ANTENNA SELECTION FOR WATER MONITORING

Fresh water supplies are becoming dangerously low in many areas of the world, and the use of technology to better monitor, control and safeguard water flow helps protect this threatened and valuable resource. Supervisory Control and Data Acquisition (SCADA) systems utilizing wireless technology offer many benefits for water management, including reduced installation and implementation costs, enhanced security and improved reliability. The selection of the appropriate antenna technology for water monitoring SCADA networks is an essential element to ensure the network's optimal performance.

Wireless Benefits

Wireless technology for SCADA water monitoring systems provides added versatility as more demands are placed on the network. Water systems need to grow as population increases, and wireless networks can make upgrading and expanding those systems easier and cost effective. Rather than excavating trenches or physically adding cables to existing installations, additional components and facilities can be added and monitored through signals sent via airwaves to control centers. This capability results in significant material and labor cost savings.

The technology also supports more efficient system operations, as wireless systems can instantly transmit information and monitor inaccessible Remote Terminal Units (RTUs) to and from a centralized location. This allows more frequent and real-time remote monitoring of sites, and results in smaller labor force requirements to operate and repair equipment. Fewer human errors that affect calculations or readings are found when these systems are in use.

In addition to reduced labor costs, enhancing SCADA designs with wireless connections can provide additional energy savings and added protection to equipment, potentially avoiding damage to the network that could result in costly property damages or heightened risk to human safety.

Ultimately, wireless water monitoring systems provide added protection for the environment, property, and the people such systems are intended to serve. More frequent or real-time readings of extremely high or low water levels translate into faster human response. Faster responses to sewage overflows, for example, could help prevent peoples' homes from flooding. Careful management and reduction of the flow of hundreds of millions of gallons of contaminated water dumped into lakes and rivers each year because of sewage overflows would be beneficial to human health and to the environment.

Selecting an Antenna

However, a wireless SCADA system for water monitoring is only as effective as the antenna technology used in its design. Traditionally used for conventional narrow band radios and related activities, antenna applications have undergone massive change with the development of digital technologies and are now used in a multitude of applications across many industries. While factors ranging from topography, to size, to Radio Frequency (RF) congestion must be considered in the

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APPLICATION NOTE

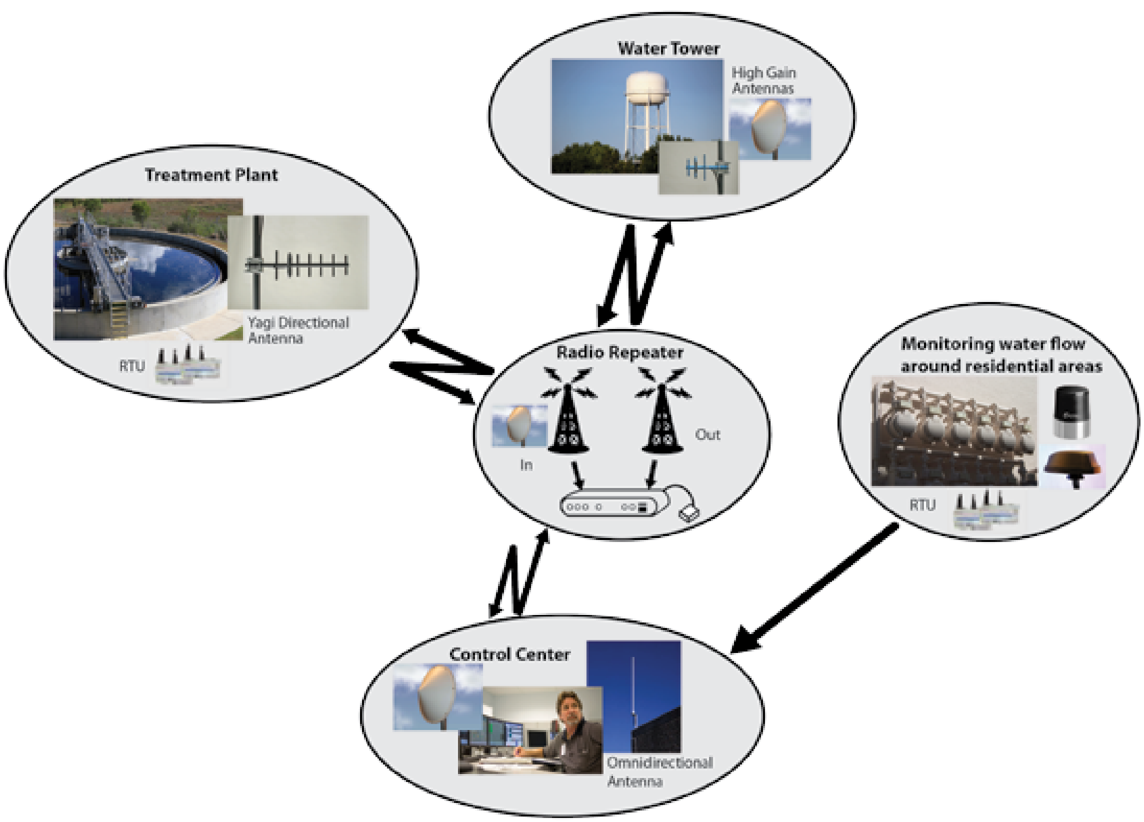
design stage of a wireless network, it is the antenna technology's efficiency and durability that become crucial for the system to reap the benefits of a wireless architecture.

To illustrate, a typical wireless SCADA water monitoring architecture uses central computers to monitor levels in water tanks. In this case, the control room is interconnected to valves, switches and other components installed on RTUs at the water tanks. The information is transmitted and received to and from the control room via Radio Frequency (RF) signals. Each segment of the network includes some type of antenna that receives and transmits the information. In a wireless water meter reading application, for example, a water meter, a service vehicle with monitoring equipment, and a utility company are interconnected through the wireless network. Each part of the network is equipped with an antenna suited to receive and transmit signals to the appropriate target.

As shown in the above diagram, multiple antennas can be used in wireless water flow systems to effectively manage information. The selection of the correct antenna technology to support these systems depends on a number of factors closely tied to the application. This decision is influenced by considerations that must be weighed in order to achieve the desired network performance.

As a start, it is important for the planner to determine the targeted area of coverage, including those areas he or she does not wish to cover for security or other reasons, and the distance between the points of propagation (e.g. tower, water tank, control center, etc.) to the farthest RTU (e.g. meter readers, etc.) This will help delineate the border for the covered territory. The planner should also become familiar with the expected usage statistics for his proposed grid as the volume of data typically transmitted and the location of the grid is an important consideration for the selection of RF technologies that will be used to support the wireless system.

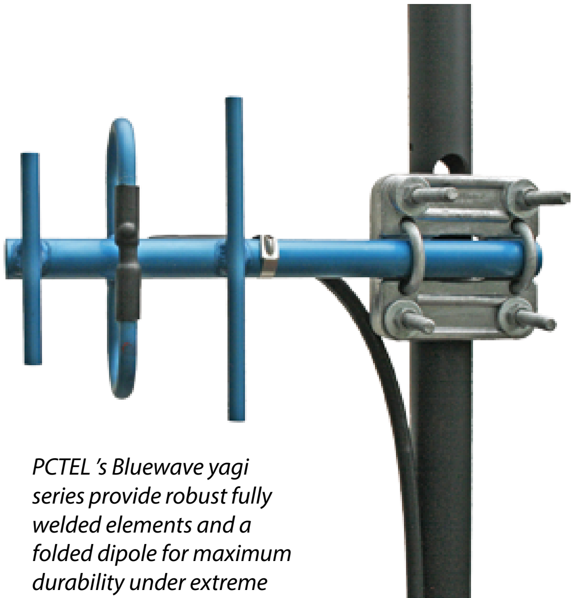
After these initial steps, a site survey covering the topography, vegetation and climatic characteristics of the target area of coverage should be conducted to account for line-of-sight and other potential RF interference issues. The resulting site map should plot the point(s) of propagation, the desired RTUs and potential network expansion areas. Next, an RF link budget must be prepared to calculate the power requirements at each access



Water Flow Systems Wireless Network

point based on the technology chosen. Finally, the equipment must be selected to meet these and FCC requirements.

Once the RF technology is selected, the site map will provide direction for the system's designers to select the optimal antenna solution for their wireless water monitoring system. A typical network will include a combination of directional and omnidirectional antennas with varying form factors, gain requirements and mounting configurations. The type of antenna used will depend on the link budget limits, environmental conditions, aesthetic requirements, and any other special considerations. If properly selected, the antennas should provide the desired signal directivity and strength required to meet the objectives of the network architecture. For example, an antenna attached to a residential water meter will have very different aesthetic and environmental requirements than one installed on top of a water tank.



PCTEL 's Bluewave yagi series provide robust fully welded elements and a folded dipole for maximum durability under extreme environmental conditions

Many of the water systems using wireless SCADA employ various frequency bands. For water meter reading applications, unlicensed spectrum frequencies are commonly used, partly to simplify the meter reading process and make the system more cost effective. Also used in many wireless SCADA are Microwave Radio and VHF/UHF Land Mobile Radio technologies. The RF frequencies used will have different wavelength and data speeds, and these considerations would have been taken into account during the site survey and equipment selection stage.

Although wireless SCADA networks operating at 900 MHz or VHF/UHF frequencies may be less susceptible to line-of-sight issues, many water flow systems now utilize Spread Spectrum 2.4 GHz and 5.8 GHz frequency bands which provide faster data rate transmissions. However, antenna selection for these systems is critical, due to the technology's inherent LOS limitations. For this reason, the location of the propagation antenna should be well above tree lines or other natural and artificial structures, as these could potentially absorb or reflect the radiated signals.

If the path of the radiated signal is relatively clear of obstructions, short low density links can be established by using a single omnidirectional antenna with enough gain to reach the RTU's antennas. However, omnidirectional antennas with too much gain could propagate over the RTU antennas, because as gain increases, the shape of the radiated pattern becomes flatter, reducing coverage directly below the antenna. Therefore, if a high gain antenna is needed to reach the RTUs, an omnidirectional antenna with an electrical down tilt should be considered as this feature could help re-direct the angle of the radiated beam closer to the perimeter of the antenna.

There are various types of directional and omnidirectional antennas designed to achieve specific pattern shapes. Omnidirectional antennas broadcast RF signal in all directions, while directional antennas focus energy in a single direction. Directional yagi antennas, commonly at the point of propagation site, have reflector and director elements that send or receive RF signals, offering higher gain (the focused strength of the radiated energy). Smaller, low profile omnidirectional antennas are typically selected for meter reader installation in wireless water monitoring applications. Vandal proof mounting is recommended in these cases to deter antenna removal.

As an example, the San Antonio Water System (SAWS) utilizes omnidirectional antennas installed on the top of water towers and other tall structures to communicate information to the SAWS headquarters about flow, pressure and possible shortages. Meanwhile, directional yagi antennas have been used to focus

Parabolic reflector antennas provide high gain properties to facilitate focused directional radiated energy.

signals between some water meters and data collection points to facilitate meter reading.

SAWS uses frequency hopping spread spectrum (FHSS) technology which sends signals over a narrow band fixed frequency before “hopping” to a different frequency. Reported benefits include improved system reliability.

Another point to consider is the RF congestion in the target area of coverage. In urban settings, for example, large number of signals traveling in an area can cross each other and cause signal deficiency. This is commonly known as co-channel interference. Highly directional antennas with narrow radiated beams are often selected for these applications because the narrow beam is the less likely to cross the signal of other nearby antennas. In these cases, vertical or horizontal orientation adaptability is helpful, as the vertical or horizontally polarized antennas can be used to radiate around the signals of neighboring radiators, reducing exposure to co-channel interference.

An important aspect of antenna selection includes the evaluation of the environmental and climate conditions to which the wireless system will be exposed. All the components of a typical wireless water monitoring system should be designed to withstand fluctuations in temperature, humidity and ultra-violet exposure without degradation. Antennas with vented housings that allow water to drain, and not condense inside the antenna, are usually a good investment as the removal and re-installation cost of a failed antenna due to water ingress can be significant. Antennas attached to water meters should be designed to be impervious to water and moisture and should include a good quality rubber gasket for added protection to the system.

Other environmental considerations include exposure to impact blows (e.g., birds, ice, etc.), wind loading and severe vibration. For instances in which these influences are present, antennas with housings constructed of rugged materials featuring superior UV stability are recommended. In addition, heavy duty mounting structures for antennas installed on masts or towers are equally important to avoid antenna movement that could affect the stability of the radiated signal. Efficient mounting designs provide added flexibility and reduced failure to the system due to antenna damage.

Other factors that determine the antenna best suited to a specific function include size, aesthetic requirements and vulnerability to theft or vandalism. Compact designs, versatile mounts and consumer-oriented housings are often used to address these issues. While easy to reach antennas such as those installed in consumer meter reader enclosures may require vandal-proof mounting mechanisms, those installed on the top of municipal water tanks generally have a low risk of theft. Aesthetic concerns, however, are an important factor in these cases. In the SAWS example, antennas are color matched to the water tank to make them less conspicuous.

Conclusion

In closing, it is important to understand that antennas are a very important, and often overlooked, component of a sound wireless communications system. Safety, reliability and efficiency of water systems can be enhanced with wireless technology, if proper network planning and correct antenna selection is conducted.

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