Design, Development, and Field Evaluation of an Arduino-Based System for Surface Water Quality Monitoring at Navajo Technical University

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ABSTRACT

Surface water contamination from mining, wastewater, and natural erosion is a concern for many communities on the Navajo Nation, where accessible water monitoring tools are often limited. This study presents the design, development, and field evaluation of an Arduino-based water quality monitoring system that measures turbidity, temperature, and electrical conductivity. Developed and tested at Navajo Technical University, the system is easy to use and demonstrates the potential of readily available sensor technology for surface water monitoring, research, and educational applications.

Introduction

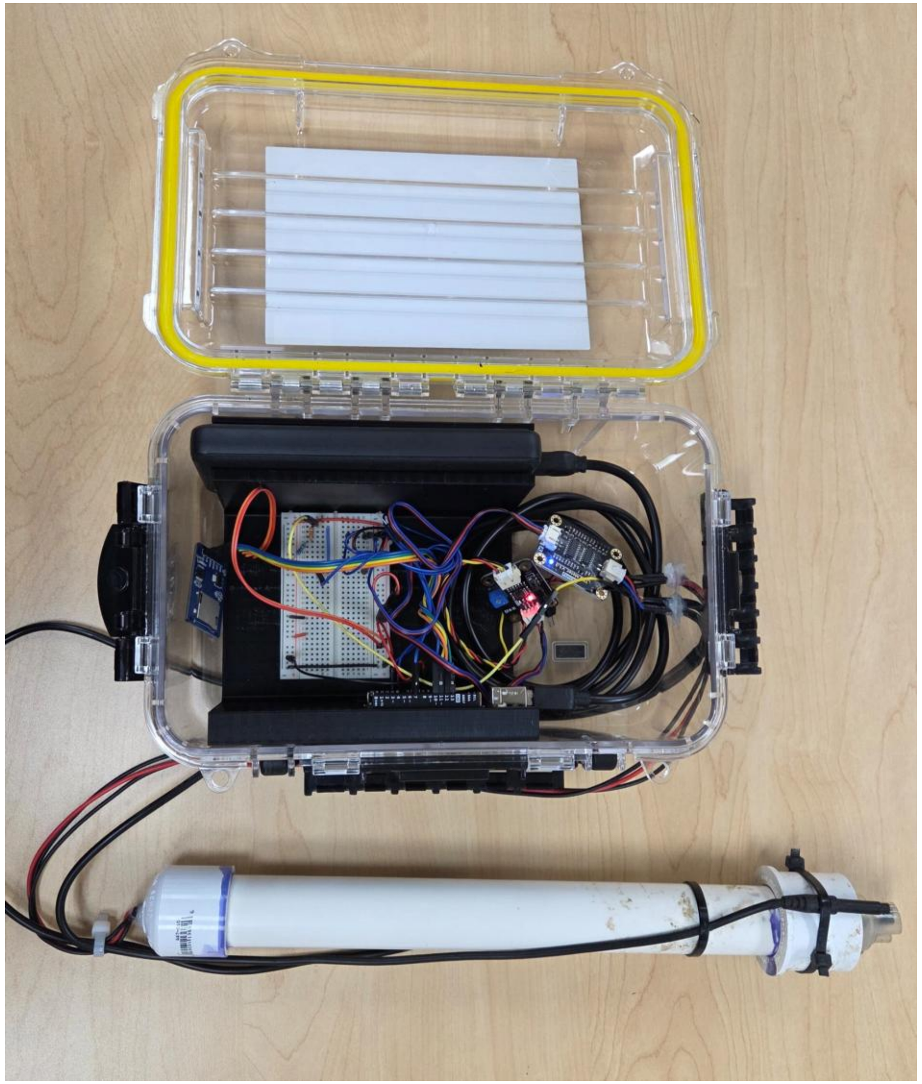
Water quality is an important environmental concern across the Navajo Nation, where many rural communities rely on surface water sources but often have limited access to monitoring tools and environmental data. This project explores the use of Arduino technology to develop a system for real-time water quality monitoring, focusing on key parameters relevant to surface water assessment. The system was designed and assembled at Navajo Technical University and field tested at the campus garden maintained by the Sustainability Club. This research highlights how sensor-based technologies can support surface water monitoring while also providing opportunities for education and research.

Photo above shows the campus garden maintained by NTU’s Environmental Club; testing site.

Objective

Develop a portable Arduino-based water quality monitoring system

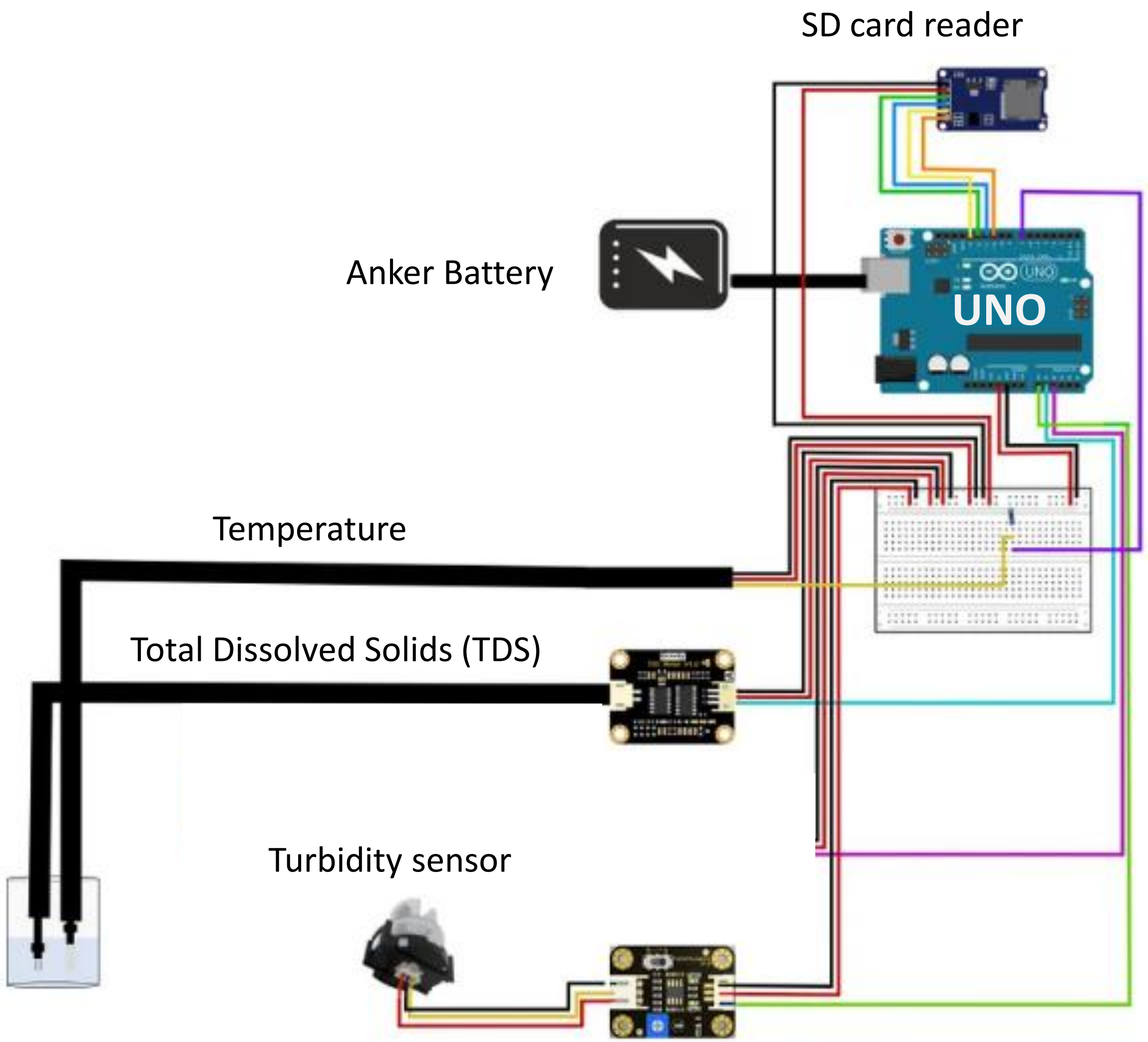
- Measure key parameters (Turbidity, temperature, Electrical Conductivity)
- Integrate readings into a Water Quality Index (WQI)
- Support safe irrigation and sustainable farming



Submersible arduino-based water quality monitoring system created for surface water testing.

System Overview

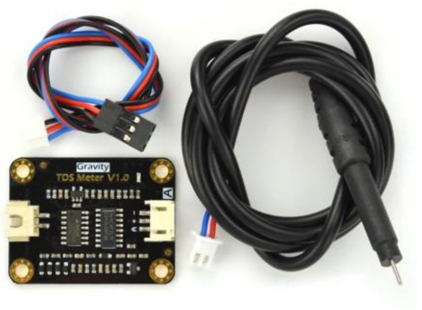
- Arduino UNO microcontroller as main processing unit
- Sensors for turbidity, Total Dissolved Solids (TDS), and temperature
- MicroSD card for data storage
- Portable battery-powered housing
- Breadboard for central connection



Visual display of the water monitor hardware

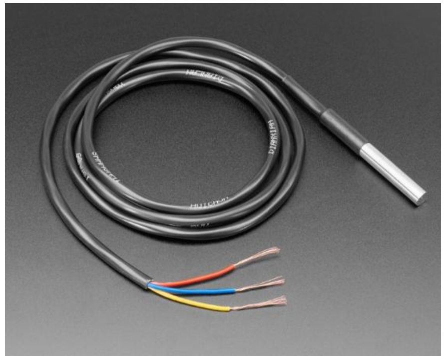
Sensors Employed

1.



1. The Gravity: Analog TDS Sensor/Meter (Electrical Conductivity/EC Sensor) measures the concentration of dissolved solids in water by converting electrical conductivity into a value that indicates water mineral content and salinity.

2.



2. The DS18B20 Waterproof Temperature Sensor provides accurate digital measurements of water temperature in wet and submerged environments using a 1-wire communication interface.

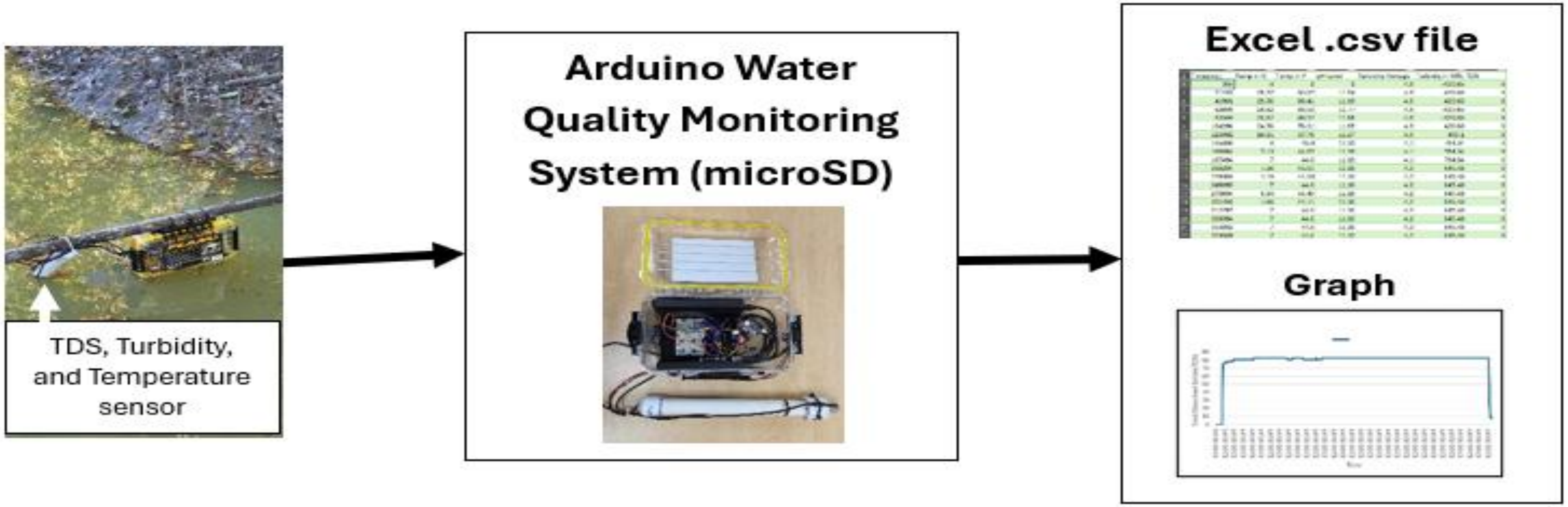
3. The Gravity: Analog Turbidity Sensor measures water clarity by detecting the amount of suspended particles in water through light scattering, indicating sediment and contamination levels.

3.

Sensor Parameters

Sensor	Description	Specifications	Sensor Measurement Capacity
DS18B20 Waterproof Temperature Sensor	Single-wire interface to measure temperature in harsh or wet environments	3.0V – 5.5V	-55°C - 125°C
Gravity: Analog TDS Sensor/Meter	Measures the Total Dissolved Solids (TDS) in liquid.	Supply: 3.3V – 5.5V Output: 0V – 2.3V	0 – 1000 parts per million (ppm)
Gravity: Analog Turbidity Sensor for Arduino	Measures water quality by detecting suspended particles.	5V DC, 40mA Max,	0-4000 Nephelometric Turbidity Units (NTU)

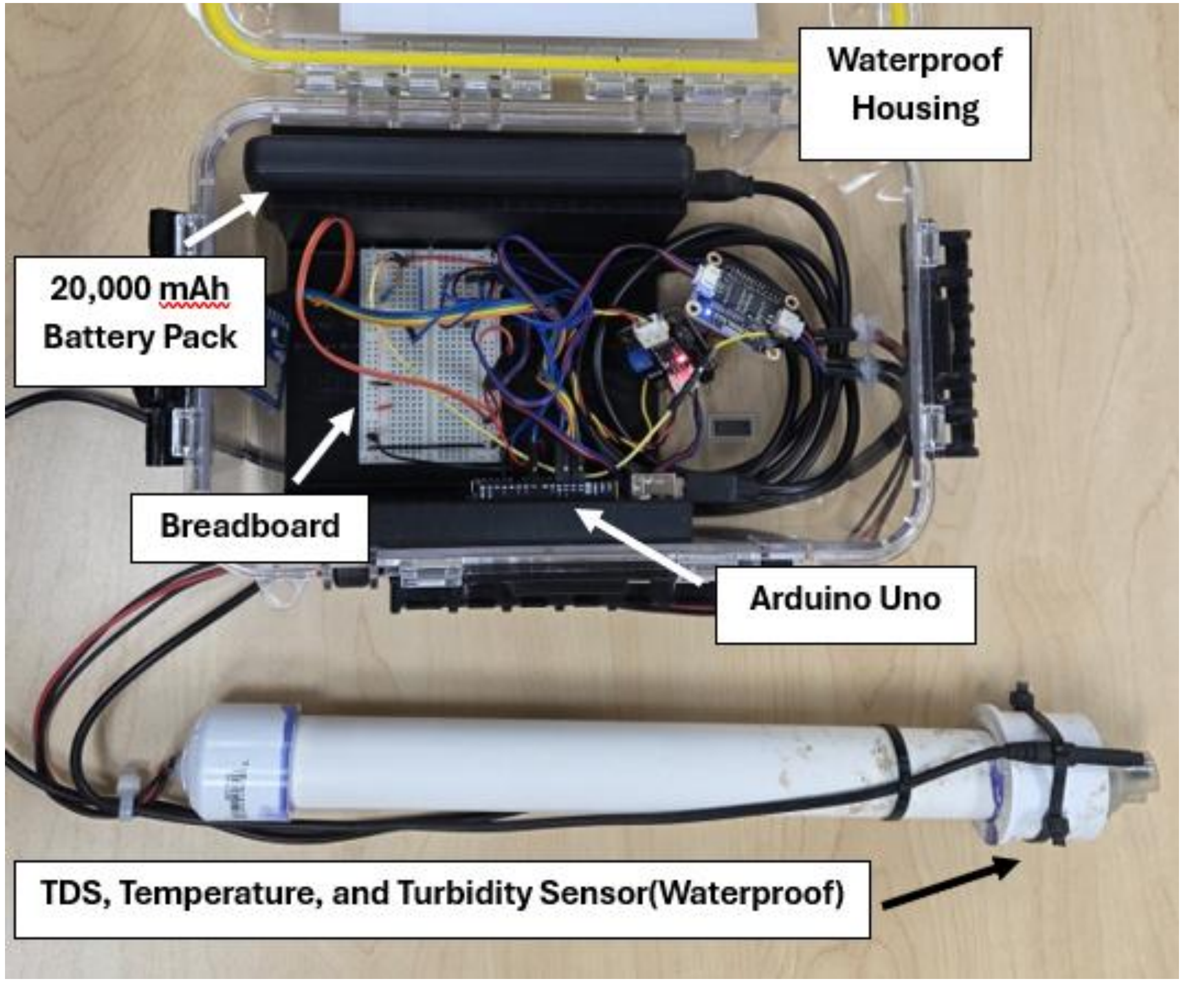
Functional Flow Block Diagram



The block diagram illustrates the water quality monitoring system collecting TDS, turbidity, and temperature data, which is then processed by an Arduino system and logged to a microSD card for analysis via Excel files and graphs.

Hardware Assembly

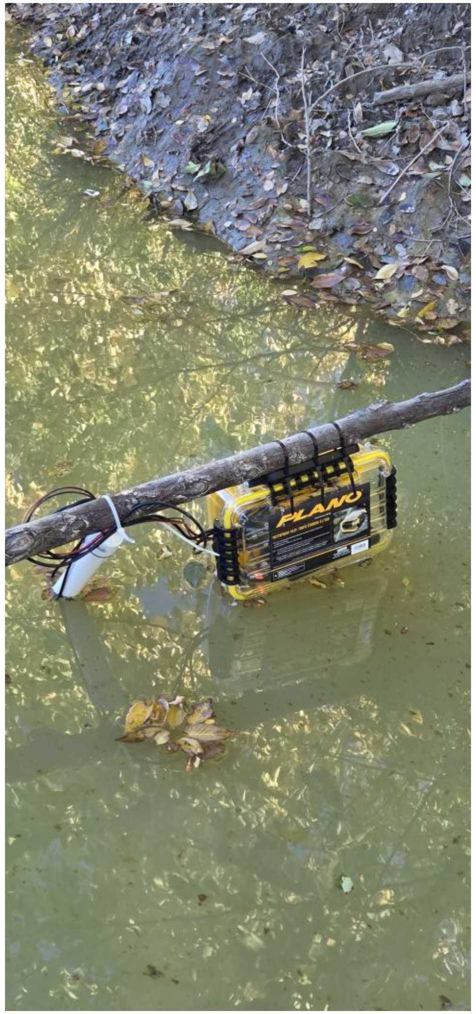
- Weather-resistant enclosure protects electronics
  - -The TDS sensor also had to be waterproofed
- Waterproof connectors for sensor deployment
- Rechargeable battery pack allows field portability



Assembled hardware of Arduino Water Quality Monitor

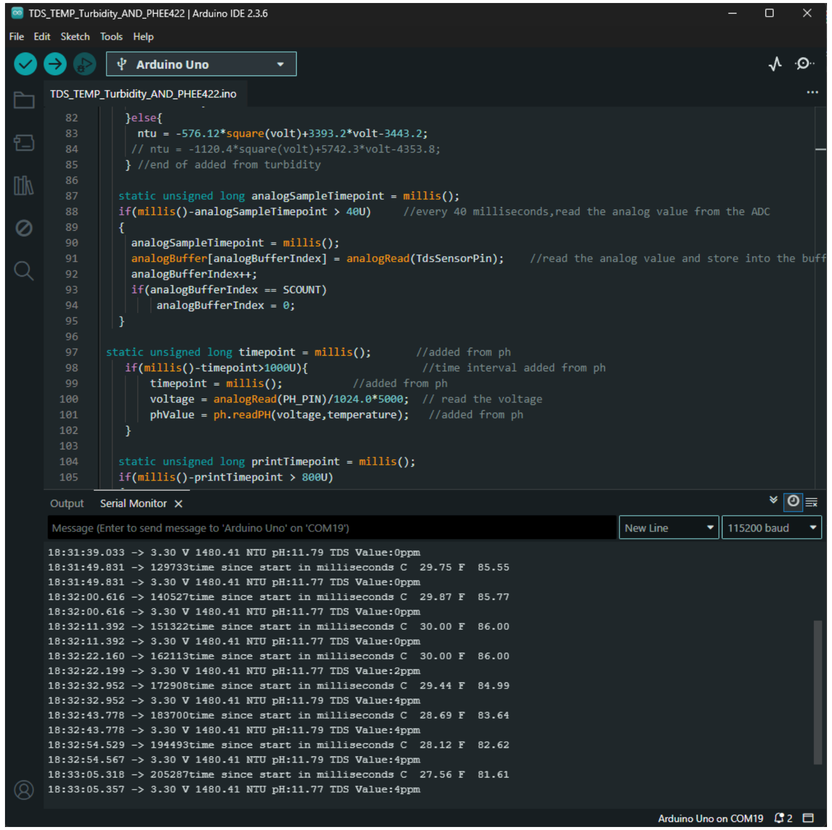
Field Deployment

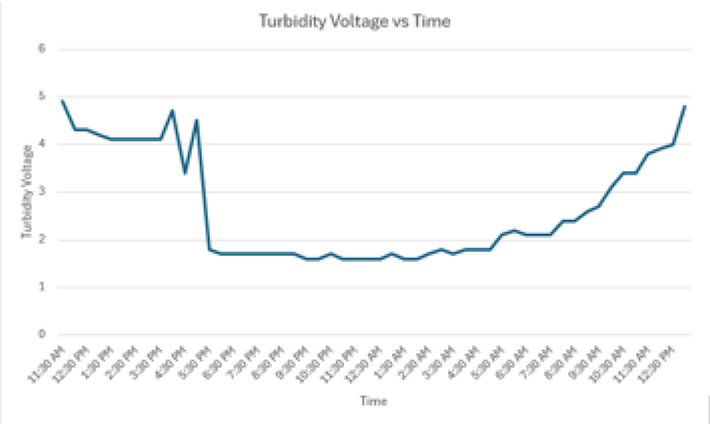
- Locations: runoff channels, rain collection points at Navajo Technical University, Irrigation Tank
- Measured under various environmental conditions (wind, rain, wildlife disturbances)
- Observed changes in turbidity, EC, temperature

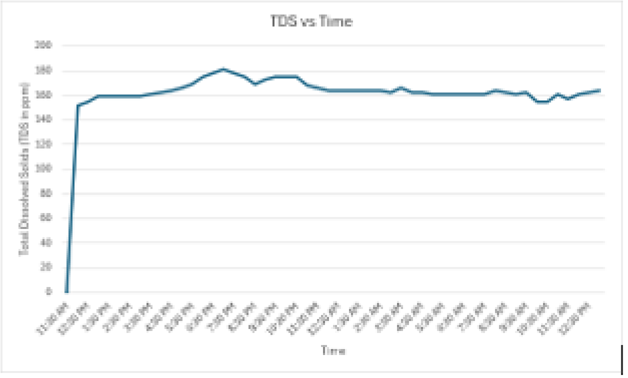


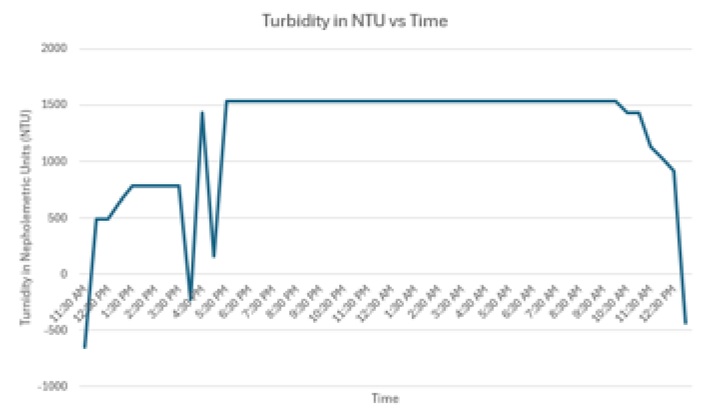
The Arduino water monitoring deployed in surface rainwater runoff

Arduino IDE and Outcomes









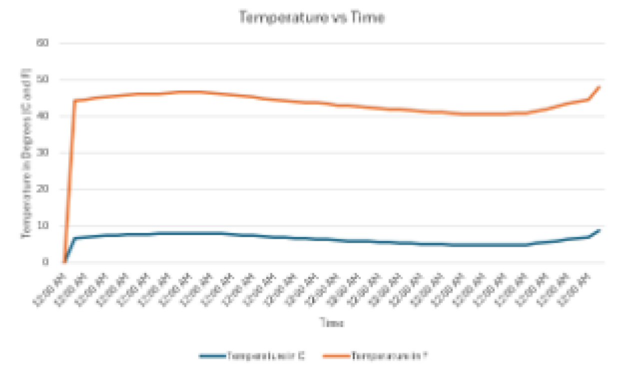
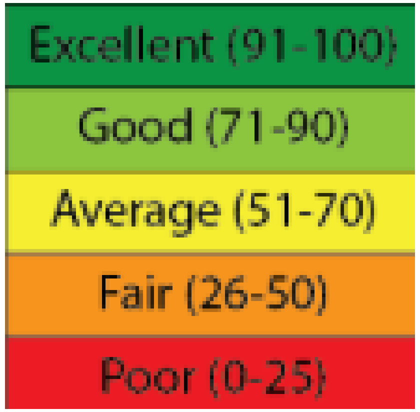


Photo to the left: C++ code that allows communication between Arduino and Sensors. **Graph photo**: Turbidity, Turbidity Voltage, TDS, Temperature sensor output in a 24-hour period.

Water Quality Index (WQI)

Sample Site	TDS (ppm)	Temperature $(^\circ C)$	Turbidity (NTU)	WQI Score	Water Quality
Irrigation Tank	320	6.1	8	92	>Good
Surface Collection Pond	690	7.5	42	74	>Moderate
Storm Runoff Area	910	8.0	70	65	>Fair
Garden Water Source	410	5.8	12	88	Good

These measurements are an average of 9 hour days for a total of eight days*



WQI Scale from SWM

[Sustainable Water Management](https://www.agry.purdue.edu/hydrology/projects/nexus-swm/en/Tools/WaterQualityCalculator.php) -online tool that takes water quality measurements to convert it into a water quality index for easy translation for the community.
https://www.agry.purdue.edu/hydrology/projects/nexus-swm/en/Tools/WaterQualityCalculator.php

Conclusion

-Portable, low-cost Arduino system measures key irrigation water parameters

-WQI provides actionable guidance for safe irrigation

-Empowers Navajo Nation communities with accessible water monitoring

-Supports sustainable agriculture/livestock and traditional farming practices

-Visual: Device in the field with WQI display (future implementation)

-Future Integration of pH sensor

Navajo Technical University Garden-water tests taken from irrigation tank and garden water source

IEEE Standards

The IEEE standards support the project by governing how the Arduino interfaces with the TDS, turbidity, and temperature sensors (1451), how the C++ code and field deployment are tested and validated (829, 1012), how the battery-powered system is reliably operated in the field (1100), and how the system could be expanded for real-time wireless data transmission in the future (802.15.4).

- **IEEE 1451:** Defines how sensors interface with microcontrollers using Transducer Electronic Data Sheets (TEDS), covering sensor identification, calibration data, and measurement ranges. Directly applicable to how the Arduino reads and interprets data from the TDS, turbidity, and temperature sensors.
- **IEEE 829:** Provides a framework for software test documentation and verification. Supports the validation of the Arduino C++ code used to collect, process, and log sensor data to the microSD card.
- **IEEE 802.15.4:** Governs low-power wireless communication protocols used in sensor networks such as Zigbee and LoRa. Relevant to future development of the system for real-time wireless data transmission across the NTU campus.
- **IEEE 1012:** Establishes requirements for system and software verification and validation. Aligns with the field deployment methodology used to test the monitoring system across multiple sites under varying environmental conditions.
- **IEEE 1100:** Covers best practices for powering and grounding sensitive electronic equipment. Applicable to the portable battery-powered design of the system and ensuring stable, accurate sensor performance in the field.

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Questions?