Staying connected

US-based geotechnical instrumentation manufacturer Geokon describes the use of wireless sensor networks in groundwater monitoring

Figs. 2 & 3: GeoNet WSN installation

Fig. 1: vibrating wire pressure transducer and piezometer

A wireless sensor network (WSN) consists of spatially distributed autonomous nodes that monitor physical or environmental conditions, such as temperature and pressure, and pass data wirelessly to a main location or gateway that provides connectivity back to the wired world.

For groundwater-monitoring applications, WSNs are beneficial in geographically challenging areas where a wired infrastructure would be expensive or impossible, for example: in dewatering schemes; aquifer recharging; lake, wetland and tidal studies; and in assessing the efficiency of wick drains and irrigation canals.

The GeoNet WSN is designed to collect data from many sensors. It consists of a network supervisor, sensor nodes, sensors and operating software. Sensors are connected to the nodes directly or multiple sensors can be connected to a single node via a multiplexer.

In groundwater applications the sensors are generally vibrating wire pressure transducers or piezometers (*see Figure 1*). A vibrating wire transducer uses a pressure sensitive diaphragm with a vibrating wire element attached to it. The diaphragm is welded to a capsule that is evacuated and hermetically sealed. Fluid pressures acting on the outer face of the diaphragm cause deflections. This changes the tension, and, therefore, the resonant frequency of the vibrating wire. Nodes electronically 'pluck' the wire and measure the resonant frequency. The vibrating wire type is preferred on account of their long-term stability, rugged construction, insensitivity to contact resistance and ability for data logging.

GEONET

Each GeoNet WSN allows up to 100 nodes per network (*see Figure 2*), or 25 nodes connected to eight-channel multiplexers, and up to 12 networks can coexist by setting each to a different operating frequency (channel). The system is low power and operates with alkaline or lithium D cell batteries.

Sensor nodes collect data from a sensor, or up to eight sensors when connected to a multiplexer, as well as node information such as battery voltage, signal strength and temperature. Each node, if disconnected from the network, functions as a stand-alone data logger and can store more than one million data arrays. The supervisor controls the network and is the aggregator of all data collected by the sensor nodes. Node data stored by the supervisor is collected by using the software provided or via any other Modbus master.

GeoNet operates at 2.4GHz or, in select regions at 900MHz, and uses mesh network cluster tree topology, which is self-configuring and self-healing. Data from the nodes is sent directly to the supervisor or by communication via other nodes. The range between nodes for the 2.4GHz system (line of sight) is 1,600m (North America) and 750m (international). The range between nodes for the 900MHz system (line of sight) is 6,500m. Networks support up to four hops, in perfect conditions this increase the range from the supervisor to the most remote node by four times.

OBSTACLES

Each transmission from node to supervisor or node to node is considered one 'hop', and there can be up to four hops. The ability to hop allows the supervisor to communicate with nodes that do not have direct radio communication, thereby allowing nodes to operate around buildings, natural obstacles or other barriers. In some instances, if communication cannot be established, it may be necessary to elevate the sensor nodes, and/or to extend the cable from the attached sensors.

Battery life is affected by temperature, the radio environment, the physical configuration of the network and the sample (scan) rate. Nodes that are the only communication link between other nodes and the supervisor will have a shorter battery life than those that have no routing responsibility. Node battery life, based on a one-hour scan rate and one hop, is estimated at more than 1,000 days.

CONFIGURATION

Configuration of the GeoNet network and collection of data is done via a PC client program by communicating with the network supervisor directly, through cellular modems or network serial servers (*see Figure 3*). Each data array consists of the record date/time, battery voltage, node temperature, vibrating wire sensor reading, sensor temperature and radio signal strength. A database on a host PC stores the data, which can be viewed in charts and easily exported for use in other data-management applications. For GeoNet networks that are continually available for communication, the program can be configured to collect and export data on a schedule to accommodate other automated systems. ▾