Abdelhafid University Center Bousouf - Mila

2024-2025 Semester 1

Water distribution and collection:

HAS PART I: DRINKING WATER SUPPLY

– Lesson 5 –

Chapter 05 : *Design and sizing of distribution networks.*

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Course Objectives 5

The objective of this chapter is to present the principles and tools of modern management of drinking water supply networks, emphasizing the contribution of remote management systems. The student should understand:

- The challenges linked to the optimal operation of drinking water supply networks (quality, continuity, performance, costs),
- Classical management methods and their limits,
- The role of remote management in supervision, control and maintenance,
- The benefits in terms of efficiency, safety and sustainability.

V.1 Introduction

The management of drinking water supply networks is a strategic issue to ensure a reliable, continuous service that meets quality standards. Traditionally, it relies on a demanding human and technical organization, mobilizing monitoring and intervention resources that are often costly and reactive.

Changing needs, increasing water demand, and environmental and economic constraints require new, more efficient approaches. **Remote management** is emerging as a modern solution enabling real-time monitoring, resource optimization, loss reduction, and better incident management.

Thus, this chapter introduces the concepts of management and remote management of drinking water networks, highlighting their complementarity and their importance from a sustainable development perspective.

V. 2 Definition of the management of drinking water supply networks

Drinking water supply system management refers to all the activities, processes, and strategies implemented to ensure the efficient, safe, and sustainable delivery of drinking water to consumers. This includes the planning, operation, monitoring, maintenance, and improvement of the infrastructure and systems that enable the distribution of drinking water.
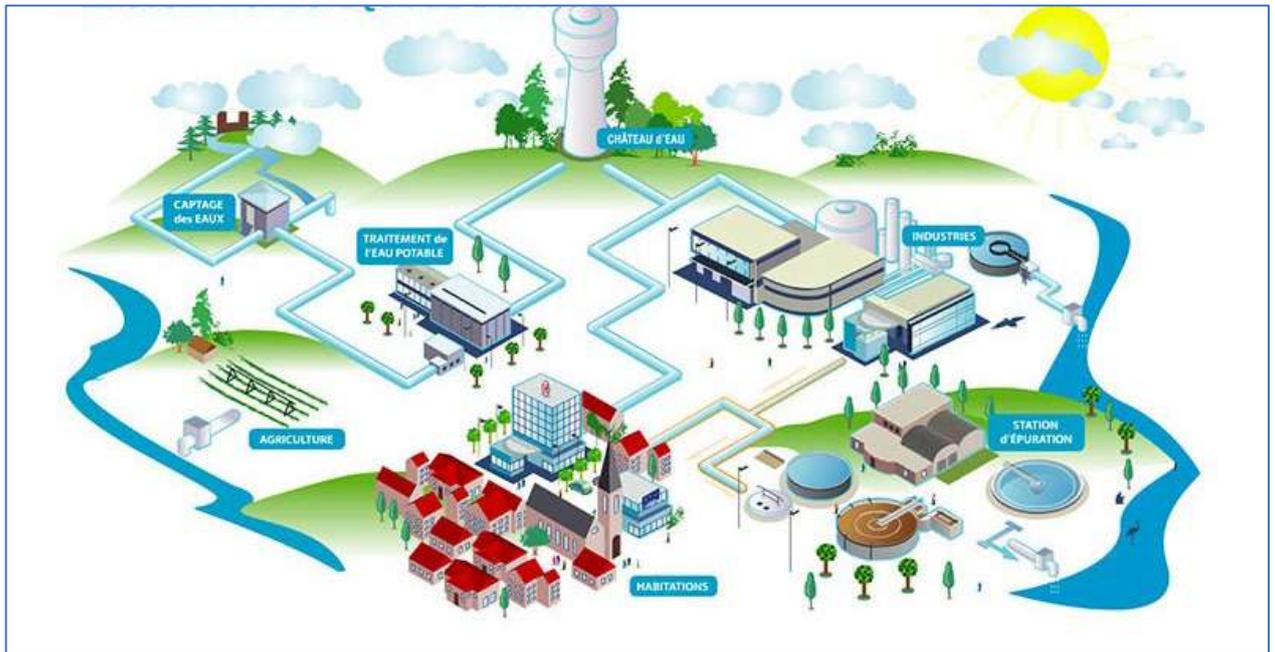
Figure 1 : Un réseau d'alimentation en eau potable.

The management of drinking water supply networks involves the coordination of several aspects, such as the collection, treatment and storage of raw water, the construction and maintenance of pipelines, reservoirs and pumping stations, the monitoring of water quality, the management of leaks and breakdowns, the regulation of pressures and flows, as well as the management of costs and resources.

V.3 Main objective of the management of drinking water supply networks

The main objective of drinking water supply network management is to ensure a safe, reliable, and sustainable water supply to the population. Here are some specific objectives of drinking water supply network management:

- ✓ **Providing quality drinking water** : The fundamental objective is to ensure that the water supplied to consumers is clean, healthy, and meets current quality standards. This involves implementing water treatment measures, quality monitoring, and compliance with health regulations.

Figure 2 : Eau potable.

✓ **Ensuring equitable water distribution** : It is essential that all users of the drinking water supply network have equitable access to this vital resource. This involves properly planning the network to reach all service areas and ensure adequate water pressure.

✓ **Reduce water losses** : Drinking water network management aims to minimize water losses due to leaks, poor management, or aging infrastructure. Reducing water losses contributes to more efficient use of available resources and environmental preservation.

Figure 3 : pertes d'eau.

✓ **Optimize energy efficiency** : Drinking water supply networks require significant energy consumption for the operation of pumps, water treatment systems, etc. The goal is to optimize energy efficiency by using efficient technologies, managing peak hours and adopting energy management practices.

Figure 4 : fonctionnement des pompes.

✓ **Improving network resilience** : Drinking water supply networks must be resilient to cope with climate change, extreme events, and emergencies. The goal is to put in place preparedness, emergency planning, and risk management measures to ensure the continuity of water supply even under difficult conditions.

✓ **Promoting sustainability** : Drinking water network management aims to adopt sustainable practices, such as preserving water resources, reducing the carbon footprint, using renewable energy sources, and promoting environmental responsibility.

Figure 5: Preservation of water resources.

V.4 The challenges of managing drinking water supply networks

The management of drinking water supply networks faces several major challenges. Here are some of the main issues:

a) **Limited water resources** : Freshwater is a limited resource, and population growth, urbanization, and climate change are putting increasing pressure on available water

resources. Drinking water network management is therefore challenged to ensure sufficient water supply to meet the population's needs.

b) **Water losses** : Water losses in distribution networks are a major issue. Leaks, outdated infrastructure, and inefficient management practices lead to significant losses. Reducing these losses is crucial to optimizing the use of water resources and improving network efficiency.

Figure 6 : pertes d'eau dans les réseaux de distribution.

c) **Water quality** : Ensuring the quality of drinking water is a major issue. Drinking water supply networks must ensure the preservation of water quality throughout the treatment and distribution process by implementing water quality monitoring and control measures.

d) **Aging infrastructure** : In many locations, drinking water network infrastructure is aging and requires renovation or replacement. Network management must take this issue into account by planning the investments needed to maintain and modernize the infrastructure.

e) **Climate change** : Climate change is impacting water resources, with phenomena such as more frequent droughts and erratic rainfall. Drinking water network management must be adapted to cope with these climatic variations, by implementing water conservation and resilience measures to cope with extreme weather events.

Figure 7 : Changement climatique.

f) **Demand management** : Growing water demand poses a challenge to the management of drinking water supply networks. There is a need to develop demand management strategies, such as raising awareness about water efficiency, adopting water-saving technologies, and promoting responsible water use behaviors.

g) **Crisis and Emergency Management** : Drinking water systems must be prepared to deal with crises and emergencies, such as power outages, water contamination, or natural disasters. Proper emergency planning, monitoring systems, and rapid response measures are essential to ensure the continuity of water supply.

Figure 8 : Catastrophes naturelles.

V.5 The main missions of the management of drinking water supply networks

➢ **Drinking water supply** : Ensuring a regular supply of drinking water to the population by collecting, treating and distributing water efficiently and safely.

Figure 9 : Approvisionnement en eau potable.

➢ **Water quality monitoring** : Conduct regular water quality checks at all stages, from source to distribution points, to ensure compliance with health standards.

Figure 10 : Surveillance de la qualité de l'eau.

➢ **Infrastructure Maintenance** : Ensure regular maintenance, repair and replacement of drinking water network infrastructure, including pipelines, reservoirs, pumping stations, valves, etc.

Figure 11: Maintenance des infrastructures.

➢ **Leak and Water Loss Management** : Identify and repair leaks in the network to minimize water losses, improve efficiency and conserve water resources.

Figure 12 : Gestion des fuites et des pertes d'eau.

➢ **Water pressure management** : Monitor and adjust water pressure in the network to ensure balanced distribution and avoid overpressure or underpressure problems.

Figure 13 : Gestion de la pression de l'eau.

➢ **Network Planning and Development** : Assess short- and long-term drinking water needs, plan and implement network development to meet population growth, urbanization and changes in water demand.

Figure 14 : Planification et développement du réseau.

➢ **Emergency and Crisis Management** : Develop emergency plans and crisis management protocols to deal with events such as power outages, natural disasters, water contamination, etc., and ensure continuity of water supply.

➢ **Water Resources Management** : Monitoring and managing available water resources, including water sources, groundwater, rivers, etc., to ensure their sustainable use and preserve ecological balance.

Figure 15 : Gestion des ressources en eau.

➢   **Cooperation and coordination** : Collaborating with other agencies and stakeholders, such as local authorities, environmental agencies and communities, for effective and integrated management of drinking water networks.

Figure 16 : Coopération et coordination.

V.6 Strategies for managing drinking water supply networks

a) Network monitoring:

✓   Importance of continuous network monitoring to detect potential problems and intervene quickly.

✓ Use of real-time monitoring systems, such as smart sensors and remote management systems, to monitor key parameters such as water pressure, flow rate and quality.

✓ Analysis of collected data to identify trends, anomalies and high-risk areas.

✓ Establishment of an early warning system to react quickly in the event of a problem, such as a leak or a change in water quality.

✓ Use of telemetry and communication technologies to collect data and monitor the network remotely.

Figure 17 : La surveillance du réseau.

b) Preventive maintenance:

✓ Importance of regular maintenance to prevent breakdowns and extend equipment life.

✓ Establishing a regular maintenance schedule for the various components of the network, such as pumps, valves and tanks.

✓ Regular inspections of infrastructure to detect signs of deterioration or wear.

✓ Periodic cleaning and flushing of lines to prevent deposit buildup and maintain adequate flow.

✓ Use of non-destructive methods, such as camera inspections, to assess the condition of underground pipelines without excavation.

Figure 18 : La maintenance préventive

c)　Network rehabilitation:

✓ Identification of parts of the network requiring rehabilitation based on criteria such as age, state of degradation and performance.

✓ Implementation of long-term rehabilitation programs for the renewal of obsolete pipelines, reservoirs and pumping stations.

✓ Use of trenchless rehabilitation techniques, such as lining, casing and horizontal directional drilling, to minimize excavation disturbance and costs.

✓ Integration of the asset management approach to optimize rehabilitation decisions based on priorities and available resources.

✓ Regular monitoring of rehabilitation work to ensure compliance with standards and long-term effectiveness.

Figure 19 : La réhabilitation du réseau

V.7 The different technologies used for the management of drinking water supply networks

- **Remote management systems** : Remote management systems enable remote monitoring and control of drinking water networks. They use sensors, communication devices, and software to collect real-time data on network parameters such as pressure, flow rate, water quality, etc.

These systems allow operators to manage networks more efficiently and quickly detect problems such as leaks or pipe bursts.

Figure 20 : Systèmes de télégestion.

1. Definition

Remote management refers to all products that implement computer, electronic and telecommunications technologies, in order to enable remote control of geographically distributed or isolated technical installations.

Purpose of remote management

The management of drinking water supply systems aims to ensure:

- Routine maintenance of the drinking water network, hydromechanical and electrical equipment works through cleaning, troubleshooting and maintenance operations;
- The proper functioning of the entire hydraulic system;
- Operation by regulating flow rates and synchronizing the operating chain (lifting, treatment, storage, distribution).
- Water billing (meter installation)

2. Principles

2.1 Works

- Pumping stations
- Tarpaulins and tanks
- Treatment plants
- Boosters

Pipes...

2.2 Objectives

- Limit travel
- Limit human intervention
- Ensure continuity of service
- Optimizing water resources
- Optimize energy

Figure 21. Diagram of management and remote management of a drinking water supply network.

2.3 Techniques

Main physical measurements:

1. Levels

- Drilling, tarpaulin, tank...

Piezzo sensors , ultrasound, radar...

Pressures

- Pipes, boosters...

Piezo sensors ...

Flow rates

- Pipes, tanks, boosters...

Mechanical, electromagnetic counters...

2. Measurement of operating parameters

- Opening/closing of valves,

- Pump start/stop (with or without variator),

- Thermal pump faults,

- Energy pricing,

- Energy consumed,

- Opening/closing doors...

❖ Source processing of measures:

- Counts

- Timings

- Flow rates

- Threshold detection

- Filtering,

- Detection of discrepancies

- Permutations

- Regulations

- Time slot management

- On-call schedules

❖ Intrusion detection

Orders

- Manual / automatic mode

- Opening/ closing valve regulation

- Start/stop pump regulation

Figure 22. Pumping station and maintenance operations in a drinking water supply network.

Telecommunications

- Communication with automatons

- Inter-site exchanges

- Alarms

- Periodic exchanges

- Forcing / inhibition

- Call cycles...

- RTC / ADSL

- GSM Data / GPRS

- UFH / VHF / 868MHz RADIO

- Fiber optic / satellite

❖ **Processes**

Remote management automation systems

- Food

Input voltage

Battery backup

Regulated sensor power supply...

- Communication ports

RTC/GSM/LS/Radio Modems

RS232/RS485 serial ports

Ethernet port...

- Inputs / outputs

TOR inputs

TOR outputs

ANA inputs 0/4-20mA 0-5/10V

ANA outputs 0/4-20mA 0-5/10V

Watchdog...

❖ **Facility**

- Wardrobe, box

- Transformers, power supplies

- Backup batteries

- Buttons, switches

- Indicator lights, dials, displays

- Relays, contactors

- Door switch

- Alarm siren

- Ventilation, heating resistance

- Lighting, electrical outlet - Electromechanical emergency services...

- **Leak detection systems** : Leak detection systems use technologies such as acoustics, data correlation, pressure sensors, etc., to locate leaks in drinking water systems. They enable early leak detection, which reduces water loss and helps prevent damage caused by leaks.

Figure 21 : Systèmes de détection des fuites

- **Geographic Information Systems (GIS)** : GIS are computer tools that integrate geographic data and drinking water network data. They allow for the visualization, analysis, and management of information on network infrastructure, water quality data, distribution areas, and more.

GIS facilitates planning, maintenance and decision-making in the management of drinking water networks.

Figure 22 : Systèmes d'information géographique (SIG)

- **Energy Management Systems** : Energy management systems aim to optimize energy consumption in drinking water supply networks. They use technologies such as energy monitoring, load management, pump optimization, etc., to reduce energy consumption and costs associated with drinking water supply.

Figure 23 : Systèmes de gestion de l'énergie

- **Data analytics systems** : Data analytics systems use advanced analytics techniques, such as machine learning and artificial intelligence, to analyze data collected from drinking water systems. They help detect patterns, predict consumption trends, optimize system operations, make informed decisions, and improve overall system management.

Figure 24 : Systèmes d'analyse des données.

- **Hydraulic modeling** : Hydraulic modeling uses specialized software to simulate the behavior of drinking water networks. This allows for the optimization of infrastructure sizing, the prediction of flow rates and pressures in the network, the analysis of management scenarios, and the improvement of overall system performance.
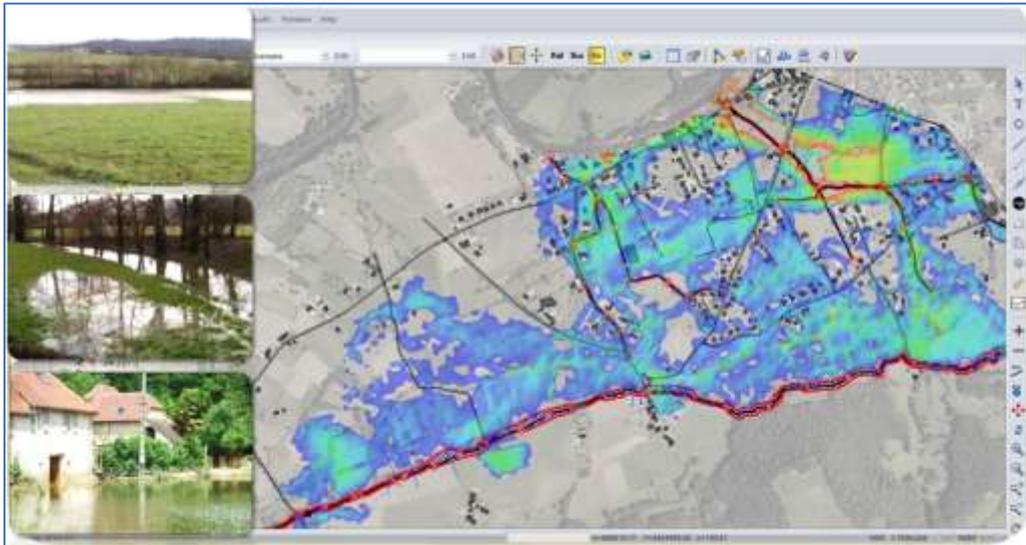
Figure 27: Modélisation hydraulique.

V.8. Innovative technologies for the management of drinking water supply networks

- **Internet of Things (IoT)**: IoT connects and collects data from sensors and smart devices installed on drinking water network infrastructure. These sensors can measure parameters such as pressure , flow rate, water quality, etc. in real time. The collected data can be used to monitor and manage the network more efficiently.

- **Artificial Intelligence (AI)** : AI can be used to analyze data collected from drinking water systems and detect patterns, anomalies, and trends. This enables more informed decisions regarding preventive maintenance, leak detection, resource optimization, and more.

- **Real-time data analysis** : Real-time data analysis technologies allow the processing and analysis of data collected from sensors installed in drinking water systems. This allows for the rapid detection of problems such as leaks, pressure drops, changes in water quality, etc., and immediate corrective action to be taken.

- **Drones and Satellite Imagery** : Drones and satellite imagery can be used to monitor drinking water systems over large geographic areas. They can detect leaks, identify at-risk areas, assess infrastructure conditions, and improve network planning and maintenance.

- **Smart distribution networks** : Smart distribution networks, also known as "smart grids ," integrate advanced communication technologies to enable real-time monitoring and

management of the drinking water network. This includes remote meter reading, leak detection, flow and pressure optimization, and water demand management.

- **Advanced Water Treatment** : Technological advances in water treatment are improving the efficiency and quality of drinking water treatment. Technologies such as reverse osmosis, ultrafiltration, advanced disinfection, etc., produce high-quality water while reducing energy consumption and chemical use.

Figure 25 : Les technologies innovantes pour la gestion des réseaux d'AEP.

Conclusion

The efficient management of drinking water supply networks cannot be conceived today without the support of remote management technologies. While traditional management lays the foundations for an operational organization, remote management paves the way for intelligent, preventive, and optimized infrastructure operation.

By combining these two approaches, operators can meet major challenges: ensuring a quality drinking water supply, reducing losses and controlling costs, while integrating sustainability and resilience requirements in the face of future developments.

Useful links

- https://youtu.be/VMxtTRv5R4I
- https://youtu.be/wuTBbeVmU8s
- https://youtu.be/giYcMSOjNCM

- https://youtu.be/eurwHp3Hsxo

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