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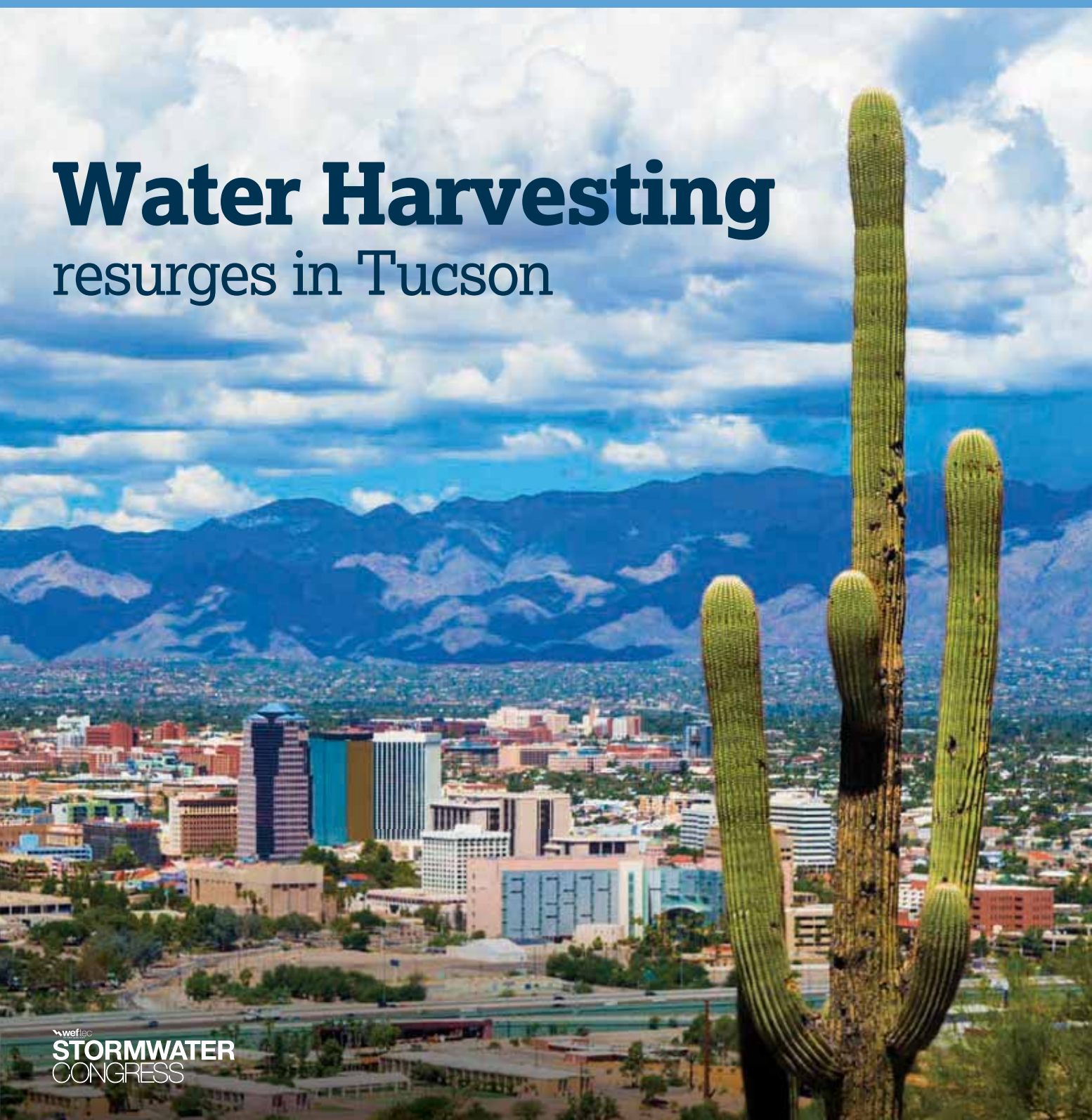

Water Harvesting
resurges in Tucson

wefTEC STORMWATER CONGRESS

Tucson leads the way

The desert city of Tucson, Arizona, United States, demonstrates how grassroots efforts in collaboration with city, county, and academic institutions can open new opportunities to secure new water resources. Green infrastructure is critical to reducing the demand on potable supplies, explain authors **Susanna Eden** at the University of Arizona Water Resources Research Center and **Evan Canfield** at the Pima County Regional Flood Control District.

Water harvesting has been used in the Tucson, Arizona region since prehistoric times and is now in resurgence. Within the past 30 years, Tucson has become a leader in desert rainwater and stormwater capture to build resilience and address growing concerns about water scarcity. Beginning with grassroots efforts focused on collective impacts of individual and neighborhood actions, a new attitude toward rainfall as a resource is flourishing. Local programs encourage citizen participation and support small-scale, distributed infrastructure, with an emphasis on retrofitting properties and roadways, while a large-scale stormwater harvesting project collects enough water to irrigate a regional sports park.

Water harvesting includes green infrastructure (GI), which captures rainwater where it falls and directs runoff to vegetation and infiltration. The benefits go beyond increasing water supply to mitigating heat impacts, managing storm flows, improving the quality of urban runoff, and reducing flooding. The current state of water harvesting in Tucson reflects the desire to beneficially use rainwater and stormwater with the national trends toward use of GI to meet Clean Water Act stormwater requirements.

History

People have lived in and around Tucson, Arizona for 12,000 years, irrigating land along perennial or intermittent stretches of the Santa Cruz River. Farming also occurred on ephemeral washes at the apex of alluvial fans where flow resulting from the sporadic and torrential summer storms supplied water to fields of beans, corn, and squash.

European settlers also diverted streamflow for irrigation and other uses, but switched to groundwater for a more reliable supply when pump technology made it feasible. As the groundwater levels declined with the demands of growing population, mining, and irrigated agriculture, virtually all surface water sources in the valley floor dried up.

Today, the community of Tucson imports Colorado River water from Arizona's western border, recycles wastewater, and once again has begun to value rainwater and stormwater.

Community actions

In the 1970s and 1980s, the University of Arizona's Page Ranch north of Tucson developed innovative ways to harvest and store runoff to support a truck farming business focusing on tree crops. In the 1990s, a small group of dedicated rainwater harvesting practitioners formed the Tucson Permaculture Guild, which provided the foundation for GI in Tucson by developing small-scale, region-appropriate methods to harvest rainwater and stormwater from urban rooftops and roadways.

Tucson resident Brad Lancaster and his neighbors cut openings in curbs to allow stormwater to fill street-side basins. The city at first objected to this unpermitted activity, but later began to recognize the benefits of water harvesting and GI to reduce demands on potable supplies. Mayor and Council directed city staff to produce the *City of Tucson Water Harvesting Guidance Manual* and in October 2005, passed an ordinance encouraging its use by developers. In 2006-2007, Lancaster wrote the two volumes of Water Harvesting for Drylands and Beyond, which provided substantial detail on implementing water harvesting in an arid environment.

Various sources of collaboration and institutional support fostered water-harvesting integration into projects that address multiple community needs. From 2011 to 2014, the University of Arizona Water Resources Research Center (WRRC) invited local professionals, educators, and researchers to a series of roundtables to discuss rainwater and stormwater harvesting efforts and support coordination and continuity through regular communication. A WRRC website, Desert Water Harvesting Initiative, continues to offer a collection of relevant resources. The City of Tucson, Pima County, and others – including university, non-profit, and consulting firm personnel with a passion for water harvesting – formed the Low Impact Development (LID) Working Group, which actively promotes GI and water harvesting in the Tucson region. Since 2007, Tucson has hosted four regional conferences devoted to implementing GI in arid and semi-arid communities.

In addition, individuals and non-profit organizations continue to demonstrate the feasibility and

benefits of water harvesting. A project that transformed the offices of The Nature Conservancy in Tucson and others at the University of Arizona's Tucson campus provided very visible evidence of how attractive and cooling landscapes can be with water harvesting – even in a desert. The LID Working Group assembled a catalog of thirty such projects developed throughout the Tucson region as a record and reference. Not-for-profit organizations, such as the Watershed Management Group and Trees for Tucson have been active in grass-roots efforts to promote GI and water harvesting through education and shared projects.

City and county actions

In 2009, the City Council passed the nation's first municipal rainwater harvesting ordinance for commercial projects, which mandated that new business, corporate, or commercial structures supply half the water needed for landscaping from harvested rainwater. Then in 2012, the city's water utility, Tucson Water, began offering rebates to its residential customers to subsidize installation of rainwater catchment systems – both to divert water onto landscaping and store it in cisterns. The City of Tucson requires participation in three hours of water harvesting training in order to receive a rebate on system and installation expenses. Local experts teach the classes. The response to these actions has been enthusiastic. By 2018, the city provided nearly US$2 million in rebates to almost 2,000 homeowners, and a 2018 statistical analysis by the city found that rainwater harvesting significantly reduced residential water demand.

Recently, Tucson expanded the program to include grants and loans to help low-income households harvest rainwater. The non-profit Sonora Environmental Research Institute administers the program that provides grants of up to $400 to families with household incomes at or below 50 percent of the area's median income and loans of up to $2,000 to families with household incomes at or below 80 percent of the area's median income.

Regarding stormwater infrastructure, the Tucson region was primed to respond to 2007 Environmental Protection Agency (EPA) guidance that created additional incentives for incorporating GI into stormwater management. The EPA endorsed the use of GI for Municipal Separate Storm Sewer (MS4) permitting, and in 2010, the Arizona Department of Environmental Quality asked agencies with MS4 permits to determine how GI could be adopted in their communities. The Pima County Regional Flood Control District developed regulatory standards and specifications in 2015 to include GI features as a component of flood management. The standards included a requirement for new development to capture the first half-inch of rainfall as a means of flood retention.

The city was adopting new ideas when, in 2013, its director of transportation signed Green Streets Active Practices Guidelines that require the incorporation of GI features into Tucson roadways whenever possible. By 2019, when Tucson adopted a complete streets policy promoting the use of GI to support shade trees and calming features on neighborhood streets, the city could cite National Association of City Transportation Officials' and Institute of Transportation Engineers' guidance supporting the integration of GI into multimodal transportation networks.

As momentum for water harvesting grows, the city and county have undertaken a number of studies to establish best practices and provide systematic assessments of official policies and practices related to water harvesting. The *Green Infrastructure and Low Impact Development Guidance Manual* (2015) provides design and application standards for structural and non-structural GI features. This study evaluated the economic, environmental, and societal costs and benefits of GI in two projects: a green street and a convenience store. The Pima County Green Infrastructure Plan (2018) identified Pima County facilities where GI could be implemented in a lead-by-example effort to achieve climate resilience targets identified in the Paris Climate Accords. The City of Tucson is in the process of exploring options and impacts of creating a dedicated funding source for GI. The Pima Association of Governments has also developed a mapping tool for GI project prioritization.

Case studies

Rincon Heights Project

Ninth Street in the Rincon Heights Neighborhood was originally configured to easily carry four lanes of traffic, but its residential status never generated such volumes. This allowed portions of the road to be narrowed. The sidewalks at some intersections were expanded toward the roadway centerline so crossing pedestrians are exposed to less traffic. Mid-block bump-outs protect parked cars. Because the city cannot maintain irrigation on residential streets, plant selection was critical. Native and desert-adapted plants can survive on harvested rainwater after an initial establishment period. The city watered the plantings for one year with a water truck. Since then, plants have survived on rainwater and supplemental water provided occasionally by neighborhood residents. This project was the first in Tucson to showcase how a neighborhood street could be transformed from a barren, hot asphalt corridor to a cooler vegetated and shady boulevard.

Left: Rincon Heights bump-outs harvest stormwater and protect pedestrians and parked cars. Photo by Sandra Bolduc, PCRFCD

Opposite: Streetside stormwater harvesting basin in downtown Tucson after a rain event. Photo by Laura Mielcarek, Wheat Design

Kino Environmental Restoration Project

The Kino Environmental Restoration Project (KERP) focused on three goals: creating native ecosystems through habitat establishment, harvesting urban stormwater for irrigation of the KERP and surrounding public facilities, and controlling flooding through retention basins that slowly release water downstream. Five distinct ecological communities were created to support high-level, onsite biodiversity. The numerous animal and bird species that use the site have attracted recognition from the Tucson Audubon Society, which calls it "one of the best birding locations in Tucson." The site harvests an average of 432,000 cubic meters of stormwater a year, which irrigates surrounding community infrastructure. Harvested stormwater replaces water from the reclaimed water system used to irrigate athletic field turf, roadway median landscaping, and hospital grounds. A 3.2-kilometer trail system – complete with rest areas, ramadas, and a connection to Tucson's The Loop trails – allows pedestrians and bicyclists to enjoy this resource.

For Tucson, the ability to take full advantage of rainfall as a resource is evolving. While much has been accomplished, more can be done. Meanwhile, desert cities and towns faced with increasing water demands can look to Tucson as a model for integrating rainwater harvesting and GI into regional water management. The Tucson experience illustrates how grassroots pressure, forward-thinking leadership, and collaboration can lead to incremental progress with demonstrable rewards.

Authors' Note

Assistant Director Susanna Eden at the University of Arizona Water Resources Research Center has worked in water resources research and outreach for more than 30 years. She led a United States Bureau of Reclamation-funded project that developed a Water Harvesting Assessment Toolbox for desert communities, and continues to write and lecture on water harvesting in addition to her other research and outreach activities.

Civil Engineering Manager Evan Canfield at the Pima County Regional Flood Control District has been active in institutionalizing the use of GI and LID in Pima County and Tucson, Arizona. He is a certified floodplain manager and a registered civil engineer in the State of Arizona.