# WDSA CCWI 2024

**3rd International Joint Conference on Water Distribution Systems Analysis & Computing and Control for the Water Industry**

**University of Ferrara**
**Science & Technology Campus**
**1 - 4 July 2024 | Ferrara, Italy**

**Editors**

Marco Franchini, Stefano Alvisi, Filippo Mazzoni and Valentina Marsili

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# 3rd International Joint Conference on Water Distribution Systems Analysis & Computing and Control for the Water Industry

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University of Ferrara, Science & Technology Campus
Ferrara, Italy
1-4 July, 2024

## Sponsors

## Partners

*Dear friends and colleagues,*

*Welcome to the 3rd International Conference on Water Distribution System Analysis (WDSA) and Computing and Control for the Water Industry (CCWI).*

*This conference aims to exchange research, developments and experiences related to the world of hydraulic infrastructures and the urban cycle. In light of this, the main topics of the conference are focused on smart urban water systems, water distribution network planning and management, irrigation networks and urban water systems in emergency, IoT in urban water systems, advances in drainage and sewer and treatment of water and wastewater.*

*The call for Abstracts has attracted more than 300 proposals which were analysed and evaluated by the Scientific Committee. In the end, about 250 contributions will be presented with authors coming from more than 40 different countries. For the presentation of the contributions, 15 areas have been defined, consistently with the topics previously indicated: design, analysis and modeling of water distribution systems; water distribution network planning and management; water demand modeling and forecasting; leak and burst management; intermittent systems; transient flow; urban water systems in emergency; irrigation systems; water quality; water supply and treatment; drainage and sewer systems; sustainable urban water systems; education in water sectors; Battle of Water Demand Forecasting (BWDF) and Industry Track.*

*A specific session will be dedicated to the results of the Battle of the Water Demand Forecasting, with the indication of the best performing teams. In this session, the problem will be presented, and methodologies proposed will be briefly described highlighting the successful level of each approach.*

*Worthy of note is also the session dedicated to the Industry Track, for which about 30 papers have been submitted. These works, developed by practitioners and technicians from the Water Industry often in collaboration with Academia, are related to topics such as the optimal control and rehabilitation of water distribution systems, the process of digitalization of water supply systems in the context of smart cities and the application of technologies for pressure management and leakage reduction.*

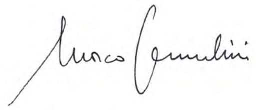
*This booklet includes the most important information related to the programme of activities.*

*We would like to thank all who have made this event possible. Thanks to the WDSA-CCWI association for selecting us for the organization of this event and to the University of Ferrara that has offered its locations both for hosting the conference and holding the social events. Thanks to all partners and sponsors for their essential invaluable support in the organization. Lastly, we would like to thank the members of the Scientific Committee for their precious work in reviewing the paper submitted, and the members of the Local Organizing Committee, and all the students and collaborators for their invaluable contribution.*

*We wish you a fruitful and informative conference.*

Conference co-chairs

*Marco Franchini*



*Stefano Alvisi*

# Committees

## *Local-organizing committees*

- Marco Franchini (Chair) – marco.franchini@unife.it
- Stefano Alvisi (Co-chair) – stefano.alvisi@unife.it
- Alessandro Valiani
- Valerio Caleffi
- Leonardo Schippa
- Valentina Marsili
- Filippo Mazzoni
- Samuele Alassio
- Alice Zaghini

## *Scientific Committees*

- Luigi Berardi — Università degli Studi “G. d’Annunzio”, Italy
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- Dominic Boccelli — University of Arizona, USA
- Joby Boxall — University of Sheffield, UK
- Bruno Brunone — Università degli Studi di Perugia, Italy
- Steven Buchberger — University of Cincinnati, USA
- David Butler — University of Exeter, UK
- Andrea Cominola — Technische Universität Berlin, Germany
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- Enrico Creaco — Università degli Studi di Pavia, Italy
- Maria da Conceição Cunha — Universidade de Coimbra, Portugal
- Graeme Dandy — University of Adelaide, Australia
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- Huan-Feng Duan — Hong Kong Polytechnic University, China
- Demetrios Eliades — University of Cyprus, Cyprus
- Raziyeh Farmani — University of Exeter, UK
- Yves Filion — Queen’s University, Canada
- Gabriele Freni — Università degli Studi di Enna “Kore”, Italy
- Orazio Giustolisi — Politecnico di Bari, Italy
- Walter Grayman — Walter M. Grayman Consulting Engineer, USA
- Mashor Housh — University of Haifa, Israel
- Pedro Iglesias — Universitat Politècnica de València, Spain
- Adesola Ilemobade — University of Witwatersrandt, SouthAfrica
- Shuming Liu — Tsinghua University, China
- Heinz Jacobs — Stellenbosch University, South Africa
- Donghwi Jung — Korea University, South Korea
- Zoran Kapelan — Technische Universiteit Delft, Netherlands
- Bryan Karney — University of Toronto, Canada
- Joong Hoon Kim — Korea University, South Korea
- Kevin Lansey — University of Arizona, USA
- Juneseok Lee — Manhattan College, USA
- Christos Makropoulos — National Technical University of Athens, Greece
- Fernando Martínez — Universitat Politècnica de València, Spain
- Daniel Mora-Meliá — University of Talca, Chile
- Bruno Melo-Brentan — Universidade Federal de Minas Gerais, Brazil
- Lindell Ormsbee — University of Kentucky, USA
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- Maurizio Righetti — Libera Università di Bolzano, Italy
- Juan Saldarriaga — Universidad de Los Andes, Colombia
- Dragan Savic — KWR-Water Research Institute, Netherlands
- Lina Sela-Perelman — University of Texas, USA
- Angus Simpson — University of Adelaide, Australia
- Robert Sitzenfrei — University of Innsbruck, Austria
- Joaquim Sousa — Instituto Politécnico de Coimbra, Portugal
- Vanessa Speight — University of Sheffield, UK
- David Steffelbauer — Kompetenzzentrum Wasser Berlin, Germany
- Rodney Stewart — Griffith University, Australia
- Ivan Stoianov — Imperial College London, UK
- Riccardo Taormina — Technische Universiteit Delft, Netherlands
- Kobus van Zyl — University of Auckland,New Zealand
- Feifei Zheng — Zhejiang University, China

## Table of contents

# 1. GENERAL INFORMATION

## Conference Venue

The conference venue will be the Science & Technology Campus located in Via Giuseppe Saragat 1, Ferrara. In particular, the main structure of the campus called Cattedrale will host the parallel sessions. Inside the Cattedrale, two floors will be dedicated to the conference.

## Secretariat Desk and Registration

A Secretariat Desk will be present:

| Date | Time | Location | Details |
|---|---|---|---|
| Monday, July 1 2024 | 08:00-09:00 | Congress Venue ground floor | Registrations only for Short Courses attendees |
| | 18:00-21:00 | Icebreaker Venue | It will only provide the badge for access to the conference and social events. Those registering for the first time at this point will pick up their conference bag at the registration desk on Tuesday, July 2 |
| Tuesday, July 2 2024 | 08:00-17:30 | Congress Venue ground floor | General registration for all attendees |
| Wednesday, July 3 2024 | 08:30-17:30 | Congress Venue ground floor | General registration for all attendees |
| Thursday, July 4 2024 | 08:30-13:00 | Congress Venue ground floor | General registration for all attendees |

Secretariat Desk and Registration will be available during all the conference. Before accessing the Scientific Session all participants are asked to register at the Secretariat Desk to collect the badge and the conference kit. Everybody is kindly asked to wear this badge at all sessions and social events.

For administrative matters, before and after the Conference, please contact the Administrative Secretariat e-mail: **convegni@unife.it**
Please note that on-site registration is not ensured during the Conference.

## Access to internet

Each attendee can access to EmiliaRomagnaWifi which is an open WiFi network managed by the Emilia Romagna Region. Alternatively, there is connection to EDUROAM network which is available at the Conference Venue.

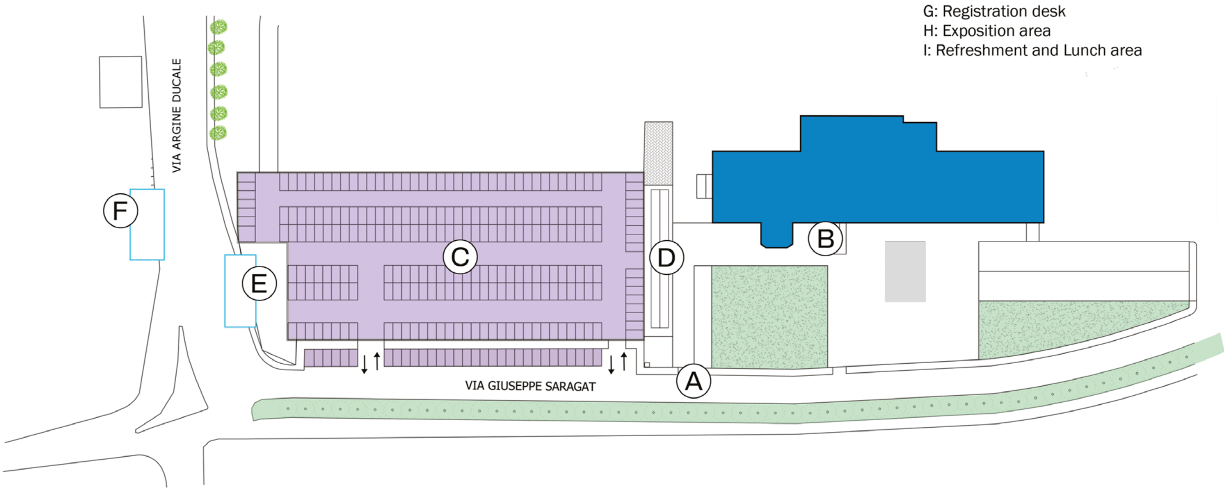
## Photography

Please note that photographs will be taken during the conference, which may be used by the University of Ferrara in any and all media without any form of compensation to you. Additional details will be made available throughout the conference. If you do not wish your photograph to be taken, please inform the photographer.

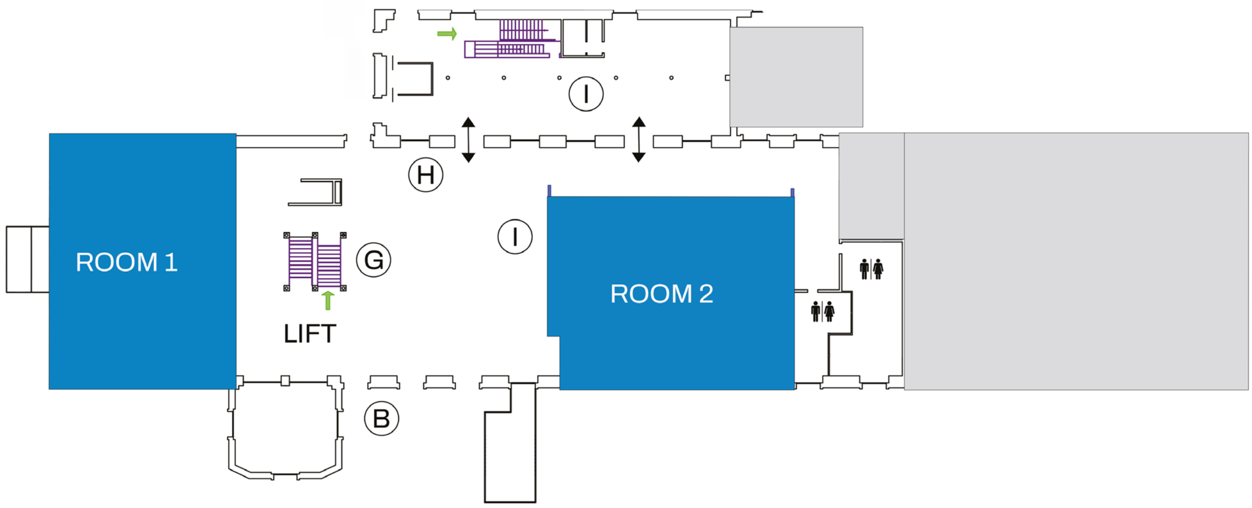
The University of Ferrara may use your photograph in promotional material. The purpose of this promotional material is to provide information about the University, the University's research and its programmes of study to audiences that may include potential home and international students, parents, members of the public, policy-makers, funders and other stakeholders. Your image may be used in printed media produced by the University of Ferrara and/or other stakeholders, such as prospectuses, guides, training products, magazines and newspapers. It may also be used online, on websites/social media hosted by the University of Ferrara and other organisations.

## Science & Technology Campus

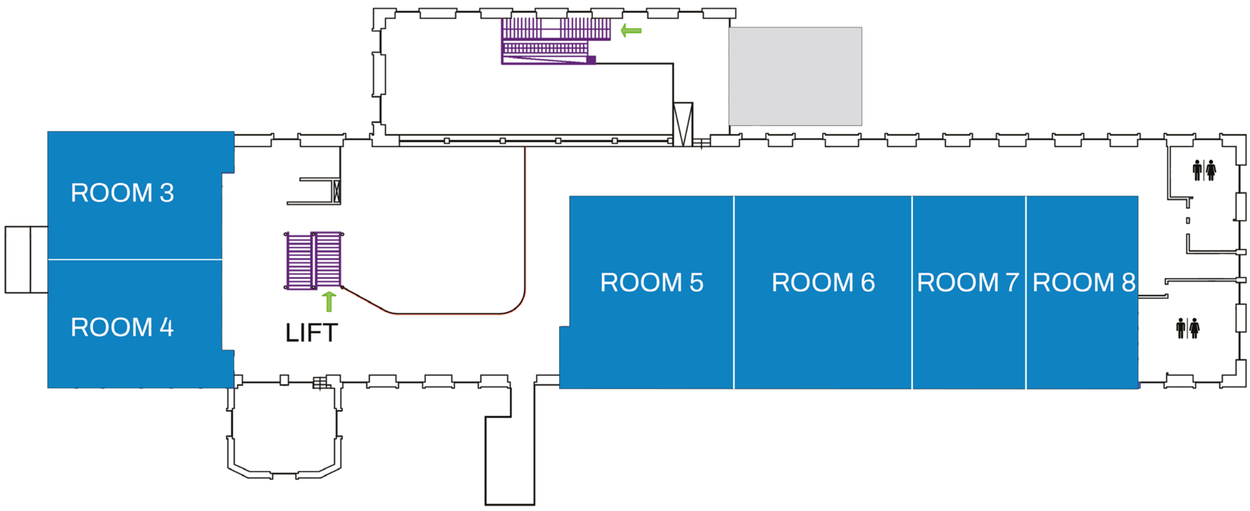
A: Science & Technology Campus Entrance
B: Main Building Entrance
C: Free Parking
D: Bike Parking
E: Bus stop
F: Bus stop
G: Registration desk
H: Exposition area
I: Refreshment and Lunch area




## Ground Floor




## First Floor



# How to get the Conference Venue

To reach the Conference Venue from the city centre, many options are available:

## By BUS

You can reach the WDSA-CCWI venue from the city center using the urban bus.
Note that bus lines 7, 3 and 4 stop at the Science & Technology Campus.

Many urban lines stop at the Ferrara railway station. From here, the congress venue is easily accessible on foot, approximately 15 minutes away (about 1 km).
To check the specific route and schedules of the bus from your location to the Science & Technology Campus, we recommend using an app like Google Maps, Omio or Moovit.

## By Taxi

Taxis in the city of Ferrara are white and are available 24 hours a day. They may be reserved by telephone or via App. It is possible to pay by credit card.

If you need a taxi:

1. call this number: Radio Taxi Ferrara: (+39) 900900
2. installing the TaxiFE APP you will have the possibility to:
   - call the taxi by entering the precise address for pick-up or simply by using geolocation
   - choose independently the type of vehicle you desire based on your needs (tall car, low car, 6 or 7-seater car, pet-friendly, station wagon, or minivan)
   - anticipate the payment method you intend to use (cash, credit card, debit card) in advance to optimize your time

## By Bike or Scooter

### Rent a bike

| | | |
|---|---|---|
| LinkToursBike | Via Garibaldi, 103 - 44121 Ferrara | Phone: +39 0532 201365<br>E-mail: bike@linktours.com<br>Web: www.linktoursbike.com |
| Ceragioli | Piazza Travaglio, 4 - 44121 Ferrara | Mobile: +39 339 4056853 |
| Ricicletta | Via Poledrelli, 21 - 44121 Ferrara | Mobile: +39 329 0477971<br>E-mail: ricicletta@ilgermoglio.fe.it<br>Web: www.ilgermoglio.fe.it |
| Todisco Bike | Via del Podestà, 4 - 44121 Ferrara | Phone: +39 0532 096507<br>Mobile: +39 346 1394287<br>E-mail: info@todisco.bike<br>Web: www.todisco.bike |

In Ferrara, is also active a rental service for **electric scooters and electric bicycles**, provided by the Dutch company Dott. Both types of vehicles can be rented on a free-flow basis, meaning users can leave them at locations different from where they picked them up. To use the rental service, simply download the free **app Dott** on your smartphone. By consulting the app, you can locate the nearest points nearest to pick up the available scooters at the moment.

# Social Events

## Icebreaker party
**PALAZZO ROVERELLA GARDEN**

Corso della Giovecca 47
44121 Ferrara – Italy

MONDAY, JULY 1
from 18:00 to 21:00

## Welcome dinner
**SANTA MARIA DELLE GRAZIE CLOISTER**

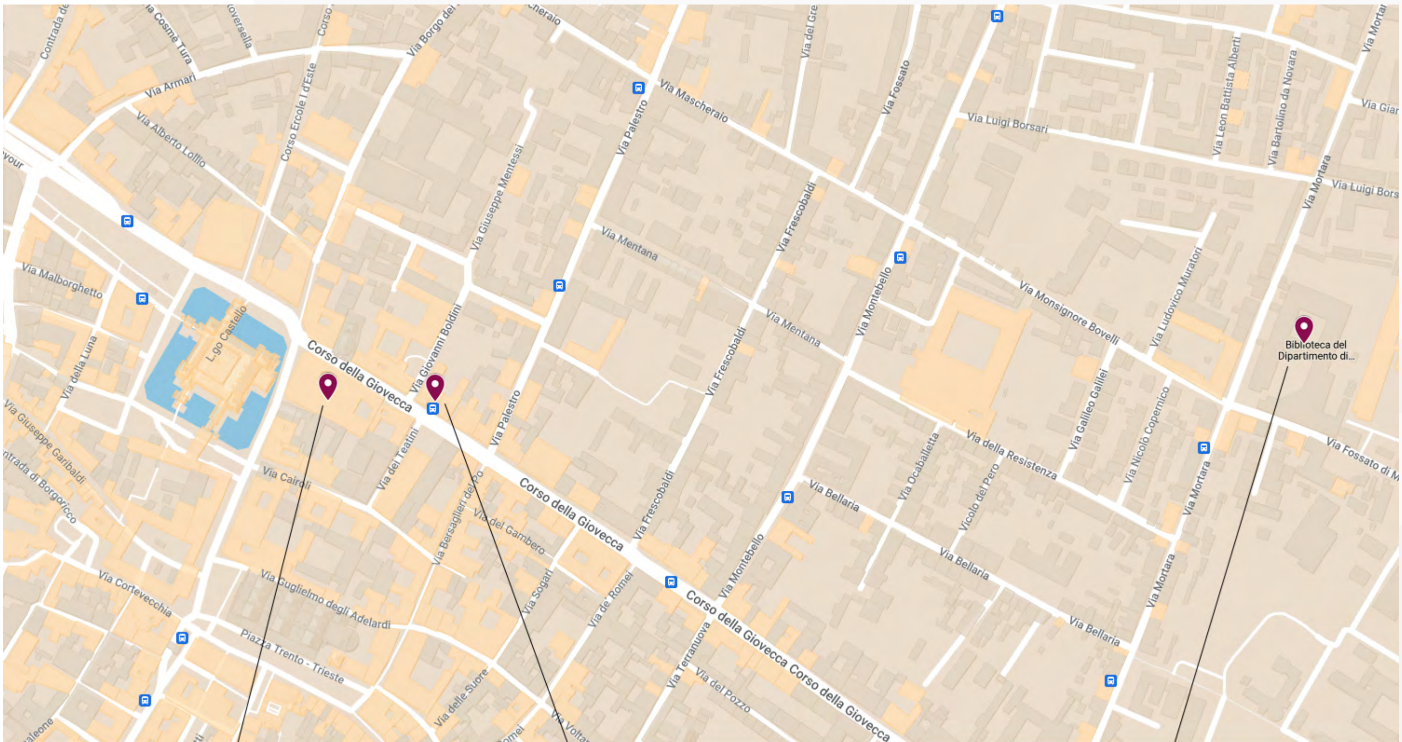
UNIVERSITY OF FERRARA
Via Mortara 70
44121 Ferrara – Italy

TUESDAY, JULY 2
from 20:00 to 23:00

## Farawell dinner
**TEATRO COMUNALE DI FERRARA**

Corso Martiri della Libertà 5
44121 Ferrara – Italy

WEDNESDAY, JULY 3
from 20:30 to 23:30




TEATRO COMUNALE DI FERRARA
Corso Martiri della Libertà, 5 Ferrara

PALAZZO ROVERELLA
Corso della Giovecca, 47 Ferrara

SANTA MARIA DELLE GRAZIE CLOISTER
Via Fossato di Mortara, 15 Ferrara

# Technical and Cultural visits

On Friday, July 5, the technical and cultural visits will take place. It is important that who is interested to these visits gives his/her confirmation at the registration Desk. For further information about the technical and cultural visits, please ask the Secretariat.

The three tours are:

## PONTELAGOSCURO POTABILIZATION WATER PLANT

The Pontelagoscuro potabilization water plant, managed by the water utility Hera S.p.A. in the municipality of Ferrara, treats surface water from the Po River and groundwater extracted from the Po River floodplain via wells, for a total plant capacity of 1,400 L/s. The water treated supplies nine different Municipalities for a total of about 240,000 citizens, through a water distribution network including over 1,500 km of pipelines.
To make water drinkable, the plant includes several treatments, from simple disinfection to more complex operations, such as the innovative "membrane treatments". Treatments are continuously evolving to ensure compliance with changes in national and European legislation, innovations in water system engineering and ongoing improvements of analysis techniques to support quality control.

## PUMPING STATIONS OF THE LAND RECLAMATION AGENCY IN FERRARA

Ferrara's Land Reclamation Agency is a public institution who has the job to land irrigation and water drainage of the area located between the city of Ferrara, the Po River delta, and the Adriatic Sea. This extensive region features predominantly flat terrain, with minimal slopes and elevations barely exceeding sea level. Consequently, rainwater runoff is artificially regulated through an intricate network of canals and drainage systems, converging at pumping stations that lift and discharge the drained water into the sea.
The peculiar features of this area are the main reason behind the ancient origins of land reclamation activity: started during the Este period, it reached its peak in the 18th Century thanks to the application of steam engines for water pumping. Nowadays, Ferrara's Land Reclamation Agency manages 4,241 km of channels with 168 pumping plants and is preserved by the constant work of technicians and practitioners, aimed at transforming uncultivated and marshy land and ensuring the safeguard of the territory.

## FERRARA CITY CENTRE

Ferrara, part of the UNESCO World Heritage since 1995, was one of the most important European capitals during the Renaissance period. The Este's family governed the city for three centuries and gave the city the appearance it has today: a city with a unique planning, which blends Medieval and Renaissance architecture, making Ferrara the first case of a modern city in Europe. Nowadays, Ferrara is a dynamic town, hosting one of the oldest universities in the world – dated 1391 – where important researchers such as Niccolò Copernico studied. The friendly city size allows reaching different places on foot or by bike, surrounded by an ancient atmosphere where many medieval and renaissance buildings – such as the Este's Castle, Saint George's Cathedral and the nearly complete ring of walls – can be seen.

# Keynote Speakers

## E.J.M. (Mirjam) Blokker

Mirjam Blokker is a Principal Scientist and team leader of the team Water Infrastructure at KWR Water Research Institute.
She is a part time associate professor at Delft University of Technology. She is an engineer in applied physics and has a PhD in civil and environmental engineering.
She is an expert in drinking water demand and developed the SIMDEUM model.
She has done research on various aspects of water quality in drinking water distribution networks, such as PAH, discolouration, temperature, and microbial regrowth.
Mirjam has worked on models for quantitative microbiological risk analysis (QMRA) in water abstraction and treatment, as well as in the distribution network.
Mirjam used her knowledge of statistics in in the research on failure of mains, valves, and fire-hydrants. She was a pioneer in the introduction of the performance indicator “customer minutes lost” (CML) in the Dutch drinking water sector.

**Title: The complexity of drinking water temperature**

## J.E. (Kobus) van Zyl

Kobus van Zyl is Professor and Watercare Chair in Infrastructure at the University of Auckland, New Zealand. He completed his Ph.D. at the University of Exeter in 2001 on operational optimisation of water distribution systems, and has focussed on water distribution and sewage systems ever since.
He current research deals with the development of pipe leaks over time, the relationship between pressure and leakage and condition assessment of sewer pipes.
He hosted the 10th WDSA Conference in the Kruger National Park, South Africa and is a Past-Chair of the ASCE standing committee on Water Distribution Systems Analysis.
He developed the Aqualibrium water distribution challenge, which is used by professional and educational institutions across the world for outreach and teaching.

**Title: Realistic modelling of the development and behaviour of leaks in water distribution systems**

# Instructions for Presenters and Chairpersons

A computer with Microsoft Powerpoint and Adobe Reader will be available at all technical sessions, so that presenters can use their previously prepared .ppt or .pdf files.
Presenters are warmly encouraged to use the Powerpoint presentation template downloadable from the conference website. The use of the template is not mandatory.

## Oral Presentations

Each presenter should follow these instructions:

- Presentation must be uploaded in the computer located in the room of your session at least 10 minutes before the beginning of the session.
- Presenters have to verify with the technical staff that the presentation file works correctly and complies with the required format (.ppt or .pdf).
- 10 minutes before session starts, presenters have to provide the chairperson a very short bio (max 3 lines) for introduction.
- Presentation must last no more than 12 minutes plus 3 minutes for questions. Presenters are asked to strictly comply with time requirements.

## Instructions for Chairpersons

Each chairperson should follow these instructions:

- Reach the room 15 minutes before the start of the session and inform the staff of your role.
- Ask presenters a short bio (max 3 lines) to present them during the session.
- Verify that all presentations of your session are available on the computer.
- Manage the time of each presentation so that it lasts no more than 15 minutes (questions included).
- The total time of the session must be respected to avoid overlapping with other sessions/conference events.
- **Don’t forget to inform the audience when the presentation is given by a young researcher who attends the competition for the Best Young Presentation. These presentations are marked with “*” in the program.**

# 2. PROGRAM

## Summary program

### July 1st, 2024

| | |
|---|---|
| 08:00 - 09:00 | Registration for partecipants to Short Courses |
| 09:00 - 13:00 | Short Courses |
| 10:30 - 11:30 | ***Open Coffee*** |
| 18:00 - 21:00 | Registration and Icebreaker |

### July 2nd, 2024

| | |
|---|---|
| 08:00 - 09:00 | Registration |
| 09:00 - 10:00 | Opening Ceremony |
| 10:00 - 11:00 | Plenary Session (**Prof. Kobus van Zyl** – Realistic modelling of the development and behaviour of leaks in water distribution systems) |
| 11:00 - 11:30 | ***Coffee break*** |
| 11:30 - 13:00 | Parallel Sessions 1 |
| 13:00 - 14:30 | ***Lunch*** |
| 14:30 - 16:00 | Parallel Sessions 2 |
| 16:00 - 16:30 | ***Coffee break*** |
| 16:30 - 17:30 | Parallel Sessions 3 |
| 20:00 - 23:00 | Welcome dinner |

### July 3rd, 2024

| | |
|---|---|
| 08:30 - 09:00 | Registration |
| 09:00 - 10:00 | Parallel Sessions 4 |
| 10:00 - 11:00 | Plenary Session (**Dr. Mirjam Blokker** – The complexity of drinking water temperature) |
| 11:00 - 11:30 | ***Coffee break*** |
| 11:30 - 13:00 | Parallel Sessions 5 |
| 13:00 - 14:30 | ***Lunch*** |
| 14:30 - 16:00 | Parallel Sessions 6 |
| 16:00 - 16:30 | ***Coffee break*** |
| 16:30 - 17:30 | Parallel Sessions 7 |
| 20:00 - 23:00 | Farewell dinner |

### July 4th, 2024

| | |
|---|---|
| 08:30 - 09:00 | Registration |
| 09:00 - 10:00 | Parallel Sessions 8 |
| 10:00 - 10:30 | ***Coffee Break*** |
| 10:30 - 11:30 | Parallel Sessions 9 |
| 11:30 - 12:00 | Plenary Session (Battle of Water Demand Forecasting) |
| 12:00 - 12:30 | Closing Ceremony |

### July 5th, 2024

| | |
|---|---|
| 09:00 - 12:00 | Technical and Cultural Visits |

# Detailed Program

## MON. JULY 1, 2024

| | |
|---|---|
| 08:00 - 09:00 | Registration – Conference Venue (Only for Short Courses attendees) |
| 09:00 - 13:00 | Course A (Room 3) – Building the geometric model of WDNs: data and information management |
| | Course B (Room 1 - Building F) – How KWR bridges science to practice and vice versa |
| | Course C (Room 4) – Introduction to the EPANET-Python toolkit (EPyT) for smart water network simulations |
| | Course D (Room 5) – WNTR and related open-source software for water distribution system analysis: training and discussion on future capabilities |
| | Course E (Room 6) – Large language models, generative AI and urban water engineering |
| | Course F (Room 7) – A probabilistic approach to solutions for sustainable stormwater control and management |
| 10:30 - 11:30 | Open Coffee |
| | |
| 18:00 - 21:00 | Registration (Icebreaker Venue) and Icebreaker Party – Palazzo Roverella Garden |

## TUE. JULY 2, 2024

| | |
|---|---|
| 08:00 - 09:00 | Registration – Conference Venue |
| 09:00 - 10:00 | Opening Ceremony (Room 1) |
| 10:00 - 11:00 | Plenary Session (Room 1) (Prof. Kobus van Zyl – Realistic modelling of the development and behaviour of leaks in water distribution systems, Moderator: Prof. Juan Saldarriaga) |
| 11:00 - 11:30 | Coffee Break |
| 11:30 - 13:00 | Parallel Session 1 |
| | 1A. (Room 2) – Design, Analysis and Modeling of Water Distribution Systems |
| | 1B. (Room 3) – Intermittent Systems |
| | 1C. (Room 4) – Water Distribution Network Planning and Management |
| | 1D. (Room 5) – Transient Flow |
| | 1E. (Room 6) – Water Demand Modeling and Forecasting |
| | 1F. (Room 7) – Industry track |
| 13:00 - 14:30 | Lunch |
| 14:30 - 16:00 | Parallel Session 2 |
| | 2A. (Room 2) – Design, Analysis and Modeling of Water Distribution Systems |
| | 2B. (Room 3) – Water Quality |
| | 2C. (Room 4) – Water Distribution Network Planning and Management |
| | 2D. (Room 5) – Transient Flow |
| | 2E. (Room 6) – Water Demand Modeling and Forecasting |
| | 2F. (Room 7) – Industry track |
| 16:00 - 16:30 | Coffee Break |

| | |
|---|---|
| 16:30 - 17:30 | Parallel Session 3 |
| | 3A. (Room 2) – Design, Analysis and Modeling of Water Distribution Systems |
| | 3B. (Room 3) – Water Quality |
| | 3C. (Room 4) – Water Distribution Network Planning and Management |
| | 3D. (Room 5) – Transient Flow |
| | 3E. (Room 6) – Battle of Water Demand Forecasting |
| | 3F. (Room 7) – Industry track |
| 20:00 - 23:00 | Welcome Dinner – Santa Maria delle Grazie Cloister |

## WED. JULY 3, 2024

| | |
|---|---|
| 08:30 - 09:00 | Registration – Conference Venue |
| 09:00 - 10:00 | Parallel Session 4 |
| | 4A. (Room 2) – Design, Analysis and Modeling of Water Distribution System |
| | 4B. (Room 3) – Water Quality |
| | 4C. (Room 4) – Leak and Burst Management |
| | 4D. (Room 5) – Drainage and Sewer Systems |
| | 4E. (Room 6) – Battle of Water Demand Forecasting |
| | 4F. (Room 7) – Industry track |
| 10:00 - 11:00 | Plenary Session (Room 1) (Dr. Mirjam Blokker – The complexity of drinking water temperature, Moderator: Prof. Joby Boxall) |
| 11:00 - 11:30 | Coffee Break |
| 11:30 - 13:00 | Parallel Session 5 |
| | 5A. (Room 2) – Design, Analysis and Modeling of Water Distribution Systems |
| | 5B. (Room 3) – Water Quality |
| | 5C. (Room 4) – Leak and Burst Management |
| | 5D. (Room 5) – Drainage and Sewer Systems |
| | 5E. (Room 6) – Battle of Water Demand Forecasting |
| | 5F. (Room 7) – Industry track |
| 13:00 - 14:30 | Lunch |
| 14:30 - 16:00 | Parallel Session 6 |
| | 6A. (Room 2) – Design, Analysis and Modeling of Water Distribution Systems |
| | 6B. (Room 3) – Water Quality |
| | 6C. (Room 4) – Leak and Burst Management |
| | 6D. (Room 5) – Drainage and Sewer Systems |
| | 6E. (Room 6) – Battle of Water Demand Forecasting |
| | 6F. (Room 7) – Industry Track |
| 16:00 - 16:30 | Coffee Break |

| | |
|---|---|
| 16:30 - 17:30 | Parallel Session 7 |
| | 7A. (Room 2) – Design, Analysis and Modeling of Water Distribution Systems |
| | 7B. (Room 3) – Water Quality |
| | 7C. (Room 4) – Leak and Burst Management |
| | 7D. (Room 5) – Drainage and Sewer Systems |
| | 7E. (Room 6) – Battle of Water Demand Forecasting |
| | 7F. (Room 7) – Sustainable Urban Water Systems |
| 20:00 - 23:00 | Farewell Dinner – Teatro Comunale di Ferrara |

## THU. JULY 4, 2024

| | |
|---|---|
| 08:30 - 09:00 | Registration – Conference Venue |
| 09:00 - 10:00 | Parallel Session 8 |
| | 8A. (Room 2) – Water Supply and Treatment |
| | 8B. (Room 3) – Water Quality |
| | 8C. (Room 4) – Leak and Burst Management |
| | 8D. (Room 5) – Drainage and Sewer Systems |
| | 8E. (Room 6) – Battle of Water Demand Forecasting |
| | 8F. (Room 7) – Sustainable Urban Water Systems |
| 10:00 - 10:30 | Coffee Break |
| 10:30 - 11:30 | Parallel Session 9 |
| | 9A. (Room 2) – Urban Water Systems in Emergency |
| | 9B. (Room 3) – Water Quality |
| | 9C. (Room 4) – Leak and Burst Management |
| | 9D. (Room 5) – Irrigation Systems |
| | 9E. (Room 6) – Battle of Water Demand Forecasting |
| | 9F. (Room 7) – Sustainable Urban Water Systems |
| 11:30 - 12:00 | Plenary Session (Room 1) (Battle of Water Demand Forecasting) – Prof. Stefano Alvisi and Dr. Elad Salomons |
| 12:00 - 12:30 | Closing Ceremony (Room 1) |

## FRI. JULY 5, 2024

| | |
|---|---|
| 09:00 - 12:00 | Technical and Cultural Visit – Pontelagoscuro potabilization water plant |
| | Technical and Cultural Visit – Pumping stations of the Land Reclamation Agency in Ferrara |
| | Technical and Cultural Visit – Ferrara city centre |

# Contribution Highlights

## Session 1A (Room 2) – Design, Analysis and Modeling of Water Distribution Systems
## Chairman: Fuchs-Hanusch D.

ID: 99 - A REVIEW OF SCENARIO-BASED APPROACHES IN WATER SYSTEMS DESIGN.* Michalopoulos C., Vertommen I., Makropoulos C. and Savic D.

- Scenario methods for tackling uncertainties in WDNs
- Scenario Generation literature review
- Deep uncertainties that have to consider in the design of WDNs

ID: 101 - BACKUP DESIGN OPTIMISATION FOR WATER DISTRIBUTION NETWORKS.* Wéber R., Tuyakbayev T., Abhijith G.R., Salomons E., Hős C. and Ostfeld A.

- Traditional diameter optimisation considers only the original network
- The study includes every backup during the isolation of a random pipe failure
- The level of service and the cost determine a Pareto front

ID: 46 - IMPROVED WDN DESIGN BY COUPLING OPTIMAL PIPE SIZING AND ISOLATION VALVE PLACEMENT.* Mottahedin A., Giudicianni C., Cunha M.C. and Creaco E

- WDN pipe sizing and isolation valve placement in a single-stage optimization
- Engineering-wise diameter distribution constrained optimization
- Comparison of the novel method with a traditional two-step design approach

ID: 190 - STAGED DESIGN OF WATER DISTRIBUTION NETWORKS: A REINFORCEMENT LEARNING APPROACH.* Tsiami L., Makropoulos C. and Savic D.

- This work explores the potential of RL in the lifecycle design of water networks
- The proposed RL approach focuses on the “staged design” of water networks
- Experiments, conducted on an adapted NYT benchmark, yielded promising results

ID: 133 - INCORPORATING FLEXIBILITY IN THE LONG-TERM DESIGN OF WATER DISTRIBUTION SYSTEMS USING OPERATIONAL VARIABLES.* Zanutto D., Castelletti A. and Savic D.

- The effects of operations on Water System design optimisation are investigated
- Joint design and operation improves design only optimization
- Operations can strongly affect the design optimisation process

ID: 226 - A FULL AND SIMPLIFIED WATER DISTRIBUTION NETWORK MODEL COMPARISON OF SKELETONIZATION RESULTS.* Tugume B., Castro-Gama M. and Ayala-Cabrera D.

- Diverse skeletonization methods simplify water distribution network models
- Achieving balance between accuracy and efficiency in WDN modelling
- Comparative analysis of software tools enhances WDN simplification

## Session 1B (Room 3) – Intermittent Systems
## Chairman: Farmani R.

ID: 289 - ENHANCING INSIGHTS INTO INTERMITTENT WATER SUPPLY SYSTEMS: UNCERTAINTY AND SENSITIVITY ANALYSIS OF HYDRAULIC MODEL.* Sarisen D., Farmani R. and Memon F.A.

- Considering uncertainty in the network model’s parameters is essential
- Supply characteristics, household tank size and water consumption are uncertain
- The most sensitive parameter affecting the model is the supply characteristics

ID: 10 - SIMULATION OF INTERMITTENT WATER DISTRIBUTION NETWORKS BY EPA-SWMM: COMPARING MODEL RESULTS AND FIELD EXPERIMENTS.* Gullotta A. and Campisano A.

- EPASWMM was used for the simulation of an intermittent water distribution system
- The whole cycle of operation of the intermittent system was simulated
- A good agreement between simulation results and filed data was found

ID: 224 - VOLUME-DRIVEN AND FLOW CONTROL APPROACH TO OPTIMIZING EQUITY IN INTERMITTENT WATER SUPPLY SYSTEMS. Hendrickson G., Abhijith G.R. and Sela L.

- Exploring drivers for consumers with hydraulically less favorable conditions
- Examining local incentives vs. global equity misalignments
- Optimizing valve schedules for equity in intermittent systems

ID: 31 - THE RESILIENCE OF INTERMITTENT WATER SUPPLY SYSTEMS UNDER LIMITED WATER AND ELECTRICITY AVAILABILITY. Ayyash F., Javadi A. and Farmani R.

- Water scarcity and power outages are key IWS systems reasons
- GRA can identify the resilience of the system to different failure modes
- Optimum operation increased IWS systems resilience

ID: 253 - ANALYSIS OF INEQUITY IN RURAL WATER SUPPLY SCHEMES – A CASE STUDY FROM CENTRAL INDIA. Kurian V., Narasimhan Sh. and Narasimhan Sr.

- Highlights challenges faced by rural water supply systems
- Provide effective recommendations using mathematical models
- Reinforce the need for pressure driven analysis of rural water supply systems

ID: 63 - TOWARDS OPTIMAL SCHEDULING OF INTERMITTENT WATER SUPPLY SYSTEM INCORPORATING CONSUMER BEHAVIOR. Boindala S.P., Abhijith G.R., Ihjas K. and Ostfeld A.

- Analysis of a real case study of Intermittent water supply system
- Considering consumer behavior and domestic storage tanks
- Practical constraints of water utilities are considered for scheduling analysis

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## Session 1C (Room 4) – Water Distribution Network Planning and Management
## Chairman: Berardi L.

ID: 18 - MONOLITHIC AND DECOMPOSITION METHODS FOR OPTIMAL SCHEDULING OF DYNAMICALLY ADAPTIVE WATER NETWORKS.* Jenks B., Ulusoy A.-J. and Stoianov I.

- Optimization problem formulated for near real-time control of water networks
- Time-coupled, nonlinear problem poses challenges for off-the-shelf solvers
- Solution methods proposed using decomposition and gradient-based optimization

ID: 56 - DATA-ENABLED PREDICTIVE CONTROL FOR OPTIMAL PRESSURE MANAGEMENT. Perelman G. and Ostfeld A.

- Introduced a data-driven approach (DeePC) for optimal pressure management in WDS
- DeePC learns system dynamics from data, bypassing modeling challenges
- DeePC outperforms traditional strategies and is robust against uncertainty

ID: 104 - TWINOPTPRO - DIGITAL PLATTFORM FOR ONLINE PUMP SCHEDULING OPTIMISATION. Bernard T., Deuerlein J.W., Dreesen M., Fischer M., Guth N., Höche R., Kühnert C., Mastaller C., Rappold G., Schlolaut G., Wunsch A. and Ziebarth M.

- Cost savings of around 20% of energy cost for pumping
- Digital platform and dashboard for model integration and result monitoring
- Bilevel-optimization tool integrating hydraulic simulation and neural networks

ID: 121 - AI-ASSISTED PUMP OPERATION FOR ENERGY-EFFICIENT WATER DISTRIBUTION SYSTEMS.* Hedaiaty Marzouny N. and Dziedzic R.

- An LLM-assisted framework was developed to optimize pump operations
- The LLM-assisted framework achieved higher energy reduction faster than GA
- Best results were achieved by short-term history and feedback loop strategies

ID: 230 - LARGE-SCALE MULTIPURPOSE BENCHMARK DATASETS FOR ASSESSING DATA-DRIVEN DEEP LEARNING APPROACHES FOR WATER DISTRIBUTION NETWORKS.* Tello A., Truong H., Lazovik A. and Degeler V.

- We provide over 1.3 million states, eliminating the need for re-simulation
- We mitigate the overuse of temporal patterns, enhancing the variability of data
- Our dataset serves as a benchmark for comparing models across different tasks

ID: 208 - CLOUD BASED CONTROL AND MONITORING OF WDN USING FREE SPECTRUM COMMUNICATION PROTOCOLS.* Raphael R., Prasath S.H.R. and Narasimhan S.

- Internet of Things, sensor networks and telemetry in water distribution
- Free spectrum communication in ISM (Industrial, Scientific and Medical) band
- Cloud based data management using ThingSpeak data platform from Mathworks

## Session 1D (Room 5) – Transient Flow
## Chairman: Brunone B.

ID: 148 - PUMP SWITCHING-INDUCED TRANSIENTS IN WATER DISTRIBUTION NETWORKS. PRELIMINARY LABORATORY EXPERIMENTS.* Capponi C., Falocci D., Brunone B., Xiaodong Y. , Chao Y. and Meniconi S.

- Effects of pump switching-on and -off in a laboratory WDN are investigated
- The pressure extreme values are influenced by the system topology
- Pressure waves induced by pump switching-off are smoother than in switching-on

ID: 107 - TRANSIENT FLOW DYNAMICS IN TESLA VALVE CONFIGURATIONS: INSIGHTS FROM COMPUTATIONAL FLUID DYNAMICS SIMULATIONS.* Zeidan M., Yondonjamts D., Nemeth M., Abhijith G.R., Wéber R. and Ostfeld A.

- In-depth insights into transient flow dynamics of Tesla valve configurations
- Validation of Tesla valves as effective transient protection devices in WDS
- Identification of pressure pockets during transient

ID: 163 - CHARACTERISING THE IMPACT OF HYDRANTS ON TRANSIENTS.* Whitelegg C., Collins R., Boxall J. and Young S.

- Unknown hydrant features make transient based leak detection less accurate
- Hydrant features are important to model even in very noisy conditions
- Inverse calibration techniques can be used to determine hydrant properties

ID: 114 - EFFECTS OF USER-INDUCED TRANSIENTS ON A SERVICE LINE: PRELIMINARY RESULTS FROM WEL (PERUGIA, ITALY). Marsili V., Falocci D., Capponi C., Meniconi S., Mazzoni F., Alvisi S., Brunone B. and Franchini M.

- Water service lines subjected to pressure transients induced by users' activity
- Laboratory tests conducted at the Water Engineering Laboratory (Perugia, Italy)
- Propagation of pressure waves induced by users' activity in service lines

ID: 97 - BURST LOCALISATION IN WATER PRESSURISED PIPELINES COMBINING NUMERICAL DATA GENERATION AND ANN TRANSIENT SIGNAL PROCESSING. Menapace A., Tavelli M., Dalla Torre D. and Righetti M.

- ANN leak detection exploiting transient signals in pressurised pipelines
- A flexible finite volume unsteady hydraulic solver for big data generation
- An embedded numerical-ANN framework paves the on-demand pipelines diagnosis

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## Session 1E (Room 6) – Water Demand Modeling and Forecasting
## Chairman: Collins R.

ID: 81 - SENSITIVTY ANALYSIS OF THE IMPACT OF BUILDING OCCUPANCY ON WATER DEMAND CHARACTERISTICS IN RESIDENTIAL BUILDINGS. * Josey B. and Gong J.

- Building occupancy influences plumbing design parameters significantly
- Occupancy impacts peak/average demand, hour consumption, and stagnation
- The integrating fixture usage and occupancy into precise plumbing design

ID: 21 - UNDERSTANDING RESIDENTIAL END USES OF WATER: EVIDENCE FROM AROUND THE WORLD. Mazzoni F., Alvisi S., Blokker M., Buchberger S., Castelletti A., Cominola A., Gross M.-P., Jacobs H., Mayer P., Steffelbauer D., Stewart R., Stillwell A., Tzatchkov V., Alcocer Yamanaka V.-H. and Franchini M.

- Overview of the state-of-art research about residential end uses of water
- Analysis and clustering of over 110 reports and studies conducted worldwide
- Quantitative discussion of the most widespread metrics for end-use analysis

ID: 112 - THE SWAMM PROJECT FOR LONG DISTANCE MONITORING AND CONTROL OF THE USER WATER CONSUMPTION. Sinagra M., Picone C., Lo Cicero G. and Tucciarelli T.

- SWAMM is for long distance metering and control of the user water consumption
- The PRS nano-turbine is fully sealed, without rotary shaft seals
- The PRS has a new efficiency saving hydraulic regulation system

ID: 238 - WATER DEMAND UNDER CLIMATE CHANGE IN THE SALT RIVER PROJECT (ARIZONA, USA). Stoker P., Lansey K., Santiago X., Zalesky T., Svoma B., Ashby J. and Beckham A.

- Novel approach to predicting water use under climate change
- Practical application to Phoenix, Arizona
- Collection of data from a range of sources

ID: 200 - APPLICATION OF A STOCHASTIC MODEL FOR WATER DEMAND ASSESSMENT UNDER WATER SCARCITY AND INTERMITTENT NETWORKS. Piazza S., Sambito M. and Freni G.

- Research evaluates water demand dynamics in intermittent networks
- Investigation of oversized local tanks prompted by scarcity concerns
- Application of stochastic models to assess user adaptation to scarcity

ID: 40 - MODELLING CONSUMER DEMAND IN INTERMITTENT WATER SUPPLY (IWS) NETWORKS: EVIDENCE FROM NEPAL.* MacRorie M., Weston S., Pudasaini K., Price R., Speight V. and Collins R.

- High-frequency meters reveal household water withdrawal across an IWS network
- Households exhibit a mixture of direct-use and tank-filling withdrawal practices
- Household withdrawal behaviour varies significantly between households

## Session 1F (Room 7) – Industry Track
## Chairman: Quintiliani C.

ID: 33 - REPLACEMENT STRATEGIES FOR SERVICE LINES: FAILURE REGISTRATION ENABLED PRIORITIZATION. Dash A., Galama-Tirtamarina A., Rombouts J., van Laarhoven K. and Beuken R.

- Survey reveals incoherence in definition/handling of service lines
- Data-driven clustering of registered failures aids rehabilitation prioritization
- Challenge lies in combining service line replacement with distribution pipes

ID: 88 - REHABILITATION PLANNING OF WATER DISTRIBUTION NETWORK USIGN OPTIMIZATION IN PRACTICE. AMSTERDAM CASE STUDY.* Mitrovic D., Hillebrand B. and van Laarhoven K.

- A real-world multi-objective rehabilitation optimization of the Amsterdam's WDN
- Using engineering knowledge to reduce the size of solution space
- Gondwana software developed by KWR was utilized to solve the optimizations

ID: 199 - ASSESSING THE IMPACT OF ASSET MANAGEMENT ON ENERGY RECOVERY: THE ENERGIDRICA PROJECT.* Ariza A., Enriquez L., Simone A., Ciliberti F.G., Laucelli D.B. and Berardi L.

- Asset management strategies and implications for energy efficiency are discussed
- Assessment of energy consumption for pumping and energy recovery by mini-hydro
- Digital Water Services to assess different management and operational scenarios

ID: 83 - EMPOWERING SMART RENEWABLE CITIES THROUGH HYDROPOWER TECHNOLOGY IN URBAN DRINKING WATER SUPPLY SYSTEM. Gamón A., Pérez A., Sánchez C., Royo H., Oltra T., de Diego C., Ponz R. and Pedro-Monzonís M.

- LIFE TURBINES reduces GHGs by decarbonising the drinking water supply
- LIFE TURBINES leverages the energy dissipated in drinking water networks
- Promoting universal access to affordable, secure and sustainable energy

ID: 261 - TOOLS FOR LONG TERM ASSET PLANNING AND PRIORITISING REPLACEMENT PROJECTS.* Schaap P., Bossers N. and van den Ende P.

- Risk reduction modelling by multiple model weighting
- Long term asset planning for infrastructure using scenario studies
- Replacement project proposals prioritised by high risk reduction potential

ID: 119 - EVERGREEN DIGITAL TWIN FOR SMART WATER GRID OPERATIONAL MANAGEMENT. Wu Z.Y., Chew A.W., Meng X., Pok J., Kalfarisi R., Zhang A.H., Wong J.M., Cao F., Lai K.C., Seow L. and Wong J.J.

- A generic Digital Twin (DT) framework for Smart Water Grids (SWG) operation
- Integrated data analytics and hydraulic model for constructing SWG DT
- Applied DT-based approach to smart water grid in Singapore with 100s of sensors

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## Session 2A (Room 2) – Design, Analysis and Modeling of Water Distribution Systems
## Chairman: Sousa J.

ID: 115 - GRAPH-BASED WARM SOLUTIONS FOR OPTIMAL RESILIENCE ENHANCEMENT OF WATER DISTRIBUTION NETWORKS.* Hajibabaei M., Minaei A., Shahandashti M. and Sitzenfrei R.

- Proposing an innovative graph-based method for resilience enhancement
- Utilizing graph-based solutions as warm solutions for evolutionary optimization
- Substantially reduced computational burden than traditional optimization

ID: 225 - APPLICATION OF PRIMARY NETWORK ANALYSIS IN REAL WATER DISTRIBUTION SYSTEMS. Zingali L.C., Monaci M. and Bragalli C.

- Algorithm based on Graph theory for Primary Network analysis in WDS
- Application of Steiner Tree to connect water resources
- Water consumption oriented identification of the most relevant edges in real WDS

ID: 140 - A HYBRID GRAPH-HYDRAULIC APPROACH FOR IDENTIFYING CRITICAL ELEMENTS IN WATER DISTRIBUTION NETWORKS.* Satish R., Hajibabaei M., Oberascher M. and Sitzenfrei R.

- Targeted interventions based on 1st level criticality
- Enhances crisis evaluations for all criticality
- Method is 68 times faster than traditional methods for 1st level criticality

ID: 125 - EFFICIENT NETWORK REPRESENTATION: GRAPH CONTRACTION STRATEGIES IN WATER DISTRIBUTION NETWORKS. Barros D., Alaggio J., Meirelles G., Brentan B. and Luvizotto E.

- Graph contraction as an alternative to skeletonization processes
- Reduction of search space through representative nodes
- Assessment of connectivity of networks represented as graphs

ID: 47 - EFFICIENT IDENTIFICATION STRATEGY OF ISOLATION VALVES TO MAINTAIN MODULARITY-BASED WDN CLUSTERING.* Mottahedin A., Giudicianni C., Brentan B. and Creaco E.

- Novel method for prioritizing isolation valve maintenances in WDNs
- The valves to be prioritized are identified on the boundaries of clusters
- Evaluating maintenance strategies under random multiple valve failure scenarios

ID: 43 - CT-SCANS: GAME CHANGER IN THE MAINTENANCE OF PVC DRINKING WATER MAINS. van Laarhoven K. and Dash A.

- CT can detect inclusions of foreign material that cause crack growth in PVC
- Micro-CT can be used to distinguish different types of inclusions in PVC
- CT will help the development of meaningful in-line inspection techniques for PVC

## Session 2B (Room 3) – Water Quality
## Chairman: Blokker M.

ID: 61 - TEMPERATURE ONLINE MODELLING IN THE HANGZONE SONNENBERG, ZURICH. Belotti F., Tarnowski H., Svitak Z. and Ingeduld P.

- Water temperature modeling runs on top of a hydraulic model every 10 minutes
- Ground temperature main factor influencing water temperature in the network
- Calibration of the bulk coefficients challenging because of many dependencies

ID: 37 - SPATIAL ANALYSIS OF WATER TEMPERATURE IN A DRINKING WATER DISTRIBUTION SYSTEM FOR CLIMATE CHANGE ADAPTATION.* Cincotta C., Blokker M., Bragalli C. and Kapelan Z.

- Persistent heat waves will probably affect drinking water temperature at the tap
- The urban ground cover should be designed to prevent excessive DWTs
- Different interventions can be combined together to adapt to climate change

ID: 245 - REINTERPRETATION OF WATER TEMPERATURE MEASUREMENTS. Galama-Tirtamarina A. and Blokker M.

- The objective is to get more information from obliged temperature measurements
- Water temperature measurements were compared to temperature prediction of STM
- Utilities can locate heat sources based on locations of temperature exceedances

ID: 110 - EXPERIMENTAL SETUP FOR MEASURING THE EFFECT OF BIOFILM BUILD-UP ON HEAT TRANSFER IN DRINKING WATER PIPES.* Glynis K., Blokker M., Kapelan Z. and Savić D.

- Effect biofouling has on heat transfer of drinking water pipes
- Very sensitive sensors and highly controlled conditions required
- Microscopic images shed light into intricate biofilm dynamics

ID: 145 - ASSESSMENT AND VARIATION OF WATER QUALITY IN URBAN DISTRIBUTION NETWORKS: FROM RESERVOIR TO FAUCET. Jeong E., Hwang K.-Y., Lee S., Jung K. and Kim H.

- Enabled time-series observations of changes in water parameters at each location
- Diverse spatiotemporal patterns depending on the location
- Chemical reactions and the physical behavior of particulate turbidity

ID: 9 - RAW WATER MAIN FLOW CONDITIONING TO MANAGE MATERIAL LOAD AND TREATMENT CAPACITY. Husband S., Walkington-Mayo N. and Boxall J.

- Cohesive material layer processes in raw water mains shown by VCDM simulations
- Simulating long term discolouration behaviour enables pro-active management
- Flow-conditioning shown effective for network risk and capacity management

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## Session 2C (Room 4) – Water Distribution Network Planning and Management
## Chairman: Haghighi A.

ID: 105 - CO-OPTIMIZATION OF WATER-ENERGY NEXUS SYSTEMS AND CHALLENGES.* Zeng J. and Liu Z.

- Novel WENS model links water and power networks via pumps
- The proposed WENS model outperforms traditional systems in efficiency and cost
- Identifies key challenges and future research for WENS

ID: 8 - INCLUSION OF WATER AGE IN CONJUNCTIVE OPTIMAL OPERATION OF WATER AND POWER GRIDS. Shmaya T. and Ostfeld A.

- An attempt to develop an analytical model to predict water age
- An analysis of water age behavior linked to pump power and tank operation
- Including water age as part of a conjunctive water-power optimization process

ID: 198 - OPTIMIZING PERFORMANCE OF WATER DISTRIBUTION NETWORKS: SECTORIZATION AND PRESSURE MANAGEMENT FOR LEAKAGE REDUCTION. Denardi M., Bianchotti J., Puccini G. and Castro-Gama M.

- A novel methodology that successfully reduces nighttime background leakages
- Optimization process divides the network into PMZ by placing valves
- Optimization evaluates the settings of the PRVs or valves to isolate PMZs

ID: 239 - AUTOMATIC DISTRIBUTION OF PRV FOR LEAKAGE REDUCTION. Pérez Magrané R., Roca Puntí G. and Grau Torrent S.

- We help in the decision making for reducing leakage through pressure reduction
- It uses a well calibrated model of a real water distribution network
- It evaluates the possible leakage reduction in different scenarios

ID: 285 - DEVELOPMENT OF AN INTEGRATED SYSTEM FOR EFFICIENT WATER RECOURCES MANAGEMENT USING ESP32, MICROPYTHON AND IOT. Lloys Llobet M., Guixà Ariza J.L., Dragoste C., Cots Sanfeliu J., Escobet Canal T. and Grau Torrent S.

- Developed PCB for ESP32 and open-source software using MicroPython
- Tested JSN-SR04T ultrasonic sensor and adapted software for signal reading
- Design and 3D printing of custom supports and casings and resistance tests

ID: 30 - THE LOTUS INTERNATIONAL MULTIFUNCTIONAL DIGITAL TWIN. Lewis G., Vamvakeridou-Lyroudia L., Chen A., Djordjević S. and Savic D.

- A digital twin for leak detection
- Leveraging model-view-controller paradigm
- Cross-national collaboration

## Session 2D (Room 5) – Transient Flow
## Chairman: Simpson A.

ID: 6 - HYDRAULIC TRANSIENT DATA ASSIMILATION IN PIPE NETWORKS USING THE KALMAN FILTER. Ye J., Zeng W., Lambert M., Zecchin A. and Do N.C.

- Novel Kalman filter approach for efficient hydraulic transient data assimilation
- An efficient elastic water column model integrated into Kalman filters
- Accurate real-time transient state estimations in extensive pipe networks

ID: 23 - HYDRAULIC TRANSIENT ANALYSIS IN WATER NETWORKS USING AN ELECTRICAL EQUIVALENT METHOD. Zeng W., Ye J., Zecchin A. and Lambert M.

- An elastic water column model is proposed for hydraulic transient analysis
- Graph theory is used to model an arbitrarily configured pipe network
- Physical-informed neural network is used to integrate measured data

ID: 186 - ADMITTANCE MATRIX METHOD FOR MODELING TRANSIENTS IN A LABORATORY WATER NETWORK. Capponi C., Falocci D., Brunone B., Zecchin A. and Meniconi S.

- The admittance matrix method is used for modeling a laboratory pipeline network
- The importance of calibrating viscoelastic parameters is highlighted
- Results show that the numerical model captures the behavior of complex systems

ID: 135 - TRANSIENT PRESSURE ESTIMATION USING DATA-DRIVEN MODELS: AN APPROACH BASED ON ENSEMBLE TREES.* Barreto R., Souza R.G., Meirelles G. and Brentan B.

- Random Forest application for building a metamodel for transient flow
- Application in gravity pipeline system and water distribution network
- Results with coefficient of determination above 0.8 indicating model's efficacy

ID: 277 - ASSESSING VISCOELASTIC PARAMETERS OF POLYMER PIPES VIA TRANSIENT SIGNALS AND ARTIFICIAL NEURAL NETWORKS.* Rahmanshahi M., Duan H.-F., Keramat A., Vafaei Rad N., Azizi Nadian H.

- Proposed an ANN-based creep function parameters
- Pressure wave speeds prediction for polymer pipes through transient flow data
- The ANN model exhibited excellent accuracy in predicting creep function

ID: 254 - CONTRIBUTIONS TO LEAK AND AIR POCKET DETECTION USING TRANSIENT PRESSURE SIGNALS. Covas D.I., Cabral M., Ferreira J.P. and Ramos H.

- Novel experimental transient tests for different air pocket locations and sizes
- Differences of the air pockets and leaks effect on the pressure signal
- The identification of the most critical air pocket location

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## Session 2E (Room 6) – Water Demand Modeling and Forecasting
## Chairman: Lansey K.

ID: 234 - DETERMINATION OF THE COSTS OF POTABLE WATER EXTRACTION IN THE MUNICIPALITY OF VILLAGRAN, GUANAJUATO, MEXICO. Sánchez-Astello M. and Dolores Cantú D.A.

- The electromechanical efficiency low indicates the replacement of the pumping
- Variable costs are determined by the power consumed and the electricity rate
- The annual domestic rate (2021) for 10 m3 of the operating agency was € 121.02

ID: 58 – OPERATING WATER DISTRIBUTION SYSTEMS FOR EQUITABLE ACCESS TO CLEAN WATER. Vizanko B., Shmaya T., Boindala S.P., Ostfeld A. and Berglund E.

- COVID-19 cut demand, causing water age hot spots
- Lack of access to clean water can create high costs for some households
- Graph theory identifies valve adjustments for water quality and equity

ID: 71 - EWA - A WEB-BASED AWARENESS CREATION TOOL FOR CHANGE IMPACT ON WATER SUPPLY. Stelzl A., Arbesser-Rastburg G., Adler V., Camhy D., Pirker J. and Fuchs-Hanusch D.

- Web-based tool for long-term planning of water distribution systems
- Combining gamification and planning in the water supply sector
- Raising awareness in the drinking water sector

ID: 42 - EXPLAINABLE METHODS FOR WATER DEMAND FORECASTING AS A KEY ASPECT TO TRUSTWORTHY ARTIFICIAL INTELLIGENCE.* Maussner C., Oberascher M., Autengruber A., Kahl A. and Sitzenfrei R.

- The EU AI Act emphasizes trustworthy, explainable AI for critical infrastructure
- The linear regression model is precise, robust and transparent at the same time
- Bayesian linear regression is a valuable extension for estimating peak demand

ID: 95 - REAL-TIME DEMAND FORECASTING AND MULTI-RESOLUTION MODEL PREDICTIVE CONTROL FOR WATER DISTRIBUTION NETWORKS.* Verheijen P. C. N., de Groot W. P., Goswami D. and Lazar M.

- Real-time demand prediction using Machine Learning methods
- Model predictive control for faster feedback response
- Multi-resolution prediction horizon for efficient computation

ID: 73 - SHORT-TERM WATER DEMAND FORECAST USING MACHINE LEARNING MODELS IN NORTHERN ITALY ACROSS DIFFERENT TIME RESOLUTIONS. Niazkar M., Menapace A., Peretti F. and Righetti M.

- Short-Term Water Demand Forecast Using four Machine Learning models
- Comparing performances of differernt ML models across five time scales
- XGBoost outperformed other models for forecasting daily water demands

## Session 2F (Room 7) – Industry Track
## Chairman: Messa G.

ID: 209 - PERFORMING THE ANALYSIS OF TOPOLOGICAL DOMAIN OF REAL WDNs TO SUPPORT ASSET MANAGEMENT. Simone A., Berardi L., Laucelli D. and Giustolisi O.

- Relevance-based edge betweenness is used to perform the domain analysis of WDNs
- The domain analysis supports several hydraulic analyses
- The work highlights the importance of topology in the study of WDNs

ID: 215 - BUILDING THE GEOMETRIC MODEL OF REAL WDNs IN THE DIGITAL TRANSITION ERA. Ciliberti F.G., Berardi L., Simone A., Piazza S., Laucelli D.B. and Freni G.

- Digital technologies boost management of WDNs
- Reliable data integration crucial for WDNs innovations
- Building geometric models: key step in WDN management

ID: 255 - DIGITAL TRANSITION OF INTEGRATED WATER CYCLE. INVESTEMENTS IN A CASE STUDY. Grau Torrent S., Lloys Llobet M., Zaragoza Bueso J.M., Costa Alcantara E., Dragoste C., Cots Sanfeliu J. and Pérez Magrané R.

- The project covers the entire water cycle
- Digital transition of Aigües de Manresa, use of new technologies and innovation
- New hydraulic modelling tools, with the joint use of EPNAET, SWMM and IBER

ID: 201 - STEADY-STATE MODELLING OF INTERMITTENT FLOW AND THE ROLE OF PRIVATE TANKS.* Piazza S., Ciliberti F.G., Bruno G., Simone A., Berardi L., Laucelli D., Freni G. and Giustolisi O.

- Research examines the function of private tanks in intermittent flow scenarios
- WDNetXL facilitates modeling of tank dynamics within urban hydraulic systems
- Study outcomes contribute to optimized design of intermittent flow networks

ID: 210 - USING AMSI TO DRIVE ASSET MANAGEMENT IN AGIRA AND ENNA TOWNS. Giustolisi O., Freni G., Bruno G. and Berardi L.

- AMSI is a novel indicator derived from advanced hydraulic modelling
- AMSI is rationale and physically based
- AMSI directs efficient investments in this era of transformation

ID: 181 - ENABLING WATER UTILITIES' ORGANIZATIONAL INTEROPERABILITY THROUGH LINKED DATA. Gueli R., Sorce M., Cristaldi G., Marciante R., Borinato E., Spampinato E., Giandolfo R., Patatu V. and Raccuglia M.

- Modelling water infrastructures through a semantic model based on NGSI-LD
- A full-scale plant has been modelled
- The NGSI model enables complex spatiotemporal reasoning involving GIS and SCADA

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## Session 3A (Room 2) – Design, Analysis and Modeling of Water Distribution Systems
## Chairman: Todini E.

ID: 260 - WATER DISTRIBUTION NETWORK RELIABILITY ASSESSMENT BEYOND THE RESILIENCE INDEX. Sousa J., Muranho J., Bonora M. and Maiolo M.

- A new index addressing known weaknesses of the original resilience index
- Inclusion of critical network features maintaining a simple structure
- A novel pressure surplus threshold sets more realistic pressure limits

ID: 67 – A MINIMUM PRESSURE APPROACH FOR WATER DISTRIBUTION NETWORK MODELLING.* Tucciarelli T., Puleo D., Nasello C. and Sinagra M.

- A new criterion for water distribution network modelling is proposed
- More detailed modelling in the event of air intrusion in pipes
- Results show relevant differences compared to the classical head driven method

ID: 34 - TOP TEN REASONS TO USE 100 mm DIAMETER PIPES IN NORTH AMERICA. Gibson J. and Karney B.

- The 150 mm pipe diameter requirement is very old
- Fire flow requirements in North America are conservative
- There are many advantages when smaller pipes are used

ID: 268 - DISTRICT INFORMATION AREAS: A DISTRIBUTED DECISION MAKING APPROACH FOR URBAN WATER SYSTEMS. Herrera M., Giudicianni C. and Creaco E.

- District information areas is a novel management tool to complement DMAs
- District information areas aids flexible & decentralised water system management
- District information areas enhance sensor coverage and aid digital twins

## Session 3B (Room 3) – Water Quality
## Chairman: Boxall J.

ID: 222 - TOOL TO MODEL THE POTENTIAL RISK OF LEGIONELLA GROWTH IN PREMISE PLUMBING SYSTEMS.* Vargas K., Waak M., Tscheikner-Gralt F. and Rokstad M.

- Water age and temperature should be monitored in premise plumbing systems
- Accurate temperature range definition for Legionella growth potential is needed
- Modelling tools offer evidence-based guidance to building managers and designers

ID: 280 - UNCERTAINTY SOURCES IN THE MECHANISTIC MODELLING OF LEGIONELLA WITHIN BUILDING WATER SYSTEMS.* Ortiz C., Hatam F. and Prévost M.

- Using EPANET-MSX holds potential for mechanistic Legionella modeling within BWS
- Considering disinfection avoids simulating unrealistic growth during stagnation
- Accurate Legionella predictions require biofilm detachment parameter calibration

ID: 137 - REGROWTH OF MICROORGANISMS FROM TREATMENT TO TAP IN OPERATIONAL DRINKING WATER SUPPLY NETWORKS.* Carneiro I., Fish K., Jarvis P., Haley J., Webber F., Gaskin P. and Boxall J.

- Flow cytometry data from network taps provide valuable insight into biostability
- Seasonal variations were observed in biostability in both distribution systems
- Biostability is essential to supply safe, aesthetically pleasing drinking water

ID: 282 - MODELING TEMPERATURE FLUCTUATIONS DURING INTERMITTENT WATER USAGE WITHIN WATER SYSTEMS: WATER QUALITY IMPACT. Hatam F., Ortiz C., Grimard Conea M. and Prévost M.

- Temperature affects microbiological activities, but it is not the sole factor
- Simulated temperature and Legionella concentrations compared with field data
- Increased stagnation emphasizes nutrient limitation for Legionella prediction

## Session 3C (Room 4) – Water Distribution Network Planning and Management
## Chairman: Pérez Magrané R.

ID: 279 - EXPLORING THE EXTRACTION OF KNOWLEDGE FROM PREVIOUS LESSONS IN WATER DISTRIBUTION NETWORKS. DISRUPTIVE EVENTS. Ayala-Cabrera D., Francés-Chust J., Castro-Gama M. and Islam S.

- Increasing of water distribution systems' preparedness through lessons learned
- Exploring the potential causal relationships of incidents systems' attributes
- Spatial analysis for knowledge extraction from leak events

ID: 273 - WATERVERSE: STRATEGIES IN STAKEHOLDER ENGAGEMENT FOR DIGITALIZATION OF A WATER DATA MANAGEMENT ECOSYSTEM.* Torello M., Seshan S., van der Meulen S. and Vamvakeridou-Lyroudia L.

- Stakeholder engagement though a multi-stakeholder forum method developed
- Data management through the development of a Water Data Management Ecosystem
- Increased reliability of water treatment through chloride prediction models

ID: 22 - THE NEED FOR INTEGRATING GOVERNANCE, OPERATIONS, AND SOCIAL DYNAMICS INTO WATER SUPPLY/DISTRIBUTION MODELING. Ormsbee L., Byrne D. and Magliocca N.

- An integrated modeling framework for water utilities is proposed
- The framework integrates hydraulic, agent, and performance models
- Potential challenges and opportunities are explored

ID: 29 - EMPOWERING WATER ENGINEERS TO DEVELOP XR LEARNING APPLICATIONS WITH THE WATERLINE PROJECT. Lewis G., Johns M., Vamvakeridou-Lyroudia L., Chen A., Djordjević S. and Savic D.

- Combination of pedagogy and game design
- Incremental development
- Design thinking with multiple stakeholders

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## Session 3D (Room 5) – Transient Flow
## Chairman: Covas D.I.

ID: 66 - SENSOR PLACEMENT FOR HYDRAULIC TRANSIENT MONITORING AND LEAKAGE LOCALIZATION.* Souza R.G., Brentan B. and Meirelles G.

- Optimal sensor locations identified for effective monitoring
- Develops guidelines for valve maneuvers to enhance leak detection
- Employs hydraulic transient analysis for leak diagnostics

ID: 274 - INVESTIGATION OF PRESSURE SIGNAL AND LEAK DETECTION IN PIPES BY USING WAVELET TRANSFORM IN TRANSIENT FLOW.* Vafaei Rad N., Azizi Nadian H., Ranzi R., Rahmanshahi M. and Shafaei Bejestan M.

- Laboratory investigation for leak detection using transient flow
- Investigating the ability of Wavelet Transform for leak detection
- Effective performance of Haar wavelet for leak detection

ID: 172 - HYBRID TRANSIENT-MACHINE LEARNING METHODOLOGY FOR LEAK DETECTION IN WATER TRANSMISSION MAINS. Capponi C., Menapace A., Meniconi S., Dalla Torre D., Tavelli M., Righetti M. and Brunone B.

- Transient Test-Based Techniques can be boosted through ML signal processing
- The proposed approach paves the way for an on-demand diagnosis of water mains
- The preliminary results show a good potential in leak localization

ID: 193 - ALLIEVI AS A TOOL FOR SIMULATING HYDRAULIC TRANSIENTS IN ENERGY RECOVERY SYSTEMS. del Teso R., Gómez E., Estruch-Juan E. and Soriano J.

- ALLIEVI is a free software for the simulation of hydraulic transients
- Simulation of a PAT at the entrance of a water supply system with ALLIEVI
- Simulation of a power station equipped with four reversible groups

## Session 3E (Room 6) – Battle of Water Demand Forecasting
## Chairman: Salomons E.

ID: 120 - CASCADE MACHINE LEARNING APPROACH APPLIED TO SHORT TERM MEDIUM HORIZON DEMAND FORECASTING.* Brentan B., Zanfei A., Oberascher M., Sitzenfrei R., Izquierdo J. and Menapace A.

- Water demand forecasting using cascade machine learning
- LSTM applied to medium term short frequence demand and minimum night flow
- MLP applied to correct the forecasted demand bases on exogenous variables

ID: 264 - MACHINE LEARNING MODEL FOR BATTLE OF WATER DEMAND FORECASTING. Pagano M., Santonastaso G.F., Di Nardo A., Cuomo S. and Schiano Di Cola V.

- Extra trees algorithm
- Water demand forecasting
- Predictive modeling

ID: 217 - BATTLE OF WATER DEMAND FORECASTING: AN OPTIMISED DEEP LEARNING MODEL. Geranmehr M., Seyoum A.G. and Kalami Heris M.

- Development of an optimized LSTM network for water demand forecasting
- Utilization of PSO to optimize LSTM hyperparameters
- Application to real case study: Ten DMAs in a city in northeast Italy

ID: 39 - APPLICATION OF A NEURAL NETWORK MODEL TO SHORT-TERM WATER DEMAND FORECASTING.* Ayyash F., Hayslep M., Ko T., Kalumba M., Simukonda K. and Farmani R.

- The 9-layer CNN model predicts all hourly demand for the forecast week at once
- The CNN model uses a separate input layer for past and future timeseries data
- Hyperparameter tuning was conducted through Bayesian Optimization

## Session 3F (Room 7) – Industry Track
## Chairman: Cunha M.C.

ID: 213 - A NOVEL KPI FOR EFFICIENCY OF LEAKAGE MANAGEMENT IN THE ERA OF DIGITALIZATION. Giustolisi O. and Mazzolani G.

- A novel indicator named Asset Management Support Indicator (AMSI) is presented
- It is derived from advanced hydraulic modelling being consistent with hydraulics
- AMSI is rationale and physically based incorporating leakage modelling outcomes

ID: 272 - ENHANCING BUSINESS EFFICIENCY AND LEAKAGE CONTROL THROUGH COMPREHENSIVE DIGITALIZATION OF THE WATER SUPPLY SYSTEM: THE STUDY CASE OF SOGIP IN SICILY. Bettin A., Antronaco G. and Parisi D.

- To face requirements from Authority, water utilities must enhance efficiency
- SOGIP uses SWMS to integrate GIS, SCADA, AMR, hydraulic models
- SWMS platform allows on-line hydraulic simulations and leakage monitoring

ID: 182 - THE NEAR REAL-TIME DIGITAL TWIN OF THE WEST SICILY WATER TRANSMISSION MAINS OPERATED BY SICILIACQUE S.P.A. Gueli R., Sorce M., Cristaldi G., Marciante R., Borinato E., Spampinato E., Giandolfo R., Patatu V. and Raccuglia M.

- Full-scale digital twin modelling water, energy and control devices
- Near real-time simulation of plants' control and automation recipes
- Coupled water quality and energy control system fine-tuning

ID: 299 - ASSESSMENT OF THE IMPACT OF PIPES REHABILITATION ON WATER DISTRIBUTION NETWORK RELIABILITY.* Messa G., Laucelli D.B. , Spagnuolo S., Giustolisi O. and Laforgia D.

- Analysis of correlation between pipe rehabilitation and WDN reliability
- The optimal rehabilitation strategy based on pipe susceptibility to failure
- Possible advantages to WDN reliability of optimal pipes replacement plans

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## Session 4A (Room 2) – Design, Analysis and Modeling of Water Distribution Systems
## Chairman: Creaco E.

ID: 48 - ADVANCING WATER DISTRIBUTION NETWORK CALIBRATION: A FRAMEWORK FOR COMPARING STATIC AND MOBILE SENSING APPROACHES. Seyoum A.G., Tait S., Schellart A.N.A., Shepherd W. and Boxall J.

- A 24-hour single mobile sensor outperforms static sensors at nearly all nodes
- Mobile sensors have the potential to transform the accuracy of network models
- The developed static and mobile sensing algorithms are generic and consistent

ID: 270 - PRESSURE SENSOR PLACEMENT FOR PIPE ROUGHNESS CALIBRATION BASED ON GRAPH-BASED SURROGATE MODEL COUPLED WITH GENETIC ALGORITHM.* Rajabi M., Hajibabaei M., Tabesh M. and Sitzenfrei R.

- Implementing a graph theory metric as a criterion for pressure sensor placement
- Utilizing a hydraulically inspired graph to mimic the hydraulics of the model
- Coupling NSGA-II with graph theory to find the critical pipes

ID: 192 - PARAMETER ESTIMATION IN WATER DISTRIBUTION NETWORKS USING AN ERROR-IN-VARIABLES APPROACH. Rahman E., Parthasarathy S.S., Venkataramanan A., Prasath S.H.R., Mathiazhagan R. and Narasimhan S.

- Using error-in-variable technique to tackle challenges in nonlinear regression
- Estimating minor and major loss coefficients crucial for accurate modeling
- Refining flow rate errors iteratively for utmost accuracy in computation

## Session 4B (Room 3) – Water Quality
## Chairman: Speight V.

ID: 251 - EXAMINING THE EFFECT OF SMALL-AMPLITUDE TRANSIENTS ON BACTERIAL COMMUNITY COMPOSITION IN WATER DISTRIBUTION PIPES.* Sass Braga A., de Souza Parra Agostinho M., Anderson B., Filion Y. and Vicente Scapulatempo Fernandes C.

- Biofilms in water pipes grew over 28 days in a lab-scale system
- Bacterial community composition was assessed from pipe walls
- Bacterial diversity in biofilms increased, forming a multifunctional community

ID: 252 - EXAMINING THE EFFECT OF SMALL-AMPLITUDE TRANSIENTS ON SHEAR STRENGTH OF BIOFILMS IN WATER DISTRIBUTION PIPES.* de Souza Parra Agostinho M., Sass Braga A., Anderson B., Filion Y. and Vicente Scapulatempo Fernandes C.

- Biofilms in water pipes grew over 28 days in a lab-scale system
- Assessed biofilm cell density on pipes and bulk water concentration
- Biofilms adapt to shear stress, affecting water quality

ID: 248 - EXAMINING THE EFFECT OF SMALL-AMPLITUDE TRANSIENTS ON BIOFILM DEVELOPMENT IN WATER DISTRIBUTION PIPES.* de Souza Parra Agostinho M., Sass Braga A., Anderson B., Filion Y. and Vicente Scapulatempo Fernandes C.

- 28-day dual-phase pipe loop experiment
- Steady vs. transient conditions compared
- Transients condition stronger biofilm adherence

## Session 4C (Room 4) – Leak and Burst Management
## Chairman: Steffelbauer D.

ID: 185 - IOLE – HUMAN-CENTERED SOFTWARE DESIGN FOR LEAKAGE DETECTION IN WATER DISTRIBUTION NETWORKS. Daniel I., Steffelbauer D., Steins E., Schorr J., Persigehl S., Campbell E., Koslowski J., Kley-Holsteg J., Lindemann B. and Cominola A.

- IOLE develops industry-ready digital leakage detection technology
- Robustness and human-centered design are considered to achieve user acceptance
- We survey and integrate all relevant stakeholders through workshops

ID: 283 - LEAK LOCALIZATION USING AUTOENCODERS AND SHAPLEY VALUES.* Mohan Doss P., Møller Rokstad M. and Tscheikner-Gratl F.

- Proposed an explainable machine learning model for preliminary leak localization
- Abrupt leaks can be localized within 100m radius using this technique
- Comparable performance for incipient leaks attained for higher leak flow rates

ID: 212 - EXPERIMENTAL VALIDATION OF GRAPH THEORY BASED LEAK DETECTION ALGORITHMS.* Saboo L., Subhashree B., Raphael R., Prasath S.H.R. and Narasimhan S.

- Graph Theory Based Leak Detection
- Reconfigurable Testbed for Control and Operation of WDN
- One-sided hypothesis test

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## Session 4D (Room 5) – Drainage and Sewer Systems
## Chairman: Taormina R.

ID: 53 - DEVELOPING A FRAMEWORK FOR SMART STORMWATER MANAGEMENT IN TALLINN, ESTONIA. Suits K., Vassiljev A., Kaur K., Kõiv K., Kändler N. and Annus I.

- Digital solutions proposed in EU water legislation may be difficult to implement
- A framework was proposed to assess stormwater managers' digitalization needs
- Framework will be tested in Estonia to showcase its applicability elsewhere

ID: 69 - SMART NATURE-BASED SOLUTIONS FOR STORMWATER MANAGEMENT IN URBAN AREAS - ANALYSIS OF PILOT CASES.* Kõiv K., Annus I., Kändler N., Truu M., Kaur K. and Suits K.

- Valuation of NBS benefits requires extensive knowledge and specific methods
- NBS with sensors can help reduce flooding and control pollution
- By valuing the benefits of NBS, it is easier to give them a monetary value

ID: 179 - DATA ANALYSIS TO ASSESS AND IMPROVE THE OPERATION OF COMBINED SEWER OVERFLOW STRUCTURES WITH STATIC OPTIMISATION. Sedki K., Brüning Y. and Dittmer U.

- Meta information of CSO structures is gathered from water level measurements
- Efficiency parameters were developed for volume usage of CSO structures
- An evolutionary algorithm was applied to optimize assessed continuation flows

## Session 4E (Room 6) – Battle of Water Demand Forecasting
## Chairman: Marsili V.

ID: 250 - BATTLE OF WATER DEMAND FORECASTING: INTEGRATING MACHINE LEARNING WITH A HEURISTIC POST PROCESS FOR SHORT TERM PREDICTION OF URBAN WATER DEMAND. Sinske A., de Klerk A. and van Heerden A.

- Focus on methodologies for limited data and resources in the developing world
- Test viability and discard non-essential exogenous parameters for forecasting
- Combining heuristic and statistical algorithms to produce satisfactory results

ID: 293 - ENHANCING WATER DEMAND FORECASTING: LEVERAGING LSTM NETWORKS FOR ACCURATE PREDICTIONS.* Boloukasli Ahmadgourabi F., Khashei Varnamkhasti M., Nosrati Habibi M., Hedaiaty Marzouny N. and Dziedzic R.

- Sinusoidal & cosine transformations used to model seasonal variations
- LSTM models show versatility across varied DMA types and demands
- Optimal LSTM setup defined for each DMA by testing on last week of data

ID: 154 - HARNESSING THE POWER OF RANDOM FOREST FOR PRECISE SHORT-TERM WATER DEMAND FORECASTING IN ITALIAN WATER DISTRICTS.* Kulaczkowski A. and Lee J.

- Random Forest is utilized as a versatile algorithm for water demand forecasting
- missForest was utilized for nonparametric missing value imputations
- Numerical and graphical outputs support model prediction performance

## Session 4F (Room 7) – Industry Track
## Chairman: Arandia E.

ID: 68 - APPLICATION OF E-FAVOR APPROACH TO WATER LEAK DETECTION IN ST SERVAIS CENTRE DMA – A FEASIBILITY STUDY. Beaujean P., Ulanicki B. and Diao K.

- Placement of 55 Hydroko meters in the St Servais Center DMA
- Investigating sensitivity of the approach using synthetic data
- Performing field experiment and evaluating the results

ID: 161 - LEVERAGING SCADA DATA TO ESTIMATE PUMP HEAD AND EFFICIENCY CURVES IN PUMP FACILITY MANAGEMENT. Berizzi P., Uber J. and Rensenhouse S.

- Use widely available SCADA data to generate a set of pump performance indicators
- Curve fitting algorithm to determine individual pump head and efficiency curves
- Algorithm is put into action across 137 pumps in the SNWA

ID: 196 - DECISION SUPPORT SYSTEM FOR CRITICAL INFRASTRUCTURE 2050 (BOS MODEL). Castro-Gama M., Hassink-Mulder Y. and Kloosterman R.

- A decision support system for large infrastructure
- Long-term vision planning via scenario computation under uncertainty
- Visual analytics of alternatives with KPI's selected by Vitens' stakeholders

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## Session 5A (Room 2) – Design, Analysis and Modeling of Water Distribution Systems
## Chairman: Deuerlein J.

ID: 298 - A HYBRID MODELLING FOR BOTH PRESSURE DEPENDENT AND VOLUME-BASED DEMAND IN PRESSURE-DRIVEN ANALYSIS. Muranho J., Sousa J., Ferreira A., Sá Marques A. and Gomes A.

- New modelling approach combining volume-based and pressure-dependent demands
- Nodal demands individually classified as demand-driven or pressure-driven
- The new approach has implemented in WaterNetGen – an EPANET extension

ID: 259 - MODELLING VARIABLE SPEED PUMPS FOR FLOW AND PRESSURE CONTROL USING NASH EQUILIBRIUM. Deuerlein J.W., Elhay S., Piller O., Fischer M. and Simpson A.R.

- Positive lower flow bounds used to model flow-controlled variable speed pumps
- Nash Equilibrium used to model pressure-controlled variable speed pumps
- Heuristics are unnecessary in both cases

ID: 123 - AN ANALYTICAL SOLUTION FOR THE HYDRAULICS OF LOOPED PIPE NETWORKS. Riyahi M.M., Bakhshipour A.E., Giudicianni C., Dittmer U., Haghighi A. and Creaco E.

- Developing a new method for analytically solving the hydraulics of WDNs
- Developing a new algorithm to detect flow directions
- Using three categories of WDNs to validate the proposed method and algorithm

ID: 231 - FAST FIREFIGHTING WATER CAPACITY ASSESSMENT USING A STREAMLINED SINGLE-LOOP HYBRID SEARCH. Hernández F.

- Method gave firefighting capacity estimates with huge accuracy improvements
- Computation time was more than 3x as fast compared to legacy methods
- Tests showed need to try various potential critical constraints simultaneously

ID: 180 - FIRST AND SECOND ORDER SENSITIVITIES OF STEADY-STATE SOLUTIONS TO WATER DISTRIBUTION SYSTEMS. Piller O., Elhay S., Deuerlein J. and Simpson A.

- First time, formulae are given for second order flow and head sensitivities
- Same generic, conservative-form system for flow and head quantities
- Low-cost improved second order estimates by using Taylor series

ID: 126 - APPLICATION OF FEEDFORWARD ARTIFICIAL NEURAL NETWORKS TO PREDICT THE HYDRAULIC STATE OF A WATER DISTRIBUTION NETWORK. Evangelista L., Móller D., Brentan B. and Meirelles G.

- Predicting the operational status of a water distribution network
- Creation of a database for training a feedforward artificial neural network
- Forecasting energy consumption, tank levels, node pressures and minimum pressure

## Session 5B (Room 3) – Water Quality
## Chairman: Boccelli D.

ID: 7 - A DATA-DRIVEN ANALYSIS FOR UNDERSTANDING AND RISK ESTIMATION OF DISCOLOURATION IN DRINKING WATER DISTRIBUTION SYSTEMS. Kyritsakas G., Husband S., Gleeson K., Boxall J. and Flavell K.

- A big data analysis for understanding and estimating the risk of discolouration
- Analysis combines complex network theory metrics with water quality data
- Analysis outputs informed the water utility for a pro-active management

ID: 12 - IDENTIFYING HYDRAULIC CONDITIONS FOR DISCOLOURATION MATERIAL ACCUMULATION.* Lokk R., Boxall J. and Husband S.

- Discolouration material accumulation was studied using full scale pipe loop
- Results indicate that at above 1.25 L/s (0.25 m/s, 0.213 N/m2) behaviour changed
- This suggests a shift from sedimentation to cohesive layers as dominant process

ID: 54 - THE IMPACTS OF CHLORINE AND CHLORAMINE ON BIOFILMS AND DISCOLOURATION WITHIN OPERATIONAL DRINKING WATER DISTRIBUTION SYSTEMS.* Rogers J., Speight V., Fish K., Moore G. and Boxall J.

- First time biofilms have been grown/analysed in pipe loops at the end of DWDS
- A chloramine residual does not restrict biofilm growth
- Chloramine biofilms may present a greater discolouration risk

ID: 86 - INCORPORATION AND MOBILISATION OF HEALTH-RELATED ORGANISMS FROM WITHIN DRINKING WATER BIOFILM. Park J., Pick F., Fish K., Quinn D., Smith C., Speight V. and Boxall J.

- Coliform incorporation within biofilms was only observed in post 24 hrs spike
- Coliforms in bulk water were reduced due to stress, such as nutrient starvation
- Young biofilm did not mobilise during flushing and coliform was not detected

ID: 160 - MODELLING THE DYNAMICS OF P. AERUGINOSA IN THE FORMATION OF BIOFILMS.* Bhandari D., Quinn D., Tsagkari E., Fish K., Pick F.C., Boxall J., Smith C., You S. and Sloan W.

- Buckingham-Pi theorem for the simulation of flux of and reflux of P. aeruginosa
- Two-phase model to assess the dynamics of bacterial transmission within systems
- Effect of shear velocity on the recombination of weakly adherent bacteria

ID: 187 - PSEUDOMONAS AERUGINOSA INTERACTIONS WITH DRINKING WATER BIOFILM AFTER AN ACUTE SPIKE IN ANNULAR BIOREACTORS – ATTACHMENT, PERSISTENCE, RELEASE AND RE-ATTACHMENT. Quinn D., Tsagkari E., Bhandari D.S., Fish K., You S., Sloan W., Boxall J. and Smith C.

- P. aeruginosa is capable of swift attachment to surfaces under DWDS conditions
- P. aeruginosa can persist on surfaces for up to 14 days following contamination
- P. aeruginosa can detach, mobilise and reattach to surfaces under shear stress

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## Session 5C (Room 4) – Leak and Burst Management
## Chairman: Savic D.

ID: 157 - UTILIZING CALIBRATION MODEL FOR WATER DISTRIBUTION NETWORK LEAKAGE DETECTION.* Shin G., Kwon S.H., Lim S. and Lee S.

- Method for calibration of hydraulic models and leak detection in water networks
- Confirmed hypothesis: pipe roughness coefficients vary post-leak events
- Real-time leak detection's potential for maintaining current hydraulic models

ID: 165 - REAL-TIME BURST LOCALIZATION IN COMPLEX WATER TRANSMISSION LINES USING HYDRAULIC GRADIENT ANALYSIS. Ko T., Farmani R., Keedwell E. and Wan X.

- Real-time burst localization using hydraulic gradient analysis
- Swift burst response by integrating historical data with DNN
- Cost-effective, segment-based burst localization improves management

ID: 195 - A NOVEL MULTI-STEP FORECASTING-BASED APPROACH FOR ENHANCED BURST DETECTION IN WATER DISTRIBUTION SYSTEMS.* Wan X., Farmani R., Keedwell E. and Zhou X.

- Propose a new burst detection method based on prediction model
- Propose a new metric to evaluate the abnormality of data pattern
- The results of both synthetic and real datasets show great improvement

ID: 227 - THE DUAL MODEL UNDER PRESSURE: HOW ROBUST IS LEAK DETECTION UNDER UNCERTAINTIES AND MODEL-MISMATCHES. Campbell E., Abraham E., Koslowski J., Piller O.and Steffelbauer D.B.

- Initial insights into the robustness of the leak-duality method are presented
- The method is highly sensitive to perturbation of roughness and based demand
- Reduced number of sensors decreases performance. Topology minor changes do not

ID: 266 - SENSITIVITY MATRIX ANALYSIS FOR LEAK DETECTION IN WATER DISTRIBUTION NETWORKS.* Jun S., Jung D. and Lansey K.E.

- Sensitivity matrix heatmaps are generated for pressure sensor placement
- The heatmaps demonstrate the density of sensors needed for leak detection
- Detection coverage overlaps between sensors are minimized using the heatmaps

ID: 77 - THREE-DIMENSIONAL CONVOLUTIONAL NEURAL NETWORK FOR LEAK DETECTION AND LOCALIZATION IN WATER DISTRIBUTION NETWORKS.* Jun S., Jung D. and Lansey K.E.

- The benefits of using AMI data for leak detection and localization
- Analysis of temporally and spatially distributed pressures using 3D CNN
- Advantages of using deep learning models over optimization algorithms

## Session 5D (Room 5) – Drainage and Sewer Systems
## Chairman: Piro P.

ID: 203 - ACCELERATING URBAN DRAINAGE SIMULATIONS: A DATA-EFFICIENT GNN METAMODEL FOR SWMM FLOWRATES.* Garzón A., Kapelan Z., Langeveld J. and Taormina R.

- We used transfer learning for developing a GNN-based metamodel of SWMM flowrates
- The GNN metamodel is highly accurate with an overall RMSE of 0.1 cms
- The GNN metamodel is 7 times faster per simulation than SWMM

ID: 28 - A QUALITATIVE APPROACH TO COMBINED SEWER OVERFLOW (CSO) MODELLING ON THE WATERVERSE PROJECT. Lewis G., Evans B., Vamvakeridou-Lyroudia L., Chen A. and Djordjević S. and Savic D.

- Development of a qualitative model of quality
- Industrial and academic research
- Tackling combined sewer overflows

ID: 26 - EVALUATING PIPE BURSTS FLOODING IMPACTS IN URBAN ENVIRONMENTS USING A HAZARD-VULNERABILITY-RISK APPROACH. Paez D. and Shen H.

- A Hazard-Vulnerability-Risk approach is used to assess impacts of pipe bursts
- 2D Modelling is used to model the urban overland flooding for all scenarios
- Pipe breaks are modelled in EPANET with arrangement of pipes, CVs, and emitters

ID: 290 - CFD ANALYSIS OF AN INNOVATIVE MULTI-PURPOSE GREEN ROOF.* Naghib S.N., Pirouz B., Javadi Nejad H., Turco M., Palermo S.A. and Piro P.

- CFD simulation of a novel multi-purpose green roof system
- Retention capacity depends not only on the soil media but also on the filter
- Numerical errors minimize by adaptive consideration of the parameters

ID: 103 - LARGE-SCALE REAL-TIME HYDRAULIC AND QUALITY MODEL OF COMBINED SEWER NETWORK – CASE STUDY IN HELSINKI, FINLAND. Sunela M., Almeida P., Riihinen H. and Björninen H.

- Tool for hydraulic, hydrologic and quality real-time sewer models was developed
- Real-time model is used for analysing and reporting CSO loads, and in operations
- Future goals include forecasting and opening results for relevant stakeholders

ID: 218 - IMPROVING THE PERFORMANCE OF BAYESIAN DECISION NETWORKS FOR WATER QUALITY SENSORS DEPLOYMENT IN UDNs THROUGH A REDUCED SEARCH DOMAIN. Sambito M. and Simone A.

- A two-step procedure for the planning of a monitoring system for UDNs
- The topology-based approach improves the results of the Bayesian model
- High contamination interception percentages for the nodes are identified

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## Session 5E (Room 6) – Battle of Water Demand Forecasting
## Chairman: Ostfeld A.

ID: 156 - INTERPRETABLE AI FOR SHORT-TERM WATER DEMAND FORECASTING. Ulusoy A.-J., Jara-Arriagada C., Liu Y., Jenks B. and Stoianov I.

- Application of interpretable decision tree method for water demand forecasting
- Predictive performance comparable with off-the-shelf time series models
- Computational efficiency compatible with near real-time demand forecasting

ID: 109 - URBAN WATER DEMAND FORECASTING USING DEEPAR-MODELS AS PART OF THE BATTLE OF WATER DEMAND FORECASTING (BWDF).* Wunsch A., Kühnert C., Wallner S. and Ziebarth M.

- Short-term hourly water demand forecasting with DeepAR models
- Flow data, weather data, weather and date features serve as inputs
- High-performing models do not necessarily perform similarly after re-training

ID: 36 - OPTIMIZING TIME SERIES MODELS FOR WATER DEMAND FORECASTING. Perelman G., Romano Y. and Ostfeld A.

- Optimized time series models boost accuracy in water demand forecasting
- The method is based on multi-model architecture and novel normalization methods
- Extensive experiments refine model configurations to better accuracy

ID: 74 - SHORT-TERM URBAN WATER DEMAND FORECASTING USING AN IMPROVED NEURALPROPHET MODEL. Yao Y., Liu H., Gao F., Guo H. and Zou J.

- Optimize the input factors of the model future regression
- Improve the interpretability of the water demand forecasting methodology
- Simple and easy to use models for practical water supply scheduling

ID: 267 - WATER DEMAND FORECASTING WITH MULTIOBJECTIVE COMPUTATIONAL INTELLIGENCE. Reynoso Meza G. and Carreño Alvarado E.P.

- Multiobjective proposal for the Battle of Water Demand Forecasting
- Two step forecasting model: Time series and Weather information
- Baseline solution improved with the proposed approach

ID: 91 - A METHODOLOGY FOR FORECASTING DEMANDS IN A WATER DISTRIBUTION NETWORK BASED ON THE CLASSICAL AND NEURAL NETWORKS APPROACH.* Coy Y., González L., Basto L., Rodriguez V., Gómez S., Perafán J., Cardona S., Tabares A. and Saldarriaga J.

- New 3-step water forecast method, using a Long Short-Term Memory (LSTM) model
- Artificial Intelligence and engineering for water management
- Accurate DMA demand prediction

## Session 5F (Room 7) – Industry Track
## Chairman: Righetti M.

ID: 16 - HOMEWATERLAB: A VERSATILE PLAYGROUND TO INVESTIGATE PHENOMENA IN RESIDENTIAL PREMISE PLUMBING SYSTEMS. Dash A., van Summeren J. and Blokker M.

- HomeWaterLab is an experimental facility mimicking a typical premise plumbing
- Versatile setup for investigation of physical, chemical, biological processes
- Defining research collaborations with HomeWaterLab is ongoing

ID: 144 - CRITICAL SCENARIOS OF FUTURE DEMAND FOR THE ROBUST DESIGN OF WATER DISTRIBUTION NETWORKS. Magini R., Ridolfi E., Marques J. and Cunha M.C.

- Demand is the main source of uncertainty for sizing water distribution networks
- An entropy-based approach to select critical nodes for changes in future demand
- “Scenario uncertainty” of demand for a more robust water distribution network

ID: 211 - A NOVEL MULTI-DEMAND MODELING FRAMEWORK FOR WATER DISTRIBUTION NETWORKS USING SMART METERING DATA AT END-USERS. Ciliberti F.G., Berardi L., Mazzolani G. and Giustolisi O.

- Smart metering drives WDN digital transformation
- Consumer data enhances hydraulic model accuracy
- Study bridges gap between WDN models and practice

ID: 243 - RESIDENTIAL AND NON-RESIDENTIAL WATER-CONSUMPTION PATTERN INVESTIGATION THROUGH HOURLY SMART-METER READING ARCHITECTURE. Pelati S., Micai V., Paviato A., Mazzoni F., Marsili V., Alvisi S. and Franchini M.

- Water-consumption analysis based on smart-meter data from nearly 1,000 users
- Seasonal, weekly, and daily water-consumption pattern definition
- Accurate leakage quantification through water balance based on data collected

ID: 249 - INTEGRATING MACHINE LEARNING WITH TRADITIONAL METHODS FOR WATER DEMAND FORECASTING OF WATER DISTRIBUTION NETWORKS. Sinske A., van Heerden A. and de Klerk A.

- GLS Swift™ tool provides valuable tool to clean monthly water consumption data
- GLS Forecast™ provides excellent ML tool to predict urban water demands trends
- Visualise trend comparisons at different aggregation levels & demand units

ID: 229 - DIGITALIZATION AND NRW REDUCTION: LESSONS LEARNT IN ITALY WITH THE RECOVERY PLAN FUNDED BY EU. Fantozzi M., Gaccione A. and Sainz L. and Gambardella A.

- Leakage reduction in water distribution networks
- International best practices for NRW management
- Smart water networks and training of utility staff

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## Session 6A (Room 2) – Design, Analysis and Modeling of Water Distribution Systems
## Chairman: Laucelli D.

ID: 263 - SENSOR PLACEMENT AND STATE ESTIMATION IN WATER DISTRIBUTION SYSTEMS USING EDGE GAUSSIAN PROCESSES. Kerimov B., Pons V., Pritsis S., Taormina R. and Tscheikner-Gratl F.

- Gaussian Processes with topological kernels enable accurate modeling of flows
- The model provides uncertainty bounds for estimated flowrate
- The uncertainty bounds serve as an indicator for sensor allocation algorithm

ID: 94 - EMPLOYING EXTENDED KALMAN FILTER FOR FAULTY SENSOR DETECTION IN WATER DISTRIBUTION SYSTEMS. Huang Y., Thomas M., Bartos M. and Sela L.

- EKF is used to estimate pressure at ungauged locations
- Relying on sensor data is critical for making operational decisions
- The masking approach coupled with EKF identifies sensor reliability

ID: 177 - OPTIMAL SENSOR PLACEMENT IN WATER DISTRIBUTION NETWORKS USING DYNAMIC PREDICTION GRAPH NEURAL NETWORKS.* Salem A. and Abokifa A.

- Integrating a DP-GNN model with GA presents a SPO framework
- Fewer strategically placed sensors could outperform a larger set of sensors
- SPO becomes particularly vital in scenarios with a limited number of sensors

ID: 269 - INVESTIGATING THE EFFICACY OF TOPOLOGICAL METHODS FOR OPTIMAL SENSOR PLACEMENT IN WATER DISTRIBUTION SYSTEMS.* Palma L., Di Nardo A., Hatam F., Santonastaso G.F. and Prévost M.

- Topological approach for sensor placement in water distribution network
- Water distribution network represented as weighted and unweighted graphs
- Evaluation of sensor systems effectiveness in detecting simulated contaminations

ID: 149 - SENSOR PLACEMENT FOR RUPTURES DETECTION USING CONTINUOUS MONITORING STRATEGY.* Batzella E., Ferrarese G. and Malavasi S.

- Ruptures localisation in water distribution networks using pressure sensors
- Cross-correlation of pressure measurements for ruptures localization
- Analysis of instrument sensitivity effect on ruptures localization

ID: 118 - ANOMALY LOCALIZATION BY APPLYING DATA-DRIVEN ANALYSIS AND PARALLEL OPTIMIZATION OF HYDRAULIC MODEL CALIBRATION. Zhang A.H., Cao F., Chew A.W., Wu Z.Y., Kalfarisi R., Meng X., Pok J., Wong J.M., Lai K.C., Seow L. and Wong J.J.

- An integrated approach was developed to localize leaks in water networks
- The approach uses both data-driven and model-based methods
- The integrated approach has been used for near real-time operation

## Session 6B (Room 3) – Water Quality
## Chairman: Cominola A.

ID: 87 - RESIDUAL CHLORINE MODELING SENSITIVITY TO DIFFERENT DECAY MODELS IN OPTIMIZED AND NON-OPTIMIZED WATER DISTRIBUTION NETWORKS. Serrano S., González L., Rodriguez V. and Saldarriaga J.

- OPUS systematically assess and optimize energy flow within the network
- Bulk chlorine consumption can be similar predicted by 2R and first-order models
- Wall decay varies depending on the model used, whatever network topology or cost

ID: 301 - EVALUATION OF CHLORINE DATA FROM ONLINE SENSORS IN A WATER SUPPLY NETWORK. Aisopou A. and Stoianov I.

- First large-scale, long-term experiment collecting continuous water quality data
- Online sensors offer unique insights into water quality dynamics
- Installation conditions significantly affect electrochemical sensor performance

ID: 152 - HYBRID CHEMICAL AND DATA-DRIVEN MODEL FOR STIFF CHEMICAL KINETICS USING A PHYSICS INFORMED NEURAL NETWORK. Frankel M., De Florio M., Schiassi E. and Sela L.

- Hybrid chemical and data-driven model to improve water quality modeling
- PINN model utilizes imperfect reactions and incomplete data
- Accurately predicting concentrations of holdout chemical species

ID: 244 - PHYSICS-INFORMED MACHINE LEARNING FOR UNIVERSAL SURROGATE MODELLING OF WATER QUALITY PARAMETERS IN WATER DISTRIBUTION NETWORKS. Daniel I., Abhijith G.R., Kutz J.N., Ostfeld A. and Cominola A.

- We present the idea for a universal surrogate model to predict water quality
- The problem of water quality dynamics is reduced to the pipe level
- We adapt the idea of meta-parameterized ANNs to account for variable conditions

ID: 151 - WATER QUALITY MODELING IN WATER DISTRIBUTION SYSTEMS: PILOT-SCALE MEASUREMENTS AND SIMULATION. Hős C., Medve D., Taczman-Brückner A. and Kiskó G.

- A pilot-scaled test rig was built to study the dynamics of biomass in WDS
- Biomass concentrations are reported over a 18-week-long measurement
- Parameters of mathematical models for biomass prediction are identified

ID: 111 - A COMPREHENSIVE VIRTUAL TESTBED FOR MODELLING DISINFECTION BY PRODUCTS FORMATIONS IN WATER DISTRIBUTION NETWORKS. Pavlou P., Kyriakou M., Vrachimis S. and Eliades D.

- A virtual testbed to simulate Disinfection By-Products (DBPs) in water networks
- Various reaction models can be used under different uncertainty scenarios
- Scenarios are evaluated collectively to assess the impact of DBPs

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## Session 6C (Room 4) – Leak and Burst Management
## Chairman: Meniconi S.

ID: 247 - USING ACOUSTIC VELOCITY VECTOR TO ASSESS THE CONDITION OF BURIED WATER PIPES.* Watts J., Johnson M.-D. and Horoshenkov K.

- Novel acoustic sensor
- Defect detection in pipes
- Acceleration based sensor

ID: 191 - 3D RECONSTRUCTION OF WATER LEAKS IN WATER DISTRIBUTION NETWORKS FROM GPR IMAGES BY EXPLORING NEW INFLUENCING FACTORS WITH MULTI-AGENT AND INTELLIGENT DATA ANALYSIS.* Islam S. and Ayala-Cabrera D.

- Uses of intelligent tools to analyse and detect water leaks in buried pipes
- Exploring new factors that influences automatic GPR image interpretation
- WDNs' health assets assessment by 3D visualisations from non-destructive methods

ID: 89 - WATER LEAKAGES PRE-LOCALIZATION IN DRINKING WATER NETWORKS VIA THE COSMIC-RAY NEUTRON SENSING TECHNIQUE. Morselli L., Lorenzi F., Basso A. and Stevanato L.

- The proposal of a novel method for water leak detection based on CRNS method
- The use of unsupervised learning for anomaly detection based on CRNS data
- Description of an experimental campaign highlighting proposed method performance

ID: 256 - A PARAMETRIC EVALUATION OF LEAKAGES IN WATER DISTRIBUTION NETWORKS.* Darvini G., Gambadori M. and Soldini L.

- An extensive laboratory investigation was carried out for WDS leakage evaluation
- Test data were analyzed by EPR method to detect factors affecting leakages
- Leakage prediction models obtained by EPR method can support the WDS management

ID: 100 - FULL-SCALE WATER SUPPLY SYSTEM PIPE BURST ANALYSIS METHOD AND APPLICATION IN CASE-STUDIES. Sunela M., Väyrynen J. and Rantala L.

- A tool for analysing effects of pipe bursts, based on EPANET, was developed
- Method was applied to four large Finnish water supply systems
- Pipe properties don't correlate with the number of people suffering from burst

ID: 52 - ESTIMATING THE RISK OF FAILURE AND DETERIORATION LEVEL OF WATER PIPES USING LOCAL GIS DATA OF A WATER PIPE NETWORK IN SOUTH KOREA. Park S., Oh C.H., Kim K. and Kang M.

- Evaluated the maintenance priorities of the water pipes
- Considered deterioration and risk of pipe failure
- Scale, cost, and duration of damage were considered in risk calculation

## Session 6D (Room 5) – Drainage and Sewer Systems
## Chairman: Sansalone J.

ID: 287 - IMPACT OF INFILTRATION SYSTEMS ON ILLICIT WATERS IN SEWER NETWORKS. Raimondi A., Casari T. and Sanfilippo U.

- Infiltration systems can cause illicit flow in sewers due to deterioration
- A model to evaluate infiltrations due to nature-based solutions is proposed
- Infiltration rates mainly depend on groundwater level, and rainfall intensity

ID: 138 – TOWARDS A CONSISTENT CLASSIFICATION SYSTEM FOR CONDITION ASSESSMENT OF DRAINAGE PIPES. Tizmaghz Z., van Zyl K. and Henning T.

- Currently no uniformly accepted classification system exists for drainage pipes
- A consistent classification system is described and motivated
- It will allow different studies to be coherently interpreted and compared

ID: 139 - EXPERIMENTAL STUDY ON THE HYDRAULIC IMPACT OF DISCRETE TOP BLOCKAGES IN GRAVITY SEWERS. Gong J., Sim J., Rousso B., Chua L. and Thomas M.

- Discrete top blockages were simulated in an experimental gravity sewer system
- Flow depths measured upstream of the blockage were compared with the literature
- The energy losses caused by discrete top blockages can be significant

ID: 162 - A HYBRID GRAPH HYDRODYNAMIC METHOD FOR MODELLING MULTIPLE PIPE FAILURE IN STORMWATER NETWORKS.* Dastgir A., Satish R., Hajibabaei M., Oberascher M. and Sitzenfrei R.

- A hybrid method is developed for modelling multiple pipe failure scenarios
- The methodology combines the advantages of both graph and hydrodynamic models
- The methodology can identify critical pipe combinations efficiently

ID: 240 - INTERPRETABLE SEWER DEFECT DETECTION WITH LARGE MULTIMODAL MODELS. Taormina R. and van der Werf J.A.

- We present tools for Sewer Defect Detection based on Large Multimodal Models
- The approach yields predictions coupled with human intelligible explanations
- Detection performance trails specialized models, but results are encouraging

ID: 164 - URBAN DRAINAGE MODELLING FOR THE DESIGN OF TREATMENT TECHNOLOGIES. Evangelisti M., Di Federico V. and Maglionico M.

- StopUP minimizes urban runoff pollution via monitoring & innovative treatments
- Italian case study focuses on the main CSO of Bologna sewer network
- Hydraulic model calibration quantifies pollutant load & assesses treatment

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## Session 6E (Room 6) – Battle of Water Demand Forecasting
## Chairman: Saldarriaga J.

ID: 197 - PROBABILISTIC FORECASTING OF HOURLY WATER DEMAND. Kossieris P., Tsoukalas I., Nikolopoulos D., Moraitis G. and Makropoulos C.

- General framework for probabilistic water demand predictions
- Training of 2 machine-learning models for hourly water demand
- The framework quantifies predictive uncertainty in deterministic models

ID: 258 - FROM DETERMINISTIC TO PROBABILISTIC FORECASTS OF WATER DEMAND.* Gabriele A., Biondi D., Gargano R. and Todini E.

- MCP integrated with NN models improves accuracy, even limiting to median values
- MCP approach provide confidence bands, improving uncertainty understanding
- Real-time applications benefit from predictive density, aiding decision-making

ID: 257 - A WEEK AHEAD WATER DEMAND FORECASTING USING CONVOLUTIONAL NEURAL NETWORK ON MULTI-CHANNEL WAVELET SCALOGRAM.* Ramachandran A., Mousa H., Maier A. and Bayer S.

- Evaluate the use of time-frequency encoding of water demand data for forecasting
- Assess deep learning models' forecasting performance across diverse time series
- Examine self-attention to capture feature importance among relevant inputs

ID: 98 - A STUDY ON SHORT-TERM WATER DEMAND FORECASTING USING STATISTICAL TECHNIQUES. Yu J., Bae H., Kang M.-S., Kim K.-J. and Jang I.-S.

- Water demand forecasting method combining statistical techniques is proposed
- The proposed method is for weekly water demand forecasts
- The proposed method is applied to urban hourly water demand dataset

ID: 233 - OPTIMIZING SHORT-TERM WATER DEMAND FORECASTING: A COMPARATIVE APPROACH WITHIN THE BATTLE OF WATER DEMAND FORECASTING. Ferreira B., Barreira R., Caetano J., Quarta M. and Carriço N.

- Five distinct techniques are considered for forecasting
- Automated parameter tuning and model selection are achieved by hindcasting
- No single technique is optimal for every possible situation

ID: 297 - WATER DEMAND FORECAST USING GENERALIZED AUTOREGRESSIVE MOVING AVERAGE MODELS. Gamboa-Medina M.M. and Campos F.

- First use of the GARMA probability model with water demand data
- Fourier series inclusion for known seasonality
- Fast and flexible method, easily retrained for different data sets

## Session 6F (Room 7) – Industry Track
## Chairman: Kapelan Z.

ID: 116 - MODELLING CHLORINE DECAY IN A COMPLEX, MULTIPLE-SOURCE WATER DISTRIBUTION NETWORK MANAGED BY ACEGASAPSAMGA.* Zaghini A., Gagliardi F., Marsili V., Mazzoni F., Tirello L., Rubin A., Nicoletto C., Alvisi S. and Franchini M.

- Pragmatic approach for chlorine decay modelling in water distribution networks
- Interval-number-based method for the characterization of reaction rates
- Chlorine-decay modelling in multi-inlet networks based on trace analysis

ID: 206 - USING SYMBOLIC MACHINE LEARNING TO MODEL CHLORINE DECAY IN A LARGE-SCALE WATER DISTRIBUTION NETWORK.* Enriquez L., Saldarriaga J., Berardi L., Laucelli D. and Ariza A.

- Chlorine decay is modelled in a large-scale water distribution network
- The approach for water quality modelling is symbolic machine learning
- The results show high accuracy for first and second order kinetics

ID: 127 - PERFORMANCE INDICES OF WATER SUPPLY SYSTEMS: THE CASE STUDY OF VALLE UMBRA. Ferrante M., Piccirillo G., Schiaroli S., Provvisiero F., Rossi F. and Montanucci S.

- Valle Umbra Servizi s.p.a. funded a research project to define a master plan
- Indices for the comparison of interconnections of water supply systems are used
- The results of a case study are shown, and results are discussed

ID: 241 - CASE STUDY: REORGANIZATION OF A DISTRIBUTION NETWORK SUPPLIED BY WELLS. Boscarello L.A., Marinoni M. and Rusconi M.

- Analysis of a water network supplied by fixed speed well pumps and a water tower
- Effects of installation of electronically operated valve at the main reservoir
- Effects of revamping of the wells pumps: optimizing exploitation and consumption

ID: 271 - FULL DIGITALIZATION, DMA DESIGN, AND PRESSURE MANAGEMENT IN A LARGE URBAN WATER DISTRIBUTION NETWORK: A CASE STUDY OF THE NAPOLI METROPOLITAN AREA. Bettin A., De Marco S., Sorgenti Degli Uberti G. and Scamardella P.

- Integrated strategies are needed for climate-induced water challenges
- ABC Napoli pioneers digitization to ensures efficiency & loss reduction
- 1360 Km of network modelling, 71 DMAs and, 21 PMZ to improve network efficiency

ID: 85 - ON THE APPLICATION OF A NONLINEAR MODEL PREDICTIVE CONTROL FRAMEWORK TO OPTIMIZE THE OPERATIONS OF WATER DISTRIBUTION SYSTEMS. Arandia E., Xing L., Uber J. and Shafiee E.

- Novel methodology for real-time optimization of water networks at scale
- Savings of over $2.5 million (10%) annually and up to 24% monthly
- Very valuable insights to change the status quo of utility operations

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## Session 7A (Room 2) – Design, Analysis and Modeling of Water Distribution Systems
## Chairman: Wu Z.Y.

ID: 79 - 24/7 CLOUD-HOSTED SOLUTION EVALUATION FOR ANOMALY DETECTION AND LOCALIZATION OF LARGE-SCALE WATER DISTRIBUTION NETWORKS IN SINGAPORE.* Chew A.W., Wu Z.Y., Zhang A.H., Cao F., Kalfarisi R., Meng X., Pok J., Wong J.M., Lai K.C., Seow L. and Wong J.J.

- Developed 24/7 cloud solution in ALF for water distribution networks
- ALF digital twin (DT) comprises of data-driven and physics-based models
- ALF DT maintains model performances to at least 95% accuracy

ID: 15 - MACHINE LEARNING BASED DIGITAL TWIN FOR WATER DISTRIBUTION NETWORK ANOMALY DETECTION AND LOCALIZATION.* Pandey P., Mucke N., Jain S., Ramachandran P., Bohte S.M. and Oosterlee C.W.

- The two different models have been developed here for leak detection
- The developed models are tested on a real time network
- The model has achieved very good accuracy

ID: 78 - MULTI-OBJECTIVE METER PLACEMENT TO MINIMIZE DETECTION OVERLAPPING IN WATER DISTRIBUTION SYSTEMS.* Oh J., Jun S. and Jung D.

- Minimized the overlapping of detection areas of pressure sensors
- Simply adopted sensitivity matrix for detection overlapping minimization
- Compared detection overlappings for multiple networks

ID: 166 - HYDROACOUSTIC MODEL FOR THE IDENTIFICATION OF THE INCIPIENT CAVITATION: A PRELIMINARY STUDY. Montillo R., Morani M.C., Fecarotta O. and Carravetta A.

- Preliminary hydroacoustic model for the study of noisy sources in water
- Application of the Lighthill's analogy for the study of the generated noise
- A study on the effect of turbulence models on the noise generated

## Session 7B (Room 3) – Water Quality
## Chairman: Sela L.

ID: 93 - OPERATIONAL EFFECTS ON WATER QUALITY EVOLUTION IN WATER DISTRIBUTION SYSTEMS.* González L., Coy Y., Boccelli D.L. and Saldarriaga J.

- Black-box models can be an appropriate alternative to physically-based models
- LSTM and CNN algorithms demonstrate high chlorine prediction capability for WDS
- Hyperparameter optimization adequately generalizes the behavior of the models

ID: 44 - EXPLORING THE IMPACT OF PULSED DEMAND MODEL ON THE QUALITY SENSOR PLACEMENT IN WATER DISTRIBUTION NETWORKS. Giudicianni C. and Creaco E.

- Nodal demand modeling in WDNs affects the fate of contaminants in the system
- Water quality sensor layout differs with a stochastic demand modeling approach
- The influence of a different demand modeling depends on the monitoring target

ID: 72 - MINIMIZATION OF WATER AGE IN WATER DISTRIBUTION SYSTEMS UNDER UNCERTAIN DEMAND.* Korder K., Salomons E., Ostfeld A. and Li P.

- Chance-constrained minimization of pressure and water age under uncertain demand
- Probability of violating constraints is evaluated by Monte-Carlo simulation
- A simple case study is used to demonstrate the proposed approach

ID: 142 - OPTIMIZED DESIGN OF DEAD-END SPOILER USING PIV. Gao J., Li K., Wu W., Qi S., Cao H., Qiu W., He J., Zhang J. and Ding J.

- Spoiler efficacy on dead-end contaminant diffusion was studied by PIV
- Spoiler design parameters were optimised under low Reynolds number turbulence
- Findings present a novel approach for improving water quality in WDNs

## Session 7C (Room 4) – Leak and Burst Management
## Chairman: van Zyl K.

ID: 57 - AREA LEAKAGE ESTIMATION IN WATER DISTRIBUTION SYSTEMS: A FOCUS ON BACKGROUND LEAKAGE.* Bandreddi R. and Farmani R.

- Localizing background leaks of size ranging between 0.14 & 0.28% of bulk supply
- Node similarity based spectral clustering of nodes of water distribution network
- A comprehensive pressure sensitivity analysis for leak occurrences

ID: 41 - STOCHASTIC INSIGHTS INTO LEAKAGE DYNAMICS ACROSS DIVERSE PIPE MATERIALS IN WATER DISTRIBUTION SYSTEMS. Beygi S., van Zyl K. and Harkness B.

- This study identified the properties of pipe failures from photographic records
- The fitted distributions were used to generate stochastic leakage models in WDS
- This study provides insights into leakage dynamics across different materials

ID: 32 - EXPERIMENTAL INVESTIGATION OF THE FATIGUE STRENGTH AND LEAKAGE FAILURE MODE OF CORRODED CAST IRON WATER PIPES.* John E., Boxall J., Collins R., Bowman E. and Susmel L.

- Laboratory tests show how fatigue load type affects life of corroded iron pipes
- Leak-before-burst shown for pipes experiencing internal water pressure fatigue
- Sharp pits reduce pipe fatigue strength by up to 4 times depending on alignment

ID: 106 - LEGACY PIPES UNEARTHED: DECRYPTING THE ENIGMA OF PRESSURE DYNAMICS AND BURST EVENTS IN LIMBURG, NETHERLANDS.* Zeidan M., Hillebrand B. and Blokker M.

- Seasonal burst patterns: Increased occurrences during summer months
- Strong correlation between spontaneous bursts and pressure anomalies
- Pipe aging identified as primary burst factor

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## Session 7D (Room 5) – Drainage and Sewer Systems
## Chairman: Iglesias-Rey P.L.

ID: 295 - SUSTAINABILITY AND ECONOMIC BENEFITS OF MAINTENANCE PRACTICES FOR URBAN DRAINAGE SYSTEMS. Raje S. and Sansalone J.

- Current structural treatment systems for urban drainage are not sustainable
- Maintenance/recovery practices recover far greater residual loads than treatment
- Load credits yield millions of USD savings/municipality compared to treatment

ID: 292 - OPTIMIZING SUSTAINABLE URBAN DRAINAGE CLARIFICATION AND ECONOMICS THROUGH COUPLING COMPUTATIONAL FLUID DYNAMICS (CFD) AND MACHINE LEARNING (ML). Li H. and Sansalone J.

- Residence time (RT) is a common metric to design volumetric treatment units
- RT is agnostic to hydrodynamic, geometrics, chemical, particulate interactions
- CFD-ML optimizes treatment & economics (10x lower) compared to RT

ID: 155 - AUTOMATED PUMP PLACEMENT ALGORITHMS FOR OPTIMAL SEWER NETWORK DESIGN IN AREAS WITH COMPLEX TERRAIN. Habermehl R., Bahkshipour A., Dilly T., Haghighi A. and Dittmer U.

- Algorithms optimize sewer design in complex terrains, improving cost-efficiency
- Real-case application in Brazil shows substantial reduction in network costs
- Graph theory and metaheuristic optimization used to automate sewer planning

ID: 117 - OPTIMAL SEWER NETWORK DESIGN INCLUDING PUMPING STATIONS. Saldarriaga J., Herrán J., González M., Coy Y. and Iglesias-Rey P.L.

- We have a new methodology to optimal minimum cost design of sewer networks
- The optimal design can include in line pumping stations
- The new algorithm allows the optimal design of sewers in very flat terrains

## Session 7E (Room 6) – Battle of Water Demand Forecasting
## Chairman: Herrera M.

ID: 175 - PREDICITVE MODEL FOR SHORT-TERM WATER DEMAND FORECASTING AND FEATURE ANALYSIS IN URBAN NETWORKS. Pesantez J., DiCarlo M., Pasha F. and Zechman Berglund E.

- Effective forecasting model that predicts up to one week of hourly water demand
- IONET explains up to 98% of the residential water demand
- IONET displays high accuracy for well-structured data sets

ID: 13 - MULTI-MODEL DEMAND FORECASTING IN WATER DISTRIBUTION NETWORK DISTRICTS. Creaco E., Giudicianni C. and Herrera M.

- Combination of three modelling elements for demand forecasting
- Various models are constructed by changing settings in the modelling elements
- Optimization performed to select the best modelling combination for forecast

ID: 262 - SEQUENCE-TO-SEQUENCE DEEP LEARNING FOR URBAN WATER DEMAND FORECASTING.* Jahangir M.S. and Quilty J.

- Deep learning models were utilized
- Transformers and long short-term memory networks were compared
- The transformers outperformed long short-term memory networks

ID: 176 - A MULTIVARIATE LSTM MODEL FOR SHORT-TERM WATER DEMAND FORECASTING.* Salem A. and Abokifa A.

- Training the M-LSTM model on a large dataset improved its prediction accuracy
- The M-LSTM model showed a pronounced sensitivity to the water demand variability
- The prediction errors ranged between 2.8% to 12.9% of the average water demand

## Session 7F (Room 7) – Sustainable Urban Water Systems
## Chairman: Ramos H.

ID: 178 - ENERGY OPTIMIZATION IN PRESSURIZED WATER NETWORKS: EXPLORING CASE STUDIES WITH ENERGOS TOOL FOR SUSTAINABLE SOLUTIONS. Gómez E., del Teso R., Estruch-Juan E. and Cabrera E.

- A simple tool allows the first stage in the process of improving efficiency
- Starting from a few data qualifies the energy performance of the system
- The aim is to facilitate the diagnosis and assessment of the saving capacity

ID: 302- ENERGY ASSESSMENT OF WATER NETWORKS BASED ON NEW PERFORMANCE INDICATORS.* Morani M.C., Carravetta A., Fecarotta O. and Montillo R.

- This work proposes the energy audit of water systems by new performance indices
- The methodology enables a spatial analysis of the critical areas of a network
- The energy benefits resulting from a pressure control are assessed in detail

ID: 64 - PRESSURE MANAGEMENT IN WATER DISTRIBUTION NETWORKS BY MEANS OF PUMPS AS TURBINES: A CASE STUDY IN NORTHERN ITALY.* Manservigi L., Marsili V., Mazzoni F., Castorino G.A.M., Farsoni S., Losi E., Alvisi S., Bonfè M., Franchini M., Spina P.R. and Venturini M.

- Energy recovery assessment through PATs in a real water distribution network
- Turbomachine selection and control definition through hydraulic regulation
- Recover of about 50% of network hydraulic energy through the optimal PAT

ID: 55 - COOPERATIVE OPERATIONAL OPTIMIZATION OF WATER AND POWER SYSTEMS UNDER EXTREME CONDITIONS. Perelman G., Shmaya T., Vrachimis S., Panteli M., Eliades D.G. and Ostfeld A.

- Communication between water and power systems boosts their resilience
- Novel strategy leverages minimal data exchange to reduce load shedding
- Efficiently improves emergency response for water and power systems

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## Session 8A (Room 2) – Water Supply and Treatment
## Chairman: Sitzenfrei R.

ID: 159 - A PYTHON-BASED TOOL FOR REAL-TIME REVERSE OSMOSIS DATA NORMALIZATION IN DESALINATION APPLICATIONS.* Prasad N., Maheshwari A., Pandian G.K. and Prasad V.

- An open source script for Normalization of real-time RO data
- RO Membrane performance monitoring with Normalized data
- Enhanced Membrane performance with reduced energy spent

ID: 82 - CALCULATING AVAILABILITY OF PRODUCTION PLANTS. Beuken R., Drolenga P. and Jong R.

- Methodology provides quantitative insight on effects and likelihood of failures
- Failure at production linked to impact on customers (substandard supply minutes)
- It shows which data and expert knowledge is useful to become data-driven

ID: 70 - NATURE-BASED SOLUTIONS IN CITIES – A VIEW FROM A WATER SUPPLY PERSPECTIVE.* Oberascher M., Dastgir A., Kinzel C. and Sitzenfrei R.

- Impacts of irrigation demand of NBS on the water supply are investigated
- Hydraulic analyses are combined with water resource availability
- A large-scale implementation requires a coordinated implementation strategy

ID: 246 - ASSESSING THE OPERATION OF A WELL FIELD BY COUPLING EPANET TO THE RESULTS OF A HYDROGEOLOGICAL STUDY. Gaitanaru D., Iancu I., Georgescu S.-C. and Georgescu A.-M.

- Well modelling using variable level tanks
- Modelling of well supply dynamics
- Balance between the extracted flow rates from each well

## Session 8B (Room 3) – Water Quality
## Chairman: Brentan B.

ID: 204 – AN INNOVATIVE MODEL-BASED METHODOLOGY FOR RAPID RESPONSE TO DRINKING WATER CONTAMINATION EVENTS.* Paraskevopoulos S., Vrachimis S., Kyriakou M., Blokker M., Smeets P., Eliades D., Medema G. and Polycarpou M.

- Modeling tools in emergency decision-making enhance response efficiency
- The use of real-time fecal sensors is imperative during pathogen emergencies
- Modeling tools reduce contamination identification time and sample needs by 50%

ID: 122 - AN INTEGRATED FRAMEWORK TO SUPPLEMENT ONLINE WATER QUALITY MONITORING IN THE DETECTION OF CONTAMINATION EVENTS IN WATER DISTRIBUTION NETWORKS.* Salcedo C. and Boccelli D.L.

- Bayesian Nets were used to estimate the likelihood of a contamination event
- An ABM was used to simulate datasets given the limited real-world outbreak data
- Fusing disparate datasets showed promising results in the detection of events

ID: 102 - PREDICTING CONTAMINATION SPREADING IN WATER DISTRIBUTION NETWORKS.* Wéber R., Sándor L., Horváth A., Barakka G., Abhijith G.R. and Ostfeld A.

- The complete mixing model is widely applied in modelling substance distribution
- CFD simulates a four-way junction to determine the angle and flow rate effect
- Tank simulations strengthen the validity of the complete mixing model

ID: 143 - COMPARATIVE RISK EVALUATION OF CONTAMINANT INTRUSION IN WATER DISTRIBUTION NETWORKS VIA COMPLEX NETWORK ANALYSIS.* Alaggio J., Barros D., Brentan B. and Meirelles G.

- Application of complex network theory in the vulnerability assessment of WDNs
- Develop network risk maps for contaminant intrusions
- Results analysis between graphs with and without direction

## Session 8C (Room 4) – Leak and Burst Management
## Chairman: Dziedzic R.

ID: 220 - AUGMENTING FAILURE PREDICTION IN WATER PIPES USING WEATHER DATA. Latifi M., Beig Zali R., Javadi A.A. and Farmani R.

- A machine learning model was developed for failure prediction in water pipes
- The model's performance was compared with and without employing weather data
- The enhanced model presented higher accuracy in predicting likelihood of failure

ID: 221 - SOIL TYPE AND ITS IMPACT ON CAPABILITY OF PIPE FAILURE PREDICTION MODELS.* Beig Zali R., Latifi M., Javadi A.A. and Farmani R.

- Proactive maintenance mitigates water disruptions
- Enhanced models outperform baseline, identify soil-failure correlation
- Soil type inclusion was crucial for accurate predictions

ID: 96 - DEVELOPING AN OPEN REPOSITORY OF WATERMAIN BREAK PREDICTION MODELS IN KITCHENER.* Boloukasli Ahmadgourabi F. and Dziedzic R.

- GitHub repository for comparing water main break prediction models was developed
- Open datasets were cleaned and prepared to benchmark prediction models
- Time-based split in data preparation led to consistent training & testing result

ID: 207 - PREDICTING THE FUTURE FAILURES OF URBAN WATER SYSTEMS: INTEGRATING CLIMATE CHANGE AND MACHINE LEARNING PREDICTION MODELS. Khashei M., Boloukasli Ahmadgourabi F. and Dziedzic R.

- Climate-aware break prediction models developed using water mains, weather data
- Machine learning models developed, with Random Forest performing best
- Climate change potentially reduce break frequency in Cast Iron pipes

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## Session 8D (Room 5) – Drainage and Sewer Systems
## Chairman: Becciu G.

ID: 288 - DESIGN STORMS FOR FIRST FLUSH MODELLING AT SEWER INLETS. Becciu G., Raimondi A. and Sanfilippo U.

- Review of build-up and wash-off models for pollutant dynamics on urban surfaces
- Build-up and wash-off continuous simulation of Milan and Odense rainfall series
- Identification of rainfall patterns maximizing wash-off mass and concentration

ID: 14 - OPTIMAL LOCATION OF BMPS FOR FLOOD MITIGATION IN URBAN DRAINAGE SYSTEMS. Creaco E., Dada A., Grossi G. and Todeschini S.

- BMPs are used to mitigate floods in urban areas
- Multiobjective optimization is performed
- Climate change scenarios are considered

ID: 90 - INTEGRATING DRONE-CAPTURED SUB-CATCHMENT TOPOGRAPHY WITH MULTIPHASE CFD MODELLING TO ENHANCE URBAN STORMWATER MANAGEMENT. Kaur K., Annus I., Truu M., Kändler N. and Paalmäe I.

- Drone survey data can be used for building information and stormwater modelling
- A CFD model of a stormwater catchment is created based on drone survey data
- Simulations compared to TWI and field observations illustrate potential uses

ID: 130 - INTEGRATING GENDER+ PERSPECTIVES IN HYDROLOGY EDUCATION. Bencivenga R., Leone C. and Taramasso A.C.

- Gender equality plans must consider the gender+ perspective in STEM teaching
- The hydrology course addresses climate challenges and an inclusive perspective
- The strategy chosen for the inclusive hydrology course can easily be replicated

## Session 8E (Room 6) – Battle of Water Demand Forecasting
## Chairman: Mazzoni F.

ID: 134 - A WATER FUTURES APPROACH ON WATER DEMAND FORECASTING WITH ONLINE ENSEMBLE LEARNING.* Zanutto D., Michalopoulos C., Chatzistefanou G.-A., Vamvakeridou-Lyroudia L., Tsiami L., Glynis K., Samartzis P., Hermes L., Hinder F., Vaquet J., Vaquet V., Eliades D., Polycarpou M., Koundouri P., Hammer B. and Savic D.

- Multiple machine learning forecasting models have been applied
- The collaborative effort and the ensemble approach proved beneficial
- The ensemble reconciliation strategy is more accurate than the individual models

ID: 131 - AN ENSEMBLE DATA-DRIVEN APPROACH FOR ENHANCED SHORT-TERM WATER DEMAND FORECASTING IN URBAN AREAS. Ebrahim Bakhshipour A., Namdari H., Koochali A., Dittmer U. and Haghighi A.

- We compared four models: NHiTS, XGBoost, 1D CNN, and an ensemble model
- XGBoost outperforms complex models like NHiTS and CNN
- Ensemble models outperform individual models on the WDSA-CCWI-2024 dataset

ID: 62 - AN APPROACH BASED ON THE USE OF COMMERCIAL CODES AND ENGINEERING JUDGEMENT FOR THE BATTLE OF WATER DEMAND FORECASTING. Iglesias-Rey A., López-Hojas C.A., Martínez-Solano F.J. and Iglesias-Rey P.L.

- Battle of Water Demand Forecasting
- Use of engineering judgement and commercial codes
- Artificial Neural Networks

ID: 49 - LEVERAGING POTENTIALS OF LOCAL AND GLOBAL MODELS FOR WATER DEMAND FORECASTING.* Groß M. and Hans L.

- Hyperparameter tuning fails to outperform default settings in most cases
- Adopting top model parameters shines across series, easing optimization
- Shared context boosts semi-global models, outperforming local and global

## Session 8F (Room 7) – Sustainable Urban Water Systems
## Chairman: Fecarotta O.

ID: 35 - SIZING BEHIND-THE-METER SOLAR PV SYSTEMS FOR WATER DISTRIBUTION NETWORKS.* Zhao Q., Wu W., Yao J., Simpson A., Willis A. and Aye L.

- Three methods for sizing behind-the-meter solar PV in water distribution systems
- The minimum total life cycle (TLCC) method provided a balanced performance
- A general guidance for selecting proper solar PV in water distribution systems

ID: 51 - CO-DESIGN OF WATER DISTRIBUTION SYSTEMS WITH BEHIND-THE-METER SOLAR.* Yao J., Wu W., Simpson A. and Rismanchi B.

- A new framework for the co-design of water-energy systems under uncertainty
- Solar energy integration improves water distribution system energy efficiency
- Solar technology development prevents oversizing water distribution systems

ID: 19 - APPLYING PUMP AFFINITY LAWS TO ISOLATED SOLAR POWERED PUMPING STATION. Martínez Solano F.J., Pons Ausina J.F., Iglesias-Rey P.L. and López-Patiño G.

- Transport and distribution of water accounts for up to 40% of energy expenses
- In agricultural applications solar powered pumping may become the only solution
- The investment may be paid back in two years and a half

ID: 132 - OPTIMIZED INTEGRATION OF SOLAR AND BATTERY SYSTEMS IN WATER DISTRIBUTION NETWORKS. Bhatraj A., Salomons E. and Housh M.

- Joint design & operation of water-power systems with renewables
- Solar & battery integration in Water Distribution Networks
- Boosting water systems' energy cost efficiency with clean energy

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## Session 9A (Room 2) – Urban Water Systems in Emergency
## Chairman: Piller O.

ID: 294 - MODELING WATER AVAILABILITY DURING A BLACKOUT UNDER CONSIDERATION OF UNCERTAIN DEMAND RESPONSE.* Sattler B.J., Tundis A., Friesen J. and Pelz P.F.

- A model of demand response affecting a water distribution system in a blackout
- Scenarios of demand reduction, regular demand, and stockpiling are considered
- Demand response is a major driver of socio-technical model uncertainty

ID: 20 - COMBINING PHYSICAL AND NETWORK DATA FOR ATTACK DETECTION IN WATER DISTRIBUTION NETWORKS.* Frappé Vialatoux C. and Parrend P.

- This paper introduces a combination scheme for Cyber-physical system's data
- A benchmark on the "Hardware in the loop" dataset evaluates the proposed scheme
- The use of combined data improves balanced accuracy up to +20% for XGBoost model

ID: 60 - REVIEW OF REDUCED-ORDER MODELS FOR ONLINE PROTECTION OF WATER DISTRIBUTION NETWORKS.* Djemel C., Piller O., Horsin T., Mimeau C. and Mortazavi I.

- Presentation of existing model reduction methods for real-time data assimilation
- A python framework for the digital twin
- A Digital twin with a retroaction loop for the model outputs and decision making

## Session 9B (Room 3) – Water Quality
## Chairman: Sass Braga A.

ID: 194 - PERFORMANCE EVALUATION OF MACHINE LEARNING METHODS FOR DRINKING WATER CONTAMINATION DETECTION. Urbanovičs V., Parshutin S., Rubulis J., Bonders M., Dambeniece K., Ozols R., Štēbelis D. and Dejus S.

- Complex and close to real world scenario for drinking water contamination
- A machine learning model was created for drinking water contamination detection
- The trained model showed over 99% accuracy and 98 % F-scores

ID: 59 - A FLUSHING DURATION MODEL FOR CONTAMINATION CAMPAIGN IN WATER DISTRIBUTION SYSTEMS.* Cao H. and Li P.

- We developed a model for determining the flushing duration
- The one-dimensional advection equation was discretized
- The result was analyzed via simulation study and laboratory Testbed

ID: 168 - A NOVEL REVERSE UNIDIRECTIONAL FLUSHING (R-UDF) METHOD TO MOBILIZE IRON OXIDE PARTICLES FROM PVC PIPES OF A FULL-SCALE LABORATORY SYSTEM.* Anderson B., Sass Braga A. and Filion Y.

- Iron oxide particles were introduced into a full scale pipe loop system
- Sequential flushing stages were conducted in forward and reverse directions
- Changing the direction of flushing increased the mobilization of particles

## Session 9C (Room 4) – Leak and Burst Management
## Chairman: Freni G.

ID: 275 - DETERMINATION OF ILI - INFRASTRUCTURE LEAKAGE INDEX USING THE ANALYSES OF MINIMUM NIGHT FLOWS. Polachova M. and Tuhovcak L.

- Methodology for ILI determination based on minimum night flows
- Analysis of actual night consumption from Smart Water Meters
- Real measurements in real District Meter Area (DMA)

ID: 76 - ATTRIBUTING MINIMUM NIGHT FLOW TO INDIVIDUAL PIPES IN REAL-WORLD WATER DISTRIBUTION NETWORKS USING MACHINE LEARNING.* Hayslep M., Keedwell E., Farmani R. and Pocock J.

- Higher pipe-MNF means a higher likelihood of a pipe failure
- Pipe-MNF predictions have predictive power for pipe failure and MNF
- Age effects plastic pipes 40 times more than metal pipes according to this model

ID: 141 - METERING ERROR ASSESSMENT MODEL CONSIDERING MULTIPLE FACTORS.* Li K., Gao J., Wu W., Qi S., Cao H., Qiu W., Tian Y. and Zhu X.

- Various factors on metering errors were analyzed by laboratory experiments
- GEP algorithm was used to create a metering error assessment model
- Offering a cost-effective tool for enhancing water supply management

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## Session 9D (Room 5) – Irrigation Systems
## Chairman: Malavasi S.

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| ID: 214 - OPTIMISING WATER ALLOCATION FOR COMBINED IRRIGATION AND HYDROPOWER SYSTEMS. Peretti F., Menapace A. and Righetti M. | • The study optimises water-energy interaction in irrigation tied to hydropower<br>• The methodology employs particle swarm optimization in a real case study<br>• 14% costs cut during peak irrigation weeks, with 11% revenue rise |
| ID: 236 - RETHINKING ON-DEMAND IRRIGATION SYSTEMS USING IOT STAND-ALONE TECHNOLOGIES. Ferrarese G., Pagano A., Troiani D., Ceni A., Hutomo I.A., Fontana N., Marini G., Mambretti S. and Malavasi S. | • Pressurized on-demand irrigation networks are diffused infrastructure<br>• The use of stand-alone IoT devices can improve the network management<br>• Network management can enhance water usage for utilities and users |
| ID: 158 - DEEP LEARNING FOR AUTOMATED WATER SEGMENTATION THROUGH CCTV IMAGES IN AGRICULTURAL RESERVOIRS. Lim S., Kwon S.H., Shin G. and Lee S. | • Evaluation with CCTV image showed segmentation accuracy ranging from 95% to 99%<br>• We used CCTV images and applied this approach to four agricultural reservoirs<br>• This approach assures enhanced water level estimation in unmeasured reservoirs |

## Session 9E (Room 6) – Battle of Water Demand Forecasting
## Chairman: Martínez-Solano F.J.

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|---|---|
| ID: 75 - WATER DEMAND FORECASTING BASED ON ONLINE AGGREGATION FOR DMA SPECIFIC ADAPTION.* Kley-Holsteg J., Sonnenschein B., Johnen G. and Ziel F. | • DMA specific adaption based on online aggregation of individual models<br>• Simple time series, high-dimensional linear, and non-linear models are applied<br>• Median-optimized estimation |
| ID: 167 - PREDICTING NET INFLOW FOR 10 DMAS IN NORTH-EAST ITALY. Arsova K., Quintiliani C., Schol D. and Walraad M. | • The model effectively captures the seasonality of the water demand time series<br>• The model exhibits challenges in accurately predicting peak demands<br>• The model performs better in commercial/industrial DMAs than in residential ones |
| ID: 237 - SHORT-TERM WATER DEMAND FORECASTING BASED ON LSTM USING MULTI-INPUT DATA. Wang D., Li Y., Hou B. and Wu S. | • Identify and rectify data based on statistical analysis<br>• Water demand forecasting procedures use water demand and temperature as input<br>• Considering the influence of rainfall and holiday |

## Session 9F (Room 7) – Sustainable Urban Water Systems
## Chairman: Eliades D.G.

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|---|---|
| ID: 286 - AN INNOVATIVE SOLAR PUMP APPLICABLE IN WATER DISTRIBUTION NETWORK. Javadi Nejad H., Pirouz B., Turco M., Naghib S.N., Palermo S. and Piro P. | • Development of a novel solar pump usable for urban water networks<br>• Low efficiency of conventional systems limited the choice of solar water pumps<br>• Novel system is suitable for networks especially areas without grid access |
| ID: 173 - CONTRIBUTIONS FOR CARBON-NEUTRALITY IN THE WATER SECTOR: FROM THEORY TO PRACTICE. Ramos H. and Covas D. | • Energy recovery and the associated digital technology in the water sector<br>• Development of integrated novel solutions<br>• Use of digital twins to improve the system efficiency |
| ID: 291 - AN INTEGRATED APPROACH TO OPTIMIZING THE ENERGY EFFCIENCY OF WATER SUPPLY - THE WAY TO EFFECTIVE MANAGEMENT.* Mečíř F., Kučera T. and Snášel D. | • Relatively high savings potential of around 45% has been demonstrated<br>• Deployment in Central European conditions has been demonstrated<br>• The integration procedure into the management process was presented |

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