

# A Digital Twin for an Advanced Water Purification System in Pilot-scale

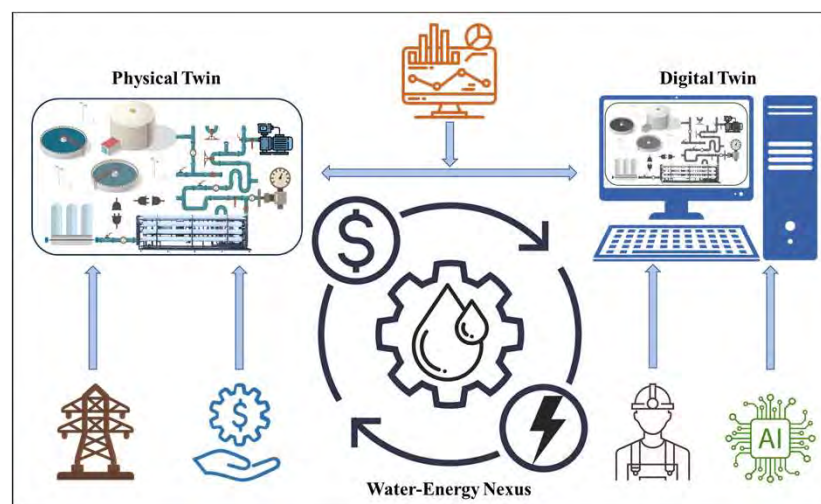
Clean Water SoCal Water Quality Committee meeting

Smarter Clean Water: Digital Twins Discussion

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Research Associate, UC Irvine



## Agenda

- Introduction to Digital Twin
- Application of Digital Twin in the Water Systems
- Case Study (Advanced Water Purification Digital Twin)
- Using Digital Twin to Maximize Process Efficiency
- Open Discussion (Q&A)

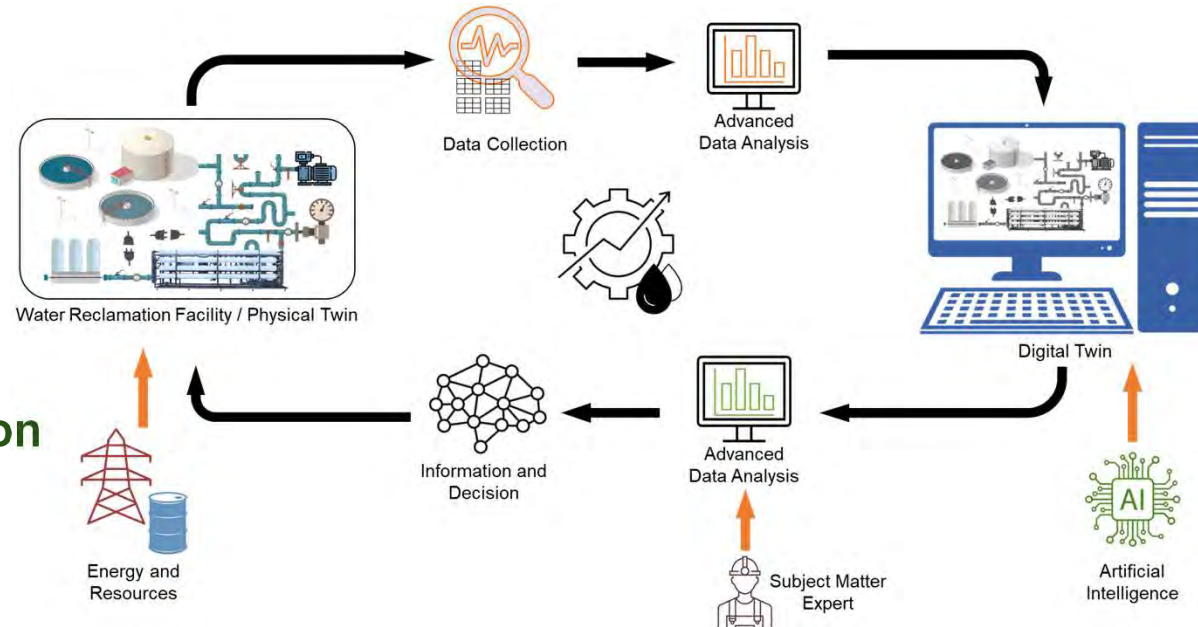
# Introduction to Digital Twin

# WHAT IS A DIGITAL TWIN?

➤ **Definition:** A virtual representation of an operating physical entity (e.g., a treatment train or a treatment plant), synchronized at a specified frequency and fidelity.

➤ **Components:**

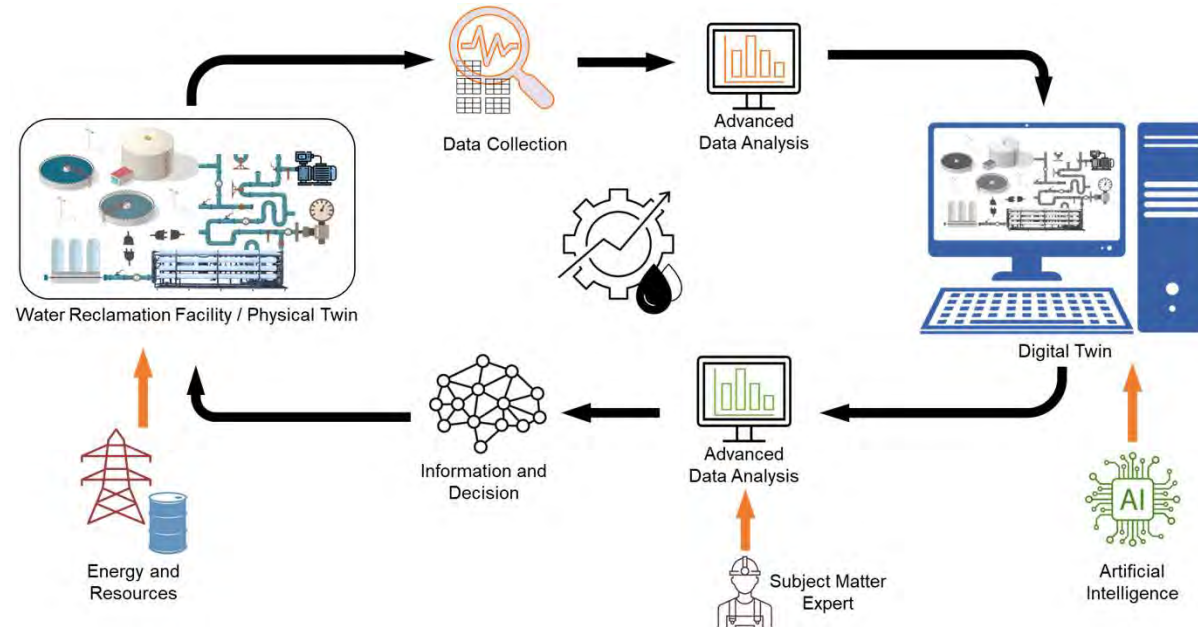
- ✓ Physical Entity (Physical Twin)
- ✓ **High-Fidelity Simulator**
- ✓ Physical Sensors
- ✓ Soft Sensors
- ✓ **Physical-to-Virtual Connection**
- ✓ Advanced Data Analysis
- ✓ Interaction and Service



# WHY DIGITAL TWIN?

➤ A Digital Twin can provide a wide range of applications, including:

- ✓ Monitoring
- ✓ Optimizing
- ✓ Autocalibrating
- ✓ Forecasting
- ✓ Sensitivity Analysis
- ✓ Wrapper (Safety)



# **Application of Digital Twin in the Water Systems**

# ROLE OF DIGITAL TOOLS IN POTABLE REUSE APPLICATIONS



**Early Warning Systems starting from the Wastewater Collection System**



**Advanced Treatment Critical Control Points (CCPs) and Log Removal Values (LRVs)**



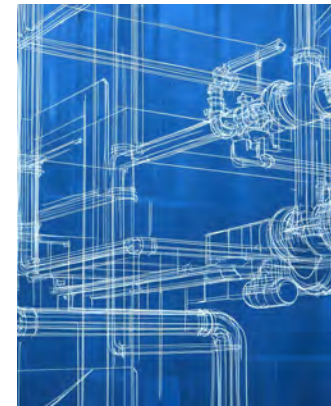
**Cost-effective Purified Water Production (OPEX optimization)**



**Finished Water Quality Monitoring**



**Water Quality/ROC Discharge Compliance**

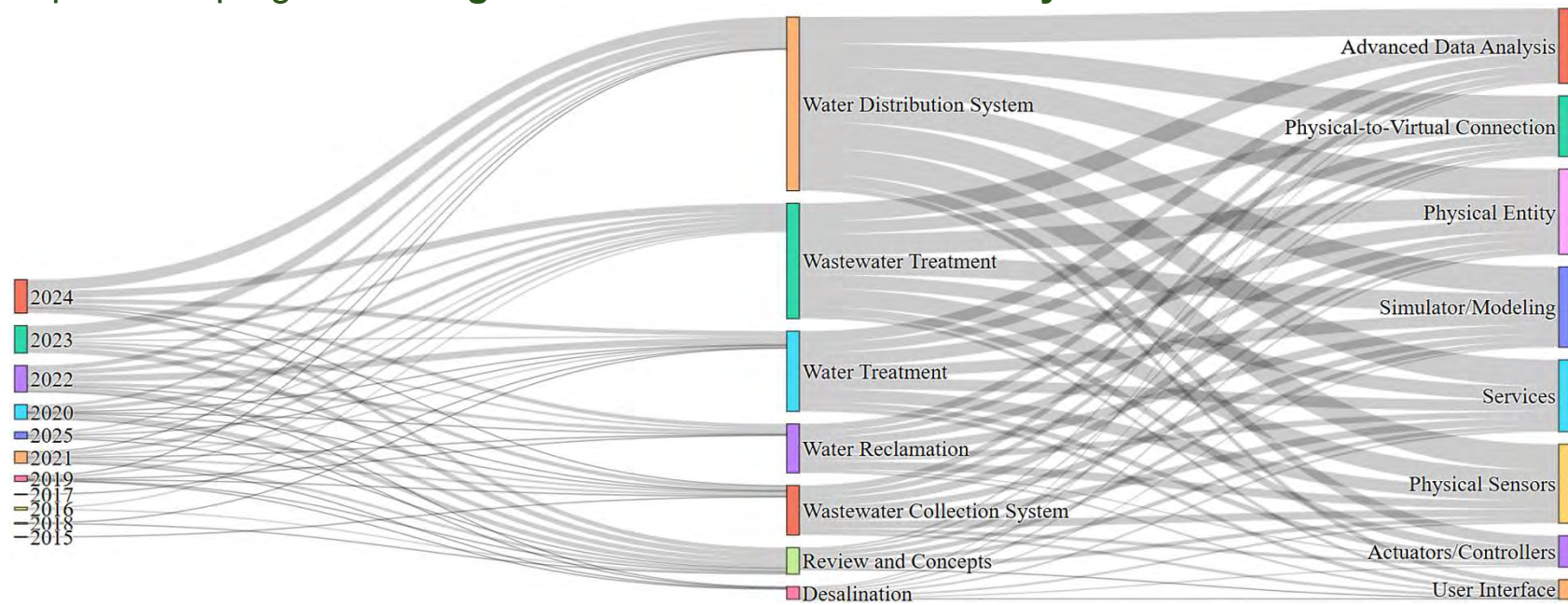


**Incorporation of Purified Water in the Existing Water Distribution System**



# DIGITAL TWIN IN THE WATER INDUSTRY

- Reviewed over **150 studies and reports** on application of DT in the water sector, world-wide
- Up-to-date progress on **Digital Works in the Water Industry**



dt\_sankey\_times.html



# DIGITAL TWIN IN THE WATER INDUSTRY

- Reviewed over **150 studies and reports** on application of DT in the water sector, world-wide
- Up-to-date progress on **Digital Works in the Water Industry**

## Findings, Major Gaps, Barriers, and Challenges of Implementation

- Only a few attempts for implementation with all required elements
- Lack of high-fidelity simulator
- Implementation of the 2-way communication
- Requirements for full-scale implementation
- Safety and cyber security concerns

2024  
2023  
2022  
2020  
2025  
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2017  
2016  
2018  
2015

Analysis  
Detection  
Entity  
Modeling  
Services  
Sensors  
Controllers  
User Interface

Desalination

User Interface



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# **Case Study (Digital Twin Pilot Project for an Advanced Water Purification System)**

## ADVANCED WATER PURIFICATION TRAIN DIGITAL TWIN AT OCWD

### ➤ Orange County Water District (OCWD)

- The world's largest water purification system for Indirect Potable Reuse (IPR)
- Operating Capacity: 130 MGD

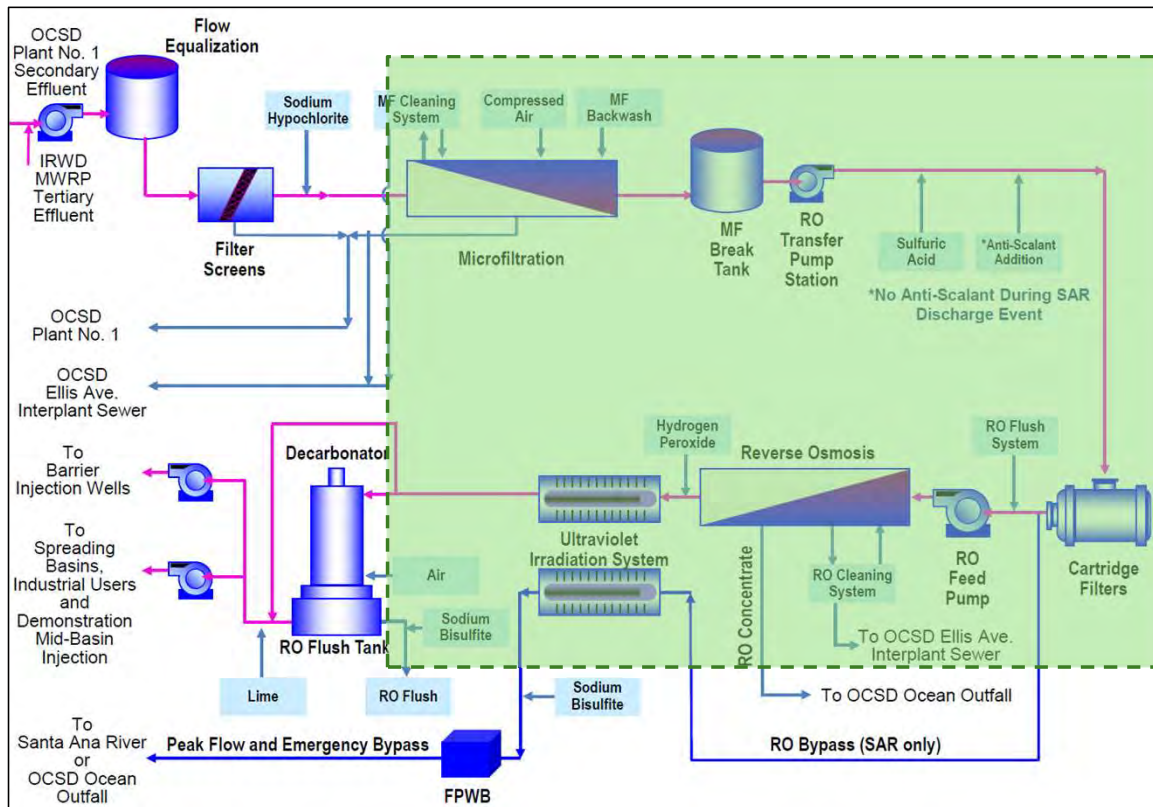
### ➤ Goals of Digital Twin Pilot Project

1. **Full-scale implementation of a DT in the water sector (Water Reuse)**
  - Identify and assess the higher-level barriers and challenges of implementation in Full-scale
2. Evaluate the developed DT performance in **Process Optimization** and **Energy Cost saving**
  - **Primary goal is to reduce the energy cost per unit water produced (\$/MG)**

## DIGITAL TWIN IN OCWD (PROJECT TEAM/SPONSORS)



# OCWD TREATMENT PROCESSES



## Treatment Process Flow at OCWD

Microfiltration/Ultrafiltration



Cartridge Filter



Reverse Osmosis

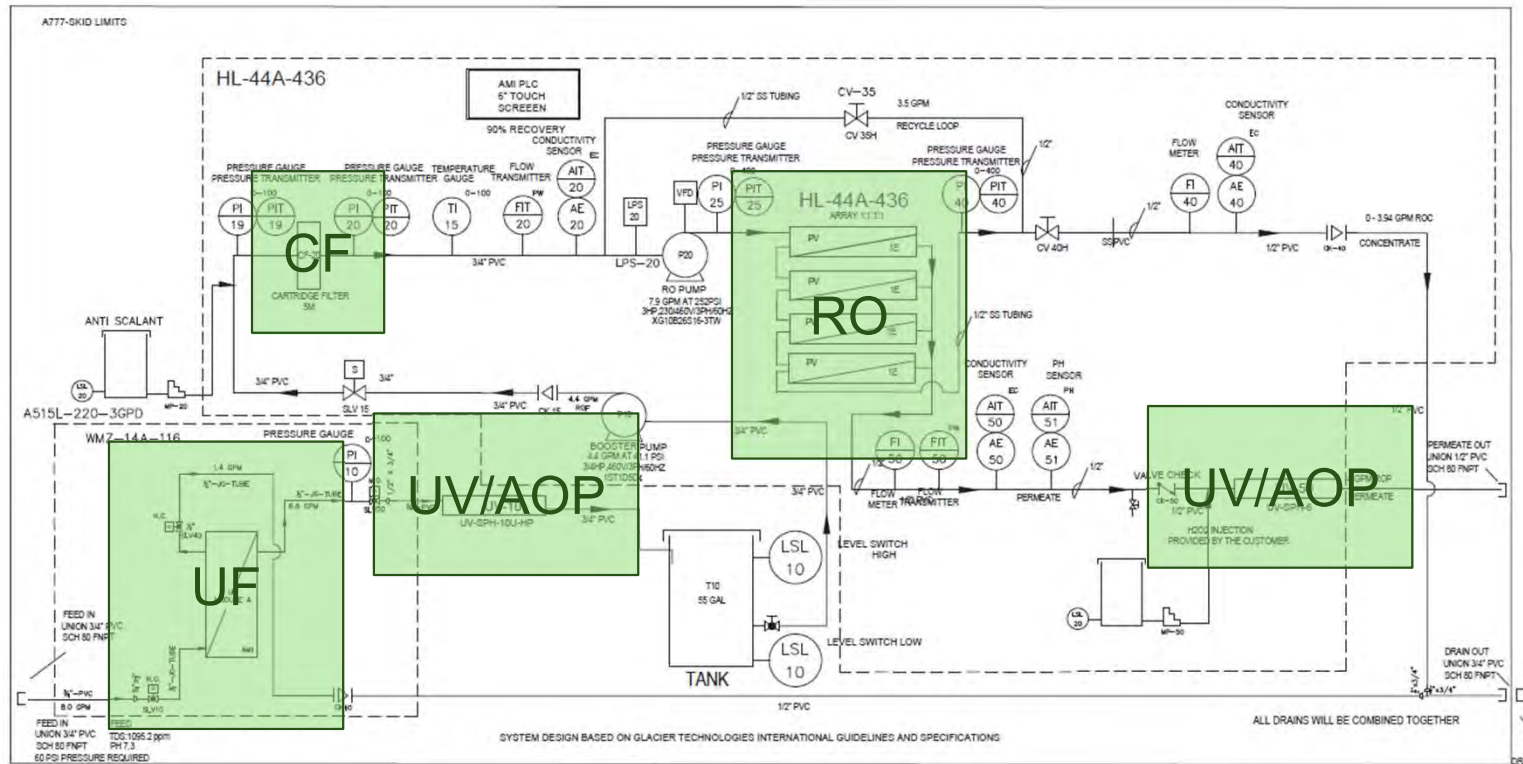


UV/AOP



Decarbonator

# DIGITAL TWIN PILOT TREATMENT PROCESSES



Treatment Process for  
the Designed DT Pilot

Ultrafiltration



Cartridge Filter



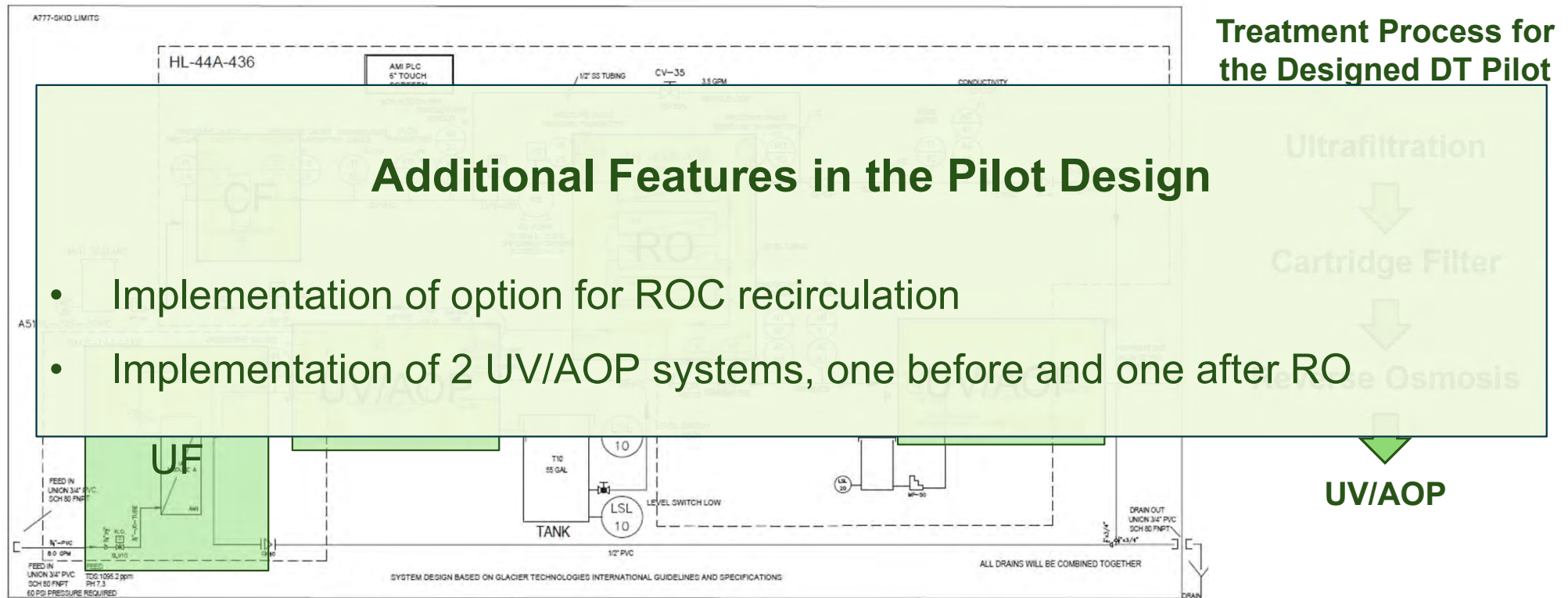
Reverse Osmosis



UV/AOP



# DIGITAL TWIN PILOT TREATMENT PROCESSES



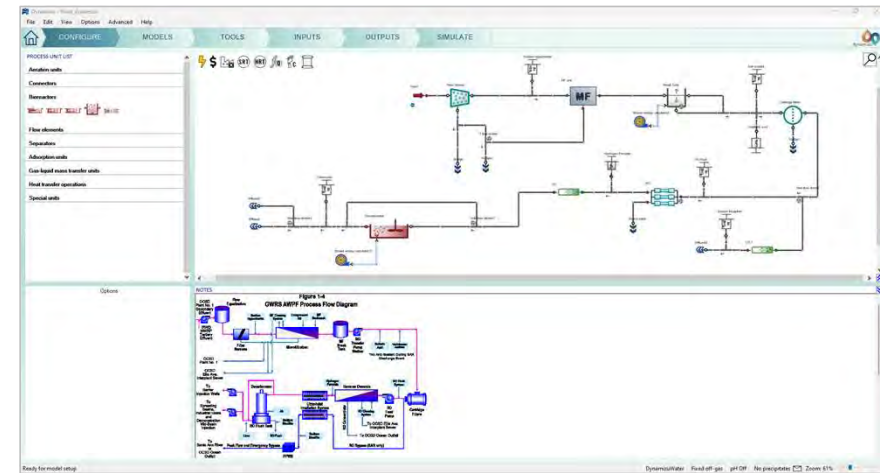


# PHYSICAL-DIGITAL TWINS CONNECTIVITY

Human-Machine  
Interface (HMI)



Physical Pilot at OCWD

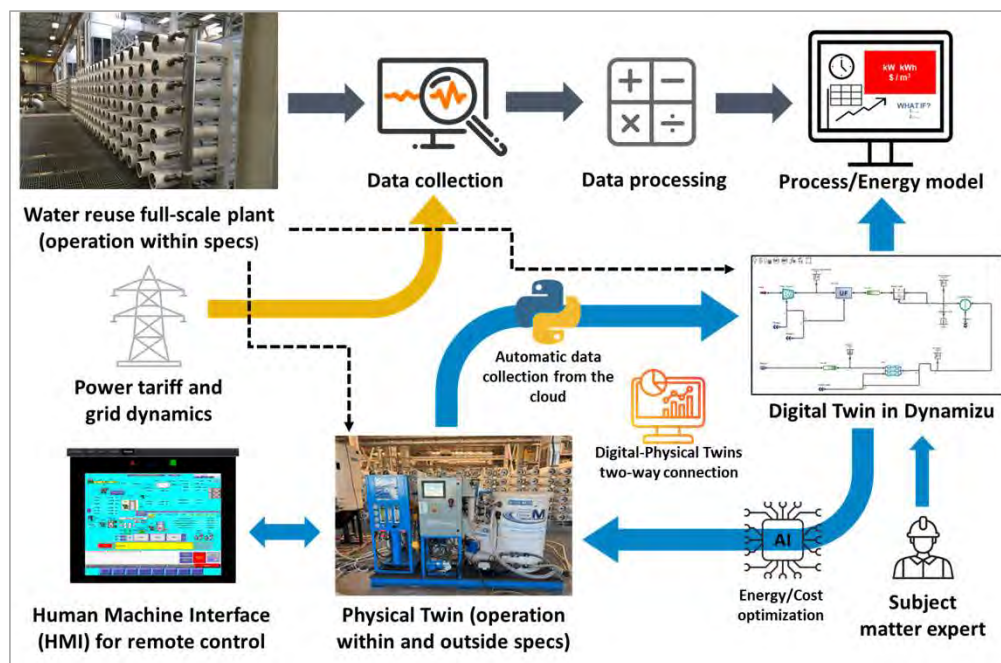


High-Fidelity Process Simulator  
(SUMO/Dynamizu by Dynamita)

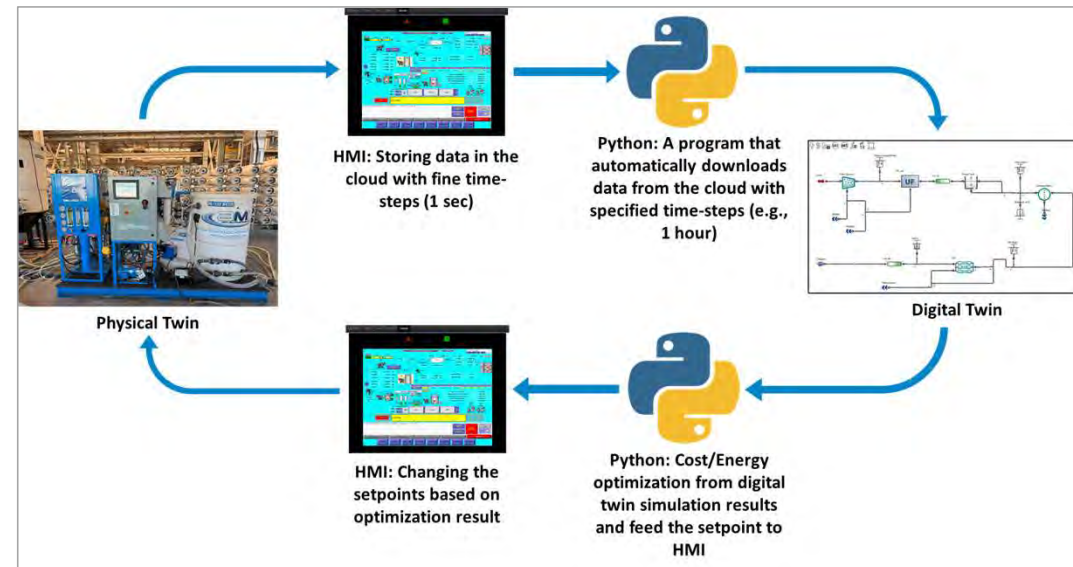
# DIGITAL TWIN PILOT'S HUMAN-MACHINE INTERFACE (HMI)



# IMPLEMENTATION OF 2-WAY COMMUNICATION FOR THE PHYSICAL-DIGITAL TWINS



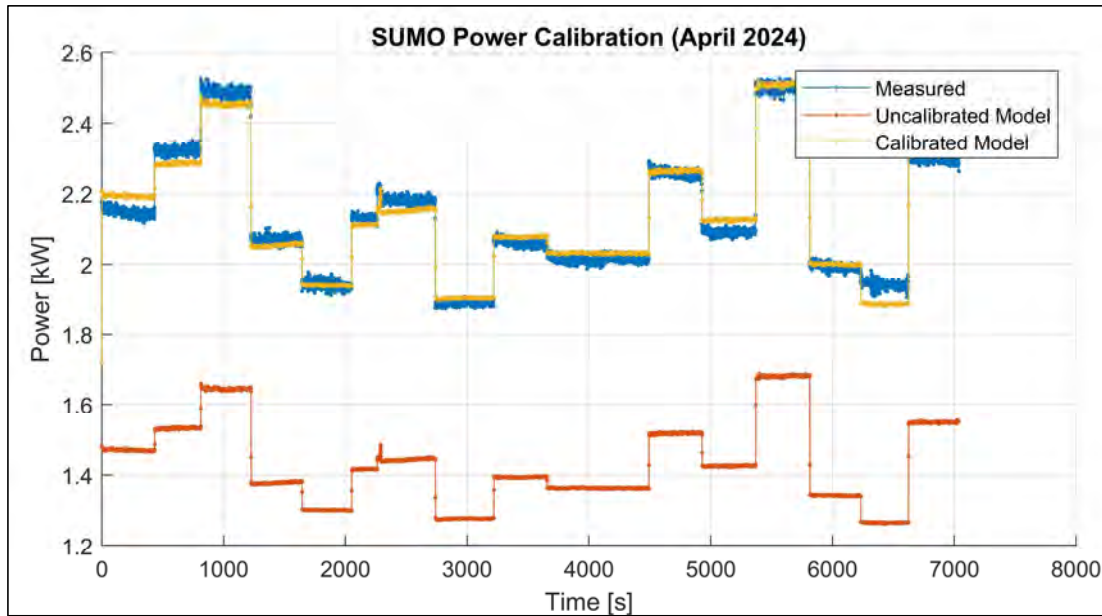
Implementation of Automated Process Control for the Physical-Digital Twins



Implementation of Data Communication between the Physical-Digital Twins

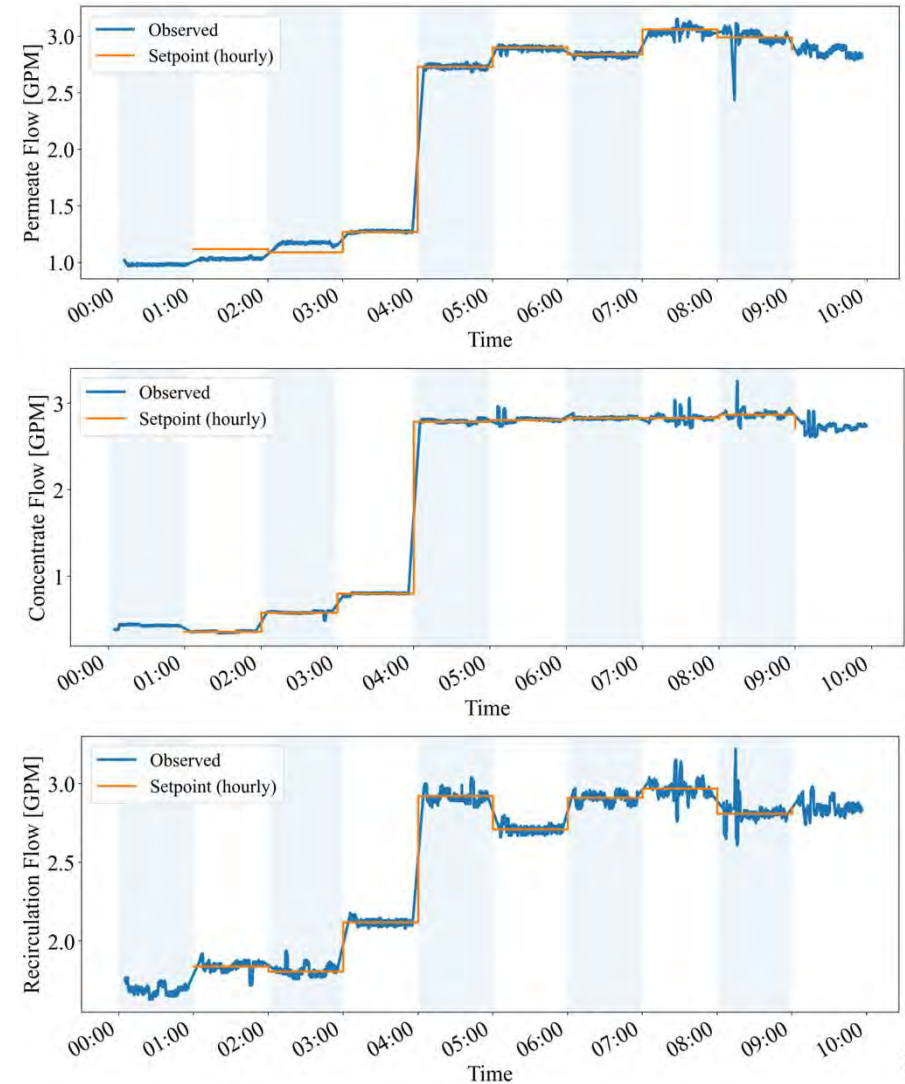


# DIGITAL TWIN CALIBRATION



The digital twin is calibrated

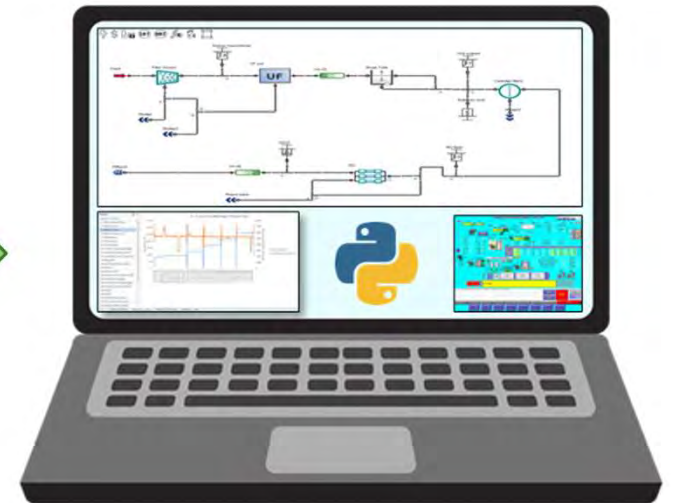
- Autonomously
- Using experimental data from the physical twin
- By adjusting the equipment specifications in the simulator



# IMPLEMENTATION OF THE PHYSICAL-DIGITAL TWINS



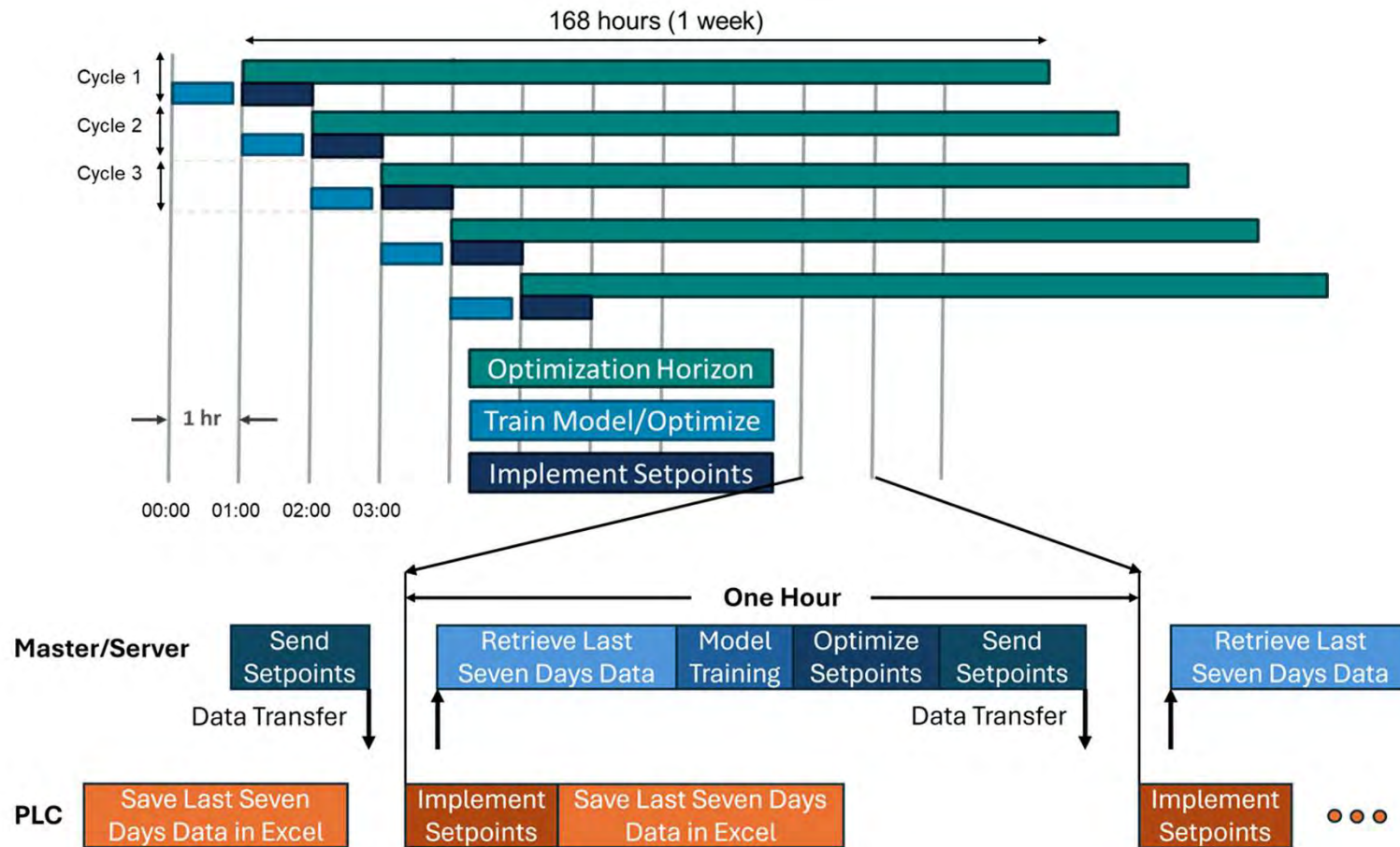
Advanced Treatment Train Pilot at OCWD



Advanced Treatment Train Pilot's Digital Twin at UC Irvine

# Using Digital Twin to Maximize Process Efficiency

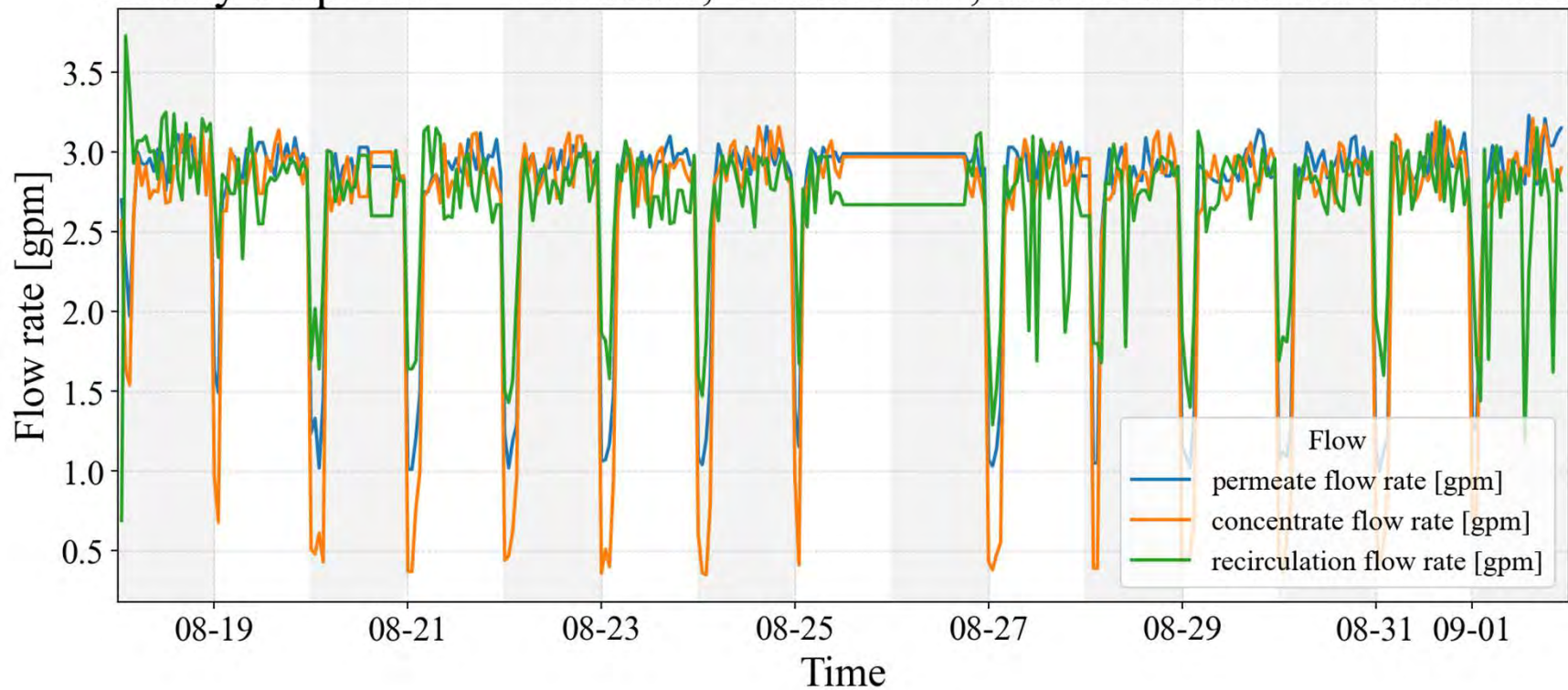
# MODEL PREDICTIVE CONTROL SCHEME TO IMPLEMENT THE OPTIMIZER



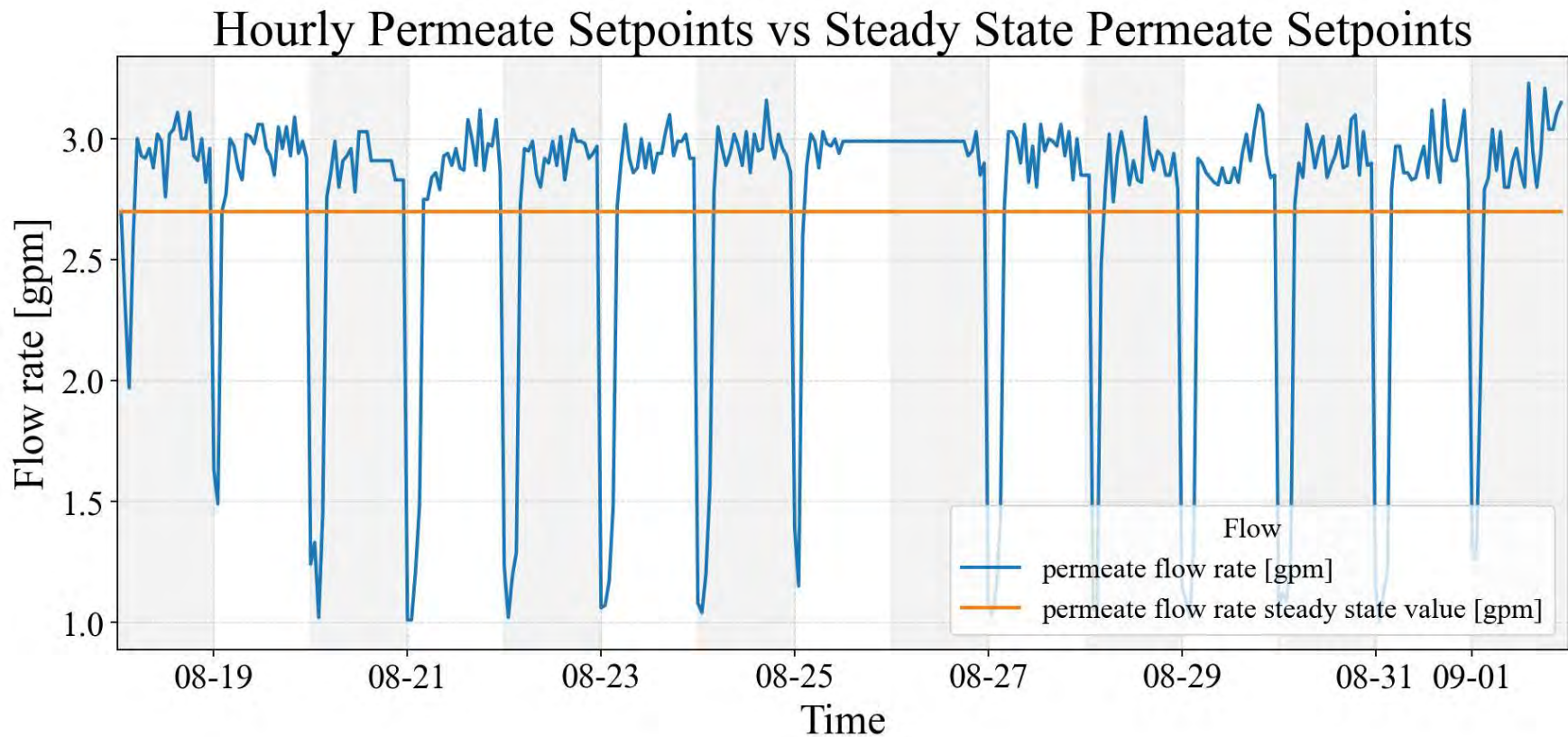


# PRELIMINARY OPTIMIZATION RESULTS

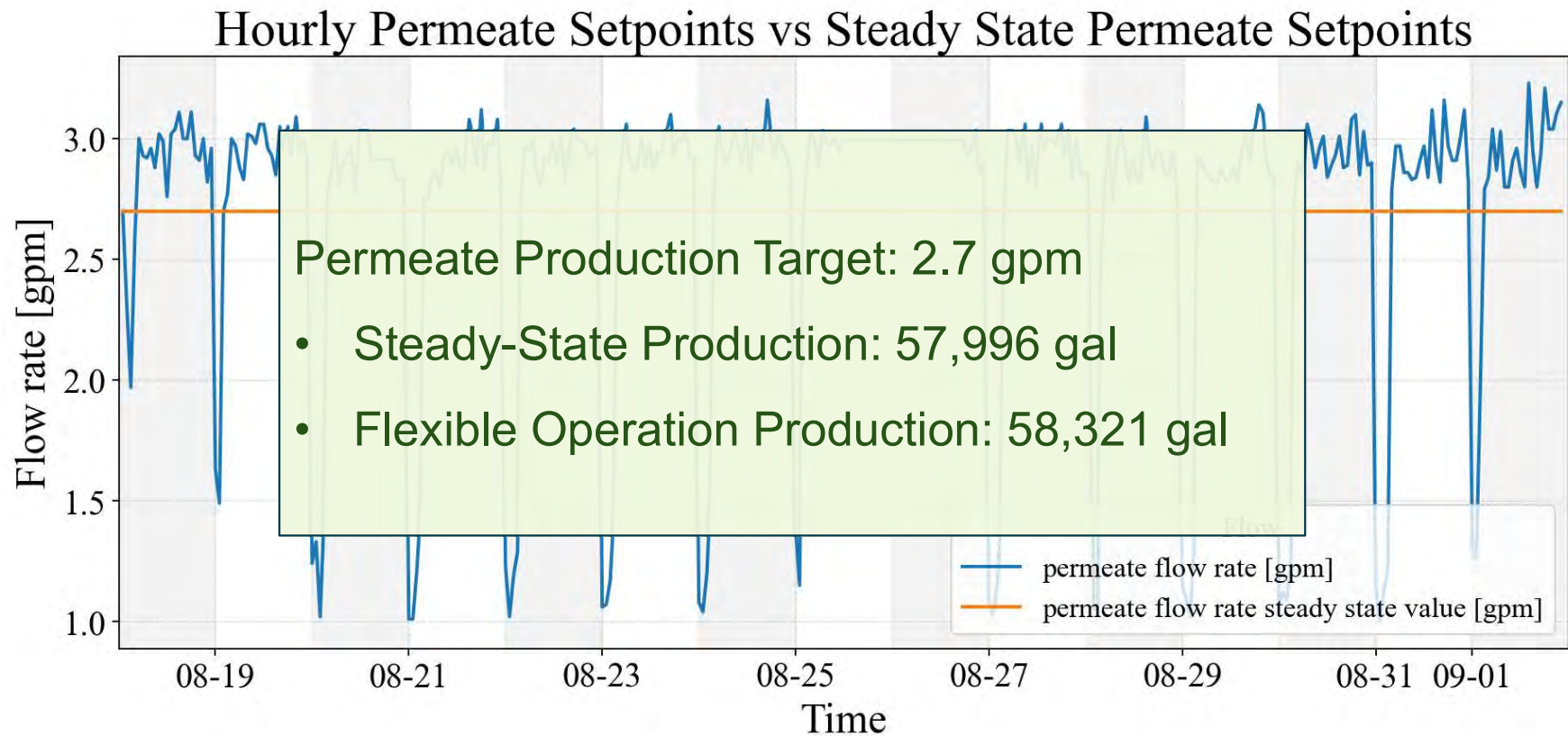
Hourly Setpoints — Permeate, Concentrate, and Recirculation Flow Rates



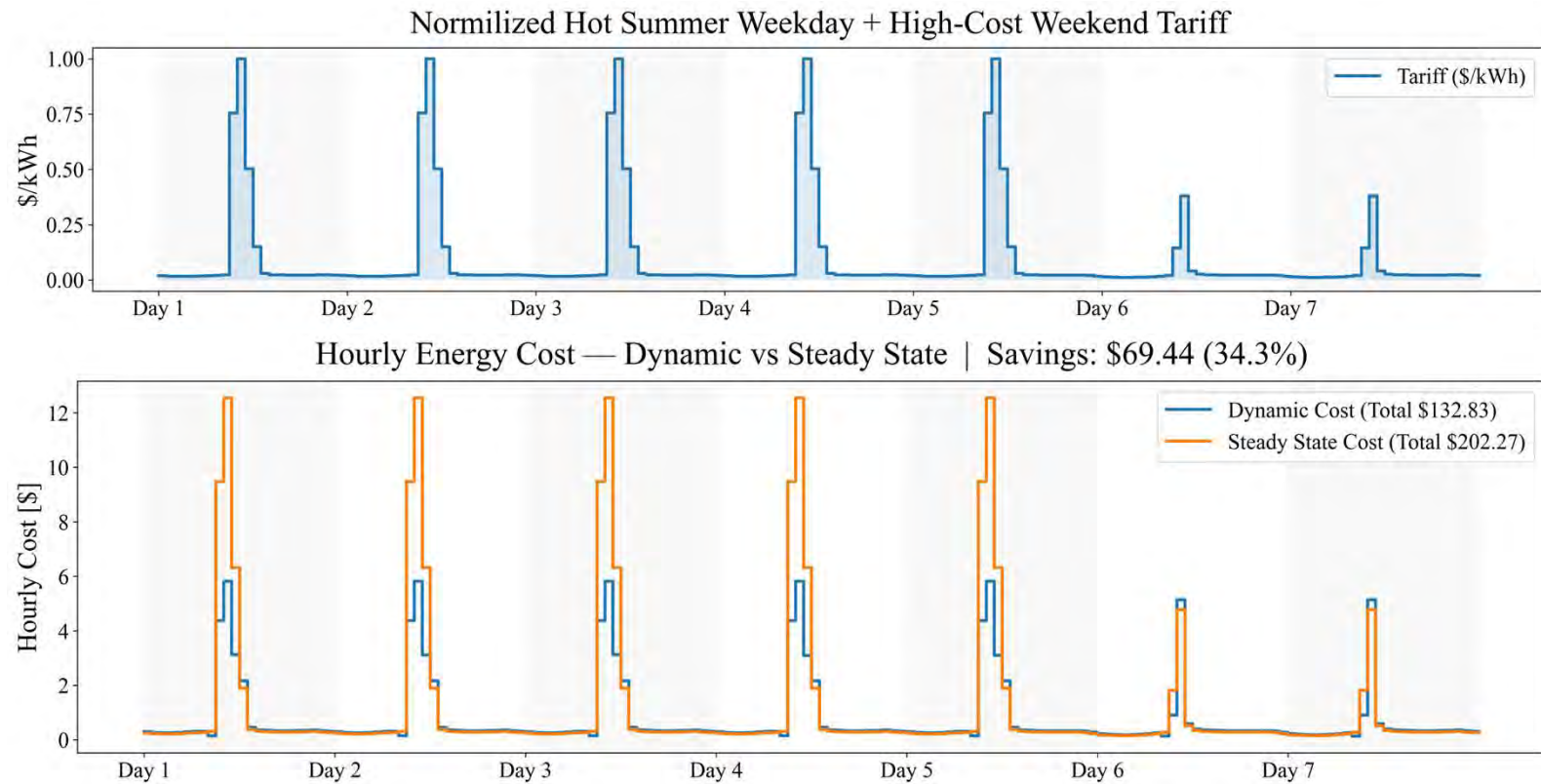
# PRELIMINARY OPTIMIZATION RESULTS



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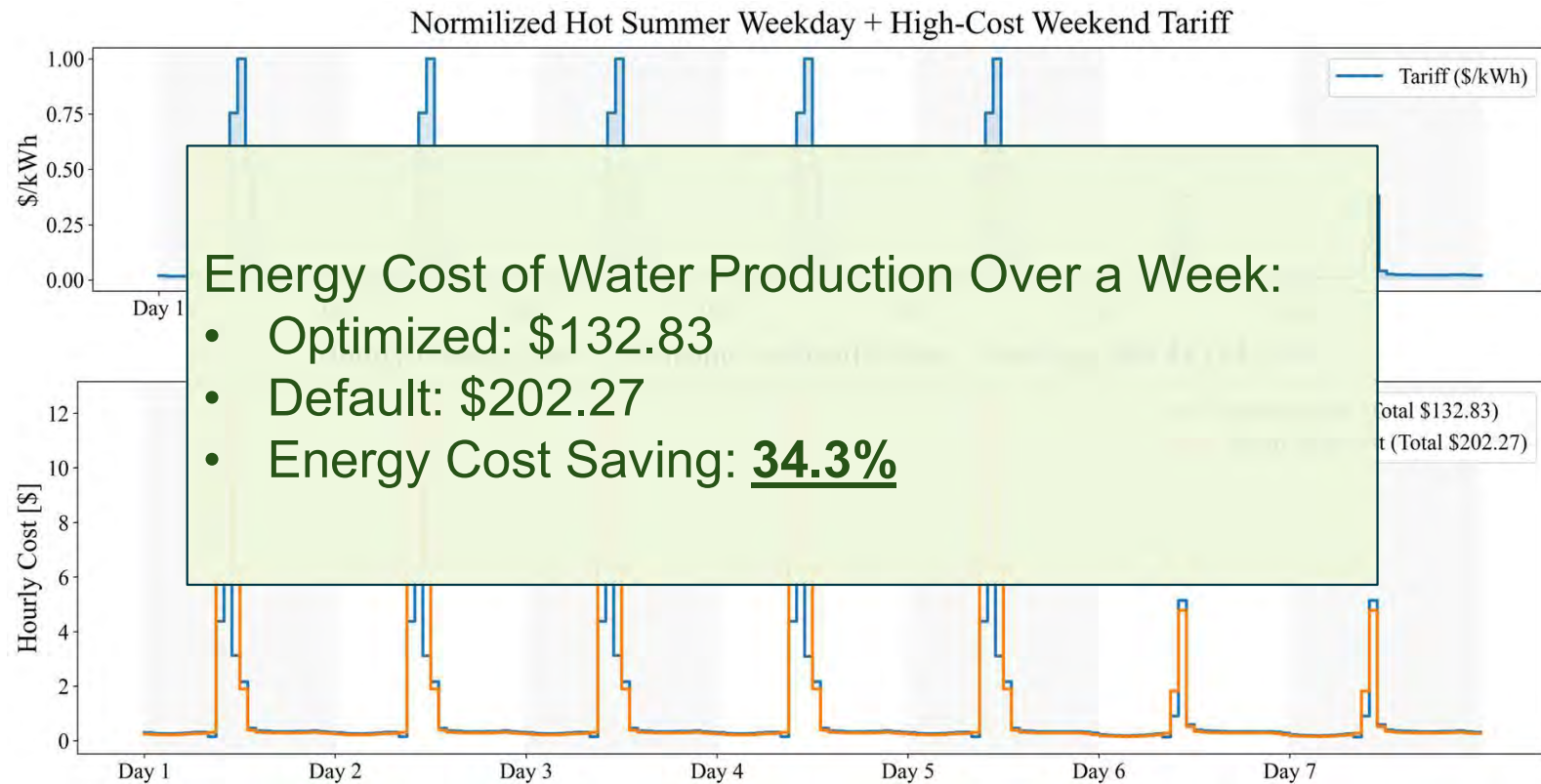


# PRELIMINARY OPTIMIZATION RESULTS





# PRELIMINARY OPTIMIZATION RESULTS



# Thank you.

Questions?

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# Our team

Digital AECOM's global team of over 2,000 digital specialists work alongside AECOM's 48,000 scientists, engineers, planners and designers to help investigate, develop, implement and evolve new and efficient approaches to deliver a better world.