ERCB/AGS Open File Report 2009-14

ERCB/AGS System Manual for the Turtle Mountain Monitoring Project, Alberta

Energy Resources Conservation Board

Alberta Geological Survey

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The Turtle Mountain Monitoring Project has been running since the summer of 2003. During that time, a number of key individuals at ERCB collaborated to develop and implement the response protocol outlined in this report. Specific recognition goes to J. Warren and G. Jean of Alberta Geological Survey; A. Jones of Durham Geo Slope Indicator; H. Bland of Pinnacle Technologies Inc.; and G. Bjorgan of McElhanney Consulting Services Ltd.

Abstract

The Turtle Mountain Monitoring System is a near–real-time monitoring system that provides data from a network of more than 80 geotechnical sensors on the South Peak of Turtle Mountain (site of the 1903 Frank Slide) in the Crowsnest Pass. As of April 1, 2005, the Energy Resources Conservation Board (ERCB), through Alberta Geological Survey, took ownership of this system and the responsibility for long-term monitoring. As part of this role, ERCB is responsible for keeping the monitoring system operational. This includes, but is not limited to, system diagnostic checks to confirm equipment functionality, and maintenance and repair of equipment that have malfunctioned. This report outlines the specific troubleshooting procedures, both remote and on site, and repair instructions for the various components that make up the monitoring system.

1 Introduction

The Turtle Mountain Monitoring System (TMMS) is a near–real-time monitoring system that provides data from a network of more than 80 geotechnical sensors on the South Peak of Turtle Mountain (site of the 1903 Frank Slide) in the Crowsnest Pass. As of April 1, 2005, the Energy Resources Conservation Board (ERCB), through Alberta Geological Survey (AGS), took ownership of this system and the responsibility for long-term monitoring.

This report is in three sections. The first section presents an overview of the hardware and software that form the various components of the data-management system at the Frank Slide Interpretive Centre (FSIC), as well as the intermediate communication stations that interact with the sensors at the top of Turtle Mountain (TM) and the recording devices in the FSIC at the base of the mountain.

The second section provides a detailed overview of the remote troubleshooting procedures for the various communication links in the data-management system of the TMMS, including a list of the most common communication problems and their possible causes.

The third section describes the installation and on-site troubleshooting instructions for the monitoring instrumentation, to enable identification of the possible cause of instrument malfunction and proper installation/replacement.

This is a living document and will be revisited and revised often, to ensure that it is current, reflects best practice and is fit for its purpose. Alberta Geological Survey will amend the report when required and based on the operational and procedural recommendations of the most recent training exercises, and lessons learned from actual alert events. In addition, a review of the document will take place once per year annually. Upon acceptance, it will be dated and identified as a revision, then forwarded via e-mail to all ERCB/AGS TM Team members by the relevant section leader.

While participating in the Turtle Mountain Monitoring Project, all ERCB/AGS TM Team members are responsible for keeping an updated hard copy of this manual.

2 System Overview

The monitoring system on Turtle Mountain was envisioned to include a number of different types of instruments that are meant to provide a near–real-time data stream and early warning for a failure of South Peak. In considering the types of sensors most suitable for providing early warning of impending slope movements, we grouped them into the following data-stream categories:

1) **Primary data link:** This is the main link between the western side of the South Peak of Turtle Mountain and the Blairmore Provincial Building, and covers both primary deformation sensors (crackmeters, extensometers and tiltmeters) and other sensors (differential GPS, weather station and thermistor).
    - Instruments are on the west side of Turtle Mountain and connected by a wireless link to the Blairmore Provincial Building.
    - From there, a second wireless link relays the data to the FSIC.
    - Data from these instruments are the primary diagnostic tool for interpreting any event on the mountain.

2) **Secondary data link:** This data link covers communications between the FSIC and the Bellevue Pump House, the location of the electronic distance measurement system (EDM) instrument.

- At present, the EDM system consists of 20 surveying prisms on the east side of Turtle Mountain and a total station at the municipal pump house in Bellevue; after substantial testing, this equipment may be moved into the primary instrumentation group.
- A wireless link relays data recorded by the total station to the FSIC.

3) **Tertiary data link:** This is the link between the FSIC and data transmission points located on the eastern side of Turtle Mountain. These data transmission points include mine spring-outflow measurements and three recently installed differential Global Positioning System (dGPS) monitoring points, as well as images from the two Web cameras (webcams) installed at Turtle Mountain (one at the top of the mountain looking down and one at the bottom of the mountain looking up).
   - The dGPS and minesite spring-water level and flow measurement systems are on the east side of Turtle Mountain and connected by wireless link to the FSIC.
   - These processed data are then written to the server's SQL database.
   - The monitoring system at the FSIC was upgraded on March 28th, 2006; the primary database server was replaced as part of this upgrade.

4) **Historical data:** All project data streams are written to the SQL database on the server at the FSIC; data older than 24 hours are considered historical data.

You can read a detailed overview of the monitoring system on South Peak in Moreno and Froese (2006). Communication is based on an Internet protocol, where the local network is connected to the Internet by a router. This allows remote access to certain elements of the network via the Internet (Figure 1). The network includes two main communication hubs: the Provincial Building at Blairmore and the Frank Slide Interpretive Centre (FSIC).

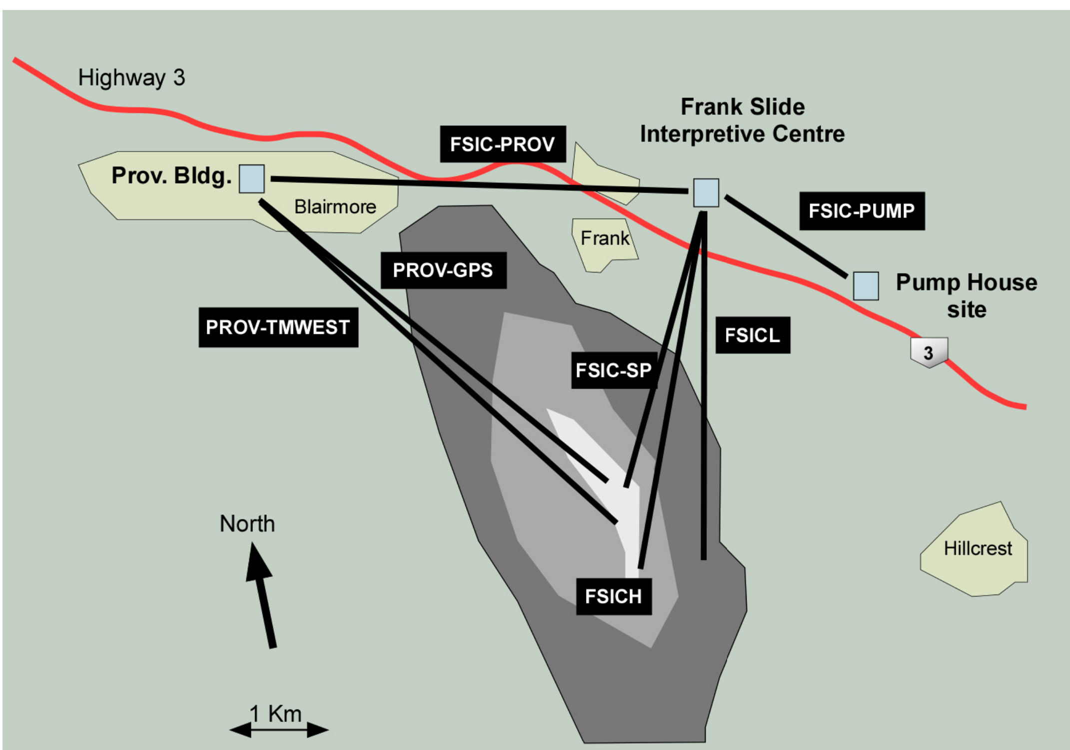


Figure 1. Schematic map of the main communication links used within the Turtle Mountain Monitoring System.

2.1 Provincial Building at Blairmore

In addition to providing the wired connection to the Internet, the Provincial Building is also the site of three wireless links (Figure 1):

- **FSIC-PROV:** This is a point-to-point link connecting the FSIC and the Provincial Building. This link is used to transmit data, coming from the PROV-GPS and PROV-TMWEST links, to the FSIC, where they are then stored in a MySQL database on the server.

- **PROV-GPS:** This is a point-to-point link connecting the Provincial Building to the new radio tower installed near the borehole site. This link connects with the GPS equipment on Turtle Mountain.

- **PROV-TMWEST:** This is a point-to-multipoint link connecting the Provincial Building with two sites on Turtle Mountain (borehole and weather-station data loggers). The data loggers relay the collected data to the Provincial Building via this link.

2.2 Frank Slide Interpretive Centre

The Frank Slide Interpretive Centre (FSIC) is a major communication hub in the Turtle Mountain Monitoring Project, with five wireless links extending from it (Figure 1):

- **FSIC-PROV:** This point-to-point link, connecting the FSIC and the Provincial Building, allows the FSIC control centre to access the two data loggers (borehole and weather station; Table 1) on an hourly basis for measurement updates.
- **FSIC-SP:** This point-to-point link, connecting the FSIC to the South Peak webcam at the top of Turtle Mountain, also provided connectivity to the now-decommissioned South Peak seismic station.
- **FSIC-PUMP:** This is a point-to-point link connecting the FSIC to the pump house, on the eastern side of the slide. The pump house, established as a secondary data-collection site for the EDM system, also houses two additional webcams.
- **FSICH:** This wireless-access network connects the FSIC to the recently installed GPS stations at the top of Turtle Mountain (Third Peak and Ridge), which are former seismic stations.
- **FSICL:** This wireless-access network connects the FSIC to the seismic-monitoring stations (River and Relay) and GPS station (Pit) at the bottom of Turtle Mountain.

Table 1. Data management by datalogging site.

Data Logger	Data
Borehole	Tiltmeters Extensometers Borehole thermocouple string Piezometers
Weather station	Crackmeters Piezometer Weather data Extensometer EX-5

3 Data Telemetry and Processing

The success of any predictive monitoring system relies not only on the adequate planning, design and implementation of a series of instruments, but also on a proper data-management strategy. On Turtle Mountain, several sets of instruments are continuously measuring and sending data. In considering how the data-management system handles these records, we can identify two main communication hubs, one relay site and three data-logging/transmitting sites. The communication hubs are located at the Provincial Building in Blairmore and the FSIC. The main logging sites, on the other hand, are at the top of Turtle Mountain. We have identified them as ‘Borehole,’ ‘Weather Station’ and ‘Radio Station.’ Finally, the pump house is a data-relay point.

This section describes all the equipment housed at these sites, common problems and the procedures to diagnose them.

3.1 Decision-Tree Troubleshooting

If you are having problems with the network system, check this list of problems and possible sources before requesting service.

3.1.1 TMClient not Updating

TMClient is a program that retrieves the latest data from the database on the server at FSIC and copies it to a Microsoft® Access file on the local desktop PC for processing. See Sections 3.1.4 and 3.1.5 for instructions on how to install and update data, respectively, using the TMClient application.

Figure 2 provides a troubleshooting procedure for the situation in which TMClient is not updating.

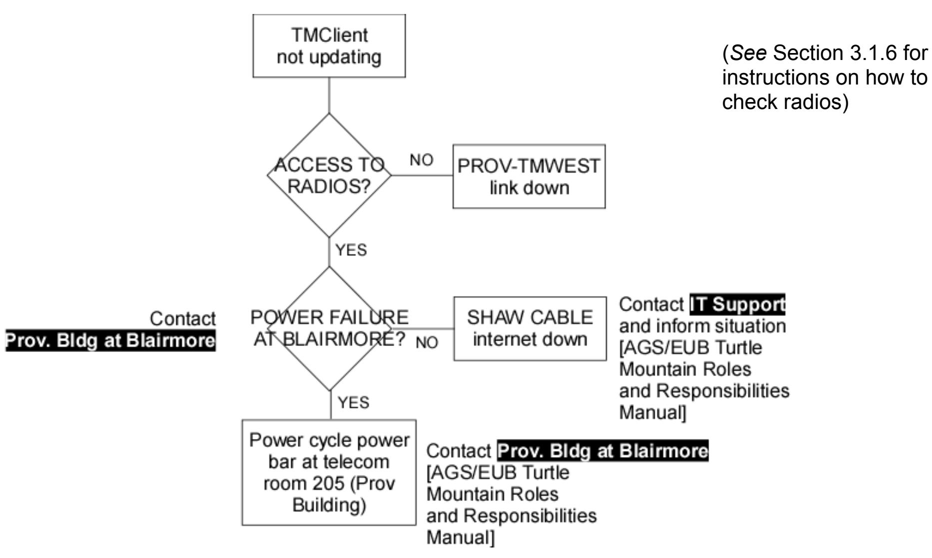


Figure 2. Decision tree for TMClient not updating.

3.1.2 TMClient Unable to Connect to Server

Figure 3 provides a troubleshooting procedure for the situation in which TMClient is unable to connect to the server.

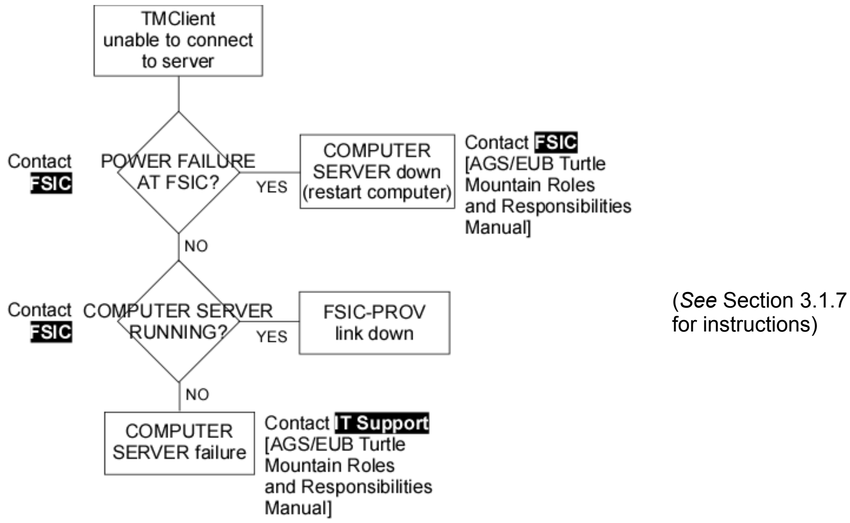


Figure 3. Decision tree for TMClient unable to connect to server.

3.1.3 Atlas not Updating

Atlas is a data-management, calculation and presentation tool. Although Atlas can be used as a general viewing tool (Durham Geo Slope Indicator, 2009), its main purpose is to generate call-outs should an alarm threshold be exceeded. We programmed Atlas to send e-mails to ERCB/AGS TM Team members when a preset threshold is exceeded on any individual sensor. A detailed description of the specific roles and responsibilities of ERCB/AGS TM Team members during normal operation of the monitoring system and during an emergency is in Moreno and Froese (2009).

The ERCB/AGS is currently using the Web-based version of Atlas, whereby the data stream from the loggers on the west side of the mountain is accessed directly via the Internet and radio links from Blairmore, and then recorded to a database housed by the company that provides the Atlas monitoring service. The Web-based version of Atlas enables access to the data via the Internet from any location in the world.

Figure 4 provides a troubleshooting procedure for the situation in which Atlas is not updating.

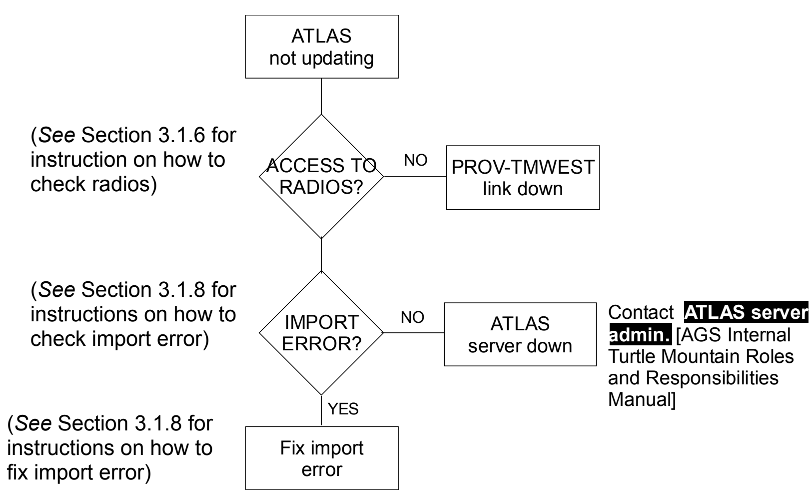


Figure 4. Decision tree for Atlas not updating.

3.1.4 TMClient Set-up

The following procedure explains how to install TM client.

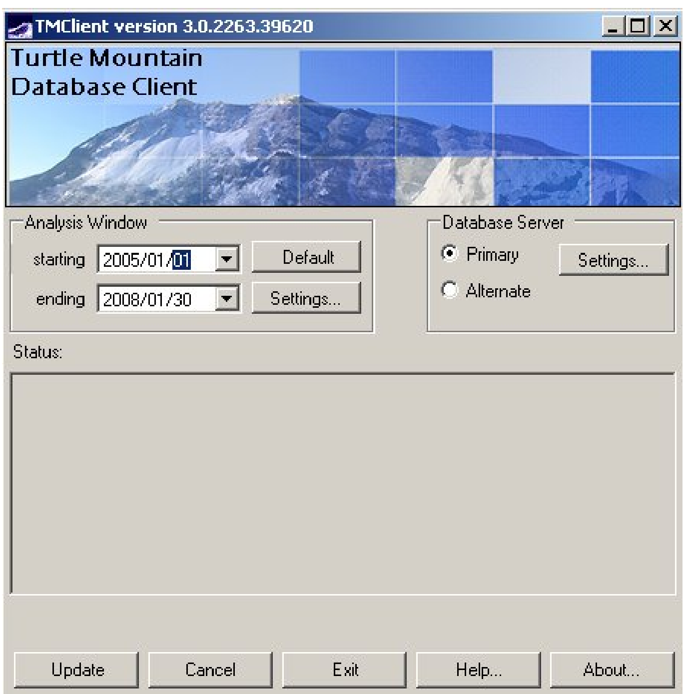
1 Navigate to the Project drive and the folder TMClient and copy it

> ***Helpful Hint***
>
> You must copy the entire folder because all the elements within it must stay together.

2 Paste the entire folder to a local drive on your computer. There is no need to alter any of the settings in any of the applications.

3 To check the settings in TMClient, start TMClient by double-clicking on the file TMClientV3.exe. This will open the Turtle Mountain Database Client window.

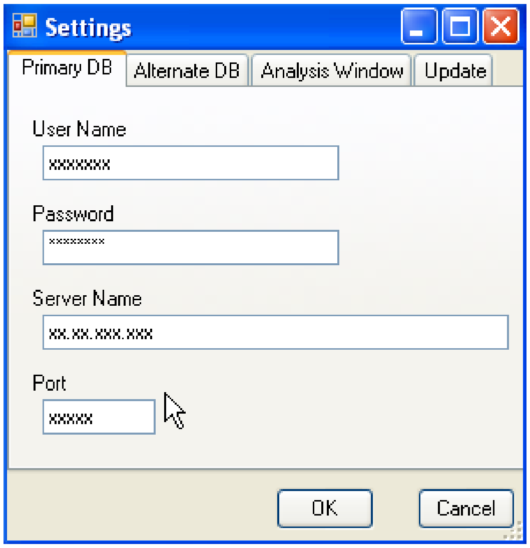
4 In the Database Server box, ensure that 'Primary' has been selected and click the 'Settings' button.



5

In the Settings dialogue box, enter the following:

Username: xxxx
Password: xxxx
Server Name: xxxx
Port: 22033



Unless these settings are deleted by mistake you won't have to repeat this process on your computer

6

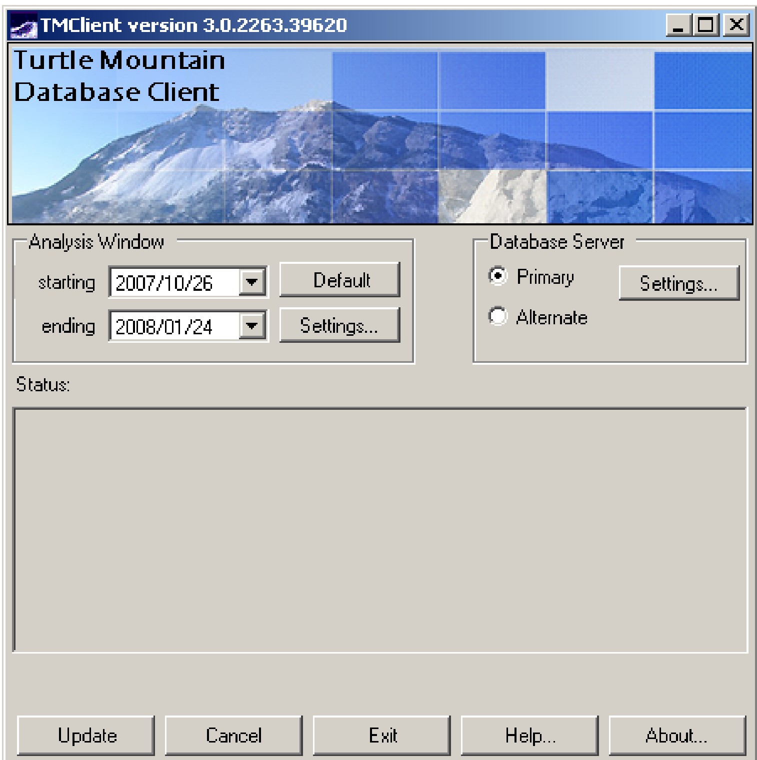
Now you can use TM Client. You can create a shortcut to the TMClientV3 application on your desktop.

3.1.5 TMClient Data Download

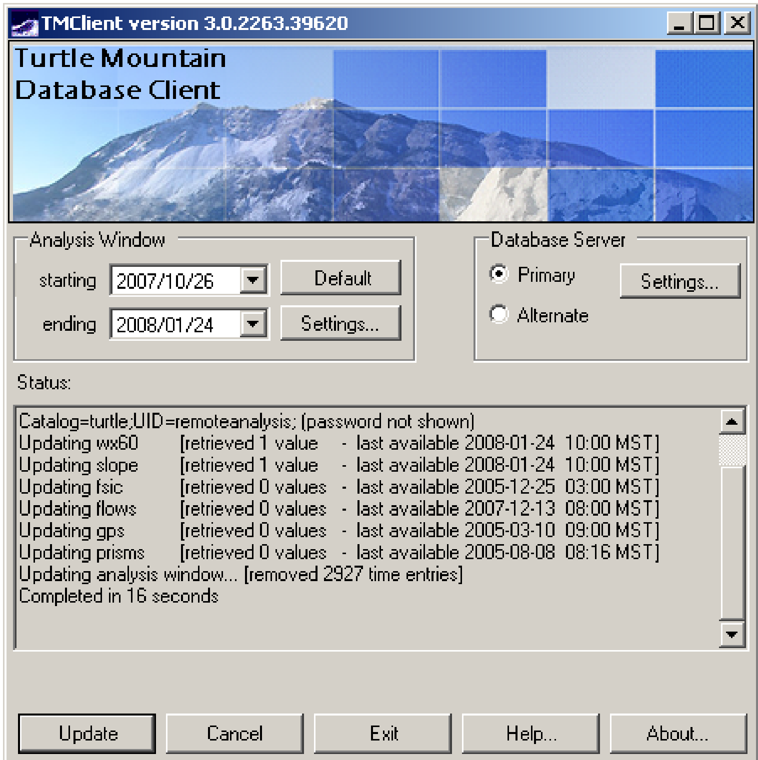
The following procedure explains how to update the TMClient Database with data from Turtle Mountain and how to view the updated data.

1 Open TMClientV3 by double-clicking the icon on your desktop or the filename in Windows Explorer.

2 With the TMClient window open, select the ‘Starting date’ and ‘Ending date’ for which you are interested in updating data and click the ‘Update’ button.

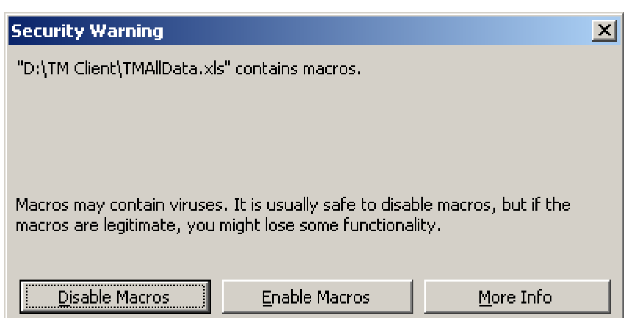


3 There will be activity in the Status box showing that the system is updating. After the update is finished, the last line in the window will show that the data download is complete. This line will also provide you with the time required for the update.

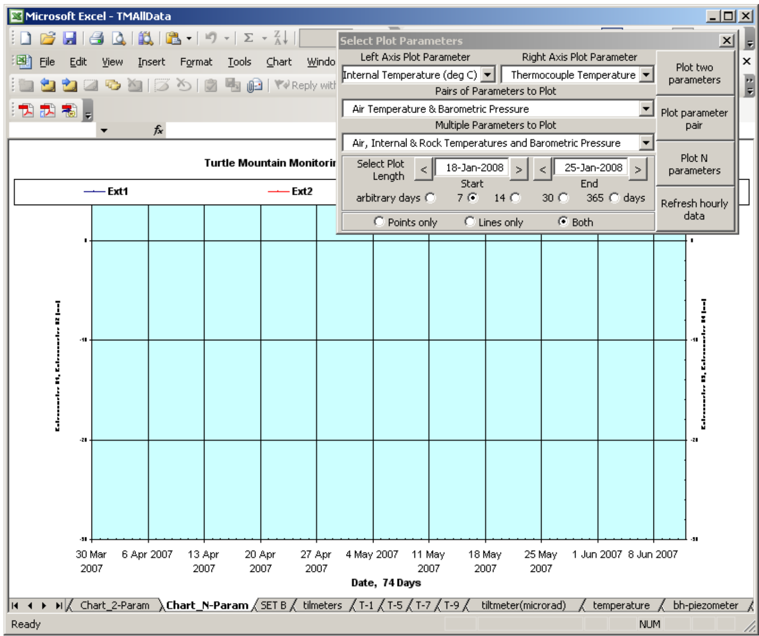


When the update is finished, click the 'Exit' button.

4 To view the values, open the TMAllData spreadsheet in your TMClient folder. When asked you if you would like to enable the macros, click 'Enable Macros.'

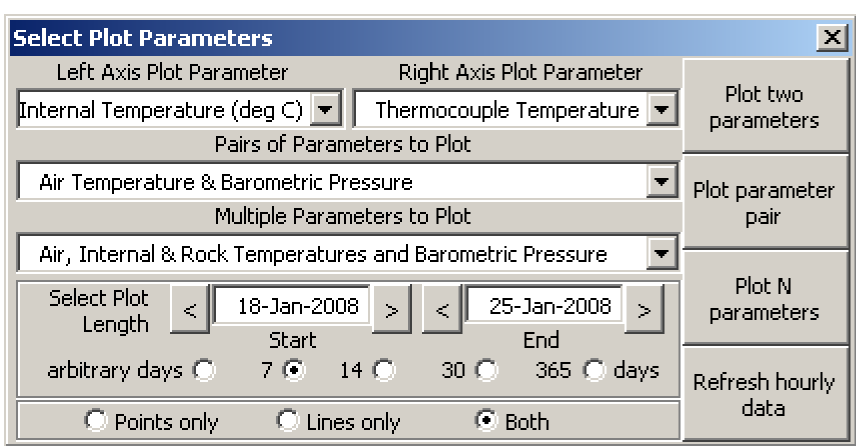


5 The spreadsheet will open in the worksheet *Chart_N-Param*. There will be a secondary window open called 'Select Plot Parameters' that allows you to choose the data you would like to display in the worksheet.



Before you can view any data, you must click the ‘Refresh Hourly Data’ button. This will import the latest data from the Access database into the spreadsheet. When a box indicates the update is complete, click ‘OK.’ If you wish to look at the data in table format, navigate to the *Data* worksheet.

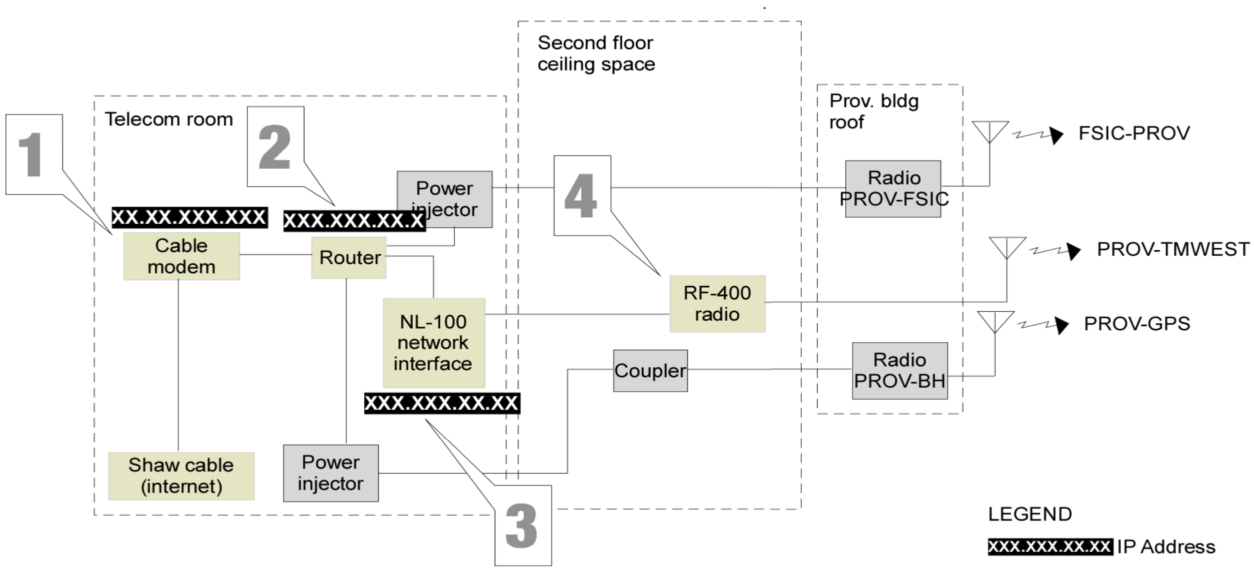
6 The ‘Select Plot Parameters’ dialogue box has many options for displaying the data. You can choose two different parameters by selecting them in the top two drop-down boxes and then clicking on the ‘Plot Two Parameters’ button. You can view data by selecting predetermined pairs in the ‘Pairs of Parameters to Plot’ drop-down box and then selecting the ‘Plot Parameter Pair’ button. You can select multiple parameters with the ‘Multiple Parameters to Plot’ drop-down box and then viewing by clicking the ’Plot N Parameters’ button.



7 When you are finished viewing the data, simply close the spreadsheet; there is no need to save (saving will not affect the data, only the layout of the spreadsheet).

3.1.6 PROV-TMWEST radio link

The following procedure will help to assess communication problems between the Provincial Building at Blairmore and the two data loggers at the top of Turtle Mountain (Borehole and Weather Station) by reviewing the current state of devices in this system.



1 Test communication link for the cable modem, using the procedure in Section 3.1.9.

2 If communication with cable modem is 'Great,' test the router, using the procedure in Section 3.1.9.

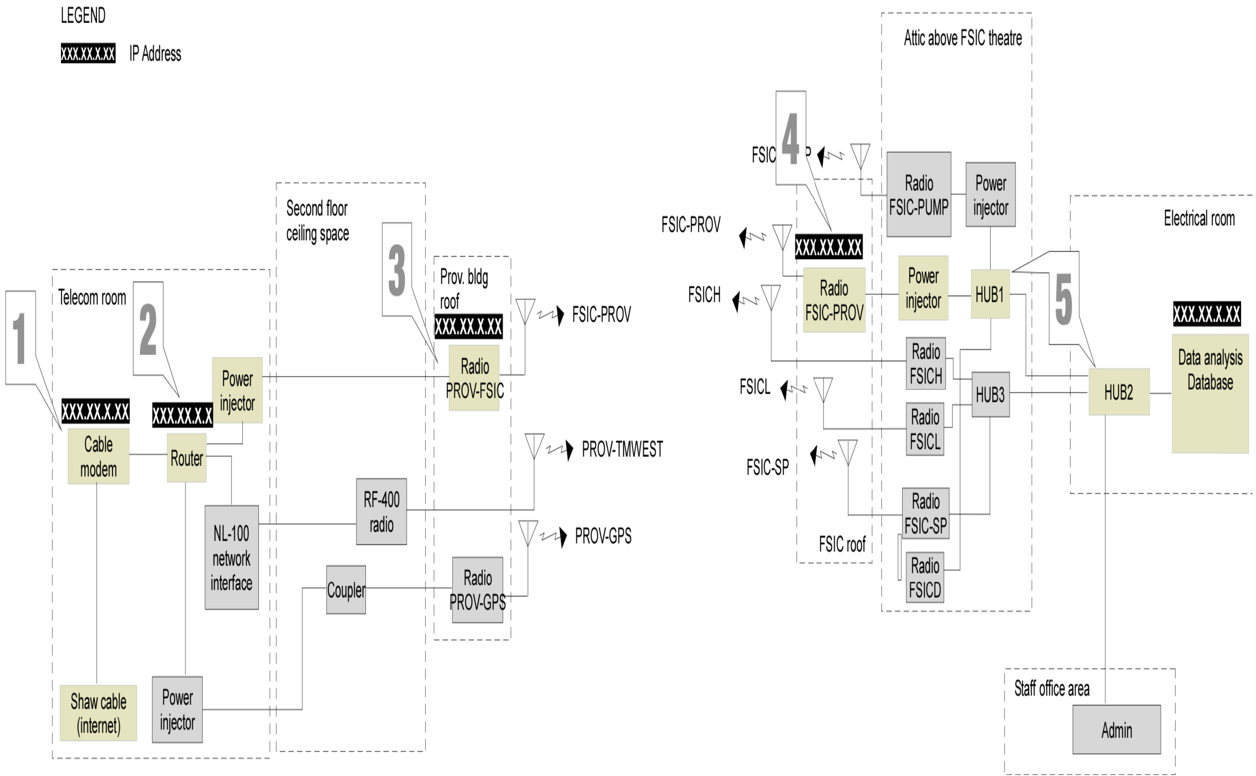
3 If communication with router is 'Great,' test the network interface NL100, using the procedure in Section 3.1.9.

4 If communication with network interface is 'Great,' test the quality of the communication to the RF400 radio at Blairmore, using the procedure in Section 3.5.1.1 or 3.5.1.2.

Helpful Hint
Never test communication between 10 minutes before and 10 minutes after the hour, as this is the time when the network sends data to the server.

3.1.7 FSIC-PROV radio link

The following procedure will help to assess communication problems at the Provincial Building in Blairmore and at the FSIC by reviewing the current state of devices in this system.



1 Test communication link for the cable modem, using the procedure in Section 3.1.9.

2 If communication with cable modem is ‘Great,’ **test** the router, using the procedure in Section 3.1.9.

3 If communication with router is ‘Great,’ test the PROV-FSIC radio link (at Blairmore), using the procedure in Section 3.1.9.

4

If communication with this link is 'Great,' test the FSIC-PROV radio link (at the FSIC), using the procedure in Section 3.1.9.

5

If communication with this link is 'Great,' then suspect a malfunction of HUB1 and/or HUB2. Contact element administrator (*see* Appendix 2).

Helpful Hint
Never test communication between 10 minutes before and 10 minutes after the hour, as this is the time when the network sends data to the server.

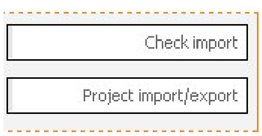
3.1.8 Check Import (Lock File)

The following procedure will verify if the automatic ASCII file import from Atlas is still running (new ASCII files are imported every hour).

1 Log in by entering the IP address or domain name in your Web browser (http://www.atlasmonitoring.com)

2 The resulting login screen requires you to enter your name, password and preferred language. Press the ‘login’ button to start.

3 Go to ‘Utilities’ and then click ‘Check Import’ from the menu.



4 The Data Import Status should read ‘Ready for next file;’ if you see a Lock File, delete it.

5 Click ‘Recalculate Statistics’ to restart the import of ASCII files. The Last Imported Time-Stamp should display the most recent timestamp that has been processed; if not, contact server administrator to solve the problem.

3.1.9 Ping Test

The following procedure will help to test the connection between your computer and a specified element of the network system by measuring the time in milliseconds for a ‘ping’ packet to travel to the site and back again.

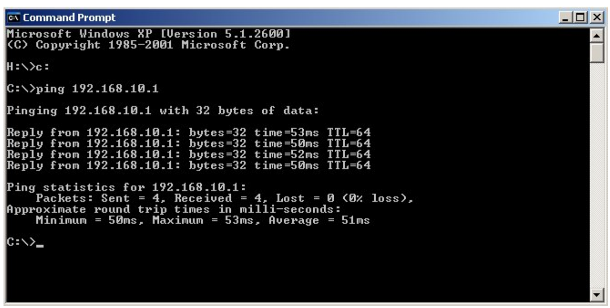
1 Open the Command Prompt (Start > Programs > Accessories > MS Dos Prompt).

2 At the C: prompt, type

PING 192.168.10.XX

(‘**XX’** is the unique IP address of the element being pinged) and press Enter.

3 This will give low, high and average round-trip times.



4 Use the table below to interpret your results

Ping Time (ms)	Ping loss	Explanation
<100	0%	Great
100–200	75%	Good
>200	< 75%	Poor

5 Repeat ping test several times (ping time and losses can vary greatly because of the random nature of Internet packet routings).

6 Consistently ‘Poor’ test results indicate malfunctioning equipment. Contact element administrator (*see* Appendix 2).

3.2 Blairmore Provincial Building

The Blairmore Provincial Building serves as one of the several communication hubs in the Turtle Mountain Monitoring Project. Three wireless links allow telemetering of weather and displacement data, and a radio link to the FSIC (FSIC-PROV) enables communication with and data transfer to the FSIC. The above wireless links connect to a router, which connects to the Internet via the Internet service of Shaw Cable (Moreno and Froese, 2006). This service uses broadband cable and a cable modem to provide Internet connectivity. Figure 5 is a block diagram that shows how the equipment at the Provincial Building is connected. Most of the equipment is located in the Telecom Room (Room 205) to ensure easy access. Figure 6 gives floor plans and access routes to all communication equipment at the Blairmore Provincial Building. Figure 7 shows the physical layout of the equipment. The cable modem is close to a telephone closet where the Internet cable terminates. An uninterrupted power supply/surge unit (UPS) provides protection for all equipment from power outages or surges. Table 2 provides a detailed inventory of the equipment in this building and Table 3 contains troubleshooting procedures.

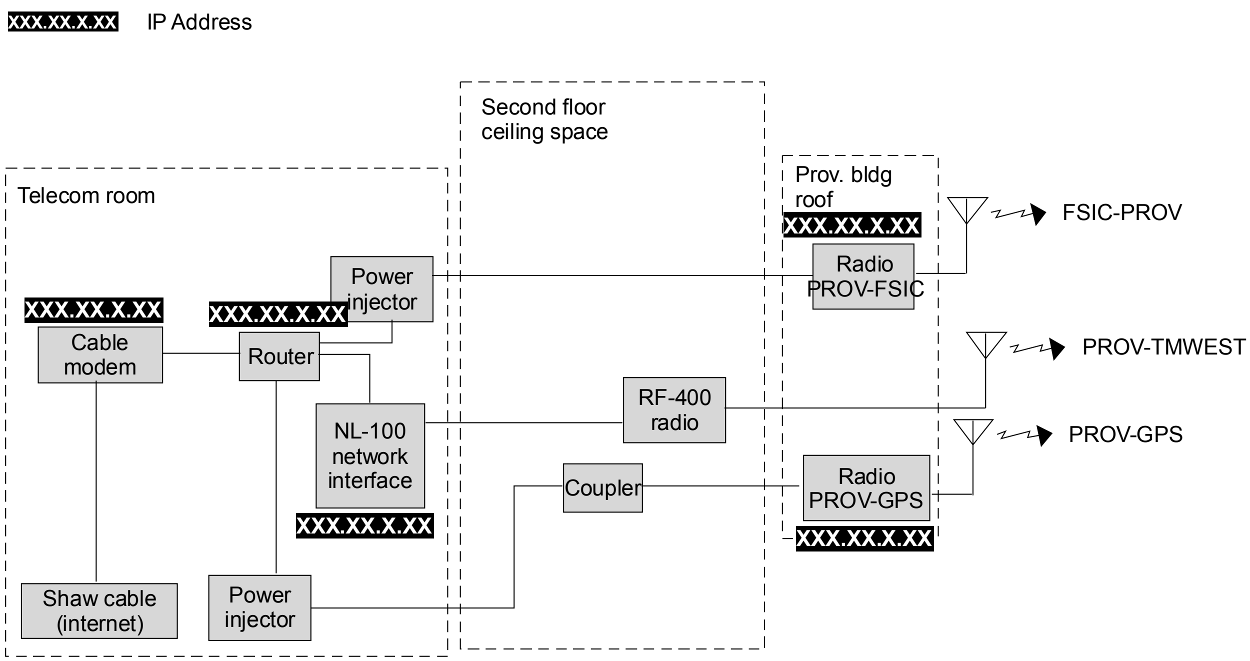
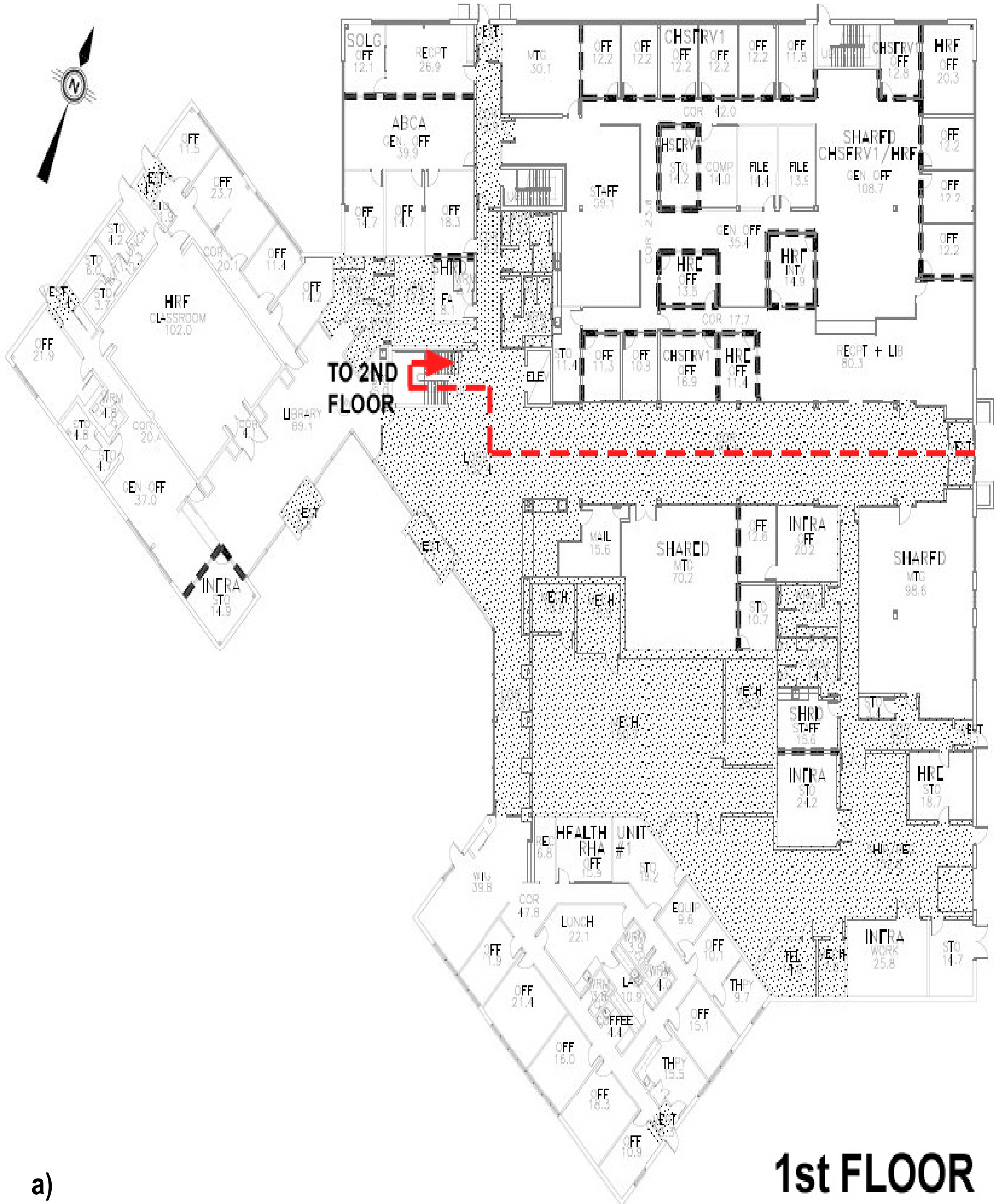
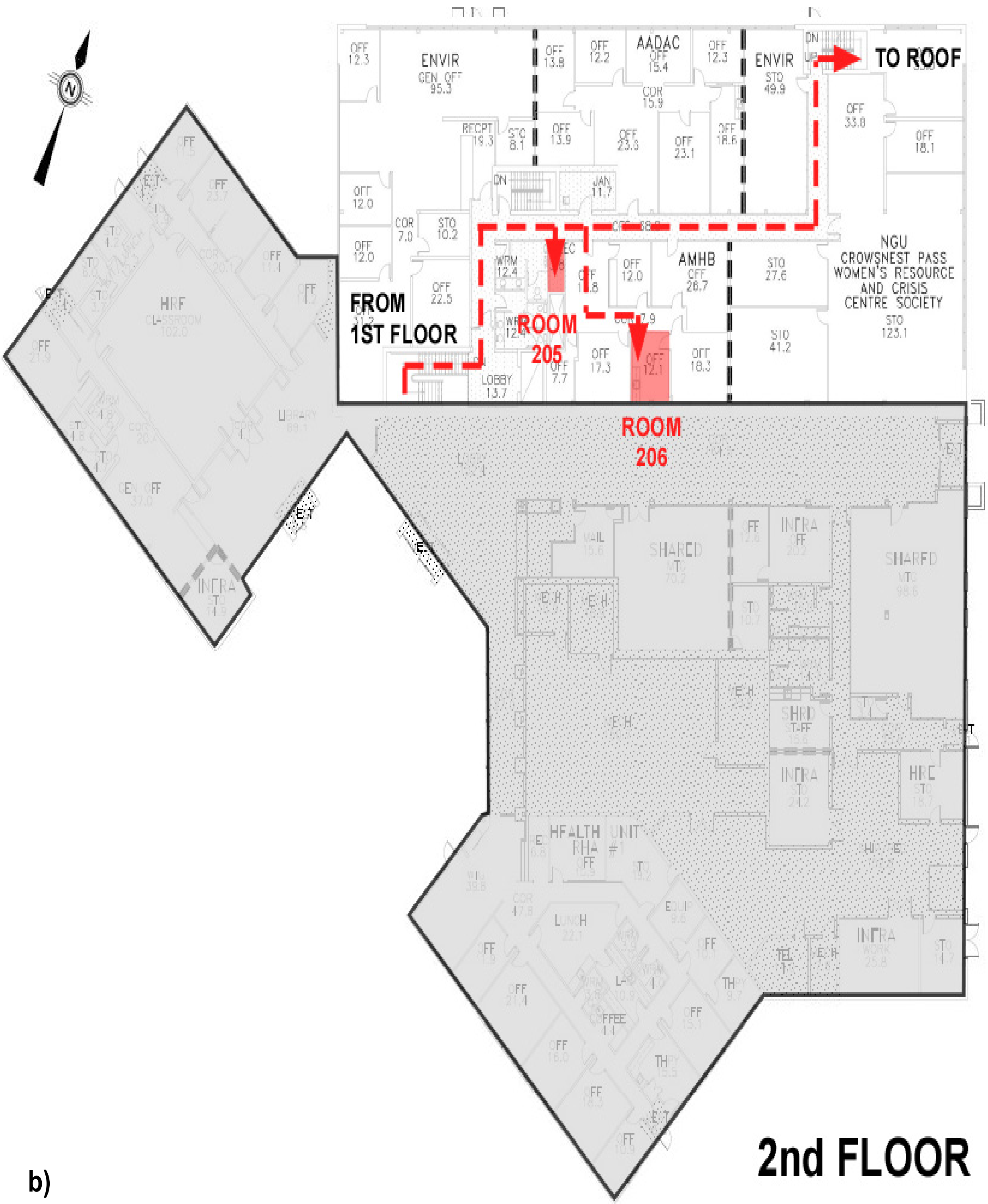


Figure 5. Schematic diagram of telemetry equipment installed at the Blairmore Provincial Building.



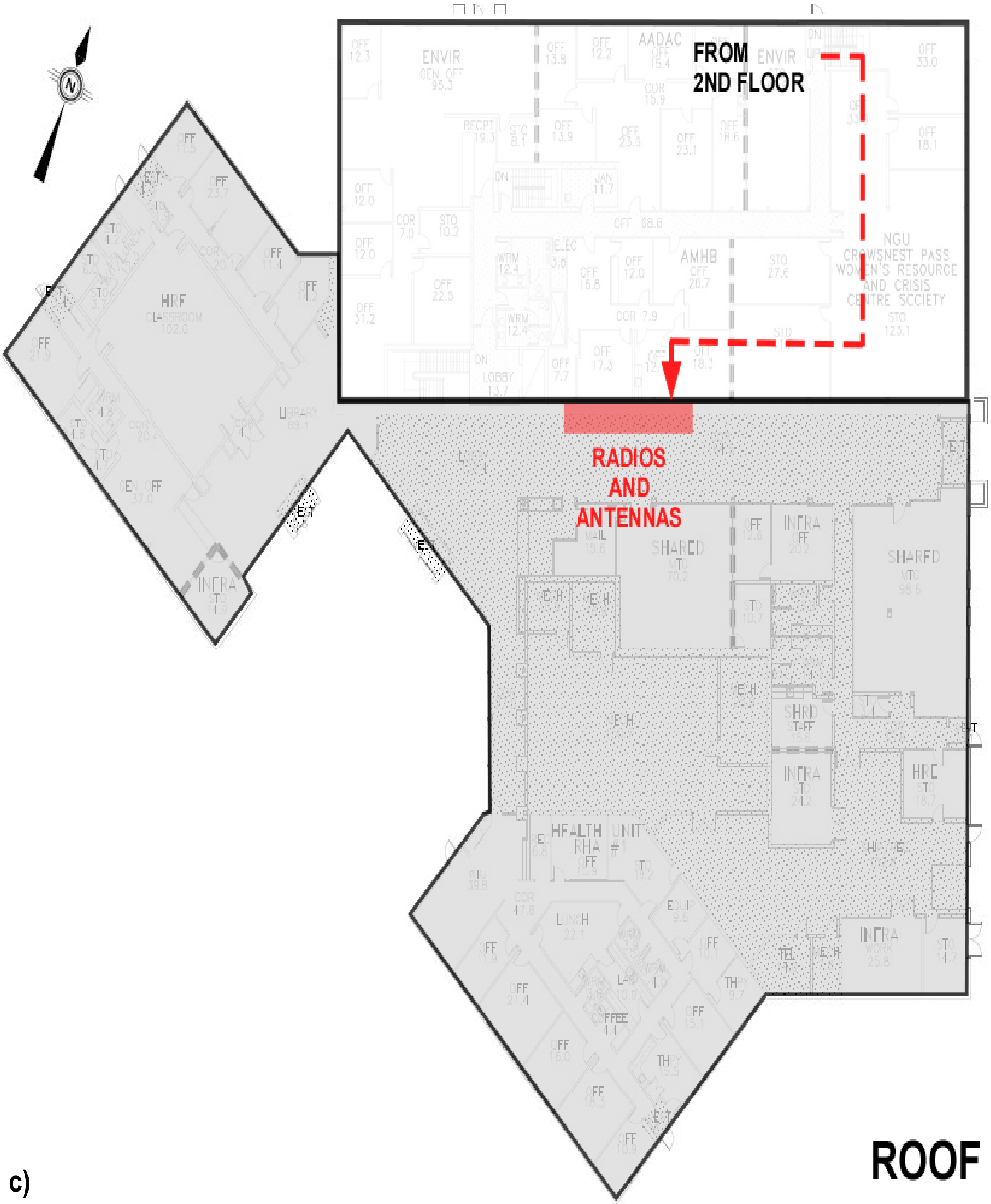
a)

Figure 6. Floor plans and access routes to all communication equipment at the Blairmore Provincial Building: a) first floor, b) second floor, and c) roof.



b)

Figure 6 (continued)



c)

Figure 6 (continued)

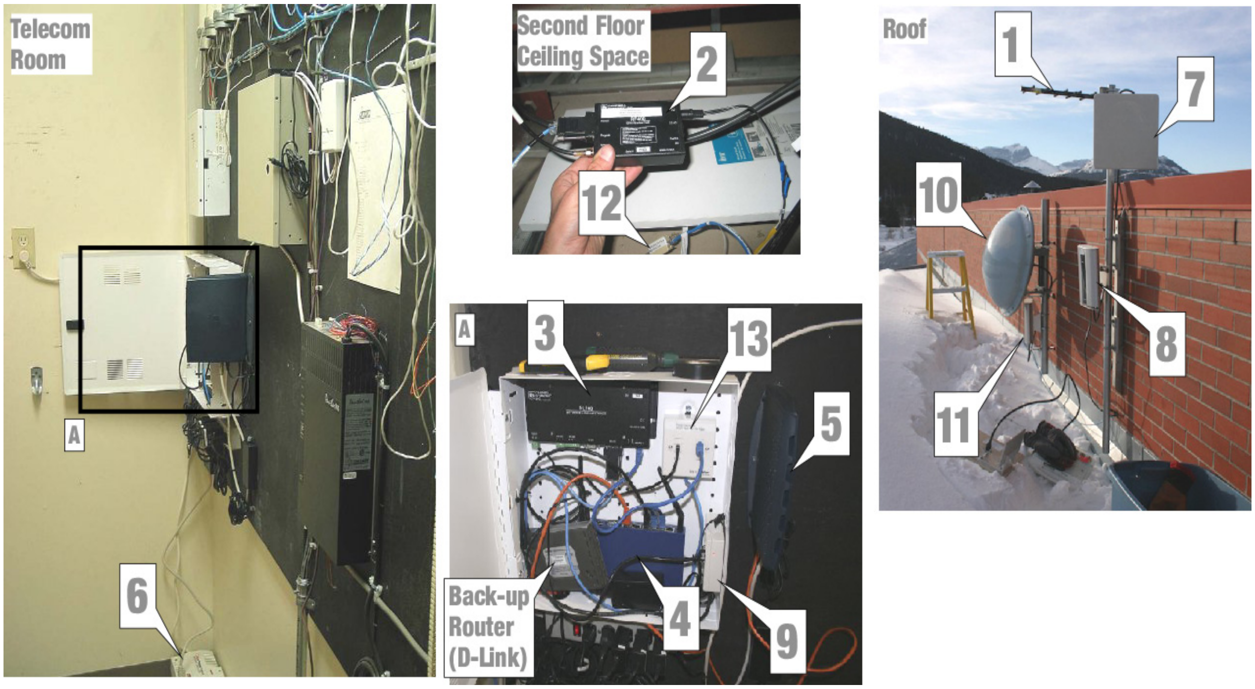


Figure 7. Physical layout of the Turtle Mountain Monitoring Project equipment installed at the Blairmore Provincial Building. Numbers refer to items in Table 2.

Table 2. Turtle Mountain Monitoring Project equipment installed at the Blairmore Provincial Building.

Item	Quantity	Vendor	Part Number	Description	Location	Link
1	1	Campbell	L14201	Antenna	roof	PROV-TMWEST
	1	Campbell	L14462	Antenna(surge protector)	roof	PROV-TMWEST
2	1	Campbell	RF400	Radio	2nd floor	PROV-TMWEST
	1	Campbell	L15966	Radio (DC unit)	telecom room	PROV-TMWEST
3	1	Campbell	NL100	Network interface	telecom room	PROV-TMWEST
	1	Campbell	L13947	Network interface (DC unit)	telecom room	PROV-TMWEST
4	1	Checkpoint	safe@office 500	Router	telecom room	PROV-TMWEST
5	1	Shaw Cable		Internet (modem)	telecom room	PROV-TMWEST
	1	Shaw Cable		Internet (subscription)	telecom room	PROV-TMWEST
6	1	NCIX	CPS 1000 AVR	Battery back-up (UPS)	telecom room	
7	1	MTI	MT485028/N	Antenna	roof	FSIC-PROV
	3'	YDI		Antenna (cable)	roof	FSIC-PROV
8	1	Smartbridges	AirHaul Nexus	Radio	roof	FSIC-PROV
9	1	Smartbridges		Radio (power injector)	telecom room	FSIC-PROV
10	1	Smartbridges		Antenna	roof	PROV-GPS
11	1	Smartbridges	AirHaul Nexus	Radio	roof	PROV-GPS
12	1			Coupler	2nd floor	PROV-GPS
13	1	Smartbridges		Radio (power injector)	telecom room	PROV-GPS
	1	Smartbridges		Radio (DC unit)	telecom room	PROV-GPS

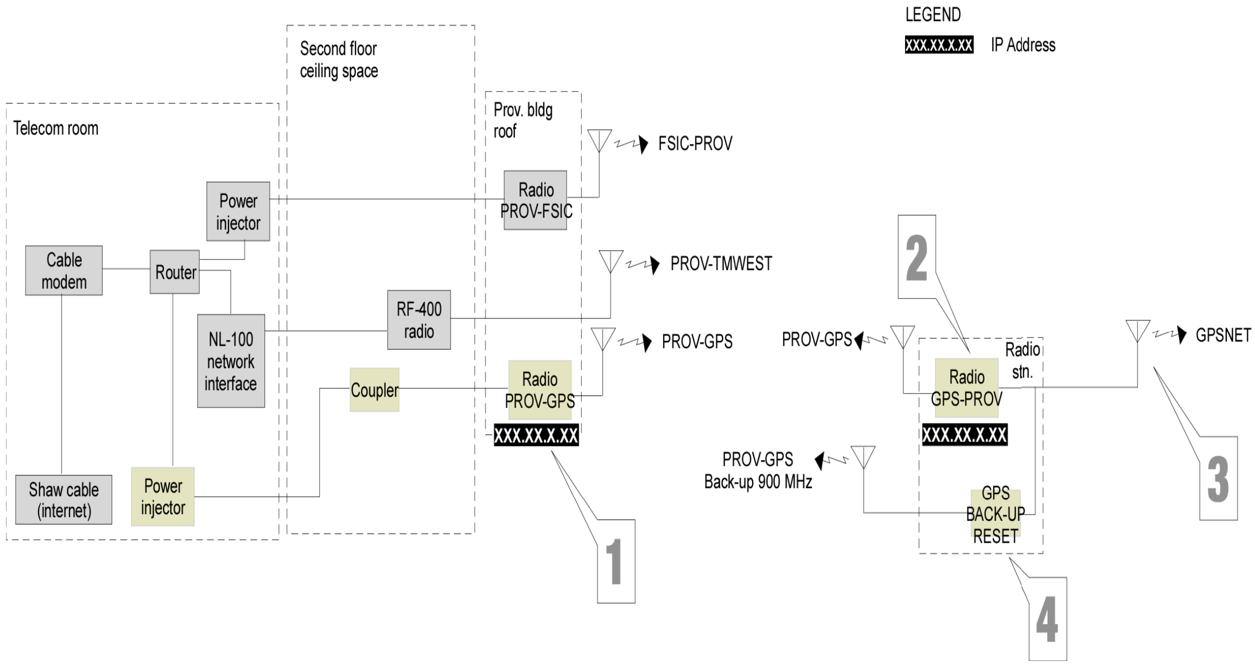
Table 3. Troubleshooting procedures for PROV-GPS radio link.

Problem	Possible Cause	Solution
GPS data only from some stations	1) Bad weather	Check webcam images[1]
	2) Defective GPS station	Check connectivity to GPS station(s), using procedure in Section 3.1.9 (Ping Test).
GPS data will not update	1) Bad weather	Check webcam images*
	2) Defective PROV-GPS link	Check connectivity, using procedure in Section 3.2.1 (PROV-GPS radio link).

[1] *See* http://www.ags.gov.ab.ca/geohazards/turtle_mountain/turtlecam/turtle_webcam.html

3.2.1 PROV-GPS radio link

The following procedure will help to assess communication problems between the Provincial Building at Blairmore and the new radio tower installed near the borehole site, by reviewing the current state of devices in this system.



1 Test communication for the PROV-GPS radio link (at Blairmore), using the procedure in Section 3.1.9.

2 If communication with this link is 'Great,' test the GPS-PROV radio link (at the top of the mountain), using the procedure in Section 3.1.9.

3 If communication with this link is 'Great,' suspect a malfunction of GPSNET radio tower antennas. Contact element administrator (*see* Appendix 2).

4 If communication with radio is 'Poor,' switch communication to the GPS BACKUP RESET (at the top of the mountain) and power-cycle the radio, using the procedure in Section 3.2.2.

3.2.2 GPS Backup Emergency Reset

The following procedure will help to power-cycle communication equipment at the GPS radio station atop Turtle Mountain.

1 Connect to Blairmore 900 MHz radio (external TCP port 6784).

2 Change radio to remote device #7 (type "+++" and "CRLF," then "ATDT7" and "CRLF").

3 Initialize reset module as follows:

Type "I" until you get "Serial 2 Ready" response, then quickly type "V"

4 If this is working but you still can't ping the GPS-PROV radio link (at the top of the mountain), then repeat the initialize sequence as follows:

Type "I" until you get "Serial 2 Ready" response, then quickly type "R." This will kill the power at the radio for 5 seconds to reboot everything.

5 If the radio still doesn't restart (cannot be pinged), then suspect malfunction of GPS-PROV radio link. Contact element administrator (*see* Appendix 2).

3.3 Frank Slide Interpretive Centre

The Frank Slide Interpretive Centre (FSIC) acts as a remote data hub for monitoring Turtle Mountain. In 2004, a wireless link was established between the FSIC and the Blairmore Provincial Building (FSIC-PROV) to provide Internet connectivity to the server at the FSIC. Later in 2004, several access points were installed (FSICH, FSICL) in the FSIC to provide wireless access to the eastern slopes of Turtle Mountain. These points transmit displacement data, from the recently installed Third Peak, Ridge and Pit GPS stations, and stream outflow data to the FSIC from Turtle Mountain. In 2005, a point-to-point link was established from the FSIC to South Peak (FSIC-SP) to obtain data from the borehole seismic recorder (Moreno and Froese, 2006). Seismic monitoring at this station ceased in 2006 after a severe lightning strike destroyed the monitoring equipment and data radio. In October 2007, when this station was selected as a camera site, the radio was replaced and a webcam installed. Finally, by early 2007, a wireless data link to the Bellevue pump house was installed. The pump house is a secondary data collection site for the EDM system (Moreno and Froese, 2008). Figure 8 is a block diagram that shows how the equipment at the FSIC is connected. Figure 9 shows the physical layout of the equipment and Table 4 provides a detailed inventory of the equipment. Table 5 contains troubleshooting procedures.

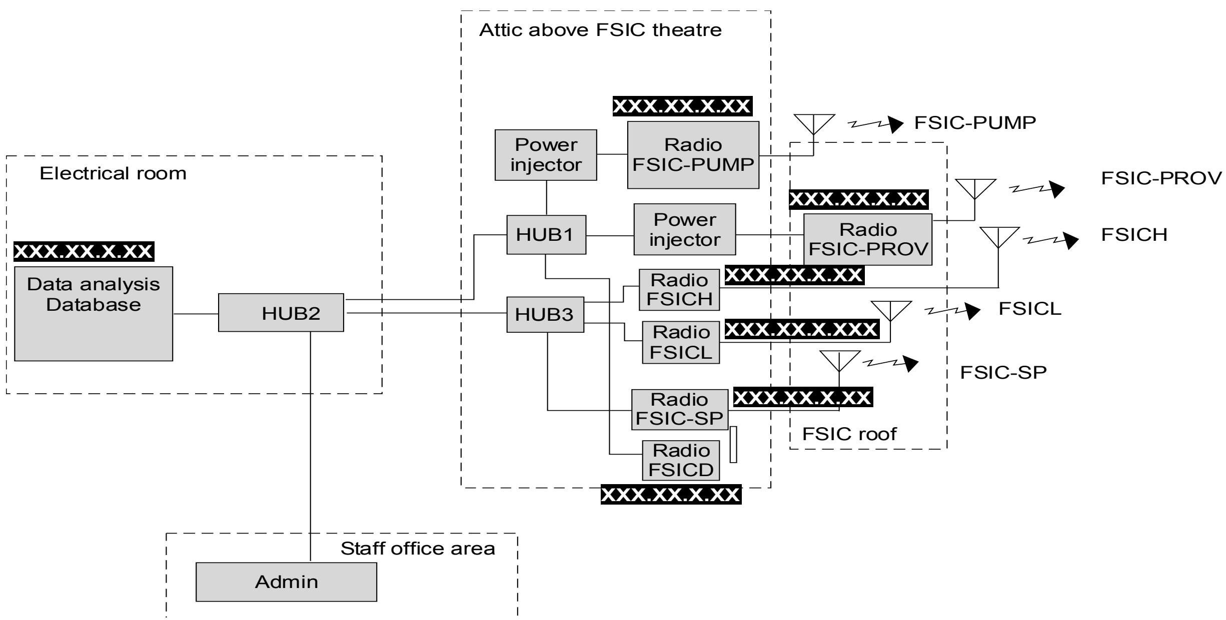


Figure 8. Schematic diagram of telemetry equipment installed at the Frank Slide Interpretive Centre.

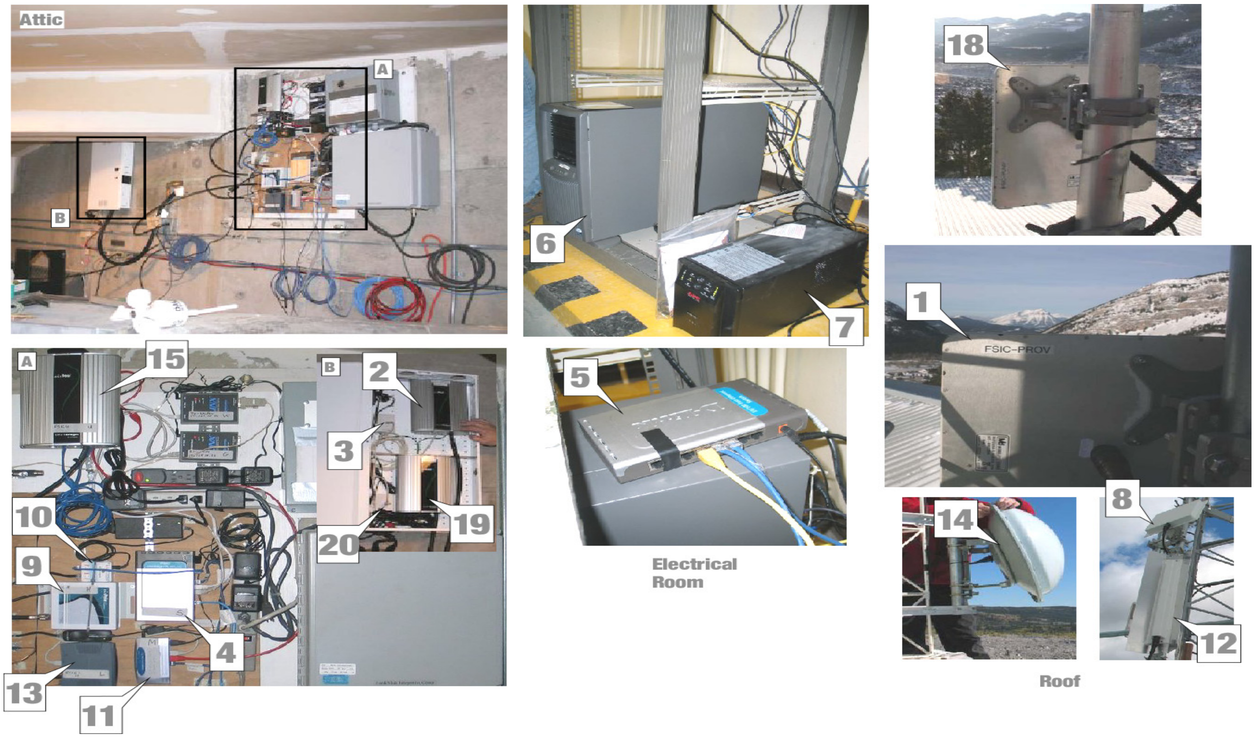


Figure 9. Physical layout of equipment installed at the Frank Slide Interpretive Centre. Numbers refer to items in Table 4.

Table 4. Equipment installed at the Frank Slide Interpretive Centre.

Item	Quantity	Vendor	Part Number	Description	Location	Link
1	1	MTI	MT485028/N	Antenna	roof	FSIC-PROV
	1		LMR600	Antenna (cable)	roof	FSIC-PROV
2	1	Smartbridges	SB3010	Radio	roof	FSIC-PROV
3	1	Smartbridges		Radio (power injector)	attic	FSIC-PROV
4	1	D-Link	8-port	HUB	attic	FSIC-PROV
5	1	D-Link	8-port	HUB	electrical room	FSIC-PROV
6	1	HP Server	Xeon 3.4 Ghz 2GB Ram	Data analysis, Marshall, Snapping, Da	electrical room	FSIC-PROV
	1	HP Server	Monitor		electrical room	FSIC-PROV
	1	HP Server	Network Card		electrical room	FSIC-PROV
7	1	HP Server	UPS		electrical room	FSIC-PROV
8	1	Hyperlink Tecl	HG2416P	Antenna	roof	FSICH
	1		LMR400	Antenna (cable)	roof	FSICH
9	1	Smartbridges	SB2510	Radio	attic	FSICH
10	1	Smartbridges		Radio (power injector)	attic	FSICH
11	1	Hawking	4-port	HUB	attic	FSICH
12	1	Hyperlink Tecl	HG2416P	Antenna	roof	FSICL
	1		LMR400	Antenna (cable)	roof	FSICL
13	1	Engenius	NL2510	Radio	attic	FSICL
14	1	Electro-comm	DA 58-29 PAC	Antenna	roof	FSIC-SP
	1		LMR400	Antenna (cable)	roof	FSIC-SP
15	1	Smartbridges	SB3010	Radio	attic	FSIC-SP
16	1	Smartbridges		Radio (power injector)	attic	FSIC-SP
18	1	MTI	MT485028/N	Antenna	roof	FSIC-PUMP
	1		LMR600	Antenna (cable)	roof	FSIC-PUMP
19	1	Smartbridges	SB3010	Radio	attic	FSIC-PUMP
20	1	Smartbridges		Radio (power injector)	attic	FSIC-PUMP

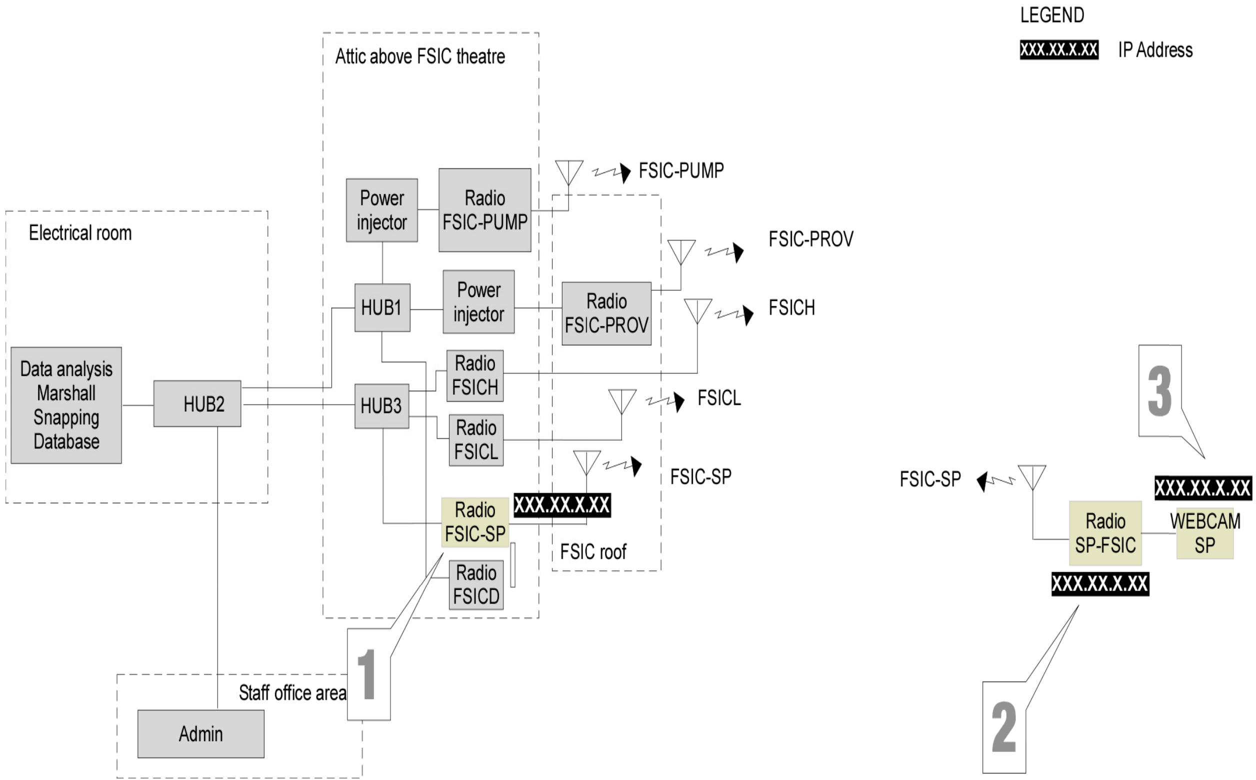
Table 5. Troubleshooting procedures for radio links at the Frank Slide Interpretive Centre.

Problem	Possible Cause	Solution
Image from the webcam at South Peak will not update.	Defective FSIC-SP link	Check connectivity, using procedure in Section 3.3.1.
Data from top GPS stations (Third Peak, Ridge) will not update	Defective FSICH radio and/or antenna	Contact element administrator[1]
Data from bottom GPS station (Pit) and weir station will not update	Defective FSICL radio and/or antenna	Contact element administrator[1]
Data from top and bottom GPS stations and South Peak webcam image will not update	HUB3 malfunctioning	Contact element administrator[1]

[1] *See* Appendix 2

3.3.1 FSIC-SP radio link

The following procedure will help to assess communication problems between the FSIC and the webcam on top of South Peak, by reviewing the current state of devices in this system.



1 Test communication for the FSIC-SP radio link (at the FSIC), using the procedure in Section 3.1.9.

2 If communication with this link is 'Great,' test the SP-FSIC radio link (at the top of the mountain), using the procedure in Section 3.1.9.

3 If communication with this link is 'Great,' suspect malfunction of SP webcam. Contact element administrator (*see* Appendix 2)

Helpful Hint

Never test communication between 10 minutes before and 10 minutes after the hour, as this is the time when the network sends data to the server.

3.4 Bellevue Pump House

The Bellevue pump house, located just north of Highway 3 in the Crowsnest Pass (Figure 10), is a small building that housed a groundwater pumping well. The municipality used the pump only in emergencies. The pump house was established as a secondary data collection site for the EDM system in early 2007 (Moreno and Froese, 2008). A wireless data link (FSIC-PUMP) connects the site to the FSIC.

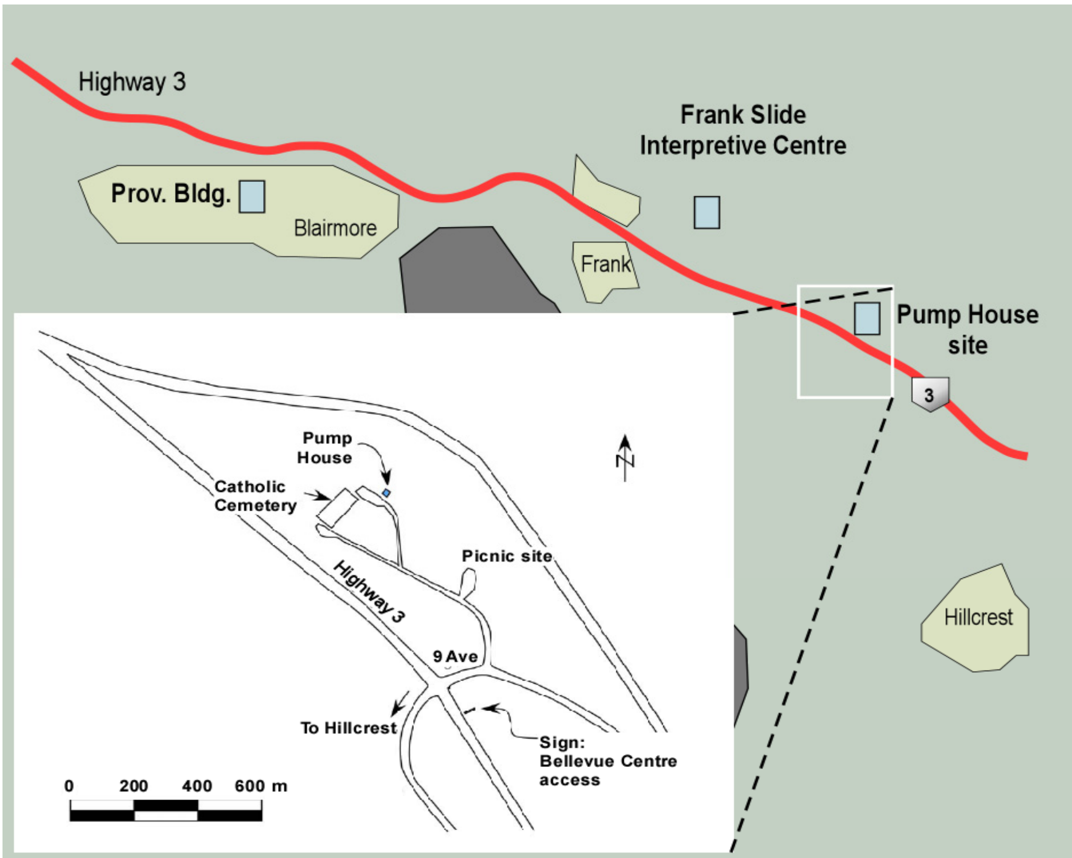


Figure 10. Location of the Bellevue pump house.

Figure 11 is a block diagram that shows how the equipment at the Bellevue pump house is connected. Figure 12 shows the physical layout of the equipment and Table 6 provides a detailed inventory of the equipment. Table 7 contains troubleshooting procedures.

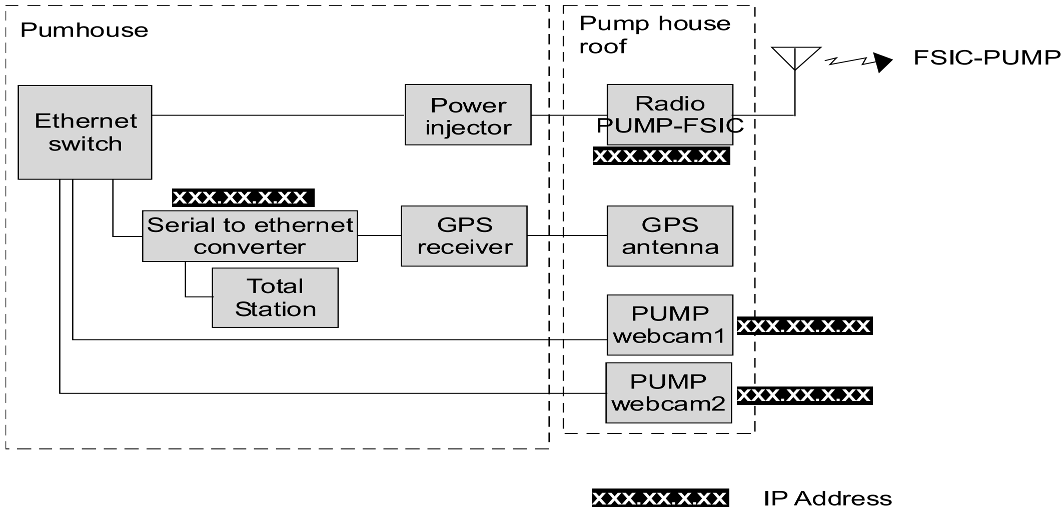


Figure 11. Schematic diagram of telemetry equipment installed at the Bellevue pump house.

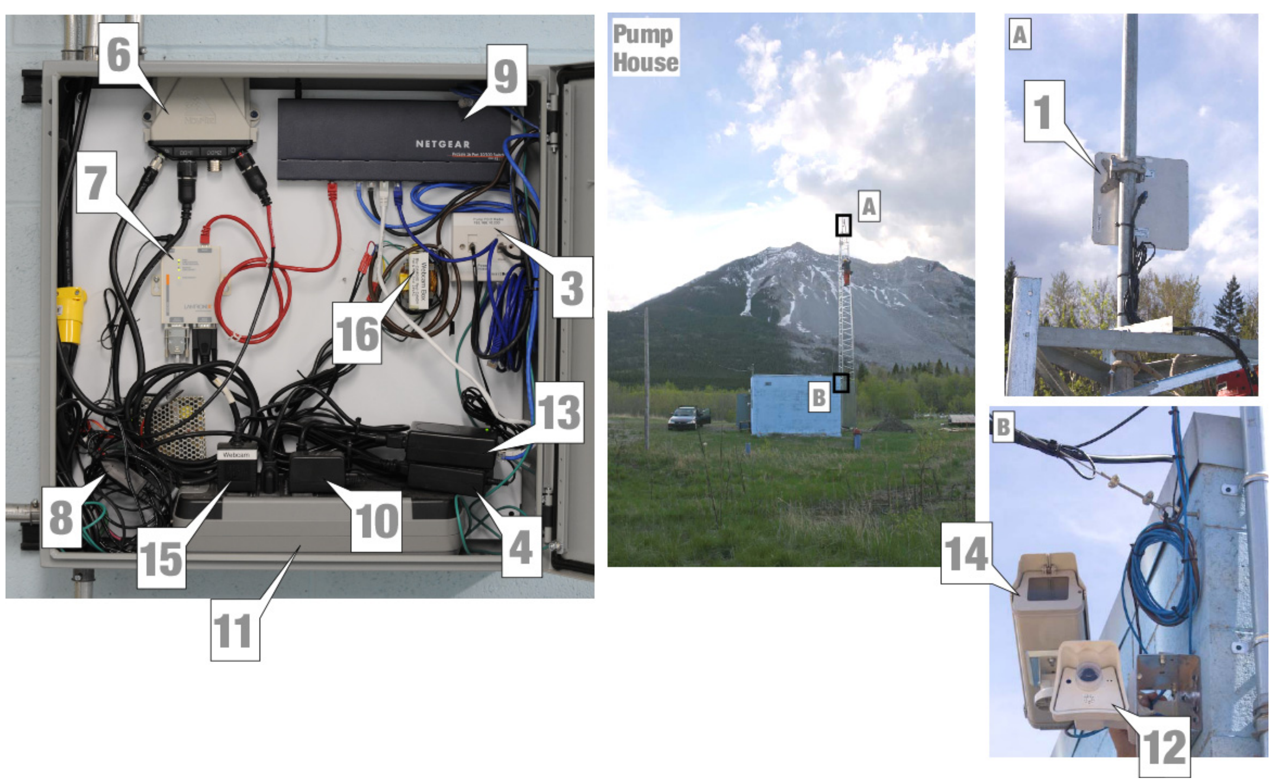


Figure 12. Physical layout of equipment installed at Bellevue pump house. Numbers refer to items in Table 6.

Table 6. Equipment installed at Bellevue pump house.

Item	Quantity	Vendor	Part Number	Description	Location	Link
1	1	MTI wireless e	MT485028/N	antenna	roof	FSIC-PUMP
2	1	Air Haul Nexu:	Smartbridges SB3010	radio	roof	FSIC-PUMP
3	1			Radio (power injector)	inside	FSIC-PUMP
4	1			Radio (power supply)	inside	FSIC-PUMP
5	1	Novatel		GPS antenna	roof	FSIC-PUMP
6	1	Novatel	SmartStar	GPS receiver	inside	FSIC-PUMP
7	1	Lantronix	UDS200	GPS (serial to ethernet)	inside	FSIC-PUMP
8	1			GPS (power supply)	inside	FSIC-PUMP
9	1	Netgear	FS116NA	Ethernet switch	inside	FSIC-PUMP
10	1			Ethernet switch (power supply)	inside	FSIC-PUMP
11	1	Belkin	F6H375-USB	UPS	inside	FSIC-PUMP
12	1	Mobotix	M22M	web camera	roof	WEBCAM
	1	Mobotix	OPT14-L65	web camera (lens)	roof	WEBCAM
13	1			web camera (power supply)	inside	WEBCAM
14	1	Hawking		web camera	roof	WEBCAM
	1	Hawking		web camera (lens)	roof	WEBCAM
15	1			web camera (power supply)	inside	WEBCAM
16	1			web camera (enclosure heater power :	inside	WEBCAM

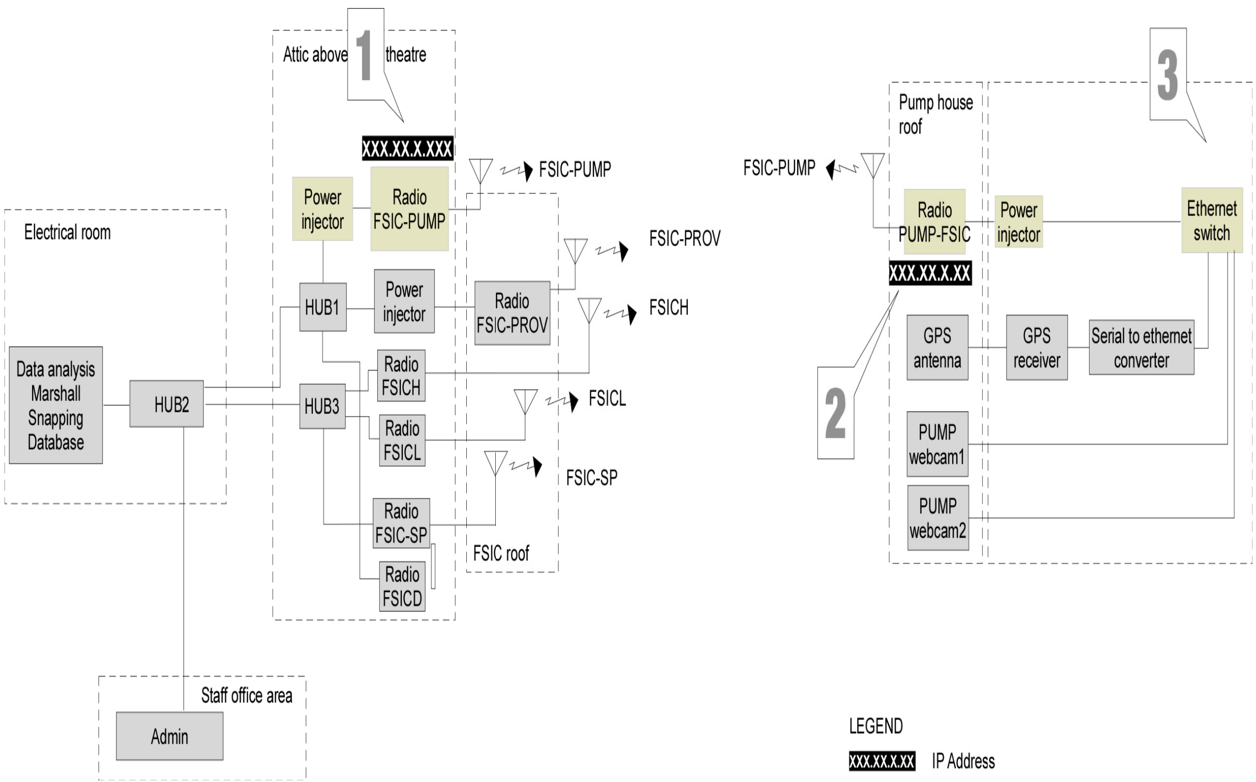
Table 7. Troubleshooting procedures for radio links at the Bellevue pump house.

Problem	Possible Cause	Solution
Image from the pump house webcam will not update	Defective camera	Contact element administrator[1]
Only some EDM data	Bad weather	Check webcam images[2]
EDM data will not update	1) Bad weather	Check webcam images[2]
	2) Defective serial to Ethernet converter	Test communication link for this element, using the procedure in Section 3.1.9. Contact element administrator[1]
	3) Total station error	
EDM data, and images from the pump house webcams will not update	Defective FSIC-PUMP link	Check connectivity, using the procedure in Section 3.4.1.

[1]*See* Appendix 2
[2]*See* http://www.ags.gov.ab.ca/geohazards/turtle_mountain/turtlecam/turtle_webcam.html

3.4.1 FSIC-PUMP radio link

The following procedure will help to assess communication problems between the pump house and the FSIC, by reviewing the current state of devices in this system.



Helpful Hint

Never test communication between 10 minutes before and 10 minutes after the hour, as this is the time when the network sends data to the server.

1 Test communication for the FSIC-PUMP radio link (at the FSIC), using the procedure in Section 3.1.9.

2 If communication with this link is 'Great,' test the PUMP-FSIC radio lin (at the pump house), using the procedure in Section 3.1.9.

3 If communication with this link is 'Great,' suspect malfunction of the Ethernet Switch at the pump house. Contact element administrator (*see* Appendix 2)

3.5 South Peak

3.5.1 Borehole

The borehole (piezometer and thermistor string) and surface (tiltmeters and extensometers) instruments connect to the data acquisition and transmission equipment. This equipment is in a lockable, weatherproof enclosure mounted on a guy-wire–supported metal tower at the borehole location. A Campbell Scientific model CR10X data logger collects the data and relays them to the Blairmore Provincial Building via a 900 MHz spread-spectrum digital radio link (Figure 1). There, the data are transmitted to the FSIC via a 5.3/5.8 GHz radio link (Figure 1), and then stored in a MySQL database on the server (Moreno and Froese, 2006). Figure 13 is a block diagram that shows how the equipment at the Borehole enclosure is connected. Figure 14 shows the physical layout of the equipment and Table 8 provides a detailed inventory of the equipment. Table 9 contains troubleshooting procedures.

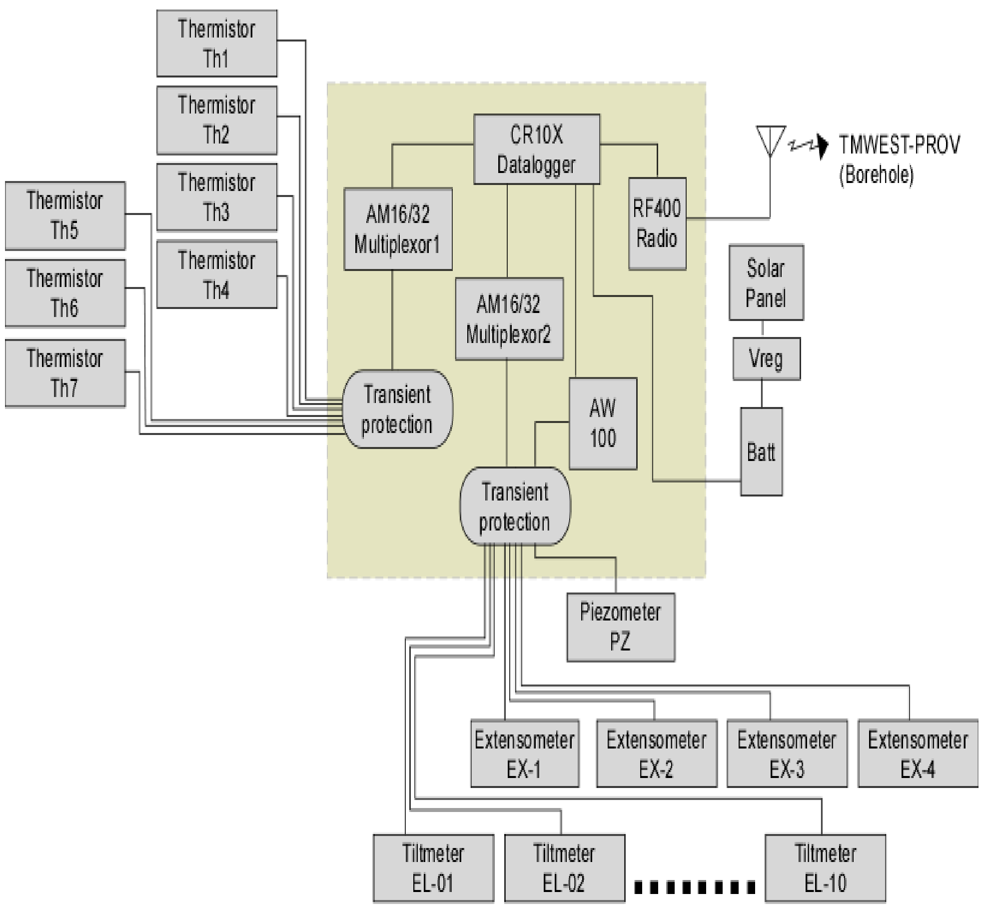


Figure 13. Schematic diagram of telemetry equipment installed at the borehole enclosure.

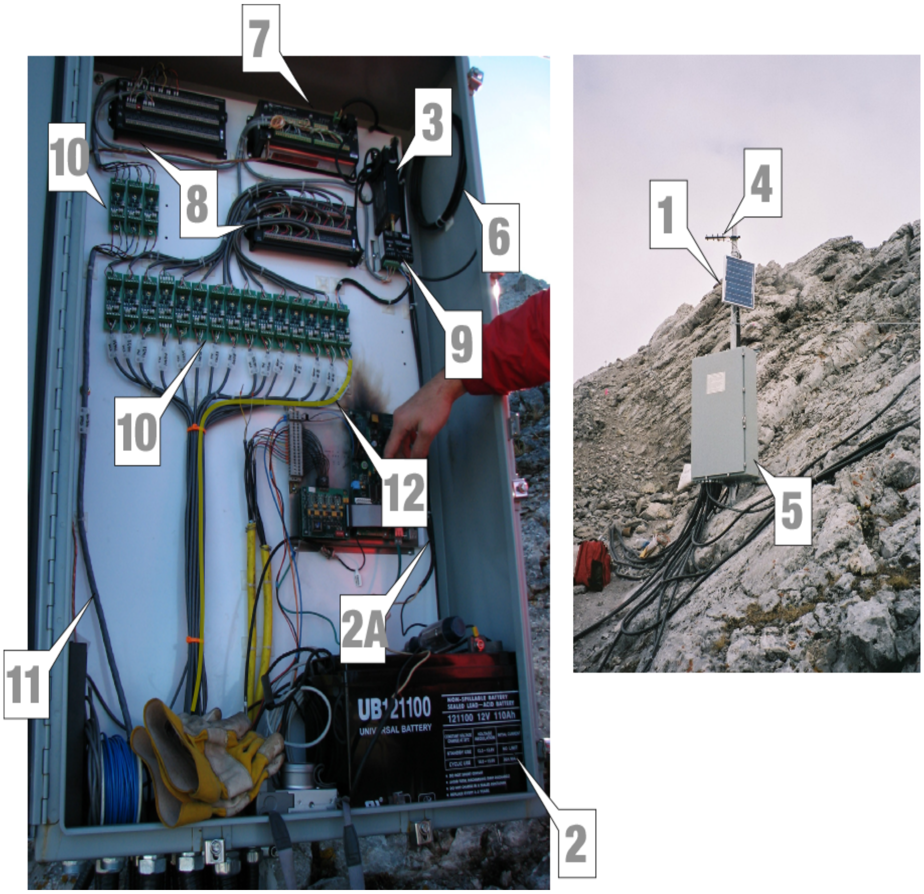


Figure 14. Physical layout of equipment installed at the borehole enclosure. Numbers refer to items in Table 8.

Table 8. Equipment installed at the borehole enclosure.

Borehole

Item	Description	Part Number	Vendor		Qty
	Power Storage and Generation				
1	SOLAR MODULE 20W	56703330		ea	1
	CHARGE CONTROLLER 12 V	INTEGRATED W PANEL			
2	BATTERY	60101162		ea	1
2A	BATTERY CABLE			m	45.5
	Wireless Communication				
3	SPREAD SPECTRUM RADIO	RF400	SLOPE INDICATOR	ea	1
4	ANTENNA (2.4 GHZ)	L14205 YAGGI	SLOPE INDICATOR	ea	1
5	ENCLOSURE NEMA4	SPECIAL	SLOPE INDICATOR	ea	1
6	ANTENNA CABLE	COAX RPSMA-L	SLOPE INDICATOR	m	9
	SURGE PROTECTOR (ANTENNA)			ea	
	Data Acquisition and Pre-processing				
7	DATALOGGER	CR10X	SLOPE INDICATOR	ea	1
8	MULTIPLEXER	56702110	SLOPE INDICATOR	ea	2
9	AW 100 (PIEZOMETER)		SLOPE INDICATOR	ea	1
10	SURGE PROTECTOR (MUX)		SLOPE INDICATOR	ea	15
11	THERMISTOR STRING (W/TEMP. SENSORS)	92600099	SLOPE INDICATOR	ea	1
12	VW PIEZOMETER (W/CABLE)	52611099	SLOPE INDICATOR	ea	1

Table 9. Troubleshooting procedures for equipment at borehole enclosure.

Problem	Possible Cause	Solution
Borehole thermistor data will not update	Defective transient protection module or Multiplexor1	Contact element administrator[1]
Extensometer and tiltmeter data will not update	Defective transient protection module or Multiplexor2	Contact element administrator[1]
Extensometer, tiltmeter and borehole data will not update	Defective borehole radio or data logger	Check connectivity, using procedure in Section 3.5.1.1.

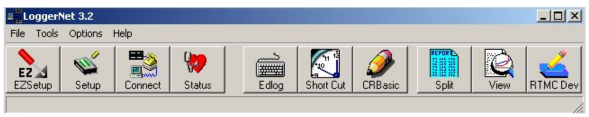
[1] See Appendix 2

3.5.1.1 Communication Test – Borehole

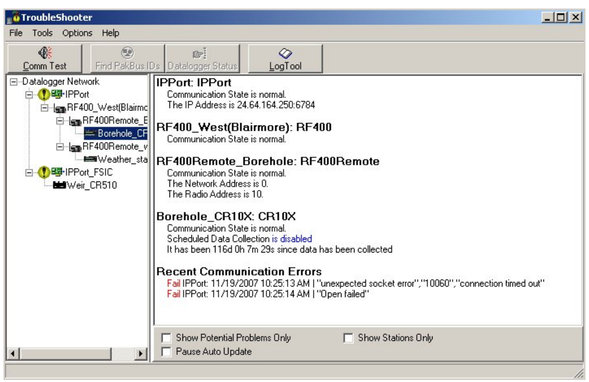
The following procedure will help to assess communication problems between the Provincial Building at Blairmore and the borehole datalogging station, by reviewing the current state of devices in this system.

1 Before proceeding with the communication test, you must verify that LoggerNet data-logger support software from Campbell Scientific is installed on your computer (use procedure in Section 3.5.3). To load LoggerNet, go to Start > All Programs and click on the program.

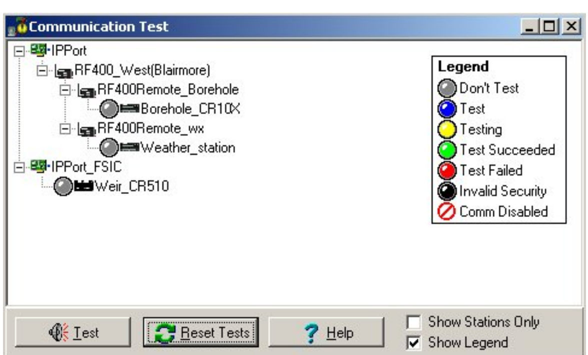
2 To start the communication test, open the Tools menu and select 'TroubleShooter.'



This will open the TroubleShooter window.



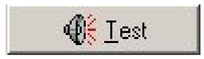
3 Click on the 'Comm Test' button to open the Communication Test window. From this window, you can test the communication link to the data logger station at the borehole.



Helpful Hint

Never test communication between 10 minutes before and 10 minutes after the hour, as this is the time when the network sends data to the server.

4 To initiate the test, click on the Borehole_CR10X data logger to select it (the circle will appear blue) and click the ‘Test’ button.



5 Repeat test several times if initial test fails (red circle). Click the ‘Reset Test’ button to clear the test results before running the test again.

6 Consistently ‘Failed’ test results indicate malfunctioning equipment. Contact element administrator (*see* Appendix 2)

7 To identify the malfunctioning device, highlight the Borehole_CR10X data logger in the TroubleShooter window. Status information will display on the right side of the window.

8 Use the following table to interpret the results:

Comm State	Device Status
Normal	Great
Marginal	Good
Critical	Malfunctioning

3.5.2 Weather Station

A Campbell Scientific model CR10X data logger gathers weather and crack-displacement data, recorded by the weather station and the crack-gauge network at the top of Turtle Mountain, and telemeters them to the Blairmore Provincial Building via a 900 MHz spread-spectrum digital radio link (Figure 1). There, a Network Link Interface (NIL) converts the data stream to standard Ethernet format and then transferred it to the FSIC via a 5.3/5.8 GHz radio link (Moreno and Froese, 2006). The data are then stored in a MySQL database on the server. Figure 15 is a block diagram that shows how the equipment at the borehole enclosure is connected. Figure 16 shows the physical layout of the equipment and Table 10 provides a detailed inventory of the equipment. Table 11 contains troubleshooting procedures.

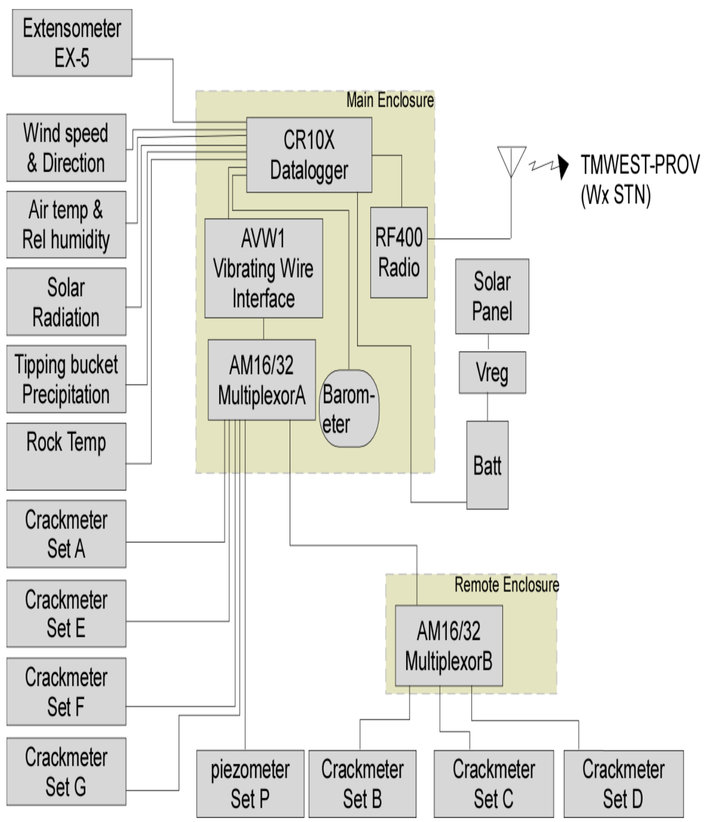


Figure 15. Schematic diagram of telemetry equipment installed at the weather station.

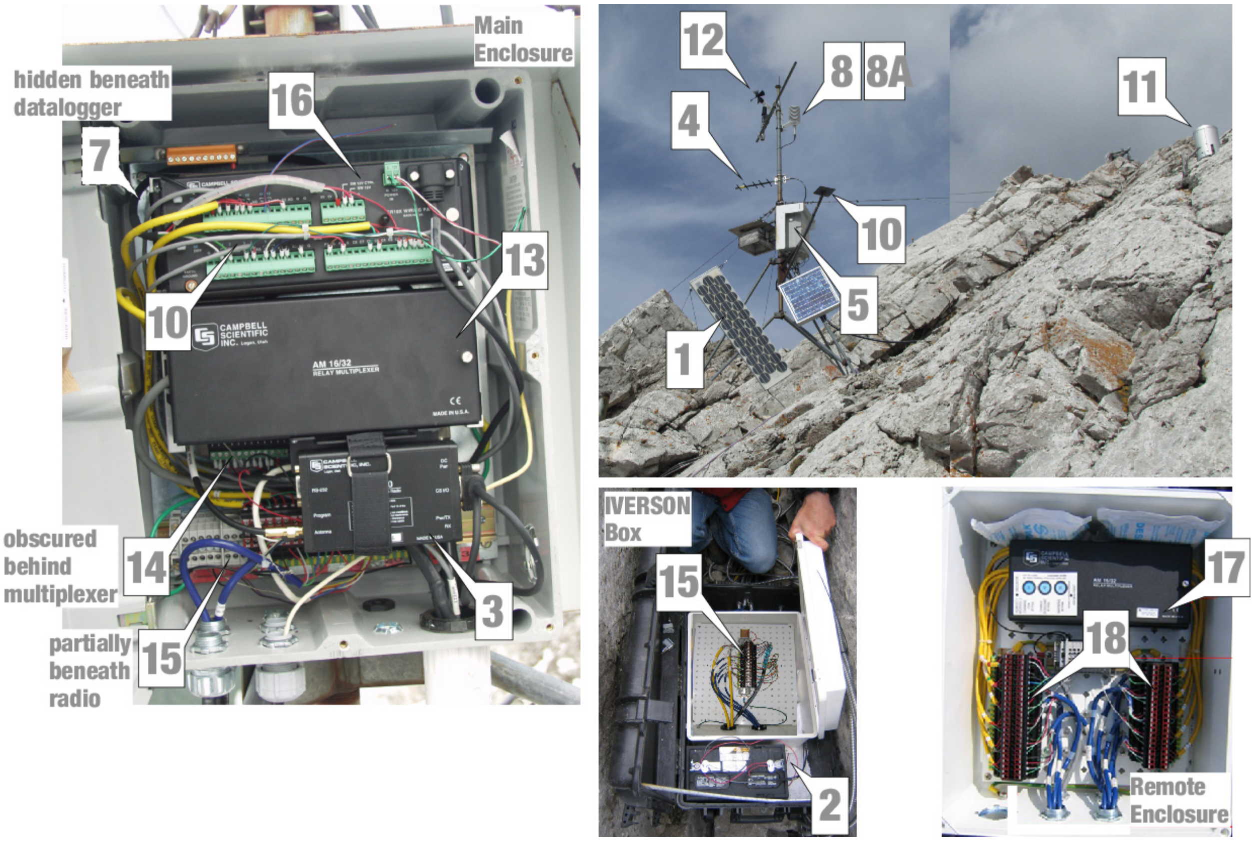


Figure 16. Physical layout of equipment installed at weather station. Numbers refer to items in Table 10.

Table 10. Equipment installed at weather station.

Item	Description	Part Number	Vendor		Qty
	Power Storage and Generation				
1	SOLAR MODULE 35W	PRC 12100	SOLTEK	ea	1
	CHARGE CONTROLLER 12 V		PHOTRON	ea	1
2	BATTERY	PRC 12100	SOLTEK	ea	1
	Wireless Communication				
3	SPREAD SPECTRUM RADIO	RF400	CAMPBELL	ea	1
4	ANTENNA (2.4 GHZ)	L14201 YAGGI	CAMPBELL	ea	1
5	ENCLOSURE NEMA4		CAMPBELL	ea	1
	SURGE PROTECTOR (ANTENNA)	L14462	CAMPBELL	ea	1
6	ENCLOSURE NEMA4 (MUX BOX)	ENC 12/14	CAMPBELL	ea	1
	Data Acquisition and Pre-processing				
7	BAROMETRIC PRESSURE	61205V	CAMPBELL	ea	1
8A	TEMP PROBE W REL. HUMIDITY	HMP45CF	CAMPBELL	ea	1
8	10 PLATE RADIATION SHIELD	41003-2	CAMPBELL	ea	1
9	TEMP PROBE W 7.5m CABLE	107B	CAMPBELL	ea	1
10	PYRANOMETER	LI200S	CAMPBELL	ea	1
11	TIPPING BUCKET RAIN GAUGE		CAMPBELL	ea	1
12	WIND MONITOR	05 103-10	CAMPBELL	ea	1
13	MULTIPLEXOR (Wx STN)	AM16/32	CAMPBELL	ea	1
14	VIBRATING WIRE INTERFACE (Wx STN)	AVW1	CAMPBELL	ea	1
15	SURGE PROTECTORS (Wx STN)	TT-SLKK5-F/110AC	PHOENIX	ea	32
16	DATALOGGER (Wx STN)	CR10X-55	CAMPBELL	ea	1
17	MULTIPLEXOR (MUX BOX)	AM16/32	CAMPBELL	ea	1
18	SURGE PROTECTORS (MUX BOX)		PHOENIX	ea	44

Table 11. Troubleshooting procedures for equipment at weather station.

Problem	Possible Cause	Solution
Data from crackmeters sets B, C and D will not update	Defective Multiplexor (remote enclosure) or signal cable	Contact element administrator[1]
Data from crackmeter sets A through G data will not update	Defective vibrating wire interface and/or defective Multiplexor (main enclosure)	Contact element administrator[1]
Crackmeter, extensometer and weather data will not update	Defective weather station radio or data logger	Check connectivity, using procedure in Section 3.5.2.1.

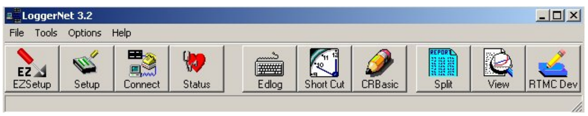
[1] *See* Appendix 2

3.5.2.1 Communication Test – Weather Station

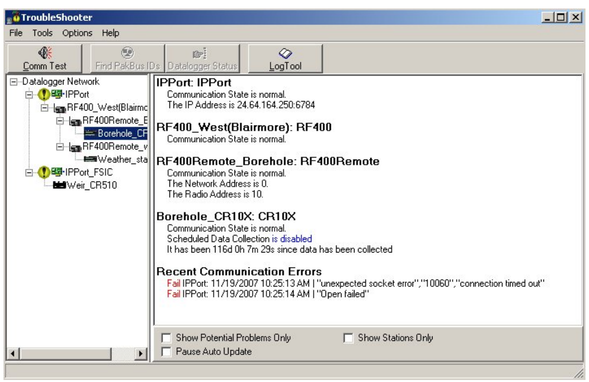
The following procedure will help to assess communication problems between the Provincial Building at Blairmore and the datalogging system at the weather station, by reviewing the current state of devices in the network link of the reference.

1 Before proceeding with the communication test, you must verify that LoggerNet data-logger support software from Campbell Scientific is installed on your computer (use procedure in Section 3.5.3). To load LoggerNet, go to Start > All Programs and click on the program.

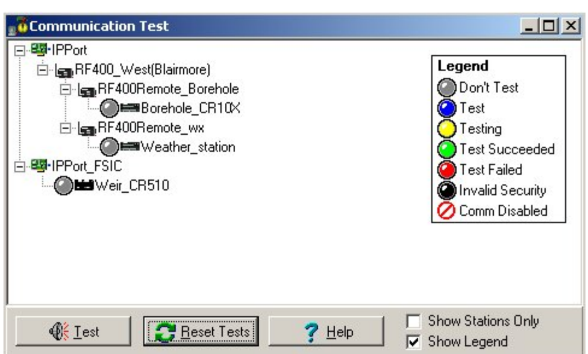
2 To start the communication test, open the Tools menu and select 'Troubleshooter.'



This will open the 'Troubleshooter' window.



3 Click on the 'Comm Test' button to open the Communication Test window. From this window, you can test the communication link to the data logger station at the borehole.



Helpful Hint

Never test communication between 10 minutes before and 10 minutes after the hour, as this is the time when the network sends data to the server.

4 To initiate the test, click on the Weather_station data logger to select it (the circle will appear blue) and click the ‘Test’ button.

5 Repeat test several times if initial test fails (red circle). Click the ‘Reset Test’ button to clear the test results before running the test again.

6 Consistently ‘Failed’ test results indicate malfunctioning equipment. Contact element administrator (*see* Appendix 2)

7 To identify the malfunctioning device, highlight the Weather_station data logger in the TroubleShooter window. Status information will display on the right side of the window.

8 Use the following table to interpret the results:

Comm State	Device Status
Normal	Great
Marginal	Good
Critical	Malfunctioning

3.5.3 Initial Set-up of LoggerNet

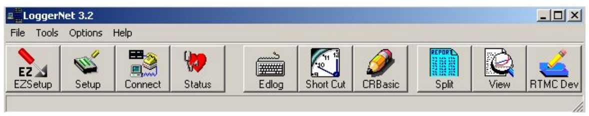
The following procedure will help to configure the communication network, which is monitored using LoggerNet (http://www.campbellsci.ca/Catalogue/LoggerNet.html). Configure the network by adding each device to the network map in the order that it appears in the actual communication link. Each device has unique settings that are entered in the software to configure it for the communication link.

1

Open LoggerNet either by double-clicking on the desktop icon or going to Start > All Programs > LoggerNet and clicking on the program.

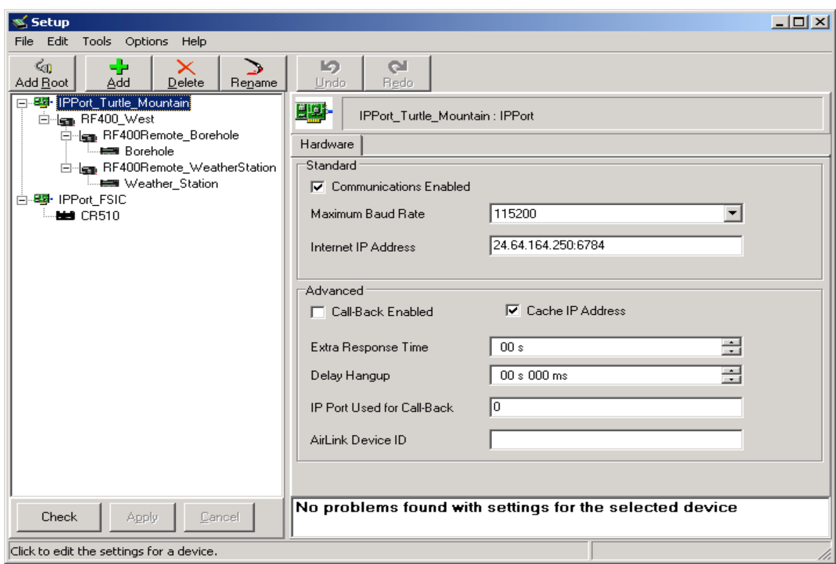
2

Click on the 'Setup' button in the LoggerNet toolbar to open the Setup screen.



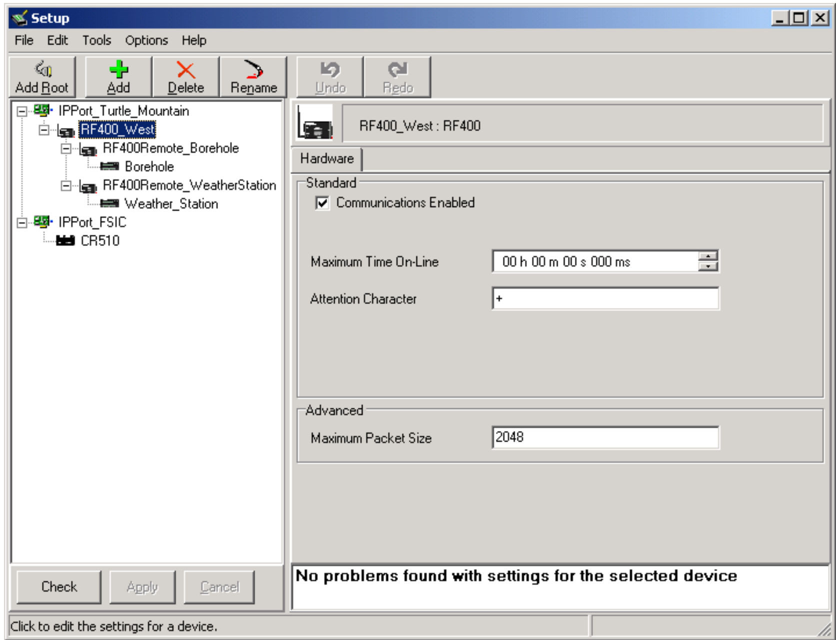
3

Click on the 'Add Root' button and select **IPPort** (Internet connection port). The new root should appear in the left window. Click on the 'Rename' button and change the name to **IPPort_Turtle_Mountain**. Enter the following value for the Internet IP Address: 24.64.164.250:6784.



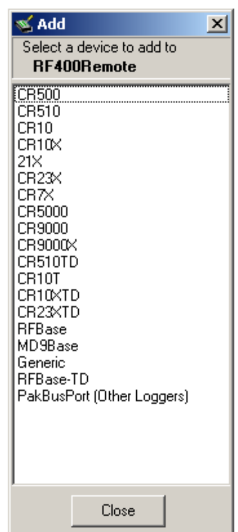
4

Click on the 'Add' button and select 'RF400.' Rename this device as 'RF400_West' and leave all settings at the default values.

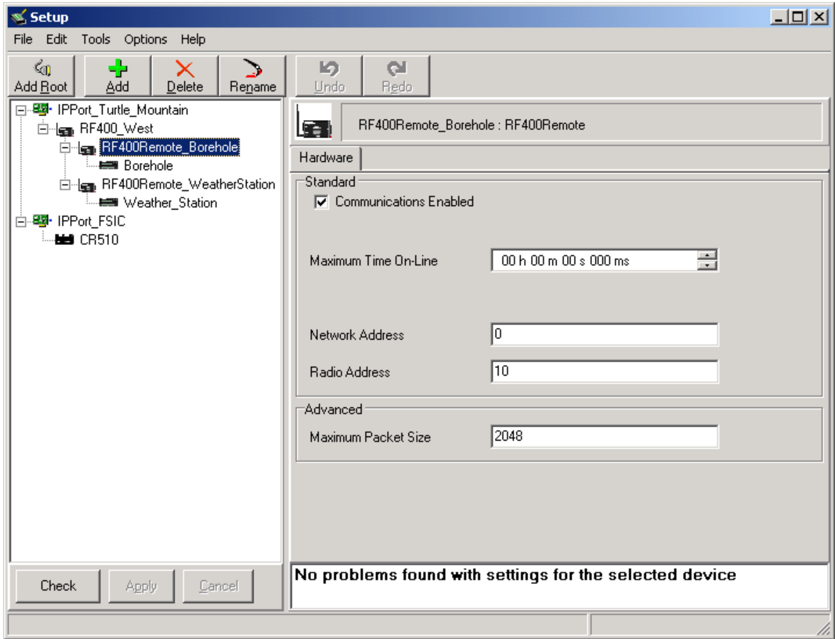


5

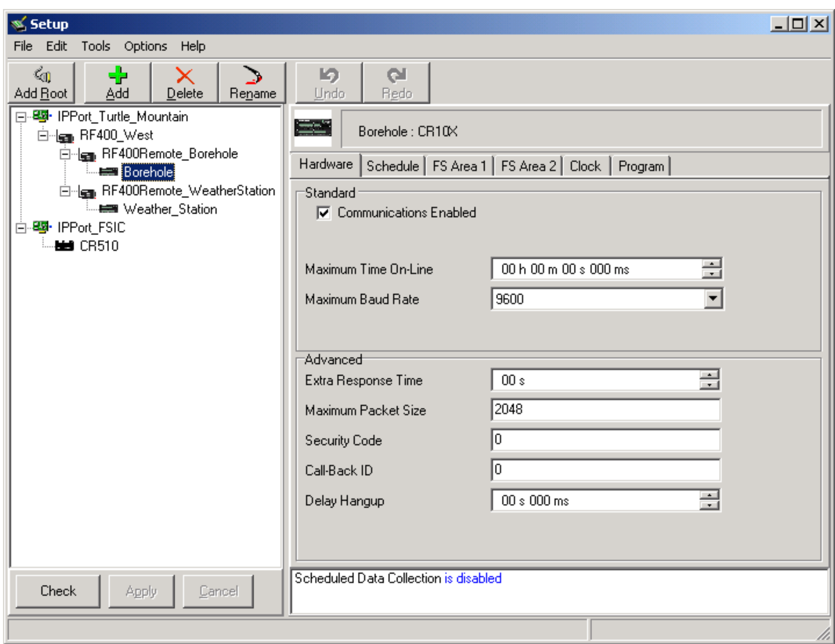
Click on the ‘Add’ button and select ‘RF400Remote.’ Another dialogue box will open displaying only those devices that are valid connections for the RF400Remote device (see below). Select ‘CR10X.’

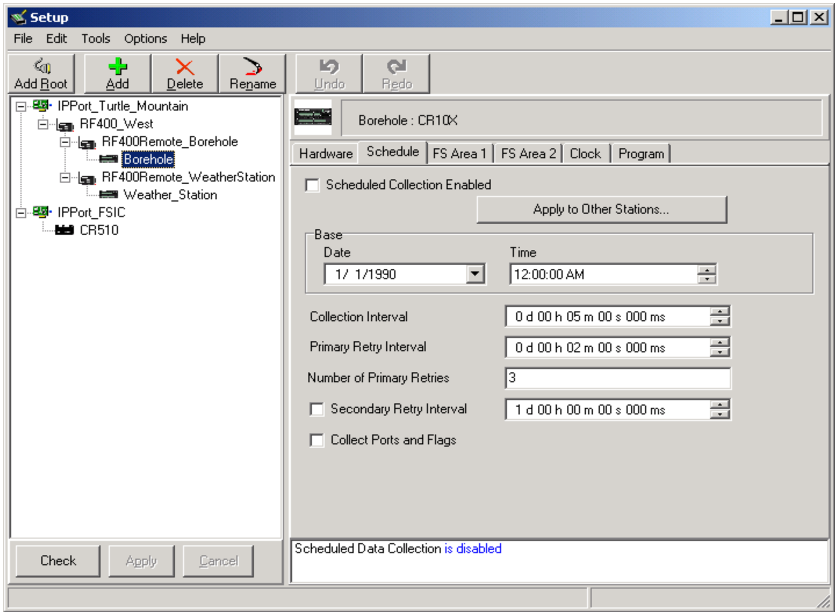


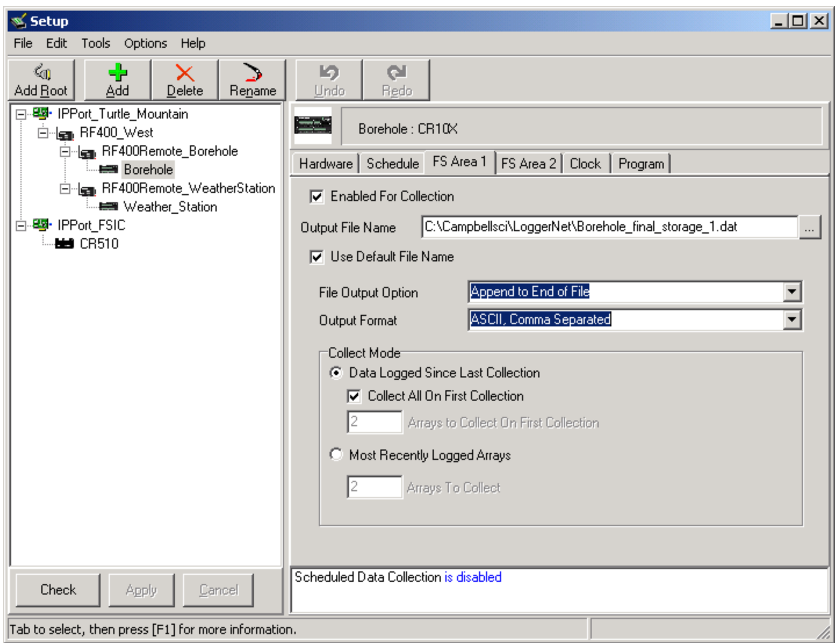
Rename ‘RF400Remote’ as ‘**RF400Remote_Borehole’** and rename ‘CR10X’ as ‘Borehole.’ With RF400Remote_Borehole highlighted, change the Radio Address to ’10,’ as shown below.

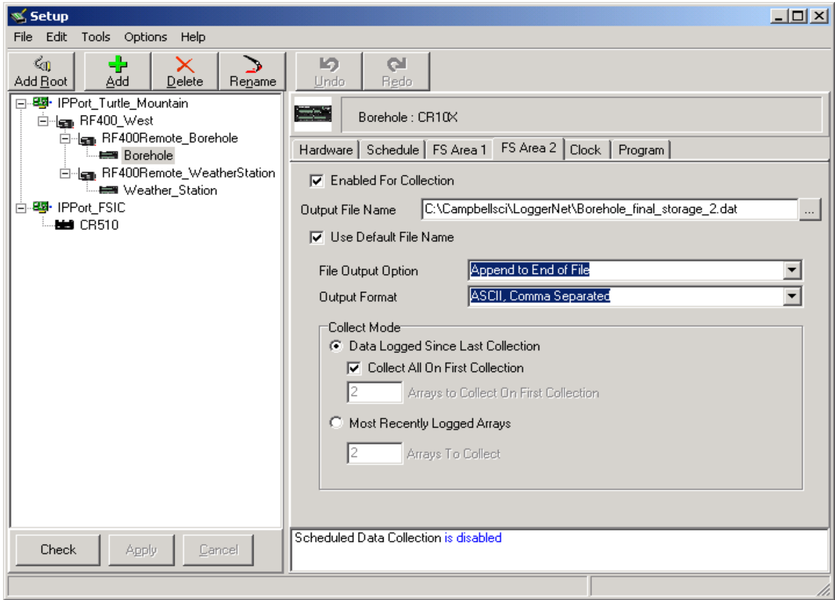


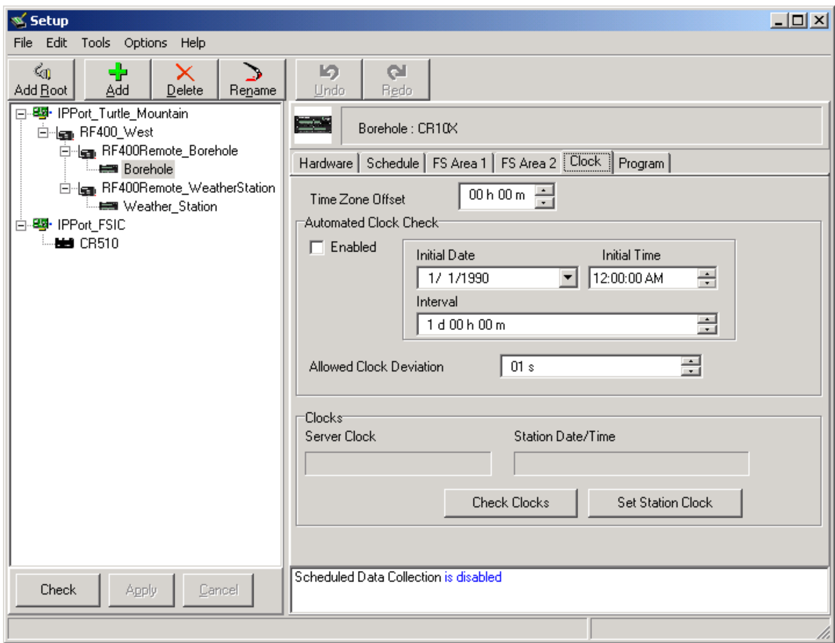
6 With the Borehole CR10X highlighted, ensure that your setup matches the dialogue boxes in following screenshots:

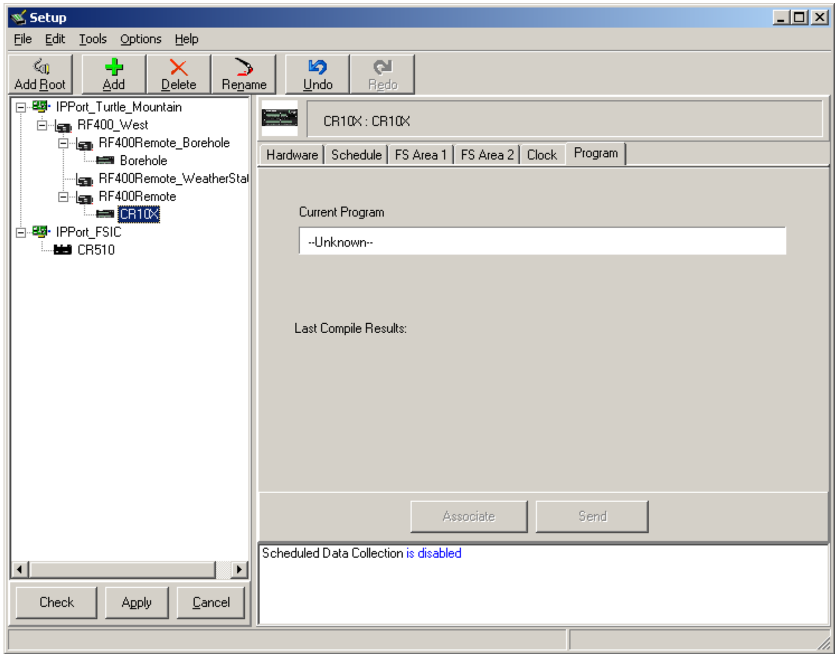



Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
Borehole : CR10X
Hardware
Schedule
FS Area 1
FS Area 2
Clock
Program
Scheduled Collection Enabled
Apply to Other Stations...
Base
Date
1/ 1/1990
Time
12:00:00 AM
Collection Interval
0 d 00 h 05 m 00 s 000 ms
Primary Retry Interval
0 d 00 h 02 m 00 s 000 ms
Number of Primary Retries
3
Secondary Retry Interval
1 d 00 h 00 m 00 s 000 ms
Collect Ports and Flags
Check
Apply
Cancel
Scheduled Data Collection is disabled

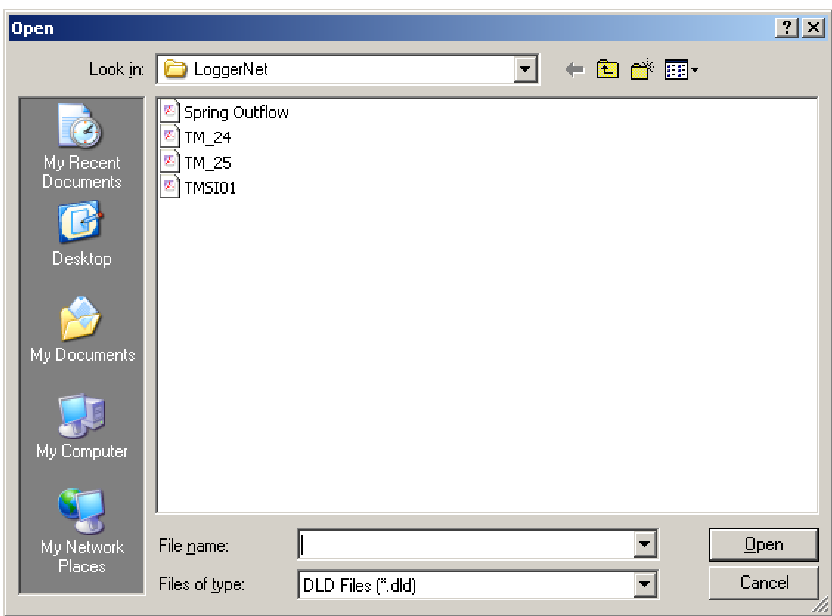

Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
Borehole : CR10X
Hardware
Schedule
FS Area 1
FS Area 2
Clock
Program
Enabled For Collection
Output File Name
C:\Campbellsci\LoggerNet\Borehole_final_storage_1.dat
Use Default File Name
File Output Option
Append to End of File
Output Format
ASCII, Comma Separated
Collect Mode
Data Logged Since Last Collection
Collect All On First Collection
2
Arrays to Collect On First Collection
Most Recently Logged Arrays
2
Arrays To Collect
Check
Apply
Cancel
Scheduled Data Collection is disabled
Tab to select, then press [F1] for more information.


Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
Borehole : CR10X
Hardware Schedule FS Area 1 FS Area 2 Clock Program
Enabled For Collection
Output File Name
C:\Campbellsci\LoggerNet\Borehole_final_storage_2.dat
Use Default File Name
File Output Option
Append to End of File
Output Format
ASCII, Comma Separated
Collect Mode
Data Logged Since Last Collection
Collect All On First Collection
Arrays to Collect On First Collection
Most Recently Logged Arrays
Arrays To Collect
Check
Apply
Cancel
Scheduled Data Collection is disabled

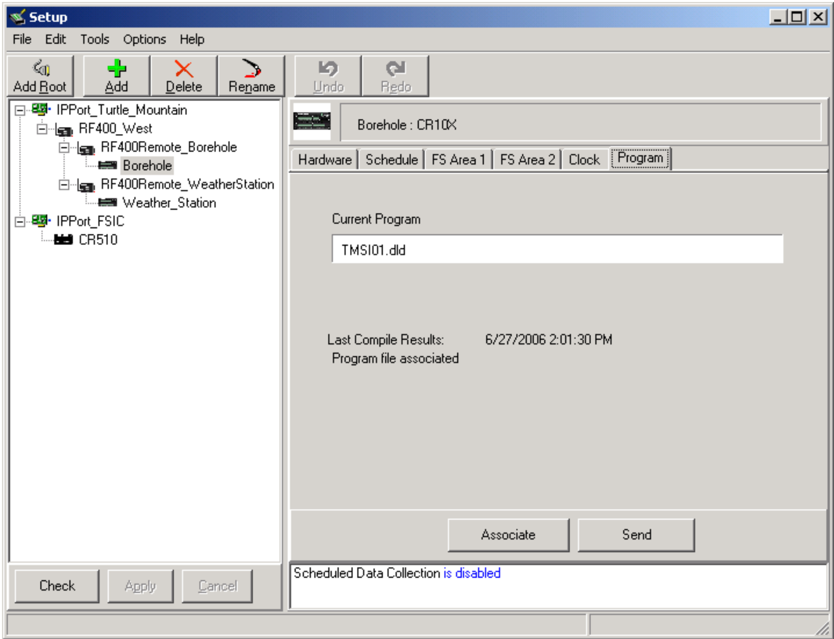

Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
Borehole : CR10X
Hardware Schedule FS Area 1 FS Area 2 Clock Program
Time Zone Offset
00 h 00 m
Automated Clock Check
Enabled
Initial Date
Initial Time
1/ 1/1990
12:00:00 AM
Interval
1 d 00 h 00 m
Allowed Clock Deviation
01 s
Clocks
Server Clock
Station Date/Time
Check Clocks
Set Station Clock
Check
Apply
Cancel
Scheduled Data Collection is disabled



Click the ‘Apply’ button to save the changes you have made. After you have clicked ‘Apply,’ the ‘Associate’ button will allow you to select the name of the program that is already running in the data logger. Click on it and, in the resulting Open window, navigate to TMSI01.dld at the [project drive.



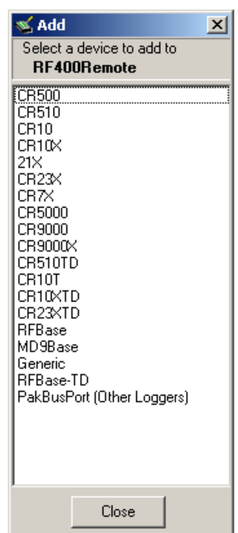
The name of the file will appear in the ‘Current Program’ field of the Setup dialogue box, as shown below.

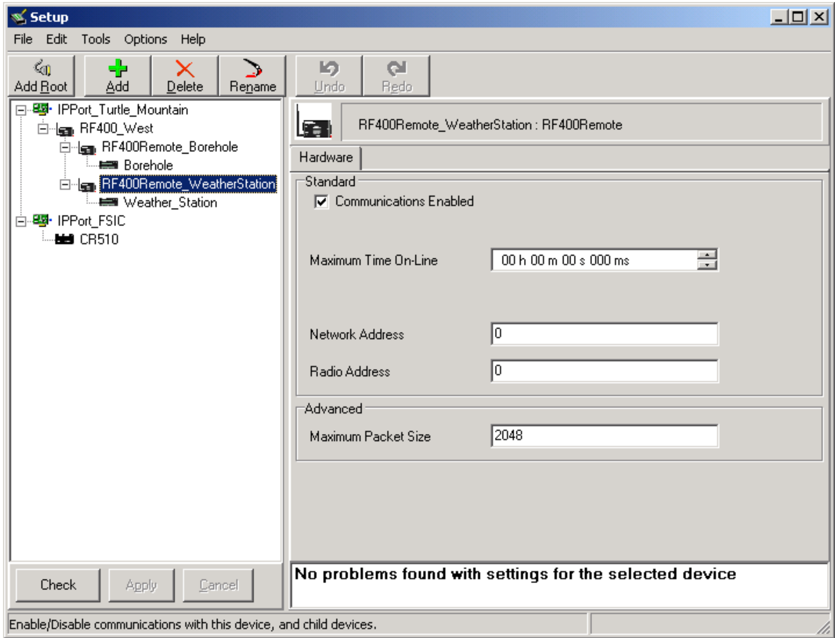


Now the Borehole CR10X is programmed properly.

7

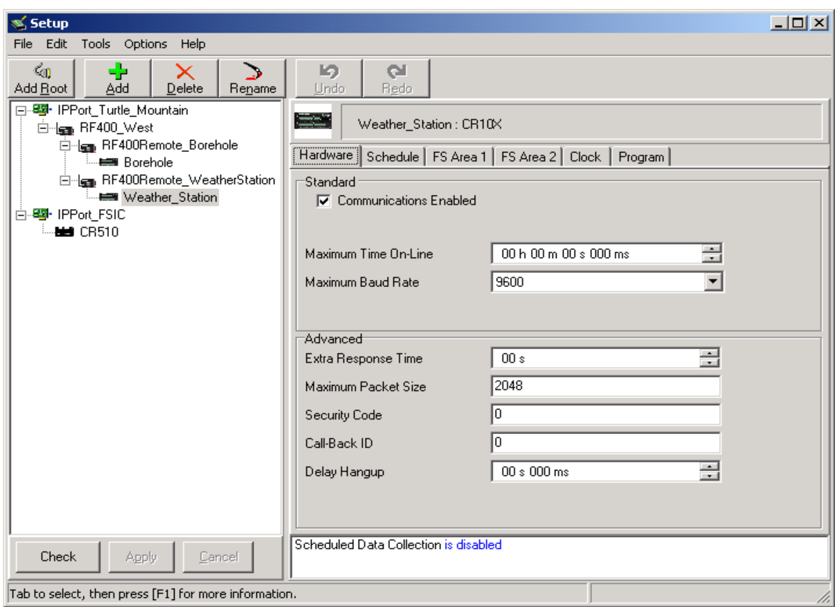
Click on the 'Add' button and select 'RF400Remote.' In the dialogue box that opens, select 'CR10X.' Rename 'RF400Remote' as 'RF400Remote_WeatherStation,' and rename 'CR10X' as 'Weather_Station.'

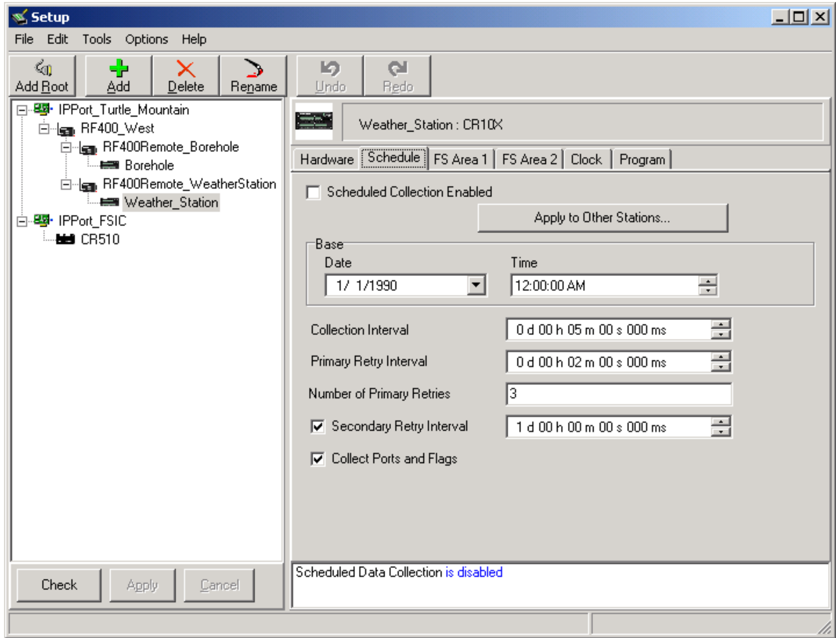


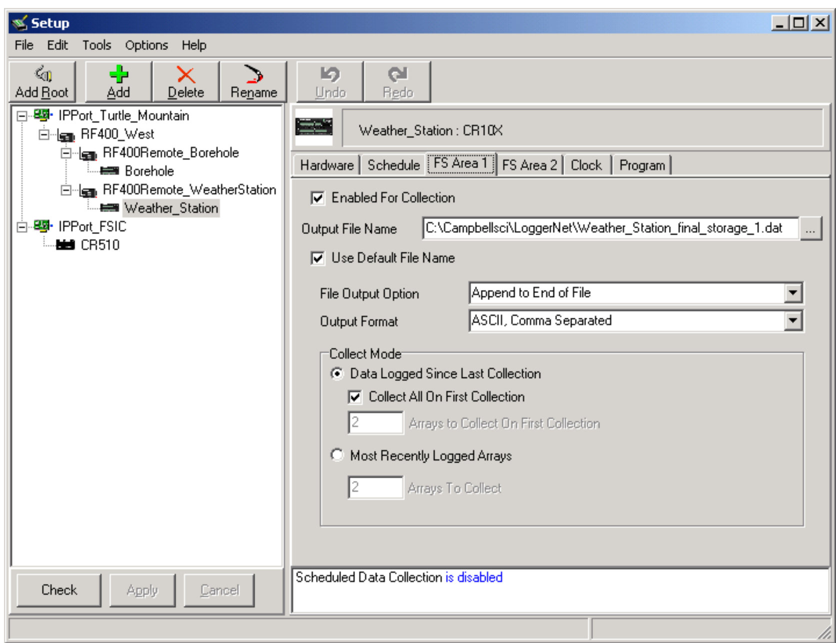


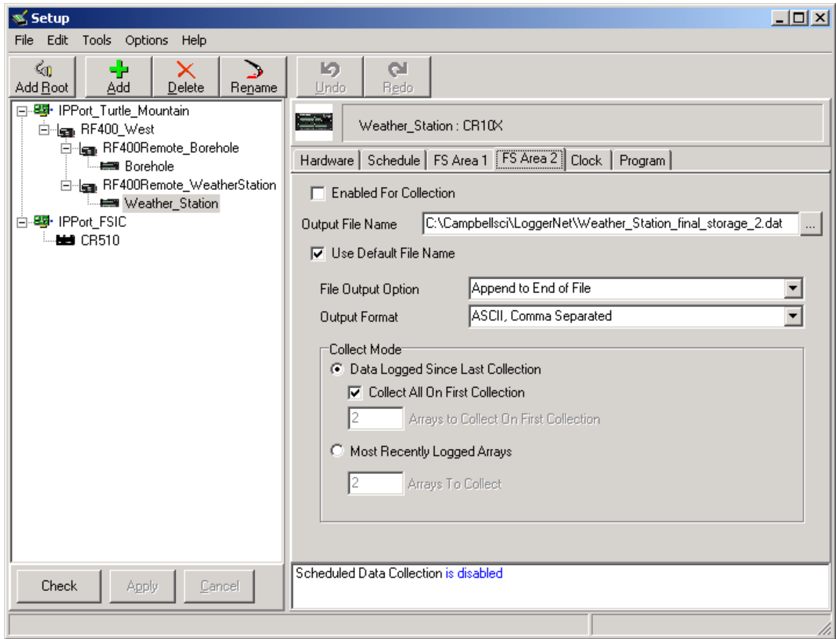
8

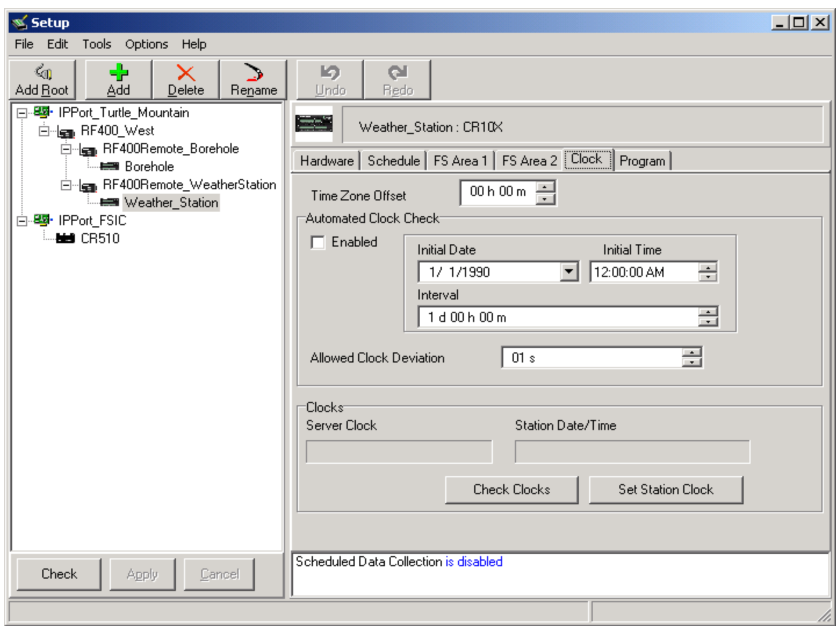
With the Weather_Station CR10X highlighted, ensure your setup matches the dialogue boxes in the following screenshots:

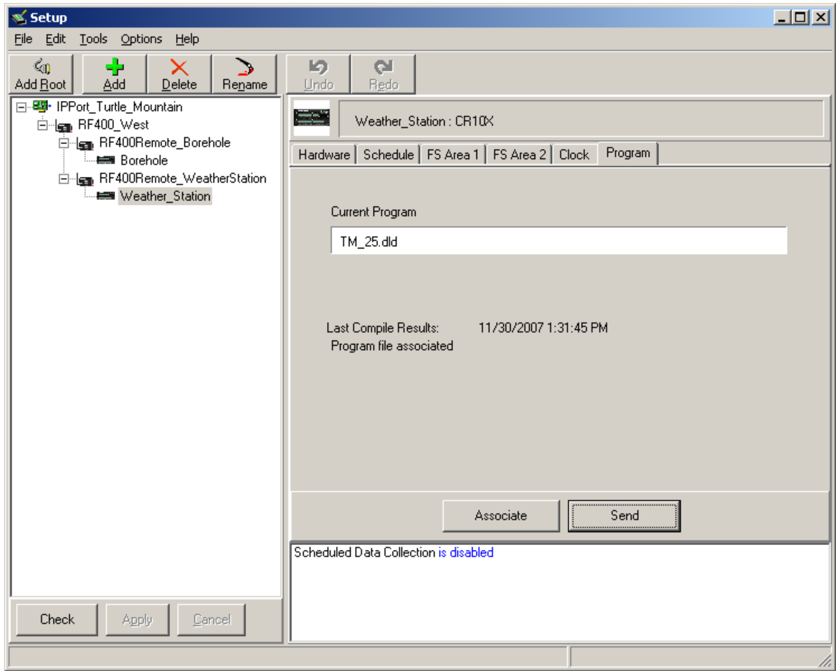



Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
Weather_Station : CR10X
Hardware
Schedule
FS Area 1
FS Area 2
Clock
Program
Scheduled Collection Enabled
Apply to Other Stations...
Base
Date
Time
1/ 1/1990
12:00:00 AM
Collection Interval
0 d 00 h 05 m 00 s 000 ms
Primary Retry Interval
0 d 00 h 02 m 00 s 000 ms
Number of Primary Retries
3
Secondary Retry Interval
1 d 00 h 00 m 00 s 000 ms
Collect Ports and Flags
Check
Apply
Cancel
Scheduled Data Collection is disabled

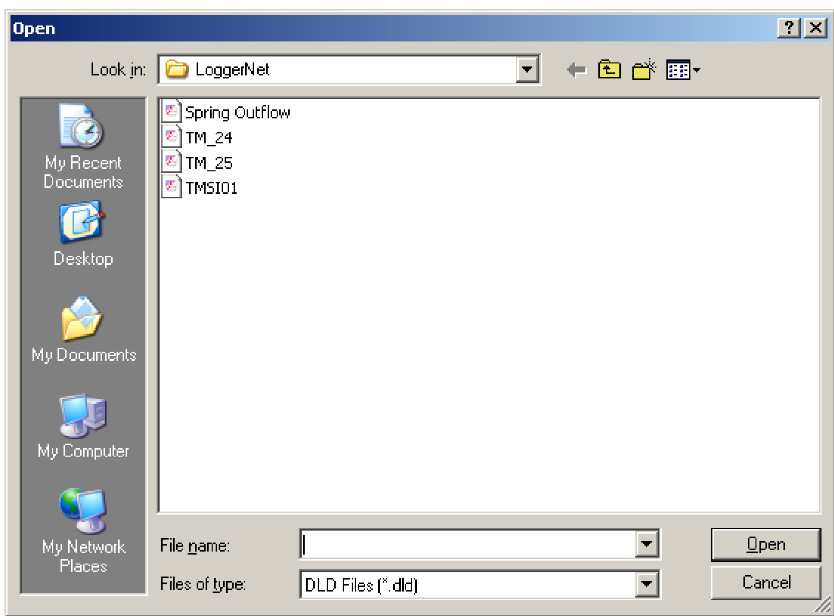

Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
Weather_Station : CR10X
Hardware
Schedule
FS Area 1
FS Area 2
Clock
Program
Enabled For Collection
Output File Name
C:\Campbellsci\LoggerNet\Weather_Station_final_storage_1.dat
Use Default File Name
File Output Option
Append to End of File
Output Format
ASCII, Comma Separated
Collect Mode
Data Logged Since Last Collection
Collect All On First Collection
2
Arrays to Collect On First Collection
Most Recently Logged Arrays
2
Arrays To Collect
Check
Apply
Cancel
Scheduled Data Collection is disabled


Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
Weather_Station : CR10X
Hardware
Schedule
FS Area 1
FS Area 2
Clock
Program
Enabled For Collection
Output File Name
C:\Campbellsci\LoggerNet\Weather_Station_final_storage_2.dat
Use Default File Name
File Output Option
Append to End of File
Output Format
ASCII, Comma Separated
Collect Mode
Data Logged Since Last Collection
Collect All On First Collection
2
Arrays to Collect On First Collection
Most Recently Logged Arrays
2
Arrays To Collect
Check
Apply
Cancel
Scheduled Data Collection is disabled


Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
Weather_Station : CR10X
Hardware
Schedule
FS Area 1
FS Area 2
Clock
Program
Time Zone Offset
00 h 00 m
Automated Clock Check
Enabled
Initial Date
1/ 1/1990
Initial Time
12:00:00 AM
Interval
1 d 00 h 00 m
Allowed Clock Deviation
01 s
Clocks
Server Clock
Station Date/Time
Check Clocks
Set Station Clock
Check
Apply
Cancel
Scheduled Data Collection is disabled

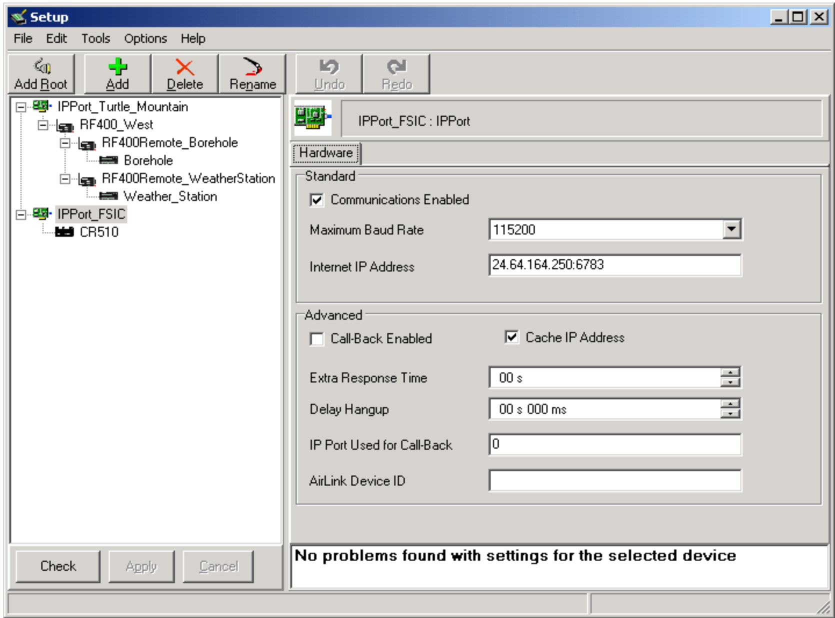


Click the **APPLY** button to save the changes you have made. Then click the 'Associate' button and, in the resulting OPEN window, navigate to TM_25.dld at the project drive.

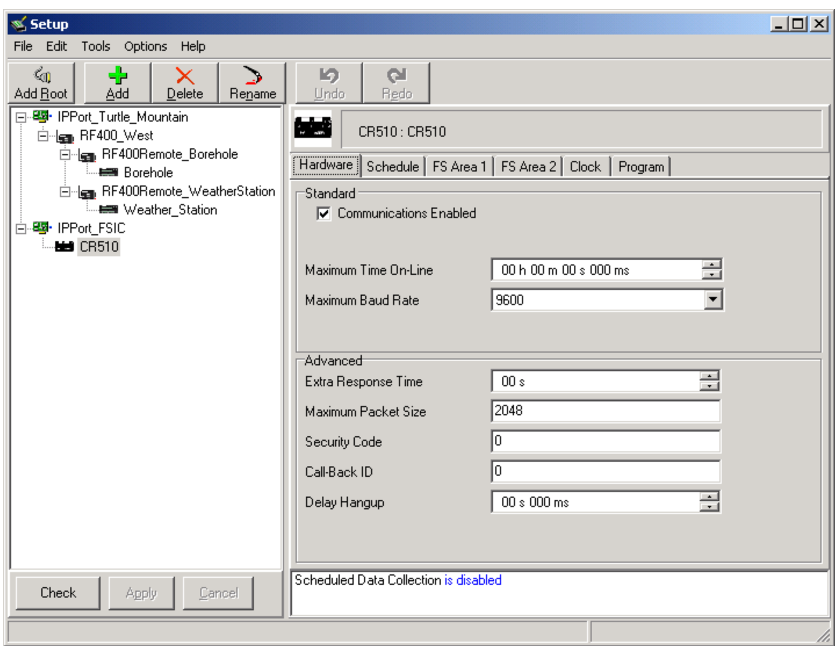


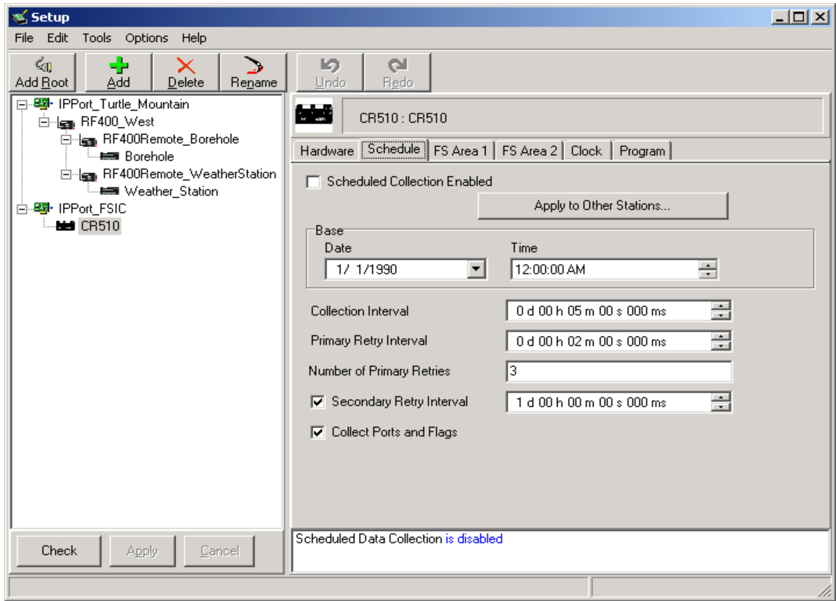
The name of the file will then display in the 'Current Program' field. Now the Weather_Station CR10X is programmed properly.

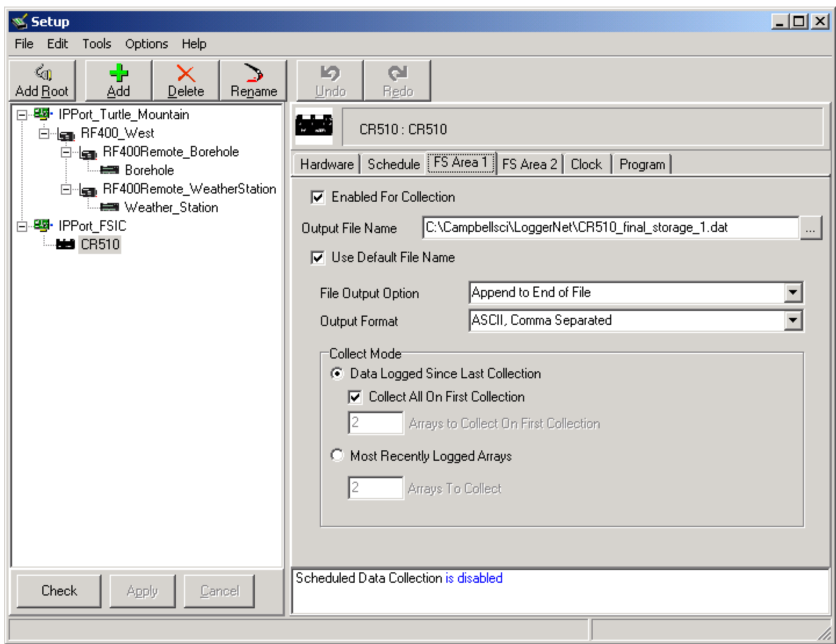
9 Click the ‘Add Root’ button and select **IPPort**. The new root should appear in the left window. Click the ‘Rename’ button and change the name to ‘IPPort_FSIC.’ Enter the following value for the Internet IP Address: 24.64.164.250:6783.

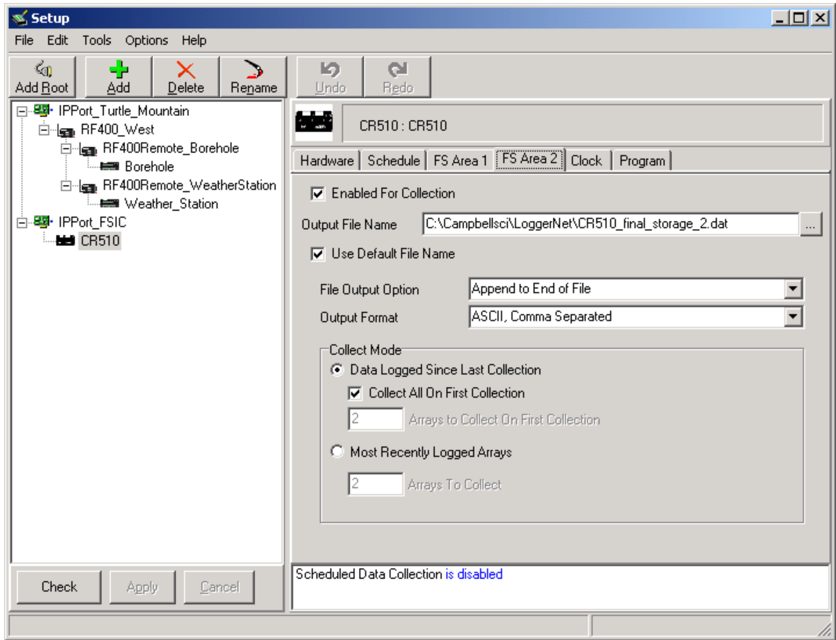


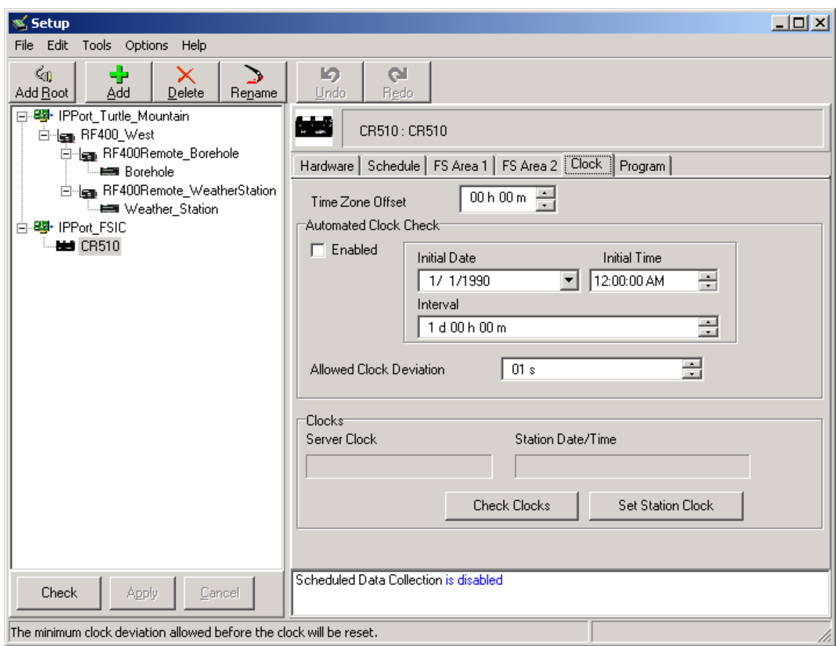
10 Click the ‘Add’ button and select ‘CR510;’ although it’s not required, but you can rename this as ‘Weir.’ With the CR510 highlighted, ensure your setup matches the dialogue boxes in the following screenshots:

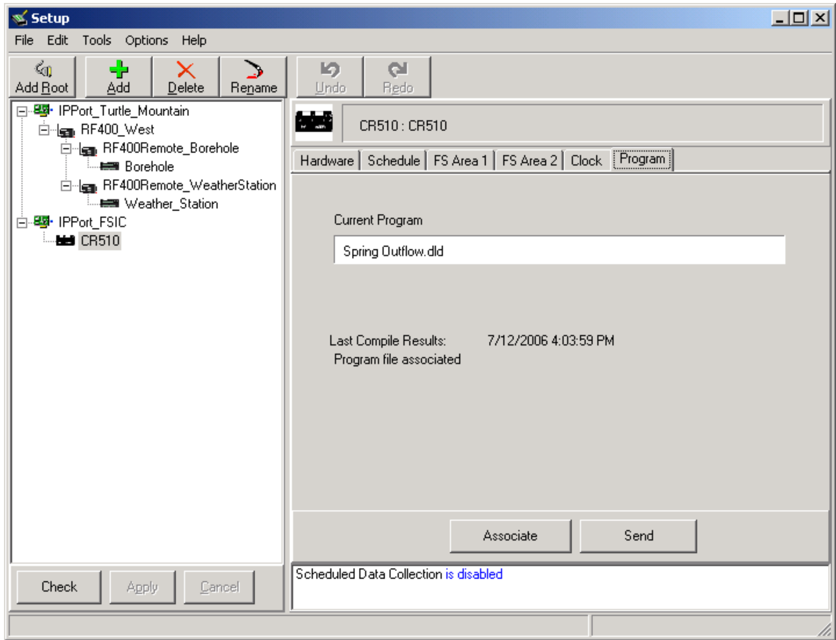



Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
CR510 : CR510
Hardware
Schedule
FS Area 1
FS Area 2
Clock
Program
Scheduled Collection Enabled
Apply to Other Stations...
Base
Date
1/ 1/1990
Time
12:00:00 AM
Collection Interval
0 d 00 h 05 m 00 s 000 ms
Primary Retry Interval
0 d 00 h 02 m 00 s 000 ms
Number of Primary Retries
3
Secondary Retry Interval
1 d 00 h 00 m 00 s 000 ms
Collect Ports and Flags
Check
Apply
Cancel
Scheduled Data Collection is disabled

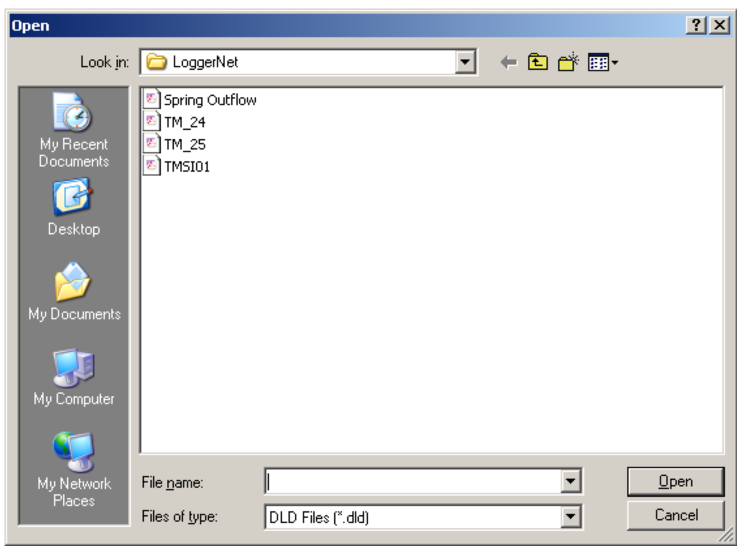

Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
CR510 : CR510
Hardware
Schedule
FS Area 1
FS Area 2
Clock
Program
Enabled For Collection
Output File Name
C:\Campbellsci\LoggerNet\CR510_final_storage_1.dat
Use Default File Name
File Output Option
Append to End of File
Output Format
ASCII, Comma Separated
Collect Mode
Data Logged Since Last Collection
Collect All On First Collection
2
Arrays to Collect On First Collection
Most Recently Logged Arrays
2
Arrays To Collect
Check
Apply
Cancel
Scheduled Data Collection is disabled


Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
CR510 : CR510
Hardware
Schedule
FS Area 1
FS Area 2
Clock
Program
Enabled For Collection
Output File Name
C:\Campbellsci\LoggerNet\CR510_final_storage_2.dat
Use Default File Name
File Output Option
Append to End of File
Output Format
ASCII, Comma Separated
Collect Mode
Data Logged Since Last Collection
Collect All On First Collection
Arrays to Collect On First Collection
Most Recently Logged Arrays
Arrays To Collect
Check
Apply
Cancel
Scheduled Data Collection is disabled


Setup
File Edit Tools Options Help
Add Root
Add
Delete
Rename
Undo
Redo
IPPort_Turtle_Mountain
RF400_West
RF400Remote_Borehole
Borehole
RF400Remote_WeatherStation
Weather_Station
IPPort_FSIC
CR510
CR510 : CR510
Hardware
Schedule
FS Area 1
FS Area 2
Clock
Program
Time Zone Offset
00 h 00 m
Automated Clock Check
Enabled
Initial Date
1/ 1/1990
Initial Time
12:00:00 AM
Interval
1 d 00 h 00 m
Allowed Clock Deviation
01 s
Clocks
Server Clock
Station Date/Time
Check Clocks
Set Station Clock
Check
Apply
Cancel
Scheduled Data Collection is disabled
The minimum clock deviation allowed before the clock will be reset.



Click the 'Apply' button to save the changes you have made. Then click the 'Associate' button and, in the resulting OPEN window, navigate to Spring Outflow.dld on the project drive.



The Setup for LoggerNet is now complete.

3.5.4 Radio Station

The communications backbone of the real-time GPS system is the primary radio system near South Peak. Data from all nine GPS stations is collected by a dual-band Smartbridges radio, which acts as both the 2.4 GHz access point (AP) for all GPS units and a 5 GHz backhaul link (PROV-GPS) for the data to the Blairmore Provincial Building (Figure 1) and ultimately to Vancouver for processing (Moreno and Froese, 2008). It is expected that, by summer 2010, these data will be transmitted to the FSIC server. Figure 17 is a block diagram that shows how the equipment at the South Peak radio station enclosure is connected. Figure 18 shows the physical layout of the equipment and Table 12 provides a detailed inventory of the equipment and Table 3 contains troubleshooting procedures.

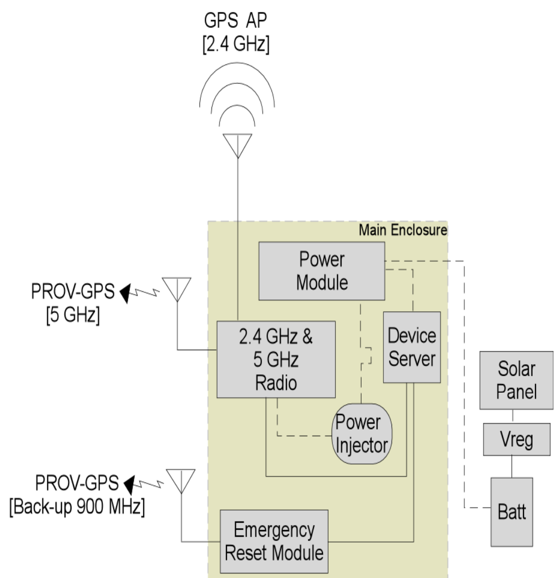


Figure 17. Schematic diagram of telemetry equipment installed at the South Peak radio station.

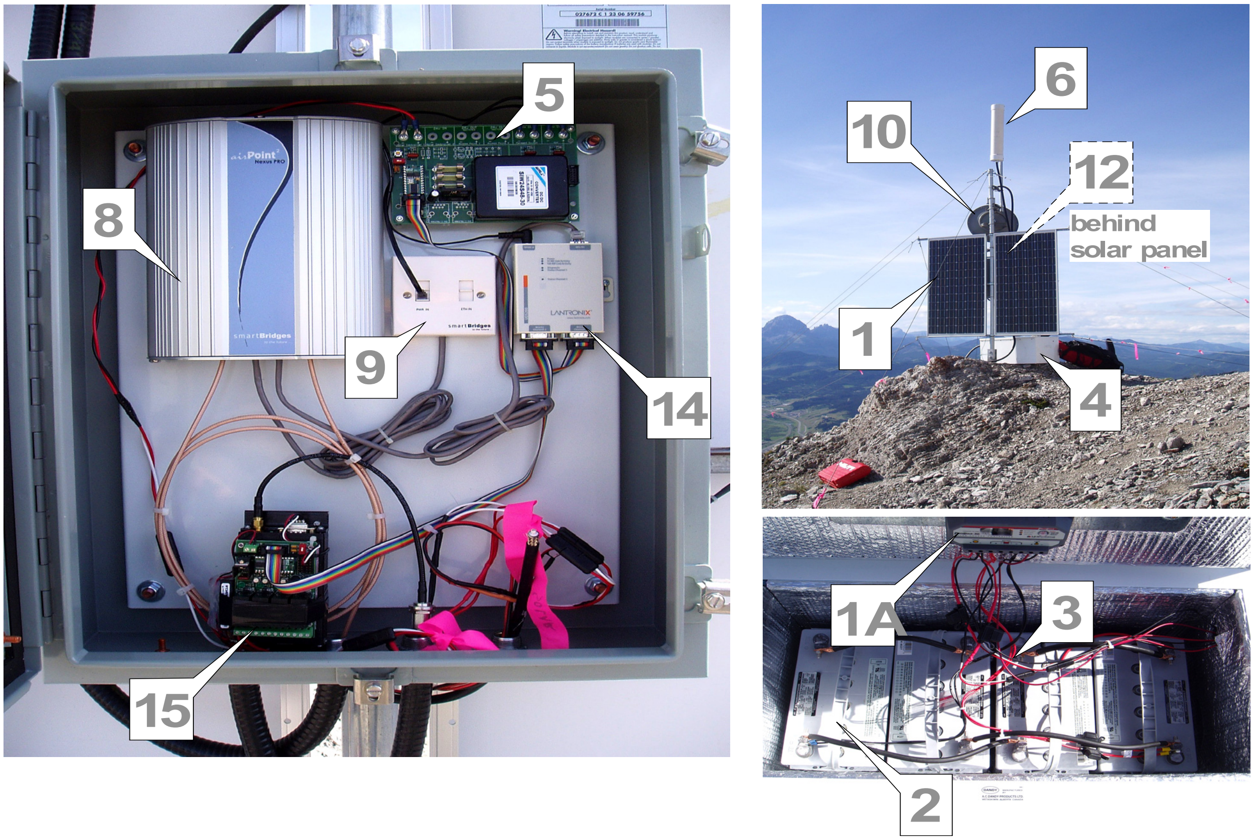


Figure 18. Physical layout of equipment installed at the South Peak radio station. Numbers refer to items in Table 12.

Table 12. Equipment installed at South Peak radio station.

Item	Description	Part Number	Vendor		Qty
	Power Storage and Generation				
1	SOLAR MODULE 24W			ea	2
1A	CHARGE CONTROLLER 12 V	Morning ProStar			1
2	BATTERY			ea	4
3	BATTERY CABLE			m	3
4	BATTERY ENCLOSURE			ea	1
5	POWER MODULE			ea	1
	Wireless Communication				
6	ANTENNA (2.4 GHZ)			ea	1
7	ANTENNA (Cable)			m	2
8	RADIO (2.4 GHz - 5 GHz)	SB3221	Smartbridges	ea	1
9	RADIO (Power Injector)		Smartbridges	m	9
10	ANTENNA (5 GHZ)			ea	1
11	ANTENNA (Cable)			m	2
12	ANTENNA (900 MHZ)			ea	1
13	ANTENNA (Cable)			m	2
14	DEVICE SERVER	UDS200	Lantronix	ea	1
15	EMERGENCY RESET MODULE			ea	1

4 Deformation Monitoring Systems

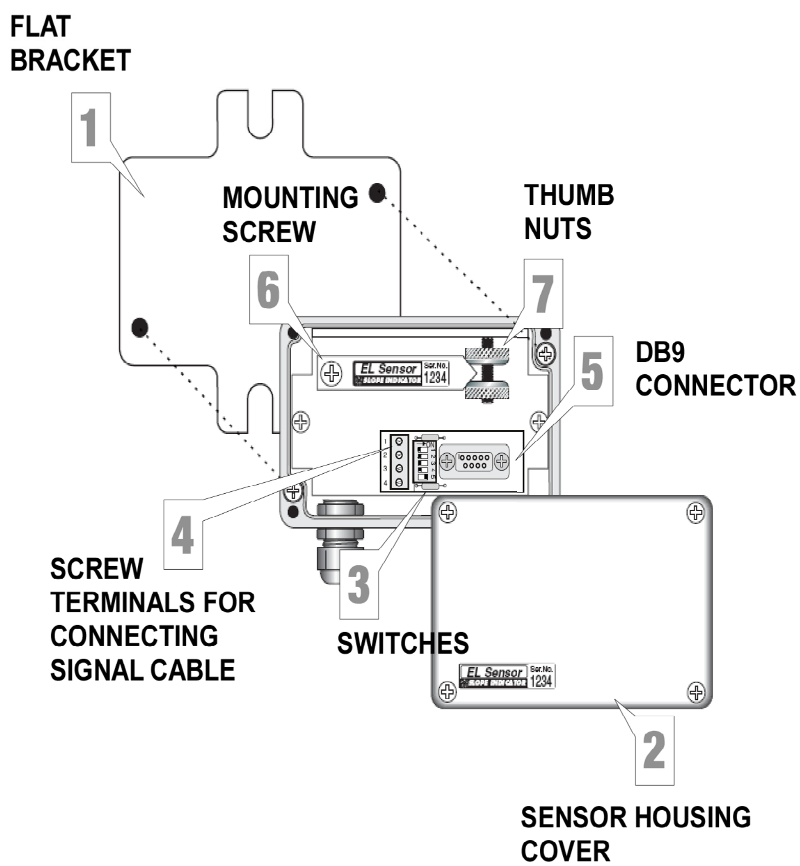
Based on the recommendations made as part of the geotechnical hazard assessment by BGC Engineering Inc. (2000), the monitoring system on Turtle Mountain was designed to include a number of different types of instruments communicating in near–real time to a data-acquisition and processing centre at the FSIC. The system measures changes in conditions that affect the potential for a rock avalanche from South Peak, and to provide early warning of extreme conditions to authorities responsible for emergency management. The monitoring system incorporates complementary types of instruments with varying sensitivities to movement and climatic influences, and has enough built-in redundancy to be able to distinguish actual movements. The primary sensors used in the rock-slope monitoring include ten tiltmeters, five surface extensometers and twenty crackmeters. These instruments provide values of displacement. One piezometer and a string of thermistors, installed in a borehole drilled on the western side of South Peak, measure the pore pressure and temperature. A weather station provides meteorological measurements. This section contains the basic instructions for installation and troubleshooting of primary sensors only.

4.1 Tiltmeter

Tiltmeters measure angular deformation (or tilt) in the vertical plane. We selected installation locations to be as close as possible to a vertical plane striking in the same direction as the possible tilt direction (Moreno and Froese, 2006). The tiltmeters installed at Turtle Mountain, which were manufactured and installed by Durham Geo Slope Indicator, have a measurement range of +/–40 arc minutes, a resolution of 1 arc second and a repeatability of +/–3 arc seconds. Ten tiltmeters were installed between October 4 and 9, 2004. Tiltmeters T5 and T10 were installed with the faceplate facing south; therefore, the positive tilt from a vertical up orientation is westerly. All of the other tiltmeters were installed with their faceplates facing north, and therefore measure positive tilt to the east relative to a vertical up orientation. Each tiltmeter was adjusted as close to vertical as possible following installation.

4.1.1 Tiltmeter Installation/Replacement

The following procedure will help to install a tiltmeter properly.



INSTRUMENT DIAGRAM

INSTALLING ANCHORS

1 Mark locations for anchors. The flat bracket requires two anchors.

2 Drill anchor holes deep enough in the rock to embed about 50 mm of anchor. Remove debris from holes.

3

Place the bracket **[1]** onto the anchors. Check that the sides of the bracket are as vertical as possible.

ATTACHING TILTMETERS

Helpful Hint

[1] See instrument diagram for identification of components.

4

Remove cover of sensor housing **[2].**

CONNECTING SIGNAL CABLE

5

When you connect signal cable, set switches 1 through 4 to the OFF position **[3].**

6

Connect signal cable in screw terminal **[4]** as shown in the table below:

Standard Terminal	Cable 50612804	Function
1	White	AC Excitation
2	not used	
3	Green	AC Output
4	Red	Analog Ground
	Drain	Not connected to sensor

7

Remove cover and set switches on terminal board. Switches 1 through 4 should be OFF. Switch 5 should be ON.

ZEROING SENSOR

8

Connect the EL zeroing device to the DB9 socket **[5]** on the sensor board and switch on.

9 Loosen sensor mounting screw **[6]** and the two thumbnuts **[7]** to allow adjustment of tilt sensor. Use the thumbnuts to adjust the sensor up or down. With the zeroing device, the object is to light the middle LED

> ***Helpful Hint***
>
> If readings are negative, move the pointed end of the sensor upward. If readings are positive, move the pointed end of the sensor downward.

10 Turn thumbnuts until both are in contact with the sensor, then gently tighten the mounting screw. Finger tight is good enough. Over-tightening can cause the reading to change and stress the sensor.

11 Check that the sensor is still zeroed, then switch off and gently disconnect the zeroing device. Record sensor location, orientation and serial number.

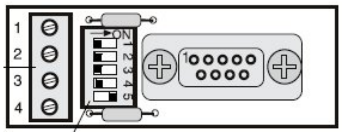
> ***Helpful Hint***
>
> Update data logger program after installation of a new instrument, using procedure in Section 4.3.5 (Updating Data Logger over LoggerNet).

12 Finally, carefully reset the switches so that switches 1, 3, and 4 are ON, and switches 2 and 5 are OFF.

4.1.2 Tiltmeter Checking

The following procedure will help to check a tiltmeter properly.

1 Remove sensor housing cover **[2]** and set switches 1 through 4 on terminal board **[3]** to OFF and switch 5 to ON.



Helpful Hint

[1] See instrument diagram for identification of components.

2 Connect the EL zeroing device to the DB9 socket **[5]** on sensor board and switch on.

3 The tilt sensor will produce a voltage value that the zeroing device records. A value of zero indicates instrument damage.

4 Switch off and gently disconnect the zeroing device.

5 Reconnect signal cable in screw terminal **[4]** as shown in the table below:

Standard Terminal	Cable 50612804	Function
1	White	AC Excitation
2	not used	
3	Green	AC Output
4	Red	Analog Ground
	Drain	Not connected to sensor

6

Finally, carefully reset the switches so that switches 1, 3 and 4 are ON and switches 2 and 5 are OFF. Check signal cable if sensor is found to be working fine (see Section 4.1.3).

4.1.3 Signal-Cable Continuity Test

The following procedure will help to determine the signal-cable integrity by testing whether or not the signal cable is capable of conducting electricity. Testing the continuity of a circuit requires the use of a multimeter or a continuity tester (a simple device that lights up to indicate continuity).

1 Set the multimeter to the ohm setting. The symbol for ohm is **Ω**, the Greek letter omega. If there is more than one ohm setting, choose the lowest.

2 Connect the testing device to one end of the black and red wire leads and have a coworker connect the other end of the cables.

3 A reading of infinity (analog meter) or 1 (digital meter) means that the cable is cut (open). A continuity tester will not light up if the cable is cut.

4 Repeat steps 2 and 3 but now connecting the red and white wire leads. Check surge arrestor if signal cable is found to be working fine (*see* Section 4.3.4).

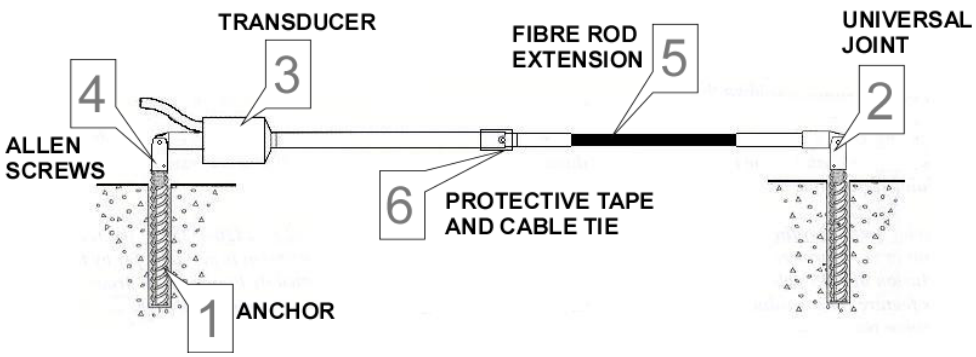
4.2 Crackmeter

Twenty vibrating-wire crackmeters were installed between October 2003 and November 2004. The crackmeters are Geokon model 4420 vibrating-wire strain gauges with a maximum range of 25 mm (or 50 mm in cluster D) and sensitivity of 10 µm. Each crackmeter incorporates a thermistor to obtain instrument temperature readings for thermal corrections to the data. All crackmeters were installed so that they were initially in approximately the middle of their sensing range, to allow measurement of both crack closure and opening. The crackmeter anchors were epoxied into 12.5 mm diameter holes drilled into the walls of the fissure. A sheet-metal roof was installed over each crackmeter array to provide protection from snow and falling rocks.

4.2.1 Crackmeter Installation/Replacement

The following procedure will help to install a crackmeter properly.

INSTRUMENT DIAGRAM



INSTALLING ANCHORS

1 Mark locations for anchors **[1]**. There is one anchor for each end of the crackmeter.

2 Drill two 0.5-inch holes approximately 3 inches deep at the proper locations.

3 Fill the holes with grout or epoxy and push in the anchors with attached universal joints **[2]** until the tops of the universal joints are flush with the surface.

Helpful Hint
[1] See instrument diagram for identification of components.

ATTACHING CRACKMETER

4 Install transducer **[3]** end of crackmeter to grouted anchor and tighten Allen screws **[4]**.

5 Remove the protective tape and cable tie **[6]** from the instrument to allow readings.

6 Attach the fibre rod extension **[5]** to the transducer (threads together), taking care not to rotate the transducer portion. Attach the universal joint to the fibre rod and attach to the other grouted anchor. Tighten the two Allen screws.

CONNECTING SIGNAL CABLE

7 Thread the crackmeter wire leads through the surge-suppressor compression fitting and into the suppressor enclosure. Attach crimp-on connectors to wire leads. Attach to circuit board hold-down screws according to the following guidelines:

Standard Terminal	Cable	Function
1	Green	Thermistor
2	White	Thermistor
3	Red	VW Sensor
4	Black	VW Sensor
5	Shield	Ground

> ***Helpful Hint***
>
> Do not pull the transducer shaft out of the transducer body beyond its calibrated range.

8 Check power inputs from the data logger to surge protector by testing between the black and red wires with the multimeter set to AC volts and between the green and white wires with the multimeter set to DC volts. You should see a quick increase in voltage every 15 seconds, indicating power to the crackmeter.

> ***Helpful Hint***
>
> Update data logger program file after installation of a new instrument, using procedure in Section 4.3.5.

4.2.2 Crackmeter Checking

The following procedure will help to check a crackmeter properly.

1. Set the multimeter to 200 ohm (Ω) scale and connect to the red and black wire leads. The resistance should read 180 ±10 Ω. If resistance reads infinite or very high (>1 MΩ), a cut wire must be suspected. If the resistance reads very low (<100 Ω), a short in the cable is likely.

2. Set the multimeter to the 200K Ω scale and connect to the white and green wire leads. Resistance should read between 3K and 10K Ω. Check signal cable if sensor is found to be working fine (*see* Section 4.2.3).

4.2.3 Signal-Cable Continuity Test

The following procedure will help to determine the signal-cable integrity by testing whether or not the signal cable is capable of conducting electricity. Testing the continuity of a circuit requires the use of a multimeter or a continuity tester (a simple device that lights up to indicate continuity).

1. Set the multimeter to the ohm setting. The symbol for ohm is **Ω**, the Greek letter omega. If there is more than one ohm setting, choose the lowest.

2. Connect the testing device to one end of the black and red wire leads and have a coworker connect the other end of the cables.

3. A reading of infinity (analog meter) or 1 (digital meter) means that the cable is cut (open). A continuity tester will not light up if the cable is cut.

4. Repeat steps 2 and 3 but now connecting the green and white wire leads. Check surge arrestor if signal cable is found to be working fine (*see* Section 4.3.4).

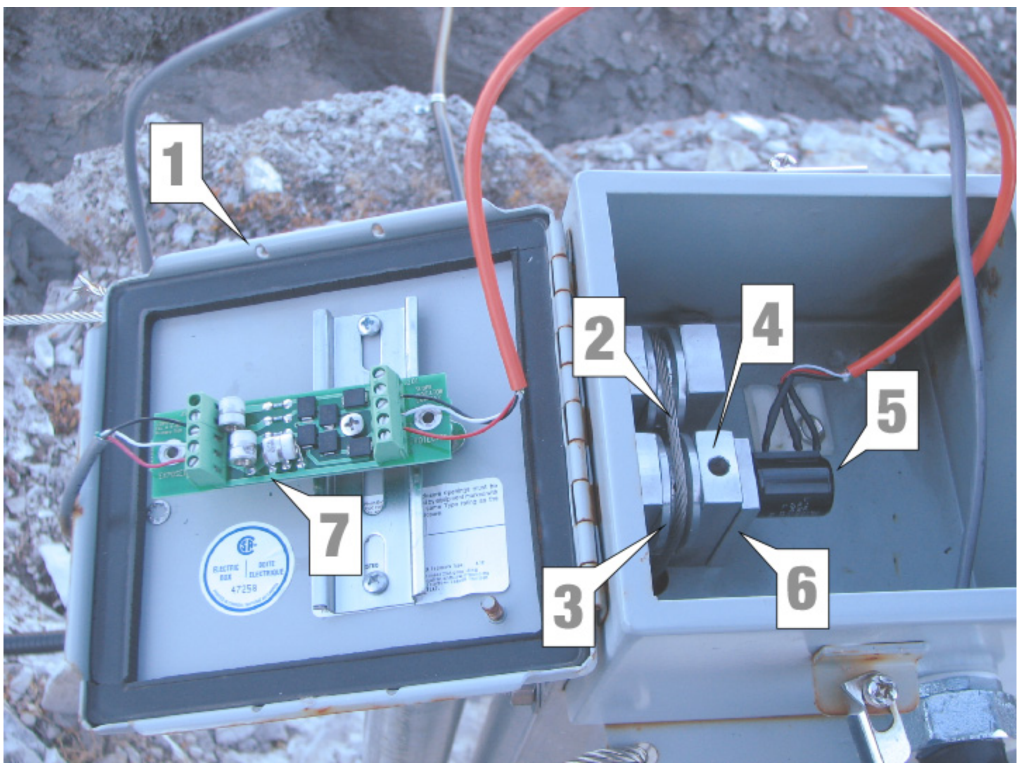
4.3 Extensometer

Durham Geo Slope Indicator (DGSI) and AMEC Earth and Environmental (2005) installed four surface-mounted extensometers in October 2004. These instruments were custom designed for this project by AMEC and DGSI. The sensitivity of extensometers should be approximately 1–2 mm. A fifth extensometer was installed during the summer of 2006 (Moreno and Froese, 2008).

4.3.1 Extensometer Sensor Installation/Replacement

The following procedure will help to install an extensometer properly.

INSTRUMENT DIAGRAM



ATTACHING POTENTIOMETER

1 Remove head assembly cover **[1]**. Pull on the stainless-steel cable **[2]** going over the potentiometer pulley and move it to one side (this will allow you to move the pulley **[3]** by hand).

Helpful Hint

[1] See instrument diagram for identification of components.

2

Looking down the access hole [4] to the right of the pulley, rotate the pulley until you can see a small Allen set screw.

3

Slacken the setscrew (not all the way, but at least two turns).

4

Pull on the potentiometer body [5] to remove from the assembly.

5

Unscrew the potentiometer body from the rectangular aluminum mount [6] and then disconnect the signal cable from the surge-arrestor module [7].

6

Install the new potentiometer by reversing steps 2 to 5.

CONNECTING SIGNAL CABLE

7

Connect the signal cable to the surge arrestor [7] as shown in the following table:

Standard Terminal	Cable	Function
B (outer)	White	AC Excitation
A (inside)	Black	AC Output
C (middle)	Red	Analog Ground

ZEROING SENSOR

8

When the potentiometer is in place, it needs to be adjusted. The potentiometer is a 10-turn unit. Rotate the potentiometer all the way left to the stop. Rotate back 5 turns to get a mid-range reading.

9

Move the stainless-steel cable **[2]** back over the potentiometer pulley and close the head assembly cover.

Helpful Hint
Update data logger program after installation of a new instrument, using procedure in Section 4.3.5.

4.3.2 Extensometer Checking

The following procedure will help to check an extensometer properly.

Helpful Hint

[1] See instrument diagram for identification of components.

1 Set the multimeter to the 200K ohm (Ω) scale and connect to the potentiometer's inside and middle prongs **[7]**. Resistance should read between 10K ±3K Ω. If resistance reads infinite or very high (>1 MΩ), damage to the instrument must be suspected

2 Repeat step 2 but connect to outside and middle prongs instead. Check signal cable if sensor is found to be working fine (*see* Section 4.3.3).

4.3.3 Signal Cable Continuity Test

The following procedure will help to determine the signal cable integrity by testing whether or not the signal cable is capable of conducting electricity. Testing the continuity of a circuit requires the use of a multimeter or a continuity tester (a simple device that lights up to indicate continuity).

1 Set the multimeter to the ohm setting. The symbol for ohm is **Ω**, the Greek letter omega. If there is more than one ohm setting, choose the lowest.

2 Connect the testing device to one end of the black and red wire leads and have a coworker connect the other end of the cables.

3 A reading of infinity (analog meter) or 1 (digital meter) means that the cable is cut (open). A continuity tester will not light up if the cable is cut.

4 Repeat steps 2 and 3 but now connecting the red and white wire leads. Check surge arrestor if signal cable is found to be working fine (*see* Section 4.3.4).

4.3.4 Surge-Arrestor test

This option will help to determine the integrity of the surge arrestor by testing whether or not it is capable of conducting electricity. Testing the continuity of a circuit requires the use of a multimeter or a continuity tester (a simple device that lights up to indicate continuity).

1

Set the multimeter to the ohm setting. The symbol for ohm is **Ω**, the Greek letter omega. If there is more than one ohm setting, choose the lowest.

2

Connect the testing device to both ends of the transient protection board, making sure they correspond to the same protected lead (e.g., connector 1 on the exposed and protected ends).

3

Refer to table below for normal resistance readings:

Standard Terminal	Resistance	Function
1	3.3 Ω ±2	AC Output
2	3.3 Ω ±2	AC Output
3	3.3 Ω ±2	AC Output
4	3.3 Ω ±2	AC Output
5	0.2 Ω ±1	Shield

4

A reading of infinity (analog meter) or 1 (digital meter) means that the cable is cut (open). A continuity tester will not light up if the surge arrestor is damaged.

4.3.5 Updating Data Logger over LoggerNet

The following procedure will help to update the data logger with new calibration factors after installation of a new instrument, such as a crackmeter.

1 Open LoggerNet either by double-clicking on the desktop icon or going to Start > All Programs > LoggerNet and clicking on the program.

2 Click the 'Edlog' button in the LoggerNet toolbar.

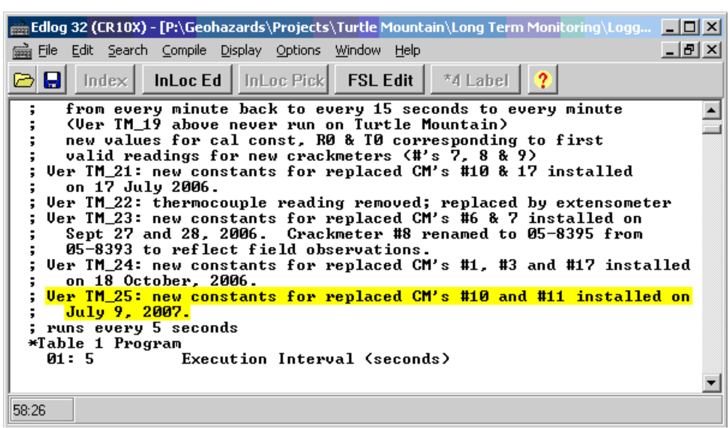
3 In the 'File' menu, select 'Open' and navigate to the latest version of program file for the data logger to be updated (e.g., the weather station is currently TM_25.dld).

> ***Helpful Hint***
>
> Program files:
>
> | | |
> |---|---|
> | Wx Stn | TM_25.dld |
> | Borehole | TMSI01.dld |
> | Weir | Spring Outflow.dld |

4 The programming window (Edlog 32) is now open. Notes from the previous programming changes will appear at the top of the page. Place the curser at the end of the last entry, hit return and insert your own notes, starting with the new version number (e.g., Ver TM_26) and explaining which instrument(s) was(were) replaced and on what date.

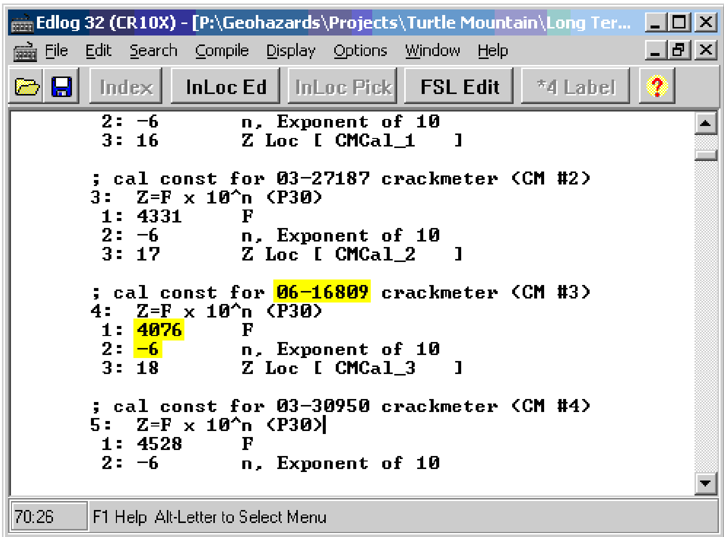
> ***Helpful Hint***
>
> Place a semicolon (;) at the beginning of the line when inserting text into the programming window.

An example is shown below:



5

Scroll down to the number of the crackmeter that has been replaced and enter the new serial number, the Linear Gage Factor **F** (line 1) and the Exponent **n** (line 2).

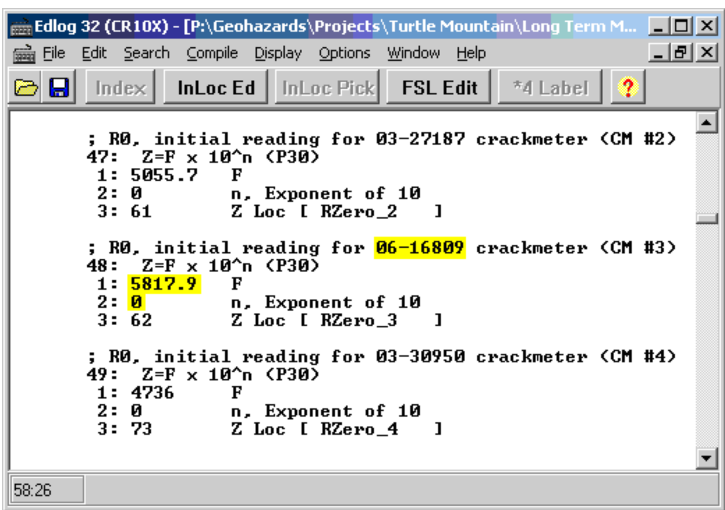


Helpful Hint

The Linear Gage Factor is in the Vibrating Wire Displacement Transducer Calibration Report, provided with the crackmeter.

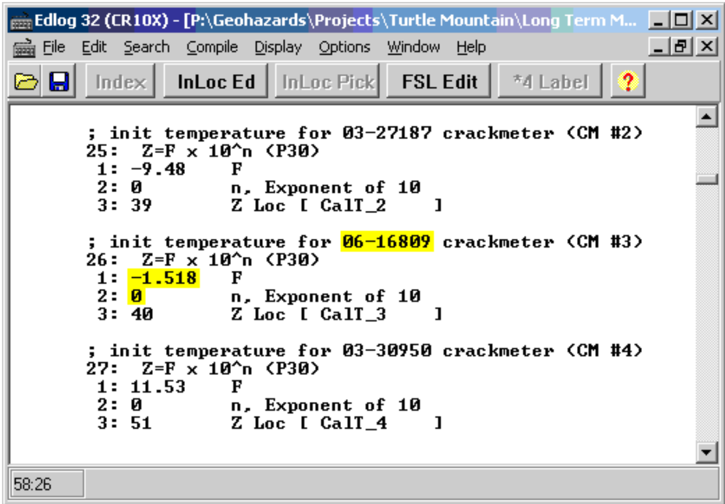
6

Scroll down to the Initial Reading (R_0) section and enter the new serial number and the initial reading (line 1).



7

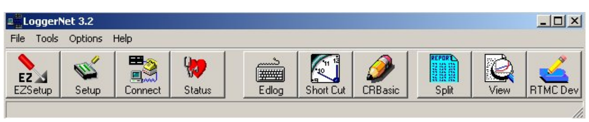
Repeat the previous step for the Initial Temperature (T_0). Be sure to change the serial number.



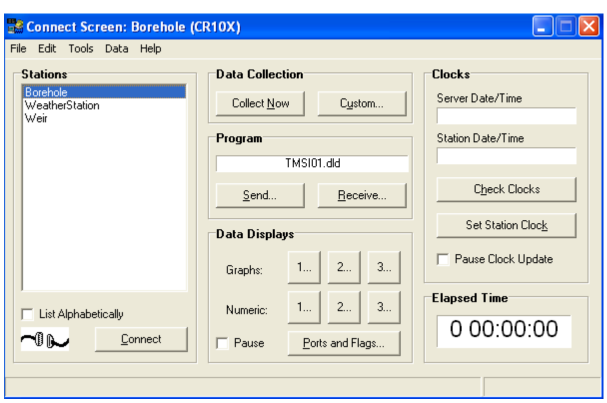
8 Save as TM_XX (currently TM_25.dld) where XX is a consecutive number used to keep track of the number of changes made to the program file (*see* step 4). **DO NOT** overwrite the old settings.

9 Before sending (updating) the new program file to the data logger, make sure to download the data from LoggerNet. Data from the station will be lost once the new program file is sent (*see* Section 4.3.6).

10 Click on the 'Connect' button in the LoggerNet toolbar:



Connect to the datalogger that you are updating by selecting it in the Stations window and then clicking on the 'Connect' button.



Helpful Hint

Never connect between 10 minutes before and 10 minutes after the hour.

11 Once connected to the data logger, click on the ‘Send’ button beneath the Program window (see screen capture in previous step)

Navigate to where the new program is saved on the project drive and open it.

A caution window will appear. When you are ready to send the new program to the data logger, click ‘Yes.’

12 The data logger now has the programming for the new instrument and should be working correctly

13 Back in the Connect window, make sure to disconnect the data logger by clicking on the ‘Disconnect’ button.

4.3.6 Downloading Data Using LoggerNet

The following procedure will show how to download data from the data loggers using LoggerNet.

1

Open LoggerNet either by double-clicking on the desktop icon or going to Start > All Programs > LoggerNet and clicking on the program.

2

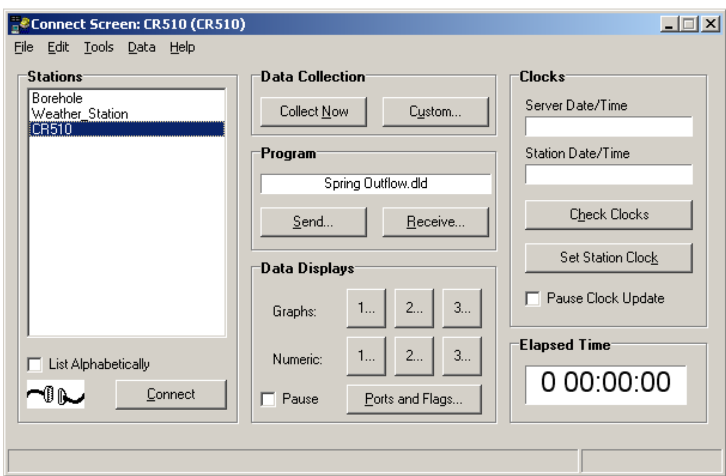
Click the 'Connect' button in the LoggerNet toolbar:

Helpful Hint

Never connect between 10 minutes before and 10 minutes after the hour.

3

This will open the Connect screen:

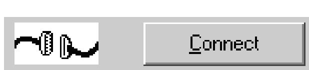


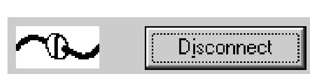
4

Select the data logger from which you would like to download data by clicking on it in the Stations window on the left side and then clicking the 'Connect' button.

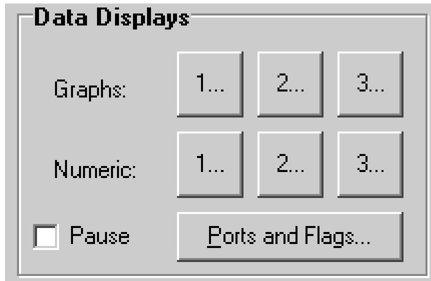
5

Once the data logger is connected, the symbol at the bottom left of the screen will show the connection and the 'Connect' button will change to a 'Disconnect' button:





6 To quickly check that the data are being recorded, you can open a graphical or numerical display of the data by clicking on either of the ‘**1…**’ buttons in the Data Displays box:



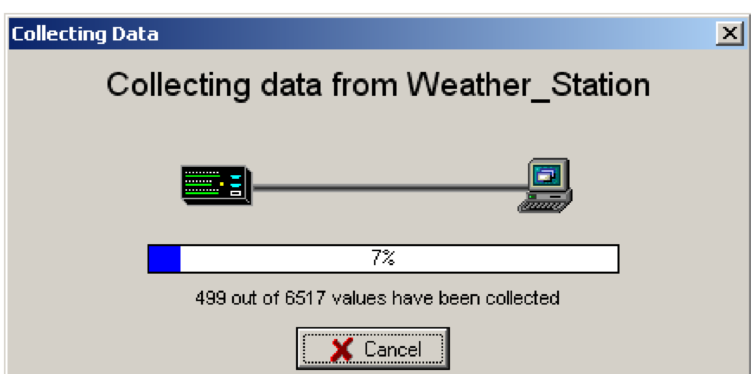
Once the relevant display is open, click on the ‘Add’ button to add any data you are interested in viewing. Click on the ‘Help’ button for detailed instructions on data viewing and plotting.

> ***Helpful Hint***
>
> The information on the data displays will be updated only as often as the data loggers perform data collection (weather station every 15 seconds, and borehole and weir every hour).

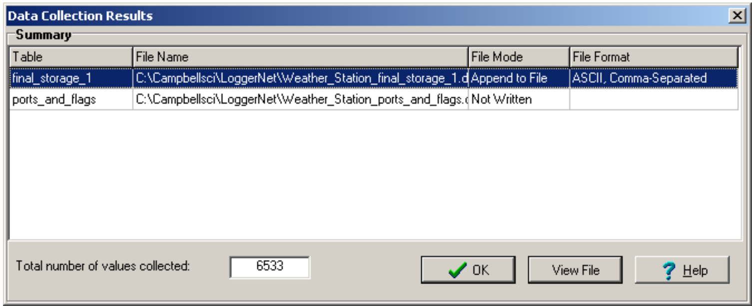
7 In the Clocks box on the Connect screen, there is a ‘Pause Clock Update’ checkbox. Just before you download the data, check this box to pause the clock. Downloading will not work if this is not done.

8 Now that the clock is paused, you can click on the ‘Collect Now’ button in the Data Collection box of the Connect screen.

9 A new window will open showing the progress of the data collection:



10 Once the data collection is finished, a new window will open showing the results of the collection and where it is saved:



Click 'OK' to finish data collection.

11 Back at the Connect screen, make sure to uncheck the 'Pause Clock Update' checkbox and then disconnect the data logger by clicking on the 'Disconnect' button.

Helpful Hint

Never connect between 10 minutes before and 10 minutes after the hour.

5 References

AMEC Earth and Environmental (2005): Turtle Mountain monitoring project, summary report – WP11.03 and 12.03, subsurface geotechnical and microseismic monitoring system; unpublished report prepared for Alberta Municipal Affairs, 17 p.

BGC Engineering Inc. (2000): Geotechnical hazard assessment of the south flank of Frank Slide, Hillcrest, Alberta; unpublished report prepared for Alberta Environment under contract 00-0153, 29 p.

Durham Geo Slope Indicator (2009): Atlas Web-based data management; Durham Geo Slope Indicator, data sheet, 2 p., URL <http://www.slopeindicator.com/pdf/atlas-datasheet.pdf> [July 2009].

Moreno, F. and Froese, C.R. (2006): Turtle Mountain Field Laboratory monitoring and research summary report, 2005; Alberta Energy and Utilities Board, EUB/AGS Earth Sciences Report 2006-07, 94 p., URL <http://www.ags.gov.ab.ca/publications/abstracts/ESR_2006_07.html> [July 2009].

Moreno F. and Froese C.R. (2008): Turtle Mountain Field Laboratory: 2007 data and activity summary; Energy Resources Conservation Board, ERCB/AGS Open File Report 2008-07, 47 p., URL <http://www.ags.gov.ab.ca/publications/abstracts/OFR_2008_07.html> [July 2009].

Moreno F. and Froese C.R. (2009): ERCB/AGS roles and responsibilities manual for the Turtle Mountain monitoring project, Alberta; Energy Resources Conservation Board, ERCB/AGS Open File Report 2009-06, 28 p., URL <http://www.ags.gov.ab.ca/publications/abstracts/OFR_2009_06.html> [July 2009].

Appendix 1 – Acronyms and Abbreviations

AGS	Alberta Geological Survey
DGSI	Durham Geo Slope Indicator
dGPS	Differential Global Positioning System
EDM	electronic distance measurement
ERCB	Energy Resources Conservation Board
FSIC	Frank Slide Interpretive Centre
GOA	Government of Alberta
GPS	Global Positioning System
MCNP	Municipality of Crowsnest Pass
TM	Turtle Mountain
TMMS	Turtle Mountain Monitoring System

Appendix 2 – Element Administrator

Provincial Building at Blairmore

Quantity	Vendor	Part Number	Description	Link	Responsible
1	Campbell	L14201	Antenna	PROV-TMWEST	AGS
1	Campbell	L14462	Antenna(surge protector)	PROV-TMWEST	AGS
1	Campbell	RF400	Radio	PROV-TMWEST	AGS
1	Campbell	L15966	Radio (DC unit)	PROV-TMWEST	AGS
1	Campbell	NL100	Network interface	PROV-TMWEST	AGS
1	Campbell	L13947	Network interface (DC unit)	PROV-TMWEST	AGS
1	Checkpoint	safe@office 500	Router	PROV-TMWEST	IT Support
1	Shaw Cable		Internet (modem)	PROV-TMWEST	IT Support
1	Shaw Cable		Internet (subscription)	PROV-TMWEST	IT Support
1	NCIX	CPS 1000 AVR	Battery back-up (UPS)		IT Support
1	MTI	MT485028/N	Antenna	FSIC-PROV	AGS
3'	YDI		Antenna (cable)	FSIC-PROV	AGS
1	Smartbridges	AirHaul Nexus	Radio	FSIC-PROV	AGS
1	Smartbridges		Radio (power injector)	FSIC-PROV	AGS
1	Smartbridges		Antenna	PROV-GPS	AGS
1	Smartbridges	AirHaul Nexus	Radio	PROV-GPS	AGS
1			Coupler	PROV-GPS	AGS
1	Smartbridges		Radio (power injector)	PROV-GPS	AGS
1	Smartbridges		Radio (DC unit)	PROV-GPS	AGS

Frank Slide Interpretive Centre

Quantity	Vendor	Part Number	Description	Link	Responsible
1	MTI	MT485028/N	Antenna	FSIC-PROV	AGS
1		LMR600	Antenna (cable)	FSIC-PROV	AGS
1	Smartbridges	SB3010	Radio	FSIC-PROV	AGS
1	Smartbridges		Radio (power injector)	FSIC-PROV	AGS
1	D-Link	8-port	HUB	FSIC-PROV	IT Support
1	D-Link	8-port	HUB	FSIC-PROV	IT Support
1	HP Server	Xeon 3.4 Ghz 2GB Ram	Data analysis, Marshall, Snapping, Da	FSIC-PROV	IT Support
1	HP Server	Monitor		FSIC-PROV	IT Support
1	HP Server	Network Card		FSIC-PROV	IT Support
1	HP Server	UPS		FSIC-PROV	IT Support
1	Hyperlink Tecl	HG2416P	Antenna	FSICH	AGS
1		LMR400	Antenna (cable)	FSICH	AGS
1	Smartbridges	SB2510	Radio	FSICH	AGS
1	Smartbridges		Radio (power injector)	FSICH	AGS
1	Hawking	4-port	HUB	FSICH	IT Support
1	Hyperlink Tecl	HG2416P	Antenna	FSICL	AGS
1		LMR400	Antenna (cable)	FSICL	AGS
1	Engenius	NL2510	Radio	FSICL	AGS
1	Electro-comm	DA 58-29 PAC	Antenna	FSIC-SP	AGS
1		LMR400	Antenna (cable)	FSIC-SP	AGS
1	Smartbridges	SB3010	Radio	FSIC-SP	AGS
1	Smartbridges		Radio (power injector)	FSIC-SP	AGS
1	MTI	MT485028/N	Antenna	FSIC-PUMP	AGS
1		LMR600	Antenna (cable)	FSIC-PUMP	AGS
1	Smartbridges	SB3010	Radio	FSIC-PUMP	AGS
1	Smartbridges		Radio (power injector)	FSIC-PUMP	AGS

Pump house

Quantity	Vendor	Part Number	Description	Link	Responsible
1	MTI wireless e	MT485028/N	antenna	FSIC-PUMP	AGS
1	Air Haul Nexu	Smartbridges SB3010	radio	FSIC-PUMP	AGS
1			Radio (power injector)	FSIC-PUMP	AGS
1			Radio (power supply)	FSIC-PUMP	AGS
1	Novatel		GPS antenna	FSIC-PUMP	AGS
1	Novatel	SmartStar	GPS receiver	FSIC-PUMP	AGS
1	Lantronix	UDS200	GPS (serial to ethernet)	FSIC-PUMP	AGS
1			GPS (power supply)	FSIC-PUMP	AGS
1	Netgear	FS116NA	Ethernet switch	FSIC-PUMP	IT Support
1			Ethernet switch (power supply)	FSIC-PUMP	IT Support
1	Belkin	F6H375-USB	UPS	FSIC-PUMP	IT Support
1	Mobotix	M22M	web camera	WEBCAM	AGS
1	Mobotix	OPT14-L65	web camera (lens)	WEBCAM	AGS
1			web camera (power supply)	WEBCAM	AGS
1	Hawking		web camera	WEBCAM	AGS
1	Hawking		web camera (lens)	WEBCAM	AGS
1			web camera (power supply)	WEBCAM	AGS
1			web camera (enclosure heater power s	WEBCAM	AGS

Software

Software	Description	Responsible
Windows 2003		IT Support
Arcserve Agent		IT Support
SQL		IT Support
PHP	Scripting language used 4dynamic web pages	AGS
Apache	Apache provides web services	AGS
ActivePerl	distribution of the Perl language	AGS
Turtle Daemons	collects data acquisition systems at TM	AGS
Campbell Scientific LoggerNet	Loggernet 4 Campbell Scientific brand of data loggers	AGS
MS .Net Framework 2.0	.NET framework is required by TMClient	AGS
java Development Kit (JDK)	runtime environment for Java application & the Java compiler	AGS
Marshall	accepts seismic data from seismic data digitizers	AGS
AutoTAR	AutoTar analyses data from the seismic digitizers	AGS
Vlinx Ethernet Serial Server	connects the weather station to the computer over Ethernet.	AGS
One Wire Weather station software	OWW reads data from the weather station at the FSIC	AGS
Kiwi System Log Daemon	accepts log data	AGS
UDPDL	Updates firmware 4 Gennix seismic digitizers	AGS
FireDaemon	makes programs look like A services	AGS
AirPoint Pro	used to configure Smartbriges	AGS
ConText	Text editor program like notepad	AGS
WinSCP	to transfer encrypted files without a VPN	AGS

Borehole enclosure

Description	Part Number	Vendor		Qty	responsible
Power Storage and Generation					
SOLAR MODULE 20W	56703330		ea	1	AGS
CHARGE CONTROLLER 12 V	INTEGRATED W PANEL				AGS
BATTERY	60101162		ea	1	AGS
BATTERY CABLE			m	45.5	AGS
Wireless Communication					
SPREAD SPECTRUM RADIO	RF400	SLOPE INDICATOR	ea	1	AGS
ANTENNA (2.4 GHZ)	L14205 YAGGI	SLOPE INDICATOR	ea	1	AGS
ENCLOSURE NEMA4	SPECIAL	SLOPE INDICATOR	ea	1	AGS
ANTENNA CABLE	COAX RPSMA-L	SLOPE INDICATOR	m	9	AGS
SURGE PROTECTOR (ANTENNA)			ea		AGS
Data Acquisition and Pre-processing					
DATALOGGER	CR10X	SLOPE INDICATOR	ea	1	AGS
MULTIPLEXER	56702110	SLOPE INDICATOR	ea	2	AGS
AW 100 (PIEZOMETER)		SLOPE INDICATOR	ea	1	AGS
SURGE PROTECTOR (MUX)		SLOPE INDICATOR	ea	15	AGS
THERMISTOR STRING (W/TEMP. SENSORS)	92600099	SLOPE INDICATOR	ea	1	AGS
VW PIEZOMETER (W/CABLE)	52611099	SLOPE INDICATOR	ea	1	AGS

Weather station enclosure

Description	Part Number	Vendor		Qty	responsible
Power Storage and Generation					
SOLAR MODULE 35W	PRC 12100	SOLTEK	ea	1	AGS
CHARGE CONTROLLER 12 V		PHOTRON	ea	1	AGS
BATTERY	PRC 12100	SOLTEK	ea	1	AGS
Wireless Communication					
SPREAD SPECTRUM RADIO	RF400	CAMPBELL	ea	1	AGS
ANTENNA (2.4 GHZ)	L14201 YAGGI	CAMPBELL	ea	1	AGS
ENCLOSURE NEMA4		CAMPBELL	ea	1	AGS
SURGE PROTECTOR (ANTENNA)	L14462	CAMPBELL	ea	1	AGS
ENCLOSURE NEMA4 (MUX BOX)	ENC 12/14	CAMPBELL	ea	1	AGS
Data Acquisition and Pre-processing					
BAROMETRIC PRESSURE	61205V	CAMPBELL	ea	1	AGS
TEMP PROBE W REL. HUMIDITY	HMP45CF	CAMPBELL	ea	1	AGS
10 PLATE RADIATION SHIELD	41003-2	CAMPBELL	ea	1	AGS
TEMP PROBE W 7.5m CABLE	107B	CAMPBELL	ea	1	AGS
PYRANOMETER	LI200S	CAMPBELL	ea	1	AGS
TIPPING BUCKET RAIN GAUGE		CAMPBELL	ea	1	AGS
WIND MONITOR	05 103-10	CAMPBELL	ea	1	AGS
MULTIPLEXOR (Wx STN)	AM16/32	CAMPBELL	ea	1	AGS
VIBRATING WIRE INTERFACE (Wx STN)	AVW1	CAMPBELL	ea	1	AGS
SURGE PROTECTORS (Wx STN)	TT-SLKK5-F/110AC	PHOENIX	ea	32	AGS
DATALOGGER (Wx STN)	CR10X-55	CAMPBELL	ea	1	AGS
MULTIPLEXOR (MUX BOX)	AM16/32	CAMPBELL	ea	1	AGS
SURGE PROTECTORS (MUX BOX)		PHOENIX	ea	44	AGS