BUREAU OF RECLAMATION

Hassayampa River Study - Assessing Green Stormwater Infrastructure for Stormwater Management

Interim Stakeholder Meeting
January 10, 2023

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Hassayampa River Study – Meeting Agenda

Topic	Presenter	Affiliation/Title
Moderator	Lisa Rivera	Reclamation, Natural Resource Specialist
Background Information	Deborah Tosline	Reclamation, Hydrologist/Study Manager
Surface Water Modeling	Valerie Swick	Reclamation, Hydrologist/Water Resources Planner
Infiltration Testing	Valerie Swick	
Economic Analysis	Deborah Tosline	
LID O&M Assessment	Deborah Tosline	
Buckeye LID Design Manual	Robert van den Akker	Buckeye, Environmental Manager/Study Manager
Conceptual Water Budget	John Rasmussen	Reclamation, Geologist/Water Resources Planner
Next Steps	Lisa Rivera	

Hassayampa River Study

- Appraisal Level - Special Study
- November 2020 to November 2023
- Cost-Share Partner City of Buckeye

BUCKEYE, AZ

Hassayampa River, near Central Arizona Project, looking west
Photo: Deborah Tosline

Study Question

Attempts to answer the question:

Can Low Impact Development (LID) be used to meet regulatory requirements for managing stormwater generated by new residential developments and in undeveloped areas?

In addition, the study will:

- assess LID O&M requirements and costs
- complete an economic analysis
- develop a City of Buckeye LID Design Manual
- develop a conceptual water budget

Green Stormwater Infrastructure (GSI) and Low Impact Development (LID)

Green Stormwater Infrastructure

- Natural or engineered-as-natural ecosystem approaches
- Control and manage stormwater runoff close to its source.
- Umbrella term for other terms, like LID.

https://www.epa.gov/G3/why-you-should-consider-green-stormwater-infrastructure-your-community

Low Impact Development

- Site specific designs that promote use of natural systems
- Harvest and infiltrate stormwater runoff close to its source.

https://www.epa.gov/nps/urban-runoff-low-impact-development

GSI and CSI Stormwater Infrastructure Alternatives

Green Stormwater Infrastructure (GSI)

- Retains most natural channels in developed areas
- Retains all channels in undeveloped areas
- Minimizes impervious surfaces
- Slows stormwater flows within natural channels
- Promotes distributive infiltration of stormwater near its source

Gabion
Photo: Cuenca Los Ojos

Conventional Stormwater Infrastructure (CSI)

- Eliminates most/all natural channels in developed areas
- Modifies natural channels in undeveloped areas
- Natural channels are replaced with impervious surfaces
- Consolidates runoff from natural channels into large straight man-made channels
- Conveys stormwater away

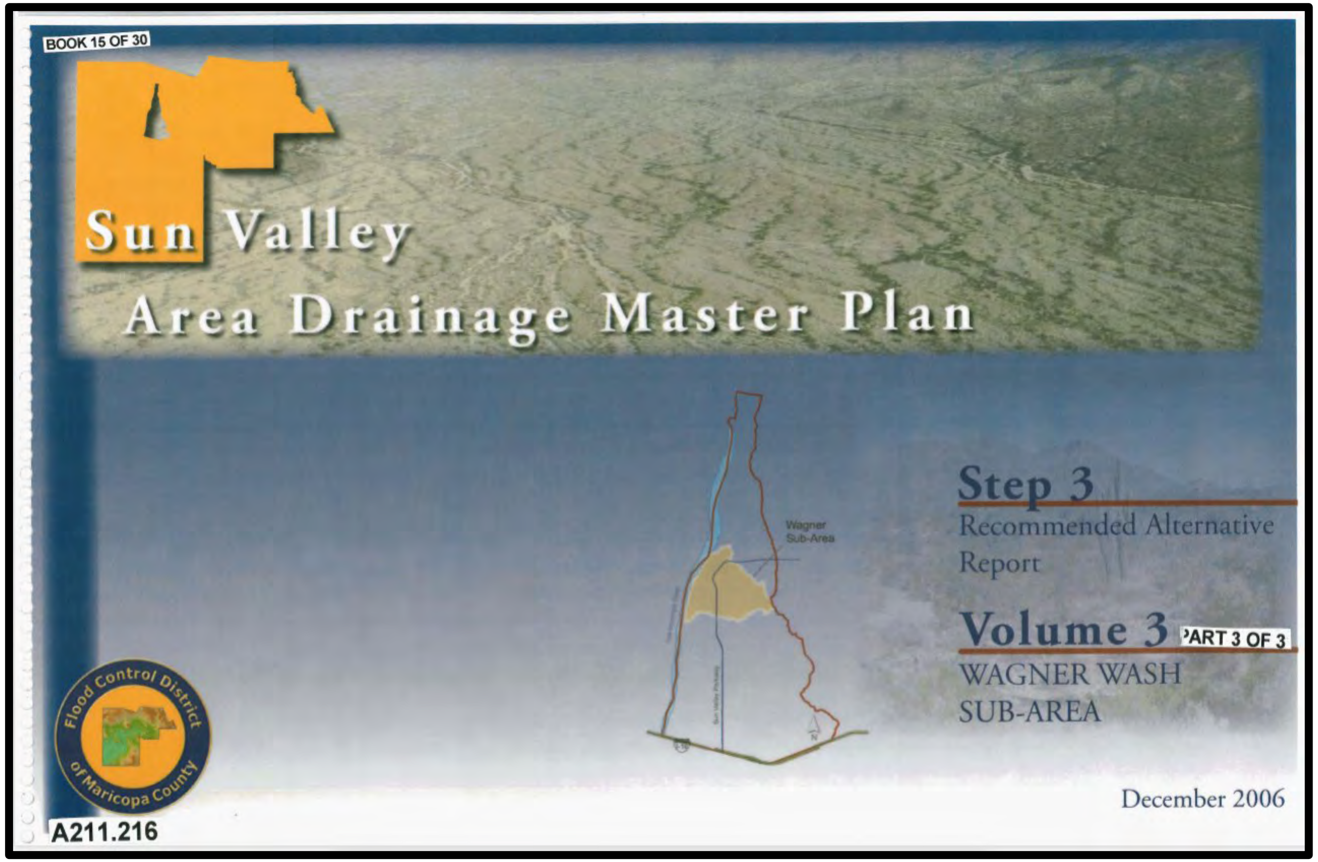
Retention Basin
Photo: ESRI/BOR images

City of Buckeye
Imagine Buckeye 2040 Vision

*"**Buckeye in 2040 is an innovative, visionary, healthy, and forward-thinking community** that is safe and secure with diverse employment, housing, education and business opportunities. Buckeye offers rural to urban lifestyles with a genuine sense of heritage **while being good stewards of our natural resources, open spaces and overall quality of life**."*

FCDMC Sun Valley Area Drainage Master Plan

Flood Control District of Maricopa County (FCDMC)


BOOK 15 OF 30

Sun Valley

Area Drainage Master Plan

Step 3

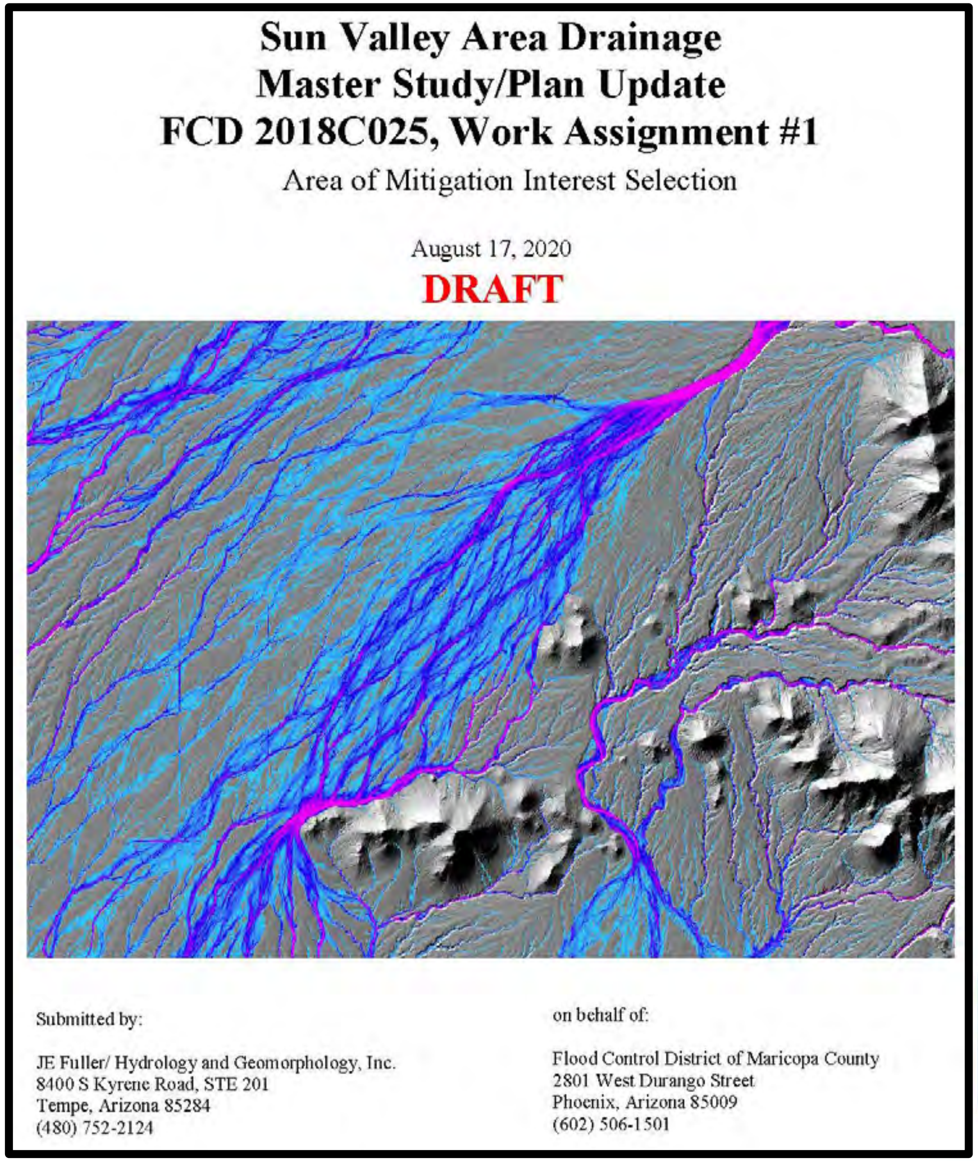
Recommended Alternative Report

Volume 3 PART 3 OF 3

WAGNER WASH SUB-AREA

December 2006

A211.216


Sun Valley Area Drainage Master Study/Plan Update

FCD 2018C025, Work Assignment #1

Area of Mitigation Interest Selection

August 17, 2020

DRAFT

Submitted by:

JE Fuller/ Hydrology and Geomorphology, Inc.
8400 S Kyrene Road, STE 201
Tempe, Arizona 85284
(480) 752-2124

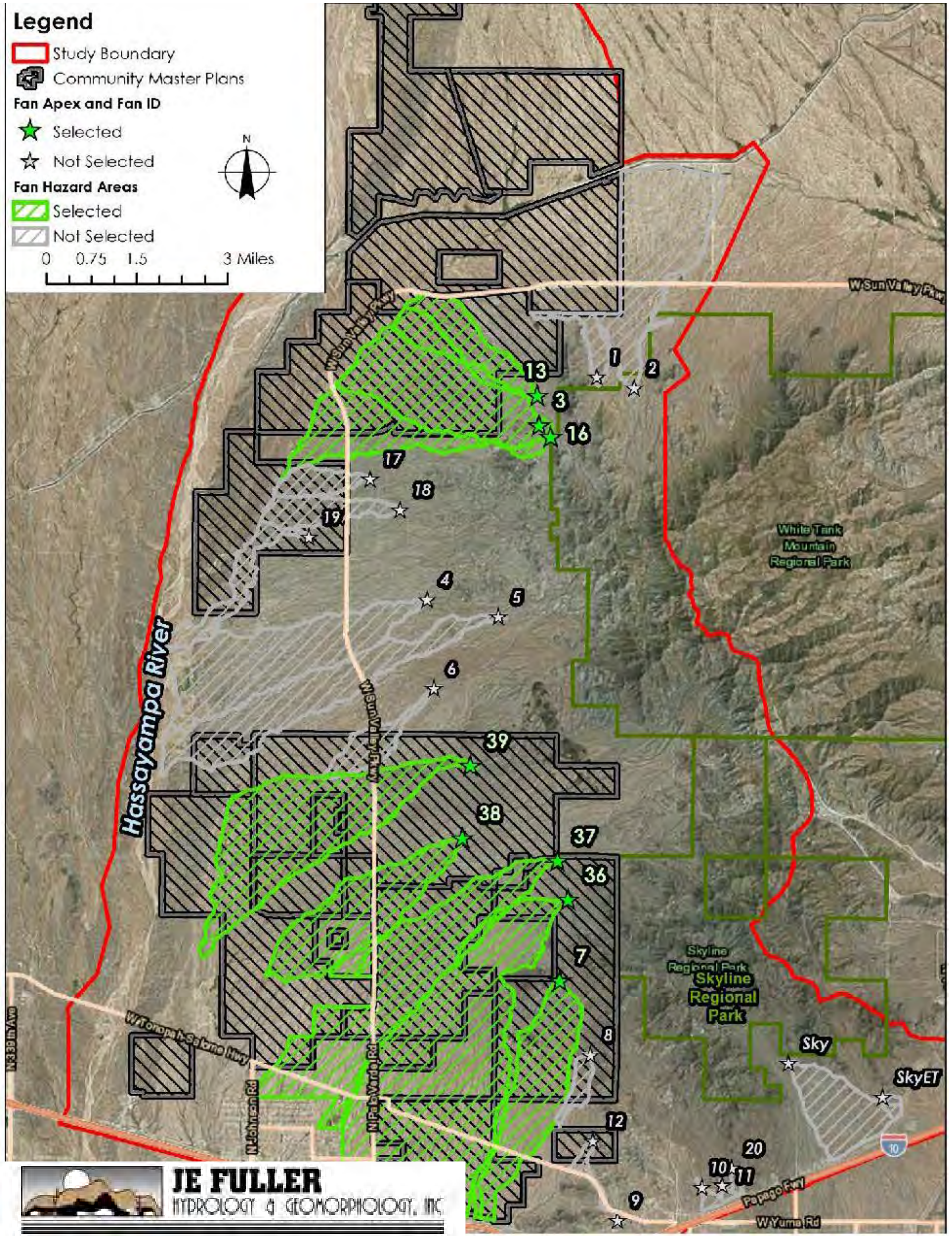
on behalf of:

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
(602) 506-1501

FCDMC Sun Valley ADMP

- Area
  - North - Gates Road
  - East - White Tank Mountains
  - West - Hassayampa River
  - South - Interstate 10

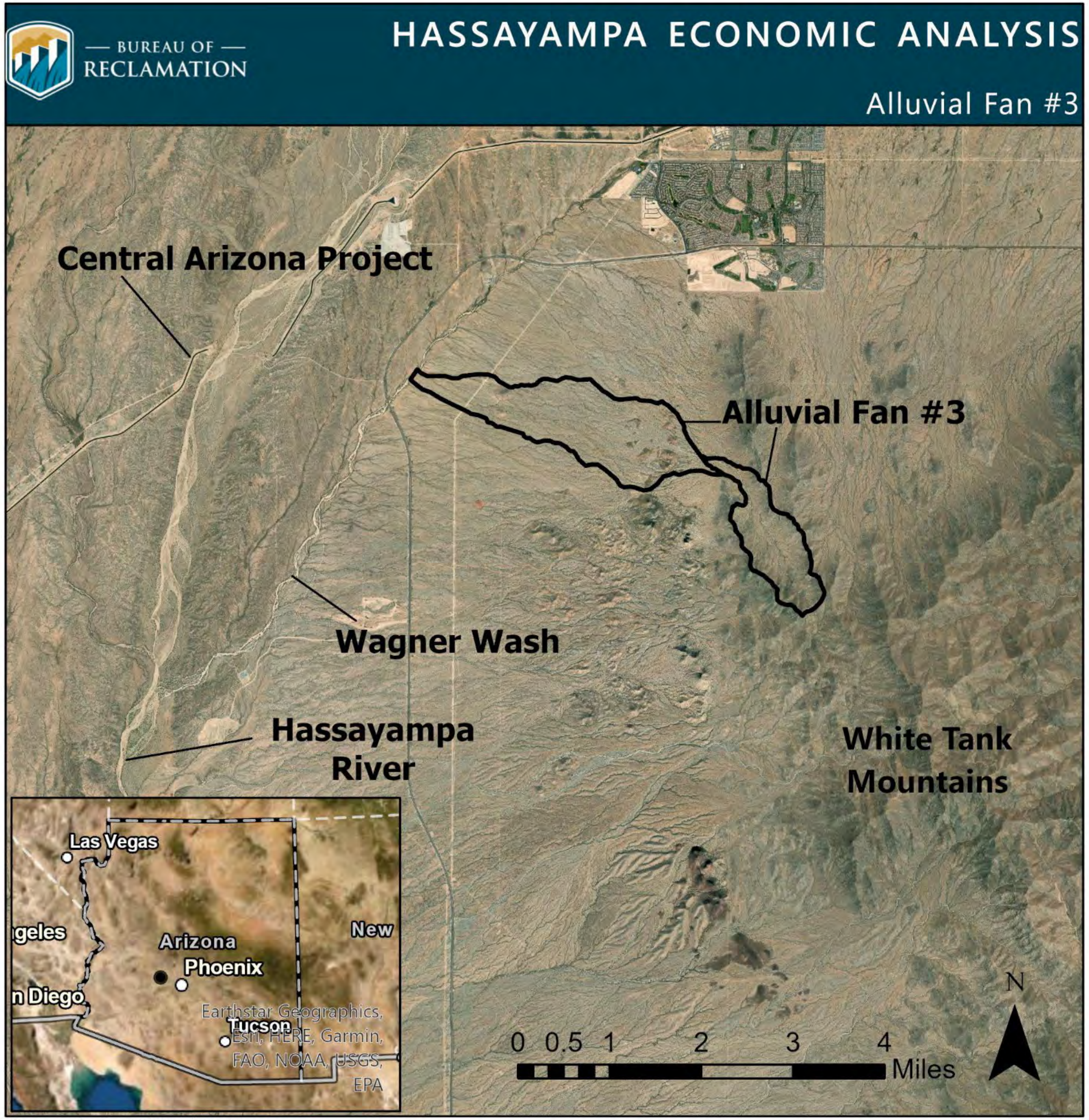
- Develops alternatives to mitigate previously identified flooding in alluvial fans.



https://apps.fcd.maricopa.gov/fcdprojects/Details/55

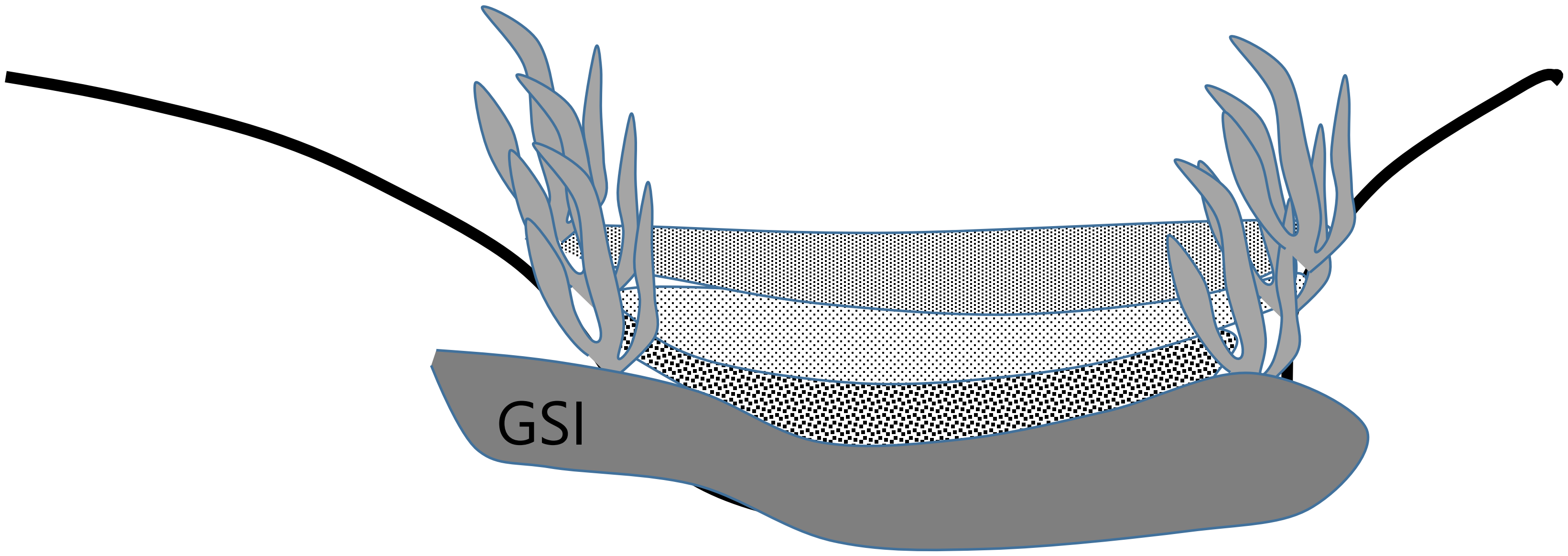
Hassayampa River Study Area

FCDMC SV ADMP
Alluvial Fan #3



Data Attribution: USBR and Esri Basemaps

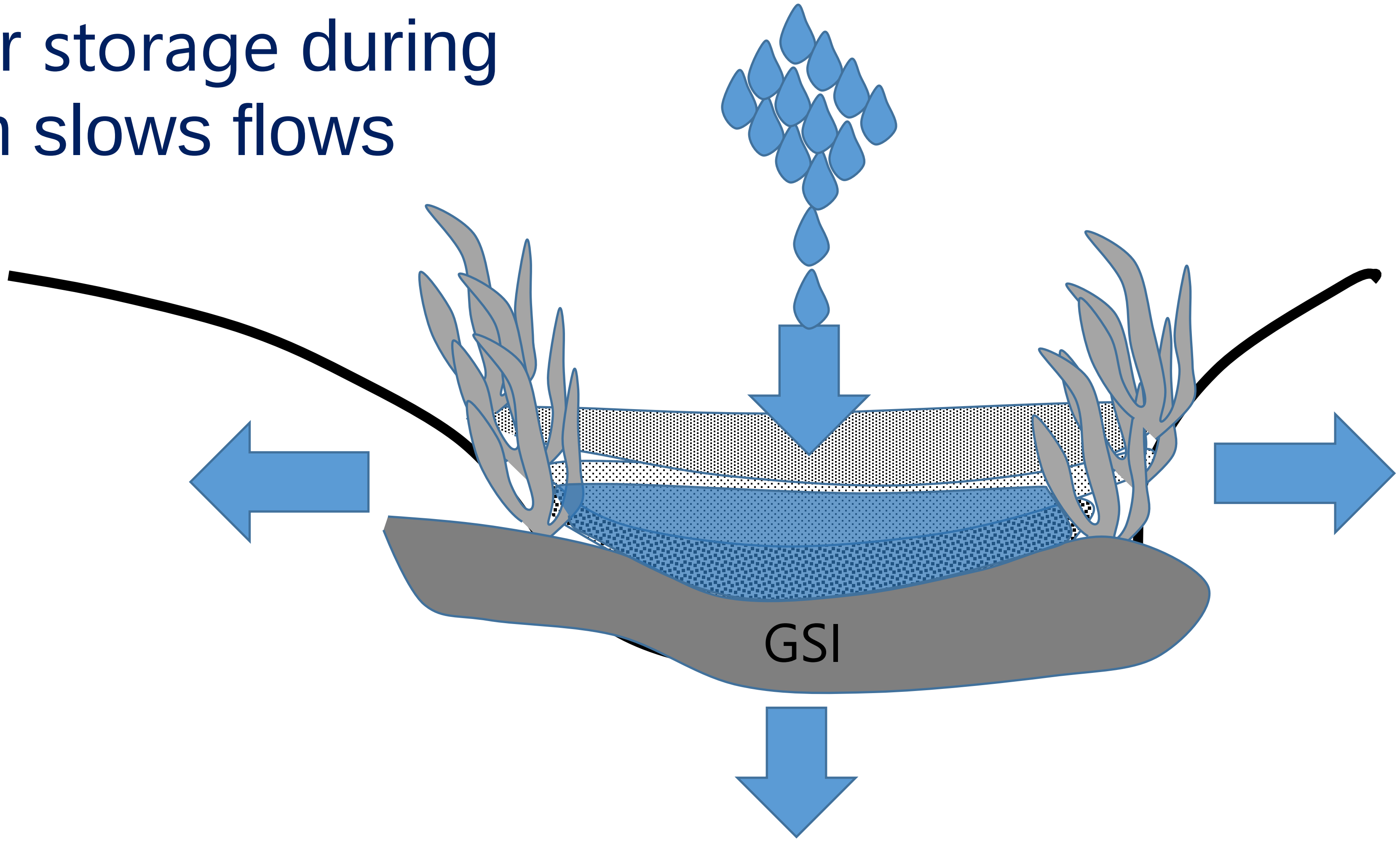
Green Stormwater Infrastructure Function



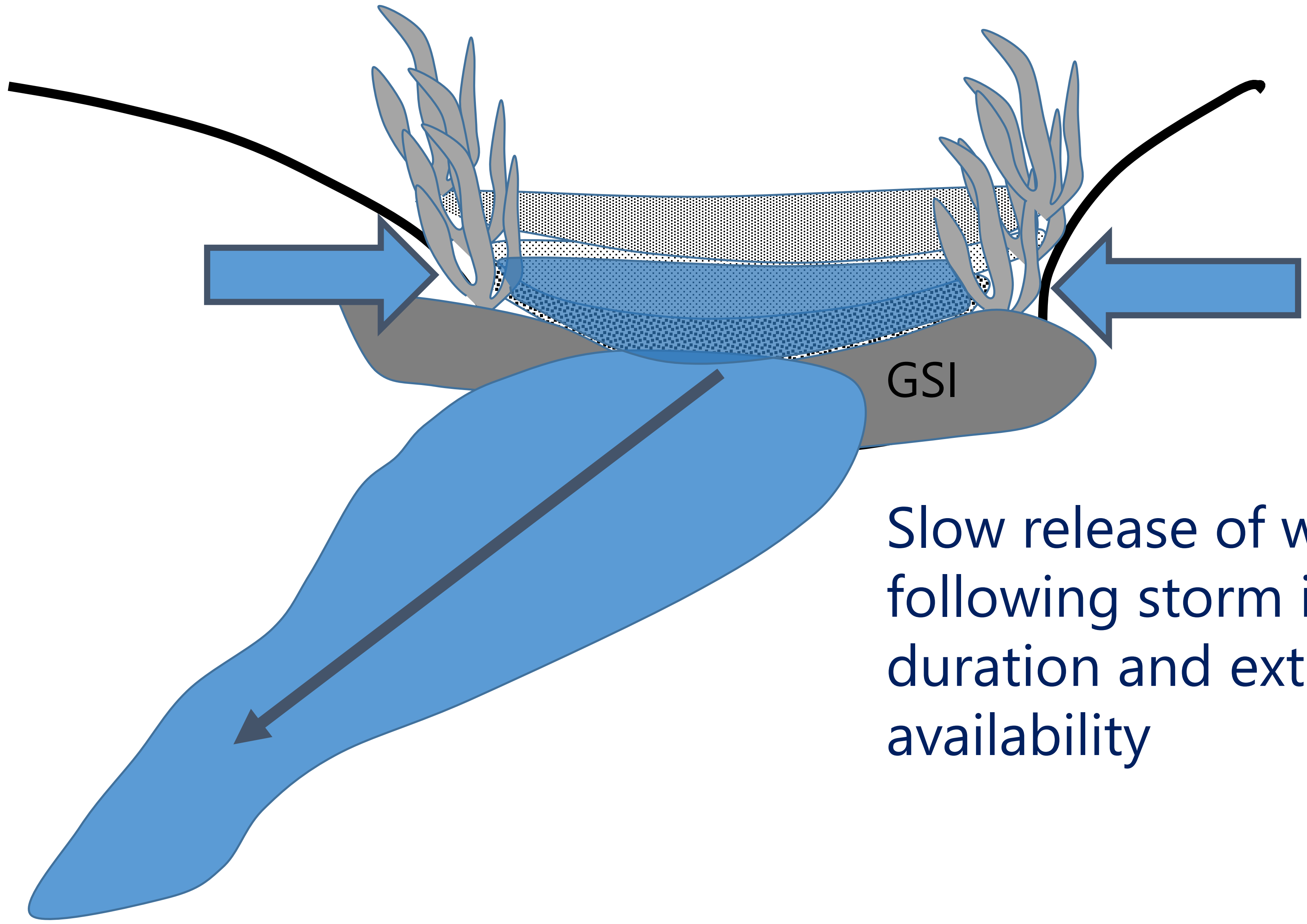
Sedimentation after storm and plant establishment

GSI When it Rains

Water storage during
storm slows flows



GSI After a Storm



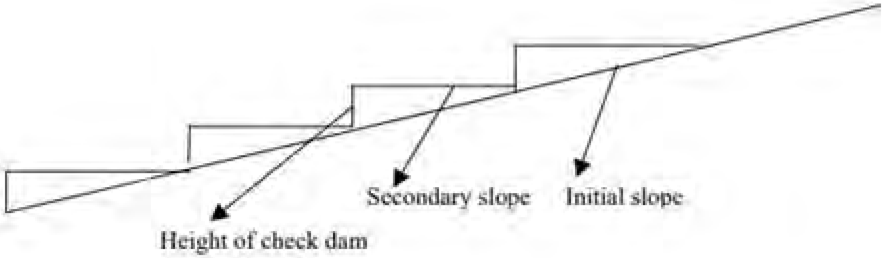
Slow release of water following storm increases duration and extent of water availability

GSI - Gabions

- modular wire mesh basket, galvanized wire increases lifespan
- hand built or pre-manufactured, assembled on site
- filled with rocks

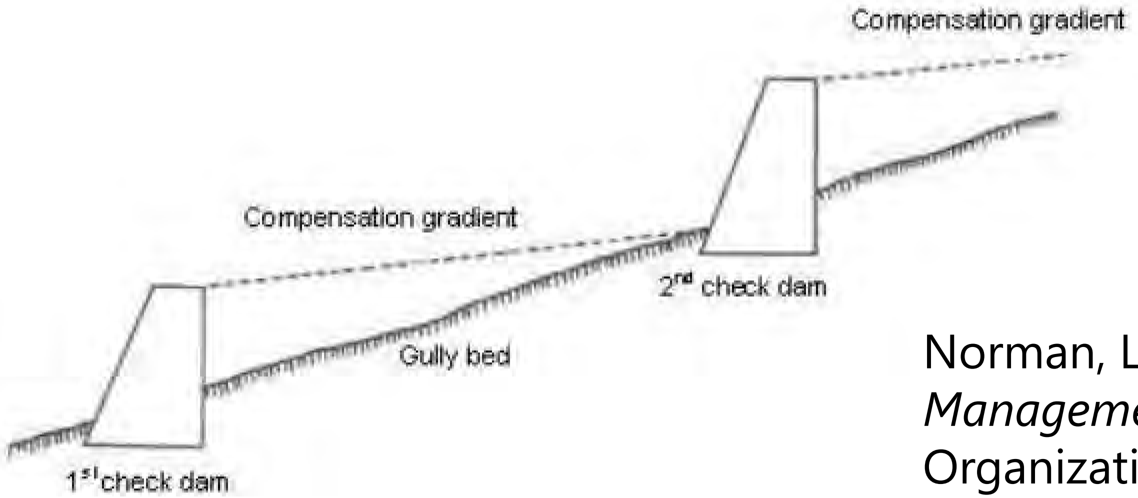
Norman, L.M., Villarreal, M.L., Pulliam, H.R., Minckley, R., Gass, L., Tolle, C., & Coe, M. (2014). Remote sensing analysis of riparian vegetation response to desert march restoration in Mexican Highlands. Ecological Engineering, 70C, 241-254, doi:10.1016/j.ecoleng.2014.05.012

Green Stormwater Infrastructure and Channel Slope



Overtime check dams/gabion installations reduce:

- channel slope
- stormflow rates
- erosion and sediment transport



Norman, Laura MGeyik, M. P. (1986). Gully Control. In *Watershed Management Field Manual* (Vol. 2). Rome: Food and Agricultural Organization of the United Nations.http://www.fao.org/docrep/006/ad082e/ad082e00.htm

Limited GSI Research in Arid Lands

USGS: Laura Norman, PhD

- Decrease peak flows for small-medium flood events
- Decrease plant stress/increase vegetation health
- Increase surface-water availability 5km downstream and 1km upstream
- Extend seasonal flows and increase volumes (by ~28%)
- Increase soil carbon sequestration and soil-moisture by ~10%)
- Decrease downstream sedimentation

http://usgs.gov/WGSC/Aridlands/
https://www.usgs.gov/staff-profiles/laura-m-norman

USGS science for a changing world
Land Change Science Program

Catena 98 (2012) 104–109

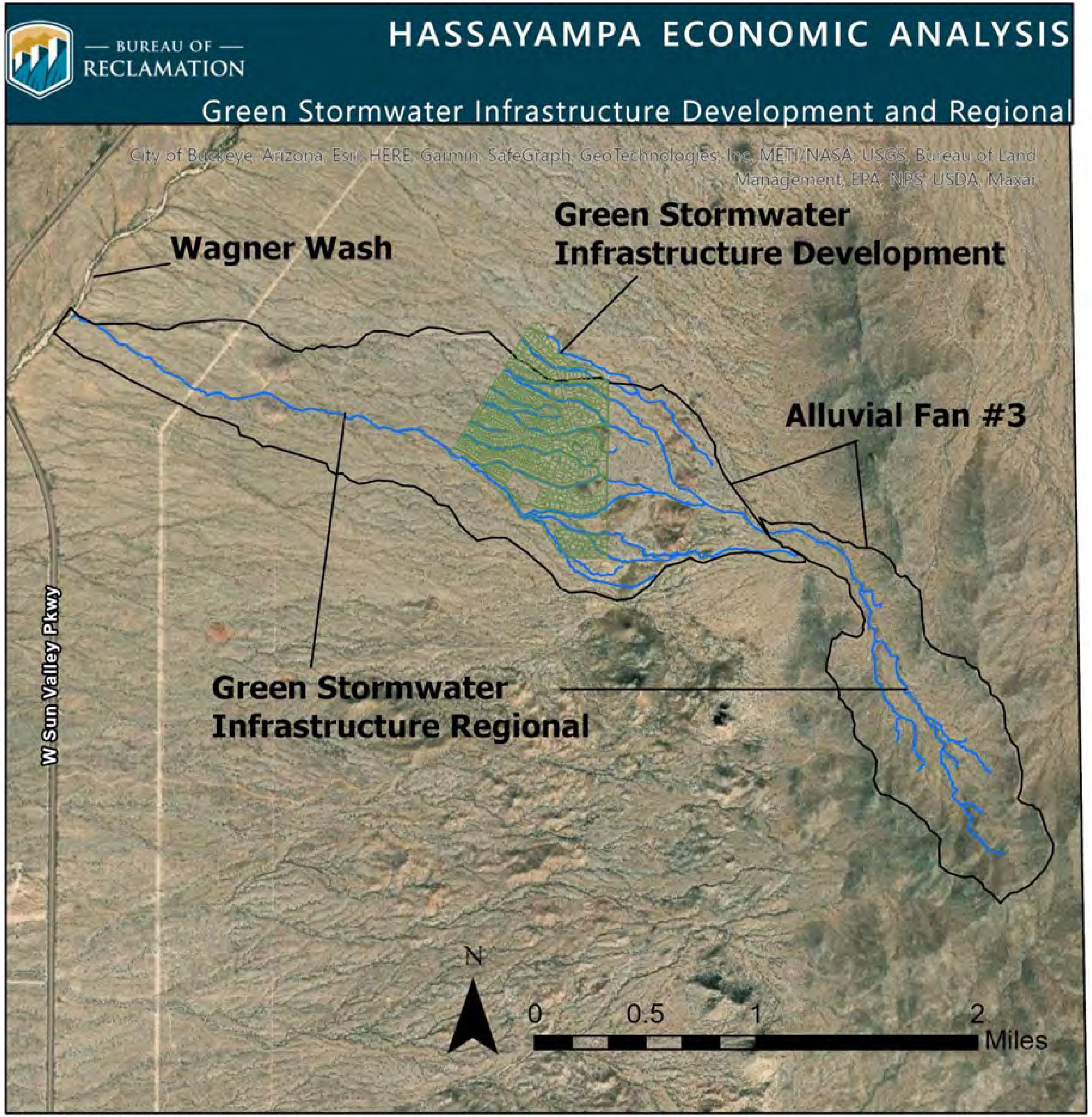
Contents lists available at SciVerse ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Short-term soil moisture response to low-tech erosion control structures in a semiarid rangeland☆

M.H. Nichols [a,*], K. McReynolds [b], C. Reed [c]



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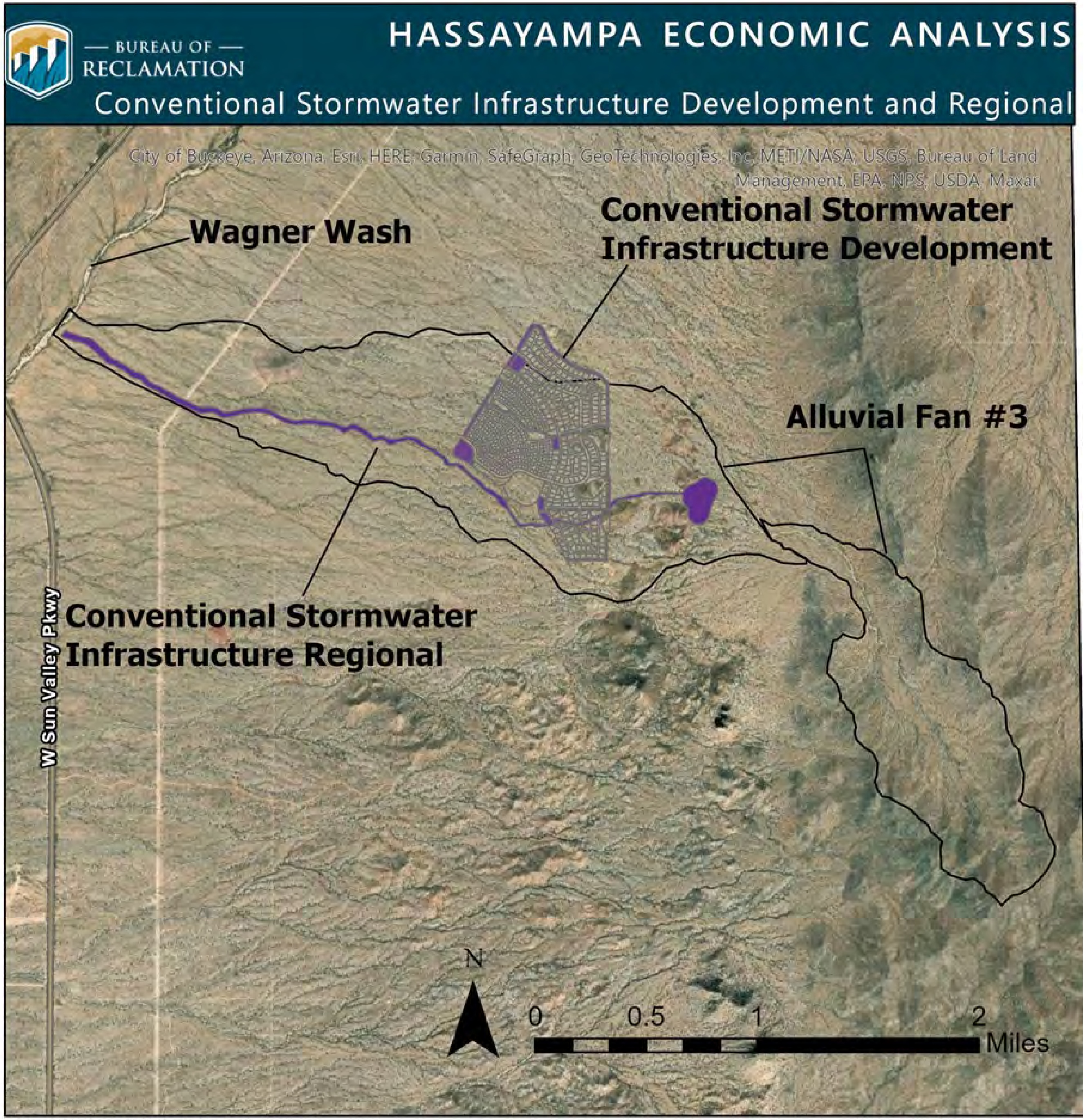
Green Stormwater Infrastructure Alternative Scenarios

- GSI regional watershed scenario
- GSI hypothetical development scenario



Data Attribution: USBR and Esri Basemaps

Conventional Stormwater Infrastructure Alternative Scenarios

- CSI regional watershed scenario
- CSI hypothetical development scenario

Surface Water Model

- Assess effectiveness of GSI as an integrated surface water, groundwater, and eco-hydrologic stormwater management.
- Minimize or eliminate conventional stormwater infrastructure.

Surface Water Model continued….

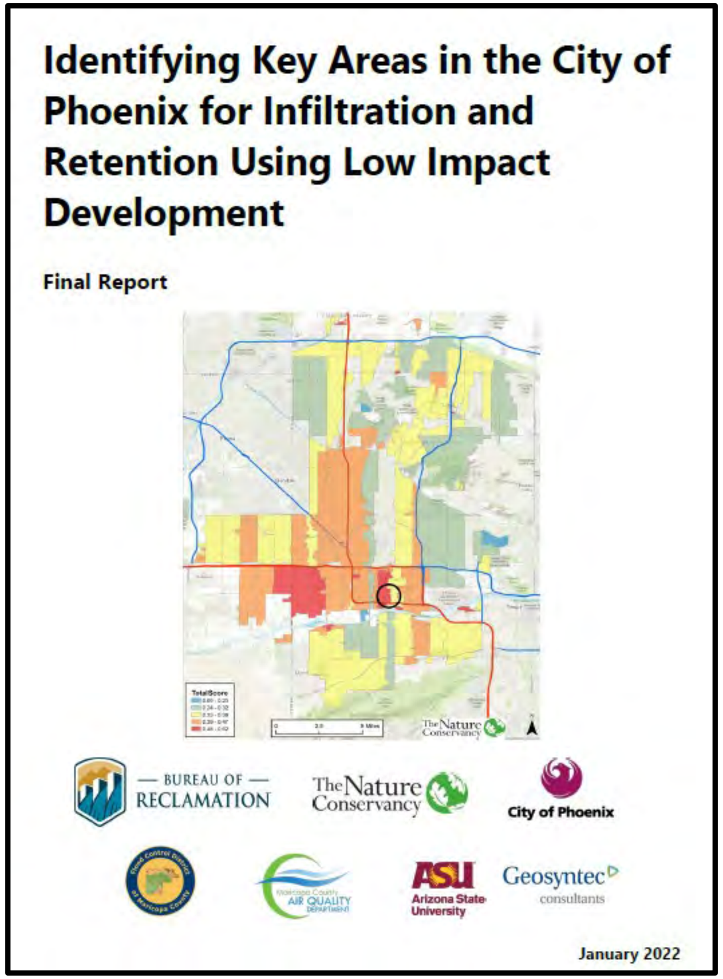
- Previous study
- Natural hydrology
- Select Area of Interest
- Modeling GSI and CSI
  - Regional watershed
  - Hypothetical development
- Identify
  - Volume and velocity of stormflows
  - Erosion and sediment transport potential
  - Pre-development infiltration measurements


Photo credit: Chloe Killian

Identifying Key Areas in the City of Phoenix for Infiltration and Retention Using Low Impact Development (LID Floodplain Study), January 2022

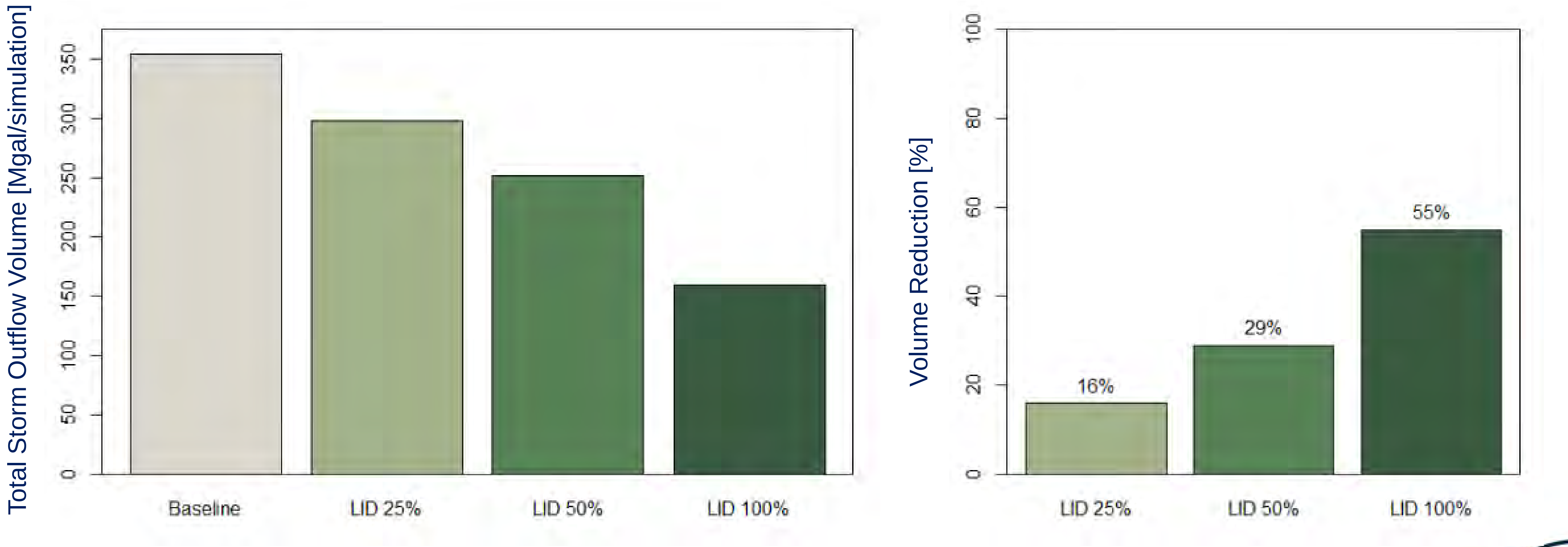
Goal of Study:

Determine the effectiveness of implementing LID/GSI at the lot level at various implementation levels.



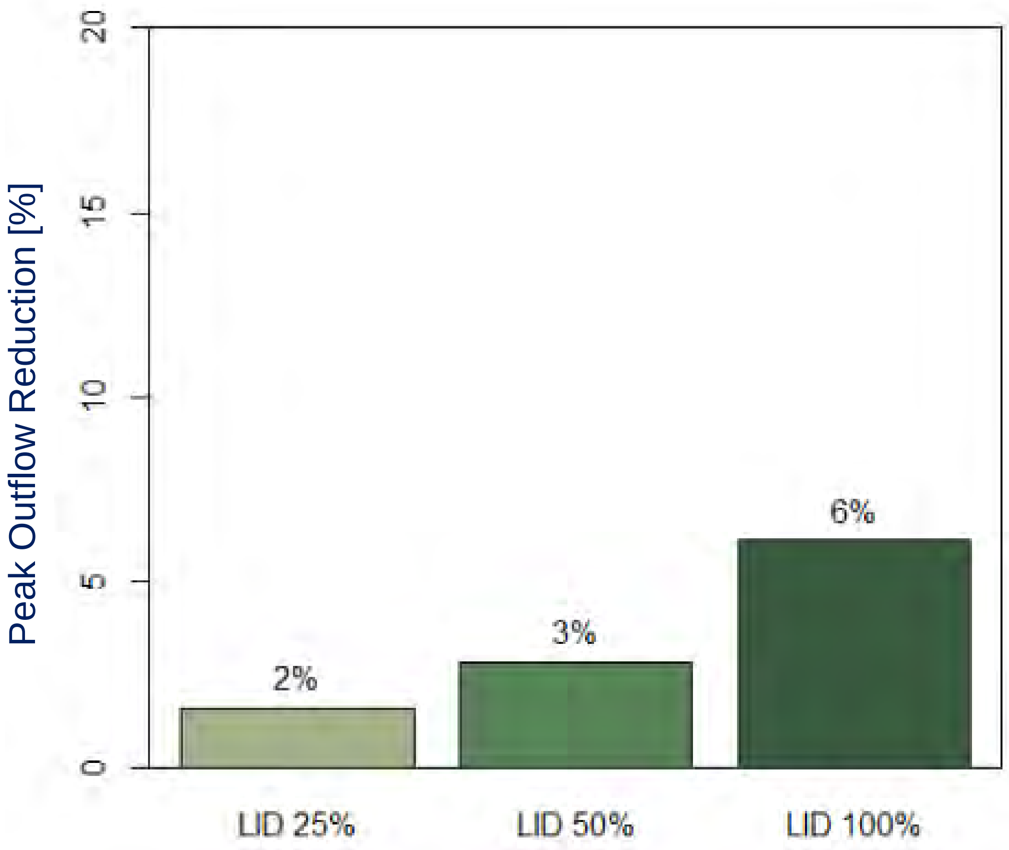
LID Floodplain Study Results - Outflow

Change in Total Outflow Volume



LID Floodplain Study Results – Peak Flows

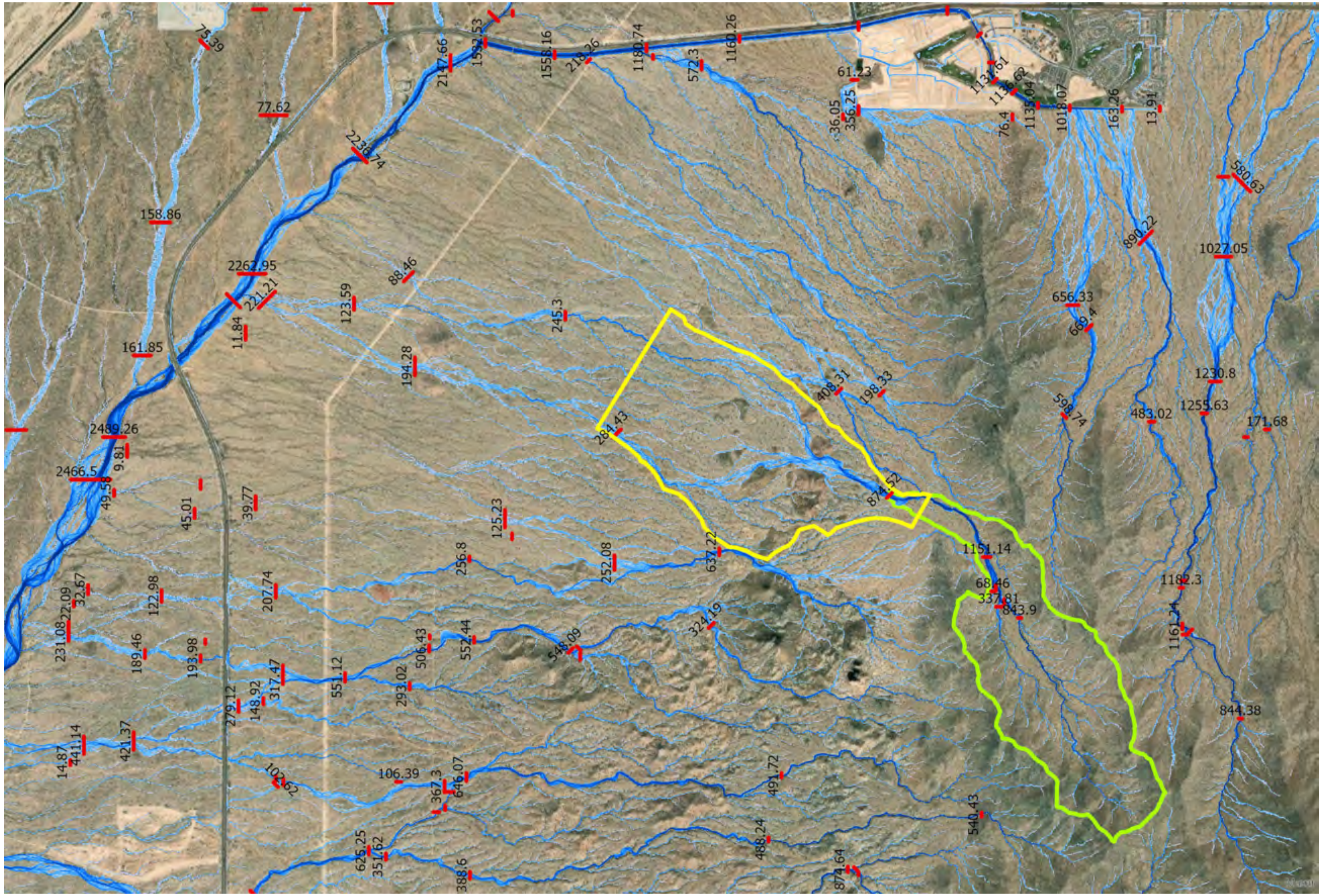
Change in Peak Outflows



Selecting Area of Interest

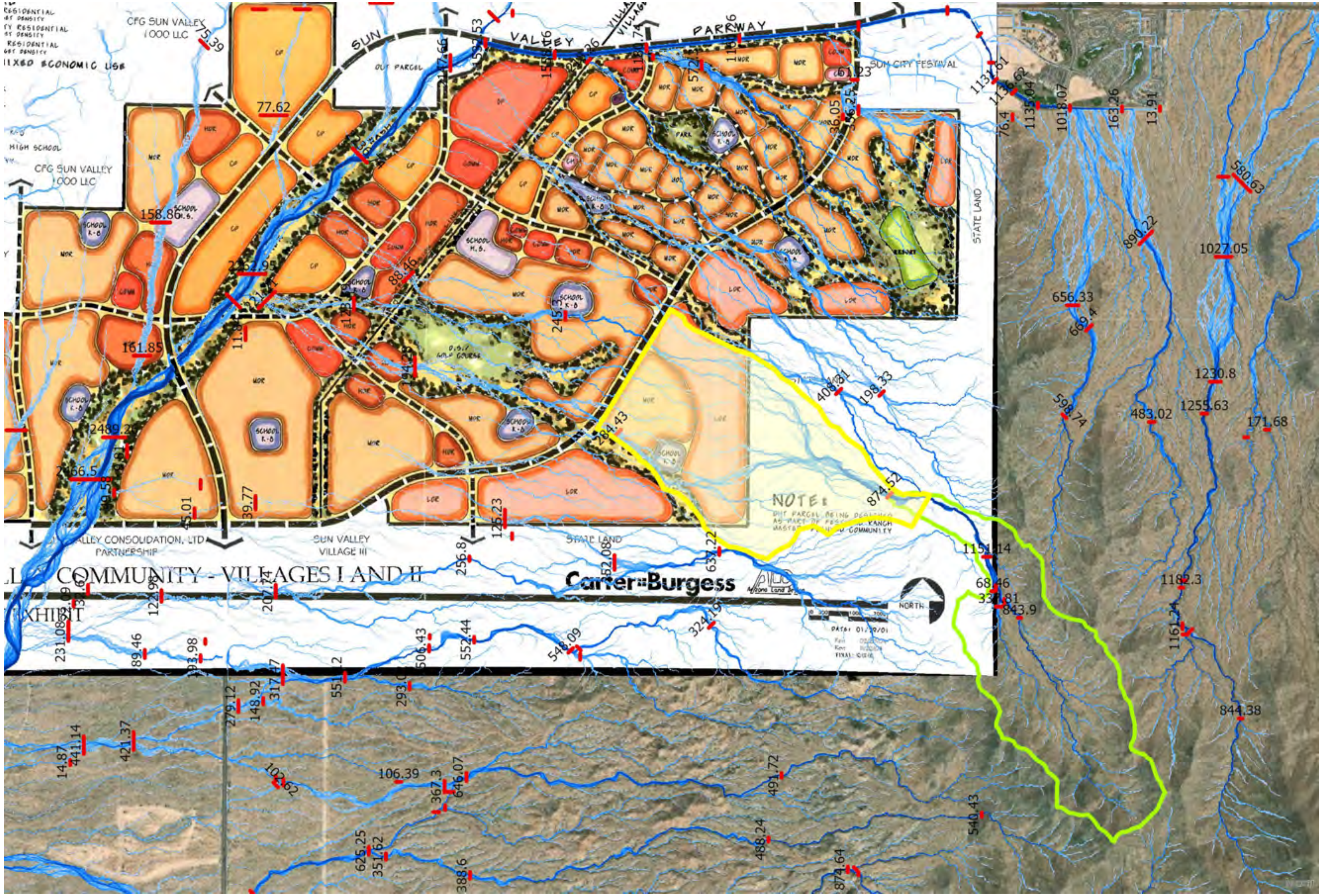
- Western slope of White Tank Mountains within the City of Buckeye
- FCDMC FLO-2D modeling area
- Small confined watershed area
- Community Master Plan with primarily residential development
- Well defined outfall
- Currently undeveloped

Natural Hydrology



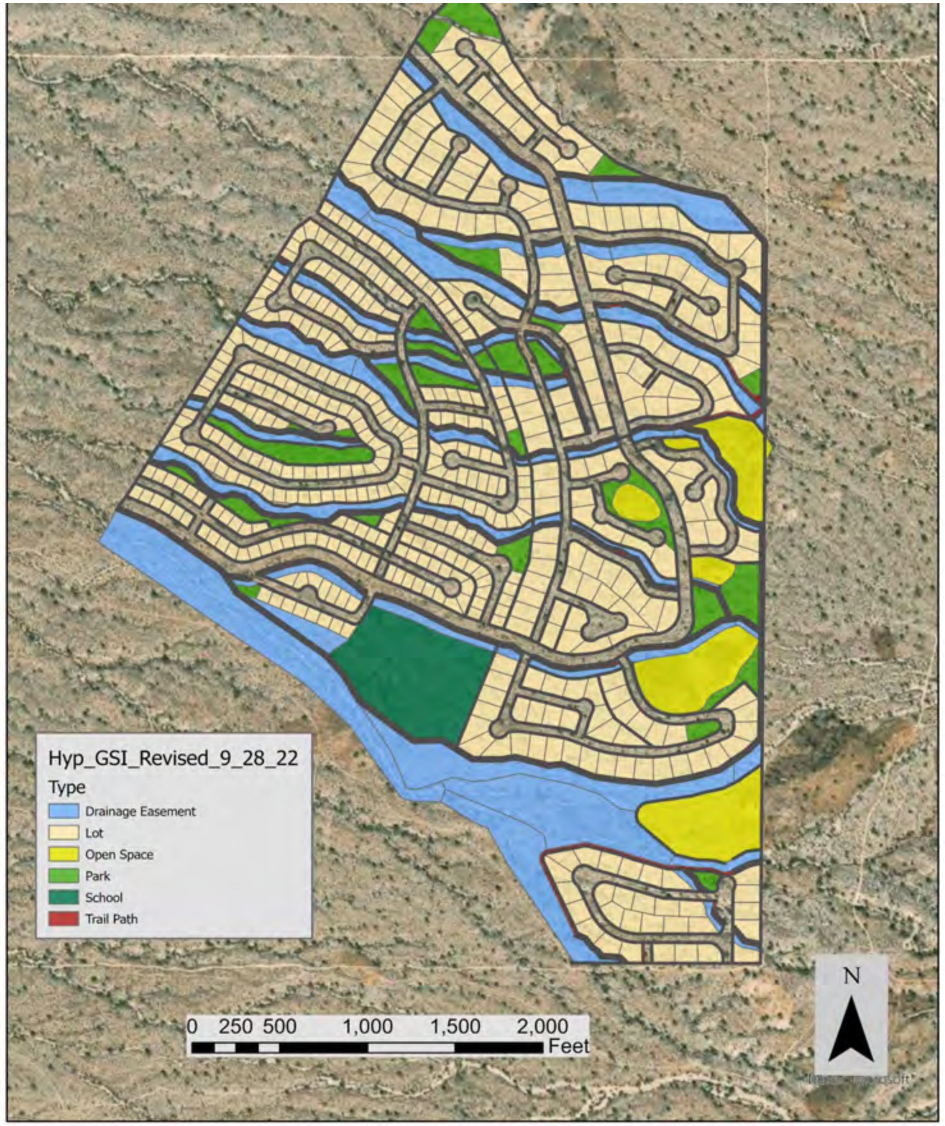
FCDMC
FLO-2D Model
from SV ADMP
Update

Community Master Plan



Hypothetical Developments

GSI



CSI

Hypothetical Development Comparisons

Land Use	Number of Lots	Average Lot Size (sq ft)	Total Open Space (sq ft)	Total Area (sq ft)	Percent Open Space
GSI Development					
LDR	229	15,293	3,171,948	7,916,053	40%
MDR	302	6,173	1,508,008	3,945,433	38%
CSI Development					
LDR	241	18,105	2,010,265	7,916,053	25%
MDR	306	7,014	749,862	3,945,433	19%

LDR = Low Density Residential
MDR = Medium Density Residential

Land Use	Lots Lost	Percentage of lots lost
LDR	12	5.0%
MDR	4	1.3%
Total	16	2.9%

Surface Water Modeling – Completed Tasks

- **Hypothetical Development Area**
  - FLO-2D data sent to Reclamation's Technical Services Center (TSC) in Denver
  - Developed PC SWMM for area
  - Calibrated PC SWMM to FLO-2D model

- **Regional Watershed Area**
  - FLO-2D data sent to USGS, Dr. Laura Norman for modeling in Soil and Water Assessment Tool (SWAT)

Surface Water Modeling – Next Steps

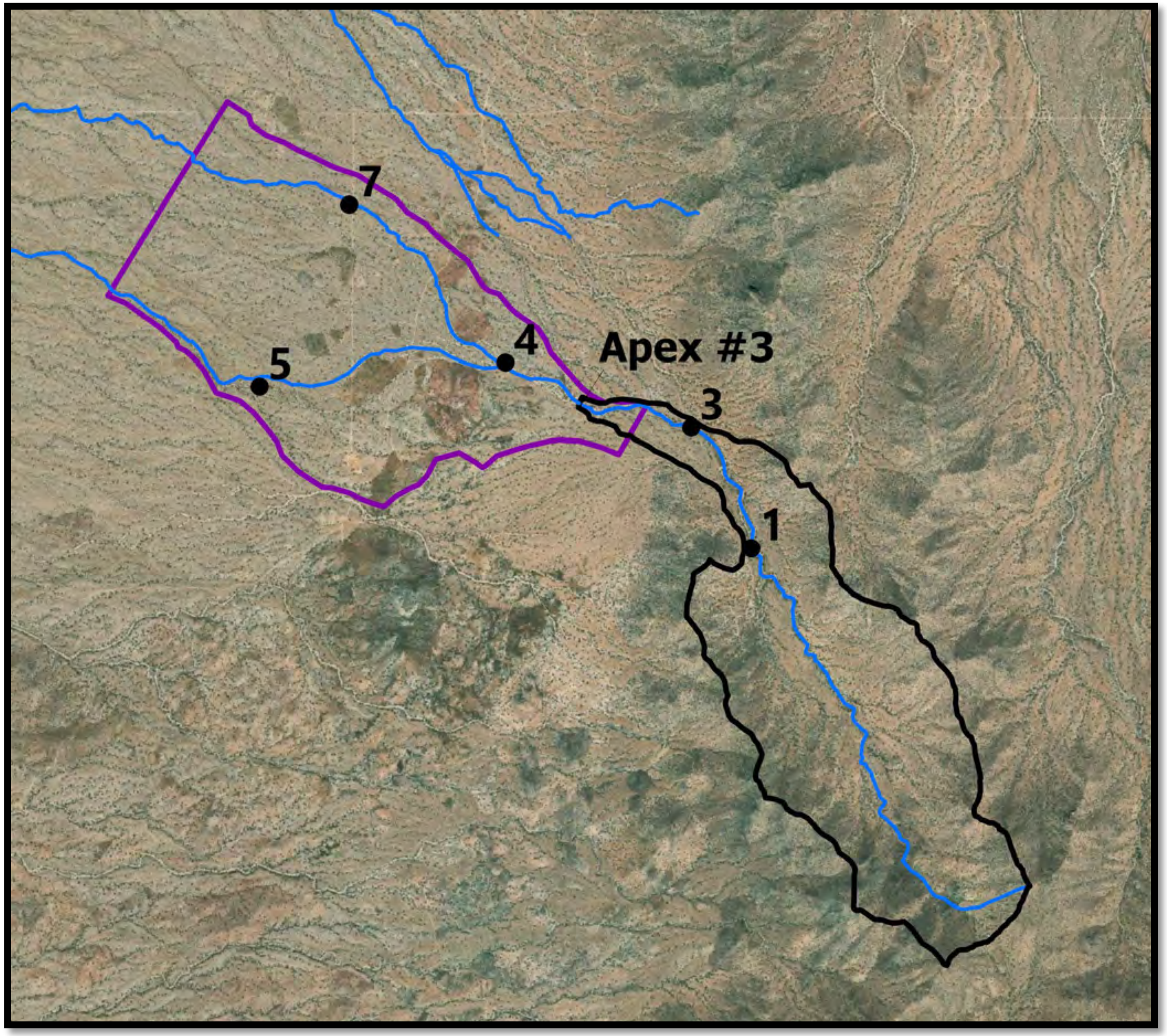
- **Hypothetical Developments**
  - TSC to model CSI hypothetical development in PC SWMM
  - TSC to model GSI hypothetical development in PC SWMM
  - Compare results for hypothetical development scenarios
- **Regional Watershed – Effectiveness of GSI Features**
  - Model upstream of the apex to assess flow reduction at the apex
  - Model the undeveloped area downstream from the apex to Wagner Wash

In-Situ Infiltration Testing

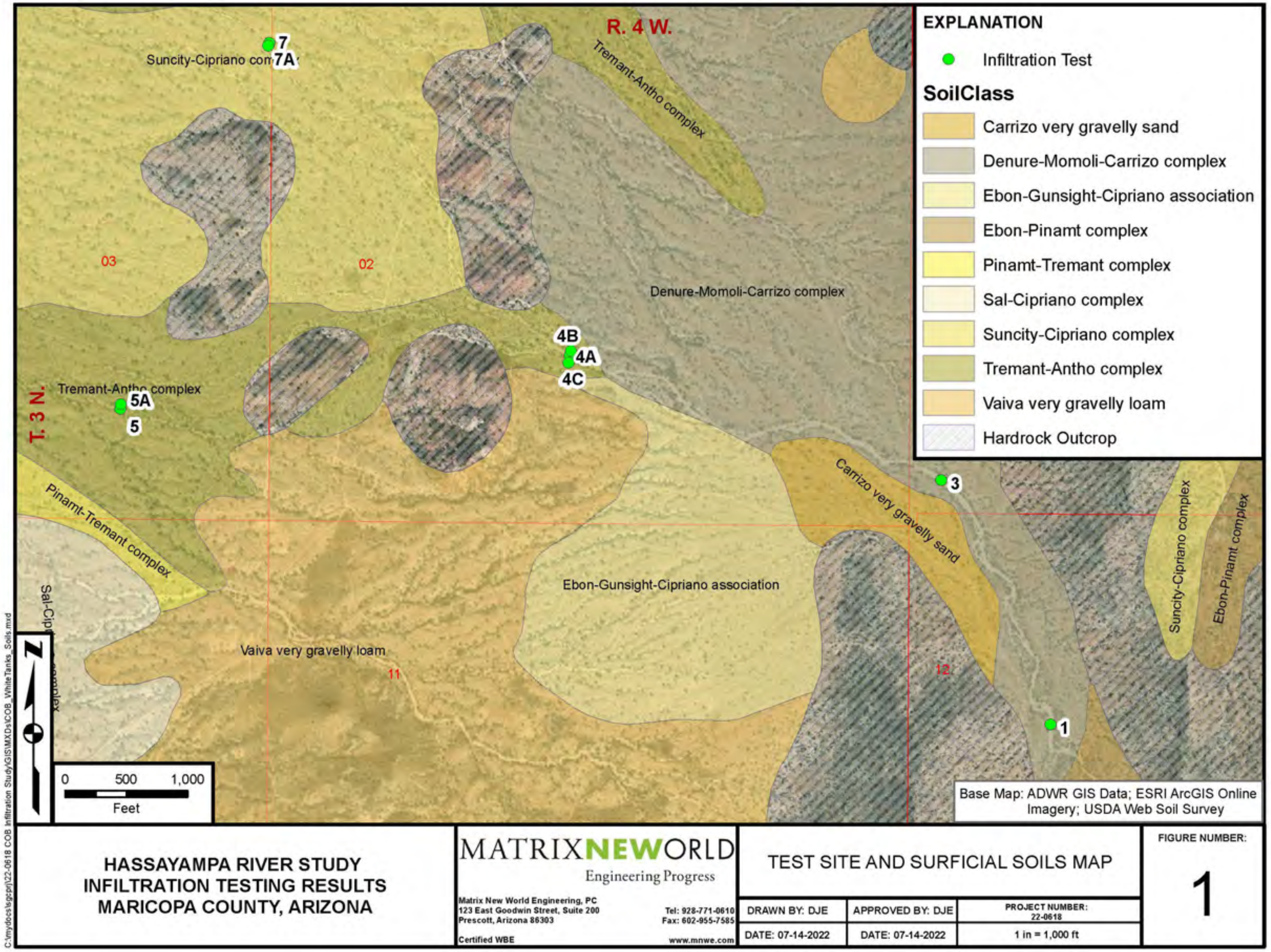
- **Selection**
  - Preliminary sites selection by Bureau of Reclamation
  - Field verified with Bureau of Reclamation, City of Buckeye and their contractor
  - Six locations selected in undisturbed, unvegetated flowline of an ephemeral wash (Two testing locations at Site #4)
  - Three locations selected on adjacent stream terrace (Sites #4, #5, and #7)

- **Methodology**
  - 24-inch diameter, Single-ring infiltrometer

In-Situ Infiltration Testing General Location



In-Situ Infiltration Testing Sites



In-Situ Infiltration Testing Results

Location Number	General Location	Soil Type	Saturated Permeability (ft/day)
1	Flowline	Well graded sand	16.45
3	Flowline	Well graded sand with gravel, bedrock at 18”	44.37
4A	Flowline	Well graded sand with gravel	58.65
4B	Flowline	Well graded sand with gravel	51.51
4C	Terrace	Well graded sand with clay	3.78
5	Flowline	Well graded sand with gravel	57.90
5A	Terrace	Clayey sand	0.58
7	Flowline	Well graded sand with gravel	28.93
7A	Terrace	Well graded sand with clay	3.95

Economic Analysis of Green and Conventional Stormwater Infrastructure

Chloe Killian, University of Arizona Student and Reclamation Resource Assistant Intern

- Economic analysis methods
- Cost and benefit estimates
- Comparison of GSI and CSI alternatives

Photo credit: Chloe Killian

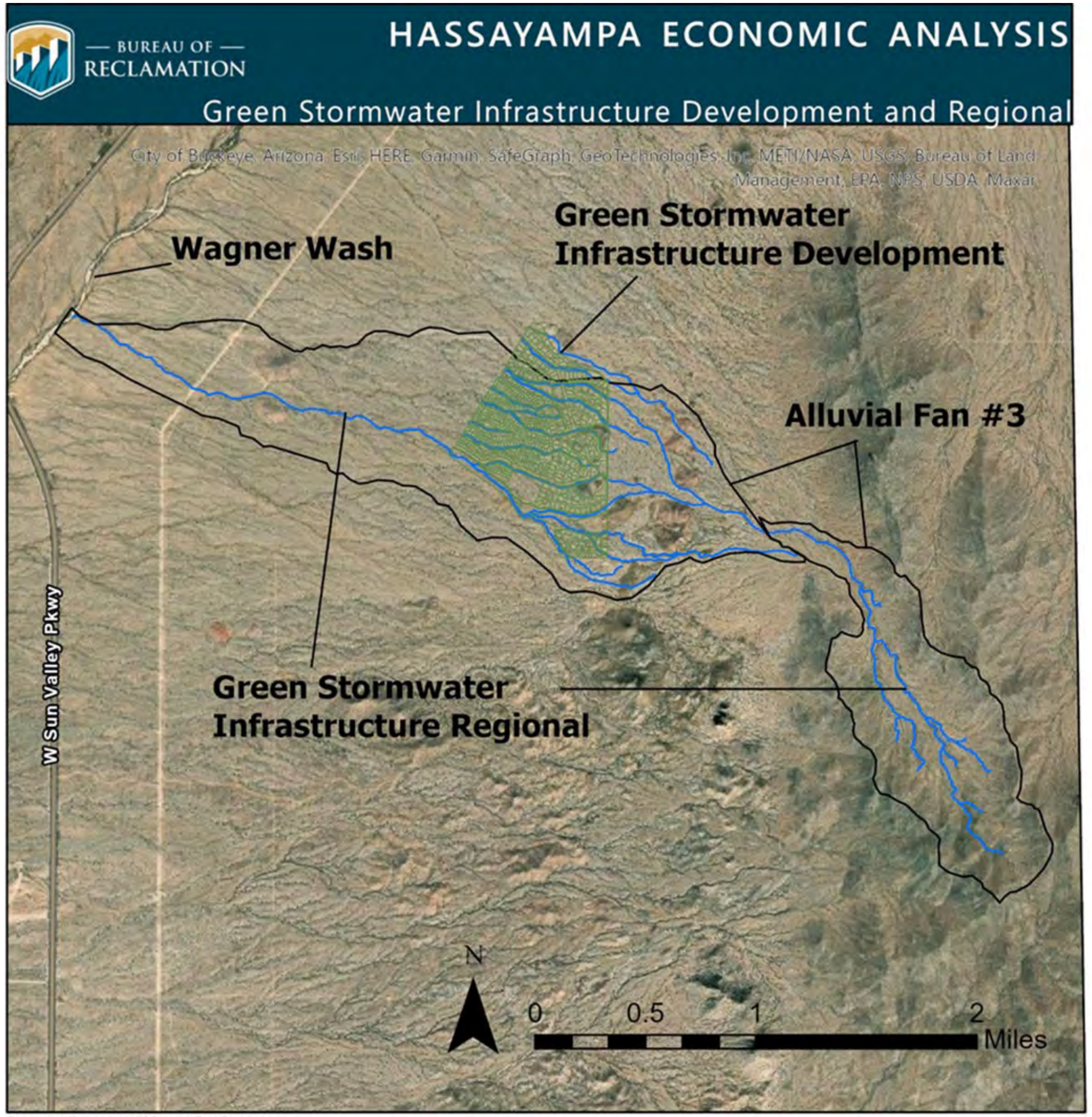
GSI Alternative

GSI Regional Watershed Scenario

- 530 theoretical gabions in natural channels from top of watershed to Wagner Wash.
- 0 culverts

GSI Hypothetical Development Scenario

- Retain 9 natural channels within development
- 347 theoretical gabions
- 27 culverts



Data Attribution: USBR and Esri Basemaps

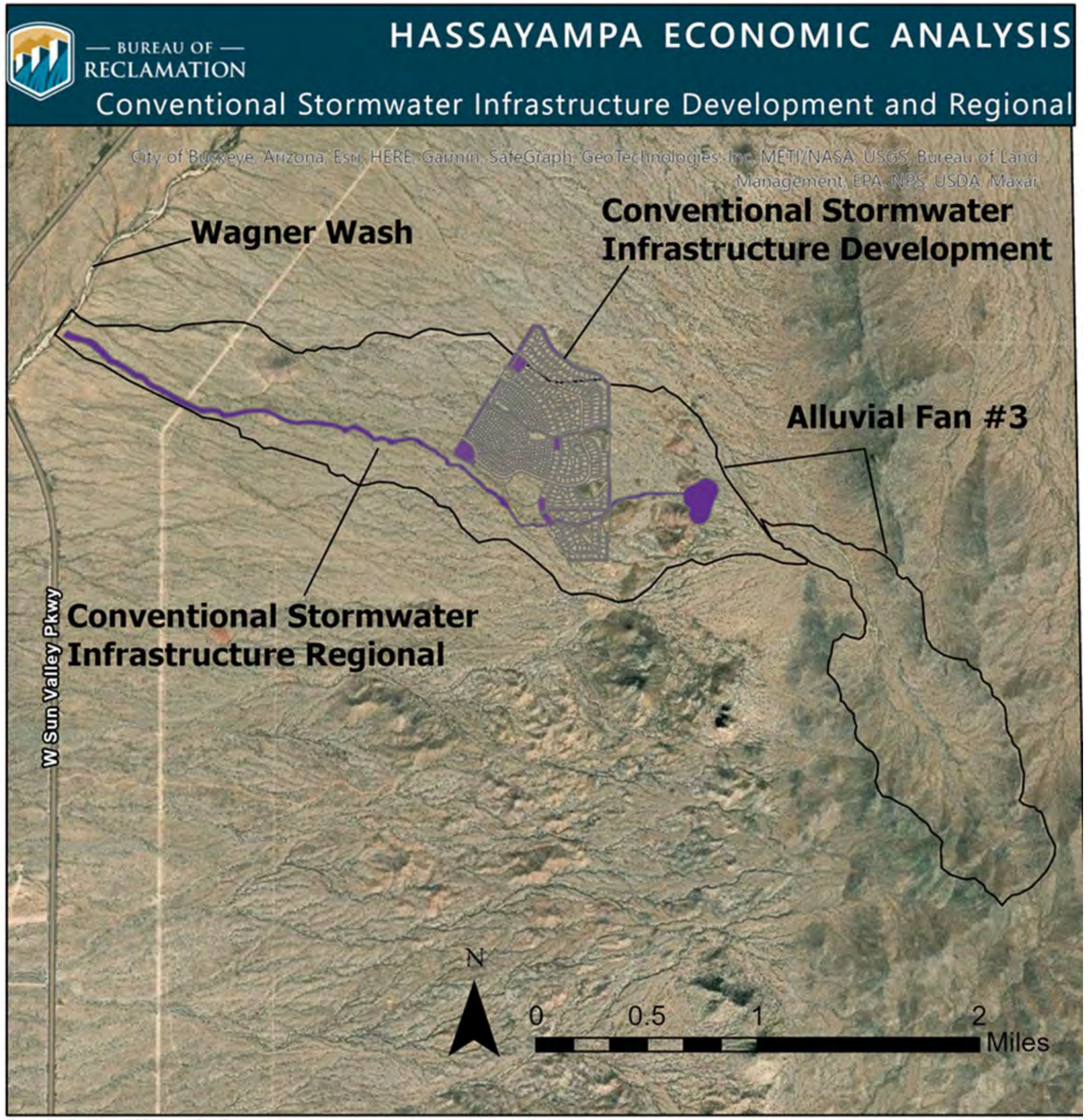
CSI Alternative

CSI Regional Watershed Scenario

- 1 dike
- 1 detention basin
- 2.5 miles of walled-levee corridors
- 19 gabions
- 0 culverts

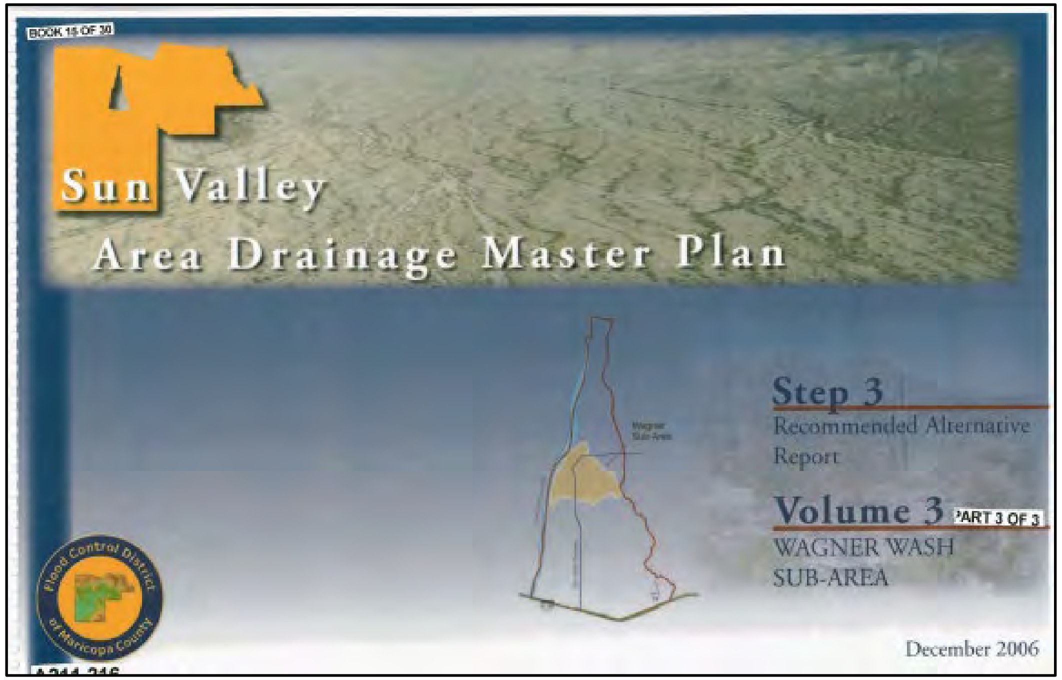
CSI Hypothetical Development Scenario

- 5 retention basins
- 2 drainage easements within and 8 drainage easements on perimeter
- 26 gabions
- 12 culverts

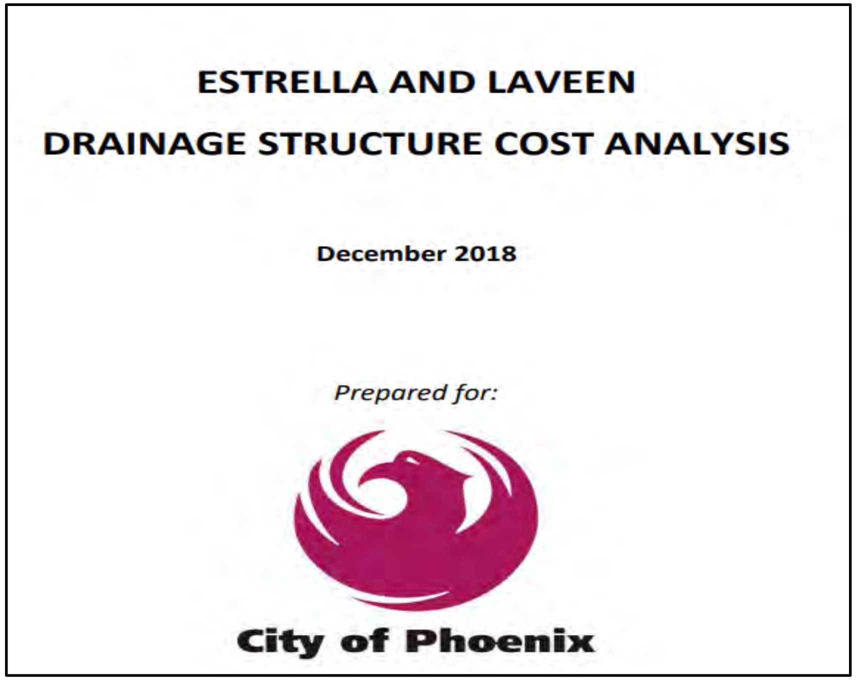


Data Attribution: USBR and Esri Basemaps

Cost Estimating Sources



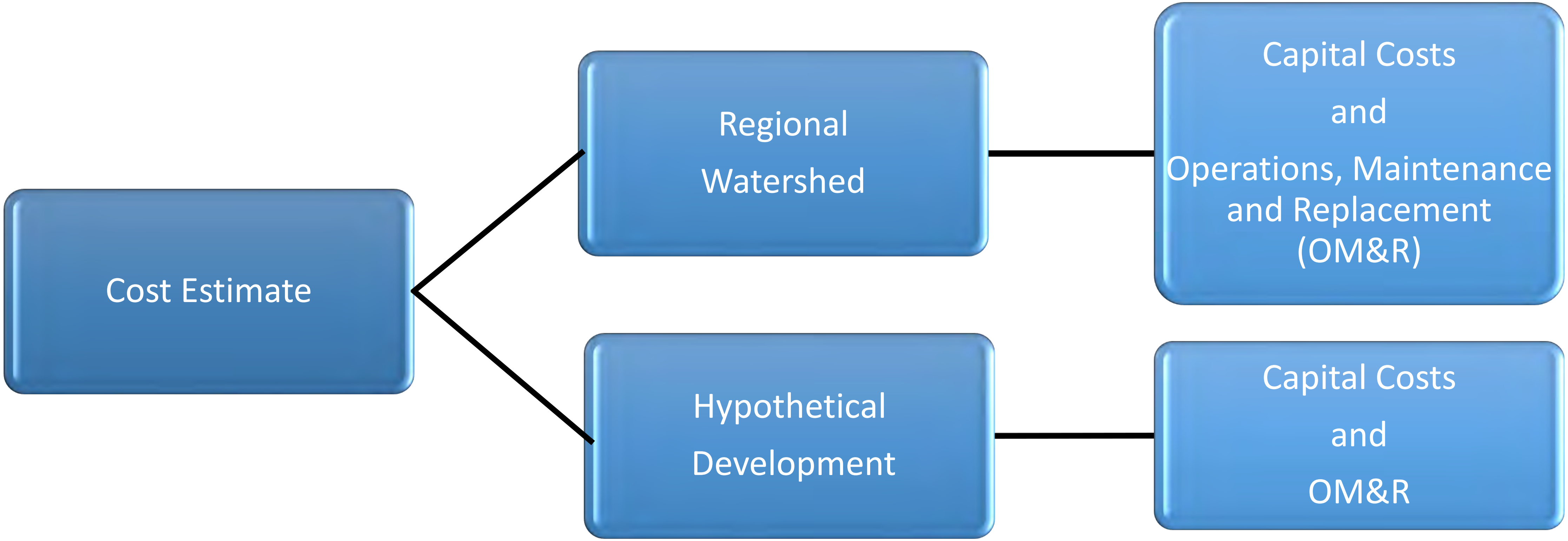
Cost source for construction and maintenance for all features excluding culverts.



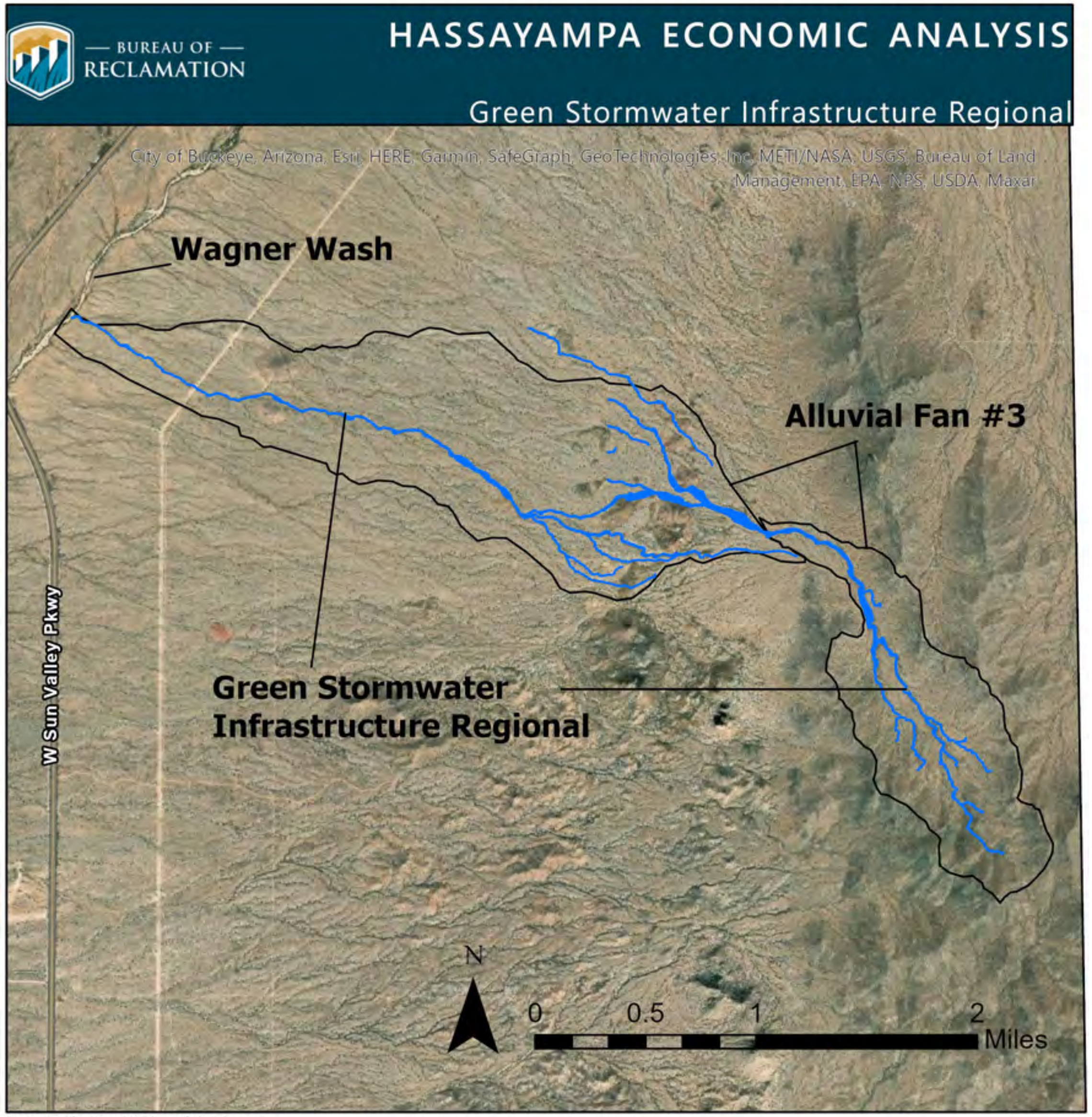
Cost source for construction and maintenance culverts.

- Culvert operations and maintenance costs were developed using RS Means, a database of current construction cost estimates.
- Assume replacement of 40% of stormwater infrastructure at 50 years.
- All costs indexed to April 2022.

Cost Estimating Methodology



GSI and CSI Regional Watershed Scenarios



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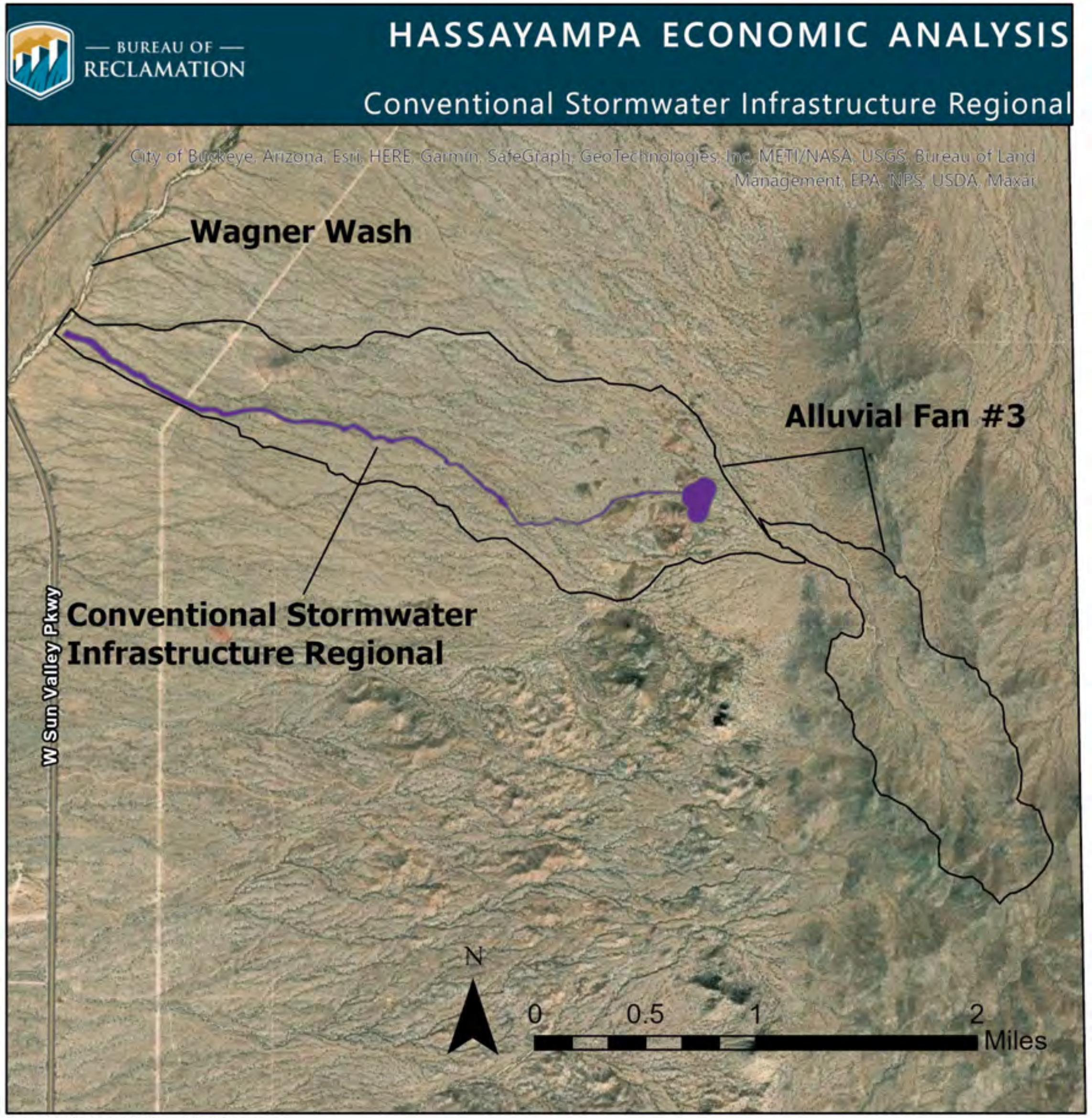


Data Attribution: USBR and Esri Basemaps

Capital Cost Comparison – Regional Watershed

Regional Watershed Field Cost Estimate - April 2022		
	GSI Regional	**Conventional Regional**
Capital Cost	$2,930,000	$15,690,000

Assume: Construction time 3 years for regional, 2 years for development

Capital costs for GSI versus CSI regional watershed scenarios

- GSI capital costs are ~19% of CSI capital costs.
- GSI costs are 5 times or ~81% less than CSI costs.
- Refined estimates for mobilization of construction materials into upper watershed may increase GSI capital costs.
- Use of native rock for GSI features would decrease GSI costs.

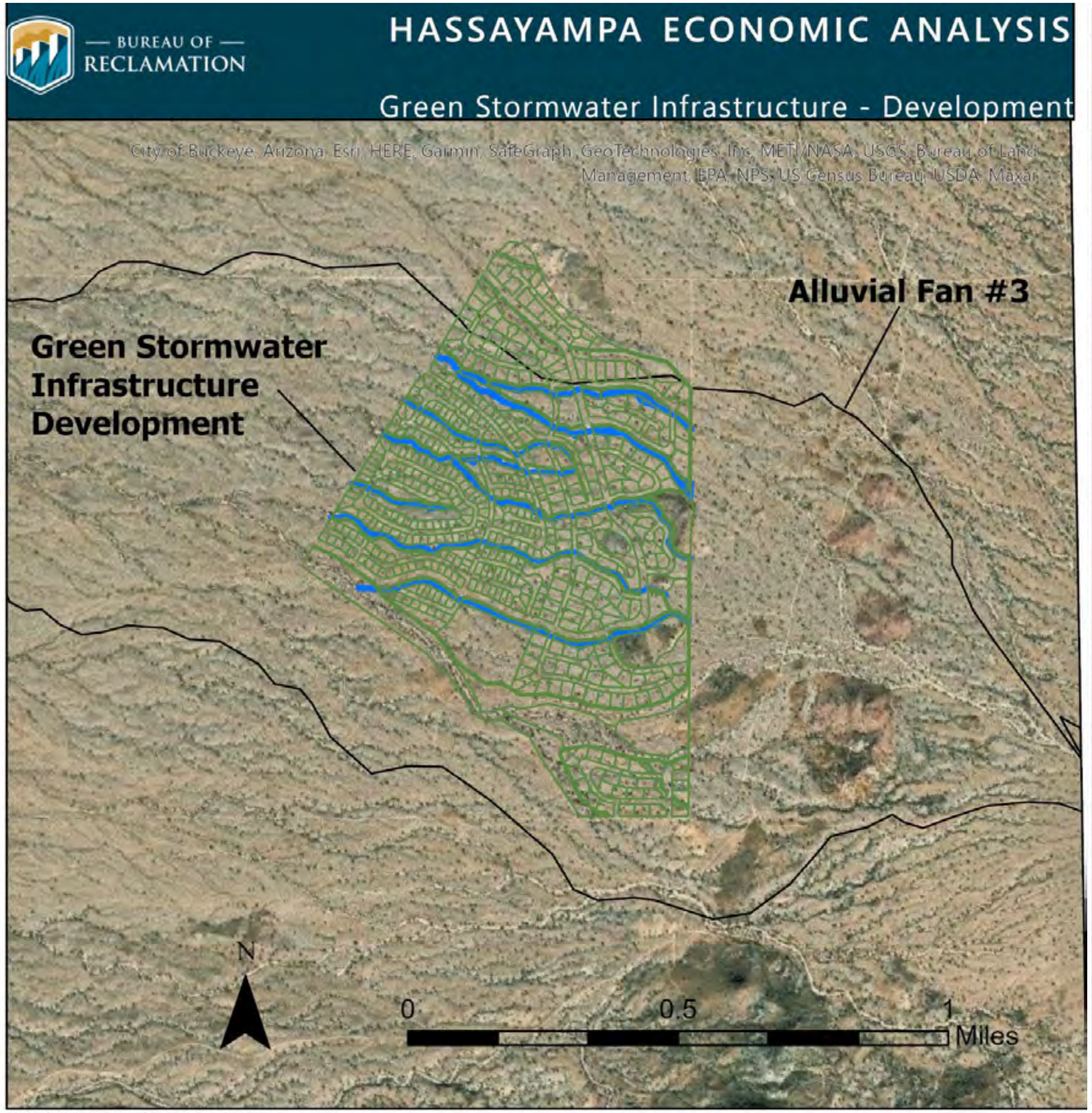
OM&R Cost Comparison – Regional Watershed

100-Year Regional Field Cost Estimate - April 2022		
	GSI Regional	**Conventional Regional**
100-Year OM&R	$1,672,000	$12,266,000

100-Year OM&R costs for GSI versus CSI regional watershed scenarios

- GSI OM&R costs are ~14% of CSI OM&R costs.
- GSI costs are ~7 times or ~86% less than CSI OM&R costs.
- Actual OM&R cost data would improve OM&R cost estimates.
- Assume replacement of 40% of infrastructure at 50 years.

GSI and CSI Hypothetical Development Scenarios



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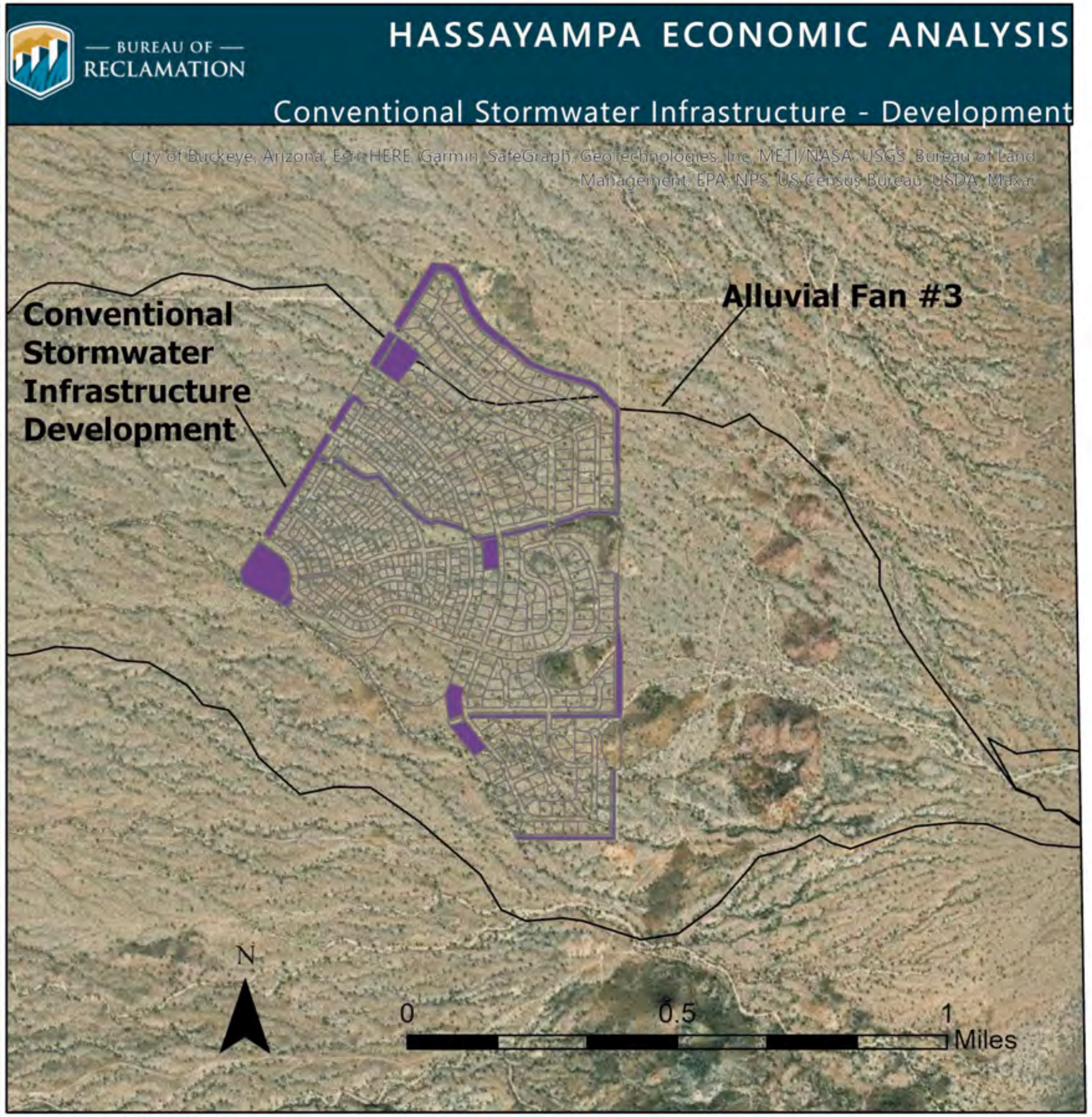


Data Attribution: USBR and Esri Basemaps

Capital Cost Comparison Hypothetical Development

Hypothetical Development Field Cost Estimate - April 2022		
	GSI Development	Conventional Development
Capital Cost	$5,290,000	$2,750,000

Assume: Construction time 3 years for regional, 2 years for development

Capital costs for GSI versus CSI hypothetical development scenarios

- GSI capital costs are ~52% more or ~1.9 times higher than CSI capital costs due to culverts.
- GSI retains 9 natural channels and requires 27 culverts (125% more than CSI).
- CSI has 2 drainage easements that require 12 culverts.

Photo: Chloe Killian

OM&R Cost Comparison Hypothetical Development

100-Year Hypothetical Development Field Cost Estimate - April 2022		
	GSI Development	**CSI Development**
100-Year OM&R	$13,251,464	$12,910,000

100-Year OM&R costs for GSI versus CSI hypothetical development scenarios

- 100-year OM&R costs for GSI are 3% more than CSI OM&R costs.
- 100-year OM&R costs include replacement of 40% of infrastructure at 50 years.
- Actual OM&R costs would improve the OM&R cost estimates.

100-Year Field Cost Estimate – April 2022

100 Year Field Cost Estimate - April 2022		
	GSI Regional	CSI Regional
Capital Cost	$2,930,000	$15,690,000
OM&R	$1,672,000	$12,266,000
Subtotal	**$4,602,000**	**$27,956,000**
	GSI Development	**CSI Development**
Capital Cost	$5,290,000	$2,750,000
OM&R	$13,251,464	$12,910,000
Subtotal	**$18,541,464**	**$15,660,000**
Total	**$23,143,464**	**$43,616,000**

100-Year Field Cost Estimate for GSI versus CSI Alternative

- GSI total capital and OM&R costs are ~47% of CSI costs.
- GSI total capital and OM&R costs and ~1.9 times or ~53% less than CSI costs.
- Updated values for capital and OM&R costs would improve the economic analysis.

GSI Benefits

Decrease/Reduce

- stormwater runoff
- local flooding
- erosion/sediment transport
- urban heat island

Increase/Enhance

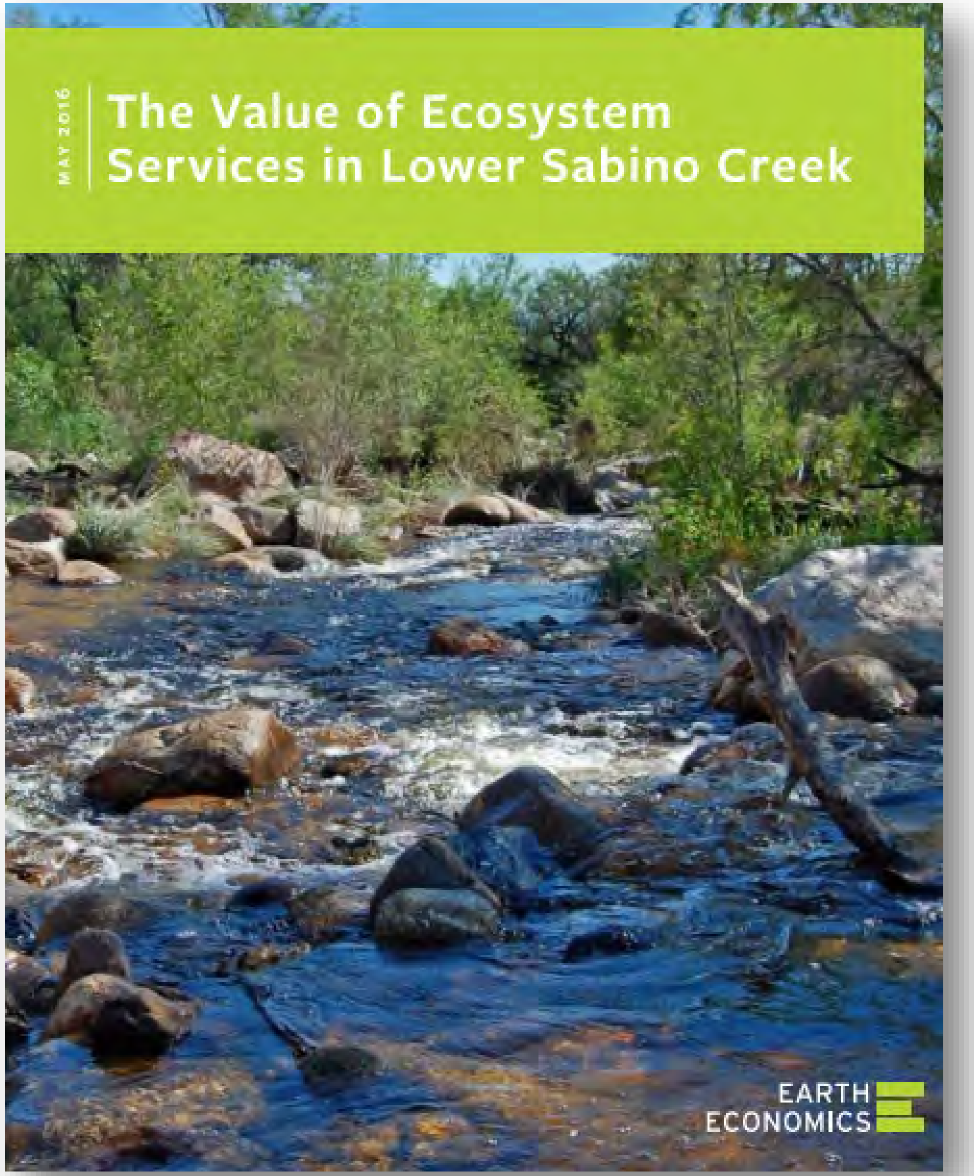
- Infiltration
- trees and vegetation
- air quality
- stormwater quality
- ecosystems and wildlife corridors
- improve watershed function
- biking/walking environment

Photo Credit: FCDMC – *Durango Campus*

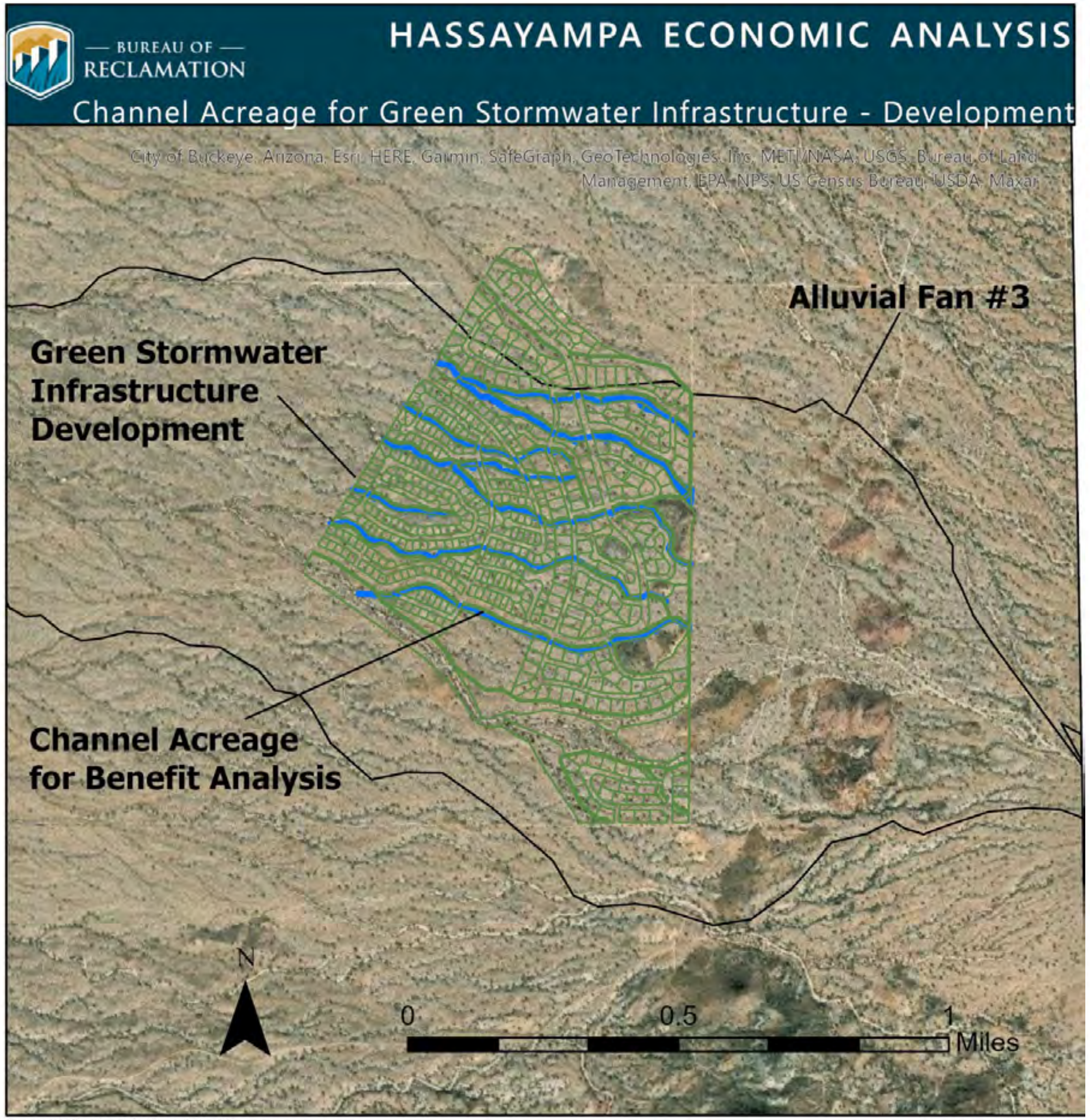
Photo: Deborah Tosline

Benefit Transfer Method (BTM)

- Used to develop cost estimates for ecosystem services benefits.
- BTM uses available information to develop a unit cost or monetary value for ecosystem function.
- Used BTM reference developed for Sabino Creek in Tucson, AZ.
- Developed unit costs for benefit estimates for shrubland ecosystem.



GSI and CSI Development Acreage



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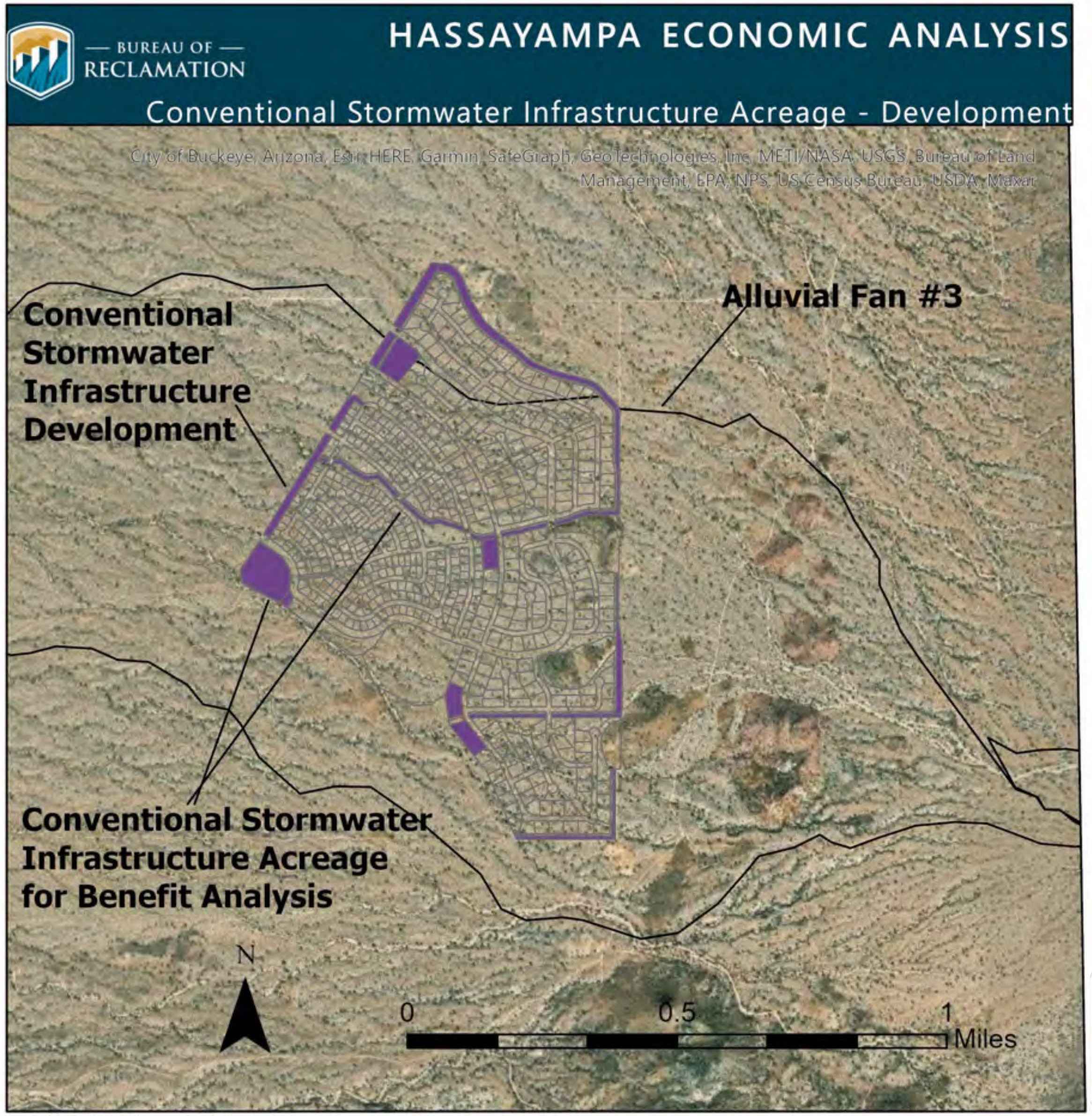

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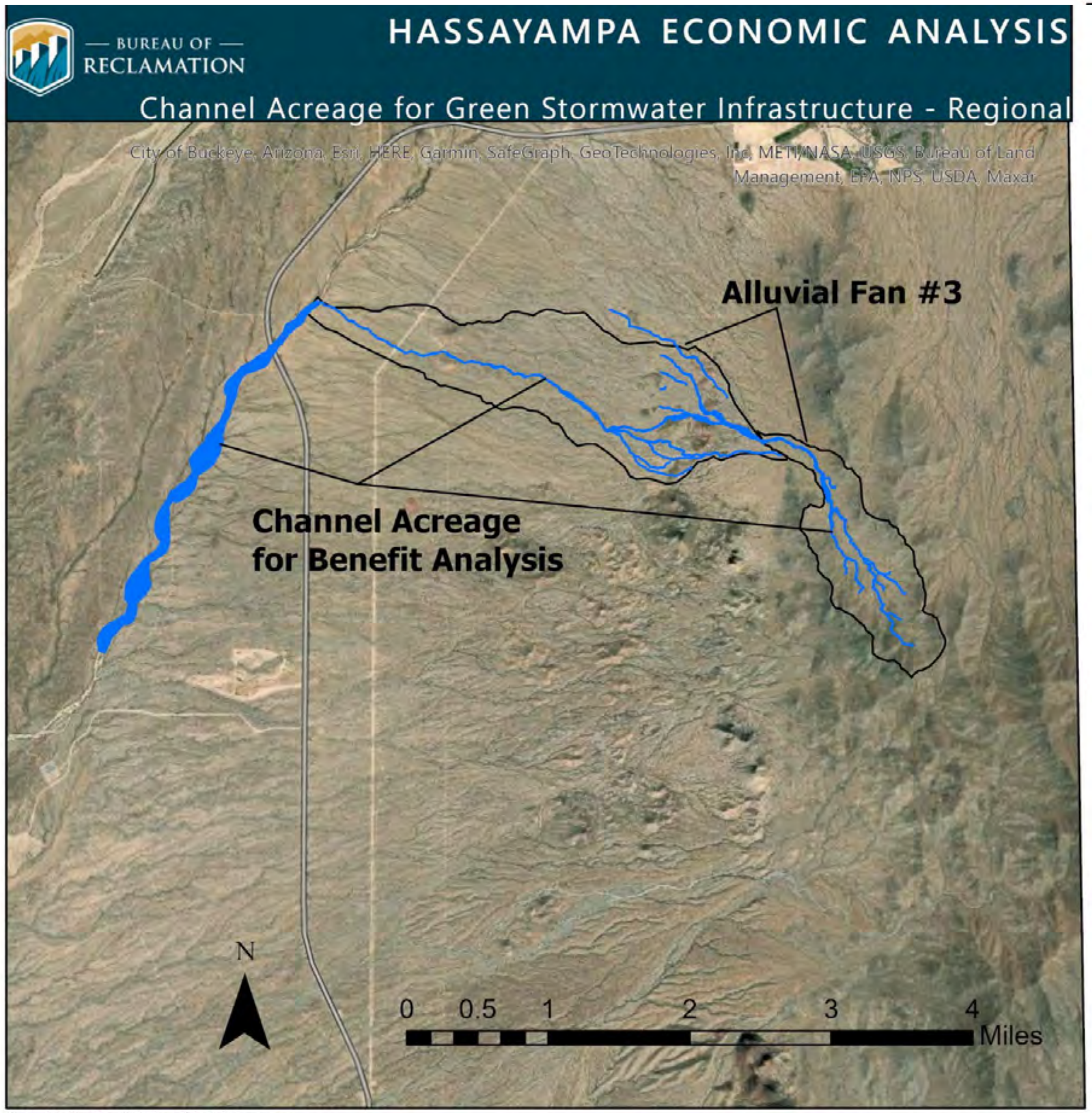
GSI and CSI Regional Acreage



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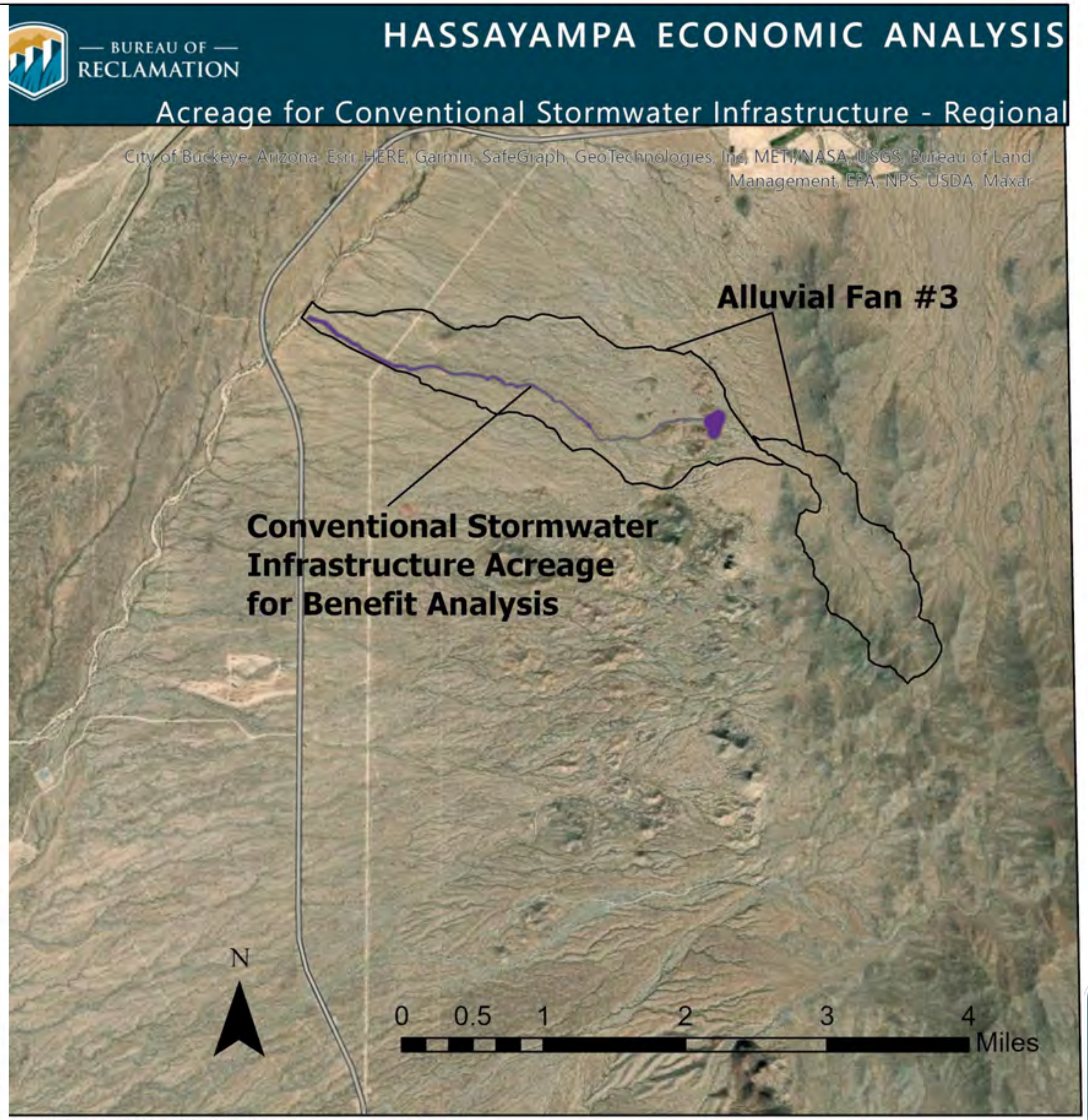


ata Attribution: USBR and Esri Basemaps

Valuing Ecosystem Services

Annual Value of Shrubland Ecosystem Services	Regional GSI (159.25 acres)		Development GSI (8.15 acres)		Regional CSI (2.16 acres)		Development CSI (1.74 acres)	
	Low	High	Low	High	Low	High	Low	High
Air Quality	$256	$256	$13	$13	$3	$3	$3	$3
Climate Stability	$3,847	$6,155	$197	$315	$52	$84	$42	$67
Disaster Risk Reduction	$10,771	$14,874	$552	$762	$146	$202	$118	$163
Recreation	$11,797	$16,669	$605	$854	$160	$226	$129	$183
Soil Retention	$2,565	$2,565	$131	$131	$35	$35	$28	$28
Water storage	$7,950	$135,150	$407	$6,927	$108	$1,834	$87	$1,480
Annual Total	$37,185	$175,669	$1,906	$9,004	$505	$2,384	$407	$1,924
Annual Average	$106,427		$5,455		$1,444		$1,166	
100-year PV Benefit	$4,277,800		$385,193		$58,041		$47,002	

$/acre/year of quantifiable shrubland ecosystem service benefits

Costs and Benefits

Estimate	GSI Development + Regional	CSI Development + Regional
100-year PV Cost (Capital + OM&R)	$23,143,464	$43,616,000
100-year PV Benefit (Ecosystem Services)	$4,662,993	$105,043

Capital Costs and OM&R

- GSI capital costs + OM&R are ~53% of CSI capital costs + OM&R.
- GSI capital costs + OM&R are ~1.9 times less than CSI capital costs + OM&R.

Ecosystems Services Benefits

GSI benefits valuation is ~98% higher/~42 times greater than CSI benefits valuation.

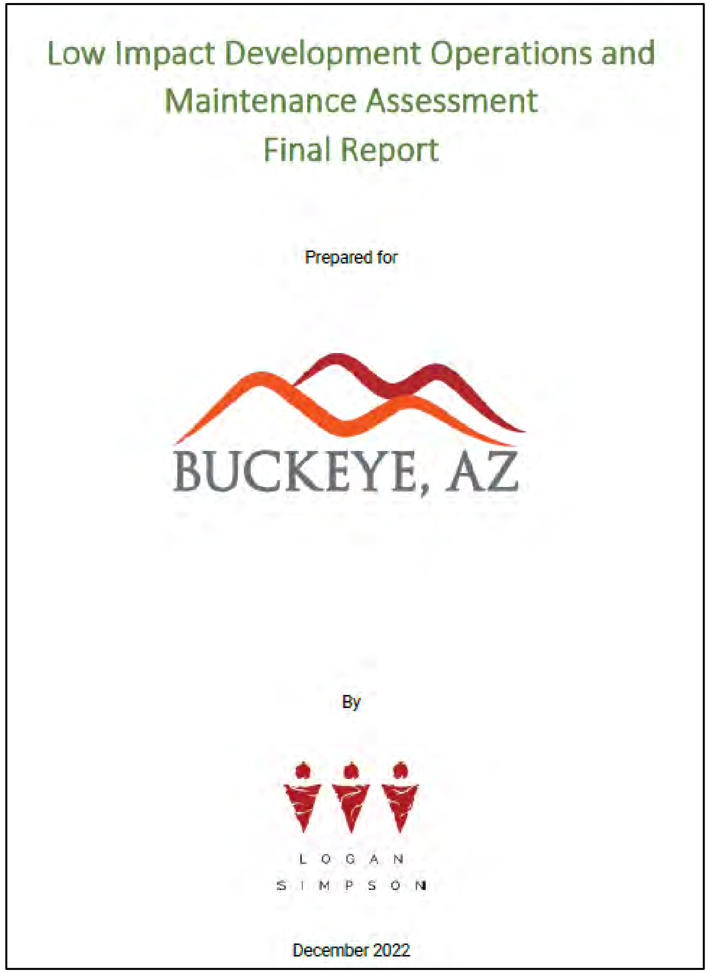
LID Operation and Maintenance (O&M) Assessment

- Use of LID for stormwater management is increasing in the Phoenix metropolitan region.
- LID are typically installed to:
  - augment conventional stormwater infrastructure
  - infiltrate to reduce stormwater runoff
  - optimize stormwater management and promote multiple benefits
  - use stormwater instead of potable water to support native/arid vegetation
  - enhance local water resources
- LID provides multi-beneficial cost-effective stormwater management to optimize water resource use.
- There is uncertainty about LID O&M requirements and costs.

FCDMC – Durango Campus

LID O&M Assessment – Objectives

- Literature search: LID O&M practices and costs in arid regions.
- Identify entities in Phoenix Metropolitan Area and other applicable regions with existing LID features.
- Pre-interviews: Contact entities with installed LID features and assess their LID O&M practices, costs, and record-keeping.
- Formal Interviews: Interview knowledgeable individuals regarding the entity's LID O&M practices, costs, and record-keeping.
- Compile and summarize interview results and prepare final report.



LID O&M Assessment – Formal Interviews

- 25 entities contacted
- 20 entities responded (pre-interviews)
- 7 formal interviews conducted with:
  - City of Buckeye
  - City of Scottsdale
  - City of Tempe
  - City of Mesa
  - City of Glendale
  - Flood Control District of Maricopa County
  - Watershed Management Group

Section 5 – Specific LID Cost/Maintenance Data

To be able to develop meaningful information about O&M costs and practices, we need to gather information about cases in which you have installed LID features.

1. Project 1 Name
   - 1.1. What is the project's location?
   - 1.2. What LID features does it contain? *(Please refer to the "Examples of LID Features" document you received before the interview.)*
     - 1.2.1. Feature 1
     - 1.2.2. Feature 2
     - 1.2.3. Feature 3
     - 1.2.4. Feature 4
   - 1.3. When was the project installed?
     - 1.3.1. 0 - 2 years
     - 1.3.2. 3 - 5 years
     - 1.3.3. 6 - 9 years
     - 1.3.4. 10+ years

Standard O&M

1. Feature 1 Name
2. Does Feature 1 contain vegetation?
   - 2.1. No
   - 2.2. Yes
     - 2.2.1. Would you say that Feature 1 contains a low, average, or above-average number of plants or plant cover?
     - 2.2.2. Would you say that the type of vegetation in Feature 1 is high-maintenance or low-maintenance?
     - 2.2.3. Do the plants in Feature 1 receive supplemental irrigation?
3. Site visit frequency for Feature 1
   - 3.1. Weekly
   - 3.2. Biweekly
   - 3.3. Monthly
   - 3.4. Quarterly
   - 3.5. No set time frame
   - 3.6. Other *(please describe)*
4. What are the top 3 – 4 tasks required to maintain Feature 1? *(please describe)*

LID O&M Assessment – Interview Results

- LID O&M practices and costs for existing features (of the seven interviewed entities):
  - Have minimal to no specific LID O&M practices
  - Do not monitor LID O&M
  - Do not maintain LID O&M records
- This study was unable to develop any level of estimated costs for LID O&M.
- Few entities track the location of LID features and projects.
- Few maintenance staff receive specific LID O&M training.
- Generally, conventional O&M and landscape practices are applied to LID O&M.
- There is an awareness of the need to identify LID O&M costs and practices.

LID O&M Assessment – Conclusions

- Primary LID complaint
  - o LID features installed in the right of way (ROW) may collect more trash on busy streets and roadways.
- No failures or outstanding LID O&M requirements or issues were identified
  - o No complaints regarding LID function
  - o LID manage stormwater as intended

Photo credit: FCDMC – *Durango Campus*

LID O&M Assessment – Additional Conclusions

City of Phoenix

- Site conditions influence LID O&M practices
  - LID installed in high pedestrian traffic areas may require higher aesthetics and more maintenance.
  - LID will function best when site specific designs and O&M requirements are identified.
- LID maintenance issues
  - LID O&M is typically wrongly maintained using conventional maintenance practices.
  - Original LID-specific vegetation may not be maintained or replaced appropriately.
  - Entities rarely inform and educate staff regarding their LID installations.
  - Staff/contractors may not be aware of LID-specific O&M requirements.
  - LID O&M costs are not segregated from conventional maintenance costs and are not recorded.

LID O&M Assessment – LID Optimization

To optimize the function and aesthetics of existing and new LID installations:

- Include site-specific installation and maintenance requirements in LID designs.
- Educate staff on LID installations, O&M practices, and landscape needs.
- Develop an LID O&M reference manual.
- Identify coordinates for LID features/project locations and show on maps.
- Use LID signage to inform and educate staff and public.
- Isolate LID O&M requirements and costs.
- Monitor and maintain records of weekly, monthly, and annual LID O&M.
- Analyze LID O&M requirements and costs for future planning.

Photo credit: City of Phoenix – Taylor Mall

City of Buckeye
Low Impact Development Design Manual

Figure 3. City of Buckeye

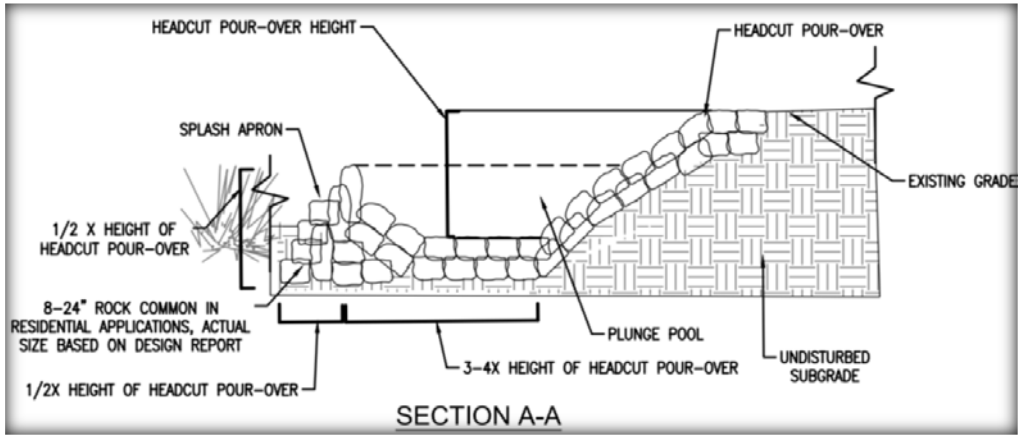


Figure 1. Zuni Bowl (Sikdar, 2019)

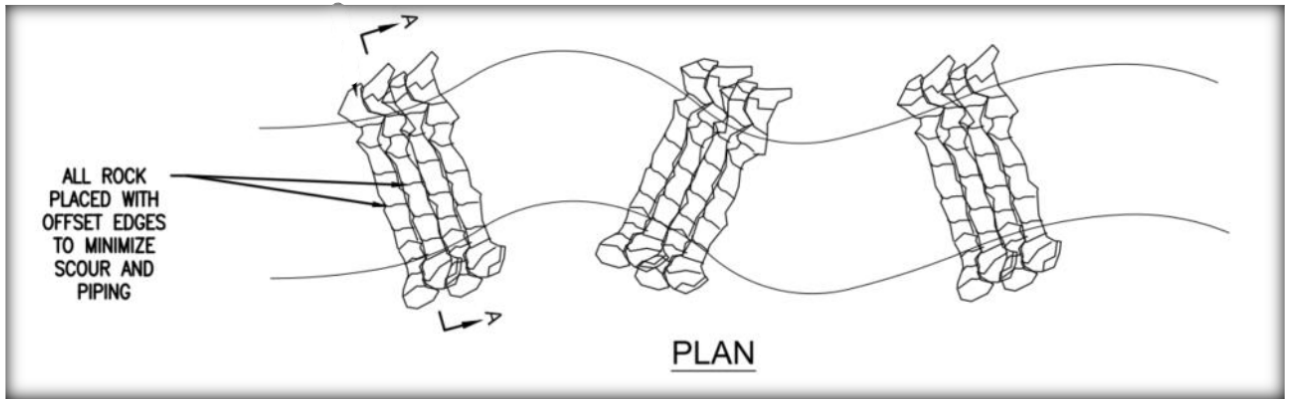
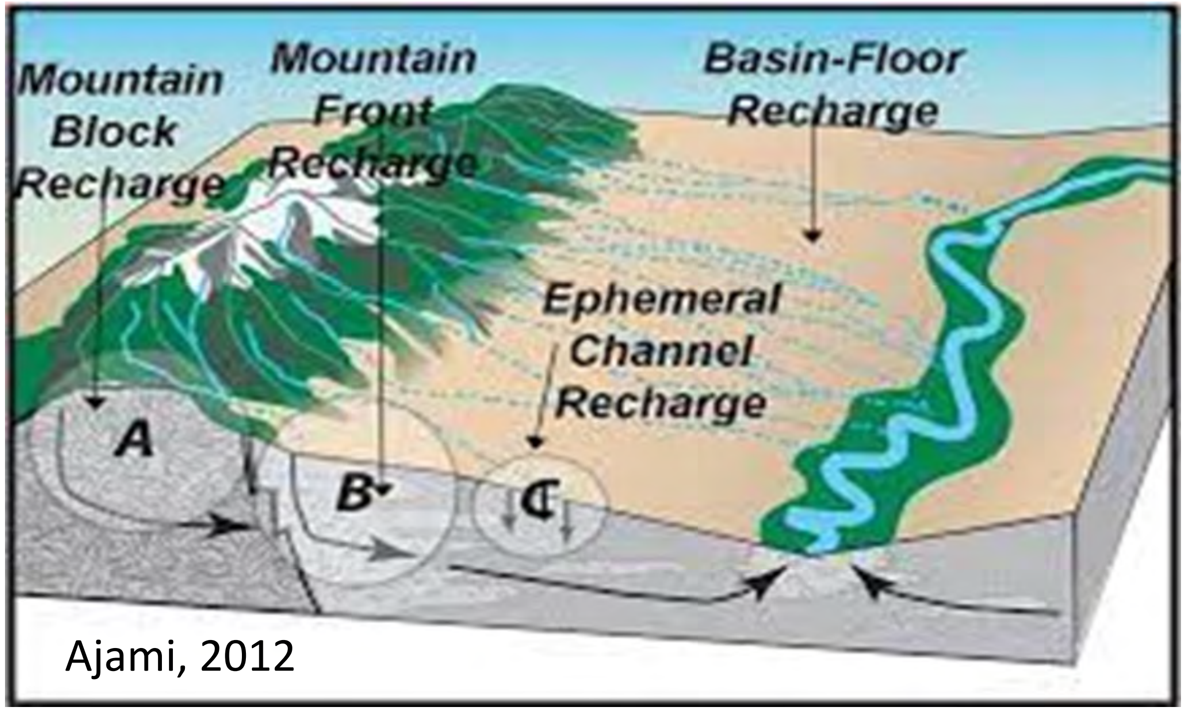


Figure 2. One Rock Dam (Sikdar, 2019)

Conceptual Water Budget

- Purpose: Compare potential changes in infiltration and groundwater recharge conditions for GSI and CSI management scenarios.
- Value to the study is advancing our knowledge of the effects of GSI on local aquifers and groundwater resources.



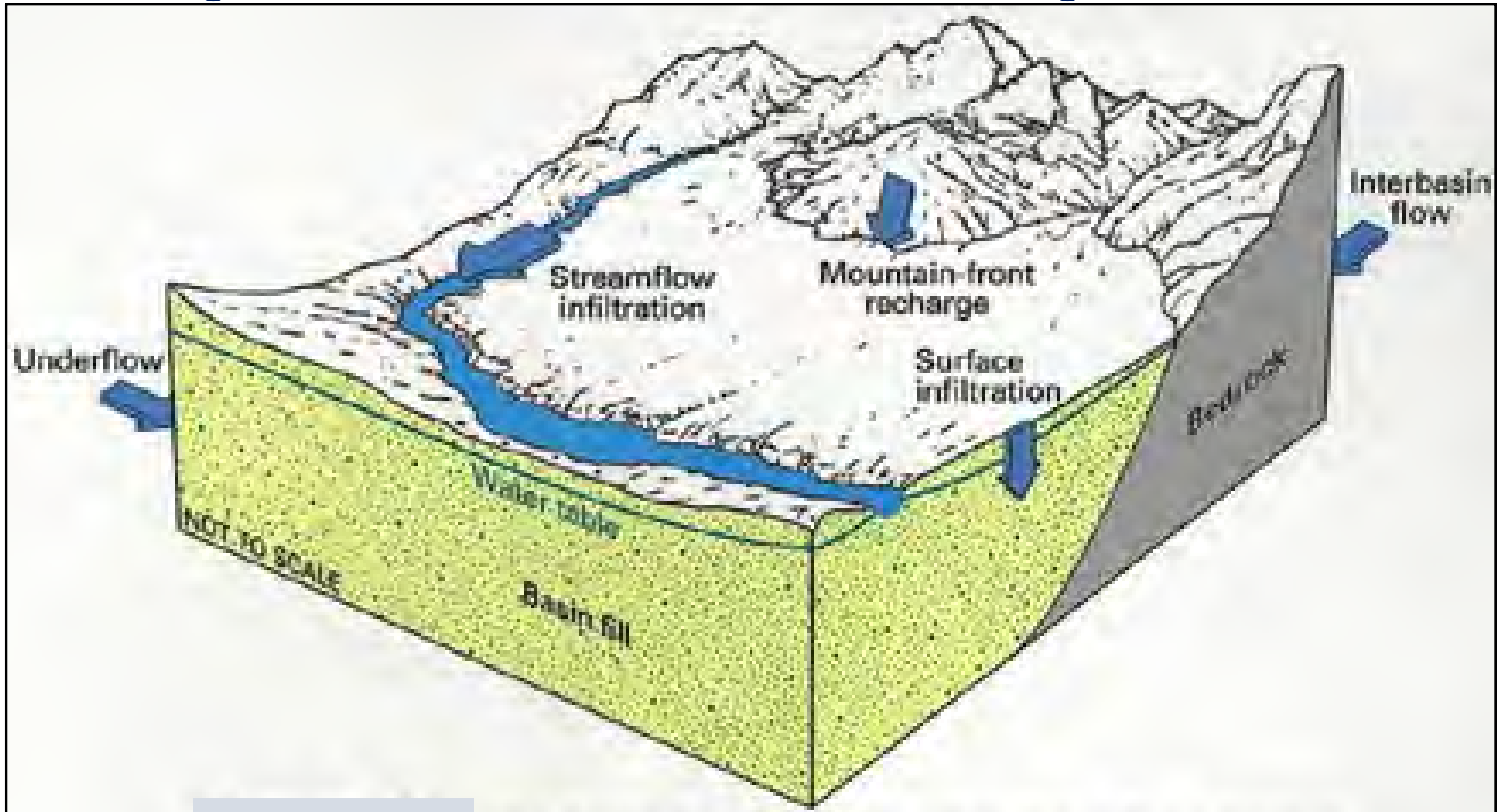
Ajami, 2012

State of Michigan, 2010

Water Budget Equation: Change in storage = Inflow - Outflow

Conceptual Water Budget – Basin and Range

In Basin and Range aquifers, streamflow infiltration is the largest component of groundwater recharge and mountain front recharge is the second largest.



USGS

The Basin and Range aquifers have five principal components of ground-water recharge. Streamflow infiltration is the largest component; mountain-front recharge is the second largest.

Source: USGS GROUND WATER ATLAS of the UNITED STATES Arizona, Colorado, New Mexico, Utah HA 730-C

Conceptual Water Budget – Equation

Water Budget Equation

$\Delta S = P + Q_{in} - ET - Q_{out}$

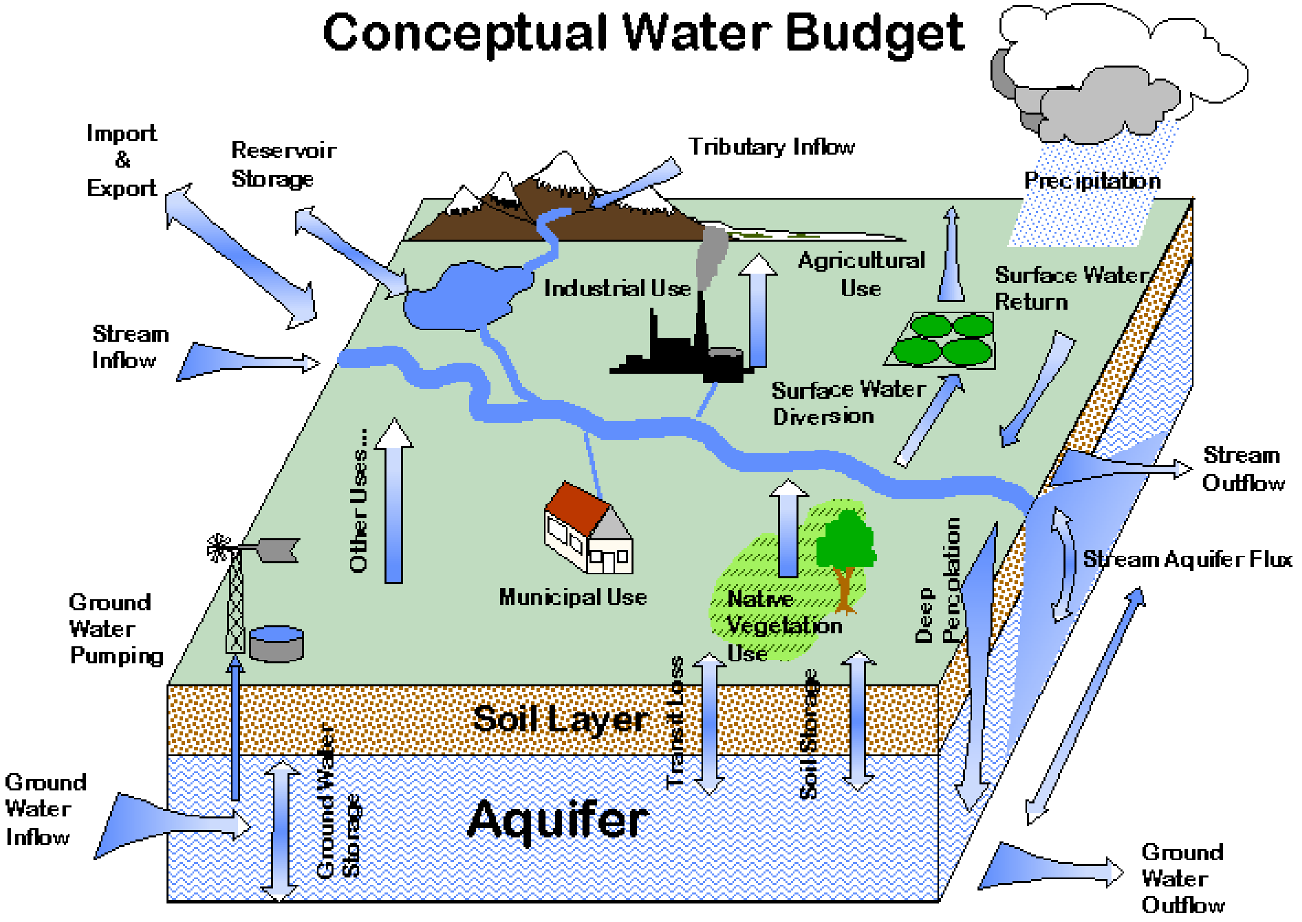
ΔS is change in water storage,

P is precipitation,

Q_{in} is water flow into the area (for an aquifer its recharge),

ET is evapotranspiration (sum of evaporation from soils, surface-water bodies, and plants),

Q_{out} is water flow out of the watershed.



From: USGS "Water Budgets: Foundations for Effective Water-Resources Management"

Conceptual Water Budget – Formulation

- The conceptual water budget for this study will include data such as:
  - Existing and inferred baseline infiltration rates
  - Surface water modeling results for GSI infiltration rates for the hypothetical development and regional watershed scenarios
  - Surface water modeling results for CSI infiltration rates for the hypothetical development and regional watershed scenarios
  - Local precipitation
  - Local groundwater pumping data
  - Local streamflow
- We are exploring our ability to extrapolate the conceptual water budget beyond alluvial fan #3 to a larger area.

Hassayampa River Study – Next Steps

- Finish surface water modeling
  - Hypothetical developments
  - Regional watershed
- Prepare Buckeye LID Design Manual
- Complete water budget
- Prepare final report, projected November 2023

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BUREAU OF RECLAMATION