Task 6. Request for Proposals: 2026

Open-Source Environmental Monitors

Task developed by: HF Sinclair, NAVFAC EXWC, El Paso Electric Co., NM Dept. of Transportation, and CSJunction Inc.

Introduction

From hazardous gases leaking from outdated appliances to contaminated water and food, environmental risks often disproportionately affect lower income communities and small businesses. Your team is invited to design an open-source environmental monitor that will empower people in these communities to live healthier lives. By making your device open source, you help expand access to essential monitoring tools for those who cannot afford existing high-cost technologies.

Problem statement

Your team is challenged to research, evaluate, and design an open-source environmental monitor, or system of monitors, to address a specific need within low-income communities and/or small businesses. This project is open-ended, giving your team the flexibility to identify a pressing need within your local community, a nearby region, across the US, or globally.

The device should be made from affordable, readily available parts. It must be easy to reproduce and use, with clear, user-friendly instructions. These should include a detailed parts list, step-by-step instructions for assembly and use, maintenance instructions, guidelines for waste disposal (if any), reuse/repurposing/recycling, and any additional information needed to help users operate the device effectively and interpret the data it produces.

To the extent possible, the design and production of the environmental monitor should utilize open-source micro-controllers and 3D-printed parts alongside low-cost commercial off the shelf (COTS) components. Student teams are required to submit a guidance package that includes all technical documentation needed to reproduce the devices (e.g., model files, code, wiring diagrams, and figures).

Background

Although great strides have been made to reduce environmental issues since the 1970s, some communities are still experiencing significant challenges from the quality of their air, water, soils, etc. Even more concerning, lower income communities and small businesses often share the brunt of these burdens [1], [2].

Teams are invited to design an innovative device or a set of devices that will serve a low-income community or small businesses. Note that efforts are being made on many fronts to develop low-cost sensors (e.g., [3], [4]). Teams must improve upon existing solutions on the market, and develop a new innovative low-cost design.

In this document, we define “sensor” as a device used to measure one or more specific environmental parameters. A “monitor” shows data from one or more sensors to gather information necessary for decision-making.

The list below outlines potential categories for your team to consider. It is not exhaustive, but it will serve as a starting point for identifying hazards and community needs. For additional insight into challenges faced by low-income communities, consult Harvard University's Dataverse [5].

Air Quality Monitoring
When air quality is compromised, people can experience worsened asthma, bronchitis, increased susceptibility to illnesses, heart issues in weakened populations, and even premature death [6]. Air quality can be monitored through ozone levels, short- and long-term particle pollution, and various components listed below [7].

- Outdoor air-quality challenges may be initiated by:
    - Natural events, such as wildfires, dust storms, volcanic activity, pollens, mold spores, etc.
    - Human-created sources such as camp fires, engine combustion, and industrial facilities that emit pollutants. For example, the EPA regulates and sets limits for six "criteria pollutants": carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide.
- Indoor air quality issues may occur in homes, schools, and businesses.
    - Hazards may arise from improper building ventilation, resulting in the accumulation of radon (second-leading cause of lung cancer in non-smokers); combustion gases from heaters, stoves, dryers, etc.; and methane gas from sewer systems. The primary hazards of combustion-gas accumulation are elevated CO and NO_2 levels.
    - Mold, dust mites, insects, animal dander, particulates, and second-hand smoke. All of these can trigger asthma attacks. The National Institute of Health reported that the highest prevalence of childhood asthma is in public housing [8].
    - Volatile Organic Compounds (VOCs) that may damage kidneys, the central nervous system, and at times, cause cancer.
- Industrial plants require proper air flow and exhaust systems to ensure that proper air pressures will drive hazardous air-borne materials toward proper ventilation routes (and away from sensitive areas, such as offices). Barometric pressure monitors could be used to assess proper air flow, ensuring worker safety. Air velocity meters can be used to assess performance of ventilation systems.

Micro Climate Monitoring
Climate variations, such as intense heat waves, cold snaps, and severe storms, can lead to a wide variety of potentially hazardous conditions that threaten lives, both outdoors and indoors.

- Vulnerable populations may experience heat stress and cold exposure stress due to temperature extremes. Sensors could be used to measure temperature and humidity. Wearable thermometers or room sensors would be useful to determine unsafe living and/or working conditions for those in hot or cold climates, people living near urban heat islands, or during power outages.
- Climatic sensors could be used to monitor conditions in remote areas that, otherwise, would be difficult to monitor.

Water Quality Monitoring
Water quality can be assessed through measuring microbial contaminants, chemicals (organic and inorganic), disinfection byproducts, and naturally occurring radionuclides [9]. Water-quality issues are often found in aging buildings and near industrial areas. People in these communities are more likely to be exposed to:

- Lead (old pipes, plumbing fixtures),
- Other heavy metals (mining & industrial discharge),
- Nitrates or nitrites (agricultural runoff)
- Microbial contamination (older buildings),
- Improper pH levels,
- Elevated total dissolved solids (TDS) in tap water.
- etc.

Food Safety
Food contamination can pose serious health risks, especially when there are no visible signs or smells to warn consumers – or if the consumer has low olfactory senses. In low-income communities, families may rely on food from sources where storage or transportation conditions are unknown or inconsistent, increasing the risk of consuming unsafe food.

Solutions could include loggers to monitor for safe temperatures during food transport or storage, UV-based systems for detecting surface bacteria on produce, and more. Potential contaminants include:

- Contamination due to E. coli, bacteria, salmonella, listeria, parasites, molds, etc.
- Chemical residues from pesticides or packaging.
- etc.

Additional Environmental Monitoring

- Tracking the fate and transport of hazardous materials in air, water, and soils can contribute to better understanding of environmental hazards leading toward mitigating the issue.
- Pesticides, herbicides, fungicides, and fertilizers can affect air, water, and soil quality. Recent studies in their detection are available [10]. Sensors would be beneficial for:
    - Identifying community exposure to excess chemicals.
    - Real-time monitoring of pests, invasive species, or plant health to promote more efficient use of pesticides, herbicides, and fertilizers. This could minimize chemical footprint, reduce waste, and reduce environmental impacts downstream.
        - For example, a drone-based sensor could identify invasive species, and targeted herbicide applications could be scheduled for individual plants.
        - Similarly, pest infestations could be monitored to determine their nature and severity, providing data for efficient pesticide treatment plans.
- Small, independent farmers operate on very tight margins and could be supported by smart sensors to monitor soil conditions, crop health, watering schedules, nutrient levels, fertilizing, etc.
- Workers in a variety of occupations: demolition, construction, industrial processing, janitorial services, etc. are likely to be exposed to conditions that warrant monitoring, many of which overlap with items in previous listings. These include exposure to chemicals, gases, noise, particulates, heat, cold, UV radiation, etc. Sensors that can test for maximum, as well as cumulative exposures, would protect workers.

Design Requirements

Your proposed design should answer the Problem Statement given on page 1 and provide specific details and outcomes as follows:

- Research the needs of a community or small business and identify sensors/monitors that can make a significant difference for that community/business.
- Determine the parameters to be measured and analysis techniques, such as air quality (PM2.5, CO_2, CO, NO_2, O3, VOCs, etc.); water quality (pH, turbidity, TDS, dissolved oxygen, temperature, etc.); soil quality (moisture, temperature, salinity, chemical constituents, texture, organics, etc.); noise levels (dB), temperature; and humidity.
- Research existing monitors, including those that are low cost, to ensure that your design is innovative and does not duplicate existing technologies. Your sensor(s) and monitor may have the same function as higher-cost units, but with the goal of being more affordable and easily reproduceable.
- Include architectures for monitoring, alerting, and response planning. The device architecture should include the mechanical and electrical designs of the data collection (sensor device) design. A communication infrastructure architectural design may be needed to show how the data is collected, aggregated, and analyzed. The infrastructure architecture should anticipate scalability (possibly a massive number of devices sending data) and reliability (high availability). These architectures take the place of the PFD referred to in the Team Manual.
- Report and demonstrate:
  - Calibration procedure, including how accuracy is verified.
  - Response time to demonstrate how quickly the monitor reacts to changes.
  - Sensitivity and detection limits, such as minimum detectable change, concentration, etc.
  - Repeatability of readings under consistent conditions.
  - Power consumption, power source, and energy storage.
  - Data format (CSV, JSON, etc.).
  - Data storage method (SD card, cloud upload, USB, etc.).
  - Data logging frequency.
  - Wireless connectivity (Wi-Fi, LoRa, Bluetooth, etc.).
  - Type of user interface (basic display, app, etc.).
  - Maintenance needs (cleaning, recalibration, replacement parts, charging, etc.).
  - Durability (resistance to water, UV light, dust, dropping from a 3’ height, etc.).
  - Operational ranges (temperature, pressure, humidity, etc.).
  - Open-source readiness:
    - Design files (CAD, 3D prints, PCB layouts, etc.).
    - Code repository (Arduino, Raspberry Pi, etc.).
    - Bill of materials (BOM) with links and part numbers.
    - Assembly instructions
- Provide a professional-quality Guidance Package that includes all technical documentation needed to reproduce the devices (e.g., model files, code, wiring diagrams, and figures). Your plans and instructions should be understandable by a high school student. In your plans:
  - Report the estimated cost for producing one device (see Techno-Economic Analysis, below). Remember to include ALL costs, including the amount of power needed to produce the device.
  - List of materials needed (BOM), including: specific materials (brand, item number, etc.), volume/quantities, market price per item, and at least 3 sources for each item.
  - Additional supplies needed: Specify which items are one-time purchases. For supplies that must be replenished, indicate how many devices can be made before new supplies are needed.
  - Equipment needed: This will include machinery, 3D printers, etc.
  - Electrical diagrams.
  - Communication infrastructure (if any) needed for data collection.

- Clear instructions for sensor production (if applicable), starting with collecting supplies and ending with the finished product.
- Well-defined instructions for using the finished monitor and how to interpret the data. Assume the user has a high-school education. Provide both written instructions and diagrams. If the target audience primarily speaks a language other than English, consider providing instructions in both languages. For demonstration purposes, your team may wish to translate only a small portion of the Guidance Package ("Excerpt from French Guidance Package").
- Estimated start-to-finish time for a beginner to build/assemble one device.
- List of anticipated maintenance requirements.
- A brochure or pamphlet that informs and educates your chosen population on the benefits of your device and encourages them to use the technology.
- Instructions posted to an online DIY maker site such as the Arduino Project Hub or Instructables.

- Provide a practical plan for distributing the devices, installing the devices, and maintaining the devices.
  - Include estimated costs
  - Describe the needed human capital for monitoring or how automation can replace humans.

- Present a Techno-Economic Analysis (a.k.a. Techno-Economic Assessment) to produce a single device. Include your estimate of capital costs (CAPEX) and operational costs (OPEX) to produce a single device, and if applicable, cost savings when produced and operated on a modestly larger scale (10 devices, 1000 devices, etc.). Include appropriate graphical representation of your cost data.
  - Capital expenses typically include, but are not limited to, equipment, pipes, pumps, wiring, etc. Do not include costs of buildings needed to assemble the device.
  - Operating expenses (OPEX) should be calculated as the of cost to operate a single device over one month and over one year. Include the cost of materials needed, including consumables (chemicals, sacrificial components, etc.) In addition to other operating costs your team identifies, include these operating costs: staff labor rate of $20/hour; solids disposal costs ($50/ton); energy requirements (research an industrial natural gas rate and state in $/MM BTU; use an electricity rate of $0.09/kWh).
  - Visualization tools: Use tools such as sensitivity analyses, graphs, and other visuals to illustrate how key parameters impact system performance and economics.

- In your written report, compare your solution with other solutions (if any) on the market. How does your solution compare? What makes it better?
- In the written report and poster, clearly identify the benefits of your selected technology and outline how it helps a specific group, community, small business, etc.
- Develop a community engagement plan to co-design your device with your chosen community to ensure that their needs are met (see Team Manual).
- Identify and address the fate of any waste products generated by your sensor technology.
- To be eligible for consideration for the P2 Award (Pollution Prevention Award), if applicable, document success in energy efficiency, pollution prevention, and/or waste minimization. Place this in a separate "Pollution Prevention" section of the report.
- Address any intangible benefits of the selected treatment process.
- Address safety aspects of monitoring your targeted parameters (such as chemicals, particulates, etc.) Safety issues for both the full-scale design and the bench-scale demonstration should be addressed in both the written report and the Experimental Safety Plan (ESP)

Bench Scale Demonstration

The Bench-scale demonstration will illustrate the *Design Requirements* listed above. The bench-scale unit will be a wearable or mountable device that demonstrates your selected environmental sensing technology. It must include a component that analyzes the collected data. Your team will demonstrate its functionality and effectiveness during the bench-scale demonstrations on Tuesday, April 14, 2026.

Your team will be responsible for providing all materials and supplies needed for testing your device, including the environmental issue to be monitored, such as particulates, chemicals, excessive heat, humidity, etc. However, if there are materials or chemicals that would be difficult/unsafe to transport during travel to the contest, your team may request that WERC provide these. (See 30% Project Review, below).

30% Project Review

An important part of preparing for your bench-scale demonstration will be your completion of the 30% Project Review. Due in late January, or a date requested by your team, it outlines the general design and functionality of your device and the details for demonstrating and testing your device during the contest in Las Cruces.

Its purpose is twofold: 1) Judges will review your plans and give helpful feedback, 2) You will help WERC prepare for a smooth bench-scale setup when you arrive at the contest.

For example, if your technology will sense toxins, your 30% Review will provide details about the specific toxins (size, composition, etc.), bench-scale-testing protocols (how you will create a testing environment, how you will introduce the toxins in the testing environment, where the sensor will be placed in the testing environment, how much time you will require for your demonstration, etc.), and similarly for the detection of other environmental constituents

The 2026 Team Manual gives general guidelines for the 30% review, but below are items specific to this project that should be included.

<u>Specific to this project:</u>

- ***Prior Authorization:*** As early as possible, ideally **in the Fall** before email us (werc@nmsu.edu) with a list of all potential hazardous materials, including chemicals, electrical connections, equipment, and supplies. NMSU's EH&S staff will review and make recommendations. This report will confirm that we can safely accommodate your setup before you delve too deeply into designing, building, and testing your prototype.
- ***Architecture:*** Submit a complete set of architectural plans for mechanical, electrical, communications, data collection and analysis. This will be reviewed by subject-matter experts from HF Sinclair, CSJunction, and NAVFAC EXWC.
    - Be sure to identify all input and output streams. (Note that even computer simulations have input and output streams.)
    - Depending on your technology, you may need to include how the target (the specific air, liquid, gas, image, etc.) enters and exits the monitoring equipment (as applicable); how it is analyzed and by what method; how results are reported; the role of any support systems (such as exhaust, cooling, auxiliary power, etc.) involved; and any waste streams that may be produced.
- ***Chemicals and Materials:*** Provide a list of all chemicals and materials required for your design, and indicate any known hazards and safety precautions related to their, handling, implementation and/or operation.
- ***Bench-scale Plans:*** Submit a draft of your plans for your bench-scale demonstration setup. The draft should be a 3-D view, drawn to-scale, with dimensions labeled.
    - Outline all bench-scale needs, including the need for ventilation, wind, sunlight, enclosed area, pressurized gas cylinders, indoor versus outdoor bench-scale demonstration area, and potential need to run the process overnight (this is approved by our Safety Officer on a case-by-case basis).
    - Consider that the contest is held at a banquet facility, without typical lab resources (e.g., no fume hoods, ovens, etc.). WERC typically provides your team with an 8' folding table with access to 120V power. See the Team Manual for more bench-scale parameters.

- ***Analytical testing:*** Outline your plans for pre-testing your monitor to establish base-line values, if warranted, as well as plans for demonstrating the effectiveness of your device and the metrics for evaluating the effectiveness of your device.
- ***Distribution***: Indicate the URL(s) of the site(s) you intend to publish the resources to build and operate your monitor.

Technical Report Requirements

The written report must address in detail the items highlighted in the Problem Statement, Design Requirements, Evaluation Criteria, and the 2026 Team Manual. The written report should demonstrate your team's insight into the full scope of the issue and include all aspects of the problem and your proposed solution.

The report must include the Guidance Materials, including plans and and instructions for building the apparatus, as well as your team's Public Engagement brochure, as outlined in the Design Requirements.

The report will be evaluated for quality of writing, logic, organization, clarity, reasoning, and coherence. Standards for publications in technical journals apply.

Evaluation Criteria

Each year, the WERC Environmental Design Contest and its sponsors award more than $30,000 in cash prizes. There are task-specific prizes and overall contest awards. See the Team Manual for more information.

Each team is advised to read the 2026 Team Manual for a comprehensive understanding of the contest evaluation criteria. For a copy of the Team Manual, Public Involvement Plan, and other important resources, visit the WERC website: https://werc.nmsu.edu/team-info/guidelines.html

Your response to this task consists of four parts and will be scored based on the rubrics in the Team Manual:

- a written report,
- a formal oral presentation,
- a demonstration of your technology using a bench-scale prototype, and
- a poster that conveys the essence of your work in a concise fashion using a mix of text and graphics.

Judges' evaluation of your entry will include consideration of the following points specific to this task.

- Potential for real-life implementation, including effectiveness, cost, expected reliability, and maintainability within low-income communities or small businesses.
- Clear instructions for use, including whether the system can be safely and consistently operated by non-experts.
- Accessibility of building instructions, including posting the design and assembly instructions to online DIY maker site such as the Arduino Project Hub or Instructables.
- Cost/benefit of your solution, with comparison with other teams.
- Thoroughness and quality of the economic analysis.
- Originality and innovation represented by the proposed technology.

Experimental Safety Plan (ESP) and Required Short Course.

See 2026 Team Manual for details. Completion dates are listed below.

Dates, Deadlines, FAQs (*dates subject to change—watch website FAQs*)

Early Fall	Email us (werc@nmsu.edu) to reserve a spot for your team and get on the email list for this task. Registration is limited.
Mid-Late Fall	Email us (werc@nmsu.edu) with a list of all potential hazardous materials, including chemicals, electrical connections, equipment, and supplies. NMSU's EH&S staff will review and make recommendations.
Weekly	Check FAQs weekly for updates: • Task-specific FAQs: 2026 Tasks/Task FAQs • General FAQs: 2026 General FAQs
November 1, 2025 - December 31, 2025	Early Bird Registration (discount applies)
December 1, 2025 – January 30, 2026	30% Project Review Due (or as arranged with WERC).
December 1, 2025 – March 01, 2026	Mandatory On-demand Course: Preparing the Experimental Safety Plan. See website and Team Manual for information.
February 17, 2026	Final date to register a team w/o permission.
March 9 -13, 2026	Experimental Safety Plan (ESP) due to Juanita Miller. Include requests for chemicals, materials, etc.
April 2, 2026	Technical Report due
April 12 – 15, 2026	Contest in Las Cruces

Contacts:

- ESP and Safety Officer: Juanita Miller, jghmil@nmsu.edu
- All other questions and concerns: Ginger Scarbrough, werc@nmsu.edu

References

[1] McCarthy, Joe. Global Citizen. February 2020. Why Climate Change and Poverty Are Inextricably Linked. (Accessed 6/27/2025).

[2] Dhruv Khullar and Dave A. Chokshi. Health, Income, & Poverty: Where We Are & What Could Help. Health Affairs. Health Policy Brief. October 2018. https://www.healthaffairs.org/do/10.1377/hpb20180817.901935/full/hpb_2017_rwjf-05_w.pdf. (Accessed 7/27/2025).

[3] Measuring Air Pollution in Southern California Using Low-Cost Sensors. July 2019. https://www.epa.gov/sciencematters/measuring-air-pollution-southern-california-using-low-cost-sensors. (Accessed 6/27/2025).

[4] Low–Cost Air Pollution Monitors and Indoor Air Quality. United States Environmental Protection Agency. https://www.epa.gov/indoor-air-quality-iaq/low-cost-air-pollution-monitors-and-indoor-air-quality. (Accessed 6/27/2025).

[5] Environmental Justice Mapping and Screening Tool (EJScreen). Harvard Dataverse, V4. https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/RLR5AX. (Accessed 6/27/2025).

[6] Yelenek, Marissa. Cities With the Worst Air Pollution in the U.S. US News and World Report. June 2025. https://www.usnews.com/news/healthiest-communities/articles/cities-with-the-worst-air-quality-in-the-u-s (Accessed 6/28/2025).

[7] Outdoor Air Quality: What are the trends in outdoor air quality and their effects on human health and the environment? https://www.epa.gov/report-environment/outdoor-air-quality#:~:text=For%20example%2C%20outdoor%20air%20pollution,respiratory%20symptoms%2C%20and%20premature%20mortality. (Accessed 6/27/2025).

[8] Northridge, J., Ramirez, O.F., Stingone, J.A., Claudio, L.. 2010. 87(2):211–224. The role of housing type and housing quality in urban children with asthma - PubMed. (Accessed 7/27/2025).

[9] Drinking Water: What are the trends in the quality of drinking water and their effects on human health? https://www.epa.gov/report-environment/drinking-water#:~:text=Drinking%20Water%20Quality,-Surface%20waters%20and&text=Common%20sources%20of%20drinking%20water,other%20heavy%20metals%2C%20or%20radionuclides. (Accessed 6/29/2025).

[10] Kamalesh, R., Karishma, S., Saravanan, A. Progress in environmental monitoring and mitigation strategies for herbicides and insecticides: A comprehensive review. Chemosphere, Volume 352. 2024. 141421. https://doi.org/10.1016/j.chemosphere.2024.141421. (Accessed **7**/27/2025)**.**