

World Environmental and Water Resources Congress 2016

Hydraulics and Waterways and Hydro-Climate/Climate Change

Selected Papers from the Proceedings
of the 2016 World Environmental
and Water Resources Congress

West Palm Beach, Florida
May 22–26, 2016



Edited by

Chandra S. Pathak, Ph.D., P.E., D.WRE



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WORLD ENVIRONMENTAL AND WATER RESOURCES CONGRESS 2016

*HYDRAULICS AND WATERWAYS
AND HYDRO-CLIMATE/CLIMATE CHANGE*

PAPERS FROM SESSIONS OF THE PROCEEDINGS OF THE 2016
WORLD ENVIRONMENTAL AND WATER RESOURCES
CONGRESS

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West Palm Beach, Florida

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

EDITED BY
Chandra S. Pathak, Ph.D., P.E., D.WRE
Debra Reinhart, Ph.D., P.E.



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Preface

We are excited to offer an engaging and challenging array of technical sessions, posters, and accompanying published papers at our Environmental and Water Resources Institute's (EWRI) 16th annual Congress in West Palm Beach, Florida. This meeting is a leading venue for professional interaction among engineers and scientists, covering disciplines relating to the needs of critical infrastructure in water and environment. As is pointed out in the American Society of Civil Engineers' Report Card for America's Infrastructure, an investment of over \$3.6 trillion is needed to return the nation's infrastructure to a state of good repair. This Congress contributes in many ways to innovative solutions to this critical problem. We proudly host the meeting under the auspices of the American Society of Civil Engineers (ASCE).

Within the five (5) collections of papers in the proceedings of the Congress you will find nearly 300 written technical papers from more than 700 oral and poster presentations dealing with the subject areas of the EWRI Councils; a list of subject area tracks is included in the acknowledgements below. Our profession advances through presentations in special state-of-knowledge tracks represented at the Congress. We hope these proceedings serve to enhance your knowledge in these areas and encourage you to follow up with more detailed publications by the same authors, typically found in ASCE technical journals.

World Environmental and Water Resources Congress 2016: Hydraulics and Waterways and Hydro-Climate/Climate Change contains papers organized by the following EWRI Councils, Committees and conference Symposium:

- **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.
- **Symposium: Hydro-Climate/Climate Change (Committee)** whose purpose is to provide a formal organizational structure within ASCE/EWRI for addressing the various engineering problems that are created by hydroclimate phenomena and climate change, fostering their science-based engineering solutions.

Acknowledgments

Preparation and planning for this Congress strongly depends on the dedication of those who plan track subjects, solicit abstracts and papers, oversee reviews of all this material and then “encourage” all authors to provide their material in a timely manner! We are deeply grateful to all who have provided this considerable effort, especially the track chairs listed below:

Track	Chairs
Symposium Hydro-Climate/Climate Change	Levent Kavvas
13th Urban Watersheds Management Symposium	Shirley Clark
14th Symposium on Groundwater and Hydraulic Fracturing	Antonella Sciortino, Teresa Culver, Amy Chan Hilton
18th Annual Water Distribution Systems Analysis Symposium	Jakobus van Zyl
Education and Research	Cassie Klump
Emerging Technologies	David Hill
Environmental	Marge Bedessem
History and Heritage	J. David Rogers
Hydraulics and Waterways	David Weston, Weiming Wu
International	Kevah Madani
Irrigation and Drainage	Garry Grabow
Planning and Management	Mashor Housh
New Professionals/Professional Development	Jeanne Van Briesen
Standards	Kathlie Jeng-Bulloch
Student	Monica Palomo
Sustainability	Ashlynn Stillwell
Water, Wastewater, and Stormwater	Sri Kamojjala
Watersheds	Levent Kavvas, Don Frevert

We also acknowledge the Congress Organizing Committee members, without whose time and efforts the event would not be possible. We also thank others not mentioned here.

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Finally, we acknowledge and thank the staff of the EWRI of ASCE who, in the end, makes it all happen. Most particularly, we thank Gabrielle Dunkley, EWRI's Manager, whose patience, perseverance, good humor, and great organizational talent ensure yet another successful EWRI Congress!

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