ECWS-8
2024
Conference

The 8th International Electronic Conference on Water Sciences

14–16 October 2024 | Online

MDPI

Assessing the Environmental and Economic Footprint of Leakages in Water Distribution Networks

Athanasios V. Serafeim[1,2], Anastasios Perdios[1,2], Nikolaos Th. Fourniotis[3], George Kokosalakis[1,2], and Andreas Langousis[1]

[1]Department of Civil Engineering, University of Patras, 26504 Patras, Greece
[2]Dipartimento di Ingegneria Civile, Ambientale ed Architettura Università degli Studi di Cagliari, 09124 Cagliari, Italy
[3]Department of Civil Engineering, University of the Peloponnese, 26334 Patras, Greece
[4]Department of Maritime Transport and Supply Chain, School of Business and Economics, Deree, American College of Greece, 15342 Athens, Greece

01. INTRODUCTION & AIM

All urban and agricultural water distribution networks (WDNs), irrespectively of their physical and operational characteristics encounter substantial leakages, which result in significant water losses, environmental degradation through increased carbon emissions and noteworthy economic burdens. The current work aims to quantify both the environmental impact, estimated in terms of CO_2 emissions, and the economic implications associated with leakages and evaluate the effect of the most widely used leakage reduction strategies. In doing so, we highlight the critical importance of sustainable water management practices in the face of growing urbanization and climate crisis pressures.

02. Data and Area of Application

To estimate the total CO_2 emissions per kWh of production, we utilize energy consumption as well as CO_2 emissions data acquired from the Greek Public Power Corporation and the Independent Power Transmission Operator, respectively. Also, to estimate the water production cost, we use high resolution energy consumption and flow data for the 6-month period from May 2023 – October 2023, as well as the associated energy billing data, from 3 pumping stations, namely: a) Karnavalika, b) Glafkos 1, and c) Glafkos 2 (see Figure 3) from the Water Distribution Network (WDN) of the city of Patras in Western Greece. The latter exhibits significant leakage rates; i.e. more than 40% of the system's input volume; see Serafeim et al. (2021).

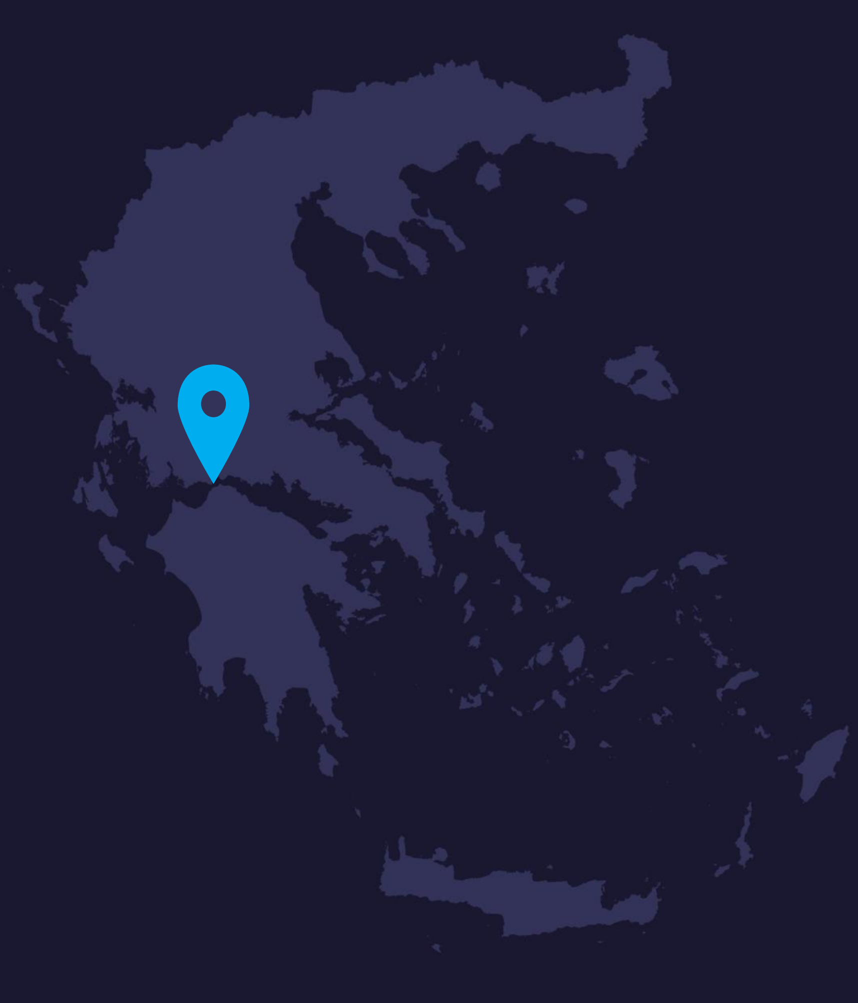

Figure 1: Map of Greece

03. RESULTS - DISCUSSION

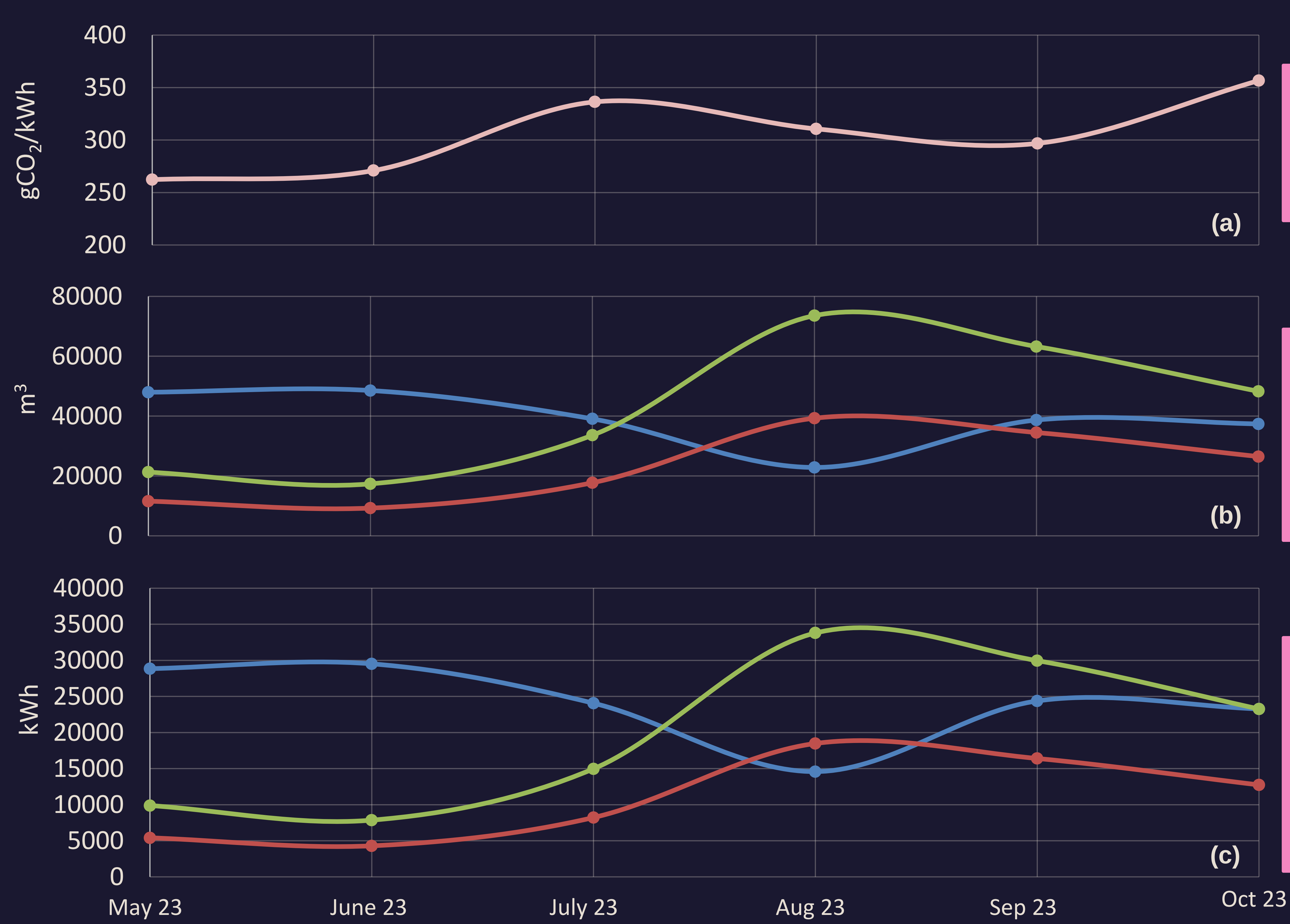

Figure 2.a: Carbon Footprint per kWh of production (in gCO_2/kWh), during the 6-month period from May 2023 – October 2023, estimated using data from the Greek Public Power Corporation and the Independent Power Transmission Operator

Figure 2.b: Volume of water pumped monthly at the examined pumping stations, during the 6-month period from May 2023 – October 2023. Blue color indicates the Karnavalika station, while red and green indicate the Glafkos 1 and Glafkos 2 stations, respectively.

Figure 2.c: Monthly Energy consumption (in kWh) for water pumping, during the 6-month period from May 2023 – October 2023. Blue color indicates the Karnavalika station, while red and green indicate the Glafkos 1 and Glafkos 2 stations, respectively.

Pumping Station	BEFORE PMAs			AFTER PMAs		
	Lost Water (m^3)	tCO_2	€	Lost Water (m^3)	tCO_2	€
Karnavalika	140,723	26.24	63,325	70,362	13.12	31,662
Glafkos 1	55,550	8.21	24,998	38,885	5.74	17,498
Glagkos 2	102,940	14.98	46,322	61,764	8.99	27,793

The results reveal that the most effective approach for mitigating leakages and their associated environmental and financial costs is by partitioning the network into smaller hydraulically isolated areas, combined with proper pressure management (i.e. design of Pressure Management Areas; see Figure 3). More specifically, the leakage rates and the associated CO_2 emissions and economic costs are reduced up to 40%. These findings highlight the importance of targeted pressure management towards achieving substantial efficiency improvements.

04. CONCLUSIONS

Mitigating water leakages in WDNs is crucial for achieving environmental sustainability and economic efficiency. By reducing leakages through network partitioning and pressure management, water utilities can significantly reduce both the carbon emissions and the operational costs, contributing to global sustainability goals, as demonstrated by a case study in the city of Patras.

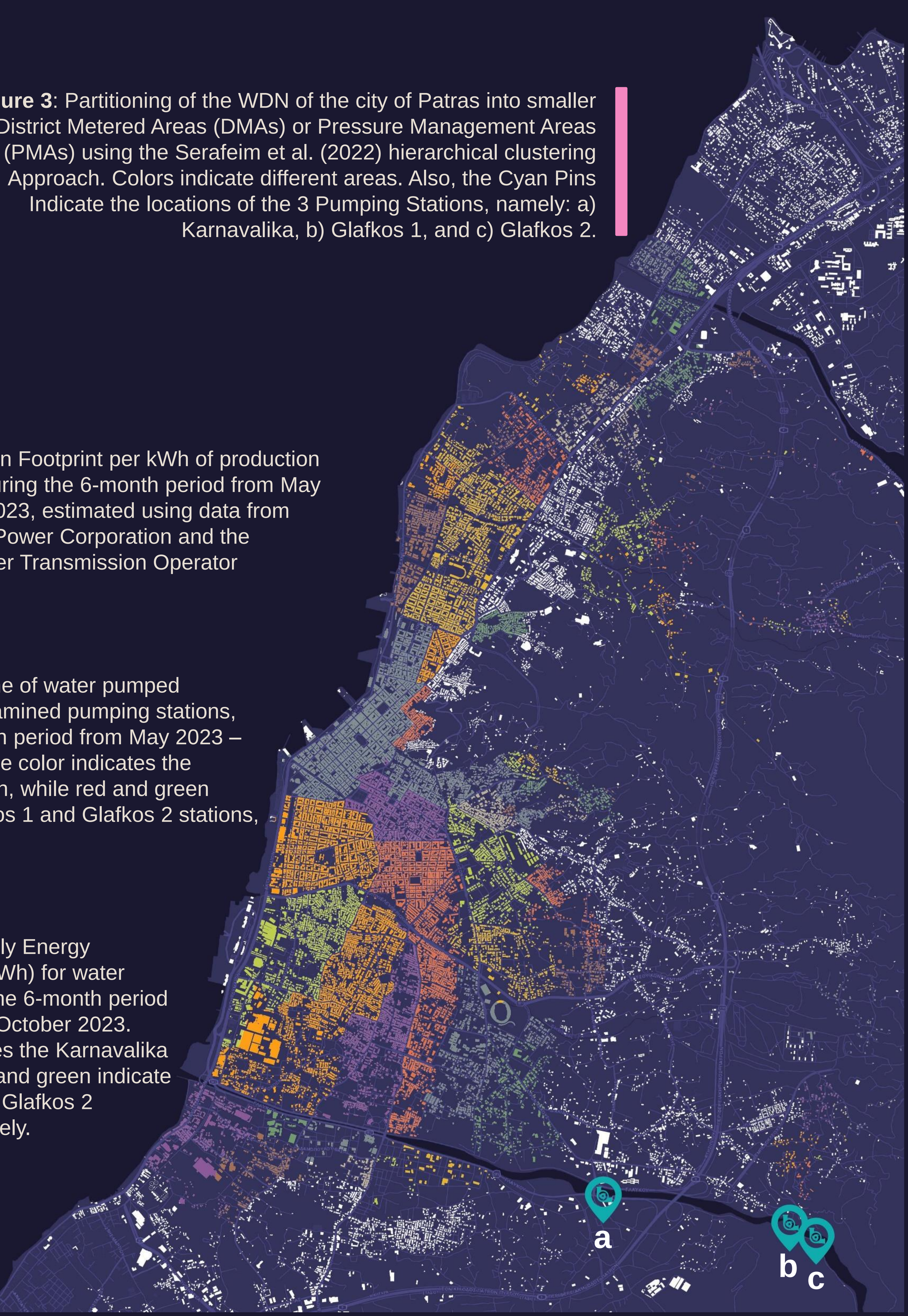

Figure 3: Partitioning of the WDN of the city of Patras into smaller District Metered Areas (DMAs) or Pressure Management Areas (PMAs) using the Serafeim et al. (2022) hierarchical clustering Approach. Colors indicate different areas. Also, the Cyan Pins Indicate the locations of the 3 Pumping Stations, namely: a) Karnavalika, b) Glafkos 1, and c) Glafkos 2.

Serafeim, A. V., G. Kokosalakis, R. Deidda, I. Karathanasi and A. Langousis (2021) Probabilistic estimation of minimum night flow in water distribution networks: large-scale application to the city of Patras in western Greece, Stoch. Env. Res. Risk Asses., https://doi.org/10.1007/s00477-021-02042-9.

Serafeim, A.V., G. Kokosalakis, R. Deidda, N. Th. Fourniotis and A. Langousis (2022) Combining statistical clustering with hydraulic modeling for resilient reduction of water loses in water distribution networks: Large scale application to the city of Patras in western Greece, Water, 14(21), 3493. https://doi.org/10.3390/w14213493.