Bowman Creek Water Monitoring Senior Design Project Proposal

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Introduction

As a part of an initiative presented by Gary Gilot, the Bowman Creek restoration.The initiative seeks to improve the overall quality of the watershed particularly by lowering pollutants and creating a liveable environment for aquatic life to thrive in. The goal is to reclaim the creek and to transform its heavily urbanized form into a form that is not only beautiful but also environmentally safe and sound. With this is mind some of the improvements that must be made are centered in the underground and piped paths of the creek. The creek must not only be clean flowing creek above ground but throughout if the overall impact of a cleaner and healthy watershed is expected.

Problem Description

We seek to solve the problems of the drastic change in flow rate due to obstructions caused by backflow in the underground sewer portions of the creek. The water flow rate as it is now is not well regulated and this leads to issues such as not only a dry creek with lack of rain but also flooding during heavy rain periods. The flow must be monitored so that regulation systems including valves can appropriately allow a reasonable rate of water flow to not only prevent damage in the piping but also to have the creek have a steady flow throughout all its portions. With these sensors some other issues come to exist with powering such devices throughout the piping systems, whether they are to independently powered or tied to the grid and if the source of power is renewable or not to maintain the environmental goals intact. Along with that is the sizing of the sensing equipment to not obstruct the flow of water whatsoever. Also the equipment must have some protection from water so to not have chance of failure due to damage to the equipment. Another issue that arises is the way the sensors communicate the water, whether to use a large network or not.

Problem Solution

In order to monitor the water depths we plan to design and build what will be a compact, affordable and durable solution to the aforementioned problems. We plan to use solar panels as a primary power source to maintain the self dependence of the sensors, back up batteries will help in cases of emergency as well as maintenance. The unit would have a protective shell to prevent water damage. RF receivers and transmitters would allow communication between the unit itself and the following one so as to send the flow from the previous one to compare and then have it sent to a flow control system decide whether of valves or larger reservoirs decide how to route the water, while also saying if cleanup is necessary.

Demonstrated Features

Battery – The rechargeable battery is the lifeline of the device. It will allow energy inputfrom our solar panel. The battery will power the native features of our device. We have not decided what type of battery to use yet as we must test the cost efficiency of each type, but considerations include nickel cadmium, nickel metal hydride, lithium ion, and lithium ion polymer.
Solar panel – One of the alternative energy sources of our device. The solar panel will charge our battery whenever light is present. Diodes will prevent energy from being drained from the battery in darkness.

RF Transmitters and Receivers- Send and receive data to and from another source to have input from other levels and output to other levels to see how flow rate changes.
Pressure Sensors- One way to determine the water flow rate is to have pressure sensors which will then communicate through the program what should be comparing the values of flow rates in order to determine the course of action.

Available Technologies

Battery:
In order to create our device, we need to use a battery that:
Is rechargeable.
Can be charged and discharged multiple times without damage to battery life.
Is affordable.
Is lightweight.
We were able to find data on a number of different battery technologies. The leading technologies for our purposes are Nickel-Cadmium, Metal-Nickel-Hydride, and Lithium-Ion. In addition, there are a number of variants of Lithium-Ion. The following statistics were taken from the Cadex website, a company specializing in battery charging and analyzing equipment.

	NiCd	NiMH	Li-ion cobalt	Li-ion Manganese	Li-ion Phosphate
Specific energy density (Wh/kg)	45-80	60-120	150-190	100-135	90-120
Internal resistance (mΩ)	100-200 in a 6V pack	200-300 in a 6V pack	150-300 7.2V	25-75 per cell	25-50 per cell
Cycle life (80% discharge)	1000	300-500	500-1000	500-1000	1000-2000
Fast-charge time	1h	2-4h	2-4h	<1h	<1h
Cell Voltage (V)	1.2	1.2	3.6	3.8	3.3

Because our users will be constantly charging and discharging our battery, we must prioritize cycle life, or how many times the battery can be charged and discharged. At this point, Li-ion Phosphate seems to be the best choice of battery because of its long cycle life. There are drawbacks to this as this battery does not hold the greatest amount of energy per kilogram. While this will be our initial choice for a battery, we will continue to explore possibilities for batteries as we discover which technologies are commercially available and at what cost.

Solar Cell:
We chose to incorporate a solar cell into our design to allow users to have a way to charge the sensing system locally and in an environmentally friendly manner.

When looking at different solar cells, the most important specification is the output power. Depending on what size voltage battery we decide for a power source, we will want a solar cell that is capable of charging up the battery in a reasonable amount of time. In order to determine how long it will take a solar panel to charge up the rechargeable battery, take the output power of the solar cell and divide it by the voltage of the battery to determine the current being provided to the battery. Next, take the capacity rating of the battery and divide it by the current going to the battery to determine the time in hours that the battery will take to charge completely provided the solar cell is outputting at its maximum power.
The table below is a comparison of different battery types to different wattage solar cells as well as a comparison of their price. Since we want out product to be small, light, and portable, we would like to have a solar cell that is also not too large but can provide enough power to charge the battery in a reasonable time.

	NiCd	NiMH	Li-ion Cobalt	Li-ion Manganese	Li-ion Phosphate
Voltage (V)	1.20	1.20	3.70	3.70	3.20
Capacity (Ah)	0.60	2.65	2.55	1.40	0.60
Current from 1W SC to Bat (A)	0.83	0.83	0.27	0.27	0.31
Current from 3W SC to Bat (A)	2.50	2.50	0.81	0.81	0.94
Current from 5W SC to Bat (A)	4.17	4.17	1.35	1.35	1.56
Time for Recharge w/ 1W SC (h)	0.72	3.19	9.44	5.19	1.94
Time for Recharge w/ 3W SC (h)	0.24	1.06	3.15	1.73	0.64
Time for Recharge w/ 5W SC (h)	0.14	0.64	1.89	1.04	0.38

The main cost of the solar cell will depend on the wattage we choose and the size of the cell. The system should not need that massive of an amount of power so we can probably get by with a solar cell no bigger than 5W since the longest charge time of any of the batteries at a 5W its about 2 hours which is reasonable but ideally we would like to have it closer to an hour or under an hour if possible. A 5W solar cell should cost us no more than $30.

Pressure Sensors - The sensors will depend on the depth specifications of the pipes as well as the cost for the accuracy and sophistication of the overall piece. In these example specs only one piece is actually within our range but they provide some idea into using other pressure sensors or developing some as in the case of using a wheatstone bridge circuit to make pressure sensor in that with pressure change there will be resistance changes which can through instrumentation amps. There also exist small barometric sensors that cost around $40, which can be outfitted to make our water pressure sensors.

		Accuracy	Operating Temperatures	Ranges	Input	Output Signal	Body Material	Dimensions L x D
	Stevens SDX	0.25% (FS)	-40 to 85 C	0-5, 0-10, 0-35, 0-50 ft ranges available	14 - 35 VDC	4 – 20 mA	PVC with copper nose cone	4.0 x 0.85 in.
	Greenspan PS 2100	0.1% (FS)	0 to 50 C	0-2.5, 0-5, 0-10, 0-20, 0-40, 0-75, and 0-100 m ranges available	9 – 30 VDC	RS 232 or SDI-12 with adapter	Stainless Steel	15 x 0.88 in.
	Greenspan PS 7000	0.1% (FS)	0 to 50 C	0-2.5, 0-5, 0-10, 0-20, 0-40, 0-75, and 0-100 m ranges available	8 – 30 VDC	4 – 20 mA	Stainless Steel	11.1 x 0.9 in.

Data from stevenswater.com

Engineering Content

The major engineering content of our project will be to integrate all the above mentioned devices to create one working product that satisfies all the needs of the user. In addition to designing each of the systems for the pressure sensor, solar power, receivers and transmitters, we will also need to design an easy to use and connect unit. We want try to design the device to be small and rugged so that it can not only withstand the environment surrounded by water as well as not be obstructive to the pipe system. Another main engineering concern is the dissipation of power through the device. We need to design the way the charging system works and how power is delivered from the battery to the different systems by using the microcontroller. We also have to create a good pressure sensor

Conclusions

With the proposed, technology and integration we hope to have a working system that monitors Bowman Creek's water levels. With this is mind, if we maintain a steady flow of the creek throughout the year,especially in the dry seasons and the flooding seasons, the creek will become not only a desirable natural resource for the community but also a viable home for aquatic life in the St. Joseph's river watershed. The system will helps solve a community problem while at the same time provide a possible solution for many many places that deal with the same issue.