



**Instrumentation  
Northwest, Inc.**

Protecting our water resources since 1982

**WaveData<sup>®</sup>**

**Radio Frequency  
Data Collection System**

**INSTRUCTION  
MANUAL**

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**WARNING**

The RF radio modules in these WaveData radio units have been certified for remote and base radio applications. They have not been certified for “portable” use. Portable use is considered by the FCC to be when the antenna is mounted closer than 20 cm to nearby persons. INW makes no claim that the RF energy levels emitted by these devices are within permissible limits, as defined by the FCC, when used closer than 20 cm to the body.

**Contains FCC ID: OUR-9XCITE**

The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i) this device may not cause harmful interference and (ii) this device must accept any interference received, including interference that may cause undesired operation.

**Contains FCC ID: OUR-9XTEND**

The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i) this device may not cause harmful interference and (ii) this device must accept any interference received, including interference that may cause undesired operation.

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## **Introduction**

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### **What is a WaveData RF Data Collection System?**

WaveData® RF Data Collection Systems combine INW's patented Aquistar® Smart Sensor/Dataloggers with radio frequency modems to create powerful data collection and monitoring systems.

Operating on the 900 MHz band, these radio frequency modems are license free. Depending on the model and usage, these low power units can run for months on alkaline batteries or virtually forever on solar systems. Communication range varies from 300 feet to 5 miles, depending on line-of-sight obstructions, height and type of antennas, power settings on radio, and additional repeaters.

The Aquistar® Smart Sensors store thousands of records, operate on low power, and feature easy to use software with powerful features, including the ability to create complex test sequences and display uploaded data in tables and graphs.

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### **Initial Inspection and Handling**

Upon receipt of your WaveData unit, inspect the shipping package for damage. If any damage is apparent, note the signs of damage on the appropriate shipping form. After opening the carton, look for concealed damage. If concealed damage is found, immediately file a claim with the carrier.

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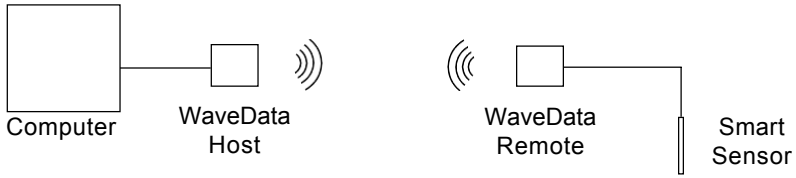
### **About this Manual**

This manual concentrates on installation and configuration of WaveData systems. It also includes information on technical details and trouble-shooting . For instructions on using the WaveData units with INW's Aqua4Plus control software, please refer to the *Aqua4Plus Control Software Instruction Manual*.

WaveData wireless data collection systems are highly configurable and expandable. Due to the plethora of possible configurations, this manual will concentrate on a basic configuration as shown in figure 1.

Bear in mind that each system may contain several remote units. Each remote may be connected to several smart sensors.

Each system, other than a very basic system, comes with documentation for setup, configuration, and installation of that specific system. Please refer to that custom documentation as needed.



*Figure 1: Basic WaveData Configuration*

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## Radio Types

### Host Radios

There are two radio types in any given radio network – a host radio and one or more remote radios. The host radio is connected directly to the controlling computer (or to a modem, in the event you are communicating via a modem.) This host radio contains a map of the entire network layout, including all radios and all sensors.

The host radio performs two functions. First it makes sure that all radios the computer is attempting to communicate with or through are awake. Second, the host passes communication back and forth between the computer and the sensors and/or remotes, making sure the information goes down the correct network leg to the destination specified by the program on the computer.

Host radios can communicate with the controlling computer program only when directly connected to a computer (or via modem, as noted above). Host radios are always at sensor address 1.

Both host and remote units have built in power saving features. The host radio goes to sleep immediately after any communication and remains asleep until there is activity on its communication line from the computer.

### Remote Radios

Remote radios are either directly connected to sensors or act as repeaters. When connected to one or more sensors, a remote radio will pass communication back and forth between the host and the sensors. A remote radio can also be used as a repeater to get further distance or to avoid obstacles such as hills or buildings. When acting as a repeater, a remote radio simply passes on whatever information it receives.

Remote radios can communicate only over the air. They cannot be directly connected to a computer for communication.

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Remote radios go to sleep 60 seconds after the last transmission or receipt of information. While in sleep mode, a remote radio wakes up very briefly every 10 seconds to see if anyone is transmitting to it.


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## Aqua4Plus Software

The WaveData system comes with INW's Aqua4Plus host software. This software is used to control the WaveData radio units, as well as program and retrieve data from the smart sensors. Install Aqua4Plus on your PC or laptop as follows:

1. Insert the Aqua4Plus CD in the CDROM drive on your PC or laptop. Installation should start automatically. If not, then follow steps 2 and 3. Otherwise, skip to step 4.
2. Click the Start button and select Run.
3. Type D:\setup.exe, where D: is the drive letter for your CDROM drive.
4. The Installation program will guide you through the installation process.

Once the software installation has successfully completed, remove the CD from your CDROM drive and store it in a safe place.

To start the Aqua4Plus software, use the Start Menu to navigate to the program group you selected during installation (typically this will be Aqua4Plus), and then click the Aqua4Plus  icon. Refer to the *Aqua4Plus Control Software Instruction Manual* for details in using the program with your WaveData unit.

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## Installation Considerations

Installations may vary widely. Refer to specific installation instructions for your particular project. All of the following installation samples are for units running on internal battery power. For more information on alternate power sources - line power, solar, generator - contact your INW representative.

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### Location

Care must be taken when locating the WaveData units. These RF radios communicate with each other via line-of-sight. In other words, they must be able to "see" each other for effective communication. (If you do not have line-of-sight, contact INW about using repeaters to reach your destination.)

Line-of-sight in the radio world is slightly different than line-of-sight in the visual world. Figure 2 shows a visual line of sight. If you were at the top of one of the antennas, you would have a straight line of vision to the second antenna.

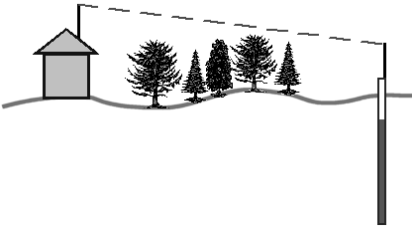


Figure 2: Visual Line-of-Sight

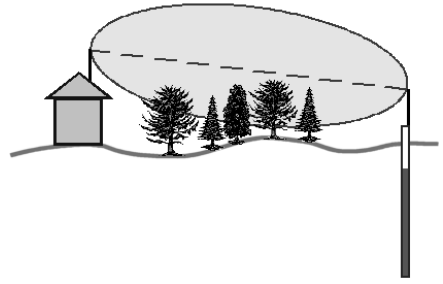


Figure 3: RF Line-of-Sight  
Fresnel zone interrupted by trees

On the other hand, radio antennas radiate in a bubble, known as the Fresnel zone. (See figure 3.) Any objects – trees, buildings, the ground – that intrude into this bubble degrade communication.

The Fresnel zone diameter increases with distance. Table 1, below, gives some approximate diameters and typical ranges. Remember that objects intruding into the Fresnel zone will shorten these distances.

Distance	Required Fresnel Zone Diameter
1000 feet	16 feet
1 mile	32 feet
5 miles	68 feet
For ground clearance, the combined antenna height should be equal to the diameter of the Fresnel zone.	

1

Table 1

In addition to location and height of your antenna, the distance and reliability with which your WaveData unit communicates is directly affected by the type and gain of antenna you are using. For further details, see INW's application note "*Antenna Selection and Location for WaveData Wireless Data Collection Systems.*"

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## Grounding Issues

Grounding does two things. First, it protects equipment and personnel from high power spikes. Second, it improves measurement accuracy by eliminating ground loops.

<sup>1</sup> Source: RF Essentials. *MaxStream Wireless Technology Training*. MaxStream. Lindon, UT: 2003.

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## Safety Concerns

It is commonly known that when using electronic equipment, both personnel and equipment need to be protected from high power spikes that may be caused by lightning, power line surges, or faulty equipment. Without a proper grounding system, a power spike will find the path of least resistance to earth ground, whether that path is through sensitive electronic equipment or **the person operating that equipment**. In order to ensure safety and prevent equipment damage, a grounding system must be used to provide a low resistance path to ground.

### Ground Loop Effects

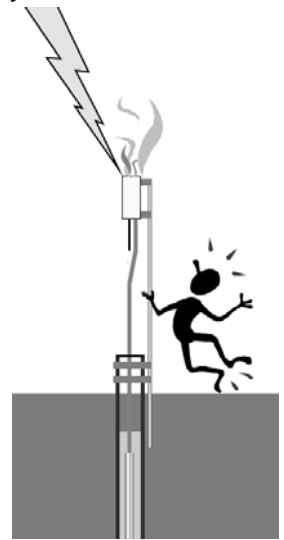
When using several pieces of interconnected equipment, each of which may have its own ground, problems with noise, signal interference, and erroneous readings may be noted. This is caused by a condition known as a **Ground Loop**. Because of natural resistance in the earth between the grounding points, current can flow between the points, creating an unexpected voltage difference and resulting erroneous readings.

### Maximizing Safety and Minimizing Ground Loop Effects

Proper grounding and the use of surge protectors are very important to ensure that your system provides a single low resistance path to ground. This will shunt high voltage spikes to ground, helping to prevent equipment damage and personal injury.

The single most important step in minimizing a ground loop is to tie all equipment (sensors, dataloggers, external power sources, housings, radios, cell modems, and any other associated equipment) to a single common grounding point.

Refer to the U.S. Consumer Product Safety Commission, the National Electrical Code, and/or an electrical engineer with experience in grounding issues before installing your system.



*Figure 4:  
Improper grounding can  
be a safety hazard!*



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## Using a WaveData RF Data Collection System

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### Connecting Radios

#### Connecting Remotes to Sensors

Connect your sensor to the connector next to the antenna. If you are going to connect several sensors via a junction box, connect the junction box at this point.

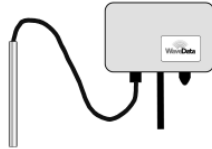


Figure 5: WaveData box connected to sensor

#### Connecting Host to Computer or Modem

Connect the host radio to your computer, as shown below.

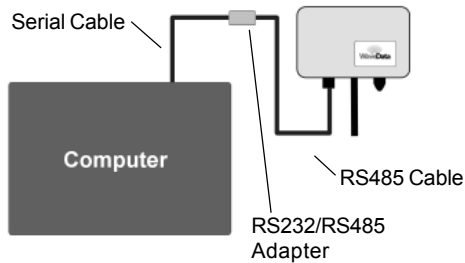


Figure 6: WaveData box connected to computer

Connect the host radio to a modem, as shown below:

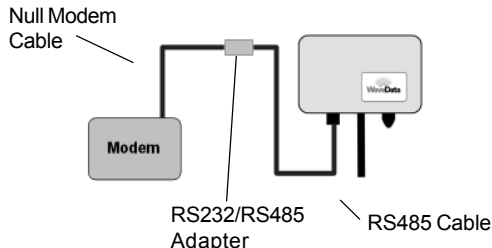


Figure 7: WaveData box connected to modem

## Configuring Radios

### Turning on Power

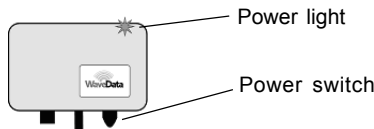


Figure 8: Power switch

Turn on power to each of the radios by pressing firmly on the power switch. When power is on, a blinking green LED will be visible in the top right corner. (You may have to look closely, as it is below the metal faceplate.)

### Configuring Host Radio

The host radio must have a map of your network. You can view and/or change this map or create a new one as follows:

- Start Aqua4Plus
- Select the COM port to which the host radio is connected.
- Set Communication Options (Options Menu > Communication)
  - From the Factory Suggested Settings, select WaveData Radios (or IP Cell Modem and Radios, if using a cellular modem).
  - Set both the Lowest Sensor Address and Highest Sensor Address to 1.
  - Be sure that the Enable S/F Radio Wakeup box is checked.
  - Click OK

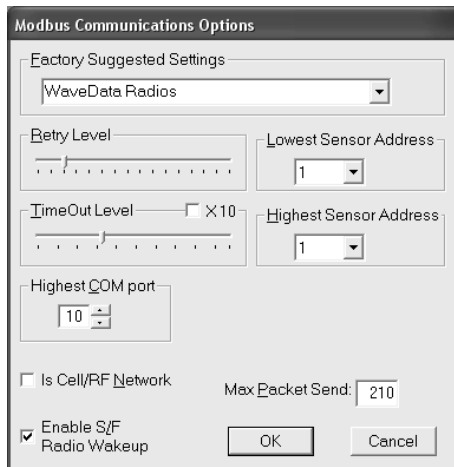



Figure 9: Communication options

- Scan for the WaveData units by clicking the  tool button. The program should find the WaveData Host and display as shown below. (Note that host radios are always on address 1.)

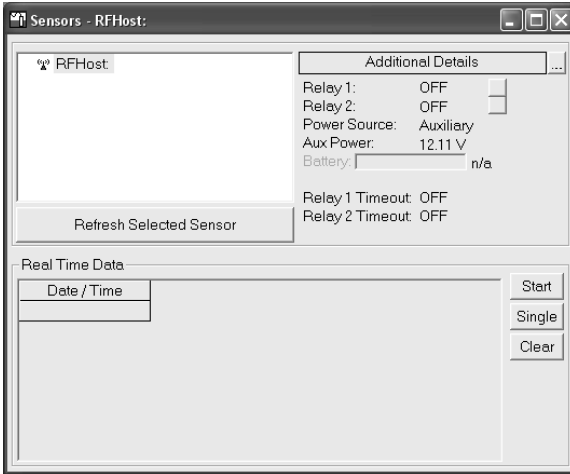


Figure 10: Sensor window showing host radio unit

- Be sure the Host is highlighted in the sensor window, then open the Radio Sensor Map: Utilities Menu > Advanced Utilities > Radio Sensor Mapper
- From the Radio Sensor Map, click the File menu. You will have the following choices:

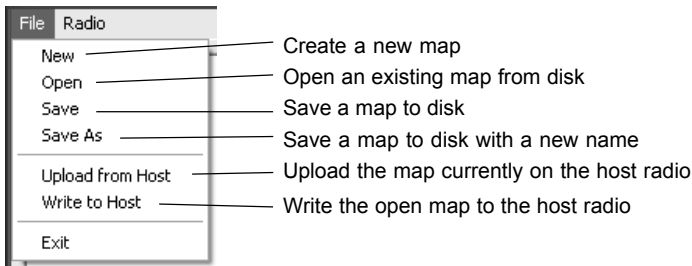


Figure 11: File menu on Radio Sensor Mapper

- Create a network map for your network.  
Every WaveData RF network must have a map loaded into the host radio that describes the layout of the network. (If INW engineers the system, we will provide the needed network map.)

Every radio and every sensor must be included in the map and must detail how they are connected and what addresses they use. Figure 12 illustrates a map for a

simple network. This network has one host radio (address 1) which communicates with one remote radio (address 2) to which is connected one sensor (address 4). Note that host radios are always on address 1.

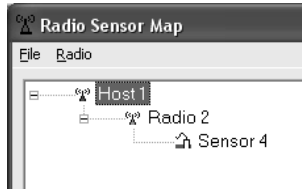


Figure 12: Simple network map

Note: For best results, when configuring your network use as low numbered addresses as possible, with as few skipped addresses. (See Appendix A for further network samples.)

- Write the map to the host.  
Once the map has been created, you must write it to the Host (File Menu > Write to Host). You may also save it to disk for future use by selecting Save or Save As. (See Appendix A for details on creating and modifying network maps.)

### Setting Communication Options

Before using your network, you must set the proper communication options in Aqua4Plus.

- Start Aqua4Plus
- Select the COM port to which the host radio is connected.
- From the Options menu, select Communications to open the Communications Dialog box.
- From the Factory Suggested Options dropdown list, select WaveData Radios (or IP Cell Modem and Radios, if using a cellular modem).
- Set the Lowest Sensor Address to 1. The host is always at address 1.
- Set the Highest Sensor Address to the highest address used on your network. (Note: For best results, when configuring your network use as low numbered addresses as possible, with as few skipped addresses.)

Your Communications Options box should look similar to the one shown in figure 13:

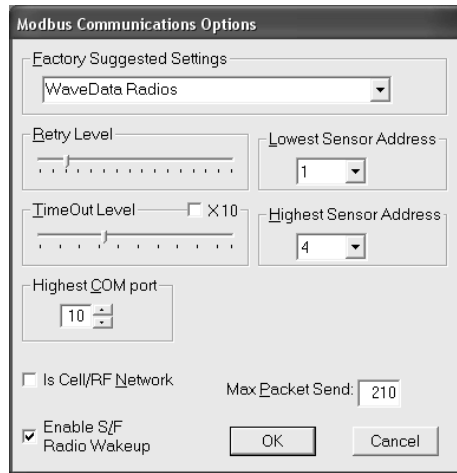




Figure 13: Communication options

## Configuring Remote Radios

- Scan for the WaveData units and sensors by clicking the  tool button. The program should find all the radios and sensors that were defined in your network map.
  - Since the radios go to sleep when not in use, the host radio will need to wake up each radio. The host handles this automatically whenever you attempt to communicate to a radio or sensor. A  message will display on the tool bar, whenever the host is attempting to wake up the radios. Be patient, this may be slow, depending on your network configuration. Once all the radios and sensors have been found, they will be displayed on the sensor panel.

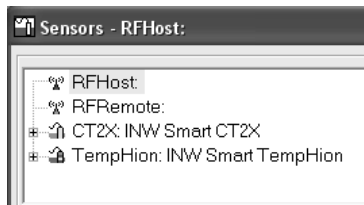


Figure 14: Radios and sensors displayed on sensor panel

- To change the description on a selected radio or sensor, click the Configure Menu, and then select Sensor Description. Enter the description and click OK.
- To change the address on a selected radio or sensor, click the Configure Menu, and then select Sensor Address. Select a new address and click OK.

**Warning!** If you change a sensor address, it will no longer be visible to Aqua4Plus. If you change a radio address, that radio and all radios and/or sensors downstream from that radio will no longer be visible to Aqua4Plus. You must update the map in the host to reflect the address changes.

## Controlling Sensors

Once your network is set up, you can access and control your sensors in the same way you would if they were directly connected to your computer. The only difference is that communication will be slower. Be patient. (See the *Aqua4Plus Control Software Instruction Manual* and the manual for your particular sensors for information on accessing and controlling the sensors.)

## Technical Information

### Wiring Diagrams

#### Pin-out on WaveData Boards

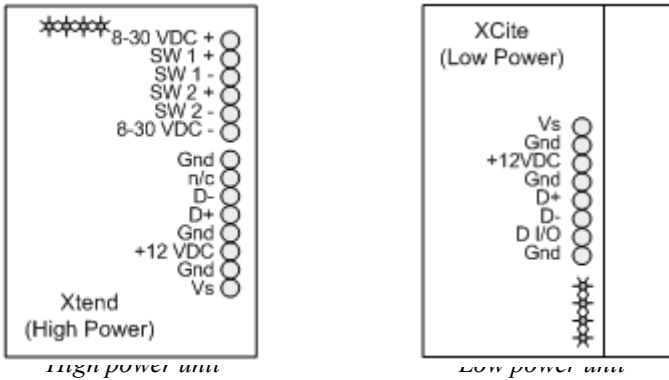
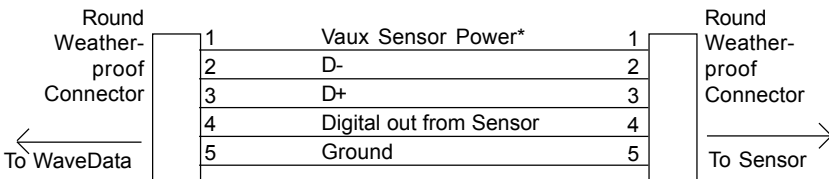


Figure 15: Pin-out on WaveData boards

### RS485 Cables

An RS485 extension cable is terminated with round weatherproof connectors on both ends and runs from a remote unit to a Smart Sensor or junction box.



\*Power to smart sensors. Limited to 15V, 100mA.  
Available only when Vaux is supplied to WaveData unit.

Figure 16: RS485 cable extension cable

An RS485 communication cable is terminated with a round weatherproof connector on one end and a 9-pin d-sub connector on the other. This cable runs from the RS232/RS485 adaptor (which connects to the PC or a modem) to a host unit.

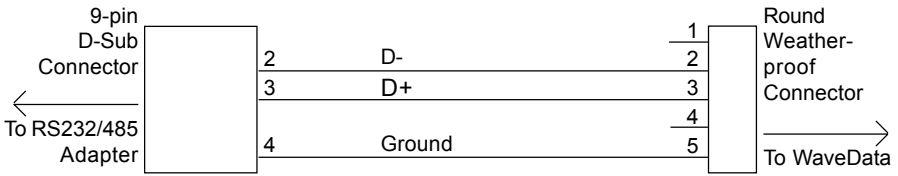


Figure 17: RS485 communication cable

### Battery Life

Basic WaveData radio packages come with a 12 VDC power supply, consisting of eight AA alkaline cells. D cell packs are also available. Battery life will vary depending on radio type, amount of usage, and whether sensors are powered from the same power pack. Table 2 shows some sample battery life scenarios.

<b>Radio Unit Only</b>				
	<b>Low Power Unit</b>		<b>High Power Unit</b>	
	<b>8 AA cells</b>	<b>8 D Cells</b>	<b>8 AA cells</b>	<b>8 D cells</b>
1 upload daily (10,000 records per day)	195 days	> 1000 days	55 days	295 days
1 upload weekly (10,000 records per week)	210 days	> 1000 days	70 days	355 days

<b>Radio Unit and Two PT2X Smart Sensors</b>				
	<b>Low Power Unit</b>		<b>High Power Unit</b>	
	<b>8 AA cells</b>	<b>8 D Cells</b>	<b>8 AA cells</b>	<b>8 D cells</b>
1 upload daily (10,000 records per day)	45 days	230 days	30 days	145 days
1 upload weekly (10,000 records per week)	130 days	645 days	55 days	290 days

Table 2

Note: Upload times, and thus power consumption, may vary depending on signal strength. Uploads times will be longer on networks with repeaters. Contact INW for other battery and solar power options.

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## Specifications

### OUTPUTS

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<b>1-Auxiliary Power Out</b>	50 mA, 12 VDC, for use by Aquistar® Smart Sensors
<b>2-Switched Power Out</b>	9-24 VDC (6 amps) (High power model only)

### RADIO TRANSCEIVER

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<b>Frequency Ranges</b>	902 - 928 MHz (Low power model) 905 - 925 MHz (High power model)
<b>Type</b>	Frequency Hopping/Spread Spectrum
<b>Transmit Power Output</b>	0.01 to 1.0 Watt (depending on model)
<b>Rx Sensitivity</b>	-108 / -104 dBm (Low power model) -110 / -100 dBm (High power model)
<b>Range-Indoor</b>	300' to 1500'
<b>Range-Outdoor</b>	Up to 5 miles (depending on model)
<b>FCC</b>	Part 15.247 certification

### POWER SUPPLY REQUIREMENTS

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<b>Battery</b>	12 VDC
<b>Auxiliary</b>	
Low Power Model	
Voltage	9 - 15 VDC
Current	100 mA @ 12 VDC
High Power Model	
Voltage	9 - 15 VDC
Current	500 mA @ 12 VDC



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## Advanced Configurations

### Configuring a Radio as a Host or Remote

Host radios can be made into remote radios and vice versa. This is done using the Radio option under the Advanced Configure menu. Contact INW for details, if you need to do this.

***WARNING! Do not attempt to make changes without guidance from INW.***

### Using Relays

Some models of WaveData radios have two switched relays on the radio board that can be used to remotely control equipment connected to those relays. These can be used to turn on/off pumps, control power booster packs, and other activities. Contact INW for details, if you are interested in using these relays.

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## Appendix A: Network Maps

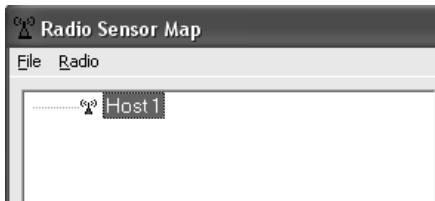
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### Creating and Modifying Network Maps

Network maps are created and modified using the Radio Sensor Mapper, which can be accessed from Utilities Menu > Advanced Utilities > Radio Sensor Mapper.

To view the network map currently loaded in the host radio, click the File menu, and then select Upload from Host. The current map will be displayed.

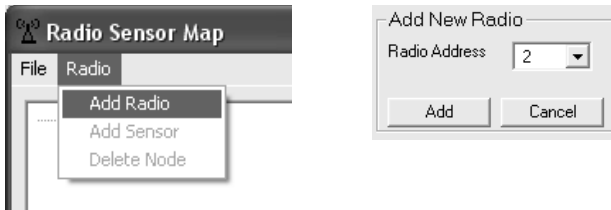
To create a new network map, click the File menu, and then select New. A map will display showing only a host radio.



*Figure 18: Radio Sensor Map showing only a host radio*

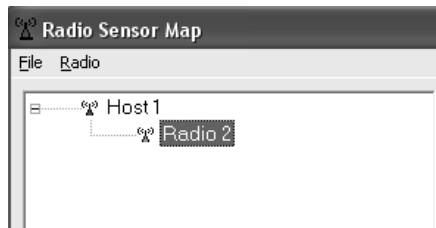
To add a radio to a map:

- Click on the radio (host or other radio) to which the new radio will be communicating.
- Click on the Radio menu, and then select Add Radio. Select the address for that radio, and then click Add.



*Figure 19: Adding a radio*

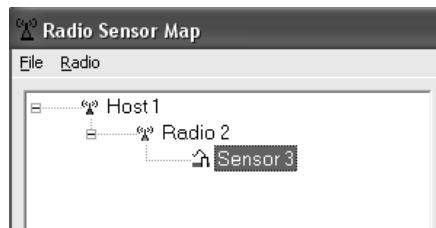
- The new radio should appear on the map, as shown below:



*Figure 20: Host and one radio*

To add a sensor to a map:

- Click on the radio (not host) to which the new sensor will be connected.
- Click on the Radio menu, and then select Add Sensor. Select the address for that sensor, and then click Add.
- The new sensor should appear on the map, as shown below:



*Figure 21: Host, Radio, and one sensor*

To delete a radio or sensor from a map:

- Click on the radio or sensor you want to delete.
- Click on the Radio menu, and then select Delete Radio or Delete Sensor. (Note: deleting a radio that has radios or sensors downstream from it will also delete those radios and/or sensors.)

## Sample Network Maps and Corresponding Networks

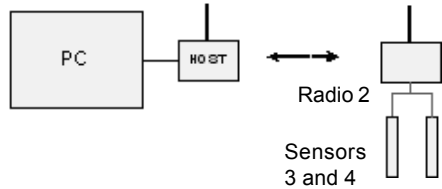
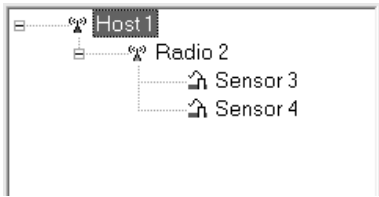


Figure 22-a: Sample network 1

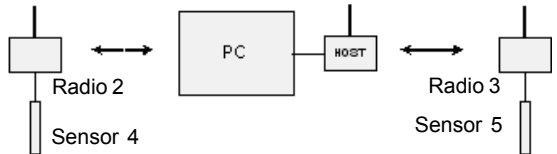
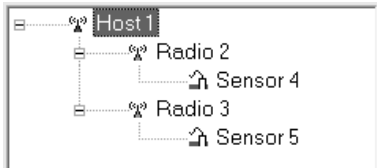


Figure 22-b: Sample network 2

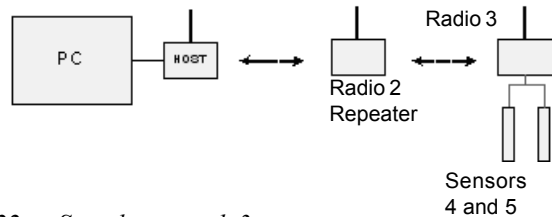
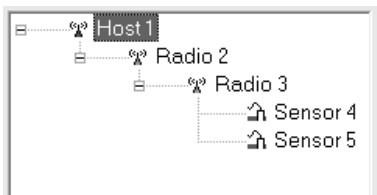


Figure 22-c: Sample network 3

## Appendix B: Trouble-Shooting

### Can't Find Host Radio

1. Be sure cabling between computer and host WaveData unit is securely attached.
2. Be sure power is on to the WaveData unit. A green LED visible through the upper right corner of the WaveData box will blink when power is on.

If running on batteries:

- The power switch is on the bottom of the WaveData box. Press in firmly to activate.
- If unit has been working but has recently stopped, replace batteries with fresh batteries.

If running on auxiliary power:

- Consult specific information for your unit to be sure power is being supplied.

3. Be sure that the correct COM port is selected in Aqua4Plus. (See figure 23.) If you do not see your COM port listed, first be sure it is not in use by another application. Then be sure that Highest COM Port is set appropriately, as Aqua4Plus will not list any COM ports higher than this setting. See the Communication dialog box under the Options Menu. (See A on figure 24).

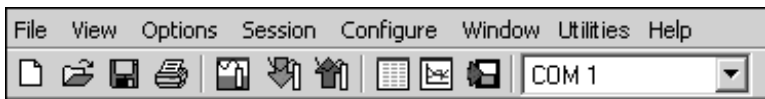


Figure 23: Selecting COM Port

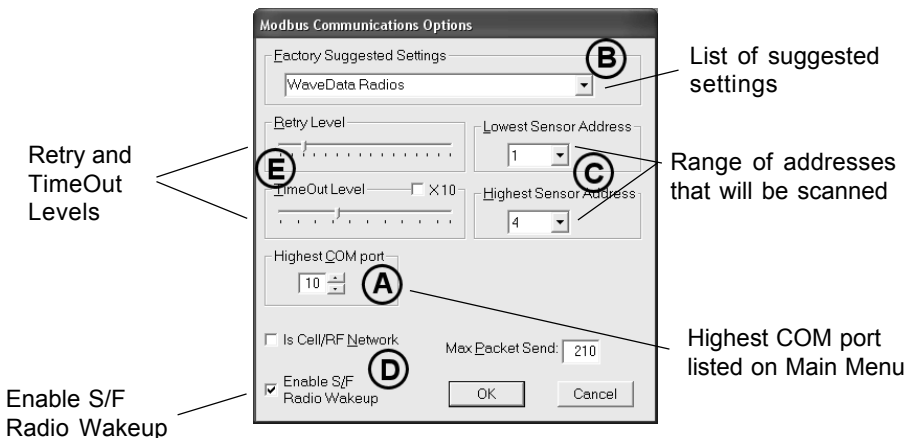


Figure 24: Communication Dialog Box

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## Can't Find Remote Radio

1. Be sure Aqua4Plus can find the Host Radio. If not, see previous section.
2. Be sure your communications options are set appropriately - Select the Communication Option on the Options Menu.
  - Be sure you have selected WaveData Radios or IP Cell Modem and Radios, if using a cellular modem. (See B on figure 24.)
  - Be sure that you are scanning the proper range of addresses to find each unit. Each WaveData unit and each Smart Sensor has a unique address, known as the Modbus address or Sensor address. To increase scanning speed, Aqua4Plus is often set to scan a limited number of addresses. Adjust Lowest and Highest Sensor Address as necessary. (See C on figure 24.)
  - Be sure Enable S/F Radio Wakeup has been checked. (See D on figure 24.)
3. Be sure the network map in the host matches your actual network layout.
4. Occasionally, Retry and TimeOut levels may need to be increased. (Options Menu, Communications options - see E on figure 24.) Retry Level is how many times Aqua4Plus tries to communicate with a remote radio or a sensor before giving up. TimeOut level is how long (in milliseconds) Aqua4Plus waits for a response from a remote radio or a sensor before retrying. If you continue to have difficulty finding remote units, increase the timeout level slightly by clicking on the indicator and dragging to the right. Note that the more retries and the higher the time outs, the longer the scan time.
5. Be sure antenna connections at both host and remote radio are secure, if using an external antenna.
6. Be sure you have a clear RF line-of-sight between the host and remote radio. (See Installation Considerations earlier in this manual.)
7. Be sure power is on to the WaveData unit. A green LED visible through the upper right corner of the WaveData box will blink when power is on.

If running on batteries:

  - The power switch is on the left side of the bottom of the WaveData box. Press in firmly to activate.
  - If unit has been working but has recently stopped, replace batteries with fresh batteries.

If running on auxiliary power:

  - Consult specific information for your unit to be sure power is being supplied.

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## Can't Find Smart Sensors

1. Be sure Aqua4Plus can see the WaveData unit to which the sensors are attached. If not, see previous section.
2. Be sure connections from WaveData unit to sensors are secure.
3. Be sure that you are scanning the proper range of addresses to find each unit. Select the Communication Option on the Options Menu. Adjust Lowest and Highest Sensor Address as necessary. (See C on figure 24.)
4. Be sure the network map in the host matches your actual network layout.
5. Increase the Timeout Level slightly. (See details under section 4 of *Can't Find Remote Radio*.)

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## Can Find Smart Sensors But Can't Reliably Communicate

1. Increase the Retry Level and/or the Timeout Level slightly.
2. Be sure connections from WaveData unit to sensors are secure.

## Appendix C: Using USB to Serial Cables

The standard communication cable/RS485-232 adapter plugs into a 9-pin serial port on the PC or laptop. Many new computers, especially laptops, do not come with 9-pin serial ports. If you have one of these computers, or if all of your serial ports are in use, you can connect to a host unit using a USB to Serial adapter, as shown below.

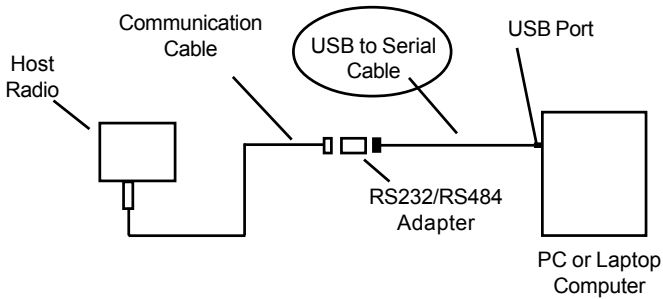



Figure 25: Connection using a USB to Serial Cable

USB-to-Serial cables are readily available from many electronics and computer stores, as well as numerous sites on the Internet. INW has tested and recommends the Keyspan USA-19HS. It is available from INW or various places on the Internet.

Install as follows:

- Plug into USB port
- Install the drivers provided with the particular unit
- Determine the port number to which the adapter assigned
  - Right-click on My Computer
  - From the popup menu, select Manage to open the Computer Management window
  - On left panel, click on Device Manager
  - On right panel, double-click on Ports
  - A list of active COM ports will be displayed. Note the COM number assigned to the adapter you just installed.

For example:  Keyspan USB Serial Port (COM8)

- Close Manager.
- Connect to the host unit.
- On the Aqua4Plus software, select the COM port. (Note: if you do not see your new COM port in the drop-down box, open the Communications dialog box from the Options menu. Increase the Highest COM port number.)

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## ***Reordering Information***

For sales & service offices, please contact:

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