Water Loss Management Research

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Water Loss in Canada

- 10 to 30% in Large cities
- Canadian Infrastructure Report Card, 25% water assets fair condition

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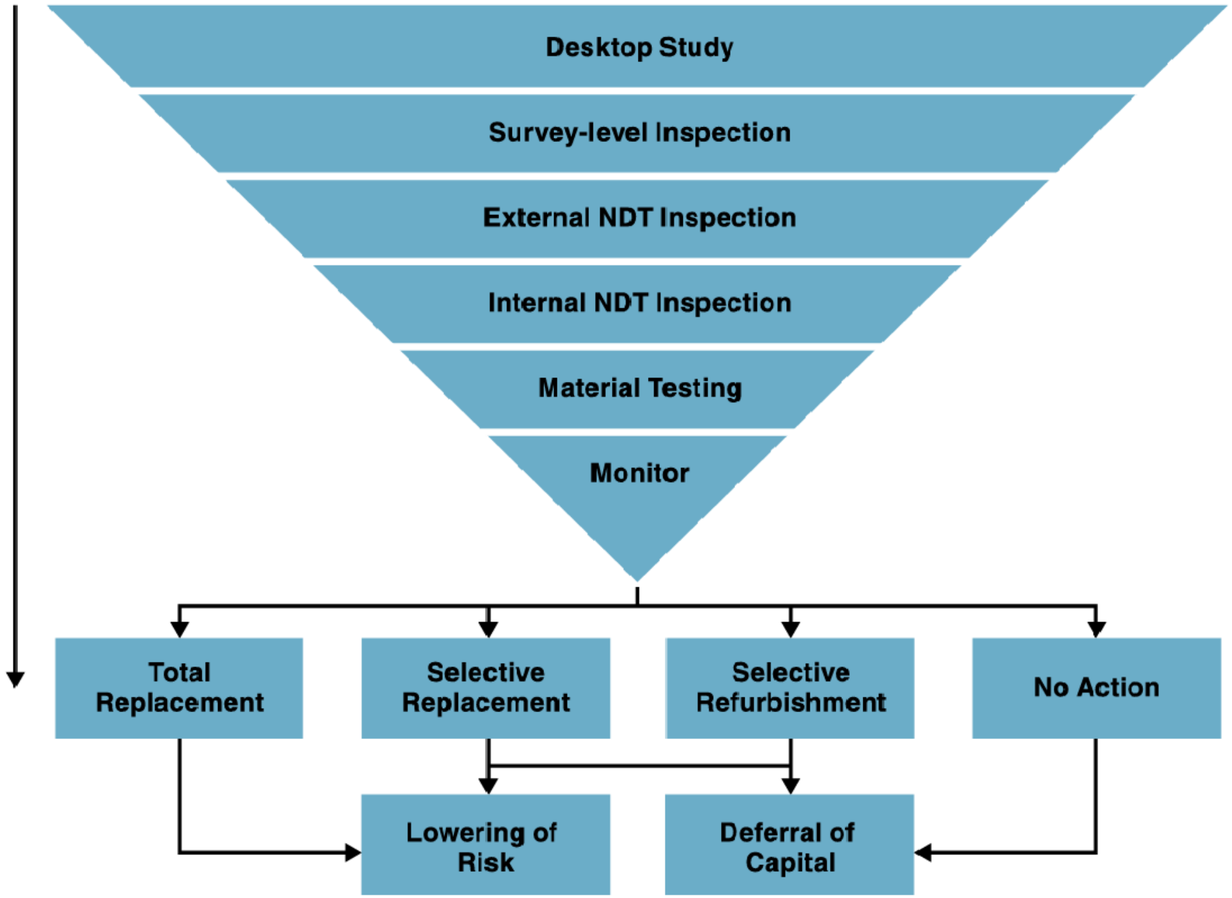
Prioritization

AWWA Manual M77

- Risk Analysis
- Leak Detection
- Acoustic Testing
- Spot Inspection
- EM Testing
- Material Testing
  - Pipe Coupon
  - Soil
  - Groundwater
- Monitoring

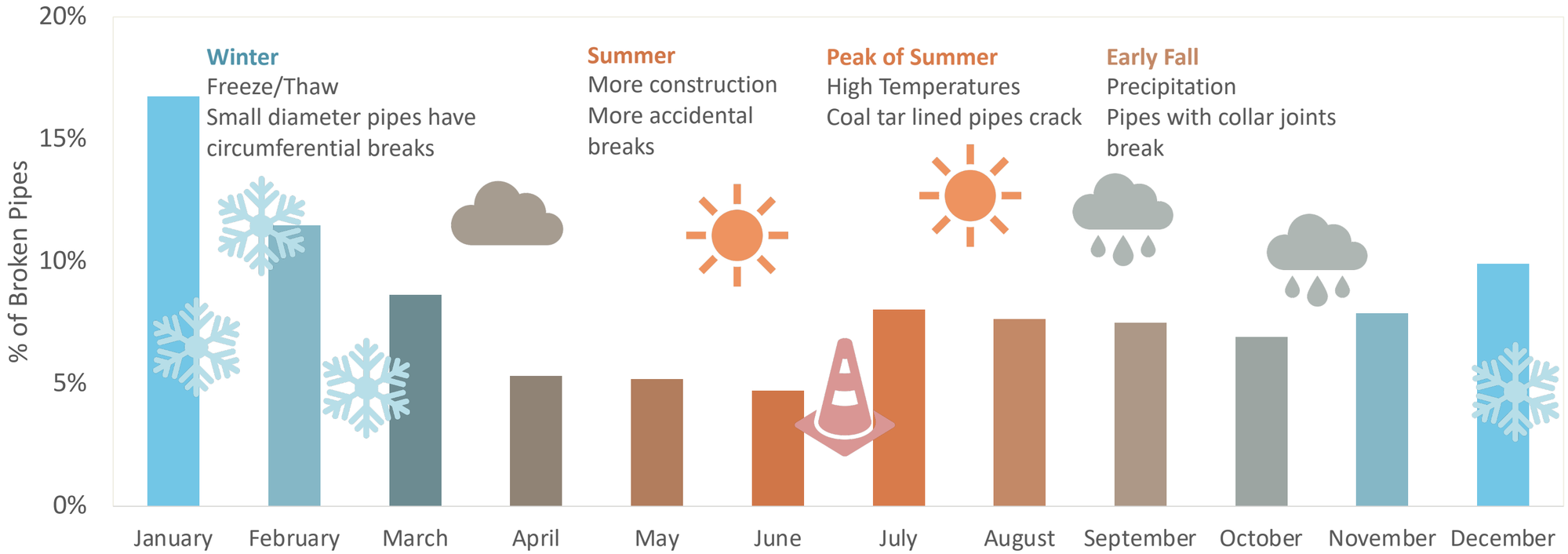


Adapted with permission from Laven (2014)
EM: electromagnetic, NDT: non-destructive technique

Figure 2-2 Progressive condition assessment and resulting actions

Factors Leading to Failure

Study of 13 Canadian Cities



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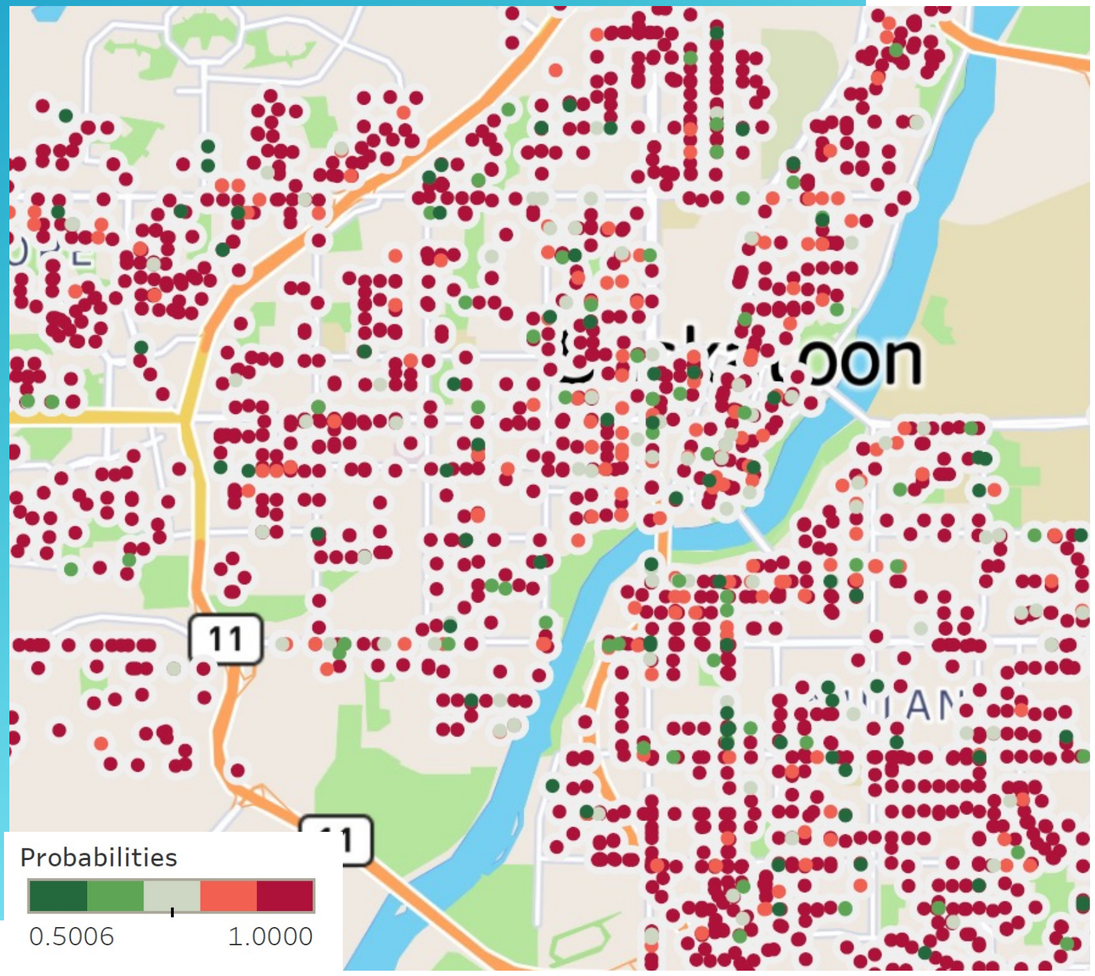

Probability of Failure Map for Case Study City

Probability of Failure

- Machine Learning
  - XGBoost and LightGBM
- Time-based model testing important for reliable results

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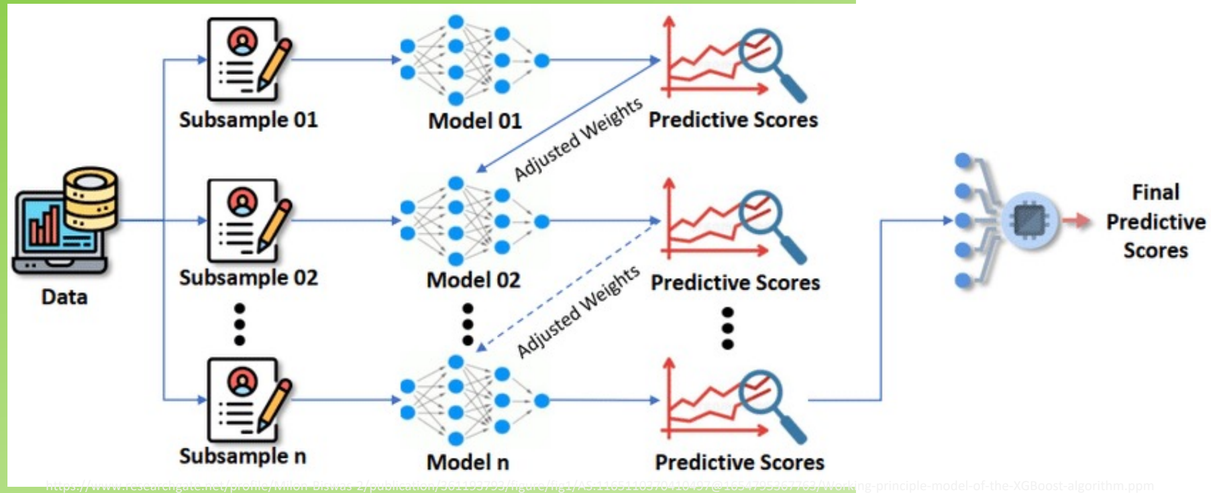
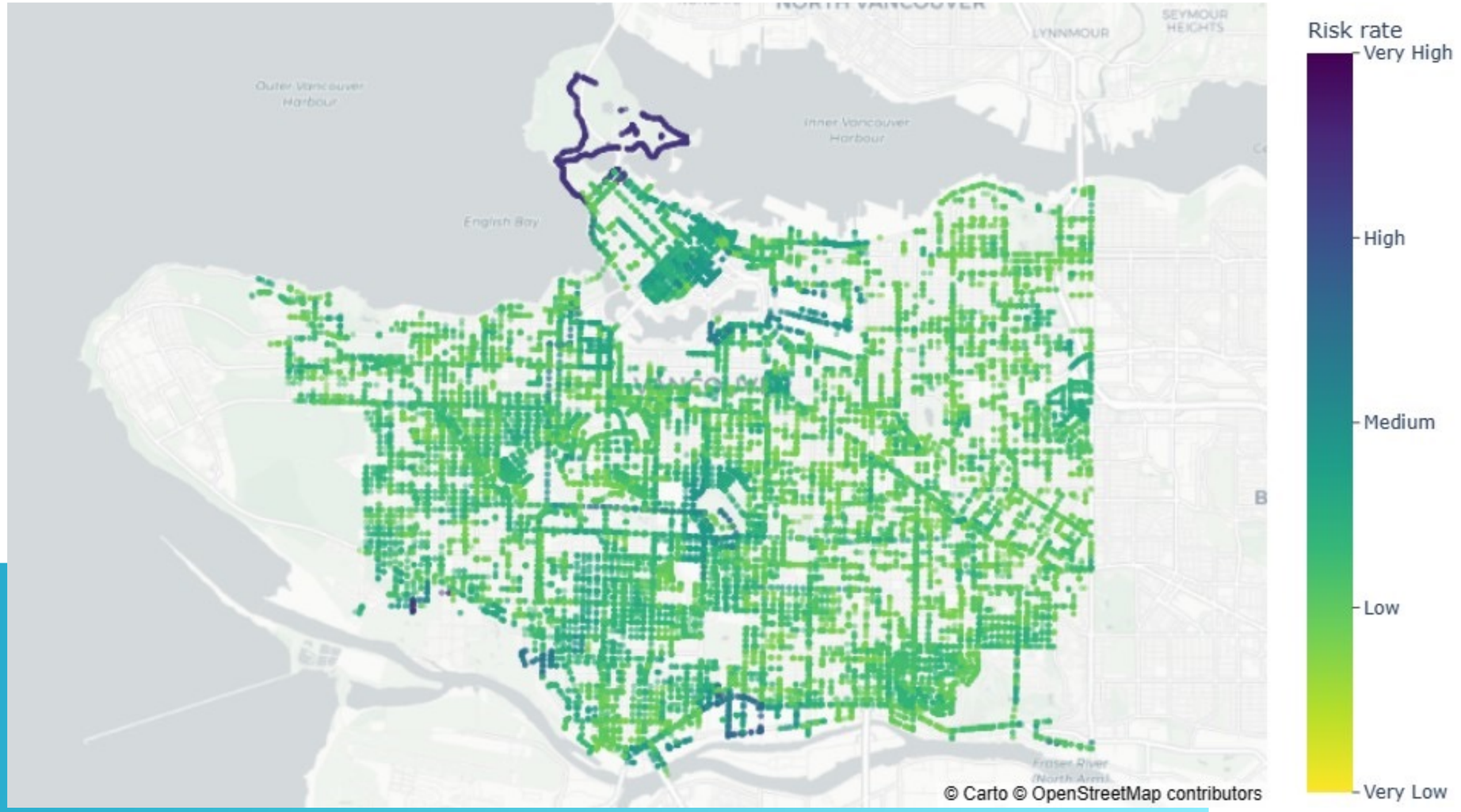
XGBoost



- Extreme Gradient Boosted Trees
- Ensemble decision tree
- Boost = Sequence of trees
- Extreme = Efficient
  - parallel construction of single trees by evaluating optimal splits
  - Penalize complex trees
  - Early stopping

Risk of Failure

- Social Vulnerability



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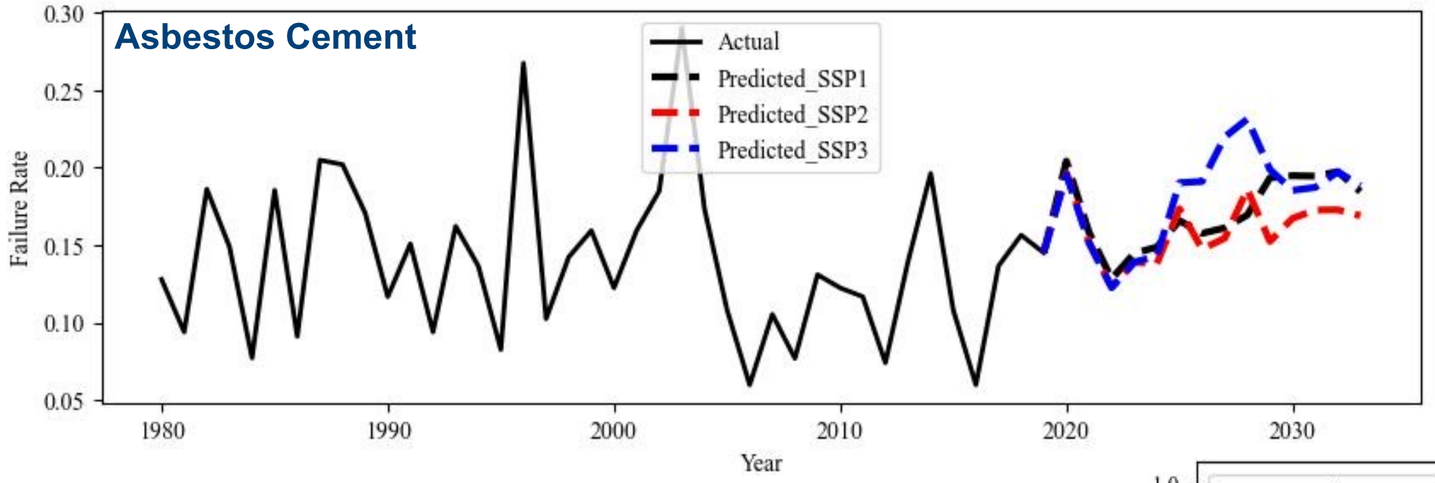
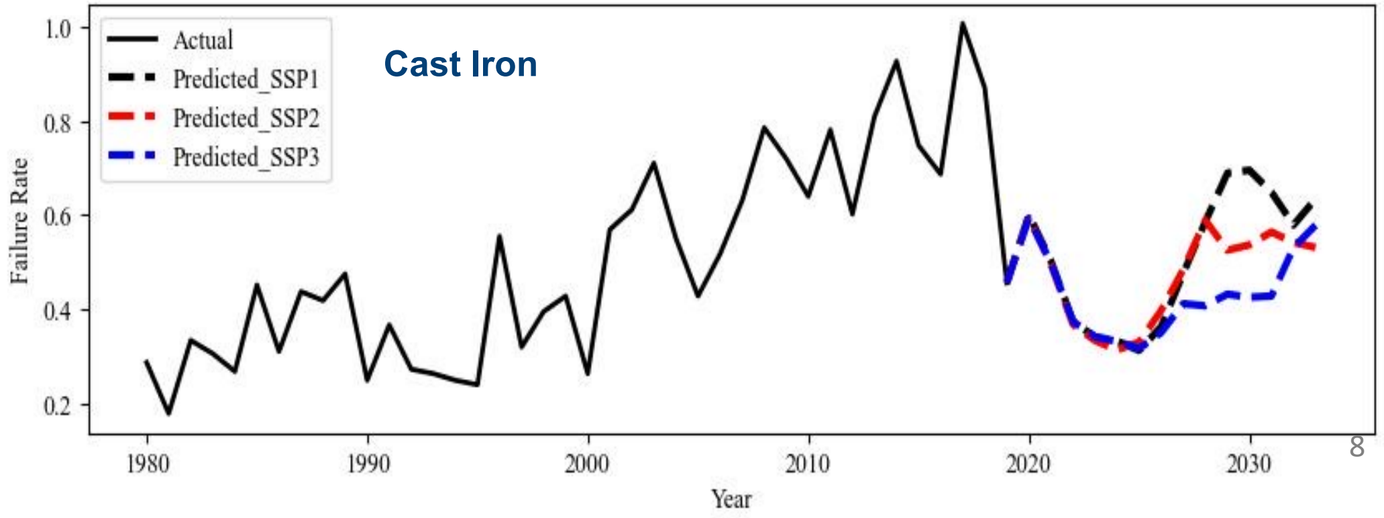
Impact of Climate Change



- LSTM Model
- Asbestos cement sensitive to warmer temperatures
- Cast iron more sensitive to cooler temperatures



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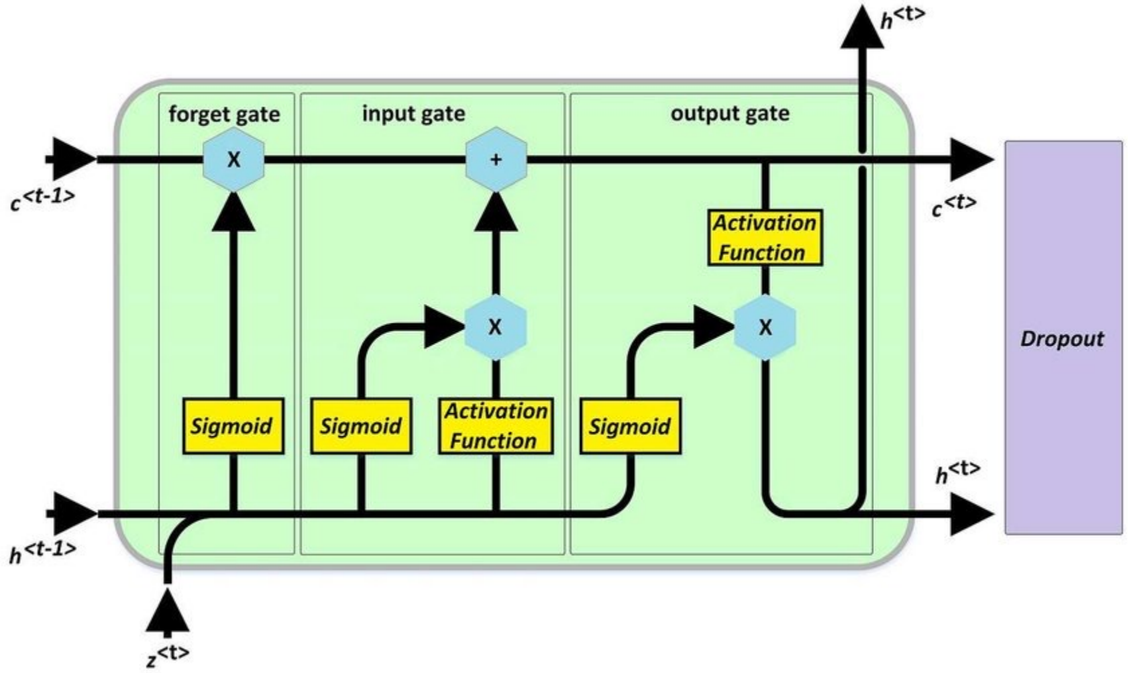
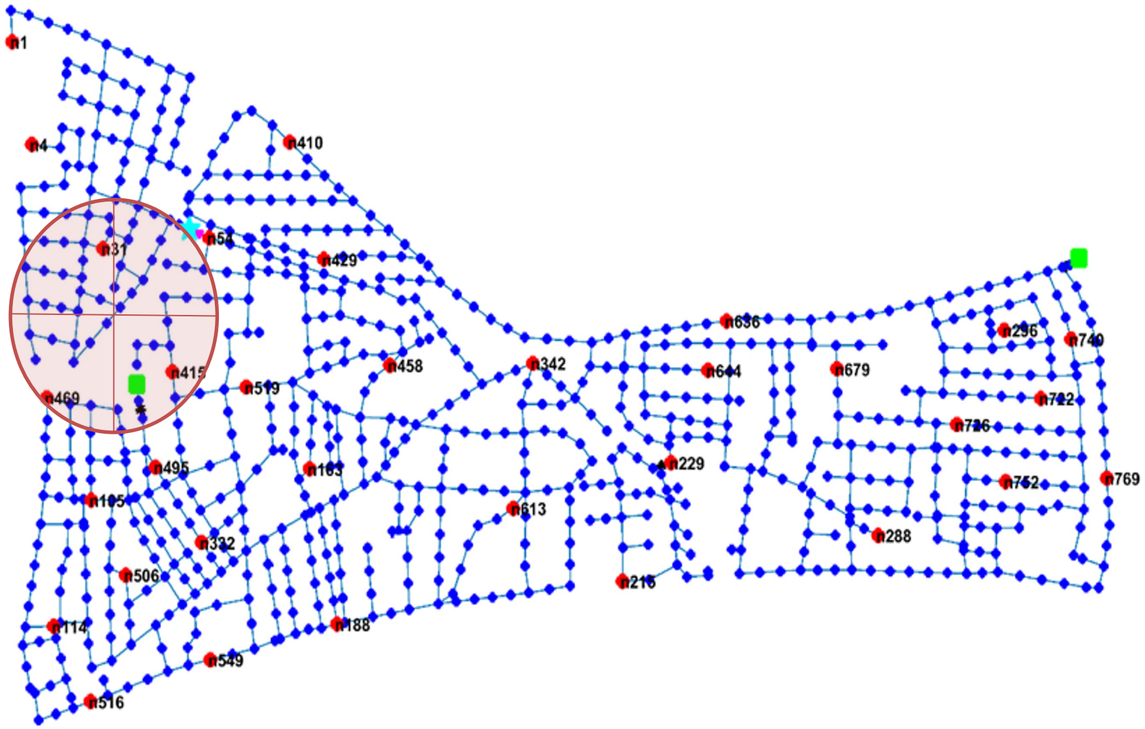


https://www.researchgate.net/publication/347446475/figure/fig2/AS:970041050804224@1608287217671/The-LSTM-Dropout-architecture.jpg

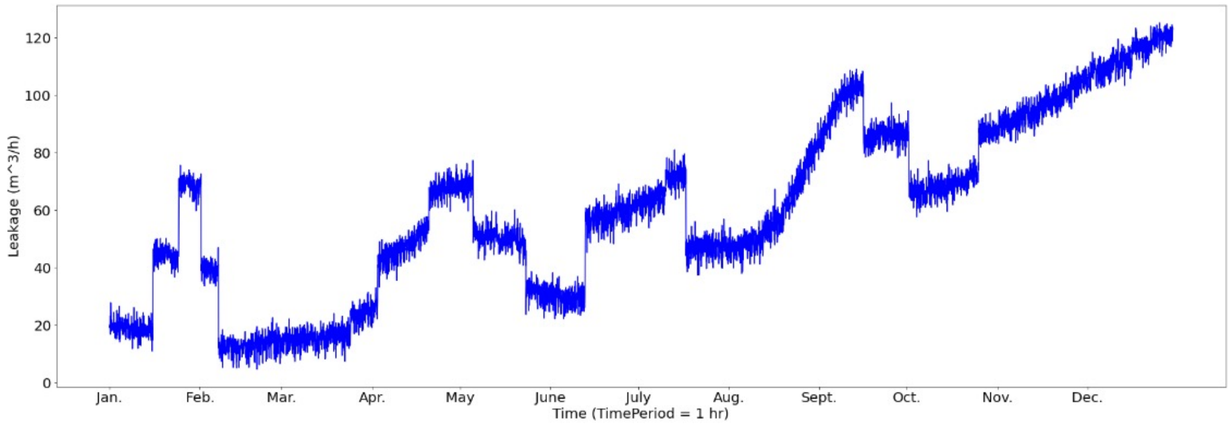
LSTM

- Long Short-Term Memory
- Type of Recurrent Neural Network
  - Sequential processing but can forget long-term dependencies
- Long = long window of historical data
- Short = Short time steps

Leak Detection



- CUMSUM + genetic algorithms to reduce search area
- Leak events identified 70%



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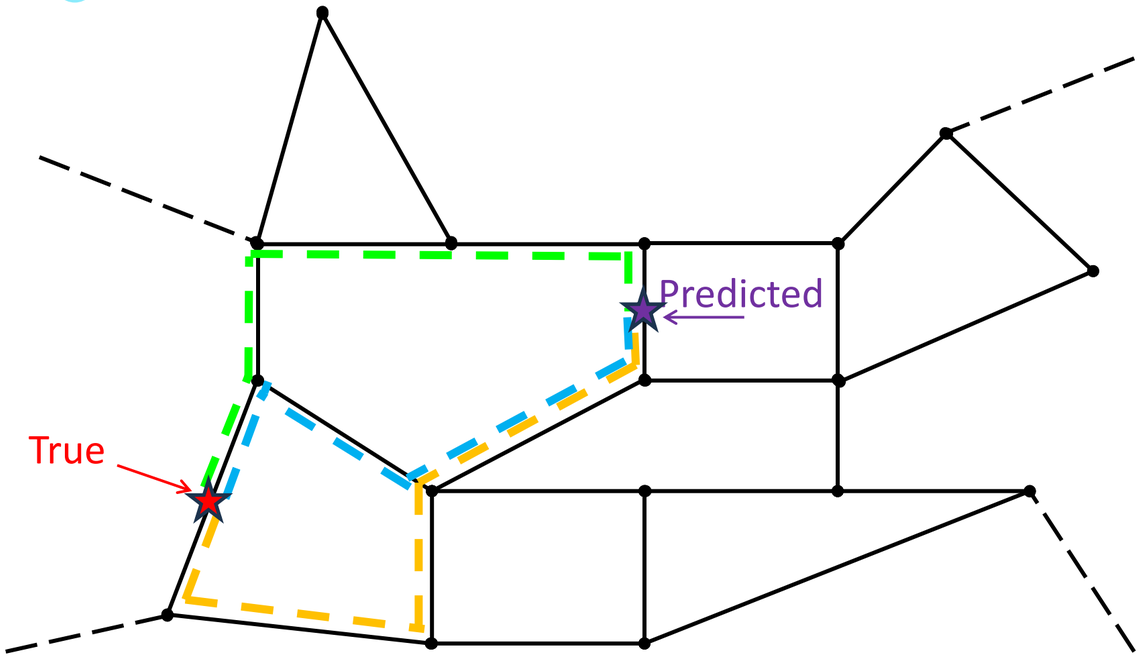
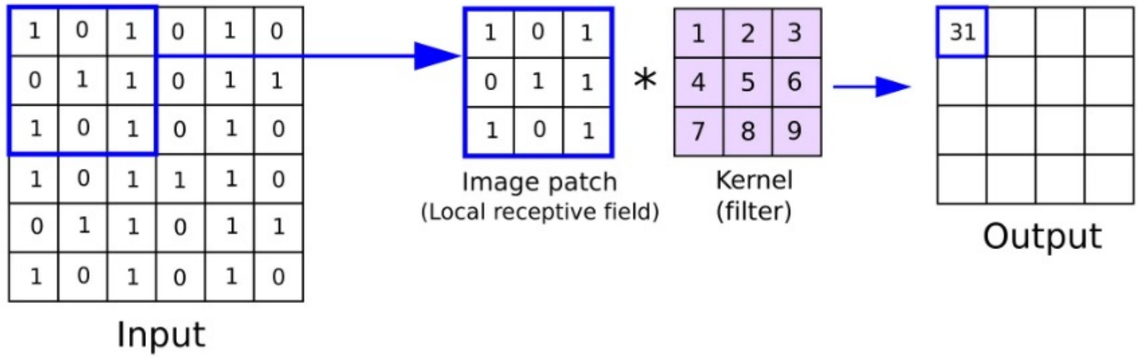
Leak Localization



- Scenarios developed with hydraulic model
- Convolutional Neural Network and Long Short Term Memory
- Distance based hybrid loss function

CNN



https://www.superannotate.com/blog/guide-to-convolutional-neural-networks

- Convolutional Neural Network
- Processes grids
- Convolution layer creates a filter, i.e. a matrix of weights to identify features
- Pattern recognition

Smart & Sustainable Management

- Lifecycle view of operations
- Impact of operations decisions on maintenance needs
- Greenhouse gas emissions of underground construction and rehabilitation

https://www.google.com/url?sa=i&url=https%3A%2F%2Fnewsroom.calgary.ca%2Fupdate-9-critical-water-main-break-affecting-city-wide-water-usage%2F&psig=AOvVaw0kY8womDI8ufSX63mWZX_&ust=1729017521506000&source=images&cd=vfe&opi=89978449&ved=0CBgQ3YkBahcKEwjgmoKswoGIAxUAAAAAHQAAAAAQBA

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