

# World Environmental and Water Resources Congress 2021

## Planning a Resilient Future along America's Freshwaters

JUNE 7–11, 2021 • Proceedings of the World  
Environmental and Water Resources Congress 2021



EDITED BY • Lily A. Baldwin, P.E.; and  
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ENVIRONMENTAL &  
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# WORLD ENVIRONMENTAL AND WATER RESOURCES CONGRESS 2021

*Planning a Resilient Future along America's  
Freshwaters*

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SELECTED PAPERS FROM THE WORLD ENVIRONMENTAL AND  
WATER RESOURCES CONGRESS 2021

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June 7–11, 2021

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## Preface

The proceedings of the 2021 World Environmental and Water Resources Congress contain technical papers associated with the diverse set of technical sessions and posters presented at the first ever virtual, American Society of Civil Engineers' (ASCE) Environmental and Water Resources Institute's (EWRI) 22<sup>nd</sup> Annual Congress. This new platform has enabled engineers and scientists from around the world to gather for the EWRI Congress to discuss the latest innovative research, case studies, and best management practices in water resources and the environment.

The theme of this year's congress, "Planning a Resilient Future Along America's Freshwaters" was inspired by the originally scheduled location Milwaukee, Wisconsin and by Lake Michigan, upon whose south west shores Milwaukee sits. Collectively with Lake Michigan's sister lakes, Lakes Superior, Huron, Erie and Ontario, the Great Lakes hold nearly 5,500 cubic miles of water, over eighty percent of North America's surface fresh water, one fifth of all the surface freshwater on our planet. A legacy of North America's last ice age, the Great Lakes are our world's largest freshwater system, geologically young and fragile, and under peril from climate change impacts. This danger to the drinking water source for over 30 million people, the ecosystems of innumerable wildlife and plants, means engineers and scientists must come together to eliminate this threat.

But climate change threats to freshwater resources are not unique to the Americas. Cape Town in South Africa, Istanbul in Turkey, major cities around the world, its population's drinking water source are under threat too. The dangers to freshwater systems, the introduction of invasive species and algal blooms as a result of changes in temperature and climate patterns, can be found everywhere. Engineers and scientists all over the world must come together to share their experiences and research so that we might solve this problem together.

The 2021 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.

The proceedings contain over 100 written scientific and technical papers from nearly 450 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 proceedings of the *World Environmental and Water Resources Congress, 2021, Planning a Resilient Future Along America's Freshwaters* contains papers organized by the following EWRI Councils:

- **Emerging and Innovative Technologies Committee** – The Emerging and Innovative Technologies Committee is part of the Interdisciplinary Council whose purpose is to develop and apply emerging and innovative technologies to support the functioning of the EWRI and Society; 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 multi-disciplinary use of these technologies.
- **Environmental** – The Environmental Council establishes a focal point and provide a forum for civil engineers and scientists to participate and exchange ideas on the full range of innovative and emerging environmental engineering topics. The Council's technical committees produce publications, webinars, and Congress sessions highlighting sustainability and interdisciplinary collaboration. The Council's awards committee reviews published technical papers and makes recommendations for 10 EWRI and ASCE awards. The committees seek to remain on the cutting edge and disseminate state-of-the-art knowledge on: 1. environmental health and water quality issues, promoting a fundamental understanding of the nature and scope of the issues; 2. environmental permitting nationally and internationally for air, water (groundwater, surface water, wastewater, and stormwater), and waste (solid and hazardous); 3. hazardous, toxic and radioactive waste topics, evaluating physical, chemical and biological treatment processes, site remediation engineering, evolving and innovative remedial approaches, and effectiveness of alternate technologies; and 4. zero waste initiatives, a proposed committee to exchange ideas on how to achieve zero waste goals through advances in solid waste management practice and design to promote diversion, composting, and recycling.
- **Groundwater** – The Groundwater Council provides a forum and structure for the creation and dissemination of knowledge on all aspects of groundwater including, but not limited to, ground water hydrology, ground water planning and management, and ground water quality, and attracts groundwater professionals to EWRI.
- **History & Heritage** – The History & Heritage Committee collects, organizes, and disseminates information related to the history and heritage of water resources and environmental engineering.
- **Hydraulics & Waterways** – The Hydraulics & Waterways Council represents 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.

- **International** – The International Council undertakes and facilitates a variety of technical and liaison activities in support of international collaboration and international promotion of the role of the Institute; to encourage high quality products and services that are international in scope and are of value to the Institute and the Society in general.
- **Irrigation & Drainage** – The Irrigation & Drainage Council promotes responsible use of water resources and protection/enhancement of the environment through the development, collection, and dissemination of information regarding the use and application of irrigation and drainage systems.
- **Planning & Management** – The Planning & Management Council creates, organizes, and manages the activities of various technical committees dealing with water resources planning and management.
- **Standards** – The Standards Council coordinates all activities of EWRI related to the establishment, use, or discontinuance of standards or other regulatory tools in the area of water and the environment.
- **Sustainability Committee** – The Sustainability Committee is also part of the Interdisciplinary Council and it promotes sustainability as a central discipline of EWRI. The Committee helps coordinate and optimize sustainability initiatives throughout EWRI and with external organizations as we all seek to create a more sustainable built environment. The mission of the Sustainability Committee is to focus the attention of those involved in environmental and water resources engineering on the ways in which sustainable development principles can and must lead to broader collaboration with other engineering and professional disciplines. This committee will provide and promote forums for considering how increased dialogue and new systems approaches can lead to regulatory reevaluations and new innovations that minimize resource consumption and maintain the economic and environmental systems needed for a sustainable future.
- **Urban Water Resources Research Council** – The Urban Water Resources Research Council advances engineering knowledge and practice through stimulating and guiding research and assisting the financing thereof in the field of urban hydrology; to organize research projects; in cooperation with professional committees, to interpret the findings of research; and to make available information and recommendations resulting from such research. The Council continuously studies the needs for new information in the subject field.
- **Water, Wastewater & Stormwater** – The Water, Wastewater & Stormwater Council creates, organizes, and manages the activities of various technical committees dealing with the engineered infrastructure and its effect on the environment, particularly water resources. Attention is focused on assessing the effects and the important interrelationships of water resources, facilities and installations and necessary

environmental and public health protection measures/systems needed for the functioning and sustainability of an adequate infrastructure.

- **Watershed** – The Watershed Council advances scientific and engineering principles for the collection, coordination, and dissemination of knowledge of watersheds from the standpoint of hydrologic, hydraulic, water quality, and environmental processes.

## 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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