THE WORKING GROUP LEVEES AND FLOOD DEFENCES UNDER THE EUROPEAN CLUB OF ICOLD Issue 11 - December 2023

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LEVEES Working Group NEWSLETTER

Note from the Chairman

By Rémy Tourment

It has been too long since we published a WG newsletter (December 2022), and it's definitely not because there was nothing happening worth sharing. There have been two important ICOLD events in Europe in 2023: the ICOLD annual meeting in Gothenburg (Sweden) in June and the EurCOLD symposium in Interlaken (Switzerland). Both had interesting levee related information during meetings, workshops, and presentations. There have also been many flood events in different European countries, as well as in the rest of the world. All of them worth analysing for lessons learned.

Unfortunately, it seems that many of us are so busy it is hard to find time to share information across the levee community. That's why there is this unusual delay between two newsletter issues. I hope we can publish our next issue before next summer, so please send us your proposals for articles. Thanks to all contributors for this issue!

Content of this issue

In this issue we have two contributions presenting research and testing related to internal erosion (a major concern for all levees), one about a national committee starting to work with levees and two case focused articles, one about a flood and one about the risk of river bed capture. All are very interesting. I hope you enjoy them as much as I did! And don't forget to share information yourself (am I insisting too much?).

Chengdu 2025 Congress Questions

During the ICOLD General Assembly in the Gothenburg ICOLD 2023 meeting, voting for the questions for the next ICOLD Congress in 2025 in Chengdu (China) was held. ICOLD Circular 2014 (https://www.icold-cigb.org/userfiles/files/CIRCULAR/CL2014.pdf) details all relevant information. The wording of the four questions, including sub-questions is below. As you can see, levees have a large place and great visibility. This is a great success for ICOLD TC LE and EurCOLD LFD WG. We will be able to share levee related knowledge within all ICOLD, not only within our TC and WG!

You can prepare to submit levees related papers yourselves, which will have to be proposed via your own national Committee: for those of you who are not familiar with ICOLD Congresses, the process is not the same as a typical conference. Papers are not submitted by authors directly to ICOLD, but through national committees. Each national committee has its own selection process before sending them to ICOLD where they are then automatically accepted, as long as the national committee does not exceeds its quota (see https://www.icold-cigb.org/userfiles/files/CIRCULAR/CL2014%20ANNEX%20B.pdf). So, get in touch with your own national committee to know the details for submitting an abstract / a paper.

Official wording and sub-questions and some personal comments

Question 108 – Dams and reservoirs for climate change adaptation

1. Dams for Pumped Storage: specific features, design, examples of implementation
2. Off-river dams for water storage and flood protection
3. Offshore dams and tidal power plant
4. Dams for recharge of aquifers and other new concepts
5. Floating solar on dam reservoirs – opportunities and risks

This question does not explicitly include levees, but nonetheess levees are definitely to consider when dealing with climate change in terms of river floods and coastal inundations. I think that anyway in sub-question 2 it is possible to include levees. Maybe also sub-question 5 as I know about some projects of having solar panels on levees or close to them, although not floating ones.

Question 109 – Dams and levees fit for the future

1. Management of an aging portfolio of dams in terms of operation, maintenance, and rehabilitation, including risk-based approaches
2. Safety during construction and rehabilitation
3. Special case for small dams and levees
4. Impact of contracting practices on dam safety (e.g., private sector involvement, EPC contracts)
5. Increasingly difficult sites and their new challenges
6. Need for global capacity building

Levees are explicitly in the title of the question, great success there, although it is a little surprising that then there is a Q1.3 with “special case of small dams and levees”.

Question 110 – Safety of dams and levees facing extreme hydrological events

1. Assessment of extreme events (e.g., flood, droughts, typhoons/hurricanes, glacial lake outburst floods) in the context of climate change, accounting for uncertainty
2. Assessment for the safety of structures for extreme floods; management options (e.g., increasing dam height, spillway capacity, reservoir operation)
3. Flood forecasting, hydraulic management of multiple projects within river systems
4. Reassessment of the flood data and mitigation e.g., fuse devices, overflow resistance, controlled breach formation, warning and evacuation, crisis and emergency management

Levees are also explicitly in the title of the question, and they are not singled out from the dams in the text of the sub-questions, so this is an even bigger success

Question 111 – Earthquake performance and safety of dams

1. Static, seismic and post-seismic monitoring of dams
2. Feedback from earthquake failures, including tailings dams and levees
3. Importance of multiple features of earthquake hazard (e.g., ground shaking, surface fault movements, mass movements)
4. Seismic design and performance criteria for dam structure, reservoir rim and impacted area
5. Earthquake safety evaluation of all types of dams and safety-critical elements (e.g., spillway, low-level outlets)

Levees are not mentioned in this question title, but they are in sub question 2. There may not be many case studies to present for this question, although the few known cases probably provide very interesting learning. For instance, I had a discussion in Gothenburg with Martin Weyland (chair of TC on “seismic aspects of dams design”) and he told me that one of the most catastrophic failures after an earthquake followed by a flood was on a levee

ICOLD 2024 in New Delhi

In the meantime, before the Chengdu ICOLD Congress, we have another ICOLD event, the ICOLD 2024 annual meeting in New Delhi (India). Dates have been rescheduled (again, after the unfortunate postponement due to COVID!), and the meeting will take place on 29th September – 3rd October. I hope to meet many of you there. There will definitely be some levee related content then, under the umbrella of ICOLD TC LE.

We are always looking for information from YOU to share in the newsletter and on our web site! We need diversity in terms of contributing countries, and are eager to learn from every member country. We welcome contributions from any countries, even non-European ones.

A 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 web site team: lfd-eurcold@irstea.fr

Summary of PhD research project on time-dependent development of backward erosion piping and effects on levee reliability

By Pol Joost

Backward Erosion Piping (BEP) is a type of internal erosion in the foundation which poses a significant threat to dams and levees. Existing BEP models such as the one by Sellmeijer predict a critical head difference but neglect the time required to develop from initiation to hydraulic shortcut, so actually assuming instantaneous erosion or an infinite load duration. Piping requires time to develop as the sand needs to be transported through small pipes in the sandy foundation. When the high-water duration is shorter than the time required for erosion, or when the process is stopped by timely flood fighting interventions, failure is prevented. This research project aimed to quantify the time-dependent behavior and how that translates into effects on levee reliability. This is achieved by a combination of experiments on different scales, numerical modeling, and probabilistic modeling.

Experiments

Small-scale experiments (0.35 m seepage length) with local measurements of pipe flow conditions such as pressure, flow velocity and depth, were used to study the piping erosion process and how factors like grain size and overloading affect the rate of pipe progression. Progression rates in the small-scale tests were in the order of 0.1-1 m/hour. The results show that the progression rate under different degrees of overloading can be well explained by the sediment transport and flow conditions (bed shear stress) in the pipe. This provides a better explanation than the previous hypothesis that the progression rate is related to the seepage velocity.
A large-scale experiment provided a validation test on a realistic levee (7.2 m seepage length) and a fine sandy aquifer, clay cover and concentrated outflow. The measured pipe progression rate of 0.3 m/hour is in line with a regression model derived from rates in previous piping experiments. To investigate whether the resistance

against BEP can also recover over time, the levee which had a fully developed pipe but just did not fail, was re-loaded nine months after the experiment. This unique strength recovery experiment showed that the levee strength had partially recovered: the erosion process started again from the exit point, albeit with 20% lower critical head and 140% higher progression rate than in the first experiment. Although strength recovery was observed in this test, quantitative predictions on the degree and rate of recovery are not yet possible.

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Modeling

To be able to predict time-dependent pipe development for field conditions, a numerical model was developed that simulates time-dependent backward erosion. It is an extension of the finite element equilibrium model dgFlow, extended with a sediment balance and a sediment transport equation for laminar flow. This model was calibrated on part of the small-scale and large-scale experiments. A major challenge of the 3D numerical modeling of BEP are scale effects in the computed critical head. At field scales, the simulated critical head in case of 3D concentrated outflows seems to be too low. However, sufficiently detailed large-scale experiments for a detailed validation of 3D scale effects are lacking. Finally, a series of model simulations with varying levee properties and hydraulic loads allowed to derive a simplified regression model of the pipe progression rate. Such a simplified model can be efficiently implemented in reliability analyses.

Reliability analysis

The next step was to quantify how these time-dependent processes affect the failure probability of levees. Therefore, a simplified time-dependent piping failure model was developed including effects of a varying water level, blanket uplift, heave, backward erosion and flood fighting interventions. This model is implemented in a time-variant reliability analysis considering cumulative pipe growth over multiple flood events and strength recovery between flood events. Results of the analysis confirm that time-dependent pipe growth has a significant positive impact on the reliability in water systems with a short flood duration (storm-surge). The coastal cases with short duration show large reductions in failure probability, ranging from a factor 10 to more than 10^6 for large seepage lengths and fine sand. Reductions are smaller for the river cases with longer flood duration but can still be considerable in particular cases (factor 100 in failure probability).

For river cases, the effectiveness of flood fighting is important in reducing the failure probability, as the longer river floods provide much more time for successful measures than the short coastal surges. These results and subsequent case-studies in The Netherlands indicate that a considerable part of the Dutch levees can benefit from including time-dependent pipe development in the BEP failure model, by reducing or postponing reinforcements for piping.

This holds particularly for storm-dominated areas, but to a lesser extent also for areas governed by river discharge.

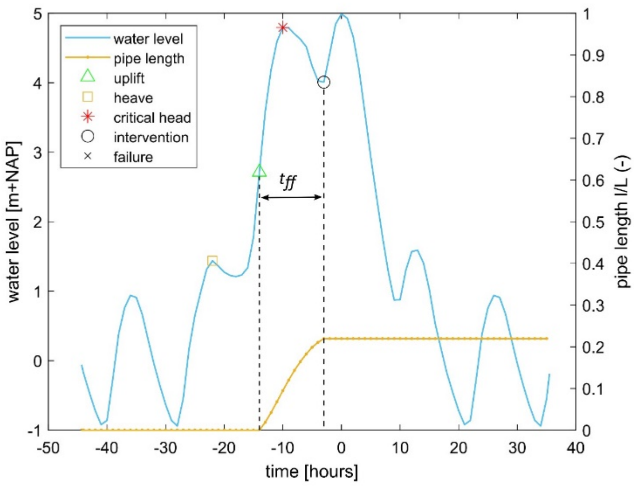

FIGURE 1 Example of pipe length development (yellow line) and other relevant events over time for a given water level timeseries during a coastal storm surge. In this case failure does not occur as l/L<1.

Acknowledgement

This research was funded by NWO Domain Applied and Engineering Sciences with project number P15–21D.

Links

The dissertation can be found here: https://doi.org/10.4233/uuid:eb5ed3b2-4210-489e-b329-59722a0c50a0

A simple explanation in a storyline can be found here: https://storymaps.arcgis.com/stories/046dc8ef9a144b798e55e4b97f6fe0e9

Website of the Dutch Allrisk research project: https://kbase.ncr-web.org/all-risk/

Towards standardization of the Hole Erosion Test

By Sylvie Nicaise, INRAE (France)

Although erosion resistance characterization tests are commonly used to study and diagnose hydraulic structures, very few are standardized. There are mainly ASTM standards for tests qualifying the dispersive behaviour of clays, and ASTM D5852 for the JET erosion test qualifying resistance to impact jet erosion (external erosion).

For other tests, procedures are described in scientific publications, and are not widely disseminated in the engineering community for operational purposes. Recently, the French Ministry of Ecological Transition and Territorial Cohesion decided to spread and emphasize new practises within the levees' technical community. The Hole Erosion Test (HET), which is relevant to evaluate resistance to concentrated leakage erosion, and therefore, adapted to internal erosion evaluation, is one of the most admitted practise in the French community. As an answer to the French Ministry request, the HET was chosen for standardization, which is the best way to publicise and spread this test.

Standardized tests set the framework for carrying out good practises: they specify the scope of validity of the test, the equipment, the operating procedure and the methods for data analysis.

A standard ensures reproducibility of the test, establishes a common terminology and makes possible comparison between different laboratories.

In France, geotechnical testing standardization is overseen by AFNOR (French national organisation for standardization), which delegates the task of drawing up and revising French standards to a number of committees. The French Earthworks committee is one of those, offering around 23 dedicated standards for Earthworks. Appointed members of this committee participate in European's standardization Technical Committee TC 396 Earthworks within the CEN (European Committee for standardization).

Within this French committee, the draft standard for the Hole Erosion Test was written by experts from research institutes, consulting companies and representatives of various interests (a structure owner, laboratories, earthwork companies): INRAE*, Université Gustave Eiffel, geophyConsult, Sol Solution, Nantes Université, Cerema, Bouygues Travaux Publics and Société du Canal Seine Nord Europe.

This draft standard was submitted for approval to the French Earthworks committee in September 2023 (commission inquiry step). Its current status is now an experimental one entitled PR XP P 94-065 "Hole Erosion Test - Principle and laboratory test method for the determination of concentrated leak erosion resistance".

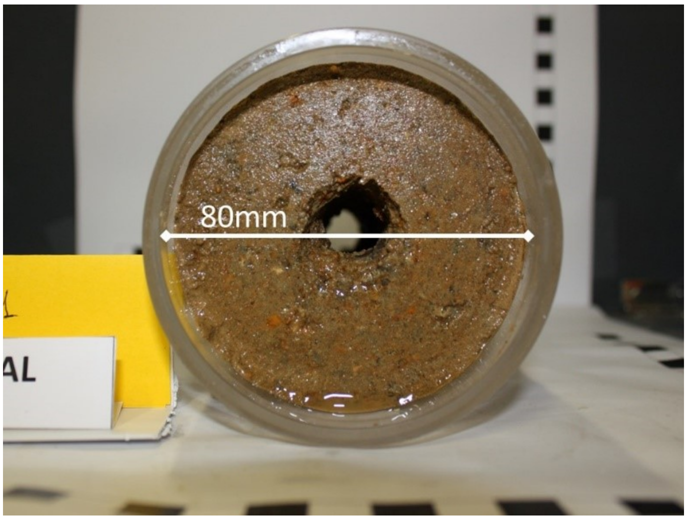

Figure 1: sample after a HET test, downstream side

As a first step, the status of experimental standard at French level meets the need for standardization. After three years, the text will be reviewed, and it will be decided whether to maintain it as an experimental standard, or to upgrade it to a NF standard, or even a European standard within TC 396. In both cases, a public inquiry step will precede publication in this new state, and all stakeholders, companies or laboratories, even those not involved in standardization work, will be able to respond.

Currently, the standard text describes through a 35 pages document, the apparatus to be used, the operating procedure; four interpretation methods are proposed for calculating hole erosion resistance parameters: critical hydraulic shear stress, erosion coefficient, erosion rate index and erosion resistance index. The text is faithful to international scientific publications on hole erosion testing, including: Benahmed and Bonelli [1], 2012; Haghighi et al., 2013 [2]; Marot et al., 2011 [3]; Wan and Fell, 2004 [4].

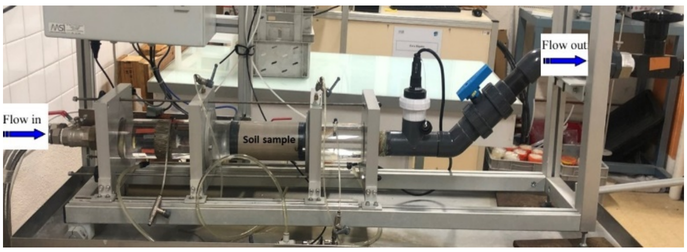

Figure 2: photograph of the INRAE's hole erosion test apparatus (HET)

* National Research Institute for Agriculture, Food and the Environment

REFERENCES

[1] Benahmed N., Bonelli S. (2012) Investigating concentrated leak erosion behaviour of cohesive soils by performing Hole Erosion Tests, European Journal of Environmental and Civil Engineering, Vol 16, N°1, pp. 43-58

[2] Haghighi I, Chevalier C., Duc M., Guédon S., Reiffsteck P. (2013). Improvement of Hole Erosion Test and Results on Reference Soils, Journal of Geotechnical and Geoenvironmental Engineering, 139, 330–339

[3] Marot D., Regazzoni P.L., Wahl T. (2011). Energy based method for providing soil surface erodibility rankings. Journal of Geotechnical and Geoenvironmental Engineering (ASCE), Vol. 137 N°12, pp. 1290 – 1293. Doi: 10.1061(ASCE)GT.1943-5606.0000538.

[4] Wan, C.F., & Fell, R. (2004). Laboratory tests on the rate of piping erosion of soils in embankment dams. Geotechnical Testing Journal, 27, 295-303, https://doi.org/10.1520/GTJ11903

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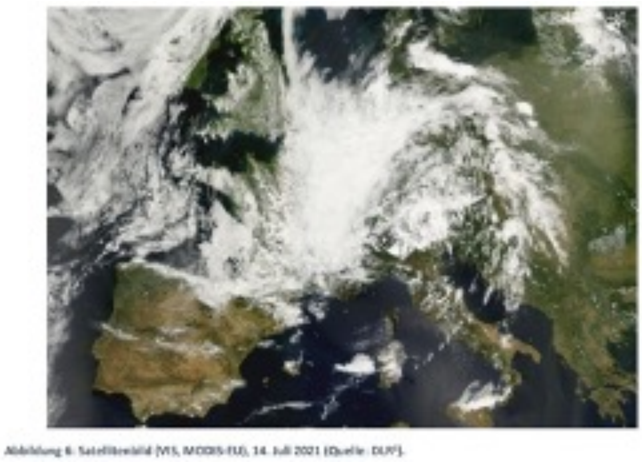
The Ahrtal Flood in 2021

By R. Haselsteiner, B. Ersoy, L. Werner

M&W Water, Koblenz, Germany

In 2021 a devasting flood struck Europe. During 13th and 15th July 2021 a low-pressure front named "Bernd" (picture 1) moved relatively slowly across France, via Belgium through Germany to East Europe. In France, Belgium and Germany major floods resulted from the occurring heavy precipitation. The floods developed fast, thus, those floods could be defined as "flash floods" (Dallmeier, 2017) for which the development period is less than 24 hours. In Germany 188 fatalities are documented of which 135 were in the county of Ahrweiler where the river Ahr is located. The financial damage announced by the insurer Münchner Rück reached 46 billion Euro in total and, exclusively, 33 billion Euro in Germany and was, by these numbers, the second biggest natural disaster ever regarding insurance damage (see also picture 2).



Picture 1: Low-pressure front „Bernd“ over Europe (Source: CEDIM, 2021)

Picture 2: Flood damage in Erftstadt Blessem (Source: https://rp-online.de/)

In Belgium and Western Germany precipitation intensities reached values of 271,5 mm/48 h and 154 mm/24 h to 207 mm/9 h, respectively. Within the Rhine catchment area related to Rhineland-Palatia the medium rivers such as Kyll and Sauer, tributaries to the Mosel reiver, showed flood incidents with a recurrence period T > 100 a whilst the bigger rivers such as Mosel and Rhine “only” revealed floods with periods of T ≈ 10 a and T ≈ 5 a, respectively.

One of the driving causes for the local extreme rainfalls could be the “weak” northern polar jet stream/vortex (figure 1) which is a result of climate change effects. The uneven temperature distribution above the northern polar area does not provide enough atmospheric pressure difference so that strong winds do not concentrate on the west east corridor but move to the south unpredictably. Thus, the event “Bernd” was driven south and stayed within the referred flood areas for a critical period.

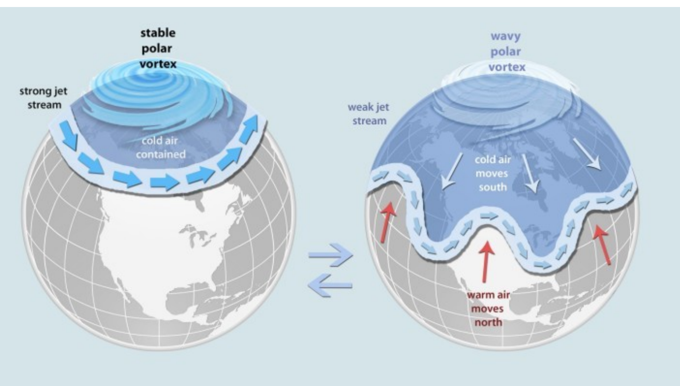


Figure 1: Polar vortex system
(Source: https://www.vindteknikk.com/)

The Ahr is a river in Rhineland-Palatia and a contributary to the Rhine River. It is located in the mountain range Eifel, left side of the Rhine. It shows a catchment area of approx. 900 km^2 and a mean flow of MQ = 7,5 m^3/s. The mean flood discharge is $MHQ_{1946-2007}$ = 91,7 m^3/s. Along the river course the Ahr collects discharge at a relatively high plateau before the river crosses the Ahr mountains where the river shows a meandering course between relatively high and steep rock slopes. In the year 2016 a flood occurred with a discharge of HQ = 236 m^3/s which corresponds more a less to a 100-year flood.

Flow gauges during the 14th July at the Ahr began to record rising water levels in the late afternoon. Within a few hours most of the flow gauges failed because the flows exceeded the applied measurement instrumentation. Later flood reconstruction modelling revealed that a peak flow at selected flow gauges should have reached a flow of HQ_{Peak} = 1,000 to 1,200 m^3/s which is four to five times higher than the former HQ_{100} value of 2016, also much higher than estimated briefly after flood (figure 2). Officially, the peak discharge 2023 is declared to be $HQ_{Peak,2023}$ = 854 m^3/s at the flow gauge Ahrweiler, which does not correspond to scientific results (Roggenkamp & Herget, 2022).

In spite of varying information about the flow data the recurrence period of the flow exceeded T = 100 a by far and according to different sources should have reached a value of T > 1,000 to 10,000 a. Those discharges resulted in water depths of locally over 11 m. Especially, in the Ahr mountains where narrow valleys dominate the flow local infrastructure such as roads, bridges, railways were soon flooded so that the people were trapped. Many moved to the first or second floor in good remembrance of the flood 2016 where the flood hardly reached the basement. The flood tables overtopped also the roof of two-storey houses and buildings where the people entrechend themselves waiting for help and evacuation measures, and many people perished this way.

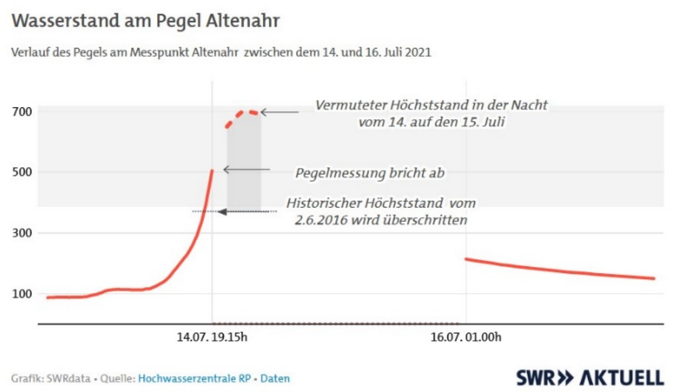


Figure 2: Preliminary discharge hydrograph after flood incident shows missing measurement data, flow gauge Ahrweiler (Source: https://www.swr.de)

Within six hours between approx. 6 to 12 pm the flow increased from Q = 100 m^3/s to over 1,000 m^3/s. Within a very few hours the affected settlements were completely cut-off from escape roads and were isolated/trapped in the narrow valley not able to go anywhere. The mobile communication network failed. Attempts of the flood responsible institutions and persons to perform measures such as flood warnings and evacuation were effectless or inefficient. The analysis and evaluation of the flood event, of the activities or misbehavior of responsible persons and institutions is continuing also in form of legal prosecution.

The impact of the flood was evaluated after the flood, e. g., by the Copernicus Emergency Management Service. In figure 3 the Ahr river loop in the vicinity of Altenburg and Altenahr is shown including documented damage spots (left). The picture on the right provides a comparison between the situation before and after the flood for the village Altenahr. The flood did exceed the existing riverbed and embraced the settlement area so that the people were trapped between two flood streams.

The recurrence period of floods exceeded the design criteria for flood protection and retention works by far. The future concepts for the Ahrtal must not focus on local protection measures such as the construction of walls, levees or flood retentions dams in the upstream catchment area. Especially for the Ahrtal region with its very special hydrological catchment situation, effective measures for flood warning, precaution and prevention have to be developed. The authors hold the opinion that evacuation plans with a very short reaction period must be implemented so that the people are able to escape the hazardous area within only a few hours and less.

The Ahrtal flood 2023 was not unique. In 1804 a historical flood was documented which should show similar discharges of more the 1,000 m^3/s (Roggenkamp & Herget, 2022). Thus, a second 1,000 to 10,000 year flood occurred within only a 200 years period which again challenges the correctness of flood statistics based on measurement data with relatively short measurement periods and special catchment characteristics such as for the river Ahr. Also, the effect of ongoing climate change effects is not represented by measurements of the past. Here, a correction needs to be implemented which also implies a resilient prognosis for the future development of flood events.

Figure 3: Documented flood damages at the Ahr within vicinity of the villages Altenburg and Altenahr

The flood caused harm on houses and infrastructure for which the reconstruction will take extraordinary investments and time (pictures 3 and 4). The discharge capacity of the flow section/riverbed was insufficient, erosion of the riverbed and banks as well as adjacent slopes caused slope failures, etc. Houses were flooded and flow velocity and forces resulted in many houses collapsing. The reconstruction of the roads, bridges and railways will take years and decades.

Picture 3: Damages on houses and infrastructure close to the villages Altenahr (Source: www.swr.de)

Picture 4: Erosion and destruction of houses in the village Dernau (Source: www.deutschlandfunkkultur.de)

Natural hazards such as floods are not the primary cause for fatalities or damage. The primary cause is the infrastructural and urban developments which increases the vulnerability of affected areas, critically. This fact is documented by flood marks at a house in the village Dernau where the water level reached the first floor during the flood event 2021 (picture 5).

Picture 5: Flood marks at a house in the village Dernau (Source: Mr. Matthias Habel, see also Roggenkamp, 2021)

The house was already existing in 1804 but the flood level was much lower in spite of similar discharges. In the year 2016 the flood did only exceed the pavement elevation in front of the house and affected the basement which also led to the fact that many inhabitants evaluated the upcoming flood risk in 2023 critically wrong.

References

Dallmeier, A. (2017): Die Naturgefahr Sturzflut - Eine Analyse des Phänomens und Dokumentation der Ereignisse der Jahre 2012 und 2013 in der URBAS-Datenbank. Wissenschaftliche Arbeit zur Erlangung des Grades B.Sc. an der Fakultät für Bau, Geo und Umwelt der Technischen Universität München, München.

CEDIM (2021): Hochwasser Mitteleuropa, Juli 2021 (Deutschland), 21. Juli 2021 – Bericht Nr. 1 „Nordrhein-Westfalen & Rheinland-Pfalz"Forensic Disaster Analysis (FDA) Group, DOI:10.5445/IR/1000135730.

Roggenkamp, T. (2021): Hochwasser im Ahrtal- Histroische Betrachtung und die Flut 2021. BUND-Symposium: Ökologisch nachsteuern nach der Flut, 13.10.2021, Remagen.

Roggenkamp, T.; Herget, J. (2022): Hochwasser der Ahr im Juli 2021 – Abflusseinschätzung und Einordnung. Hydrologische Notizen, Projektberichte – Workshops – Konferenzen, HW 66, Heft 1, 2022, S. 40-49.

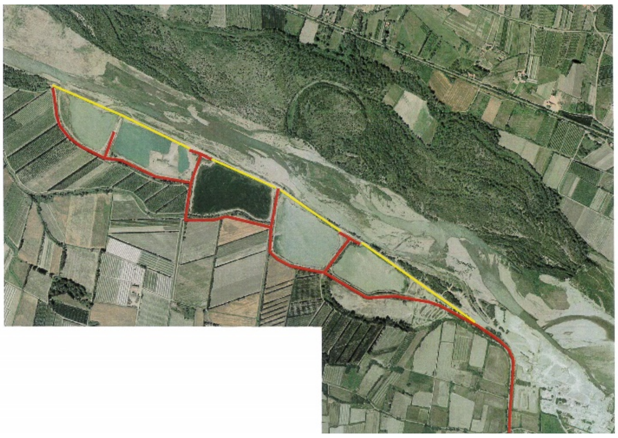
On the Durance, SMAVD takes over the levees to avoid the capture of a gravel pit lake

By Bertrand Jacopin, Florian Bérail et Laurèns Deuffic (SMAVD)

On the banks of the Durance River in Mallemort, a former gravel pit is protected by a series of groyneswhich may cause a risk of capture in case of a breach in the levee system. The SMAVD has launched construction works to lower this risk.

SMAVD (Durance Valley Development Union) is responsible for managing the Durance River over a stretch of approximately 250 km of river. It groups different local authorities: all the intercommunalities bordering the Durance, the Departments of Hautes Alpes, Alpes de Haute Provence, Bouches du Rhône and Vaucluse but also the Provence Alpes Côte d'Azur Region. Its missions cover the areas of flood prevention, biodiversity restoration , management of the fluvial public domain and also water resources. With several decades of internal expertise, SMAVD also carries out numerous studies and works on behalf of its members through its own engineering services. To find out more: https://www.smavd.org/

In the town of Mallemort (France), on the left bank of the Durance facing the Luberon (https://en.wikipedia.org/wiki/Luberon), there is a former gravel pit creating risks. Operated after 1994, it is located behind a several kilometers long levee and five protective groynes. These construction works are included in a vast program. Past extractions were carried out, close to the river bed, in deep pits separated from each other by transverse dikes (groynes) and separated from the river by a longitudinal levee (figure 1 – year 1993). The major floods of 1994 destroyed the longitudinal dike between each groyne and led to the capture of extraction waste by the watercourse (figure 2 - year 1998)



Environmental evolution between 1993 (left) and 1998 (right)

The extraction activity then moved into the flood plain to form today a 21 000 m^2 and 10 meters depth lake. The levee, being several meters high without a reinforced section to resist spill, causes once more a major morphological risk. In the event of uncontrolled overflow, a breach of the levee would be inevitable and would lead to drive the main stream to the pit, which in turn would trap all the sediment flow for decades. The consequences on the functioning of the river would obviously be catastrophic with regressive erosions upstream and progressive erosions downstream, a sinking of the river bed and consequently of the groundwater table. A 20 km section of the river would be impacted leading to ecological and economical sections.

Environment Setup 2021

The protective works

The "Digue des Carriers" is made up of a main levee 3,200 meters long, parallel to the axis of the minor bed of the Durance River and an upstream levee approximately perpendicular to the axis of the river. These structures are supplemented by 5 protective groynes, 50 to 200 meters long, anchored perpendicularly into the dike and which separate the former extraction pits.

Improved level of security

The construction work, which began in the summer of 2023, mainly consists of reducing the hydraulic impacts of the groynes that have, until now, caused a significant increase of water level during floods: retreat of the heads of the groynes, lowering and strengthening of their linear parts. These operations make it possible to guarantee a comfortable margin before overflow on the main levee which is the subject of fairly limited work like slope adaptation of the embankments and installation of filtration devices. The risk of breach will thus be controlled up to the 100-year flood and very low up to the exceptional flood (about 500-1000 year). A safety spillway is installed upstream of the protection line, in an area where the elevation between the upstream and the downstream lands is particularly low. The overall protection level (preventing water entry into the protected zone) will be equivalent to the 5000 m^3/s centennial flood. Beyond that, the system has been designed to avoid a major structural failure until the exceptional flood of 6500 m^3/s exceptional flood.

Works to set back and lower the groynes of the Carriers dyke

Deadlines and studies

Four years of technical and environmental studies were necessary to develop and obtain the legal authorizations for the project. Located in a Natura 2000 classified area, the project mainly required an impact study on the potential damages to biodiversity. The design of the works as well as the monitoring of its execution were carried out by the engineering services of the SMAVD: hydraulic modelling, sizing of protections, drawing up of plans, conduct of calls for tenders and supervision of the construction work.

Co-financing

This refurbishment of the Carriers Levee and the associated hydromorphological restorations represent a work budget of 2.5 million Euros financed with funds from the department of Bouches du Rhône, the Rhône-Mediterranean Water Agency, the Provence Alpes Côte d'Azur Region, Electricité De France and the Aix-Marseille-Provence Metropolis, to which the municipality of Mallemort is affiliated.

Bridging Gaps in Flood Defense: Canada's Journey Towards Enhanced Dike Safety

By Vincent Cormier, WSP Canada Inc.

Canada's extensive river system, divided into five continental watersheds, drains into the Pacific and Atlantic Oceans, the Arctic, Hudson Bay, and the Gulf of Mexico (Mississippi River drains part of Southern Alberta and Saskatchewan). The country is home to some of the world's largest rivers, including the Mackenzie River, which boasts a watershed area of approximately 1.79 million square kilometers, nearly three times the size of France. These rivers were instrumental in Canada's political and economic development during the European colonization period, facilitating the transport of furs and trade goods. As a result, major population centers emerged along these rivers, evolving into key urban areas such as Metro Vancouver by the Fraser River, Calgary at the confluence of the Bow and Elbow Rivers, Winnipeg along the Red River, Montreal on the Saint-Lawrence River, and Toronto near Lake Ontario. Despite Canada's vast land area of 9.985 million square kilometers, making it the second-largest country globally, about 90% of its population resides within a narrow 200 km-wide corridor

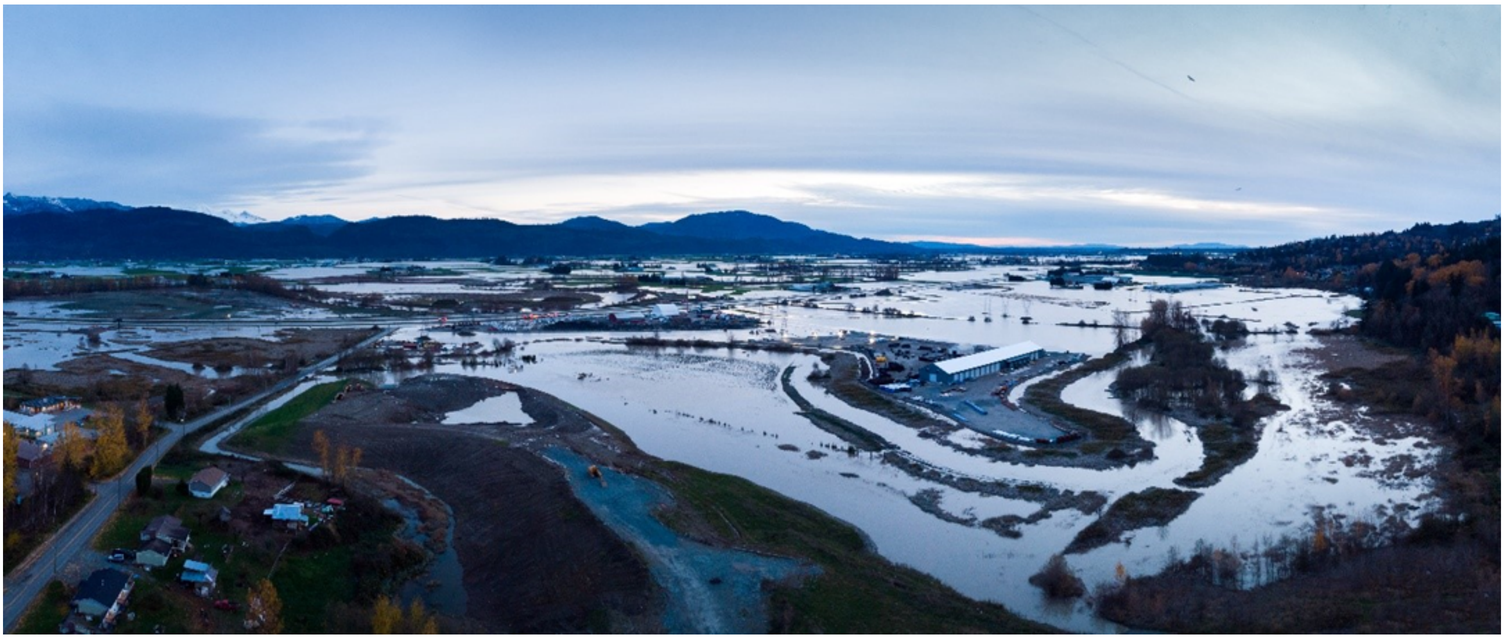


Figure 2: 2021 Flood in the City of Abbotsford, British Columbia (Photo by Adam Melnyk)

While Canada's dam safety management system is robust and internationally recognized, supported by provincial regulations, legislations, and national guidelines, a notable gap exists in specific national guidelines or guidance documentation for dikes. Recognizing the importance of effective dike management for public safety, the Canadian Dam Association (CDA - ICOLD National Committee for Canada), a group of owners, operators, regulators, consultants, suppliers and academics interested in dams and reservoirs, established a working group in 2022 to conduct a comprehensive landscape review of the current Canadian dike management practices. This initiative aims to summarize current Canadian practices in dike and levee management, identifying technical gaps and issues. The working group plans to complete their landscape review by the second quarter of 2024 and will subsequently determine the best course of action to enhance the Canadian dikes and levees safety management system. One potential outcome may involve developing comprehensive, overarching dike and levee safety reference materials, such as technical bulletins, workshops, and guidelines.

Initial findings from the landscape review indicate a considerable variation in the sophistication of dike management practices among the provinces. Most provinces lack comprehensive inventories of their dike portfolios, with the notable exception of British Columbia, which maintains a good inventory of regulated dikes. Other provinces, like Quebec, are on the cusp of initiating their provincial inventories, while some, such as Alberta, lack a detailed inventory of their dikes. Regarding technical guidance, only British Columbia, Nova Scotia, and New Brunswick provide provincial guidelines. This lack of uniform guidance has led some dike owners, including the city of Calgary, to develop their own guidelines for managing their dike portfolios. An example of a dike in the City of Calgary designed according to their guidelines is shown in Figure 2. A review of available provincial and municipal documentation reveals significant variance in design criteria, analyses and assessments. This inconsistency underscores the potential need for overarching national guidance to standardize dike management practices across Canada.

Figure 3: Flood wall in the City of Calgary. (Photo by City of Calgary)

Although the CDA's focus is on Canadian practices, the CDA working group is also interested in exchanging experiences with the International Commission on Large Dams (ICOLD) Technical Committee on Levees and in garnering best practices and technical guidance from the Committee. This international collaboration could be instrumental in helping the Canadian Dam Association address the gaps and challenges within the Canadian Dike management system.

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