1. Student First Name *

Anwar

2. Student Last Name *

Khan

3. Student Email address *

anwarok209@gmail.com

4. Guardian/Parent Name *

Arif Khan

5. Guardian/Parent Email: *

sl300gullwing@gmail.com

6. School Name *

Atholton High School

7. School Full Mailing Address (equipment awards will be shipped directly to student's school) *

6520 Freetown Rd, Columbia, MD 21044

8. Teacher Name *

Bryce Cramer

9. Teacher Email *

Bryce_Cramer@hcpss.org

10. Teacher Phone Number *

Enter your answer

11. Project Description, including overall objectives & goals (we know this may evolve, but share what you have in mind!) *

Enter your answer

12. Please select from the list below which testing package(s) you are requesting for your project: *

Potential equipment awards (with the water quality parameters they measure) can be seen here: https://shorturl.at/rLZmz

Please select at most 6 options.

- [ ] General Labware Kit
- [ ] Variable Volume Pipet 0.1 – 1.0 mL
- [ ] Variable Volume Pipet 1 – 10 mL
- [x] Turbidity
- [x] pH
- [x] Conductivity in Freshwater
- [ ] Conductivity in Saltwater
- [x] Dissolved Oxygen
- [ ] Free Chlorine
- [ ] Total Chlorine
- [ ] Iron
- [x] Phosphate
- [ ] Nitrate & Nitrite
- [x] Ammonia
- [ ] Fluoride
- [ ] Sulfate
- [ ] Hardness
- [ ] Alkalinity
- [ ] Other

11.

Section 1: Rationale

Our student team at Atholton High School's Electronics Club is competing in the **2025-2026 Samsung Solve for Tomorrow** competition, aiming to address the environmental vulnerability of Columbia, Maryland's core water resources. The recent 1.3 million-gallon sewage overflow near Watchlight Court, and the recent health advisories due to Harmful Algal Blooms (HABs) in Lake Centennial and Triadelphia Reservoir have sparked the interest of students within Atholton HS to develop a tool that provides early warning of a crisis. Our goal is to augment existing monitoring efforts by providing continuous data and an automated flagging system to direct human attention to areas of heightened risk. Our project, the Aqua-Guardian, is a student-built, cellular-enabled IoT buoy designed to fill the existing data gap by providing real-time environmental intelligence that can be used to… target areas of elevated risk, draw attention to areas that need further testing, and provide citable evidence for research, which can especially be used to advocate for stronger environmental policy.

Section 2: Aqua-Guardian: Low-Power, High-Efficiency Hardware

- **Computation & Power Management:** The system relies on the *Firebeetle ESP32 IOT Board* for its remarkable efficiency, achieving a deep sleep, which ensures months of operation via solar power.
- **Cellular Connectivity:** For guara*nteed off-shore data relay, we use the Crowtail CRT01260S Cellular + GPS Board*. This enables data transfer from remote locations and hard-to-reach areas within a water body.
- **Sensor Array:** The buoy integrates seven sensors to provide a complete picture of water chemistry: **pH**, **Dissolved Oxygen**, **Electrical Conductivity**, **Turbidity**, **Temperature**, **Oxidation-Reduction Potential**, and an internal **Water Leak Sensor**.

Section 3: Environmental Intelligence for Targeted Action

The core innovation is our AI-enhanced platform, which converts raw sensor readings into clear diagnostic indicators, automatically flagging users when follow-up monitoring is needed:

- **Nutrient Enrichment Indicator:** This indicator tracks simultaneous spikes in EC and drops in ORP/DO after heavy rain/runoff. Sustained low ORP and DO also signify decomposing Organic Pollution (like sewage).
- **Algal Bloom Risk Score:** An aggregated score correlating rising Temperature, increasing Turbidity, rising pH, and the severe DO fluctuations (photosynthesis/respiration)

characteristic of HABs. This score provides a priority flag for further and more precise testing.

- **Chemical/Industrial Pollution:** Anomalous readings in extreme pH, high EC, and abnormal ORP are flagged.
- Our system will integrate the use of AI to help with deriving a water body's condition and to filter out invalid readings caused by natural weather patterns, ensuring users are alerted only by scientifically significant deviations.

Section 5: Challenges

- **Sensor Calibration:** Electrochemical sensors like pH and ORP probes naturally suffer from sensor drift over time and require recalibration to maintain data accuracy. The use of industrial probes is meant to counter this, but the timeframe of deployment is still unknown..
- **Data Integrity and Preventing False Positives:** To prevent false flags from natural variables like heavy sediment flow or seasonal lake turnover, our system first establishes a dynamic baseline of the water body's normal rhythm, allowing our algorithm to intelligently distinguish true anomalies from these predictable fluctuations.
- **Biofouling:** Preventing **biofouling** (algae/bacteria growth) on sensor heads corrupts readings, particularly for optical sensors like turbidity.
- **Determining Sample Rate:** As aforementioned, tides and the presence of daylight can affect what the norm for sensor readouts should be. Not only that, but sampling at various times of the day can indicate other things like algae growth. Sampling rate will be customizable based on application, but for testing, we will need to know what to look out for.

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15. General Timeline:

Phase 1: Design & Pre-Acquisition (October 19, 2025 – November 5, 2025)
This initial phase focuses on design, research, and preparation for the SSFT application.

October 19 – November 4, 2025:
- Hull & Component Design: Model various hull shapes and create rough CAD models of sensors and microcontrollers to plan for integration.
- Dependent Value Research: Consult with environmental groups for important measurements , find the formulas for these calculations , and research their corresponding danger thresholds.

November 5, 2025: SSFT Application Entry Deadline

Phase 2: Rapid Prototyping, Testing & Development (December 5, 2025 – January 14, 2026)
Following the advancement notice, this is an intensive period to build, test, and develop all core features of the project, including the AI and website, to have a complete solution ready for the video.

December 5, 2025: SSFT Advancement Notice

December 6 – December 27, 2025:
Component Assembly & Testing:
- Breadboard sensors individually to the Firebeetle ESP32 for testing.
- Once calibrated, connect all sensors to the ESP32 to check the current load and calculate power consumption.
- Wire and test the solar panels and battery system.
- Set up the Crowtail cellular chip and waterproof the antenna.
- Hull Construction & Integration:
- Print, test, and select the most effective hull design.
- Water seal the hull with epoxy and test the seals overnight.
- Begin building and inserting all electronics into the hull.
- Initial Field Test: Conduct the 3-Day Test #1 to verify sensor calibration and data transmission.

December 28, 2025 – January 14, 2026:
- Long-Term Test & Data Collection: Commence the 7-Day Test #2 on a water body to verify data uploads and collect a substantial dataset.
- AI Training & Website Development:
- Use the autogenerated XLSX file from the test to begin AI model training.
- Purchase a domain and embed the data file for analytics.
- Automate the data analysis for each new upload and integrate it into the webpage.
- Finalize the website design, including an account system and an aesthetic data display.

Phase 3: Video Production & Submission (January 15, 2026 – January 21, 2026)
This week is dedicated exclusively to producing the video for the next phase of the competition.
- January 15 – January 21, 2026: Create, edit, and finalize the 3-minute video showcasing the completed project.
- January 21, 2026: SSFT Phase 2: 3-Minute Video Submission Deadline

Phase 4: Research & Competition Advancement (January 22, 2026 – April 15, 2026)

Immediately following the video submission, the team will begin formalizing its findings while awaiting further results from the SSFT competition.

January 22 – April 14, 2026:
- Formulate Research Paper: Synthesize all collected data into a research paper. The paper will highlight the low cost of the product , address the key community problems solved , and discuss future applications.
- SSFT Advancement Notice: Await results from judges on February 11, 2026.
- SSFT Voting Period Ends: Conclude social media voting on March 6, 2026.

April 15, 2026: Stockholm Junior Water Prize Application Deadline

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14.
We have actively sought and secured support from both community organizations and professional experts to ensure the success and scientific validity of our project. Our efforts to date include:

- **Financial Sponsorship:**
    - We have successfully reached out to the **Sierra Club**, which has agreed to sponsor our project, providing 36% of our $900 required funding budget.
    - After reaching out to DF Robot, we have received a small discount on some equipment.
- **Expert Consultation:** To guide the scientific and technological aspects of our work, we have assembled a team of advisors with extensive experience in water quality testing and environmental policy. We are honored to have the support of the following professionals who have agreed to serve as advisors:
    - Radhika Wijetunge
    - Ann Strozyk
    - Fred Tutman
    - Arif Khan

16.
As students at Atholton High School's Electronics Club, our project is rooted in our local community of Columbia, Maryland. Our inspiration stems directly from recent environmental crises that have exposed the vulnerability of our community's core water resources. We witnessed the impact of a 1.3 million-gallon sewage overflow near Watchlight Court and saw health advisories posted at Lake Centennial and Triadelphia Reservoir due to Harmful Algal Blooms (HABs). In addition to these events, our county also faces a systemic challenge:

inadequate stormwater management, a problem highlighted by the 2016 Ellicott City flood which caused a $67.2 million reduction in economic activity.

Despite these clear dangers, funding for stormwater management in Howard County has been decreasing, while upstream development continues to increase runoff. Our Aqua-Guardian project is designed to provide direct, tangible support to local environmental groups, such as the Sierra Club, who are actively pushing our county council for stronger policies and better funding. Our buoy's sensor array will provide objective, real-time data showing the immediate impact of stormwater on local water bodies like the Patuxent River. Our website will provide a *Nutrient Enrichment Indicator* which has been designed to flag conditions signifying decomposing organic pollution, like sewage , while the "Algal Bloom Risk Score" correlates key water quality parameters to identify the risk of HABs. By deploying this buoy in Howard County, we aim to provide an automated flagging system that directs human attention to areas of heightened risk, augmenting existing monitoring efforts. This data provides the exact "citable evidence" that advocacy groups can use to demonstrate the severity of runoff pollution and advocate effectively for policy change.

While our focus began with local challenges, we recognize that the issues of stormwater management, sewage contamination, and algal blooms are pervasive global problems. Our goal extends beyond our local waterways; we aim to create a valuable, open-source digital asset for local environmental monitoring. By doing so, we hope our work can serve as a model for other communities facing similar threats, empowering them with the data needed to protect our shared water resources and advocate for a more sustainable future.