iBATHWATER

Advanced urban water management to efficiently ensure bathing water quality

LAYMAN'S REPORT

eurecat
Centre Tecnològic de Catalunya

Ajuntament de Barcelona | Barcelona Cicle de l'Aigua SA

KWB
Kompetenzzentrum Wasser Berlin

adasa

PROJECT DETAILS

Locations

Barcelona

Berlin

Reference: **LIFE17 ENV/ES/000396**

Duration: **1/9/2018 - 30/9/2022**

Budget: **2.274.164 €**
(contribution from the European Union: 1.364.497 €, 60%)

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PARTICIPATING INSTITUTIONS AND ENTERPRISES

Coordination

Fundació Eurecat

Associated entities

Adasa Sistemas

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Barcelona Ciclo del Agua, S.A.

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Wasser Berlin

THE RAISON D'ÊTRE OF LIFE IBATHWATER

The intelligent management of the drainage network and urban sewerage system

The **function of the urban drainage system and sewage system** is to collect urban wastewater, rainwater, and surface runoff. When the system is a combined system, it transports this water via the same pipes. When the water reaches the treatment plants, it is treated to remove suspended solids and pollutant load, and then returned to the environment (rivers, lakes, and coastal areas). Sustainable management of this water helps to close the anthropic water cycle, guarantee public health, and reduce the pollution that reaches the environment.

During **episodes of intense or prolonged rainfall**, the volume of water may exceed the capacity of the sewage system or of the treatment plants; in these cases, the untreated water is directly discharged into the environment directly. These discharges have a negative effect on aquatic ecosystems and their physical-chemical and microbiological quality, as well as on bathing water and on public health, as beaches, rivers, and lakes are leisure spaces.

Fig. 1 - During episodes of intense rainfall, the volume of water may exceed the capacity of the sewage system or of the treatment plants; in these cases, the water reaches the environment directly, without prior treatment.

iBATHWATER is a full-scale demonstration project for a new integrated system to manage the sewage network and bathing water. Application of this system is expected to reduce the impact on the natural environment of untreated urban rainwater runoff, thus improving the quality of bathing water during and after episodes of heavy rainfall. The proposed innovations have been applied in Barcelona and Berlin. These systems make it possible to anticipate risks and provide the highest healthcare guarantees.

THE OBJECTIVES OF IBATHWATER

The impact of discharges on the environment and health

The **main goals of the iBATHWATER project** are the following::

- Minimize the health risks to bathers associated with the quality of recreational waters.
- Reduce the number and volume of sewer overflows during episodes of rainfall.
- Reduce the quantity of land-based floating solids and debris discharged into the sea during episodes of intense rainfall.

To achieve these goals,...

– a system has been developed to **support operational decision-making**, both for bathing areas and for urban drainage infrastructure;

– real-time continuous monitoring was performed of **microbiological parameters using measuring devices (aquaBio technology**;

– the quality of the water in bathing and leisure areas was modelled based on the **new parameters introduced during monitoring** in real time and on a continuous basis (including the indicators specified in the European directive on bathing waters);

– and **data harmonization**, **interoperability**, **and open standards** were facilitated to encourage replicability in and transferability to other cities and regions.

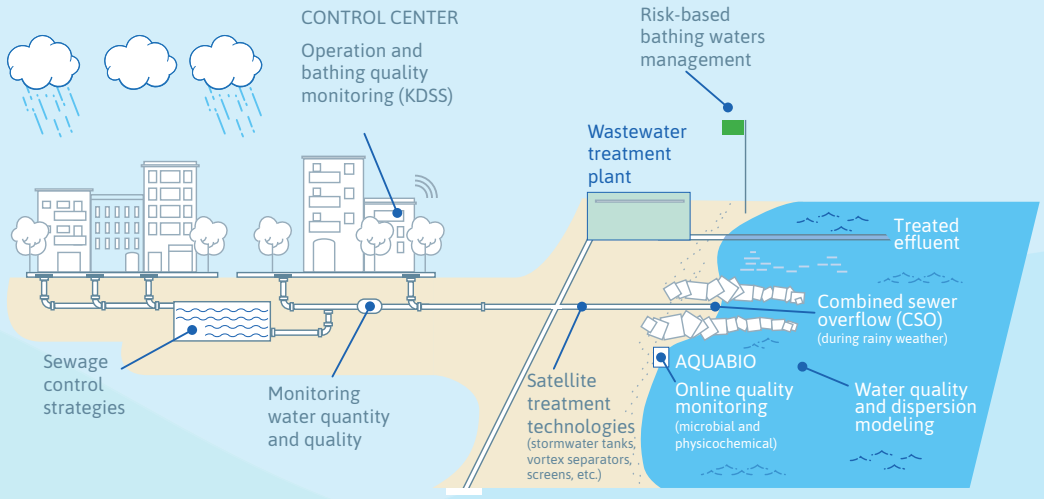


Fig. 2 - iBATHWATER scheme. a full-scale demonstration project for a new integrated system to manage the sewage network and bathing water.

CONTRIBUTIONS AND RESULTS OF THE PROJECT

1 AquaBio technology to minimize the health risks associated with the quality of recreational waters

AquaBio is a **measuring device** that determines the microbiological indicators of faecal pollution by simultaneously measuring **total coliforms and *Escherichia coli* and *enterococci*,** in a continuous and automatic way, and with low maintenance requirements. It provides an alert on the health risk of the waters in areas where untreated rainwater is discharged.

The **analytical method** used is based on the breakdown of a specific substrate, and colorimetric and/or fluorimetric detection that quantifies the concentration of these microorganisms. aquaBio provides quantitative values in a period of between 4 and 10 hours, depending on the concentration, after automatic sampling.

To obtain ETV (Environmental Technology Verification) certification, the process of verifying aquaBio was carried out; this is an initiative of the European Commission that consists of determining and validating the functioning of an environmental technology by qualified third parties based on data obtained following the application of previously established protocols.

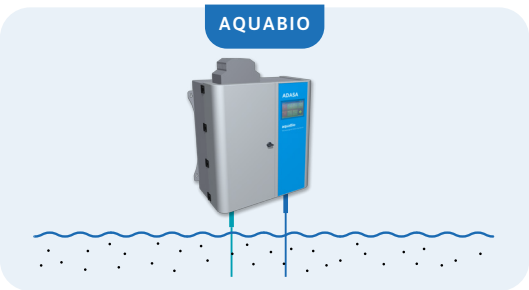


Fig. 3 - AquaBio measuring device

Fig. 4 - Port Olympic installation where the quality of water at Somorrostro beach is measured using the aquaBio device.

In Barcelona, aquaBio was installed at two beaches: Nova Icària and Somorrostro. The device provides information on the quality of the sea water. This information has become important for managing the beaches - especially in light of the impacts of climate change, which has caused the recreational season to extend to cover the entire year - and will contribute to improving the confidence of the users.

Episodes of poor quality are closely linked to rainfall of a certain level of intensity. aquaBio therefore has an **operating mode in which it monitors the evolution of the pollution**. The data obtained allow beach managers to observe how the quality of the bathing waters recovers following episodes of rainfall and provide support for decision-making. This helps to prevent having to close beaches for an unnecessarily long period of time and prevents the consequent economic impacts on neighbouring activities.

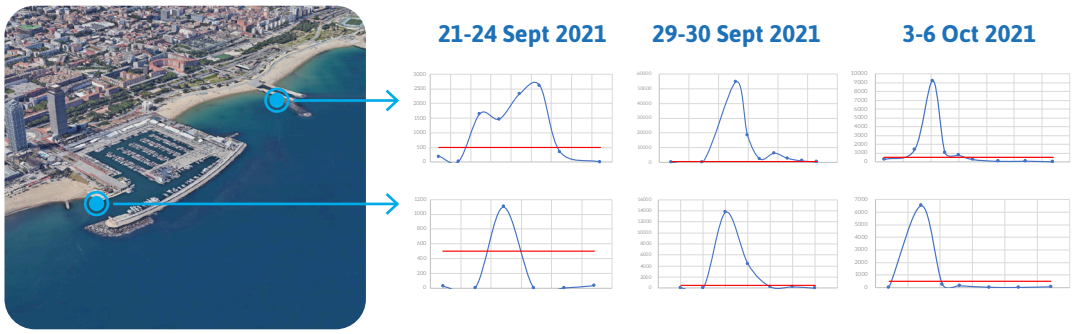


Fig. 5 - Monitoring of three episodes of discharge of untreated rainwater during episodes of intense rainfall at the Nova Icària and Somorrostro beaches in Barcelona.

The red line is the maximum value for E. coli permitted in order to maintain a good quality rating.

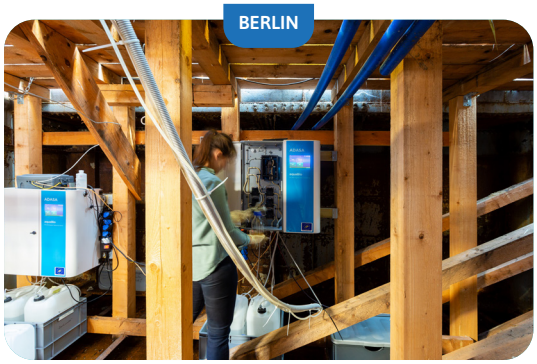


Fig. 6 - Installation in the Flussbad, where the quality of the Spree Canal is measured.

In Berlin, aquaBio was installed at three points on the river where it runs through the city. The results indicate an increase in faecal contamination after overflows of the sewer system due to episodes of rainfall. Considering the duration of the entire project, we can confirm that this device is able to detect reliably episodes of pollution caused by this type of discharge.

The technology has been validated by contrasting the measurements taken by the device with conventional analyses in accredited laboratories. A high level of agreement has been observed between the two sets of results, which was possible thanks to the continuous improvement and specific calibration done with river water.

A decision-support system was also developed to improve management of the quality of bathing waters, specifically for Berlin. The decision-support system records the daily readings determined by aquaBio, prediction provided by an AI model, and information from the sewer system. It sends alerts when deterioration is observed, contemplates different recommendations based on the type of alert, establishes the level of risk for bathing, and makes recommendations to the users.

Milestones of the iBATHWATER project with the aquaBio technology

- **Fine tuning of the technology for measuring intestinal enterococci and also for saltwater matrixes for *E. coli* and enterococci.**
- **Installation of 4 devices in Barcelona and 4 in Berlin, which have taken daily measurements of the microbial quality of bathing waters.**
- **Programming of a new operating mode, which is activated during episodes of rainfall that cause overflow of untreated rainwater. This mode makes it possible to carry out continuous real-time measurements and, therefore, to determine the exact moment when the bathing water regains sufficient quality, based on the limits indicated by the Bathing Waters Directive.**
- **Demonstration that the aquaBio technology reliably detects episodes of bathing water pollution with a 60% reduction in minimum time compared to conventional monitoring of water quality.**

2 MOLIBATH, an urban-drainage management tool for improving monitoring of the quality of recreational waters in Barcelona

As part of the iBATHWATER project, a **tool for predicting in real time the bacteriological quality of the bathing waters at the beaches of Barcelona** using numerical models was also developed: Molibath. These models provide, in less than an hour, the forecast of the evolution of pollution once an overflow of untreated rainwater from the sewerage system has occurred, and make it possible to calibrate it with the campaigns of collected samples.

The **MoHiBa water model** takes the amount of precipitation collected in the city's 24 rain gauges as its input data. The **MoLiBa litoral model** calculates the spread of pollution after a discharge (i.e., the bacteriological concentration - E. coli and enterococci) at each point on the shore, based on maritime hydrodynamic conditions and wave and current evolution.

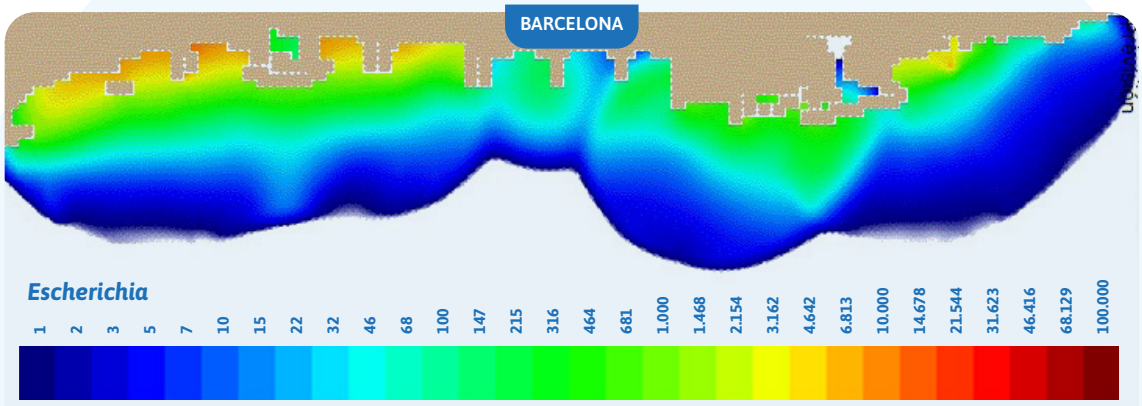


Fig. 7 – Result of the simulation of water quality using the Molibath tool.

Milestones of the iBATHWATER project with the Molibath technology

- **Real-time continuous monitoring of bathing-water quality using the open-source models integrated in the Molibath platform.**
- **Development of a tool that improves decision-making in management of bathing water quality, as it makes it possible to determine the specific moment when the quality falls below regulatory limits.**
- **The tool makes it possible to notify bathers that the bathing water quality is good even before laboratory analysis results become available.**

3 Determination of the microbiological health risks for more optimal management of the quality of recreational waters in Barcelona

As part of the iBATHWATER project, a **new risk-assessment model** was developed based on the determinations of pathogenic microorganisms at the Barcelona beaches performed during the sampling campaigns and on measurements of E. coli and enterococci provided by the aquaBio devices throughout the duration of the project.

To calculate this risk, **reference microorganisms were selected** that are known to cause gastroenteritis or respiratory diseases: the bacterium *Campylobacter*, the protozoan *Cryptosporidium*, and the viruses norovirus and adenovirus. Given that the project period coincided with the SARS-CoV-2 pandemic, this virus was also analysed in the water samples collected during the campaigns.

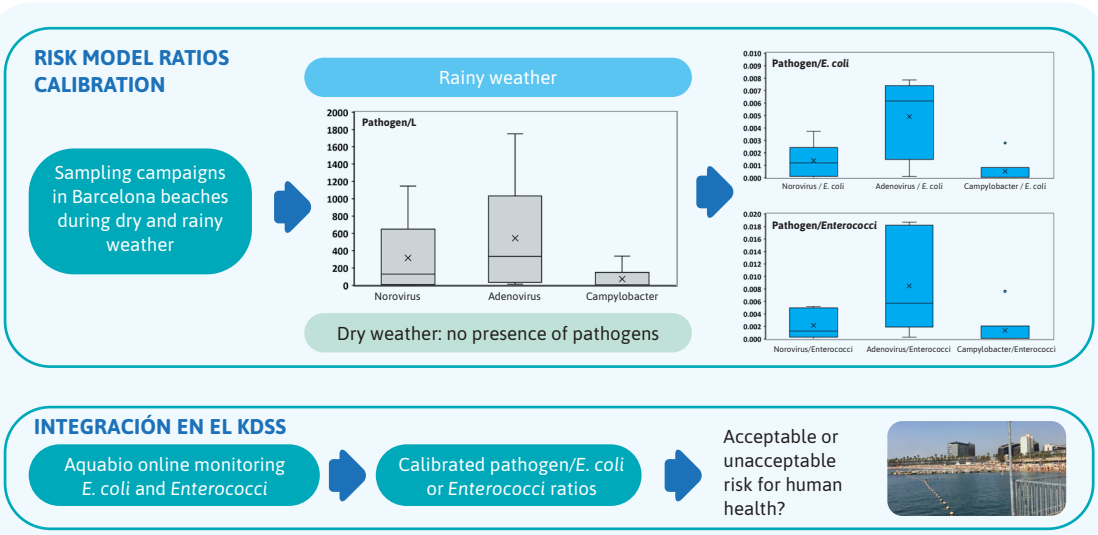


Fig. 8 – Workflow carried out in the quantitative determination of microbiological risk in the iBATHWATER project.

Milestones of the iBATHWATER project in terms of microbiological risk to health

- Analysis of reference pathogens at different points of the beaches of Barcelona in dry and rainy weather. In dry weather (outside episodes of rain that caused overflow of the sewage system), no pathogens were detected, whereas in episodes of rain, three were detected (norovirus, adenovirus, and *Campylobacter*), based on which the risk model was developed.
- Calibration of the pathogen/*E. coli* and pathogen/*enterococci* ratios.
- Integration of the risk model in a decision-support system (KDSS) based on the calibrated ratios and on the measurements provided by the aquaBio device.
- Additional analysis of SARS-CoV-2. The virus was not detected at any point of the sampling campaigns on the beaches, but it was detected in the sewage system during two episodes of rainfall in April and August of 2022.

4 Evaluation of the strategies for managing the sewage network to improve the quality of bathing waters in Berlin

In the case of Berlin, **two other strategies for managing the sewage network** were evaluated; the strategies aimed to reduce the volume of overflow of the sanitation system and improve the quality of bathing water, while also taking into consideration their environmental and economic sustainability. The simulation centred around the basin of the river that passes through the city centre, the Spree canal.

One strategy enables additional storage volume by means of a mobile dam located upstream from the overflow point. The other strategy uses a bypass channel to collect the discharged effluent, before it enters a bathing area, and discharges it downstream. These two scenarios were simulated for the 2016 bathing season (average precipitation) and the 2017 bathing season (more intense rainfall).

The results of the simulation show a reduction in discharged wastewater of ~80% for 2016 (normal rainfall year) and of ~32% for 2017 (extreme rainfall year) and for all the discharge episodes using the mobile dam to enable additional storage volume.

For safe management of the bathing areas, the strategy based on the mobile dam requires **real-time monitoring of the microbiological quality of the water and prediction of potential episodes of overflow with sufficient notice**. This can be achieved by implementing the iBATHWATER solution: aquaBio devices for rapid monitoring of the water quality, multiparameter sensors to detect pollution episodes, and a predictive model for overflows.

The **sustainability assessment** highlights the fact that the iBATHWATER solutions are more sustainable in environmental and economic terms than the construction of major infrastructure, such as the bypass channel. This latter model is also more expensive (+57%) and has a greater environmental impact than the intelligent management of existing infrastructure and the application of advanced options for the control of water quality (6 times more CO_2 emissions).

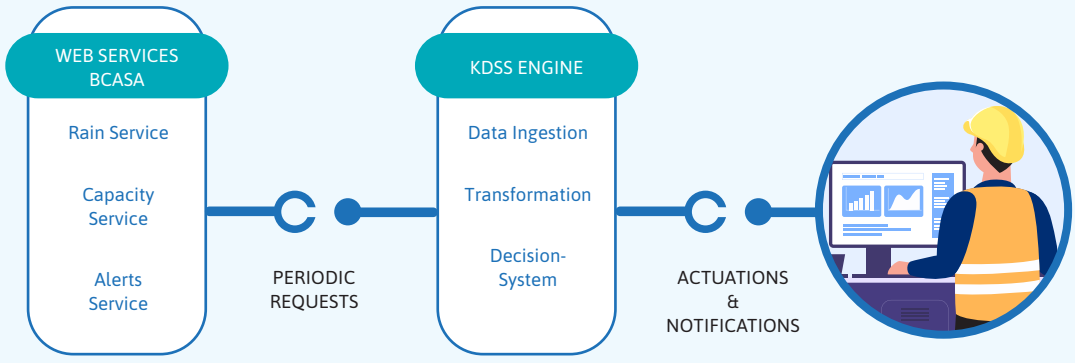
Milestones of the iBATHWATER project in terms of sewage system management

- **Simulation of two different sewage-network management strategies in Berlin**
- **The first strategy, consists of enabling additional storage volume by means of a mobile dam, reduces the volume of wastewater discharged by between 30% and 80%.**
- **The second strategy consists of building a bypass canal; although this option makes it possible to reduce the total amount of water discharged, it has a much higher economic and environmental cost than the use of new technologies based on continuous monitoring of the water quality**

5 Decision-support system (KDSS) to reduce the number and volume of sewer overflows during episodes of rainfall in Barcelona

The main aims of the **Decision-support system (KDSS)** developed as part of the project are to recommend the most efficient strategy for managing urban drainage and to evaluate the risk due to the presence of pathogens in bathing areas.

In the **case of Barcelona**, this management is carried out by regulating the volumes of water in the city's rainwater tanks. These tanks can be operated in one of two ways: to prevent flooding in the urban area or to reduce discharges of untreated wastewater into the environment. Management is carried out by means of protocols defined by the KDSS: as anti-flooding or as anti-CSD (combined-system discharge).



1. Periodic collection of data from the different services (BCASA, ADASA) providing information on: rainfall data, water level in tanks, sewage-system levels in different areas, pathogen levels in water samples.
2. Analysis depending on the criteria and protocols defined based on the strategy to be used (anti-flooding or anti-CSD)..
3. Activation and notification of the strategy to be employed.

Fig. 10 - Flow diagram of the Barcelona KDSS.

Milestones of the iBATHWATER project in terms of the KDSS system

- **Reduction of the annual volume of overflows of untreated rainwater into the environment by 30%.**
- **Reduction of the pollutant load discharged into the environment during episodes of rain by 25%.**
- **Reduction of up to between 3 and 12.5 times the environmental and economic impact by using the iBATHWATER digital platform (KDSS) instead of building additional water tanks to achieve a reduction of 30%.**

6 Solid waste retention systems in Barcelona

To achieve the goal of **reducing the quantity of debris and floating solids discharged into the sea during episodes of intense rainfall**, as part of the iBATHWATER project, waste-trapping systems have been installed at the overflow points of the beaches of Barcelona. The system consists of a tilting metal structure with different hooks that can trap a large part of the solid waste circulating in the sewage system.

Fig. 10 - Solid-waste retention systems in combined sewer overflow points

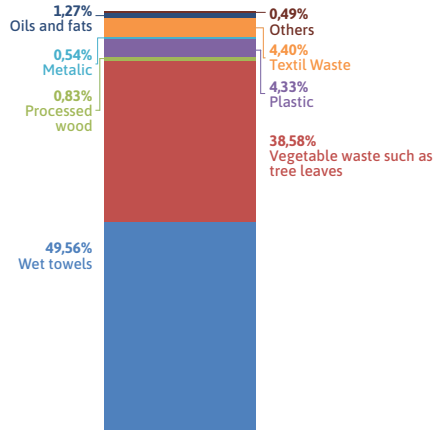


Fig. 11 - Characterization of the debris removed through the solid-waste retention systems on the Barcelona seafront during episodes of combined sewer overflow

Milestones of the iBATHWATER project in terms of retention of floating waste

- **Coverage of all of the overflow points on the beach seafront of Barcelona with waste-retention systems (prior to the project, only 2 of the 4 overflow points were covered).**
- **Installation of 49.5 linear meters of waste-trapping systems (with a total coverage of 147 meters).**
- **Retention of more than 230 m^3 of waste in 2021.**
- **Almost 50% of the waste collected on the beaches consisted of wet wipes.**
- **The results highlight the need to promote new awareness-raising campaigns on the correct use of wet wipes.**

The implications of the results of the project in terms of environmental policies at the European level

Many of the results obtained in the iBATHWATER project have major implications that must be taken into account when reviewing and/or proposing new or existing regulations in the environment in the framework of the European Union. For example: the water framework directive (2000/60/CE), the bathing water directive (2006/7/CE), and the directive on the treatment of urban wastewater (91/271/EEC).

Following are some of the results with legislative implications:

- The **aquaBio devices** provide quantitative values on the microbiological quality of the bathing water that agree with the laboratory results that use accredited quantification methods.

  They also provide daily information throughout the year, almost in real time (10-12 h at most, both river and sea), providing an opportunity to inform the public more frequently. Furthermore, they make it possible to monitor quality during short-duration pollution episodes and provide rapid knowledge of the expected time to regaining healthy levels.

- **The models of pollution spread** developed in both cities, together with the information from aquaBio, provide predictions of microbial quality at high spatial resolution.

- The **development and implementation of a decision-support system** in the management of the sewage system of a city like Barcelona can potentially reduce discharges by between 20% and 30% in volume.

- The **digital tools developed in the project** help with the holistic management of the sewage system and bathing waters.

- Major barriers to the broader use of these technologies for bathing water management include the strict reliance of the current BWD on laboratory results obtained via standard ISO methods. A new BWD directive should allow for more flexibility in cases where validated predictive models or alternative indicators and measurement methods have proven and been locally validated to achieve reliable results.

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