Site Design and Green Infrastructure for Changing Weather Patterns

Green Infrastructure Isn't just for Stormwater Management

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Uconn Middlesex County Extension Center
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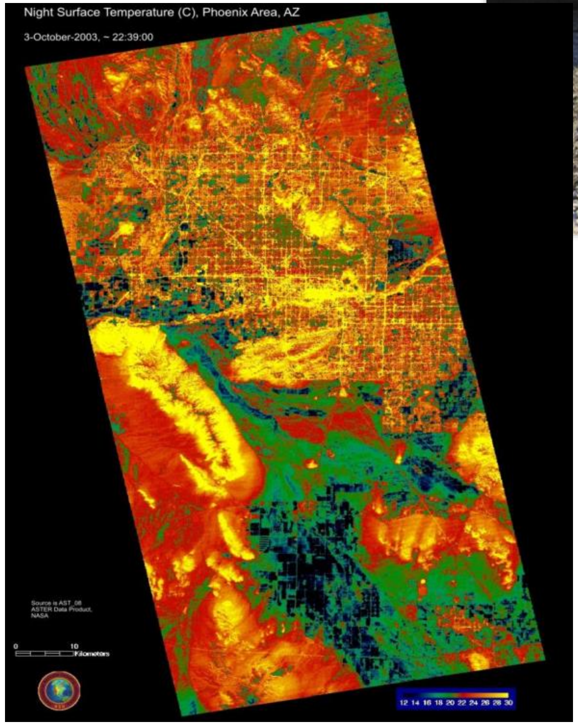
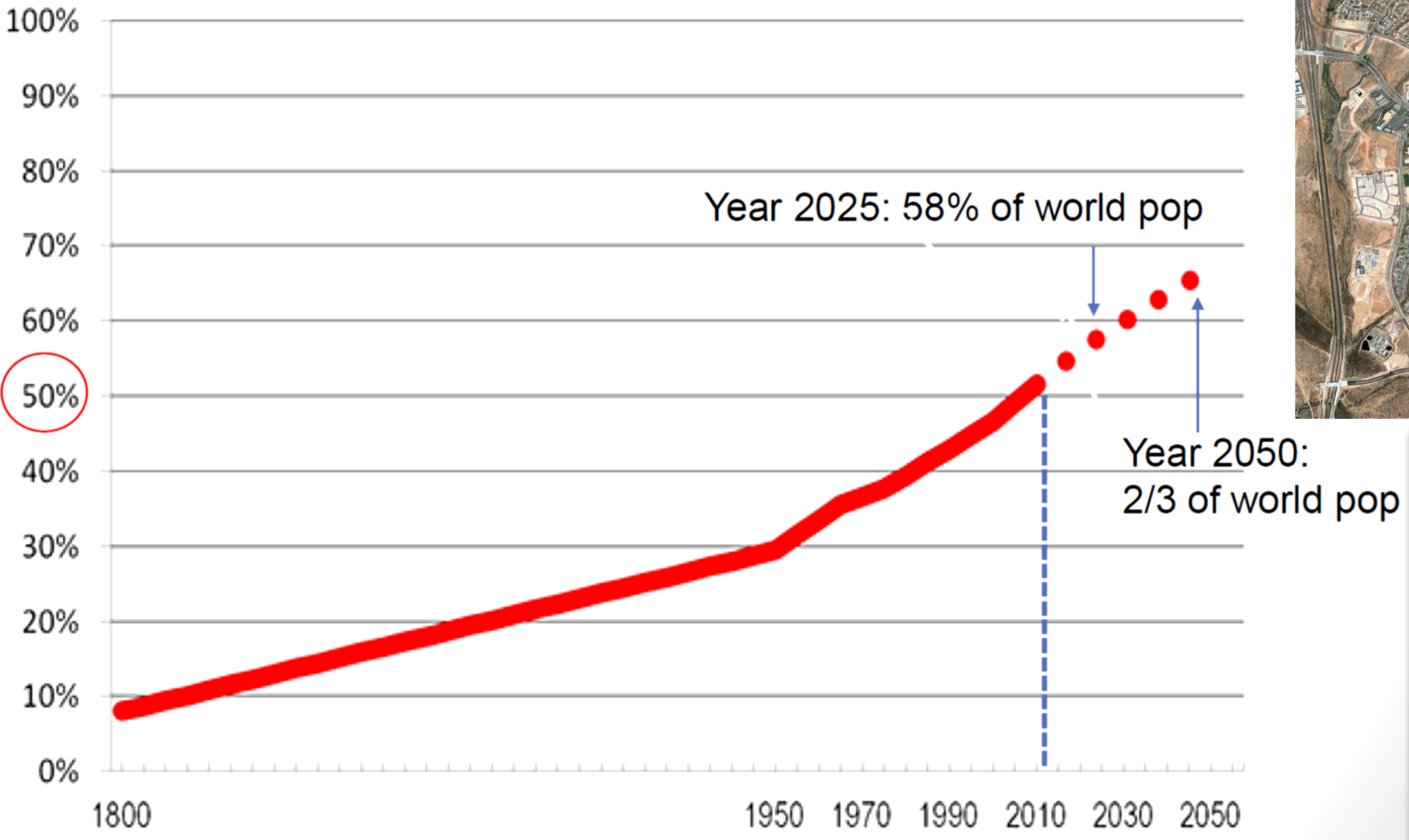
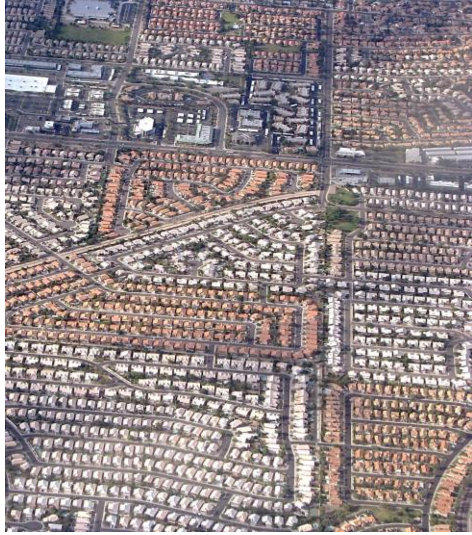
WRONG WAY

Night Surface Temperature (C), Phoenix Area, AZ
3-October-2003, ~ 22:39:00

The Water
is
Rising
Pleas

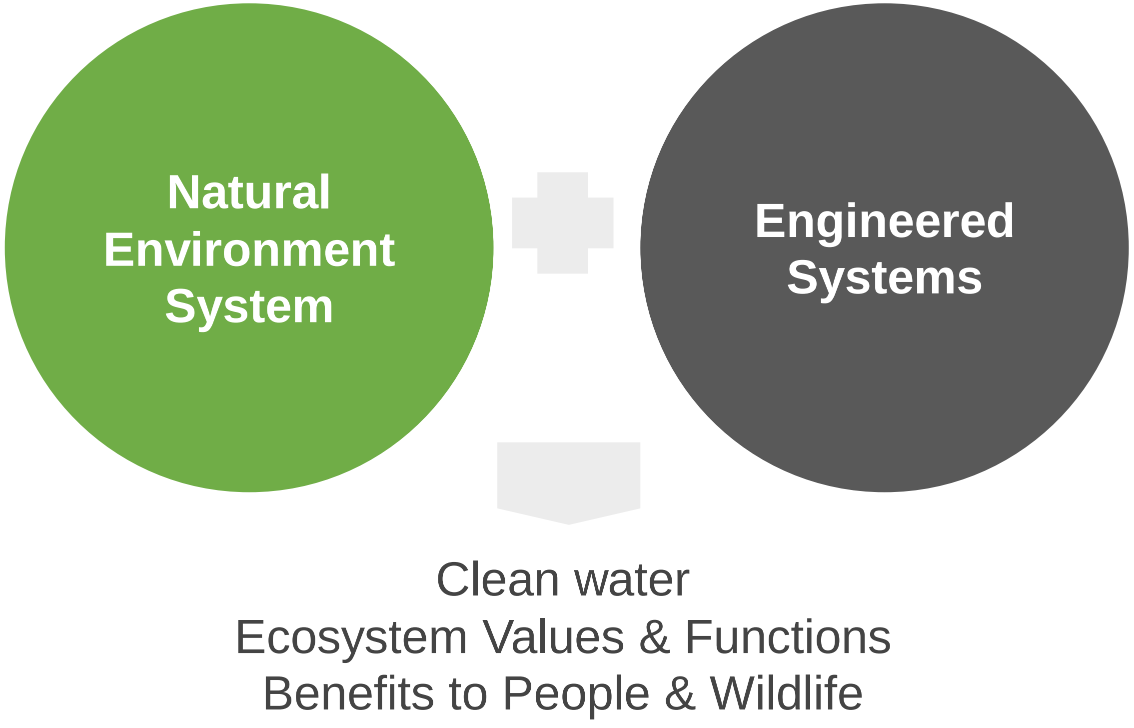
World Population: Urban Share
1800 - 2050





GI is defined as…

- Cost-effective, resilient approach to managing wet weather impacts that provides many community benefits (U.S. EPA)
- An approach to water management that protects, restores, or mimics the natural water cycle



Traditional Solutions (hard engineering)	**Natural Solutions** (soft engineering)
Building costly new water treatment plant	**Planting trees and restoring wetlands**
Building a new water supply dam	**Choosing water efficiency**
Building taller levees	**Restoring floodplains**

GI in U.S. Context

1972: Clean Air Act

1987: Amendments to the U.S. Clean Water Act

New provisions for management of diffuse pollutant sources from urban land uses; Regulatory need for practices that, unlike conventional drainage infrastructure, managed runoff at source.

1990: EPA regulations for municipalities

Development of stormwater pollution prevention plans and the implementation of "source control practices“; EPA's 1993 handbook identified BMPs including vegetative controls, filtration practices and infiltration practices (trenches, porous pavement).

1994 Term GI Coined in Florida

In a report to the governor on land conservation strategies, the term was intended to reflect the notion that natural systems are equally, if not more, important components of our “infrastructure.”

2007 EPA use of the term GI as BMPs for LID

GI as built structures for stormwater management; Low impact development (LID) as a design strategy for maintaining and replicating predevelopment hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic site design

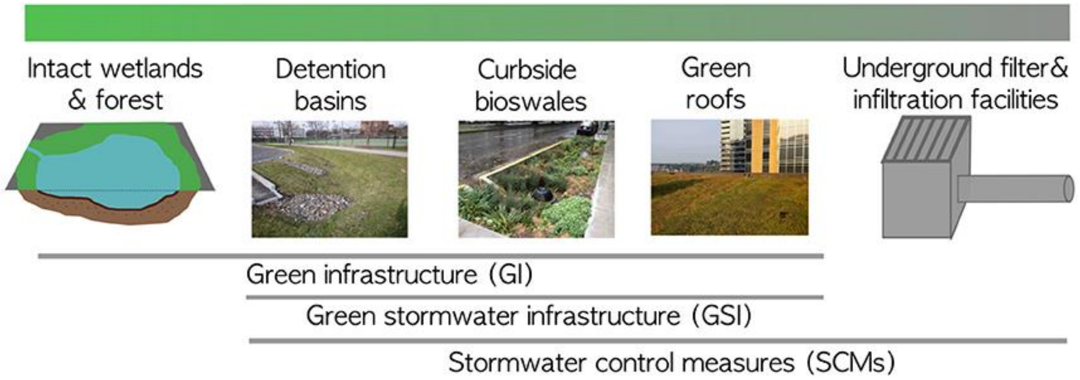
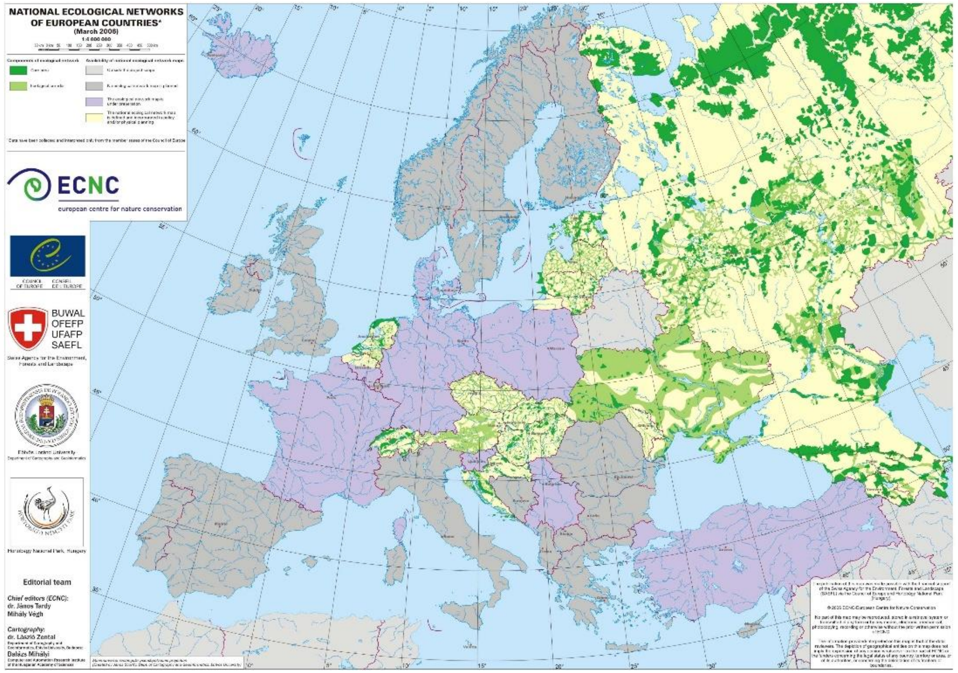


Image Credit: McPhillips & Matsler (2018)

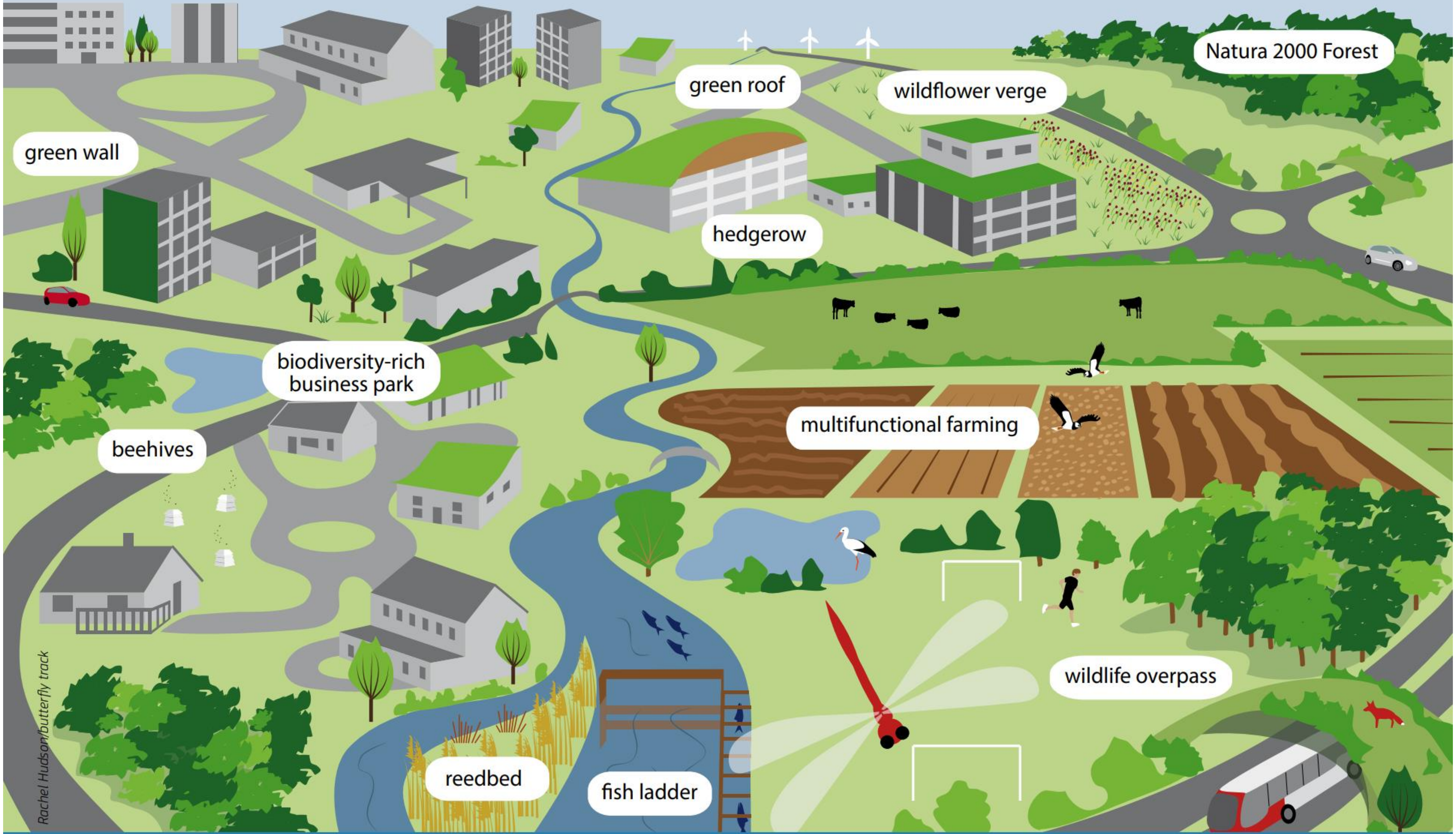
GI in European Context

- A strategically planned **network of natural and semi-natural areas** with other environmental features designed and managed to deliver a wide range of **ecosystem services**' in both **rural and urban** settings (European Commission, 2013)

- GI is based on the principle that 'protecting and enhancing nature and natural processes that are consciously integrated into **spatial planning** and **territorial development** (European Commission, 2013)



Pan-European Ecological Network (PEEN)



Potential components of a Green Infrastructure

Ecosystem Services

"The benefits people obtain from ecosystems"

Image Credit: Danielle D Pieranunzi

GI in Practice

Rain Garden
Bioretention
Detention pond
Bioswale
Dry swale
Filter strip
Vegetated roof
Vegetated wall
Pervious paving
Rainwater harvesting

Riparian buffer
Tree box filter
Surface sand filter
Underground sand filter
Infiltration trench
Infiltration basin
Constructed wetland

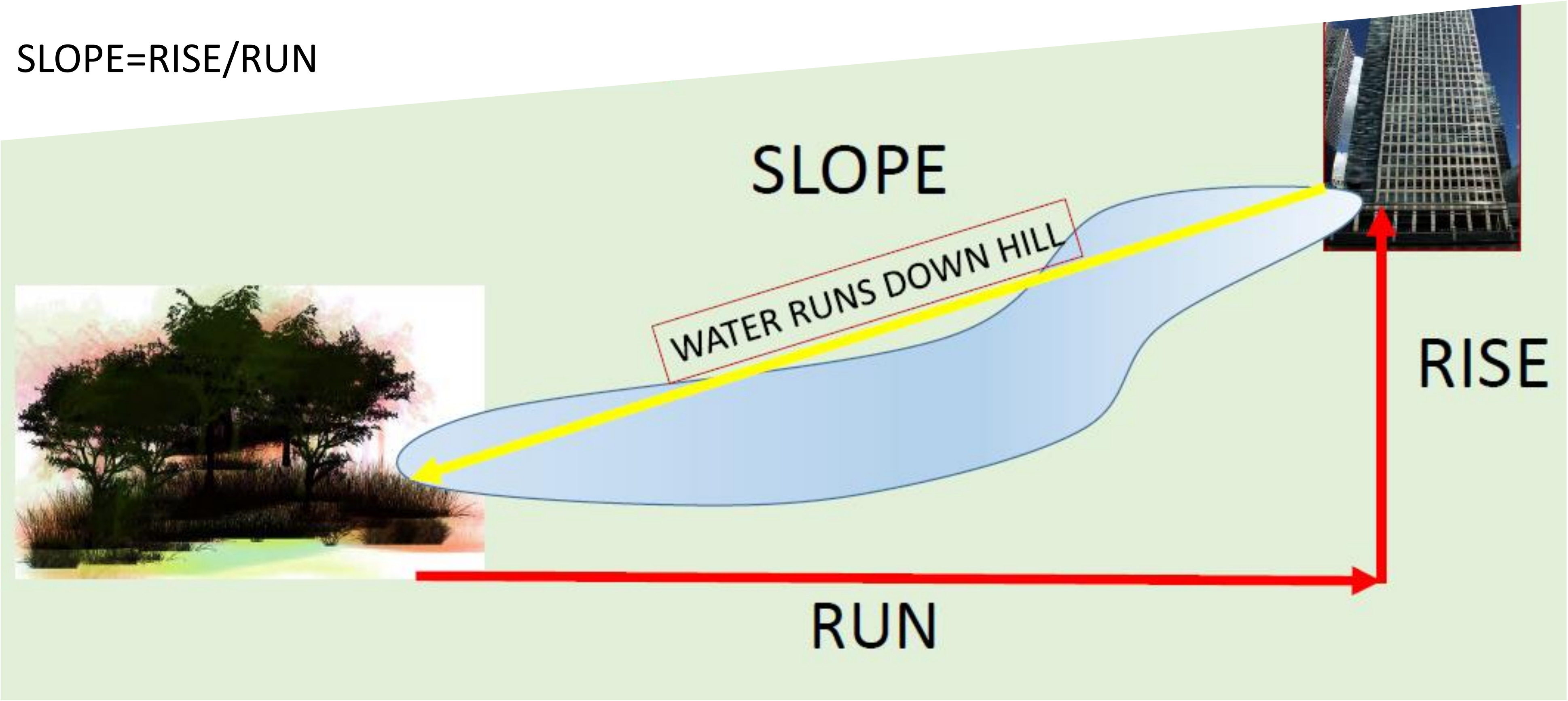






Swales vs Bioswales

SLOPE=RISE/RUN



BIOSWALE

Slope: 2%-10% for grassed swales




BIORETENTION

Process in which contaminants, sediments, and excessive flows from stormwater are collected

Through a process of infiltration water is cleaned and returned to the ground water or sent along in a stormwater mitigation chain.

Water can persist in a retention situation permanently; compared to detention, where the water should drain out within 24 to 48 hours

Detention VS. Retention

DETENTION

Temporary = Dry Pond

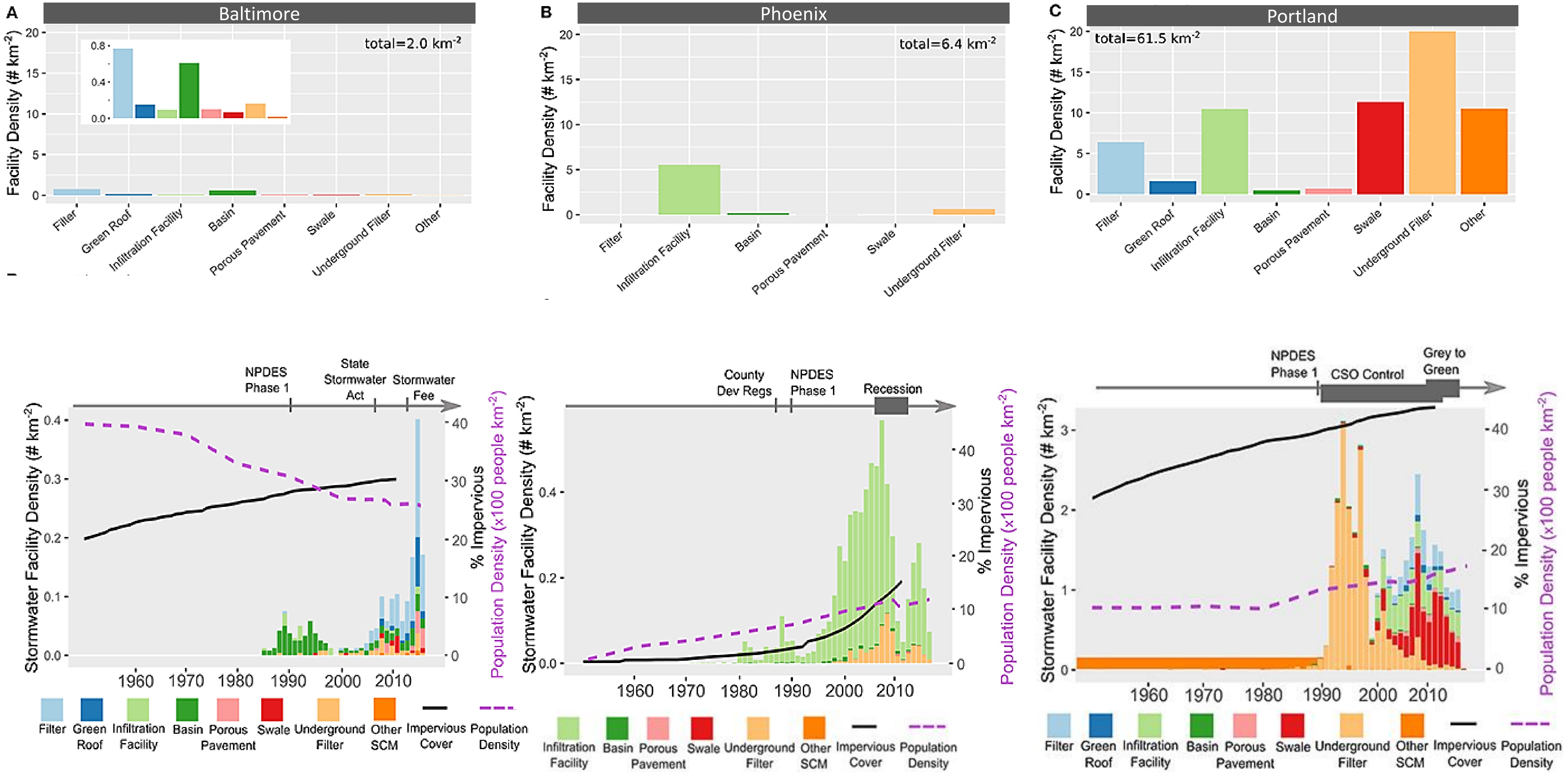
RETENTION

More permanent = Wet Pond

DETENTION

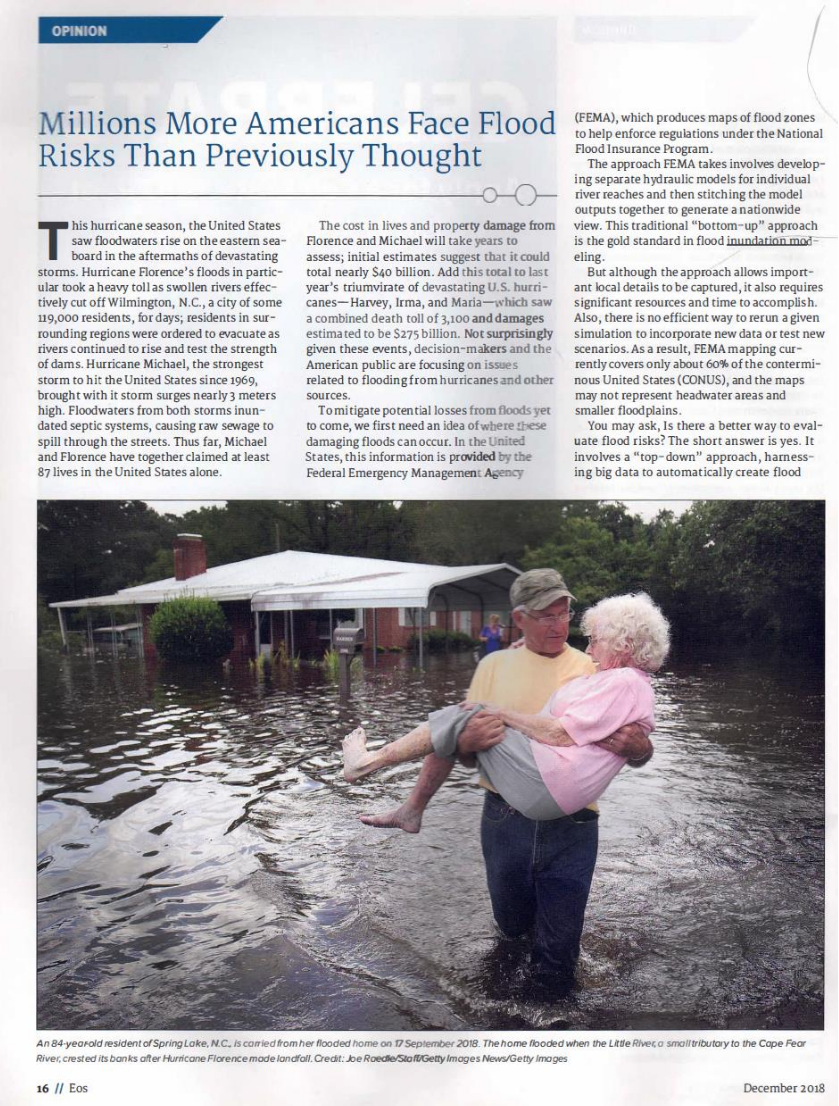
RETENTION

Slope: 25% on grassed banks for detention basins



Source: McPhilliips & Matsler (2018)

People Exposed At Risk of 100-yr Flood



OPINION

Millions More Americans Face Flood Risks Than Previously Thought

This hurricane season, the United States saw floodwaters rise on the eastern seaboard in the aftermaths of devastating storms. Hurricane Florence's floods in particular took a heavy toll as swollen rivers effectively cut off Wilmington, N.C., a city of some 119,000 residents, for days; residents in surrounding regions were ordered to evacuate as rivers continued to rise and test the strength of dams. Hurricane Michael, the strongest storm to hit the United States since 1969, brought with it storm surges nearly 3 meters high. Floodwaters from both storms inundated septic systems, causing raw sewage to spill through the streets. Thus far, Michael and Florence have together claimed at least 87 lives in the United States alone.

The cost in lives and property damage from Florence and Michael will take years to assess; initial estimates suggest that it could total nearly $40 billion. Add this total to last year's triumvirate of devastating U.S. hurricanes—Harvey, Irma, and Maria—which saw a combined death toll of 3,100 and damages estimated to be $275 billion. Not surprisingly given these events, decision-makers and the American public are focusing on issues related to flooding from hurricanes and other sources.

To mitigate potential losses from floods yet to come, we first need an idea of where these damaging floods can occur. In the United States, this information is provided by the Federal Emergency Management Agency (FEMA), which produces maps of flood zones to help enforce regulations under the National Flood Insurance Program.

The approach FEMA takes involves developing separate hydraulic models for individual river reaches and then stitching the model outputs together to generate a nationwide view. This traditional "bottom-up" approach is the gold standard in flood inundation modeling.

But although the approach allows important local details to be captured, it also requires significant resources and time to accomplish. Also, there is no efficient way to rerun a given simulation to incorporate new data or test new scenarios. As a result, FEMA mapping currently covers only about 60% of the conterminous United States (CONUS), and the maps may not represent headwater areas and smaller floodplains.

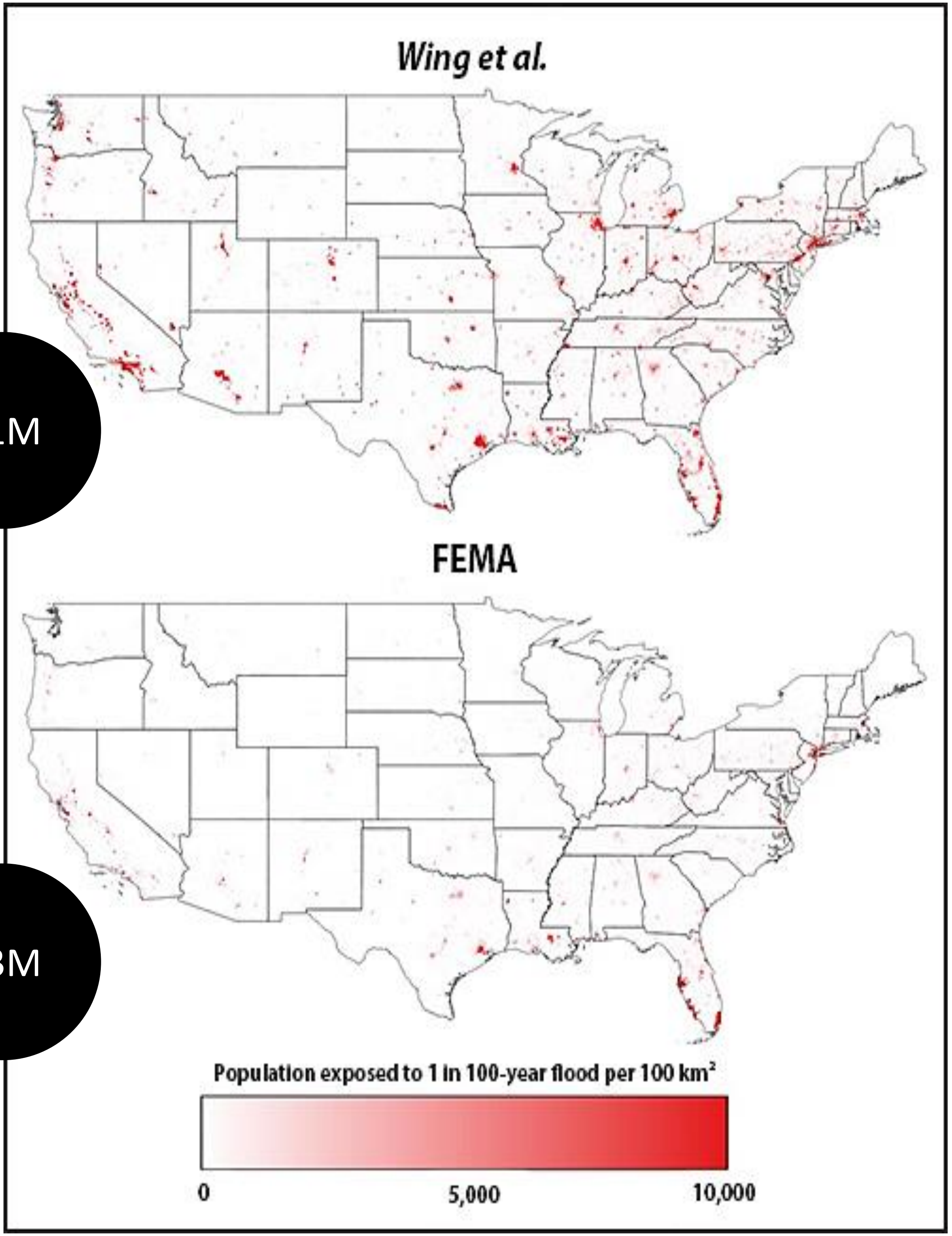
You may ask, Is there a better way to evaluate flood risks? The short answer is yes. It involves a "top-down" approach, harnessing big data to automatically create flood

An 84-year-old resident of Spring Lake, N.C., is carried from her flooded home on 17 September 2018. The home flooded when the Little River, a small tributary to the Cape Fear River, crested its banks after Hurricane Florence made landfall. Credit: Joe Roedle/Staff/Getty Images News/Getty Images

16 // Eos December 2018

41M

13M



Green Infrastructure in Red Zones

How would communities be resilient?

Ecosystem resilience

Would the plants thrive?

Multifunctionality & GI Co-Benefits

Environmental Benefit

- Clean water
- Removal of air/water pollutants
- Pollination enhancement
- Protection against soil erosion
- Rainwater retention
- Increased pest control
- Improvement of land quality
- Mitigation of land take and soil sealing

Climate Change Adaptation /Mitigation Benefits

- Flood alleviation
- Strengthening ecosystem resilience
- Carbon storage and sequestration
- Migration of urban heat island effects
- Disaster prevention (storms, forest fires, landslides)

Social Benefits

- Human health and well-being
- Job creation
- Diversification of local economy
- Attractive, greener cities
- Higher property values
- Integrated transport/energy solutions
- Enhanced tourism/recreation opportunities

Biodiversity Benefits

- Improved habitats for wildlife
- Ecological corridors
- Landscape permeability

The Southwest

Arid environment
Sonoran Desert
Xeriscape

The Southwest

THE UNIVERSITY OF ARIZONA UNDERWOOD FAMILY SONORAN LABORATORY

A model of water-conscious design

ARIZONA STATE UNIVERSITY BIODESIGN INSTITUTE

Image Credits: Ten Eyck Landscape Architects

Biodiversity
Permeability
Judicious use of hardscape

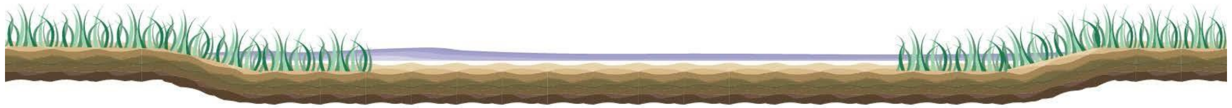
The South - NW Texas

- Panhandle Plains
- Dry Steppe
- Flat
- Playa system
- Local flooding
- Dust
- Drought

How Do Playa Lakes Currently Function?

- Catch runoff that collects in low spots.
- Naturally restore capacity by evaporation or infiltration –slow process.
- Some overflow to the next downstream playa in larger rainfall events.
- Some lakes do not overflow even in a 0.2% chance annual rainfall event.

Forgotten Ecosystem Services

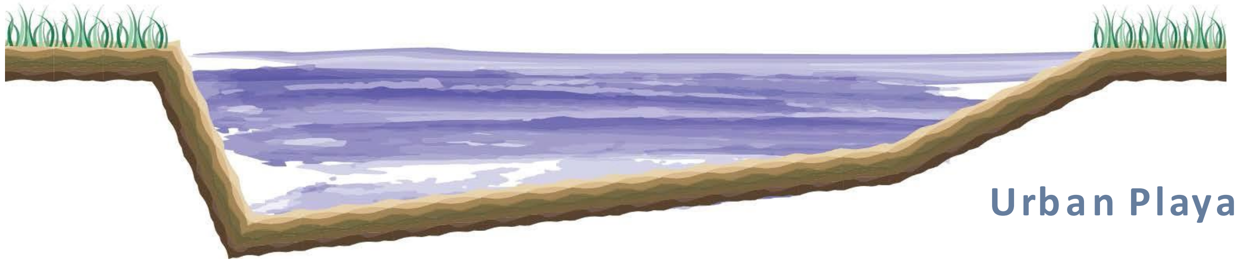


Seasonal wet/dry cycles that encourage diversity of plants to support wildlife

Filtration/Nutrient uptake/Phytoremediation

Marginal habitat

Altered Form

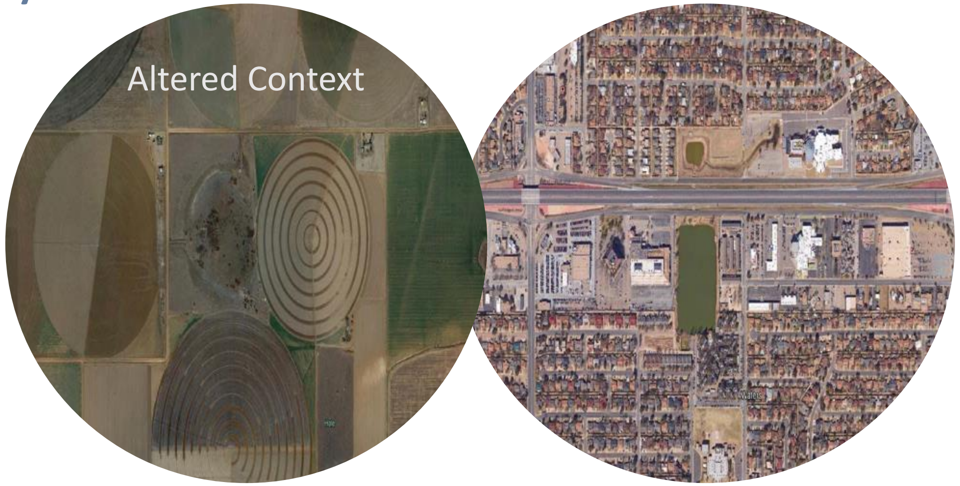


Concentrated Pollution

Increased Erosion

Increased opportunity for longer-period wet cycles

Urban Playas



May 2015 Storm Event

Sohyun Park
May 4, 2015 ·

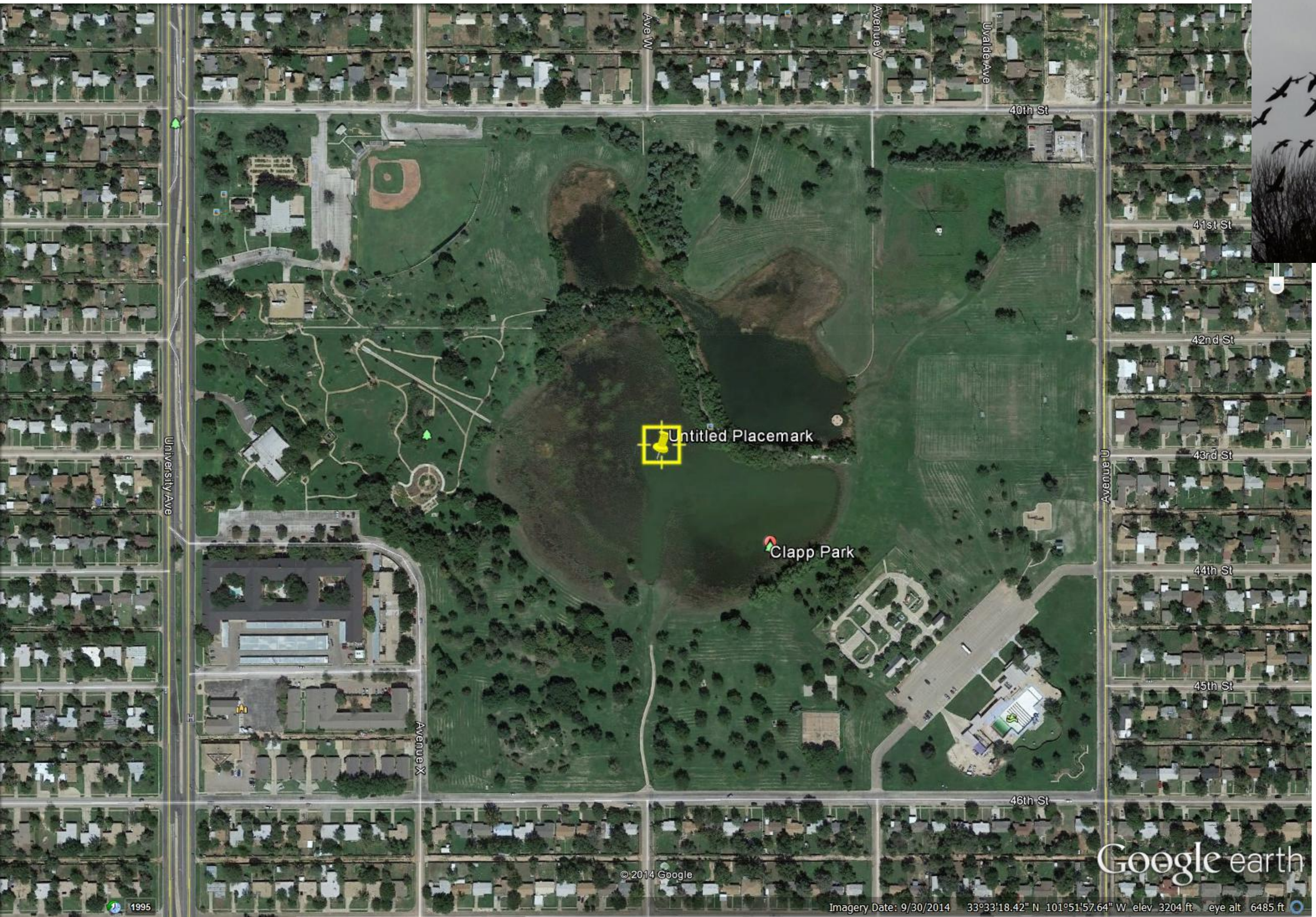
We may have a torrential downpour, lighting and thunderstorm but how much we should be patient with chronic flooding in this city? How long should we aquaplane, see stopped vehicles in the middle of a street, be surrounded by an incessant ambulance siren, and roll up trousers to walk on the campus? Total chaos!

City planners and engineers, can't we really think of any alternatives other than the playa system?

https://www.facebook.com/hannah.mulloy1/videos/10206712380354465/

Lubbock Arboretum Clapp Playa Lake Park

111 acres of the entire project area: 93 acres of park and 18 acres of two playa lakes bisected by the walking path across it

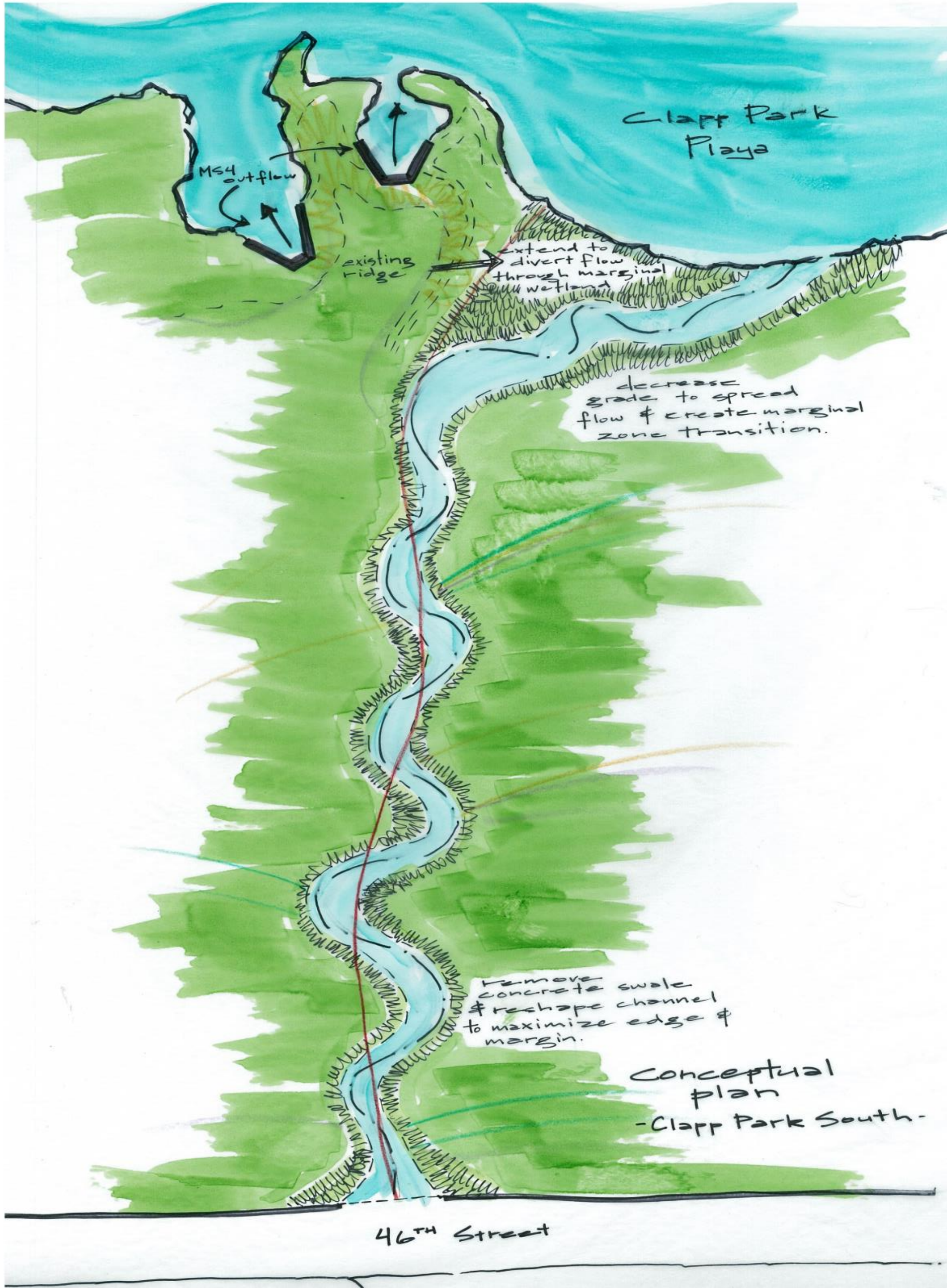


RESTORATION PARTNERSHIP Proposal

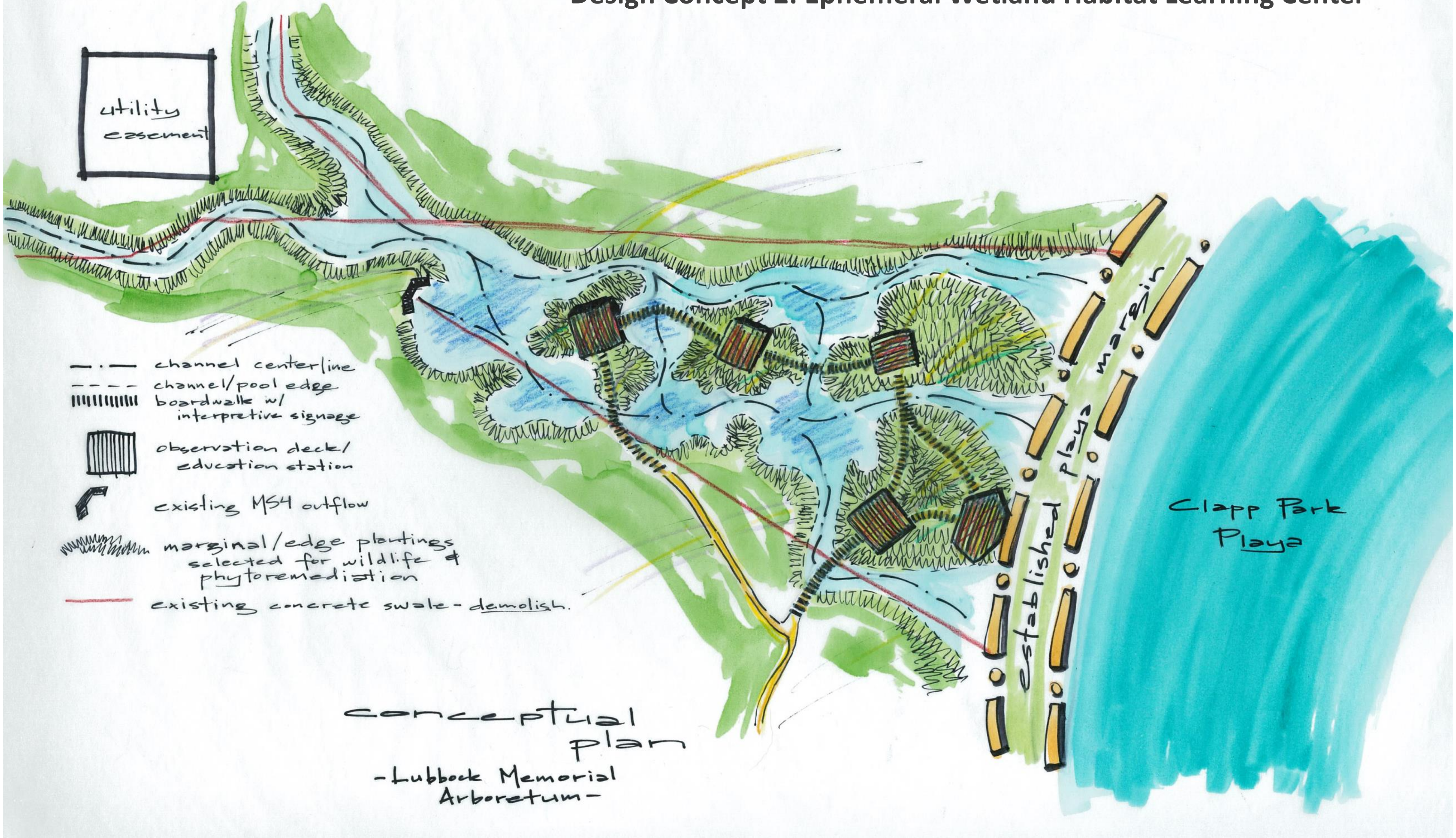
- Removing litter
- Planting native seedlings
- Restoration planning and design
- Designing and **implementing bioswales with vegetated buffers**
- Sampling for water and sediment quality
- Assessing water and sediment quality using bioassays
- Macro-invertebrate sampling


OF 4223

Design Concept 1: Swale Removal & Revegetation



Design Concept 2: Ephemeral Wetland Habitat Learning Center




Conflicting Values between Storm Water Management and Ecological Integrity in Urban Playa Lakes
Challenges to Change
-or-
"Taxpayers paid for that concrete."

UTEP (El Paso, TX)

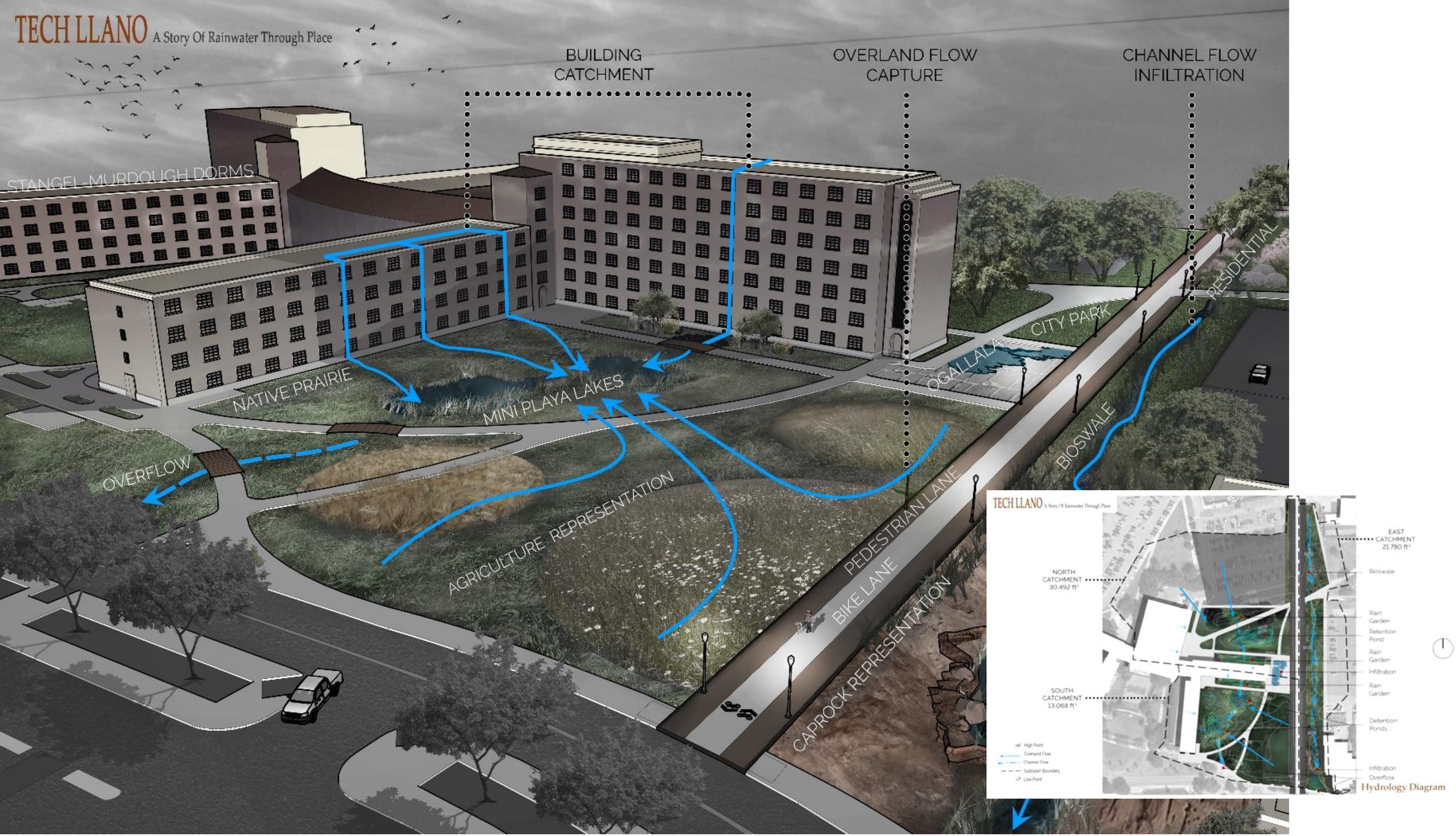

Image Credits: Ten Eyck Landscape Architects

Image Credits: Ten Eyck Landscape Architects

Image Credits: Ten Eyck Landscape Architects

GI Site Design Cases


TECH LLANO
A Story Of Rainwater Through Place
The functional concept of the Llano Estacado, paired with the visual concept of a road trip on the Llano, provides a unique regional context to green infra-structure implementation while educating the public about the unique aspects of the region.



Hydrology Diagram

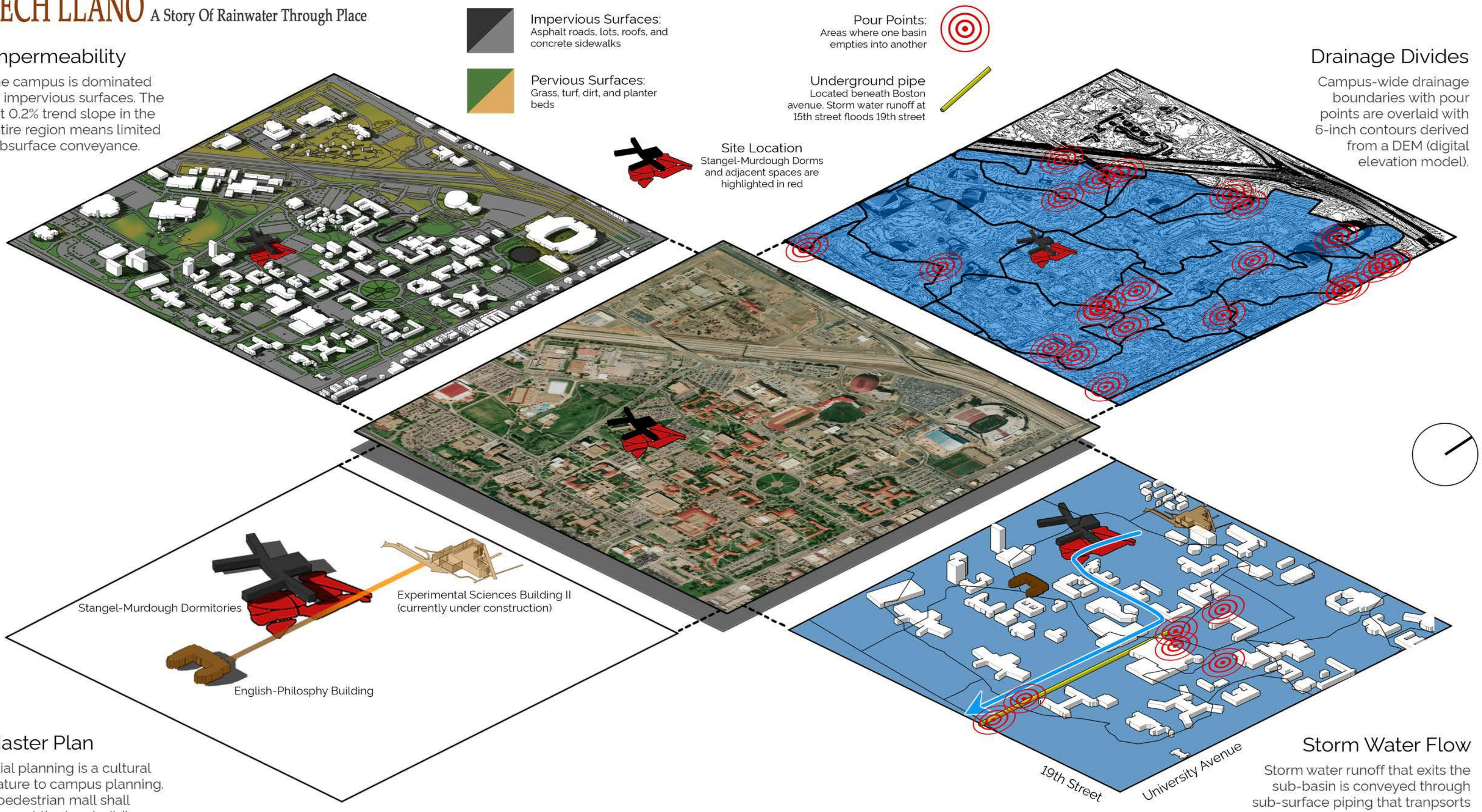
TECH LLANO A Story Of Rainwater Through Place

Impermeability

The campus is dominated by impervious surfaces. The flat 0.2% trend slope in the entire region means limited subsurface conveyance.

Drainage Divides

Campus-wide drainage boundaries with pour points are overlaid with 6-inch contours derived from a DEM (digital elevation model).



Master Plan

Axial planning is a cultural feature to campus planning. A pedestrian mall shall connect the two buildings while intersecting the spaces of Stangel-Murdough.

Storm Water Flow

Storm water runoff that exits the sub-basin is conveyed through sub-surface piping that tranpsorts runoff into 19th street.

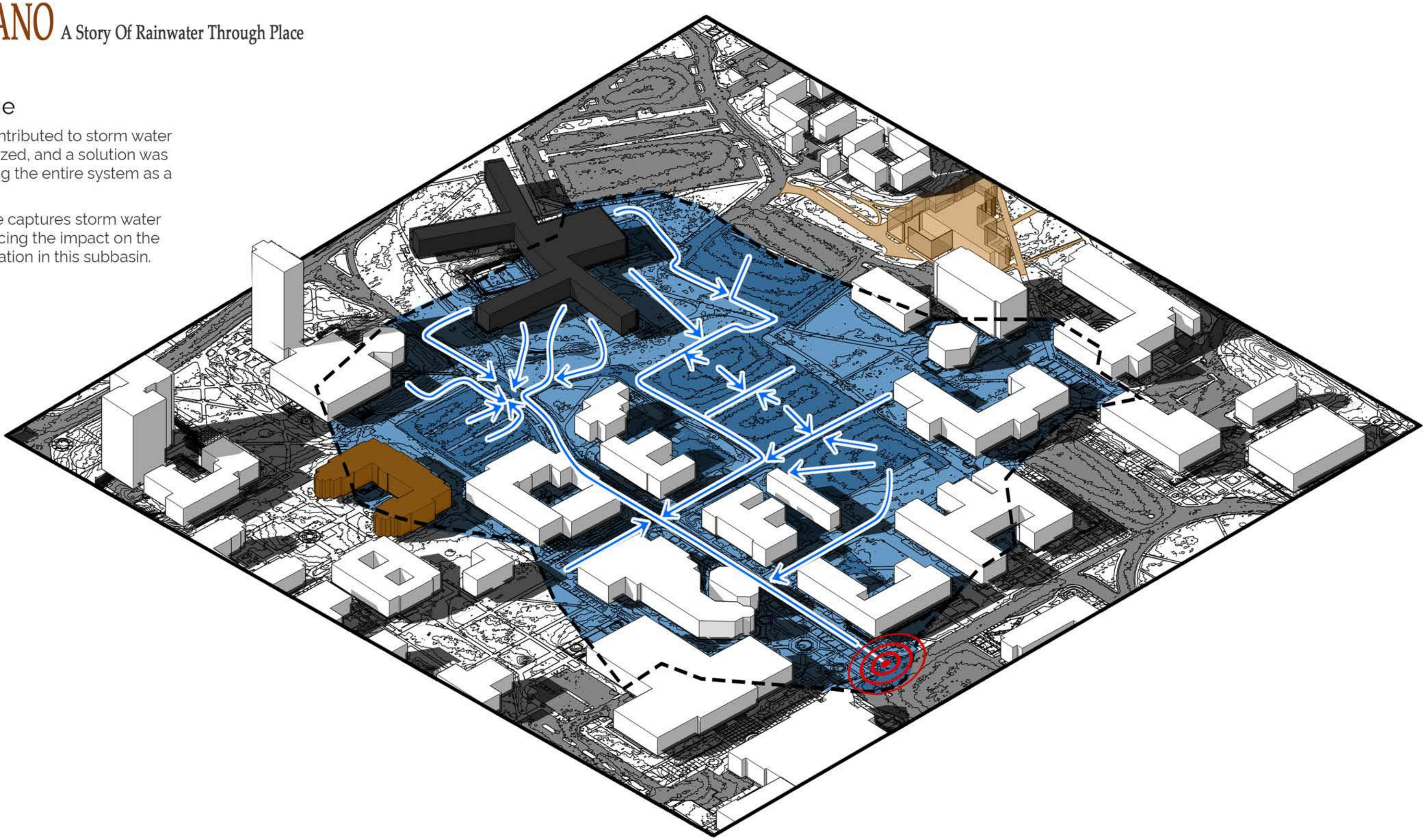
Site Inventory and Analysis

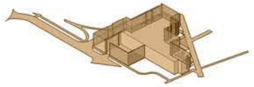
TECH LLANO A Story Of Rainwater Through Place

Site Drainage

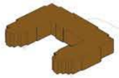
Elements that contributed to storm water runoff were analyzed, and a solution was derived by viewing the entire system as a whole.

The designed site captures storm water runoff, thus, reducing the impact on the point of concentration in this subbasin.

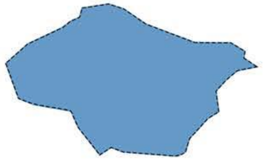




Experimental Sciences Building II
(In construction)



English-Philosophy Building
(Existing)



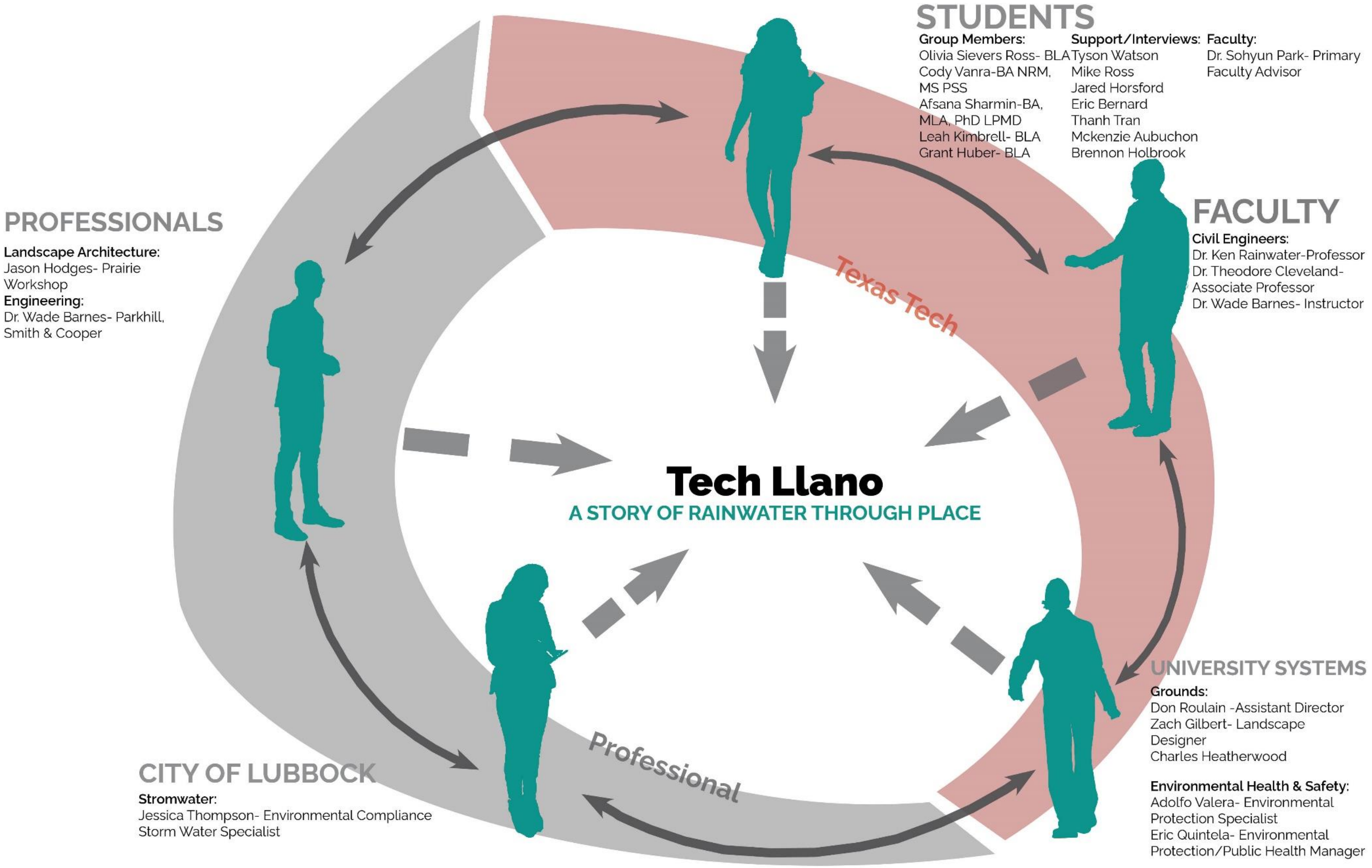
Drainage Divide:
A boundary where storm water enters from the exterior and exits at the pour point.

Pour Points:
Areas where one basin empties into another.

Storm Water Runoff

Composite Site Inventory Model

Native Prairie
Playa Lake Representation
Native Prairie
Agriculture Representation
Pedestrian Mall
Caprock Representation


STUDENTS
Group Members:
Olivia Sievers Ross- BLA
Cody Vanra-BA NRM, MS PSS
Afsana Sharmin-BA, MLA, PhD LPMD
Leah Kimbrell- BLA
Grant Huber- BLA
Support/Interviews:
Tyson Watson
Mike Ross
Jared Horsford
Eric Bernard
Thanh Tran
Mckenzie Aubuchon
Brennon Holbrook
Faculty:
Dr. Sohyun Park- Primary Faculty Advisor
PROFESSIONALS
Landscape Architecture:
Jason Hodges- Prairie Workshop
Engineering:
Dr. Wade Barnes- Parkhill, Smith & Cooper
FACULTY
Civil Engineers:
Dr. Ken Rainwater-Professor
Dr. Theodore Cleveland- Associate Professor
Dr. Wade Barnes- Instructor
Texas Tech
Tech Llano
A STORY OF RAINWATER THROUGH PLACE
Professional
CITY OF LUBBOCK
Stromwater:
Jessica Thompson- Environmental Compliance Storm Water Specialist
UNIVERSITY SYSTEMS
Grounds:
Don Roulain -Assistant Director
Zach Gilbert- Landscape Designer
Charles Heatherwood
Environmental Health & Safety:
Adolfo Valera- Environmental Protection Specialist
Eric Quintela- Environmental Protection/Public Health Manager

TECH LLANO A Story Of Rainwater Through Place

City Park Demonstration - Altered Playa Lake

Within the urban setting, playa lakes have been altered to retain storm

Ogallala Aquifer Representation

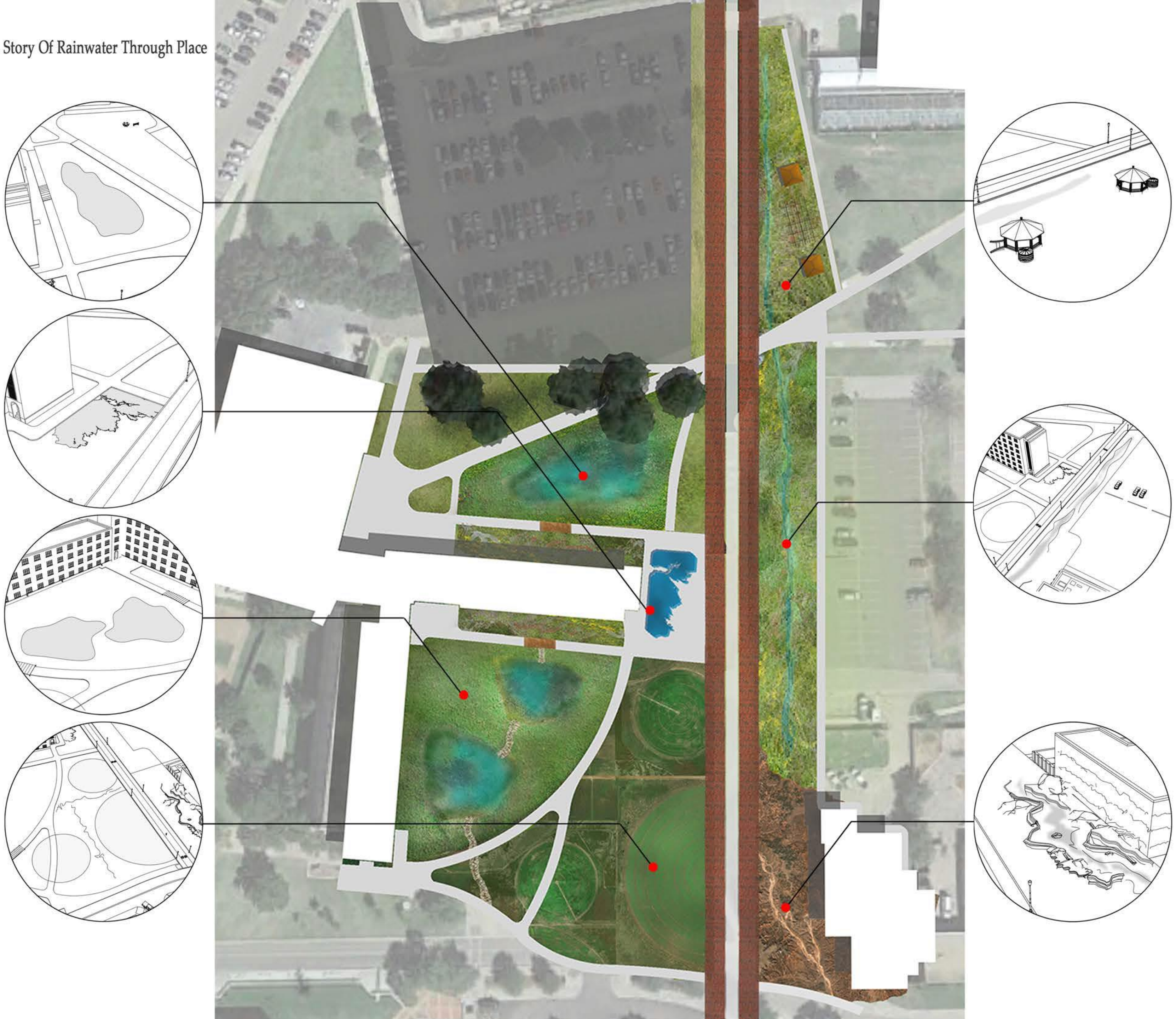
The Ogallala is the main source of life-supporting water in the Texas Panhandle. It is also being depleted faster than it can be replenished.

Native Prairie - Mini-Playa Lakes

Playa lakes are only found in the northwest portion of the state of Texas and they generally come in two forms: altered and unaltered.

Agricultural Representation

Agriculture has been a driving economic and cultural force on the Llano Estacado for many years.



Residential Demonstration

The residential zone illustrates green infrastructure practices with pitched roofs connected to a downspout system that feeds into rain barrels.

Bioswale

Bioswales slow down the time of concentration of storm water and, with appropriate plant selection, increases storm water quality before it enters the municipal sewer system or local bodies of water.

Caprock Representation

The edge of the Llano Estacado is called the Caprock Escarpment. It is the geographic transition as the Llano descends into the surrounding landscape, and has a very distinct red sandstone laced with white gypsum.

Site Plan

OASIS:

RETROFITTING UCONN'S ICONIC MIRROR LAKE

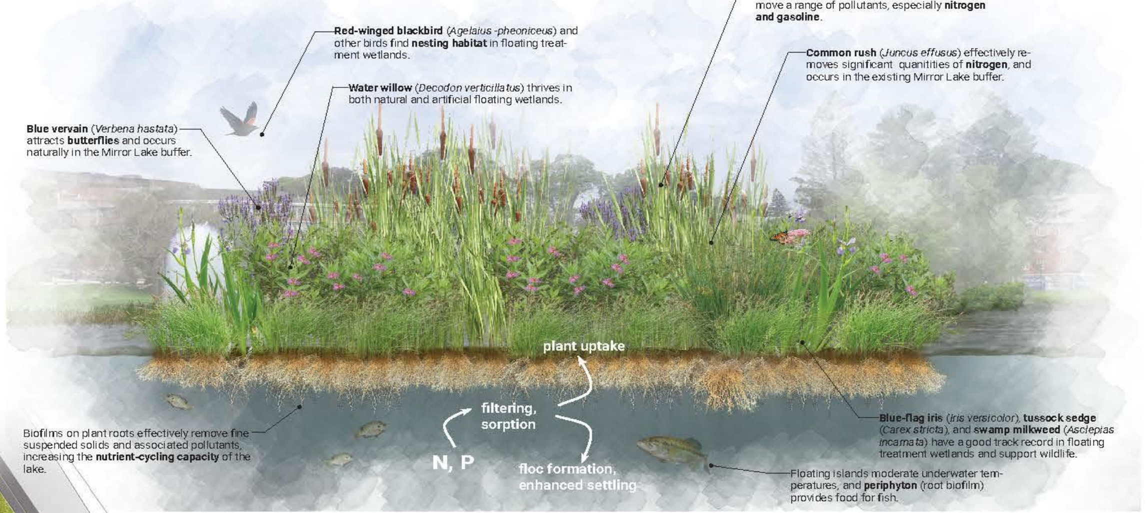
REGISTRATION NO. M30

ROCK GARDEN VIEW

IMPLEMENTATIONS

1. Eleven planted floating islands
2. Engaging Floating Island Educational Walkway
3. Tributary Rain Gardens
4. Restoration of 1.2 acres of native meadow
5. Enhancement of existing lake buffer

FLOATING ISLAND SECTION



SITE ANALYSIS

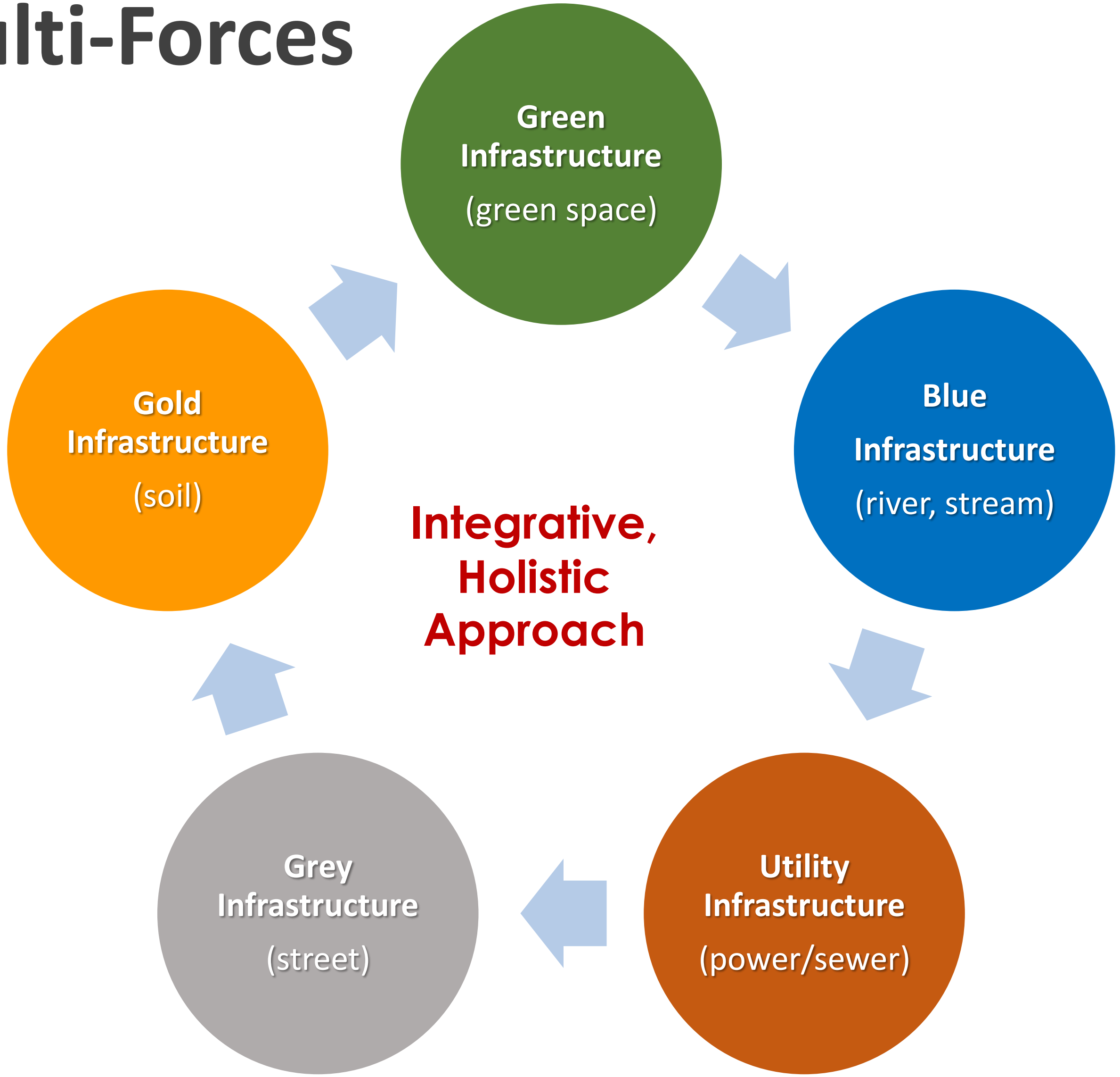
PLAN

PERGOLA VIEW

PROJECT OUTCOMES

1. Up to 50% more removal of nitrogen, phosphorus and sediment due to floating islands alone
2. Decreased phosphorus, gasoline and chloride loading from the immediate watershed
3. Reduced impairment of Roberts Brook downstream
4. Public engagement via the Floating Island Educational Walkway
5. Improved waterfront access around the perimeter of the lake
6. Increased biodiversity and ecosystem services
7. A celebration of Roberts Brook

Multi-Forces



Natural Climate/Landscape Solutions

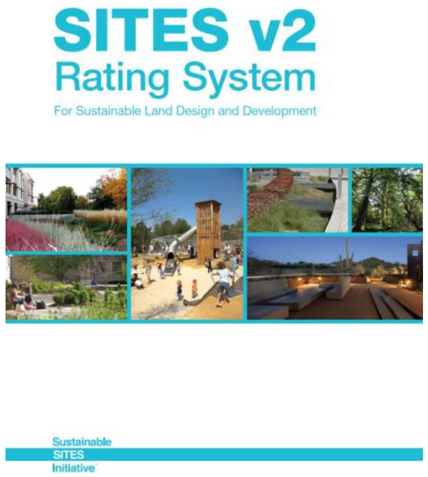
Social Infrastructure

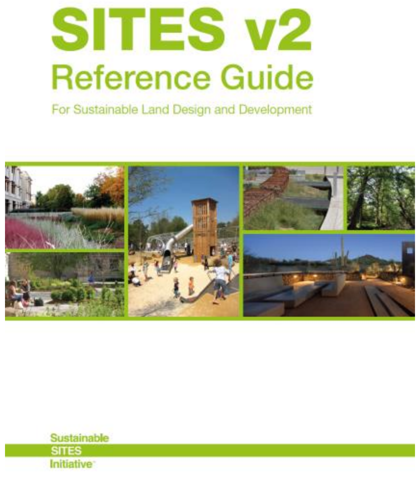
GI governance
Culture/political will
Land use policy/planning
Civic engagement

Sustainable SITES Initiative

- Sustainable Landscape Design and Development
- 5 SITES APs in Connecticut out of 240 in the U.S.

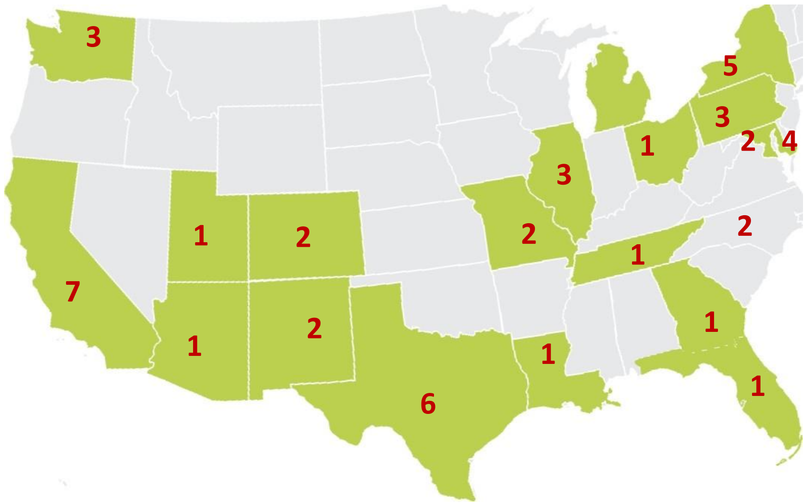
2016	**The 1st SITES v2 Certified Project**
2014	SITES v2 *Rating System & Reference Guide* GBCI
2009	SITES v1 (Pilot Version) *Guidelines and Performance Benchmarks* 46 certified projects in 20 states (1-4 stars)
2000 **1993**	**LEED Rating System** **USGBC established**





SITES Projects in U.S.

- 21 states
- 46 certified pilot projects (1-4 stars)
- 317 acres in total, 15 acres on average under SITES
- 80% redeveloped project (greyfield → open space)
- 3 rural, 16 suburban, 27 urban
- Total $99M, Ave. $10M



Green: US States w/ pilot projects
Red: Number of certified projects (incl. v2) as of Jan. 2017

Take Home Message

Design Interventions that Care and Value

Ecosystem Services (Delivery)

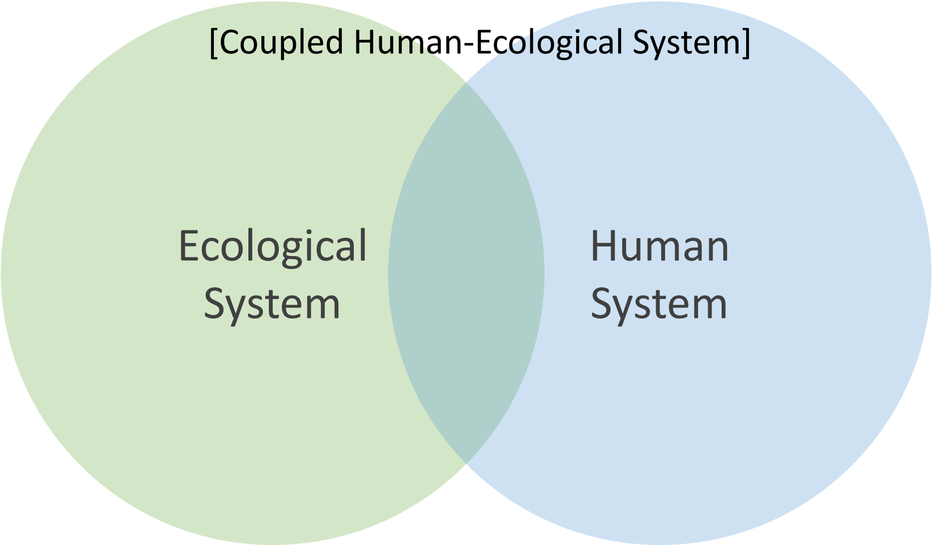
Aesthetics

Process

Education

System Thinking

Ecological Integrity
Urban ecology
Natural resources conservation



Safety
Wellness
Health
Quality of Life
Community Resiliency
Sustainability

Green infrastructure enhances ecosystem health and climate change resilience, and contributes to biodiversity, and benefits human populations.

Thank You!

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