

WORLD ENVIRONMENTAL AND WATER RESOURCES CONGRESS 2020

*EMERGING AND INNOVATIVE TECHNOLOGIES AND
INTERNATIONAL PERSPECTIVES*

SELECTED PAPERS FROM THE WORLD ENVIRONMENTAL AND
WATER RESOURCES CONGRESS 2020

May 17–21, 2020
Henderson, Nevada

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

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



Published by the American Society of Civil Engineers

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4382
www.asce.org/publications | ascelibrary.org

Any statements expressed in these materials are those of the individual authors and do not necessarily represent the views of ASCE, which takes no responsibility for any statement made herein. No reference made in this publication to any specific method, product, process, or service constitutes or implies an endorsement, recommendation, or warranty thereof by ASCE. The materials are for general information only and do not represent a standard of ASCE, nor are they intended as a reference in purchase specifications, contracts, regulations, statutes, or any other legal document. ASCE makes no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed in this publication, and assumes no liability therefor. The information contained in these materials should not be used without first securing competent advice with respect to its suitability for any general or specific application. Anyone utilizing such information assumes all liability arising from such use, including but not limited to infringement of any patent or patents.

ASCE and American Society of Civil Engineers—Registered in U.S. Patent and Trademark Office.

Photocopies and permissions. Permission to photocopy or reproduce material from ASCE publications can be requested by sending an e-mail to permissions@asce.org or by locating a title in ASCE's Civil Engineering Database (<http://cedb.asce.org>) or ASCE Library (<http://ascelibrary.org>) and using the “Permissions” link.

Errata: Errata, if any, can be found at <https://doi.org/10.1061/9780784482940>

Copyright © 2020 by the American Society of Civil Engineers.
All Rights Reserved.
ISBN 978-0-7844-8294-0 (PDF)
Manufactured in the United States of America.

Front cover: Photos courtesy of Sajjad Ahmad, Ph.D., P.E. Used with permission.

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:

- **Emerging and Innovative Technologies Committee (Interdisciplinary Council)** whose purpose is to develop and apply emerging and innovative technologies to support the functioning of EWRI , to advance the development , knowledge, and application of emerging and innovative technologies for the planning and management of water resources and the protection and enhancement of the environment; to encourage the reporting, discussion of technical and social issues, and information transfer of applications of emerging and innovative technologies; and to foster the multidisciplinary use of these technologies.
- **International Council** whose purpose is to undertake and facilitate a variety of technical and liaison activities in support of international collaboration and international promotion of the role of the Institute.
- **Symposium: Smart Water (Interdisciplinary Council)**: The Smart Water Symposium explored the development of emerging and innovative technologies through three technical sessions: Smart Sensing, Smart Water Grid and Intelligent Analytics. The papers cover interesting applications of "smart" technologies to drinking water, wastewater, stormwater and source water
- **Cyber-physical Security of Urban Water Infrastructure**: The continuous modernization of critical infrastructure relies on the integration of physical processes and assets with networked devices that monitor and control the operations of the entire system. While digitalization significantly improves the automation and performance of urban water infrastructure, it also exposes it to cyber threats—as demonstrated by the recent, sharp increase in the number of attacks to water utilities. These papers discuss topics broadly related to cyber-physical security of urban water infrastructure.

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:

Cyber Physical Security of Urban Water Infrastructure	Mohsen Aghashahi, Ph.D.
Desalination Symposium	Berrin Tansel, Ph.D., P.E., D.WRE, F.EWRI, F.ASCE
Education	William Gonwa, Ph.D., P.E., M.ASCE
Emerging & Innovative Technologies	Barak Fishbain, Ph.D., A.M.ASCE
Environmental	Wendy Cohen, P.E., M.ASCE Lisa Hayes, P.E., M.ASCE Rory Klinger, Ph.D., P.E., M.ASCE
Groundwater Symposium	Paul Mathisen, P.E., M.ASCE
History & Heritage (Nevada & California Water History Symposium)	Larry Magura, P.E., D.WRE(Ret.), F.ASCE
Hydraulics & Waterways	Fabian Bombardelli, A.M.ASCE
Hydro-climate/Climate Change Symposium	Levent Kavvas, Ph.D., Dist.M.ASCE
International Issues	Erfan Goharian, Ph.D., EIT, A.M.ASCE Ali Mirchi, Ph.D., A.M.ASCE
Irrigation & Drainage	Stuart Styles, Ph.D., P.E., D.WRE, M.ASCE Anastasia Chirnside, Ph.D., A.M.ASCE
New Professionals	Nur Orak, Ph.D.
Planning and Management	Mashor Housh, Ph.D., R.Eng, M.ASCE Debora Piemnonti, Ph.D., A.M.ASCE
Professional Practice	Kristin White
Standards	Kathlie S. Jeng-Bullock, Ph.D., P.E., CFM, D.WRE, M.ASCE
Smart Water Symposium	Sudhir Kshirsagar, P.E., M.ASCE
Stormwater Symposium	Sarah Waickowski, E.I. Ryan Winston, Ph.D., P.E., M.ASCE
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.

General Chair

Sri Kamojjala, P.E., D.WRE, M.ASCE

Local Arrangements Chair

Joseph Cetrulo, M.ASCE

Technical Program Chairs

Sajjad Ahmad, Ph.D., P.E., M.ASCE

Regan Murray, PhD

Sponsorships Chair

Heidi A. Dexheimer, P.E., M.ASCE

Technical Program Coordinator

Veera Gnaneswar Gude, Ph.D., P.E., F.ASCE

Member at Large

Kristina Swallow, P.E., ENV SP, F.ASCE

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

Director, EWRI

Brian K. Parsons, M.ASCE

Conference Coordinator, EWRI

Nicole Erdelyi

Senior Manager, EWRI

Gabrielle Dunkley

Sponsorship and Exhibit Sales Manager

Drew Caracciolo

Technical Manager, EWRI

Barbara Whitten

Manager of Member Services, EWRI

Jennifer Jacyna

Senior Conference Manager, EWRI

Mark Gable

Contents

Cyber-Physical Security of Urban Water Infrastructure

Securing the Digitally Managed Water Supply.....	1
Chuck Louisell and Kevin Heaslip	

Emerging and Innovative Technologies

A Remotely Controlled Framework for Gravity-Driven Water Release in Shallow and Not Shallow Storage Ponds.....	12
Vivek Verma, Linlong Bian, Aditia Rojali, Dogukan Ozecik, and Arturo Leon	

Efficiency Improvement of a Novel Submerged Oscillating Water Column (SOWC) Energy Harvester.....	23
Mohammadamin Torabi and Bruce Savage	

Reliability and Robustness Evaluation of a Remotely Operated Siphon System for Flood Mitigation during Hurricanes.....	31
Vivek Verma, Krishna Sai Vutukuru, Linlong Bian, Aditia Rojali, Dogukan Ozecik, and Arturo Leon	

Sediment Color Effects on the Estimation of Suspended Sediment Concentration from Digital Imagery	40
Shah Md. Imran Kabir and Habib Ahmari	

International Issues

Infrastructure Development in Closed River Basin: Impact Assessment Analysis on Lower Indus Basin	51
Zarif Khoro, Pervaiz Khahro, and Nisar Samejo	

Water Security in Eswatini, Africa.....	64
Avital L. Breverman, Jacob E. Helminiak, and Stephen M. England	

Smart Water Symposium

Urban Water Process Observation and Analysis: A Case Study in Shenzhen of Southern China	73
Zexing Liu and Yangbo Chen	