# Towards a Long-Term Water Monitoring with a Continuous and a Real-Time Autonomous System

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## Introduction

Rivers are one of the most important natural resources to conserve. They provide water not only for drinking but also for power generation, farming, and factory operation. However, rivers are prone to contamination due to hazardous chemicals or sewer overflows from urban, industrial and agricultural sites.

- US Environmental Protection Agency (USEPA) :
  *55% of rivers and streams in the US are in poor biological condition.*
- River quality monitoring is necessary to supply clean water to humans, animals and plants.
  - Important tasks : Water sampling, Sediment sampling, pollution monitoring
- Objective

**Continuous system**
- Precise analysis on the trend of river quality by continuous data collection

**Real-time system**
- Determine immediate changes of river condition

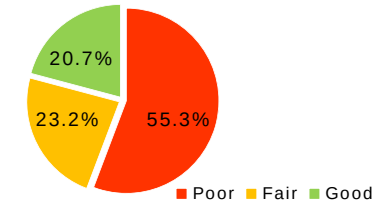
**Autonomous system**
- Integrated robotic technologies

→ **Long-term monitoring**
- Frequent data comparison between the past and the present
- Determine upcoming problems
- Establish the future plan

- Test site : Wabash River
  - One of the longest river in the US
  - Main stream of Indiana state
  - Provides drinking water to approx. 70% of Indiana counties

[Wabash River]

[US Environmental Protection Agency]




[Biological condition of the US rivers and streams]

## Background

A number of organizations and companies put great efforts into developing effective water monitoring system. However, it is still challenging to monitor and understand rivers and streams.

- Human water sampling

  - Important activity to observe the condition of water
  - The most common technique for a long period of time
  - *Hazardous environment (i.e. deep and fast flow)*
  - *Slow and costly*

- Autonomous water monitoring system

**Floating sensor**
- Real-time monitoring and data collection
- Water flow, pollutants and fish migration monitoring
- *Accessibility*

**Water sampling Unmanned Aerial Vehicle**
- Quick dispatch system
- Collect samples from multiple points with single deployment
- *Short duration time*

**Water monitoring Unmanned Surface Vehicle**
- Environmental monitoring, geological mapping
- Long-term and multi-point monitoring
- *Not suitable for small and shallow streams*

## Challenge & Scenario

We are planning to develop the autonomous robotic teams that integrate a variety of technologies including robots, sampling systems, crowdsourcing, advanced region of interest (ROI) selection and path planning. However, there are many inherent challenges.

- Real-time system challenges
  - Frequent level change of rivers due to weather condition
  - Real-time data transmission for remote analysis
- Real-time system scenarios
  - UAV and USVs collaboration team
  - UAV provides real-time global map before USVs deployment
  - Broadband wireless network technology

- Continuous system challenge
  - Stationary system limits the area of monitoring
- Continuous system scenarios
  - Maneuverability system to monitor larger area
  - Scheduled patrolling USVs


**Example scenario**

*Mission* – Monitor multiple points in the Wabash river using robotic teams
- *Step 1* – Provides updated map information using UAVs (e.g., exact area of river surface)
- *Step 2* – Produce efficient paths for USVs based on the Travel Salesman Problem algorithm
- Step 3 – Patrol along the paths using USVs

## Future Works

- Various tasks capability (sediment sampling, pollution monitoring, early flood warning)
- Test bed for sampling system in dynamic conditions