



# Integrating Green Infrastructure Tools into Hazard Mitigation Plans



**Sustainable  
Communities**  
Building Blocks

# Introductions



**FEMA**



**City of Phoenix**







Since 1996, EPA has helped communities grow in ways that expand economic opportunity, protect human health and the environment, and create and enhance the places that people love.

- ✓ Provide technical and planning assistance to communities
- ✓ Develop tools and publications to help communities achieve their goals
- ✓ Coordinate across federal, state, and local governments, non-profits, and the private sector to help implement smart growth strategies that meet community goals
- ✓ Provide grants to develop non-point source watershed plans, implement projects to reduce polluted runoff, fund land conservation, and promote public access to urban waters.



# **Workshop Purpose**

**Identify green infrastructure  
recommendations to incorporate into  
the 2020 Maricopa County MHMP**





# Goals of Technical Assistance

1. Expand the range of flood risk tools.
2. Promote water management co-planning and co-benefits of GI/LID.
3. Institutionalize GI/LID into planning.
4. Develop strategies and recommendations for implementing GI/LID in the area
5. Identify FEMA and other funding opportunities for GI/LID.



# Presentation Overview

- Hazard Mitigation Plans
- Green Infrastructure Options
- Green Infrastructure Benefits
- GI/LID Considerations
- Integrating GI/LID into HMPs





# HMP Overview



*Image Credits:* Left: GI for Desert Communities, Watershed Management Group. Right: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual.



# What is a Hazard Mitigation Plan?

- Disaster Mitigation Act of 2000 - Requires state, local, and tribal governments to have a FEMA approved hazard mitigation plan (HMP) in order to establish eligibility for FEMA's Hazard Mitigation Assistance (HMA) funding programs.
- Focus on mitigating natural hazard that impact the community
- Projects must align with the plan's priorities and mitigate the vulnerabilities and impacts identified.
- Plans must be updated every 5 years and can be amended throughout the 5-year plan lifecycle.





# What's in a HMP?

- Identify Hazards
- Assess Risks and Vulnerabilities
- Outline Mitigation Capabilities
- Strategies to Reduce Risk

# Potential Mitigation Activities

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Planning and policy

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Capital projects

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Development requirements

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Education programs

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# Integration of Hazard Mitigation into Local Planning Mechanisms

- Capital Improvement Plans
- Zoning Ordinances
- Subdivision Ordinances
- Building Codes.
- Stormwater Management
- Post-Disaster Recovery Ordinances/Plans

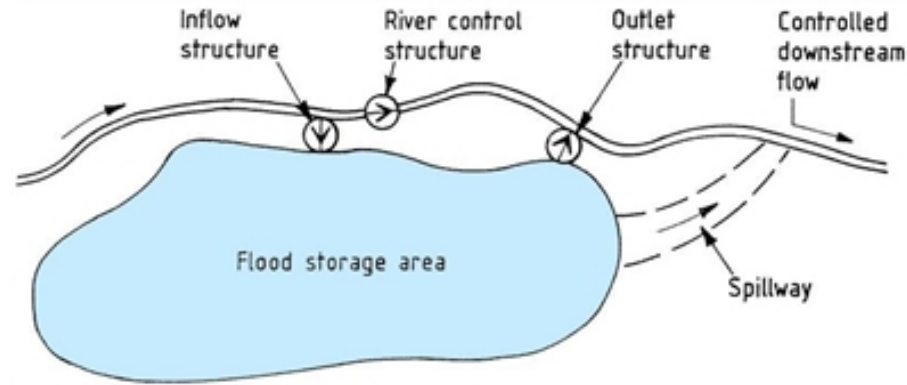


## Why Consider GI/LID in HMPs now?

FEMA recently incorporated into HMP Guidance

- More focus on integrated planning including natural resources
- Future conditions considerations including impervious area expansion
- Incentives to exceed the minimum plan content requirements - “Enhanced Plans” are eligible for more post-disaster funding
- FEMA focus on Resilience creates openness for local initiatives integrated into planning.

# New Resiliency Project Types



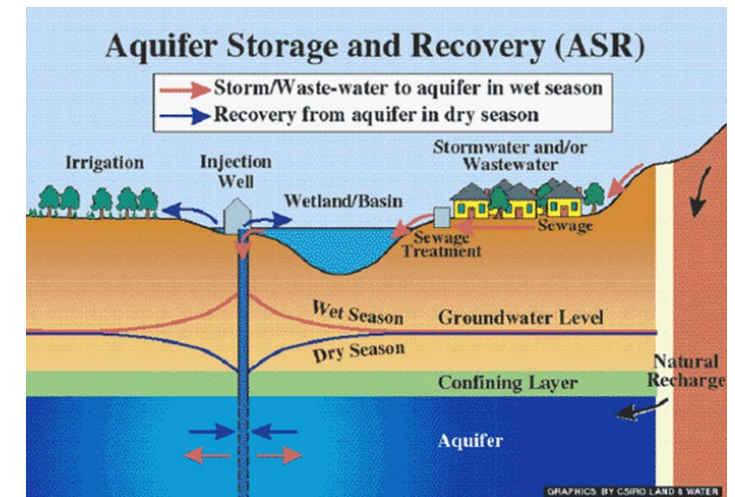
Flood diversion and storage



Green infrastructure



Floodplain and stream restoration



Aquifer storage and recovery



# 2015 MHMP Risks Most Suitable for GI Mitigation Strategies



**DROUGHT MITIGATION** through water storage and lower potable water demand



**EXTREME HEAT MITIGATION** through reduced urban heat island effect



**FLOOD MITIGATION** through diversion, infiltration and storage



# Green Infrastructure

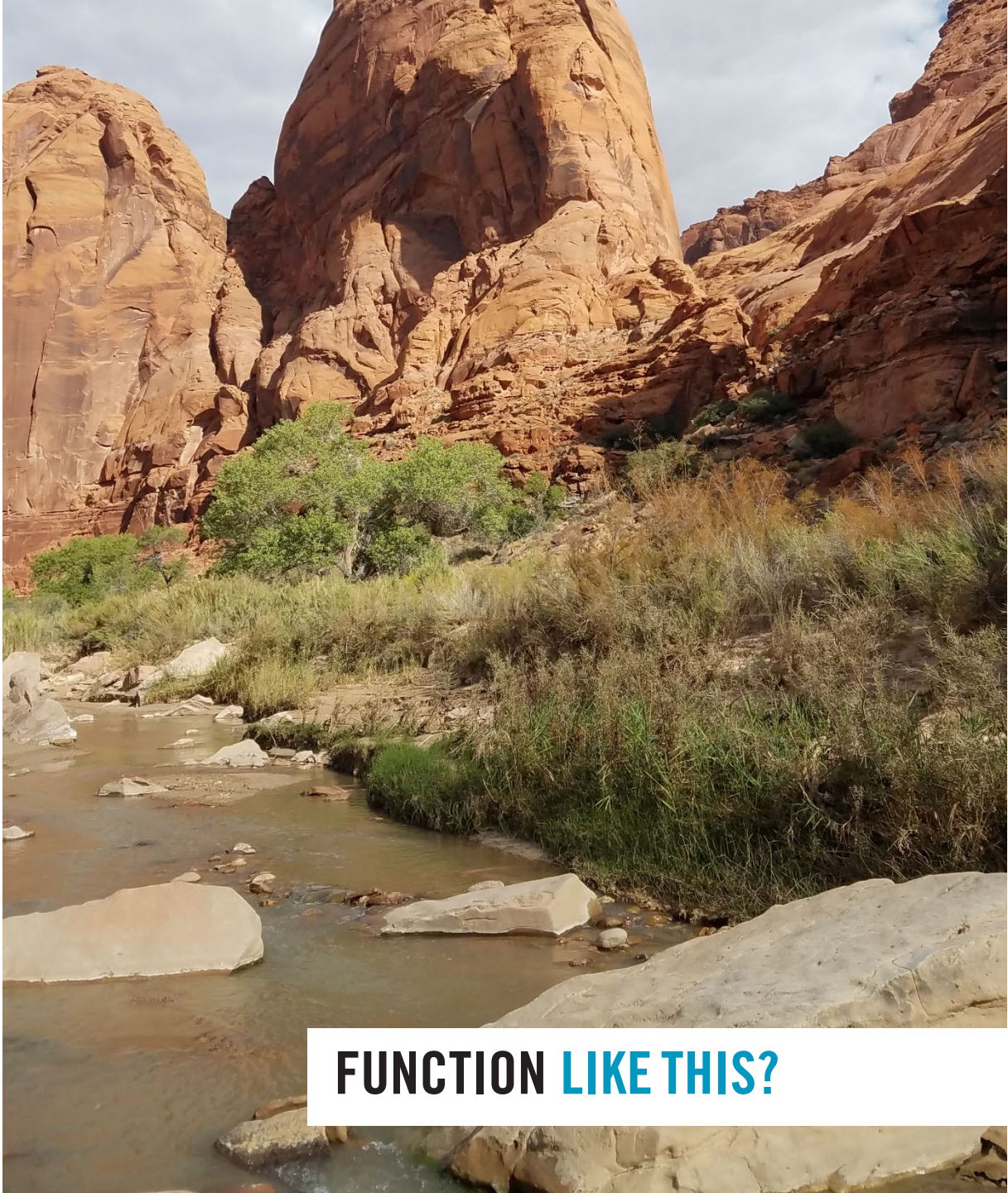


*Image Credits:* Left: GI for Desert Communities, Watershed Management Group. Right: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual.





HOW DO WE MAKE THIS...



FUNCTION LIKE THIS?



# GREEN INFRASTRUCTURE

- An integrated approach to water management
- Design emphasizes functions of soils, plants and grading
- Preserve, enhance, or recreate natural systems



# GREY INFRASTRUCTURE

**Serves only one function at high cost**



# GREEN INFRASTRUCTURE

**Provides multiple benefits simultaneously**





# GI STORMWATER FUNCTIONS



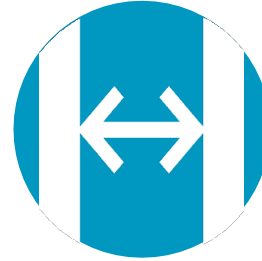
**CAPTURE**  
stormwater for  
specific use



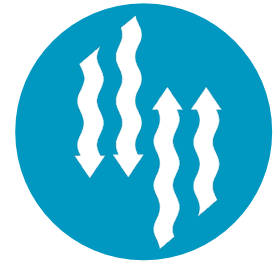
**DETAIN**  
stormwater and  
slowly release it at  
a controlled rate



**INFILTRATE**  
stormwater into the  
ground



**DISCONNECT**  
impervious areas to  
divert stormwater



**SLOW**  
the movement  
of stormwater



# GI/LID Technologies



*Image Credits: Left: GI for Desert Communities, Watershed Management Group. Right: Greater Phoenix GI Handbook.*



# MENU OF GI/LID TECHNOLOGIES

- Infiltration trench
- Dry well
- Vegetated or rock bioswale
- Bioretention system
- Stormwater harvesting basin
- Sediment trap
- Permeable pavement
- Green roof
- Conservation area
- Cistern
- Curb extension

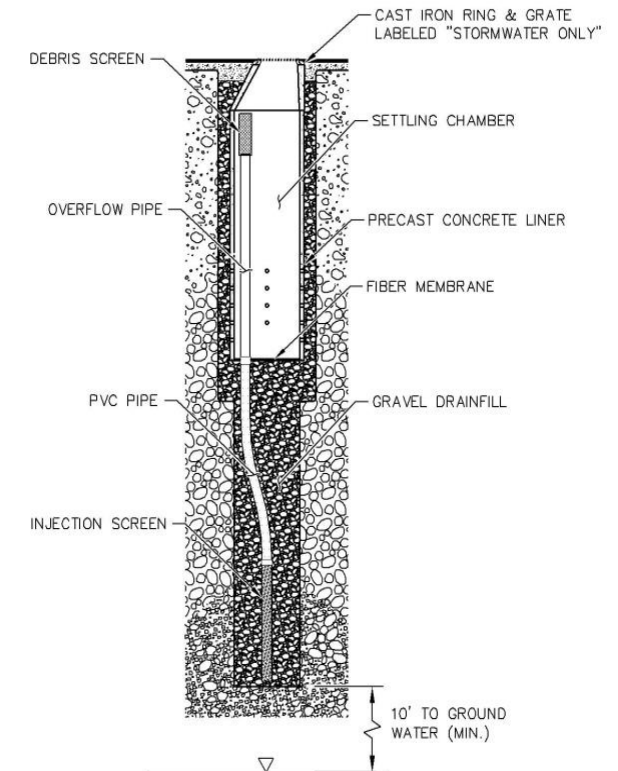
# INFILTRATION TRENCH

Long, narrow channels that are filled with gravel to retain stormwater or transfer it to another location



# DRY WELL

Excavations that are only a few feet in diameter and are filled with gravel





# VEGETATED OR ROCK SWALE

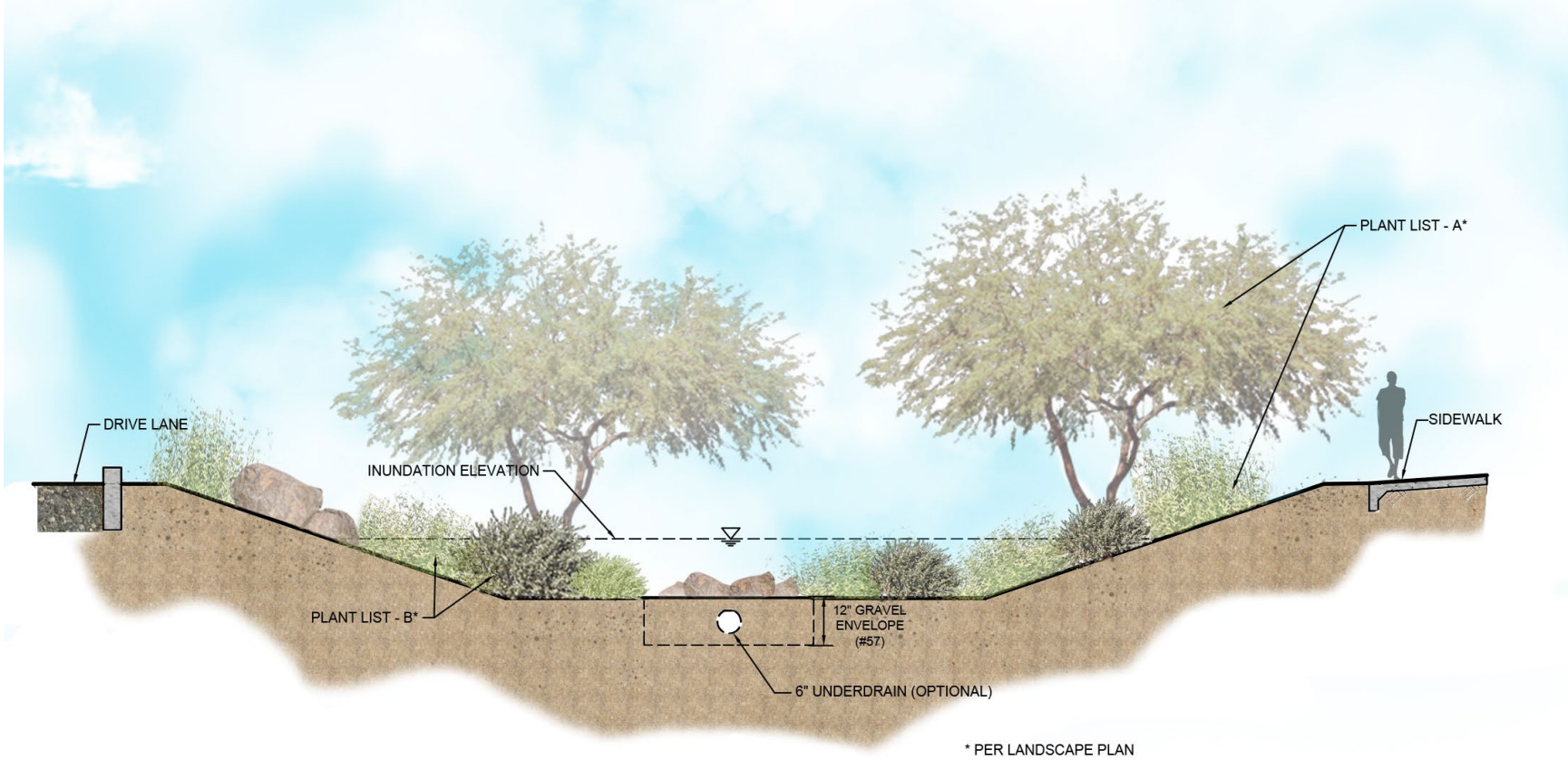
Elongated, shallow channels covered by vegetation and pervious rock or gravel



# BIORETENTION SYSTEM

Use vegetation to remove pollutants from stormwater





# STORMWATER HARVESTING BASIN

Shallow depressions that collect runoff and use it to support planted vegetation

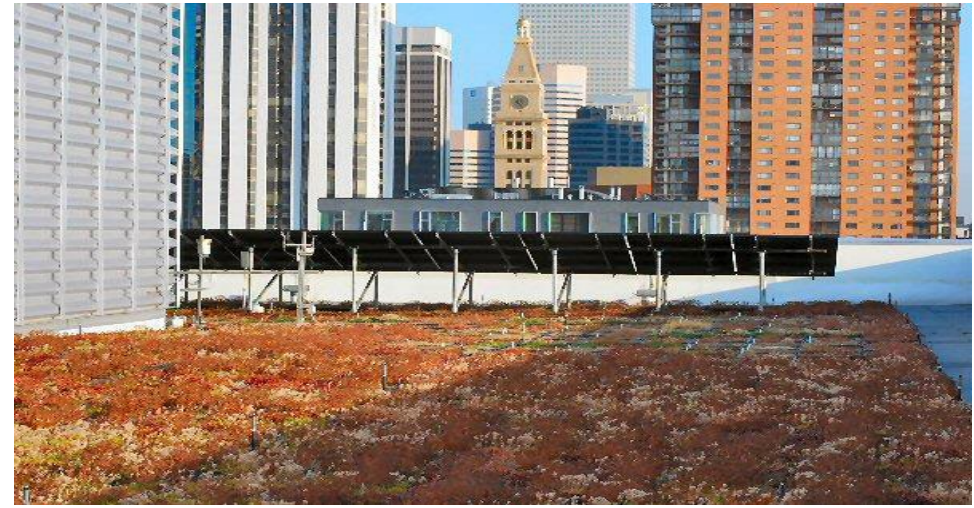






## PERMEABLE PAVEMENT

Pavement with small voids to allow water to infiltrate or drain into a reservoir below



## GREEN ROOF

Use vegetation and soils on building rooftops to retain stormwater





# CONSERVATION AREA

Protect undeveloped drainage areas to tap into their natural infiltration and storage capacity



# CISTERN

Metal, plastic or concrete containers that collect rain for non-potable use

- Typically can hold several thousand gallons.





# SEDIMENT TRAP

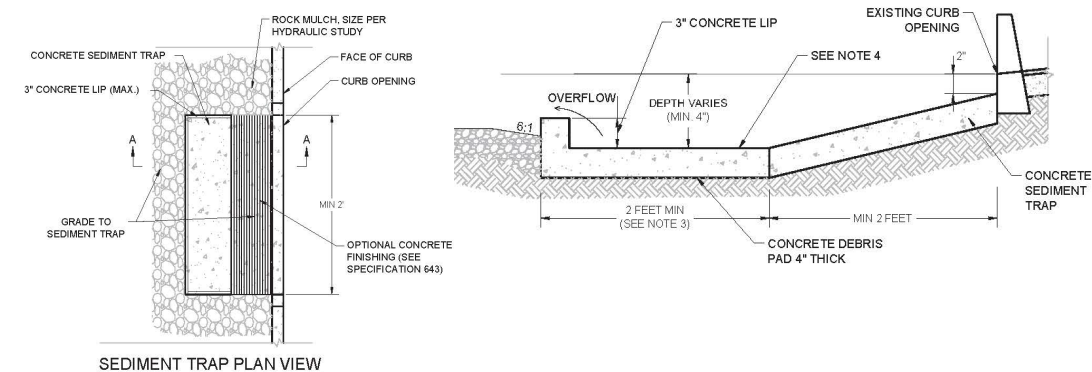
Depressions at inlets with debris pads to collect sediment from concentrated stormwater flows

Provide some pretreatment before stormwater enters a stormwater capture feature



# CURB EXTENSION

Landscaped areas built out from a vehicle travel or parking lane





# GI CONSIDERATIONS



*Image Credits:* Left: GI for Desert Communities, Watershed Management Group. Right: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual.



# Considerations for Arid Climate

Local rainfall, temperatures and soils may affect design specifications such as:

## *Plants*

Tolerance for semi-arid environments and periodic inundation

## *Sizing*

Maricopa County recommends the 0.5-inch rainfall event as the minimum sizing requirement for GI/LID features



# Maintenance Considerations

Without the appropriate maintenance, GI/LID features may not perform at optimum levels. Maintenance generally includes:

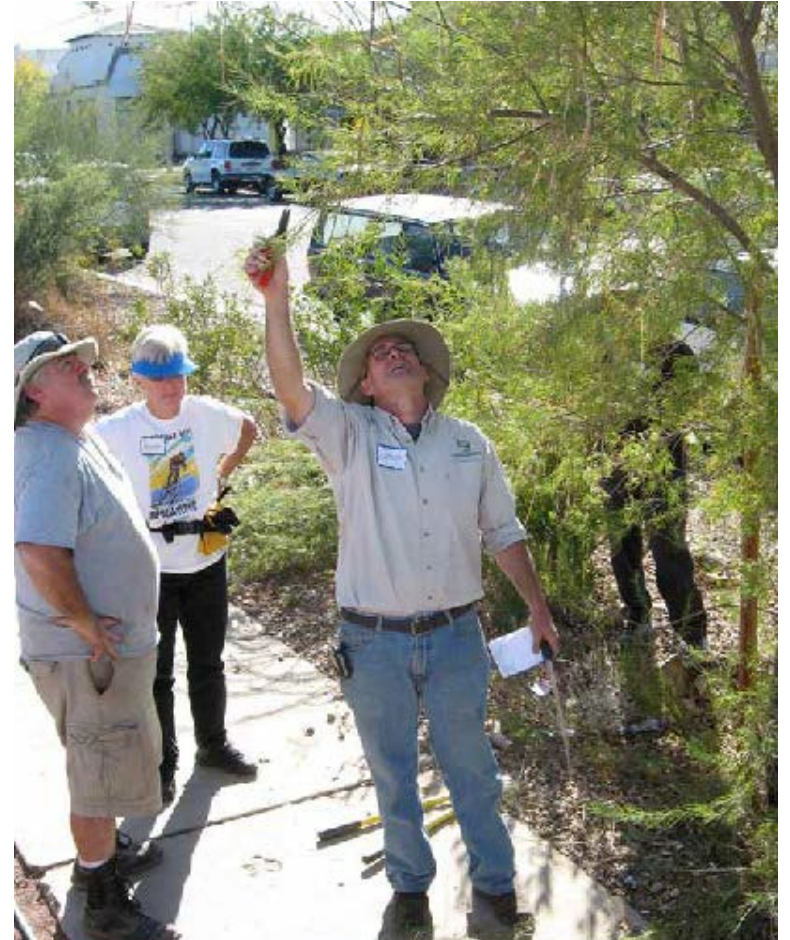
**REMOVING** debris, sediments and weeds

**REPLACING** dead plants and mulch

**WATERING** vegetation during establishment or drought periods

**PRUNING** trees and shrubs

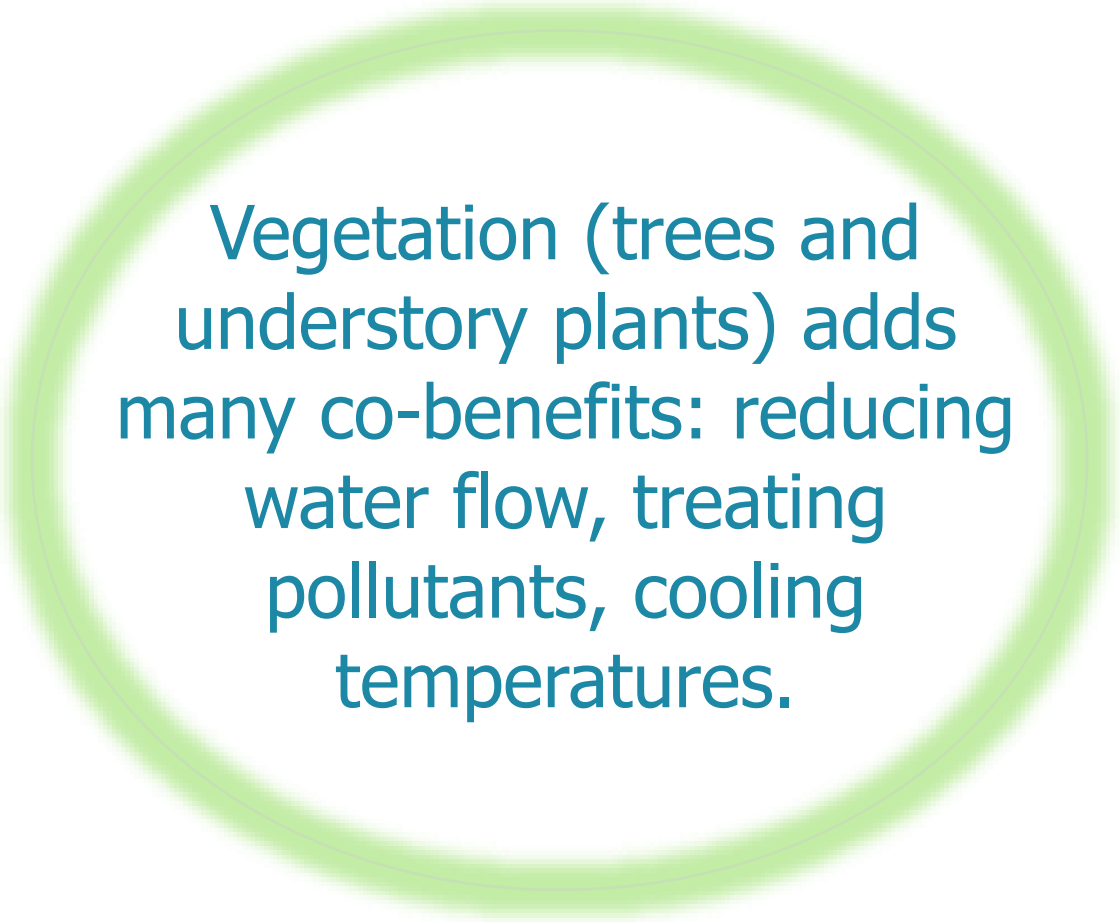
**REPAIRING** any damage from erosion or human activity





# Increasing GI/LID Performance

- Include accessory features (rock check dams)
- Sequence features in a treatment train
- Benefits are cumulative as more GI/LID features are installed at a larger scale



Vegetation (trees and understory plants) adds many co-benefits: reducing water flow, treating pollutants, cooling temperatures.

# APPLICABILITY TO LAND USE

	Street	Open space	Parking lot	Commercial/ institutional	Residential building	Residential subdivision
Infiltration trench	X	X	X	X	X	
Curb extension	X		X	X		X
Sediment trap	X		X	X		
Bioswale	X	X	X	X	X	X
Bioretention system	X	X	X	X		
Stormwater harvesting system	X	X	X	X	X	X
Permeable pavement	X*		X	X	X	X
Green roof				X		
Conservation Area		X		X	X	X
Cisterns				X	X	X
Dry well			X	X	X	X



# GI Benefits



*Image Credits:* Left: GI for Desert Communities, Watershed Management Group. Right: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual.



# 2015 MHMP Risks Most Suitable for GI Mitigation Strategies



**DROUGHT MITIGATION** –  
rainwater harvesting can reduce  
household water use by 66%



**EXTREME HEAT MITIGATION**  
green roofs can reduce roof  
temps from 134 to 86 degrees



**FLOOD MITIGATION** bioswales  
can capture over 98% of the  
rainfall from one-inch storm



# GI FEATURES CONTRIBUTE CO-BENEFITS



Improved **water quality**



Improved **air quality**



Lower **carbon emissions**



Enhanced **pedestrian safety**



Enhanced **community wellness**



Improved **property values**



Long-term **cost savings**

# Co-Benefits by the Numbers

76-99%

TSS reduction from  
bioswales

60%

building energy  
consumption from green  
roofs

58,700

tons of carbon stored by  
urban trees in Phoenix



# Social benefits of green space



Improved  
attention and  
mood



Reduced stress  
through time  
spent outdoors



Increased  
physical activity  
through biking  
and walking



Increased social  
interaction  
among  
neighbors



Strengthen sense  
of place, safety  
and trust

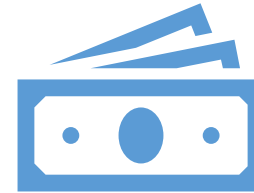
# Economic Benefits of GI



Increased property values



Increases of up to 30% in  
property value near parks



Greater net benefits than  
conventional infrastructure



# RELATIVE BENEFITS OF GI/LID

Technology	Relative Cost	Mitigates the Following HMP Risks					Quality of Life Benefits
		Flooding	Drought: Water Demand	Drought: Water Storage	Urban Heat Island	Water Quality	
Infiltration trench	\$	●	◐	●	○	●	
Curb extension	\$\$	◐	●	○	◐	◐	Habitat, planting feature, traffic calming, aesthetics, trash capture
Sediment trap	\$	◐	○	○	○	◐	Important O&M feature to include with bioswales and basins.
Vegetated or rock bioswale	\$\$	●	●	○	●	●	Habitat, planting feature, aesthetics, trash capture, traffic calming, air quality
Bioretention system	\$\$	●	●	●	●	●	Wildlife habitat, planting feature, aesthetics, air quality
Stormwater harvesting basins	\$\$	●	●	●	●	●	Wildlife habitat, planting feature, aesthetics, air quality

**Key: Benefits** ● = high; ◐ = medium; ○ = low

**Relative Costs (Capital and O&M)**  
 \$\$\$=high; \$\$=medium; \$=low

# RELATIVE BENEFITS OF GI/LID

Technology	Relative Cost	Mitigates the Following HMP Risks					Quality of Life Benefits
		Flooding	Drought: Water Demand	Drought: Water Storage	Urban Heat Island	Water Quality	
Permeable pavement	\$\$-\$\$\$	●	◐	◐	◐	●	Traffic calming
Green roof	\$\$\$	◐	○	○	●	◐	Wildlife habitat, planting feature, aesthetics
Conservation area	\$	●	◐	●	●	●	Wildlife habitat, planting feature, aesthetics, air quality
Cistern	\$	◐	●	◐	◐	◐	
Dry well	\$	●	◐	◐	○	●	

**Key: Benefits** ● = high; ◐ = medium; ○ = low

**Relative Costs (Capital and O&M)**  
 \$\$\$=high; \$\$=medium; \$=low



# 1<sup>st</sup> Breakout Session Questions

Are these the appropriate GI/LID technologies?  
Anything to remove? Anything missing?

*Refer to  
presentation  
handout for more  
information about  
GI/LID technologies*

- Infiltration trench
- Dry well
- Vegetated or rock bioswale
- Bioretention system
- Stormwater harvesting basin
- Sediment trap
- Permeable pavement
- Green roof
- Conservation area
- Cistern
- Curb extension



# GI and Heat Mitigation



*Image Credits:* Left: GI for Desert Communities, Watershed Management Group. Right: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual.



# 2<sup>nd</sup> Breakout Session Questions

What is the relative ability of GI to mitigate HMP risks?

Which provide the most benefit

- For flood?
- For drought?
- For extreme heat?

Any adjustments?

Technology	Relative Cost	Mitigates the Following HMP Risks					Quality of Life Benefits
		Flooding	Drought: Water Demand	Drought: Water Storage	Urban Heat Island	Water Quality	
Infiltration trench	\$	●	◐	●	○	●	
Curb extension	\$\$	◐	●	○	◐	◐	Habitat, planting feature, traffic calming, aesthetics, trash capture
Sediment trap	\$	◐	○	○	○	◐	Important O&M feature to include with bioswales and basins.
Vegetated or rock bioswale	\$\$	●	●	○	●	●	Habitat, planting feature, aesthetics, trash capture, traffic calming, air quality
Bioretention system	\$\$	●	●	●	●	●	Wildlife habitat, planting feature, aesthetics, air quality
Stormwater harvesting basins	\$\$	●	●	●	●	●	Wildlife habitat, planting feature, aesthetics, air quality
Permeable pavement	\$\$-\$\$\$	●	◐	◐	◐	●	Traffic calming
Green roof	\$\$\$	◐	○	○	●	◐	Wildlife habitat, planting feature, aesthetics
Conservation area	\$	●	◐	●	●	●	Wildlife habitat, planting feature, aesthetics, air quality
Cistern	\$	◐	●	◐	◐	◐	
Dry well	\$	●	◐	◐	○	●	

**Key: Benefits** ● = high; ◐ = medium; ○ = low

**Relative Costs (Capital and O&M)** \$\$\$=high; \$\$=medium; \$=low



# GI/LID in HMPs



*Image Credits:* Left: GI for Desert Communities, Watershed Management Group. Right: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual.



## Incorporate GI/LID into HMP Goals

“Support mitigation initiatives and policies that promote disaster resiliency, **nature-based solutions**, cultural resources and historic preservation, and climate adaptation strategies”

*2018 Colorado NHMP*

“Minimize the impact of natural hazards **while protecting, restoring, and sustaining environmental processes**”

*2015 Oregon NHMP*

# Incorporate GI/LID into Mitigation Strategies

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Planning and policy

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Capital projects

---

Development requirements

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Education programs

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# Examples from City of Phoenix

*Where can  
GI/LID  
technologies  
be included?*

## Current Strategies in the 2015 MHMP

Planning	Capital projects	Development requirements	Education and stewardship
Updates to the Drought Response Plan.	Drainage facilities to mitigate flooding hazard.	Building permits for compliance with floodplain regulations.	Water use awareness outreach program.
Policies in the General Plan that designate areas for open space.		Revisions to existing building codes.	

# Examples from City of Phoenix

## *Where can GI/LID technologies be included?*

Planning	Capital projects	Development requirements	Education and stewardship
<p>Updates to the Drought Response Plan, including GI/LID measures to reduce potable water use and increase storage.</p> <p>Policies in the General Plan that designate areas for open space, with emphasis on natural drainage areas.</p>	<p>Drainage facilities, with a priority on GI/LID, to mitigate flooding hazard.</p>	<p>Building permits for compliance with floodplain regulations.</p> <p>Revisions to existing building codes, including requiring GI/LID features for roofs, parking and landscape areas, and water storage/reuse.</p>	<p>Water use awareness outreach program, including education on drought tolerant and GI/LID landscape guidance.</p>



# Examples from City of Tempe

*Where can  
GI/LID  
technologies  
be included?*

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## Current 2015 Strategies in the MHMP

Planning	Capital projects	Development requirements	Education and stewardship
Development of water infrastructure master plan	Projects to mitigate flooding affecting freeways.	Building permit compliance with floodplain regulations.	Education on the hazards of extreme heat.

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# Examples from City of Tempe

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## *Where can GI/LID technologies be included?*

Planning	Capital projects	Development requirements	Education and stewardship
Development of water infrastructure master plan, including GI/LID storage.	Projects to mitigate flooding affecting freeways, including GI/LID stormwater management.	Building permit compliance with floodplain regulations, and GI/LID stormwater management features.	Education on the hazards of extreme heat, including guidance on GI/LID features to mitigate extreme heat.

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# Unincorporated Maricopa County

*Where can  
GI/LID  
technologies  
be included?*

Current 2015 Strategies in the MHMP			
Planning	Capital projects	Development requirements	Education and stewardship
Area drainage studies Floodplain management plan	Flood control projects.	Building permits for compliance with floodplain regulations.	Education on flooding hazards and water conservation.

# Unincorporated Maricopa County

## Where can GI/LID technologies be included?

Planning	Capital projects	Development requirements	Education and stewardship
Area drainage studies that prioritize GI/LID. Floodplain management plan that prioritizes GI/LID.	Flood control projects that prioritize GI/LID.	Building permit compliance with floodplain regulations and requirements to manage stormwater with GI/LID.	Education on flooding hazards and water conservation, including guidance on installing GI/LID to manage onsite water.



# Discussion Questions



*Image Credits:* Left: GI for Desert Communities, Watershed Management Group. Right: Pima County and City of Tucson. Low Impact Development and Green Infrastructure Guidance Manual.



# 3<sup>rd</sup> Breakout Session Questions

Part 1: Looking at the current strategies in the 2015 MHMP, where are there opportunities to integrate GI/LID?

Current Strategies by Jurisdiction in the 2015 Maricopa County MHMP

Jurisdiction	Planning	Capital Projects	Development Requirements	Stewardship and Education
	How can GI technologies mitigate for drought, flood and extreme heat in...			
	relevant planning documents?	capital improvement projects?	development requirements?	education and stewardship programs?
City of Phoenix (Table 6-8-18, 2015 MHMP)	Updates to the Drought Response Plan.  Policies in the General Plan that designate areas for open space.	Drainage facilities to mitigate flooding hazard.	Building permits for compliance with floodplain regulations.  Revisions to existing building codes.	Water use awareness outreach program.
City of Tempe (Table 6-8-24, 2015 MHMP)	Development of water infrastructure master plan to identify vulnerabilities in the water supply.  2002 Water Resources Plan, the 1999 Tempe Integrated Water System Master Plan, and the 2002 Drought Management Strategy Plan.	Projects to increase groundwater storage and recovery.  Projects to mitigate flooding affecting freeways.  Projects related to flood control and storm drainage.	Building permits for compliance with floodplain regulations.	Education on the hazards of extreme heat.  Workshops and conferences on hazard mitigation.
Unincorporated Maricopa County (Table 6-8-26, 2015 MHMP)	Area Drainage Master Studies/Plans.  Updates to the framework of hazard mitigation in the 2009 Comprehensive Floodplain Management Plan.	Projects to mitigate flooding hazards through the Flood Control Capital Improvement Program.	Building permits for compliance with floodplain regulations.  Revisions to existing building codes.	Public education program about flooding hazards and water conservation.  Outreach to highlight renewable water uses for subdivision developers.



# 3<sup>rd</sup> Breakout Session Questions

Part 2: Where are there opportunities to integrate GI into:

- Planning documents?
- Capital programs?
- Development requirements?
- Education programs?

Planning	Capital Projects	Development Requirements	Stewardship and Education
Include GI/LID in relevant planning documents such as: <ul style="list-style-type: none"><li><input type="checkbox"/> General Plan (designate areas for connected and multi-purpose open space)</li><li><input type="checkbox"/> Flood management plan</li><li><input type="checkbox"/> Area drainage studies and plans</li><li><input type="checkbox"/> Water infrastructure plan</li><li><input type="checkbox"/> Drought management plan</li><li><input type="checkbox"/> Parks and trails plan</li></ul>	Integrate GI/LID into capital improvement projects such as: <ul style="list-style-type: none"><li><input type="checkbox"/> Flood control</li><li><input type="checkbox"/> Storm drainage</li><li><input type="checkbox"/> Groundwater storage</li><li><input type="checkbox"/> Street improvements</li><li><input type="checkbox"/> Parks and trails</li><li><input type="checkbox"/> Civic projects such as schools, libraries, community centers and municipal buildings</li></ul>	Adopt development requirements to allow, incentivize or require GI/LID such as: <ul style="list-style-type: none"><li><input type="checkbox"/> Parking lots – decrease stall and aisle size and add porous pavement and GI/LID planted areas</li><li><input type="checkbox"/> Building design – allow for green roofs, cisterns and other GI/LID elements</li><li><input type="checkbox"/> Landscape standards – integrate drought tolerant landscapes and GI/LID stormwater management</li></ul>	Promote voluntary GI/LID implementation through education including programs focused on: <ul style="list-style-type: none"><li><input type="checkbox"/> Water conservation</li><li><input type="checkbox"/> Landscape guidance</li><li><input type="checkbox"/> Extreme heat</li><li><input type="checkbox"/> Flooding hazards</li><li><input type="checkbox"/> Urban forestry</li></ul>