Hydraulic model as a main tool for water distribution system management

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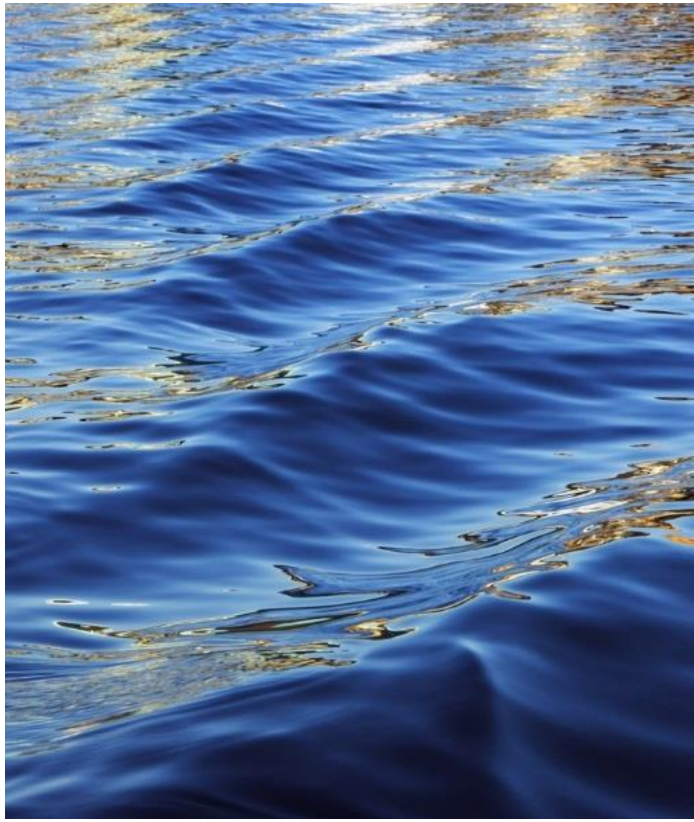

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Content

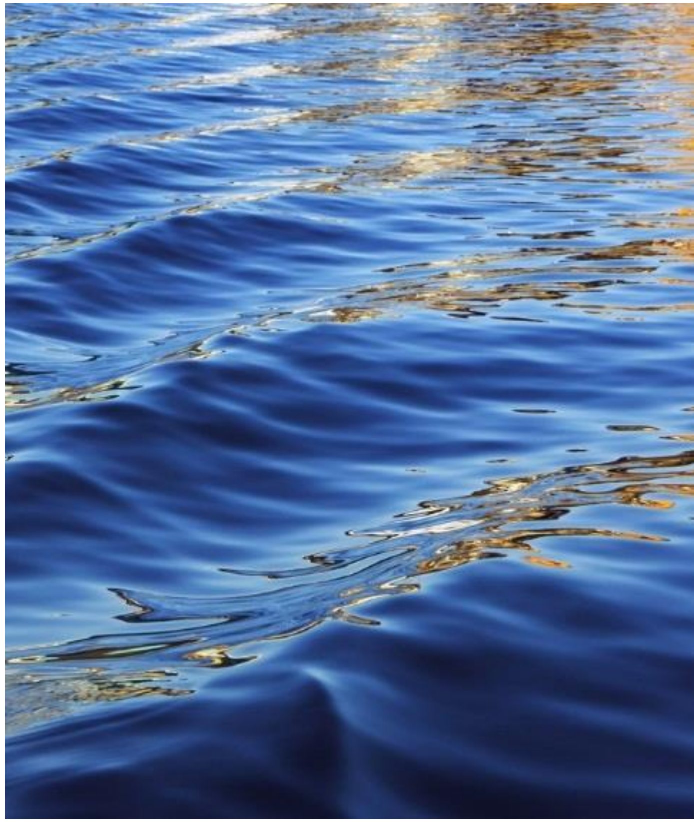
QUESTIONS

- What tools are needed for WDS management?
- How to start?
- Why is hydraulic model important?

ANSWERS – CASE STUDIES

- Soft measures as main starting point
- Hydraulic model as an operational and decision making tool
- Conclusion → Costs

What tools are needed for WDS management?



Soft tools

- Existing state information
- GIS
- Model
  - Flow and pressure measurement
  - DMA design
- Leak detection

Hard tools

- DMA construction
- Pressure management
- Water loss reduction

Administrative tools

- Capacity building
- Asset management
- Finances

Soft tools

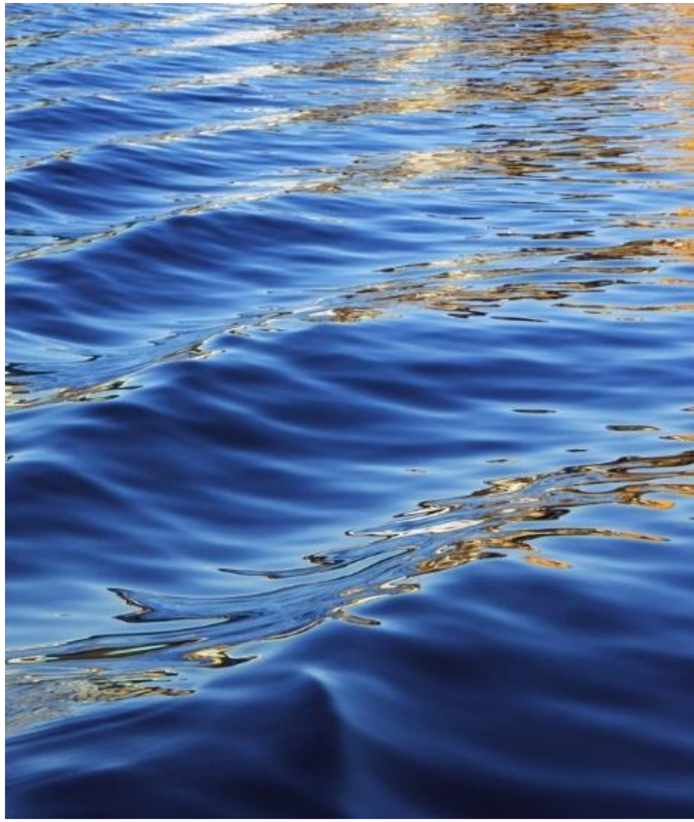
Main subject of this presentation

- Existing state information
- GIS
- Model
  - Flow and pressure measurement
  - DMA design
- Leak detection

- DMA construction
- Pressure management
- Water loss reduction

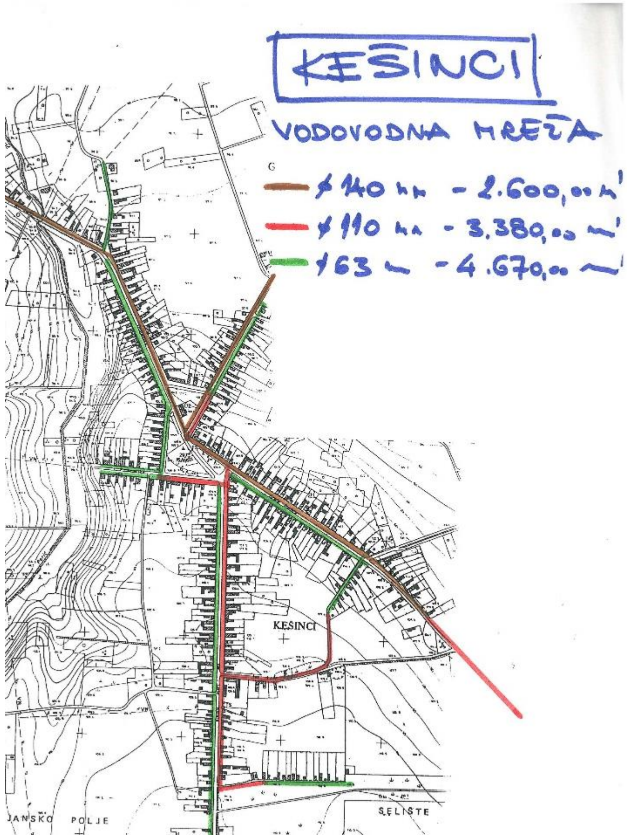
- Capacity building
- Asset management
- Finances

How to start?



Existing state due-diligence → combining all the existing knowledge with intense site investigation

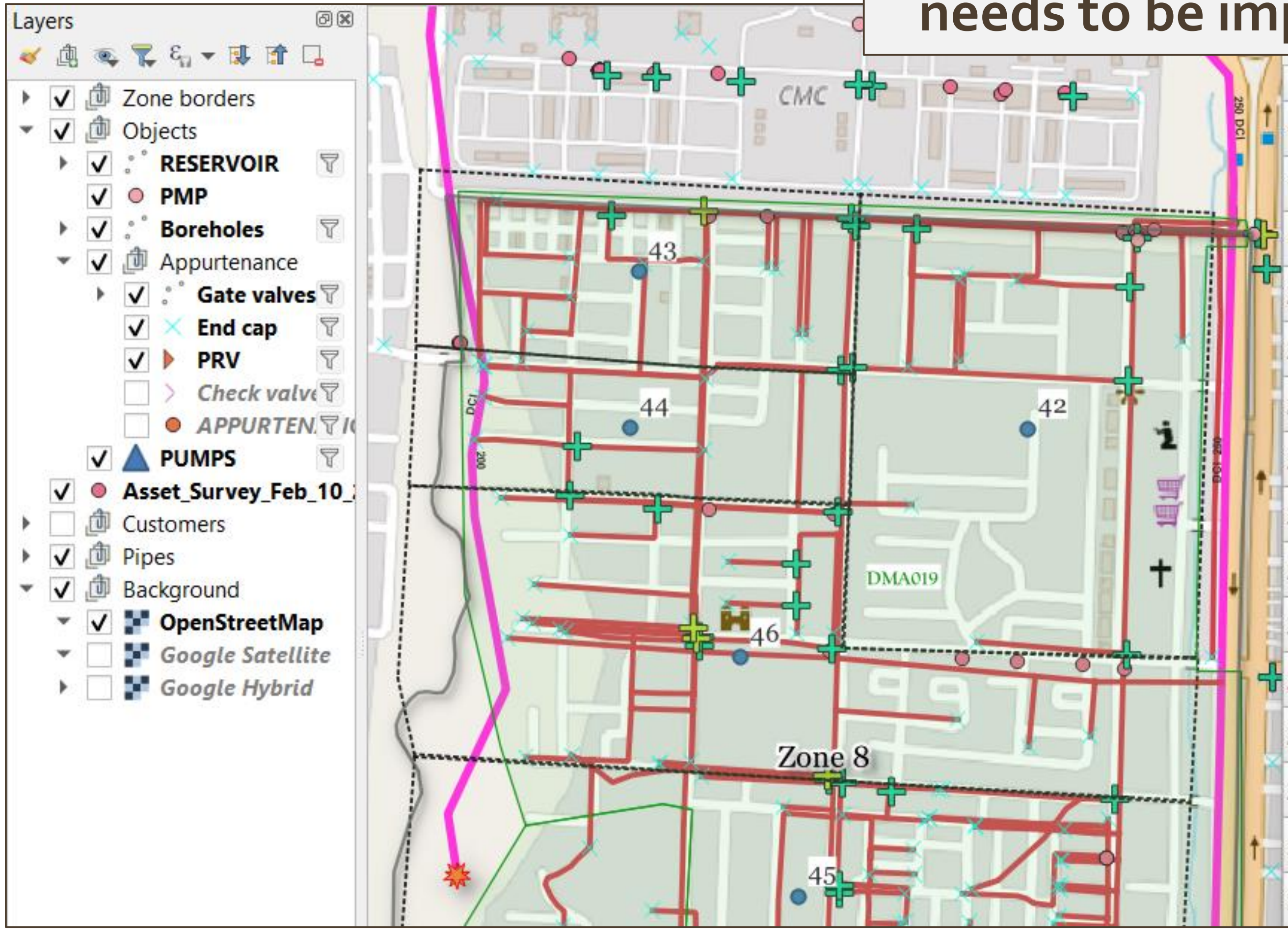
Existing drawings: hand drawings, CAD, GIS, "by memory" → EVERYTHING!!!



Site investigation → object characteristics, pipe layout confirmation, data sheets, existing documents, …

Creating **GIS**: “single source of truth”

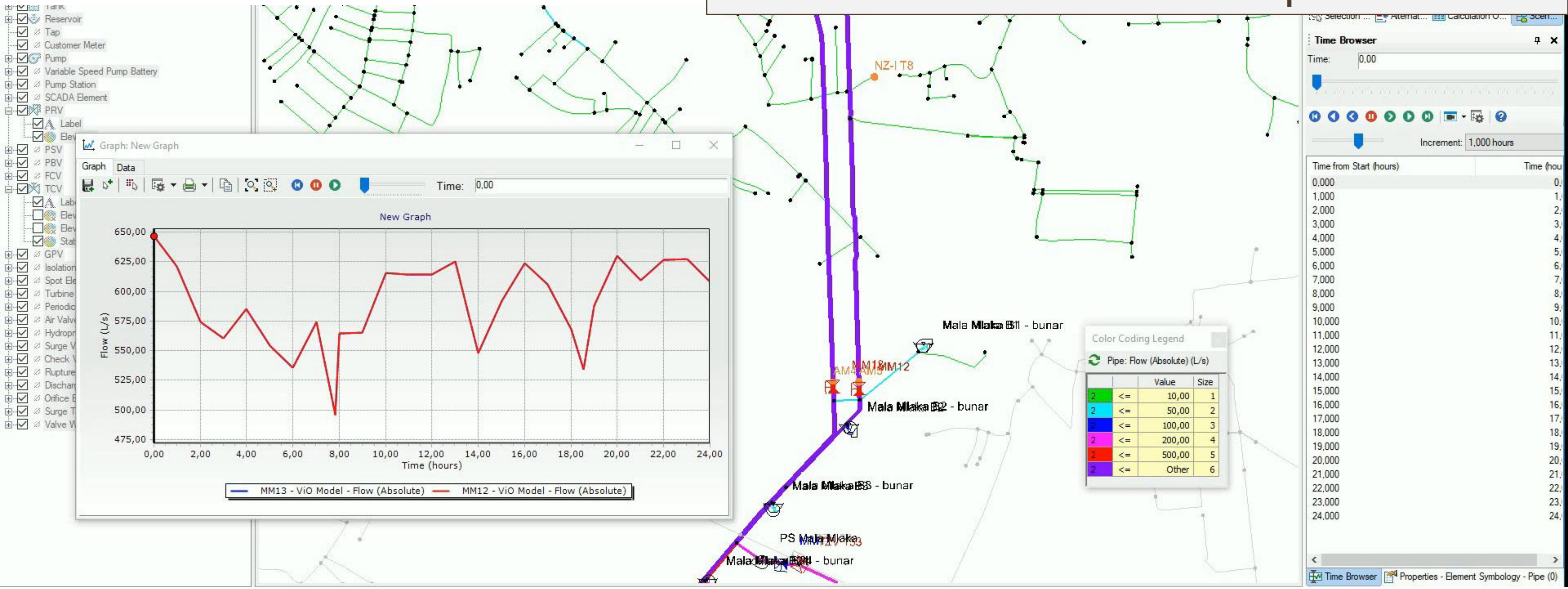
Every information that was collected in previous steps needs to be implemented or connected to GIS data.



	OBJECTID	PIPE_ID	CATEGORY	NOM_DIAM	MATERIAL
17	17	P-17	Primary - Groun...	350	DCI
18	18	P-18	Primary - Groun...	350	DCI
19	19	P-19	Primary - Groun...	350	DCI
20	20	P-20	Primary - Groun...	350	DCI
21	21	P-21	Primary - Groun...	300	DCI
22	22	P-22	Primary - Groun...	300	DCI
23	23	P-23	Primary - Groun...	300	DCI
24	24	P-24	Primary - Groun...	300	DCI
25	25	P-25	Primary - Groun...	250	DCI
26	26	P-26	Primary - Groun...	250	DCI
27	27	P-27	Primary - Groun...	250	DCI
28	28	P-28	Primary - Groun...	250	DCI
29	29	P-29	Primary - Groun...	250	DCI
30	30	P-30	Primary - Groun...	250	DCI
31	31	P-31	Primary - Groun...	250	DCI

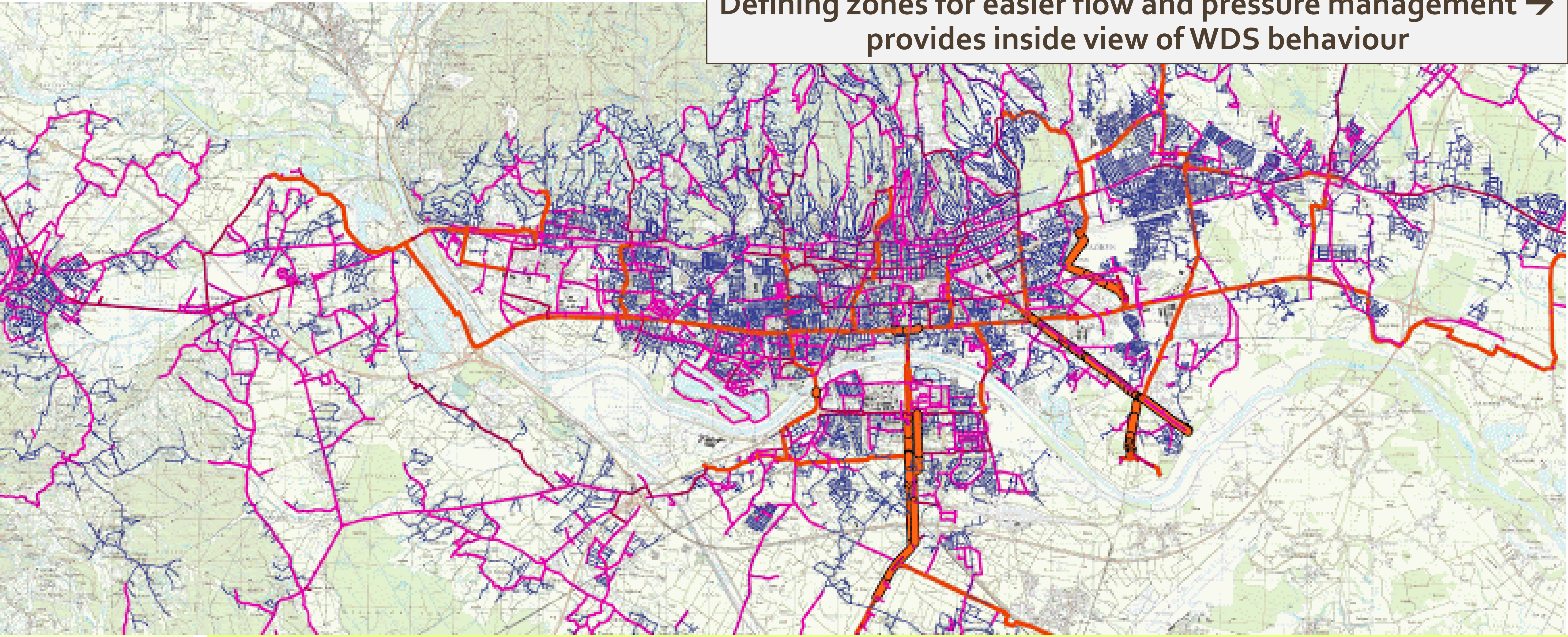
Developing **hydraulic model**

Hydraulic model is a digital twin of a WDS → giving a life to a static GIS map!



DMA (district metering area) design

Defining zones for easier flow and pressure management → provides inside view of WDS behaviour



Measurement campaign → flow, pressure and water level measurement for model calibration

Flow measurement using ultrasonic flow meter

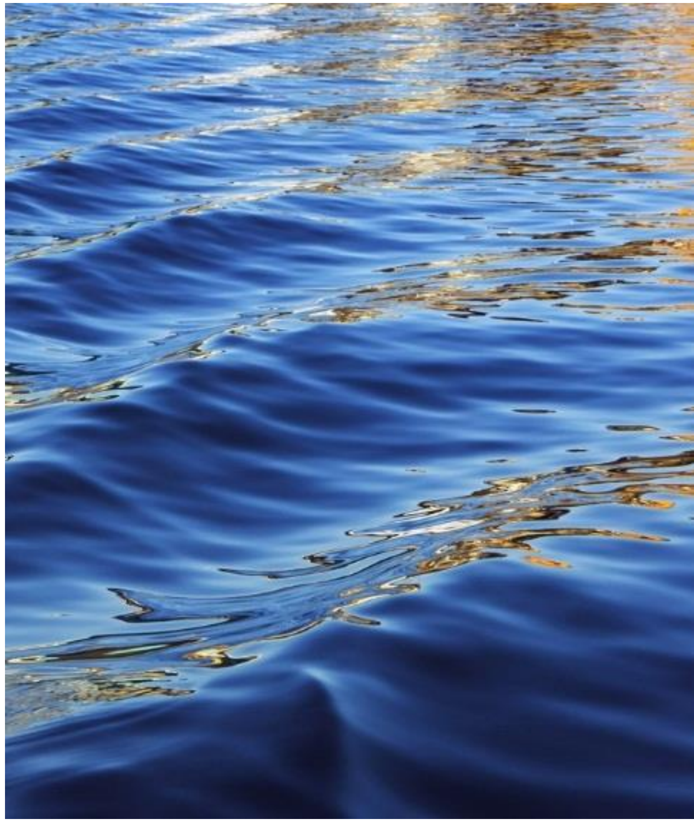
Pressure measurement

Leak detection→ step test, acoustic devices, corelation methods, etc.

Step test preparation

Site inspection

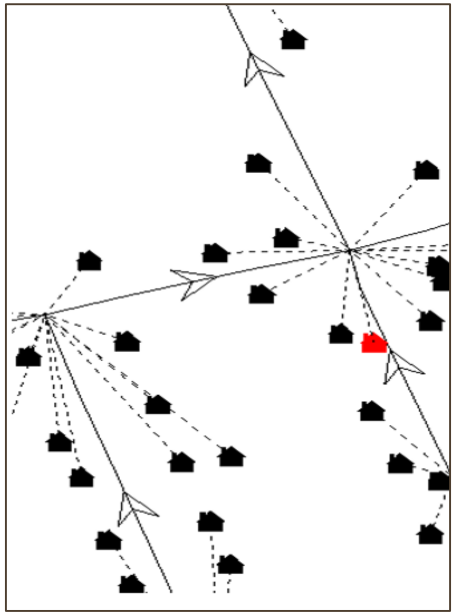
Why is hydraulic model important?

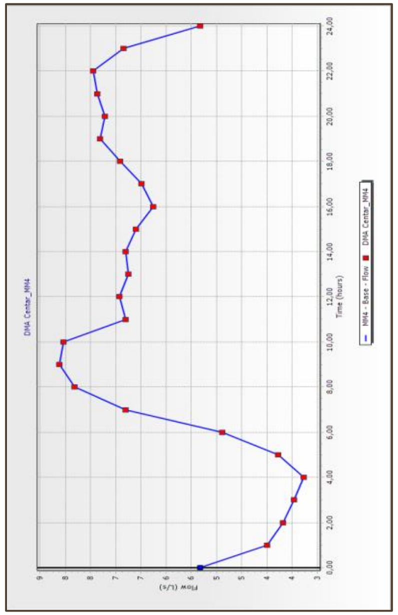


Hydraulic model combines all information (GIS, object data, etc.) and all the measurements for better decision making and confident distribution system management

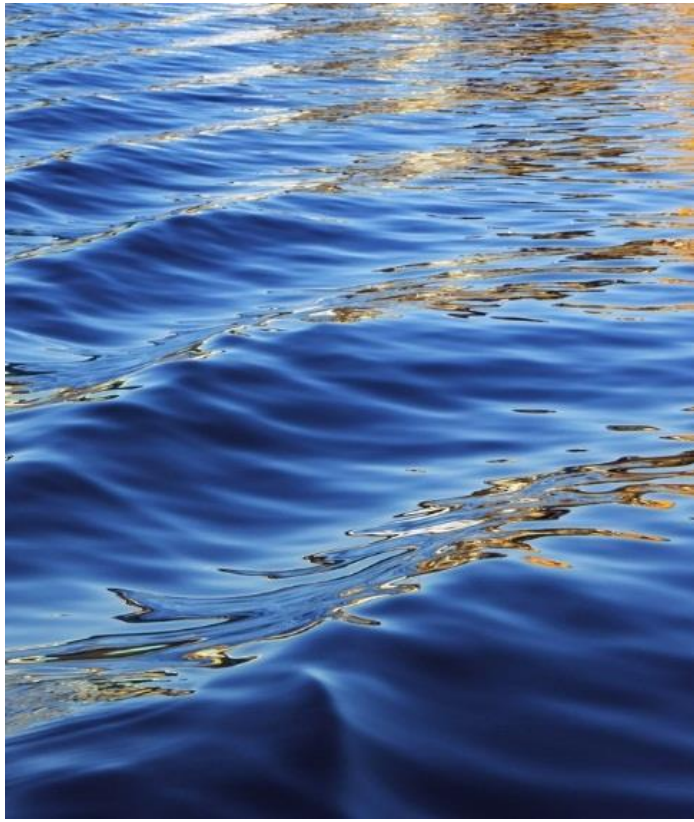
Input data → Data processing → GIS/Model → Measurement → Calibration





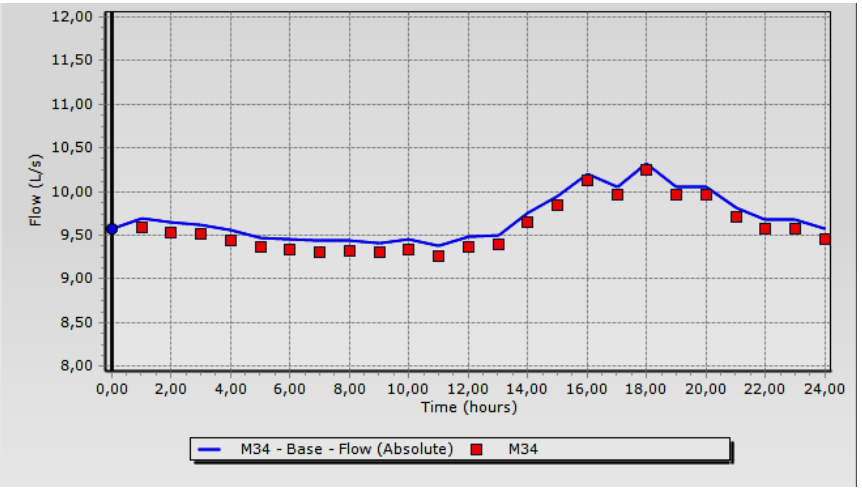


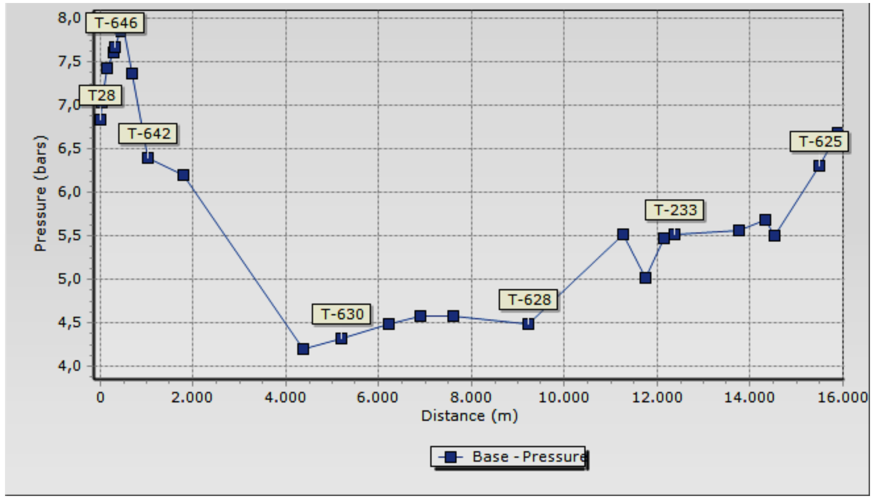
Case studies of problem solving and decision making using hydraulic model



Case 1: Pipe burst

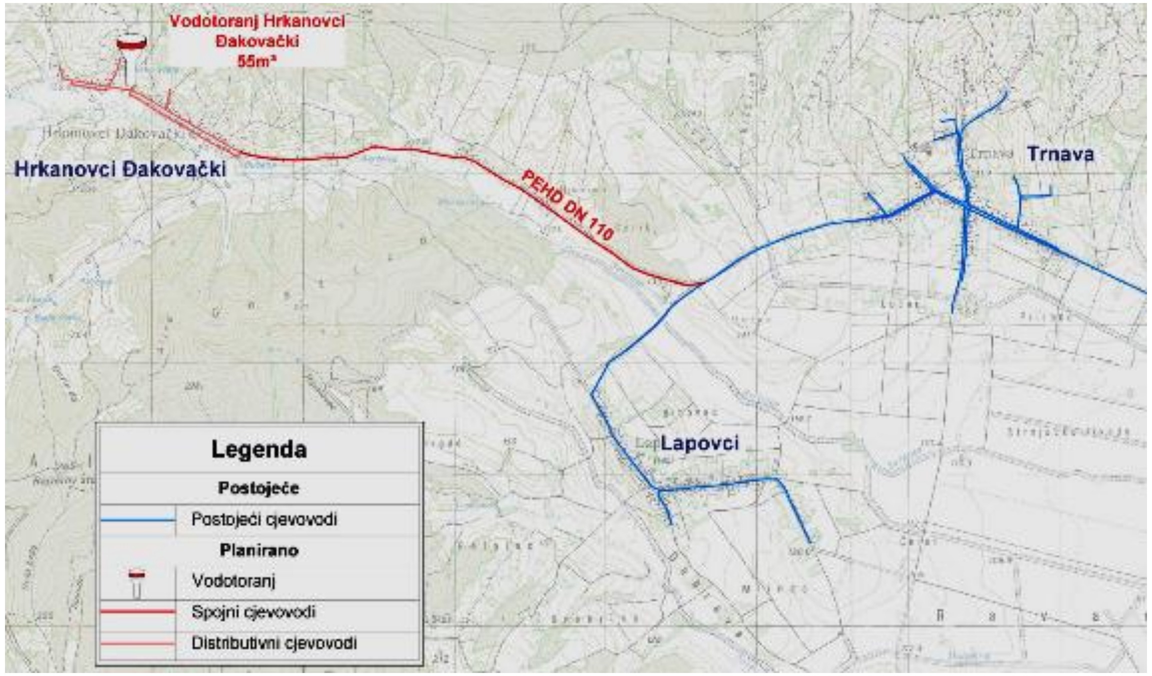
- Measurement campaign discovered 280.000 m3/y leak on 16 km main pipe
- Pressure analyses suggested pipe burst as main leak cause
- Using pressure profile inside hydraulic modelling software, pipe burst location was estimated and confirmed on site using leak detection equipment





Case 2: WDS network extension – different solution

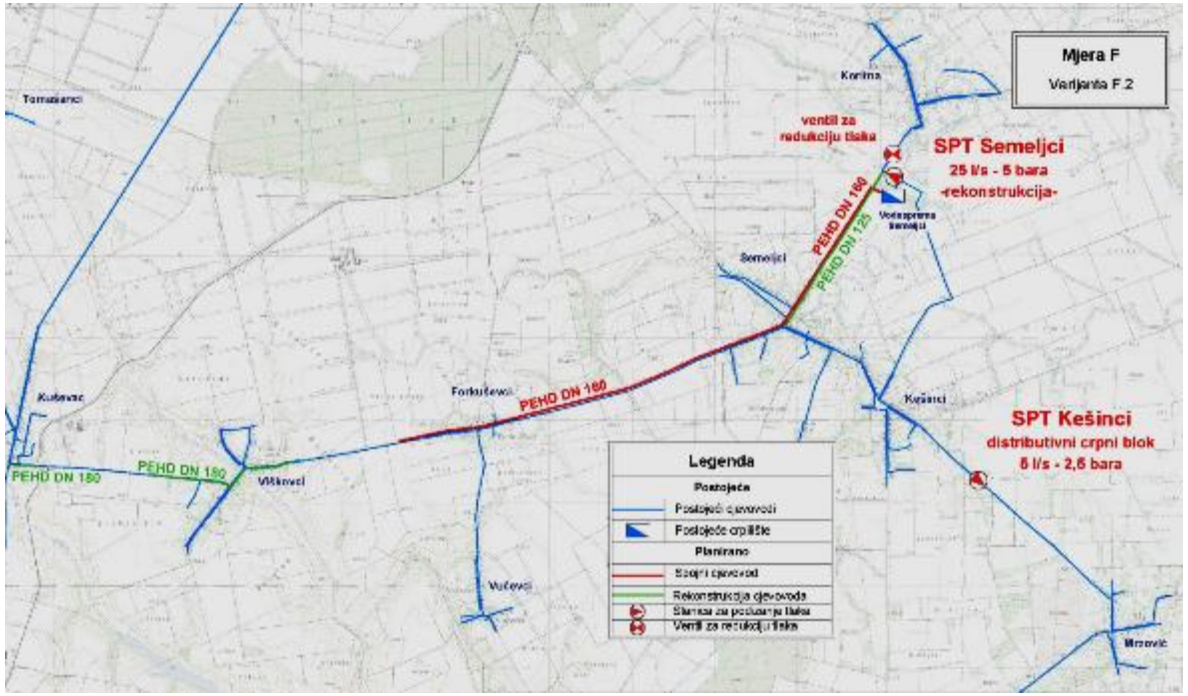
- Network extension was suggested by Water company and Designer did hydraulic calculation giving pipe diameter and cost estimate (first variant)
- Hydraulic modeler used model of entire network and offered second variant solution by lowering pipe diameter and implementing water tower as peak demand element
- Second variant lowered construction cost by 18%, operation cost by 14% and nett present value by 31%



Variant	CAPEX	OPEX	NPV (4%)
V1	3.132.100	25.917	3.284.512
V2	2.261.100	22.447	2.283.597
Difference	18%	14%	31%

Case 3: Water quality issue – different solution

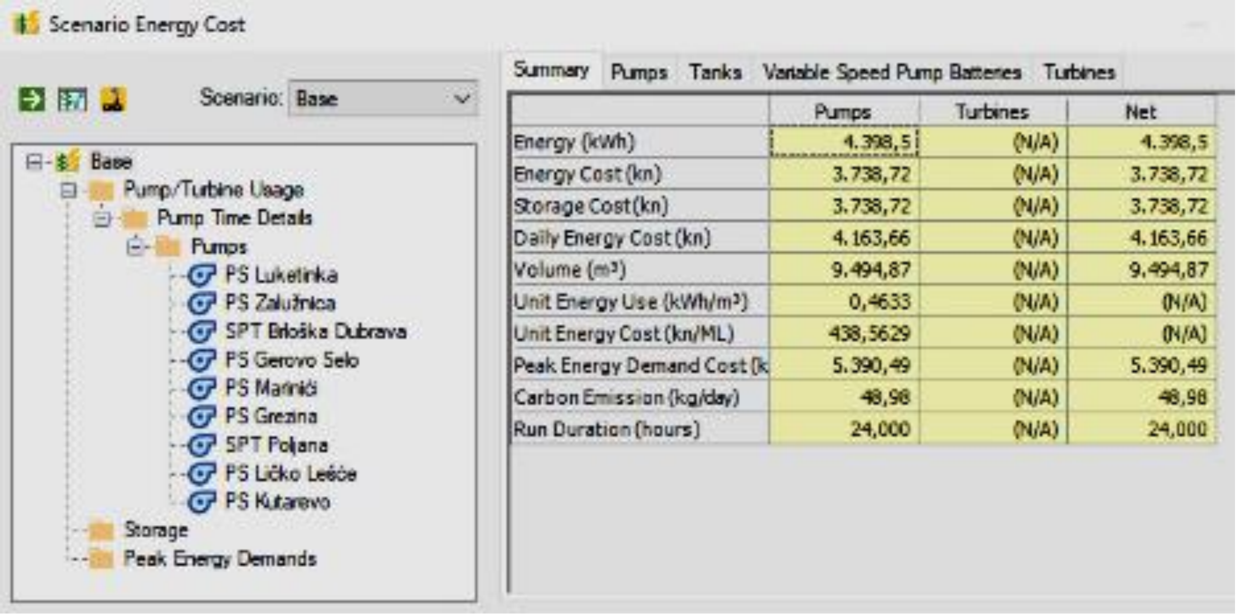
- Old water production facility stopped working properly and big reconstruction was suggested (first variant)
- Using hydraulic model and measured water balance, second variant was proposed by connecting subjected sub-system to main system with good water quality and sufficient distribution capacities
- Second variant for 15% increase in construction cost lowered operation cost by 23% and nett present value by 43%



Variant	CAPEX	OPEX	NPV (4%)
V1	5.624.975	721.843	24.753.411
V2	6.464.488	553.441	14.220.302
Difference	-15%	23%	43%

Case 4: Pressure management for electricity savings and water loss reduction

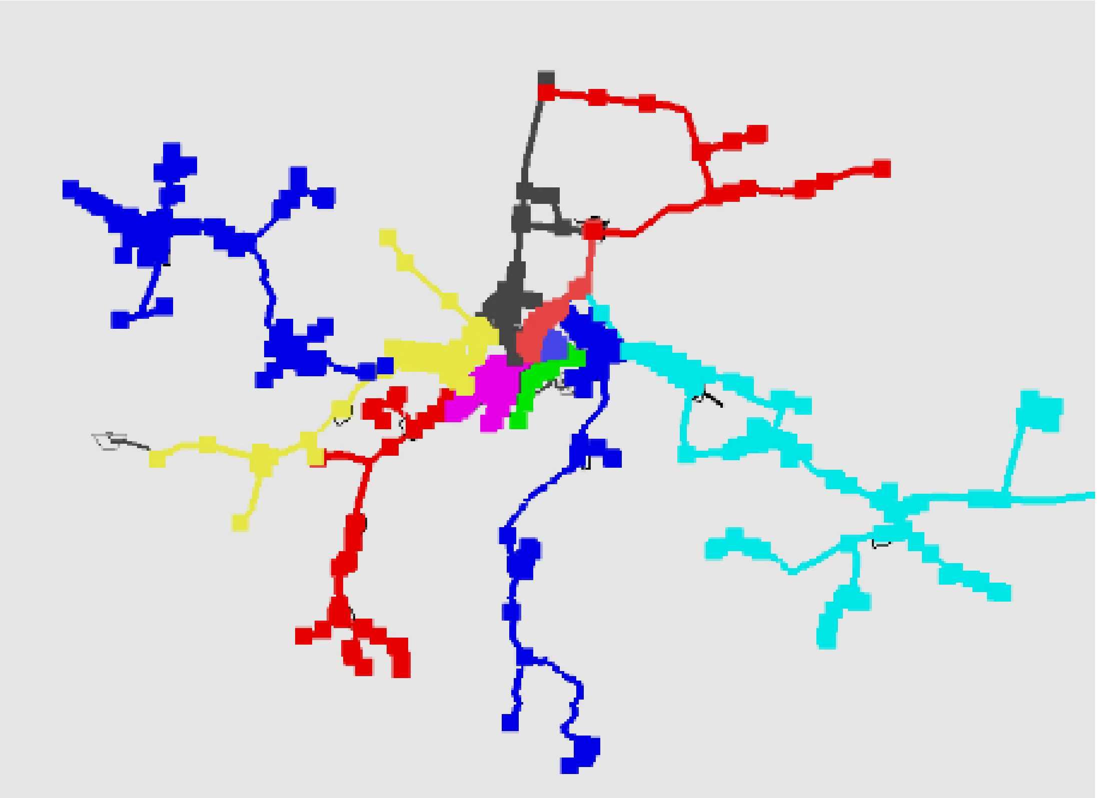
- Pumps were pumping from deep wells (50 – 100 m) directly to consumers
- Using hydraulic model, low pump efficiency was detected
- Suggest solution consist of updating pump variable frequency drive and separation of pumping system from distribution system
- Result 1: savings of 400.000 kWh/y of electricity
- Result 2: Water loss reduction of 250.000 m3/y
- Investment return period: 4 years



	Pumps	Turbines	Net
Energy (kWh)	4.398,5	(N/A)	4.398,5
Energy Cost (kn)	3.738,72	(N/A)	3.738,72
Storage Cost (kn)	3.738,72	(N/A)	3.738,72
Daily Energy Cost (kn)	4.163,66	(N/A)	4.163,66
Volume (m³)	9.494,87	(N/A)	9.494,87
Unit Energy Use (kWh/m³)	0,4633	(N/A)	(N/A)
Unit Energy Cost (kn/ML)	438,5629	(N/A)	(N/A)
Peak Energy Demand Cost (k	5.390,49	(N/A)	5.390,49
Carbon Emission (kg/day)	48,98	(N/A)	48,98
Run Duration (hours)	24,000	(N/A)	24,000

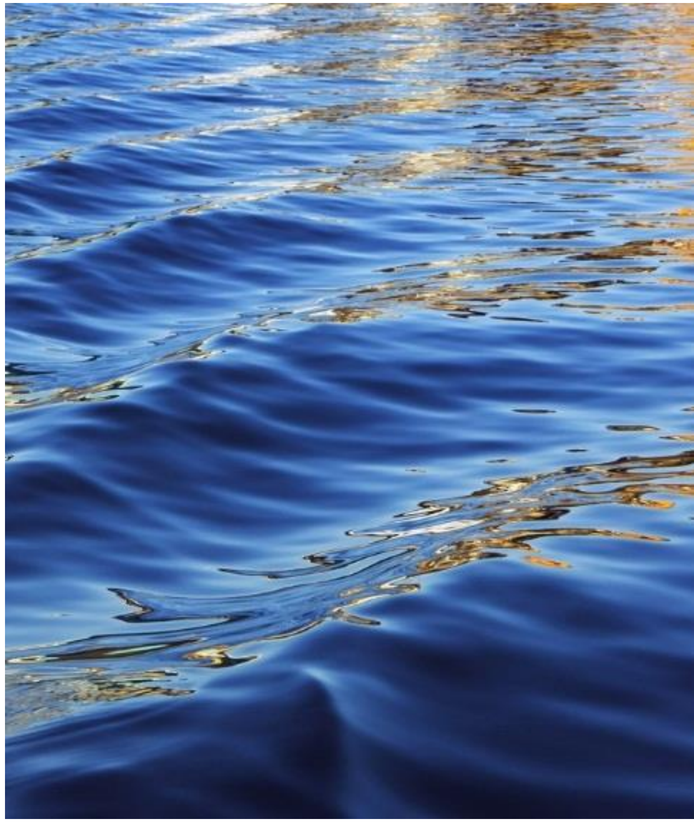
Case 5: Implementing DMA and PMA for better decision making

- Hydraulic model was designed to return exact pressure/loss corelation by implementing emitter coefficient
- Real time pressure management and loss reduction with direct results obtaining
- This way, decision making process is done using model simulation before any construction work or equipment installation



Pressure Zone	Zone	Net Volume (m^3)	Volume Demanded (m^3)	Maximum Elevation (m)	Minimum Elevation (m)	Maximum Hydraulic Grade (m)	Minimum Hydraulic Grade (m)	Maximum Pressure (bars)	Minimum Pressure (bars)
Pressure Zone - 1	<None>	158,9	158,9	265,00	129,31	291,33	174,18	10,7	-0,1
Pressure Zone - 2	<None>	- 228,4	- 228,4	235,00	114,47	255,44	158,46	7,8	2,0
Pressure Zone - 3	<None>	739,6	739,6	155,21	130,00	181,13	178,71	5,0	2,4
Pressure Zone - 4	<None>	553,8	553,8	165,00	90,81	194,58	118,41	5,7	2,2
Pressure Zone - 5	<None>	303,5	303,5	135,06	119,22	161,19	157,59	4,1	2,2
Pressure Zone - 6	<None>	343,5	343,5	165,00	128,81	195,98	177,26	5,1	1,3
Pressure Zone - 7	<None>	244,7	244,7	135,13	103,27	148,37	146,31	4,4	1,3
Pressure Zone - 8	<None>	- 2.811,5	256,0	131,96	106,50	161,92	106,99	5,4	0,0
Pressure Zone - 9	<None>	282,7	282,7	190,00	118,76	204,48	148,08	5,6	1,3
Pressure Zone - 10	<None>	127,1	127,1	103,79	97,92	132,97	132,45	3,4	2,8
Pressure Zone - 11	<None>	272,4	272,4	199,07	114,22	244,46	152,72	10,2	2,1

Conclusion



Recommendations

FOR CONSULTANTS and ENGINEERS

- Soft measures meaning data collection, GIS and hydraulic model should contain every pipe, every valve, every object → **there are no less important pipes or objects**
- For generating calibrated hydraulic model, DMA design and detail measurement campaign should be conducted
- **Active communication with Water company employees is critical for system functionality recognition**

FOR WATER COMPANIES and INVESTORS

- Check every step of project → **if necessary, out-source technical supervision**
- Ask for results and explanation of every illogicality or anomaly → **that is why calibrated hydraulic model is used for**
- Soft measures are your permanent ownership → **do not allow questions or unfinished work to remain**
- Educate yourself, build your team and use everything every day → **you paid for it!**

Conclusion

STARTING POINT

- Increasing of water distribution system management starts with soft activities
- Good project preparation results in investment and operating cost decrease
- Implementing GIS and hydraulic model enables better decision making for water loss management, pressure management, water balancing, energy consumption optimization, water billing, network extension, ...
- **Active system management with precise prediction of consequences**

COSTS

- Soft measures value is around 10% of total price of a water loss programme
- Soft measures for 1.500 km of pipe network cost less than 5 km pipe reconstruction

Thank you for your attention and may the water force be with you!

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