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Real-time Monitoring for Water Systems in Developing Communities

Background and Design Criteria

As of 2017, an estimated 2.1 billion people do not have access to safely managed water services. The Sustainable Development Goals (SDGs), declared by the United Nations, include a goal that all humans will have access to safely managed water services by 2030.

By leveraging inexpensive microcontrollers with cellular connectivity, municipalities in developing countries can be provided with a platform of monitoring and documenting the current status of water systems in nearby villages. This device could enhance the feedback loop between the water provider and the supporting municipality, and provide data that could be used to understand the state of a country's water needs.

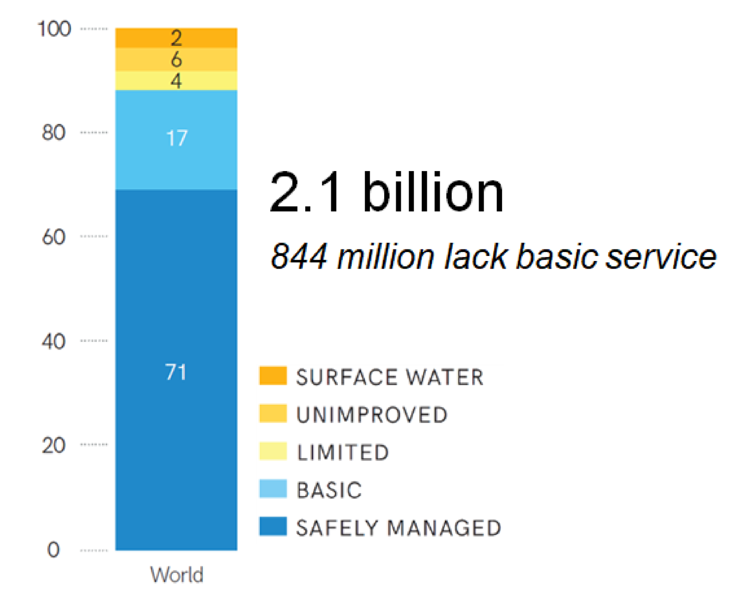
To guide the proposed project, the following design criteria were identified;

Functions:
- Measure Flow Rates
- Publish Data through Cellular Connection

Objectives:
- Be Inexpensive
- Be Simple for Operators

Requirements:
- Must be capable of functioning off-grid

Constraints:
- Must cost less than $250



Source: WHO/UNICEF JMP. Progress on Drinking Water, Sanitation and Hygiene, SDG baselines. 2017.

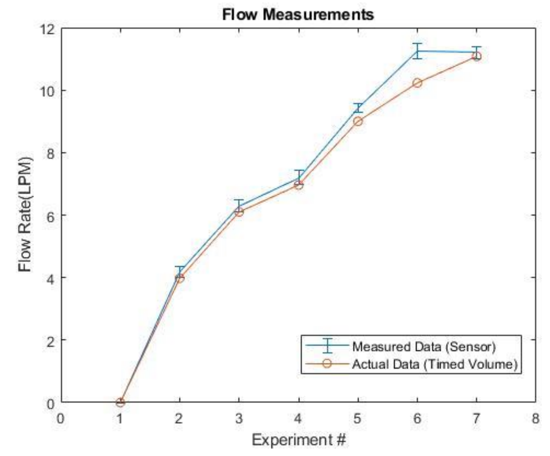
Materials List

	Component	Description	Cost
	Particle Electron	The Electron is a microcontroller with cellular connectivity. Particle provides a data plan service, which greatly simplifies the project. There is extensive documentation and an active online community for Particle's products.	$69.00
	Adafruit Flow Sensor	Adafruit offers an inexpensive flow sensor that functions by sending out a pulse for every 2.25 mL that flows through the device.	$9.95
	Voltaic 6W Solar Panel	To charge the device during implementation, a 5v 6W Voltaic solar panel was purchased.	$59.00

Assembly and Testing

The output from the flow sensor is connected to a digital input of the Electron. The microcontroller is programmed to count the pulses from the sensor and calculate the corresponding flow rate, which is then published to the Particle server at a specified frequency.

To test the functionality of the flow sensor, the sensor was connected to a faucet and the flow rates were measured with both the sensor, and manually by recording the fill time of a one liter container.

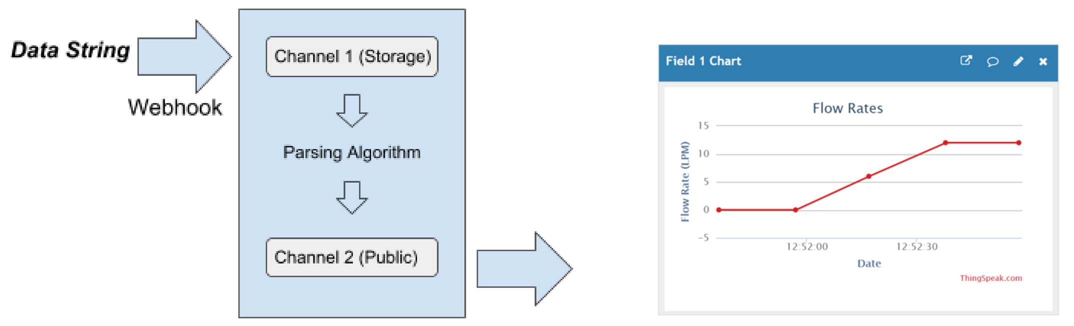


Graph displaying flow rate measurements taken with sensor and measurements taken "by-hand"

Visualizing the Data

To store values and create a visualization from the flow rate measurements, the data must be transferred from the Particle server to a new server. ThingSpeak was selected as the IoT platform for this project because it supports MATLAB for data analysis, and is free for the extent of this project.

Each data publish requires a new "handshake", so concatenating values into a single string saves data and power. The data flow chart below demonstrates how ThingSpeak was configured so that multiple values can be sent in a single publish.

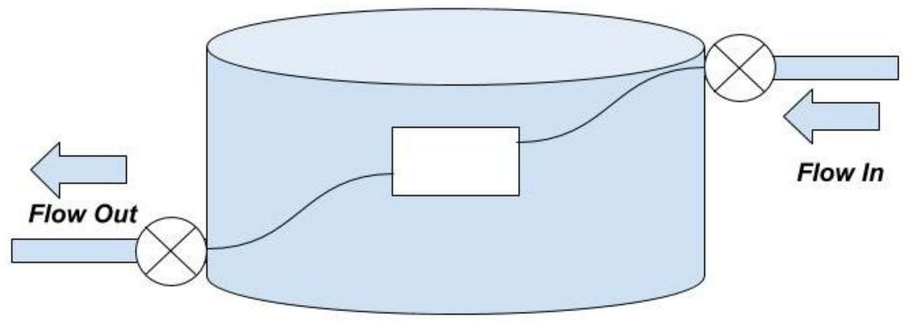


ThingSpeak data pipeline, starting with a data string imported from Particle and ending with graphs of each imported variable

Future Implementation

Next steps for the project include placing the components into a water proof case, and testing the system in the field for an extended period of time.

Flow sensors will be placed on the *inside* of a water storage tank, on the inlet and outlet valves. This will prevent the sensors from compromising the functionality of the water system by leaking. The illustration below demonstrates the relative placement of the flow rate sensors on the storage tank.



Anticipated placement of flow sensors on a water storage tank