: Depth that the Colloidal Borescope Instrument is at (Focal point).

Date: Automatic Date Field (Can be modified)

Magnetic Declination(Angle): Magnetic Declination can be found in trouble shooting section of this help guide for the United States only.

Other Commands:

Save the File
Save the file in the directory of choice.

Open a File
Opens a previously created file.

Print the File
Option allows user to print report, graph or both
(see Print and Preview commands below)

Preview the File
Allows user to see report, graph or both prior to printing.

Print Setup
Allows user to select printer and printer options

Report Font
Allows user to select from many font types for report output.

Export Log Data
Allows user to export data for use in other spreadsheet (excel).

Import Log Data
Allows user to import data from previous versions of AquaVIEW/LITE

Copy Graph to Clipboard
Allows user to export graph to the Windows Clipboard.

Copy Graph to File
Allows user to save the graph image to disk (jpg, bmp or wmf)

Copy Summary Data to File/Clipboard
Allows the user to copy the statistics to a file or computer clipboard.

Exit
Exits the program.

'Print' and 'Print Preview' Commands:

```
AquaVISION The Ground Water Experts
Colloidal Borescope System


                        Well Analysis Summary

Well Name:   Example
Depth:       100 Feet
Angle:       0.00
Date:        Nov 12, 1998
Time:        15:28:09 - 15:48:12
Data Points: 221



           Avg Dir      Med Dir      Min Dir      Max Dir      Std Dev

           280.01       315.10       0.80         359.40       94.72

           Avg Vel      Med Vel      Min Vel      Max Vel      Std Dev

um/sec:     68.64        55.00        12.10        200.30       44.55
ft/day:     19.50        15.62        3.44         56.90        12.66
ft/day / 2: 9.75         7.81         1.72         28.45        6.33
ft/day / 3: 6.50         5.21         1.15         18.97        4.22
ft/day / 4: 4.88         3.91         0.86         14.23        3.16



           Velocity Vector:

           Azimuth:   328.37

           Actual Velocity

           um/sec:     57.44
           ft/day:     16.32
           ft/day / 2: 8.16
           ft/day / 3: 5.44
           ft/day / 4: 4.08
```

Explanation of Well Analysis Summary Sheet:

The AquaVISION Env., Llc. ™ software offers a report for the user. The report gives the well, date and data information (top), general statistical analysis (middle), and a vector analysis (bottom).

The general information (top) gives the well name; the statistical analysis (middle) offers the basic statistics that can be used for direction and velocity determination. These values are taken from the data file and are simply run for average, median, minimum, maximum direction, and the standard deviation. These values must be scrutinized for accuracy of depth of observation, angle or azimuth reading entered while collecting the data, date, time, and total number of data points collected during the observation. In addition, average direction values should be compared with velocity vector azimuth, as there can be problems with the directions of 0 vs. 360. The report also gives the same statistics for the velocity data. This data must also be scrutinized, as an elevated average will occur if the file was initially started before flow stabilized from insertion of the borescope into the well.

The Vector Analysis (bottom) was created to help with determining the true direction and velocity due to larger variations in the data. One must be careful in comparing the vector values with the average flow rate or directional measurements. Flow rates and directions determined by the vector addition programs are obviously vectors. Consequently, the magnitude of flow will impact the calculated direction. If a uniform flow file with steady flow rates and directions were analyzed using both software packages, then the direction and rates would be similar. However, if there is a large variation in the flow direction and a corresponding variation in flow rates, then there will be differences. For example, if a particle is moving due north at 200 um/s and a second particle is moving due south at 100um/s, then

the average velocity and direction would show a flow rate of 150 um/s in a due east direction, respectively. The vector addition will show a flow rate of 100 um/s in a due north direction. There are cases; that is, if two nonadjacent quadrants contain the highest number of data points, then an erroneous reading can results. This case, however, is rare and based on our experience only occurs during swirling flow--which is unreliable to begin with. The software will note that these files are "unreliable for direction determination" for the Velocity Vector reading. The Well Analysis Summary Sheet has been offered to the user only as an added benefit for determining the "True" direction and velocity. Only a certified Colloidal Borescope Operator should make the appropriate determination of direction and velocity.

Configuration Field: Well, Tracking, Video and Graph.

Well Field allows modification of well parameters, i.e., name, depth, azimuth and date.

Capture Delay (milliseconds): Sends a signal to the frame grabber to snap the second comparative image every 1 to 99999 milliseconds. Setting the window to 1 allows the software to grab as fast as possible.

Particle Sensitivity: This parameter acts like a filter. Increase this value if large amounts of colloids exist or electrical interference is present. Lower the value if only a few colloids exist and the electrical source is clean. This parameter will need to be changed throughout a session as colloids decrease (Normal Range is between 2800-5800). This is ONLY the Normal Range can be smaller or larger depending on the conditions of the aquifer.

Minimum Particle Size (um): Another option to filter out small electronic interference or slimes. Set the number higher to remove small particles.

Maximum Velocity: Filters out matches higher than this number (good for filtering out bad matches or electrical interference). Set this value 100-200 higher um/sec than observed particle velocity. Be Observant! Velocity can and will change during observations.

Minimum Matches: The number (1 to 999999) tells the software to only enter the value in the data if the conditions exist that number of matched exists. 1 to 2 is the normal operating value.

Borescope Image Size (microns): These numbers will be calculated before purchase. DO NOT CHANGE. These numbers are the actual size (in microns) of the fixed focal point. If accidentally removed, use 2100 x 1600 as default and call AquaVISION for actual numbers.

Alpha and Beta Particle color allows the user to specify the color of the first and second grabs for easy display.
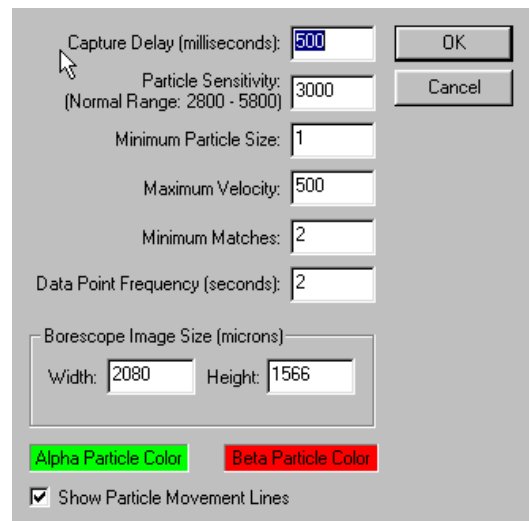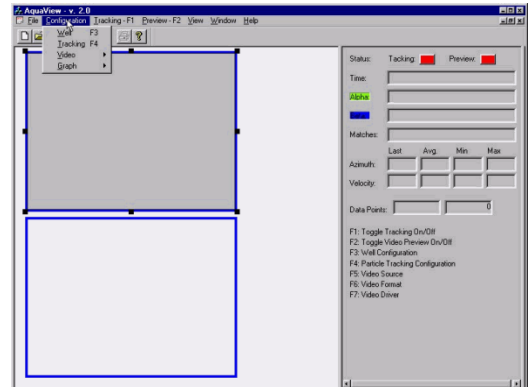
Show Particle Movement Lines Turns on or off the matching line between particles.

Configuration Video allows changes in the video driver and configuration. IMPERX VCE cards will show a different screen. See users guide.

Video Configuration. Allows the user to specify the specific video parameters i.e., RGB and color settings.

X-offset and Y-offset crops the capture image and removes interference on side of image.

B (Brightness) sets the image brightness. This will need to be adjusted after borescope is inserted into well.

C (contrast) sets the image contrast. This will need to be adjusted after borescope is inserted into well.

S (Saturation) sets the saturation (leave at 0).

H (hue) sets the Hue (leave at 0).

All Other fields will be set back to original if modified!

Video Driver sets the MRT Video Port video capture device driver (If error code states video card no longer exists, then reboot computer).
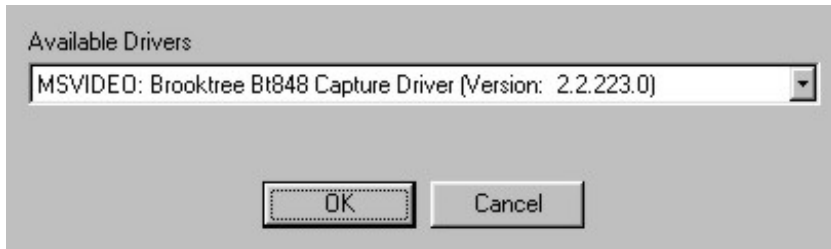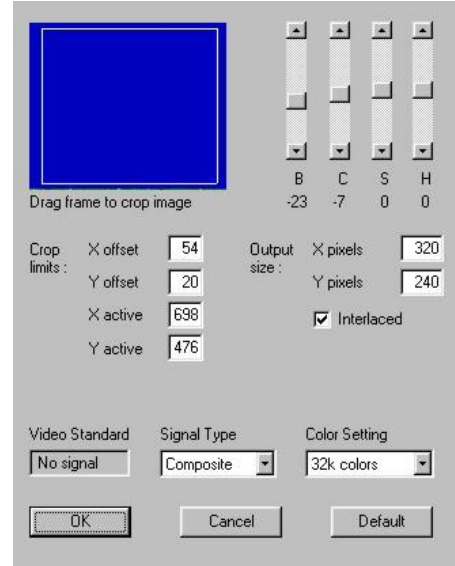
Configuration Graph allows changes in the graph appearance.

This option allows multiple changes to all aspects of the graphing software. There are too many options to describe in the help guide. The main options that the user will find beneficial are the Data Tab and the Colors and Styles Tab.
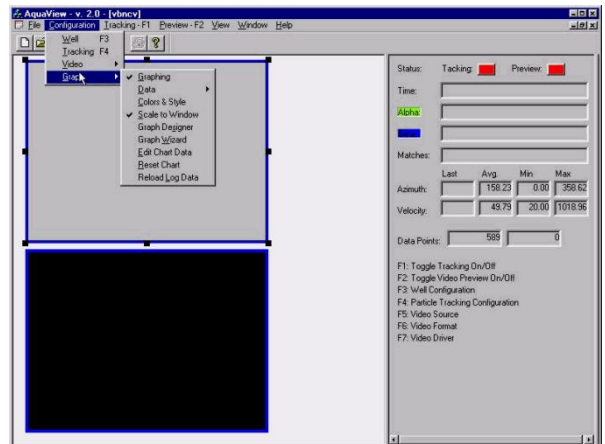
Tracking Menu- (F1) or clicking on the red tracking button (located in the upper left-hand corner of the data information window) starts the tracking program in the upper image box. The preview button (F2) must be activated before the tracking operation will work! Once the tracking button is on, the upper video window will display the alpha and beta particles with the yellow matching line in between. Change the tracking configuration as outlines earlier for the most grabs. Turn tracking off before changing any configuration parameters.

Preview Menu- (F2) or clicking on the red preview button (located in the upper right hand corner of the data information window) previews the image in the lower image box. Preview allows the user to see the video image in the well. Change the brightness and contract parameters detailed in the Video Format Menu, if the picture is too light or dark or out of focus.
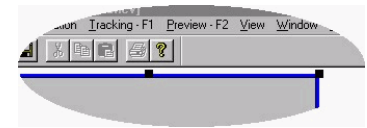
View Menu-Normal, Graph, Tool Bar and Status Bar

Normal View displays both the preview screen and the tracking screen with status area (normally highlighted)
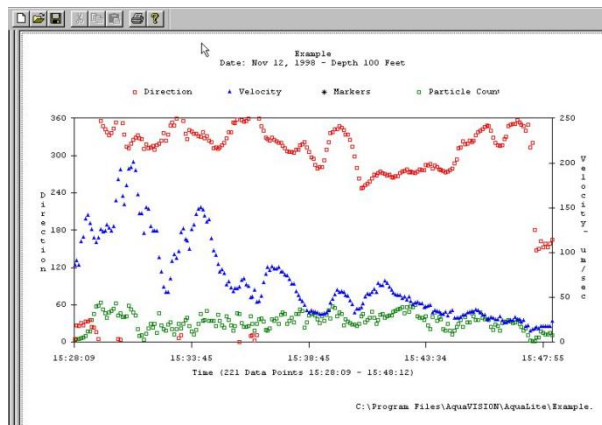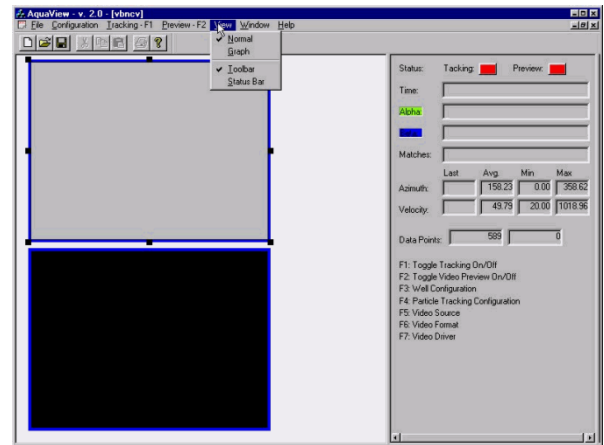
Graph View displays the graph only "below"(while in tracking mode, the graph will automatically update as the data is captured). This utility allows the user to track the data (i.e., a preferential flow zone or a swirling flow zone). Having the graph view on however, will slow the program as this takes up the available computer memory. Hence it is a good idea to check the graph regularly then return to the normal view.

Tool Bar-on/off on turns the toolbar on and off turns the tool bar off (normally in on position)

Status Bar shows the condition of the program on the bottom left screen (normally in off position)
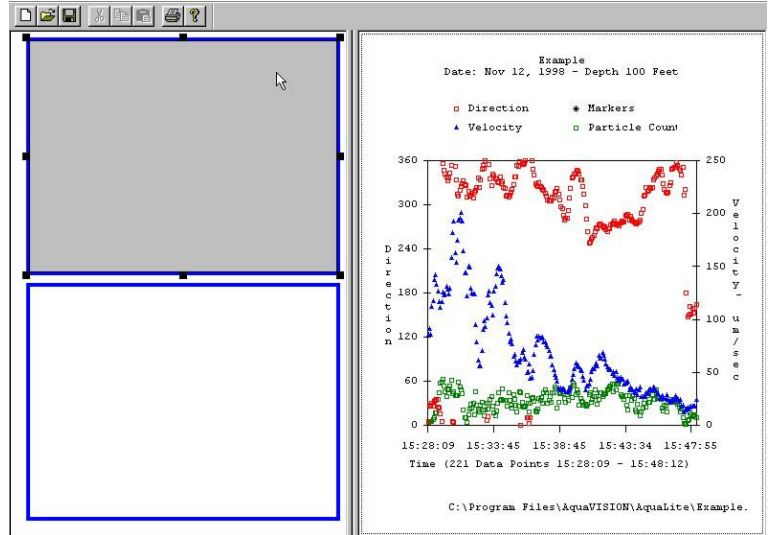
Window Menu:

New option allows for a new tracking window. Primarily used if an existing file has been used.

Cascade Aligns the windows from upper right to lower left. Used if multiple files are open.

Tile Aligns the windows from upper center to lower center. Used if multiple files are open.

Arraign Icons Typical Windows aligning protocol.

Split View displays the graph and the Tracking screen. Not recommended while tracking is on as computer resources can be depleted. To go back to normal view simply clicks <u>V</u>iew-Normal. If tracking has stopped then double click on the tracking button to start the tracking.

Help Menu: Software License AquaVISION Env., LLC. Software license- user must agree to terms and conditions prior to execution of software. The License information Tab allows user to see key information i.e., license I.D., Version, Registered User and Expiration Date.
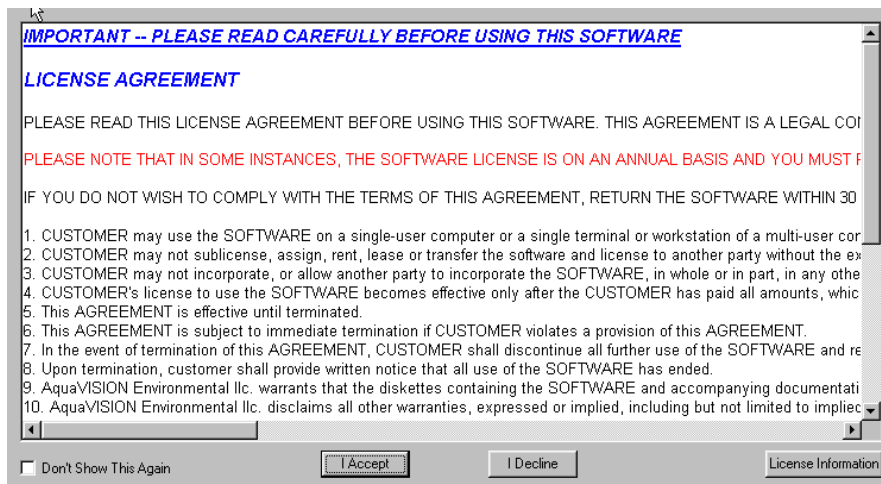
About AquaLITE AquaVISION Env., Llc. reloads the introduction screen. Brings up your personal HTML editor with this help guide

Section 3: Field Measurements

For the colloidal borescope to provide reliable measurements of groundwater flow rates and directions, it is important that the instrument be placed in a high quality well. The well screen should consist of mechanically slotted screen with a minimum of three columns of slots or wire-wound screen. Prior to measurements, the well should be adequately developed using a jetting tool or mechanical surging. A low permeable skin surrounding the well screen will result in groundwater flowing around the well and swirling flow within the well. Finally, any devices in the well such as dedicated pumps should be removed from the well at least 24-hrs prior to testing. This will allow the ambient hydraulic conditions in the well and the surrounding porous media to re-establish and any turbidity effects from removing the pump to subside.

Prior to placing the colloidal borescope in a test well, the video image should be checked by placing an object such as a finger between the lens and the back light. The borescope should be slowly lowered into the well to prevent disturbing the formation, which may result in excessive turbidity in the well. If this occurs, there will be not be a picture on the video screen and several hours or perhaps a full day may be required for the well water clarity to return.

The colloidal borescope provides depth specific measurements of groundwater flow direction and velocity. There are several important factors that must be considered in order to obtain a reliable measurement. It is widely accepted that flow occurs in preferential flow zones within subsurface aquifers. These preferential flow zones dominate groundwater flow even in "homogeneous" aquifer. For a reliable measurement, the colloidal borescope must be placed in these preferential flow zones.

A combination of relevant geologic information and the proper utilization of the colloidal borescope system are necessary to locate and measure these preferential flow zones. Prior to flow measurements, the geologic log for a particular well should be consulted and possible high permeable zones selected. Based on this information, the borescope should be placed in the center of these zones. Subsequent measurements should offset by selected intervals from the initial zone until a preferential zone is located.

Prior to recording data for a flow measurement, it is necessary to properly orient the colloidal borescope in the well. By pressing the F5 key on the camera control unit keyboard, the reading from the flux gate compass is displayed on the screen. This value from the flux gate compass is the derivation of the top of the viewing screen from magnetic north. By adding the magnetic declination to the value from the flux gate compass into the software program, directional data collected from the colloidal borescope will be oriented to true north.

The software system that accompanies the colloidal borescope is a key component in obtaining a reliable flow measurement. Typically, there are two types of measurements that can be obtained in a well. If consistent horizontal flow in a steady direction for two or more hours occurs, then the borescope is in a preferential flow zone where groundwater flow is occurring. If particles remain in focus across at least one half of the field of view, then horizontal flow conditions dominant the measurement zone. The other type of flow measurement consists of varying flow velocities and directions during the period of measurement. Varying flow can occur after two hours of measurement. The software system provided with the colloidal borescope contains graphing packages that are continually updated as data is collected. Consistent flow rates and directions can be determined using the software. If variable flow conditions persist, then the instrument should be moved to a different depth. Experience has shown that if swirling flow conditions persist after 15 to 20 minutes, especially if the borescope has been in the

well at other test intervals, then a non-preferential flow zone has been encountered and the instrument should be moved to a new test interval.

When the colloidal borescope is inserted into the well, the ambient groundwater flow is disturbed. The borescope acts as a slug that can cause water from the well bore to flow into the surrounding aquifer and affect flow measurements. These effects commonly last 10 to 30 minutes before ambient flow conditions re-establish in the well bore. Using the graphing function in the tracking software, it is important to view the consistency of the directional measurements and changes in the magnitude of the velocity. If directional measurements are consistent but the velocity decreases with time, then additional measurements are needed to ensure a reliable flow file. It has commonly been observed that consistent flow directions can occur but as the velocity slowly decreases, the flow directions can change and become swirling. This is typically of initial flow measurements in "nonpreferential" flow zones. It is important that both direction and velocity stabilize before a measurement can be considered reliable. There are, however, exceptions such as fluctuating pumping rates or boundary conditions. Each situation must be evaluated on a site-specific basis.

There are a variety of conditions that may be encountered in a monitoring well. It is always important to remember that the instrument is providing a direct measurement of flow conditions in the well at the selected depth interval. Fluctuating boundary conditions such as a river undergoing stage-level changes, cycling pumping wells, or other factors that can induce pressure changes in the aquifer will affect the colloidal borescope measurements. These external influences must be considered in order to obtain reliable flow measurements.

It is recommended that the operator read the journal article by Kearl (1997, Journal of Hydrology, 200, 323-344) for an understanding of the theory of groundwater flow in a borehole, observed flow conditions, and laboratory testing of the instrument. This and other articles can be found on our web site at http://www.AquavisionEnv.com.

Easy to Use Magnetic Declination Map to Determine True North
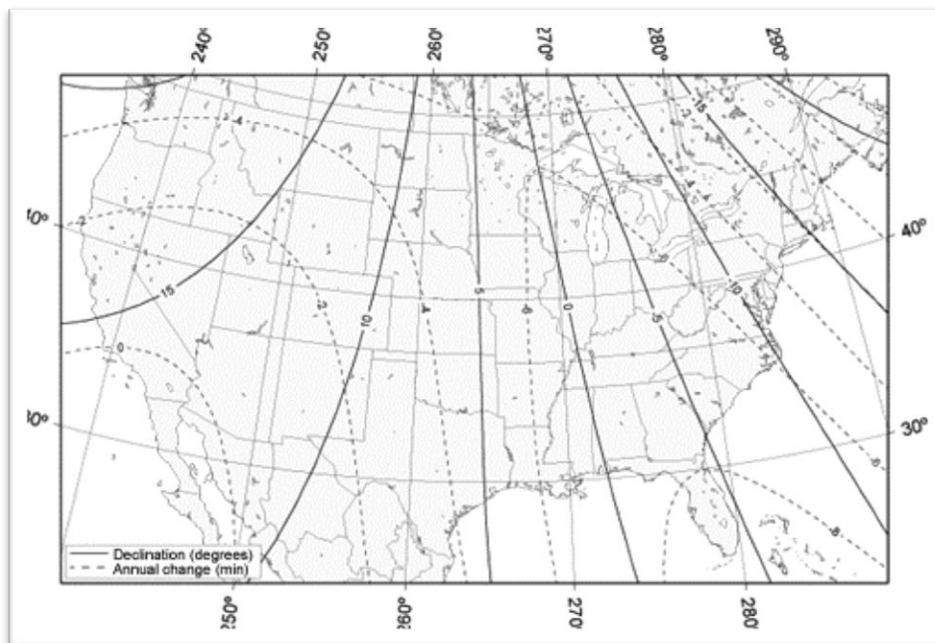
Section 4: Trouble Shooting

This troubleshooting guide is an on-going process. If you have difficulties with any of the Colloidal Borescope System and have determined how to fix… please feel free to e-mail Geoteach at sales@geotechenv.com so that others may benefit from your experience!

Problem: No picture with the instrument in the well

There are several possible causes of no picture from the instrument while in the well. First, make sure all connections are complete as shown in Figure "A". Check contrast and brightness levels in the *Video Source Menu* (increase or decrease brightness depending on preview color, if preview screen is blue then check to see if the BNC cable from the monitor to the computer pcmcia or Express slot are plugged in). There is a light adjustment switch on the Camera Control Unit; however this is only for small light increases.

Is system powered up? Check to see if the Colloidal Borescope red backlight is **ON.** Camera control unit, monitor and computer **ON**! Is borescope sending the compass readout to the screen **F5** on C.C.U. keyboard? If the flux gate compass is providing a reading, then the turbidity of the well may be too high. Remove Borescope from well and look at lenses. Place object under lens to see if image comes back. If not, check to see that the seals have not been breached and water has entered the camera compartment. If image looks fine on surface then well is most likely too turbid to characterize. Another well should be selected until the water clarity returns. If there is no compass reading, recheck all power supplies and cables. Make sure to use grounding wire if a Power Inverter is being used to supply power to equipment in the field. If the grounding wire is not used, damage can occur to the camera.

Problem: Abrupt change in groundwater flow direction

If consistent directional flow is interrupted by an abrupt change in flow direction, the first item to check is the velocity graph. If there has been a steady decline in the magnitude of the velocity when the directional change occurred, then chances are the measurement zone is a non-preferential flow zone and the borescope should be moved to a different test interval. If velocity is consistent, check for outside interference such as pumping wells, tidal influences, or fluctuating river stages. Even in steady preferential flow zones, short-term directional changes can occur. Continue to observe for 10 -15 minutes. If direction charges to a third direction, then the borescope is in a non-preferential flow zone.

Problem: Numerous particles are being grabbed but no data is being recorded

If this condition occurs, then the maximum velocity setting in the Tracking Configuration is lower than the velocity of the particles. Reset the maximum velocity to a value approximately twice the measured velocity.

Problem: Numerous particles are being grabbed but computer is slow writing to file

If this condition occurs, then two options exist. First option is to increase the particle sensitivity till only a few particles are being grabbed. The second option is to click on the tracking window and manually drag (decrease) the size of the window so that the grabbing area is smaller. This tells the software to only grab that portion of screen. This works well if there is something obstructing a portion of the video image i.e., large debris, mud, or man-made material on the lens or back-lighting source (drag the preview box away from that portion of the frame grabber).

Problem: Loss of particles in the viewing area

For aquifers that contain few colloidal particles such as coarse grain sands, particle density may decrease to one or two particles every minute. Be sure to set the delay between frames to the minimum values possible. The particles between the two frames, however, should not overlap to ensure an accurate measurement. Several hours may be required at a test interval in order to obtain enough particle matches to ensure a reliable flow zone.

Another potential problem is if the particles become blurry and then disappear altogether. This effect could result from a dirty well. Numerous particles can settle on the backlight source and decrease the amount of light available for viewing. Gently shaking the borescope can remove these particles and allow a good image without disturbing the fines in the surrounding formation. Be sure to carefully lower the borescope into these types of wells.

Problem: No flow zones detected in a well

First, keep trying different zones within the well screen. Remember, preferential flow zones can be in small laminar zones (inches), *so keep on looking!*

Finally, if 5 to 10 measurement where taken in a 5-ft well screen and no steady consistent flow zones where found, then the instrument should be moved to a new well. It is possible that the well is located in a stagnant flow zone within the aquifer, however, it is more likely that the well was poorly developed and there is a low permeable skin surrounding the well thus deflecting groundwater around the well. Another possibility is that the well was screened is a low permeable zone of the aquifer with surrounding preferential flow zones that do not intersect the well screen.

It may seem obvious, but recheck the well log to ensure that the borescope is located in the well screen and not the well casing.

Problem: Poor flow zones with particles that appear on the screen then rapidly disappear.

If this problem occurs then there are large vertical gradients in the well. Particles that stay in focus only briefly are moving across the focal plane of the lens. Well screens that intersect two or more permeable flow zones with different potentials can result in vertical flow in the well. Attaching packers to the instrument may reduce this vertical flow component.

Problem: Poor flow zones in large diameter wells

If this condition occurs, then it is recommended that the packers be attached to the instrument. The packers centralize the borescope, keeping it off the sides of the well screen and minimize vertical flow that may be affecting the measurements.

Problem: Software Crashes

Restart by double clicking on AquaView LITE icon.
If problem still exists then reboot computer.

Problem: Software won't track colloids

First check the delay setting in the *Tracking configuration menu*. The faster the colloids are moving the smaller the capture delay frame value should be and vice versa.

Then check the *Particle Sensitivity* in the same menu screen. If numerous colloids exist on the preview screen then the sensitivity should be increased to approx. 2500-4500). If only a few colloids are visible then the sensitivity should lowered to be between 500-2000.

If the visible amount of colloids is overwhelming, click on the tracking preview window (upper) and drag the box corners in so that the image window is smaller. This tells the software to only grab that portion of screen. This works well is there is something obstruction a portion of the video image i.e., large debris, mud, or man-made material (drag the preview box away from that portion of the frame grabber). Turn particle tracking off and on again.

Turn tracking off while viewing graph and/or modifying parameters. Turn back on after changes are made.

Problem: Backlight source doesn't work

Check all cables to ensure connections are right. Check 1 amp fuse in back of Camera Control Unit (above plug outlet). If camera is sending image (use auxiliary light and look at monitor) and if no light is present, it is possible that the internal camera unit has been jarred and is not contacting the two light source connections. (THE FOLLOWING SHOULD BE PERFOMED BY AN AUTHORIZED/TRAINED COLLOIDAL BORESCOPE OPERATOR) Remove three screws from lower light unit on borescope (note position of light unit compared to borescope, mark with pen if needed). Pull the light unit apart. Check with a multi-meter for power from borescope, voltage should read approximately 12 millivolts. Tap instrument so that camera unit slides towards the open end. Replace light unit (matching pen lines). Light should come on at this point. Remove light unit again and replace rubber seals and add silicon (vacuum grease). Replace light unit (matching pen lines) If light does not work at this point, check depth of contact with ruler and check depth of light source to ensure contact is being made. If camera unit will not move or there is no power to light source, equipment must be sent back to AquaVISION for repair.

Problem: Compass software can't find port.

Close AquaLITE and from the Windows start menu click **Settings – Control Panel – System – Hardware – Device Manager – Ports** and simply see which port is being used by AquaLITE. Then go back into AquaLITE and in the **compass calibration – automatic – port** – scroll down to highlight the appropriate port and retry.

Section 5: Calibration Information

Calibration Procedures for the Colloidal Borescope

Calibration of the colloidal borescope system consists of a multiple step procedure. These procedures include a laboratory, factory, pre-shipping and software calibration. Since the colloidal borescope provides a direct image of groundwater flow directions and rates, the entire calibration process is a simple procedure that is only required prior to the initial deployment of the instrument. The field operator should periodically check certain data inputs in the software system, discussed in detail in the software and filed calibration section. However, once the colloidal borescope system is calibrated, it is not necessary to conduct any further calibration.

Laboratory Calibration

An extensive laboratory-testing program was undertaken to determine the accuracy of the colloidal borescope for determining groundwater flow direction and rate. Details of these laboratory tests are presented in Kearl (Observations of particle movement in a monitoring well using the colloidal borescope. 1997 Journal of Hydrology, 200, 323-344). Flow directions observed using the colloidal borescope were checked in a sand tank under controlled groundwater flow conditions. Flow directions consistent with known flow directions in the sand tank were measured by colloidal borescope. Flow velocities measured by the colloidal borescope were verified using a laminar flow chamber developed at the Desert Research Institute in Boulder City, Nevada. At a flow velocity in the laminar flow chamber of 0.10 cm/s, and verified by a tracer test, the colloidal borescope measured a comparable velocity value of 0.11 cm/s (Kearl, 1997).

Factory Calibration

The second test checks the magnification of the lenses attached to the CCD camera. The Pulnix TMC-5LC cameras have a 1/4" format sensor. The image sensor has an aspect ratio of 4:3. [H = 3.6mm, V = 2.7mm] The cell size is 7.15um x 5.55um and there are 510 [H] by 492 [V] pixels in the array. Since the magnification factor from the lens manufacturer is already calibrated at 130X, this test simply checks the magnification factor of the assembled system relative to the video monitor. A micrometer scale is placed at the focal point of the lens and the image is captured on the monitor. The size of the image on the video screen is compared with the actual scale and the magnification factor is determined.

Pre-shipping calibration

Prior to shipping the colloidal borescope system to a field site, the magnetometer and alignment software are checked to ensure the factory calibration of the instrument remains consistent. The top of the viewing screen is aligned with magnetic north as determined independently by a Compass. The azimuth display from the video monitor and the video image in the software are checked. When the colloidal borescope is aligned to magnetic north as described in the software calibration section so that the top of the view screen is perpendicular to magnetic north, the azimuth reading from the magnetometer should read zero. If this reading varies by more than a degree or two, the alignment of the compass is rechecked and the procedure is repeated. After the alignment is rechecked, if the magnetometer reading continues to vary by more than two degrees, then there is a problem with the alignment of the magnetometer relative to the downhole video camera. In this case, the instrument is sent to the manufacturer to be recalibrated at the factory.

The magnification factor for the software is also checked prior to shipping. The width and length of the field of view is measured using a micrometer. Since this distance will not change, the software is simply checked to ensure these values have not been accidentally changed.

The final pre-shipping test involves the placement of an object in the field of view and testing the frame grabber software. The object is slowly moved and the resulting digitized image is viewed on the software screen as described in the operational manual. The digitized image should show the same direction as the object is moved. For example, if the object is inserted at the top of the field of view and moved toward the bottom of the field of view, then the resulting direction calculated by the imaging software should be approximately 180 degrees.

Field Calibration

As stated above, calibration of the Colloidal Borescope is mainly conducted in the lab and or from the manufacturer. Because of the simplicity of the system, calibration in the field is not required. A simple test to determine if the top of screen vs. magnetometer north is checked occasionally in the field. This is done by first determining magnetic north with a Compass. Then, holding the borescope in an up-right position and turning the scope until the top of camera (detailed above) is pointed to magnetic north. Readings on the screen/software output should be read zero degrees within a degree or two due to human error.

Thank you for purchasing the **AquaVISION Env. Llc. Colloidal Borescope System**. If you have any questions don't hesitate to contact your nearest Colloidal Borescope distributor. Check out our WEB site at http://www.aquavisionenv.com as there are several screens that show actual data, graphs and helpful hints!

Last Edited January 4th, 2013

Replacement Parts List:

QTY	Parts Description	Parts List
1	ASSY,PROBE,DOWNWELL,BORESCOPE	52070003
1	CONTROL BOX,BORESCOPE	52070002
1	FLYING CABLE,INLINE,100'BORESC, STD CONN,NO REEL CONNECTION	52070006
1	FLYING CABLE,INLINE,200'BORESC, STD CONN,NO REEL CONNECTION	52070005
1	ASSY,POWER CORD,AC,W/AMP	57500007
1	ASSY,POWER CORD,DC W/ AMP	57500008
1	VIDEO CARD,BORESCOPE,W/CABLE	22070030
1	MANUAL,BORESCOPE	22070014
1	FLYING CABLE,INLINE,200'BORESC, STD CONN,NO REEL CONNECTION	52070005
1	REEL, HAND, BLACK,IN-SITU,"B",00520000XX-06	72050629
2	O-RING,NTL,38MM X 2MM	12070037
1	O-RING,NTL,22MM X 2.5MM	12070038

Contact Geotech Environmental Equipment, Inc. for repair and replacement of all other cable lengths.
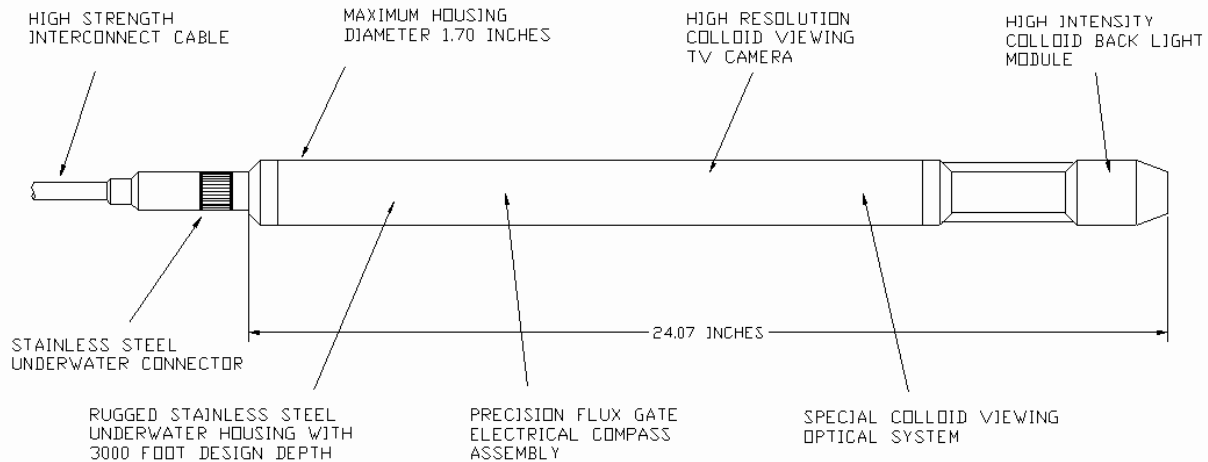
RCS-1100-FG COLLOID BORESCOPE WITH FLUX GATE COMPASS

Shipping/Equipment List: (Standard Laptop model)

QTY	Parts Description	Parts List
1	ASSY,PROBE,DOWNWELL,BORESCOPE	52070003
1	CONTROL BOX,BORESCOPE	52070002
1	ASSY,POWER CORD,AC,W/AMP	57500007
1	ASSY,POWER CORD,DC W/ AMP	57500008
1	VIDEO CARD,BORESCOPE,W/CABLE	22070030
1	SOFTWARE,AQUALITE,VERSION 7.2	22070031
1	MANUAL,BORESCOPE	22070014
1	FLYING CABLE,INLINE,200'BORESC, STD CONN,NO REEL CONNECTION	52070005
1	CASE,PELICAN,1600,BLACK,W/FOAM	17500020

Non-standard systems could include the following:

QTY	Parts Description	Parts List
1	REEL,PORTABLE,SMALL	11400010
1	REEL,PORTABLE,LARGE	11400011

The Warranty

For a period of one (1) year from date of first sale, product is warranted to be free from defects in materials and workmanship. Geotech agrees to repair or replace, at Geotech's option, the portion proving defective, or at our option to refund the purchase price thereof. Geotech will have no warranty obligation if the product is subjected to abnormal operating conditions, accident, abuse, misuse, unauthorized modification, alteration, repair, or replacement of wear parts. User assumes all other risk, if any, including the risk of injury, loss, or damage, direct or consequential, arising out of the use, misuse, or inability to use this product. User agrees to use, maintain and install product in accordance with recommendations and instructions. User is responsible for transportation charges connected to the repair or replacement of product under this warranty.

Equipment Return Policy

A Return Material Authorization number (RMA #) is required prior to return of any equipment to our facilities, please call 800 number for appropriate location. An RMA # will be issued upon receipt of your request to return equipment, which should include reasons for the return. Your return shipment to us must have this RMA # clearly marked on the outside of the package. Proof of date of purchase is required for processing of all warranty requests.

This policy applies to both equipment sales and repair orders.

FOR A RETURN MATERIAL AUTHORIZATION, PLEASE CALL OUR
SERVICE DEPARTMENT AT 1-800-833-7958.

Model Number: _____

Serial Number: _____

Date of Purchase: _____

Equipment Decontamination

Prior to return, all equipment must be thoroughly cleaned and decontaminated. Please make note on RMA form, the use of equipment, contaminants equipment was exposed to, and decontamination solutions/methods used. Geotech reserves the right to refuse any equipment not properly decontaminated. Geotech may also choose to decontaminate equipment for a fee, which will be applied to the repair order invoice.