Creating a digital smart flood warning system for surface water flooding in West Yorkshire: Flood and Coast Conference paper

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Creating a digital smart flood warning system for surface water flooding in West Yorkshire

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Introduction

Surface water flooding presents one of the most complex challenges in flood risk management. Events are highly localised, driven by short-duration heavy rainfall, and difficult to forecast with confidence (Speight et al 2025). Across England, ~4.6 million properties are in areas at risk, and the impacts of climate change are expected to increase the frequency and intensity of extreme rainfall events (UKCEH, 2025; Environment Agency, 2025).

In practice, pluvial flood risk management in the UK remains largely reactive. Risk management authorities (RMA) rely on limited monitoring data, public reports, and site visits to understand conditions during an event (Hargreaves & Bond, 2024). This constrains timely, coordinated response and limits opportunity for proactive intervention.

Digital smart flood warning systems offer a potential solution for improving flood mitigation and the efficiency of flood infrastructure management. One such approach is the use of LoRaWAN (Long Range Wide Area Network) technology, which enables low-cost, real-time transmission of environmental data over large areas. While widely used in other sectors, its application to surface water flood monitoring remains underdeveloped.

Project overview & Approach

The West Yorkshire Flood Innovation Programme (WYFLIP) brings together five lead-local flood authorities, the Environment Agency, Yorkshire Water, West Yorkshire Combined Authority and the University of Leeds to reduce the impact of flooding and climate change in the region. This WYFLIP project investigates the use of LoRaWAN technology for flood monitoring and management and follows on from a 2023 scoping study (Hargreaves & Bond, 2024) which identified LoRaWAN as a practical and affordable mechanism for flood infrastructure monitoring and response.

This paper presents findings from laboratory evaluation of water level sensors and real-world deployment as part of an ongoing pilot scheme in Wakefield, demonstrating how digital monitoring can support operational flood risk management. The project aims to combine scientific research with operational practice to develop a monitoring system that is both technically robust and practically useful. The current approach comprises four key components: i) laboratory validation of sensor performance; ii) development of a real-time data transmission and visualisation system; iii) field deployment in operational flood risk locations; iv) knowledge exchange to inform application of good practice.

LoRaWAN architecture has been implemented to enable real-time monitoring (Figure 1), whereby sensors transmit data via a gateway to The Things Network (TTN), with data routed to cloud-based dashboards for storage and visualisation. Platforms including TagoIO and PowerBI are used to present live data, enabling operational teams to monitor conditions and respond more effectively.

Three commercially available sensors were evaluated: the Decentlab ultrasonic level sensor, MaxBotix ELSYS ELT2 distance sensor, and Milesight EM500 ultrasonic distance/level sensor. This work represents an early-stage pilot to assess the feasibility and operational value of LoRaWAN monitoring and inform future regional-scale deployment.

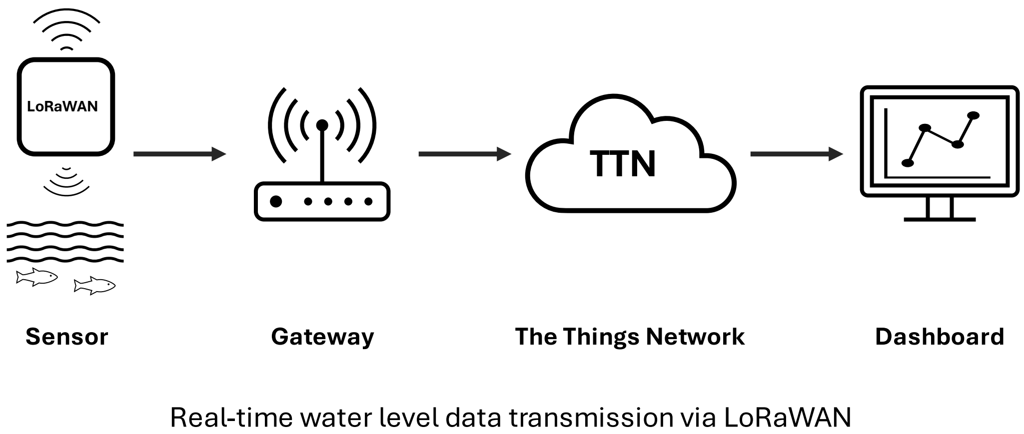

Figure 1: Schematic of LoRaWAN system architecture (sensor → gateway → TTN → dashboard).

Laboratory validation

Controlled laboratory testing was undertaken in the Sorby Fluid Dynamics Laboratory at the University of Leeds to assess sensor performance under controlled static and dynamic flow conditions. All sensors demonstrated high precision (<1.15mm) under static conditions, with sub-millimetre variability and low measurement error.

Due to laboratory constraints, only the Decentlab and Maxbotix sensors were tested under dynamic conditions. Performance varied between sensors, with increasing measurement variability as water surface motion increased. For wave frequencies of up to 35 Hz, dynamic precision was <3.75 mm with a measurement error of <3.00 mm. The Decentlab sensor demonstrated the most consistent performance under dynamic conditions.

These findings highlight that while sensor accuracy is generally high, performance is influenced by environmental conditions. This has important implications for sensor selection and deployment in real-world settings; sensor choice should be made with consideration of site geometry, environmental complexity, affordability, and operational configuration. After careful consideration of site requirements, the Maxbotix ELSYS ELT2 sensor was chosen to trial in real-world conditions.

Field deployment example: Oakenshaw Beck

Multiple pilot schemes are underway across Leeds, Kirklees and Wakefield RMA regions to trial LoRaWAN-based monitoring flood monitoring systems. One pilot has been deployed over Oakenshaw Beck at Agbrigg retention basin in Wakefield, where a watercourse runs directly alongside residential properties (Figure 2). The site includes penstocks used to control water levels and manage flood risk. The project is trialling sensors at the permanent watercourse before further planned testing in surface water flooding hotpots.

Evaluation of sensor performance is ongoing, but the system has proved effective through the wet conditions early in 2026. For example, on 6th February 2026, rising water levels were observed via the real-time sensor data and used to inform operation of the upper penstock. At approximately 10:00, the penstock was partially closed in response to observed conditions. Sensor data (Figure 3) showed a clear divergence in water levels with levels increasing upstream of the penstock (sensor 1) and lower levels along the residential reach (sensor 2). This confirmed that water was being temporarily stored upstream, reducing the relative risk to properties downstream. Prior to deployment, the only strategic-level information was provided via an Environment Agency gauge; during 6th Feb, monitoring of the Environment Agency gauge provided reassurance that there was sufficient upstream capacity to hold additional water. While useful at a strategic level, this gauge alone offered limited visibility of local conditions along the beck itself. This example demonstrates how localised, real-time data can directly inform operational decision-making and reduce reliance on reactive response.

Figure 2: Agbrigg retention basin, Wakefield, and sensor locations

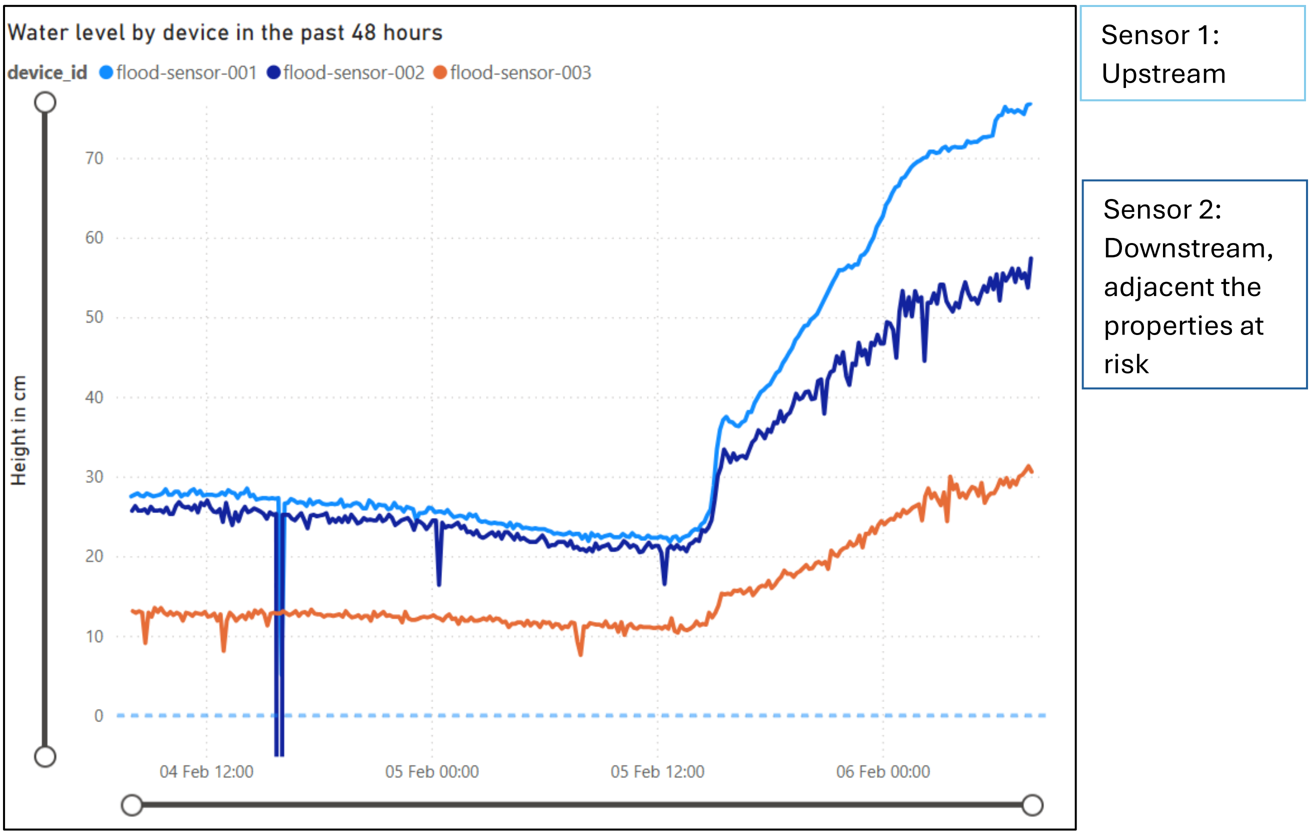

Figure 3: Water level response upstream and downstream of Agbrigg penstock during the 6th February 2026 event.

Investigation of good practice and future plans

In addition to laboratory and pilot testing, WYFLIP has reviewed examples of good practice for flood monitoring and response across the UK, focusing on LoRaWAN-based systems where possible. Initiatives examined include the Blue Heart project (East Sussex), flood warning road signs (North Yorkshire), and the FAIR project (Staffordshire), alongside community-led schemes such as the Pang Valley Flood Forum. These approaches combine sensor networks, rainfall data and digital dashboards to improve real-time situational awareness.

Common challenges were identified. Establishing reliable trigger thresholds for flood warnings remains difficult, particularly where historical data are limited or flooding is infrequent. Long-term sustainability is also a concern, with many systems reliant on short-term funding and ongoing maintenance. Despite this, successful examples demonstrate clear potential, particularly where real-time data are combined with local knowledge to support targeted interventions such as asset operation and community alerting. These findings have informed the WYFLIP pilot and will guide future scaling across West Yorkshire.

Summary and lessons learned

This project demonstrates the potential for LoRaWAN-enabled monitoring to transform surface water flood risk management by providing real-time, localised data to support operational decision-making. Through a combination of laboratory validation and field deployment, WYFLIP has established a robust pilot framework for evaluating low-cost sensor technologies in real-world environments.

Early results from deployments in West Yorkshire show that real-time water level data can significantly enhance situational awareness and confidence in decision-making. At Oakenshaw Beck, sensor data enabled proactive operation of assets during a flood event, reducing risk to properties without the need for repeated site visits or trial-and-error intervention. This represents a clear shift from reactive to more proactive flood risk management.

A key strength of this work is the collaborative approach through WYFLIP, which has enabled effective knowledge exchange and ensured that technical innovation is aligned with operational needs. The work also highlights important challenges, particularly in establishing reliable warning thresholds without long-term datasets, and in managing system maintenance, data handling and long-term resourcing.

Key lessons from this pilot include:

- Validation of sensor performance is essential prior to deployment
- Sensor performance is influenced by dynamic field conditions and site characteristics
- Real-time data can support a transition from reactive to proactive flood management
- Systems must be designed with end users in mind, ensuring data is accessible and actionable
- Collaboration between research and operational partners is critical to successful implementation

Future work will scale deployment across West Yorkshire, expanding sensor networks, refining alert thresholds, and integrating data into operational systems. There is also potential to incorporate technologies such as automated road-closure and gully monitoring systems to enhance flood response. Overall, this work demonstrates how low-cost digital technologies can enable a more proactive, data-driven approach to surface water flood management, with potential for wider application.

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