EAU DANS LA VILLE

WORKING GROUP
SELF-MONITORING OF SYSTEMS
SANITATION

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EAU & TERRITOIRES

METROLOGY IN WASTEWATER SYSTEMS

INSTRUMENTATION OF STORM OVERFLOWS: KEY ELEMENTS

Les déversoirs d’orage

« DO »

Storm overflows

- Storm overflows (SOs) **are water overflow structures** in a collection system that may be partially or totally combined (mixing wastewater and rainwater). In the event of heavy rain, they allow part of the wastewater flowing through the collection system to be discharged directly into the receiving environment.

- They were **initially designed with a** **<u>hydraulic objective to "discharge" in</u>** order to limit the flow retained in the combined sewer system during major rainfall events; this protects it functionally and limits the quantity of water discharged or directed downstream.

- However, with the growing awareness of the pollution carried by effluents (wastewater and rainwater), depending on their position and number, storm overflows can also have the **<u>objective of preserving the quality of the environment</u>** by limiting the frequency and volume of discharges and the flow of pollution into the natural environment.

A wide range of DOs!

The DOs built into sewage networks have **a wide variety of shapes and behaviours.**

If we use a geometric classification, we can distinguish between weirs:

▶ with frontal thresholds (thin or thick; high or low crest, inclined, multiple . . .)

▶ with side thresholds (high or low crest)

▶ with neither front nor side sills

There are other types of category, based on the way they function.




DOs, facilities subject to regulatory self-monitoring by local authorities

French regulations require local authorities to monitor discharges at the DOs that have the greatest impact.

Depending on the gross load of organic pollution collected in dry weather at a weir, local authorities must either estimate or measure this flow.

> FOR THE RECORD - **Definition of an estimate**: an estimate is made using a method that is not standardised and that has not been the subject of a specific study to qualify the data produced.
> Contrary to measurement.
>
> *See Technical Comment AM 21/07/2015 - Part 2 Self-monitoring - Sheet 2*

Estimation/Measurement at DO
Focus on the Order of 21 July 2015

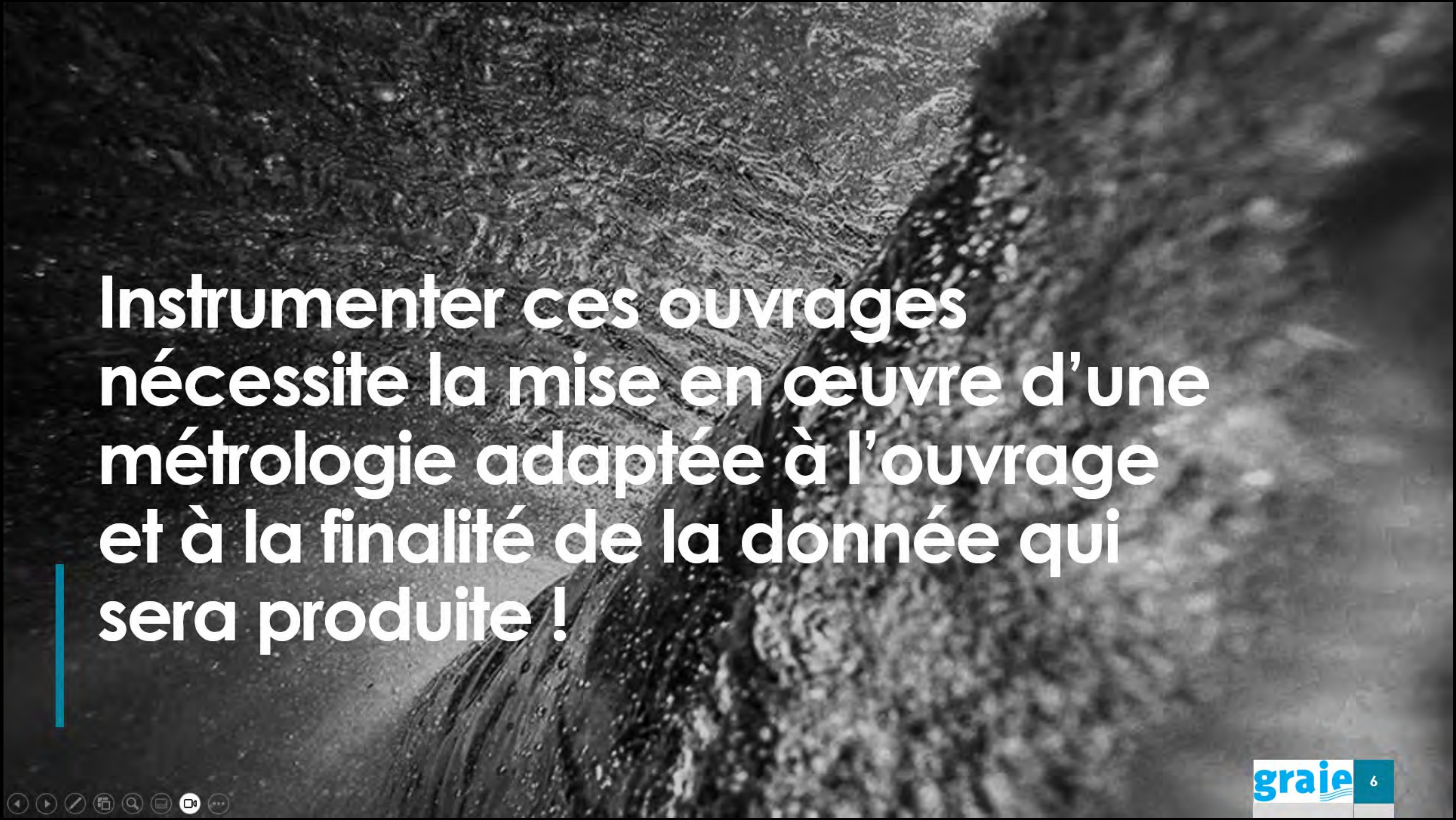
For Storm Overflows DO ≥ 120 kg/d of BOD5, it is necessary to

- measure the daily discharge time
- estimate the flows discharged

For DOs ≥ 600 kg/d of BOD5 and discharging more than 10 days/year on a five-year average

- continuously measure and record flow rates
- estimate the pollution load (BOD5, COD, SS, NTK, Ptot)
- if representativeness and reliability are demonstrated, data derived from modelling are accepted

ODs also **include lift station overflows ≥ 120 kg/d of BOD5** for which it is necessary to measure the daily discharge time.


Instrumenter ces ouvrages nécessite la mise en œuvre d'une métrologie adaptée à l'ouvrage et à la finalité de la donnée qui sera produite !
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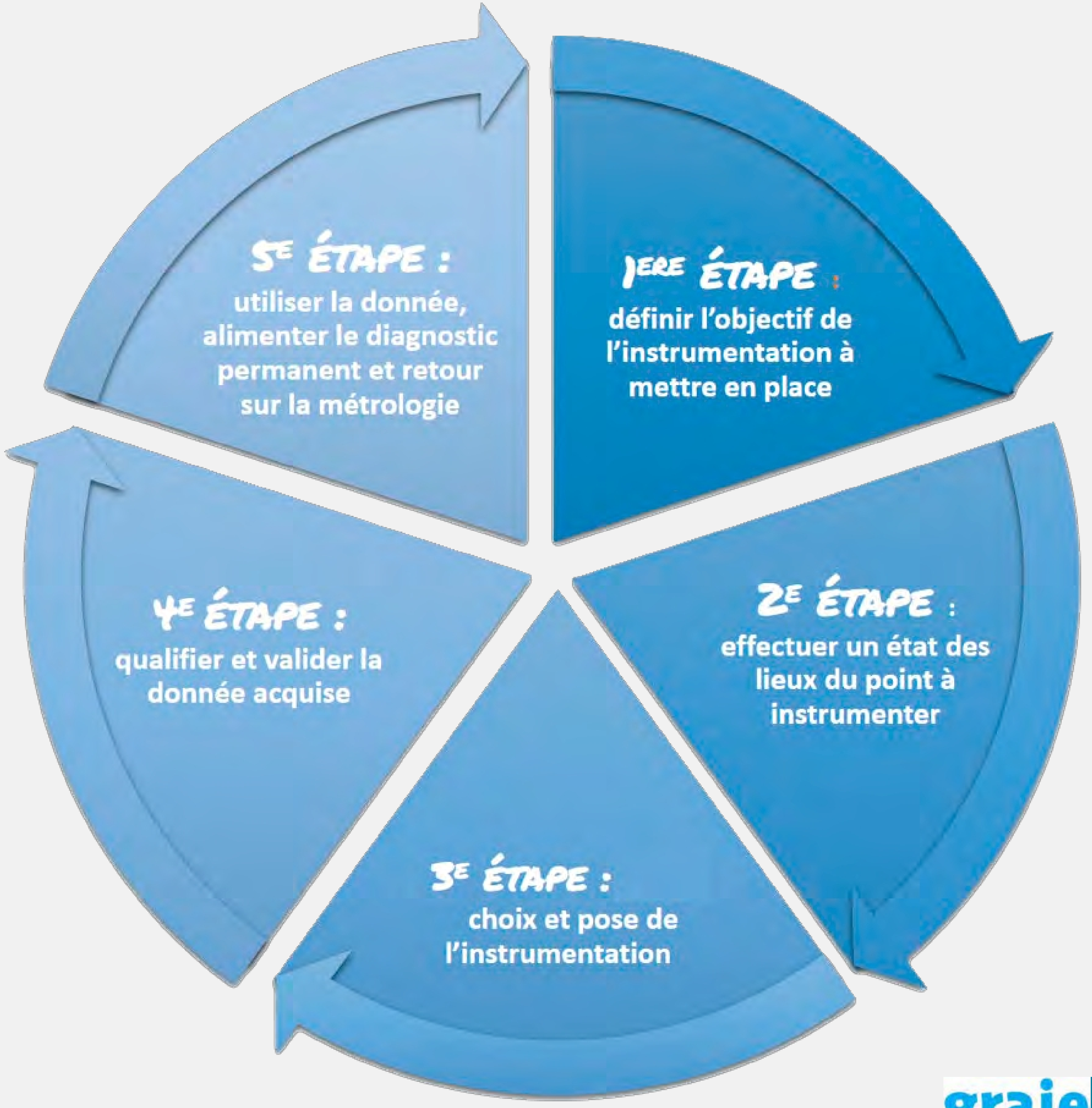
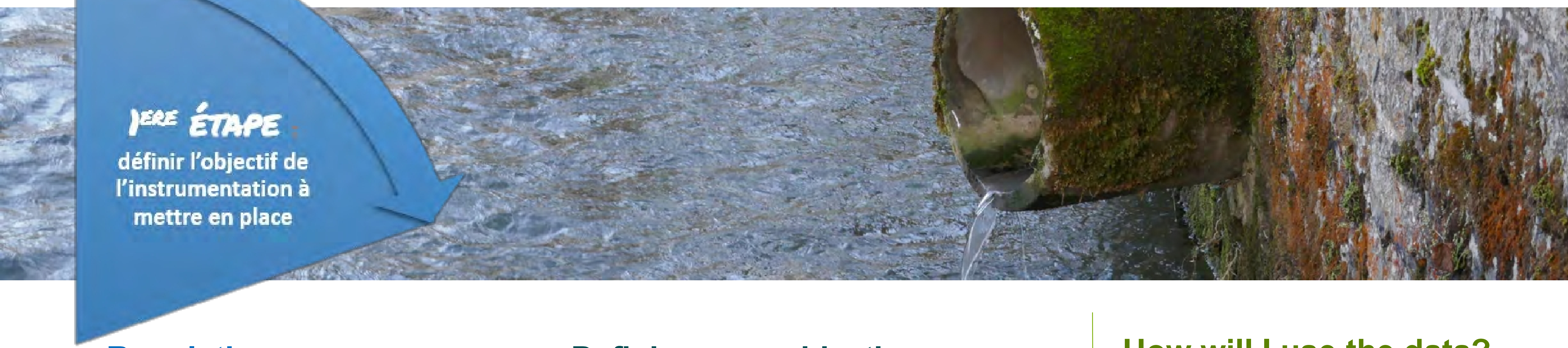
In this context, **instrumenting a DO is complex**, and requires **5 key steps to** be borne in mind before proceeding launch!



Step 1: Define the objective of the instrumentation to be put in place



Regulations

Review national and local regulatory requirements at the point to be equipped

Defining your objective

- What will the data produced be used for?
- What is the purpose of the planned instrumentation?

Responding to regulatory, local (environmental, health, etc.) and other issues ...

How will I use the data?

- Drawing up an estimate
- Taking a measurement
- Using data to calibrate a model

Step 2: Take stock of the point to be instrumented

Visit the structure to be equipped and carry out a site survey

- ☐ ite accessibility and safety
- ☐ identify the direction of the flow, the slopes, the height and the load of the flow (traces of water on the walls),
- ☐ take measurements (crest, downstream),
- ☐ look at the space available to set up instrumentation and the power supply,
- ☐ ind out whether there is electricity or an internet connection nearby
- ☐ exchanging information upstream with public authorities (ownership of certain areas)

Step 2: Take stock of the point to be instrumented

Drawing up an inventory of fixtures before instrumentation

It is essential to carry out a preliminary diagnosis to optimise the installation and future maintenance. Keep a record of this assessment, detailing the characteristics and constraints of the site, in particular:

- **The location and configuration** of the structure (dimensions, geolocation of the discharge point, etc.)
- **The characteristics** of the discharge structure and its outlet (valve, discharge to the environment, range of flow through...); identification of the type/nature of the OD and its hydraulic operation.
- **Access** features (manhole, ladder, manhole cover)
- **Take photos or videos of the work**

Step 2: Take stock of the point to be instrumented

Launch additional studies if necessary before instrumentation

If the information collected or available is not sufficient, do not hesitate to launch, for example :

- A geometric study
- A hydraulic study
- ...

Step 3: Choosing and launching the instrumentation

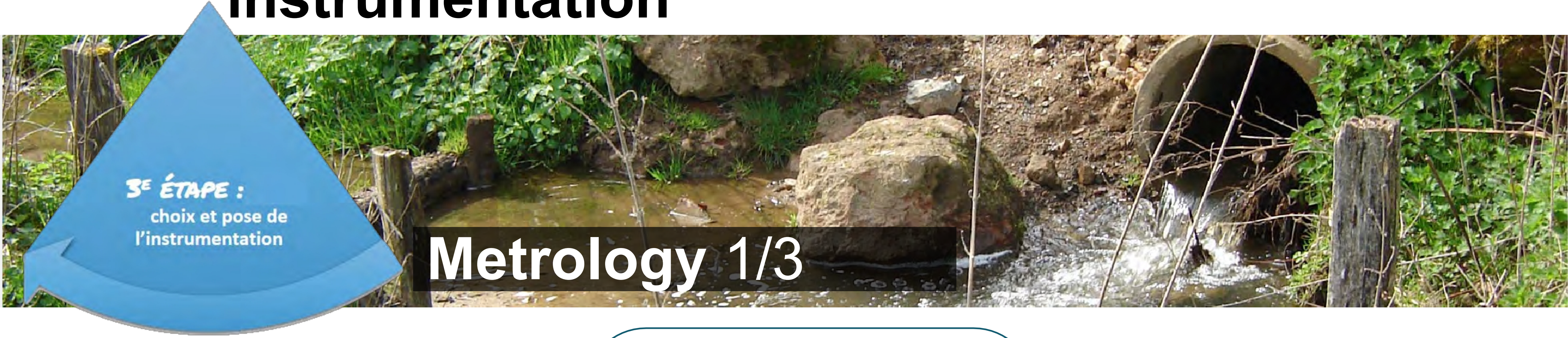
Choice of metrology

Installing the equipment

Think about maintenance and control as soon as the equipment is installed

A wide range of measurement options and equipment are available. There's no such thing as a perfect solution - we're looking for the best compromise!

Step 3: Choosing and launching the instrumentation



Drawing up specifications

This instrumentation is complex (except for simple DOs, but these are rare...). If the service is delegated, it is a good idea to draw up detailed specifications covering the 5 key stages of the process

Need for phasing of instrumentation

A. pre-study
B. validation / modifications
C. final instrumentation
D. iterations if necessary

Think well in advance about installation, maintenance and calibration

If possible, keep as many tools as possible on hand to carry out routine actions (calibration decoys, rulers, etc.) or dismantle the sensors to send them to a special centre. test bench.

Step [3]: Choosing and launching the instrumentation

Type of equipment

Promoting instrumentation :

- light and unobtrusive
- reliable with the right protection factor
- robust enough to withstand the environment (floating, ice jams, humidity, immersion, etc.)
- usable and controllable

Have the right instrumentation for your objectives and the range of measurements required on site

Equipment redundancy

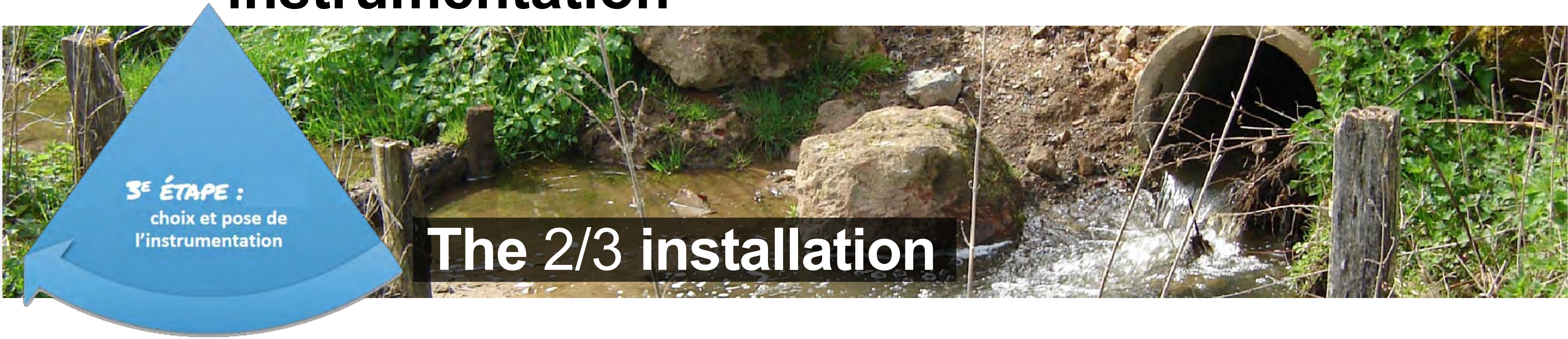
Encourage redundancy to make measurements more reliable (double measurement with a different technology)

Warning: doubling the data collection does not turn an estimate into a measurement!

Life sheet

Keep track of the choice of sensors, their positioning and enable them to be monitored

Step [3]: Choosing and launching the instrumentation



Civil engineering works

Do not hesitate to make adaptations / reconstructions of structures in order to instrument under standard and normalised conditions.

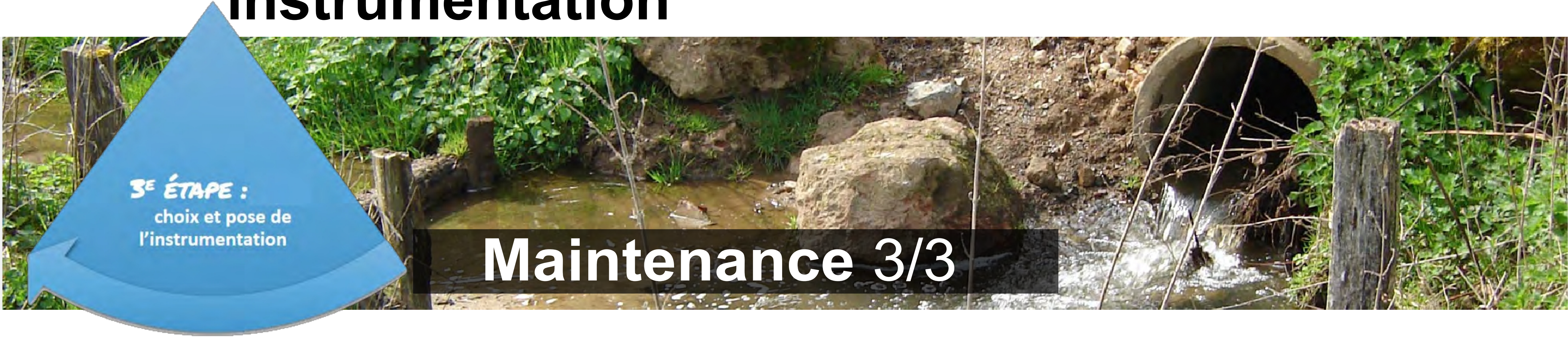
Site accessibility

Make the site safely accessible for maintenance, calibration and inspection work

WATCH OUT!

The installation of measuring equipment in an OD frequently requires the collector to be adapted, often resulting in a reduction in the flow cross-section and therefore a downstream influence on the network. This influence must not jeopardise the network in the event of exceptional rainfall.

Step 3: Choosing and launching the instrumentation

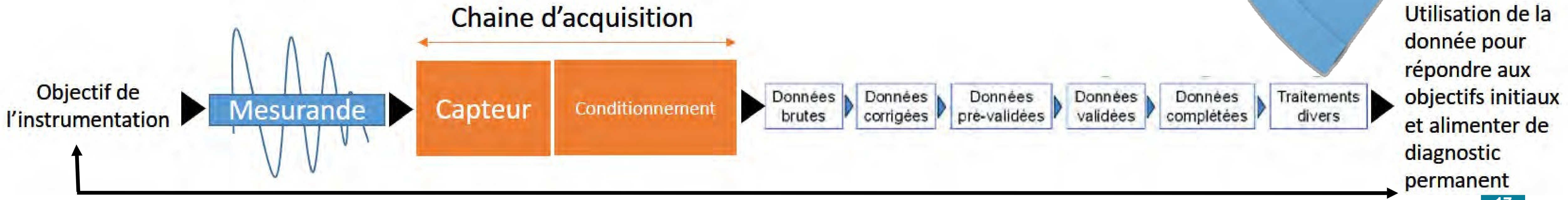


Carry out systematic checks on the measurement chain

- Calibration of sensors every year
- Regular maintenance / checks
- Comparison / validation (speed fields, and/or tracing, etc.)

Stages 4 & 5: Qualify, validate, use the data and feed the ongoing diagnosis back to the system metrology implemented

A measurement system is not limited to the installation of a sensor; it integrates the entire measurement chain. (including validation) and its use.



Feedback loop on the measurement chain

Comment mesurer un débit déversé ?

Points Clés

The flow rate can be :

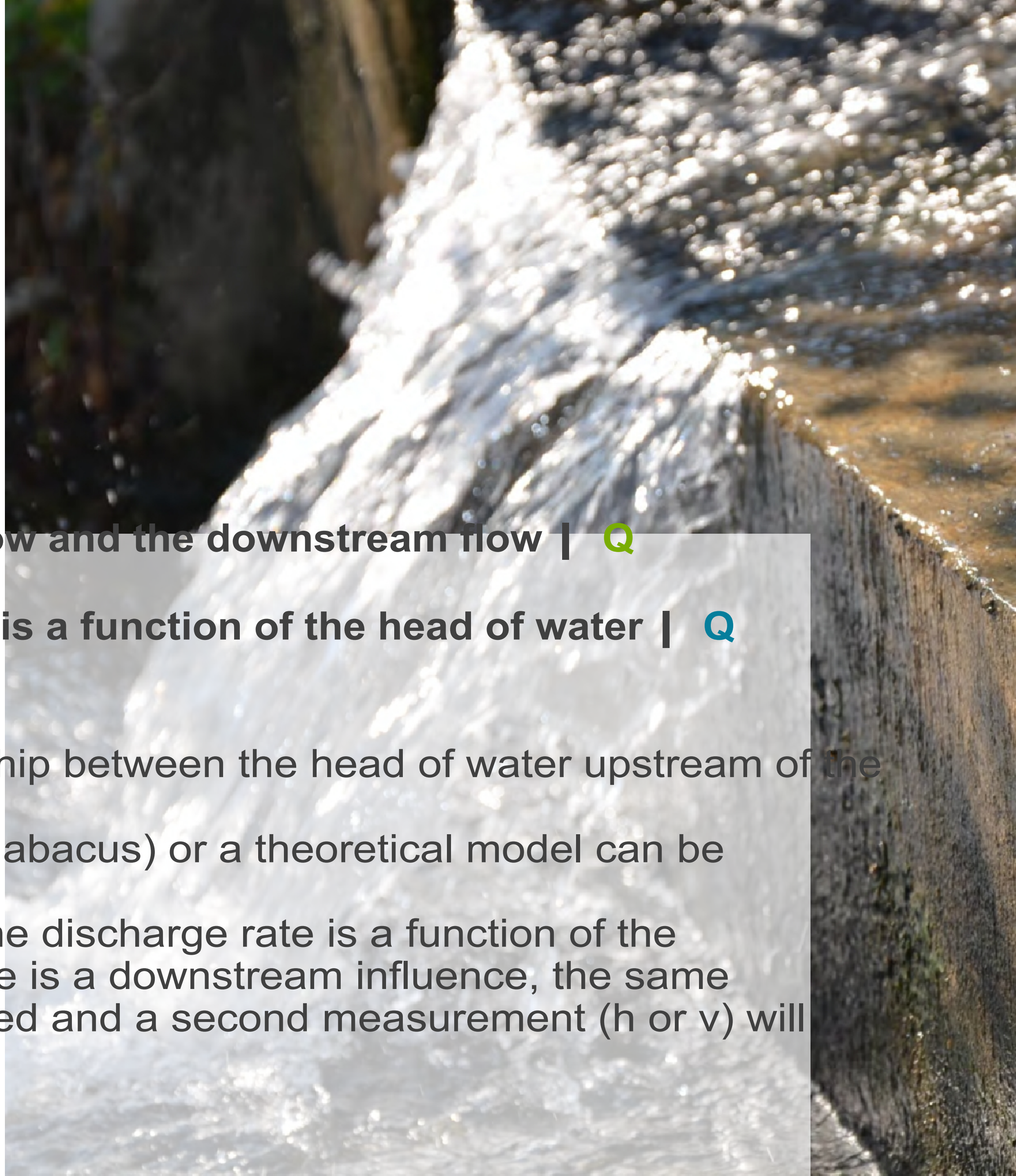
m^3/s	f (h)	m^2 x m/s
Volume/ temps	Une fonction de la hauteur	Section/ vitesse

There are 3 METHODS for measuring the flow discharged through a discharge pipe:

Either A: the difference between the upstream flow and the downstream flow | Q discharged = Q upstream- Q downstream Or B: it is a function of the head of water | Q discharged = f(h)

In this second case, there is a one-to-one relationship between the head of water upstream of the threshold and the spill flow.
An empirical relationship (experimental calibration, abacus) or a theoretical model can be used to carry out this calculation.
If there is no downstream influence, for example, the discharge rate is a function of the discharge height and the measured velocity. If there is a downstream influence, the same applies, but a corrective factor will have to be applied and a second measurement (h or v) will be necessary.

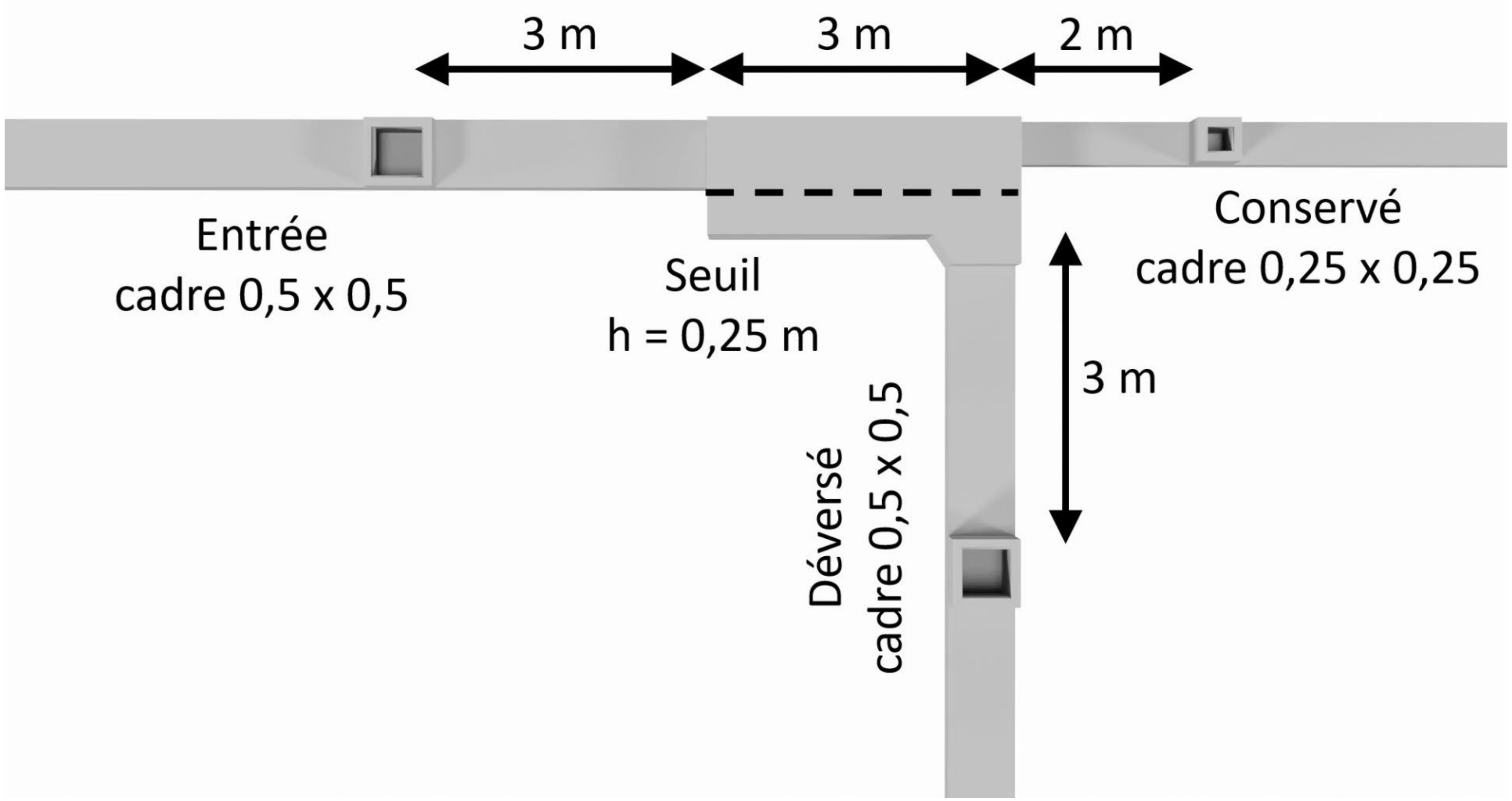
Either C: measured directly in the discharge pipe



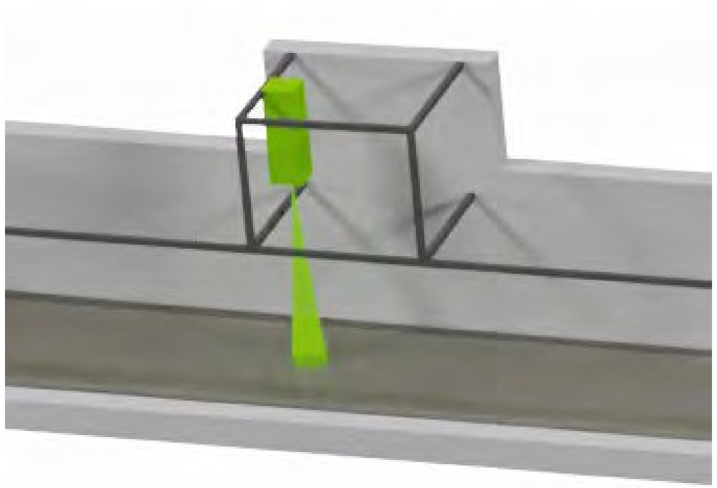
In this 3rd case, by installing a flowmeter (h/v) in the discharge pipe, the flow rate discharged can be measured directly.

Presentation of methods and principles

We will symbolise the network and the discharge as follows



Symbolisation of a sensor and its measurement cone



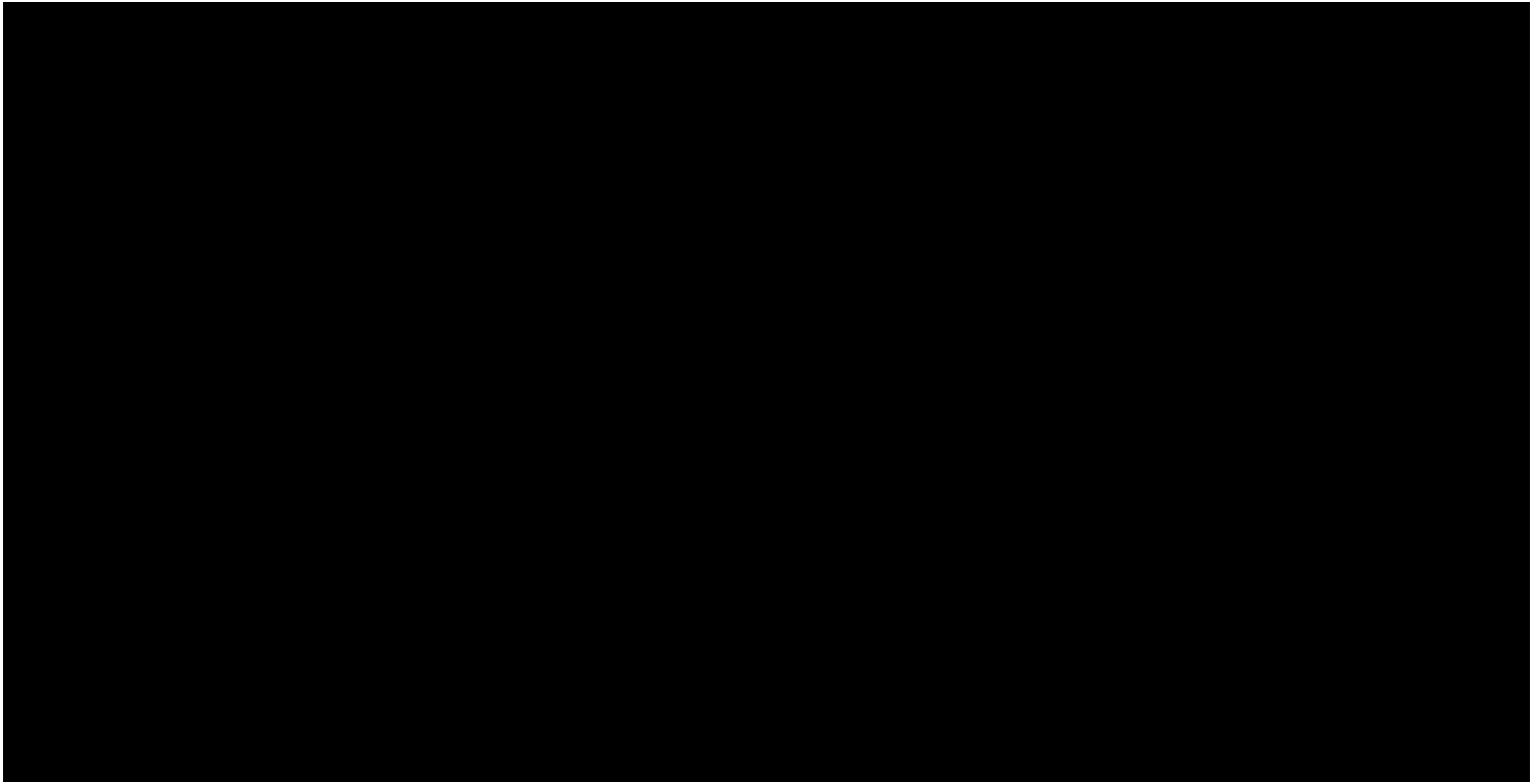
2 different network configurations will be presented, one with a <u>high threshold</u> and the other with a <u>low threshold.</u>

The video examples below represent application situations close
real cases in the field.

These situations are not intended as installation recommendat
but as illustrations.

NO METHOD IS PERFECT AND EACH HAS ITS LIMITS!

Display of 2 different configurations - **Low and high thresholds**

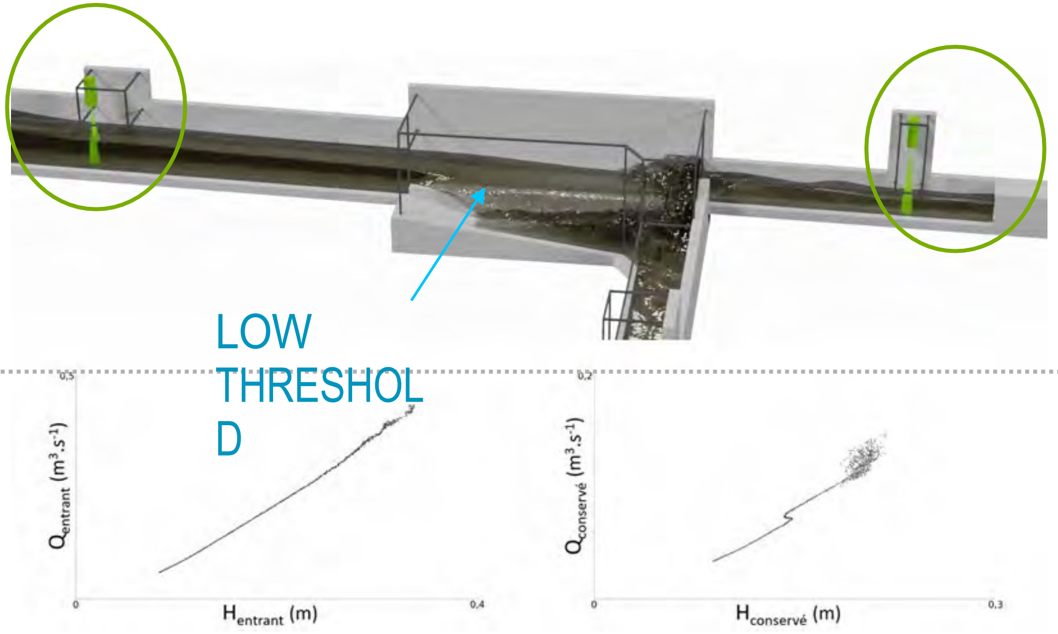


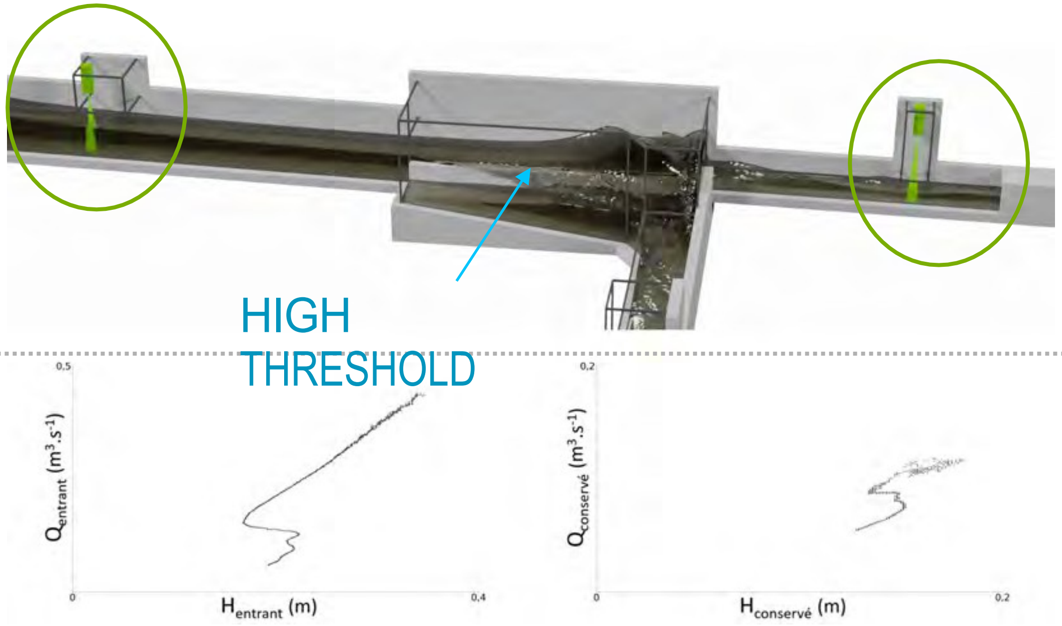
How do you choose between these 3 methods? 1/3

Method A: the difference between the upstream flow and the downstream flow

- This relationship **is generally and simply applicable**
- **Doubling the number of measurement points is necessary**, which means that servicing and maintenance costs are doubled
- **Uncertainty about the flow rate deserves to be compared**... it is essential to assess uncertainties
- This method **makes it** possible to **compare flow rates**
- It **can pose a problem if there are many inputs/outputs**
- **Dry weather monitoring is required** to ensure the reliability of the data (removal of false positive spills).
- This method provides a **"permanent diagnostic" point** because, in addition to measuring the flow discharged, it makes it possible to monitor the operation of the collection network and better identify the origins of discharges.

Method A - Examples

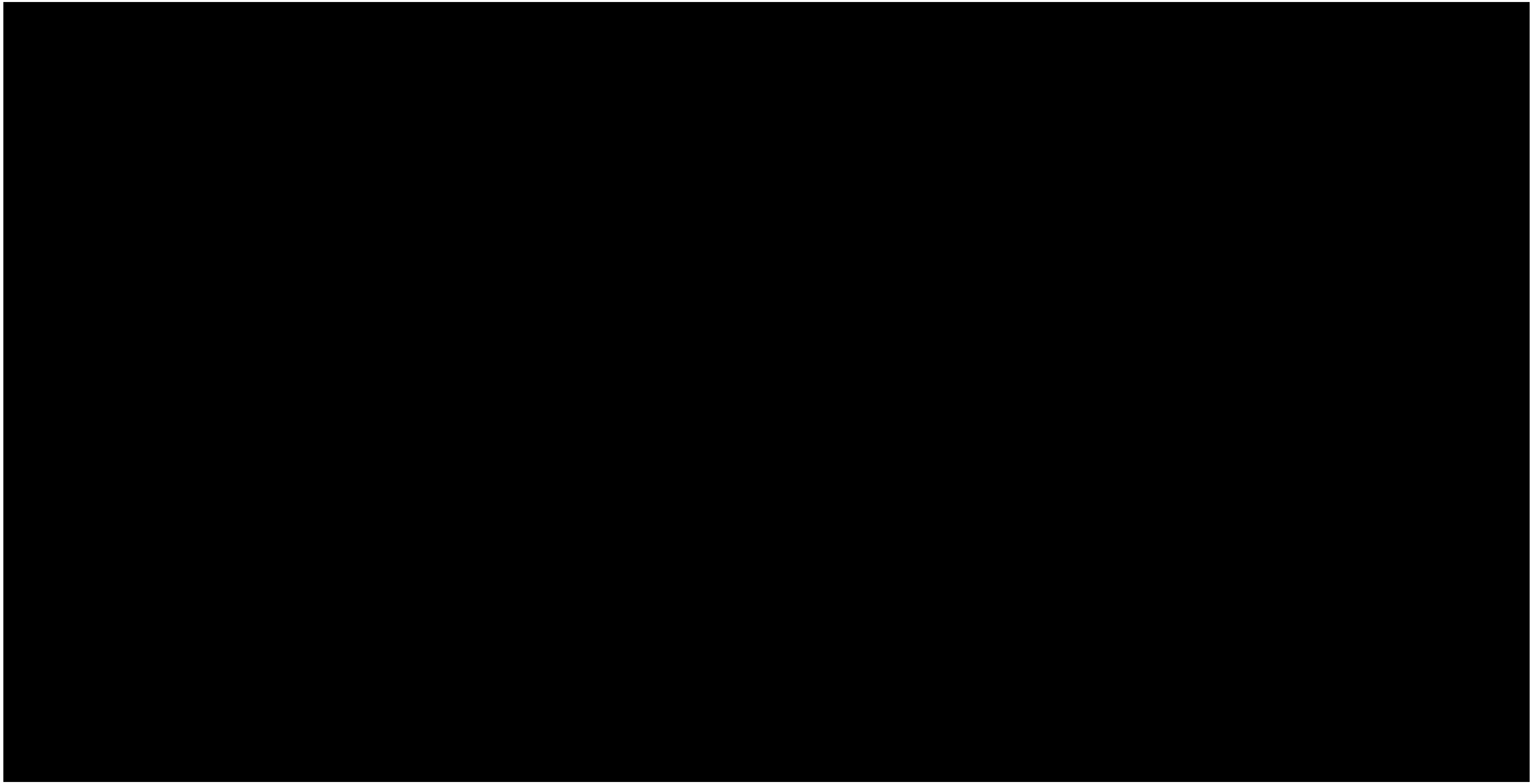




Examples of situations with low and high thresholds with

- 2 height sensors in the inlet pipe and in the retained section
- Display of the height measured and the flow rate calculated using method A

Display of 2 different configurations - **Low and High thresholds**



Method A

| Q overflow = Q upstream - Q downstream |

These examples are worth remembering

Despite the simple geometry, measurement is not easy

In these examples ,

High threshold: the inflow can be represented relatively well with an average law until the hydraulic surge exceeds the sensor. Beyond this point, it is impossible to represent the flow, so the calculated flow is false,

Low threshold: there is a good correlation between the measurement on the reservoir and that upstream. An average law can be established for each flow (right). The difference in flow rates gives a good measure of the spill flow, as the upstream measurement is always under torrential conditions.

▶▶In **both cases, a more distant measurement of the height in the conserved would improve this method .**

How do you choose between these 3 methods? 2/3

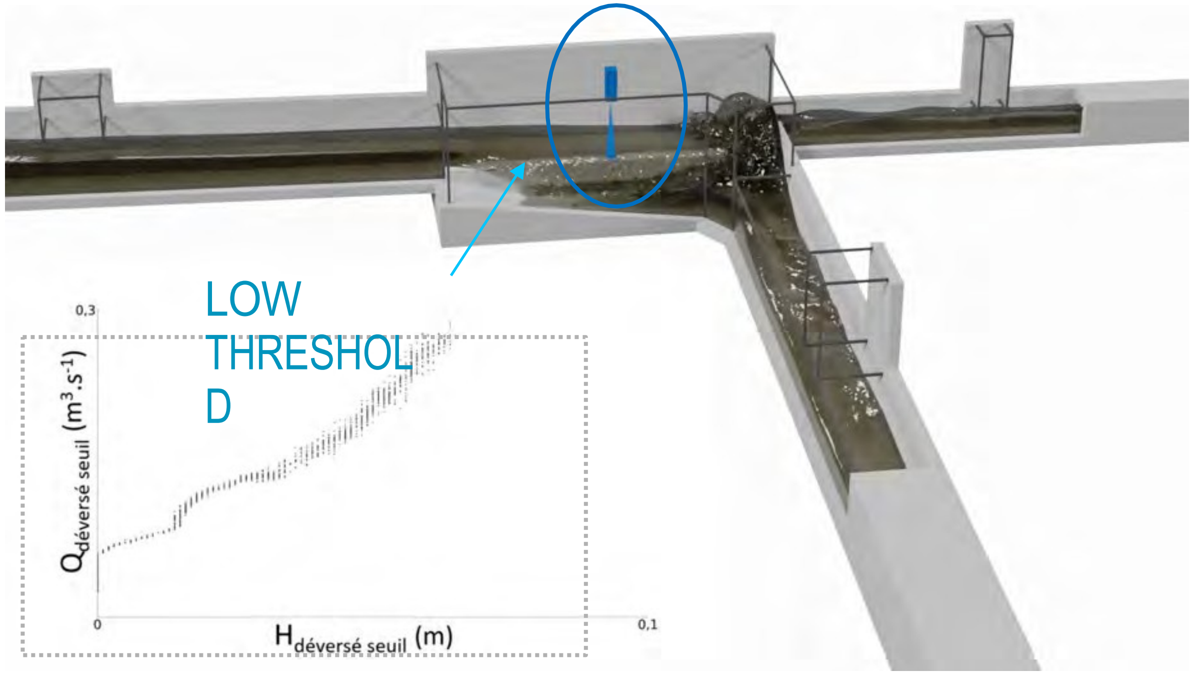
Method B: Flow rate is a function of water level

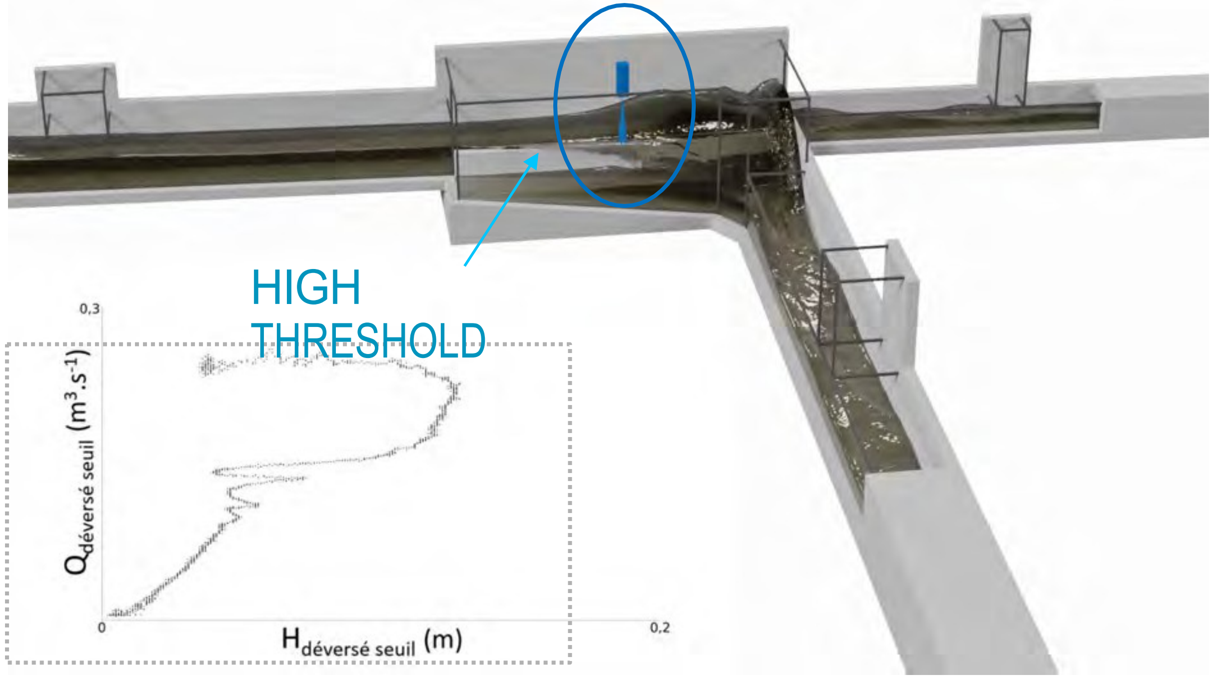
- **Easy on single DO**
- **Apart from simple DO, several sensors are required** (*except possibly in the case of 3D modelling, which can simplify metrology but will require greater initial investment (in research)*).

2 sensors if DO short (L threshold < 2 D downstream)	**3 sensors otherwise**	**> 3 sensors if complex OD**	**1 sensor if using 3D modelling**

- Requires **optimised positioning of** height **sensor(s)**
- Requires **monitoring in dry weather** (removal of false positive spills)
- Establishment of **a discharge law specific to the structure** and its properties: the relationship f(h) will be invalid if there is a deposit or an obstacle to flow

METHOD B - Examples

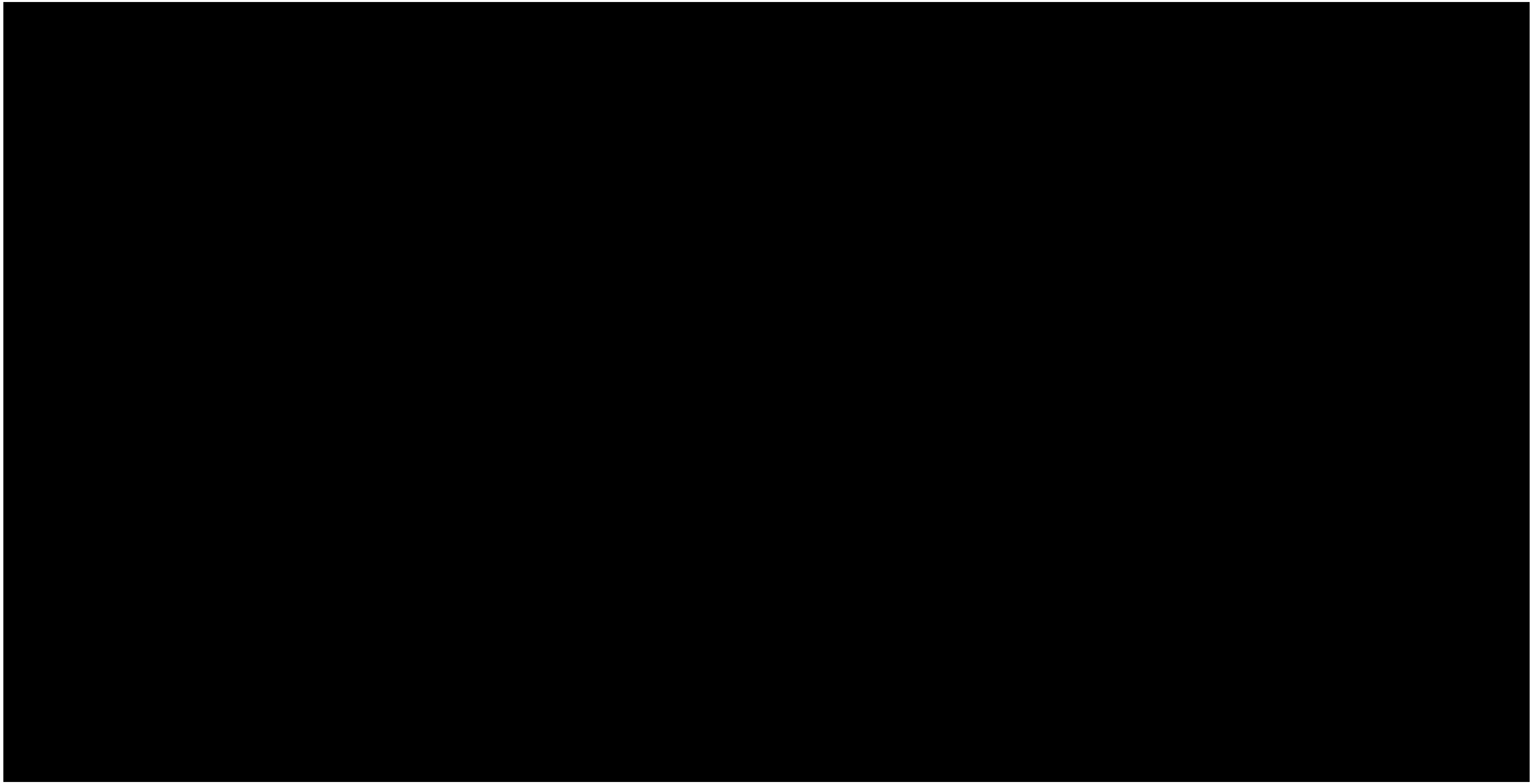




Examples of situations with low and high thresholds with

- **1 height sensor in the discharge chamber at weir level**
- **Visualisation of the measured height and flow rate calculated using method B**

Display of 2 different configurations - **Low and high thresholds**



These examples are worth remembering

The sensor positioned in this way cannot determine all the flow rates.

In these examples ,

High threshold: the inflow can be represented relatively well with an average law up to the hydraulic jump. Beyond this point, it is impossible to represent the flow, so the calculated flow is false.

Low threshold: on the other hand, at the beginning of the event and the spill is not seen by the sensor and it is therefore impossible to determine the spilled flow at the beginning of the event. At the end of the event, despite the uncertainties, an average law could be used to determine the flow rate.

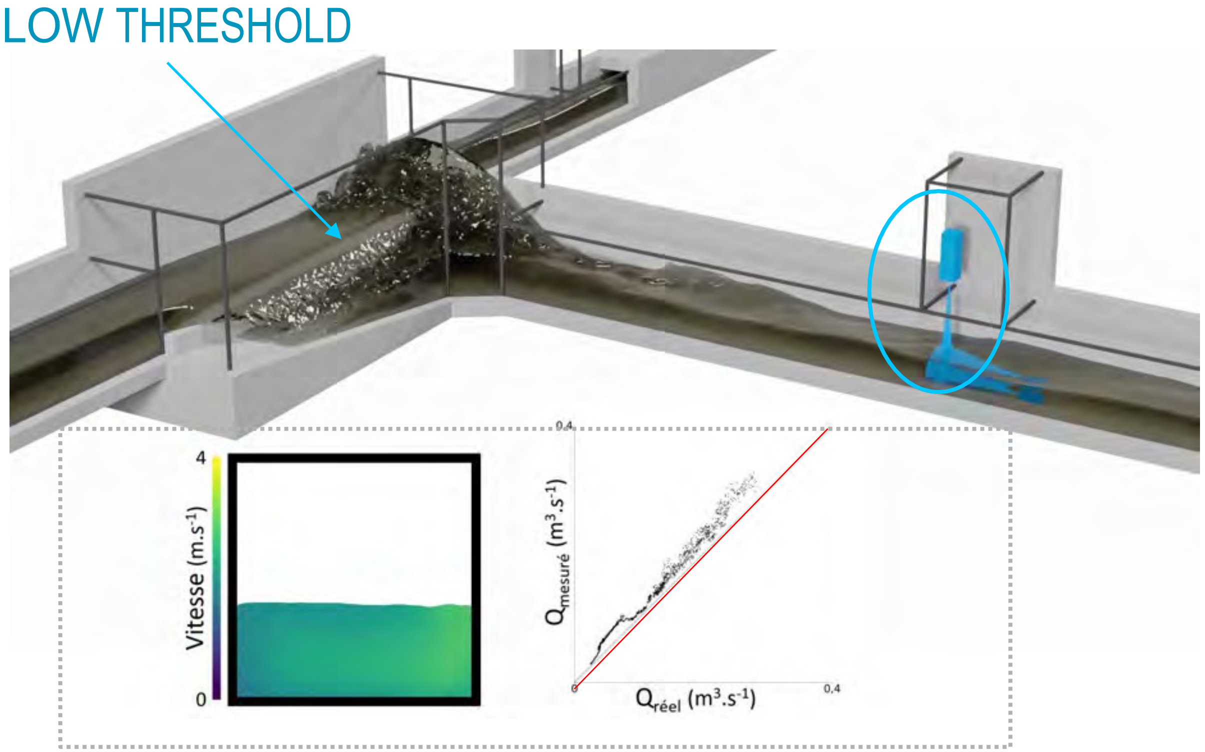
▶▶In **both cases, a hydraulic study is required to position the sensor correctly and use the method.**

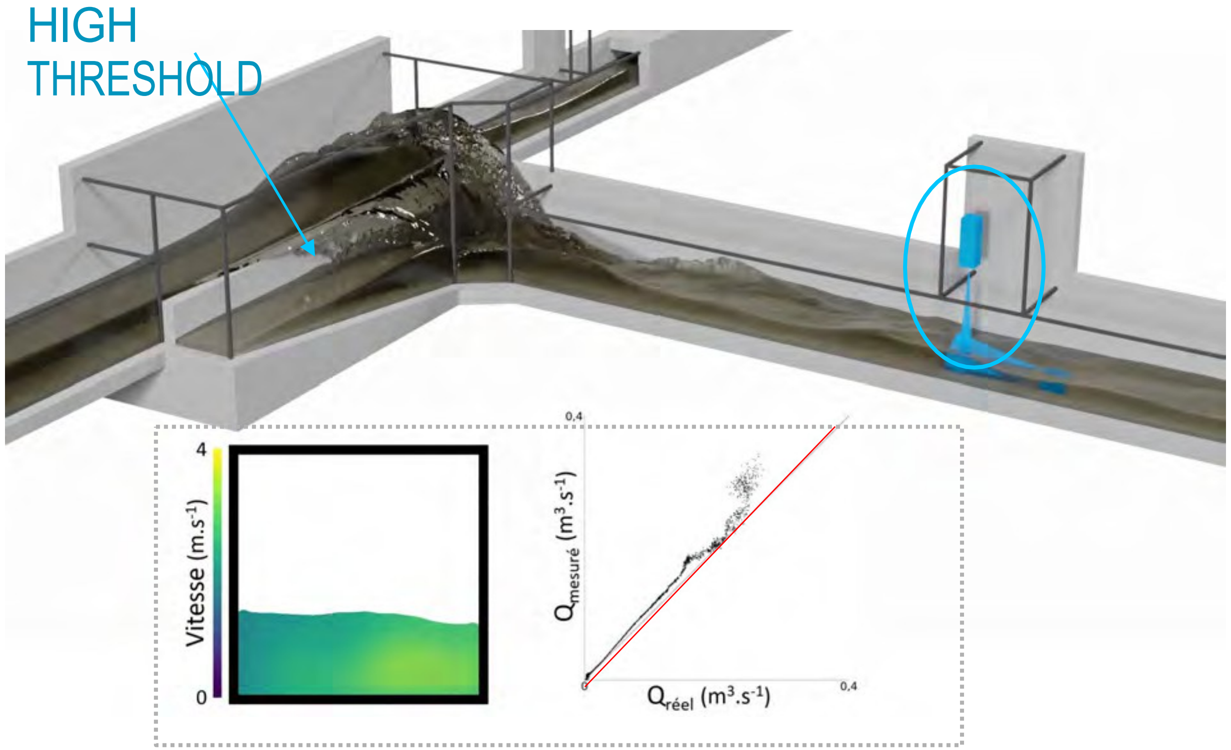
How do you choose between these 3 methods? 3/3

Method C: flow measured directly in the discharge pipe using an h/v.

- **Direct measurement of spill flow** using a single measurement point
- Discharge pipe often accessible but of variable shape/structure
- The location of sensors within the discharge pipe is **not always suitable for sensor maintenance**
- Can be **effective on sites subject to downstream influence.**
  In the event of intrusion of the aquatic environment, a height/speed measurement must be set up.
- Most of the time, these sensors (speed/height) will be "dry", which means that **drift cannot be monitored.**
- **Any type of h/v sensor can be used**

Method C - Examples

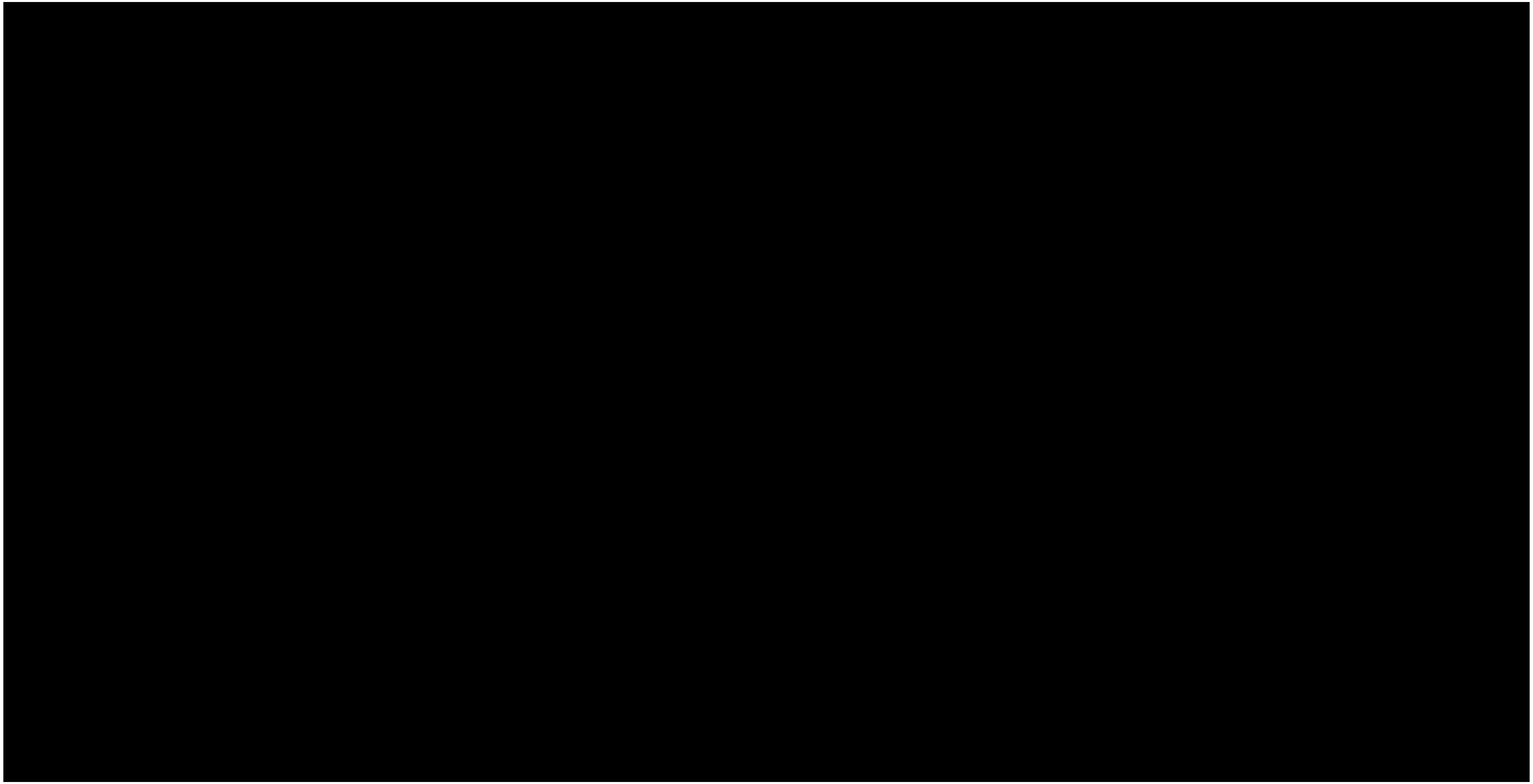




Examples of situations with low and high thresholds with

- **1 height/speed sensor in the discharge pipe**
- **Visualisation of pipe filling speed + comparison between flow rate calculated using method C and actual flow rate.** *The red line shows a perfect similarity between the actual flow rate and the measured flow rate.*

Display of 2 different configurations - **Low and high thresholds**



These examples are worth remembering

Sensor incorrectly positioned too close to discharge pipe inlet

In these examples ,

High threshold: low inflow not represented. Then good trend up to a certain threshold, beyond which the flow is too turbulent and the uncertainties very high. This makes the measurement unreliable.

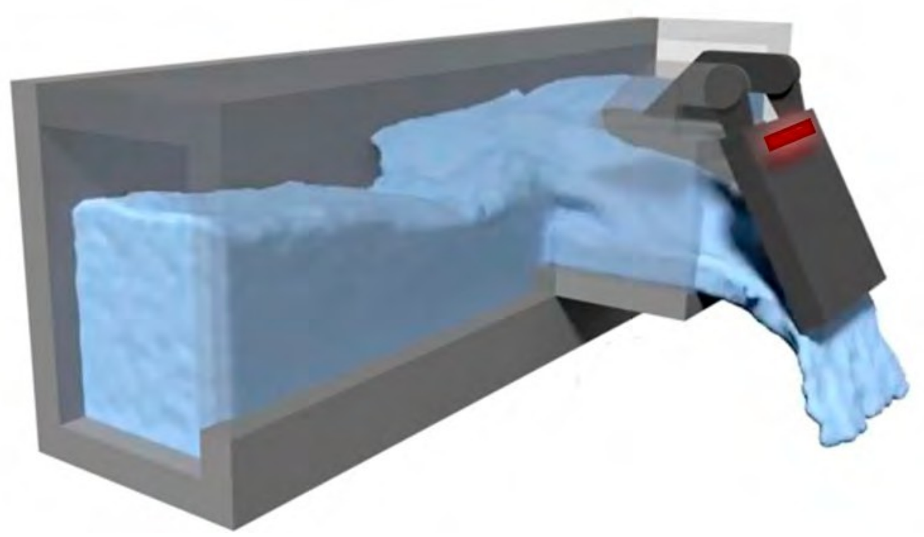
Low threshold: same observation, the water level becomes very unstable and/or the speed field read by the sensor is no longer representative of the average speed.

▶▶ In both cases, for this C method to be used correctly, the h/v sensor must be placed between 20 and 50 times the width of the pipe (unlike the video).

>>To find out more: GRAIE | Technical sheets from the working group on the various measurements of speed and height (in particular the limit conditions for use and how to check them)

Outlook: **Method D in the making**

| Q spilled = f (angle of opening of a flap gate) | (angle of opening of a flap gate)



For accessible ODs :

- fitted with a heavy valve (cannot be lifted with one finger)
- that do not operate continuously between drowning and flooding

Thanks to a specific study of the hydraulic behaviour of the structure, the inclination of the flap gate can be linked to the outflow from the OD using a mathematical law.

▶▶ The flow rate can then be determined using the angle given by an inclinometer placed on the flap.

Measuring flow using an inclinometer is a developing technique, and knowledge and feedback on the limit conditions of use and maintenance are still evolving.

>>FURTHER INFORMATION: GRAIE | Technical Sheet No. 12: Flow measurement using an inclinometer on an existing flap valve

KEY POINTS TO REMEMBER

- ▶ Instrumenting a DO is <u>COMPLEX</u>

- ▶ Think about the life of the structure: *in situ* instrumentation will need to be maintained, monitored and will evolve

- ▶ D o n 't forget the 5 key steps to successful instrumentation

- ▶ The choice of method for measuring spill flows depends on your objectives, your financial and human resources, and the characteristics of your OD!

- ▶ To guide your choices: don't hesitate to carry out a hydraulic study of the weir's operation

- ▶ NO METHOD IS PERFECT

- ▶ ...asuring low flows still remains a major difficulty within DOs

Thanks to the contributors

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