



Risk management in water supply networks

Fernanda Rodrigues¹; Manuela Borges¹; Hugo Rodrigues²

¹ RISCO, Civil Engineering Department, University of Aveiro, Portugal,
mfrodrigues@ua.pt; manuela.borges@ua.pt

² RISCO, School of Technology and Management, Polytechnic of Leiria, Portugal
hugo.f.rodrigues@ipleiria.pt

Outline

Introduction

- Justification of the issue under study
- Objectives

Case study

- Aveiro Water Supply Network
- Risk and Vulnerability Analysis

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- Results and Discussion
- Conclusions



Justification of the study

- The infrastructures safety management is a current challenge as for governments as for owners and operators of critical infrastructures.
- The critical infrastructures systems and installations are subject to diverse and different failure modes.
- It is important to anticipate the possible failure modes, its probability of occurrence and the gravity of its consequences.



Justification of the study

- The hazards under which the critical structures are exposed can be intentional, e.g. terrorism, sabotage, cyberattacks, or non-intentional as accidents, aging, natural catastrophes, etc.
- Nowadays, different network infrastructures as transports, energy, water, communications, are intrinsically connected.
- This interconnection implies that changes in the capacities of one are felt in others.
- Local changes in a network several times have regional adverse effects or even global in certain domains.

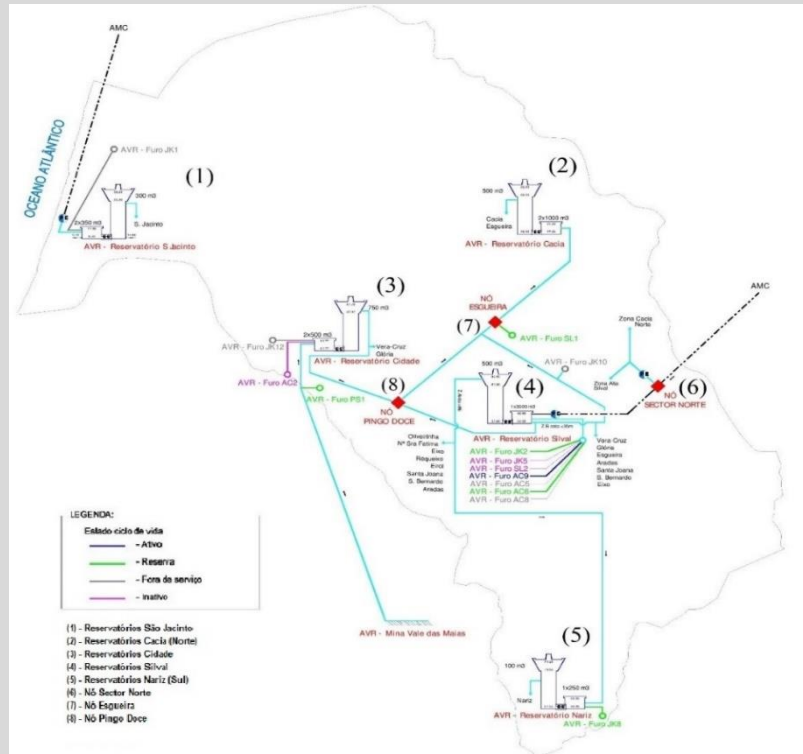
Objectives

The urban network of water supply is almost always composed by water abstraction sources, adductor conducts, treatment stations, and supply networks, being exposed to a great variety of risks threatening its functioning . As the water is essential for Human life, the analysis, mitigation or elimination of those risks must be a priority.

- This paper aims to present the risk assessment for the upcoming risk management of a water supply network applied to a case study: the Aveiro municipality water supply system, located in the midland Portugal.

Case study

- The case study under study consist on the water supply network of Aveiro municipality that supply almost 78 450 persons (according to Censos 2011), is composed by 8 significant points in 5 parishes



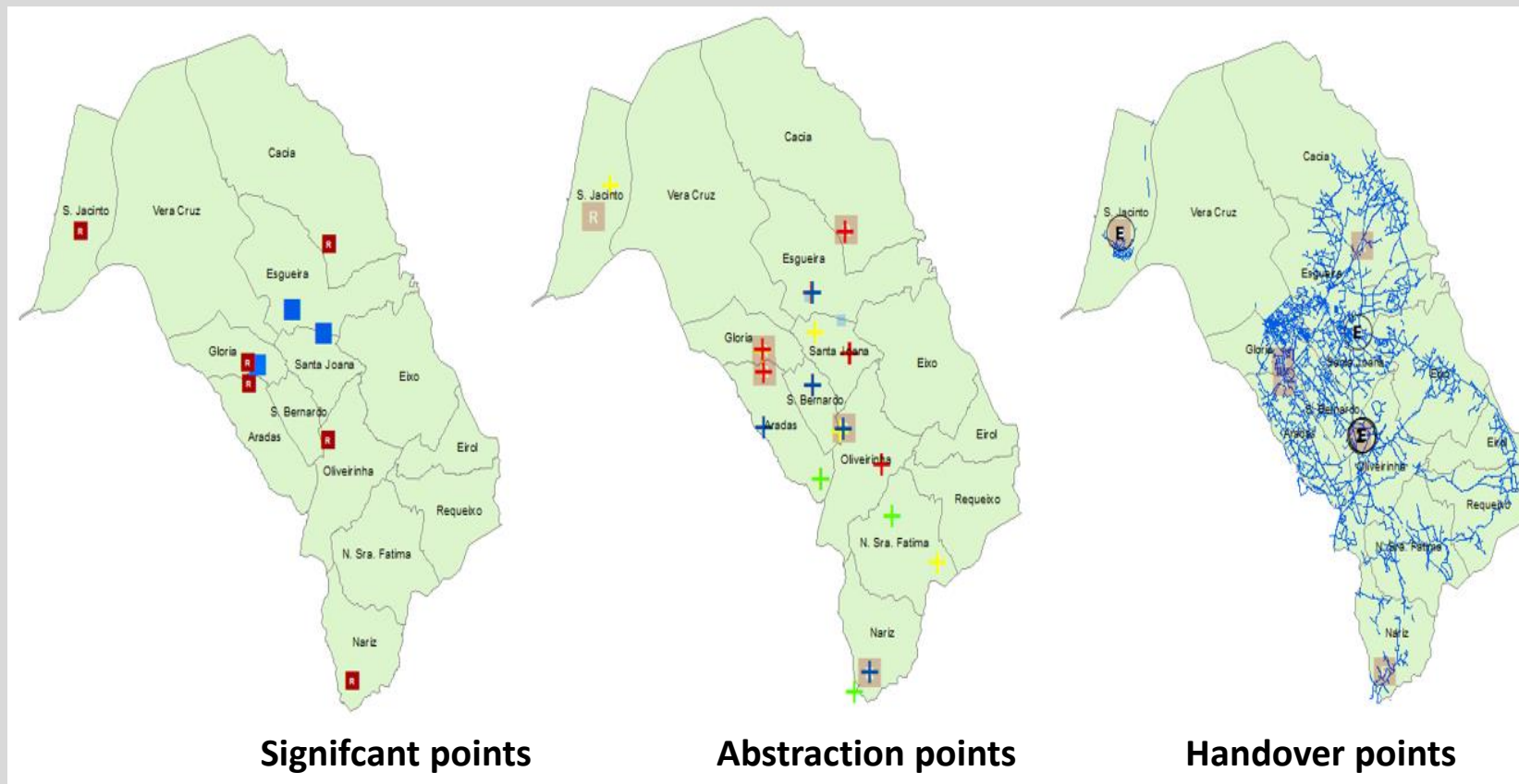
Each one of these significant points consist on water reservoirs with different capacities:

- (1) 3 reservoirs, one with 300 m³ and two with 350 m³, suppling 1000 inhabitants that increase in summer due the littoral location.
- (2) 3 reservoirs, one with 500 m³ and two with 1000 m³.
- (3) 3 reservoirs, one with 750 m³ and tow with 500 m³.
- (4) 4 reservoirs, three with 500 m³ and one with 3500 m³.
- (5) 2 reservoirs, one with 100 m³ and one with 250 m³.
- (6) Without reservoir but permitting strengthen the network
- (7) and (8) are points of operation and of control of the supply system.

- Network Characterization

Case study

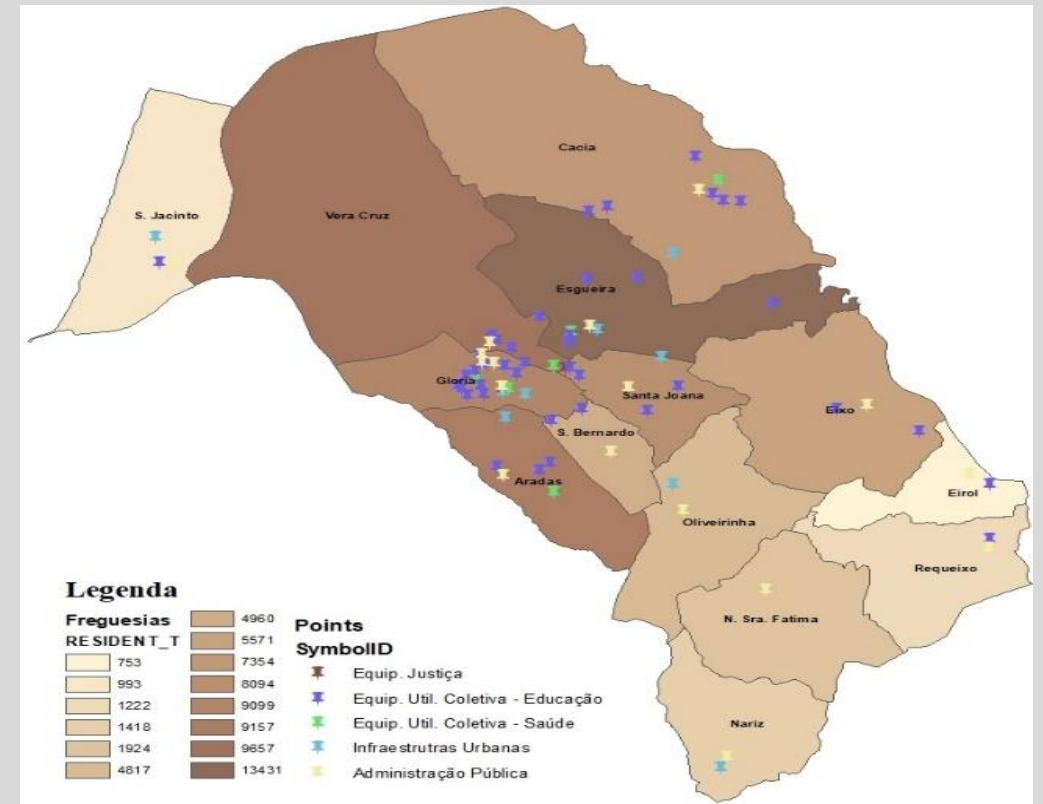
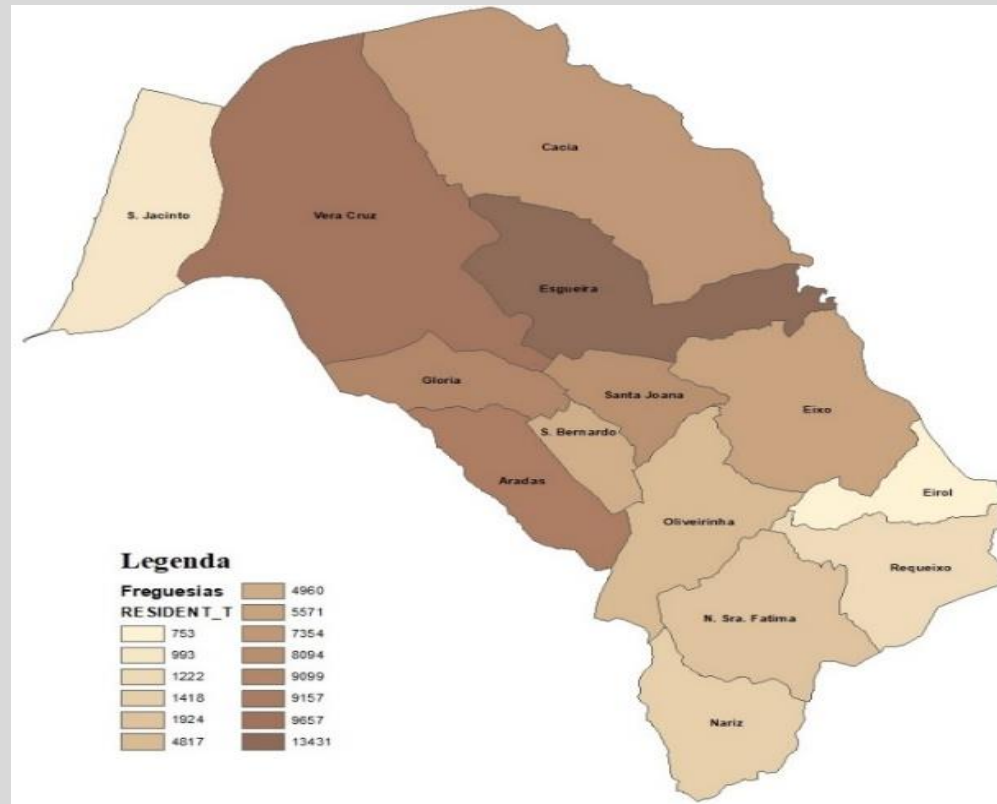
Water supply network's elements: significant points, abstraction points, the pipelines and the handover points together with the pipes



- Network Characterization

Case study

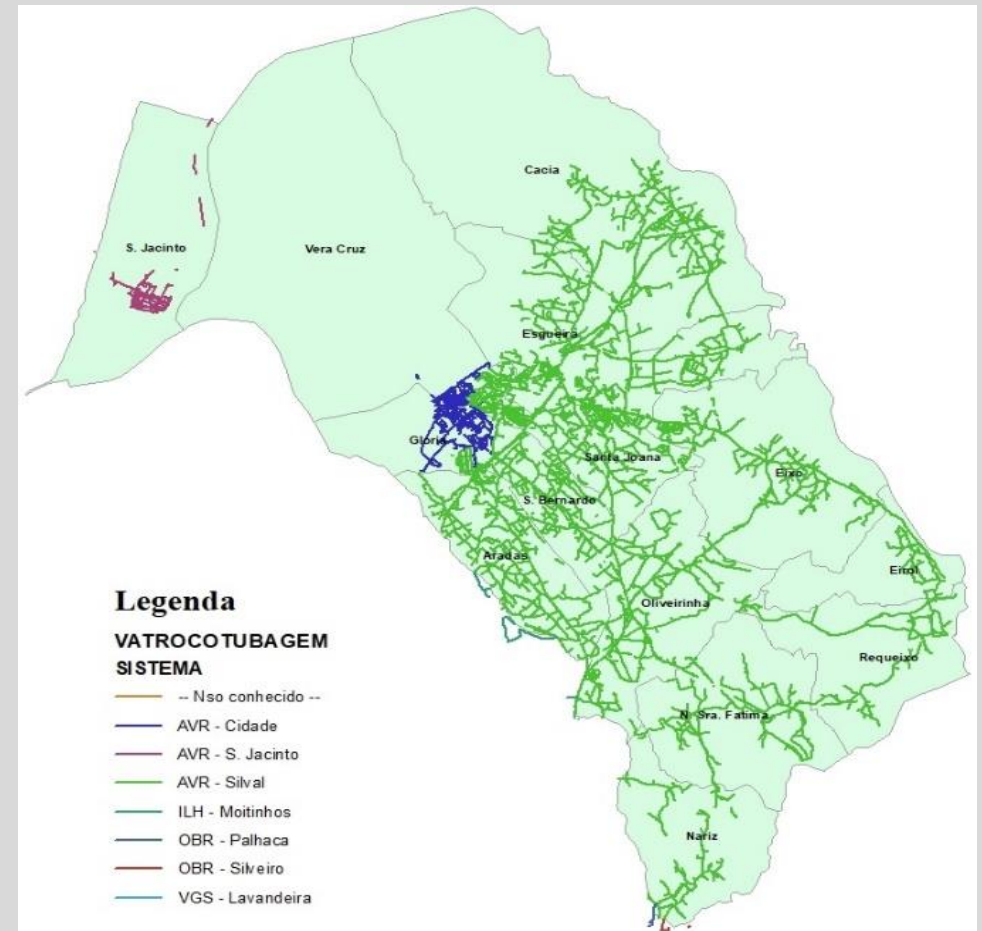
Population density of Aveiro and Infrastructures that can be affected by the events affecting the water supply system



- Network Characterization

Case study

Infrastructures Water abstraction and supply points and area of influence of the systems



- Network Characterization

Case study

Risk and Vulnerability Analysis (RVA) implementation

Table 1 – Scenarios to be considered

Scenario	Title	Threat category/Incident type
1	Electric energy failure in the significant point of Silval	Destruction or failure of critical society functions
2	Earthquake – Intensity VII	Extreme natural event
3	Remote management failure	Destruction or failure of critical society functions
4	Failure of sodium hypochlorite dosing pumps	Destruction or failure of critical society functions
5	a) Cyberattack against IT systems (remote management)	Other threats: Crime
	b) Destruction of Silval reservoir	Other threats: Crime
	c) Water contamination	Other threats: Crime
6	Failure in the abstraction system of Carvoeiro	Destruction or failure of critical society functions

- Risk and Vulnerability Analysis (RVA)

Case study

Risk and Vulnerability Analysis implementation

Table 2 - Probability indexes

1	Highly unlikely
2	Very unlikely
3	Probable
4	Very probable
5	Highly probable

Table 3 - Consequence levels

1	Limited
2	Moderated
3	Serious
4	Severe
5	Critical
	Not relevant
	Unknown

Table 4 – Levels of risk

1	Very low risk	9	Medium risk
2	Very low risk	10	Medium risk
3	Very low risk	12	Medium risk
4	Low risk	15	High Risk
5	Low risk	16	High risk
6	Low risk	20	Very high risk
8	Medium Risk	25	Very high risk

- Risk and Vulnerability Analysis (RVA)

Case study

Risk and Vulnerability Analysis implementation

Table 5 – Indexes for the preparation assessment, response capacity and relief and recovery capacity

1	Adequate
2	Mostly adequate/some faults
3	Some severe faults
4	Many severe faults
5	Unsuitable
	Not relevant
	Unknown

- Risk and Vulnerability Analysis (RVA)

Results Discussion

Table 6 – Assessment results for scenario 1

Probability	1 – Highly unlikely
General consequences	4 - Severe
Risk	4 – Low risk
Preparation	2 – Mostly adequate/some faults
Recovery capacity and relief	4 – Many severe faults
Recovery capacity	1 - Adequate

Table 7 – Matrix of Risk

Probability	Highly probable (5)					
	Very probable (4)			Scenario 4		
	Probable (3)				Scenario 2 and 3	
	Very unlikely (2)					Scenario 6
	Highly unlikely (1)				Scenario 1, 5 a) and b)	5 c)
	Very high risk					
	High risk	Limited (1)	Moderate (2)	Serious (3)	Severe (4)	Critical (5)
	Medium risk					
	Low risk					
	Very low risk	Consequences				

- Risk and Vulnerability Analysis (RVA)

Results Discussion

Table 8 – Vulnerability profile

<div><div></div><div></div><div></div><div></div><div></div></div> Very high vulnerability		Assessment of vulnerability levels		
<div><div></div><div></div><div></div><div></div></div> High vulnerability		Preparation (plans, preventive measures, etc.)	Response and relief capacities	Recovery capacities
<div><div></div><div></div><div></div></div> Medium vulnerability				
<div><div></div><div></div></div> Low vulnerability				
<div><div></div></div> Very low vulnerability				
Threats` scenarios	Scenario 1 – Electrical failure Silval	<div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div></div>
	Scenario 2 - Earthquake	<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div></div>	<div><div></div><div></div></div>
	Scenario 3 – Remote management failure	<div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div>	Unknown
	Scenario 4 – Failure of dosing pumps	<div><div></div><div></div></div>	<div><div></div><div></div></div>	<div><div></div></div>
	Scenario 5 a) – Cyberattack	<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>
	Scenario 5 b) – Destruction of Silval reservoir	<div><div></div><div></div><div></div></div>	<div><div></div><div></div></div>	Unknown
	Scenario 5 c) – Water contamination	<div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div>	Unknown
	Scenario 6 – Failure in the abstraction system of Carvoeiro	<div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div></div>

- Risk and Vulnerability Analysis (RVA)

Conclusions

- Regarding the risk profiles and vulnerability, the risk matrix permits verify that the developed scenarios have low or medium levels of risk.
- This matrix also leads to the scenarios identification with higher probability of occurrence and with severe consequences permitting to prioritize scenarios in which must invest in mitigation and prevention measures.
- Risk maps to each scenario were developed to the water network and specific ones to the most critical point of Silval.
- It was concluded that to decrease the vulnerability of the water supply network of Aveiro municipality a set of emergency and contingency plans must be develop:
 - **Maintenance plans; Investment plans; Contingence plans (aiming to prepare the organization to respond efficiently to emergencies and to its potential human impact); Emergency plans (systematizing a set of standards and rules to minimize the forecast catastrophe effects, managing effectively the available resources); Evacuation plan and an Action plan.**



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THANK YOU FOR YOUR ATTENTION!

Fernanda Rodrigues ¹; Manuela Borges¹; Hugo Rodrigues²

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