



World Environmental and Water Resources Congress 2020



Hydraulics, Waterways, and Water Distribution Systems Analysis

Selected Papers from the Proceedings of the
World Environmental and Water Resources Congress 2020
Henderson, Nevada • May 17–21, 2020



EDITED BY

Sajjad Ahmad, Ph.D.



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WORLD ENVIRONMENTAL AND WATER RESOURCES CONGRESS 2020

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SYSTEMS ANALYSIS*

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SPONSORED BY
Environmental and Water Resources Institute
of the American Society of Civil Engineers

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Sajjad Ahmad, Ph.D.
Regan Murray, Ph.D.



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Preface

Welcome to the proceedings of the 2020 World Environmental and Water Resources Congress! These proceedings contain technical papers associated with the diverse set of talks, posters, and workshops presented at the American Society of Engineers' (ASCE) Environmental and Water Resources Institute's (EWRI) 20th Annual Congress, held in Henderson, NV, May 17-21, 2020. Engineers and scientists from around the world gather at the EWRI Congress to discuss the latest innovative research, case studies, and developing best practices in water resources and the environment.

The theme of this year's conference is, "Be Smart and Sustainable: Don't Gamble with your Infrastructure." Across the globe, infrastructure is in urgent need of investment and careful attention. ASCE's 2017 Infrastructure Report Card found the national grade for infrastructure remains near the bottom of the scale at a "D+" and estimates that an investment of over \$4.5 trillion is needed to return the nation's infrastructure to a state of good repair. The ASCE Failure to Act study notes that "deteriorating infrastructure, long known to be a public safety issue, has a cascading impact on our nation's economy, impacting business productivity, gross domestic product (GDP), employment, personal income, and international competitiveness". If this investment gap is not addressed throughout the nation's infrastructure sectors by 2025, the economy is expected to lose almost \$4 trillion in GDP.

Internationally, water infrastructure is critically important to the public's health, safety and security. The ASCE Report Card rated components of water infrastructure separately, assigning America's drinking water, inland waters and dams a "D," wastewater a D+, and bridges a "C+". The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. Sustainable Development Goal (SDG) 6 focuses on ensuring availability and sustainable management of water infrastructure and sanitation for all. Compounding the state of water infrastructure are the variability and uncertainty of future changes in climate. A systems approach is needed to address these complex challenges that cross the boundaries of water, energy, health, environment and the economy. Professionals in the water and environmental fields are in the best position to find creative and practical solutions to build resilience and sustainability into the world's water infrastructure.

The 2020 EWRI Congress covers a wide range of topic areas related to drinking water, groundwater, wastewater, stormwater, waterways, and irrigation and drainage infrastructure. Many overarching themes such as sustainability, smart water, security, systems analysis, and innovative technologies will also be addressed.

Within the six (6) volumes of the proceedings, more than 160 written scientific and technical papers from nearly 850 oral and poster presentations focusing on the subject areas of various EWRI Councils are included. A list of the subject area technical tracks is included in the acknowledgements below. We hope these proceedings enhance your knowledge base and inspire you to read other publications by the same authors or on similar topics that can be found in ASCE technical journals and publications.

The collection of papers in this volume of the Proceedings of the *World Environmental and Water Resources Congress, 2020, Be Smart and Sustainable: Don't Gamble With Your Infrastructure* contains papers organized by the following EWRI Councils:

- **Hydraulics and Waterways Council** whose purpose is to represent EWRI in technical matters pertaining to all aspects of hydraulic engineering of natural and man-made environmental systems. The Council promotes responsible water resources management and protection to foster sustainability and enhancement of the environment through the development, collection and dissemination of information and technology regarding the advancements and application of hydraulic engineering.
- **WDSA (Committee)**: Water distribution systems analysis (WDSA) involves the quantitative planning, design, operations, management, modeling, and monitoring of hydraulics and water quality of water distribution systems. The purpose of the committee is to provide coordination for all activities within EWRI related to the field of water distribution systems analysis.

Acknowledgments

The EWRI Congress depends on the dedication of volunteers who plan technical session topic areas, solicit abstracts and papers, oversee reviews of submitted abstracts and papers, identify moderators, and ensure the overall success of the program. We appreciate the efforts of everyone involved, especially the track chairs listed below:

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Student Competition	Wes Lauer, Ph.D., P.E., M.ASCE
Sustainability	Joshua Peschel, Ph.D., A.M.ASCE Kelly Sanders, Aff.M.ASCE

Water Distribution Systems Analysis Symposium	Mohsen Aghashahi, Ph.D.
Water, Wastewater and Stormwater	Arnold Strasser, P.E., M.ASCE Bridget Wadzuk, Ph.D.
Watershed	Levent Kavvas, Ph.D., Dist.M.ASCE Don Frevert, Ph.D., P.E., D.WRE(Ret.), F.ASCE
Watershed Management Conference (co-located with the EWRI Congress)	Rosanna LaPlante, P.E., F.ASCE

We also acknowledge the members of the Congress Organizing Committee; without whose time and efforts the event would not be possible.

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Finally, we acknowledge and thank EWRI staff who make this conference possible.

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Contents

Hydraulics and Waterways

3D CFD Simulation: Terrain-Conforming versus Terrain-Embedding Method	1
Yong G. Lai	
Air Demand of Baffle Drop Structures	12
Mookencheryl Cherian and Troy Lyons	
Alluvial Flow Resistance—Engelund Sediment Waveform.....	21
George K. Cotton	
An Experimental Study: Effects of Boulder Spacing on Mean and Turbulent Flow Characteristics	31
Amir Golpira, Kaitlyn Koehler, Andrew All, and Abul B. M. Baki	
Analysis of Equilibrium Morphologies Downstream of a PK Weir Structure	43
Michele Palermo, Brian Crookston, and Stefano Pagliara	
Assessing Biological Impacts from Storm Flow Diversions: A Case Study	52
David A. Jaffe, Eric Stein, and Marc T. Blain	
Characteristics of Hydraulic Jumps in Stilling Basins with Permeable Six-Legged Elements	65
Vida Attashi, Yeo Howe Lim, Maryam Khajavi, and Mahmood Shafai-Bajestan	
Effects of Bridge Pier Location and Debris Accumulation on Equilibrium Morphology	76
Simone Pagliara and Michele Palermo	
Enhancing Maximum Scour Depth Determination for Spur Dikes Using a Validated Two-Dimensional Model.....	84
Yeo Howe Lim and Mathew Lee Cox	
Equivalent Manning's Roughness in Combining Open Channel Junction Flows	99
Abhishek K. Pandey, Pranab K. Mohapatra, and Vikrant Jain	
Historical Loss of Flood Plains in the Upper Turtle Creek Watershed	108
Joseph R. Dietrick	
Improved Adaptive Immersed Boundary Method for Smooth Wall Shear.....	119
Yalan Song, Yong G. Lai, and Xiaofeng Liu	
Modulation of Turbulent Flow by Surrogate Asian Carp Eggs	129
Yilan Li, Sean Bennett, and Zhenduo Zhu	

Momentum Interpolation Corrections	137
Yaoxin Zhang and Yafei Jia	
Numerical Modeling of Flow, Sediment, and Salinity in Lake Pontchartrain during the Bonnet Carré Spillway Flood Release	144
Xiaobo Chao and Yafei Jia	
Numerical Modeling of Hydrodynamics, Waves, and Salinity in Matagorda Bay and Ship Channel, Texas	155
L. Lin, Z. Demirbilek, and Mohammad S. Islam	
Optimization and Risk Assessment in Design and Operation of Hydraulic Structures Using Three-Dimensional CFD Modeling	170
Jie Zeng, Zubayed Rakib, Matahel Ansar, and Seyed Hajimirzaie	
Resistance Partitioning of Headwater Mountain Streams—A Case Study in Southern Ecuador	183
Sebastián Cedillo, Luis Timbe, Esteban Samaniego, and Andrés Alvarado	
Sedimentation and Small Dams	195
Jon Fripp, Greg Morris, Seyed Hajimirzaie, and Claudia C. Hoeft	
Sensitivity of River Sediment Transport Changing Conditions	202
Brian D. Barkdoll, Jennie Tyrrell, Yang She, and Jui Patankar	
Simulation of Shoreline Changes on the Delaware Coast near the Indian River Inlet	210
Yan Ding, Sung-Chan Kim, Rusty Permenter, Richard Styles, and Jeffrey A. Gebert	
Study of Bend Scour and Spur Protection for Fengshan River of Taiwan	220
Dong-Sin Shih and Tzu-Yi Lai	
The Impacts of Time Integration Schemes on the Pressure Surge Prediction in a Closed Conduit Transient Flow	225
Arman Rokhzadi and Musandji Fuamba	
Understanding Suitability of MIKE 21 and HEC-RAS for 2D Floodplain Modeling	237
Alen Shrestha, Linkon Bhattacharjee, Sudip Baral, Balbhadra Thakur, Neekita Joshi, Ajay Kalra, and Ritu Gupta	
Understanding the Patterns of Sediment Dynamics in Lower Green Bay, Lake Michigan	254
Bahram Khazaei, Eric J. Anderson, Todd R. Miller, Jeffrey V. Klump, and Hector R. Bravo	
Utilization of Stable Water Isotopes and Geochemistry for Detecting Seepage Pathways within North Texas Dam	264
Eric Lam, Bryan Freymuth, and Carmen Berry	

Water Distribution Systems Analysis

A Smart Metering Program for Water Consumption Patterns Assessment: Case Study; Brasília, Brazil.....	273
Diogo Fidelis Costa and Alexandre Kepler Soares	
An Overview of the Transient Simulation in Water Distribution Networks (TSNet)	282
Lu Xing and Lina Sela	
Analyzing the Effects of Temperature and Precipitation in the Context of a Water Demand Model.....	290
Alexander M. Roper and Richard N. Palmer	
Application of Thevenin Theorem for Model Reduction and Analysis of Large Water Distribution Networks	304
Raman Balireddy, Anjan Chakravorty, Soumendra Nath Kuiry, and S. Murty Bhallamudi	
Dynamic Clustering for Water Distribution System Water Quality Management	318
Mengning Qiu and Avi Ostfeld	
Identifying Vulnerable and Critical Water Distribution Segments	329
Noha Abdel-Mottaleb and Tom Walski	
MINLP Modeling for Detection of SCADA Cyberattacks in Water Distribution Systems	340
Faegheh Moazeni and Javad Khazaei	
Modeling and Design of a Multi-Use Fresh/Produced Water System with Significant Demand Variations.....	351
Guohua Li, Michelle McInerney, and Hamid Bidmus	
Modeling Dynamic Consumer Decisions during Disruptions of Intermittent Water Supply Systems	360
Saad Aljadhari and Dulcy M. Abraham	
Optimizing Tank Design to Improve THM Removal with Spray Aeration.....	374
Alicia Qui Cheung, David Rouhani, and Erica J. Marti	
Pressure Transients in a Sewage Pumping System: Field Tests and Hydraulic Modelling.....	385
Arthur Brito Nunes Diniz, Alexandre Kepler Soares, and Dídía Isabel Cameira Covas	
Spread of Salt through a Looped Water Distribution System and an Alternative to Conventional System Flushing	395
Darud E. Sheefa and Brian D. Barkdoll	