Report defining software and communication architecture for IT infrastructure deployment

Deliverable DB4.1

Real-time pollution-based control of urban drainage and sanitation systems for protection of receiving waters

Document Title : **LIFE RUBIES DB4.1 –**	
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Modifications (dates)
June 2022: Initial validated version

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2.1 Natural environment sensors (MEL – LASIRE)

2.1.1 Station D1

Station D1 on the Deûle canal was chosen as the upstream point of the MEL pilot site. The Guy Lefort and Café des fleurs sites are indeed located upstream of D1 but the discharges are located downstream. More precisely, D1 is located on the site of the Grand Carré lock Figure 1Figure 1 : Probable location of the cabin in D1 (Grand Carré lock). It will be located against the fence, at the corner., just upstream of the lock. It is a protected area owned by VNF and has a power supply. It will not be possible to work on the site on holidays and at night.

Figure 1 : Probable location of the cabin in D1 (Grand Carré lock). It will be located against the fence, at the corner.

At this station, an aluminum cabin (floor area: 2m2) has been ordered to house the following equipments:

1. an Exo 2 ISY multiparameter probe (O2, pH, T, turbidity and conductivity) with measurements every 10 minutes and a calibration procedure once a week. Note that turbidity and dissolved oxygen levels are measured with optical probes;

2. an ICON ammonium analyzer (Metrohm) based on spectrophotometric measurements with the use of reagents that will be recovered. It is planned to measure every 2 hours. The increase of the frequency of analysis during rainy weather was finally abandoned because a dependence on an internet connection was considered too error-prone. Moreover, the regularity of the measurements allows to better anticipate the consumption of reagents which are expensive and can degrade if they are prepared too long in advance. This analyzer was delivered in June 2022.

As soon as the cabin and the multiparameter probe are received (initially planned for May but postponed by the supplier to mid-September 2022), a small hydraulic circuit will be installed in the cabin to supply the analyzer and the probe with water from the Deûle River continuously.

D1 (as well as D2 and D3) is also considered for manual campaigns in dry weather (1 campaign per year) and in rainy weather (if possible 4 campaigns per year) with the deployment of passive samplers.

2.1.2 Station D2

Station D2 is located in a site belonging to the MEL and on which a pumping station is installed (station clos de l'abbaye) Figure 2.

Figure 2 : Location of the D2 station (clos de l'abbaye).

D2 was chosen because it is located downstream and not far from the set of stormwater overflows controlled by AQUADVANCED but upstream the WWTP and the confluence with the Marque. D2 is also powered by electricity and the LASIRE decided to locate its mobile laboratory there Figure 3.

Figure 3 : External view of the mobile laboratory of LASIRE located at the D2 station.

For this project, the following equipments are deployed:

- a multiparameter probe Manta (Eureka) [(O2, pH, T, turbidity and conductivity] Figure 4
- an ICON ammonium analyzer (Metrohm) Figure 4;
- our prototype filtering sampler FILEAU Figure 4 whose sampling will be slaved to the results of the multiparameter probe measurements in order to take samples, particularly during rainy weather. This servo-control is done using an algorithm developed previously (Mougin et al., 2022). The volumes collected by this sampler are of the order of about twenty mL;
- An automatic "large volume" Hach Lange sampler will also be installed and used occasionally for special needs, such as for the calibration of Chemcatcher which requires large volumes of water of the order of a liter. This sampler will not be linked to the results of the multiparameter probe.

Figure 4 : Apparatus deployed in the mobile laboratory for high frequency measurements: 1) an ammonium analyser; 2) a multi-parameter probe; and 3) the filtering sampler "FILEAU".

The first tests of monitoring started early June 2022, but one problem remains: the transmission of data and alerts via our 4G key regularly cuts out without the possibility of resetting it. Tests are underway for an alternative solution.

2.1.3 Station D3

Station D3 is located in a cabin belonging to VNF at the marina of Wambrechies Figure 5. It is kindly provided by VNF and is powered by electricity. As for station D1, an Exo 2 ISY multiparameter probe and an ICON ammonium analyzer (Metrohm) will be installed after setting up a water circuit. As in D1, the multiparameter probe is still not delivered so this point is not yet operational.

Figure 5 : Internal view of the D3 station (Marina of Wembrechies).

2.1.4 Stations M1 and M2

The wastewater treatment plant of Marquette-lez-Lille is included in the network control system of AQUADVANCED and is discharged into the Roubaix channel which extends the Marque River before its discharge into the Deûle River. It thus seemed relevant to add two monitoring stations: one upstream the treatment plant and a second one downstream the discharges (including the main discharge and the rainy water channel). The latter is located very close to the confluence with the Deûle, downstream of the Marquette lock. For these two stations, no power supply and cabin are available so that the monitoring will be different from the stations D1-D3. The measurement campaigns will last 4-5 days and passive samplers will be deployed on the 5 stations simultaneously, mainly during rainy weather (grab samples will also be taken at the beginning and end of the campaign). In this case, the issue will be the estimation of average concentrations (or even flows) of pollutants over the whole rainy event.

2.1.5 Transect between D1 and D3

The choice of the 5 monitoring stations is already very ambitious in terms of logistics and manpower. However, the spatial resolution is very limited and it seems relevant to us to carry out longitudinal profiles on the Deûle River between D1 and D3 to better understand the evolution of the water quality on a spatial scale of a hundred meters. To do this, VNF provides us a boat Figure 6 and two pilots to carry out these campaigns during which water samples are taken at strategic points (Figure 7 and Table 1). The multiparameter probe of the D2 station is also used for performing measurements every minute. It corresponds globally to approximately 120 measurements over 4 km of river. The first two campaigns carried out during dry weather have fully justified the relevance of the choice of the 5 monitoring stations (D1, D2, D3, M1 and M2) for the Rubies project. The results will not be discussed in this deliverable because some data are still being validated.

Figure 6 : boat belonging to VNF for the longitudinal profile campaigns and preparation of the sampling tubes.

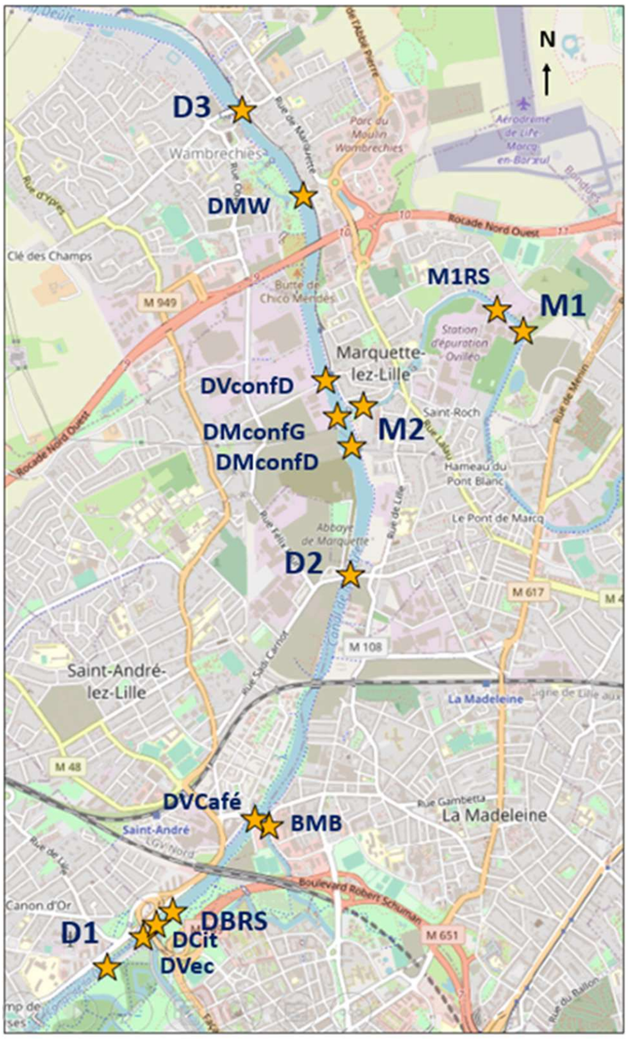


Figure 7 : summary of the sampling stations.

Table 1 : location of the stations sampled during the transects wit the boat.

Station	Description of the station	Latitude	Longitude
D1	VNF site: « Grand Carré » lock	50.647012	3.04397748
DVec	Station just downstream the lock	50.6486668	3.04719891
Dcit	Station close to « la Citadelle »	50.648905	3.047902
DBRS	Discharge of the stream « La Citadelle »	50.648773	3.047695
BMB	Discharge of the stream « Les bâteliers »	50.653802	3.056262
DVCafé	Station dowstream the discharge « Café de fleurs »	50.6541323	3.05517886
D2	Station at « Clos de l'abbaye »	50.665883	3.062423
DMconfD	Station upstream the confluence with the Marque river (left side)	50.6720713	3.06253248

DMconfG	Station upstream the confluence with the Marque river (right side)	50.6735041	3.06143484
DVconfD	Station downstream the confluence (right side)	50.6752408	3.0605517
D3	Station at Wembrechies (VNF cabin)	50.688226	3.054222
DMW	Station upstream Wembrechies marina	50.6841103	3.05885358
M1	Station uptream the WWTP (Marque River)	50.677606	3.075536
M1RS	Unknown discharge downstream M1 (Marque River)	50.677991	3.075112
M2	Station downstream the WWTP (including the rainwater discharge) (Marque River)	50.6739999	3.06341179

2.1.6 Data recovery and storage strategy

Data from the probes and ammonium analyzers will be stored on a field computer in csv (text) format. At each maintenance (once a week), a copy will be made for storage in the laboratory.

The data from the analysers present in the laboratory (ICP, Ion Chromatography...) will first be collected on a USB key in Excel format after validation.

All the data will then be recorded in a single file. For each measurement point, it will be specified: the date, time, duration (for passive samplers and the Hach Lange sampler) the time of withdrawal / end (for the passive samplers and the Hach Lange sampler), the GPS coordinates, the name of the site if existing and the type of monitoring [high frequency (probes and ammonium analyzer), transect, PS (passive sampler), AS (automatic sampling) and MS (manual sampling)]. Of course, the measured parameters and their values will also be recorded. The file will be regularly exported in csv format on the Rubies project sharepoint and accessible to all partners.

2.1.7 Bibliography

Jérémy Mougin, Pierre-Jean Superville, Cyril Ruckebusch, Gabriel Billon. Optimising punctual water sampling with an on-the-fly algorithm based on multiparameter high-frequency measurements. Water Research, IWA Publishing/Elsevier, 2022, 221, pp.118750. ⟨10.1016/j.watres.2022.118750⟩. ⟨hal-03715742⟩.

2.2 Network sensors (MEL – LYRE)

2.2.1 Implementation schedule of the measurement points

The installation of the quality sensors took place in August and September from 10/08/2022 to 30/09/2022 :

- 10/08/2022 : DO328-001 Café des Fleurs LAMBERSART
- 12/09/2022 : DO350-001 Bateliers LILLE
- 26/09/2022 : DO350-002 Maracci LILLE
- 09/29/2022 : PC527-001 Ste Hélène / Thiers SAINT-ANDRE-LEZ-LILLE
- 30/09/2022: PC527-002 Ste Hélène / Pasteur SAINT-ANDRE-LEZ-LILLE

2.2.2 Common characteristics of the measurement points

The characteristics of the installation are as follows:

Turbidity sensor, and its self-cleaning system:

The turbidity sensor was installed in a PVC protective pipe fixed to keep the probe away from the wall to ensure proper operation of the self-cleaning system brush.

The control box for the self-cleaning system of the turbidity sensor was attached to the ceiling of the weir chamber. The cleaning cycle is programmed every 6 hours. It will be adapted according to the quality of the data and the level of fouling of the sensor.

Conductivity sensor:

The conductivity sensor was installed in the same protective pipe

Large capacity battery:

The installation was carried out at the top of the manhole.

The large capacity of the battery allows the installation to be longer autonomous.

Recorder and its remote antenna :

The recorder was positioned on the upper part of the manhole, near the large capacity battery.

The antenna is placed as close as possible to the manhole cover in a pre-drilled hole with a diameter of 12 mm, and a depth of 34 cm.

Cable routing :

The cables were protected with a split wire loom tubing.

The cables were fixed every 30 cm or so with wall plugs and double-headed hose clamps.

Programming of the recorder :

The programming of the LOGGER has been done with the help of IJINUS - AVELOUR 6.9.5 software and WIJI module. The SIM card was installed and a GSM signal check was performed.

The data are then uploaded on an ftp server where the Topkapi supervision (CAURALI) retrieves them in order to allow a visualization of the graphs.

The parameters for local data recording are as follows:

- - Time step of 15 min - this time step will be changed to 5 min during the bi-monthly maintenance scheduled from 02/11/2022.
- - Sending data on supervision every 12 hours (12:00 and 00:00).

Turbidity sensor and self-cleaning system fixed on the PVC protective pipe

Conductivity sensor fixed on the PVC protective pipe

2.2.3 Point 1 - Café des fleurs – Weir 328-001 – Lambersart

Data logger and battery pack :

Battery pack and programmer for the turbidity probe self-cleaning system :

Sensors installed in the sewer:

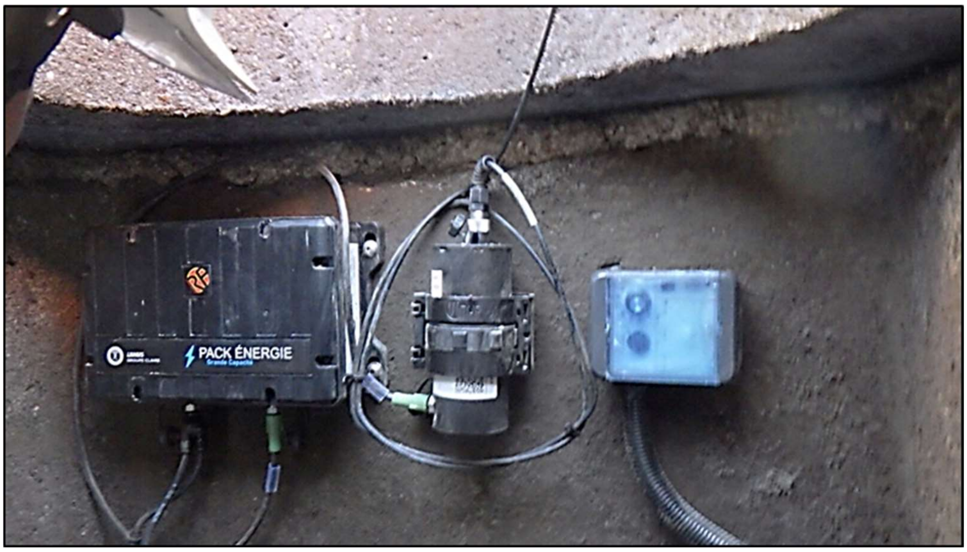
2.2.4 Point 3 - Ste Hélène Thiers – PC527-101 – Saint André

Data logger, battery pack and programmer for the turbidity probe cleaning system:

Sensors installed in the sewer:

2.2.5 Point 2 - Ste Hélène Pasteur – PC527-101 – Saint André

Data logger, battery pack and programmer for the turbidity probe cleaning system:



Sensors installed in the sewer:

2.2.6 Point 4 – Bateliers – Weir 350-001 – Lille

Data logger, battery pack and programmer for the turbidity probe cleaning system:

Sensors installed in the sewer:

2.2.7 Point 5 – Maracci – Weir 350-002 – Lille

Data logger, battery pack and programmer for the turbidity probe cleaning system:

Sensors installed in the sewer:

3 AQDV Deployment (3S)

3.1 IT Architecture

The implementation of the IT architecture around the application was co-constructed with the IT department of MEL and Suez Smart Solutions.

Aquadvanced is a centralized solution which is articulated around an application server and a storage server. It takes care of all the operations and the business processes required by a real time system: continuous validation, specific calculations, management of the hydrological and hydraulic models, processing of the forecast data, detection of events, generation and diffusion of alerts.

The central platform is composed of 3 sets:

- A database storage server that stores both the configuration and the data.
- A real-time application server to ensure the continuous operation of the application.

A set of client applications (HTML5) to both process data and configure the system.

All the logical machines presented above are hosted on physical servers managed by the MEL information service.

In order to ensure continuity of service of the application in production, a pre-production instance of Aquadvanced UD is installed on the same server as the production one. This allows for testing before updating the production instance of Aquadvanced UD.

Below is the Table 2 of flows necessary for the AQDV application and the Figure 8 is a schematic representation of the flow.

Table 2 : IT flow chart

	Root	Target
Topkapi reading	IP address of the Aquadvanced application server	IP address of the Topkapi server
Topkapi writing	IP address of the Aquadvanced application server	IP address of the Topkapi server
Map backgrounds	OpenStreetMap Map Tile Servers a.tile.openstreetmap.org b.tile.openstreetmap.org c.tile.openstreetmap.org	User client stations
Sending alarms by e-mail (optional)	IP address of the Aquadvanced application server	SMTP server IP address
Consultation of user accounts in the company directory	LDAP directory server	IP address of the Aquadvanced application server

	Root	Target
5 min radar precipitation data + Mid-term forecast data **METEO France**	Local FTP server	IP address of the Aquadvanced application server
Remote maintenance	SUEZ Smart Solutions computer (via internet)	IP address of the Aquadvanced application server
	SUEZ Smart Solutions computer (via internet)	Adresse IP du serveur de base de données.

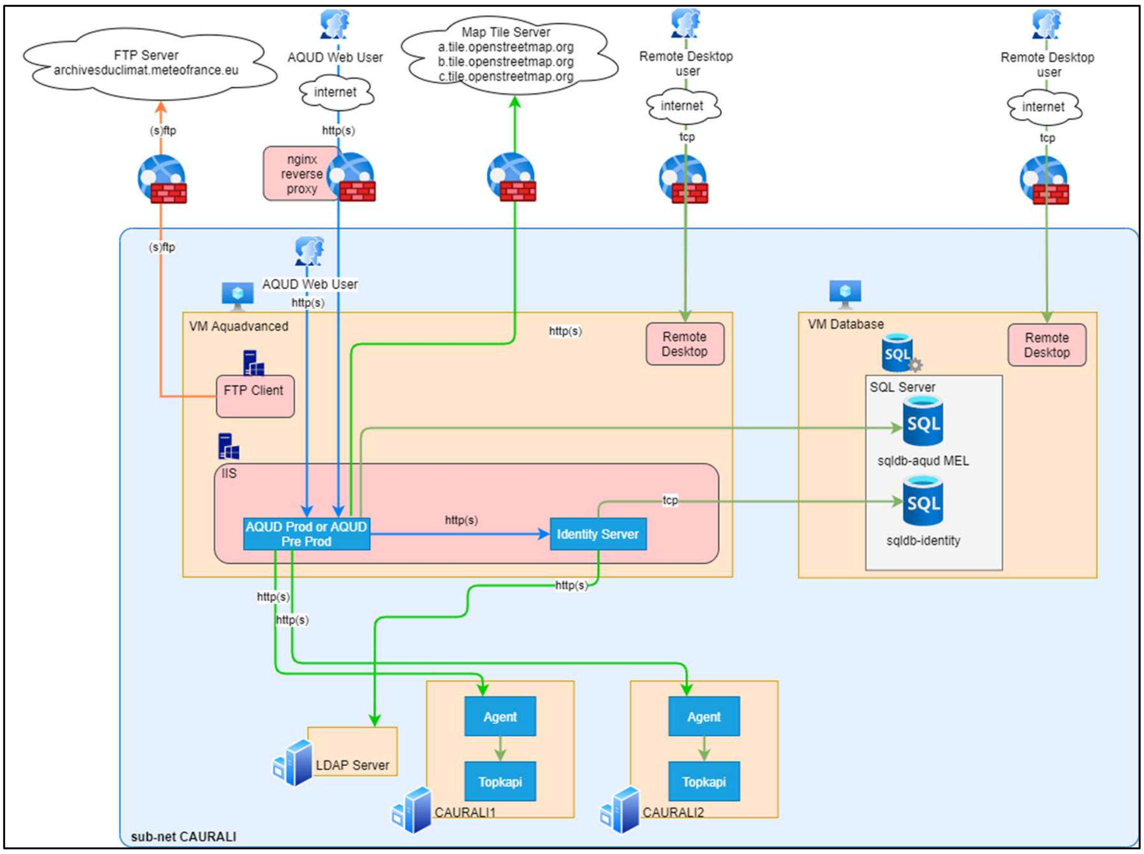


Figure 8 : IT schematic flow

3.2 Weather data connexion

3.2.1 Radar Data

The meteorological radar data are provided by the company MétéoFrance.

The data are spatialized and have a temporal resolution of 5 minutes and a spatial resolution of 1 km x 1 km. The scope of the spatialized data will cover the whole territory of the MEL.

They will be made available by MeteoFrance with a maximum delay of +8 minutes.

3.2.2 Rain gage Data

In addition to the radar data and as stated in DA1.3, MEL will provide weather data from 8 rain gage spread across the study area. These data will be used mostly for calibration purpose and retrospective analysis.

3.2.3 Connexion

Radar data will be pushed by MétéoFrance on the dedicated FTP server hosted by the MEL.

Rain gage data will be read by AQDV UD as well as all other MEL Sensor through a Topkapi connexion and an exchange table system. Following table is an extract of the exchange table for 5 raingage on Cauralie1 MEL Server.

Table 3: Raingage variable exchange table

Variable (mnémonique)	TYPE	Transmission	Commentaires
P04.DEFAULTCALL	BOOL	API → TPK → PC	Défaut comm Pluvio Quesnoy
P04.PLUVIO.PRECIPITATION_CUMUL	REEL	API → TPK → PC	Index Pluvio Quesnoy
P08.DEFAULTCALL	BOOL	API → TPK → PC	Défaut comm Pluvio Marquette
S26.PLUVIO.PRECIPITATION_CUMUL	REEL	API → TPK → PC	Index Pluvio Marquette
P11.DEFAULTCALL	BOOL	API → TPK → PC	Défaut comm Pluvio Lille
P11.PLUVIO.PRECIPITATION_CUMUL	REEL	API → TPK → PC	Index Pluvio Lille
P12.DEFAULTCALL	BOOL	API → TPK → PC	Défaut comm Pluvio Lomme
P12.PLUVIO.PRECIPITATION_CUMUL	REEL	API → TPK → PC	Index Pluvio Lomme
P14.DEFAULTCALL	BOOL	API → TPK → PC	Défaut comm Pluvio Lezennes
P14.PLUVIO.PRECIPITATION_CUMUL	REEL	API → TPK → PC	Index Pluvio Lezennes

Due to a recent change in format used by MétéoFrance, a new connector will be developed in early 2023 in order to use and display radar data in AQDV UD. Meanwhile, Rain gage data will be used to perform real-time analysis with the hydrological model.

The two weather sources will be displayed in AQDV UD weather view as well with KPI indicators and early warning in case of extreme rain event.

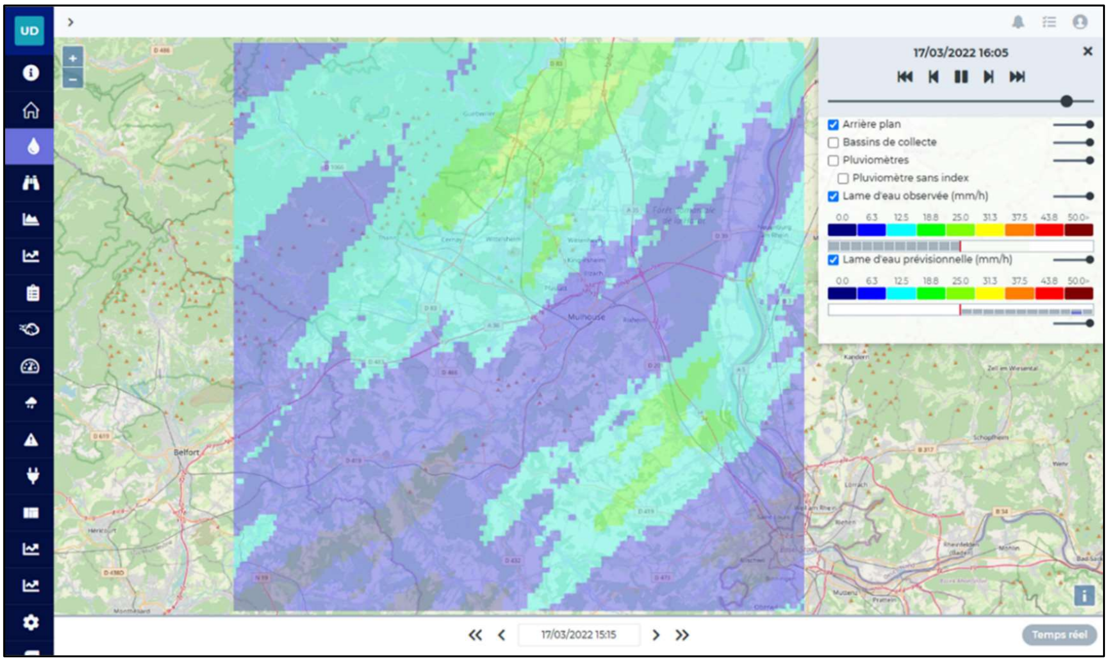


Figure 9: Screenshot of AQDV UD weather view

3.3 Hydraulic model connexion

At each calculation cycle, AQUADVANCED UD® is in charge of preparing the data input of the models, launching the simulation over the period corresponding to the real time and extracting the results. In order to ensure continuous operation of the calculation chain, the system integrates all hot restart mechanisms (preservation of previous conditions to limit the initialization period).

AQDV UD solution is composed of two different model directly integrated in the application:

- One hydrological model that converts rain into flow by considering meteorological conditions. Theses conditions will be ascertained by radar data and rain gage data.
- One hydraulic model to represent flow condition at all points in the network. This simulation will automatically be updated with the latest configuration set for each equipment (valve position, number of pump activated…) from MEL Caurali servers through Topkapi connector.

After a cycle of simulation for the hindcast time, AQDV UD will run a hydraulic analysis and select a strategy to apply to the system based on a decision tree. Then, it will perform a second simulation on forecast time with new settings for each controlled site based on the applied strategy.

These new settings will then be uploaded to each controlled site through Topkapi connector and Caurali Network system.

3.4 Mass-Volume curve-based controller module connection to Aquadvanced (LYRE / 3S)

Every 5 minutes, Aquadvanced® performs the sequencing of the quality and hydraulic simulations. This sequence will also include the provision of data needed by quality controller through Python® scripts. The whole sequencing is described in the deliverable DB2.1

The following paragraph describes the data needed by the quality controller and provided by Aquadvanced to execute the MV curve approach.

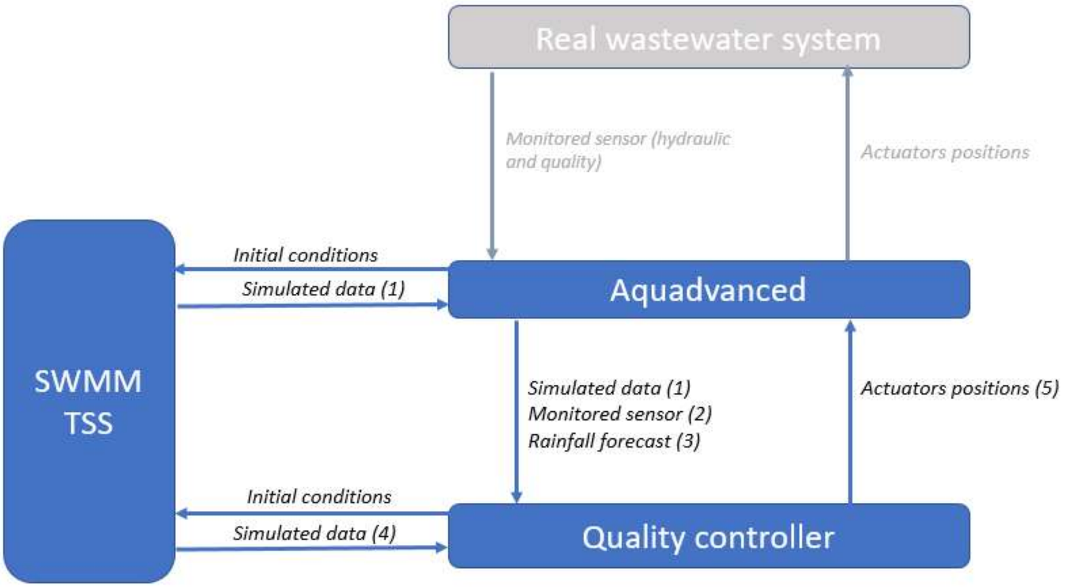


Figure 10 - Block diagram of closed-loop simulation scheme and integration with AQDV UD

Quality control of the sewage system is relevant when water discharge is unavoidable. Otherwise, the objective is to store the entire volume to avoid spills.

The controller aims to fill the tank during the highest peaks of the TSS flux. To capture such peaks, the controller predicts the MV curve at an upstream pipe of the tank. To calculate the MV curve, the controller needs some hydraulic and quality parameters simulated by SWMM TSS (1) in order to calculate the MV curve :

- flow in pipes, pumps, orifices, weirs, outlet, outfalls…
- Volume in storage units
- TSS in pipes, nodes, tanks…

This curve is first split in various Control Time Intervals (CTIs). The controller can identify the CTIs with the highest increases of load versus volume, corresponding to the sharpest gradients of the MV curve.[1]

The real current conditions in the sewer system (2), such as water level in the tank, allows to know the remaining capacity in each tank. Once the CTIs are defined and ranked from the MV curve, the controller tries to fill the tank as much as possible following the ranking order until the tank is full. In addition, the controller takes into account the precipitation forecast (3) to optimize the control of the storage units (filling and emptying).

When the tank is full (data given by monitored sensor (2)), and if other TSS peaks are predicted in the future (3), the algorithm compares the simulated TSS in the tank and in the pipe upstream the tank (predicted by SWMM TSS (4)). If the water quality is better in the tank than in the pipe, then the tank is drained to fill it with the worst quality water coming from the pipe.

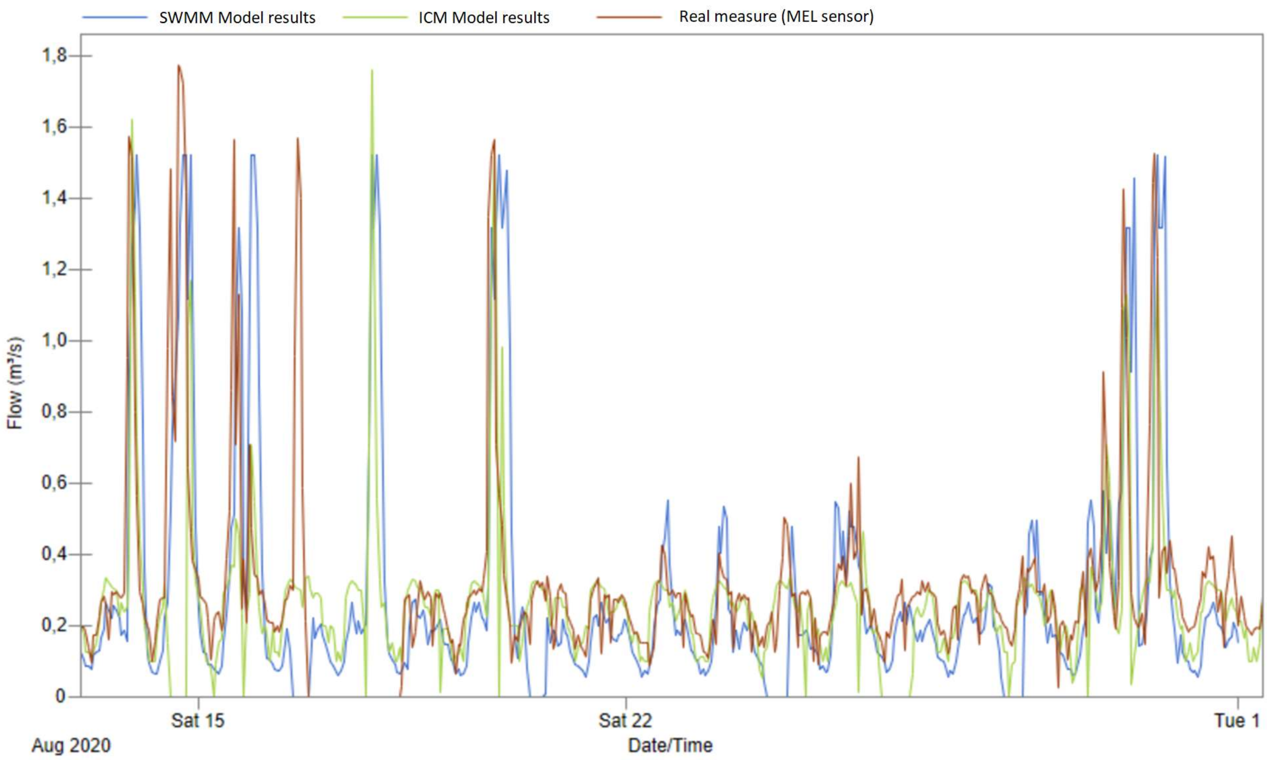
Finally, the controller provides to Aquadvanced actuators positions of regulated items (5) and other additional data to display quality controller results in the Aquadvanced interface.

3.5 Hydraulic, hydrology and quality model calibration (3S)

AQDV solution is based on SWMM as simulation software. Therefore, first step was to translate the Infoworks model to SWMM. All characteristics, patterns, curves, etc. were checked to be sure that they matched previous model and reality (based on GIS and other source).

The provided model was supposed to be already calibrated hydraulically. Second step was to ensure that the SWMM model is a good depiction of the real hydraulic situation by comparing model results with real measures and ICM model on key point. This analysis was done on two different period March-April 2020 and July-August 2020 to check the ability to reproduce the reality in different hydrological context. Following figure illustrate this analysis on one of the key point : Batelier West Side pump in August (Blue : SWMM, Green : ICM, Red : Real measure).

[1] For more details on the MV curve approach, please refer to the report DA1.1, section 3.4



Globally, the translation was good enough and didn't require any major update. All curves for each key point and both period analyzed were provided to MEL. On October 26, MEL did validate the SWMM Model calibration and hydraulic-hydrologic model was soon after put online on AQDV application.

Existing model was not calibrated on quality component, this will be fully treated separately when all sensors will be setup in the incoming month.

3.6 Hydraulic analysis for decision tree building and control principle

MEL network is mostly a combined sewer type where wastewater and rainwater are flowing in the same pipe. All pipes are designed to handle a specific flow of sewage plus rainwater based on rain with specific duration and intensity that can stagger from a month to a 10-year return period probability. The overall network design is also induced downstream by the Wastewater Treatment Plant (WWTP) hydraulic capacity.

Marquette WWTP is composed of two different treatment line:

- A biological treatment line with a maximum flow of 2.8 m3/s.
- A stormwater treatment line with a maximum flow of 5.3 m3/s.

In addition, European Standard NF-EN-752 prescribe to design network (pipe and storage) to reduce flood frequency depending on urbanization density of the area:

- Rural area: 1 flood every 10 years
- Residential area: 1 flood every 20 years
- City center, Industrial and shopping area: 1 flood every 30 years
- Specific transport (car, train) key underground asset area: 1 flood every 50 years

Any rain with a higher intensity than the one chosen for pipe design will generate more water than what can be conveyed to the wastewater treatment plant. To prevent any flood in the street and respect the European Standard some storm overflow weirs are spread across the city to discharge excessive water flow into the river or specific rainwater network. To mitigate impact of such discharge on natural environment, storage basin and other civil engineering construction can be built.

The Hydraulic design and management of such network is often split into 5 different phases called "Level of services" based on weather as stated in the ASTEE Guide:

- Level 0 - Dry Weather: Only sewage water flow in pipes. All water is routed to the WWTP.
- Level 1 - Light Rain (rain with duration or intensity far below the rain used to designed network capacity -usually 1 month to 1 year rain-): wastewater and rainwater are mixed, and all flow are routed to the WWTP. No overflow is allowed but water can be stored in stormwater basin to prevent it. Main objective of this level is to protect natural environment.
- Level 2 - Medium Rain (rain with duration or intensity equal the rain used to designed storage capacity - usually 2 to 5 years -): wastewater and rainwater are mixed, and all flow are routed to the WWTP. Most pipes operate at full section flow and some overflow can occurred when stormwater basins are full.
- Level 3 - Heavy Rain (characteristics exceeding the design rain - up to 20 years-): Network and storage are at full capacity and water is discharged by security-overflow weir of stormwater basin and all network weirs. Overflow on streets by manhole or road drain can locally occurred but shall be limited. Main objective of this level is to protect goods (car, real estate) and maintain public services.
- Level 4 - Exceptional rain event (50-100 years period return): at this stage, network contribution to drain the rainwater is minor as most of the flow is run-off water on surface and start to become a major threat to goods and people (more than 50cm of water depth in the street induce floating car and prevent safe pedestrian evacuation). This level of design shall only be considered if major civil engineering structure such as discharge dam, dike or large rain/river pumping station exist on the study area.

Rain return period and threshold between each level is always a political decision that should consider the probability and hazard of each rain event versus funds necessary to mitigate the risk for Natural environment, goods, and people.

Our proposed strategy will be based on these management phases and network capacities.

3.7 Quality analysis for decision tree building control principle (LYRE)

As a reminder, the quality approach only makes sense when rainfall forecasts are significant enough to cause discharges into the natural environment.

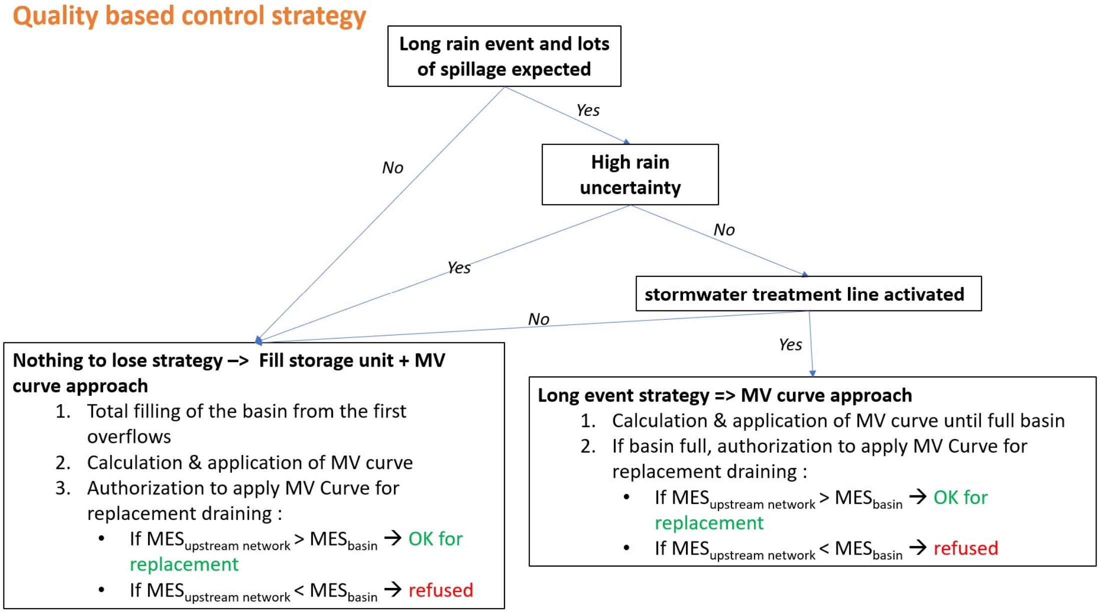
As long as spills can be avoided, the hydraulic approach will be activated to avoid generating spills. On the other hand, when spills appear to be inevitable, then quality control will select the periods to be stored by seeking to minimize the mass of pollution to be spilled.

This quality-based approach needs to be adapted to the context of each pilot site. It must also take into account the possible uncertainties linked to precipitation forecasts. The diagram below shows the adaptation of the MV curve approach for the Guy Lefort basin.

Depending on the rainfall forecasts, their uncertainties but also on the state of the stormwater treatment line in the WTP, it could be decided to fill the basin completely or not before applying the MV curve rules. Thus, in case of high uncertainty on future discharges, it will be ensured that a minimum volume will be discharged into the natural environment. Then, the MV curve algorithm will be applied and will select the volumes to be stored according to their degree of pollution. If the basin is full, then it will compare the concentration of TSS stored in the basin with the expected discharge volume. If the pollution in the network is more important than the pollution in the basin, then the controller will apply a volume replacement instruction. The volume of the basin, less polluted, will be discharged into the natural environment to store the volume of the more polluted network.

This approach will also be adapted to the context of the Batelier basin in the coming months

Quality based control strategy



3.8 Synoptic

Synoptic schematic is the showcase of this project as well as the first visual displayed when the AQDV Application is open. Its importance is very high, and an iterative process took place to produce a final shot with desired features:

- A geographic-based map: respect asset position in the synoptic map, remarkable landmark and river network displayed to help understanding.
- Main network asset easily spotted: WWTP, Bâtelier and Guy Lefort Tank are 3D rendered. Main Pumping station name are displayed with their names.
- Display of all sensor information and controlled asset state needed for technical operation.

Based on these features, we decided to use two level of synoptic supervision:

- Level 1 - Overview: Main view need to display all managed network and allow a quick understanding of network state with a clear display of tank level, Flow at key point and gate position.
- Level 2- Zoom-in - Tank view: two specific views for Bâtelier and Guy Lefort Tank in 3D with every controlled asset state (gate, pump) and sensor (level, flow, quality) displayed.

Following figures display the principal synoptic map and Bâtelier synoptic view to illustrate both type of view.

{Insert last version of synoptic here}

3.9 Operating principle of the controlled sites

3.9.1 Calculation of strategies

3.9.1.1 Objectives of the strategies

The management strategies have been defined in order to meet the following 2 major objectives:

- Protection of the aquatic environment, by avoiding spills during dry weather or low and medium rainfall by optimizing the filling of the storage facilities
- Protection of properties and people, by avoiding overflows and by securing the structures.

In order to reach these objectives, nine strategies have been defined, in connection with the treatment capacities of the wastewater treatment plant.

Below, the Table 4 present the strategies and their objectives.

Table 4 : Definition of strategies and their objectives

Strategy	Hydrometeorological and hydraulic conditions	Objectives	Quality objectives
Dry weather	Dry weather inputs or low rainfall	No spill / Optimized operation of pumping stations / No storage in the tanks	Keep all the polluted flow
Non saturated WWTP rainy weather process (< 5.3 m3/s)	Rainy weather conditions. Rainy weather process is not saturated.	No spill / Saturation of the pumping station / Saturate the WWTP dry weather process / Solicit storage tank capacity	Replacement of the less polluted stored flow by a more polluted incoming flow Prioritization of inputs between the "Guy Lefort" branch and the "Batelier" branch
Saturated WWTP rainy weather process (> 5.3 m3/s)	Rainy weather conditions. Rainy weather process is saturated.	Avoid spill / Saturation of the pumping station / Saturation of the wet weather process / Storage tank capacity requested	Replacement of the less polluted stored flow by a more polluted incoming flow Prioritization of inputs between the "Guy Lefort" branch and the "Batelier" branch
Heavy rainy weather - Spill	Heavy rainy weather conditions. Situation where the pumping stations are saturated and all the storage volumes have been solicited or can no longer be solicited	Avoid spill / Saturation of the pumping station / Saturation of the wet weather process / Storage tank capacity requested / Limitation of spills and prioritization according to the least polluted flows	Replacement of the less polluted stored flow by a more polluted incoming flow Prioritization of inputs between the "Guy Lefort" branch and the "Batelier" branch

Achieving these objectives, requires calculating in real time the various indicators that allow us to ensure the right choice of management strategy.

3.9.1.2 Indicator definition and tree decicions

The indicators are used to define the most appropriate strategy according to the current and future state of the wastewater system. These indicators are continuously calculcate by the system.

All the indicators used in the decision trees are presented in the following Table 5:

Table 5 : Indicators used to choose the optimal strategy

Indicators	Objectives
Saturation of Rainy weather process	Know and anticipate the capacity situation of the WWTP
Weather context	Evaluate the future meteorological situation
Spill	Know the condition of the network

The decision trees are calculated every 5 minutes or on variation of the indicators presented above.

The following Figure 11 shows an example of a decision tree used by the system.

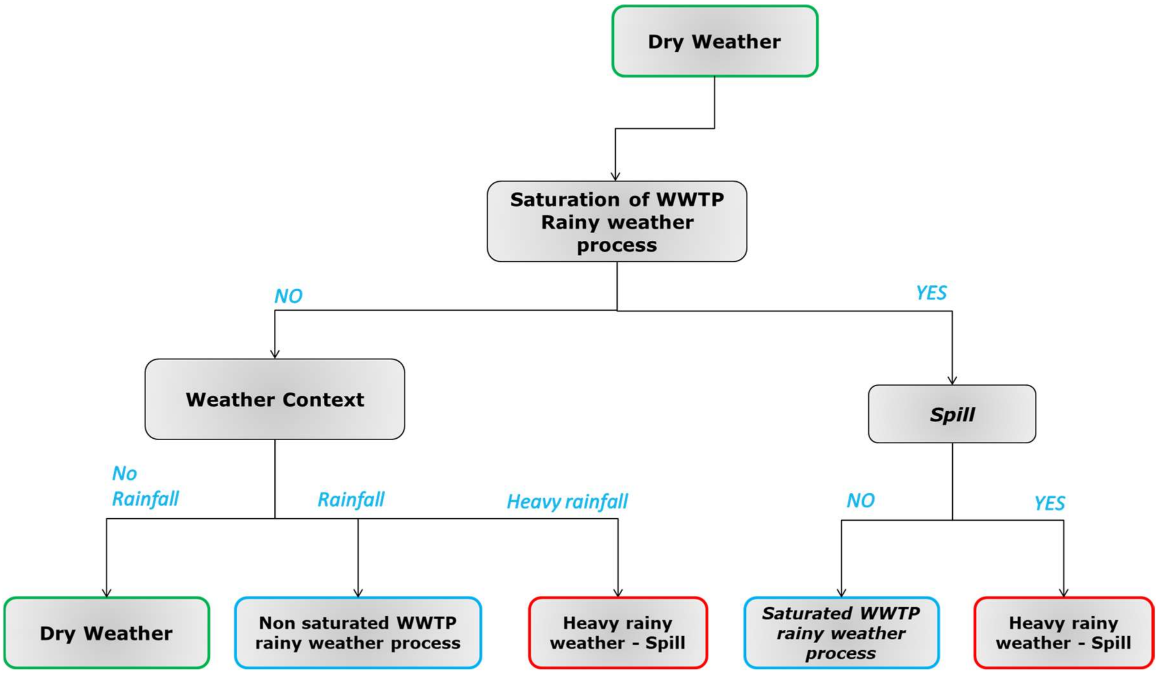


Figure 11 : Example of a tree decision

3.9.2 Operating principle of the controlled sites

The objective of this part is to define all the operating principles defined by the AQDV solution.

To understand the operation of the equipment, it is necessary to define the metrology in place and the local control rules that are applied.

3.9.3 Storm water Tank Guy Lefort

3.9.3.1 Instrumentation diagram

Below the Figure 12 is the instrumentation diagram of the Guy Lefort storm water tank.

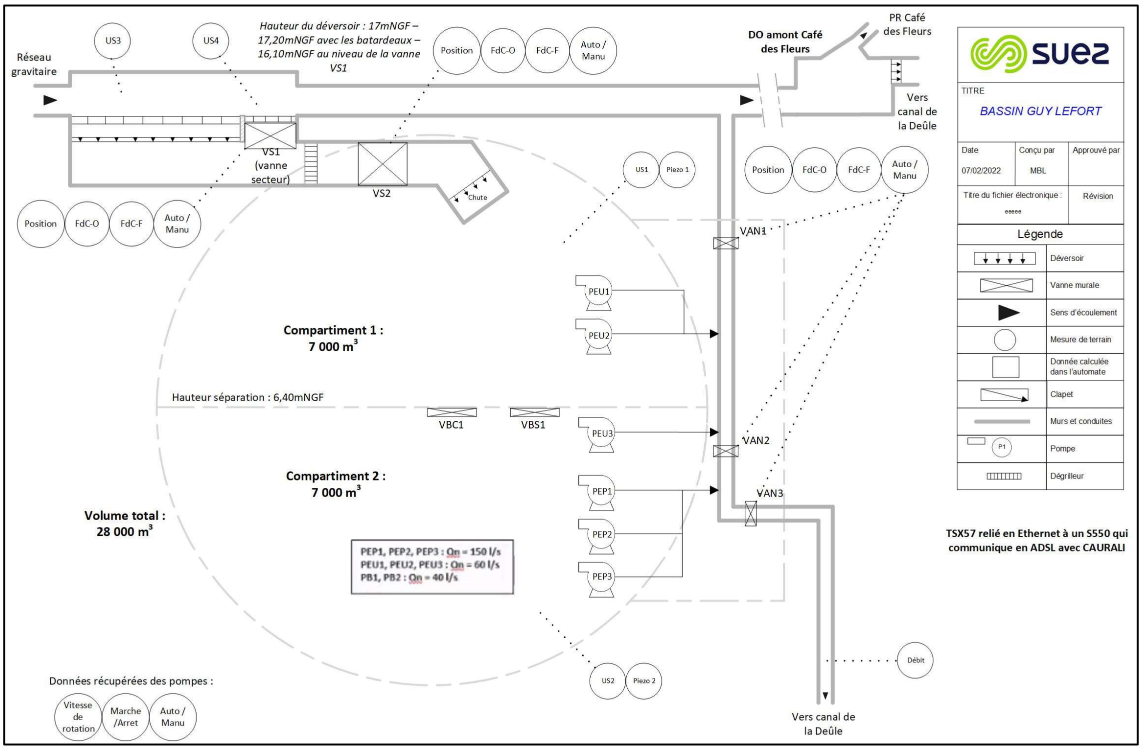


Figure 12 : Instrumentation diagram of Guy Lefort storm water tank

All the information symbolized by a circle, are variables that are used by AQDV application, and which are used either to calculate indicators or to control the equipments.

3.9.3.2 Exchange table

Below the Table 6 is an example of the exchange table of the Guy Lefort storm water tank.

Table 6 : Example of an exchange table on Guy Lefort storm water tank

Variable (mnémonique)	TYPE	Transmission	Commentaires	Contrôle cohérence
MESURES Possibilité pour les niveaux d'avoir l'unité en m simple (retirer « NGF»)				
B47.C1.NIVEAU_NGF_US1	Real	Topkapi → AQDV	Hauteur US1 compartiment 1	Configuré
B47.C1.M_US1	Boolean	Topkapi → AQDV	Défaut US1	Configuré
B47.C1.NIVEAU_NGF_SP1	Real	Topkapi → AQDV	Hauteur Piezo1 compartiment 1	Configuré
B47.C1.M_SP1	Boolean	Topkapi → AQDV	Défaut Piezo 1	Configuré
B47.C2.NIVEAU_NGF_US2	Real	Topkapi → AQDV	Hauteur US2 compartiment 2	Configuré
B47.C2.M_US2	Boolean	Topkapi → AQDV	Défaut US2	Configuré
B47.C2.NIVEAU_NGF_SP2	Real	Topkapi → AQDV	Hauteur Piezo2 compartiment 2	Configuré
B47.C2.M_SP2	Boolean	Topkapi → AQDV	Défaut Piezo 2	Configuré
B47.DEVERSOIR.NIVEAU_NGF_US3	Real	Topkapi → AQDV	Hauteur US3 collecteur	Configuré
B47.DEVERSOIR.M_US3	Boolean	Topkapi → AQDV	Défaut US3	Configuré
B47.DEVERSOIR.NIVEAU_NGF_US4	Real	Topkapi → AQDV	Hauteur US4 collecteur	Configuré
B47.DEVERSOIR.M_US4	Boolean	Topkapi → AQDV	Défaut US4	Configuré

The exchange table is the link between the application and the supervision. It lists all the available variables and their properties.

3.9.3.3 Control-principle

The control principle is the declination of the strategy for the piloting of the equipment of the controlled site.

In the case of Guy Lefort, the control principle is applied on:

- The wastewater pumps of compartment 1, which allow the emptying of compartment 2 according to an operating mode based on the different scenarios integrated in the PLC program
- The wastewater and rainwater pumps in compartment 2, which allows to empty the compartment 2 according to an operating mode based on the different scenarios integrated in the PLC program
- The filling gate installed at the inlet of the storm tank is used to regulate the level upstream, to maintain the flow, and to regulate the level into the storm tank, to optimize its filling.

The Table 7 shows the different operating modes assigned according to the strategy.

Table 7 : Example of operating modes according to the strategy

	Controlled site		
	Guy Lefort		
Strategy	Pumps Compartment 1	Pumps Compartment 2	Filling Gate
	PEU 1 / PEU 2	PEU3 / PEP1 / PEP2 / PEP3	VS1
Dry weather	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Closed at 0%
Non saturated WWTP rainy weather process (< 5.3 m3/s)	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Upstream level control at 16.5m IGN
Saturated WWTP rainy weather process (> 5.3 m3/s)	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Downstream level control at 4.5 m IGN in Compartment 2
Heavy rainy weather - Spill	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Downstream level control at 4.5 m IGN in Compartment 2

3.9.4 Storm water Tank Bâtelier

3.9.4.1 Instrumentation diagram

Below the Figure 12 is the instrumentation diagram of the Bâtelier storm water tank.

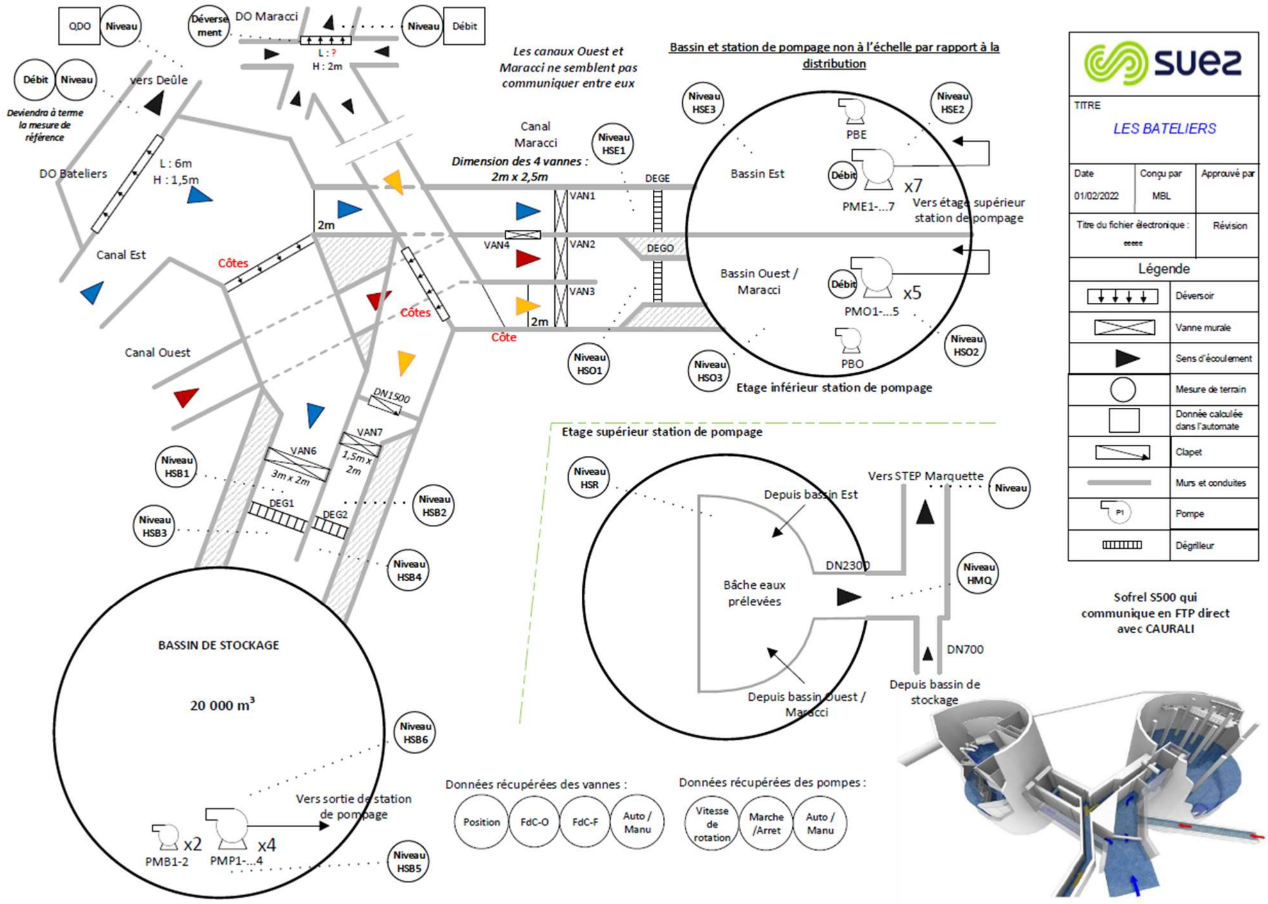


Figure 13 : Instrumentation diagram of Bâteliers storm water tank

All the information symbolized by a circle, are variables that are used by AQDV application, and which are used either to calculate indicators or to control the equipments.

3.9.4.2 Exchange table

Below the table 8 is an example of the exchange table of the Bâtelier storm water tank.

Table 8 : Example of an exchange table on Bâteliers storm water tank

Variable (mnémonique)	TYPE	Transmission	Commentaires	Contrôle cohérence
MESURES				
BC1.PLC1.NIV_HSB1	Real	Topkapi → AQDV	Niveau HSB1 (mIGN69)	Config
BC1.PLC1.DEF_IW3_4	Boolean	Topkapi → AQDV	Défaut niveau HSB1	Config
BC1.PLC1.NIV_HSB2	Real	Topkapi → AQDV	Niveau HSB2 (mIGN69)	Config
BC1.PLC1.DEF_IW3_6	Boolean	Topkapi → AQDV	Défaut niveau HSB2	Config
BC1.PLC1.NIV_HSB3	Real	Topkapi → AQDV	Niveau HSB3 (mIGN69)	Config
BC1.PLC1.DEF_IW3_5	Boolean	Topkapi → AQDV	Défaut niveau HSB3	Config
BC1.PLC1.NIV_HSB4	Real	Topkapi → AQDV	Niveau HSB4 (mIGN69)	Config
BC1.PLC1.DEF_IW3_7	Boolean	Topkapi → AQDV	Défaut niveau HSB4	Config
BC3.PLC3.NIV_HSB5	Real	Topkapi → AQDV	Niveau HBS5	Config
BC3.PLC3.DEF_IW3_0	Boolean	Topkapi → AQDV	Défaut niveau HSB5	Config

The exchange table is the link between the application and the supervision. It lists all the available variables and their properties.

3.9.4.3 Control-principle

The control principle is the declination of the strategy for the piloting of the equipment of the controlled site.

In the case of Bâtelier, the control principle is applied on the number of maximum pumps allowed to start for East and West compartment:

- When dry weather WWTP is saturated as we are looking to store additional rainwater in storage to prevent the wet weather WWTP to be activated
- In all other weather context, Bâtelier is considered as high priority other regulated site and will pump at max capacity based on the admissible flow at WWTP
- The table 9 shows the different operating modes assigned according to the strategy.

Table 9 : Example of operating modes according to the strategy

	Controlled site		
	Guy Lefort		
Strategy	Pumps Compartment 1	Pumps Compartment 2	Filling Gate
	PEU 1 / PEU 2	PEU3 / PEP1 / PEP2 / PEP3	VS1
Dry weather	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Closed at 0%
Non saturated WWTP rainy weather process (< 5.3 m3/s)	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Upstream level control at 16.5m IGN
Saturated WWTP rainy weather process (> 5.3 m3/s)	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Downstream level control at 4.5 m IGN in Compartment 2
Heavy rainy weather - Spill	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Downstream level control at 4.5 m IGN in Compartment 2

3.9.5 Pumping station Café des fleurs

3.9.5.1 Instrumentation diagram

Below the Figure 12 is the instrumentation diagram of the Café des fleurs storm water tank.

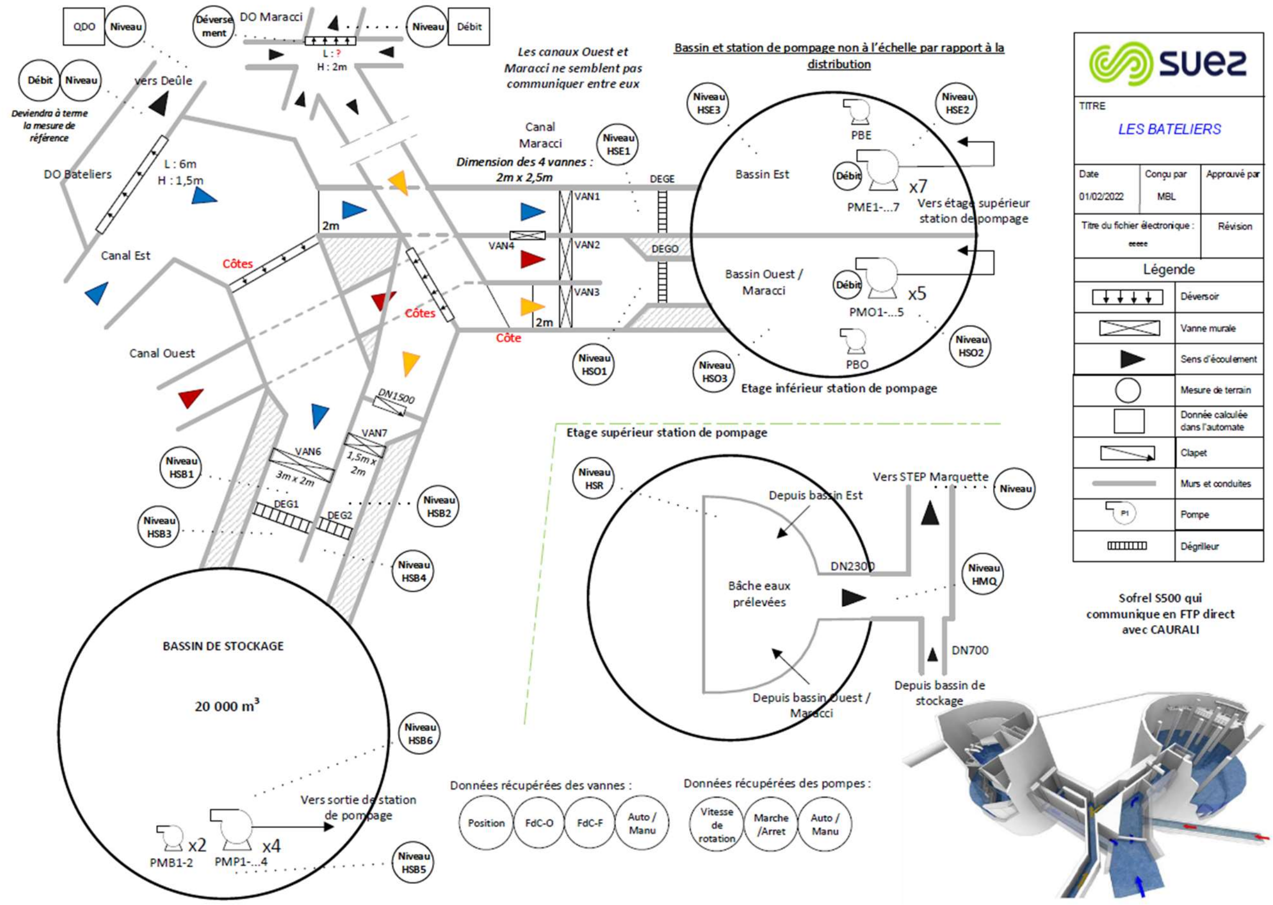


Figure 14 : Instrumentation diagram of Café des fleurs storm water tank

All the information symbolized by a circle, are variables that are used by AQDV application, and which are used either to calculate indicators or to control the equipments.

3.9.5.2 Exchange table

Below the Table 6 is an example of the exchange table of the Café des fleurs storm water tank.

Table 10 : Example of an exchange table on Café des fleurs storm water tank

Variable (mnémonique)	TYPE	Transmission	Commentaires	Contrôle cohérence
MESURES				
BC1.PLC1.NIV_HSB1	Real	Topkapi → AQDV	Niveau HSB1 (mIGN69)	Config
BC1.PLC1.DEF_IW3_4	Boolean	Topkapi → AQDV	Défaut niveau HSB1	Config
BC1.PLC1.NIV_HSB2	Real	Topkapi → AQDV	Niveau HSB2 (mIGN69)	Config
BC1.PLC1.DEF_IW3_6	Boolean	Topkapi → AQDV	Défaut niveau HSB2	Config
BC1.PLC1.NIV_HSB3	Real	Topkapi → AQDV	Niveau HSB3 (mIGN69)	Config
BC1.PLC1.DEF_IW3_5	Boolean	Topkapi → AQDV	Défaut niveau HSB3	Config
BC1.PLC1.NIV_HSB4	Real	Topkapi → AQDV	Niveau HSB4 (mIGN69)	Config
BC1.PLC1.DEF_IW3_7	Boolean	Topkapi → AQDV	Défaut niveau HSB4	Config
BC3.PLC3.NIV_HSB5	Real	Topkapi → AQDV	Niveau HBS5	Config
BC3.PLC3.DEF_IW3_0	Boolean	Topkapi → AQDV	Défaut niveau HSB5	Config

The exchange table is the link between the application and the supervision. It lists all the available variables and their properties.

3.9.5.3 Control-principle

The control principle is the declination of the strategy for the piloting of the equipment of the controlled site.

In the case of Café des fleurs, the control principle is applied on:

- The wastewater pumps of compartment 1, which allow the emptying of compartment 2 according to an operating mode based on the different scenarios integrated in the PLC program
- The wastewater and rainwater pumps in compartment 2, which allows to empty the compartment 2 according to an operating mode based on the different scenarios integrated in the PLC program
- The filling gate installed at the inlet of the storm tank is used to regulate the level upstream, to maintain the flow, and to regulate the level into the storm tank, to optimize its filling.
- The Table 7 shows the different operating modes assigned according to the strategy.

Table 11 : Example of operating modes according to the strategy

	Controlled site		
	Guy Lefort		
Strategy	Pumps Compartment 1	Pumps Compartment 2	Filling Gate
	PEU 1 / PEU 2	PEU3 / PEP1 / PEP2 / PEP3	VS1
Dry weather	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Closed at 0%
Non saturated WWTP rainy weather process (< 5.3 m3/s)	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Upstream level control at 16.5m IGN
Saturated WWTP rainy weather process (> 5.3 m3/s)	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Downstream level control at 4.5 m IGN in Compartment 2
Heavy rainy weather - Spill	Sending a number that corresponds to the local management scenario to be activated	Sending a number that corresponds to the local management scenario to be activated	Downstream level control at 4.5 m IGN in Compartment 2

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