WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.2.4 Ex Post Evaluation report** *Joint Deliverable*
Sub-Deliverables integrated	**D.5.1.4, D.5.2.4, D.5.4.4, D.5.5.4**
Project Beneficiary No	**PB2, PB3**
Beneficiary Institution	**Municipal Water Supply and Sewerage Company of Thermi** **University of Thessaly-Special Account Funds for Research-Department of Civil Engineering**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Table of Contents

Chapter 1. Introduction: The WATER RESCUE project in brief

1.1 The Project in brief

WATER RESCUE project's concept is based on the common cross-border (CB) water management problems in the two international river basin districts (RBDs) shared between Greece & Bulgaria (Struma-Strymonas; Maritsa-Evros). The common CB problems include water resources quality & quantity being at risk due to natural and human activities and climate change conditions. The consequence is that water bodies fail to meet the good ecological status (GES) (recorded in the river basin management plans-RBMP). In particular, drinking water faces significant risks due to the deteriorated water resources quality while at the same time significant water volume is lost in the water distribution networks (WDNs). The project aims at the sustainable and efficient management of drinking water supply by increasing drinking water use efficiency in WDNs and improving water quality in the whole water supply cycle (from the source and back to the environment). Good Ecological Status can be achieved by improving water quality and reducing water abstraction and can be maintained by taking climate change adaptation measures. The project focuses in drinking water supply management suffering from high Non-Revenue Water (NRW) levels and deteriorated water quality jeopardizing the drinking water consumers' safety and health and their quality of life. Urban water volumes end up to the sewerage networks while wastewater treatment plants are a pressure to water resources quality. Surface water bodies are both used for drinking water abstraction and are the final recipient of treated effluents. Thus, their ecological status is affected by both water quantities abstracted and water quality in the whole water supply cycle (from the resource to the water supply and the wastewater treatment plant and back to the environment).

1.2 Theme of the Project

WATER RESCUE project is expected to achieve Non-Revenue Water/water losses reduction by upgrading and adapting already developed methodologies, technologies and tools including Water Balance assessment and Performance Indicators, hydraulic simulation models, decision support systems and GIS tools. Additionally, WATER RESCUE is expected to achieve water quality improvement across the entire water supply chain (from the water intake point and the raw water treatment plant, back to the environment after the waste water treatment plant) through constant monitoring of water quality parameters in real time, water quality simulation models (including water age) and automatic chlorination systems on line and in line. Climate change impacts will be assessed to finally propose and adopt measures for climate change adaptation. WATER RESCUE has a clear innovative character since the methodologies and tools are integrated and do not tackle individual problems. It is the first time that integrated methodologies will be adapted to include the entire drinking water supply cycle. These methodologies/tools will serve as Early - Warning Systems both for water quantity and quality. WATER RESCUE results will improve drinking water management. At the same time as drinking water is involved, the consumers' safety and health are safeguarded and their quality of life is improved. Non-Revenue Water reduction will increase water resources efficiency, since less water will be abstracted from surface and groundwater bodies and reduce energy consumption as water and energy are interconnected in water supply systems (water-energy nexus). Drinking water quality will be improved through real time monitoring of water quality parameters across the entire water supply chain, from the water intake points, to the water treatment plant and the water distribution network, back to the environment through the wastewater treatment plant. Thus, drinking water quality will be safeguarded from its source up to the consumer's tap. As wastewater effluents return to water resources, their quality monitoring prevents water resources degradation due to this pressure. Water and energy resources efficiency will be promoted and the ability of the cross-border area to adapt to climate change conditions will be improved as all possible natural and man-made pressures will be evaluated, including climate change conditions. Water saving will be accomplished through water losses reduction and increase of the environmental awareness of the public. The quality of life is expected to be upgraded with special emphasis to the protection of the natural environment. Joint policy recommendation guidelines and papers will be developed. Good governance, transparency and participation of all stakeholders in the design, implementation and monitoring of these policies is expected. Know-how and technology transfer will take place not only among the beneficiaries but also in the stakeholders' network that will be developed.

1.3 Project Objectives

The project's main objective is the sustainable cross –border drinking water supply management aiming at water resources efficiency and conservative use through:

1. Adaptation of a joint methodological framework for water resources management (qualitatively and quantitatively) in relation to the climate change and the natural and human activities and reduction of the water resources vulnerability;

2. Increase water use efficiency through the reduction of Non-Revenue Water and water losses in the water supply networks by implementing measures tackling NRW causes;

3. Improve water quality and safety in the whole drinking water supply cycle, from the water resources to the water distribution network and back to the environment through the continuous monitoring of water quality parameters in real time and the in-line disinfection to reduce the risk of low chlorine residuals and excessive concentrations of THMs (toxic substances causing cancer);

4. Increase innovative technologies use through the integrated management of water resources including GIS-based applications; hydraulic simulation models & decision support systems;

5. Development of "green behavior", increase water saving & reduce water consumption through public awareness campaigns.

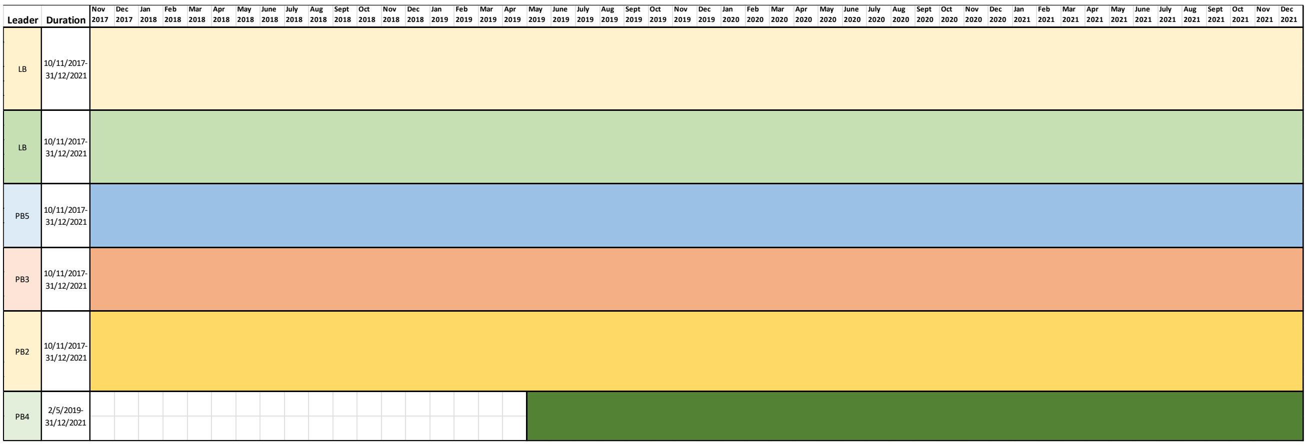

Figure 1.1. WATER RESCUE timetable

1.4 The Project structure and timetable

The project consists of six work packages:

- WP1: Project Management and Coordination
- WP2: Project Communication and Dissemination
- WP3: Current Status Analysis & Assessment
- WP4: Common Methodology and Tools

- WP5: Pilot Actions
- WP6: Policy Recommendation

The initial total project duration was 24 months, but extensions were given (mainly due to Covid-19 pandemic) and the final total duration is 50 months, from 10/11/2017 to 31/12/2021 (Figure 1.1).

1.5 Project Beneficiaries

Lead Beneficiary is the Municipal Water and Sewerage Company of Komotini (Greece); Beneficiary 2 is the Municipal Water and Sewerage Company of Thermi (Greece); Beneficiary 3 is the University of Thessaly-Special Account Funds for Research-Department of Civil Engineering (Greece); Beneficiary 4 is the Municipality of Kardzhali (Bulgaria); Beneficiary 5 is the Municipality of Gotse Delchev (Bulgaria); and Beneficiary 6 is the Municipal Water and Sewerage Company of Thermaikos (Greece).

Table 1.1. WATER RESCUE beneficiaries

PB #	PP name	City	Country
PB1	Municipal Water Supply and Sewerage Company of Komotini	Komotini	Greece
PB2	Municipal Water Supply and Sewerage Company of Thermi	Thermi	Greece
PB3	University of Thessaly-Special Account Funds for Research-Department of Civil Engineering	Volos	Greece
PB4	Municipality of Kardzhali	Karddzhali	Bulgaria
PB5	Municipality of Gotse Delchev	Gotse Delchev	Bulgaria
PB6	Municipal Water Supply and Sewerage Company of Thermaikos	Neoi Epivates	Greece

1.6 The present deliverable

1.6.1 The subject of the present deliverable

The present deliverable refers to WP5.4., and specifically the ex-post evaluation of the pilot actions regarding water use efficiency and water quality assessment. The general characteristics of the pilot areas are initially presented. Then a brief description of the pilot action is given. Each beneficiary presented the results from the pilot actions elaborated regarding water user efficiency and/or water quality. An evaluation between the ex ante and the ex post status takes place in order to present the impact of the pilot action.

1.6.2 The approach applied developing the present deliverable

As the topics the WATER RESCUE project is dealing with, need precise knowledge of the way water supply and distribution systems operate, it was made clear, even during the kick-off meeting of the project, held in Komotini in January 2018 that WATER RESCUE beneficiaries, beyond their common agreement to work closely together, should be guided by the scientific beneficiary, University of Thessaly, to ensure the prompt delivery of what was expected by the WATER RESCUE project. Thus, the University of Thessaly, assisted the WP lead beneficiary to prepare the questionnaires for this task. University of Thessaly supplied the software water audit tool WB/PI_CalcUTH (developed by the University of Thessaly) to all beneficiaries to use it for the estimation of the Water Balance and the Performance Indicators. Municipal Water Supply and Sewerage Company of Thermi (PB2) as the WP Leader took over the responsibility to prepare the joint deliverable of Phase 5.4.

Regarding the implementation of Phase 5.4., the beneficiaries reported on the ex-post evaluation of their Water Supply System(s) (WSS) regarding water use efficiency and water quality. University of Thessaly (PB3) provided a questionnaire consisting of the following chapters: (a) Introduction; (b) for the beneficiaries with pilot action referring to water use efficiency b1)Water Balance Assessment; (b2) Performance Indicators; (c) for the beneficiaries referring to water quality (c1) Water Quality Evaluation of the water distribution network; (c2) Performance Indicators. All beneficiaries provided their deliverables to the WP leader, who properly elaborated the data in order to prepare the joint deliverable. The WP leader together with the University of Thessaly (PB3) prepared the respective deliverable D5.4.

Chapter 2. Water Audit Methodology in Drinking Water Supply Systems

2.1 The Water Balance

The International Standard IWA Water Balance (WB) is a useful tool of "best practice" (Lambert, 1999). The IWA WB is a diagnostic approach, well acknowledged, which has been implemented in cases all around the world. It estimates NRW values and allocate the water volume which enters the water distribution network to its uses (several kinds of consumption or water losses).

The principal components definitions of the IWA WB are the following (Lambert et al., 1999; Farley and Trow, 2003) (Table 2.1):

Table 2.1: The WB variables, their symbols and meaning

Symbol	Variable	Meaning
A3	System Input Volume	the annual volume of water entering the system or part of the system
A14	Authorized Consumption	The annual water volume, metered and unmetered, used by registered customers who are authorized to use water
A21	Non-Revenue Water (NRW)	the difference between system input volume and billed authorized consumption
A13	Unbilled Authorized Consumption	The water volume legally consumed but not billed due to the policy of the water utility: metered and unmetered. It includes: fire-fighting, flushing of mains and sewers, cleaning of suppliers' storage tanks, water taken from hydrants, water used for cleaning streets, watering of municipal gardens, public fountains, frost protection, water, building, etc.
A18	Apparent Losses	The water volumes consumed but not registered due to metering errors or/and theft and illegal use.
A16	Unauthorized consumption	Water volume illegally used due to illegal connections, water theft, etc. It reasonable managed systems should not exceed 1% of the system input volume
A17	Customer metering errors	Include: (a) random errors due to accounting procedures such as misread meters, incorrect estimates for stopped meters, computer programming errors, etc. and (b) systematic errors due to under-registration or over-registration of customer meters.
A19	Real Losses	Annual water volumes lost through leaks, breaks or tanks' overflows. When leakage data are available, real losses can be estimated by performing the "bottom up" approach. Real losses consist of (Alegre et al., 2006): ✓ Real losses on raw water mains and at the treatment works; ✓ Leakage on transmission and/or distribution mains; ✓ Leakage and overflows at transmission and/or distribution storage tanks; and ✓ Leakage on service connections up to the measurement point.

Following the initial launch of the International Standard IWA Water Balance, McKenzie et al. (2007) and Kanakoudis and Tsitsifli (2010) proposed two amendments. The first one (by McKenzie et al. (2007)) introduces the water billed but not paid for element, which is a common issue in low income countries where the consumers cannot afford to pay their water bills. The second amendment (by Kanakoudis & Tsitsifli (2010)) introduced the concept of “Minimum Charge Difference” (MCD) which is actually water losses recovered by the water utilities and thus provide revenues (Figure 2.1). MCD is not actual water volumes consumed. MCD refers to the amount of money water utilities recover through their pricing policies and in particular through the fixed charge the water utilities charge to their consumers regardless their water consumption.

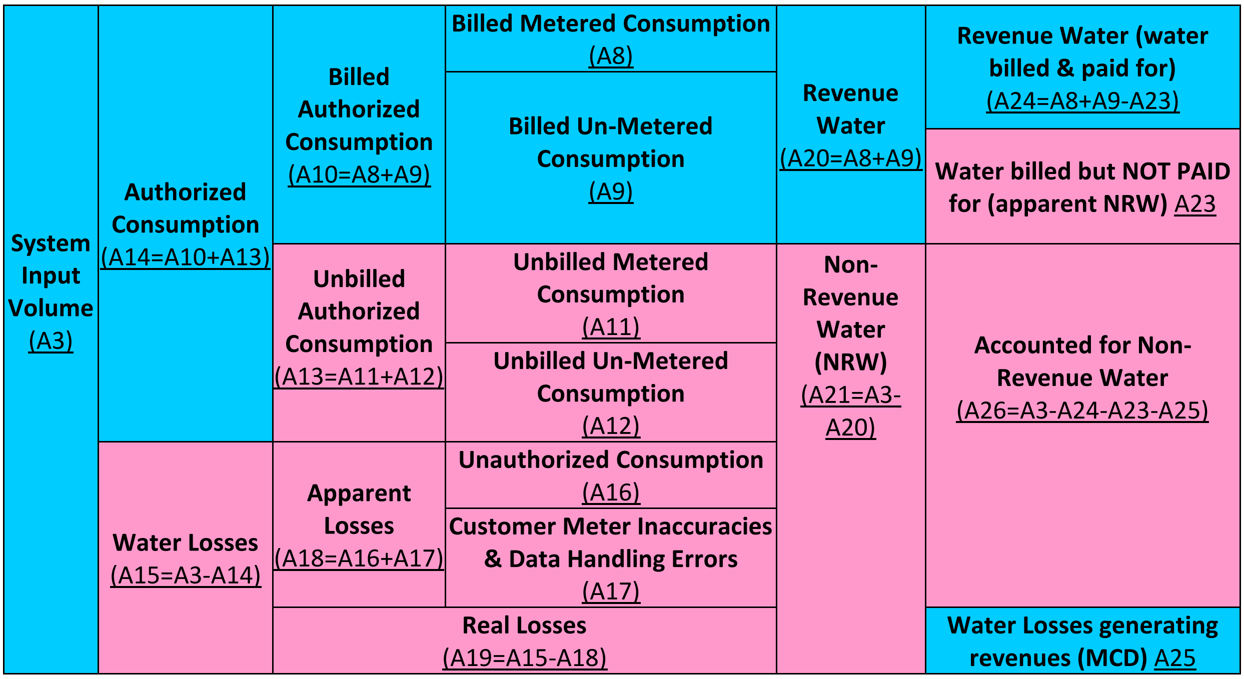

Figure 2.1. The 2nd modified Water Balance (Kanakoudis & Tsitsifli, 2010)

2.2 The concept of MCD

Usually water utilities charge the fixed charge to their consumers by following two pricing policies:

- the fixed charge is expressed in water volume: there is a minimum water volume charged (threshold), either consumed or not. When the actual water use is below that “threshold”, a minimum use is being charged for, resulting in a difference between the actual metered consumption level and the billed one.

- the fixed charge is expressed in monetary units: there is a minimum charge. Water consumption charge is added to this fixed charge.

2.3 Performance Indicators

Performance indicators measure the provided services efficiency and effectiveness and are the result of several variables combination. IWA has recorded 170 performance indicators (Alegre et al, 2016). The performance indicators consist of general indicators providing an overview of the efficiency and effectiveness and detailed indicators dealing with specific aspects of the utility functionally. They are divided in 6 groups: water resources (WR); Personnel (Pe); Quality of Services (QS); Operational (Op); Physical (Ph); and Economic and Financial (Fi) (Table 2.3). 232 variables are used to calculate the 170 PIs (Alegre et al., 2016). The variables are divided in 8 groups (A to H).

Table 2.3. PIs groups (Alegre et al., 2016)

PIs	PIs no.	PIs	PIs no.	PIs	PIs no.
Water Resources	**4**	**Operational**	**44**	**Economic and financial**	**47**
Personnel	**26**	Inspection & maintenance of physical assets	6	Revenues	3
Total Personnel	2	Instrumentation calibration	5	Costs	3
Personnel per main function	7	Electrical & signal transmission equipment inspection	3	Composition of running costs per type of costs	5
Technical services personnel per activity	6	Vehicle availability	1	Composition of running costs per main function of the water utility	5
Personnel qualification	3	Mains, valves and service connection rehabilitation – pumps rehabilitation	7	Composition of running costs per technical function activity	6
Personnel training	3	Operational water losses	7	Composition of capital costs	2
Personnel health & safety	4	Failure	6	Investment	3
Overtime work	1	Water metering	4	Average water charges	2
Quality of service	**34**	Water quality monitoring	5	Efficiency	9
Service coverage	5	**Physical**	**15**	Leverage	2
Public taps and standpipes	4	Treatment	1	Liquidity	1
Pressure & continuity of supply	8	Storage	2	Profitability	4
Quality of supplied water	5	Pumping	4	Economic Water losses	2
Service connection and meter installation & repair	3	Transmission & distribution	2		
		Meters	4		
Customer complaints	9	Automation & Control	2		

Regarding Water Quality evaluation, the Performance Indicators are:

Table 2.4. PIs for water quality evaluation

Performance Indicators		Units
Op40	Tests carried out	%
Op41	Aesthetic tests carried out	%
Op42	Microbiological tests carried out	%
Op43	Physical-chemical tests carried out	%
Op44	Radioactivity tests carried out	%
QS11	Bulk supply adequacy	%
QS18	Quality of supplied water	%
QS19	Aesthetic tests compliance	%
QS20	Microbiological tests compliance	%
QS21	Physical-chemical tests compliance	%
QS22	Radioactivity tests compliance	%

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Chapter 3. Results – Discussion

The analysis is based on pilot case basis. Each beneficiary with a pilot case (PB1, PB2, PB4, PB5, PB6), evaluated the water efficiency and water quality of his pilot area (whole water network or a part of it), after the implementation of the pilot action (ex-ante).

3.1. PB1 – Municipal Water Supply and Sewerage Company of Komotini, Greece

3.1.1. General description of the pilot area

Municipal Water Supply and Sewerage company of Komotini (DEYAK) supplies with water the municipality of Komotini, located in the Water District of Thrace (EL12). The people supplied with water is 65,000. The area covered is 385.3 km^2 and the average altitude is 45m. The total pipes' length is 400 km consisting of pipes from PE (with diameters 90-450mm) and from steel (with diameters 600mm). The water pipes network is old enough. The average operating pressure is 4 atm and the total number of water meters is 48,500. The number of service connections is about 17,000. The billing period is 2 months for the city of Komotini and 4 months for the municipal districts. The river basin where water is taken from is the river basin of Komotini – Loutro Evrou stream (area 1,958.3Km^2). Water is taken from Vosvozis river (EL1209R0000010085N) and the groundwater system of Rodopi (EL1200120). All the information is given in Table 3.1.1.

Table 3.1.1. General data for the city of Komotini

Data (base year 2017)	
Total population served	65,000
Total area covered (km^2)	385.3
Total pipes' length (km)	549
Mean altitude (m)	45
Mean operating pressure (Atm)	4.0
Types of pipes (material, diameters)	PE (90-450mm) and steel (600mm)
No. of water meters	48,500
No. of service connections	17,000
Billing period	2 months for Komotini city; 4 months for municipal districts
River Basin where water is taken from	Komotini – Loutro Evrou stream

The water supply system consists from a group of 10 boreholes and the water supply from Simvola (surface water body). 58.1% of the water abstracted comes from boreholes and 49.1% comes from Simvola.

3.1.2. Pilot action description

The water utility faces problems related to high Non-Revenue Water (NRW) which was estimated for 2017 to be 38% of SIV. Specifically, the water supply network suffers from pipes breaks, invisible leaks, unauthorized consumption. The main cause is that the water distribution network is old in many parts of the city.

The pilot action refers to the provision of services for the supply and installation of IT applications to directly support the water utility operations and indirectly contribute to the water use efficiency (by reducing NRW). The applications are expected to provide:

• Failure history mapping. The application will present the failures history in an interactive map. It will provide the possibility of selection of filters depending on, e.g. the severity of the problem, the time period, the cost of confrontation measures etc. The data will be presented alone but also cumulatively in the form for example of cluster map or heat map. The possibility to choose the time period of reference of the problems to give the opportunity someone to be able to see their time evolution. Additionally, the application will provide a problems management environment.

• Field applications. Utilizing the water utility's background in GIS software, field applications will be developed, in tablet environment that will be used from the utility's repair teams to provide them access to the data (e.g. distribution networks) but also to inform immediately the water operators regarding the problems faced and recorded from the personnel in the field. These applications will allow a more efficient coordination and a significant reduction in the troubleshooting time, contributing to water saving.

• Applications for the public. Internet based applications for the public will be developed. The consumers will be able to report a problem and the water utility will inform the consumers for possible water interruptions or other problems.

The pilot action was elaborated in 2018. The pilot action targets the real losses pillar “speed and quality of repairs”. By using these IT applications, the water utility will be able to:

- Be informed about the failures in the water supply and distribution system and assess their spatial and temporal variability. This will act as a decision-making tool for the water utility.
- React quicker to any failure event reducing the response time and also reduce the repair time as all the data will be available to the staff. Time reduction will eventually result in real losses reduction.
- Be informed quicker as the public will be able to report any problems asap and thus reduce the reaction and repair time.

The IT applications developed consist of applications for the public accessible at https://komotini.getmap.gr/ (Figures 3.1.1) and spatial mapping of failures accessible at https://deyakmap.getmap.gr for the managers of the utility having full access (Figures 3.1.2, 3.1.3 & 3.1.4).

The total cost of the pilot action is 88,000.00€.

Figure 3.1.1. Application interface

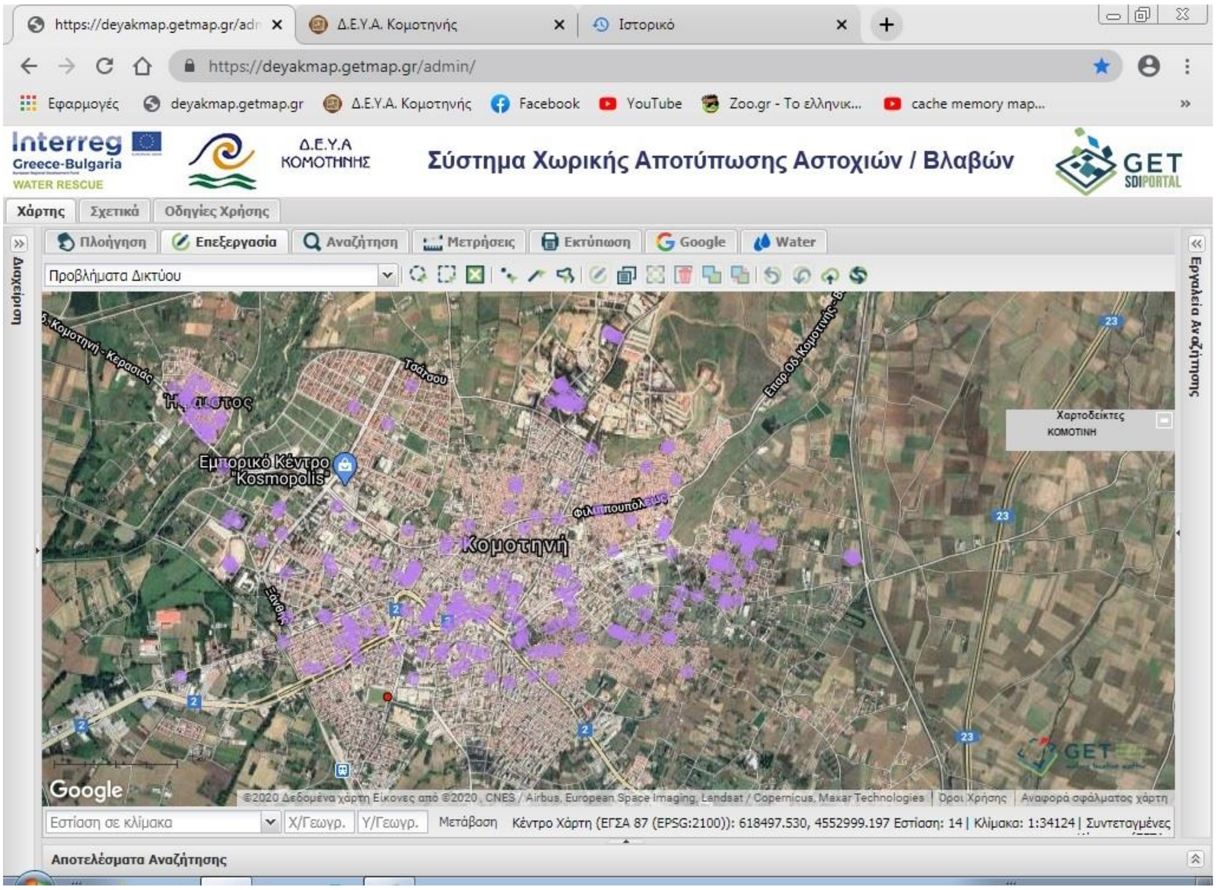

Figure 3.1.2. Failures shown in the map

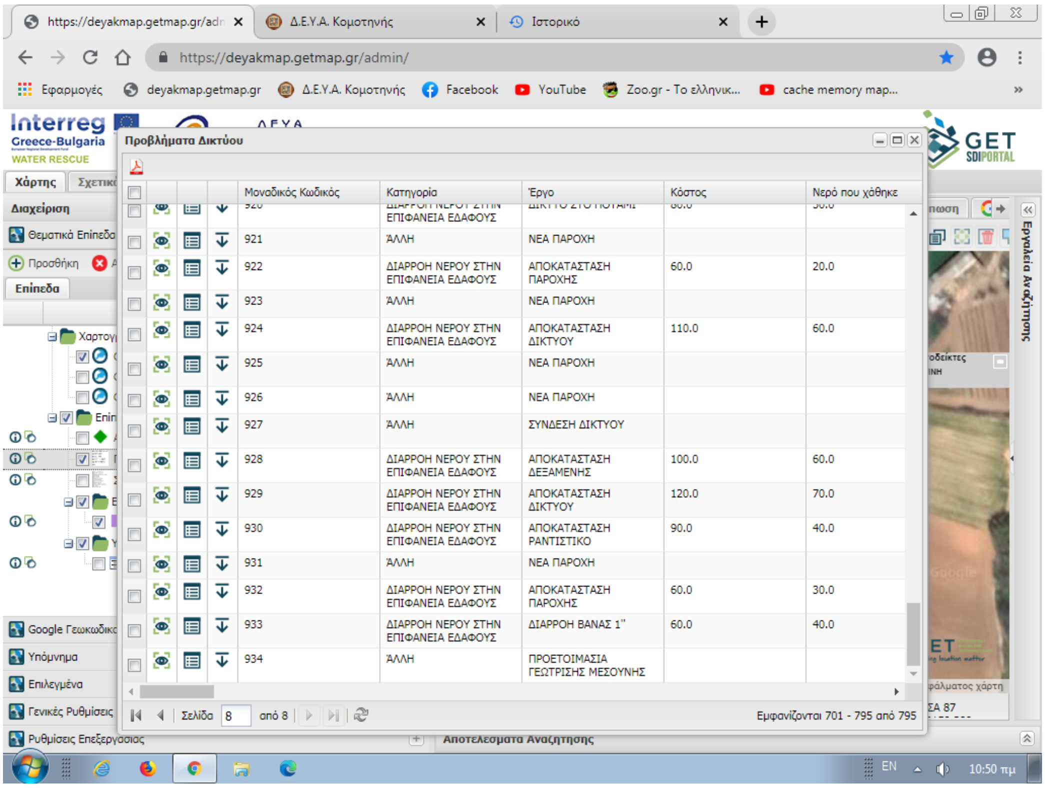

Figure 3.1.3. Failures' list

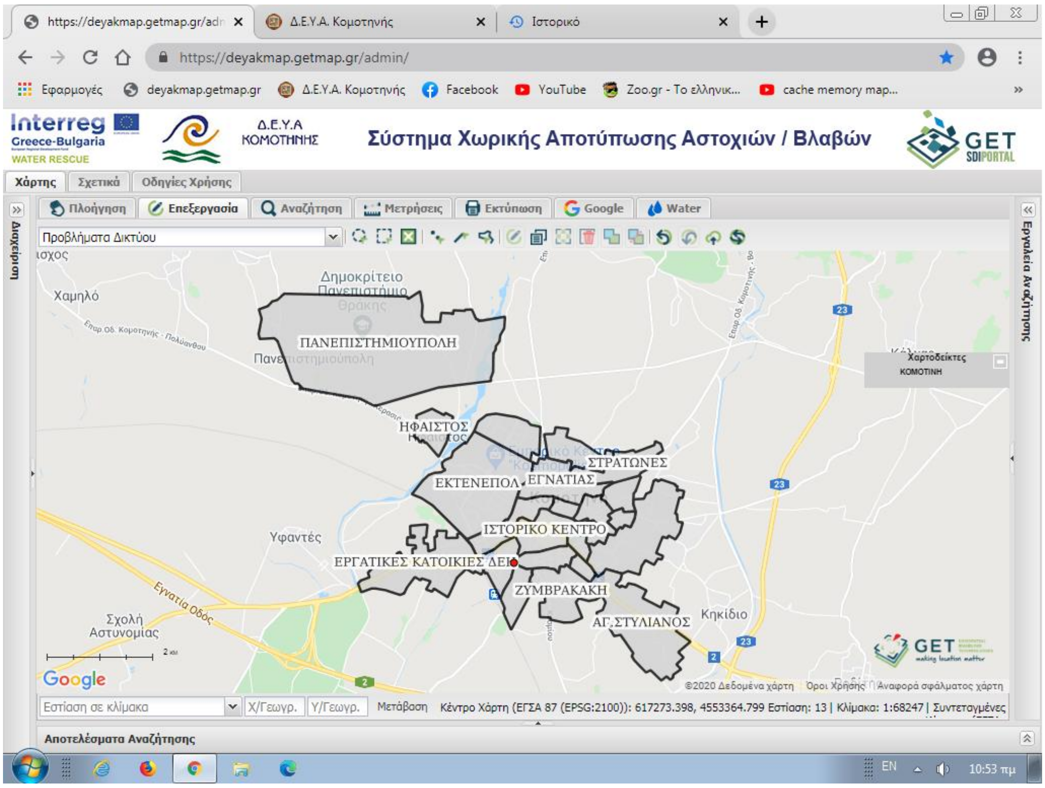

Figure 3.1.4. Statistical data of the failures inserted

<table>
<tr><td rowspan="7">System Input Volume
(A3)
5.300.000</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
3.053.000</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
3.000.000</td><td>Billed Metered Consumption
(A8)
3.000.000</td><td rowspan="2">Revenue Water
(A20=A8+A9)
3.000.000</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
53.000</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non Revenue Water (NRW)
(A21=A3-A20)
2.300.000</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
53.000</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
2.247.000</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
503.000</td><td>Unauthorized Consumption
(A16)
53.000</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
450.000</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
1.744.000</td></tr>
</table>

Figure 3.1.5. The Water Balance for the whole water supply network of Komotini city for 2020

3.1.3. Water Balance assessment for the water distribution network of the pilot area

The WB for the water distribution network of Komotini city has been elaborated for 2020 (whole year). The water utility provided data regarding the water entering the network and the water volume billed and consumed. The water volume consumed but not billed and unauthorized consumption and meters' errors are not known for the network. The water consumed but not billed is assumed to be 1% of the SIV. Meter

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inaccuracies and under-registration are estimated to be 15% of the billed metered consumption and unauthorized consumption is assumed to be 1% of SIV. Based on those data and assumptions, the Water Balance of the whole water utility of Komotini is given in Figure 3.1.5.

3.1.4. Performance Indicators

Based on the data provided above, the following Performance Indicators are estimated for the water supply network of Komotini city. The results compared to those of 2017 and 2018 are shown in Table 3.1.2.

Table 3.1.2. Performance Indicators for the water supply network of Komotini (2017, 2018 & 2020)

Performance Indicators		2017	2018	2020	Units
WR1	Inefficiency of use or water resources	35.6	42.5	32.9	%
Op23	Water losses per connection	154.88	175.67	132.17	m^3/connection/year
Op24	Water losses per mains length	18.03	20.45	15.39	m^3/km/year
Op26	Apparent losses per system input volume	9.14	8.24	9.49	%
Op27	Real Losses per connection	337.66	403.16	281.06	L/connection/day when system is pressurised
Op28	Real Losses per mains length	14,350.50	17,134.35	11,945.21	L/km/day when system is pressurised
Op29	ILI	6.56	7.84	5.46	-
Op39	Unmetered water	45.74	51.75	43.39	%
Fi46	Non-revenue water by volume	45.74	51.75	43.39	%

From Table 3.1.2, NRW is 43.39% of the System Input Volume (SIV) for 2020. Apparent losses as % of SIV is 9.49% and real Losses in 2020 are 32.91% of SIV and 281.06 L/connection/day. ILI is 5.46 in 2020. It is obvious that NRW levels are high for this network and this is mostly due to real losses. The results show a slight decrease in NRW in 2020 compared to previous years but the data are not enough.

3.1.6. Discussion and Conclusions

The water distribution system of Komotini supplies with water 65,000 people through 400 Km of pipes and 48,500 water meters. The total area covered is 385.3 Km^2. The mean operating pressure is 4 atm. The water audit showed that NRW levels are 51.75% of the SIV for 2017, 45.78% for 2018 and 43.39% for 2020. Apparent losses are 8.24% of SIV and real losses are 42.51% of SIV for 2017, for 2018 apparent losses are 9.14% and real losses 35.60% and for 2020 apparent losses are 9.49% of SIV and real losses are 32.91% of SIV. Real losses expressed as L/Km/day are 14,350 for 2017, 17,134 for 2018 and 11,945.21 for 2020. Water losses in m^3/Km/year are 18.03 (2017), 20.45 (2018) and 15.39 (2020). NRW levels are quite high and are mainly due to real losses. NRW level and other PIs are lower in 2020, however results for the coming years are needed for verification.

3.2. PB2 – Municipal Water Supply and Sewerage Company of Thermi, Greece

3.2.1. General description of the pilot area

Municipal Water Supply and Sewerage Company of Thermi (DEYA Thermis) is the water utility supplying with water the area of Thermi including several municipal districts: Thermi, Mikra, N. Redestos, Tagarades, N. Risio, Vasilika, Souroti, Agia Paraskevi, Agios Antonios, Lakkia, Peristera and Livadi. The area covered by DEYA Thermis is 1559.34 Km^2. The area's altitude ranges from 0-200m. The water meters (active) are 25,786 supplying with water a population of 53,070 people (2011 census). The total pipes' length is about 700Km and the pipes are made of PE (60%) and PVC (40%). The pipes are installed since 1970 until now. The average operating pressure is about 5 atm (Table 3.2.1).

DEYA Thermis is supplying the municipal district of Thermi with water from groundwater boreholes from three groundwater subsystems: down flow of Antemountas; Thermi – N. Risio; and Cholomontas – Oreokastro (Chalkidiki river basin). DEYA Thermis water abstraction is allocated in the groundwater systems as shown in Table 3.2.2. The major water volume (97.8%) comes from the subsystems of Anthemountas down flow and Thermi – N. Risio. The first subsystem is assessed in bad quantitative and chemical status, while the second is assessed in good quantitative and chemical status. Only 2.1% of water volume comes from the Cholomontas - Oreokastro subsystem which is found to be in good chemical and quantitative status.

Table 3.2.1. General data of the water supply network of DEYA Thermis (base year 2019)

General data	
Total population served	53,070
Total area covered (Km^2)	1,559.34
Total pipes' length (Km)	700
Mean altitude (m)	0-200
Mean operating pressure (atm)	5
Types of pipes (material, diameters, lengths)	PE (60%); PVC (40%)
Age of pipes (per material, diameter)	Since 1970
No. of water meters	25,786
Billing Period	Every 3 months
River Basin where water is taken from	Chalkidiki river basin

Table 3.2.2. Water availability, average annual abstraction and DEYA Thermis abstraction of three groundwater systems (source: RBMP, 2017)

Groundwater subsystem	**Towns supplied with water**	**Water availability (10^6 m^3)**	**Average annual abstraction (10^6 m^3)**	**DEYA Thermis (m^3)**	**Chemical status**	**Quantitative status**
Down flow of Anthemountas	Thermi, Mikra, N. Redestos, Tagarades, N. Risio, Vasilika, Souroti, Ag. Paraskevi	33.6	37.02	7,187,700	Bad	Bad
Thermi – N. Risio	Thermi, Mikra, N. Redestos, Ag. Antonios, Lakkia				Good	Good
Cholomontas - Oreokastro	Peristera, Livadi	99	81.64	158,500	Good	Good

3.2.2. Pilot Action description

The pilot action of DEYA Thermis refers both to water efficiency and water quality.

3.2.2.1 Water Efficiency

DEYA Thermis uses 54 boreholes for water abstraction. However, the water volume abstracted is not actually recorded, resulting in assumptions on the estimation of these water volumes. The fact that the water volume entering the water distribution network is estimated based on the pumping stations data, does not

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allow the water utility to do the water balance based on actual data. The consequences are that the water balance could not show the actual Non-Revenue water (NRW) values and the actual causes of NRW. Additionally, based on national legislation the Water Directorate issued water use permits for the boreholes used and the water utility is obliged to install flowmeters for the monitoring and recording of the water abstraction. During the pilot action, flowmeters are supplied and installed in 45 boreholes (Table 3.2.3). The installation took place from 27/11/2019 until 16/12/2019. The flowmeters conform with the European Directive MID 2004/22/EC or the later MID 2014/32/EC.

The total cost for the supply and installation of the flowmeters is 66,150.00€ (no VAT included).

Table 3.2.3. The locations of the installed flowmeters

a/a	Location / Borehole	Name of the location
1	Thermi	Aeroporias
2	Thermi	Firos Sideras
3	Thermi	Kosmidis
4	Thermi	Emporiki
5	Thermi	Ergotaxio
6	Thermi	Thermokipio
7	Thermi	Interbeton
8	Thermi	Lida Maria
9	Thermi	Parsourakou-2
10	Thermi	Patsourakoy-new-3
11	Thermi	Toumpas B
12	Triadi	Triadi
13	Thermi	Hayat
14	Thermi	Eurotech
15	N. Redestos	Kanavou
16	Filothei	Filotheis -1 (Redestos)
17	Filothei	Filotheis -2 (new)
18	Filothei	Filotheis -3 (old)
19	N. Redestos	Hempe
20	N. Redestos	Christoforou
21	Tagarades	Tagaradon -1
22	Tagarades	Tagaradon-3 (Livadi) new
23	N. Risio	Zampetoglou
24	N. Risio	N. Risiou - C3
25	N. Risio	N. Risioy – C4
26	Vasilika	Ai Gianni (BA3)
27	Lakkia	North Oikismo LA1
28	Lakkia	Inverter 1
29	Lakkia	East Oikismos LA2
30	Ag. Paraskevi	Anthemounta P. (ACP1)
31	Souroti	Koukos (S1)
32	Livadi	Entos Oikismou(L1)
33	Livadi	Ektos Oikismou (L2)
34	Kardia	Christodoulidis
35	Kardia	Kloni
36	Kardia	Kakarimou
37	Epanomi	Apostolou
38	Plagiari	Rema

39	Plagiari	A1.3-Osia Xeni (Garou)
40	Plagiari	A2.1
41	Plagiari	A2.2
42	Plagiari	New A2
43	Plagiari	A1.2-Trigonou
44	Plagiari	A1.1
45	Ag. Paraskevi	S1(Ag. Paraskevi)

3.2.2.2 Water Quality

DEYA Thermis uses chlorination for the disinfection of water in water tanks. There are 29 chlorination points to cover the whole water supply network of DEYA of Thermi. The major problem faced regarding water quality is the increased value of some physical-chemical parameters that sometimes is near the allowable maximum values of the legislation. The cause of this problem is the groundwater geological background. Another problem is the excessive increase of turbidity which is due to the excessive abstraction of the groundwater. The tanks did not have automated chlorination systems.

The pilot action is the supply and installation of automated chlorination systems in 6 water tanks (out of the 29 chlorination points, that is 20.7%) (Table 3.2.4). The installation was concluded in 6/12/2019. The automated chlorination systems provide assurance that water quality parameters are within the limits set by legislation and regulations.

The total cost for the supply and installation of the six automated chlorination systems is 28,140.00€.

Table 3.2.4. The locations of the installed automated chlorination systems

a/a	Settlement name	Tank	Population
1	Kardia	Sterna	3,394
2	Plagiari	Central tank	5,392
3	N. Redestos	Pefkakia (small)	3,869
4	Ag. Paraskevi	Upper tank	2,244
5	Souroti	Upper tank	1,560
6	Peristera	D2	770

3.2.2.3 Hydraulic Simulation model

PB3, University of Thessaly, Civil Engineering department, developed the hydraulic simulation model for the water distribution system of Thermi. From the model water flow and water pressure are modelled (Figure 3.2.1). The water distribution network was divided in three zones, using existing and new isolation valves (Figure 3.2.2). At the entrance of each zone a pressure reduction valve (PRV) is installed (virtually) and pressure was regulated.

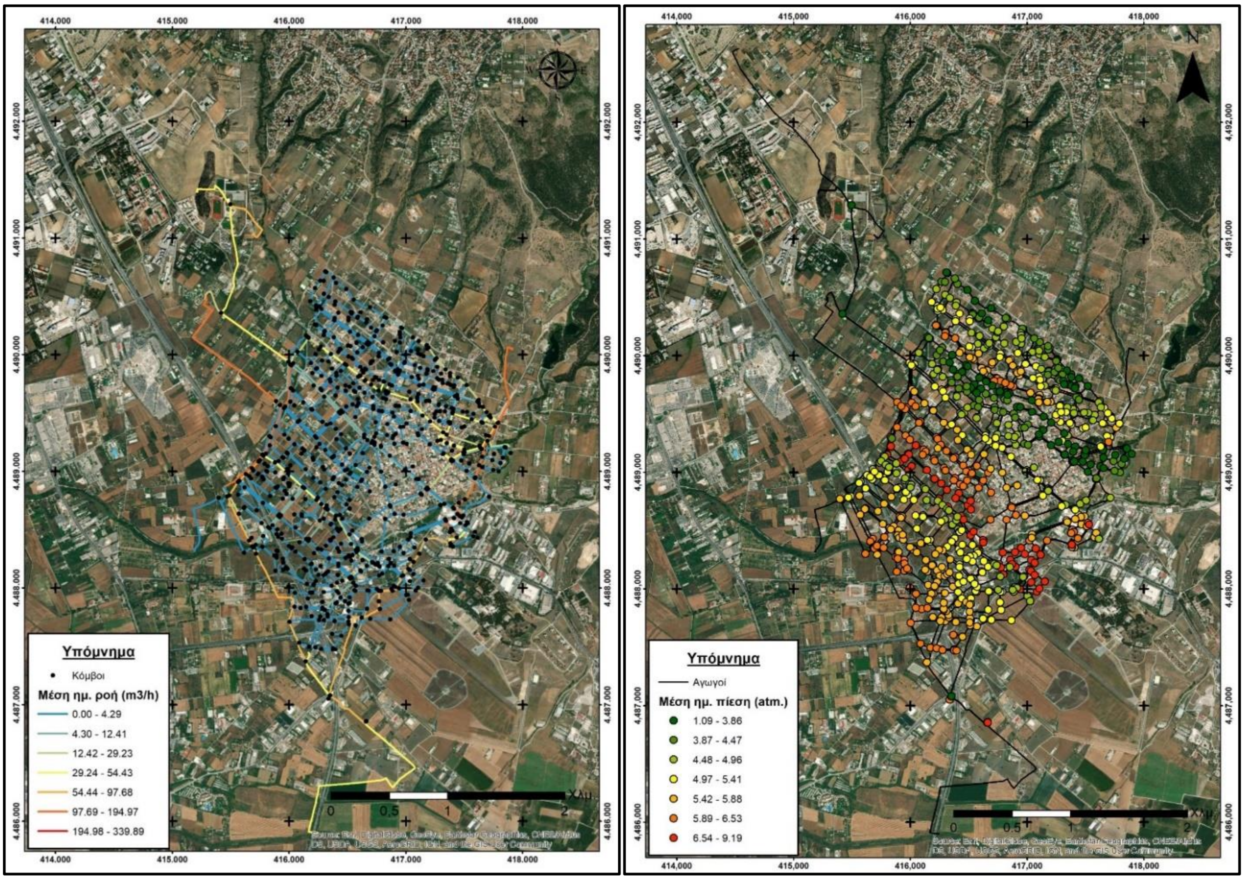

Figure 3.2.1. (a) Average water flow; (b) average water pressure

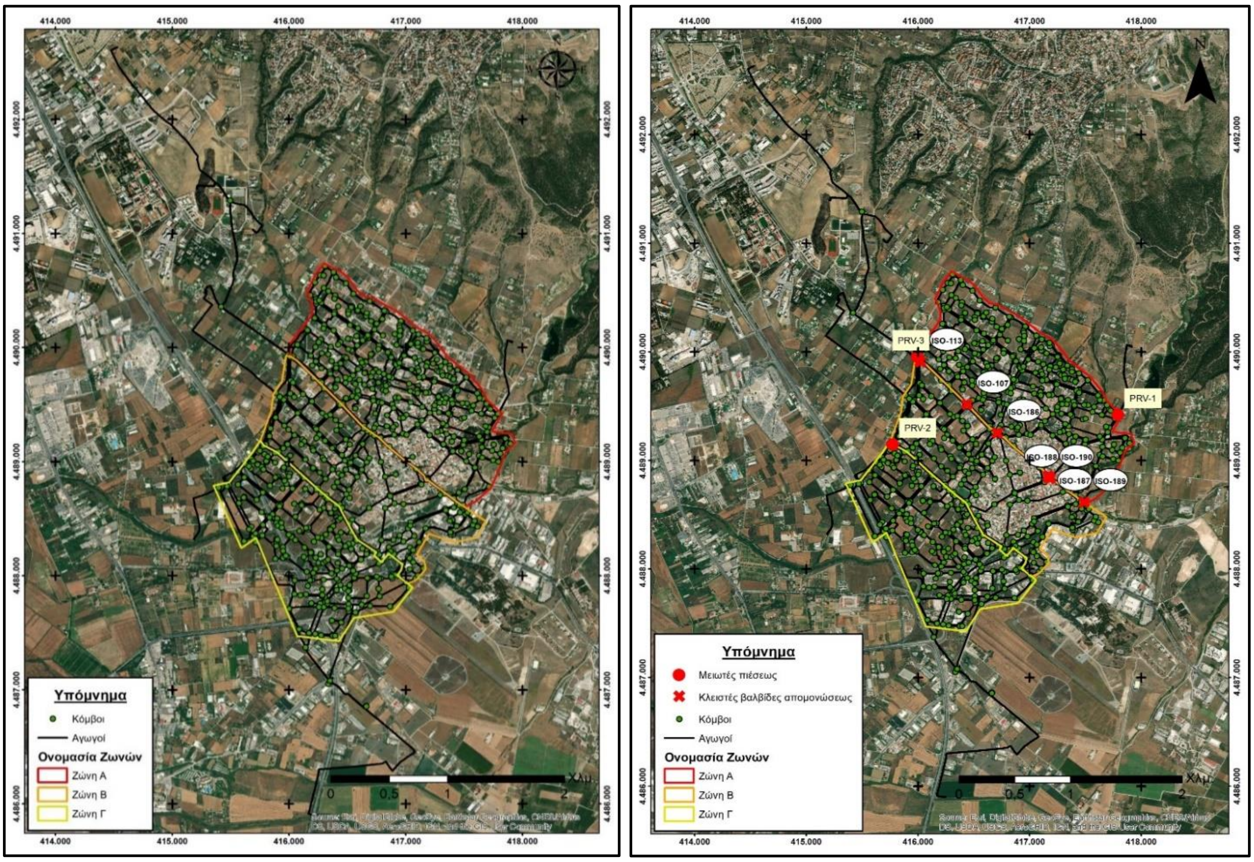

Figure 3.2.2. (a) Three pressure zones suggested; (b) PRVs and isolation valves

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<table>
<tr><td rowspan="7">System Input Volume
(A3)
4.112.015</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
3.484.966</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
3.279.127</td><td>Billed Metered Consumption
(A8)
3.279.127</td><td rowspan="2">Revenue Water
(A20=A8+A9)
3.279.127</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
205.839</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
832.888</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
200.839</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
627.049</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
369.033</td><td>Unauthorized Consumption
(A16)
41.120</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
327.913</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
258.016</td></tr>
</table>

Figure 3. IWA International WB for Thermi water distribution network for 2019

3.2.3. Water Balance assessment for the water distribution network

The WB for the whole water distribution network of Thermi has been elaborated for 2019. Specifically, the WB has been elaborated for the whole year and also per 4-month periods (as the billing period is 4 months). The water utility provided data regarding the water entering the network, the water volume billed and consumed, and the water volume consumed but not billed. Unauthorized consumption is not known for the network, but it is assumed that it represents 1% of the system input volume (entering the network). Meter inaccuracies and under-registration is also not known. According to the utility's knowledge for the network, meters errors are estimated to be 10% of the billed metered consumption.

Based on the available data and on the estimations made, the WB has been elaborated (Figures 3.2.3-3.2.6).

<table>
<tr><td rowspan="6">System Input Volume
(A3)
1.280.200</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
1.029.323</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
965.726</td><td>Billed Metered Consumption
(A8)
965.726</td><td rowspan="2">Revenue Water
(A20=A8+A9)
965.726</td></tr>
<tr><td>Billed Unmetered Consumption
(A9) 0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
63.597</td><td>Unbilled Metered Consumption
(A11) 0</td><td rowspan="4">Non-Revenue Water (NRW)
(A21=A3-A20)
314.474</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
63.597</td></tr>
<tr><td rowspan="2">Water Losses
(A15=A3-A14)
250.877</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
109.375</td><td>Unauthorized Consumption
(A16)
12.802</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
96.573</td></tr>
</table>

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		Real Losses (A19=A15-A18) 141.502		

Figure 3.2.4. IWA International WB for Thermi water distribution network for the 1st 4-month period of 2019

System Input Volume (A3) 1.351.555	Authorized Consumption (A14=A10+A13) 1.160.880	Billed Authorized Consumption (A10=A8+A9) 1.093.401	Billed Metered Consumption (A8) 1.093.401	Revenue Water (A20=A8+A9) 1.093.401
			Billed Unmetered Consumption (A9) 0	
		Unbilled Authorized Consumption (A13=A11+A12) 67.479	Unbilled Metered Consumption (A11) 0	Non-Revenue Water (NRW) (A21=A3-A20) 258.154
			Unbilled Unmetered Consumption (A12) 67.479	
	Water Losses (A15=A3-A14) 190.675	Apparent Losses (A18=A16+A17) 122.856	Unauthorized Consumption (A16) 13.516	
			Customer Meter Inaccuracies and Data Handling Errors (A17) 109.340	
		Real Losses (A19=A15-A18) 67.819		

Figure 3.2.5. IWA International WB for Thermi water distribution network for the 2nd 4-month period of 2019

System Input Volume (A3) 1.480.260	Authorized Consumption (A14=A10+A13) 1.294.763	Billed Authorized Consumption (A10=A8+A9) 1.220.000	Billed Metered Consumption (A8) 1.220.000	Revenue Water (A20=A8+A9) 1.220.000
			Billed Unmetered Consumption (A9) 0	
		Unbilled Authorized Consumption (A13=A11+A12) 74.763	Unbilled Metered Consumption (A11) 0	Non-Revenue Water (NRW) (A21=A3-A20) 260.260
			Unbilled Unmetered Consumption (A12) 74.763	
	Water Losses (A15=A3-A14) 185.497	Apparent Losses (A18=A16+A17) 136.803	Unauthorized Consumption (A16) 14.803	
			Customer Meter Inaccuracies and Data Handling Errors (A17) 122.000	
		Real Losses (A19=A15-A18) 48.694		

Figure 3.2.6. IWA International WB for Thermi water distribution network for the 3rd 4-month period of 2019

The Water Balance components per year for the three years of study, 2017, 2018 and 2019 are given in Table 3.2.6.

The results from the pilot action implementation include the exact recordings of the flowmeters in the boreholes (Table 7). Data are gathered on 28/1/2020, 30/6/2020 and 9/2/201. The data from the last registration are taken into consideration to estimate the total water volume entering the network. The time the flowmeters were metering is from 27/11/2019 – 9/2/2020 (440 days average). The total water volume recorded during this time period is 8,212,705m^3.

The total cost for the supply and installation of the flowmeters is 66,150.00€ (no VAT included).

Table 3.2.5. Flowmeters' recordings

a/a	Location / Borehole	Name of the location	Water volume abstracted until 28/1/2020 (m^3)	Water volume abstracted until 30/6/2020 (m^3)	Water volume abstracted until 9/2/2021 (m^3)
1	Thermi	Aeroporias	96,077	245,488	688,420
2	Thermi	Firos Sideras	42,715	153,549	268,160
3	Thermi	Kosmidis	36,302	120,550	212,420
4	Thermi	Emporiki	27,115	76,399	202,170
5	Thermi	Ergotaxio	10,503	26,050	81,175
6	Thermi	Thermokipio	44,357	104,618	273,270
7	Thermi	Interbeton	62,123	141,866	381,123
8	Thermi	Lida Maria	32,841	32,888	32,902
9	Thermi	Parsourakou-2	0	0	0
10	Thermi	Patsourakoy-new-3	19,313	59,228	201,621
11	Thermi	Toumpas B	0	0	0
12	Triadi	Triadi	15,068	49,881	155,208
13	Thermi	Hayat	12,990	60,609	235,725
14	Thermi	Eurotech	71,527	154,946	337,422
15	N. Redestos	Kanavou	479	588	604
16	Filothei	Filotheis -1 (Redestos)	88,569	204,357	472,930
17	Filothei	Filotheis -2 (new)	56,174	106,247	284,100
18	Filothei	Filotheis -3 (old)	626	5,537	50,028
19	N. Redestos	Hempe	4,067	14,518	50,768
20	N. Redestos	Christoforou	20,027	69,821	249,489
21	Tagarades	Tagaradon -1	21,091	110,913	224,675
22	Tagarades	Tagaradon-3 (Livadi) new	68,251	118,745	142,070
23	N. Risio	Zampetoglou	0	0	0
24	N. Risio	N. Risiou - C3	24,806	68,839	191,750
25	N. Risio	N. Risioy – C4	40,929	106,682	294,600
26	Vasilika	Ai Gianni (BA3)	19,698	116,948	196,370
27	Lakkia	North Oikismo LA1	20,935	42,855	97,633
28	Lakkia	Inverter 1	0	0	39,356
29	Lakkia	East Oikismos LA2	0	1,544	19,345
30	Ag. Paraskevi	Anthemounta P. (ACP1)	58,786	147,245	444,500
31	Souroti	Koukos (S1)	2,501	3,094	162,078
32	Livadi	Entos Oikismou(L1)	0	0	0
33	Livadi	Ektos Oikismou (L2)	6,003	17,651	1,316
34	Kardia	Christodoulidis	44,996	130,682	389,000
35	Kardia	Kloni	27,732	86,712	236,934
36	Kardia	Kakarimou	925	19,203	82,903
37	Epanomi	Apostolou	0	0	0
38	Plagiari	Rema	0	0	0

39	Plagiari	A1.3-Osia Xeni (Garou)	35,614	53,488	132,394
40	Plagiari	A2.1	0	0	0
41	Plagiari	A2.2	3,997	70,188	275,177
42	Plagiari	New A2	25,914	61,811	100,900
43	Plagiari	A1.2-Trigonou	0	0	46,341
44	Plagiari	A1.1	28,218	55,515	159,956
45	Ag. Paraskevi	S1(Ag. Paraskevi)	157,176	411,569	797,872

Given that this amount of water is abstracted from 45 out of the 54 boreholes, the total amount abstracted from all the boreholes for the same period of 440 days is estimated to be 9,855,246m^3. That means that in a year time the total water volume abstracted is estimated to be 8,175,375m^3. The water utility estimates that during one year the total water volume abstracted is about 4,100,000m^3. The water volume abstracted is highly underestimated (almost 100%)! Given that the water volume consumed is recorded in the water consumers, the NRW levels are very high! Based on the recording of the 45 flowmeters, the system input volume is 8,175,375m^3 per year, then the water balance components are as shown in Table 3.2.6.

The results show that NRW values are significantly higher when the actual SIV values are used. In order to have solid results, flowmeters should be installed to the remaining 9 boreholes.

The hydraulic model of the network is developed. The results show that the smaller / local pipes show the lowest flow rates, while the main water distribution pipes show the highest average daily flow. Given that pressure is not regulated through pressure reduction valves, the results showed that the nodes at the highest altitudes of the network have low pressure, while as altitude decreases pressure increases to quite high pressures.

Three zones are developed virtually using the hydraulic model and using combinations of altitude and pressure. For the creation of the three zones some of the isolation valves are closed and some other are added. To regulate the pressure, three pressure reduction valves are installed at the entrance of each zone in order to achieve minimum pressure of 2 atm in every node. PRV-1 is set at 4.15 atm, PRV-2 is set at 2.10 atm and PRV-3 is set at 2.50 atm. The critical nodes are identified: (a) zone A, higher altitude node J-327 and lower altitude node J-33; (b) zone B, higher altitude J-417 and lower altitude node J-196; and (c) zone C, higher altitude node J-749 and lower altitude node J-587.

It is noted that there is a reduction in pressure in all zones, with the maximum reduction up to 58% while the minimum reduction is 4% (Table 3.2.7). In addition, there is a stabilization of pressure during zoning, where the average pressure per zone remains constant regardless of time, in contrast to the time before the zones' creation where a strong fluctuation in pressure is noted. The model showed that if zoning takes place the water volume entering the network is reduced by 3.44%.

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Table 3.2.6. WB data for 4-month periods of 2017, 2018 and 2019 and annually

m^3	1st 2017	2nd 2017	3rd 2017	1st 2018	2nd 2018	3rd 2018	1st 2019	2nd 2019	3rd 2019	2017	2018	2019 (estimated)	2019 (Calculated)
System Input Volume	1.306.553	1.341.222	1.362.964	1.271.948	1.349.577	1.495.264	1.280.200	1.351.555	1480260	4.010.739	4.116.789	4.112.015	8.175.375
Authorized Consumption	1.033.145	1.060.559	1.077.751	1.005.781	1.067.166	1.182.366	1.029.323	1.160.880	1.294.763	3.171.455	3.255.313	3.484.966	3.484.966
Billed Authorized Consumption	967.817	993.498	1.009.603	942.184	999.687	1.107.603	965.726	1.093.401	1.220.000	2.970.918	3.049.474	3.279.127	3.279.127
Billed Metered Consumption	967.817	993.498	1.009.603	942.184	999.687	1.107.603	965.726	1.093.401	1220000	2.970.918	3.049.474	3.279.127	3.279.127
Billed Un Metered Consumption	0	0	0	0	0	0	0	0	0	0	0	0	0
Unbilled Authorized Consumption	65.328	67.061	68.148	63.597	67.479	74.763	63.597	67.479	74.763	200.537	205.839	205.839	205.839
Unbilled Metered Consumption	0	0	0	0	0	0	0	0	0	0	0	0	0
Unbilled Unmetered Consumption	65.328	67.061	68.148	63.597	67.479	74.763	63.597	67.479	74763	200.537	205.839	205.839	205.839
Revenue Water	967.817	993.498	1.009.603	942.184	999.687	1.107.603	965.726	1.093.401	1.220.000	2.970.918	3.049.474	3.279.127	3.279.127
Water Losses	273.408	280.663	285.213	266.167	282.411	312.898	250.877	190.675	185.497	839.284	861.476	627.049	4.690.409
Apparent Losses	109.847	73.022	84.302	88.094	103.468	125.713	109.375	122.856	136.803	337.199	346.115	369.033	409.666
Unauthorized Consumption	13.066	13.412	13.630	12.719	13.496	14.953	12.802	13.516	14.803	40.107	41.168	41.120	81.754
Meter Inaccuracies & Data Handling Errors	96.782	59.610	70.672	75.375	89.972	110.760	96.573	109.340	122.000	297.092	304.947	327.913	327.913
Real Losses	163.561	207.641	200.911	178.073	178.943	187.185	141.502	67.819	48.694	502.085	515.361	258.016	4.280.743
Non-Revenue Water	338.736	347.724	353.361	329.764	349.890	387.661	314.474	258.154	260.260	1.039.821	1.067.315	832.888	4.896.248

Table 3.2.7. Average pressure before and after the creation of the zones and the difference in percentage

Time (hours)	Before zoning			During zoning			Difference (%)		
	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C
0	4,53	6,48	5,41	4,00	3,60	2,85	-11,73%	-44,49%	-47,33%
1	4,56	6,49	5,43	4,00	3,60	2,85	-12,24%	-44,61%	-47,52%
2	5,42	8,53	5,42	4,02	3,60	2,85	-25,92%	-57,82%	-47,46%
3	5,39	8,49	5,42	4,45	3,60	2,85	-17,41%	-57,64%	-47,42%
4	5,39	8,49	5,41	4,45	3,60	2,85	-17,50%	-57,62%	-47,38%
5	5,38	8,46	5,41	4,01	3,60	2,85	-25,44%	-57,49%	-47,33%
6	4,54	6,49	5,43	4,36	3,59	2,85	-3,88%	-44,64%	-47,54%
7	5,00	7,68	5,41	4,14	3,59	2,84	-17,14%	-53,26%	-47,42%
8	4,50	6,49	5,40	4,00	3,57	2,84	-11,07%	-44,95%	-47,45%
9	4,52	6,46	5,38	3,99	3,56	2,83	-11,84%	-44,86%	-47,35%
10	4,48	6,41	5,39	3,98	3,56	2,83	-11,21%	-44,46%	-47,48%
11	4,48	6,43	5,38	3,98	3,57	2,83	-11,06%	-44,56%	-47,34%
12	4,47	6,42	5,40	3,98	3,57	2,84	-10,92%	-44,37%	-47,49%
13	4,48	6,44	5,39	3,98	3,57	2,84	-11,09%	-44,58%	-47,38%
14	4,50	6,44	5,38	3,97	3,57	2,84	-11,68%	-44,56%	-47,28%
15	4,48	6,42	5,40	3,98	3,57	2,84	-11,23%	-44,39%	-47,47%
16	4,48	6,44	5,39	3,98	3,57	2,83	-11,13%	-44,66%	-47,38%
17	4,49	6,44	5,37	3,97	3,56	2,83	-11,64%	-44,72%	-47,24%
18	4,49	6,43	5,37	3,98	3,55	2,83	-11,38%	-44,86%	-47,34%
19	4,48	6,43	5,37	3,98	3,55	2,83	-11,27%	-44,80%	-47,39%
20	4,48	6,41	5,38	3,98	3,55	2,83	-11,16%	-44,54%	-47,43%
21	4,49	6,44	5,37	3,97	3,56	2,83	-11,66%	-44,65%	-47,23%
22	4,49	6,43	5,39	3,98	3,57	2,84	-11,28%	-44,41%	-47,37%
23	4,50	6,45	5,40	3,98	3,59	2,84	-11,58%	-44,36%	-47,32%
24	4,50	6,47	5,41	4,00	3,60	2,85	-11,03%	-44,42%	-47,38%

3.2.4. Water Quality evaluation

The water utility of Thermi uses groundwater sources for water supply. The utility conforms with the national and European legislation regarding drinking water quality. Disinfection is applied as water treatment at the boreholes or at the water tanks. At the boreholes, chlorine is injected to the borehole supply pipe. At the water tanks, chlorine is added inside the water tank.

The major problem faced regarding water quality is the increased value of some physical-chemical parameters that sometimes is near the allowable maximum values of the legislation. The cause of this problem is the groundwater geological background.

Another problem is the excessive increase of turbidity which is due to the excessive abstraction of the groundwater.

Regarding chlorination, the water utility implements the national legislation. There are 29 chlorination points, given in Table 11. Chlorination takes place is tanks, in boreholes, pumping stations and in other sites. Table 3.2.8 shows also the tanks where the automated chlorination systems are installed.

Table 3.2.8. Chlorination types and sites for DEYA Thermis

Network	Chlorination point	Chlorination	Comments	Automated

		type		chlorination systems installed
Lida Maria	Tank	3	The automatic system is out of order	
Toumba	Foiros Sideras	2		
Litsa small	Foiros Sideras	2		
Litsa large	Foiros Sideras	2		
Hayat	Tank	1		
Triadi up tank	Pumping station Triadi	1		
Triadi down tank	Pumping station building site	1		
N. Redestos big tank	Tank	1	The automatic system is out of order	
N. Redestos small tank	Tank	1		√
Filothei	Tank	1		
Tagarades	Preselection tank	4		
N. Risio	Tank	1		
Vasilika	Borehole BA1	1		
Lakkia	Borehole ΛA1	1		
Kato Peristera	Borehole	1		
Peristera source	In the network	5		
Up tank Peristera	Church Peristera spring	6		
Down tank Peristera	Tank	6		√
Livadi	Borehole	1		
Agios Antonios	St John	3		
Monopigado	St John	3		
Souroti	Tank	3		√
Agia Paraskevi	Tank	1		√
Kardia	Sterna	2		√
Trilofos Kotroni	Conjunction & 4 SEASON	1 & 2	The automatic system is extracted	
Trilofos Profitis Ilias	Conjunction	1	The automatic system is extracted	
Plagiari	Upper tank & down tank in the summer	3 & 7		√
Kato Sholari	Conjunction	1	The automatic system is extracted	
Ano Sholari	Conjunction	1	The automatic system is extracted	

Meaning of chlorination type:

1: Chlorination pump connected to the borehole
2: Chlorination pump connected to the pump
3: Chlorination pump connected to the sensor
4: Automatic chlorination system
5: Solid chlorine
6: 24hours continuous electricity
7: works with timer

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The chlorination systems work based on sampling of water and analyzing the free chlorine concentrations. These chlorination systems do not ensure that water is chlorinated when needed, that is when free chlorine concentrations are below limits. Automated chlorination systems measure continuously the free chlorine concentration and define the required dose. The 6 tanks are selected as they were presenting unstable conditions in chlorination process. These tanks were more difficult to monitor and presented high deviations regarding chlorination.

The results from the installation of the automated chlorination systems are:

- More efficient chlorination since the automated system allows for the correct dose after measuring the level of the free chlorine in water;
- Better water quality for the consumers;
- Saving of resources.

The total cost for the supply and installation of the six automated chlorination systems is 28,140.00€. The water volume properly chlorinated is 1,285,000m^3/year (Table 3.2.9).

Table 3.2.9. Tank details and related maps

a/a	Settlement name	Tank	Capacity (m^3)	Consumption (m^3/year)	Related figure
1	Kardia	Sterna (Δ1)	40	290,000	Fig. 3.2.7
2	Plagiari	Central tank (Δ14)	240	400,000	Fig. 3.2.7
3	N. Redestos	Pefkakia (small) (Δ1)	75	45,000	Fig. 3.2.8
4	Ag. Paraskevi	Upper tank (Δ1)	400	295,000	Fig. 3.2.9
5	Souroti	Upper tank (Δ1)	200	205,000	Fig. 3.2.10
6	Peristera	Δ2	200	50,000	Fig. 3.2.11

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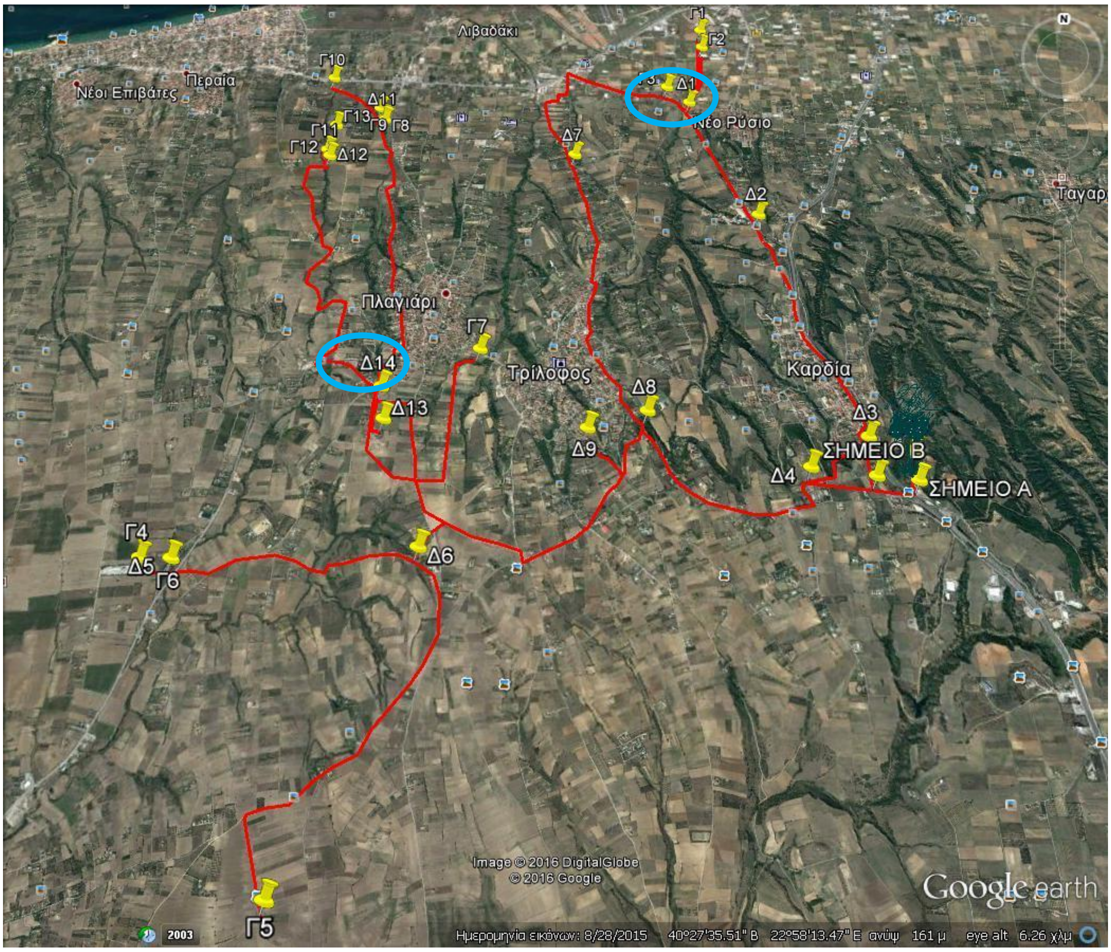

Figure 3.2.7. Map of boreholes and tanks in Mikra – tanks Δ1 & Δ14 (where automated chlorination systems are installed) are shown in circles

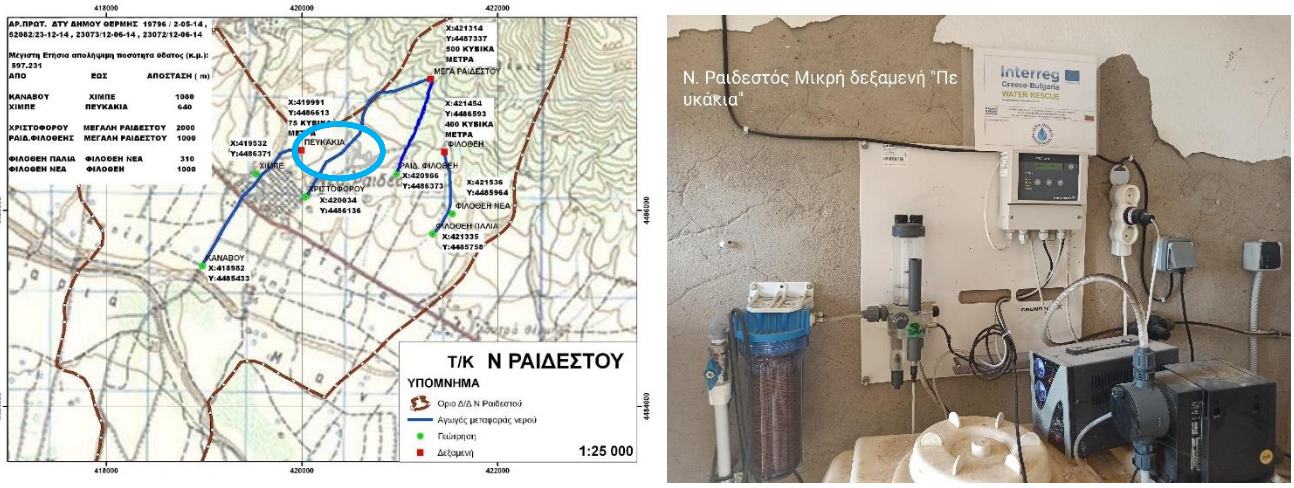

Figure 3.2.8. Map of boreholes and tanks in N. Redestos – tank Δ1 - Pefkakia (where automated chlorination system is installed) is shown in circle

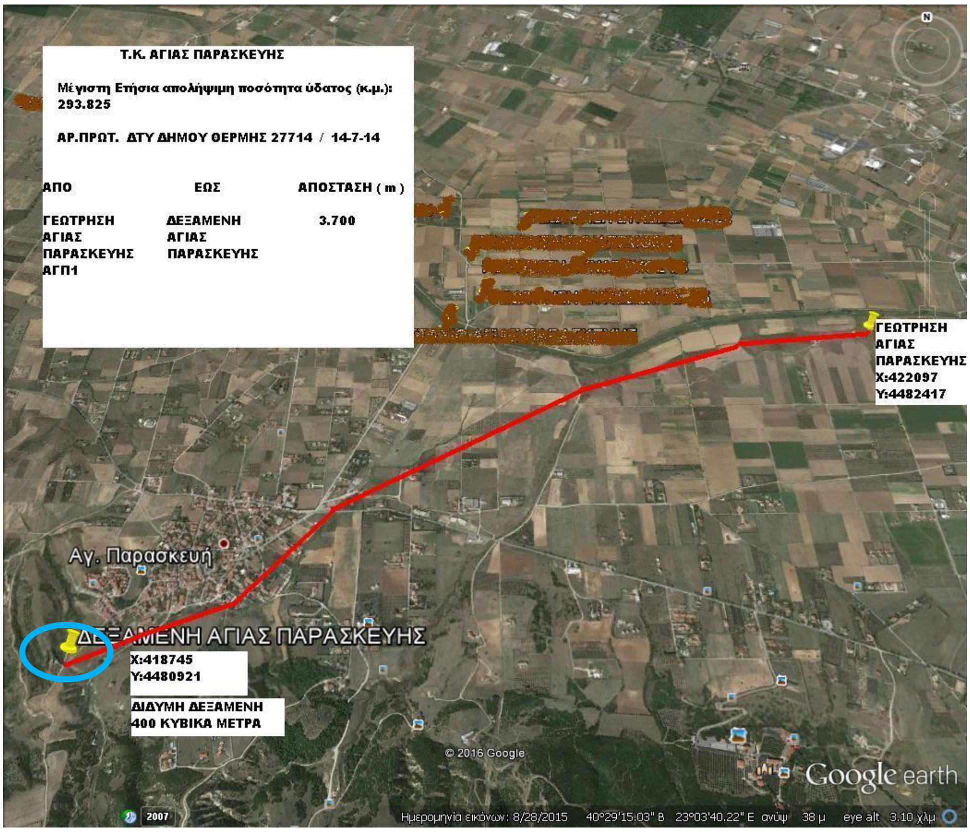

Figure 3.2.9. Map of boreholes and tanks in Ag. Paraskevi – tank Δ1 (where automated chlorination system is installed) is shown in circle

Figure 3.2.10. Map of boreholes and tanks in Souroti – tank Δ1 (where automated chlorination system is installed) is shown in circle

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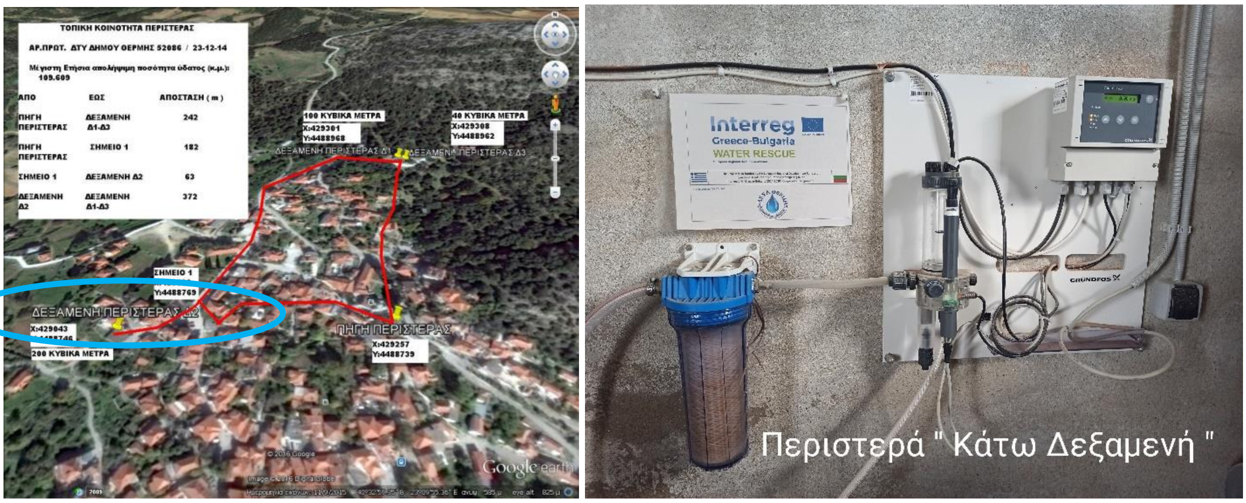

Figure 3.2.11. Map of boreholes and tanks in Peristera – tank Δ2 (where automated chlorination system is installed) is shown in circle

3.2.5. Performance Indicators

Based on the data above, several performance indicators (PIs) have been calculated for 2019, annually. The PIs are given in the Table 3.2.10, including the values for 2017 and 2018.

The results show that NRW by volume (as % of SIV) is 25.93% for 2017 and 2018 but it is lower (20,25%) for 2019. Apparent losses are 8.41% of SIV for 2017 and 2018 but 8.97% for 2019 and real losses are 12.52% of SIV for 2017 and 2018 but 6.27% for 2019. Real losses expressed as L/Km/day are 1,965.11 for 2017, 2,017.07 for 2018 and 1,009.85 for 2019. Water losses in m^3/Km/year are 3.28 (2017), 3.37 (2018) and 2.45 (2019).

NRW levels are quite high and are mainly due to real losses. However, as estimations are used to calculate the water volumes, the flowmeters established are able to provide actual data on water entering the network. Thus the PIs based on the recordings from the flowmeters and the updated WB for 2019 show that inefficiency of use of water resources is increased to 43.84% and the water losses per mains length to 13.42 m^3/Km/year. The same happens for real losses per mains length, unmetered water and NRW by volume. This increase is due to the higher SIV volumes resulting in higher NRW since revenue water is considered stable and accurate.

Table 3.2.10. PIs for 2017, 2018 and 2019 annually

Performance Indicator		2017	2018	2019 (estimated)	2019 (calculated)	Units
WR1	Inefficiency of use of water resources	12.52	12.52	6.27	52.36	%
Op24	Water losses per mains length	3.28	3.37	2.45	18.36	m^3/km/year
Op25	Apparent losses	8.41	8.41	8.97	5.01	%
Op26	Apparent losses per system input volume	8.41	8.41	8.97	5.01	%
Op28	Real losses per mains length	1,965.11	2,017.07	1,009.85	16,754.37	L/km/day when system is pressurised
Op39	Unmetered water	25.93	25.93	20.25	59.89	%
Fi46	Non-revenue water by volume	25.93	25.93	20.25	59.89	%
	Real Losses (% SIV)	12.52	12.52	6.27	52.36	%

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

The water utility applies all the necessary tests for water quality. Performance indicators for those tests are estimated and presented in Table 3.2.11.

Table 3.2.11. PIs regarding water quality for 2017, 2018 and 2019

Performance Indicators		2017	2018	2019	Units
Op40	Tests carried out	100	100	100	%
Op41	Aesthetic tests carried out	100	100	100	%
Op42	Microbiological tests carried out	100	100	100	%
Op43	Physical-chemical tests carried out	100	100	100	%
Op44	Radioactivity tests carried out	100	100	100	%
QS11	Bulk supply adequacy	100	100	100	%
QS18	Quality of supplied water	96,61	97,76	93,30	%
QS19	Aesthetic tests compliance	100	100	73,6	%
QS20	Microbiological tests compliance	95,56	97,26	98,18	%
QS21	Physical-chemical tests compliance	96,77	96,77	96,8	%
QS22	Radioactivity tests compliance	100	100	100	%

In general, the water utility elaborates all necessary tests. Some of the tests are not in compliance with the legislation, specifically microbiological tests and physical – chemical tests. However, the percentage is very high, showing that there are only a few cases with non-compliance.

3.2.6. Conclusions

The water distribution system of Thermi supplies with water 53,070 people through 700 Km of pipes and 25,786 water meters. The total area covered is 1,559Km^2. The mean operating pressure is 5 atm. The installation of 45 flowmeters allowed the water utility to record water volumes entering the network (SIV in water balance). Thus, updates are made at the 2019 WB for the water supply network of Thermi. SIV is increased by 98.8% and since revenue water is stable, NRW levels are also increased. The water audit showed that NRW levels are about 25% of the SIV for 2017 and 2018, while for 2019 NRW is 59.89%. Apparent losses are 8.41% of SIV in 2017 and 2018 while for 2019 they are 5.01% of SIV. Since apparent losses are estimated based on percentages of SIV and water consumption, this PI cannot be taken as a reliable one. Real losses are 12.52% of SIV in 2017 while in 2019 they are 52.36%. All PIs cannot show the impact of the pilot action at this time as 2019 is the first year where water volumes abstracted are actually recorded. Therefore, the impact of the pilot action is the accurate and reliable recording of water volumes entering the network.

Regarding water quality the water utility implements the national legislation regarding chlorination. There are 29 chlorination points, in tanks, boreholes, pumping stations and in other sites. However, some of these systems are not functional. In general, the water utility elaborates all necessary tests. Some of the tests are not in compliance with the legislation, specifically microbiological tests and physical – chemical tests. However, the percentage is very high, showing that there are only a few cases with non-compliance. With the pilot action it is safeguarded that in 6 chlorination points, chlorination takes place in a safe way, ensuring good water quality for the consumers. The water volume properly chlorinated in these 6 points is 1,285,000m^3/year supplied to 17,229 people.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

3.3. PB3 – University of Thessaly – Special Account Funds for Research – Civil Engineering Department, Greece

3.3.1. General description

The University of Thessaly does not have its pilot case. However, based on the project's application form, PB3 is responsible for developing the hydraulic simulation model for the water distribution network of PB2. All the data and the results are given in section 3.2.

3.4. PB4 – Municipality of Kardzhali, Bulgaria

3.4.1. General description

The water supply and distribution system of Kardzhali supplies with water 55,019 people, through 19,854 service connections. The mean operating pressure is 4-5 atm (Table 3.4.1). The average age of the pipes are 35 years. The billing period is monthly. Water is taken from Borovitsa river, the dam of Borovitsa and Perpereshka river. Data for the pipes are given in Table 3.4.2.

Table 3.4.1. General data of the water supply network of Kardzhali (base year 2019)

General data	
Total population served	55,019
Mean operating pressure (atm)	4-5
No. of service connections	19,854
Billing Period	monthly
River Basin where water is taken from	Arda river, Borovitsa river, dam of Borovitsa, Perpereshka river.

Table 3.4.2. Pipes data for water supply network of Kardzhali

MUNICIPALITY	length of the water supply network			
	in the settlements		out of populated areas	
	Φ ≤300 мм	Φ > 300 мм	Φ ≤ 300 мм	с Φ > 300 мм
	км	км	км	км
MUNICIPALITY KARDZHALI	171171	7608	143539	33380
Incl.				
ethericity	97668	7608	122202	33380
steel	11975		12811	
PEPP and PVC	61528		8526	

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

3.4.2. Pilot action description

Water use efficiency

The flowmeters included in the project will help to locate sections of the water supply system where there is a suspected loss or theft of water, and after their installation very accurately and quickly it will be possible to identify possible accidents in those sections.

Four ultrasonic flowmeters were installed under the project - 3. in the town of Kardzhali and 1 pc. on the border of Kardzhali municipality and Momchilgrad municipality. The locations are as follows (Figure 3.4.1 & 3.4.2):

1. On Bulgaria Blvd. at the roundabout at the exit of the city to bl. Coca-Cola - measures the water quantities at the entrance to the Baikal district. It is mounted on an F 600 pipe.

2. At the crossroads of Struma Street and Osmi Oktomvri Street - measures water quantities for the central part of the city. It is mounted on an F 400 pipe.

3. To PS PETLINO after a pressure tank of 5000 m3 - measures water quantities for Gledka and Gorna Gledka districts. It is mounted on an F 300 pipe.

4. On the border of the municipality of Kardzhali and the municipality of Momchilgrad to the village of Pepelishte - measures water quantities for the municipality of Momchilgrad by the “Dam. Borovitsa ”. It is mounted on an F 500 pipe.

Ultrasonic flow meters are of the frequency pulse type in which the speed of movement of the fluid / water / is determined by measuring the time for the passage of ultrasonic pulses against and in the direction of movement of the fluid. The ultrasonic flow meters installed under the project measure the passed water quantities every minute. The data reported by the device are in l / sec for instantaneous consumption, accumulated volume for the hour, for the day, for the month and for the year.

All appliances are software installed on a computer of a dispatcher who monitors the readings of flow meters 24 hours a day, 7 days a week. The same software through remote access to the computer of the dispatcher can be monitored by an unlimited number of employees / manager, ch. engineer, DWTP technologist, technical managers, etc./ for timely action in case of events.

Data and graphs for the past period / hour, day, week and month / can be extracted from the software. Comparing them with the collected water in the area of operation of the flow meter, analyzes are made for the condition and losses of the network. The dispatcher, who is on duty on a shift, monitors the readings and in case of deviation from the normal ones signals the emergency teams for possible accidents and leaks in the network.

The system allows to display data and graphs from which the minimum night consumption of the system can be determined at the lowest consumption by users, the amount of water loss from hidden leaks. After locating the area by stopping cranes from end to nearby streets and monitoring the cost, the street with the problem area is located. To more accurately determine the hidden leak, our company has portable terrestrial noise microphones, point correlators and point noise bearings. In addition to these devices under the project, the company has installed 9 more. ultrasonic flow meters for measuring water quantities and two level meters, which are included in the same software. Attached we present screenshots with data and graphs from the readings of the devices installed under the project.

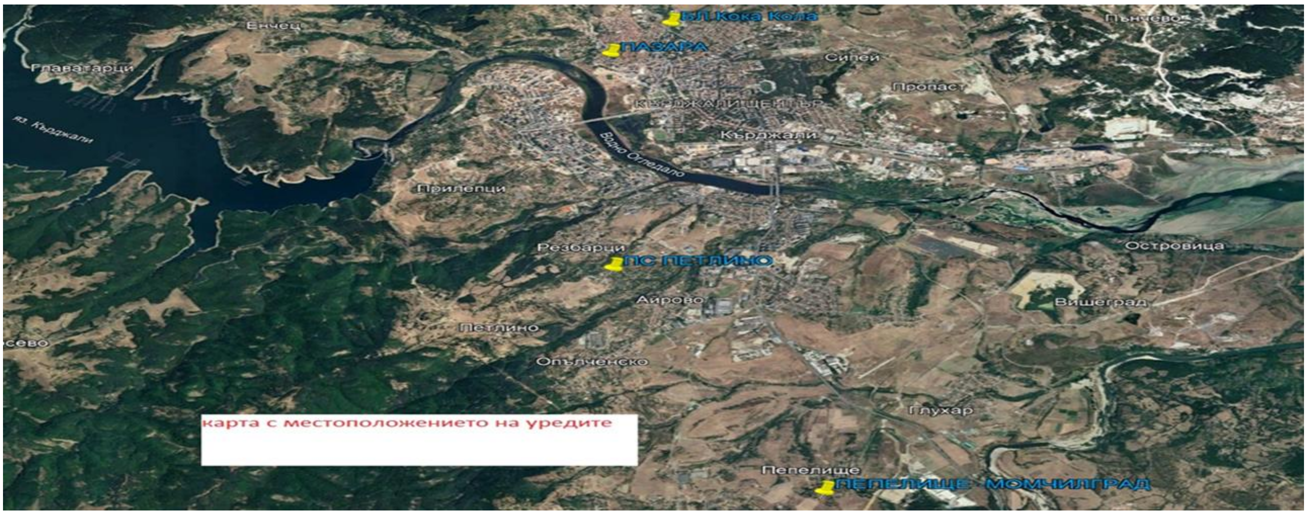

Figure 3.4.1. The locations where the 4 electromagnetic flowmeters are installed

Figure 3.4.2. Installation of the flowmeters

Water quality

With respect to the monitoring and requirements for drinking water quality, it is necessary that the laboratory equipment used by the operator operating the water supply system be able to carry out as many analyzes as required by the relevant regulations (Ordinance 9 on drinking water quality) and be accurate as a research method. Current laboratory equipment limits the number of indicators tested and requires much of the research to be outsourced, which involves a long time for sample analysis and high costs.

The laboratory equipment provided in the project will enable the investigation of a large number of indicators required by the relevant drinking water quality regulations, will enable the rapid and timely analysis of the samples, as well as the measurement with high accuracy and correctness.

On December 22, 2021, the mass spectrometer was installed, configured, tested and ready for operation (Figure 3.4.3). During the functional tests of the system, the following standard procedures were performed to check the qualification of the installation, operational readiness and verification of the equipment for operation.

- the equipment has no obvious transport defects **yes**
- The supply voltage of the system corresponds to the Bulgarian standards **yes**
- The configuration of the system corresponds to that ordered by the customer **yes**
- When the system is turned on, the displays light up and the keys function normally **yes**
- When each of the modules of the system is switched on, it successfully passes its initial testing and initialization procedure **yes**
- The software product is configured to work with the specific system **yes**
- There is normal two-way communication between the system and the control software, the status of the device is available in real time on the computer screen **yes**
- Each of the modules of the device reaches its set parameters and goes into the status "ready for analysis" **yes**
- All operating parameters of the system / hardware and software / fully comply with the technical specifications of the manufacturer **yes**
- The start signal works normally and the system modules are in full sync **yes**
- The software automatically processes information and generates a correct result **yes**
- In analysis and standard sample, the results meet the requirements **yes**
- The manufacturer's standard operating procedure for checking the qualification of the installation, operational readiness and verification of the equipment for operation has been completed successfully **yes**

Good quality water is a valuable and limited resource of paramount importance for human health, economic prosperity and social well-being. This is the main challenge - the establishment of such management in the water sector, through which to meet the needs of water in the required quantity and quality, both to ensure the life and health of the population and the needs of the economy, while providing conditions for reproduction and development of aquatic ecosystems.

Increasing the efficiency of water use has direct economic and environmental positive effects. Reducing water losses, water as a natural resource is protected and the pressure on water resources is reduced. Reduced NRW levels provide economic benefits to water supply as less water is extracted, purified and distributed. Also, reducing visible losses means direct economic benefits, as larger water volumes are registered and water thefts are reduced. When the level of NRW decreases, then the total price of water decreases, which means that the price of water is lower. This is a social benefit as consumers pay less for the same amount of water consumed.

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Figure 3.4.3. Mass spectometer

3.4.3. Water Balance assessment for the water distribution network

Water consumption by month for 2017, 2018 and 2019 is given in Table 3.4.3. Water losses are estimated to be 45.39%.

Table 3.4.3. Water consumption for 6 months 2017, 2018, 2019

2017	2018	2019
1,251,099	1,270,087	1,258,463

Water balance - 6 months for 2018.

- Supplied water – 2,186,724 m^3 Collected water – 1,270,087 m^3

Water balance - 6 months for 2019.

- Supplied water – 2,003,475 m^3 Collected water – 1,258,463 m^3

№	name of the settlement	population number	WATER SUPPLY m3	INVOICED WATER population m3	INVOICED WATER companies m3	TOTAL INVOICED WATER m3	LOSS %	WATER SUPLED BY THE WATER SUPPLY SYSTEM	INVOICED WATER IN THE WATER SUPPLY SYSTEM	LOSS %
KARDZHALI Municipality - surface water sources										
	Water supply system "BOROVITSA dam" for the municipality of Kardzhali							4393742	2399260	45,39

3.4.4. Results

From the implementation of the WATER RESCUE project and the implemented pilot actions, lessons have been learned related to the efficiency of water use. The project action of delivery and installation of flow meters made possible to locate sections of the water supply system where there is a suspicion of water loss or theft. Also, after their installation it is possible to identify possible accidents in these sections very accurately and quickly. The results of the implementation of the pilot actions showed that there is a serious underestimation of the water volume, which leads to a false assessment of non-revenue water. Thus, the water supply cannot identify the actual value of the NRW and the reasons for this in order to develop strategies and take measures to reduce them. On the basis of the performed real measurements the project beneficiaries managed to estimate the real water losses and to consider separately a certain part of the city water supply network and to prove the need for rehabilitation there. Targeted actions in the most critical part of the network gave significant results in the conditions of impossibility to replace the whole network of one city. The implementation of the pilot action showed that the water supply and sewerage has a very good knowledge of the spatial and temporal distribution of accidents, which allows to design the next steps regarding the repair of network assets or even their replacement when necessary. Also, the repair time is reduced, as the water supply and sewerage system is immediately informed of any damage to the water distribution network. Consumers are notified of specific water problems or outages, improving their relationship with the water company. A methodology for increasing water efficiency has also been developed. The first step towards this goal is to develop a water balance and identify the causes of NRW. Then, based on the reasons for NRW, several measures are presented. Water operators can choose from measures based on criteria they set, such as economic, cost-benefit, criteria related to the effectiveness of the measure or consumer concerns, and more.

3.4.5. Performance Indicators

The performance indicators calculated for water quality are shown in Table 3.4.4.

Table 3.4.4. PIs regarding water quality

Performance Indicators		2017	2018	2019	Units
Op40	Tests carried out	100	99.0	99.9	%
Op41	Aesthetic tests carried out	100			%
Op42	Microbiological tests carried out	100			%
Op43	Physical-chemical tests carried out	100			%
QS18	Quality of supplied water	98.66	98.0	98.9	%
QS19	Aesthetic tests compliance	98.92			%
QS20	Microbiological tests compliance	97.91			%
QS21	Physical-chemical tests compliance	99.04			%
QS30	Water quality complaints		0.5	0.01	%

In general, the water utility elaborates almost all necessary water quality tests. There are some tests not in compliance with the legislation. However, the percentage is very high, higher than 98%.

The cost of the pilot action of the installation of flowmeters is 13,743.53 € while the cost of the pilot action for the supply of the mass spectrometer is 112,249.02 €.

3.4.6. Conclusions

The water supply and distribution system of Kardzhali supplies with water 55,019 people, through 19,854 service connections. The mean operating pressure is 4-5 atm. The average age of the pipes are 35 years. The billing period is monthly. Water is taken from Borovitsa river, the dam of Borovitsa and Perpereshka river. NRW level is 35.5% of SIV. PIs for water quality are calculated. All tests are carried out. However, there is not compliance with all tests but the percentages are high.

The flowmeters included in the project will help to locate sections of the water supply system where there is a suspected loss or theft of water, and after their installation very accurately and quickly it will be possible to identify possible accidents in those sections.

The laboratory equipment provided in the project will enable the investigation of a large number of indicators required by the relevant drinking water quality regulations, will enable the rapid and timely analysis of the samples, as well as the measurement with high accuracy and correctness.

3.5. PB5 – Municipality of Gotse Delchev, Bulgaria

3.5.1. General description

Pilot actions will take place in sub DMA called Dunav. Due to specificity of the areas covered mainly from 4-5 floors blocks, DMA has high level of non-revenue water with relatively short main pipeline and small number of service connections. The population served is 1,650 people through 1.14 Km of pipes and 49 service connections. The area covered is 0.20Km^2. The area's mean altitude is 525m. The pipes' length is 1,141m of steel pipes of 200mm diameter and 539m of brass pipes (service connections) of 32mm diameter. The pipes are installed more than 30 years ago (Table 3.5.1). The mean operating pressure is 4.5 atm.

Table 3.5.1. General data of the water distribution network of Dunav DMA (base year 2018)

General data	
Total population served	1,650
Total area covered (Km^2)	0.20
Total pipes' length (Km)	1.14
Mean altitude (m)	525
Mean operating pressure (atm)	4.5
Types of pipes (material, diameters, lengths)	Steel with diameter 200mm=1,141m; brass with diameter 32mm=539m
Age of pipes (per material, diameter)	>30 years
No. of service connections	49
Billing Period	monthly
River Basin where water is taken from	Mest river basin

3.5.2. Pilot action description

The main problem of the selected area of water supply network of Gotse Delchev is high level of real water losses. Based on measurements and data analysis elaborated as a part of current project real water losses and other indicators directly affected by level of real water losses for DMA Dunav are following:

- NRW by volume (Fi46) (%) = 66,08%
- Water Losses per connection (Op23) (m3/connection/year) = 2884,69
- Water Losses per mains length (Op24) (m3/Km/year) = 339.7
- Apparent Losses (Op25) (%) = 15.55%
- Apparent Losses per SIV (Op26) (%) = 15.55%
- Real Losses per connection (Op27) (L/connection/day when system is pressurized) = 6,979.42
- Real Losses per mains length (Op28) (L/km/day when system is pressurized) = 299,992.8

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- ILI = 115.4

As a part of overall project following actions were performed:

- Design of DMA, construction of a manhole, installation of measuring equipment and data analysis – as a part of that part of pilot actions insertion flow meter with autonomous power supply was supplied and installed. In addition data was implemented in specialized software for data management and water loss calculation.

Figure 3.5.1 – manhole with insertion flow meter at the entrance of DMA Dunav

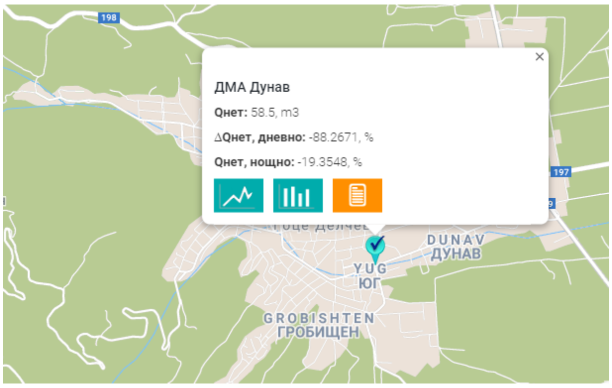

Figure 3.5.2 – View from system for data management and water loss reduction

- Rehabilitation of water main in DMA Dunav – final stage of the project was related with rehabilitation of certain pipe sections with following sizes and length:
  - Φ110 – 601 m
  - Φ90 – 552 m
  - Φ63 – 294 m

The cost of reconstruction of pipeline is 96,550.36€ and cost for DMA set up is 10,000.00€.

Figure 3.5.3 – Reconstruction of pipeline

Figure 3.5.4 – Reconstruction of pipeline

3.5.3. Pilot action results

The most important results from the pilot action implementation are:

➢ Reduction in net flow delivered at entrance of DMA.

The water supplied in the DMA is reduced after the pilot action implementation. Specifically, the reduction ranges from 25% (July) to 38% (April).

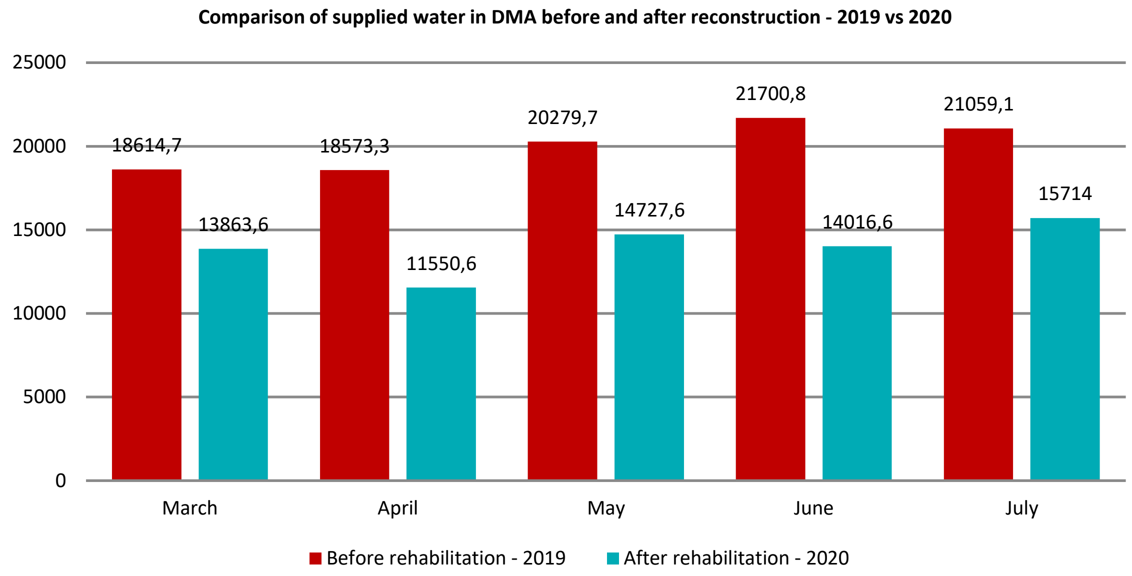

Figure 3.5.5. Water supplied in DMA before and after the implementation of the pilot action

Table 3.5.2. Water supplied before and after rehabilitation and the related reduction in %

Time period	Before rehabilitation - 2019	After rehabilitation - 2020	Reduction in supplied water in DMA
March	18,614.7	13,863.6	26%
April	18,573.3	11,550.6	38%
May	20,279.7	14,727.6	27%
June	21,700.8	14,016.6	35%
July	21,059.1	15,714.0	25%

➢ Reduction of net night flow which is directly related with level of real losses

Average night flow is reduced after the pilot action implementation. The reduction percentage ranges from 43% to 57.9%. The highest reduction percentage is met in June.

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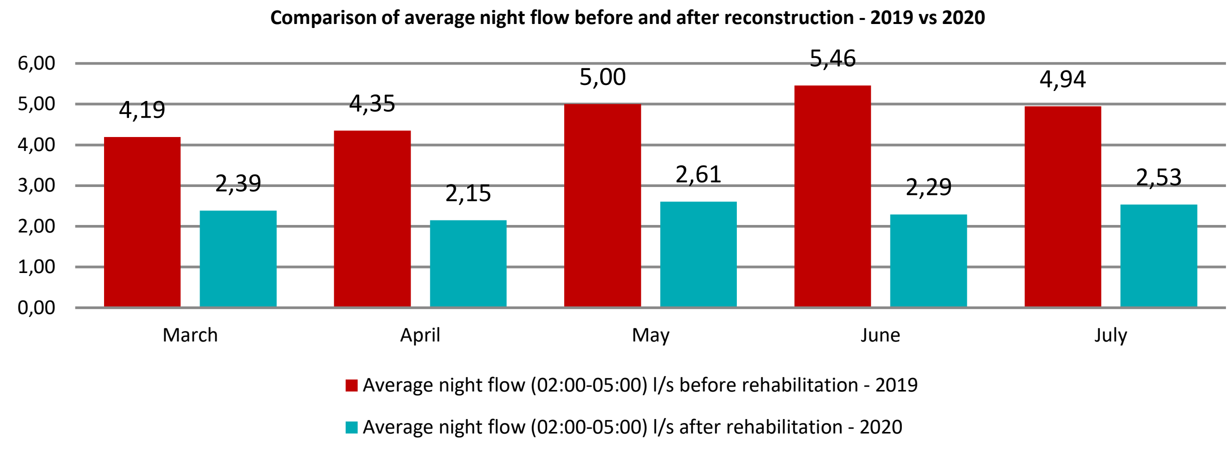

Figure 3.5.6. Average night flow in DMA before and after the implementation of the pilot action

Table 3.5.3. Average night flow before and after rehabilitation and the related reduction in %

Time	Average night flow (02:00-05:00) L/s before rehabilitation - 2019	Average night flow (02:00-05:00) L/s after rehabilitation - 2020	Reduction
March	4,19	2,39	43,0%
April	4,35	2,15	50,6%
May	5,00	2,61	47,8%
June	5,46	2,29	57,9%
July	4,94	2,53	48,7%

➢ Reduction of ILI index which measures level of real losses

ILI index is reduced radically. The reduction ranges from 44% to 59%. ILI values after the implementation of the pilot action range from 46.98 to 57.73 compared to 94.65 to 124.14 before the pilot action implementation.

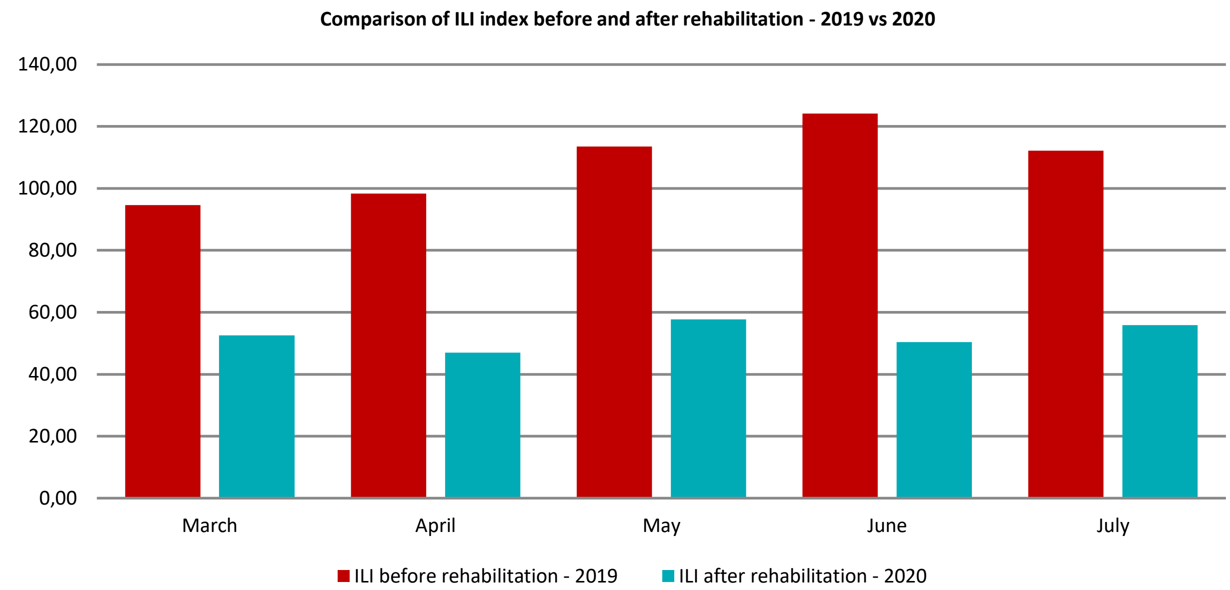

Figure 3.5.7. ILI index values in DMA before and after the implementation of the pilot action

Table 3.5.4. ILI index values before and after rehabilitation and the related reduction in %

Time	ILI before rehabilitation - 2019	ILI after rehabilitation - 2020	Reduction
March	94,65	52,59	44%
April	98,29	46,98	52%
May	113,52	57,73	49%
June	124,14	50,43	59%
July	112,20	55,84	50%

3.5.4. Performance Indicators

Based on the available data the following PIs (Table 3.5.6) have been estimated for the pilot are of the water distribution network of DMA “Danube” for 2017 and 2019.

Table 3.5.6. Performance Indicators for the pilot area in Gotse Delchev (2017 and 2019)

PI	PI name	PI value (2017)	PI value (2019)	Measured in
WR1	Inefficiency of use of water resources	58.35	N/A	%
Op23	Water losses per connection	2,884.69	1,316.57	m^3/ connection / year
Op24	Water losses per mains length	339.7	107.16	m^3/km/year
Op25	Apparent Losses	15.55	21.0	%
Op26	Apparent Losses per SIV	15.55	21.0	%
Op27	Real losses per connection	6,979.42	2,051.44	L/connection/day when system is pressurised
Op28	Real losses per mains length	299,992.8	N/A	L/km/day when system is pressurised
Op29	ILI	115.42	53.65	
Fi46	NRW by volume	66.08	58.07	%

The pilot action results in reduced real losses as the water pipes are replaced and therefore leaks are minimized. With the implementation of the pilot action, the customer service is improved, real losses are significantly reduced and water is saved. For six months period (March to July) the water volume saved is 40,829.29m^3.

3.5.5. Conclusions

Municipality of Gotse Delchev (PB5) pilot action refer to the purchase and installation of electromagnetic flowmeters and pressure meters in the DMA in "Danube" area in Gotse Delchev water supply network and the replacement of pipes with diameter 90 and 110 in DMA "Danube" area. The total population of 1,650 people is supplied with water through 1,140 Km of pipes at a mean operating pressure of 4.5 atm. The number of connections are 49. As real losses are extremely big in this DMA (NRW is 66.08% of SIV and ILI is 115 in 2017) and the water distribution network is very old, the municipality decided to install flowmeters and pressure meters at this DMA at the beginning to record all the necessary data. Then they decided to replace water pipes. The results showed that the water supplied in the DMA is reduced after the pilot action implementation. Specifically, the reduction ranges from 25% (July) to 38% (April). Average night flow is reduced after the pilot action implementation. The reduction percentage ranges from 43% to 57.9%. The

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highest reduction percentage is met in June. ILI index is reduced radically. The reduction ranges from 44% to 59%. ILI values after the implementation of the pilot action range from 46.98 to 57.73 compared to 94.65 to 124.14 before the pilot action implementation.

The cost of the pilot action (reconstruction of pipeline) is 96,550.36€.

3.6. PB6 – Municipal Water Supply and Sewerage Company of Thermaikos, Greece

3.6.1. General description

The water utility of Thermaikos has set the whole water supply network as the pilot case. The general data of the pilot case are given in Table 3.6.1. The water utility supplies with water a population of 50,264 people through 654 Km of pipes and 32,656 service connections. The total area covered is 135.5 Km^2 and the mean altitude 55m. The mean operating pressure is 3 atm.

Table 3.6.1. General data of the water supply network of DEYA Thermaikos (base year 2017)

General data	
Total population served	50,264
Total area covered (Km^2)	135.5
Total pipes' length (Km)	654
Mean altitude (m)	55
Mean operating pressure (atm)	3
Types of pipes (material, diameters, lengths)	PVC, asbestos cement
Age of pipes (per material, diameter)	PVC: 33 years; asbestos cement: >55 years
No. of service connections	32,656
River Basin where water is taken from	Chalkidiki river basin

3.6.2 Pilot action description

The pilot action for the Municipal Water Supply and Sewerage Company of Thermaikos consists of the development of IT applications for: (a) Water distribution networks management allowing water operators to manage the spatial data of the water distribution networks (e.g. Identification of the areas affected by water interruptions or failures, etc.) and; (b) Mapping of the failures history in an interactive map.

Both IT applications are developed internally at the systems of DEYA Thermaikos.

The first application allows the water utility to manage the geospatial data related to the water supply and distribution network and the infrastructure. This application gives the ability to provide basic tools such as the location of areas affected by failures or interruptions in water supply. The application is GIS-based. The user can enter data using user-friendly forms (Figure 3.6.1). These forms refer to different parts of the network, such as bulk water meters, connection points, distribution points, district metered areas (DMAs), fittings, water intake points, manholes, water meters, pipelines, etc. There are forms for data entry for damages and failures, maintenance, repair, etc. The application gives various abilities: (a) topology: for any change in the water supply and distribution network; (b) combined search, for example pipe diameter and material (Figure 3.6.2); (c) reporting: the user can get printable reports (figure 3.6.3) and; (d) statistics: the user can create any form of statistics.

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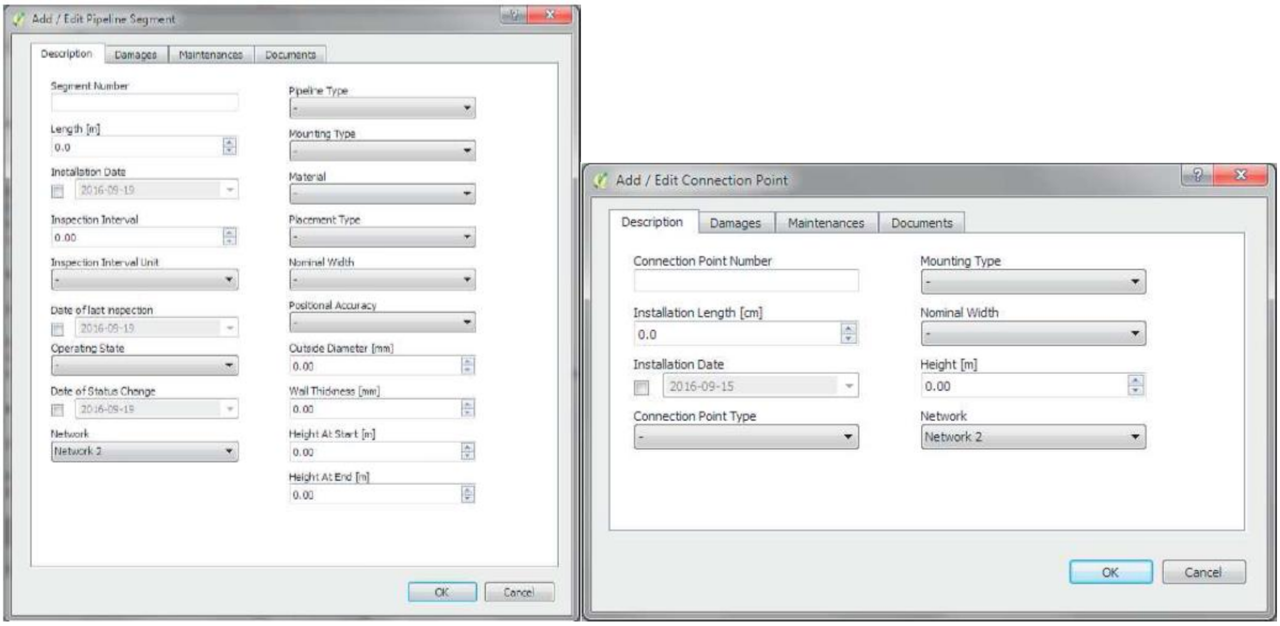

Figure 3.6.1. The forms for data entry

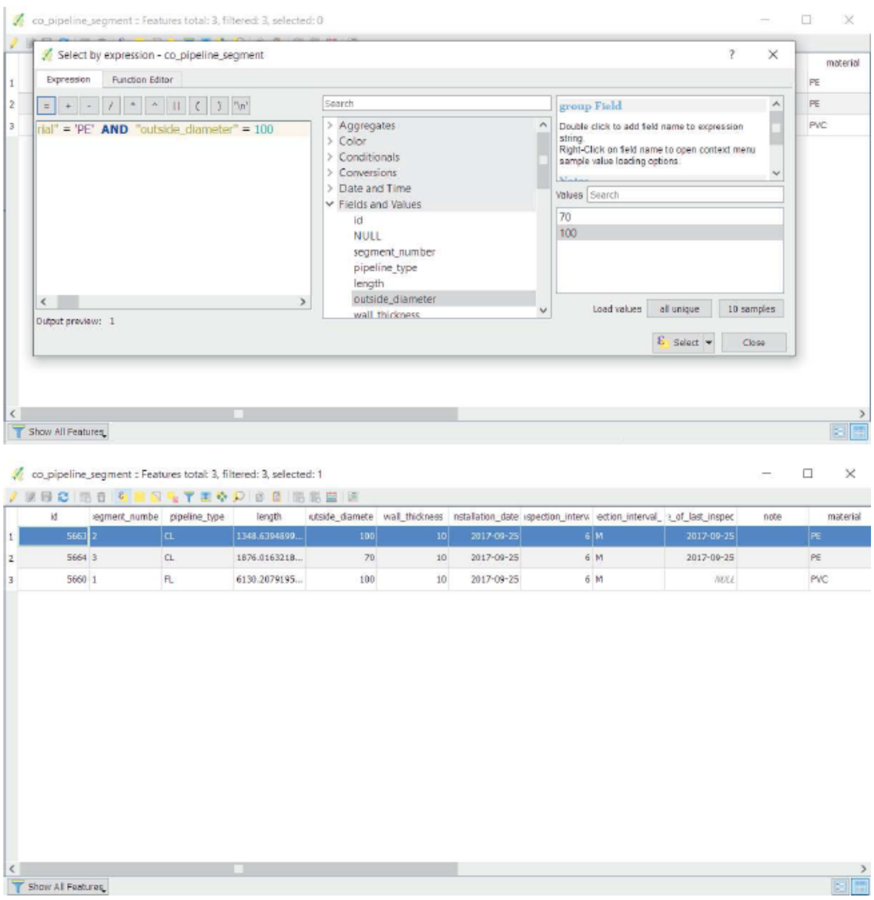

Figure 3.6.2. Combined search

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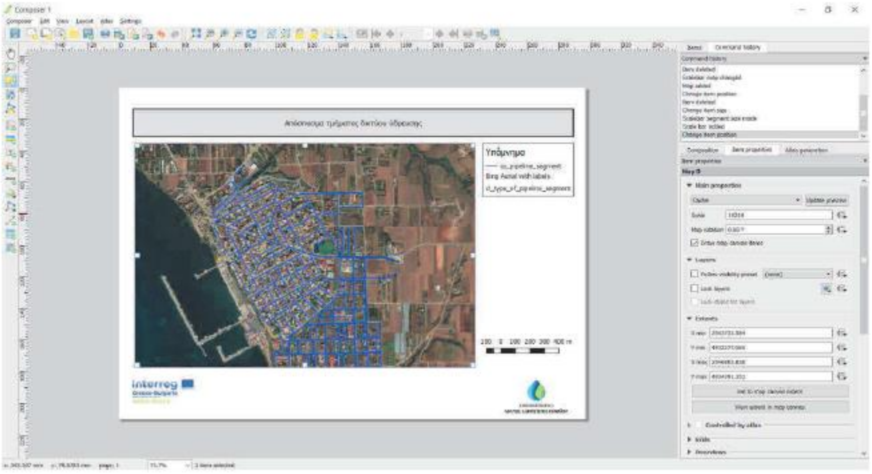

Figure 3.6.3. The preface for printable reports

The second application gives the ability to the water utility to monitor the time and spatial evolvement of failures in the water distribution network (Figure 3.6.4). Each failure and its related data (such as cost, water lost, materials used, etc.) are imprinted in a map where the user can search using the appropriate filters and perform spatial analysis. In this way the water utility can locate the areas where there are significant water losses and the repair cost is high and therefore plan the implementation of works and interventions in order to improve the operation of the water distribution network and at the same time to reduce the operational cost and the cost of the related Non-Revenue Water.

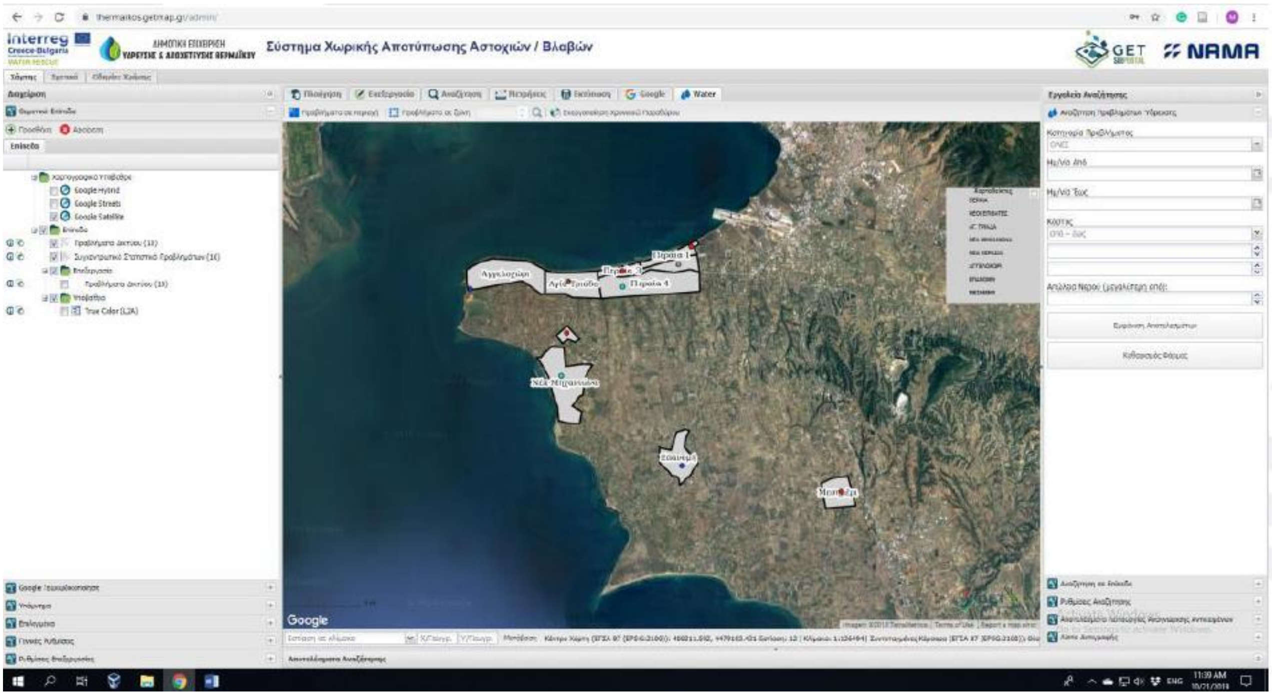

Figure 3.6.4. The application for spatial mapping of failures

3.6.3. Results

The IT applications are developed for the water supply network of DEYA of Thermaikos, both internal (Figure 3.6.5 & 3.6.6) and external (Figure 3.6.7). The user has maps with the infrastructure of the water distribution network and at the same time can get information about any failures or water interruptions.

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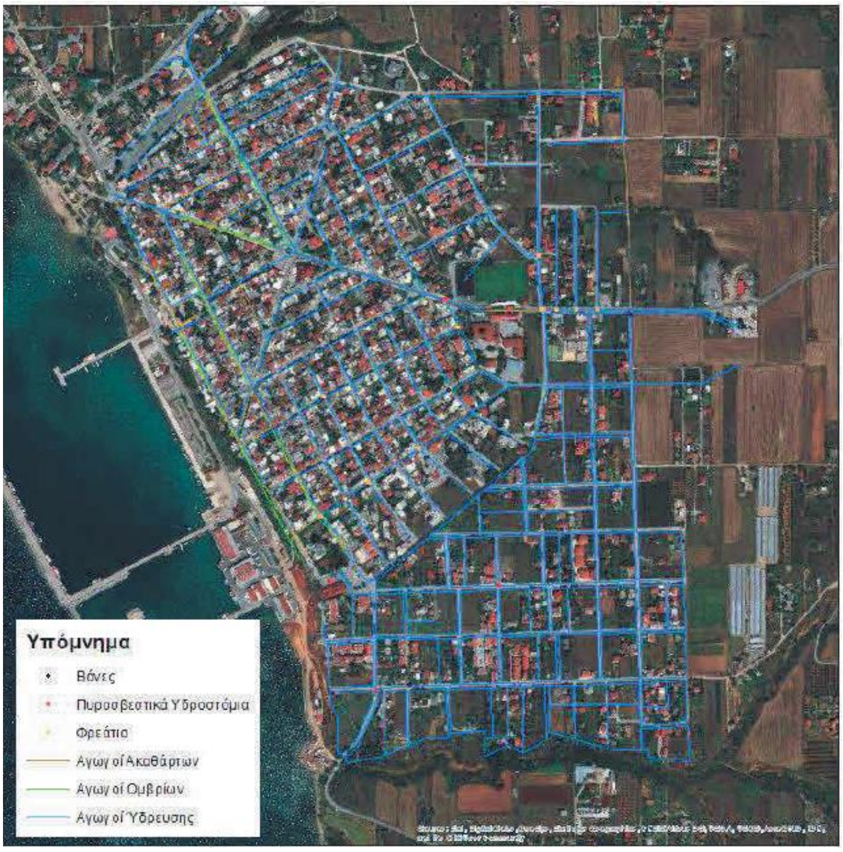

Figure 3.6.5. The water distribution network of New Mihaniona

Figure 3.6.6. The water distribution network of Ano Peraia

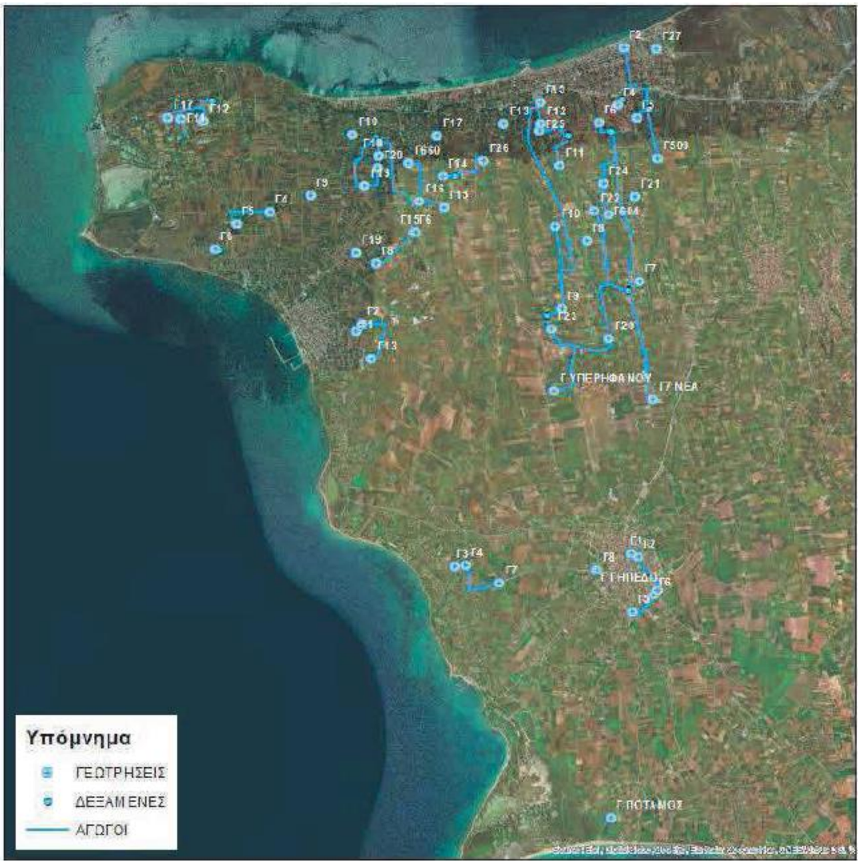

Figure 3.6.7. The external water supply network

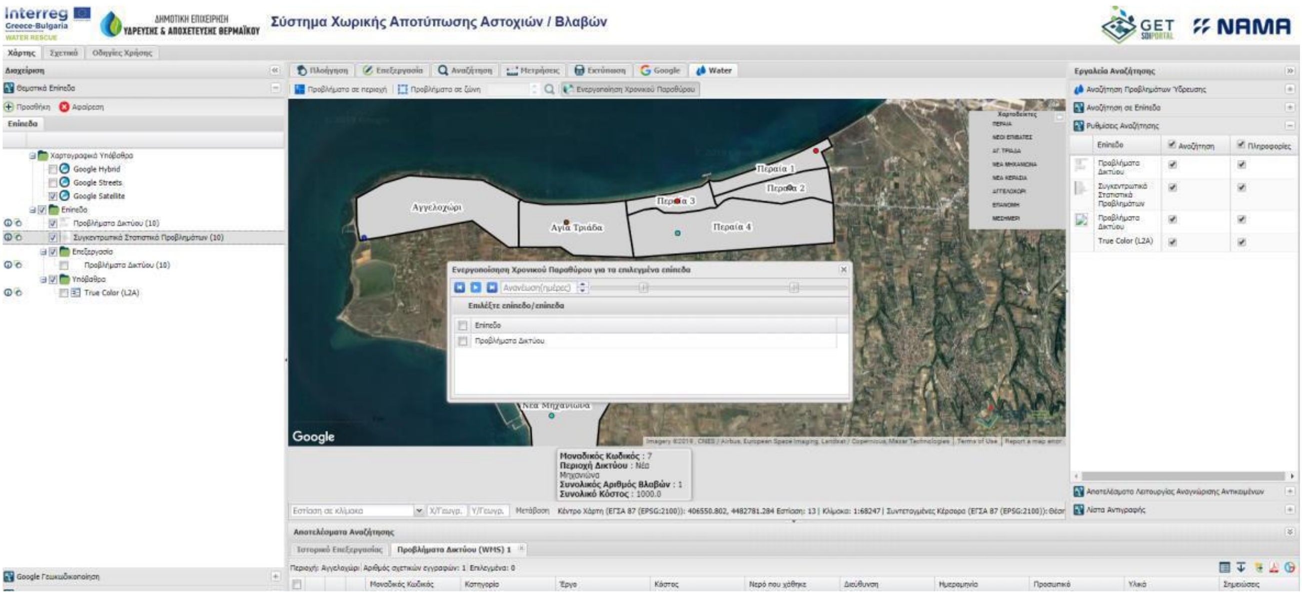

Figure 3.6.8. Failures indicated in the application

The spatial mapping application provides data about the failures in the water distribution network. The user can monitor both the time and spatial distribution of these failures. This allows the water utility managers to locate areas with high number of failures and plan the necessary actions. Also, the application gives information about the cost of the repairs of the failures. Thus, the water utility managers can set their criteria in order to prioritize their actions (Figures 3.6.8, 3.6.9, 3.6.10 and 3.6.11).

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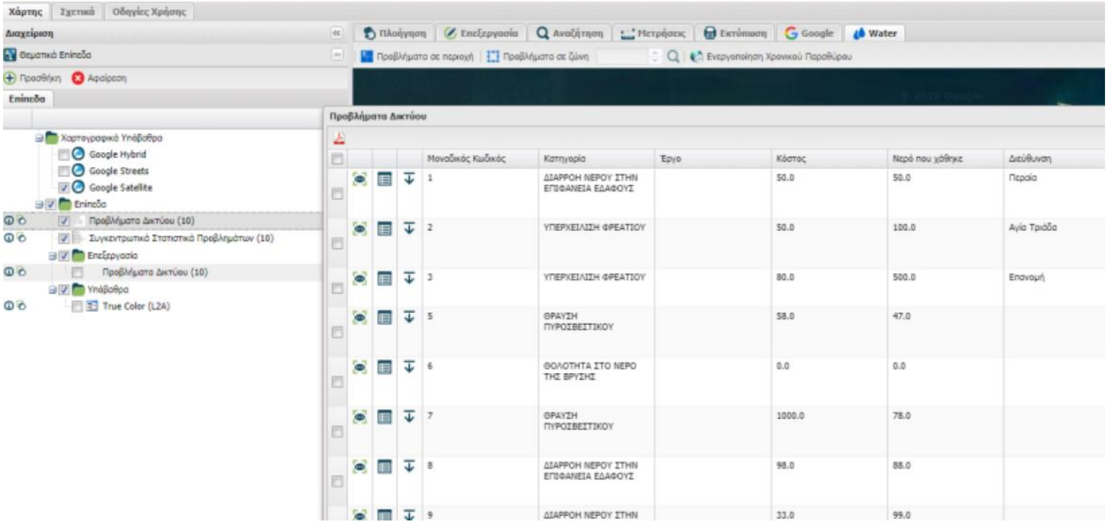

Figure 3.6.9. Information list view

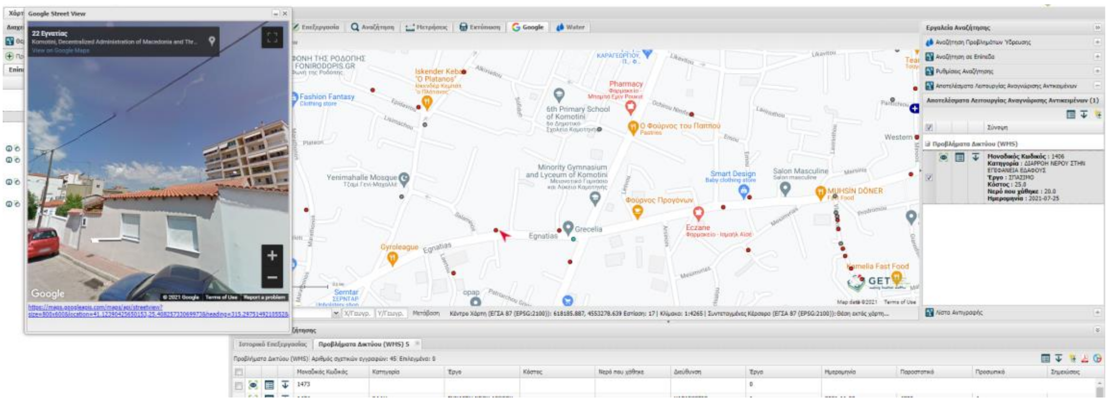

Figure 3.6.10. Street view

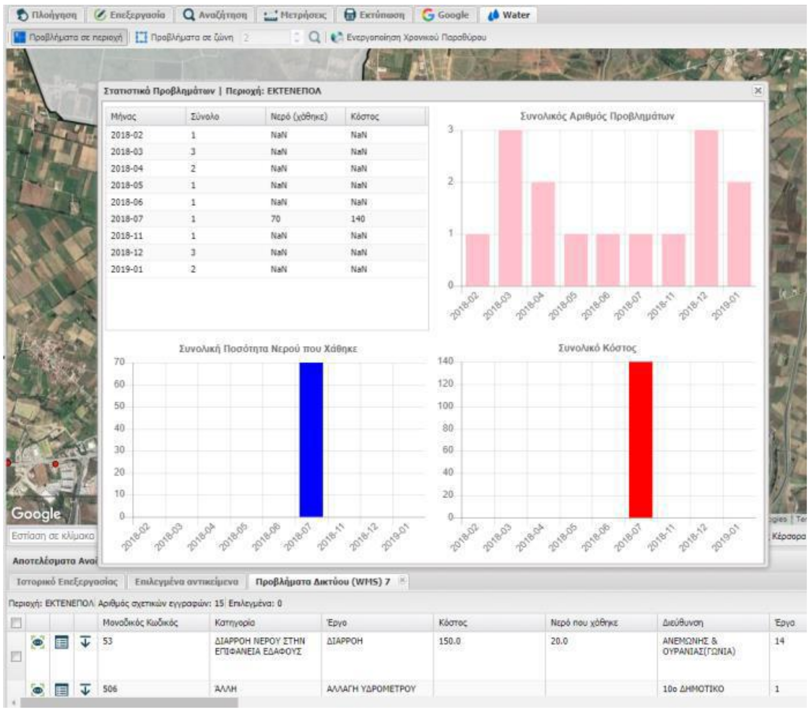

Figure 3.6.11. Statistics and reports

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3.6.4. Conclusions

The water distribution system of Thermaikos supplies with water 50,264 people through 654 Km of pipes and 32,656 service connections. The total area covered is 135.5 Km^2. The mean operating pressure is 3 atm. The water utility developed IT applications to provide a useful decision-making tool that can be connected to other IT tools for a more efficient water distribution system management. The pilot action targets the "speed and quality of repairs" real losses reduction pillar.

Chapter 4. Discussion & Conclusions

4.1 Pilot Areas Description

The beneficiaries involved in pilot actions are DEYA Komotinis (PB1), DEYA Thermis (PP2), University of Thessaly (PB3), Municipality of Kardzhali (PB4), Municipality of Gotse Delchev (PB5) and DEYA Thermaikos (PB6).

The Water Utility of Komotini supplies with water the municipality of Komotini, located in the Water District of Thrace (EL12). The people supplied with water is 65,000 for Komotini city through 400 km of pipes' length. The average operating pressure is 4 atm and the total number of water meters is 48,500. Municipal Water Supply and Sewerage Company of Thermi (DEYA Thermis) is the water utility supplying with water the area of Thermi including several municipal districts of a total population of 53,070 people through 25,786 active water meters. The total pipes' length is about 700 Km and the average operating pressure is about 5 atm. The University of Thessaly does not have its pilot case. However, PB3 is responsible for developing the hydraulic simulation model for the water distribution network of PB2. The water supply and distribution system of Kardzhali supplies with water 55,019 people, through 19,854 service connections. The mean operating pressure is 4-5 atm. The average age of the pipes are 35 years. Pilot actions takes place in sub-DMA called Dunav, for the Municipality of Gotse Delchev. The DMA has high levels of non-revenue water. The total population of 1,650 people is supplied with water through 1,140 Km of pipes at a mean operating pressure of 4.5 atm. The number of connections is 49. The water utility of Thermaikos selected as its pilot case the total water distribution network. 50,264 people are supplied with water through 654 Km of pipes and 32,656 service connections. The mean operating pressure is 3 atm (Table 4.1).

4.2 Pilot actions

The pilot actions the beneficiaries implemented refer to water use efficiency and/or water quality. The pilot actions related to water use efficiency target to NRW components, such as Real Losses. All water utility or municipality beneficiaries implemented pilot actions related to water use efficiency and only two of them (PB2 and PB4) implemented also water quality related pilot activities. More specifically:

DEYA Komotini (LB), selected as a pilot action to develop IT applications to tackle real losses management pillar of speed and quality of repair. As the water distribution network of Komotini city suffers from high NRW levels (45.74% of SIV in 2017), the water utility decided to develop IT applications to reduce the total time for the repair of failures in the distribution network and at the same time provide a decision-making tool to the utility managers. This tool is valuable as the managers can monitor the evolution of the failures both spatially and temporally and can localize the parts of the network where interventions are needed. Additionally, the IT applications developed will improve the quality of service to the consumers as they can be informed in real time for any water interruptions, and they can also report any unusual event that is due to a failure in the water distribution network.

DEYA Thermi (PB2) implemented pilot actions related to both water use efficiency and water quality. Specifically, 45 flowmeters are installed in the boreholes of the water utility to record with accuracy the water volumes abstracted. This activity will result in a more accurate elaboration of the water balance in order to estimate NRW and its causes and then develop a strategy to reduce them. Additionally, the water utility installed 6 automated chlorination devices in selected water tanks in order to develop an accurate chlorination system that can ensure safe water for the consumers.

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Table 4.1. Pilot areas characteristics

General Data	Komotini (GR)	Thermi (GR)	Kardzhali (BG)	Gotse Delchev (BG)	Thermaikos (GR)
Total population served	65,000	53,070	55,019	1,650	50,264
Total area covered (Km^2)	385.3	1,559.34		0.20	135.5
Total pipes' length (Km)	400	700		1,140	654
Mean altitude (m)	45	0-200	4-5	525	55
Mean operating pressure (atm)	4.0	5		4.5	3
Type / age of pipes (per material, diameter)	PE (90-450mm) and steel (600mm)	PE (60%); PVC (40%); since 1970	Steel and PVC. Average 35 years	Steel (200mm): 1,141m; brass (32mm): 539m. Age >30 years	PVC: 33 years; asbestos cement: >55 years
No. of service connections	17,000		19,854	49	32,656
No. of water meters		25,786			

University of Thessaly, Civil Engineering Dept. (PB3) developed the hydraulic simulation model for the water distribution network of PB2 to monitor the operation of the network in terms of flow and pressure. PB3 also divided the water distribution network in 3 zones (virtually) using the hydraulic simulation model and installed one PRV at the entrance of each zone (virtually). The PRVs regulated pressure in such a way, that pressure at the critical points of each zone is 2 atm. Based on the model's calculations, pressure is reduced resulting in lower water losses and lower water volumes entering the network.

Municipality of Kardzhali (PB4) decided to implement 2 different activities in the context of its pilot action, one related to water use efficiency and the other to water quality. Municipality of Kardzhali installed flow meters at the water abstraction points to record accurately the water volumes. This will help the water utility to estimate the water balance and the NRW level reliably and then decide on the measures to reduce it. The second pilot activity refers to the supply of an inductively coupled plasma mass spectrometry (ICP-MS). Using the ICP-MS the water utility it is possible to implement permanent operational monitoring of drinking water quality and wastewater and to analyze samples of the drinking water, wastewater and sludge for elemental composition. The ICP-MS allows the implementation of timely and prompt measures for improving the quality of water. In this way the water utility provides safe water to its customers.

Municipality of Gotse Delchev (PB5) pilot action refer to the purchase and installation of electromagnetic flowmeters and pressure meters in the DMA in "Danube" area in Gotse Delchev water supply network and the replacement of pipes with diameter 90 and 110 in DMA "Danube" area. As real losses are extremely big in this DMA (NRW is 66.08% of SIV and ILI is 115 in 2017) and the water distribution network is very old, the municipality decided to install flowmeters and pressure meters at this DMA at the beginning to record all the necessary data. Then they decided to replace water pipes. These activities reduce real losses as they target on the real losses management pillar of pipeline and asset management.

DEYA of Thermaikos (PB6) implemented a pilot action to tackle real losses and specifically the pillar of speed and quality of repairs. PB6 developed IT applications for water distribution network management to localize the areas affected by water interruptions etc. and mapping failures history. The applications are developed in a GIS environment. Although the NRW assessment in 2017 was not very high, the water utility does not possess all the necessary data for reliable and accurate estimations of NRW and water losses. This is why the water utility decided to develop the water distribution network management application in order to gather all the necessary data for the water distribution network and at the same time to be able to use this application as a decision-making tool. The failures mapping application gives the possibility to the water utility to reduce the total repair time for failures and also act as a decision-making tool for the managers in order to decide whether a specific part of the network needs further actions.

4.3 Water Balance assessment for the water distribution network

The assessment of Water Balance is done in the pilot areas addressing water use efficiency, especially in the Municipal Water Supply and Sewerage Company of Komotini and Thermi, using the Standard IWA WB. The WB assessment results are shown in Table 4.2.

For the comparison of the WB components, the data for 2017 and 2019 are taken into consideration (Table 4.2). For DEYA Komotinis the water balance and PIs assessment revealed that NRW level in 2017 is 3,045,274m^3, representing 51.75% of SIV, while in 2019 NRW is reduced to 2,300,000 m^3, representing 43.39%. The water balance assessment revealed that at the pilot area of DEYA Thermis, NRW level in 2017 is 1,039,821 m^3, representing 25.93% of SIV, while in 2019 NRW levels are much higher. This is because SIV values are reliably estimated. The underestimation of SIV before the installation of the flowmeters was up to 100%. In Gotse Delchev pilot area, NRW level in 2017 is 66.07% of SIV, while after the interventions and the replacement of the pipes NRW level reduced to 58.07%.

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Table 4.2. WB components for the pilot areas for 2017 and 2019 (ex-ante and ex-post evaluation)

	Komotini (GR)		Thermi (GR)	
	2017	**2019**	**2017**	**2019**
System Input Volume	5.885.000	5.300.000	4.010.739	8.175.375
Authorized Consumption	2.898.576	3.053.000	3.171.455	3.484.966
Billed Authorized Consumption	2.839.726	3.000.000	2.970.918	3.279.127
Billed Metered Consumption	2.839.726	3.000.000	2.970.918	3.279.127
Billed Unmetered Consumption	0	0	0	0
Unbilled Authorized Consumption	58.850	53.000	200.537	205.839
Unbilled Metered Consumption	0	0	200.537	0
Unbilled Unmetered Consumption	58.850	53.000	0	205.839
Revenue Water	2.839.726	3.000.000	2.970.918	3.279.127
Water Losses	2.986.424	2.247.000	839.284	4.690.409
Apparent Losses	484.809	503.000	337.199	409.666
Unauthorized Consumption	58.850	53.000	40.107	81.754
Meter and Metering Errors	425.959	450.000	297.092	327.913
Real Losses	2.501.615	1.744.000	502.085	4.280.743
Non-Revenue Water	3.045.274	2.300.000	1.039.821	4.896.248

4.4 Water Quality assessment for the water distribution network

The beneficiaries whose pilot cases are about water quality are DEYA Thermis (PB2) and Municipality of Kardzhali (PB4). In Thermi, groundwater is used for the supply of the municipality. The major problem faced regarding water quality is that the chlorination devices are not automated. The water utility decided to implement a pilot action installing automated chlorination devices to add chlorine based on the measurements of the residual chlorine. There are 29 chlorination points taking place in boreholes, pumping stations, tanks, and in other sites. Some of the chlorination devices do not work properly or at all, causing problems at the efficient chlorination of the water supply network.

Municipality of Kardzhali selected as its pilot action the supply of laboratory equipment to perform as many water analyses as possible. Current laboratory equipment limits the number of indicators tested and requires much of the research to be outsourced, which involves a long time for sample analysis and high costs. The laboratory equipment provided in the project enables the investigation of a large number of indicators required by the relevant drinking water quality regulations, and also enables the rapid and timely analysis of the samples, as well as the measurement with high accuracy and correctness. The mass spectrometer is able to analyze the following elements: arsenic, chromium, selenium, copper, lead, cadmium, boron, nickel, zinc, sodium, aluminum, manganese, iron, antimony, barium, mercury, uranium, strontium and others.

4.5 Performance Indicators

IWA performance indicators (PIs) are calculated for the pilot cases.

Regarding water use efficiency, in Komotini pilot case NRW per SIV reduced from 45.74% in 2017 to 43.40% in 2019 (Figure 4.2). Specifically, water losses per mains length were 18.03 m^3/Km/year in 2017, while in 2019 they are reduced to 15,39 m^3/Km/year. Real losses are the major part of NRW representing 42.51% of SIV or 337.66L/connection/day and 14,350L/Km/day in 2017. In 2019, after the implementation of the pilot action, real losses reduced to 32.91% of SIV or 281.06L/connection/day and 11,945.20L/Km/day. Apparent losses represented 9.14% of SIV in 2017 while in 2019 they were slightly increased to 9.49% (Figure 4.1). ILI value for 2017 is 6.56, while in 2019 ILI is reduced to 5.46. In DEYA Thermis pilot area the exact recording of water entering the network showed that in 2017 SIV value was 4,010,739m^3 per year while in 2019 SIV increased to 8,175,375m^3 per year. The pilot action showed the underestimation of the water volume entering the network. Now the water utility is able to estimate reliably NRW values, which for 2019 it is 59.89% and it is mainly due to real losses (52.36% of SIV). However in order to plan specific measures for the reduction of NRW, further analysis must be elaborated to estimate reliably NRW causes. In the pilot case of Gotse Delchev (DMA Dunav) NRW reduced from 66.08% of SIV in 2017, to 58.07% in 2019 (Figure 4.2). Water losses per mains length reduced from 339.7m^3/Km/year in 2017 to 107.16 m^3/Km/year in 2019. Real losses are significantly reduced from 6,979.42L/connection/day to 2,051.44L/connection/day (reduction 70.6%) showing the efficiency of the measures taken. ILI value was also reduced from 115.42 in 2017 to 53.65 in 2019.

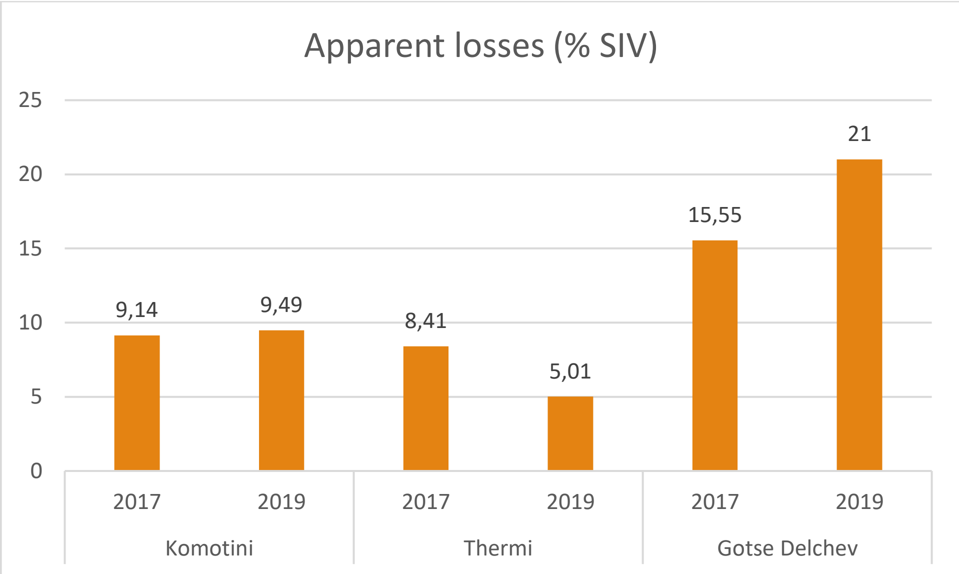

Figure 4.1. Apparent losses as % of SIV for 2017 & 2019

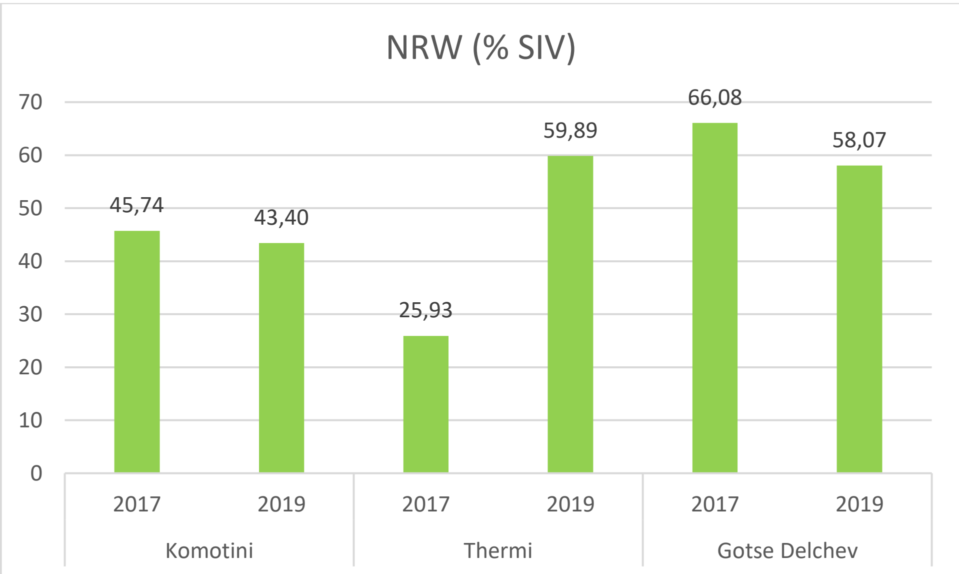

Figure 4.2. NRW as % of SIV for 2017 & 2019

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Table 4.3. PIs for the pilot areas – ex ante and ex post evaluation

Performance Indicators	Units	Komotini (GR)		Thermi (GR)		Kardzahli (BG)		Gotse Delchev (BG)	
		2017	2019	2017	2019	2017	2019	2017	2019
Inefficiency of use of water resources	%	35.60	32.91	12.52	52.36	33.51	N/A	58.35	N/A
Water losses per connection	m^3/conn/day	154.88	132.18	N/A	N/A	N/A	N/A	2,884.69	1,316.57
Water losses per mains length	m^3/Km/year	18.03	15.39	3.28	18.36	N/A	N/A	339.70	107.16
Apparent losses	%	9.14	9.49	8.41	5.01	N/A	N/A	15.55	21.0
Apparent losses per system input volume	%	9.14	9.49	8.41	5.01	N/A	N/A	15.55	21.0
Real losses per connection	L/conn/day	337.66	281.06	N/A		N/A	N/A	6,979.42	2,051.44
Real losses per mains length	L/Km/day	14,350.5	11,945.20	1965,11	16,754.37	N/A	N/A	299,992.8	N/A
Infrastructure Leakage Index (ILI)	-	6.56	546	N/A	N/A	N/A	N/A	115.42	53.65
Unmetered water	%	45.74	43.40	N/A	59.89	33.51	N/A	66.08	58.07
Non-revenue water by volume	%	45.74	43.40	25.93	59.89	33.51	N/A	66.08	58.07
Revenue Water as % of SIV	%	48.25	56.60	74.07	40.11	66.49	N/A	33.93	N/A
Real Losses as % of SIV	%	42.51	32.91	12.52	52.36	N/A	N/A	50.52	N/A
Real Losses as % of NRW	%	82.15	75.83	48.29	87.43	N/A	N/A	76.46	N/A
Apparent Losses as % of NRW	%	15.92	21.87	32.43	8.37	N/A	N/A	23.54	N/A
Tests carried out	%	N/A	N/A	100	100	100	99.9	N/A	N/A
Aesthetic tests carried out	%	N/A	N/A	100	100	100	N/A	N/A	N/A
Microbiological tests carried out	%	N/A	N/A	100	100	100	N/A	N/A	N/A
Physical-chemical tests carried out	%	N/A	N/A	100	100	100	N/A	N/A	N/A
Quality of supplied water	%	N/A	N/A	96.61	93.3	98.66	98.9	N/A	N/A
Aesthetic tests compliance	%	N/A	N/A	100	73.6	98.92	N/A	N/A	N/A
Microbiological tests compliance	%	N/A	N/A	95.56	98.18	97.91	N/A	N/A	N/A
Physical-chemical tests compliance	%	N/A	N/A	96.77	96.8	99.04	N/A	N/A	N/A

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Regarding PIs related to water quality, Kardzhali and Thermi estimated the PIs regarding the tests carried out, aesthetic test carried out, microbiological tests carried out and physical chemical tests carried out. The values for these PIs are 100% for each PI for the pilot case of Thermi. Regarding Kardzhali case study the tests carried out were 99.9% (still very high percentage) in 2019. Quality of supplied water PI takes the value of 98.66% for Kardzhali in 2017 and was increased in 2019 to 98.9%. In Thermi pilot area microbiological tests compliance increased from 95.56% in 2017 to 98.18% in 2019.

The results from the pilot cases showed that NRW was targeted and specifically real losses which where reduced due to the interventions implemented. Also, the pilot activities resulted in better knowledge of the network and the water volumes entering it. This is an important first step for the water utilities in order to be able to estimate the Water Balance in a reliable way. Several tools are implemented and developed including IT applications for monitoring failures, the hydraulic simulation model, etc. which can act as decision support systems for the water utilities.

Regarding water quality, the two beneficiaries with pilot cases related to water quality managed to improve water quality monitoring as specific equipment has been supplied to monitor specific pollutants and also effective chlorination of drinking water is achieved.

4.6 Conclusions

The pilot actions implementation in WATER RESCUE showed that water utilities face high NRW levels in their water distribution networks. The first step is to identify the cause of the high NRW problem and then design a strategy to reduce NRW levels. In WATER RESCUE context water use efficiency was one of the pillars. Water utilities decided to tackle real losses addressing the pillar of “speed and quality of repairs”. Some of the water utilities decided to reliably record the water volume entering the network, as a first step towards the NRW management. The results showed that there was decrease in NRW and its targeted component (real losses). Also, the pilot actions revealed the problem of water volumes not metered causing underestimations during the water balance elaboration. Useful tools such as GIS-based tools, the hydraulic model of the network, etc. can be used as decision-support systems for the water utility operators.

Regarding water quality, the water utilities need equipment of latest technology in order to analyze various pollutants and also achieve a reliable chlorination.

The water utilities reported problems mainly due to bureaucratic procedures for the supply of the equipment. All beneficiaries stated that they suggest to other water utilities facing the same problems to design and implement NRW reduction strategies. They also noted that public funding should be available for such activities.

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Appendix A: Beneficiaries' reports

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.1.4 Ex post evaluation report** *Questionnaire*
Project Beneficiary No	**LB/PB1**
Beneficiary Institution	**Municipal Water Supply and Sewerage Company of Komotini**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Table of Contents

Name of the organization/institution: Municipal Water Supply and Sewerage Company of Komotini
Beneficiary number: LB/PB1

1 Introduction

Municipal Water Supply and Sewerage company of Komotini (DEYAK) supplies with water the municipality of Komotini, located in the Water District of Thrace (EL12). The people supplied with water is 65,000. The area covered is 385.3 km^2 and the average altitude is 45m. The total pipes' length is 549 km consisting of pipes from PE (with diameters 90-450mm) and from steel (with diameters 600mm). The water pipes network is old enough. The average operating pressure is 4 atm and the total number of water meters is 48,500. The number of service connections is about 17,000. The billing period is 2 months for the city of Komotini and 4 months for the municipal districts. The river basin where water is taken from is the river basin of Komotini – Loutro Evrou stream (area 1,958.3Km^2). Water is taken from Vosvozis river (EL1209R0000010085N) and the groundwater system of Rodopi (EL1200120). All the information is given in Table 1.

Table 1. General data on the water supply system of DEYA Komotinis

Data (base year 2018)	
Total population served	65,000
Total area covered (km^2)	385.3
Total pipes' length (km)	549
Mean altitude (m)	45
Mean operating pressure (Atm)	4.0
Types of pipes (material, diameters)	PE (90-450mm) and steel (600mm)
No. of water meters	48,500
No. of service connections	17,000
Billing period	2 months for Komotini city; 4 months for municipal districts
River Basin where water is taken from	Komotini – Loutro Evrou stream

2 Pilot action

The water utility faces problems related to high Non-Revenue Water (NRW) which was estimated for 2017 to be 38% of SIV. Specifically, the water supply network suffers from pipes breaks, invisible leaks, unauthorized consumption. The main cause is that the water distribution network is old in many parts of the city.

The pilot action refers to the provision of services for the supply and installation of IT applications to directly support the water utility operations and indirectly contribute to the water use efficiency (by reducing NRW). The applications are expected to provide:

• Failure history mapping. The application will present the failures history in an interactive map. It will provide the possibility of selection of filters depending on, e.g. the severity of the problem, the time period, the cost of confrontation measures etc. The data will be presented alone but also cumulatively in the form for example of cluster map or heat map. The possibility to choose the time period of reference of the problems to give the opportunity someone to be able to see their time evolution. Additionally, the application will provide a problems management environment.

• Field applications. Utilizing the water utility's background in GIS software, field applications will be developed, in tablet environment that will be used from the utility's repair teams to provide them access to the data (e.g. distribution networks) but also to inform immediately the water operators regarding the problems faced and recorded from the personnel in the field. These applications will allow a more efficient coordination and a significant reduction in the troubleshooting time, contributing to water saving.

• Applications for the public. Internet based applications for the public will be developed. The consumers will be able to report a problem and the water utility will inform the consumers for possible water interruptions or other problems.

The pilot action was elaborated in 2018. The pilot action targets the real losses pillar “speed and quality of repairs”. By using these IT applications, the water utility will be able to:

- Be informed about the failures in the water supply and distribution system and assess their spatial and temporal variability. This will act as a decision-making tool for the water utility.
- React quicker to any failure event reducing the response time and also reduce the repair time as all the data will be available to the staff. Time reduction will eventually result in real losses reduction.
- Be informed quicker as the public will be able to report any problems asap and thus reduce the reaction and repair time.

The IT applications developed consist of applications for the public accessible at https://komotini.getmap.gr/ (Figures 1) and spatial mapping of failures accessible at https://deyakmap.getmap.gr for the managers of the utility having full access (Figures 2, 3 & 4).

The total cost of the pilot action is 88,000.00€.

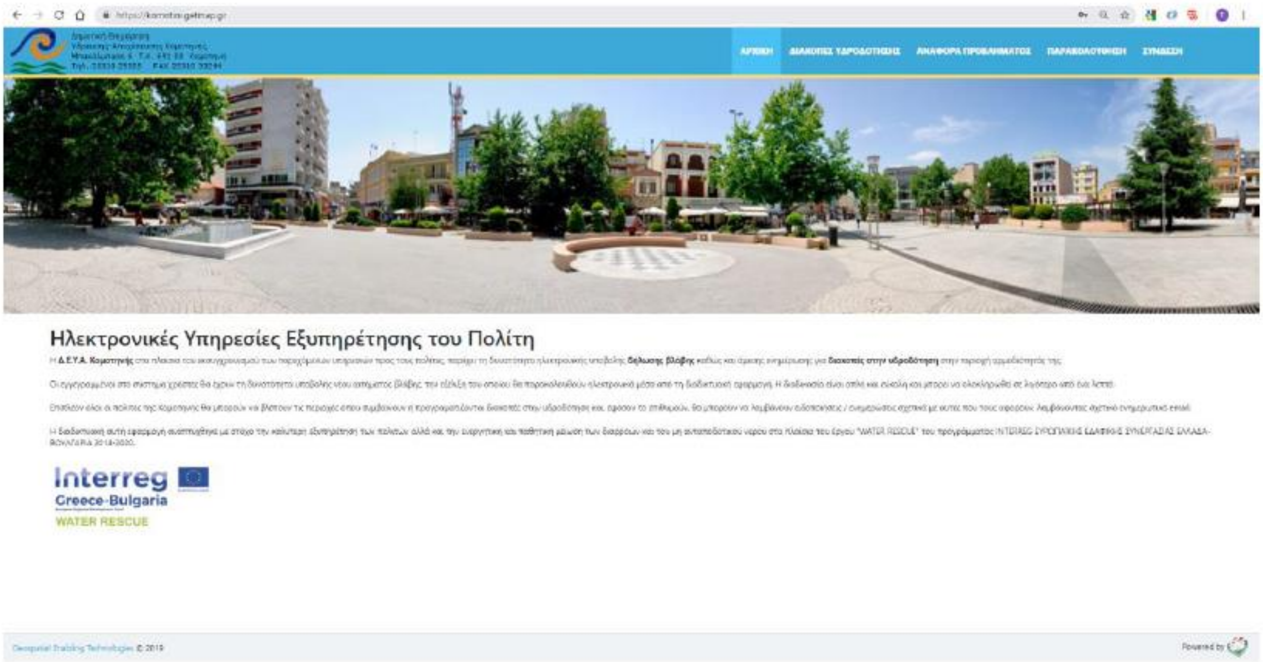

Figure 1. Application interface

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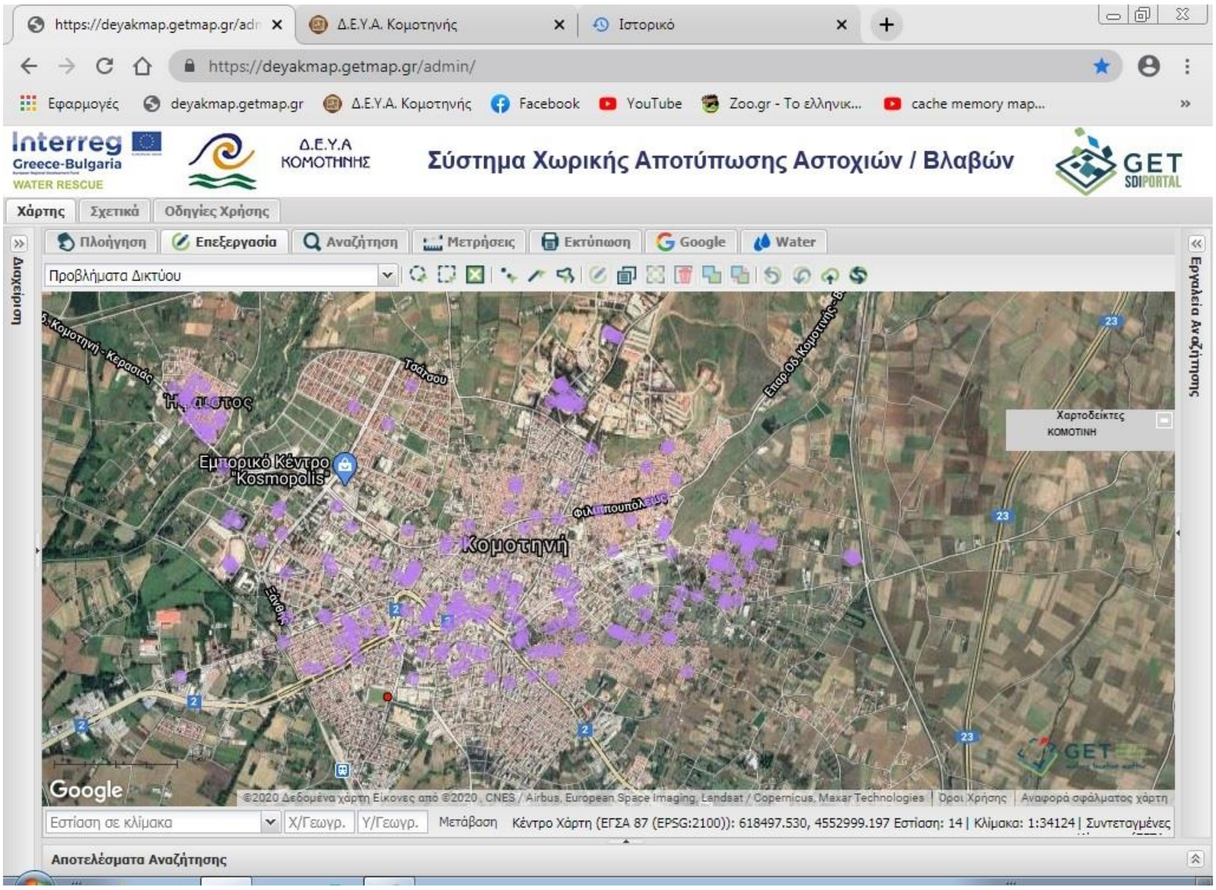

Figure 2. Failures shown in the map

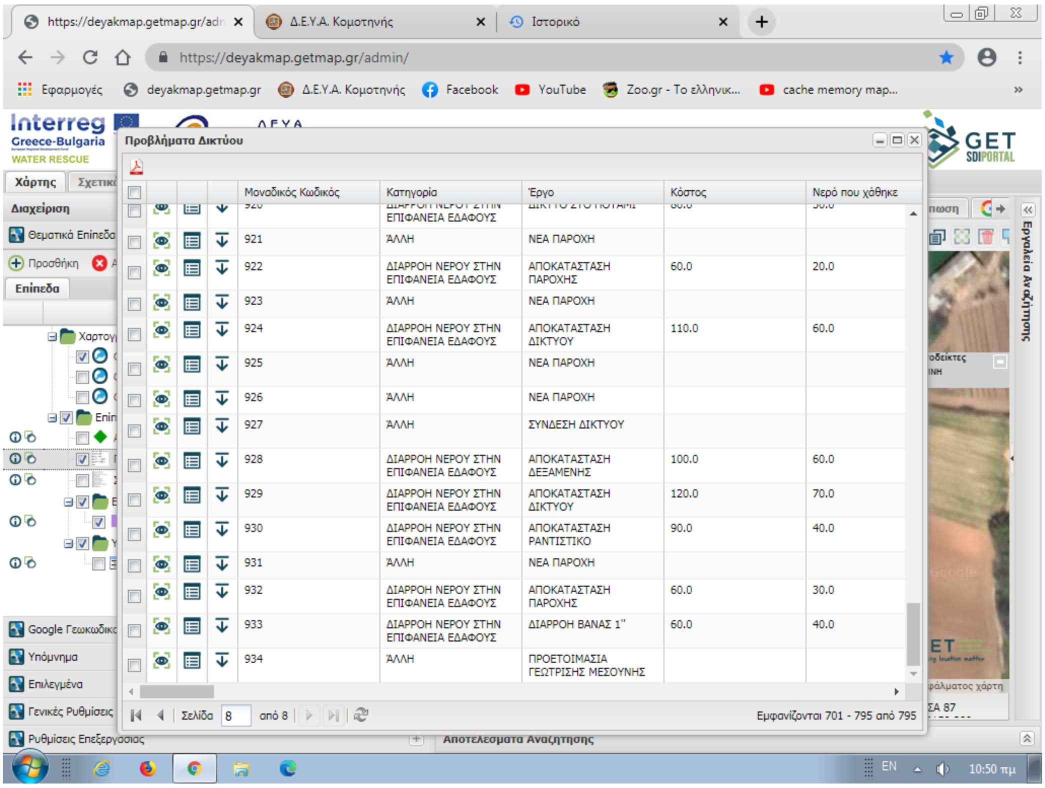

Figure 3. Failures' list

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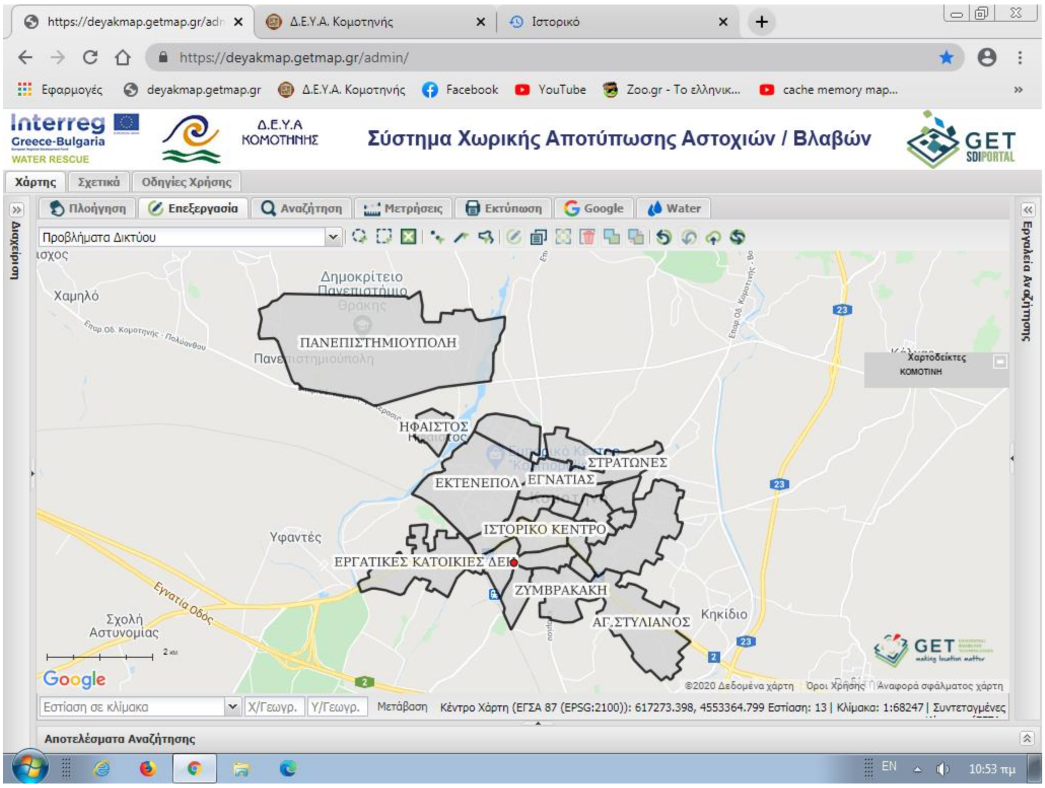

Figure 4. Statistical data of the failures inserted

System Input Volume (A3) **5.300.000**	**Authorized Consumption** (A14=A10+A13) **3.053.000**	**Billed Authorized Consumption** (A10=A8+A9) **3.000.000**	**Billed Metered Consumption** (A8) **3.000.000**	**Revenue Water** (A20=A8+A9) **3.000.000**
			Billed Unmetered Consumption (A9) **0**	
		Unbilled Authorized Consumption (A13=A11+A12) **53.000**	**Unbilled Metered Consumption** (A11) **0**	**Non Revenue Water (NRW)** (A21=A3-A20) **2.300.000**
			Unbilled Unmetered Consumption (A12) **53.000**	
	Water Losses (A15=A3-A14) **2.247.000**	**Apparent Losses** (A18=A16+A17) **503.000**	**Unauthorized Consumption** (A16) **53.000**	
			Customer Meter Inaccuracies and Data Handling Errors (A17) **450.000**	
		Real Losses (A19=A15-A18) **1.744.000**		

Figure 5. The Water Balance for the whole water supply network of Komotini city for 2020

Water Audit

3 Water Balance assessment for the water distribution network

The WB for the water distribution network of Komotini city has been elaborated for 2020 (whole year). The water utility provided data regarding the water entering the network and the water volume billed and consumed. The water volume consumed but not billed and unauthorized consumption and meters' errors are not known for the network. The water consumed but not billed is assumed to be 1% of the SIV. Meter inaccuracies and under-registration are estimated to be 15% of the billed metered consumption and unauthorized consumption is assumed to be 1% of SIV. Based on those data and assumptions, the Water Balance of the whole water utility of Komotini is given in Figure 5.

4 Performance Indicators

Based on the data provided above, the following Performance Indicators are estimated for the water supply network of Komotini city. The results compared to those of 2017 and 2018 are shown in Table 2.

Table 2. Performance Indicators for the water supply network of Komotini (2017, 2018 & 2020)

Performance Indicators		2017	2018	2020	Units
WR1	Inefficiency of use or water resources	35.6	42.5	32.9	%
Op23	Water losses per connection	154.88	175.67	132.17	m^3/connection/year
Op24	Water losses per mains length	18.03	20.45	15.39	m^3/km/year
Op26	Apparent losses per system input volume	9.14	8.24	9.49	%
Op27	Real Losses per connection	337.66	403.16	281.06	L/connection/day when system is pressurised
Op28	Real Losses per mains length	14,350.50	17,134.35	11,945.21	L/km/day when system is pressurised
Op29	ILI	6.56	7.84	5.46	-
Op39	Unmetered water	45.74	51.75	43.39	%
Fi46	Non-revenue water by volume	45.74	51.75	43.39	%

From Table 2, NRW is 43.39% of the System Input Volume (SIV) for 2020. Apparent losses as % of SIV is 9.49% and real Losses in 2020 are 32.91% of SIV and 281.06 L/connection/day. ILI is 5.46 in 2020. It is obvious that NRW levels are high for this network and this is mostly due to real losses. The results show a slight decrease in NRW in 2020 compared to previous years but the data are not enough.

5 Obtained results

The water utility staff inserted the reported failures for 2018 and 2019 in the application. Specifically, in 2018 66 failures related to pipes' leaks and breaks were reported while in the first 9 months of 2019 135 failures were reported and inserted in the application. The main failures are pipes' leaks and breaks, followed by network repair and connections' leaks in 2019 (Figure 6).

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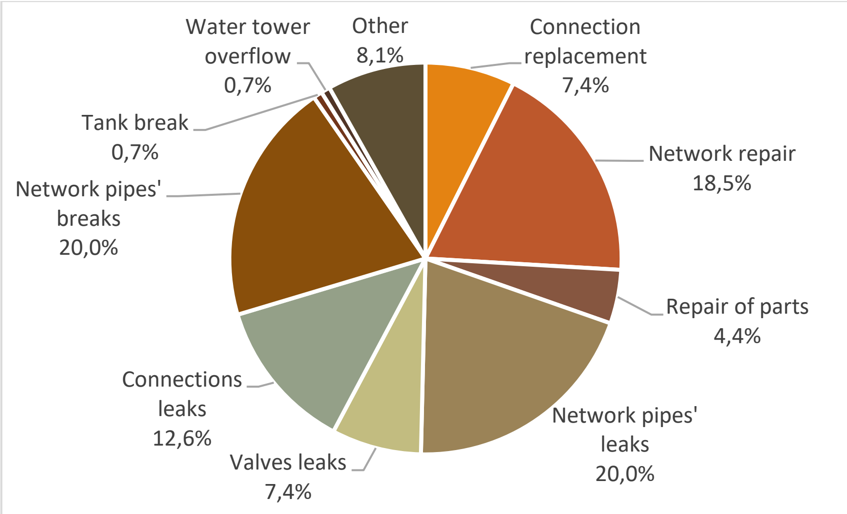

Figure 6. The main failure types in 2019

The use of the developed applications aims at targeting the speed of repairs, being a real losses reduction pillar. Additionally, the applications aim at improving the quality of services to the consumers. The total cost of the pilot action is 88,000.00€.

The benefits of the pilot action are the time reduction for the repair of failures by the online information from the public and the provision of all data regarding a failure online, informing the customers for any emergency situation, better analysis of the failures of the water supply network in order to schedule and organize any actions, etc. By reducing the time to repair, less water volume is lost and the costs are reduced. Also the water utility managers can use these IT applications as decision-making tools. The data gathered from the application regarding failures provide a good insight on the main problems of the water supply network and their spatial allocation, allowing the water utility managers to prepare the tenders for the necessary works. Finally, the water utility provides improved water services to its customers.

6 Comments

No comments.

Appendix A:

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.2.4 Ex post evaluation report** *Questionnaire*
Project Beneficiary No	**PB2**
Beneficiary Institution	**Municipality Water Supply and Sewerage Company of Thermi**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Table of Contents

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Name of the organization/institution: Municipal Water Supply and Sewerage Company of Thermi
Beneficiary number: PB2

1 Introduction

Municipal Water Supply and Sewerage Company of Thermi (DEYA Thermis) is the water utility supplying with water the area of Thermi including several municipal districts: Thermi, Mikra, N. Redestos, Tagarades, N. Risio, Vasilika, Souroti, Agia Paraskevi, Agios Antonios, Lakkia, Peristera and Livadi. The area covered by DEYA Thermis is 1559.34 Km^2. The area's altitude ranges from 0-200m. The water meters (active in 2019) are 25,738 supplying with water a population of 53,070 people (2011 census). The total pipes' length is about 700Km and the pipes are made of PE (60%) and PVC (40%). The pipes are installed since 1970 until now. The average operating pressure is about 5 atm.

DEYA Thermis is supplying the municipal district of Thermi with water from groundwater boreholes from three groundwater subsystems: down flow of Antemountas; Thermi – N. Risio; and Cholomontas – Oreokastro (Chalkidiki river basin). DEYA Thermis water abstraction is allocated in the groundwater systems as shown in Table 2. The major water volume (97.8%) comes from the subsystems of Anthemountas down flow and Thermi – N. Risio. The first subsystem is assessed in bad quantitative and chemical status, while the second is assessed in good quantitative and chemical status. Only 2.1% of water volume comes from the Cholomontas - Oreokastro subsystem which is found to be in good chemical and quantitative status.

Table 1. General data of the water supply network of DEYA Thermis (base year 2019)

General data	
Total population served	53,070
Total area covered (Km^2)	1,559.34
Total pipes' length (Km)	700
Mean altitude (m)	0-200
Mean operating pressure (atm)	5
Types of pipes (material, diameters, lengths)	PE (60%); PVC (40%)
Age of pipes (per material, diameter)	Since 1970
No. of water meters	25,738
Billing Period	Every 4 months
River Basin where water is taken from	Chalkidiki river basin

Table 2. Water availability, average annual abstraction and DEYA Thermis abstraction of three groundwater systems (source: RBMP, 2017)

Groundwater subsystem	**Towns supplied with water**	**Water availability (10^6 m^3)**	**Average annual abstraction (10^6 m^3)**	**DEYA Thermis (m^3)**	**Chemical status**	**Quantitative status**
Down flow of Anthemountas	Thermi, Mikra, N. Redestos, Tagarades, N. Risio, Vasilika, Souroti, Ag. Paraskevi	33.6	37.02	7,187,700	Bad	Bad

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Thermi – N. Risio	Thermi, Mikra, N. Redestos, Ag. Antonios, Lakkia				Good	Good
Cholomontas - Oreokastro	Peristera, Livadi	99	81.64	158,500	Good	Good

2 Pilot action

The pilot action of DEYA Thermis refers both to water efficiency and water quality.

Water Efficiency

DEYA Thermis uses 54 boreholes for water abstraction. However, the water volume abstracted is not actually recorded, resulting in assumptions on the estimation of these water volumes. The fact that the water volume entering the water distribution network is estimated based on the pumping stations data, does not allow the water utility to do the water balance based on actual data. The consequences are that the water balance could not show the actual Non-Revenue water (NRW) values and the actual causes of NRW. Additionally, based on national legislation the Water Directorate issued water use permits for the boreholes used and the water utility is obliged to install flowmeters for the monitoring and recording of the water abstraction. During the pilot action, flowmeters are supplied and installed in 45 boreholes (Table 3). The installation took place from 27/11/2019 until 16/12/2019. The flowmeters conform with the European Directive MID 2004/22/EC or the later MID 2014/32/EC.

The total cost for the supply and installation of the flowmeters is 66,150.00€ (no VAT included).

Table 3. The locations of the installed flowmeters

a/a	Location / Borehole	Name of the location
1	Thermi	Aeroporias
2	Thermi	Firos Sideras
3	Thermi	Kosmidis
4	Thermi	Emporiki
5	Thermi	Ergotaxio
6	Thermi	Thermokipio
7	Thermi	Interbeton
8	Thermi	Lida Maria
9	Thermi	Parsourakou-2
10	Thermi	Patsourakoy-new-3
11	Thermi	Toumpas B
12	Triadi	Triadi
13	Thermi	Hayat
14	Thermi	Eurotech
15	N. Redestos	Kanavou
16	Filothei	Filotheis -1 (Redestos)
17	Filothei	Filotheis -2 (new)
18	Filothei	Filotheis -3 (old)
19	N. Redestos	Hempe
20	N. Redestos	Christoforou
21	Tagarades	Tagaradon -1

22	Tagarades	Tagaradon-3 (Livadi) new
23	N. Risio	Zampetoglou
24	N. Risio	N. Risiou - C3
25	N. Risio	N. Risioy – C4
26	Vasilika	Ai Gianni (BA3)
27	Lakkia	North Oikismo LA1
28	Lakkia	Inverter 1
29	Lakkia	East Oikismos LA2
30	Ag. Paraskevi	Anthemounta P. (ACP1)
31	Souroti	Koukos (S1)
32	Livadi	Entos Oikismou(L1)
33	Livadi	Ektos Oikismou (L2)
34	Kardia	Christodoulidis
35	Kardia	Kloni
36	Kardia	Kakarimou
37	Epanomi	Apostolou
38	Plagiari	Rema
39	Plagiari	A1.3-Osia Xeni (Garou)
40	Plagiari	A2.1
41	Plagiari	A2.2
42	Plagiari	New A2
43	Plagiari	A1.2-Trigonou
44	Plagiari	A1.1
45	Ag. Paraskevi	S1(Ag. Paraskevi)

Water Quality

DEYA Thermis uses chlorination for the disinfection of water in water tanks. There are 29 chlorination points to cover the whole water supply network of DEYA of Thermi. The major problem faced regarding water quality is the increased value of some physical-chemical parameters that sometimes is near the allowable maximum values of the legislation. The cause of this problem is the groundwater geological background. Another problem is the excessive increase of turbidity which is due to the excessive abstraction of the groundwater. The tanks did not have automated chlorination systems.

The pilot action is the supply and installation of automated chlorination systems in 6 water tanks (out of the 29 chlorination points, that is 20.7%) (Table 4). The installation was concluded in 6/12/2019. The automated chlorination systems provide assurance that water quality parameters are within the limits set by legislation and regulations.

The total cost for the supply and installation of the six automated chlorination systems is 28,140.00€.

Table 4. The locations of the installed automated chlorination systems

a/a	Settlement name	Tank	Settlement population
1	Kardia	Sterna	3,394
2	Plagiari	Central tank	5,392
3	N. Redestos	Pefkakia (small)	3,869
4	Ag. Paraskevi	Upper tank	2,244
5	Souroti	Upper tank	1,560
6	Peristera	D2	770

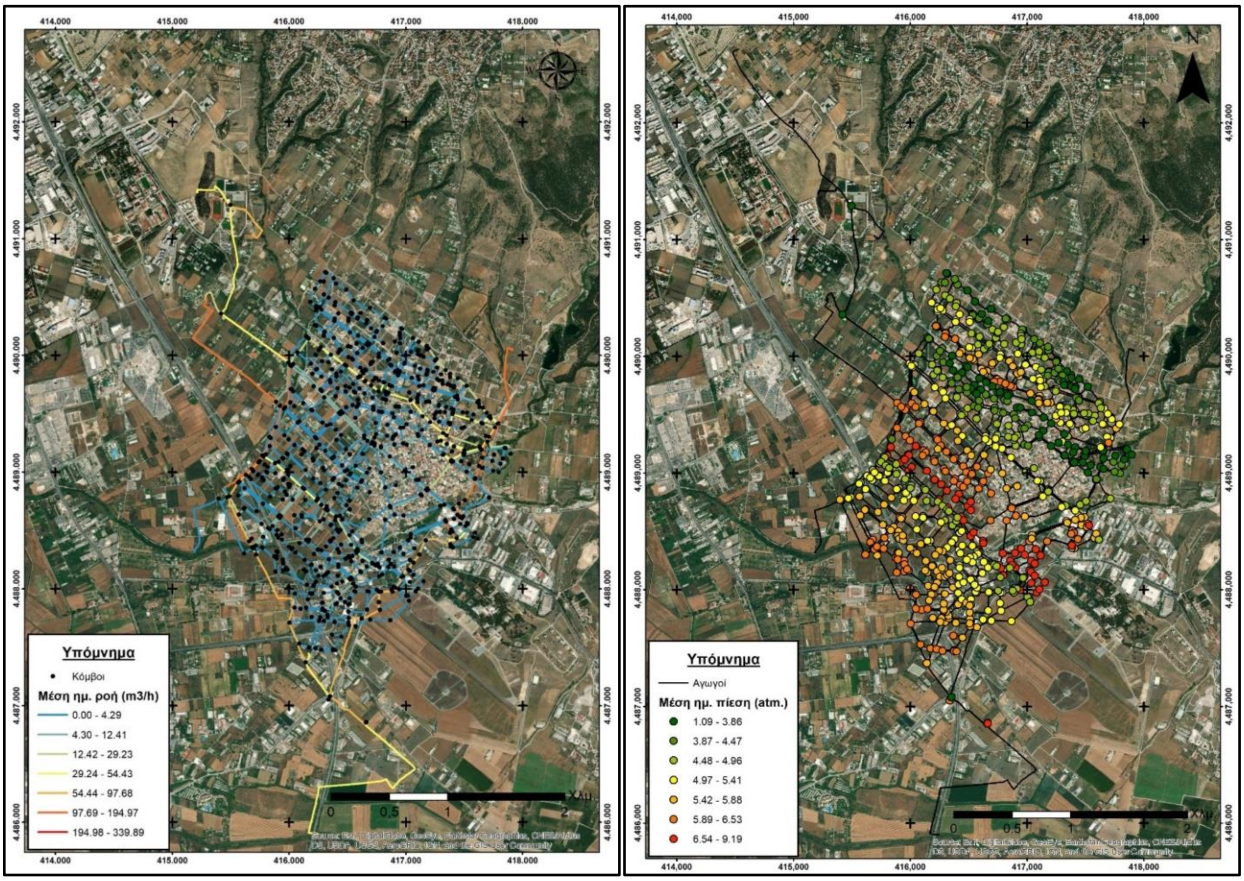

Figure 1. (a) Average water flow; (b) average water pressure

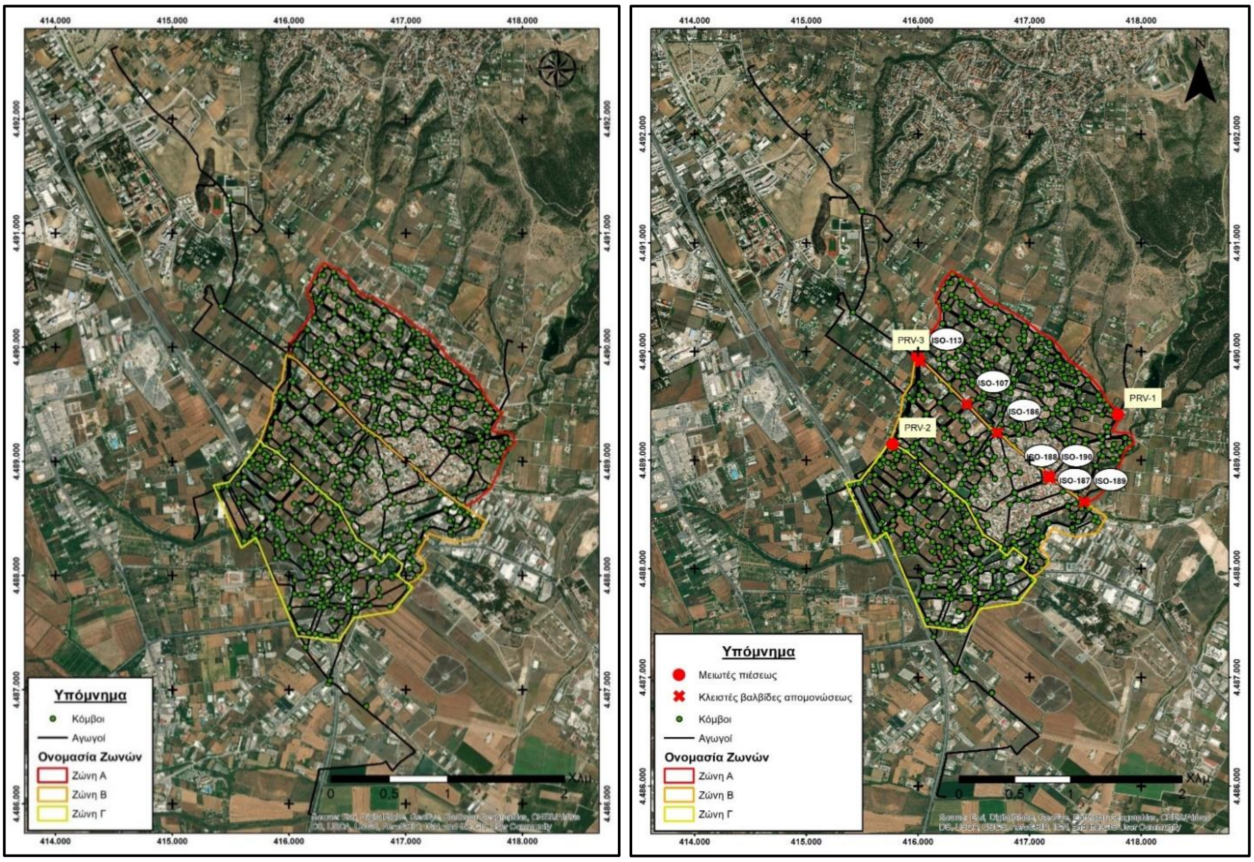

Figure 2. (a) Three pressure zones suggested; (b) PRVs and isolation valves

Hydraulic Simulation model

PB3, University of Thessaly, Civil Engineering department, developed the hydraulic simulation model for the water distribution system of Thermi. From the model water flow and water pressure are modelled (Figure 1). The water distribution network was divided in three zones, using existing and new isolation valves (Figure 2).

Water Audit (for PBs with pilot action referring to water use efficiency)

3 Water Balance assessment for the water distribution network

The WB for the whole water distribution network of Thermi has been elaborated for 2019. Specifically, the WB has been elaborated for the whole year and also per 4-month periods (as the billing period is 4 months). The water utility provided data regarding the water entering the network, the water volume billed and consumed, and the water volume consumed but not billed. Unauthorized consumption is not known for the network, but it is assumed that it represents 1% of the system input volume (entering the network). Meter inaccuracies and under-registration is also not known. According to the utility's knowledge for the network, meters errors are estimated to be 10% of the billed metered consumption.

Based on the available data and on the estimations made, the WB has been elaborated (Figures 3-6).

<table>
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(A3)
4.112.015</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
3.484.966</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
3.279.127</td><td>Billed Metered Consumption
(A8)
3.279.127</td><td rowspan="2">Revenue Water
(A20=A8+A9)
3.279.127</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
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(A13=A11+A12)
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(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
832.888</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
200.839</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
627.049</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
369.033</td><td>Unauthorized Consumption
(A16)
41.120</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
327.913</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
258.016</td></tr>
</table>

Figure 3. IWA International WB for Thermi water distribution network for 2019

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

<table>
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(A3)
1.280.200</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
1.029.323</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
965.726</td><td>Billed Metered Consumption
(A8)
965.726</td><td rowspan="2">Revenue Water
(A20=A8+A9)
965.726</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
63.597</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
314.474</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
63.597</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
250.877</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
109.375</td><td>Unauthorized Consumption
(A16)
12.802</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
96.573</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
141.502</td></tr>
</table>

Figure 4. IWA International WB for Thermi water distribution network for the 1st 4-month period of 2019

<table>
<tr><td rowspan="7">System Input Volume
(A3)
1.351.555</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
1.160.880</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
1.093.401</td><td>Billed Metered Consumption
(A8)
1.093.401</td><td rowspan="2">Revenue Water
(A20=A8+A9)
1.093.401</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
67.479</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
258.154</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
67.479</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
190.675</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
122.856</td><td>Unauthorized Consumption
(A16)
13.516</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
109.340</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
67.819</td></tr>
</table>

Figure 5. IWA International WB for Thermi water distribution network for the 2nd 4-month period of 2019

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

<table>
<tr><td rowspan="7">System Input Volume
(A3)
1.480.260</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
1.294.763</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
1.220.000</td><td>Billed Metered Consumption
(A8)
1.220.000</td><td rowspan="2">Revenue Water
(A20=A8+A9)
1.220.000</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
74.763</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
260.260</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
74.763</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
185.497</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
136.803</td><td>Unauthorized Consumption
(A16)
14.803</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
122.000</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
48.694</td></tr>
</table>

Figure 6. IWA International WB for Thermi water distribution network for the 3rd 4-month period of 2019

The Water Balance components per year for the three years of study, 2017, 2018 and 2019 are given in Table 5.

Table 5. WB data for 4-month periods of 2017, 2018 and 2019 and annually

m³	1st 2017	2nd 2017	3rd 2017	1st 2018	2nd 2018	3rd 2018	1st 2019	2nd 2019	3rd 2019	2017	2018	2019
System Input Volume	1.306.553	1.341.222	1.362.964	1.271.948	1.349.577	1.495.264	1.280.200	1.351.555	1480260	4.010.739	4.116.789	4.112.015
Authorized Consumption	1.033.145	1.060.559	1.077.751	1.005.781	1.067.166	1.182.366	1.029.323	1.160.880	1.294.763	3.171.455	3.255.313	3.484.966
Billed Authorized Consumption	967.817	993.498	1.009.603	942.184	999.687	1.107.603	965.726	1.093.401	1.220.000	2.970.918	3.049.474	3.279.127
Billed Metered Consumption	967.817	993.498	1.009.603	942.184	999.687	1.107.603	965.726	1.093.401	1220000	2.970.918	3.049.474	3.279.127
Billed Un Metered Consumption	0	0	0	0	0	0	0	0	0	0	0	0
Unbilled Authorized Consumption	65.328	67.061	68.148	63.597	67.479	74.763	63.597	67.479	74.763	200.537	205.839	205.839
Unbilled Metered Consumption	0	0	0	0	0	0	0	0	0	0	0	0
Unbilled Unmetered Consumption	65.328	67.061	68.148	63.597	67.479	74.763	63.597	67.479	74763	200.537	205.839	205.839
Revenue Water	967.817	993.498	1.009.603	942.184	999.687	1.107.603	965.726	1.093.401	1.220.000	2.970.918	3.049.474	3.279.127
Water Losses	273.408	280.663	285.213	266.167	282.411	312.898	250.877	190.675	185.497	839.284	861.476	627.049
Apparent Losses	109.847	73.022	84.302	88.094	103.468	125.713	109.375	122.856	136.803	337.199	346.115	369.033
Unauthorized Consumption	13.066	13.412	13.630	12.719	13.496	14.953	12.802	13.516	14.803	40.107	41.168	41.120
Meter Inaccuracies & Data Handling Errors	96.782	59.610	70.672	75.375	89.972	110.760	96.573	109.340	122.000	297.092	304.947	327.913
Real Losses	163.561	207.641	200.911	178.073	178.943	187.185	141.502	67.819	48.694	502.085	515.361	258.016
Non-Revenue Water	338.736	347.724	353.361	329.764	349.890	387.661	314.474	258.154	260.260	1.039.821	1.067.315	832.888

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

4 Performance Indicators

Based on the data above, several performance indicators (PIs) have been calculated for 2019, annually. The PIs are given in the Table 6, including the values for 2017 and 2018.

The results show that NRW by volume (as % of SIV) is 25.93% for 2017 and 2018 but it is lower (20,25%) for 2019. Apparent losses are 8.41% of SIV for 2017 and 2018 but 8.97% for 2019 and real losses are 12.52% of SIV for 2017 and 2018 but 6.27% for 2019. Real losses expressed as L/Km/day are 1,965.11 for 2017, 2,017.07 for 2018 and 1,009.85 for 2019. Water losses in m^3/Km/year are 3.28 (2017), 3.37 (2018) and 2.45 (2019).

NRW levels are quite high and are mainly due to real losses. However, as estimations are used to calculate the water volumes, the flowmeters established will be able to provide actual data on water entering the network.

Table 6. PIs for 2017, 2018 and 2019 annually

Performance Indicator		2017	2018	2019	Units
WR1	Inefficiency of use or water resources	12,52	12,52	6,27	%
Op24	Water losses per mains length	3,28	3,37	2,45	m^3/km/year
Op25	Apparent losses	8,41	8,41	8,97	%
Op26	Apparent losses per system input volume	8,41	8,41	8,97	%
Op28	Real losses per mains length	1.965,11	2.017,07	1.009,85	L/km/day when system is pressurised
Op39	Unmetered water	25,93	25,93	20,25	%
Fi46	Non-revenue water by volume	25,93	25,93	20,25	%
	Real Losses (% SIV)	12,52	12,52	6,27	%

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5 Obtained results

The results from the pilot action implementation include the exact recordings of the flowmeters in the boreholes (Table 7). Data are gathered on 28/1/2020, 30/6/2020 and 9/2/201. The data from the last registration are taken into consideration to estimate the total water volume entering the network. The time the flowmeters were metering is from 27/11/2019 – 9/2/2020 (440 days average). The total water volume recorded during this time period is 8,212,705m^3.

The total cost for the supply and installation of the flowmeters is 66,150.00€ (no VAT included).

Table 7. Flowmeters' recordings

a/a	Location / Borehole	Name of the location	Water volume abstracted until 28/1/2020 (m^3)	Water volume abstracted until 30/6/2020 (m^3)	Water volume abstracted until 9/2/2021 (m^3)
1	Thermi	Aeroporias	96,077	245,488	688,420
2	Thermi	Firos Sideras	42,715	153,549	268,160
3	Thermi	Kosmidis	36,302	120,550	212,420
4	Thermi	Emporiki	27,115	76,399	202,170
5	Thermi	Ergotaxio	10,503	26,050	81,175
6	Thermi	Thermokipio	44,357	104,618	273,270
7	Thermi	Interbeton	62,123	141,866	381,123
8	Thermi	Lida Maria	32,841	32,888	32,902
9	Thermi	Parsourakou-2	0	0	0
10	Thermi	Patsourakoy-new-3	19,313	59,228	201,621
11	Thermi	Toumpas B	0	0	0
12	Triadi	Triadi	15,068	49,881	155,208
13	Thermi	Hayat	12,990	60,609	235,725
14	Thermi	Eurotech	71,527	154,946	337,422
15	N. Redestos	Kanavou	479	588	604
16	Filothei	Filotheis -1 (Redestos)	88,569	204,357	472,930
17	Filothei	Filotheis -2 (new)	56,174	106,247	284,100
18	Filothei	Filotheis -3 (old)	626	5,537	50,028
19	N. Redestos	Hempe	4,067	14,518	50,768
20	N. Redestos	Christoforou	20,027	69,821	249,489
21	Tagarades	Tagaradon -1	21,091	110,913	224,675
22	Tagarades	Tagaradon-3 (Livadi) new	68,251	118,745	142,070
23	N. Risio	Zampetoglou	0	0	0
24	N. Risio	N. Risiou - C3	24,806	68,839	191,750
25	N. Risio	N. Risioy – C4	40,929	106,682	294,600
26	Vasilika	Ai Gianni (BA3)	19,698	116,948	196,370
27	Lakkia	North Oikismo LA1	20,935	42,855	97,633
28	Lakkia	Inverter 1	0	0	39,356
29	Lakkia	East Oikismos LA2	0	1,544	19,345
30	Ag. Paraskevi	Anthemounta P. (ACP1)	58,786	147,245	444,500
31	Souroti	Koukos (S1)	2,501	3,094	162,078
32	Livadi	Entos Oikismou(L1)	0	0	0
33	Livadi	Ektos Oikismou (L2)	6,003	17,651	1,316
34	Kardia	Christodoulidis	44,996	130,682	389,000
35	Kardia	Kloni	27,732	86,712	236,934
36	Kardia	Kakarimou	925	19,203	82,903

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37	Epanomi	Apostolou	0	0	0
38	Plagiari	Rema	0	0	0
39	Plagiari	A1.3-Osia Xeni (Garou)	35,614	53,488	132,394
40	Plagiari	A2.1	0	0	0
41	Plagiari	A2.2	3,997	70,188	275,177
42	Plagiari	New A2	25,914	61,811	100,900
43	Plagiari	A1.2-Trigonou	0	0	46,341
44	Plagiari	A1.1	28,218	55,515	159,956
45	Ag. Paraskevi	S1(Ag. Paraskevi)	157,176	411,569	797,872

Given that this amount of water is abstracted from 45 out of the 54 boreholes, the total amount abstracted from all the boreholes for the same period of 440 days is estimated to be 9,855,246m^3. That means that in a year time the total water volume abstracted is estimated to be 8,175,375m^3. The water utility estimates that during one year the total water volume abstracted is about 4,100,000m^3. The water volume abstracted is highly underestimated (almost 100%)! Given that the water volume consumed is recorded in the water consumers, the NRW levels are very high! Based on the recording of the 45 flowmeters, the system input volume is 8,175,375m^3 per year, then the water balance components are as shown in Table 8.

Table 8. WB components taking into consideration the new SIV compared to the estimated one

m^3	2019 (estimated)	2019 (calculated)
System Input Volume	4,112,015	8,175,375
Authorized Consumption	3,484,966	3,484,966
Billed Authorized Consumption	3,279,127	3,279,127
Billed Metered Consumption	3,279,127	3,279,127
Billed Un Metered Consumption	0	0
Unbilled Authorized Consumption	205,839	205,839
Unbilled Metered Consumption	0	0
Unbilled Unmetered Consumption	205,839	205,839
Revenue Water	3,279,127	3,279,127
Water Losses	627,049	4,690,409
Apparent Losses	369,033	409,666
Unauthorized Consumption	41,120	81,754
Meter Inaccuracies & Data Handling Errors	327,913	327,913
Real Losses	258,016	4,280,743
Non-Revenue Water	832,888	4,896,248
NRW as % of SIV	20.25	59.89

The results show that NRW values are significantly higher when the actual SIV values are used. In order to have solid results, flowmeters should be installed to the remaining 9 boreholes.

Table 9. Performance Indicators for 2019 (initial and updated) and the differences (%)

PI	**2019**	**2019 updated**	**Units**	**Difference %**
Inefficiency of use or water resources	6.27	52.36	%	735.09
Water losses per mains length	2.45	18.36	m^3/km/year	649.39

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Apparent losses	8.97	5.01	%	-44.15
Apparent losses per system input volume	8.97	5.01	%	-44.15
Real losses per mains length	1,009.85	16,754.37	L/km/day when system is pressurised	1,559.09
Unmetered water	20.25	59.89	%	284.64
Non-revenue water by volume	20.25	59.89	%	284.64

The exact recordings of the water volume will allow the water utility to estimate accurately the NRW level and design strategies and measures to reduce it.

Hydraulic simulation model

The hydraulic model of the network is developed. The results show that the smaller / local pipes show the lowest flow rates, while the main water distribution pipes show the highest average daily flow. Given that pressure is not regulated through pressure reduction valves, the results showed that the nodes at the highest altitudes of the network have low pressure, while as altitude decreases pressure increases to quite high pressures.

Three zones are developed virtually using the hydraulic model and using combinations of altitude and pressure. For the creation of the three zones some of the isolation valves are closed and some other are added. To regulate the pressure, three pressure reduction valves are installed at the entrance of each zone in order to achieve minimum pressure of 2 atm in every node. PRV-1 is set at 4.15 atm, PRV-2 is set at 2.10 atm and PRV-3 is set at 2.50 atm. The critical nodes are identified: (a) zone A, higher altitude node J-327 and lower altitude node J-33; (b) zone B, higher altitude J-417 and lower altitude node J-196; and (c) zone C, higher altitude node J-749 and lower altitude node J-587.

It is noted that there is a reduction in pressure in all zones, with the maximum reduction up to 58% while the minimum reduction is 4% (Table 10). In addition, there is a stabilization of pressure during zoning, where the average pressure per zone remains constant regardless of time, in contrast to the time before the zones' creation where a strong fluctuation in pressure is noted. The model showed that if zoning takes place the water volume entering the network is reduced by 3.44%.

Table 10. Average pressure before and after the creation of the zones and the difference in percentage

Time (hours)	Before zoning			During zoning			Difference (%)		
	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C
0	4,53	6,48	5,41	4,00	3,60	2,85	-11,73%	-44,49%	-47,33%
1	4,56	6,49	5,43	4,00	3,60	2,85	-12,24%	-44,61%	-47,52%
2	5,42	8,53	5,42	4,02	3,60	2,85	-25,92%	-57,82%	-47,46%
3	5,39	8,49	5,42	4,45	3,60	2,85	-17,41%	-57,64%	-47,42%
4	5,39	8,49	5,41	4,45	3,60	2,85	-17,50%	-57,62%	-47,38%
5	5,38	8,46	5,41	4,01	3,60	2,85	-25,44%	-57,49%	-47,33%
6	4,54	6,49	5,43	4,36	3,59	2,85	-3,88%	-44,64%	-47,54%
7	5,00	7,68	5,41	4,14	3,59	2,84	-17,14%	-53,26%	-47,42%
8	4,50	6,49	5,40	4,00	3,57	2,84	-11,07%	-44,95%	-47,45%
9	4,52	6,46	5,38	3,99	3,56	2,83	-11,84%	-44,86%	-47,35%
10	4,48	6,41	5,39	3,98	3,56	2,83	-11,21%	-44,46%	-47,48%

11	4,48	6,43	5,38	3,98	3,57	2,83	-11,06%	-44,56%	-47,34%
12	4,47	6,42	5,40	3,98	3,57	2,84	-10,92%	-44,37%	-47,49%
13	4,48	6,44	5,39	3,98	3,57	2,84	-11,09%	-44,58%	-47,38%
14	4,50	6,44	5,38	3,97	3,57	2,84	-11,68%	-44,56%	-47,28%
15	4,48	6,42	5,40	3,98	3,57	2,84	-11,23%	-44,39%	-47,47%
16	4,48	6,44	5,39	3,98	3,57	2,83	-11,13%	-44,66%	-47,38%
17	4,49	6,44	5,37	3,97	3,56	2,83	-11,64%	-44,72%	-47,24%
18	4,49	6,43	5,37	3,98	3,55	2,83	-11,38%	-44,86%	-47,34%
19	4,48	6,43	5,37	3,98	3,55	2,83	-11,27%	-44,80%	-47,39%
20	4,48	6,41	5,38	3,98	3,55	2,83	-11,16%	-44,54%	-47,43%
21	4,49	6,44	5,37	3,97	3,56	2,83	-11,66%	-44,65%	-47,23%
22	4,49	6,43	5,39	3,98	3,57	2,84	-11,28%	-44,41%	-47,37%
23	4,50	6,45	5,40	3,98	3,59	2,84	-11,58%	-44,36%	-47,32%
24	4,50	6,47	5,41	4,00	3,60	2,85	-11,03%	-44,42%	-47,38%

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Water Quality Evaluation (for PBs with pilot action referring to water quality)

6 Water Quality assessment for the water distribution network

The water utility of Thermi uses groundwater sources for water supply. The utility conforms with the national and European legislation regarding drinking water quality. Disinfection is applied as water treatment at the boreholes or at the water tanks. At the boreholes, chlorine is injected to the borehole supply pipe. At the water tanks, chlorine is added inside the water tank.

The major problem faced regarding water quality is the increased value of some physical-chemical parameters that sometimes is near the allowable maximum values of the legislation. The cause of this problem is the groundwater geological background.

Another problem is the excessive increase of turbidity which is due to the excessive abstraction of the groundwater.

Regarding chlorination, the water utility implements the national legislation. There are 29 chlorination points, given in Table 11. Chlorination takes place is tanks, in boreholes, pumping stations and in other sites. Table 11 shows also the tanks where the automated chlorination systems are installed.

Table 11. Chlorination types and sites for DEYA Thermis

Network	Chlorination point	Chlorination type	Comments	Automated chlorination systems installed
Lida Maria	Tank	3	The automatic system is out of order	
Toumba	Foiros Sideras	2		
Litsa small	Foiros Sideras	2		
Litsa large	Foiros Sideras	2		
Hayat	Tank	1		
Triadi up tank	Pumping station Triadi	1		
Triadi down tank	Pumping station building site	1		
N. Redestos big tank	Tank	1	The automatic system is out of order	
N. Redestos small tank	Tank	1		√
Filothei	Tank	1		
Tagarades	Preselection tank	4		
N. Risio	Tank	1		
Vasilika	Borehole BA1	1		
Lakkia	Borehole ΛA1	1		
Kato Peristera	Borehole	1		
Peristera source	In the network	5		
Up tank Peristera	Church Peristera spring	6		
Down tank Peristera	Tank	6		√
Livadi	Borehole	1		
Agios Antonios	St John	3		
Monopigado	St John	3		
Souroti	Tank	3		√

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Agia Paraskevi	Tank	1		√
Kardia	Sterna	2		√
Trilofos Kotroni	Conjunction & 4 SEASON	1 & 2	The automatic system is extracted	
Trilofos Profitis Ilias	Conjunction	1	The automatic system is extracted	
Plagiari	Upper tank & down tank in the summer	3 & 7		√
Kato Sholari	Conjunction	1	The automatic system is extracted	
Ano Sholari	Conjunction	1	The automatic system is extracted	

Meaning of chlorination type:
1: Chlorination pump connected to the borehole
2: Chlorination pump connected to the pump
3: Chlorination pump connected to the sensor
4: Automatic chlorination system
5: Solid chlorine
6: 24hours continuous electricity
7: works with timer

The chlorination systems work based on sampling of water and analyzing the free chlorine concentrations. These chlorination systems do not ensure that water is chlorinated when needed, that is when free chlorine concentrations are below limits. Automated chlorination systems measure continuously the free chlorine concentration and define the required dose. The 6 tanks are selected as they were presenting unstable conditions in chlorination process. These tanks were more difficult to monitor and presented high deviations regarding chlorination.

7 Performance Indicators

The water utility applies all the necessary tests for water quality. Performance indicators for those tests are estimated and presented in Table 12.

Table 12. PIs regarding water quality for 2017, 2018 and 2019

Performance Indicators		2017	2018	2019	Units
Op40	Tests carried out	100	100	100	%
Op41	Aesthetic tests carried out	100	100	100	%
Op42	Microbiological tests carried out	100	100	100	%
Op43	Physical-chemical tests carried out	100	100	100	%
Op44	Radioactivity tests carried out	100	100	100	%
QS11	Bulk supply adequacy	100	100	100	%
QS18	Quality of supplied water	96,61	97,76	93,30	%
QS19	Aesthetic tests compliance	100	100	73,6	%
QS20	Microbiological tests compliance	95,56	97,26	98,18	%
QS21	Physical-chemical tests compliance	96,77	96,77	96,8	%
QS22	Radioactivity tests compliance	100	100	100	%

In general, the water utility elaborates all necessary tests. Some of the tests are not in compliance with the legislation, specifically microbiological tests and physical – chemical tests. However, the percentage is very high, showing that there are only a few cases with non-compliance.

8 Obtained results

The results from the installation of the automated chlorination systems are:

- More efficient chlorination since the automated system allows for the correct dose after measuring the level of the free chlorine in water;
- Better water quality for the consumers;
- Saving of resources.

The total cost for the supply and installation of the six automated chlorination systems is 28,140.00€. The water volume properly chlorinated is 1,285,000m^3/year.

Table 13. Tank details and related maps

a/a	Settlement name	Tank	Capacity (m^3)	Consumption (m^3/year)	Related figure
1	Kardia	Sterna (Δ1)	40	290,000	Fig. 7
2	Plagiari	Central tank (Δ14)	240	400,000	Fig. 7
3	N. Redestos	Pefkakia (small) (Δ1)	75	45,000	Fig. 8
4	Ag. Paraskevi	Upper tank (Δ1)	400	295,000	Fig. 9
5	Souroti	Upper tank (Δ1)	200	205,000	Fig. 10
6	Peristera	Δ2	200	50,000	Fig. 11

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

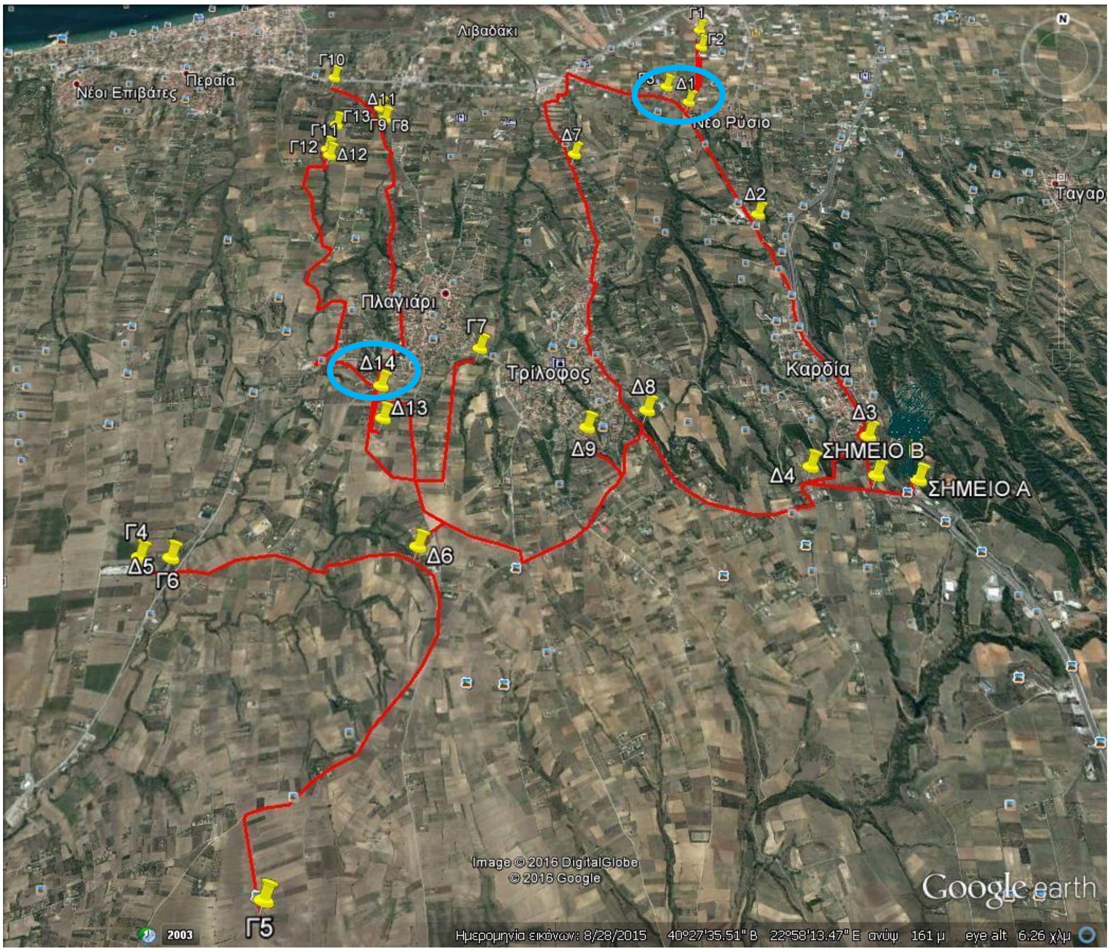


Figure 7. Map of boreholes and tanks in Mikra – tanks Δ1 & Δ14 (where automated chlorination systems are installed) are shown in circles

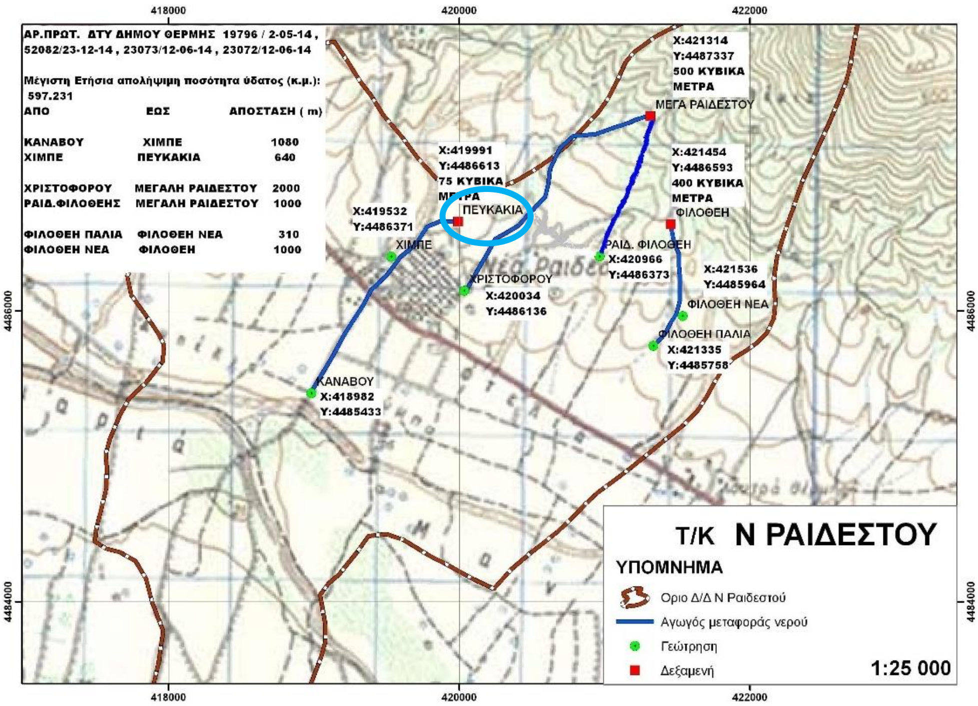


Figure 8. Map of boreholes and tanks in N. Redestos – tank Δ1 - Pefkakia (where automated chlorination system is installed) is shown in circle

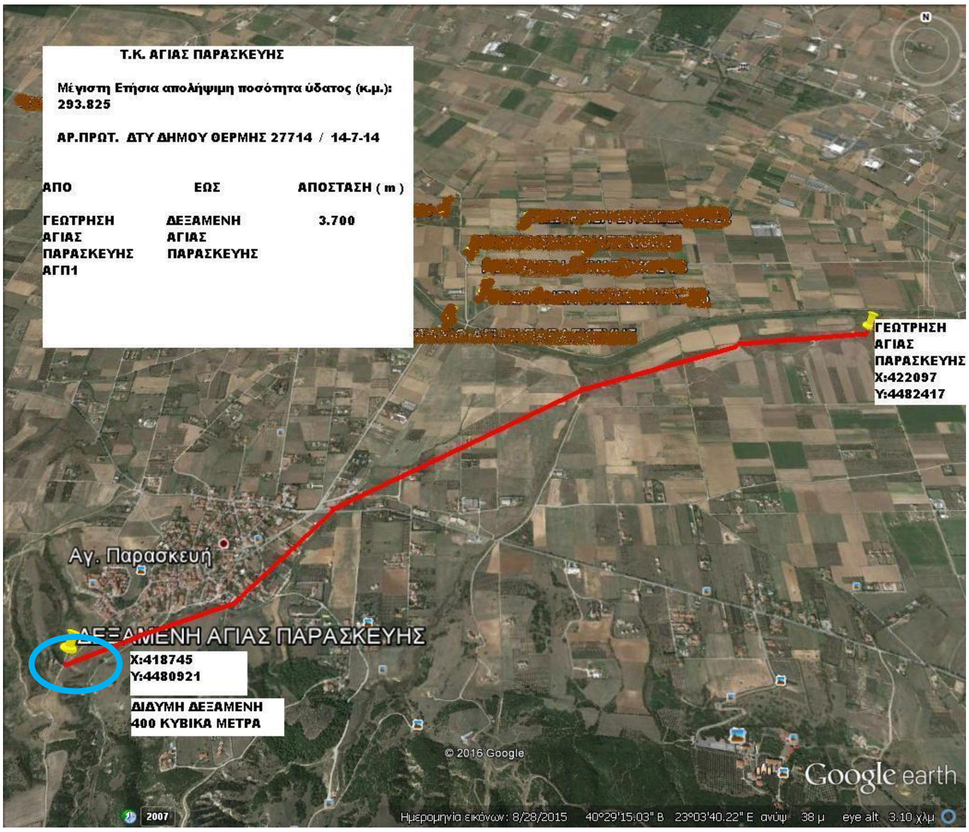


Figure 9. Map of boreholes and tanks in Ag. Paraskevi – tank Δ1 (where automated chlorination system is installed) is shown in circle

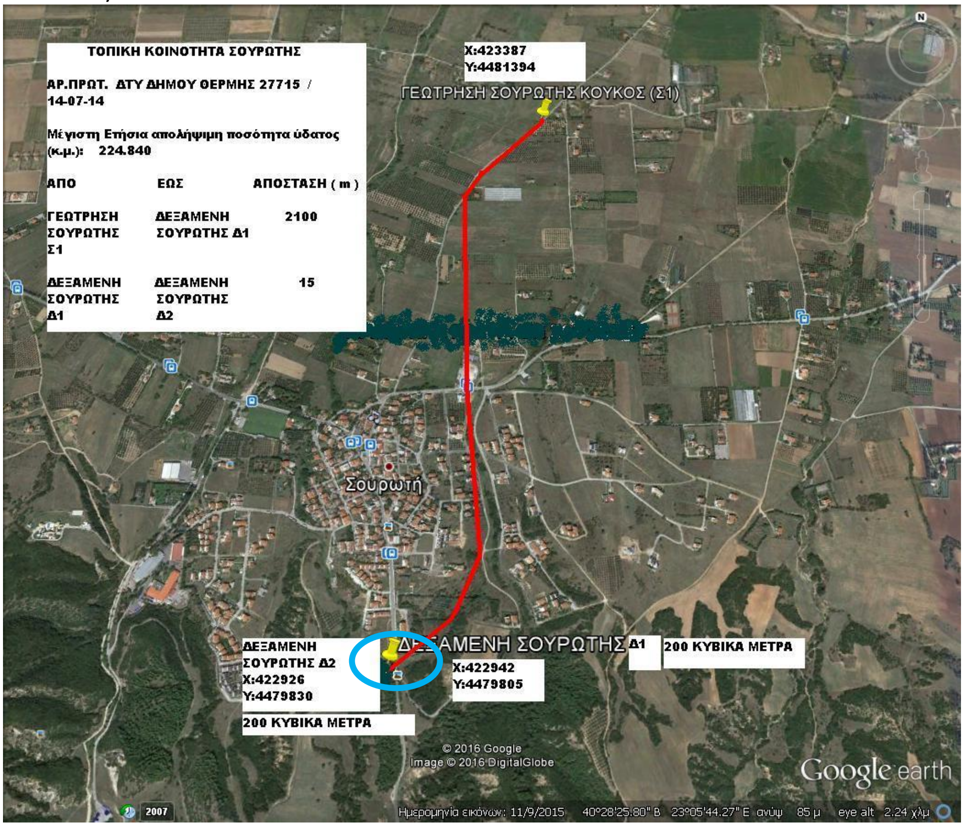


Figure 10. Map of boreholes and tanks in Souroti – tank Δ1 (where automated chlorination system is installed) is shown in circle

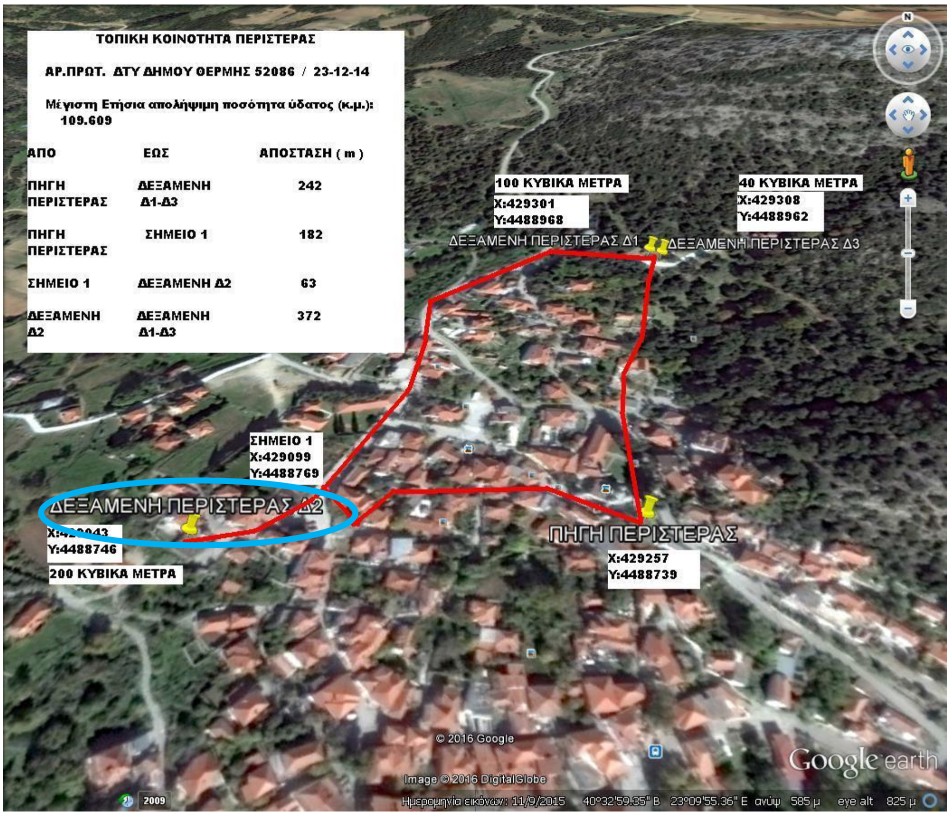


Figure 11. Map of boreholes and tanks in Peristera – tank Δ2 (where automated chlorination system is installed) is shown in circle

9 Comments

No comments.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Appendix A:

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.4.4 Ex post evaluation report** *Questionnaire*
Project Beneficiary No	**PB4**
Beneficiary Institution	**Municipality of Kardzhali**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Table of Contents

Name of the organization/institution:
Beneficiary number:

1 Introduction

Please describe your water distribution network, where the pilot action took place.

Water Utility Level (2018 base year or for 2019 if there are any data)

- Total population served = 122 / l / inhabitants / day
- Total area covered (Km^2) = 55 019
- Total pipes' length (Km) =
- Mean altitude (m) = 356
- Mean operating pressure (atm) = 4-5
- Types of pipes (material, diameters, lengths) = Asbestos-cement - 203 km; Steel - 18 km; HDPE and PVC - 135 km;
- Age of pipes (per material, diameter) = Asbestos-cement - year of construction from 1960 to 1990; Steel - from 1960 to 2000; HDPE and PVC - after 2000;
- No. of service connections = 19854
- Billing Period = monthly
- River Basin where water is taken from = Arda River, Varbitsa River

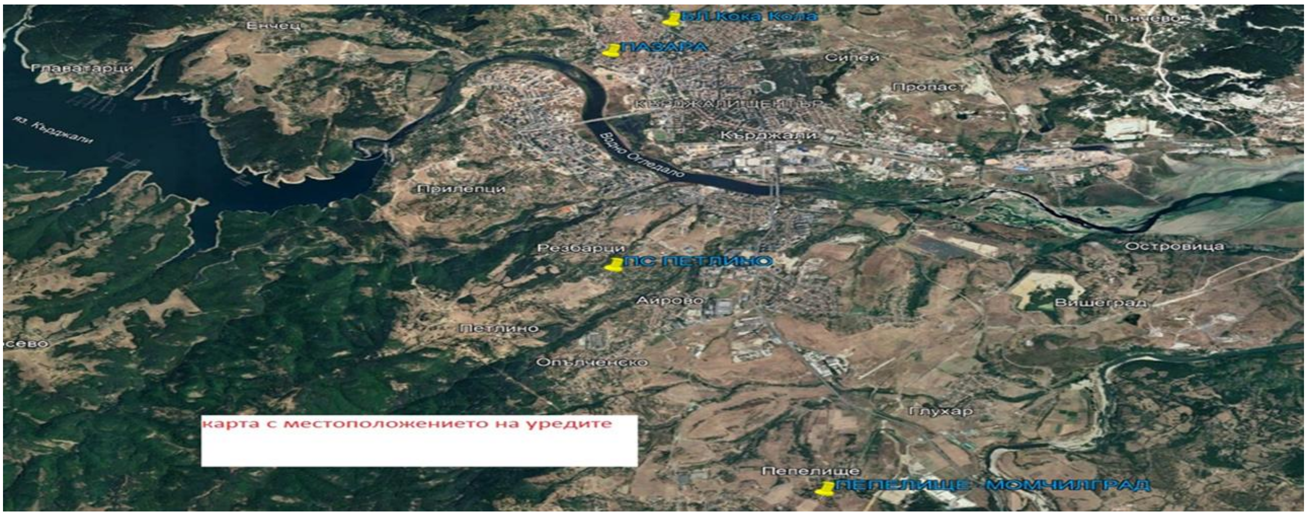
2 Pilot action

- Define and present the specific problems you are facing and made you choose the specific pilot action (present as many data as you can)
- Define and present the specific pilot action: e.g. what kind of equipment you have installed and where you installed them, etc. (please present as many photos as you can)
- Present the results you expected to have from the pilot action.
- Present any difficulties encountered during the pilot action implementation.
- Define the cost of the pilot action

With respect to the monitoring and requirements for drinking water quality, it is necessary that the laboratory equipment used by the operator operating the water supply system be able to carry out as many analyzes as required by the relevant regulations (Ordinance 9 on drinking water quality) and be accurate as a research method. Current laboratory equipment limits the number of indicators tested and requires much of the research to be outsourced, which involves a long time for sample analysis and high costs. The flowmeters included in the project will help to locate sections of the water supply system where there is a suspected loss or theft of water, and after their installation very accurately and quickly it will be possible to identify possible accidents in those sections.
The laboratory equipment provided in the project will enable the investigation of a large number of indicators required by the relevant drinking water quality regulations, will enable the rapid and timely analysis of the samples, as well as the measurement with high accuracy and correctness.
Delivery and installation of four electromagnetic flow meters
Contractor SONICS Ltd
Four ultrasonic flowmeters were installed under the project - 3. in the town of Kardzhali and 1 pc. on the border of Kardzhali municipality and Momchilgrad municipality.
The places are as follows:
1. On Bulgaria Blvd. at the roundabout at the exit of the city to bl. Coca-Cola - measures the water quantities at the entrance to the Baikal district. It is mounted on an F 600 pipe.

2. At the crossroads of Struma Street and Osmi Oktomvri Street - measures water quantities for the central part of the city.
It is mounted on an F 400 pipe.
3. To PS PETLINO after a pressure tank of 5000 m3 - measures water quantities for Gledka and Gorna Gledka districts.
It is mounted on an F 300 pipe.
4. On the border of the municipality of Kardzhali and the municipality of Momchilgrad to the village of Pepelishte - measures water quantities for the municipality of Momchilgrad by the "Dam. Borovitsa "
It is mounted on an F 500 pipe.
Ultrasonic flow meters are of the frequency pulse type in which the speed of movement of the fluid / water / is determined by measuring the time for the passage of ultrasonic pulses against and in the direction of movement of the fluid. The ultrasonic flow meters installed under the project measure the passed water quantities every minute. The data reported by the device are in l / sec for instantaneous consumption, accumulated volume for the hour, for the day, for the month and for the year.
All appliances are software installed on a computer of a dispatcher who monitors the readings of flow meters 24 hours a day, 7 days a week. The same software through remote access to the computer of the dispatcher can be monitored by an unlimited number of employees / manager, ch. engineer, DWTP technologist, technical managers, etc./ for timely action in case of events.
Data and graphs for the past period / hour, day, week and month / can be extracted from the software. Comparing them with the collected water in the area of operation of the flow meter, analyzes are made for the condition and losses of the network. The dispatcher, who is on duty on a shift, monitors the readings and in case of deviation from the normal ones signals the emergency teams for possible accidents and leaks in the network.
The system allows to display data and graphs from which the minimum night consumption of the system can be determined at the lowest consumption by users, the amount of water loss from hidden leaks. After locating the area by stopping cranes from end to nearby streets and monitoring the cost, the street with the problem area is located. To more accurately determine the hidden leak, our company has portable terrestrial noise microphones, point correlators and point noise bearings. In addition to these devices under the project, the company has installed 9 more. ultrasonic flow meters for measuring water quantities and two level meters, which are included in the same software. Attached we present screenshots with data and graphs from the readings of the devices installed under the project.

Map with the location of the devices



Delivery and installation of mass spectrometer with inductively connected plasma Plasma ICP - MS.

Contractor "ASM2" Ltd

Upcoming activities are:

1. Construction of ventilation.

2. Installation.

3. Testing the suitability of the system.

4. Commissioning.

5. Training and assistance in the development of the first analytical method for elemental analysis.

On December 22, 2021, the mass spectrometer was installed, configured, tested and ready for operation. During the functional tests of the system, the following standard procedures were performed to check the qualification of the installation, operational readiness and verification of the equipment for operation.

- the equipment has no obvious transport defects **yes**
- The supply voltage of the system corresponds to the Bulgarian standards **yes**
- The configuration of the system corresponds to that ordered by the customer **yes**
- When the system is turned on, the displays light up and the keys function normally **yes**
- When each of the modules of the system is switched on, it successfully passes its initial testing and initialization procedure **yes**
- The software product is configured to work with the specific system **yes**
- There is normal two-way communication between the system and the control software, the status of the device is available in real time on the computer screen **yes**
- Each of the modules of the device reaches its set parameters and goes into the status "ready for analysis" **yes**

- All operating parameters of the system / hardware and software / fully comply with the technical specifications of the manufacturer **yes**
- The start signal works normally and the system modules are in full sync **yes**
- The software automatically processes information and generates a correct result **yes**
- In analysis and standard sample, the results meet the requirements **yes**
- The manufacturer's standard operating procedure for checking the qualification of the installation, operational readiness and verification of the equipment for operation has been completed successfully **yes**

Water Audit (for PBs with pilot action referring to water use efficiency)

Одит на водата (за PB с пилотно действие, отнасящо се до ефективността на използването на водата)

Good quality water is a valuable and limited resource of paramount importance for human health, economic prosperity and social well-being. This is the main challenge - the establishment of such management in the water sector, through which to meet the needs of water in the required quantity and quality, both to ensure the life and health of the population and the needs of the economy, while providing conditions for reproduction and development of aquatic ecosystems.

Increasing the efficiency of water use has direct economic and environmental positive effects. Reducing water losses, water as a natural resource is protected and the pressure on water resources is reduced. Reduced NRW levels provide economic benefits to water supply as less water is extracted, purified and distributed. Also, reducing visible losses means direct economic benefits, as larger water volumes are registered and water thefts are reduced. When the level of NRW decreases, then the total price of water decreases, which means that the price of water is lower. This is a social benefit as consumers pay less for the same amount of water consumed.

3 Water Balance assessment for the water distribution network

3 Оценка на водния баланс на водоразпределителната мрежа

Please provide the Water Balance of the water distribution network (you can use the xls file named “WB-PI_Calc-UTH_version 2.2_EN”) for the period 2018 and 2019 (6 or 9 months)

Water balance - 6 months for 2018.

- Supplied water - 2 186 724 m3 Collected water - 1 270 087 m3

Water balance - 6 months for 2019.

- Supplied water - 2 003 475 m3 Collected water - 1 258 463 m3

4 Performance Indicators

IMPORTANT NOTICE: It is important to estimate those Performance Indicators that will show the impact of your pilot action

№	name of the settlement	population number	WATER SUPPLY м3	INVOICED WATER population м3	INVOICED WATER companies м3	TOTAL INVOICED WATER м3	LOSS %	WATER SUPLED BY THE WATER SUPPLY SYSTEM	INVOICED WATER IN THE WATER SUPPLY SYSTEM	LOSS %
	KARDZHALI Municipality - surface water sources									
	Water supply system "BOROVITSA dam" for the municipality of Kardzhali							4393742	2399260	45,39

	gravitational	0	0	0	0	0	
	pumped	**54431**	**4393742**	**1818683**	**580577**	**2399260**	**45,39**
	total	**54431**	**4393742**	**1818683**	**580577**	**2399260**	**45,39**
	non-drinking water	**44098**	**0**	**0**	**0**	**0**	**#DIV/0!**

5 Obtained results

Please present the results you obtained from the pilot action.

Please also give the following data:

- Water saving (m^3/specific time period:
- No. of consumers that could be supplied with water
- Other benefits from the pilot action
- Cost of the pilot action
- Time of depreciation (comparing the cost to the cost of the water saving)

From the implementation of the WATER SAVING project and the implemented pilot actions, lessons have been learned related to the efficiency of water use. The project action of delivery and installation of flow meters made possible to locate sections of the water supply system where there is a suspicion of water loss or theft. Also after their installation it will be possible to identify possible accidents in these sections very accurately and quickly. The results of the implementation of the pilot actions showed that there is a serious underestimation of the water volume, which leads to a false assessment of non-revenue water. Thus, the water supply cannot identify the actual value of the NRW and the reasons for this in order to develop strategies and take measures to reduce them. On the basis of the performed real measurements the project banaficiaries managed to estimate the real water losses and to consider separately a certain part of the city water supply network and to prove the need for rehabilitation there. Targeted actions in the most critical part of the network gave significant results in the conditions of impossibility to replace the whole network of one city. The implementation of the pilot action showed that the water supply and sewerage has a very good knowledge of the spatial and temporal distribution of accidents, which allows to design the next steps regarding the repair of network assets or even their replacement when necessary. Also, the repair time is reduced, as the water supply and sewerage system is immediately informed of any damage to the water distribution network. Consumers are notified of specific water problems or outages, improving their relationship with the water company. A methodology for increasing water efficiency has also been developed. The first step towards this goal is to develop a water balance and identify the causes of NRW. Then, based on the reasons for NRW, several measures are presented. Water operators can choose from measures based on criteria they set, such as economic, cost-benefit, criteria related to the effectiveness of the measure or consumer concerns, and more. The partners implemented several measures to reduce NRW and increase water efficiency. Such measures include the speed and quality of repair and replacement of water mains aimed at real losses, reliable assessment of incoming water and more.

Water Quality Evaluation (for PBs with pilot action referring to water quality)

6 Water Quality assessment for the water distribution network

Please explain how the pilot action contributed to achieving better quality.

7 Performance Indicators

Please estimate the following performance indicators (at least). You can use the xls file named “WB-PI_Calc-UTH_version 2.2_EN” for 2018 and 2019 (6 or 9 months)

	2018	2019
- Tests carried out (Op40) (%) =	99	99.9
- Aesthetic tests carried out (Op41) (%) =		
- Microbiological tests carried out (Op42) (%) =		
- Physical-chemical tests carried out (Op43) (%) =		
- Radioactivity tests carried out (Op44) (%) =		
- Quality of supplied water (QS18) (%) =	98	98.9
- Aesthetic tests compliance (QS19) (%) =		
- Microbiological tests compliance (QS20) (%)		
- Physical-chemical tests compliance (QS21) (%) =		
- Radioactivity tests compliance (QS22) (%) =		
- Water quality complaints (QS30) (%) =	0.5	0.01
- Other (related to your pilot action – you can use the WB/PI Calc-UTH tool)		

IMPORTANT NOTICE: It is important to estimate those Performance Indicators that will show the impact of your pilot action

8 Obtained results

Please present the results you obtained from the pilot action.

Please also give the following data:

- No. of consumers that supplied with better water quality
- Other benefits from the pilot action
- Cost of the pilot action

The flowmeters included in the project will help to locate sections of the water supply system where there is a suspected loss or theft of water, and after their installation very accurately and quickly it will be possible to identify possible accidents in those sections.

Delivery and installation of four electromagnetic flow meters

Contractor SONICS Ltd

Cost of the pilot action – 13743.53 €

The laboratory equipment provided in the project will enable the investigation of a large number of indicators required by the relevant drinking water quality regulations, will enable the rapid and timely analysis of the samples, as well as the measurement with high accuracy and correctness.

Cost of the pilot action – 112 249.02 €

9 Comments

Please provide any comments.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Appendix A:

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.5.4 Ex post evaluation report** *Questionnaire*
Project Beneficiary No	**PB5**
Beneficiary Institution	**Municipality of Gotse Delchev**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Table of Contents

Name of the organization/institution:
Beneficiary number:

1 Introduction

Please describe your water distribution network, where the pilot action took place.

Water Utility Level (2018 base year or for 2019 if there are any data)

- Total population served = 1 650
- Total area covered (Km^2) = 0,20
- Total pipes' length (Km) = 1,680
- Mean altitude (m) = 525
- Mean operating pressure (atm) = 4,5
- Types of pipes (material, diameters, lengths) =

Material	Diameter	Length
Steel (main pipeline)	200 mm	1 141 m
Brass (service connections)	32 mm	539 m

- Age of pipes (per material, diameter) =

Material	Diameter	Age
Steel (main pipeline)	200 mm	>30 years
Brass (service connections)	32 mm	>30 years

- No. of service connections = 49
- Billing Period = Monthly
- River Basin where water is taken from = Mesta river basin

2 Pilot action

- Define and present the specific problems you are facing and made you choose the specific pilot action (present as many data as you can)
  Main problem of the selected area of water supply network of Gotse Delchev is high level of real water losses. Based on measurements and data analysis did as a part of current project real water losses and other indicators directly affected by level of real water losses for DMA Dunav are following:
  - NRW by volume (Fi46) (%) = 66,07%
  - NRW by cost (Fi47) (%) = 1,5%
  - Water Losses per connection (Op23) (m3/connection/year) = 2884,69
  - Water Losses per mains length (Op24) (m3/Km/year) = 123 882,59
  - Apparent Losses (Op25) (%) = 15,53%
  - Apparent Losses per SIV (Op26) (%) = 15,53%
  - Real Losses per connection (Op27) (lt/connection/day when system is pressurized) = 6 042,63
  - Real Losses per mains length (Op28) (lt/km/day when system is pressurized) = 259 499,33
  - UARL = 3 294,59
  - ILI = 90
- Define and present the specific pilot action: e.g. what kind of equipment you have installed and where you installed them, etc. (please present as many photos as you can)
  Project can be divided in three phases:

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- DMA set up – as a part of this stage DMA Dunav was set up by construction of a measuring manhole and installation of flow meter and telemetry devices
- Data analysis – data for flow and pressure at entrance of DMA was collected for a period of one year. Based on those data team has performed analysis and level of real water losses was assessed
- Rehabilitation of pipe section – final step of the project was related with rehabilitation of most problematic secondary branches in DMA

- Present the results you expected to have from the pilot action.
  Main result which was expected after implementation of all three phases of the project was reduction of real water losses. Due to the replacement of most problematic secondary branches level of new burst is expected also to be reduced
- Present any difficulties encountered during the pilot action implementation.
  All phases of the project was well scheduled and team didn't meet any difficulties during its implementation
- Define the cost of the pilot action
  Cost of reconstruction of pipeline is 96 550,36EUR and cost for DMA set up is 10 000EUR

Water Audit (for PBs with pilot action referring to water use efficiency)

3 Water Balance assessment for the water distribution network

Please provide the Water Balance of the water distribution network (you can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN") for the period 2018 and 2019 (6 or 9 months)

4 Performance Indicators

Please estimate the following performance indicators (at least). You can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN" for 2018 and 2019 (6 or 9 months)

- NRW by volume (Fi46) (%) =58,07%
- NRW by cost (Fi47) (%) = 1,05%
- Water Losses per connection (Op23) (m3/connection/year) =1 316,57
- Water Losses per mains length (Op24) (m3/Km/year) = 107 162,92
- Apparent Losses (Op25) (%) = 21%
- Apparent Losses per SIV (Op26) (%) = 21%
- Real Losses per connection (Op27) (lt/connection/day when system is pressurized) = 2 051,44
- Real Losses per mains length (Op28) (lt/km/day when system is pressurized) = 88,10
- ILI = 53,65
- Other (related to your pilot action – you can use the WB/PI Calc-UTH tool)

IMPORTANT NOTICE: It is important to estimate those Performance Indicators that will show the impact of your pilot action

5 Obtained results

Please present the results you obtained from the pilot action.

Please also give the following data:

- Water saving (m^3/specific time period: 40 829,28 m3/year
- No. of consumers that could be supplied with water:
- Other benefits from the pilot action: reduction of burst frequency
  Cost of the pilot action: Cost of reconstruction of pipeline is 96 550,36EUR and cost for DMA set up is 10 000EUR
- Time of depreciation (comparing the cost to the cost of the water saving)

Water Quality Evaluation (for PBs with pilot action referring to water quality)

6 Water Quality assessment for the water distribution network

Please explain how the pilot action contributed to achieving better quality.

7 Performance Indicators

Please estimate the following performance indicators (at least). You can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN" for 2018 and 2019 (6 or 9 months)

- Tests carried out (Op40) (%) =
- Aesthetic tests carried out (Op41) (%) =
- Microbiological tests carried out (Op42) (%) =
- Physical-chemical tests carried out (Op43) (%) =
- Radioactivity tests carried out (Op44) (%) =
- Quality of supplied water (QS18) (%) =
- Aesthetic tests compliance (QS19) (%) =
- Microbiological tests compliance (QS20) (%)
- Physical-chemical tests compliance (QS21) (%) =
- Radioactivity tests compliance (QS22) (%) =
- Water quality complaints (QS30) (%) =
- Other (related to your pilot action – you can use the WB/PI Calc-UTH tool)

IMPORTANT NOTICE: It is important to estimate those Performance Indicators that will show the impact of your pilot action

8 Obtained results

Please present the results you obtained from the pilot action.

Please also give the following data:

- No. of consumers that supplied with better water quality
- Other benefits from the pilot action
- Cost of the pilot action

9 Comments

Please provide any comments.

Appendix A:

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".