

Reframing water from a hazard to a resource: The case of Tucson, AZ

Presented by:

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October 28, 2022

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I work with stakeholders and community partners to answer questions related to water security, urban resilience, and environmental justice, by focusing on greenspace/green infrastructure.

I am originally from Monterrey, Mexico. I did my undergraduate studies on architecture at ITESM in Monterrey.

I hold two advanced degrees from the UArizona:

- a master of architecture degree with a concentration in design and energy conservation
- a doctoral degree in arid lands resource sciences with a minor in global change.



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Overview of the seminar



First day – Water management in Tucson

- ◆ Introduction – why Tucson?
- ◆ Tucson before water pumping
- ◆ Institutional context
- ◆ Action at the local level
- ◆ Water policy at the state level
- ◆ Water policy at the county level
- ◆ Water policy at the city level
- ◆ Education and outreach
- ◆ Conclusion

Second Day – From a hazard to a resource

- ◆ Reframing water from a hazard to a resource
- ◆ Green infrastructure and urban design
- ◆ Challenges for mainstreaming green infrastructure in Tucson
- ◆ Justice issues
- ◆ Institutionalization of green infrastructure
- ◆ Conclusions

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Centralized vs. decentralized systems

In Tucson, water infrastructure's paradigm is based on three strategies:

1. groundwater is pumped for potable and non-potable uses and distributed through a single infrastructure system
2. wastewater is conveyed to a central treatment facility
3. a percent of reclaimed water is used for landscape irrigation and the rest is discharged into water bodies.

Centralized systems are easier to operate up to a certain scale.

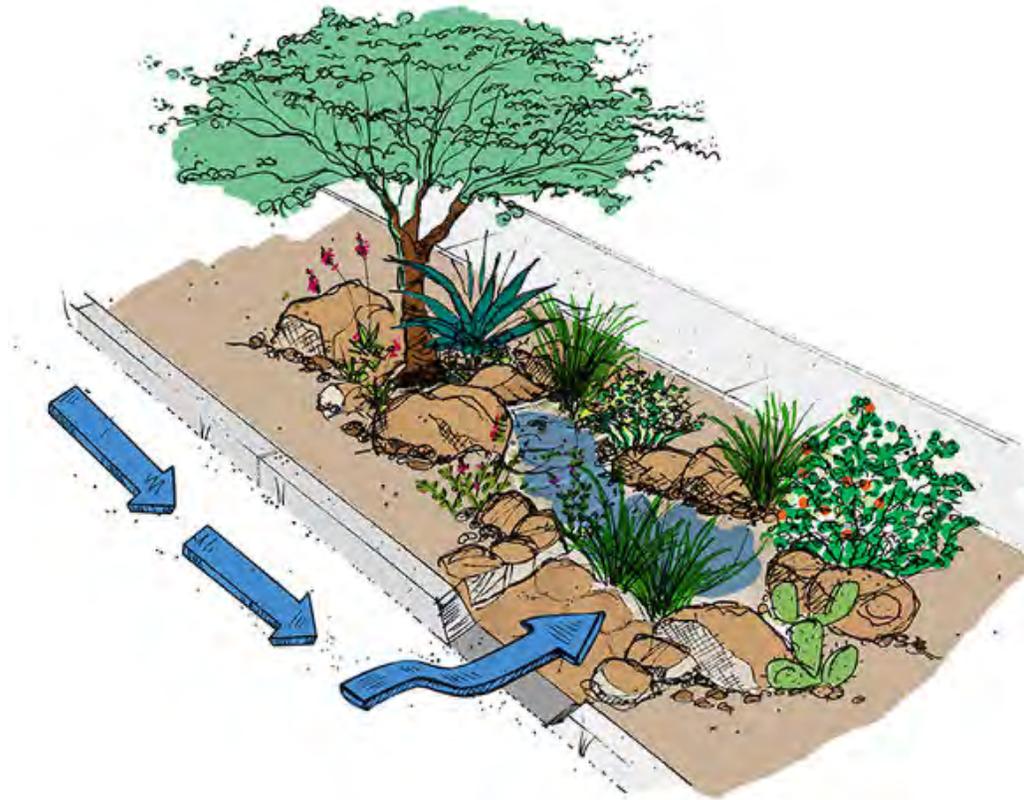
But **decentralized systems** have been recognized as effective complements to an ageing infrastructure and a lack of funding to upgrade it



Santa Cruz Heritage Project

Green infrastructure – a decentralized approach

Vegetated spaces in cities that can function as retention/detention basins (e.g., swales, rain gardens, green roofs).



Credit: Watershed Management Group

Green infrastructure

Green infrastructure plays a critical role in providing the ecosystem services that support livable, resilient and sustainable cities, including:

- **Flood control**
- **Replenishment of aquifers**
- **Improved water quality**
- Reduced heat (shade)
- Local food production
- Improved air quality
- Improved aesthetics
- Increased recreational opportunities
- Enhanced social interaction
- Reduced stress, noise, and overcrowding



Overview of the seminar



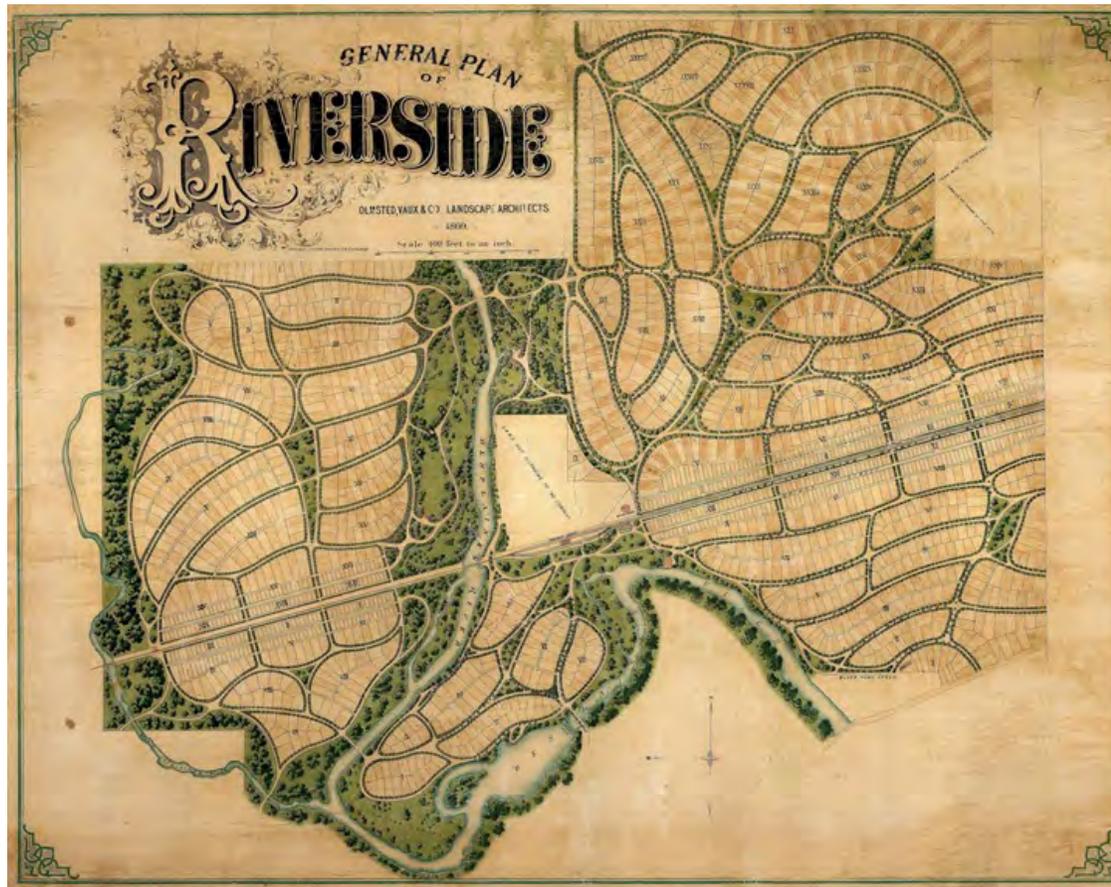
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- ◆ Reframing water from a hazard to a resource
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Green infrastructure in urban design in the 1800s

Frederick Law Olmsted

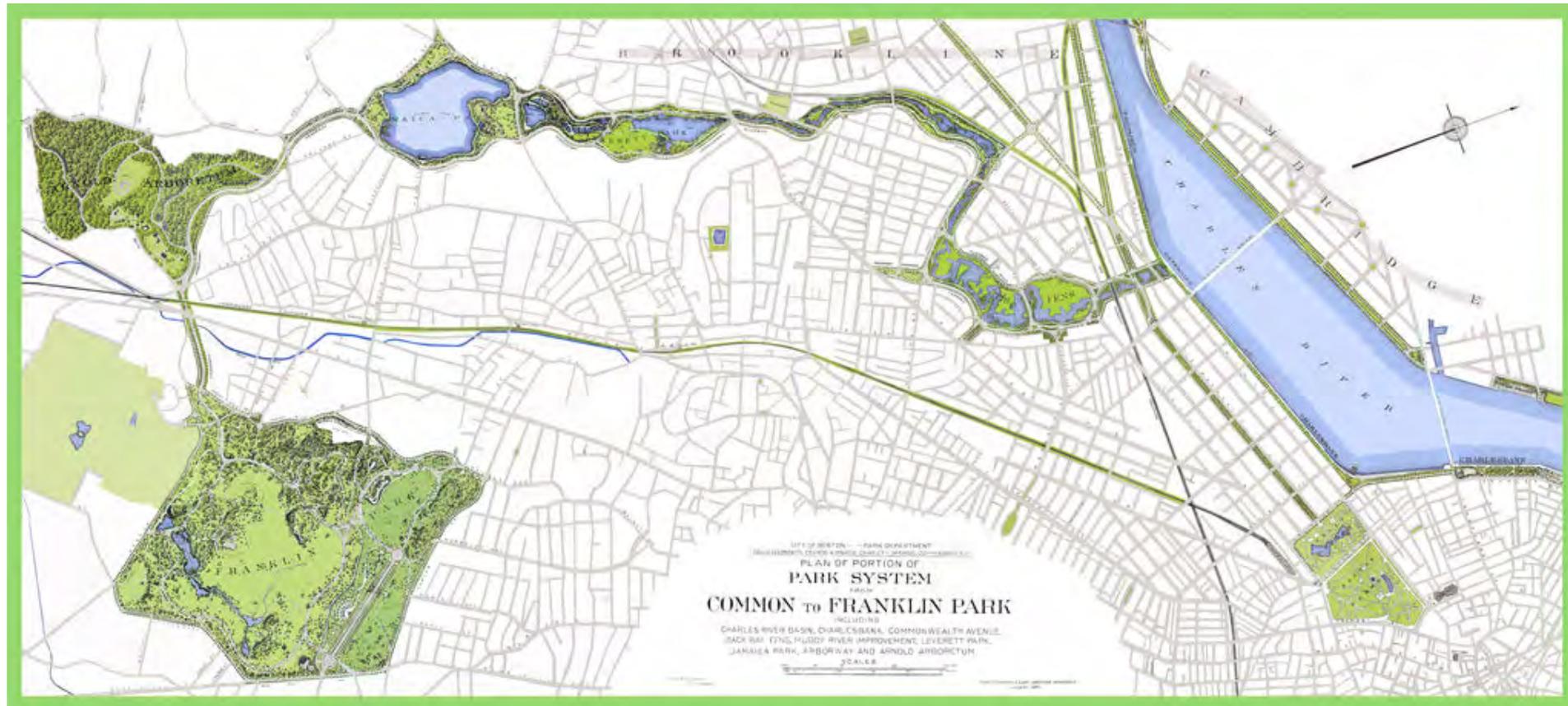
First master planned community, Riverside, Illinois (1869)



Green infrastructure in urban design in the 1800s

Frederick Law Olmsted

The Emerald Necklace, Boston, MA

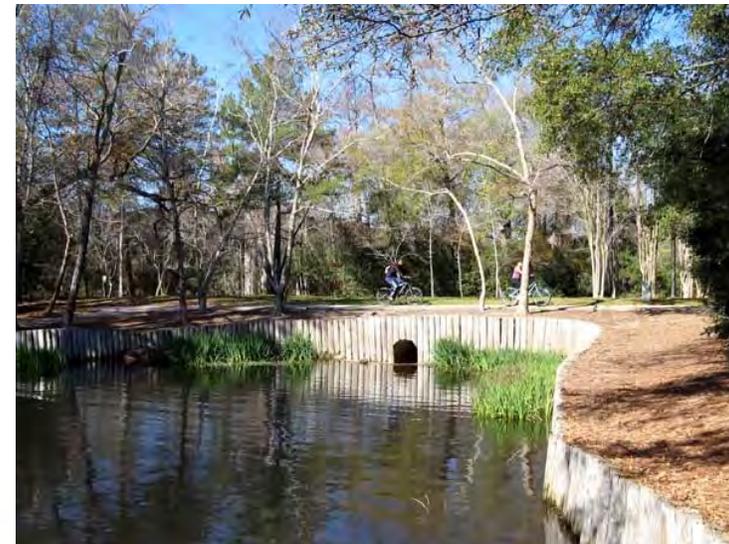


Green infrastructure in urban design in the 1970s

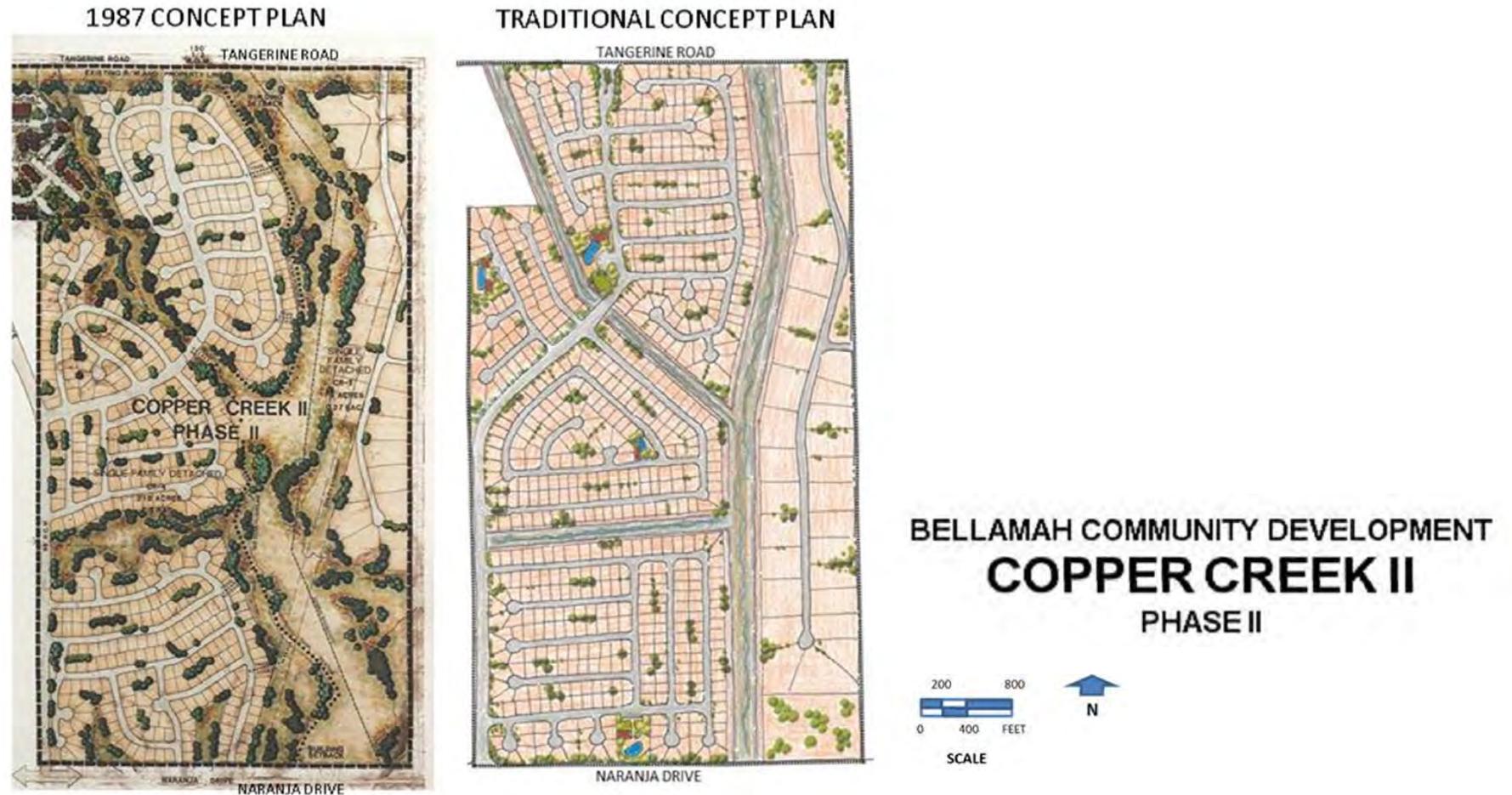
Design with Nature, Ian McHarg

The Woodlands in Houston

- Ecological planning - based on the study of natural processes.
- Identify sites for human land use and protection of sensitive areas.
- Looks at the region, city and neighborhood as a natural system.
- Has mitigated flooding events over time



Design with Nature in Tucson



Alternative concept plan	Traditional plan
559 lots – less profit	728 lots – more profit
Natural drainage - More open space and habitat	Concrete channels - Less open space and habitat

Design with Nature in Tucson



Figure 14. Copper Creek vegetation growth since construction.

Green infrastructure

Definition - The creative combination of natural and artificial structures (blue, green and gray) with the intention of achieving specific goals of resilience (flood management, public health, etc.) with broad public support and attention to the principle of appropriate technology.

Blue



Green



Grey



Staddon, C., Ward, S., De Vito, L., Zuniga-Teran, A., Gerlak, A., Schoeman, Y., Hart, A., Booth, G. (2018). Contributions of green infrastructure to enhancing urban resilience. *Environment, Systems and Decisions*.

Environment Systems and Decisions
<https://doi.org/10.1007/s10669-018-9702-9>



Contributions of green infrastructure to enhancing urban resilience

Chad Staddon¹  · Sarah Ward¹  · Laura De Vito¹  · Adriana Zuniga-Teran²  · Andrea K. Gerlak²  · Yolandi Schoeman³  · Aimee Hart⁴ · Giles Booth⁴

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Journal of Environmental Planning and Management

ISSN: 0964-0568 (Print) 1360-0559 (Online) Journal homepage: <https://www.tandfonline.com/loi/cjep20>

Challenges of mainstreaming green infrastructure in built environment professions

Adriana A. Zuniga-Teran, Chad Staddon, Laura de Vito, Andrea K. Gerlak, Sarah Ward, Yolandi Schoeman, Aimee Hart & Giles Booth



ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in
Environmental
Sustainability

Urban resilience and green infrastructure systems: towards a multidimensional evaluation

Adriana A Zuniga-Teran, Andrea K Gerlak, Brian Mayer, Tom P Evans and Kevin E Lansey



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Challenges in mainstreaming green infrastructure

- Design standards
- Financeability
- Regulatory
- Innovation
- **Socio-economic**

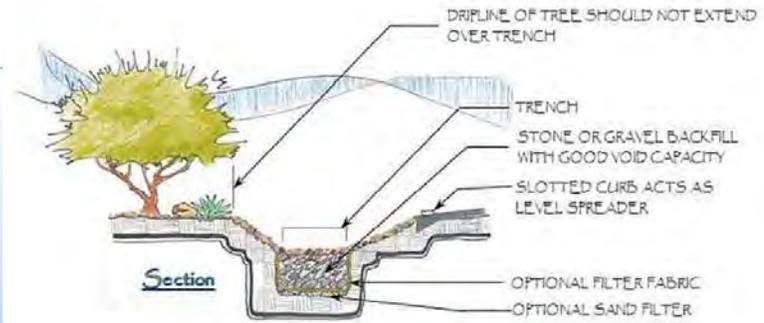


Zuniga-Teran et al. 2019. Challenges in mainstreaming green infrastructure into built environment professions.
Journal of Environmental Planning & Management.

Tucson - Design Standards challenge

Low Impact Development and Green Infrastructure Guidance Manual

March 2015



INFILTRATION TRENCH



Tucson - Financeability challenge

- **Green Stormwater Infrastructure Program** - approved by Mayor and Council in 2019.
- **Storm to Shade Program** funded through a fee (~\$1) in water bill.
- **Rainwater Harvesting Rebate Program** (reimburses \$2,000) funded by a “conservation fee” (~\$1) in water bill.
- **Low-Income Rainwater Harvesting Loan/Grant Program**
- **Flood Control Funds**
- **Conserve 2 Enhance** – funds GI neighborhood projects on floodplains



Rainwater Harvesting



Water Matters



Putting Stormwater to Work!



Stormwater Management Program

Managed by the City of Tucson Department of Transportation

Promotes the use of rights-of-ways and boulevards as vegetated spaces designed to capture runoff and infiltrate stormwater into the aquifer.

Although the focus of the program from the transportation perspective is to keep non-point source pollutants out of the drainage system, this practice helps to augment aquifer levels, hence water supply for Tucson.

As this practice is complemented by native vegetation that require no irrigation, this lack of irrigation of urban forestry reduces water demand.



Stormwater management along streets

Tucson - Regulatory challenge

Year	Policy	Description
1980s	CoT Riparian Veg. Preser. & Protect.	Codes, policies & stds protecting riparian vegetation
1998	Sonoran Desert Conservation Plan	Protects natural drainage systems at the regional level
2004	Xeriscape Lands. & Screening Ord.	Use of native plants for landscape
2005	Stormwater Quality Ordinance	No non-point source pollutants enter the water system
2008	Comm. Rainwater Harvesting Ord.	Use of rainwater harvesting for landscape irrigation
2010	PC Riparian Management Ord.	Floodplain permits to protect riparian areas
2011	TDOT's Stormwater Mgmt. Program	Codifies GI requirements along roads, boulevards
2018	GI Action Plan	Set of GI policies
2018	Res. Graywater Ord.	Mandatory dual-plumbing system
2020	Land Use Code	Stormwater harvesting to be used for landscape irrigation

Zuniga-Teran and Tortajada. 2021. Water Policies and their effects on water usage: The case of Tucson, Arizona. *Water Utiliy Journal*.

Stormwater Quality Ordinance 10209

Managed by the City of Tucson Department of Transportation

- Mandates that business, facilities and construction sites do not contribute with non-point source pollutants (oil, grease, trash, and sediment) to the drainage system.
- GI is a way to comply with this regulation.
- However, this practice of GI has been found to be difficult to implement because of stringent regulations on width of right-of-way that result in the denial of curb cut permits (Gerlak & Zuniga-Teran, 2020). Indeed, transportation engineers have been known to be the last adopters of GI practices.



Stormwater management using GI to improve water quality

Tucson as a leader in green infrastructure

"Emerald Cities," listed darkest to lightest by the number of key green infrastructure actions taken

City	Long-term green infrastructure (GI) plan	Retention standard	Requirement to use GI to reduce some portion of the existing impervious surfaces	Incentives for private-party actions	Guidance or other affirmative assistance to accomplish GI within city	Dedicated funding source for GI
Philadelphia, PA	★	★	★	★	★	★
Milwaukee, WI	★	★	★	★	★	★
New York, NY	★		★	★	★	★
Portland, OR		★	★	★	★	★
Syracuse, NY	★		★	★	★	★
Washington, D.C.		★	★	★	★	★
Aurora, IL	★	★			★	★
Toronto, Ontario, Canada	★	★		★	★	
Chicago, IL		★		★	★	
Kansas City, MO				★	★	★
Nashville, TN	★				★	★
Seattle, WA				★	★	★
Tucson, AZ		★		★		
Pittsburgh, PA		★			★	
Rouge River Watershed, MI					★	



UPDATE October 2013



Natural Resources Defense Council

Green infrastructure in Tucson, Arizona is the result of neighborhood action



Green infrastructure is the result of leaders and local NGOs

search this site... Search

Rainwater Harvesting for Drylands and Beyond by Brad Lancaster

- Home
- Store
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- Offerings
- Images, Video & Audio
- Rainwater Harvesting
- Street-Runoff Harvesting
- Greywater Harvesting
- Condensate Harvesting
- Wind & Snow Harvesting
- Sun & Shade Harvesting
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The Best-Selling, Award-Winning Books on Harvesting Water – and More

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Turn water scarcity into water abundance! These books show you how to conceptualize, design, and implement sustainable water-, sun-, wind-, and shade-harvesting systems for your home, landscape, and community. They enable you to access your on-site resources (rainwater, greywater, topsoil, sun, plants, and more), give you a diverse array of strategies to maximize their potential, and empower you with guiding principles to create an integrated, multi-functional resource-harvesting and -enhancing landscape plan specific to your site and needs. These books will help bring your site to life, reduce your cost of living, endow yourself and your community with skills of self-reliance and cooperation, generate renewable on-site power, and create living air conditioners of vegetation that grow beauty, food, flood-control, and

Drops in a Bucket Blog

- Bandsar Agriculture: Indigenous Runoff-Harvesting & Climate-Change Resilience from Iranian Drylands
- Important Elevation and Slope Relationships of Eddy or Backwater Basins

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Tour Gratis del Laboratorio Viviente y Centro de Aprendizaje

Aprenda sobre todos los sistemas de cosecha de agua de lluvia a detalle y lo que puede hacer en su propia casa.

Sábado, 23 de Septiembre, 8:00-9:30 a.m.

Regístrese aquí!

Overview of the seminar

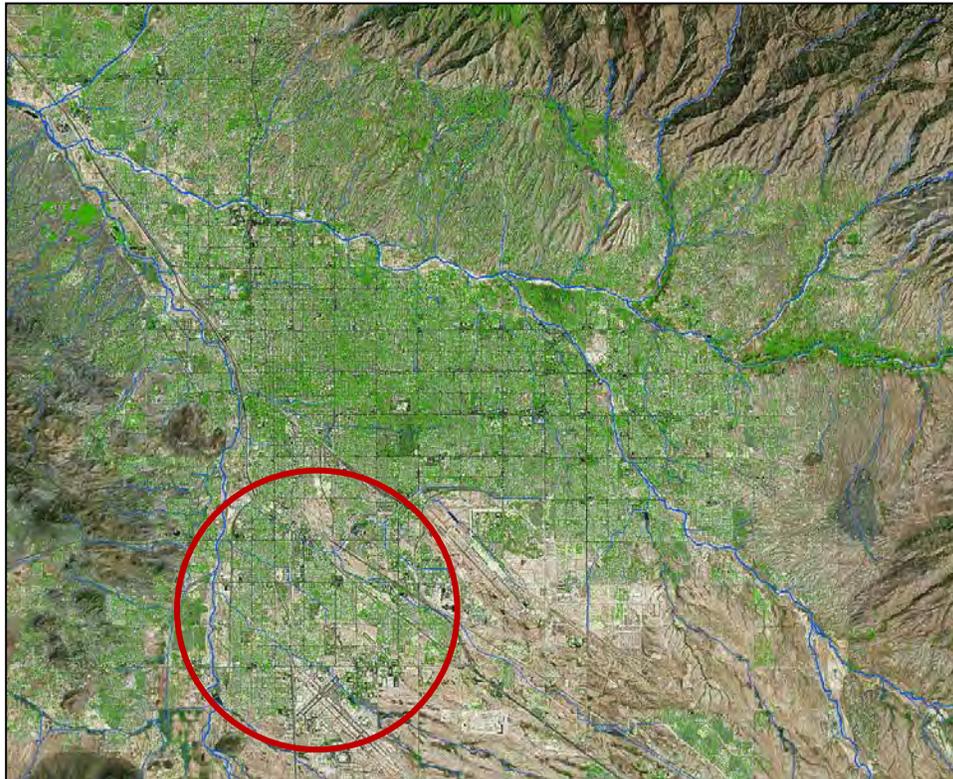


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- ◆ Conclusions

Socioeconomic challenge - Inequities in green infrastructure

- Although Tucson is considered a leader in green infrastructure, there are considerable equity issues



Tree canopy in Tucson, AZ (data from Pima Association of Governments, PAG)



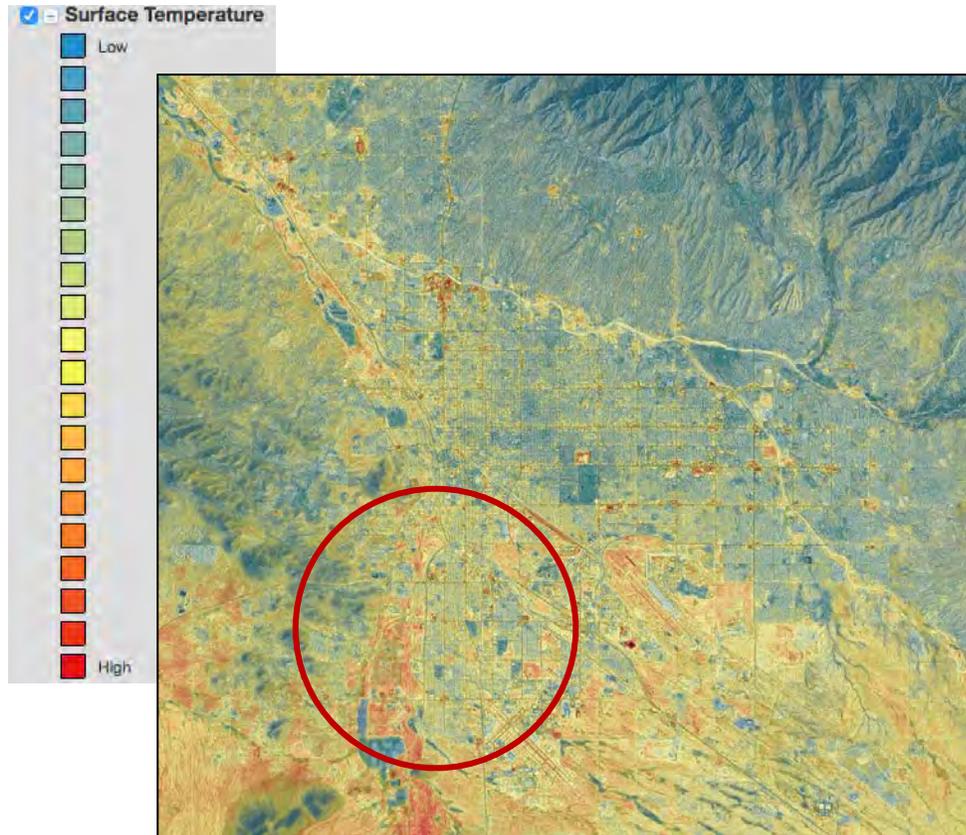
Street in the south side of Tucson



- Predominantly Hispanics
- Low income
- Younger population
- Larger households

Insecurities

- The south side of Tucson is vulnerable to flood and extreme heat



Surface temperature in Tucson, AZ (data from PAG)



Flooding in the south side of Tucson

Rainwater Harvesting Rebate Program

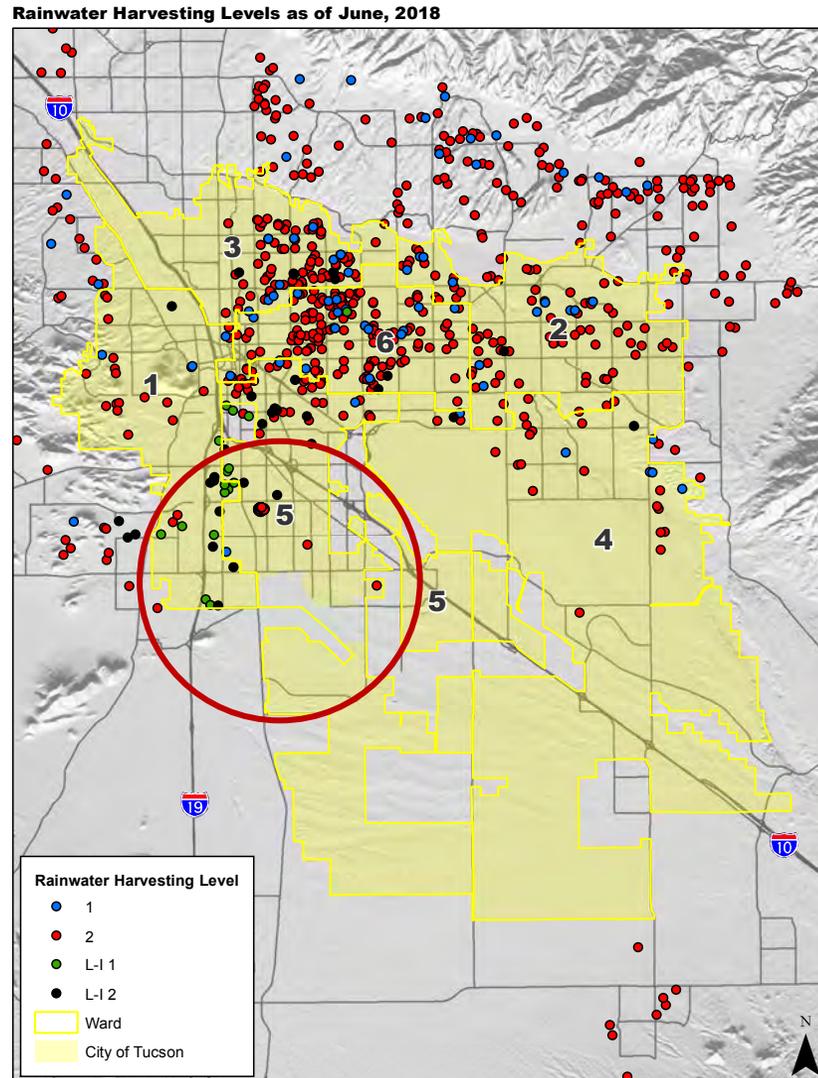
Funded by Tucson Water through a conservation fee

- Gives \$2,000 back to water customers who apply.
- Targeted to property owners.
- Required to attend a workshop for training.
- Funds the installation of active rainwater harvesting systems, which require maintenance.



Active rainwater harvesting system

Rainwater harvesting programs in Tucson



June 2018 Data from Tucson Water

Programs and incentives to harvest rainwater have not been implemented in the south side of the city.

Tucson Water is taking action to address this issue in the next iteration of the programs.

Low-income Rainwater Harvesting Program

Funded by Tucson Water and managed by the Sonora Environmental Research Institute, Inc

- Designed to address equity issues caused by the *Rainwater Harvesting Rebate Program* by giving grants and loans to low-income families to be able to apply to the rebate program.
- Caveat - it is focused on active systems (cisterns, tanks) that require yard space and maintenance, and low-income households usually have less space in their yards and less time available for maintenance, reinforcing injustices.
- Tucson Water adjusted the program to include passive systems, and renters.



Active rainwater harvesting system

Socioeconomic challenge – Community engagement

Community engagement is a key factor in the long term benefits of green infrastructure – Ensures maintenance.



Roundabout where neighbors worked together to install artwork and vegetation, and maintain it



Roundabout in a neighborhood where neighbors were not engaged

Our project

To address inequities in green infrastructure funding, siting, and implementation

- A collaborative, participatory **community engagement** partnership to facilitate the design and adoption of GI demonstration projects in underserved communities in Tucson

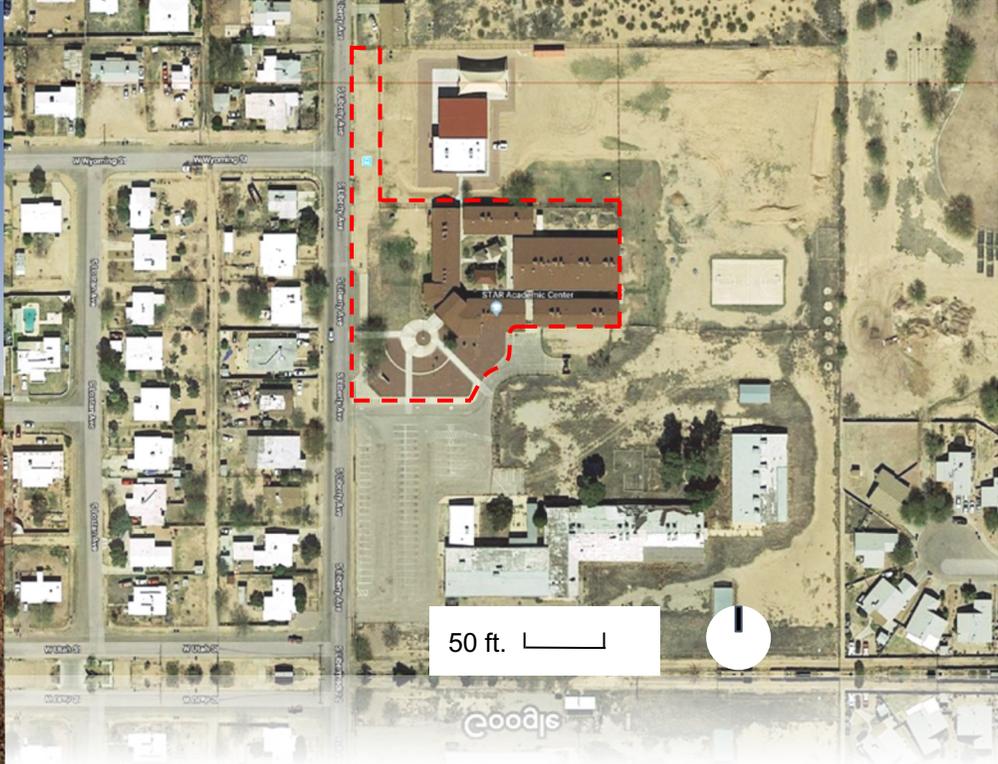
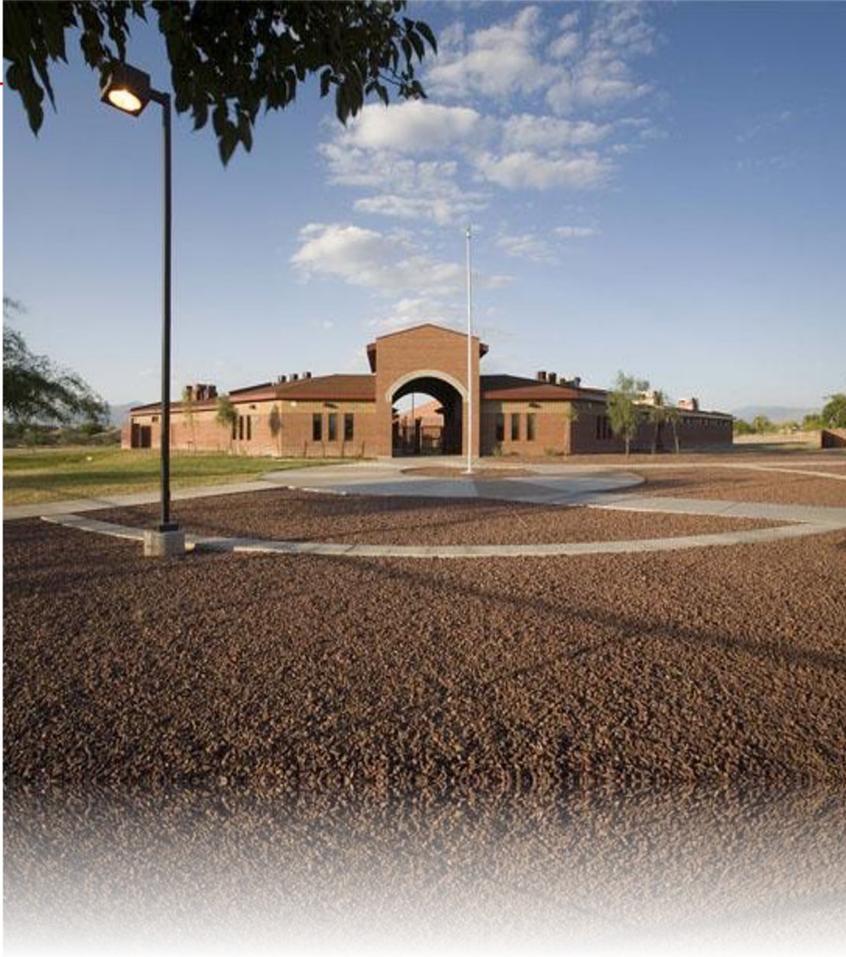


Agnese Nelms Haury Program
in Environment and Social Justice



- Engagement at two levels:
 - Organizations
 - On-the-ground





Site Location
STAR Academic High School
Tucson, Arizona

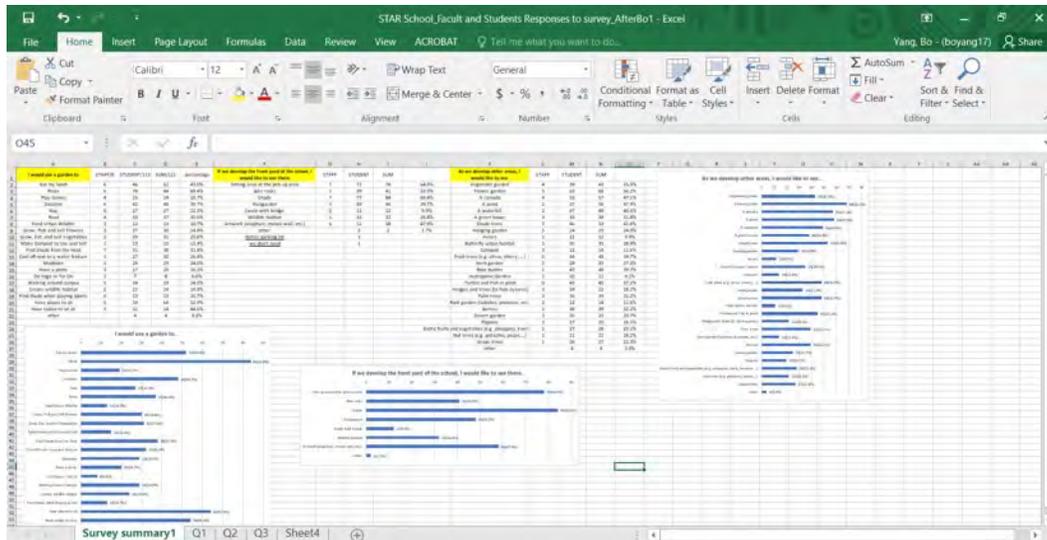
Engagement – STAR Academic High School, 2017-2018

- Engaged with school principal and science teacher (summer 2017)
- Talks to students (fall 2017)
- UA Landscape Design professor Bo Yang used this site for his design studio class (spring 2018)



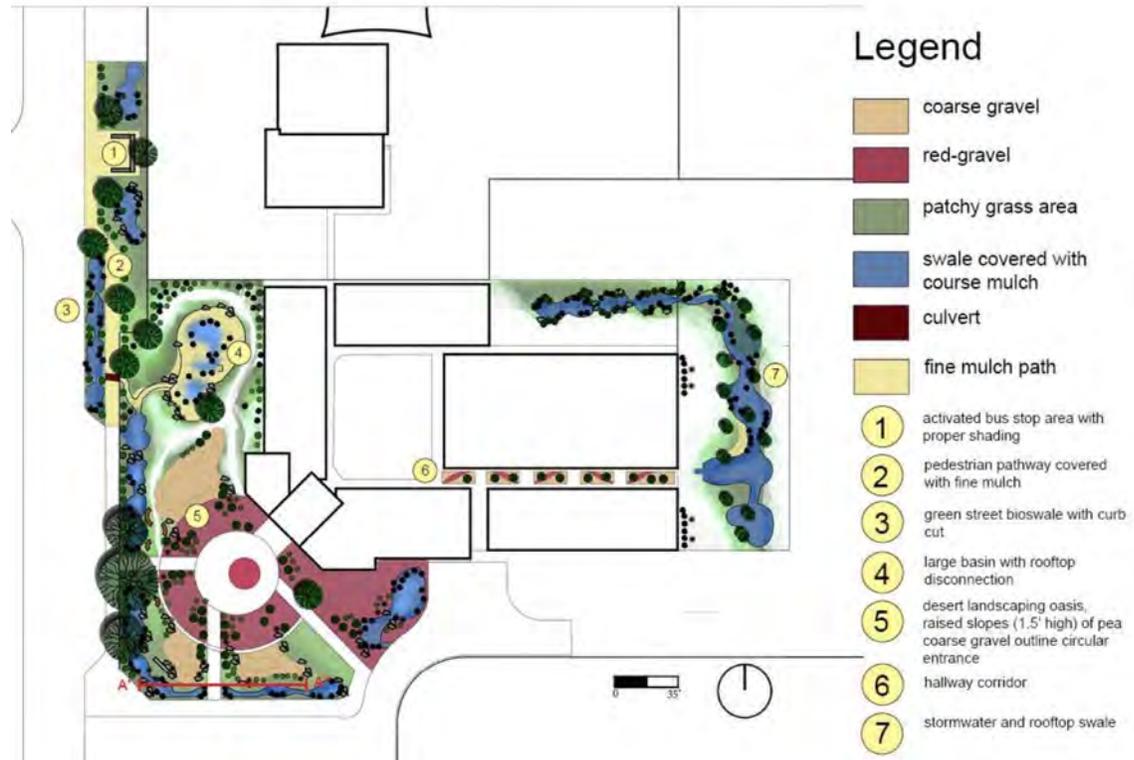
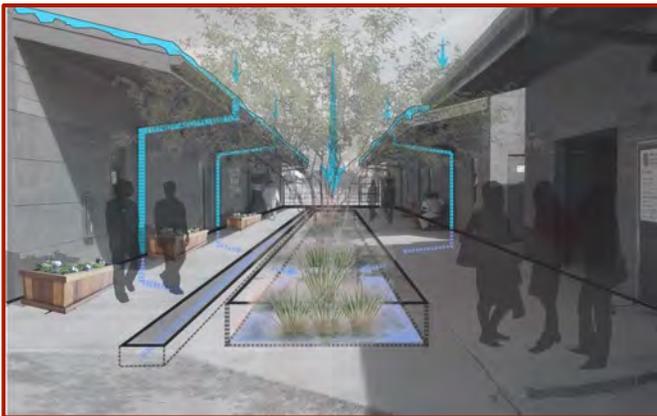
Participatory Design Process

- Collected data through a survey and interviews
- Consulted with the STAR community through the design process



Landscape Design for West Campus
Grace Stoner, Jinqiao Deng, Mario Nuño-Whelan, Penelope Cottrell-Crawford

UA Green Fund awarded us \$25K to implement GI at STAR



Student engagement efforts



Kickoff meeting in Sept. 2018

We engaged some 32 UA students in planning

- graduate students
- undergraduate students
- Internships
- volunteers



Regular meetings with team leaders

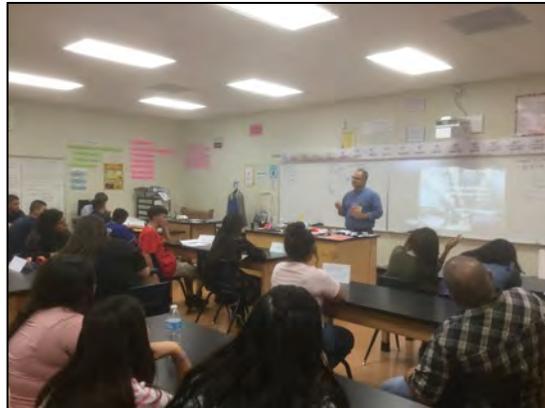
Student engagement efforts

We engaged about 80 STAR students

- Science class
- Art class (4 sections)
- JTED class



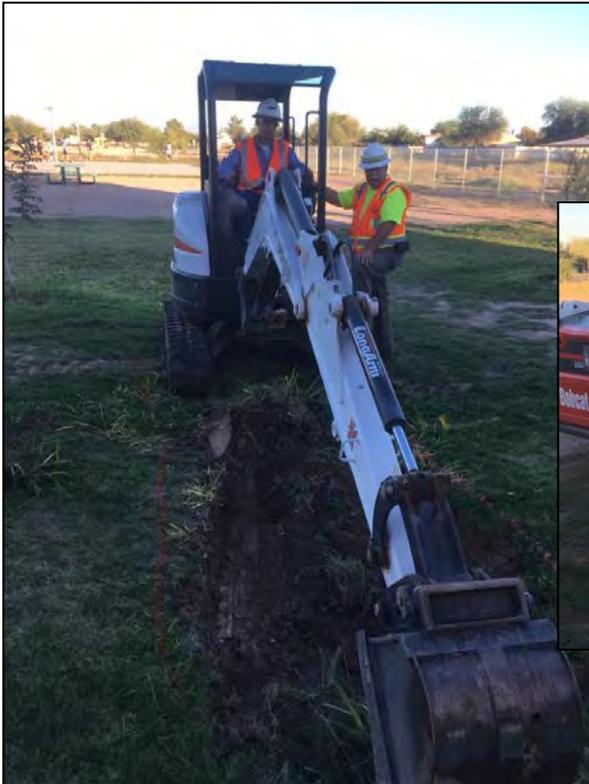
STAR student working on signage



Student engagement at STAR

We engaged JTED (Joint Technological Education District) students

- used their machinery to dig basins while training STAR students



The big event: Implementation at STAR

80 people involved in activities – planting, digging, mixing



Side projects

- Side projects attracted more students
- Engaged with local builder and artist to create straw bale benches with mosaic artwork



Star student designed mosaic work



Together, building benches



Finished benches

The big event: Implementation at STAR

Connecting communities – UA, Star, NGOs, Gov

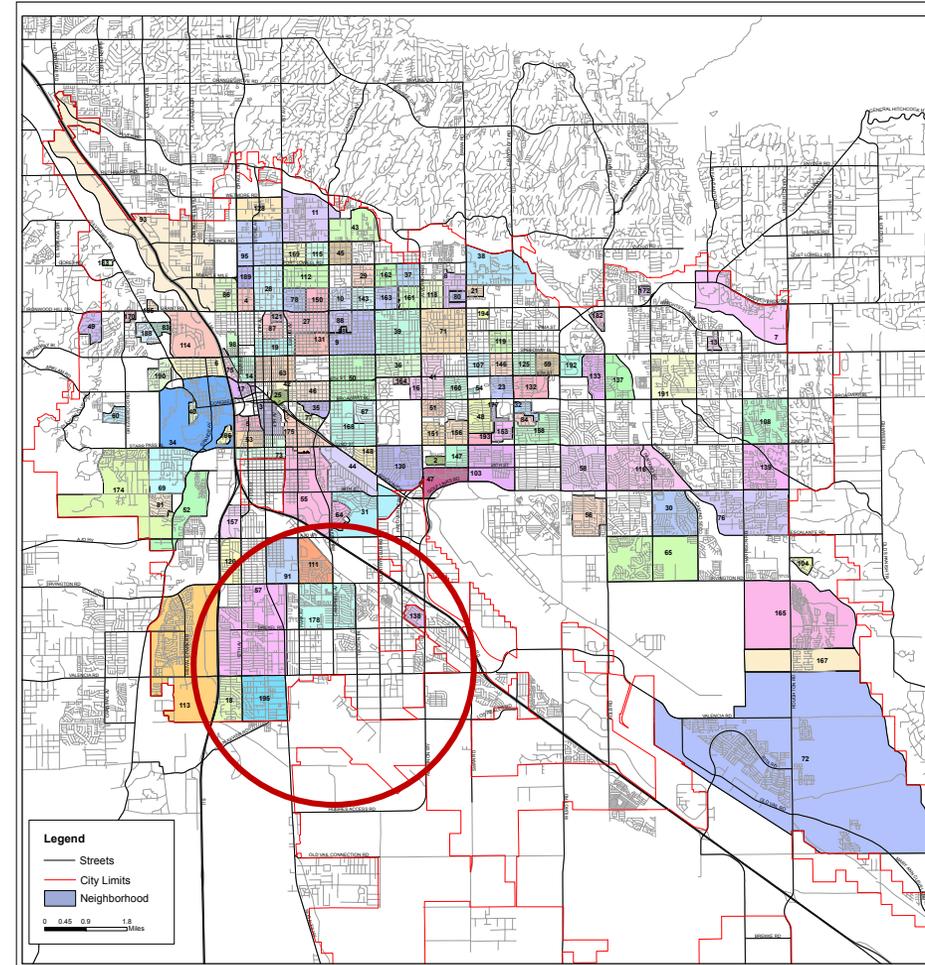


Greening Tucson...



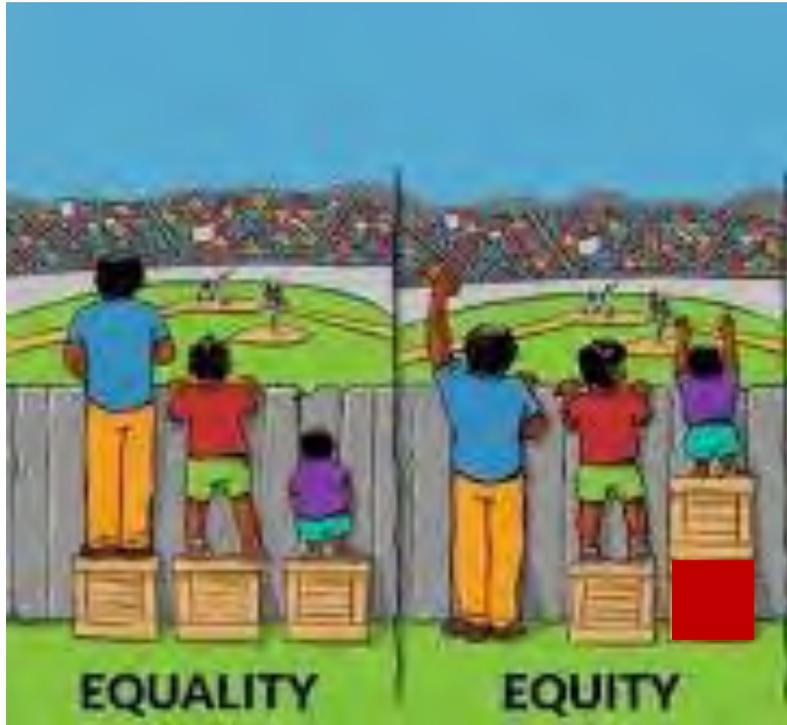
Obstacles to community engagement

- **Lack of representation** – no neighborhood associations = no voice in the City.
- **Land tenure** - Most people rent their homes.
- **Immigration status** - Concentration of foreign-born undocumented families.



Neighborhood associations in Tucson

Equality vs. Equity



(L. Perales – from TYLO)



- Underserved communities without an established social organization need an “extra block” of help
- Extra block = time, effort, and resources to build capacity and trust, and engage with.

Governance, collaboration and agency



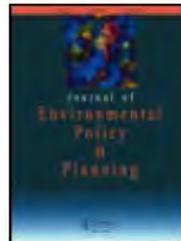
Environment: Science and Policy for Sustainable Development



ISSN: (Print) (Online) Journal homepage: <https://www.tandfonline.com/loi/venv20>

Green Infrastructure: Lessons in Governance and Collaboration From Tucson

Andrea K. Gerlak, Alison Elder, Timothy Thomure, Catlow Shipek, Adriana Zuniga-Teran, Mitch Pavao-Zuckerman, Neha Gupta, Marissa Matsler, Lena Berger, Adam Douglas Henry, Bo Yang, Joaquin Murrieta-Saldivar & Thomas Meixner



Journal of Environmental Policy & Planning



ISSN: (Print) (Online) Journal homepage: <https://www.tandfonline.com/loi/cjoe20>

Agency and governance in green infrastructure policy adoption and change

Andrea K. Gerlak, Alison Elder, Mitch Pavao-Zuckerman, Adriana Zuniga-Teran & Andrew R. Sanderford

Greenspace Justice

Socio-Ecological Practice Research (2020) 2:149–159
<https://doi.org/10.1007/s42532-020-00052-5>

PERSPECTIVE ESSAY



Addressing injustice in green infrastructure through socio-ecological practice: What is the role of university–community partnerships?

Andrea K. Gerlak¹ · Adriana Zuniga-Teran²

Received: 8 April 2020 / Accepted: 29 May 2020 / Published online: 15 June 2020
© Springer Nature Singapore Pte Ltd. 2020



Review

A Multidisciplinary Approach to Analyzing Questions of Justice Issues in Urban Greenspace

Adriana A. Zuniga-Teran^{1,2,*} and Andrea K. Gerlak^{1,3}

Overview of the seminar



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- ◆ **Institutionalization of green infrastructure**
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Tucson – Innovation challenge - Low Impact Development Working Group

A community of practice gets together every month to share lessons learned and expedite implementation.



Pima County Regional Flood Control District

PDRFCD has adopted GI strategies to manage flooding

Reason = 90% of rainfall events are 1" in depth and can be managed by GI

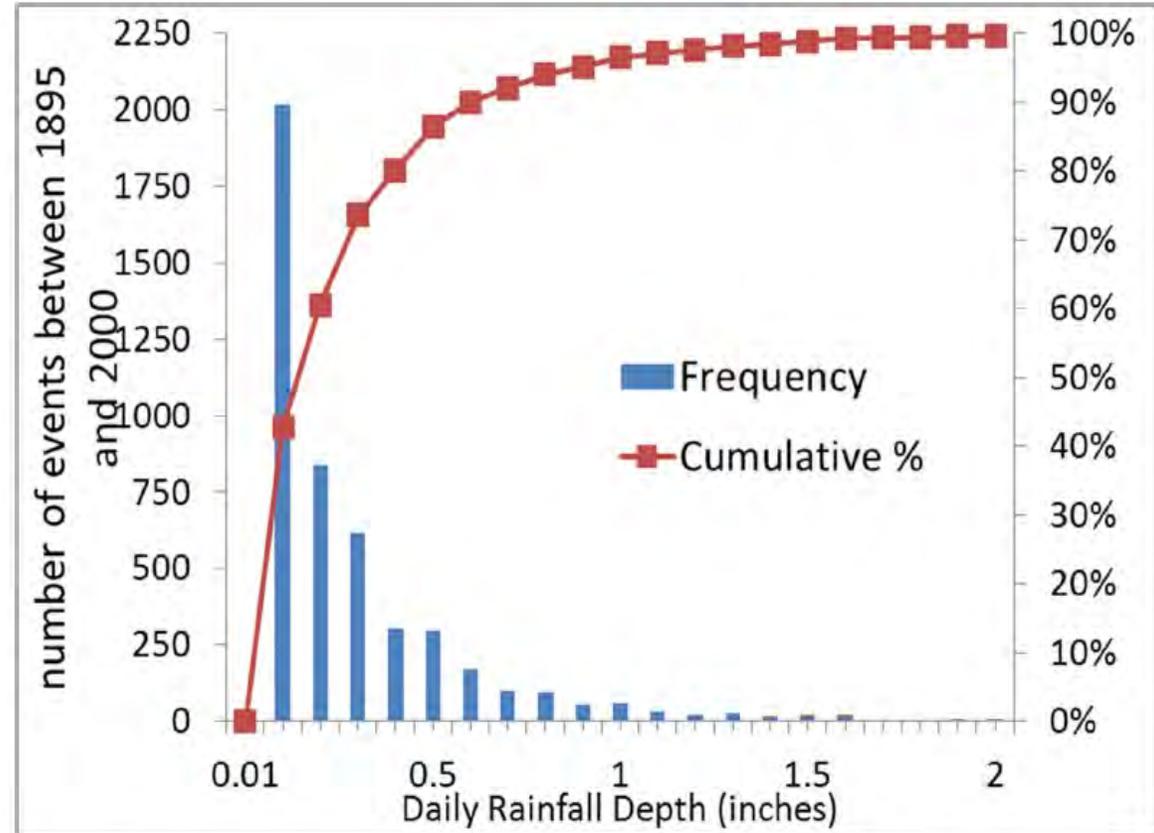


Figure 8. Distribution of rainfall events measured at the University of Arizona between 1895 and 2000.

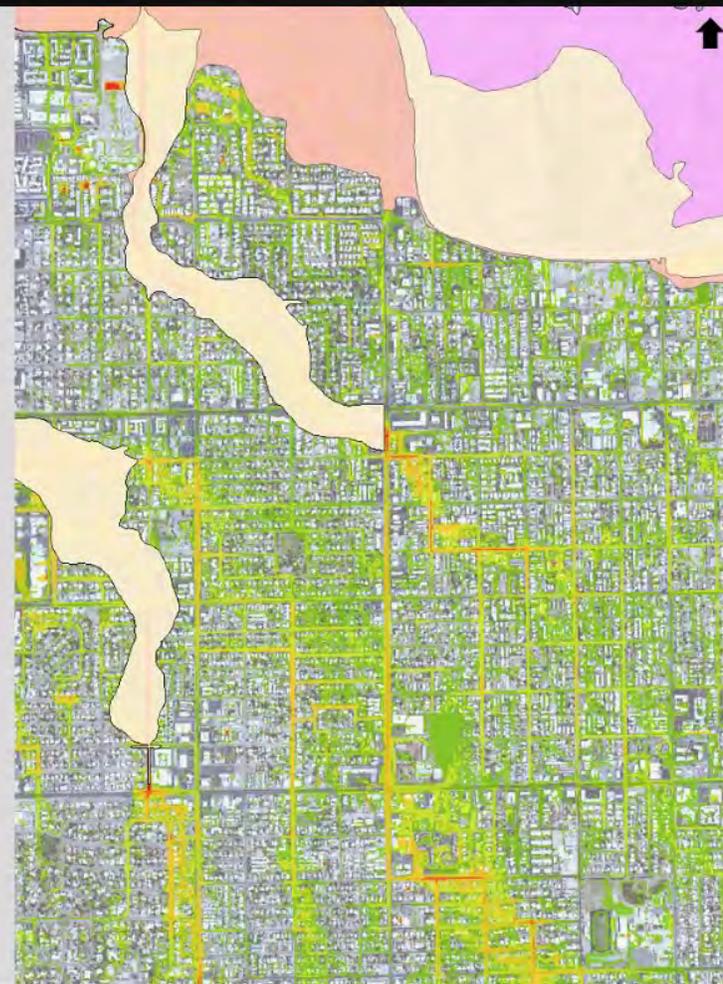
Pima County and the City of Tucson. 2015. Low Impact Development and Green Infrastructure Guidance Manual. March. 296 pp.

Credit: Jacob Prieto, Pima County Regional Flood Control District

Pima County Regional Flood Control

Existing Conditions

- City of Tucson Priority Watersheds
- FLO-2D rainfall/runoff models

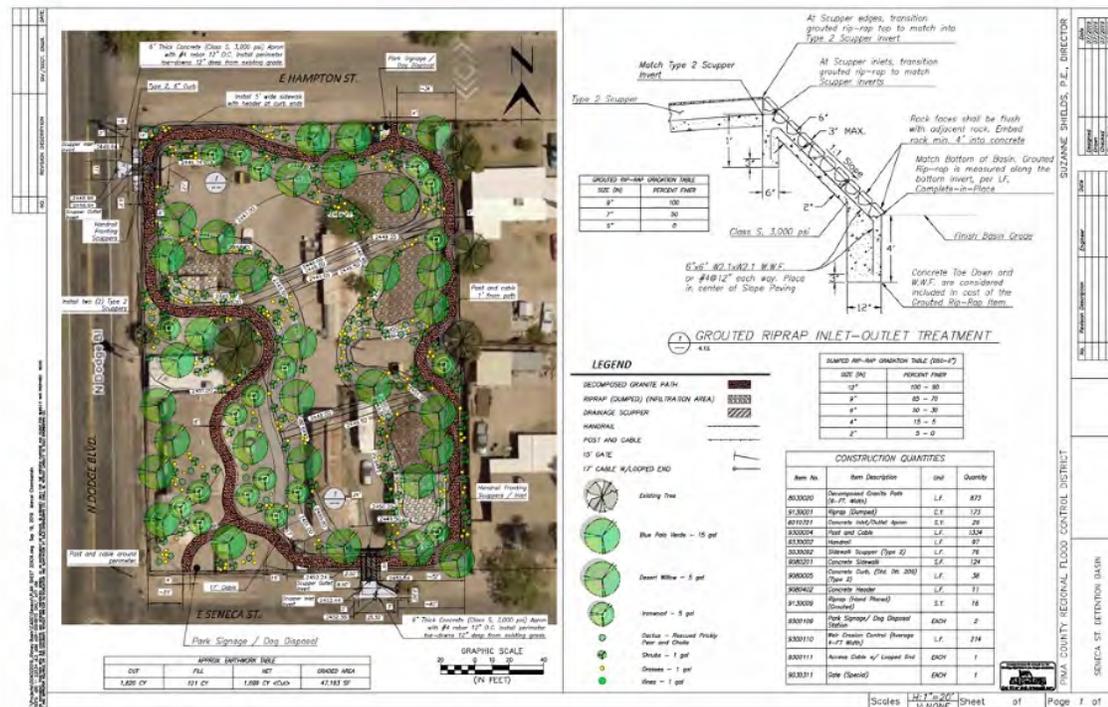


Jacob Prietto, CFM
Chief Hydrologist
Pima County Regional Flood Control District

Pima County Regional Flood Control

Seneca Park (2019)

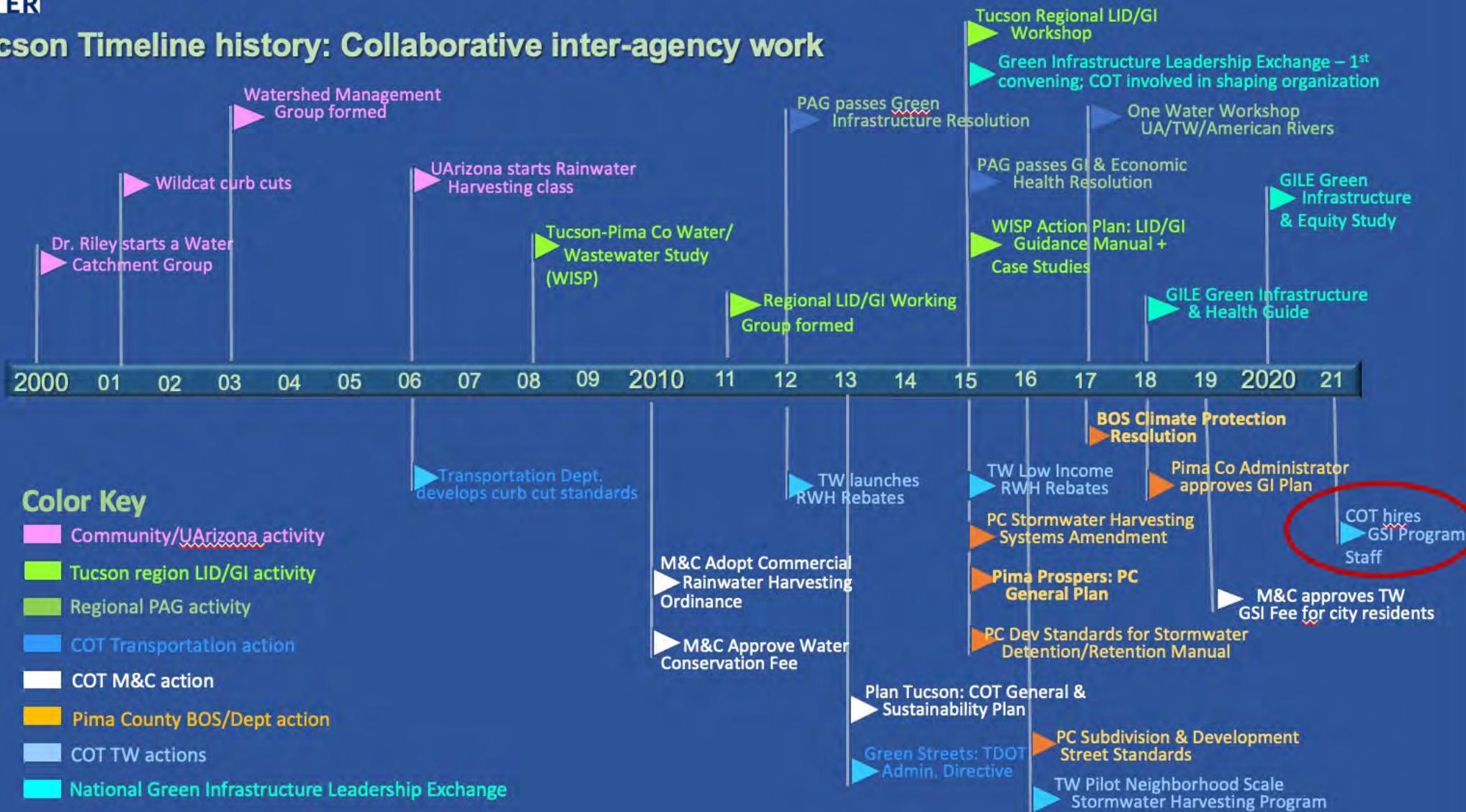
- State of Arizona
- Tax Lien Acquisition



Credit: Jacob Prieto, Pima County Regional Flood Control District

Institutionalizing Rainwater Harvesting

Recent Tucson Timeline history: Collaborative inter-agency work



Credit: Irene Ogata, Tucson Water, City of Tucson



Storm *to* Shade

City of Tucson Green Stormwater
Infrastructure Program

Blue Baldwin
Program Manager

The City of Tucson's GSI Program Goals

1. Establish a Capital Improvement Program to build GSI throughout the 6 Wards in the COT
2. Maintain existing and new GSI

DISCOVER
Green Stormwater Infrastructure (GSI)
 GSI directs stormwater runoff from streets, parking lots, and rooftops into landscaped areas where it infiltrates the soil to support vegetation.

Check out the 10 benefits of GSI!

GSI locations

- ✓ Neighborhood streets
- ✓ Parks
- ✓ Public parking lots
- ✓ Bike Boulevards
- ✓ Greenways

[FAQs, VIDEO & MORE TUCSONAZ.GOV/GSI](http://TUCSONAZ.GOV/GSI)

Credit: Blue Baldwin, Tucson Water, City of Tucson

Capital Program

- Project identification
 - Leveraging existing COT improvement projects
 - Ward Office input
 - Priority areas of investment
 - Tree Equity Score
- ✓ Approx. 30 projects in design, 3 in/near construction



Credit: Blue Baldwin, Tucson Water, City of Tucson

Mx Program

- Contain and manage GSI assets “owned” across different departments
- Create a COT Mx protocol for GSI
- Hire contractors to maintain some existing and all S2S- built GSI
- Train COT staff and community





Tucson Tree Equity Scores



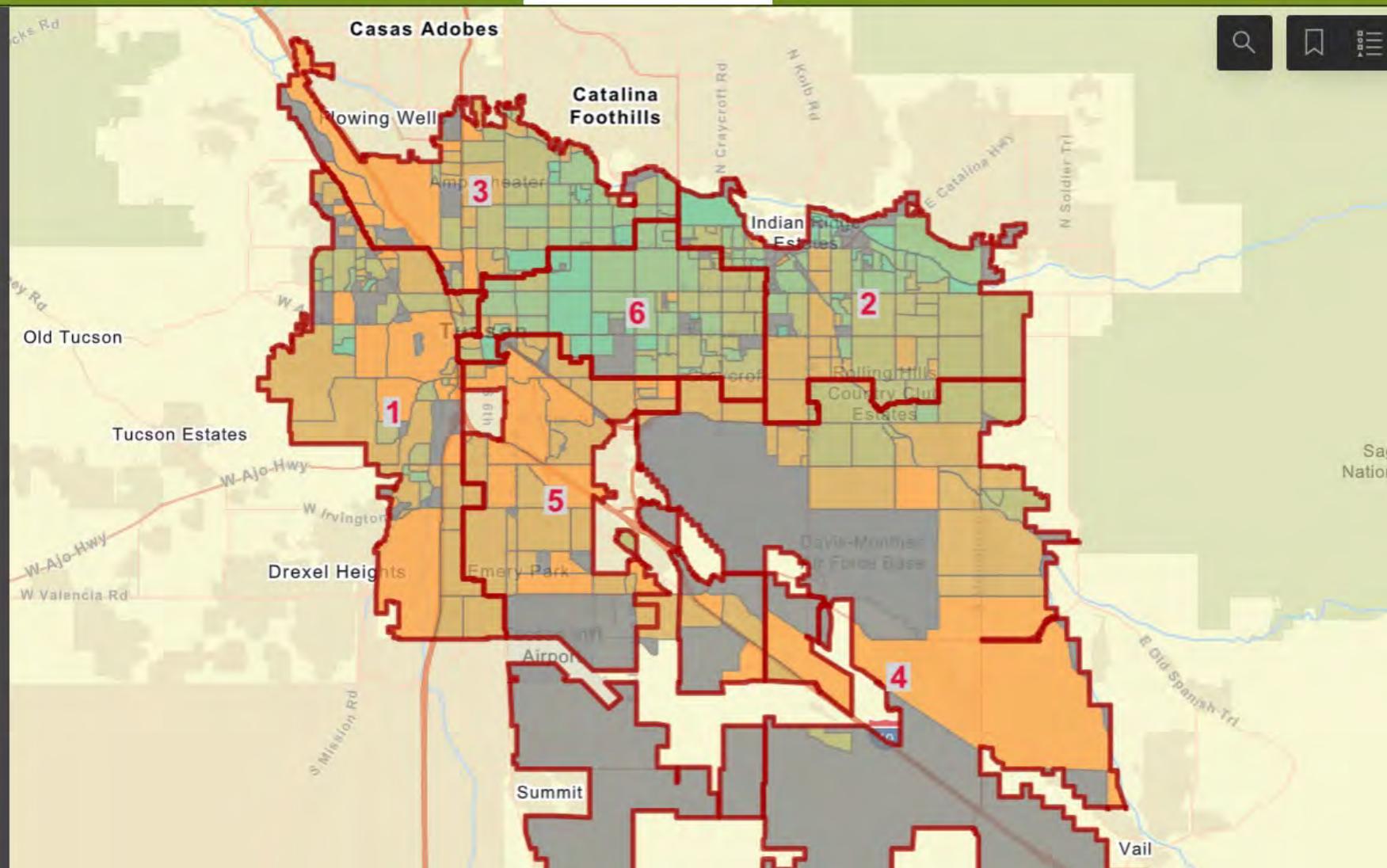
Preliminary Tree Equity Scores for Tucson neighborhoods

This dashboard was developed using American Forests' Tree Equity Score methodology. The

Tree Equity Scores

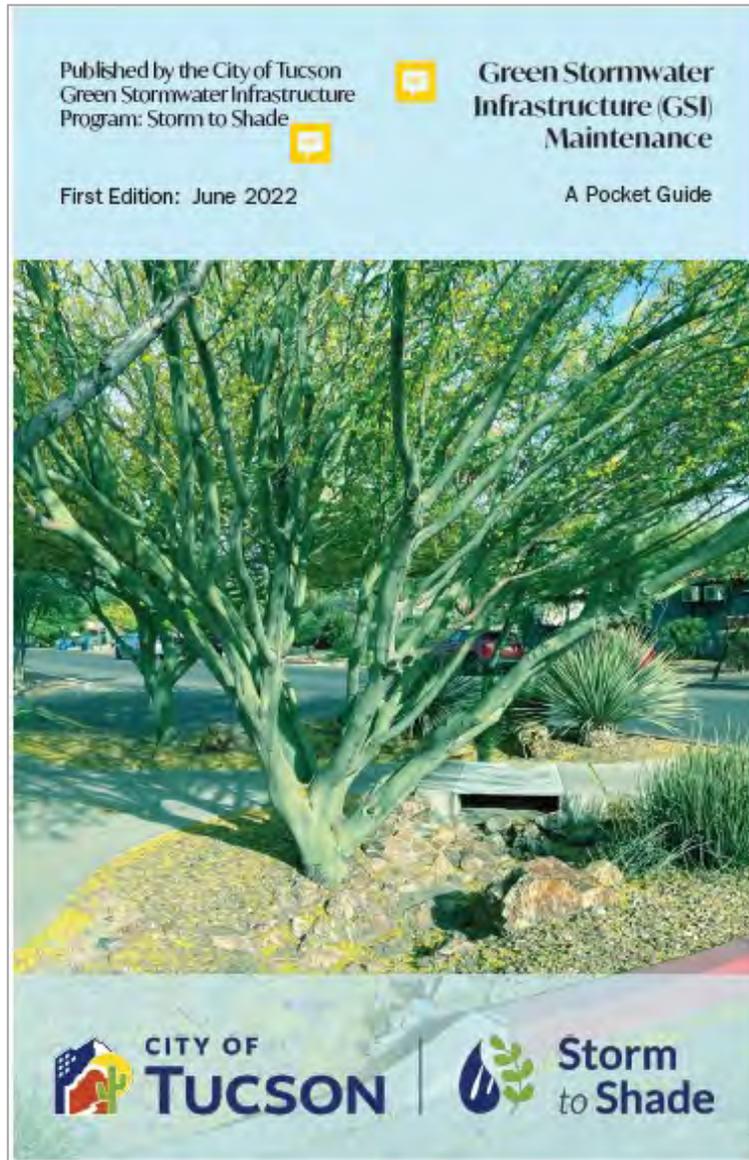
TES

99 - 100



Credit: Blue Baldwin, Tucson Water, City of Tucson

GSI Maintenance Pocket Guide



The structural elements of GSI

INLETS/OUTLETS
Conveyance allowing stormwater to flow into or out of a GSI feature

CURB CUT
Removed section of curbing that serves as an inlet or outlet

CURB CORE
Circular core drilled through curbing that serves as an inlet or outlet

SEDIMENT TRAP
Rough area at inlet that allows sediment to settle before water enters a basin

INFILTRATION BASIN
Depression within a GSI feature that allows stormwater to infiltrate the soil

PLANTING SHELF
Elevated planting area within a GSI feature

GSI Maintenance
the tools of the trade

Credit: Blue Baldwin, Tucson Water, City of Tucson

PAG's Regional GI Collaboration

Planning Tools and Collaborative Data Investments

- GIS GSI Online Prioritization Mapping Tool
- Heat and tree data development- Maintain partnerships for additional source data
- Return on Investment study (AutoCASE)

Data Driven Goals Setting, Assessment and Metrics

- Regional Green Stormwater Infrastructure Plan
- Prioritizing vulnerable areas – Environmental Justice

Regionally Cohesive Outreach Messaging

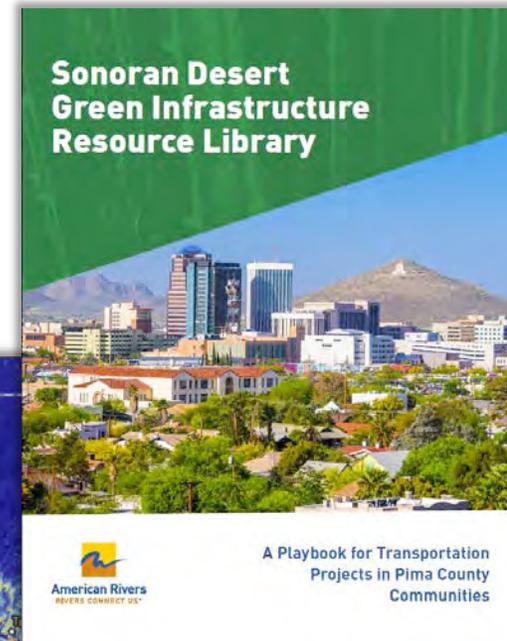
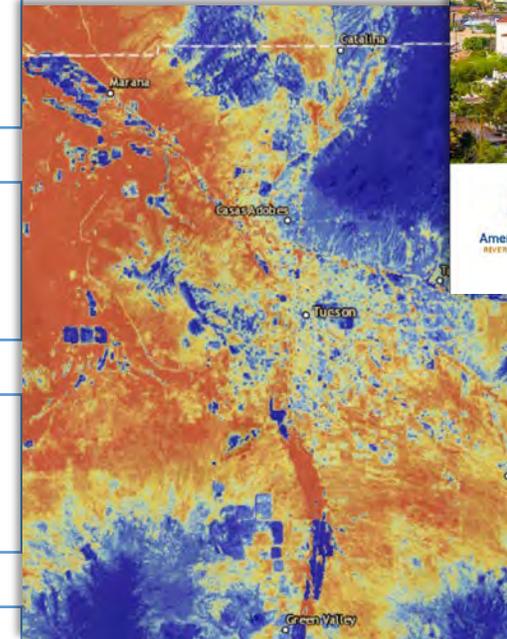
- LID in Stormwater (MS4) Pollution Prevention Outreach Materials
- Integrated LID into Post Construction BMP resources

Learning from Models and Examples

- Regional Policy Inventory and Book of Standard Designs and Specifications
- Regional Council Resolutions

Regional Consistency and Guidance

- Sonoran Desert Green Infrastructure Resource Library: A Playbook for Transportation
- Advisory role in partner efforts
- Multiple Workshops



Credit: Mead Mier, Pima Association of Governments

Conclusions

Green infrastructure has **broken siloes** for water management and has engaged other organizations.

Through GI, **equity issues become visible** – either you have it, or you don't – and maintenance is a challenge.

Community engagement is critical to address equity issues in GI, but resources are needed to do this work.

Bottom line – it takes a village! Water managers need to collaborate with each other and other organizations and invest in community engagement efforts for greening to ensure water security.



Thank you!

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