Water System Monitor

Project Concept

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Overview

A well water system servicing a rural vacation home is a critical component of habitability - if the water system fails then the home is not habitable.

In April 2018 a friend of Jim's was explaining recent failures to his well water system and how he had to work to overcome them. This naturally led to the idea of some kind of remote monitoring that could assure one of the health of the system. A second goal would be to predict pending failures.

The purpose of this project is to instrument the well water system, log the measurements into a database, and provide a smart phone app that will present relevant information about the current status of the monitoring system.

The Water System

The system in question has several components.

1. Well - A six-inch hole lined with pipe that extends about 200 feet into the ground. The well has some level of water in it. The water level can vary over time. The level of the water below the surface is an indicator of well health. Also, the recharge time - time it takes the well to refill after a significant amount of water has been pumped out - indicates overall well health. Boring a deeper well is a very expensive operation.

2. Well Pump - The pump is attached to a half inch pipe and immersed in the well, about 20 feet under the nominal water level. Power wires run down the pump pipe. When the pump is powered on it pumps water up through the attached pipe. Replacing the well pump is expensive.

3. Storage Tank - A 1500 gallon plastic tank that holds water. The storage tank has a float level sensor on it. When the level is too low the well pump is turned on. When the level reaches a set amount the pump is turned off. There is hysteresis in the system so that the pump is only turned on when the level in the tank has dropped a certain amount. When water is being used the well pump may not run at all. The well pump will only run when a significant amount of water has been used from the storage tank. This infrequent usage prolongs the life of the well pump.

   The storage tank can also be filled from a tanker truck.

4. Pressure Tank - A smaller 80 gallon steel tank that holds the water under pressure. When a tap in the house is turned on then water flows from this tank.

5. Pressure Pump - The pressure pump is used to move water under pressure into the pressure tank. It runs whenever the pressure in the pressure tank decreases by some set amount. When water is being used this pump will run frequently. Replacing or servicing the pressure pump is of reasonable cost.

6. Alternate Pressure Tank - There is an older pressure tank that can be used if the primary pressure tank fails. Valves can be manually set so that the well pump directly fills this alternate pressure tank. This is a sub optimal design because it requires the well pump to run quite often when water is being used and can shorten the life of the well pump.

7. Control System - A dedicated control system reads the various levels and controls the various pumps. The power control is effected via a set of relays. These relays each have a low voltage relay controlling the higher power relay. The relays have extra sets of contacts that are unused at this time.

Desired Information

A. How much water is being used over time?
B. How often is the well pump running?
C. How often is the pressure pump running?
D. What is the level of the water in the well?
E. How fast is the well replenishing?

Monitoring Design

Sensors

While we could monitor everything, we propose to monitor just the well pump and the pressure pump. Each time a pump comes on and goes off we will log an event with the name of the pump and the time. Once we have established a baseline of behavior over a year (to account for seasonality), then deviations can be considered significant.

Inferences

1. When the pressure pump is running, water has been consumed.

    a. The time the pressure pump runs indicates water usage

2. When the well pump is running we are replacing consumed water.

    a. The time the well pump is runs indicates water usage.

3. There will be some relationship between pressure pump run time and well pump run time. If the well pump begins to run longer then something is wrong.

    a. There is a leak in the system before the pressure pump
    b. The well pump has become less efficient and may be pending failure
    c. The well is not charging fast enough and the pump is running dry

Display

The event data is all stored in a cloud database and can easily be plotted using native database tools.

A smartphone application will report the current status of the system and will allow the monitoring system to be tested for proper operation.

We will not be raising alarms in the first version of the system. Once the system is operational we may be able to recognize some alarm conditions and code them into a second release of the system.

Monitoring System

Onsite Device

We will use the TPP Water Leak Detector hardware with a Particle Photon as the base of our system.

We will modify the sensor inputs to provide just a sense line and ground. These will be run to the unused control relay contacts for each of the pumps. When the pump goes on the line will be pulled low. When the pump goes off the line will be held high internally.

The Photon will be connected to locally provided WiFi. Alternatively an Electron could be employed to use the cellular data network at a cost of $3/month.

The device will have a test button that temporarily turns off the button indicator LED and writes a test event to the log storage.

Log Storage

Each trip of a sensor will be logged to a Google Sheet with sensor name and a timestamp.

Google Sheets provide graphing capability that will be sufficient for discovering behavioral patterns in the data.

Device to Cloud Link

We will use IFTTT or a Particle WebHook to connect the Onsite Device to Log Storage.

Smartphone

A smartphone app will be written using MIT AI2 or Thunkable. The initial target is Android, but a cross platform app is desired.

The app will

1. Display the current time and firmware version of the monitoring system.
2. Display the current value of all reported sensors

Future Plans

We would like to extend the system in several ways.

Well Water Level

A key indicator of the health of the well is how much water is in it. There are a number of technical challenges in measuring the water height. First, the current well has a nominal water level at 200 feet below the surface. The well shaft is six inches in diameter. Down the middle of the well shaft is the two inch water pipe. Every thirty feet the water pipe is fitted with a “snubber” that keeps it centered in the well shaft.

The owner would like to know the well water level when the well is at rest. He would also like to know how much the water level drops when the well pump is on. And he’d like to know how long it takes for the water level to return to normal after the well pump stops.

Storage Tank Level

It would be interesting to report on the level of water in the storage tank. There is hysteresis built into the switch that triggers the well pump. The setting of this low/high level is arbitrary. It is also possible for a component in the system to fail and have the storage tank run dry; obviously it would be good to avoid this situation. If we monitor the storage tank level directly, we might report any time the level spends significant time below the point where the well pump should come on.

Tank Pressure Level

The pressure tank is monitored by a control with hysteresis. The high level is set to remain within the pressure limit of the downstream system. The low level is set to maintain appropriate pressure to the house.

Pressure Relief Valve

The pressure system has a high pressure relief valve. It would be useful to monitor this device and report if the valve is triggered.

Smartphone App

We would like to use the AI2 iOS kit to make an iPhone version of the app. It would also be nice if the app could retrieve historical data and provide a graph directly in the app; this would eliminate the need for pivot tables and such.