# LEVEES WORKING GROUP NEWSLETTER

Issue 13 | MAY 2026
THE WORKING GROUP ON LEVEES AND FLOOD DEFENCES UNDER THE EUROPEAN CLUB OF ICOLD

Flood victims in the village of Maasbommel, 25 km west of the city of Nijmegen – Featured on Page 19

Rémy Tourment | Chairman

## Note From the Chairman

Welcome to the 13th issue of the LFD WG newsletter (number 13 – maybe a lucky one!). Once again, we have received several very interesting articles from members and associates of our Working Group. This issue also includes a special feature from our Dutch colleagues, who present a flood event from the past.

It may sometimes seem that we publish articles mainly from the same countries. This is not a conscious choice, but we would very much welcome contributions from a wider range of countries, across Europe and also from the rest of the world.

As you will see in two dedicated sections, one about the EurCOLD LFD WG and another about the ICOLD TC LE, 2026 will be an important year for the international levee community.

The team (Matt, Phil and I) wish you an enjoyable read and please do not hesitate to send feedback.

Matthew Brooks | Editor

## Note From the Editor

As editor, I have had the pleasure of bringing together a great collection of articles from across Europe. In this edition, we cover a wide range of topics relevant to the levee community. This edition reflects the knowledge, experience and commitment of our contributors. I would like to thank everyone who took the time to share their work.

It would be fantastic to see even more countries involved in future issues, so that we can showcase the excellent work being done from an even wider range of perspectives. Sharing experiences across borders helps us all to learn and improve our practice.

I also look forward to connecting with some of you in person at the ICOLD conference in Guadalajara this May.

## IN THIS ISSUE

# **NEW Q&A SECTION**

## Welcome to a new forum for Questions & Answers

**BY MATTHEW BROOKS**

We are pleased to introduce a new section in our newsletter: Questions and Answers. This section is our new forum for sharing questions and practical experience within the levee and flood defence community.

In our field, there is rarely a single correct answer. Solutions often depend on experience, local context and national practise. Exchanging views with colleagues, especially from different countries, can offer valuable perspectives and help to improve all of our approaches.

We will publish selected questions from members and readers along with answers received from the community. The aim is to make the newsletter more interactive and to encourage active discussion and knowledge sharing.

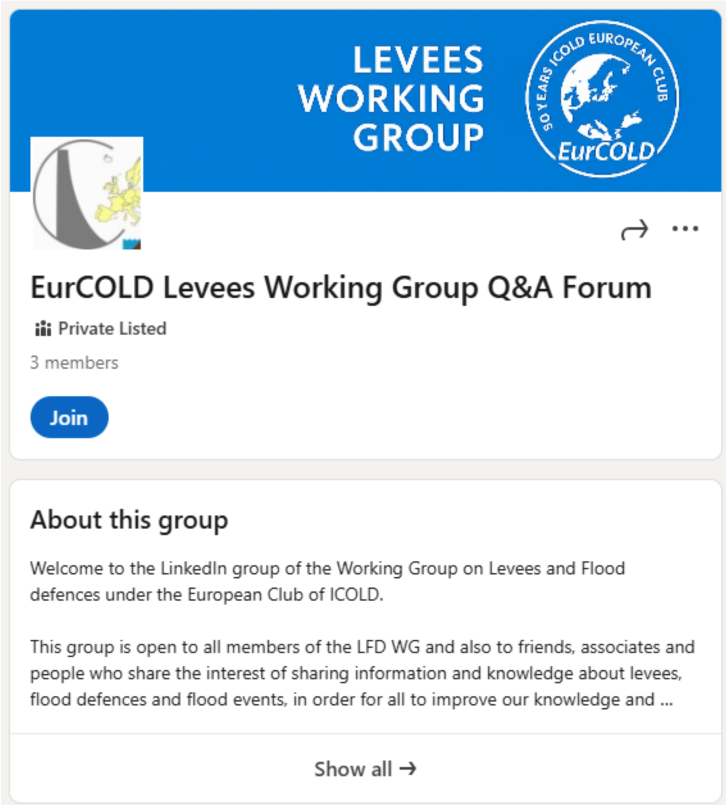
### HOW TO TAKE PART

The Questions and Answers forum is primarily supported by a **New Private LinkedIn Discussion Group** that is **ONLY** open to members of the **LFD Working Group**. The purpose of the group is to share knowledge and improve professional practice through discussion and exchange.

Within the group, members can:

- Post questions to the whole community.
- Receive answers from colleagues across Europe (and potentially beyond)
- Take part in technical and practical discussions.
- Share innovative ideas

**CLICK HERE TO JOIN THE LINKEDIN GROUP**




### PLEASE NOTE:

- This is a private group, visible only to members.
- You may invite other connections, but all new members must be approved by the admin team.
- Posts are moderated by the admin team before publication.

We encourage you to join the LinkedIn group to take part in discussions. However, you can also submit questions via our website if you prefer. A selection of questions and answers will be published in each edition of the newsletter.

For sharing general or "raw" information (outside of discussions and questions), we will continue to use the website and the newsletter.

Please visit: https://lnkd.in/exZiA4Xv

### EXAMPLE QUESTION & ANSWER

#### QUESTION

How do you define the number of levees? Is it just the number of embankments or do you consider two embankments as one dam (levee) if they protect the same city or if they are located in same river but opposite sides of the river or if they are located in same reservoir or with some other idea?

#### ANSWER

Very interesting question not so easy to answer but I can give you thinking elements:

- at the moment and after some changes the regulation consider levee SYSTEMS which altogether provide protection to an area so potentially a single levee or multiple ones
- it's also possible in the same levee different levee segments based on different factors like type of construction details.
- the limit between individual levees can have different origins history, administrative limits… (answer continued on LinkedIn)

# Simpli-MANA

## A Role-Playing Game to Explore Flood Risk Management and Nature-Based Solutions

BY FRANCK TAILLANDIER & ANNABELLE MOATTY

Flood risk management requires collaboration between multiple stakeholders and the implementation of integrated approaches such as nature-based solutions as they have potential co-benefits for risk management, environmental conservation and, in the medium and long term, quality of life. Serious games and role-playing simulations have recently emerged as effective tools to facilitate dialogue, learning and collective decision-making in complex risk environments.

Sim-MANA is designed to explore these challenges through a role-playing game supported by a digital simulation tool (MANA-Flo). Its game board is a 3D model showing the assets and land use in a virtual city, La Vita, and flood simulations generated using MANA-Flo. The game's objective is to put participants in a position of accountability for developing their community based on three goals: ensuring residents' safety from flood risks (flooding and runoff), preserving the environment and biodiversity, and enhancing the town's attractiveness to ensure its future development. By assigning participants the roles of the elected municipal staff, technical services, the environmental association, representatives of business owners and merchants, and citizens, Sim-MANA allows players to experience how different stakeholders interact when planning flood risk management strategies.

### A SIMPLIFIED AND TRANSFERABLE VERSION OF THE SIM-MANA SIMULATION

Simpli-MANA is a simplified version of the Sim-MANA game developed within the MANA project supported by the MAIF Foundation [1]. The objective of this second version is to provide a format that easily transferable to different contexts or audiences, and easier to facilitate for game masters who are not experts in land-use planning and flood risk management.

Participants have individual goals related to their roles, as well as collective goals aiming at protecting the city of La Vita from flooding while balancing economic, environmental and political considerations. To reach this goal, players can choose from a range of land-use projects to implement various flood risk reduction measures, including nature-based solutions. The projects selected by participants are incorporated into a numerical simulation tool that simulates the progression of a flooding event quantifies the damage caused or avoided. Because the flood simulation considers the decisions made, players can test different land-use strategies and observe their impact on flood risk prevention, biodiversity conservation, and the overall attractiveness of the city [2].


*Figure 1 – Example of the game board or participants during a session (Credit: Franck TAILLANDIER)*

### ROLE-PLAYING DIFFERENT STAKEHOLDERS

The game can involve between 5 and 25 participants, who may play individually or in small teams. Each participant or group represents one of the key stakeholders involved in land-use management: the elected municipal staff and technical services responsible for infrastructure and urban planning; the environmental association advocating for ecological protection and nature-based solutions; representatives of business owners and merchants concerned with economic development; and citizens representing residents' concerns regarding quality of life. Through these roles, participants must negotiate, cooperate and sometimes compete to develop their projects that must balance their individual interests with the collective good.

### GAME SESSION

A game session lasts between 1.5 and 2.5 hours and is organized into two to three rounds. The first round begins with a presentation of the territory, its strengths and vulnerabilities, followed by a simulated flood to introduce players to the at-risk areas. Then, they review the projects they can implement and select those they would like to discuss with the entire group. Each player or team has a budget, and most projects are too expensive to be implemented by a single player. The challenge for each player is therefore to defend their choices, negotiate, and persuade others to vote in their favor, as well as make concessions.

The projects may strengthen existing flood protection measures or introduce new approaches, particularly solutions that are more environmentally friendly and beneficial for biodiversity. Participants must also consider indicators such as the efficiency regarding flood risk reduction, biodiversity conservation and city attractiveness. At the end of the round, the numerical simulation tool triggers a flood event and evaluates its

Article Continued Overleaf...

impacts, including potential human and material losses. Based on these results, the system recalculates the indicators, allowing participants to analyze the consequences of their decisions. This feedback helps them adapt their strategy for the next round, in which a new flood event – defined by the scenario – occurs.

*Figure 2 – Flood simulation visualization on La Vita's map*

## A TOOL FOR AWARENESS, TRAINING AND DIALOGUE

Simpli-MANA is designed for a wide range of audiences, including elected officials, technical staff, students and the public from the age of 16. By placing participants in realistic decision-making situations, the game helps them better understand the complexity of flood risk management and the importance of cooperation between stakeholders.

Beyond its educational value, the simulation also provides a space for discussion and collective reflection on the role of nature-based solutions, land-use planning choices and the trade-offs involved in protecting communities against flooding. The game is currently delivered by trained facilitators, ensuring that discussions remain constructive and that participants can fully explore the different strategic options available to them.

*Figure 3 - Participants discussing the projects to be implemented (credit: Laurent GUICHARDON)*

## REFERENCES


[1] Taillandier, F., Moatty, A., Brueder, P., Curt, C., Di Maiolo, P., Beullac, B., Schleyer-Lindenmann, A., 2025. Sim-MANA: A Learning Game to Promote Integrated Flood Risk Management Using Nature-based Solutions. Simulation & Gaming 10468781251351191. https://doi.org/10.1177/10468781251351191

[2] Taillandier, F., Moatty, A., Brueder, P., Curt, C., Beullac, B., Di Maiolo, P., 2023. A Learning Game to promote Nature-based Solutions to manage flood risk. Presented at the ISAGA 2023, La Rochelle. https://doi.org/10.1177/10468781251351191



*Further information, if needed can be obtained from: franck.taillandier@inrae.fr and annabelle.moatty@cnrs.fr*


# CALL FOR CONTRIBUTIONS

Information about levees and flood defences projects and works

*****

News, medias or press releases on current flood or storm events involving levees and flood defences.

*****

Current, ongoing or recently completed research projects.

*****

Documents related to levees or flood defences: handbooks, guidance, reports and regulations.

*****

Information on any event or conference relating to levees or flood defences.

*****

Links to informative / educational web sites and related organisations

*****

Pictures to be used in the web site banner, randomly chosen every time a page loads (resolution has to be 1024*300)

Contact the WG website team: prj-lfd-eurcold@inrae.fr

## Levees & Flood Defences Working Group News

**BY RÉMY TOURMENT**

For our European Working Group, as for the ICOLD Technical Committee on Levees, 2026 will be an important year.

In September, the European Club of ICOLD—under which our Working Group is organised—will hold its 13th symposium. This event will be hosted by our Polish colleagues from POLCOLD (see http://www.ecs2026.pl). EurCOLD symposiums usually take place every three years, and only every three years. This makes it a rare opportunity for dam and levee specialists, engineers, and managers to meet, exchange information, and discuss common issues.


Our LFD Working Group will of course take part in the symposium and plans to hold a meeting and/or a workshop. The details are currently being discussed with the organising committee. I hope to see many of you there.

In addition, following the update of the EurCOLD By-Laws last year—which included new information on how EurCOLD Working Groups should operate—we now need to update our Terms of Reference and our membership list to ensure compliance.

Soon, current members will be contacted by email to help prepare these updated Terms of Reference. These documents will shape the future of our Working Group and its activities.

After this email exchange, a web meeting will be organised to finalise the proposals, so that they can be presented to the EurCOLD Board during the symposium.

If you wish, you may also send us your ideas and suggestions now, even before you are contacted.

## ICOLD Technical Committee on Levees News

**BY RÉMY TOURMENT**

The ICOLD Technical Committee on Levees is closely linked to our European Working Group. We share many common interests. This year is an important moment for this Committee.

The Committee is finishing its first working period. The ICOLD Board agrees that levees are an important topic. For this reason, it has decided to continue the Committee. It has also proposed to reappoint the Chair. This decision will be voted on at the ICOLD General Assembly in May, in Guadalajara, Mexico.

Each National Committee must now decide if it wants to be part of the Committee for the new period. If yes, it must name a delegate.

New Terms of Reference have been prepared. They will also be presented to the General Assembly. For the period 2026–2029, the main activities are:

i. Update existing national appendices to Bulletin 196, or prepare new ones for countries that do not have them.

ii. Prepare a position paper on levees.

iii. Write a bulletin on animal burrows and vegetation management on levees.

iv. Collect and share case studies and techniques for levee maintenance, repair, and upgrading

v. Work with other ICOLD Technical Committees.

vi. Share knowledge and experience, especially through webinars.

These Terms of Reference will be presented and discussed during a workshop and a meeting of the Committee at the 2026 ICOLD meeting in Guadalajara.

Members and friends of the EurCOLD LFD Working Group are encouraged to stay in contact with this Committee and to contribute to its work. This can be done directly, as a committee member, or indirectly through a national support group, or through our own Working Group.

The annual ICOLD Meeting in Guadalajara (https://www.icoldmexico2026.com) will include as usual a lot more activities than the workshops and meetings from the Technical Committees, in particular a symposium, during which without any doubt many presentations will be interesting for levee engineers and managers.

# Managing Asset Condition

## Using Geophysical Techniques to Create an East Anglian Plan

BY GEORGIE-LEE HEELEY & JOANNE NORRIS

Jacobs and BAM are employing innovative geophysical techniques alongside long-term, real-time monitoring of groundwater, river levels, and rainfall data to proactively identify structural defects within earthwork embankments. This early detection enables targeted interventions, improving cost-effectiveness and efficiency. This is another example of innovative use of geophysical techniques in ground investigations, as previously highlighted in the Kendal Flood Risk Management Scheme and the Guildford Flood Alleviation Scheme. However, this application is distinct in its use of these techniques to identify defects and anomalies within earth embankments.

### BACKGROUND

The Environment Agency is developing a Management Plan for the Ten Mile Bank/Ely Ouse stretch of the River Great Ouse to assess embankment conditions and reduce failure risk. This is due to be completed by the end of 2025. By mapping risks and prioritising investment, the plan builds long-term resilience, cuts emergency repair costs, and ensures embankments provide a reliable Standard of Service. The Fens 2100+ strategy is being developed to guide long-term management of the Fens' flood assets beyond 2100, but it won't take effect for another 10–15 years. Meanwhile, there have been unexpected failures along Ten Mile Bank within the last 10 years that have required costly emergency works, underlining the need for a proactive interim approach. A Management Plan is therefore essential to close the knowledge gap, improve confidence in asset stability, and prevent unplanned failures until the long-term Fens 2100+ strategy is in place.

### What Did You Do Differently?

Over a two-month programme, Jacobs and BAM carried out a comprehensive ground investigation combining innovative geophysical techniques—ground-penetrating radar, electrical conductivity and resistivity tomography—with cable percussion drilling, cone penetration testing, window sampling, and topographical surveys. This was complemented by a year-long programme of remote groundwater, river level and rainfall data monitoring, providing real-time data rather than periodic site extractions. In-situ testing and laboratory testing from the ground investigation fed into an engineering assessment of the Ten Mile Bank site including slope stability and seepage calculations. This provided real-time data rather than periodic site extractions.

The engineering assessment, based on asset condition and baseline ground data, identified nine defect groups affecting the embankments. These were analysed through slope stability calculations to see how they affected resilience and performance. We established a base stability level from soils interpretation and remote water monitoring, tested additional scenarios for desiccation cracks, loading, highway activity, and changes in river/groundwater water levels. The assessment produced risk maps rating issues as Red, Amber, or Green, directly linked to asset condition. This evidence provides the foundation for the Management Plan, guiding targeted interventions.

Benefits The Management Plan helps to:

- Support long-term resilience of the embankments.
- Reduce emergency repair costs by replacing them with maintenance regimes and cost-effective interventions.
- Ensures the embankments meet a reliable Standard of Service, protecting the surrounding area, infrastructure and people.

*Figure 1: Cone Penetration Testing (credit: Georgie-Lee Heele)*

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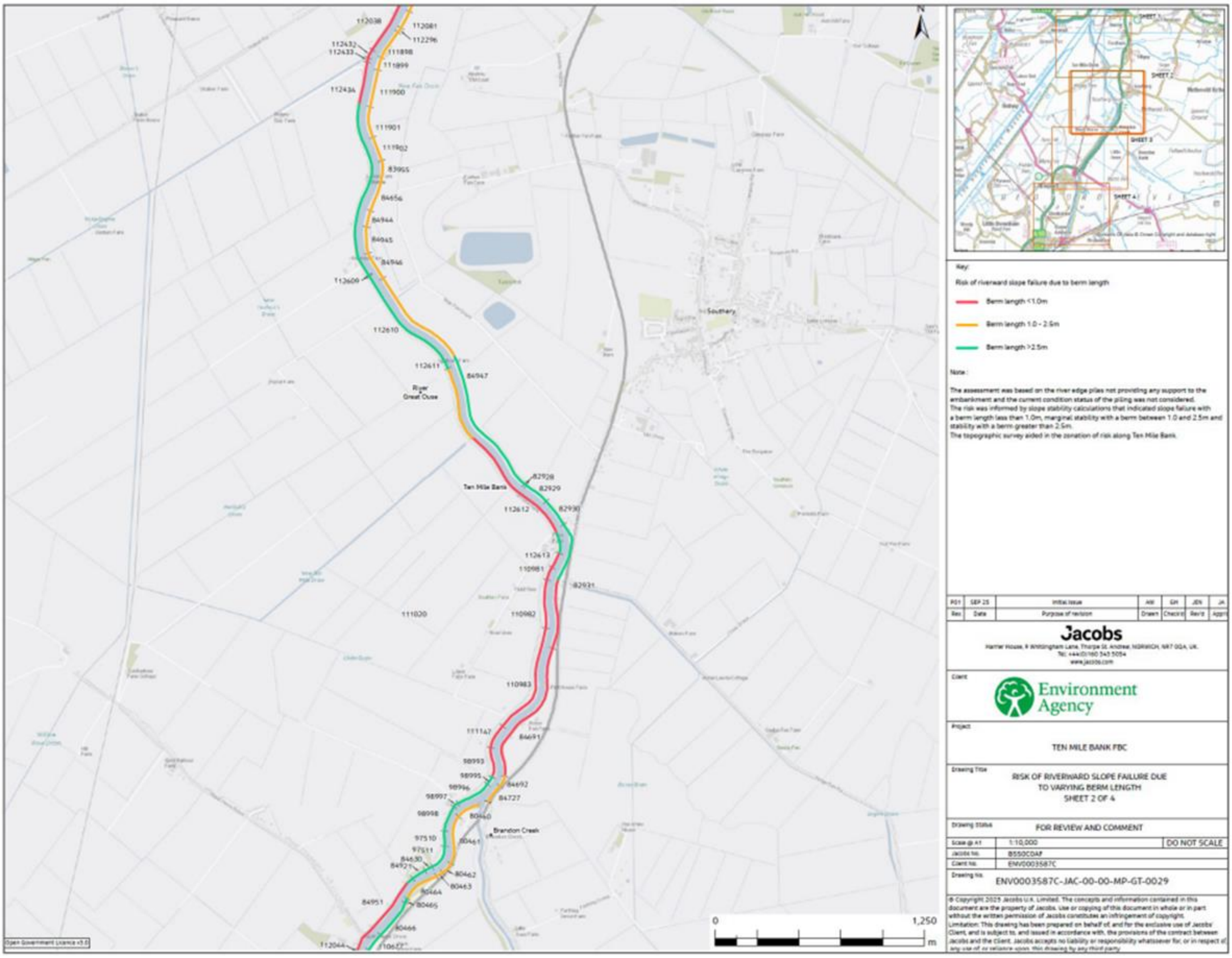
*Figure 2: Visible sheep rutting on embankment crest (credit: Georgie-Lee Heele)*

The Management Plan sets out how to identify structural defects and recommends maintenance and repair techniques, supported by typical drawings. Using the risk maps, remediation can be targeted to vulnerable areas typically associated with defects, such as reduced berm lengths, vehicle damage at the bank toe, or overgrazing of the crest, through planned consultation and works. The aim is to establish a management and inspection regime that preserves embankment integrity, highlights defects early, and enables cost-effective interventions over costly large-scale failures, through planned consultation and works.

## KEY LESSONS LEARNED

The ground investigation was completed and met its objectives, with the final Management Plan due by the end of 2025. Key lessons include:

- Remote water monitoring provides continuous, accessible live data rather than monthly extracted data.
- Ground-penetrating radar, electrical conductivity and electrical resistivity tomography techniques are successful for identifying embankment conditions and defects.
- Programming geophysical techniques before intrusive investigation techniques means intrusive ground investigation can target anomalies.
- Early stakeholder engagement is essential for smooth implementation.




*Further information, if needed can be obtained from: Georgie-Lee Heeley, Graduate Engineering Geologist, Jacobs georgie-lee.heeley@jacobs.com Joanne Norris (Dr), Associate Director, Jacobs joanne.norris@jacobs.com*

# Flood and Coastal Risk Management on Réunion Island: Levees, Sediment Transport, and Coral Reef Protection

A synthesis of three articles about Réunion Island published by the French association of levee managers, France Digues in December 2025

BY THIBAULT LESCUYER

Réunion Island, a French overseas territory in the southwestern Indian Ocean, faces exceptional flood and coastal hazards shaped by its volcanic topography and tropical climate. The island rises to 3,070 m at Piton des Neiges and descends steeply to a 250 km coastline, creating rainfall events with extremely short response times. Intense rainfall—among the highest recorded on Earth—feeds a dense network of rivers and "ravines" (steep, seasonal watercourses) prone to flash floods and torrential transport of boulders, gravel and debris.

Cyclones Belal (2024) and Garance (2025) struck in successive years, underscoring vulnerabilities that had been partly overlooked. Garance, a category-3 system, made landfall near Sainte-Suzanne in February 2025, triggering major sediment flows in the northern watersheds. These events have accelerated efforts to strengthen flood-prevention planning and asset management across the island.

Under the French GEMAPI regulatory framework (Gestion des Milieux Aquatiques et Prévention des Inondations), inter-municipal authorities (intercommunalités) are responsible for managing levee systems and associated structures. In the island, five such authorities exist. Their flood protection action plans are often framed through pluri-annual Flood Risk Prevention Action Programmes (PAPI), though most remain at preliminary-study stage or are incomplete. Post-cyclone, the State is pushing to advance these programmes, which allow State-financing once they are validated and to improve coordination among actors.

*Figure 1 – Coastline on the West Coast, showing volcanic topography, Boucan Canot (c-commons, Flick Miwok)*

## LEVEE SYSTEMS AND PROTECTION STRUCTURES

Réunion's classified levee systems (systèmes d'endiguement) are located exclusively along rivers and ravines—none protect the coastline. This reflects both the island's morphology (43 % of the shoreline consists of rocky cliffs or steep slopes) and the dominant coastal hazard mechanism: wave overtopping rather than still-water overflow. Conventional sea dikes are of limited use where the threat comes from breaking waves hurled onshore by cyclonic swells.

River levees are typically earth embankments reinforced with riprap or gabions. Many date from the 1980s–1990s and were designed primarily to contain water levels, with less attention to the solid-load component that characterises Réunion's torrential hydrology. Upgrading these structures to cope with sediment surcharge is a current priority.

## MANAGEMENT CHALLENGES

Inter-municipal authorities have progressively built technical capacity since GEMAPI transfer, but several challenges persist :

- Post-event inspections and emergency works require rapid mobilisation of equipment and qualified staff; resources remain limited on a small island.
- Regulatory and hydrological studies compete for the same engineering consultancies, creating bottlenecks.
- Funding for major rehabilitation or new construction depends heavily on State and European co-financing, through PAPI programmes that are slow to mature.

The successive cyclones of 2024–2025 have nonetheless accelerated institutional learning. Several intercommunalités have reinforced their GEMAPI teams and are negotiating new PAPI with the regional environment directorate (DEAL).

## SEDIMENT TRANSPORT: THE MOST DELICATE RISK

Réunion's torrential hydrology means that solid-load transport during floods can exceed water-flow hazards in severity. Boulders, cobbles, gravel, uprooted trees and other debris are mobilised on steep slopes and deposited in downstream reaches, raising bed levels and increasing overflow risk for subsequent events. Following Cyclone Garance, aerial surveys revealed massive sediment accumulation in several northern

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ravines. For instance, on the Ravine de Patate à Durand, managed by the CINOR inter-municipality, authorities estimated a need to extract 235,000 m³ of material over 18 months, with a target of 60,000 m³ before the 2025–2026 cyclone season. Extraction takes place in a 4-hectare sediment-trap basin located upstream of the levee system.

## FIND A POLITICAL AGREEMENT

Sediment-removal operations have sparked disagreement between intercommunalités and the State. Questions include :

- Who bears the cost ? Emergency clearance is eligible for disaster-relief funding, but routine maintenance is a local responsibility.
- Environmental constraints : Extraction in watercourses requires authorisation under water-law and may conflict with biodiversity objectives.
- Destination of materials : Extracted gravel and boulders can be reused for construction aggregates, but commercial valorisation raises legal and logistical issues.

Resolving these tensions is essential for sustainable management, given that sediment input is a permanent feature of Réunion's landscape, not merely a post-cyclone anomaly.

## RELOCATION OF AT-RISK HOUSING

In July 2025, the first relocations of dwellings situated on ravine banks took place in Saint-Denis, marking a policy shift toward managed retreat where structural protection is impractical. Further relocations are being studied.

## "HAMMER SPUR" GROYNES (ÉPIS MARTEAUX)

A distinctive feature of Réunion's flood-protection arsenal is the épi marteau ("hammer spur"), a T-shaped groyne installed in river channels. These structures were developed following a 1966 hydraulic study. Construction began in the early 1980s on several rivers, notably the Rivière des Pluies and the Rivière des Galets. Each spur comprises a head made of masonry or concrete weight wall, resting on a footing slab, and a body built of compacted fill, protected in its most exposed sections by gabions or by a linked rock armor shell [source: Étude SOGREAH, 1966].

They have three main objectives:

- Dissipate the energy of torrential flows by inducing lateral expansion;
- Promote controlled sediment deposition upstream of the structure;
- Deflect flow away from vulnerable levees or vulnerable infrastructure.

*Figure 2 – Hammer Spur on the Rivière des Galets (credit : Territoire de l'Ouest)*

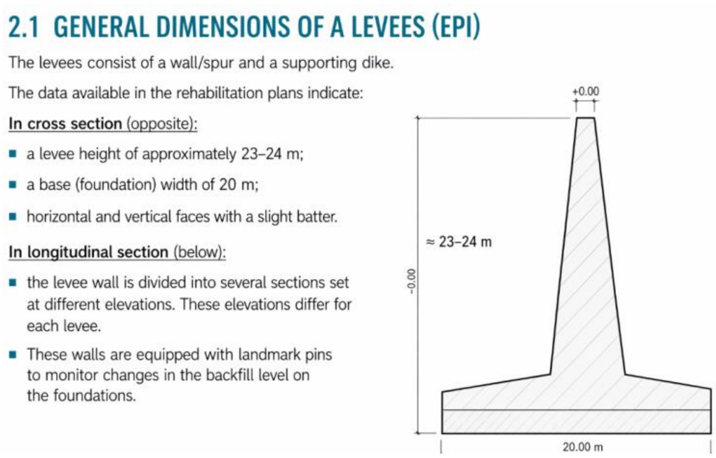


*Figure 3 – Dimensions of a Hammer spur (credit : Territoire de l'Ouest) Translated by Matthew Brooks*

On the Rivière des Galets, nine spurs and their adjoining levees form a system that collectively contribute to protecting approximately 22,000 residents of the lower plain. The hydraulic regime is extremely dynamic, with high sediment loads and rapid morphological adjustments. In recent years, this dynamic has weakened the stability of several spurs and levees, where scour and bed lowering have occurred.

The risk of levee subsidence has led to engineering reinforcements: attached rock armouring in 2022, and emergency material recharges after Cyclone Garance. These works illustrate the need for ongoing adaptation in highly mobile riverbeds where hydraulic conditions can change dramatically from one cyclone to the next.

## COASTAL FLOODING AND THE ROLE OF CORAL REEFS

Approximately 11,000 residents live in areas exposed to coastal flooding risk on Réunion Island. Flooding here results primarily from wave overtopping—packets of water thrown inland by powerful swells—rather than from tidal surge or gradual sea-level rise. Austral swells from the south and cyclonic swells from the north can generate waves exceeding 6 m or even reaching 10 m in the north.

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During Cyclone Garance, swell heights were significant but the event's short duration limited coastal damage. Nonetheless, climate-change projections suggest that extreme wave events may intensify, compounding chronic erosion already observed on several beaches

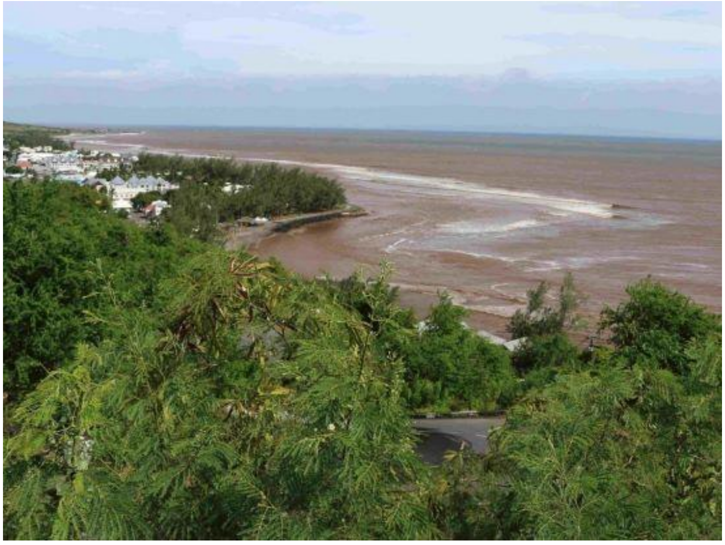

*Figure 4 – The coast of Saint Leu after Cyclone Fakir (credit: BRGM, 2018)*

## CORAL REEFS AS NATURAL BREAKWATERS

As noted, no classified coastal levees exist on Réunion. Engineering studies have concluded that conventional dike designs offer limited benefit against wave-overtopping hazards and may induce false security or interfere with natural sediment dynamics. Meanwhile Réunion's fringing reefs, concentrated along the western coasts, provide measurable wave-energy dissipation and protection. Healthy reef crests cause waves to break offshore, reducing run-up on adjacent beaches and lowlands. Studies have calculated that the coral reef reduces up to 90% of wave energy.

However, reefs are under pressure from thermal bleaching linked to rising sea-surface temperatures and from sedimentation and nutrient pollution from land-based sources through river mouths, in particular following intense rains.

Integrating reef conservation into coastal risk-management strategies is therefore both an ecological and a civil-protection priority. Current efforts include runoff mitigation, coral-gardening pilots, and updated coastal monitoring.

## CONCLUSION

Réunion Island illustrates how volcanic-island settings demand tailored approaches to flood and coastal protection. River levees and hammer-spur groynes address the torrential regime of inland watercourses, while sediment-management operations are indispensable complements to structural defences. On the coast, coral reefs serve as the primary—and irreplaceable—buffer against wave attack, reinforcing the case for nature-based solutions and integrated land–sea planning.

The back-to-back cyclones of 2024–2025 have galvanised local and national actors. Accelerating PAPI programmes, clarifying sediment-management responsibilities, and investing in reef resilience will be crucial for the next flood-risk strategies in the island.

Please visit the France Digues website for 3 articles on flood protection structures in Réunion (in french):

- Challenges of flood prevention on the island - lessons learned from Cyclone Garance : https://www.france-digues.fr/actualites/a-la-reunion-le-cyclone-garance-a-donne-un-coup-de-collier-a-la-prevention-des-inondations/
- Sediment Transport in rivers and ravines - the most delicate risk : https://www.france-digues.fr/actualites/ile-de-la-reunion-sur-les-rivieres-et-les-ravines-le-risque-le-plus-delicat-est-le-transport-des-materiaux-solides-1/
- Coastal submersion - the role of coral reefs : https://www.france-digues.fr/actualites/risques-de-submersion-marine-environ-11000-personnes-concernees-a-la-reunion/

*Further information, if needed can be obtained from:*
*beatrice.tourlonnias@france-digues.fr*


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# Onsite Materials Testing

## Saving time and cost by testing directly at the Littleborough and Rochdale site

**BY DOMINIC DEMPSEY & RHYS BRINDLE**

An on-site material testing laboratory for concrete, soil and aggregate was brought into operation by VolkerStevin on Phase 1B of the Littleborough and Rochdale Flood Risk Management Scheme to bring site testing under direct control of the site team. This approach improves the immediacy of decision-making, mitigates programme risks by preventing delays and rework, and delivers measurable efficiencies in time, cost, and environmental impacts.

### BACKGROUND

The £150 million Littleborough and Rochdale Flood Risk Management Scheme, led by the Environment Agency, will deliver a range of flood defences along the River Roch in two phases, providing better protection for 723 homes and 489 businesses. The project's scale created an opportunity for VolkerStevin to establish an on-site materials testing facility, supported by sister company VolkerFitzpatrick's UKAS accreditation. The key advantage of on-site testing lies in its immediacy—eliminating delays from off-site analysis and enabling swift, informed decision-making. This responsiveness reduces costly rework, mitigates risks, and streamlines delivery, translating into measurable programme and cost efficiencies.

### ON-SITE MATERIAL TESTING LABORATORY

The practical value of on-site testing was demonstrated during the construction of an embankment in Littleborough, where a stockpiled sample of imported clay underwent a compaction test. Within 24 hours, results showed the clay's moisture content exceeded acceptable limits. Immediate feedback allowed the team to implement corrective measures to 750 $m^3$ of clay, which was loosened and aerated for even moisture reduction and left to dry for three days during forecasted sunny weather. During this period, work was redirected elsewhere to avoid operational downtime. Once retested on-site, the clay passed and was immediately laid and compacted onto the embankment.

Had the testing been undertaken off-site, turnaround time would have extended to at least five to six days. In that period, multiple clay layers might have been compacted above the defective one. Reassessment would then require excavating a trench to expose and retest the material, introducing safety risks and additional waiting time. Depending on test results and client instructions, this process could escalate to removing all overlying layers to treat or replace the clay—causing major delays and higher costs.

The rapid turnaround of on-site testing eliminated the delay of conventional methods, cutting two weeks from the earthworks programme. This saved £240k in programme efficiency.

Similarly, the availability of an on-site testing lab enabled fast Particle Size Distribution (PSD) results during grading works for a bespoke riverbed in a new channel. Immediate PSD data allowed the team to tailor grain-size mixes for specific river sections and bends. By avoiding off-site testing, which could have added up to seven days of delay, it prevented significant downtime

### BENEFITS

- On-site laboratory setup requires upfront investment but remains cost-effective— around 80% of the tender typically allocated to an external testing provider.
- Equipment can be reused on future projects, further reducing expenditure.
- Forecasted a two-week programme saving worth £240k while reducing H&S risks.
- Lowered carbon emissions by avoiding transport of site of samples, rework, and extended site presence.
- Flexibility to test concrete cubes at different curing time periods can potentially allow for the early stripping of formwork.

*Figure 1: On-site testing prevents delays and rework (credit: Rhys Brindle)*

### KEY LESSONS LEARNED

The experience of implementing onsite material testing has highlighted several key lessons:

- Quick turnaround and streamlined processes proved critical in reducing programme risk, preventing costly delays and enabling corrective measures on non-compliant materials.
- However, an earlier opportunity to digitise the testing workflow and certification would improve efficiency and support faster decision making.

*Further information, if needed can be obtained from: Dominic Dempsey, Laboratory Manager, VolkerStevin. Dominic.Dempsey@volkerstevin.co.uk Rhys Brindle, Sustainability Engineer, VolkerStevin. Rhys.brindle@volkerstevin.co.uk*

# Preliminary Feedback on the Management of the February 2026 Flood Event in the Lower Loire River Basin

BY SIMON DIEUDONNÉ, VIRGINIE GASPARI, LUCIE NDI

The Loire River Basin Authority (Établissement public Loire / EPL) is a French public institution responsible for the management of levee systems on behalf of local authorities at the scale of the Loire river basin. The Angers operational unit manages a total of 172 km of levees in the downstream section of the basin (i.e. 11 levee systems), located in northwestern part of France. The unit comprises nine staff members (engineers and technicians) and includes all competencies required for the management of levees. This reinforced organizational structure ensures continuous condition monitoring, rapid intervention capability, and the availability of technical expertise, particularly during flood events. Since its establishment in 2019, the Angers unit has also played a key role in the skill development of local authority personnel through targeted training in flood-time levee surveillance, thereby strengthening field coordination and collective preparedness for extreme flood scenarios.


*Figure 1: Location of Loire River Basin Authority*

In early 2026, the Loire basin experienced a series of significant rainfall events, resulting in a marked increase in water levels in the Loire and its tributaries. Under these conditions, the Angers unit went on high alert from 12$^{th}$ February, ensuring the enhanced monitoring of the levee systems and flood dynamics. Following an intensified on-call period over the weekend of 14-15$^{th}$ February, a crisis management unit was activated from 16$^{th}$ February to 2$^{nd}$ March. All personnel were mobilized on a continuous (24/7) basis to ensure real-time coordination of monitoring activities and, where required, emergency response operations.

Field surveillance was carried out by local authority teams through rotational shifts, including nighttime inspections in certain sectors. Concurrently, EPL personnel provided technical support from the operations centre, responding to anomalies reported from the field and ensuring information relay to state authorities.

*Figure 2: View of the levee at Saint-Georges-sur-Loire during a flood (Source: EPL, February 20, 2026)*

During the flood event, the Angers unit core functions included: (i) assessing the severity of observed levee anomalies; (ii) determining appropriate on-site response strategies; and (iii) mobilizing, where necessary, accredited engineering consultancies (acting as independent safety assessors for hydraulic structures) as well as emergency works contractors. This continuous, reinforced operational posture enabled anticipation, assessment, and rapid implementation of protective measures to ensure levees' integrity and support local authorities. In addition, dedicated instant messaging channels were established for each levee system to streamline communication, facilitate real-time sharing of field observations, and ensure rapid dissemination of essential information.

*Figure 3: The crisis room at the Angers unit during the flood (Source: EPL, March 2026))*

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The flood event, which persisted for over two weeks and corresponds to an estimated 20-year return period (based on the "Lower Loire" and "Saumur Loire" sections of the national flood forecasting platform Vigicrues), resulted in the following: activation of surveillance for all 11 levee systems managed by the Angers unit; exceedance of the protection level for 6 levees; suspension of monitoring for 2 levees; and recommendation of precautionary evacuation for populations protected by 4 levees. Preliminary feedback from the event indicates: over 100 recorded anomalies across the levee network; 8 emergency intervention operations undertaken to secure the most critically stressed structures; 14 days of continuous crisis unit operation involving full mobilization of the Angers unit staff and local authority personnel, with additional support from the Orleans unit; and 10 nights of on-call duty including nocturnal monitoring visits.

Several categories of anomalies were identified during the flood event, including: clear-water and sediment-laden seepage (in some cases associated with sand boils); slope instability on the river-facing side; overtopping of a submersible levee section; localized ground subsidence consistent with sinkhole formation; and operational or sealing deficiencies affecting hydraulic appurtenances (valves and floodgates).

*Figure 4: Sediment-laden seepage – Saint-Georges-sur-Loire levee (Source: EPL, February 22, 2026)*

*Figure 5: Sandboil – Montjean-sur-Loire levee (Source: EPL, February 24, 2026)*

Emergency works implemented included: construction of filter and drainage berms at locations affected by sediment-laden seepage to mitigate internal erosion mechanisms (4 interventions on the Saint-Georges-sur-Loire levee; 1 on the Montjean-sur-Loire levee); sealing of a flap-type check valve (Bertignolles levee) and a floodgate (Boire Torse levee); and removal of vegetation obstructing inspection of a sediment-laden seepage zone (Saint-Georges-sur-Loire levee). In addition, surveillance teams at the Montjean-sur-Loire levee carried out remedial works consisting of the installation of localized filter and drainage patches at five seepage-affected areas.

*Figure 6: Emergency works on an area of material-laden leakage – Saint-Georges-sur-Loire levee (Source: EPL, February 22, 2026)*

Following the return to normal conditions, the Angers unit conducted an initial post-event review with all local authorities to consolidate operational lessons learned. Furthermore, post-flood inspections of levee systems have been initiated to assess structural integrity, including pre-existing defects, damage incurred during the flood, and issues arising during the recession phase. These assessments will support the development of a rehabilitation and strengthening program aimed at addressing identified deficiencies, with implementation scheduled from summer 2026 onward.

*Further information, if needed can be obtained from:* *simon.dieudonne@eptb-loire.fr*, *virginie.gaspari@eptb-loire.fr*

## VISIT THE WEBSITE

Over the past months, the EurCOLD website has been updated with several new articles showcasing work from across our community. Some highlights are featured in this newsletter and we encourage readers to explore the website for deeper insight and additional content

**New series of webinars on Flood Risk Management**

A new series of webinars on Flood Risk Management, created for everyone who works with water, risk, and everything in between. Within our newly established European FRM network, we're bringing together practitioners and researchers to sh...

**EurCOLD 2026 Symposium**

The 13th EurCOLD Symposium will be held in Bydgoszcz (Poland) on 21-25 September 2026.

**Flood Early Warning Systems**

Floods continue to devastate communities worldwide, with increasing frequency and intensity. Effective Flood Early Warning Systems (FEWS) are critical for reducing the impact of natural disasters and advancing climate resilience.

**ICOLD 2025 Congress proceedings**

The proceedings for the ICOLD 2025 Congress in Chengdu (China) are now available

**Retrofitting and reinforcement of Levees**

The ISSMGE Technical Committee 201 (TC201) on Dikes and Levees is preparing a joint report on the retrofitting and reinforcement of levees. This report aims to advance the international exchange of knowledge on techniques for strengthening levees.

**Dam World 2025**

I was happy and proud to be part of the international Dam World 2025 conference in Lisbon (https://dw2025.lnec.pt) where I have been invited to give a lecture about levee failure modes.

**Emergency Management of Flood Defences**

An international working group has published a book with the basic principles of emergency management for flood defences. The handbook is more a practical guidance with principles, issues, methods and examples as well in the preparedness as in t...

**Joining forces against flooding: International Handbook launched**

The International Handbook on Emergency Management for Flood Defences, set to launch on December 10th, 2024, aims to save lives and minimize flood damage worldwide. Its ultimate goal is to build an international community of flood defe...

**Keynote lecture on complex levee failure scenarios**

I was happy and proud to be part of the XXXIInd national meeting organised by the Mexican Society of Geotechnical Engineering in Mexico City where I have been invited to give a keynote lecture. The title of this lecture was " Levee failure scenarios - Comp...

**Call for contributions to INTERPRAEVENT 2024**

The topic of the conference INTERPRAEVENT 2024 is "Natural hazards in a changing climate – How to manage risks under global warming?". The conference takes place in Vienna 10-13 June 2024.

## FEEDBACK REQUEST

**We are always seeking for ways to improve this newsletter content and topical areas, and would welcome your feedback too**

## NEWSLETTER TEAM CONTACT

**prj-lfd-eurcold@inrae.fr**

**Rémy Tourment | Phil Welton | Matthew Brooks**

# COMING UP...

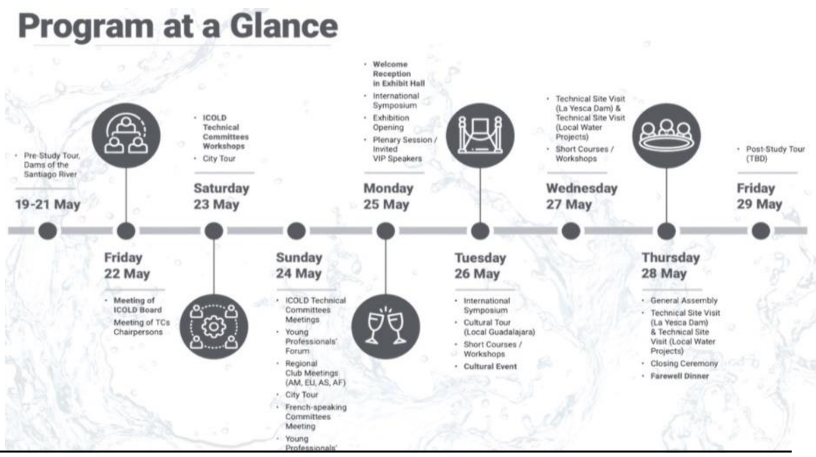
2026
May 23-29th

## ICOLD 2026 in Guadalajara (Mexico)

May 23-29th 2026

Next year's ICOLD annual meeting will be held in Mexico. There will definitely be some levee related content then, under the umbrella of ICOLD TC LE, but also in the symposium organised by the Mexican Committee. Check the meeting web site: https://icoldmex2026.com.

There is a reduced registration rate valid until the of this year 2025: https://www.icoldmexico2026.com/copia-de-registro.




2026
June 14-19th

## 21st International Conference on Soil Mechanics and Geotechnical Engineering in Vienna (Austria)

June 14-19th 2026

Registration is open now! If you need help, here you will find a short instructional video on how to register for ICSMGE 2026 in Vienna.

Instructional video for registration

2026
June 22-26th

## 32nd EWG-IE & 7th EWG-OOE Meeting

June 22-26th 2026

BY RÉMY TOURMENT

Deltares, Rijkswaterstaat and TU Delft are organising the 32nd workshop of EWG-IE (internal erosion) and the 7th workshop of EWG-OOE (overflow and overtopping erosion), which will take place in Delft from 22-26 June 2026. This event follows similar sessions held in Brno in 2025.

📌 **22–24 June** – *32nd EWG-IE Meeting* (Internal Erosion in Embankment Dams and their Foundations)

📌 **24 June** – *Technical visits*

📌 **24–26 June** – *7th EWG-OOE Meeting* (Overflow and Overtopping Erosion)

The aim of the workshops is to share the latest knowledge and innovations in the field of dam and levee safety, with a focus on internal erosion, overflow, and overtopping erosion.

The workshops are intended for the broader water management community, including academics, consultants, and practitioners involved in the design, management, technical supervision, and research of hydraulic structures.

More detailed information can be found on the conference website: ewgiooe2026.sciencesconf.org. You are invited to submit an extended abstract, conference contribution, or academic journal article by **18 January 2026.**

**32nd EWG-IE Meeting**
**7th EWG-OOE Meeting**
Delft, the Netherlands
22-26 June 2026

2026
September 21-25th

## 13th ICOLD European Club Symposium in Bydgoszcz, Poland

September 21-25th 2026

Polish Committee on Large Dams (POLCOLD) is happy to invite You to the 13th ICOLD European Club Symposium, which will be held from the 21st to the 25th of September 2026 in Bydgoszcz, Poland.

During this meeting we will celebrate CFBR/French-COLD 100th anniversary, founded in 1926.

More information can be found on the symposium website: ECS 2026

Programme

| TIME | Monday 21.09.2026 | Tuesday 22.09.2026 | Wednesday 23.09.2026 | Thursday 24.09.2026 | Friday 25.09.2026 |
|---|---|---|---|---|---|
| morning 0900-1200 | | Openning Ceremony 0900-1000 general session 1000-1200 | 2 parralel technical sessions | 2 parralel technical sessions | 0900-1600 field technical trip "dams around Bydgoszcz" |
| afternoon 1200-1800 | registration starts at 1400<br>1600-1800 European Club Board Meeting<br>1400-1600 Young Proffesionals Meeting<br>1400-1600 EWG' meetings | 2 parralel technical sessions | 1430-1730 session special CFBR/French-COLD 100 anniversary | 1200-1600 general session<br>1600-1700 Closing Ceremony | |
| evening 1900-2300 | | welcome reception and cultural event | 1930-2200 French Wine Evening | 1900-2300 farewell dinner | |
| all day | | technical exhibition<br>accompanying persons programme | technical exhibition<br>accompanying persons programme | technical exhibition<br>accompanying persons programme | |

# The 1926 Meuse and Rhine River Flood - A Forgotten Disaster

BY ROY M. FRINGS, MARCEL BOTTEMA

## INTRODUCTION

Barely 10 years after the Zuiderzee storm surge disaster of 1916 with its flooded areas stopping just short of the Dutch capital city of Amsterdam, the Netherlands were hit by another flood disaster caused by levee breaches along the Rhine branches and especially the Meuse River. These river floods of early 1926 were just as destructive in terms of levee breaches and area flooded (see Figure 1).

Both floods were also the trigger for large engineering works: the 1916 storm surge disaster was the trigger for the closure of the Zuiderzee estuary through the 32 km long Afsluitdijk ('closure dike') and for several subsequent land reclamation works, whereas the 1926 river flood disaster was the trigger for a fundamental redesign of the Meuse river system.

One century later, especially the 1926 floods seem to have escaped from collective memory, as memories to the 1953 storm surge disaster with its death toll of over 1800 people, the 200 000 people mass evacuation of the Betuwe area due to the 1995 flood threat, and in some regions the 2021 summer floods may have become more prominent.

Yet the 1926 floods and the lessons that can be learnt from it are relevant enough to highlight again during its 100 year's commemoration, despite or maybe rather because of their forgotten status.

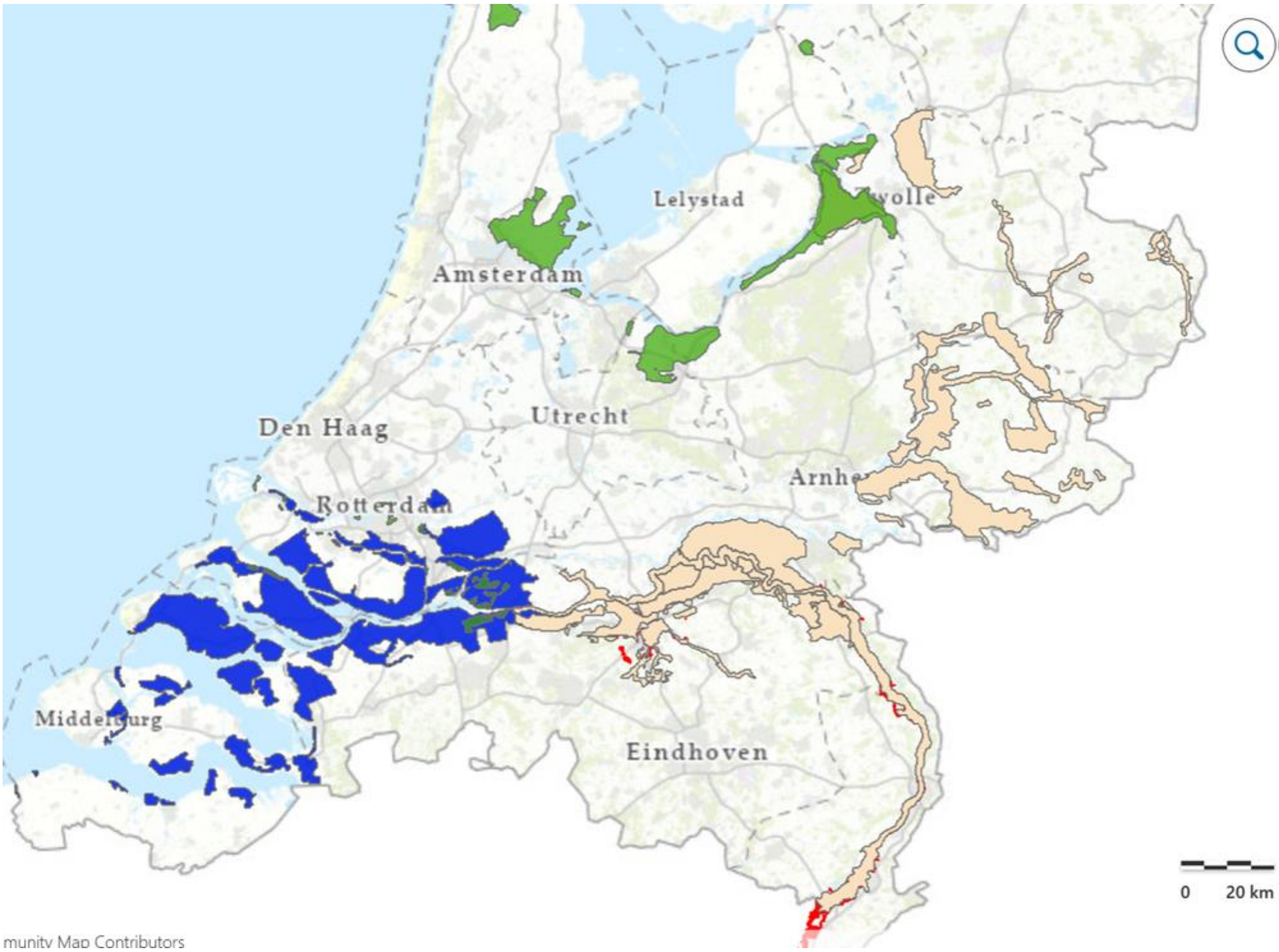



*Figure 1: Extent of the 1916 (green) and 1953 (blue) flood extent through storm surge and levee failures compared to (in orange) the extent of the 1926 floods (various causes including levee failures). Source: Rijkswaterstaat.*

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## METEOROLOGY AND HYDROLOGY

In the last week of November and first days of December 1925, several decimetres of snow fell in the Netherlands, and even more in the hilly areas along the middle reaches of the Rhine and Meuse. A very cold week followed, and then two more weeks with either mild frost or mild thaw, together with moderate precipitation as rain, or snow on higher grounds.

From the 20th of December 1925 to the 2nd of January 1926, Atlantic depressions took over with a spell of mild or even very mild weather, strong 5-7 Beaufort southwesterlies during a significant part of the time, and especially abundant precipitation. In the centre of the Netherlands, two months' worth of rain (over 135 mm) fell in just two weeks, and probably significantly more (in an absolute sense) on the higher grounds along the middle reaches of the Rhine and Meuse in Germany and the Belgian Ardennes region. The latter regions also experienced quite a sudden melt of a significant amount of accumulated snow, aided by extremely mild weather around the 30th of December, with temperatures of around 13°C in The Netherlands and even over 17°C in cities like Karlsruhe and Strasbourg. During the first week of January 1926, the extremely mild and wet weather abated, but what followed was a frosty spell which added to the suffering of the flood victims.

In terms of precipitation and given some extremely wet spells in recent decades, the 1926 event is not unique. However, the large contribution of snow melt made 1926 an exceptional flood. For the Rhine, the 1926 top discharge at the Dutch-German border (about 12600 $m^3/s$) is still the largest recorded so far, with an estimated return time close to 100 years. For the Meuse, the top discharge near Maastricht (of about 3000 $m^3/s$) had an estimated return time of about 50 years, a value which was only exceeded (by about 9%) by the 2021 summer flood, which however had a shorter duration.

## FAILURE OF FLOOD DEFENCE INFRASTRUCTURE ALONG THE MEUSE RIVER

First of all, it is important to realise that one century ago, the Dutch levees were not as high and as strong as they today, especially along the Meuse. Moreover, many river training works only took place in the decades after the 1926 flood. As a result, a discharge with moderate return times of 50-100 years was still able to wreak havoc at that time. Non-optimal governance also played a role in this, as levee governance at that time was characterised by a multitude of very small levee owners.

During the 1925-1926 flood event, the first severe floods occurred upstream, for example in the town of Seraing, which is part of the Walloon city of Liège.

As water levels raised during the last week of December 2025, the Dutch levee system along the Meuse began to give way as well. The Liège–Maastricht Canal was only just kept safe from failure. Major parts of Maastricht were inundated. Along the Common Flemish-Dutch Meuse, long known weak spots once again failed and 35 levee breaches redirected floodwaters across ancient channels and low-lying floodplains. In Central Limburg the levees proved to be systematically too low. Levee overtopping combined with levee breaches caused extensive regional flooding and damage to local infrastructure. North of this zone, the failures multiplied. In the Boxmeer-Oeffelt-Cuijk corridor southwest of the city of Nijmegen, numerous breaches undermined the railway system, resulting in collapsed viaducts, bridges and embankments. These failures revealed the structural limitations of the sand-based levees with only thin clay top layers.

## FAILURE OF FLOOD DEFENCE INFRASTRUCTURE ALONG THE RHINE AND OTHER RIVERS

The flood damage in upstream countries appeared to be smaller than the overall damage in the Netherlands, but along the German Rhine it was still significant, with 760 $km^2$ and over 28000 houses flooded.

In the Netherlands, several levee failures occurred along the IJssel and along other Rhine branches. As opposed to the Meuse levee breaches that were largely due to overflow and overtopping, geotechnical mechanisms often played a key role in the levee breaches along the IJssel and other Rhine branches. In fact, the 8 January 1926 levee failure near Zalk (between the towns of Zwolle and Kampen) was the first well-documented case within the Netherlands of what is probably an internal erosion levee failure.

## THE "BEERSE OVERLAAT" SPILLWAY

For centuries, the Beerse Overlaat spillway had served as a pressure valve for the Meuse system, allowing controlled spillover into Noord Brabant. After repeated calls from the Brabant population suffering from these planned inundations, the spillway was raised in 1922 to reduce its frequency of operation. During the 1926 floods, the water levels raised to an extent that the spillway functioned to its full extent again and inundated large parts of Noord-Brabant, either directly or because local streams and pumping stations were no longer able to discharge their water in the swollen Meuse. The 1926 flood clearly demonstrated that the modification of the Beerse Overlaat spillways had been insufficient. Sixteen years after the flood disaster, by 1942, it was permanently closed. Nowadays, with the Netherlands having become a densely populated land, such a spillway solution would have been a less suitable solution anyway.

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## FLOODING OF THE "LAND VAN MAAS EN WAAL" POLDER AREA

The most severe structural failure along the Meuse occurred on 31 December 1925 at Nederasselt, 10 km Southwest of the city of Nijmegen. For a river levee, the failure type was relatively unique, because the strong winds that day generated sufficiently high wind waves to cause the levee to fail from wave overtopping rather than from overflow or geotechnical failure. The levee which was already weakened by saturation of its sandy core collapsed around 7 o'clock in the morning. The resulting breach rapidly flooded an area of over 200 km$^2$ between the Maas and Waal River branches, called the Land van Maas en Waal (Figure 2). Despite improvised emergency works with canvas, gravel and rails, the breach widened quite rapidly to hundreds of meters. Only after military engineers cut openings in the downstream levees of Alphen and Dreumel water could be released back to the Meuse. The region remained inundated for months.

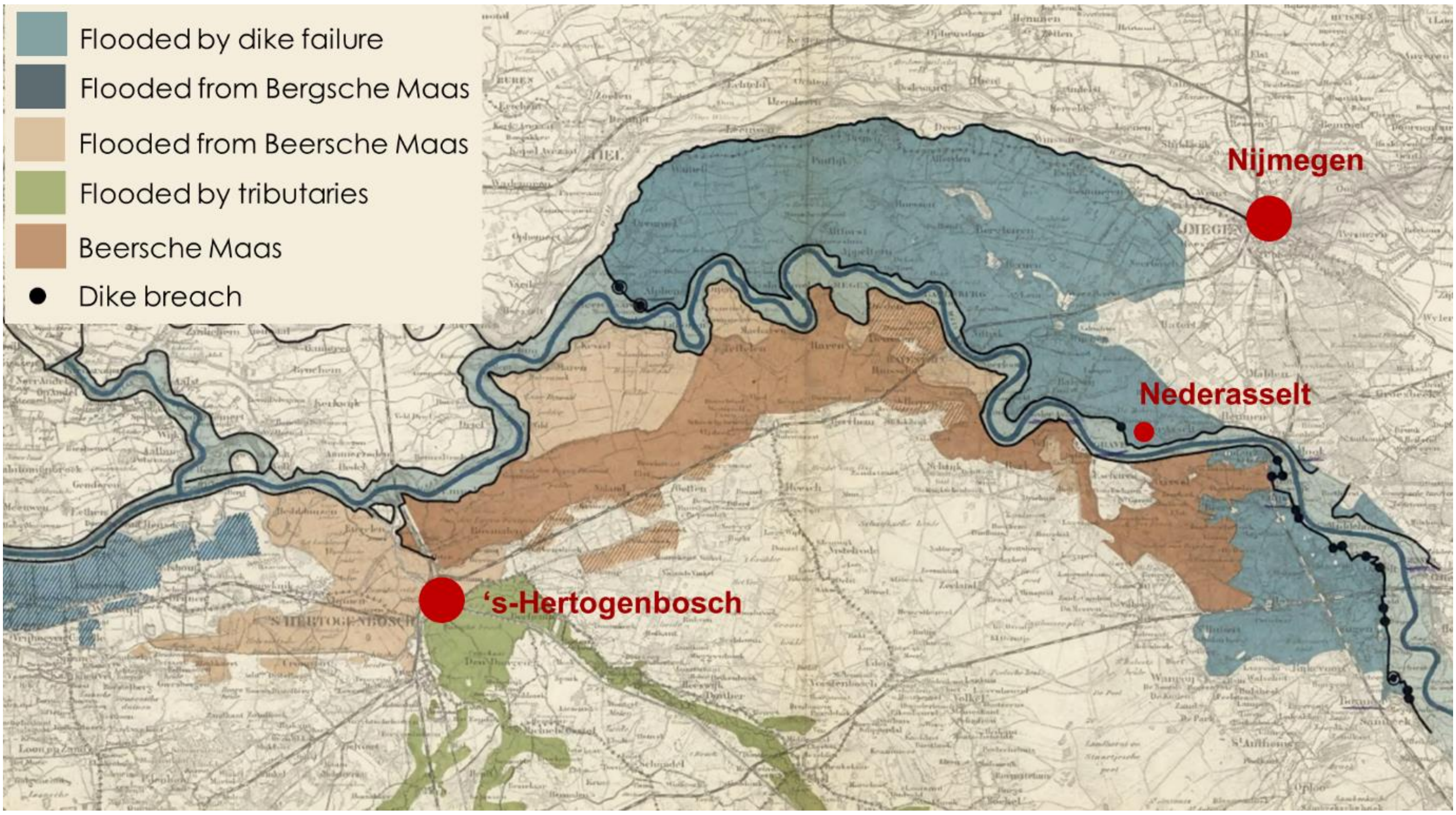


*Figure 2: Different types of inundation between Nijmegen and 's Hertogenbosch (Rijkswaterstaat).*

## SOCIETAL DISRUPTION

The human impact of the levee breach at Nederasselt was severe. Dozens of villages in the Land van Maas en Waal were submerged, in places more than two metres deep (see Figure 3). About 3,000 houses collapsed under the combined load of flood waters, wind and wave action and frost. Flooded polders became vast sheets of ice, worsening suffering and obstructing relief. Roads and railways were heavily damaged, leaving transport and aid dependent on military boats. Livestock drowned and winter fodder spoiled. When the water finally receded, residents faced the risk of disease. Homes and farmsteads had to be disinfected with creoline, lysol or lime, extending disruption long after the peak of the flood.

Many villages elsewhere in the provinces of Limburg, Brabant, Gelderland and Overijssel did not escape from the floods either, be it through levee breaches, through spillways allowing water into the hinterland, or simply due to locally accumulated water.

## FORGOTTEN VICTIMS OF A FORGOTTEN DISASTER?

The resigned government was hesitant to provide financial support given its status and given financial constraints. At first, it did not provide financial support to those affected, reasoning that river floods were not an unexpected disaster like the 1925 Borculo tornado but an intrinsic part of (the risk of) living along rivers. When nearly one year after the disaster the government decided to provide loans for recovery, people were often unable to meet the requirements.

Luckily, there were private fundraising campaigns on a national level, which collected substantial sums of money, albeit insufficient to cover all the damage. Unfortunately, the aid disproportionately supported wealthier homeowners with stronger houses allowing for easier repair, while poorer families received little to no assistance under the rationale that "those who own nothing have nothing to lose." This exclusion sparked growing public criticism. Local leaders and national advocates eventually mobilized additional support, which enabled the construction of 46 modest homes for the

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"forgotten families". The episode revealed how natural disasters can reinforce pre-existing social inequalities.

The above lack of government involvement may also help to explain why the 1926 was so easily forgotten, although it is quite likely that other factors have played a role as well. For example the fact that fast mass communication media like radios were not yet widely in use by 1926, and the fact that the more recent 1953 storm surge disaster with its over 1800 people death toll has had a much stronger imprint on public memory, even strengthened by its active commemoration efforts in the 70 years that followed. However, the significant number of commemoration activities that recently took place in the region may help to counter this trend and may help to restore the position of the 1926 flood disaster in public memory.

## RIVER REFORM

The 1926 flood disaster underscored the urgency of a fundamental redesign of the Meuse river system. Proposed measures included cutting major bends, deepening and widening the channel, excavating floodplains and canals, installing weirs, improving embankments, and permanently closing the Beerse Overlaat spillway. These plans shaped the large-scale canalization and river-engineering works of the 1930s, marking a decisive shift toward a more regulated and hydraulically controlled Meuse. Continuous investments since the 1930s have further improved flood safety and navigability

*Een boerderij in Maasbommel.*

*Figure 3: Flood victims in the village of Maasbommel, 25 km west of the city of Nijmegen (source:  Beeldbank Rijkswaterstaat)*

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## COMPARISON BETWEEN 1926 AND 2021

The 2021 Meuse flood exhibited a slightly higher discharge than the 1926 flood, with a steeper hydrograph. However, water levels remained markedly lower and the Meuse levee system resisted without breaches or major inundation. Because of the growth of the population and economy since 1926, a river flood causing an inundation with the depth and extent of the order of 1926 flood would nowadays cause €10 billion in losses, lead to around 100 fatalities and affect approximately 145,000 residents (D. Riedstra, RWS, pers. comm.).

## CONCLUSIONS

The 1926 Meuse flood was more than a hydrological extreme involving a large number of levee breaches: it was a systemic crisis that exposed weaknesses in levee design, emergency preparedness, and social safety nets. It revealed the impact of the deep social inequalities of that time, that also had its impact on disaster recovery. The disaster also triggered far reaching engineering reforms that were implemented in the decades that followed. Even today, the event remains a key reference point for understanding modern flood risks in the Meuse basin and even though the flood event itself may be forgotten by many, its lessons continue to resonate in contemporary flood management practice.

## ACKNOWLEDGEMENTS

Many thanks to our colleagues Durk Riedstra, Niels Tuinman and Immanuel Hemati for providing us with Figure 1 and 2, and to our colleagues Reindert Stellingwerff and Bram Semeijn for helpful suggestions regarding this text. Final thanks to the NCR centre of River Knowledge for allowing us to reuse parts of the text of a recent NCR-symposium abstract submitted to by the first author.

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*Further information, if needed can be obtained from: Roy M. Frings, Marcel Bottema marcel.bottema@rws.nl, Rijkswaterstaat, NL*