Sonoran Desert Green Infrastructure Resource Library

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A Playbook for Transportation Projects in Pima County Communities

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A Playbook for Transportation Projects in Pima County Communities

This report was co-authored by Jeff Odefey (American Rivers), Mead Mier (Pima Association of Governments), and Catlow Shipek (Watershed Management Group). The authors gratefully acknowledge the contributions of Stacey Detwiler, formerly of American Rivers, whose 2015 report "*Rivers and Roads: Opportunities to Better Integrate Green Infrastructure and Transportation Projects in Atlanta, GA and Toledo, OH*" directly informed portions of this guide. The authors were also greatly assisted by input from staff at Pima Association of Governments' Transportation and Integrated Planning Departments, Pima County Departments of Housing & Urban Development and Transportation, the Pima County Regional Flood Control District and the City of Tucson's Water and Transportation Departments as well as the City Administrator's office.

The authors are responsible for any factual errors. The recommendations are those of American Rivers and any views expressed in this report are those of the authors and do not necessarily reflect the views of our funders or those who provided review.

Please note that active hyperlinks are embedded throughout the document, and indicated by red or blue text with a red underlined text.

Historic flows restored in the Santa Cruz River.
Photo: American Rivers

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Native Tucson vegetation in a curbcut.
Photo: PAG

Introduction

Many of the requirements of street construction can be addressed cost-effectively through Green Infrastructure (GI) including managing surface drainage, providing all weather crossings, mitigating transportation's surface pollutants, meeting safety goals for all transportation modes, and ensuring final stabilization of the soils.

The Tucson region is a desert community with streets designed to convey stormwater. Like much of the West, storm sewers are separated from the sanitary sewer system. Oftentimes this creates flooding issues on bicycle and pedestrian facilities. In high water situations, rainfall can also impact the safety of a roadway facility. Localized flooding deposits unwanted sediment on the region's roads, bike lanes, and pedestrian facilities. Traditional street designs also create risks including increased heat, decreased absorption, and decreased water quality. GI offers opportunities to decrease those risks and add cost-effective approaches to protect the post-construction integrity of the roadway, mitigating stormwater pollutants from transportation sources, providing drought and heat resilient landscapes, reduced ponding and flood attenuation. Benefits also include increased access to urban green space, improved air quality, and reduced demand on grey storm sewer infrastructure and the cost of constructing expensive underground pipe systems.

Purpose of the Playbook

Transportation project leaders have increasingly used GI approaches over the last few decades. This guide was created to address common issues that inhibit the implementation of GI in the Tucson region transportation network. Many of these issues can be solved by including GI in each planning phase and through policies, funding and practices tailored to the region's urban and suburban environments, each of which have a dedicated section in this guide. Metropolitan Planning Organizations (MPOs), local governments and transportation entities are important players in creating a healthy built environment and essential to successful implementation of GI since streets are where stormwater flows. Issues and corresponding solutions in this resource guide were identified by local experts in GI and transportation engineering and planning. Top local concerns that were addressed in this document include utilities, flooding, sediment, and maintenance. This playbook is a product of American Rivers based on a general national guide filled in with local details by jurisdictions within Pima County where examples were available or with other Western examples to address any remaining gaps and models. This guide is intended to be a resource for transportation-oriented staff and to provide examples and illustrations of planning, funding, and project design approaches that may be relevant to the Pima County area. It is in no way intended to be interpreted as administering official policy, preferences, or design specifications.

Green Infrastructure Pedestrian Canopy on Scott Avenue Green Street.
Photo: American Rivers

Green Infrastructure? Green Stormwater Infrastructure? WHAT'S IN A NAME?

The terminology involved in nature-based approaches to managing stormwater can be confusing. Many practitioners use the term "green infrastructure," which has recently been incorporated into the Clean Water Act:

Section 502 of the Clean Water Act defines green infrastructure (GI) as the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to server systems or to surface waters.

However, this term has a second historical usage to refer to the parks, green spaces, preservation of large scale landscapes, and other areas that provide habitat in an urban environment. In an effort to distinguish stormwater management practices from this broader definition, many people are adopting the more specific term "green stormwater infrastructure." To add further confusion, the term "low impact development" (LID) is often used to include, among other things, the types of stormwater management approaches that utilize "green infrastructure" techniques. For the sake of consistency with local design manuals and policies, the authors of this guide will use the term "green infrastructure" throughout the document except in places where it's more appropriate to echo a usage of other terms used in policies such as stormwater harvesting, low impact development or green stormwater infrastructure.

Defining the Needs

The Tucson region has several key issues that can be addressed through urban design that includes GI along streets.

Extreme heat is the leading cause of weather-related deaths in the United States and the highest rates of impact on residents nationally are found in Arizona. Heat is amplified by hardscape, such as streets, creating heat islands. Extreme heat exacerbated by urban heat islands can lead to increased respiratory difficulties, heat exhaustion, and heat stroke. Physical, social and economic factors create a disproportionate impact on older persons, children, homeless, the poor, socially isolated, and those with mobility restrictions or health concerns. As temperatures rise in Arizona, the region will have more contiguous 100+ degree days in combination with higher nighttime temperatures. Heat-related illnesses and deaths are directly related to prolonged exposure to high temperatures in the absence of intermittent cooling down periods. Unfortunately, economically disadvantaged parts of the community are often especially impacted because under-investment in urban forestry has created denuded neighborhoods where residents commonly depend on public transportation which requires walking outdoors in the heat. Tree shade can mitigate heat and provide cooling for active modes of transportation.

The Santa Cruz currently has reaches that do not meet applicable water quality standards due to pollutants associated with transportation sources including copper and zinc. These pollutants are toxic to organisms with aquatic phases that rely on the region's ephemeral waters and rare perennial and intermittent waters. Sediment from construction is also considered a pollutant and field screening has found oil sheen in runoff. The Santa Cruz River also suffers from "impaired" status due to *E. coli* contamination from animal waste. Bioretention basins along streets can prevent accumulation of pollutants in our waterways and break down hydrocarbons and pathogens.[1]

A severe local drought began in our region about 20 years ago, triggering Drought Stage 1 in local Drought Response Plans. Drought Stage 2 will occur if there are shortages on the imported Colorado River supplies. Should irrigation restrictions need to take place in Drought Stage 2, many local jurisdictions identify stormwater harvesting as a way to prepare for landscape resiliency in their Plans. It is critical

SAFER STREETS THROUGH GI

While some people may assume that trees pose risks for drivers, far less than 1% of U.S. annual vehicle crashes involve a tree on an urban street. Crash prevention efforts should address high-risk conditions, such as reducing plantings at curves, rather than generalized tree removal. The most recent research suggests that trees may improve driving safety. Drivers seeing natural roadside views show lower levels of stress and frustration compared to those viewing all-built settings. One study found a 46% decrease in crash rates across urban arterial and highway sites after landscape improvements were installed. Another study found that placing trees and planters in urban arterial roadsides reduced mid-block crashes by 5% to 20%. Several studies comparing roads with and without landscaping and trees have found a marked decrease in the number of pedestrian and bicyclist fatalities and injuries by up to 80%.*

Is GI appropriate for all street types? Yes, and different GI feature types fit each street type.

The Dallas Complete Streets Design Manual (Design Element Priorities Chart, page 85 in the document) shows an example of prioritizing trees and greenspace for almost all street types. The LA Model Design Manual for Living Streets describes which GI features work with different street typologies (Best Fit for Streetwater Tools by Street Context, Table 11.1).

Rincon Heights bumpout decreases pedestrian crossing distance.
Photo: City of Tucson

**Studies can be found in Wolf, K.L. 2010. Safe Streets - A Literature Review. In: Green Cities: Good Health (www.greenhealth.washington.edu). College of the Environment, University of Washington.*

that transportation departments work in coordination with water planners to utilize stormwater as a water resource. This will prepare a more resilient streetscape.

In the semi-arid climate of Pima County, Arizona, stormwater is a valuable resource that has historically been disposed of as a nuisance and a hazard. The rain that does reach the desert floor in a summer monsoon or a fall tropical cyclone typically does so with great vigor. The altered flow regime created by traditional roadways additionally increases runoff volume and peak flows, damaging the environment and creating a risk to property downstream. These erosive flows in receiving streams will cause downcutting, clear water scours, or excessive sedimentation. As documented in studies described later in this document, GI has been found to reduce stress on traditional stormwater infrastructure, pull sediment hazards out of the travel lane, and reduce the peak of the hydrograph, which reduces the stormwater nuisances on streets and reduces the risks of flood damage to adjacent properties.

Each year, close to 4,000 Tucsonans are injured and more than 50 people lose their lives while traveling on city streets.[2] Jurisdictional leaders are committed to changing this. According to a 2019 report released by the Governors Highway Safety Association, pedestrian deaths have increased by 35 percent in the last decade. Arizona has also been ranked the second deadliest state for pedestrians per capita.[3] According to Pima Association of Governments' (PAG's) performance measures in 2020, the fatality rate for people on bikes and people walking are unfortunately trending upward per capita even as more bicycle and pedestrian facilities are built. Through the 2045 Regional Mobility and Accessibility Plan (RMAP 2045) process, over 300 miles of bicycle and pedestrian safety facilities and over 200 miles of improved roadways have been identified to address poor or fair

safety ratings. Road safety can be improved when GI is incorporated on any street size and is an important part of street modernization projects including medians/islands, crossings, curb extensions, etc.[4]

The greater purpose of the guide is to:

- Increase proper utilization of GI to provide safer road conditions with reduced flood hazards and time for streets to dry
- Improve the safety and comfort of people bicycling and walking by installing traffic calming and buffer elements
- Increase transit rider comfort with enhanced shelters, shade, and greenscape at transit stops (critical to growing transit as a mode)
- Make the biking and walking environment more healthy by reducing temperature, attenuating noise, and improving air quality
- Use trees as visual friction to increase driver self-regulation and geometric features in the road can be placed to calm traffic and improve traffic safety conditions.

  (Reference: NACTO Urban Street Stormwater Guide)

Definition

Green infrastructure practices reduce stress on traditional grey stormwater infrastructure and restore natural flow functions with a variety of stacked benefits for the environment and community. Also related to Low Impact Development (LID) or stormwater harvesting, examples include structures that improve infiltration, enhance or maintain vegetation, and/or capture and reuse stormwater.
GI practices emphasize the preservation and restoration of natural landscape features and connectivity. Within the transportation network, technologies may include permeable pavements, bioretention in chicanes or parking lots, curb inlets that direct stormwater, and infiltration in check-dams in rights-of-way.

Regional Interest

With more than 300 days of sunshine each year, 60 to 70 of which exceed 100-degree temperatures, shade is a critical consideration for improving the pedestrian environment. Water conservation is key to sustaining shade in the desert.

Community support and implementation of GI has grown over time and this demand has been documented in several assessments.

The PAG 2014 Regional Pedestrian Plan found, through a survey of 670 self-selected participants, that increased shade is the most common improvement desired by pedestrians (49 percent). Obstacles such as lack of shade create barriers for people who would otherwise like to walk, in addition to presenting a hazard for people who don't have other options.

In 2015, PAG used an online public engagement tool called Engage 2045 to seek public input on future transportation investment options and long-term transportation priorities for the long range transportation plan. Once again, PAG found a strong interest in GI. Of the 1,903 people who participated, 77 percent were willing to spend at least an additional $0.30 per household per month to fund GI elements of transportation projects indicating widespread interest. Forty percent even indicated a willingness to spend the maximum choice offered - $3 per household per month, which is the typical amount needed to fund a stormwater utility.

The Pima County Department of Environmental Quality conducts an annual community survey to gauge public awareness and attitudes toward air and water quality, including GI. This statistically valid survey reaches a wide spectrum of Pima County residents and business owners and in 2019 found that at least one third of the community implemented various GI practices.[5] Using the social theory of innovation to evaluate these results, it appears our community has moved from early adopters to early majority phases. During this phase, further guidance and education can aid proper implementation.

Early regional gap and barrier assessments for GI, including a 2012 Arid LID Conference in Tucson, found that funding created limitations on implementation and there were some research areas that would help leaders feel more confident in supporting GI with policy. These areas included questions about street integrity, feasibility of GI to reduce peak flows and potable water irrigation, and whether the community would support funding. Since that time, some steady funding sources have been established and guidance is now available based on modeled scenarios, local case studies, and nation-wide research. As illustrated above in the public surveys, community support also is no longer a barrier to implementation.

PART 1

Incorporating Green Infrastructure into Project Planning

Most challenges have guidance available for solutions. Encourage education of staff about these resources and practices. Use this guide's recommendations for regionally consistent practice.

Summary Of Key Planning Recommendations

Plan for GI early in process

It is critically important to consider GI measures as appropriate stormwater management strategies early in the road project design process including coordination with utilities and appropriate planning for budget. Retrofits on a built road are a more costly effort. GI should not be thought of as optional but instead an enhanced way to achieve drainage and final stabilization goals.

Utilize Context Sensitive Solutions (CSS) Planning Process

Transportation agencies in the Santa Cruz watershed should fully implement CSS planning approaches in the programmatic and project design process in order to formalize the consideration of the environmental and community impacts (and potential benefits) of a transportation project. One of the core principles of CSS is to use flexibility and creativity to preserve and enhance community and natural environments, which supports the overall goal of green infrastructure to use natural or engineered systems that mimic natural systems to capture and filter rainwater, reducing stormwater runoff to protect water quality.

Implement Green Streets Policies and Design Guides

Many local governments across the nation have established green street policies and programs to encourage the integration of forward-thinking GI stormwater management in road and street projects. City and County planners and project engineers can better integrate GI on roads and highways by updating technical manuals and design standards to support and encourage GI.

Prioritize GI in Transportation Projects through Capital Improvement Planning Processes

The Capital Improvement Planning (CIP) process can be a valuable pathway to leverage transportation-related sources of funding to achieve community GI goals. By anticipating the GI opportunities created by transportation construction, upgrades, and repairs and allocating appropriate budget resources to GI features, local governments can meet multiple goals with their infrastructure investments.

Integrate with Available Stormwater, Climate and Tree Canopy Plans

GI associated with transportation projects can be a means to accomplish the public benefit goals of other community plans and policies. Considering these plans can both leverage transportation funding to provide these benefits and potentially provide non-transportation funding for street projects. Additionally, the coordination implicit in these integration efforts can result in greater public buy-in, increased economic, engineering and construction efficiencies and more consistent provision of public benefits. The City of Tucson, Pima County and other regional municipalities have climate adaptation, urban tree canopy, stormwater management and other plans that support GI implementation on roadway projects.

Identify Priority Locations and Targets

The effectiveness of using GI to manage stormwater and provide other benefits can be optimized when individual projects are identified and implemented as part of a cohesive, prioritized approach. Using GIS-based tools like PAG's Green Infrastructure Prioritization Tool can help transportation staff recognize priority locations for GI and tailor project designs to address high-priority issues within the project's context (e.g., lack of shade, high heat island effect, etc.).

Include GI Performance Measures within Long-Range Transportation Plans (LRTP)

PAG members and staff develop and update the region's RMAP which takes a performance based approach to achieving regional transportation and related goals. By including GI related performance measures in future planning or allowing GI features to count toward safety and

environmental measures, RMAP could be an effective mechanism for driving GI implementation. Similarly, the five year Transportation Improvement Program (TIP) prepared by PAG could integrate GI measures and leverage multiple sources of funding to deliver GI benefits to regional projects.

Ensure Maintenance Provisions Are Included in Project Designs and Long Term Plans

Maintenance can be 'built in' to the project design from its early stages. The maintenance implications of plant and tree selection, drainage configuration, soil compaction and other factors need to be contemplated during the design process. Similarly, maintenance plans and resources should be coordinated with the departments that conduct maintenance and developed prior to project finalization in order to ensure that maintenance crews have proper instruction and resources to achieve long-term GI performance of the investment.

Review project proposals for compliance with GI standards and policies

While public agencies, including transportation departments, have a necessary role in advancing GI, their reach generally is limited to projects on public property. There are considerably more GI opportunities on private properties, and realizing these opportunities requires the participation of property owners, managers, real estate developers and contractors. In order to meet community GI goals, agency project review and planning staff must encourage developers to design and install GI practices as part of their compliance with local codes, ordinances, and community plans. A local successful example is the City of Tucson Commercial Harvesting Ordinance review process.

Gila Monster Reading, Dunbar Springs, Tucson.
Photo: American Rivers

Planning and Project Development Recommendations for Regional and Local Transportation Agencies

Plan for Green Infrastructure early in process

It is critically important to consider GI measures as appropriate stormwater management strategies early in the road project design process. GI should not be thought of as optional landscaping to be added or altered after other design goals have been realized. While GI measures can fulfill landscaping purposes, their primary function is to manage runoff from impervious surfaces; overall project designs succeed when they embrace GI runoff reduction and management principles from the onset. At the pre-design stage, project planners should evaluate conditions in the project area for their capability to support GI and to promote delivery of community benefits. During the scoping process, GI alternatives should be evaluated for their relative abilities to satisfy runoff reduction and management requirements and relationship to other community plans and policies. Retrofits on a built road are a more costly effort.

Utilize a collaborative team of advisors to review public and private road designs early in the process. An integrated team may include members from sustainability or water departments involved in climate and drought resilience goals, MS4s, Regional Flood Control District (RFCD) and urban forestry professionals knowledgeable about landscape and canopy requirements such as Landscape architects.

Utilize Context Sensitive Solutions Planning Process

Local transportation agencies in the Santa Cruz watershed should consider requiring CSS as a planning framework for road and highway projects. This approach has been adopted by transportation agencies for decades in order to design and plan transportation projects that maintain or enhance the existing environment. Environmental stewardship practices in line with CSS can mitigate costs associated with energy consumption, material storage, environmental mitigation, and waste generation.[6] As a design and planning process, CSS requires practitioners to understand their project corridor within the environment of community goals, the street network, and land use. This process allows practitioners to link the goals and objectives of their particular communities to the physical elements of street design that will best support those goals.[7] Most importantly, the CSS approach ensures that goals and values beyond transportation infrastructure, such as environmental and public health and safety, are considered in the design of a roadway project.[8]

CSS is defined by the Federal Highway Administration (FHWA) and American Association of State Highway and Transportation Officials (AASHTO) as "a collaborative, interdisciplinary approach that involves all stakeholders in providing a transportation facility that fits its setting. It is an approach that leads to preserving and enhancing scenic, aesthetic, historic, community, and environmental resources, while improving or maintaining safety, mobility, and infrastructure conditions."[9] Both FHWA and AASHTO encourage its use in project planning and design.[10] As part of its recommendations, the FHWA suggests that planners work collaboratively to understand the landscape, community, and resources before the engineering design stage begins.[11] One of the core principles of CSS is to use flexibility, innovativeness and creativity to preserve and enhance community and natural environments.[12] This is in line with GI goals to use low-tech natural or engineered systems that mimic natural systems to capture and filter rainwater, reducing stormwater runoff to protect water quality. Tucson area streets also function to carry stormwater and GI designs are available to fit various needs from flood reduction to pedestrian enhancements depending on the traffic flow and storm flow regimes. This is an important *context* to consider for many streets in our region. Best practices with the CSS planning approach involve developing an upfront planning process that allows stakeholders including the public and environmental agencies to identify issues as well as identifying and considering existing plans relating to land use, water and sewer, and watershed management.[13]

For roadway projects in Pima County, CSS can be valuable at both the broader scale planning level and when designing specific projects. The process envisions an iterative, step-wise approach to ensure that multimodal corridor construction and reconstruction will play a relevant role in meeting a broad array of community and General Plan goals. Because of the outsized influence that street and roadway projects have on a community, transportation planners have an opportunity, and a responsibility, to factor the broad range of impacts and benefits that can result from individual projects and long-range plans. Using a CSS approach is important as a means of planning successful transportation projects, helping facilitate community dialogue, and helping build stronger communities.[14]

It would be appropriate, even preferable for City, Town, regional and County transportation departments to adopt CSS policies and practices. In advance of formal adoption, transportation planners and engineers working in the Pima County communities should take active steps to embrace CSS approaches.

These approaches include:

- Understanding the Whole Context
- Engaging Relevant Disciplines
- Engaging Affected Stakeholders
- Beginning with an Open Mind and a Blank Sheet
- Developing Consensus on Performance-based Goals[15]

Additional detail about these approaches and their application to transportation-specific planning can be found in the Federal Highway Administration Context Sensitive Solutions Primer and the Institute of Transportation Engineers (ITE), Implementing Context Sensitive Design on Multimodal Corridors: A Practitioner's Handbook. An additional, and seemingly useful resource could be a process diagram or matrix that guides practitioners through the application of CSS to a roadway project. The City of Dallas' recently adopted Complete Streets Design Manual provides an example of such a resource.[16]

There are opportunities to bring these approaches to project planning and development at different stages.

- Planning level. As regional entities, the County or cities develop capital and strategic plans, CSS approaches can be used to broaden public engagement and support for projects, plans and funding requests. At the same time, CSS approaches will ensure that complementary plans and policies are considered in development of future and reconditioned roadways. At the local level, these plans include:
    - Regional Transportation Authority and City of Tucson Process for Grant Road Improvement Plan: The City of Tucson selected the Institute of Transportation Engineer (ITE) recommended practice, Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities, for planning and preliminary design of the Grant Road Improvement Plan, which resulted in implementation of GI along the corridor.
- Project level. When reviewing or designing individual projects, CSS approaches can help ensure that project designs best address multiple community needs and provide opportunities to realize a range of community benefits. Individual projects must reflect the designs and resilience goals embedded in city and County policies and plans. To ensure success of General Plans and transportation plans, it is essential that transportation planners and plan reviewers look for opportunities to meet these plans, goals, and policies in all project opportunities. For example, even street repaving or utility work can be leveraged to include landscaping enhancements that treat stormwater.
    - City of Tucson Transit Development Handbook: includes Context Sensitive Design in the Streetcar Corridor

Implement Green Streets Policies and Design Guides

By using CSS, Tucson-area transportation planning and project design will be better able to support the implementation of the City of Tucson's emerging Complete Streets Policy as well as similar "green streets" initiatives elsewhere in Pima County.

The City's Complete Streets Policy was adopted in February 2019 and sets out design principles that "guide the development of a safe, connected, and equitable transportation network." [17] These principles are translated into action via the design specifications

GRAND RAPIDS VITAL STREETS

The City of **Grand Rapids, MI** has adopted and is moving to implement a Vital Streets Plan. The City defines "Vital Streets" as Complete Streets plus Green Infrastructure.[21] The overall goal of the Vital Streets Program is to improve the condition of the city's streets to good or fair as measured through the PASER rating system; however, Grand Rapids has recognized that improvements in street conditions come from more than just the integrity of the asphalt, they are intertwined with core community values:safety, healthy places, vibrant economy, environmental sustainability and diverse transportation options.[22] The plan prioritizes design and construction of street projects that are developed collaboratively with community stakeholders, reflect local land use and community objectives, and protect and enhance the natural environment. The accompanying Vital Streets Design Guidelines provide detailed design specifications to ensure that street projects achieve these and other goals. The guidelines incorporate appropriate GI practices.[23]

The National Association of City Transportation Officials (NACTO) has published a series of design guides that advance innovations in community street principles and designs. The Urban Street Stormwater Guide reflects a collaboration between municipal transportation, public works, and stormwater staff to create a resource that contains national best practices for sustainable stormwater management in the public right-of-way.[24] The guide couples recommendations for planning "stormwater streets" with generalized design specifications for stormwater treatment elements.

contained in the Complete Streets Design Guide.[18] The design guide incorporates green streets principles to manage drainage and streetwater generated from the street system. The key concept of green streets for Tucson is to retain, detain, infiltrate and/or filter runoff from streets and sidewalks using adjacent landscaped areas.[19] In addition to managing runoff, these landscape-based GI practices are expected to reduce ground-level ozone and provide cooling shade for streets and sidewalks.

Peer cities have adopted and implement similar policy preferences that aim to transform traditional roadway planning into collaboratively developed, multi-benefit public infrastructure. For example, in 2014 the City of Austin (Texas) adopted a "complete streets" policy which includes "green streets" as an integral component. Austin describes green streets as public rights of way (ROWs) that are context sensitive and which include landscape features, GI and sustainability measures to enhance non-motorized transportation options. The City of Austin has recognized that the street network must be adapted to function as part of the City's ecosystem as well as its public space inventory; that it must provide economic benefits through reduced maintenance and urban energy costs; and that streets and roads have a critical role in improving resilience to climate change by managing runoff in a manner that values the water supply and heat island reduction benefits of stormwater.[20]

The Pima County Subdivision Street Standards refer to the Pima County landscaping standards for landscaping requirements in the right-of-way. An update to the Subdivision Street standards may benefit from including the "first flush" concept or other GI requirements either in the right-of-way or by directing street runoff to subdivision multi-use common areas. An updated Landscape Manual would help to provide clarification to the Pima County codes and standards where modifications of roadway rights-of-way overlap with landscape, vegetation and stormwater harvesting concerns. A manual update was initiated in 2017.

Prioritize Green Infrastructure in Transportation Projects through Capital Improvement Planning Processes

At the local level, there are also opportunities to better integrate GI into transportation projects to manage polluted runoff. Specifically, the CIP process offers an importation pathway to prioritize GI for roads and highways. Funding sources

for transportation construction, upgrades, and repairs are typically much larger than those for stormwater management, which typically does not have a dedicated funding source.

THE CITY OF BREMERTON, WA

The City of **Bremerton, Washington** updated its National Pollutant Discharge Elimination System (NPDES) permit in 2009 to encourage the use of GI and, as a result, also updated its Stormwater Management Plan to be in line with the new permit's requirements. This plan was integrated into the City's Comprehensive Plan which was approved by the city council, and the capital improvement plan included a specific line item for GI projects. Additionally, Bremerton included a line item in its transportation improvement program specifically for green streets.[25]

Municipalities and MPOs should consider prioritizing GI in transportation projects within the CIP process. Examples include objective numeric performance measures, standards or criteria to mimic pre-development hydrology, specific GI requirements, or limits on the amount of effective impervious area.

The local government should implement criteria to prioritize transportation projects that incorporate GI or to set aside a small percentage of capital dollars to be used for green designs. At the department level, the capital improvement plan for the relevant transportation department should include, at a minimum, requirements for coordination among the relevant water quality, water resource, flood control, permitting, and environmental departments in the planning process. The transportation department should develop and implement criteria to prioritize transportation projects in the CIP process that integrate GI elements.

The capital planning process at both the department and municipal scales represents an opportunity to better leverage transportation dollars to fund GI elements that help to cost-effectively meet permit requirements and protect water quality while providing extensive benefits to transportation safety.

Integrate Mobility Planning with Available Stormwater, Climate and Tree Canopy Plans

Much of the preceding discussion was focused on adopting best practices for incorporating GI into transportation project design development and planning review. These efforts are critically important but can succeed more fully when they also achieve the goals adopted in municipal and/or county plans and policies that also prioritize GI. Multiple departments can achieve goals collaboratively and more efficiently for overall savings and greater benefits to the jurisdiction and residents. Plans may be merged as well, such as a Green Complete Streets Plan, for increased coordination and consistent practice.

City of Tucson Green Streets Active Practice Guidelines

The City of Tucson established its Green Streets Policy in 2013. The policy requires the Tucson Department of Transportation and Mobility (TDTM) to design new and upgraded streets that convey stormwater into GI features, capturing at least the first half-inch of rainfall onsite. Additionally, the policy requires TDTM to include native vegetation so that the streets are covered by a 25% tree canopy along with sufficient understory to ensure the function of the bioretention area. Increased water consciousness among community members and leaders about the City's drinking water sources played a large role in encouraging the Green Streets Policy.

Pima County Sustainable Action Plan

Adopted in 2018, the County's Sustainable Action Plan sets forth a broad set of actions and goals for County activities intended to foster resilience to the effects of climate change. Installing GI is one of the six climate change adaptation targets identified by the plan. Specifically, the plan sets a goal of installing at least 40 GI projects in prioritized locations on County properties; implementing the County's Green Infrastructure Action Plan; and utilizing CIP funding for GI wherever possible.[26]

City of Tucson Plan Tucson

Adopted in 2013, Plan Tucson outlines broad goals and specific targets to improve livability, reduce greenhouse gas contributions and

energy consumption, increase climate change resiliency, and foster economic vitality. The plan recognizes the role that GI plays in relationship to these separate goals and includes specific policies to encourage GI projects on public and private property and as part of development and redevelopment projects.[27]

City of Tucson Mayor Romero's Million Trees Initiative

Tucson Mayor Regina Romero launched the Tucson Million Trees campaign in April 2020, which aims to plant one million native, drought tolerant trees by 2030 to help mitigate the effects of climate change by reducing utility bills, improving mobility, combating the urban heat island and cooling our city. Mayor Romero is exploring priority planting locations including schools, neighborhood streets, private properties, the city's landfill, the banks of the Santa Cruz River, and urban bosques. The program is connected to the GI fund and a large portion of tree planting in Tucson will be managed by nonprofit groups, including Tucson Clean and Beautiful, which runs the Trees for Tucson urban forestry program.

Make Marana 2040 General Plan

Subject to voter approval in August 2020, the updated General Plan for the Town of Marana reflects the town's projected growth patterns and sustainability platform. Goal RS-8 is that stormwater is efficiently and sustainably managed in a way that reduces flood risks and respects water quality. Policy RS 8-3 considers establishing sustainable stormwater methods, such as GI and permeable pavements, in new development. Under the Water Resources goal is policy RS 4-3 to identify best practices for water conservation programs that can be implemented throughout the community, such as stormwater harvesting or conservation-oriented tap fees.

Aspire 2035 - Sahuarita General Plan

Policy statements encourage the adoption of GI standards that rely on natural processes for stormwater drainage, groundwater recharge and flood management.

In addition, transportation planners and project engineers should be familiar with the following plans, standards and ordinances and their respective GI-related components. These components may be relevant to either the planning and implementation of public-sector transportation projects or the review of development proposals:

Pima County Regional Flood Control District 2020 Floodplain Management Plan

includes GI (stormwater harvesting) practices among the types of appropriate actions.

Pima County Detention and Retention Requirements

The Pima County RFCD Design Standards for Stormwater Detention and Retention include a requirement for retention of the first-flush (first 0.5 inch of rainfall). To incentivize the use of LID practices, the manual allows LID practices to mitigate first-flush retention volume and provides a method to reduce the required volume of detention facilities when stormwater harvesting basins are used throughout a site. The manual standards also incentivize other LID practices when quantifiable flood control benefits can be measured.[28]

City of Tucson Commercial Rainwater Harvesting Ordinance

This ordinance requires developers of commercial properties to harvest rainwater for at least 50 percent of their landscaping needs within three years. Development standards were created with development of the ordinance including parking lot concepts.

MS4 Stormwater Management Plans

The Town of Oro Valley, Pima County, City of Tucson and the Town of Marana each have a stormwater plan and MS4 permit responsibilities

City of Tucson Drought Response Plan and Pima County Drought Response Plan

both encourage increased stormwater use at each increased drought stage.

Tucson Water 2020 Strategic Plan

summarizes policies in Plan Tucson and the Water Infrastructure Supply study regarding increasing stormwater use as part of the water portfolio.

City of Tucson Bicycle Boulevard Master Plan

includes many design and project planning elements and encourages integration with GI approaches. Uses sample evaluation of tree canopy cover to achieve shade goals.

Resolutions have been passed by the PAG Regional Council supporting Rainwater Harvesting (2008), Low Impact Development (2012), Green Infrastructure (2015), Climate Resiliency (2016), Complete Streets (2015), and Heritage of Desert Waters (2017). Resolutions highlight benefits, commend progress, affirm regional values and provide recommendations and endorsement for future direction by regional leaders.

Identify Priority Locations and Targets

PAG created the GI Prioritization Tool to help municipalities, non-profits, and neighborhood groups to select priority locations that would benefit the most from increased GI. GI resources can be distributed to areas with opportunities for enhanced stormwater management, mobility and livability. Plans can be created dynamically by the community for various related concerns and opportunities depending on criteria for a project's funding sources, goals, and requirements. Print options available on this tool aid grant applications for municipalities, non-profits and community groups. PAG's interactive web map is a publicly available tool that was first developed by PAG in 2012 and has been used to select priority locations for GI by multiple jurisdictions. The GI Prioritization Tool helps decision-makers allocate limited financial resources and support GI efforts.

The interactive map contains multiple layers to allow users to explore the relationships between environmental conditions and social demographics. Available data layers include several layers processed from PAG LiDAR data such as regional tree canopy, impervious surfaces, and stormwater flow paths. Layers were compiled by building numerous partnerships with other agencies including RFCD, UA, the Trust for Public Lands and the State Public Health Department. PAG recommends using the following priorities when assessing multi-benefit opportunities using the PAG GI Prioritization Tool.

Location Priorities:

- Below Average (7%) tree canopy
- Proximity to shallow groundwater
- Proximity to watercourse
- Above average heat
- Heat vulnerable demographics
- Bus stops, bikeways, schools, parks
- Pedestrian activity areas

Related resources:

- PAG GI Prioritization Tool

For the City of Tucson's Green Stormwater Infrastructure Fund Proposal (2019), the City requested and utilized the diverse compilation of layers from the PAG map to assess priority locations for distribution of the funds. Prioritization of the GI projects was performed adding weights to criteria of heat vulnerable populations and low canopy as well as the City's identified priority stormwater management system areas and CIP project areas. Other example uses include City and County selection of below average canopy and above average heat for priority planting locations. In Fall 2018, the County utilized PAG's geographic assessment of those priorities to identify locations for GI on public properties in the Sustainable Action Plan for County Operations. This plan sets sustainability goals through 2025, emphasizing mitigation and adaptation measures to meet U.S. objectives for the international Paris Agreement.[29] GI prioritization examples have also been provided by PAG for the Tucson Bicycle Boulevard Plan. Landscape, transportation, and active modes plans, and guidelines would likewise benefit from GI priority location analysis and use of GI in design typologies.

PAG's 2018 Green Stormwater Infrastructure Plan includes the regional canopy cover assessments based on PAG's 2008 LiDAR datasets and recommends canopy targets based on geographic assessments. PAG found the tree cover averaged almost 8 percent in our region and approximately 3 million tree points. PAG found the region has a 4 percent lower canopy than the average for other arid Southwest urban areas. This varies widely from 1 percent to above

LONG -RANGE REGIONAL TRANSIT PLAN

Bus stop with tree shade incorporated.
Photo: PAG

RTA's Long -Range Regional Transit Plan

The RTA's Long -Range Regional Transit Plan discusses various levels of bus and streetcar stops improvement recommendations for each typology. This would be an opportunity to discuss the inclusion of GI for tree shade and other safety benefits. Planting a tree behind the bench would likely be a much more cost-effective way to provide shade than building a shade structure for all stops. Given the aforementioned risks to pedestrians on roads and the vulnerabilities of these demographics to heat related health issues, tree shade should be prioritized at the stops as well as the walksheds that users rely on to get to their stops. Appropriate contexts may be stops that are between intersections (to avoid sight visibility triangles) and that have resources for tree establishment period. If the LRRTP station typologies were translated into actual design guidelines, then GI could be incorporated at that time. While the plan is created by the RTA, the city has traditionally handled bus stop infrastructure, funding, and construction so to be implemented it would likely depend on the city adopting the idea.

District of Columbia, Sustainable DC Plan

Sustainable DC Plan calls for increasing GI in the public right-of-way (ROW) and taking actions to improve the health of the city's waterways. Under the plan, the District's Department of Transportation (DDOT) is installing GI as part of construction projects and in retrofit projects to reduce stormwater runoff. Where watershed and infrastructure improvements are prioritized, DDOT may construct green street and green alley projects that utilize GI techniques. DC's Long Range Transportation Plan includes an Environmental Inventory Map with GI features. DC's Fiscal Year 2019 - 2024 Transportation Improvement Plan, includes GI projects. In 2014, DDOT released the GI Standards which included technical drawings, specifications, design manual, plant list, and maintenance schedules. The Department has also released a GI guide, "Greening DC Streets," which summarizes GI opportunities and constraints in the District.[31]

Wasatch Front Regional Council, Regional Transportation Plan 2019-2050

This comprehensive regional plan reflects the value of integrating GI provisions throughout the planning process. The Council recognized that both green and gray infrastructure function together and that there are environmental and community benefits which arise when transportation practitioners draw from both fields to understand and respond to the complexities of the urban landscape. The plan envisions that GI will play a role in contributing to the increased resiliency of the regional transportation system by reducing or mitigating stormwater impacts.

20 percent across the region. While tree canopy provides shade benefits, understory can provide additional habitat, aesthetic and watershed health qualities. Other vegetative cover was nearly 30 percent. To reach 25 percent canopy in the urban area, the region would need a total of 7.5 million more trees. Since new hardscape, including streets, create more runoff this is sometimes referred to as "new water." Pre-development, this water would have otherwise evaporated, as very little of it naturally recharges aquifers in desert regions. "Stormwater Harvesting and Management as a Supplemental Resource Technical Paper'' from the Water and Wastewater Infrastructure, Supply and Planning Study, Phase II (Pima County and the City of Tucson, 2009) has calculated "new water" amounts that can be used as stormwater harvesting targets. That paper states that about 30,000 to 40,000 acre-feet (AF) of "new water" could be harvested from impervious surfaces in the City of Tucson in an average year. This harvestable water could theoretically support up to 4.3 million trees within the urban footprint of Pima County, depending on distribution of stormwater and vegetation types.[30] Therefore, the 25 percent canopy goal would be feasible from a stormwater availability standpoint. However, establishment periods, extreme drought, and reflective and radiant heat along streets create more stress on young trees, and so supplemental irrigation may be needed at times. Transportation projects can be a major vehicle to achieve these goals when coordinated across multiple departments.

Recommended Targets

- Create a target of 15-25% average cover over the full urban area within 20 years (by 2040)
- Focus outreach and capital improvement efforts in areas with less than average tree cover
- Implement greater cover in areas of greater mitigation need (see priorities list above)
- Utilize street runoff wherever feasible to support vegetation and achieve a goal of 40,000 AF
- At least 90% of new trees to be irrigated primarily by stormwater
- Convert impervious space to green space

Include GI Performance Measures within Long-Range Transportation Plans (LRTP)

PAG's RMAP is the region's long-range transportation plan covering a minimum of a 20-year planning period. Based on federal requirements, this plan takes a performance based approach. Performance measures were identified as targets to help the regional and operating agencies assess system wide progress relative to regional goals. This helps ensure that investments are achieving national and regional goals. Establishing similar performance based planning measures for GI, and including GI as a measurable ingredient in system wide roadway planning, could be an approach to folding GI into roadway design. Some of PAG's performance measures include System Maintenance, Safety, Multimodal Choices, System Performance, and Environmental Stewardship. Metrics toward these targets include pedestrian and bicyclist fatalities, pedestrian and cyclist facilities, air pollution and greenhouse gas emissions, and vehicle miles traveled. Performance metrics that evaluate effectiveness of the performance targets could include reduction of road closures due to water in the roadway, shade improvements (tree canopy), increased pedestrian activity, reductions in irrigation, mitigated runoff from impervious surfaces, and improved infiltration rates.

The TIP process, prepared by PAG, also utilizes the performance-based approach. Projects are reviewed for anticipated impacts to the transportation network and how they may advance the progress toward target achievement. Ideally, projects included in both the RMAP and TIP will have a positive impact in achieving the desired performance outcomes. Based on this approach, GI performance targets could be considered as part of the overall performance of the transportation network.

Related, PAG Safety Assessments gather data on incidence of trees/bushes as part of traffic incidents with injury and fatality and found that trees/bushes relate to safety in less than 1% of the incidents. Gravel and standing water are also tracked as part of the road conditions for the assessments.

Establish GI Project Performance Goals

By designing to meet performance goals for GI projects, project managers can ensure the effectiveness of the drainage benefits and of the landscape to meet its intended purposes. These are based on but may vary from Tucson's Green Streets Active Practice Guideline Performance Goals and are proposed as general minimal guidelines for use by other local jurisdictions to enhance consistency and ease of practice for practitioners and improve performance as a region.

The guiding principles for these goals include:

- Prioritize tree planting and engaging the community in areas with the greatest needs and multiple benefits.
- Use on-site non-potable water sources for irrigation before any imported water source. Invest potable water in the short term to establish trees as needed.
- Wherever possible, natural drainages should be the primary stormwater infrastructure.
- Wherever possible, canopy and natural drainages should be preserved, restored and maintained to create the primary stormwater infrastructure by protecting arroyos, creating green streets and daylighting underground systems.
- Use the conventional storm drain system as the overflow approach, not the primary system to manage stormwater. (Visible water flow systems are easier to notice and maintain.)
- Use public right-of-way stormwater installations to inspire private property installations and serve as model installations for neighborhoods.
- Decrease connectivity of impervious space and convert to green space. Use water harvesting to reduce runoff from hardscape from reaching the street. Emphasize harvesting efforts at the top of each watershed.

Drainage Performance Goals

1. **Routing and Conveyance.** Hardscape and landscape features will be designed to slow stormwater runoff and to encourage infiltration within the landscape. Additionally, design of all features will be mindful to:

    a. route stormwater runoff from the roadway and direct through GI features in parkways and medians before entering storm drains or natural drainage ways to provide moisture in the soil for plants and trees and provide stormwater pollution mitigation,

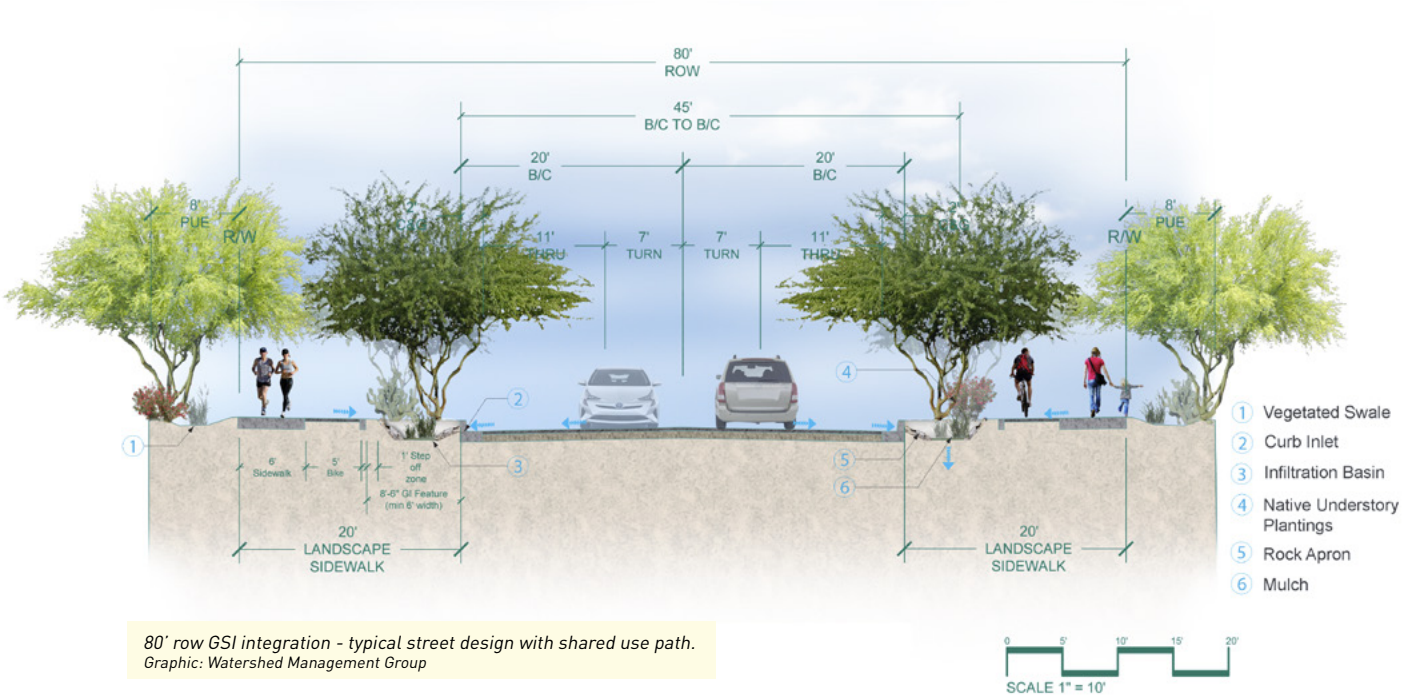
    b. ensure ease of maintenance, and

    c. use and integrate 'waste' materials (e.g. tree trimmings as mulch and salvaged concrete in place of mined rock for rip-rap or screened rock mulch).

2. **Runoff Collection.** Landscape areas along streets are designed to:

    a. retain at least the first 0.5 inch of rainfall falling on the roadway and public right-of-way (not including run-on from other streets and properties) dependent on right-of-way width, to mimic pre-development conditions and capture first flush, and

    b. accept a maximum final pooling depth of eight inches of stormwater for public safety.



80' row GSI integration - typical street design with shared use path.
Graphic: Watershed Management Group

3. **Infiltration.** Infiltration of retained stormwater runoff is a critical function of GI. Several items will be considered when designing the feature to ensure infiltration within 24 hours to prevent mosquitos and promote soil health.

    a. Compaction of landscape areas will be avoided. A 12"-18" depth for tilling or ripping will be performed in all plant-able and infiltration areas which have been compacted.

    b. On-site soil percolation tests will be used to evaluate the ability of the soil to transmit water through the soil profile. If a restrictive soil layer is present (e.g. caliche, or clay accumulation) then it is recommended to auger or rip through the restrictive layer to allow water percolation to underlying soil layers. Coarse, well drained soils often underlie caliche and clay lenses.

    c. Soil amendments and structural soils may be used if necessary, to ensure sufficient infiltration of stormwater runoff. Use of amended soils may be impractical at a larger scale due to high construction cost.

Landscape Performance Goals

1. **Irrigation.** The planting plan is based on a water budget where plants associated with GI elements can be fully supported by collected stormwater in seasons receiving 80% of average rainfall for drought resilience. Where feasible, plan for plants that require no irrigation after establishment. First and foremost, plant to capture rain that falls on the project site.

2. **Plant composition.** Plant composition must include a minimum of 75% native, low water use plants so that water demands match seasonal availability. The 25% non-native may be needed for space constraints. All plants shall be in a low water use, low water use/ drought tolerant category to reduce overall demand.

3. **Vegetation coverage.** GI is a living engineered system that requires plants as a functional element to achieve desired primary and co-benefits. The following guidelines will ensure a functional feature that safely infiltrates stormwater while providing for myriad co-benefits. When using goals to create policies, ensure they are simple to calculate and understand in order to aid compliance and review.

    a. Create a goal setting process based on street typologies that help to meet larger community canopy goals. Streets are major opportunities for increasing overall canopy coverage due to access to street runoff. Example goal: Canopy of shade trees, when mature, covers a minimum of 25% of the rights-of-way without creating sight visibility, pedestrian or utility conflicts.

    b. Coverage of understory vegetation, based on mature diameter, is a minimum of 25% of the Stormwater Infiltration Area.

Stormwater Infiltration Area is defined as the maximum pooling extent within a landscape area. This will ensure that sufficient root mass is present to facilitate infiltration and increase of soil organic content critical for long-term soil health.

c. Coverage of understory vegetation for other permeable landscapes should resemble natural plant community densities to facilitate water savings by not requiring long-term irrigation once plants are established.

4. **Other.** As part of final landscape stabilization, 100% of disturbed and/or barren areas to be covered with native revegetation mix and equal replacement of trees, shrubs, herbaceous plants and succulents. To save expense and prevent excess heat, stabilization with hydroseed is preferred over gravel and rock and use of large rip-rap is recommended only for slope stabilization. Provide enough space to allow the tree to grow to maturity.

Ensure Maintenance Foresight is Included in Project Designs and Long Term Plans

In transportation projects, the original funding often covers only the establishment period for vegetation for a limited number of years due to restrictions on use of some funding types on maintenance. For example, RTA projects excluded maintenance due to state laws until there was a recent legislative change. A supplemental plan for ongoing maintenance resources is key to long term success of the investment. Locally, maintenance of GI along streets in subdivisions and neighborhoods relies on agreements by adjacent private homeowners and often assisted by stewards such as through Tucson Clean and Beautiful. In the City of Tucson, businesses are also responsible for maintaining the adjacent ROW and buffer yards and the City assists with maintenance when critical for safety. ROW maintenance is the County responsibility in the unincorporated County. Sites that are maintained by municipalities could improve results by setting standards for GI training for employees and qualifications for contractors. Challenges with community pushback for a tidier look could be addressed through outreach.

Design is also key to success of the project over the long term. GI sites can be designed for cost-effective maintenance from the onset. Further information on design, installation, and operations and maintenance (O&M) best practices can be found in Part 3 along with associated guidance checklists.

Additionally, it is critical to preserve future GI retrofit opportunities especially behind the street curb. This may include a review check before issuing permits for utility installations, upgrades, or other ROW infrastructure work which could limit or hinder the ability to design and install GI.

Review project proposals for compliance with GI standards and policies

Project review and permitting staff in development services have an important role in ensuring and encouraging private developers to implement GI to manage roadway and parking lot runoff and should coordinate with transportation departments and others. Existing standards and policies incentivize or require GI/rainwater harvesting for many private development projects. Staff can help leverage these projects for the benefit of the community by ensuring that development projects routinely and consistently comply with these policies/standards. It is worth noting that multiple policies may apply to a project depending on the jurisdiction. For example, a commercial development in the City of Tucson could claim that their grading addressed both the first flush requirement and the commercial water harvesting requirement.

Leadership at municipal and County levels have provided staff with a foundation of support by implementing GI policies and standards. Development services, transportation departments and their civic and community partners can assist with compliance by undertaking targeted outreach and education efforts. The resources, example design guides, and checklists provided in this document can be valuable tools in departmental efforts to resolve barriers, challenges and uncertainties about the feasibility and benefits of GI. Through consistent application of existing standards and policies, the private development community can become valuable champions of GI.

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