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# Turbinator, a non-contact sensor advancing sewer surveillance through real-time monitoring, AI, and predictive maintenance

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**Abstract:** The Turbinator, developed under the SCOREwater project, is an innovative contactless laser-based sensor technology designed to revolutionize sewer network monitoring by addressing the limitations of traditional submerged sensors. By leveraging AI-driven image analysis, the Turbinator provides accurate real-time turbidity and water level measurements while reducing maintenance needs and operational disruptions. Building on the Turbinator's proven prototype, this project aims to develop an AI-driven anomaly detection framework for sewer systems, enabling predictive maintenance strategies. High-resolution sewer images are collected from four Swedish municipalities to identify anomalies such as fat and oil deposits, iron, and sediment accumulation, while also screening for unidentified issues. Using IVL's pilot well, AI algorithms are trained to replicate and predict specific anomaly cases, supporting proactive maintenance and resource optimization.

Integrated with enhanced real-time sensing, the system generates actionable insights via an anomaly detection and alarm dashboard, transitioning sewer maintenance from routine practices to predictive strategies. Preliminary findings demonstrate the technology's ability to detect critical anomalies, mitigate the impact of turbulent flow conditions, and provide near-real-time alarms. This contactless under-lid solution ensures efficient, cost-effective, and energy-saving sewer monitoring, minimizing manual inspections and streamlining operations. Future evaluations will quantify the resource savings and operational benefits achieved through this innovative approach, reinforcing its transformative potential for sewer management.

**Keywords**: Real-time monitoring; AI-driven sensor; Sewer anomaly detection; Predictive maintenance

## Background

Traditional wastewater monitoring relies heavily on submerged sensors subject to clogging, performance degradation, and high maintenance demands. The Turbinator, developed under the

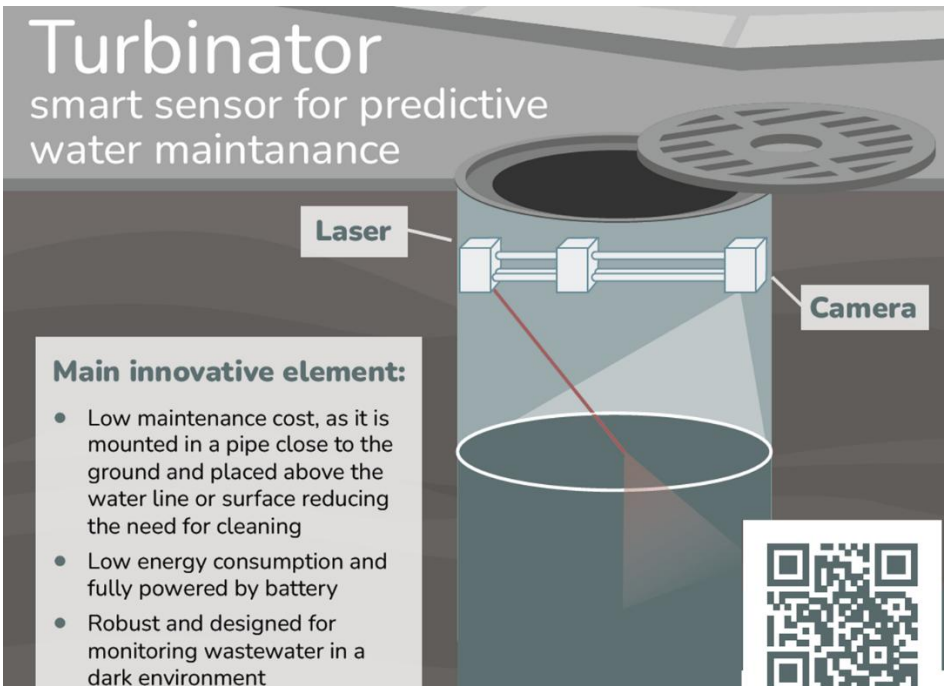


*Figure 1: The Turbinator prototype with laser-based sensing and combined AI-driven image analysis of water turbidity and distance to water surface.*

SCOREwater project, revolutionized turbidity and water level monitoring by introducing a contactless, laser-based sensing solution. This novel sensor uses a laser beam combined with AI-driven image analysis to determine turbidity and distance to water surface, eliminating common issues associated with submersion and improving measurement accuracy and operational reliability. However, despite the proven effectiveness of the prototype, challenges persist in scaling these technologies for predictive maintenance within sewer networks.

Routine sewer maintenance practices often result in inefficient resource use and delayed responses to potential blockages, posing risks to infrastructure and water quality. Current approaches lack the ability to provide actionable, real-time insights for prioritizing maintenance tasks, highlighting the critical need for predictive, data-driven decision-making tools.

**Project aim**

Building upon previous achievements of the Turbinator technology, this project aims to create a comprehensive anomaly detection framework for sewer systems by developing an image database of sewer network conditions. The project focuses on identifying anomaly cases through AI-driven image analysis, with training on selected specific cases to predict and prioritize anomalies most critical for sewer infrastructure. Controlled setups are used to refine the detection and prediction of anomalies, enabling targeted maintenance and proactive management strategies.

**Methodology**

In collaboration with four Swedish municipalities, this project develops an AI-driven anomaly detection framework for sewer systems by leveraging a comprehensive image database of sewer network conditions. High-resolution images were collected from sewer networks to identify known anomalies such as fat and oil deposits in combined sewers, iron deposits, and sediment accumulation in storm sewers, while screening for previously unidentified issues. Using IVL's pilot well, the AI is trained to replicate specific anomaly scenarios, enabling precise detection and predictive maintenance capabilities. Real-time sensing technologies, integrated with the Turbinator's enhanced functionalities, provide continuous monitoring of critical parameters, in addition to turbidity changes. An anomaly detection and alarm dashboard service complement the data output to deliver actionable insights and support operational decision-making. The results should align with the transition from routine maintenance to predictive strategies, achieving significant cost, resource, and energy savings for sewer management.

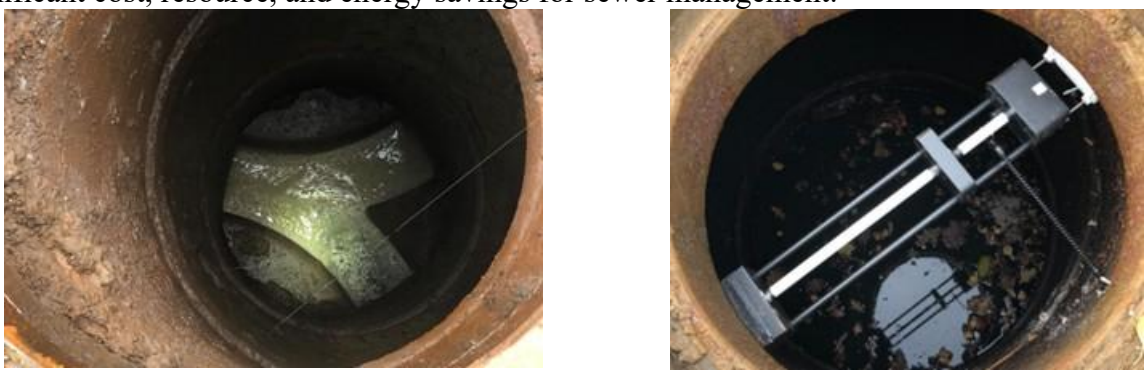

*Figure 2: Examples of manholes where anomalies are being screened for. Left: combined sewer with a significant build-up of fat. Right: storm water manhole close to a big parking lot where oil accumulate, and a Turbinator sensor.*

**Results and Application**

The implementation of an AI-driven anomaly detection framework has the potential to detect specific sewer anomalies, by training AI algorithms on a comprehensive sewer picture database. The image learning technology enables near-real-time anomaly detection, providing actionable insights for sewer maintenance personnel. While limitations such as turbulent flow conditions and impaired picture quality due to ambient sewer conditions may affect detection accuracy of anomalies, this can be mitigated by the integration of meteorological and sewer event data correlated with flow conditions. The system, deployed as an under-lid and contactless solution, supports both remote and on-site data communication, offering flexibility and reliability for sewer monitoring. The potential for this technology to deliver near-real-time alarms for anomalies enables a proactive approach to maintenance, minimizing costs associated with reactive responses. Engagement with sewer maintenance personnel has highlighted the significant impact of the solution on reducing routine maintenance efforts, optimizing resource allocation, and improving overall efficiency. The contactless, under-lid design also reduces the need for physical inspections, further streamlining maintenance processes.

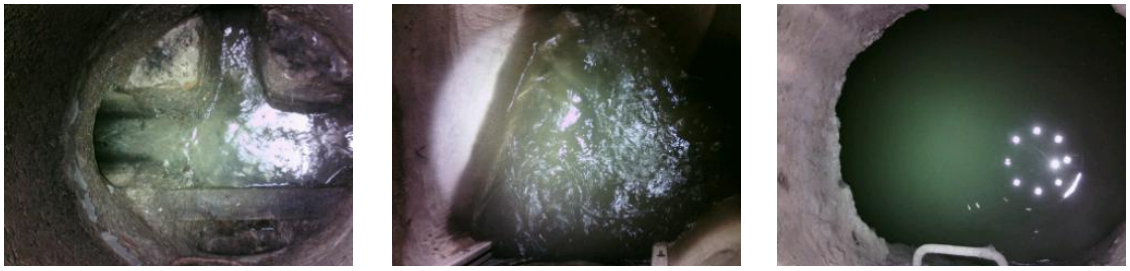

*Figure 3: Sewer images from sensor prototypes in three different manholes demonstrate the potential of using this technology to avoid manual inspections.*

Future assessments will focus on quantifying the resource savings, cost reductions, and operational improvements achieved by integrating this technology into municipal sewer maintenance routines.

**Conclusion**

The integration of contactless monitoring with AI-driven analytics in sewer systems represents a transformative step toward achieving predictive maintenance. This project not only ensures operational resilience but also provides a scalable blueprint for modern sewer management, reinforcing sustainability goals and benefiting water utilities and maintenance personnel alike.

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