Environmental Monitoring and Early Warning System Design

Robert Chan, Ty Le, Alan Manlucu and Lee-Ann Tsan

***Abstract* -- This paper presents an environmental monitoring and early warning system (EWS) for use in the Grand River Watershed. The design consists of two major sub-systems. The first is a sensor system that houses seven sensors and two sampling ports. The second system houses a wireless data logger, reeling system and batteries.**

***Index Terms* -- Alarm Systems, Detectors, Monitoring, Water**

I. INTRODUCTION

Canada is often viewed as a nation rich in water resources. This perception of abundance masks the realities regarding the ready availability of these resources for human consumption [1]. Thus, as the demand for clean drinking water increases so too does the need to find alternative sources of clean, safe and reliable water. Currently, some municipalities have opted to use treated surface water as potable water; however, this method is more susceptible to contamination and thus creates a need for an early warning system (EWS). An EWS has the following core requirements: it provides a rapid response, detects a wide range of contaminants, and is self-powered, portable, reliable and durable. Furthermore, this device must also be remote operable, low-maintenance with minimal upgrade costs.

Currently, the United States Environmental Protection Agency has developed a similar approach to their EWS. Their goal is to use multi-parameter water quality monitors to provide an early warning of an unspecified contaminant [2]. Our EWS is innovative as it has sensors that will relay information through a cable to a microprocessor on-shore for analysis. This processor will have a wireless device associated with it, and information will be sent to a data logger at a nearby personal computer for easy access and high mobility. The milestone for this project is an in-depth operator's manual to accompany the device. It includes contact information, drawings, setting up procedures, troubleshooting techniques and recommendations for other compatible products.

II. CONCEPTUAL DESIGN/METHODOLOGY

A. Overall Design

This design has a sensor system submerged in water that will first detect the contaminants in the Grand River. Secondly, there is a wireless reeling system located on-shore that will upload the measured data onto a website via satellite as seen in Figure 1.

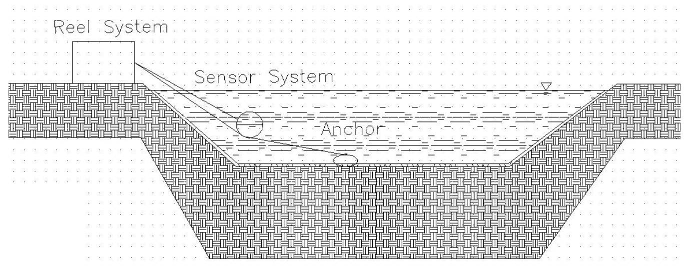

Figure 1: Overall System Design

The sensor monitoring unit is cylindrical in shape with a 20 kg ellipsoid anchor, used to stabilize the system under high flows and other impacts. The casing consists of reinforced, clear waterproof UV-protected PVC with a thickness capable of shock absorbance against floating debris. The on-shore system is responsible for transmitting data as well as reel in the sensor and anchor systems. The reel system has two spools, one for the tow line and the other for the data cables. There is enough capacity to house 12 m of cable for each reel. The data is uploaded to a website to be retrieved anywhere in the world. The entire system requires 6 W of energy to run continuously and is powered by two rechargeable lithium-ion (li-ion) batteries supplemented by solar power. The batteries require changing every 30 days for recharging.

If the water parameters exceed acceptable levels, the system will alert authorities by having an automated telephone message to an on-call cellular device. The data logger will provide the monitored data and will also compare the high contaminant level to acceptable levels set in the Provincial Water Quality Objectives or Federal Environment Quality guidelines. Simultaneously, the underwater unit will begin a process of taking a sample of the water and storing it within the system. The system must be drawn back on land for sample retrieval.

B. Major Components

The design has been broken down to a few major components including: sensors, satellite telemetry, data logging, energy and warning system.

III. DETAILED DESIGN

A. Sensors

The presence of the contaminants in a watershed is a concern for the drinking water detection system. Most sensor systems can now be monitored remotely, continuously and/or in real-time [3]. The most appropriate sensor systems were selected to use in this project based on the site conditions (the contaminants that exist in the watershed), the available sensor technologies and cost effectiveness. Temperature, pH, conductivity and dissolved oxygen are the water quality parameters of most importance. The sensors associated with these parameters were therefore selected for use in our design. Ammonium, phosphate and nitrate sensors were selected because they are commonly released from sewage treatment plants, industrial plants or farms-common industries found within the Grand River Watershed.

B. Satellite Telemetry and Data Logging

The data logger is responsible for transmitting sensor data to a computer through internet satellite telemetry technology. Typical latency time, which is the time it takes the user to receive data between the two devices, is approximately 2.5 minutes. If the view to the satellites is obstructed, it will take longer. Data can be retrieved and instructions given to the device through a website. The data logger is powered using the rechargeable li-on battery.

C. Energy

The optimal configuration for providing energy was found to be a combination of li-ion battery power and solar power. The energy system can provide continuous power for 36 days under a fairly conservative estimate power demand of 6.3 W. Li-ion batteries have a disadvantage of losing charge when exposed to warm temperatures. For this reason, the batteries will need to be replaced once every two years to keep enough charge to run the system for 30 days. The majority of the energy demand comes from the wireless data logger which requires 24 W of power when transmitting. It was found that if the device transmitted once every 15 min then the system can be run continuously for 36 days.

D. Warning System

This technology enables the user to establish an alarm system for the parameters of temperature, pH, conductivity, dissolved oxygen, nitrate, phosphate and ammonia. Alarm messages are sent if measured readings are above the limit specified by the operator or when an input deviates from the last reading by a pre-set percentage. When an alarm is triggered, the sample sensor would immediately release a valve for the storing of a water sample for further analysis at a laboratory. Should the system go offline due to interference or obstacles in the wireless transmission of data, a warning will be sent to an on-duty officer.

False alarms occur when the data collected is inaccurate. This can happen due natural fluctuations of the water quality, algae misshaping and passing through the device and clogging the system, or because of an un-calibrated sensor. Therefore, it is important to calibrate the sensors every three months to minimize false alarms and take notice of unusual readings.

IV. Discussion

Further recommendations to improve the design include building a bench scale and pilot testing. From this, we will be able to understand all the technicalities and iron out details that may have been overlooked during the theoretical design. We would also like to have other people test our design to gauge user-compatibility. Mores specific recommendations are to find cost-effective sensors for phosphate, currently valued at $1,300, and to build casings that take ergonomics into account.

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