Developing a Low-Cost Water Quality Sensor for Communities with Limited Water Treatment Infrastructure

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Clemson Engineers for Developing Communities

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Mission

The mission of the Water Quality Sensor Project is to develop a low-cost, deployable water quality sensor system for communities with little to no development in water treatment infrastructure. The goal of this system is to primarily serve as an early-warning detection system, not as a point of absolute truth. The goal of this project is to lower the rate contaminated water consumption specifically in areas with little, to no existing infrastructure.

Figure 1. Left to Right: KiCad, Fusion 360, Solidworks.

Background

The project uses the ESP32 microcontroller to interface with a suite of sensors measuring turbidity, conductivity, temperature, pH, chlorine residual and more. Data is to be collected at regular intervals and sent to the cloud where the Data Visualization team will use this data to analyze parameter trends and make recommendations to the effectiveness of water treatment.

Water Quality Monitoring Thresholds

Parameter	Normal	Warning	Critical
Turbidity (NTU)	0–1.5	1.5–3.0 or +0.5/hr	>3.0 or +1.0 spike/hr
pH	6.5–8.5	±0.3 or ±0.2 in 12h	<6.2 or >8.8 or ±0.3 in 24h
Temperature (°C)	5–20	20–25 or +2°C/12h	>25°C + low chlorine/turbidity
TDS (mg/L)	<600	600–1000 or +100/day	>1000 or >20% deviation
Conductivity (µS/cm)	<400	400–1200 or +10%	>1200 or +20%
Chlorine (mg/L)	0.2–1.0	0.1–0.2 or >1.0	<0.1 or 0.0
Flow Rate	>80%	60–80% or decline	>40% drop

Figure 2. Proposed Early-Warning Thresholds for Continuous Water Quality Monitoring.

Project Charter + Literature Review

Our project charter established the mission, scope, and phased development plan for building a low-cost water quality sensor system, outlining stages from breadboard prototyping and calibration to PCB integration, networking, durability, and documentation. The system focuses on monitoring key parameters including pH, turbidity, conductivity, temperature, and residual chlorine to support early detection of contamination events. The literature review strengthened this foundation by defining measurable early-warning thresholds, narrowing deployment to high-risk and low-visibility segments of distribution systems, and grounding parameter selection in established standards. It also analyzed current manual and industrial monitoring approaches, identifying their cost, accessibility, and continuity limitations.

Kepner Tregoe

After the literature review, the team focused on the prototyping process and thus developed a Kepner-Tregoe Analysis to compare different parts and their potential for being a part of the final design. This is done by giving different weights to parameters of interest and comparing final scores for the parts of preference.

Kepner Tregoe Analysis - Turbidity Sensor

		Ratings (1-10)			Scores		
Factors	Weight (1-10)	DF Robot	SEEED	TST-10	DF Robot	SEEED	TST-10
Cost	10	9	8	10	90	80	100
User Friendly	7	6	7	2	42	49	14
Power Consumption	7	8	8	9	56	56	63
Durability	8	7	5	10	56	40	80
Accuracy	6	8	6	3	48	36	18
Time until Callibration	7	8	5	10	56	35	70
				Sum	348	296	345

Kepner Tregoe Analysis - Temperature Sensor

		Ratings (1-10)			Scores		
Factors	Weight (1-10)	DS18B20	Amphenc	EVVO	DS18B20	Amphenc	EVVO
Cost	10	8	10	9	80	100	90
User Friendly	5	8	3	3	40	15	15
Power Consumption	7	9	9	10	63	63	70
Durability	8	9	8	8	72	64	64
Accuracy	6	7	4	9	42	24	54
Time until Callibration	7	10	10	10	70	70	70
				Sum	367	336	363

Figure 3. Kepner-Tregoe Analysis Table.

Figure 4. Sensors From Left to Right: ORP, Flow Rate, pH.

Sensor System

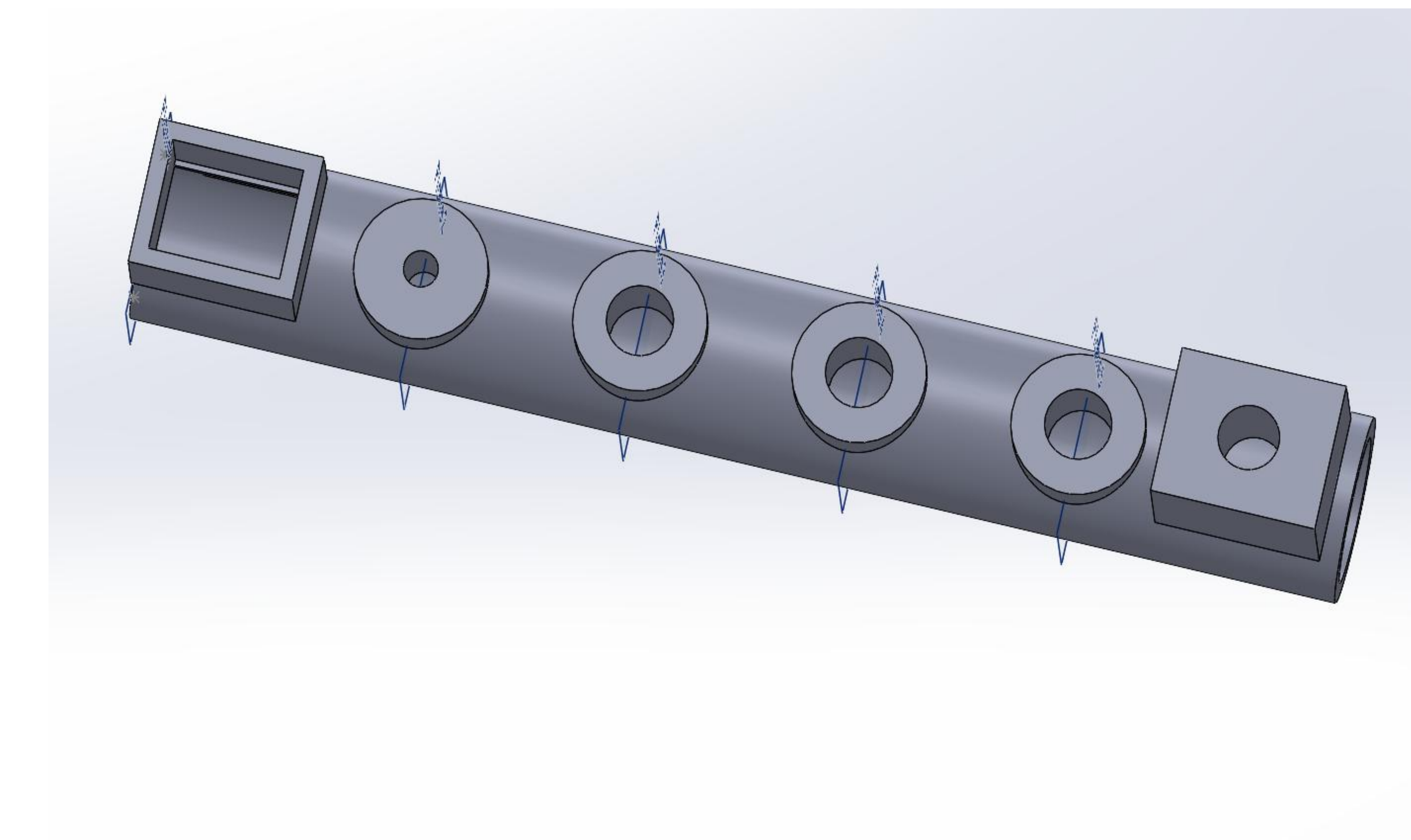

Figure 5. Prototype 3-D Model of Testing Pipe.

Specific sensor models have been selected and prototyping has started based on the specific needs and sizes of each individual sensor. The breakout board has also been designed for ease of testing with large ESP32 Development board width.

Future Plans

The sensors have been picked out so the next step would be ordering the sensors and integrating them with the ESP-32 microcontroller, followed by field testing the different sensors for checking accuracy and performance. From there, a final prototype would be made where we create a full casing and make one cohesive unit. This would include bring the ESP32 Module onto a custom PCB board and minimizing the size and wiring requirement for implementation.

Conclusions

As the semester wraps up, the WQSP team has maintained a strong foundation for the development of our water quality sensor suite and has continued to strive to make a functioning prototype. Our sensor choices have been refined, and our team feels that the choices made for parts have the best chance at being both successful and robust. We thus prepare all our current documentation to prepare next semester where we will order all parts to build the project next semester.

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