HYDRAULIC MODELING

PROGRESS REPORT

BUDAPEST WATERWORKS

NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION OFFICE
HUNGARY

PROJECT FINANCED FROM THE NRDI FUND
MOMENTUM OF INNOVATION

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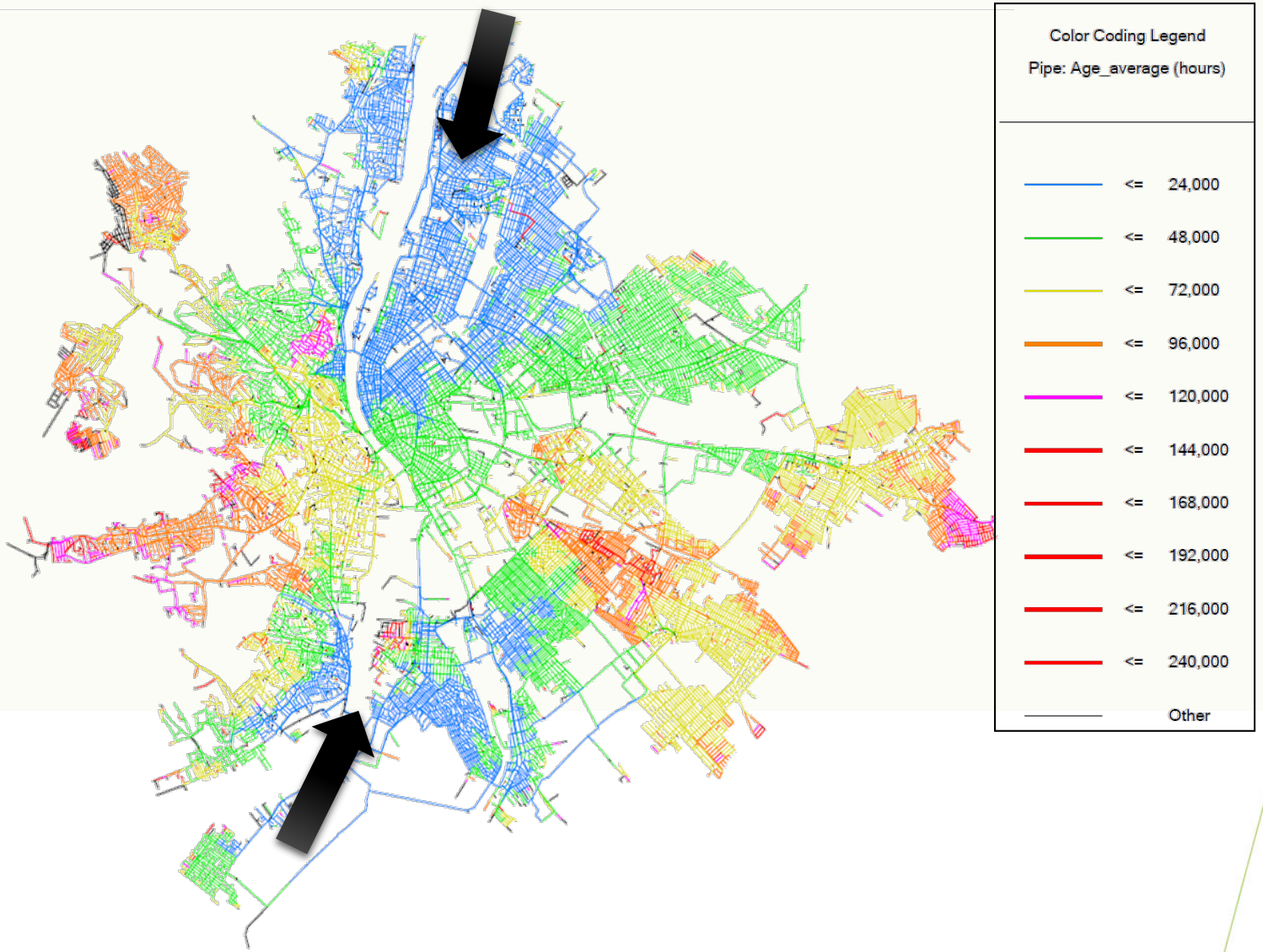
Previous results – Residence times



- Water demand: Average
- Simulation Duration: 10 days
- Control based simulation
- Time since last chlorination is more relevant!

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Measurement campaign support

- Sampling at hydrants
- On-site free chlorine measurements
- Considering temporal and spatial distribution of water age
- Objective:
  - **take samples from the same water segment in different times**
- Unknown variables:
  - When should we take the samples?
  - Which hydrants should we choose?

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Measurement campaign support

- Unknown variables:
  - When should we take the samples?
  - Which hydrants should we choose?
- Sampling area:
  - Pesthidegkut (Zone 10)
  - Accessible hydrants
  - Control-based operation

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Measurement campaign support

- Unknown variables:
  - ~~When should we take the samples?~~ **Fixed sampling times**
  - Which hydrants should we choose? **Water age simulation**
- Sampling area:
  - Pesthidegkut (Zone 10)
  - Accessible hydrants
  - Control-based operation

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Measurement campaign support

- Assumed water ages were used
  - Model based on 2017.06.22
  - High water demand (summer scenario)
- Selection of hydrant and sampling schedule were determined days before the campaign
- Retrospective simulations will have been used to adjust residence time values

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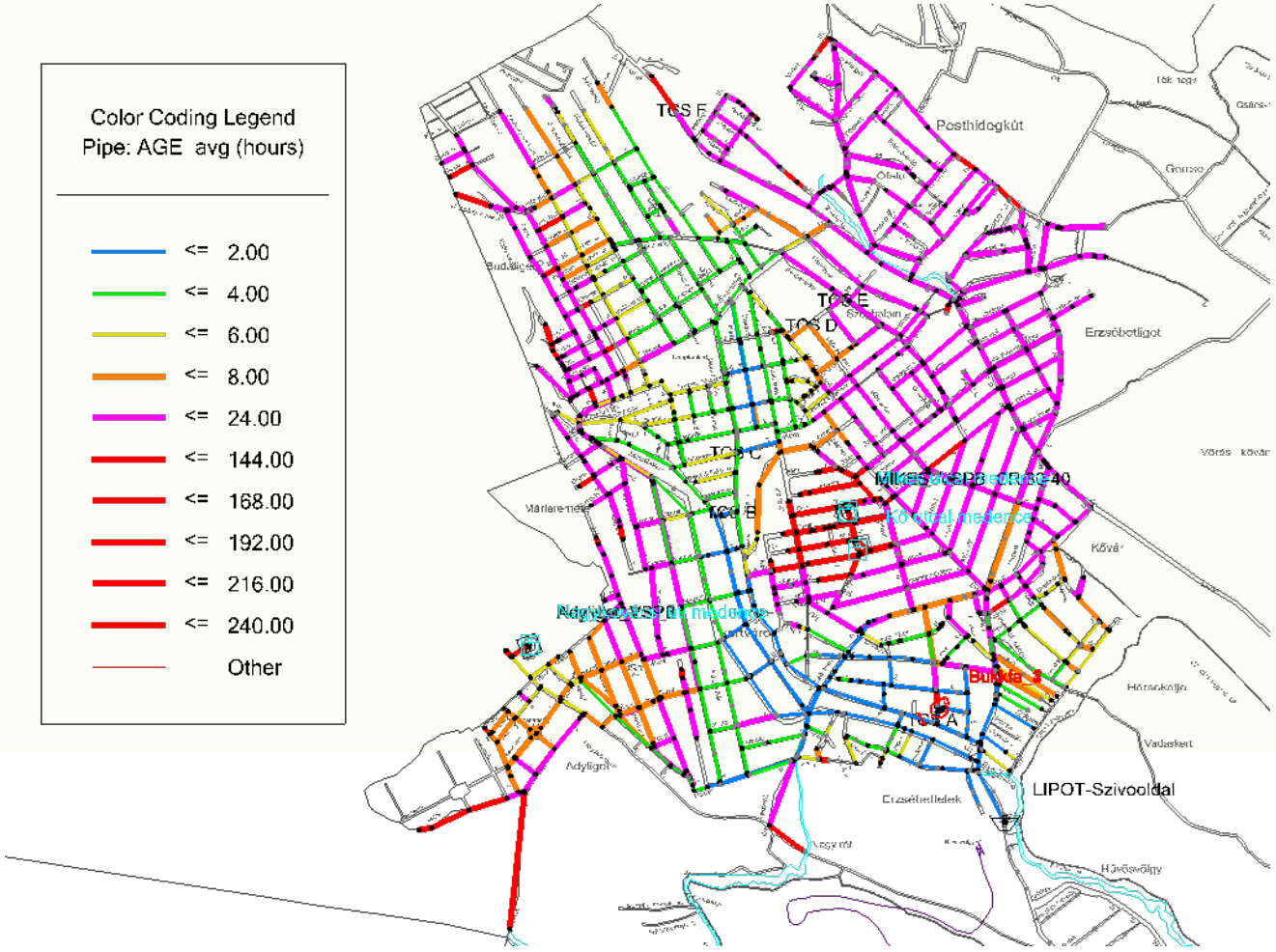
Measurement campaign support



- **Assumed** water ages were used:
  - Model based on 2017.06.22
  - High water demand (summer scenario)
- t_0+0,2,4,6,8,24 hrs
- ±1 hr uncertainty

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Measurement campaign support

- Choosen hydrants for sampling:

MSLINK	ID	Δt[hrs]
791010347	A	0
791002423	B	+2
792009031	C	+4
790001920	D	+6
790001825	E	+8
790001820	F	+24

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Measurement campaign support

- The volume of the hydrant connection is not neglectible!
- Flushing volume should be determined to sample the water segment in the main pipe

MSLINK	ID	D[m]	L[m]	V[m3]	V_{tcs}[m3]	V_{tot}[liter]
791010347	A	0.08	2.3	0.011561	0.010	**21.6**
791002423	B	0.08	0.5	0.002513	0.010	**12.5**
792009031	C	0.08	1.15	0.005781	0.010	**15.8**
790001920	D	0.08	1.3	0.006535	0.010	**16.9**
790001825	E	0.08	1.016	0.005107	0.010	**15.2**
790001820	F	0.08	2.82	0.014175	0.010	**24.3**

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Measurement campaign support

- **Calculated** water ages:
  - Model based on 2019.07.03
  - High water demand (matching summer scenario)
- Model is based on SCADA data:
  - Flow rates
  - Pressures
  - Pump schedule
  - Pump speed

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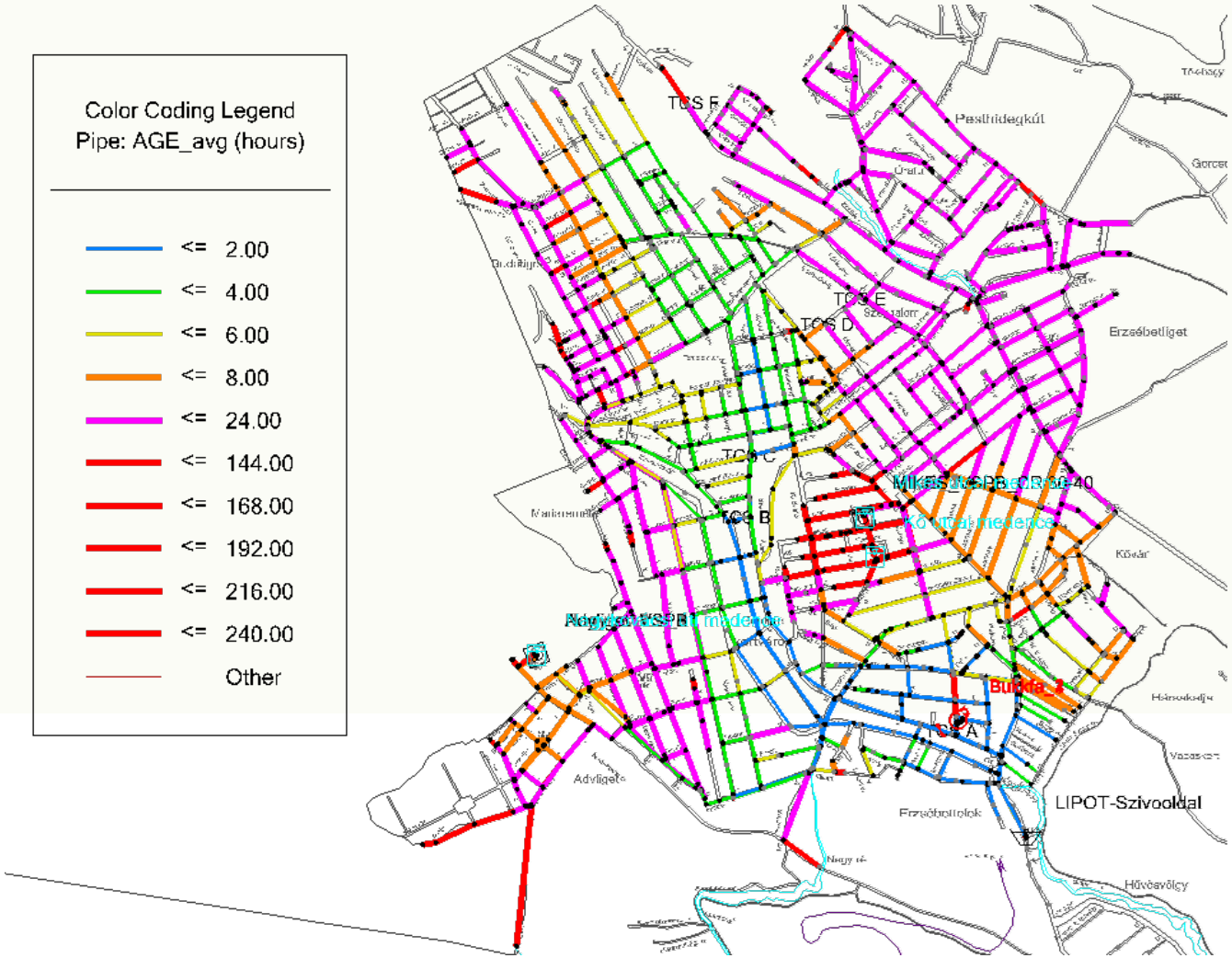
Measurement campaign support



- **Calculated** water ages:
  - Model based on 2019.07.03 (actual samping day)
  - High water demand (matching summer scenario)
- t_0+0,2,4,6,8,24 hrs
- ±1 hr uncertainty

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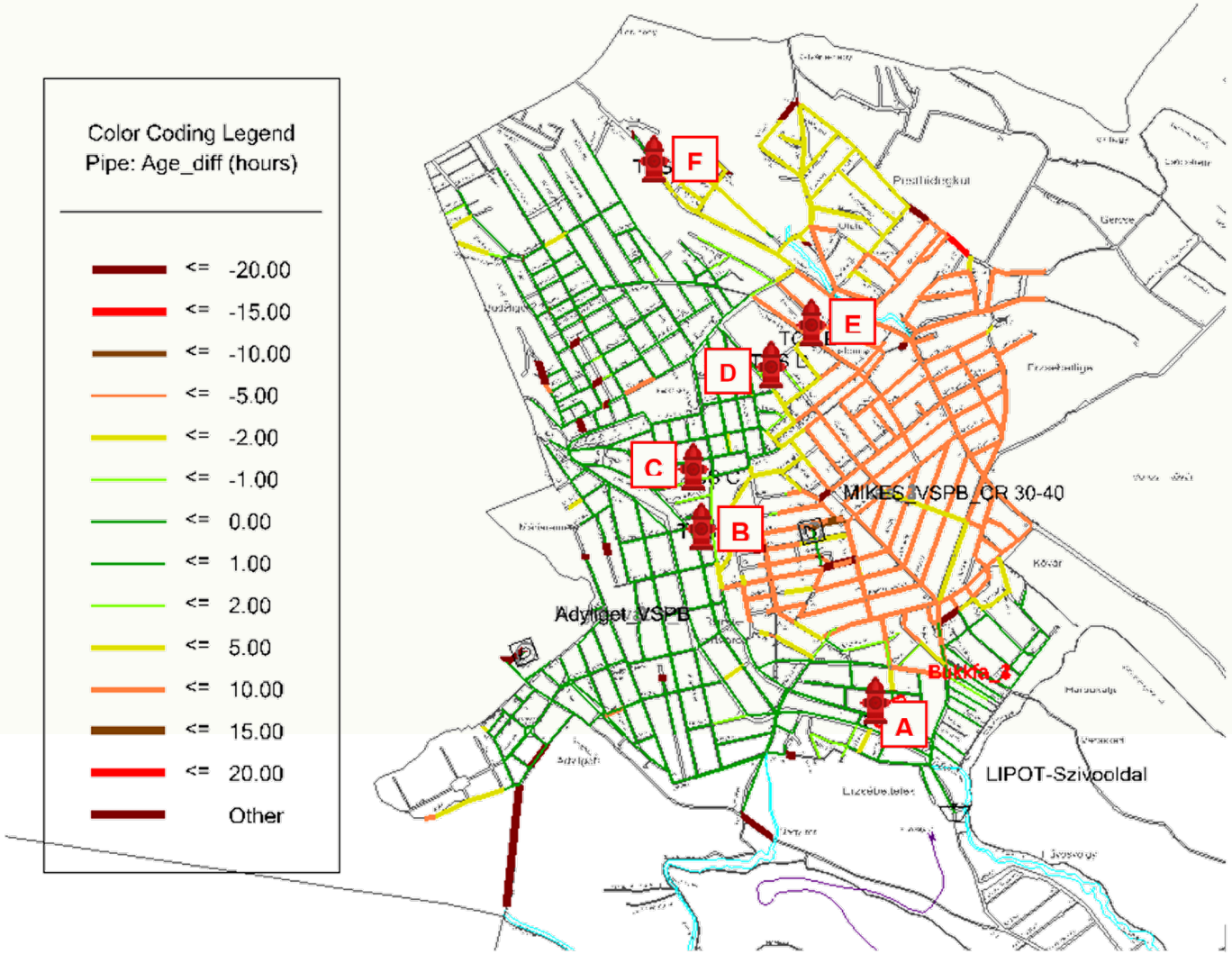
Water age assumption accuracy



- Error in water age
  - Assumed (2017.06.22)
  - Actual (2019.07.03)
- They are in the <1.0 hr region

  Except ‚E’

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Sedimentation simulations

- A sediment transport module was developed based on jar tests
- The ODE's were implemented in EPANET MSX
- Simulation environment: Bentley's WaterGEMS
  - Ease of debugging
  - Visualization
  - Scenario comparison
  - Results export and processing

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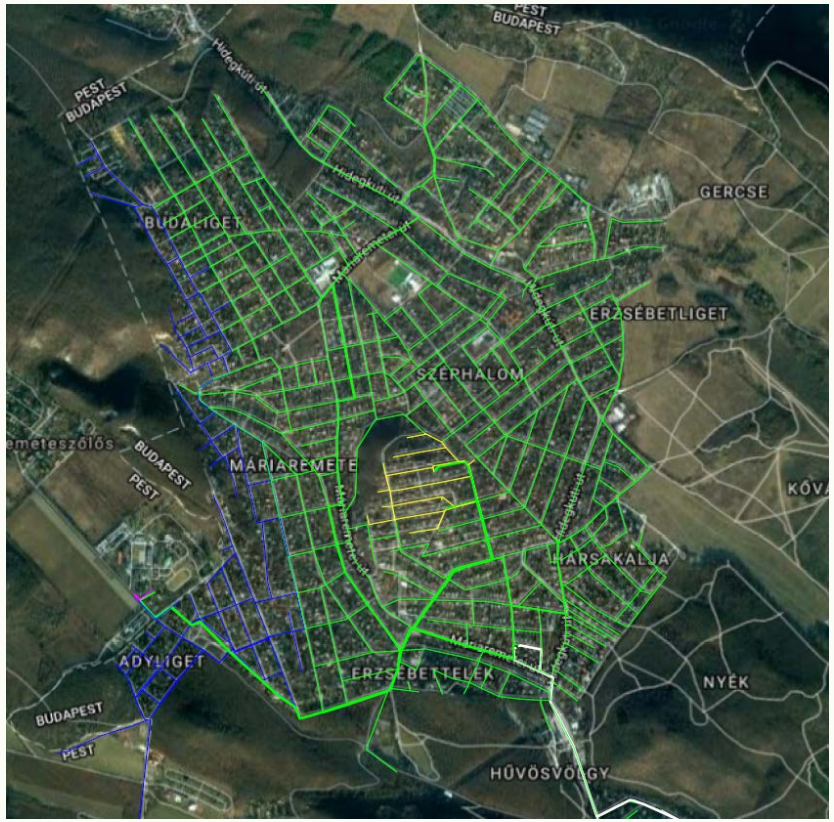
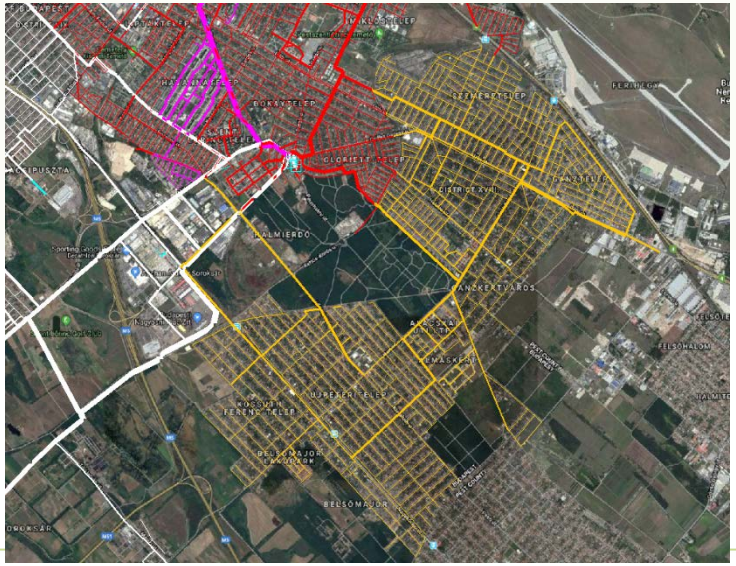
Sedimentation simulations

- Two models were set up for simulation:
  - 23/1 – Pestszentlőrinc
  - 10 – Pesthidegkút
- Winter scenarios
  - Lower demand → Higher water age





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Sediment transport simulations

- 23/1 Pestszentlőrinc:
- Deposited particles [mg/m^2]
- Highly sensitive to demand weights

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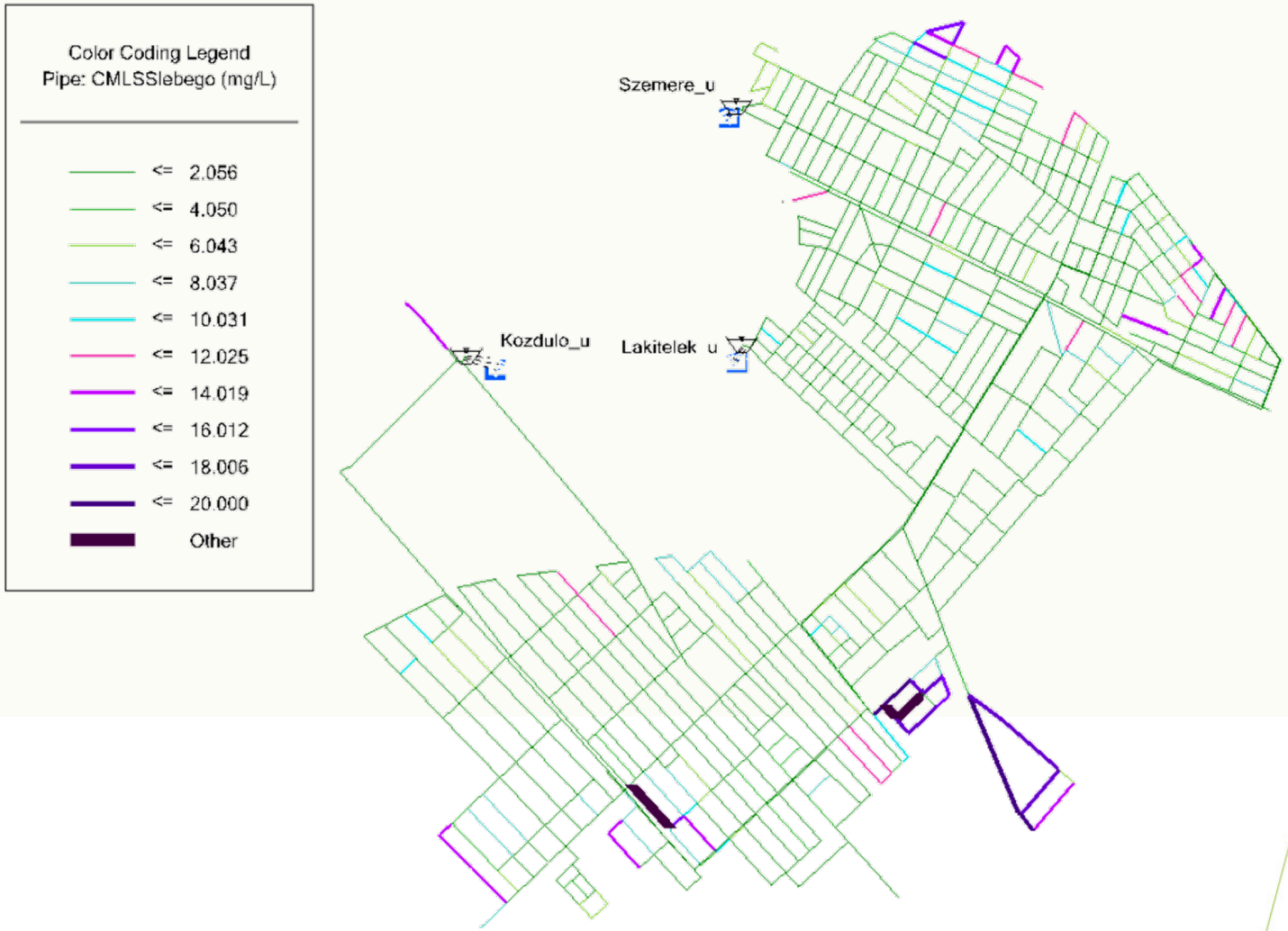
Sediment transport simulations



- 23/1 Pestszentlőrinc:
- Resuspended particles [mg/m^2]
- Problems occur in pipes where no or minor resuspension occurs

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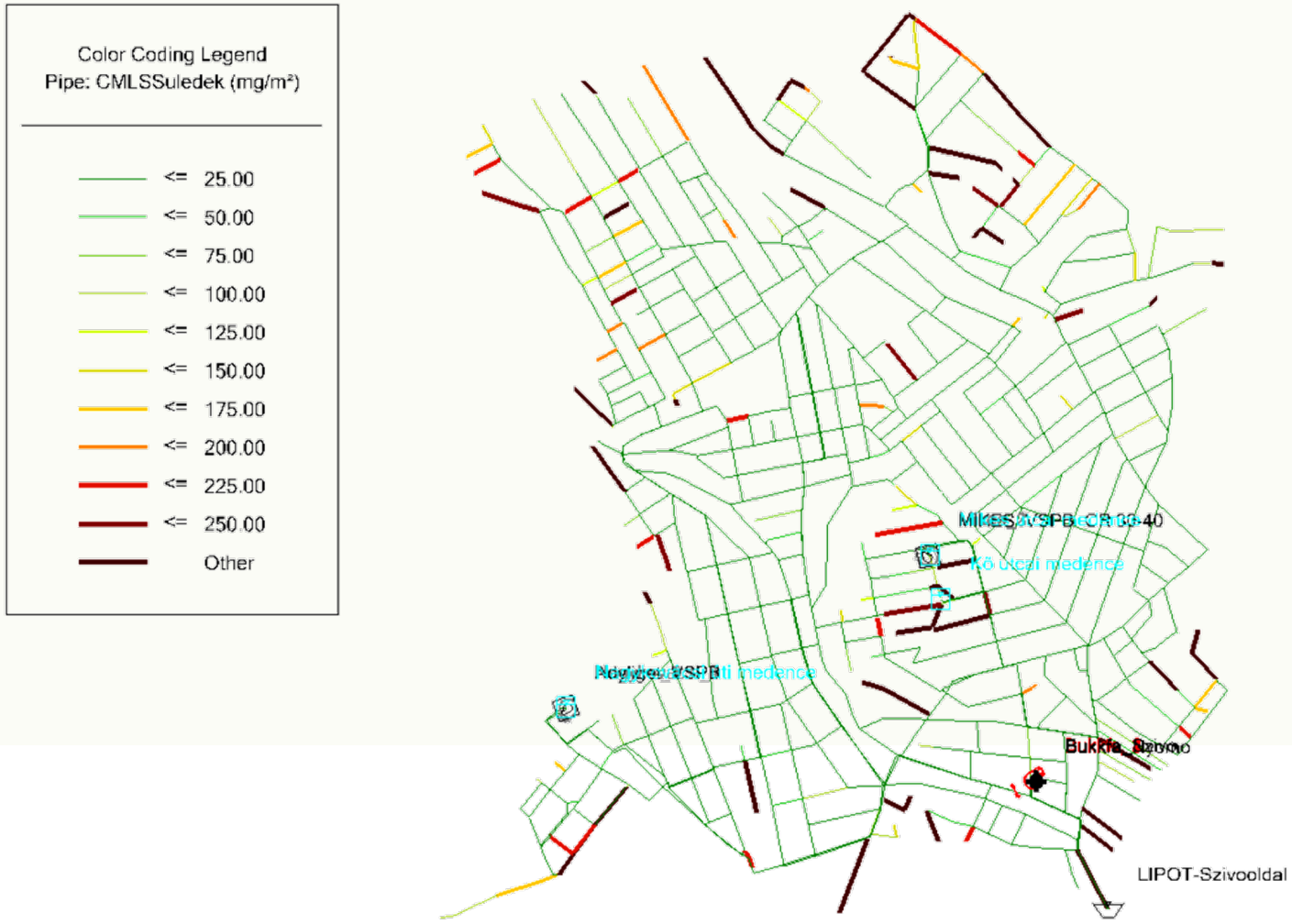
Sediment transport simulations



- 10 - Pesthidegkut:
- Deposited particles [mg/m^2]
- Highly sensitive to demand weights

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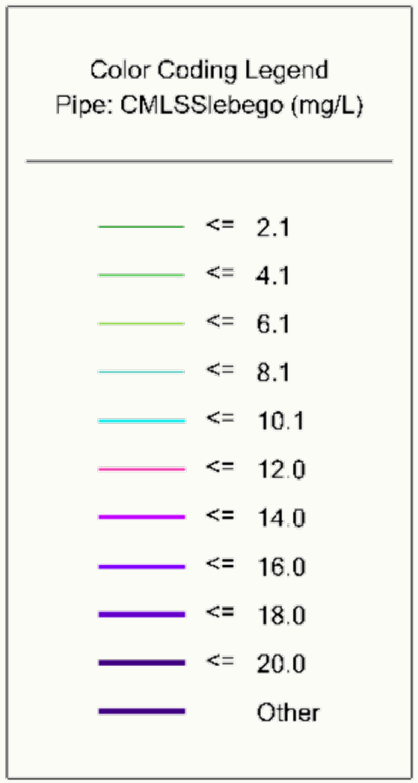
Sediment transport simulations



- 10 Pesthidegkút:
- Resuspended particles [mg/m^2]
- Problems occur in pipes where no or minor resuspension occurs

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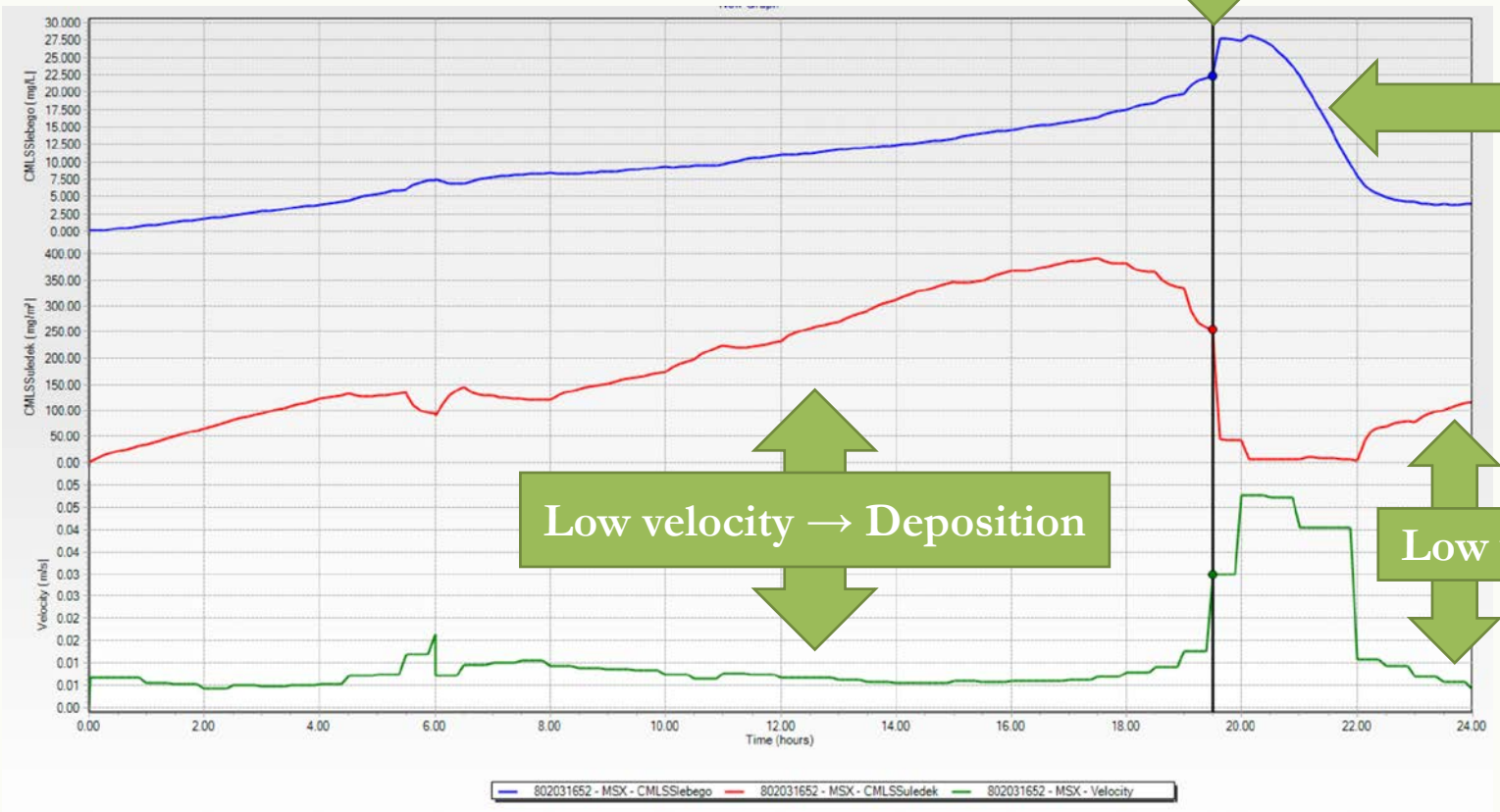
Sediment transport simulations



Resuspension

Resuspended particles leave the pipe segment

Low velocity → Deposition

Low velocity → Deposition

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Sedimentation simulations - Results

- The results are promising
- The evaluation of distribution networks can be done based on the results
- Computationally intense
- It concentrates more on the network than the tanks
- Fine-tuning of the parameters is still ongoing
- It is senstitive to near-zero flow dead-ends and extremely short pipes

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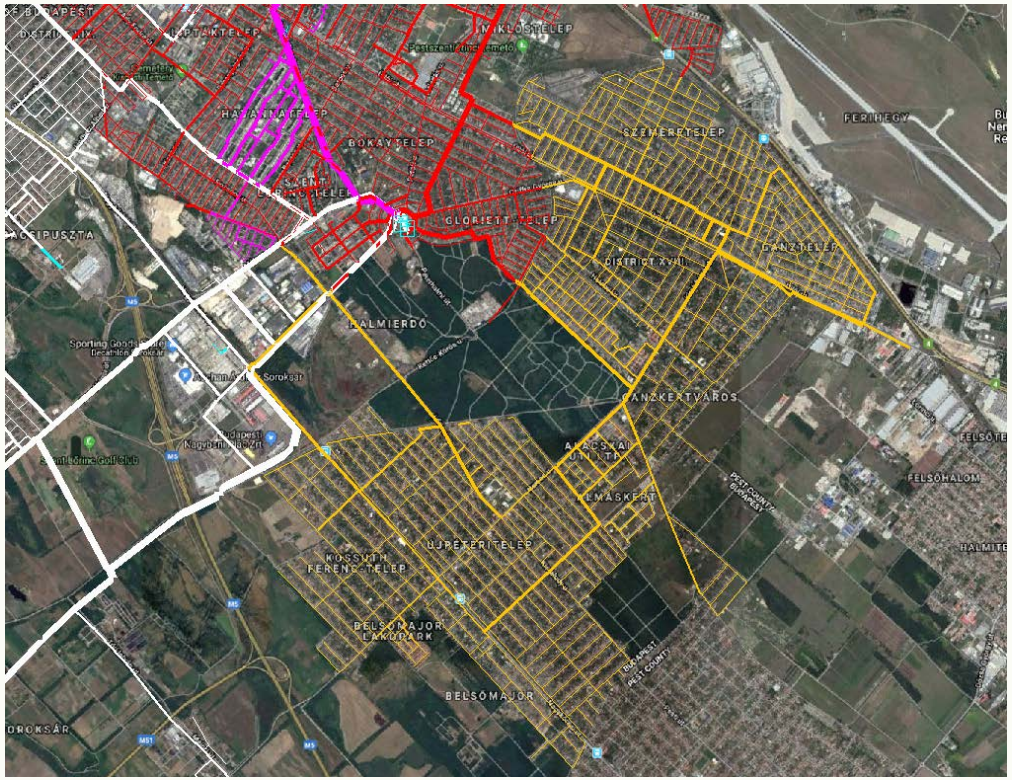
Free chlorine decay simulations

Under development:

- 23/1 – Pestszentlőrinc zone
  - No tanks → ease of prototyping

Included constituents:

- Sedimented particles
- Iron
- Ammonium



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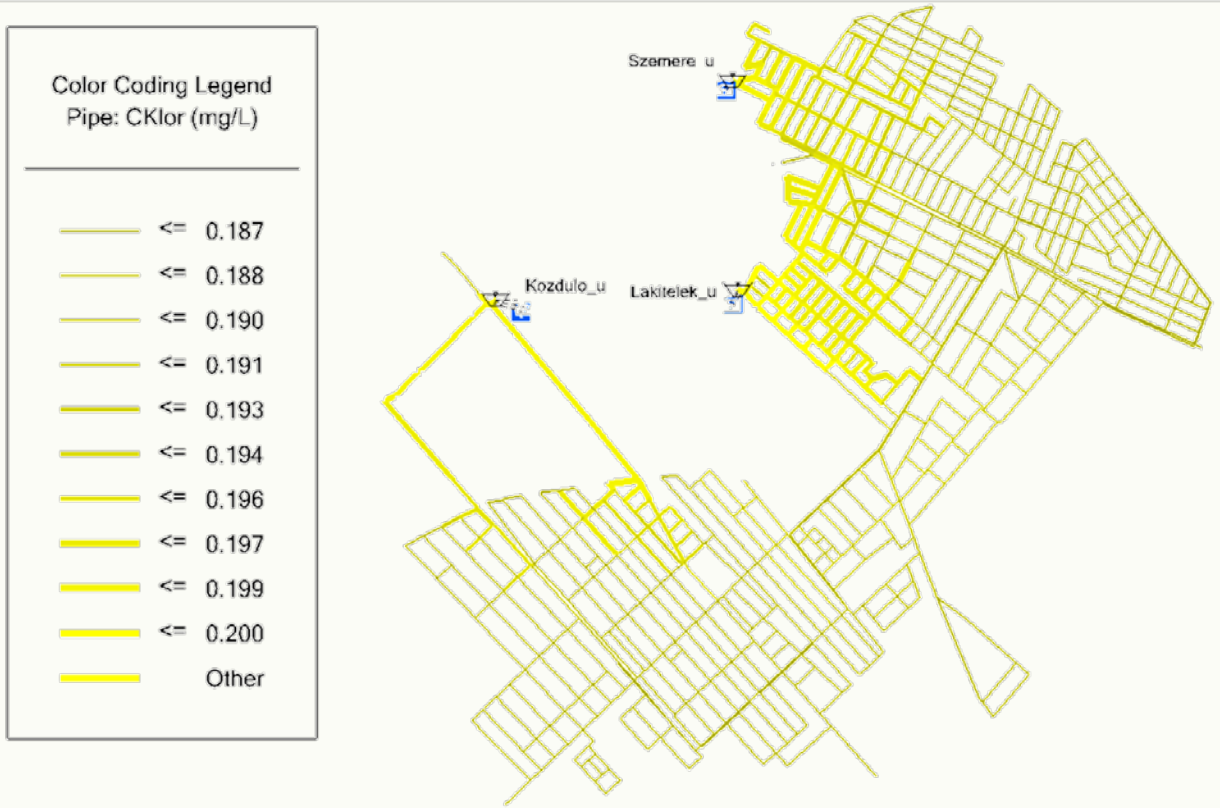
Chlorine decay simulations



Sample run:

- 23/1 – Pestszentlőrinc zone
  - No tanks → ease of prototyping
- Requires fine-tuning to increase stability

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Budapest Waterworks

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