

An Integrated Device for Monitoring Water Quality of Streams Used for Hydroelectric Power

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AISES Energy Challenge

<https://www.youtube.com/watch?v=Ycs1kttGSCQ>

Abstract

The pristine rivers and streams of the Sierra Nevada Mountains are a significant source of clean, renewable hydroelectric power. For each new hydroelectric facility introduced into these Sierran water systems, it is critical to include a water quality monitoring and assessment program to ensure preservation of the quality of the effected riparian ecosystems. This monitoring covers many data parameters, each requiring specialized and typically expensive sampling devices. These devices have to be carried into and through the streams and creeks by water quality specialists and local citizen volunteers resulting in a time-consuming and expensive operation. This proposal describes a design for integrating a large portion of the various sensor devices and data collection tools into a single low-cost, hand-held device that is easy to carry and use in the field. The device leverages the pole and D-net normally used for collection of benthic macroinvertebrate (BMI) samples and integrates onto it all the other necessary, but currently separate, monitoring sensors for water flow and depth, temperature, dissolved oxygen, conductivity, pH, turbidity, and other assessment parameters. This device is intended to be low-cost, lightweight, and adaptable to local water project monitoring objectives and budgets. This tool will be tested in the field on local watershed projects which include local Native American tribal participation, and is intended to be further developed and tested in collaboration with other existing Native American tribal hydroelectric and water quality projects.

Background

Need to balance dual national objectives on energy and the environment

- Leverage and expand on hydro-electric power as a significant source of clean, renewable energy – DOE (1)
- Monitor and maintain the quality of water in streams, creeks, and other surface water systems – EPA (2)

Support the increasing number of Native American renewable energy and clean water projects on tribal lands. (3,4)



Problem Statement 1

- Hydroelectric facilities alter the natural flow of water systems, via dams, canals, etc.
- Changes in water flow effect local riparian ecosystems. (5, 6)
- A key goal is to design hydroelectric systems to minimize effects on riparian ecosystems. (7)
- Requires monitoring of water systems to ensure environmental objectives are also met

Problem Statement 2

- EPA recently expanded scope of streams, creeks, etc to be monitored (8)
- Comprehensive monitoring of every individual water system will be a significant effort:
 - People and time including training, sampling, identifying, data entry and analysis
 - Equipment and resources for each assessment parameter

Local Relevance

- The local Bear River Watershed (where I live) has been historically impacted by numerous water use facilities including those for hydroelectric power.
- A new dam is proposed to be added on the Bear River for hydroelectric and other beneficial purposes.
- The new dam will change water flows and effect the local riparian environment.
- New water monitoring and analysis will be done throughout the Bear River watershed to evaluate the impact of existing and new hydroelectric facilities.
- This work is being done in cooperation with local Nisenen Tribe, and can serve as a model for other Native American water use and quality efforts.

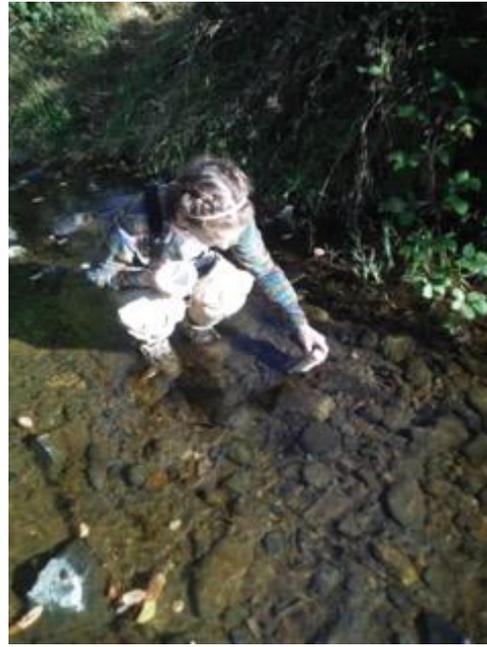
Typical Water Monitoring Parameters to be Assayed - per EPA/SWAMP (9)

There are many important data parameters that need to be obtained and correlated in a typical water quality analysis:

- Physical/Ambient
 - Geology, Water Flow, Temperature, Turbidity
- Chemical
 - Oxygen, Nitrogen, Phosphorus, Phosphates, pH
- Biotics
 - Benthic Macroinvertebrates, Algae, Fish, Amphibians, Birds

Problem Statement 3

- Sampling multiple parameters typically done by different people, at different transects (sampling points in the water system)
 - Expensive (time, people, equipment) (10)
 - Hard to correlate data that is currently taken at different locations and times (eg correlating flow velocity with biotic indices)
Example: Local water flow velocity directly effects the types and makeups of macroinvertebrate feeding “guilds” which are used to interpret water health (11)



Typical Set of Equipment used to sample Water Quality at a single site



Device	Cost
D-Net	\$100
Flowmeter	\$500
Temperature	\$100
pH Meter	\$150
Dissolved Oxygen Meter	\$1000
Conductivity Meter	\$1000
Turbidity Tester	\$1000
Sample bottles	\$50
Depth Gauge	\$100
Total	\$4000+

Example of need to Correlate Sampled Data: Some Assay Parameters effecting BMI feeding guilds

Guild	Example	Description	Example effectors
Schredder	Stonefly (plecoptera)	feed on plant material and some animal material, which is generally dead, and break it into smaller particles through their feeding and digestive process	Prefer high dissolved oxygen and cold, clean, flowing water
Filter-Collector	caddisflies (trichoptera) and blackflies (diptera)	feed on this fine particle material which they filter from the water	Can tolerate lower dissolved oxygen, and slower waters, but not increased turbidity
Grazer	snails and beetles	feed on algae and other plant material living on rocks and on plant surfaces	Beetles can tolerate lower oxygen in slower waters
Predators	dobsonflies (magaloptera) or dragonflies (odonata)	feed on other macroinvertebrates	Lower tolerance for turbid/cloudy waters

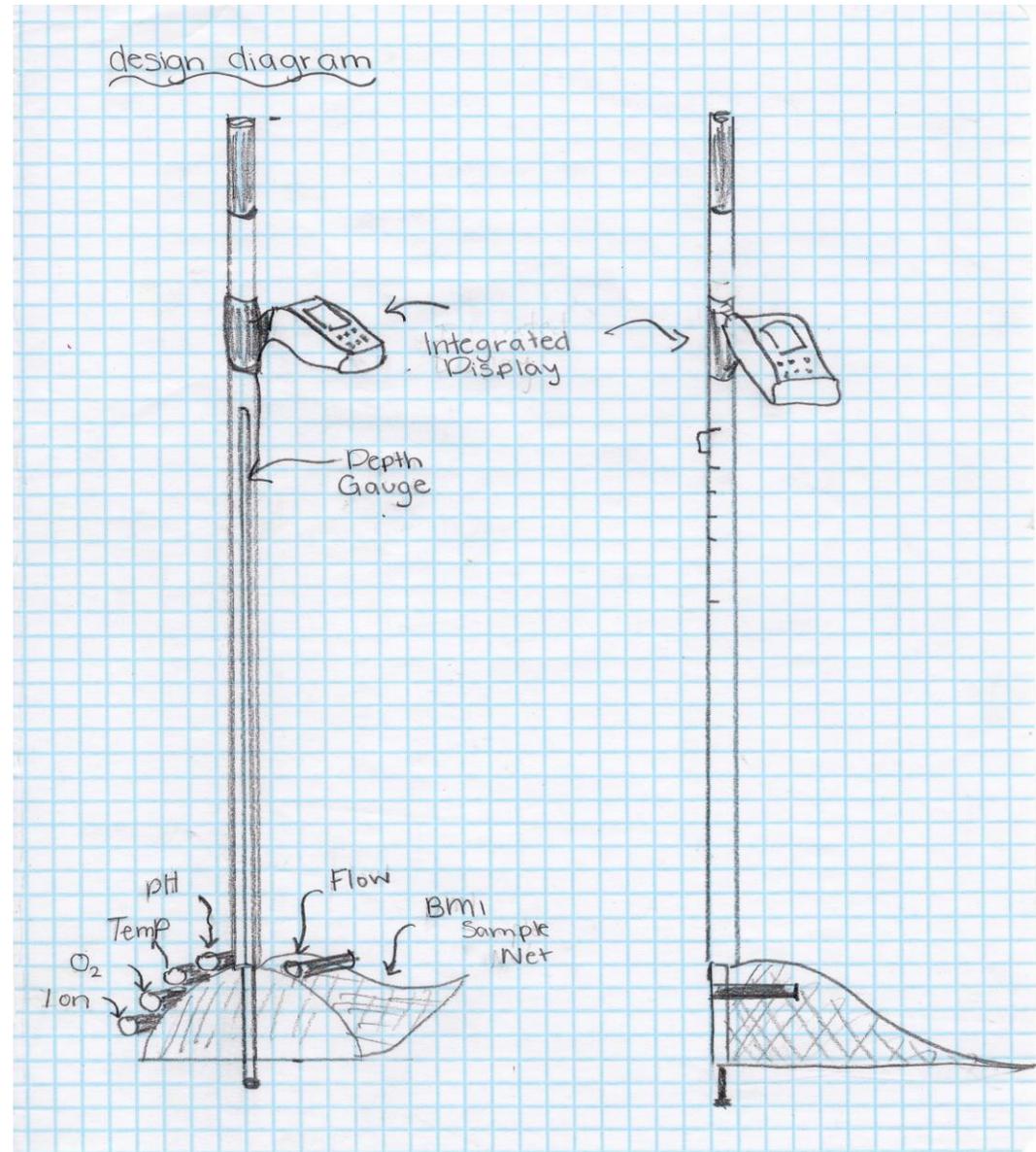
Design Proposal

- Integrate multiple sensors and sampling tools into single monitoring device which can be easily carried and used by an individual to collect and record data for multiple stream assay parameters.

Design Requirements

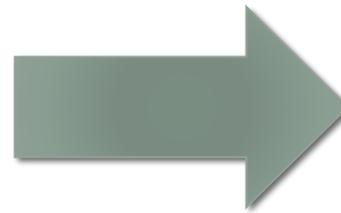
- Integrate multiple data collection elements into a single tool which can be carried to and through a water system.
- Reliable: produce reliable data which can be used for published water quality analyses and compared to regional (example CEDEN) and national data sets.
- Reduced/low cost making it available to enterprises or citizen scientist.
- Lightweight (<5lbs) to allow it to be carried through water system.
- Durable: able to be dropped on rocks and into water.
- Flexible: allow quick attachment of different sensors according to the sampling requirements
- Expandable: allow for new sensors as they become available
- Provide for per-transect (local) sampling, including:
 - BMI
 - Water Flowrate, Temp, Turbidity
 - Dissolved Oxygen, pH, Conductivity
- Allow for local data capture and storage for entire sampling event
- Allow for potential wireless data communication with bank-side capture

Design Diagram

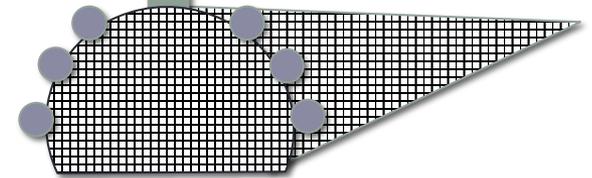


Design Benefits

- Multiple complex, expensive, and cumbersome devices get integrated into a single low-cost, lightweight, easy-to-use device



Single,
Lightweight
, Low-cost,
Integrated
Tool



Macroinvertebrate
Net with Sensors

Prototype

The fabrication and testing of the integrated prototypes will be done in 3 phases of increasing complexity:

- Phase 1: BMI net + Flowmeter + Depth
- Phase 2: Add Oxygen, Conductivity, pH, Temp
- Phase 3: Integrate other assay parameters
- Phase 4: Integrate wireless and mobile device Application

Testing Prototype

- Complete validation testing will be done with Sierra Streams Institute, Nevada City, Ca in conjunction with their ongoing Deer Creek Watershed Project and new Bear River Watershed Project.
- Testing of prototype at single reach on existing Deer Creek Site with 10+ sampling transects.
 - Sites have 10+ years of existing baseline data
 - Compare overall reach data to samples from prototype
 - Compare and correlate transect data collected by prototype.

Test Passing Criteria

Users (from Sierra Streams Institute) evaluate the prototype for satisfying the following criteria:

- the device is lightweight, easy to carry and use within the water system to sample the initial water quality data.
- the device allows for successful collection of BMI+Flow+Depth for each sampling point and with necessary data quality.

Phase 1 Prototype Costs

Item	Cost
• D-Net with pole	\$100
• Extra Nets (10)	\$50
• Flow-meter	\$500
• Thermometer	\$100
• Depth Meter/Gauge	\$30
Total Prototype Cost	\$780
• Macroinvertebrate Identification and Data Analysis	\$100
Total Prototype + verification	\$880

Future Opportunities

- Development of Open-system Architecture for environmental sensor integration for broader use by tribal, state, national, and international efforts.
- Develop smartphone app for bank-side data collection
- Integration with broader data processing and existing Local, State, National Environmental Databases
- Integration of GPS for seamless GIS integration and map production
- Collaboration across current and future water quality efforts on Native American lands (initially working with Nisenan, Osage, and Cherokee)

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Thank You

