Green Stormwater Infrastructure for Urban Flood Resilience

Opportunity Analysis for Dallas, Texas

Kathy Jack, Ph.D. ,
The Nature Conservancy

Fouad Jaber, Ph.D., P.E,
Texas A&M AgriLife Extension

Susan Alvarez, PE, CFM,
City of Dallas - OEQS

Nature.org/DallasGSI
Executive Summary

The Nature Conservancy

Texas A&M AgriLife Extension

Analysis and report produced by The Nature Conservancy (TNC) and Texas A&M AgriLife Extension, in collaboration with the City of Dallas and The Trust for Public Land (TPL). This analysis was made possible with the support of Lyda Hill Philanthropies.

The Nature Conservancy

Kathy Jack, Ph.D.

Texas A&M AgriLife Extension

Fouad Jaber, Ph.D., P.E.
Bardia Heidari Ph.D., E.I.T.
Victoria Prideaux

Dallas Environmental Quality & Sustainability

Susan Alvarez, P.E., CFM

dallas water utilities city of dallas

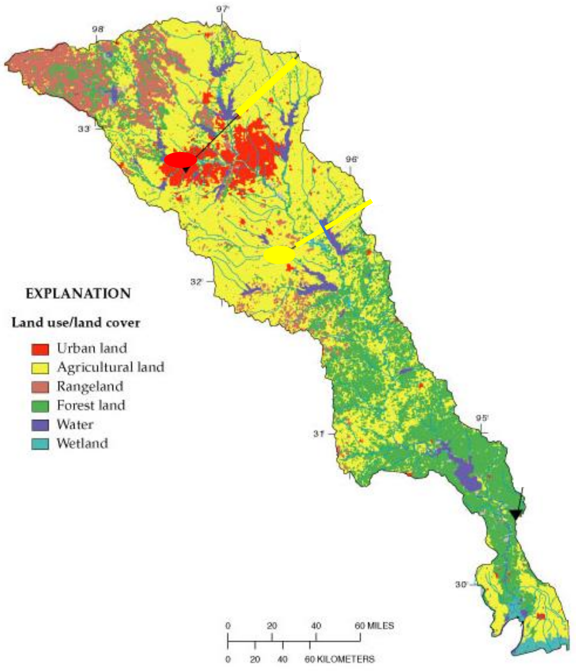
Sarah Standifer
Kim Dewailly, P.E., CFM
Stephen Parker, P.E., CFM
David Phan, P.E., CFM

The Trust for Public Land

Mitch Hannon
Nick Viau
Robert Kent
Molly Plummer

The Challenge: Impervious Cover & Stormwater

Dallas-Fort Worth is the fastest growing metropolitan area in the United States (U.S. Census Bureau, 2020). With rapid and widespread conversion of natural land cover to impervious surfaces.



Trinity Basin Land Uses. Adapted from USGC.

KJ

The Challenge: Climate Change

- "This last year has proven that climate change is no longer a distant threat; its effects are happening right now, in real-time." (Dr. Katharine Hayhoe, Chief Scientist for the Nature Conservancy)
- "It is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred."(IPCC AR6)
- Texas leads the country in federally declared natural disasters[1] and "Texas has seen its number of natural disasters increase by 244% over the past four decades."[2] ([1]Congressional Research Services, 2017; [2] Insurancenews.net. January 9, 2020).
- Texas is expected to see "increases in the magnitude and frequency of heavy precipitation," due to climate change, which " will place more stress on existing water resource infrastructure." (U.S. Global Change Research Program, Fourth National Climate Assessment (NCA4), 2018)
- By 2036, flooding in our cities is estimated to become up to 50% more frequent, and projections show that floodplains are already expanding in real-time across many parts of the state. (Texas A&M University. Office of the Texas State Climatologist. Assessment of Historic and Future Trends of Extreme Weather in Texas, 1900-2036)

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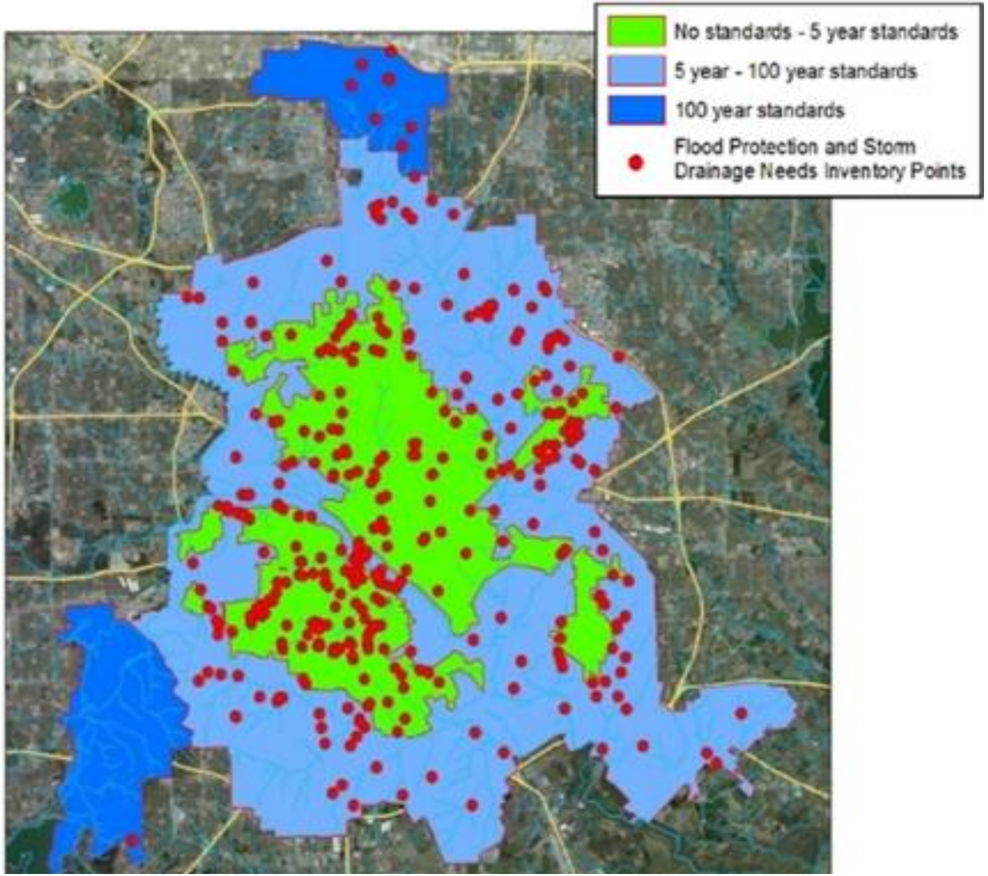
The Challenge: Outgrowing Drainage Networks

Most of the drainage needs in the City are associated with areas developed prior to current Drainage Standards



Total City-wide Estimated Needs:
$2.1 B

2017 Drainage Bond Proposition:
$48.75 M

City of Dallas

City of Dallas Drainage Standards & Needs Inventory

SA

The Opportunity: Natural Solutions

- Cities across the world are increasingly utilizing green stormwater infrastructure (GSI) practices, engineered plant and soil systems that recreate natural hydrological processes, to enhance stormwater management in urbanized watersheds.

- In addition to improving water quality, GSI can provide an important and cost-effective tool to enhance urban flood management.

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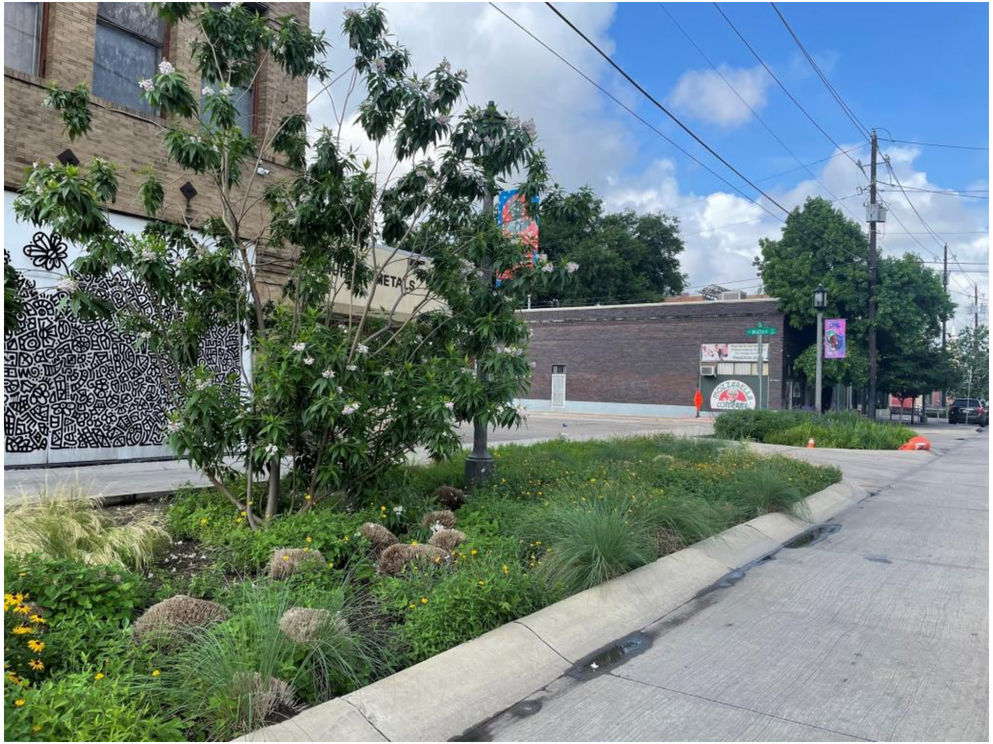
City of Dallas- GSI

Since 2007, The City has worked to better integrate GSI, into City planning and design manuals, and to support regional efforts.

- iSWM- voluntary
- USEPA report on GSI Barriers and Opportunities.
- Impervious surface drainage fees
- Complete Streets; Green Streets
- *Resilient Dallas*
- iSWM in Paving, Street and Drainage Design Manuals



Sidewalk bioretention areas in Deep Ellum. © Katy Evans/ City of Dallas

City of Dallas

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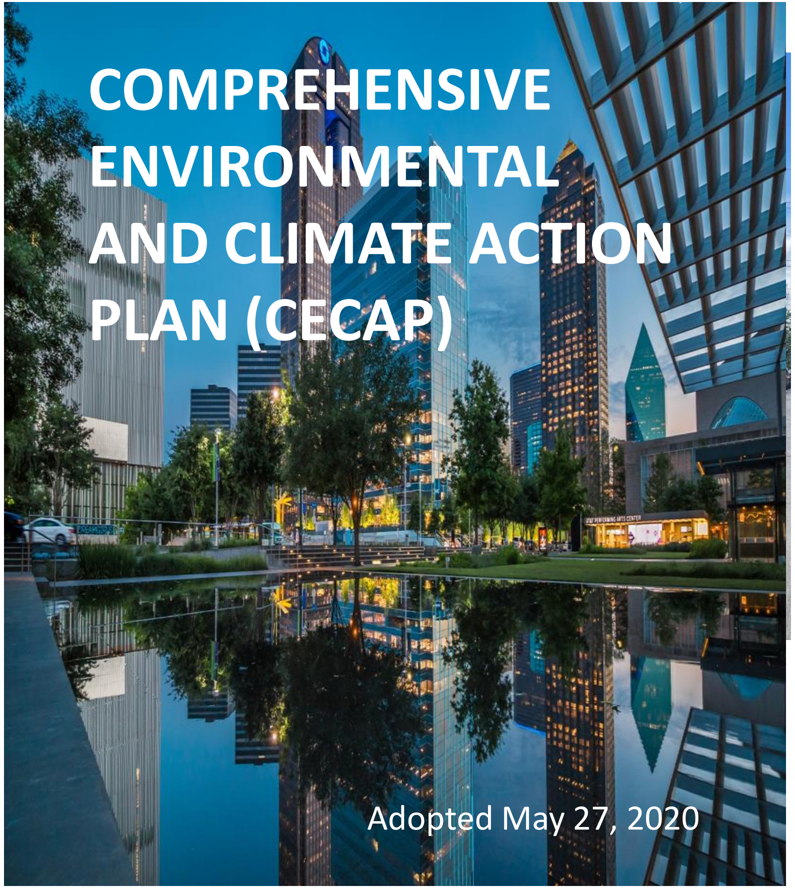
City of Dallas



CECAP GSI Goals

- **Incorporate green infrastructure** to mitigate adverse impacts of development. (WR10)
- Establish **urban greening factor** that quantifies stormwater benefits. (EG1)
- **Increase and improve access to Green Space** to reduce impacts of urban heat islands, localized flooding, and improve public health. (EG1)
- **Assess opportunities for Blue-Green Infrastructure** in the Public realm to reduce flood risk. (EG2)
- **Implement green infrastructure programs** that treat the ROW as both a mobility and green infrastructure asset. (T15)

SA

Green Stormwater Infrastructure for Urban Flood Resilience: Opportunity Analysis for Dallas, Texas.

Research question:

Where can green stormwater infrastructure (GSI) most effectively enhance urban flood management within the City of Dallas, Texas, when considering capacity, cost, and future impacts of climate change?

This study utilized hydrologic modeling (USEPA SWMM v. 5.1) and spatial analysis to help answer this question.

Dallas flooding. © Steven Luu.

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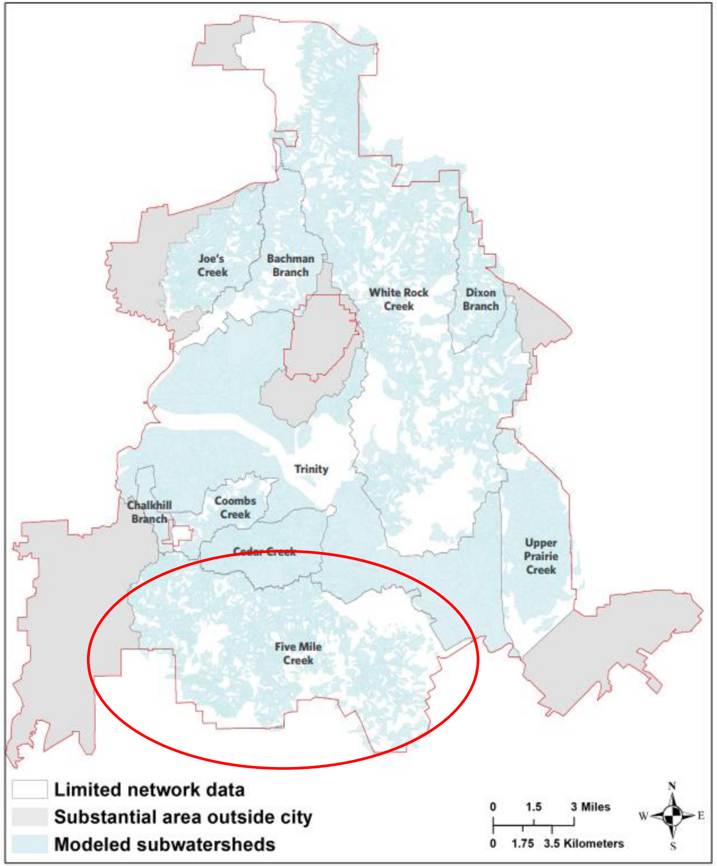
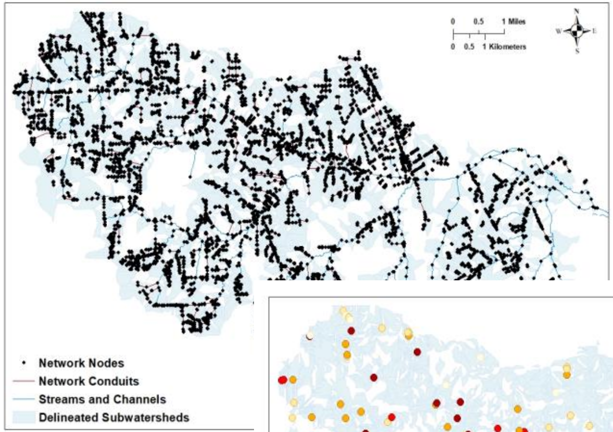
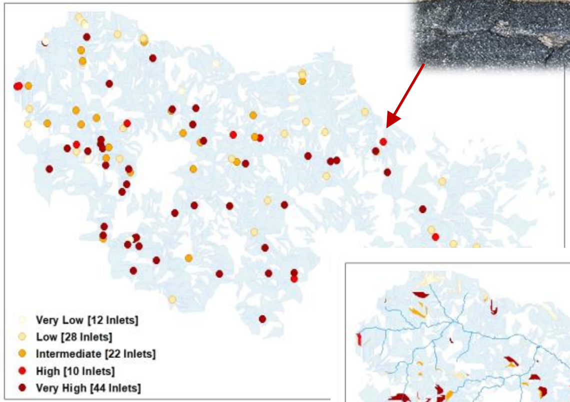
Overview

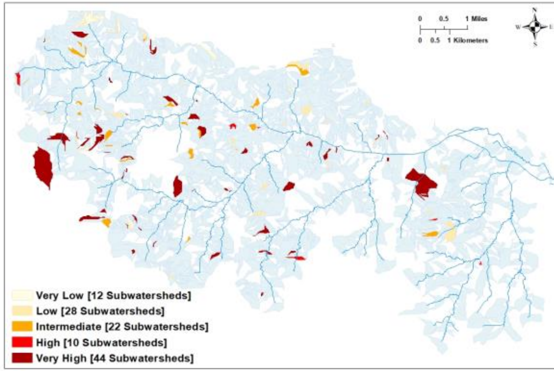
- Part I : Identify System Hotspots, and Challenged Sub-watersheds
- Part II: Identify and Quantify Green Stormwater Infrastructure Opportunities
- Part III: Pre- and Post-GSI Analysis
- Recommendations

Part I : Identify System Hotspots and Challenged Sub-watersheds









The study was limited to areas with complete stormwater drainage system, and included a total of 118,418 acres, or 53% of watershed area within the City.

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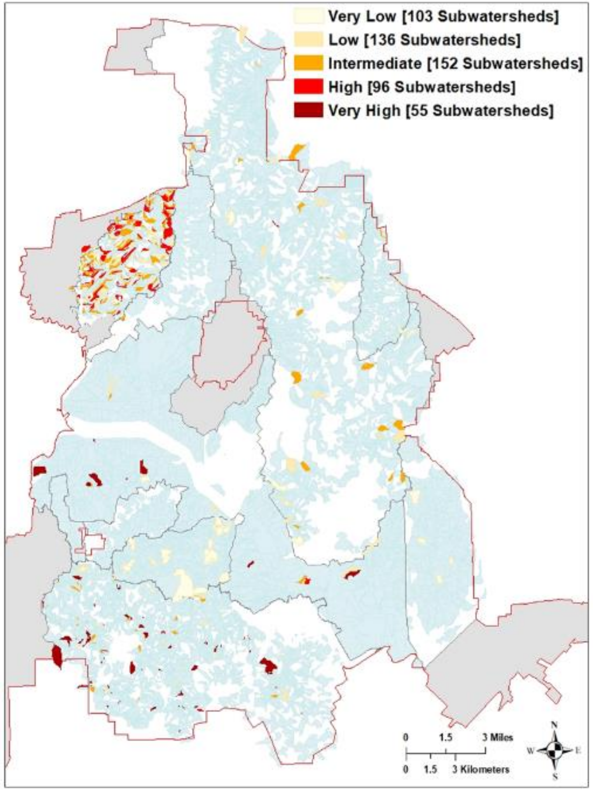
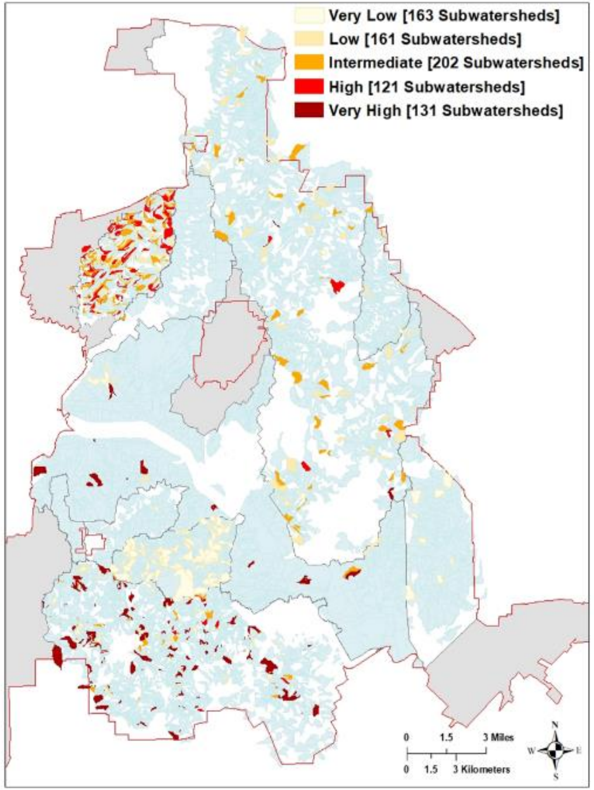
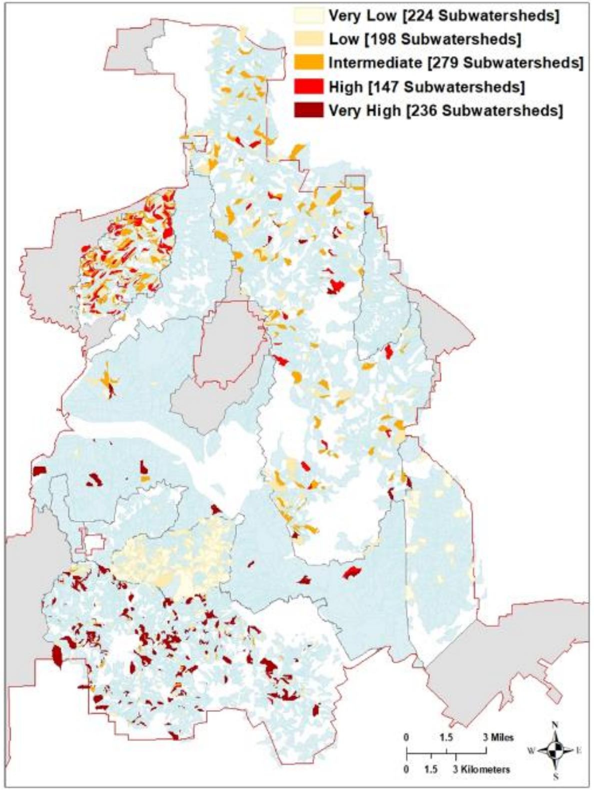
Part I : Identify System Hotspots and Challenged Sub-watersheds



2-year (50%)



10-year (10%)



100-year (1%)

Challenged Subwatersheds, Classified by Severity of Inlet Overflows, as Modeled for Return Period Storms,

Current Conditions

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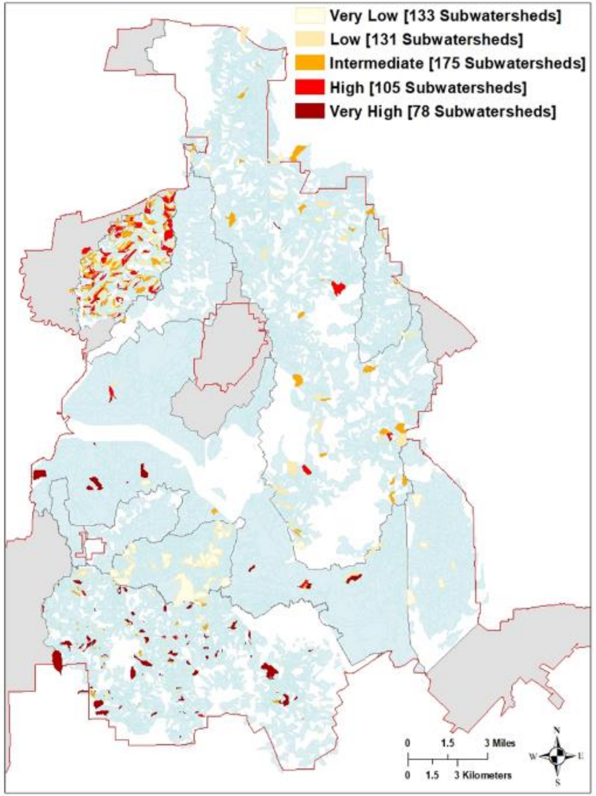

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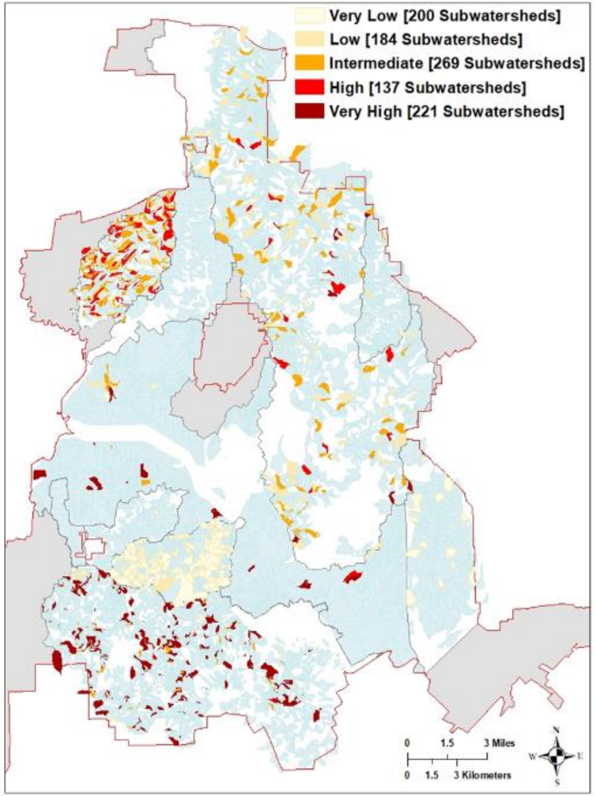
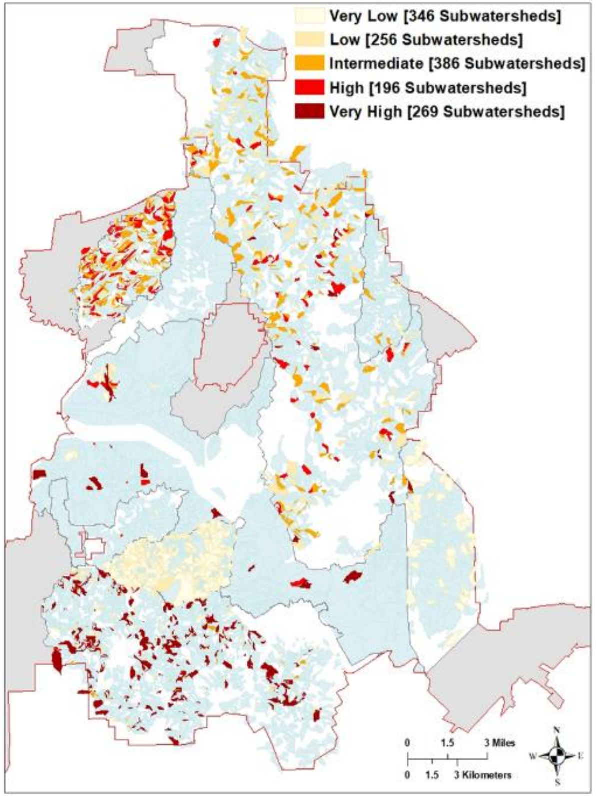


10-year (10%)



100-year (1%)

Challenged Subwatersheds, Classified by Severity of Inlet Overflows, as Modeled for Return Period Storms,

Forecasted Conditions (2045)

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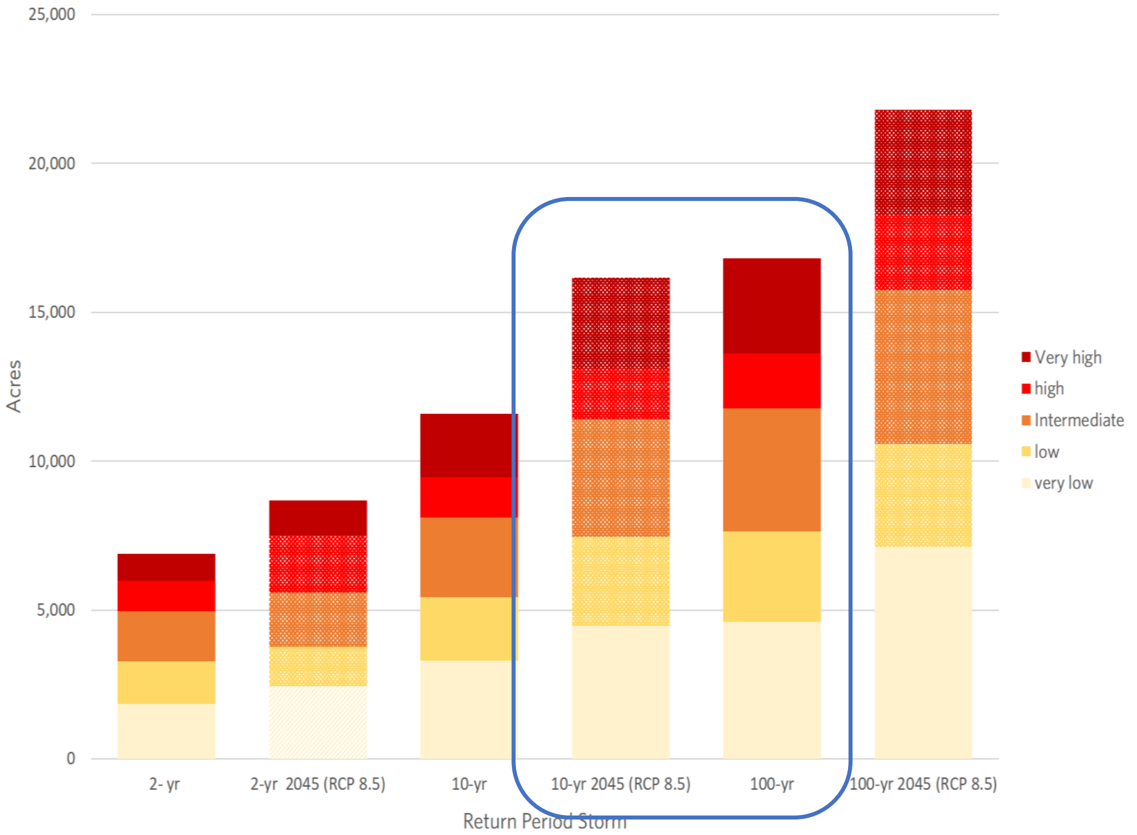
Part I: Key Findings

- Identified areas of concern.
- More precipitation will lead to more and more severe, system hotspots and contributing subwatersheds.
- Climate change will result in an average increase in the number of system hotspots (+26%) and area of challenged watersheds (+30%)
- Precipitation amounts and hotspots for the 10-year storm forecasted for 2045 resemble those for today's 100-year storm.



Challenged Subwatershed Area (acres), Classified by Severity of Inlet Overflows, as Modeled for Return Period Storms, Current and Forecasted Conditions

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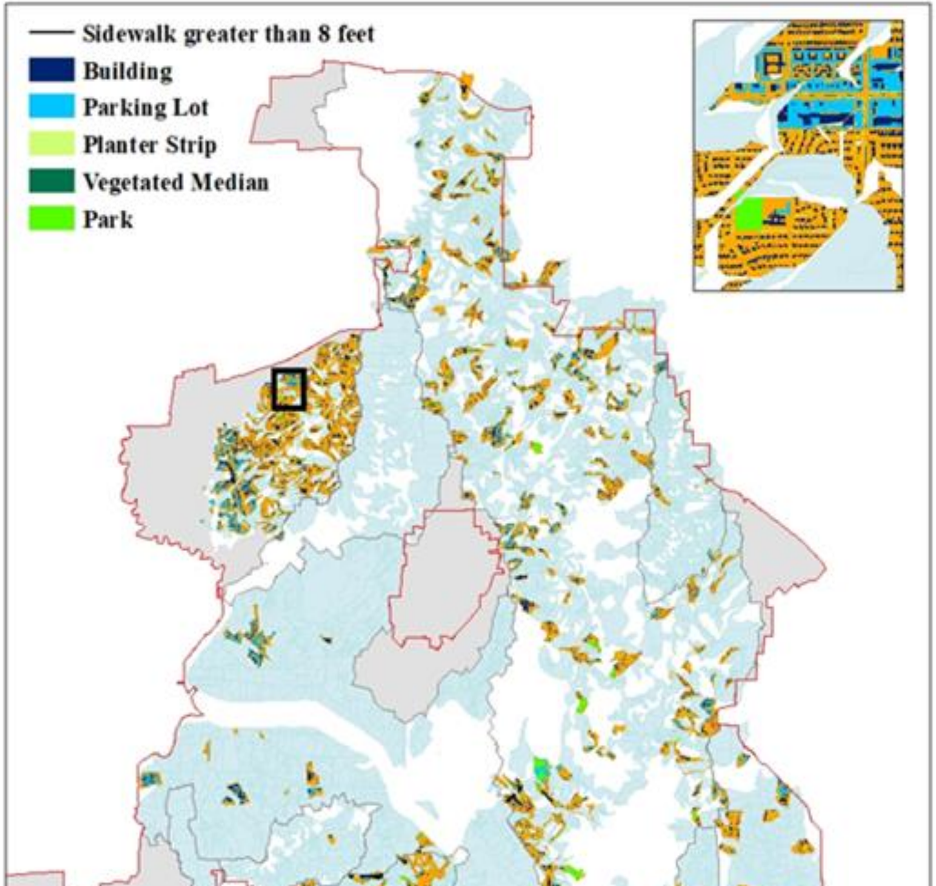
Part II: Identify & Quantify Green Stormwater Infrastructure Opportunity



Bioretention areas

Raingarden

Rainwater Harvesting

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Part II: Identify and Quantify Green Stormwater Infrastructure Opportunities

	BIORETENTION AREAS	RAIN GARDENS	RAINWATER HARVESTING CISTERN
Design criteria	$1 ft^2 = 1.5 ft^3 = 11.2$ gal	1 ft2 = 0.5ft3 = 3.7 gal	1 tank= 750 gal (1000-gal tank, 75% empty)
Spatial criteria	apply following (%) to available area. ▪ Parking lots (10%) ▪ Parks and Trails (10%) ▪ Planting Strips and Medians (35%) ▪ Commercial sidewalks nonresidential sidewalks, > 8 ft wide. (35%)	▪ Residential and Commercial structures: a (100%), a 200 ft2 rain garden, each	▪ Residential and Commercial structures: a (100%), a 1,000-gal cistern each
Construction costs (20% engineering)	$17.70/ft2	$12.72/ft2	$2.09/gal
Estimated costs per gallon (no maintenance)	$1.58/gal	$3.44/gal	$2.09/gal
Estimated costs per gallon (with maintenance)	$1.76/gal	$4.78/gal	$2.63/gal

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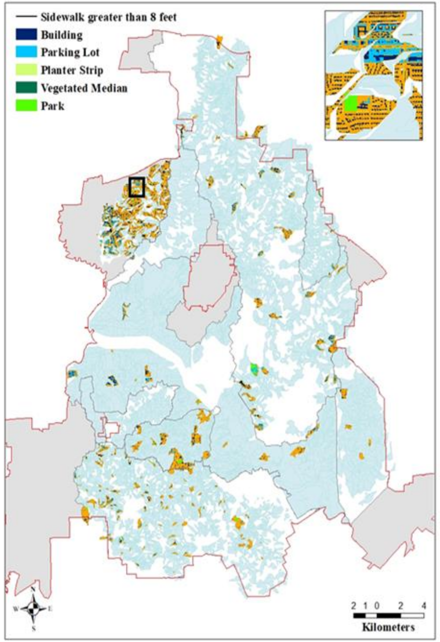
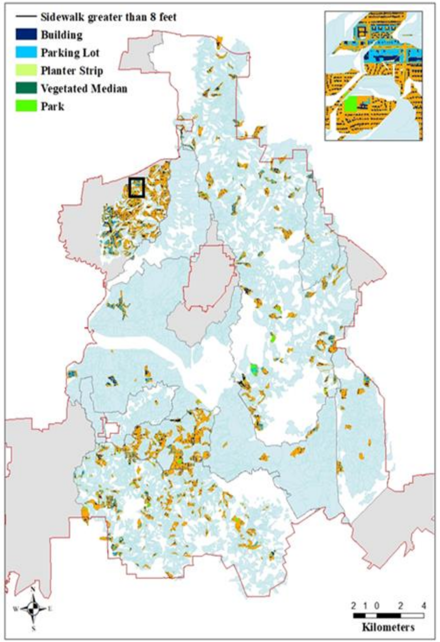
Part II: Identify & Quantify Green Stormwater Infrastructure Opportunity

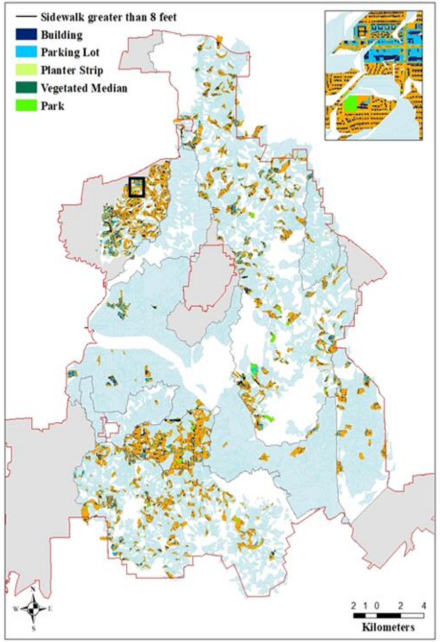
2-year (50%)



10-year (10%)



100-year (1%)



Estimated Maximum Stormwater Volume Capture Capacity for GSI in challenged sub-watersheds, Based on Standard System Designs and Spatial Criteria

2-year (50 %)	**GSI TOTAL**	111.2 MG
	Bioretention	78.4 MG
	Raingarden	16.4 MG
	Rainwater Harvesting	16.4 MG

10-year (10 %)	GSI TOTAL	191.6 MG
	Bioretention	135.6 MG
	Raingarden	28.1 MG
	Rainwater Harvesting	27.9 MG

100-year (1 %)	GSI TOTAL	284.7 MG
	Bioretention	200.9 MG
	Raingarden	42 MG
	Rainwater Harvesting	41.8 MG

- Identified substantial opportunities to deploy GSI.
- Bioretention areas—particularly in parking lots—have the most widely available siting opportunities and represent the "biggest bang for the buck."

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Part II: Identify and Quantify Green Stormwater Infrastructure Opportunities

Estimated Stormwater Management Capacity Potential Reduction of Modeled Overflows, and Costs per Gallon Captured by GSI, per Storm Event

WATERSHED	2-Year (50%)				10-Year (%10)				100-Year (1%)			
	CAPTURE CAPACITY/EVENT (MG)	OVERFLOW REDUCTION (%)	AVERAGE COST ($/GAL)[c]	AVERAGE COST WITH MAINTENANCE ($/GAL)	CAPTURE CAPACITY/EVENT (MG)	OVERFLOW REDUCTION (%)	AVERAGE COST ($/GAL)[c]	AVERAGE COST WITH MAINTENANCE ($/GAL)	CAPTURE CAPACITY/EVENT (MG)	OVERFLOW REDUCTION (%)	AVERAGE COST ($/GAL)[c]	AVERAGE COST WITH MAINTENANCE ($/GAL)
Bachman	No overflow				No overflow				No overflow			
Cedar Creek[b]	11.9	49%	2.3	2.9	27.9	0.4	2.3	2.9	47.0	23%	2.2	2.8
Chalk Hill	No overflow				No overflow				No overflow			
Coombs Creek	No overflow				0.2	33.9%	2.3	2.9	0.2	21.4%	2.3	2.9
Dixon[a]	0.3	58.9%	1.7	2.0	1.1	37.0%	2.0	2.4	1.1	19.5%	2.0	2.4
Five Mile[a,b]	15.5	35.9%	1.9	2.2	38.7	29.1%	1.9	2.2	55.5	19.4%	1.9	2.2
Joe's[a,b]	51.4	29.1%	1.9	2.3	56.6	19.6%	1.9	2.3	61.7	12.4%	1.9	2.2
Trinity	10.9	25.8%	1.7	1.9	15.0	19.4%	1.7	2.0	18.6	12.8%	1.7	1.9
Upper Prairie	1.7	20.9%	2.1	3.1	5.0	16.2%	2.1	2.6	11.0	10.6%	2.1	2.6
White Rock[b]	19.5	28.7%	2.0	2.4	47.3	28.7%	1.9	2.3	89.5	20.6%	1.9	2.3
City of Dallas TOTAL	**111.2**	**31%**	**1.9**	**2.4**	**191.6**	**25%**	**2.0**	**2.4**	**284.5**	**17%**	**2.0**	**2.4**

Gray (Pipe) Infrastructure	414.4	24.6%	10.6
Green & Gray Infrastructure	699.1	41.5%	7.1

[a] Problematic watersheds as identified by the City of Dallas watersheds.
[b] Key Opportunity watersheds identified in the analysis.
[c] Maintenance not included.

- GSI reduced modeled overflows for all storms (17-31% reduction).
- GSI is 77% less costly than upgrading gray infrastructure alone, to meet modelled overflows.
- Combination of green and gray provides the maximum cost-effective benefits.

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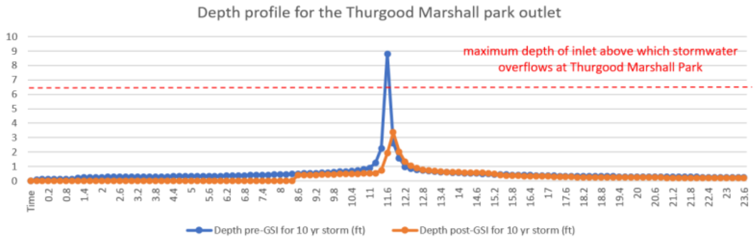
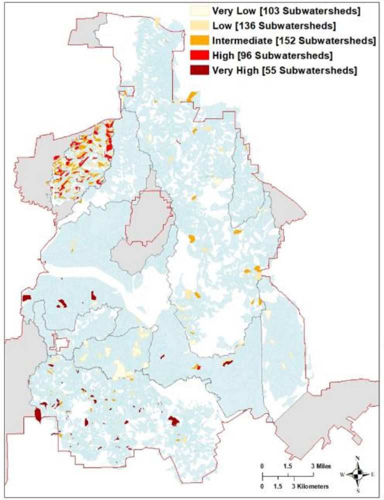
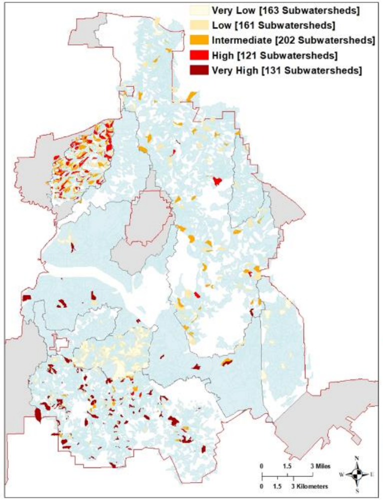
Part III: Pre- and Post-GSI Analysis

- Reduction in hotspots and challenged subwatersheds.
- Less severe flooding.
- Substantial peak flow reduction and delay resulting from GSI

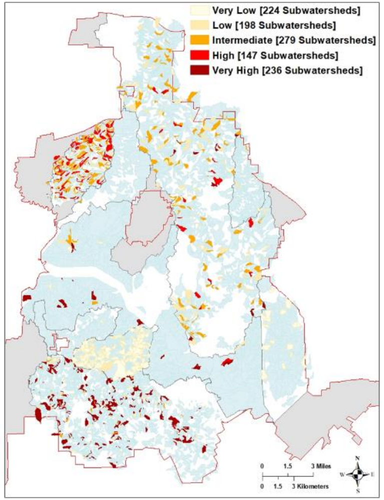




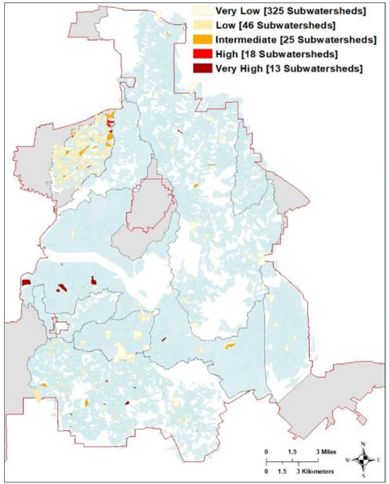
2-year (50%)

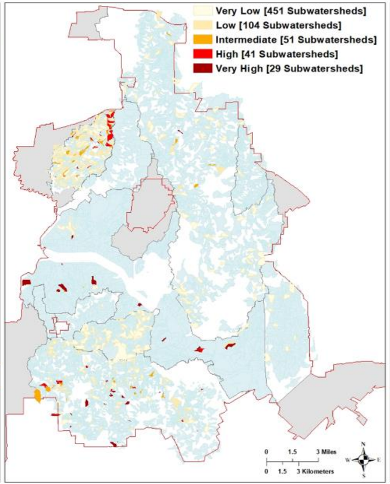


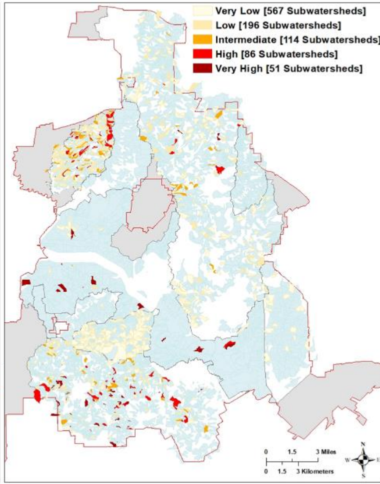
10-year (10%)



100-year (1%)







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Overall

- When comprehensively deployed in the fabric of a City, GSI can achieve substantial cost-effective flood management benefits, particularly in combination with gray solutions.

- GSI should be considered for stormwater management from site to scale.

- Together with additional “greening” interventions— GSI can support multiple community health and resilience goals, by enhancing urban flood management, improving water quality, reducing urban heat island impacts, and improving ecological function of city landscapes.

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Application & Next Steps

- GIS layers have been integrated into TPL's Smart Growth decision-support tool for consideration with additional data and planning objectives, including equity and land-use.

- Outputs shared with additional City departments and stakeholders to evaluate planning and policy opportunities, and consideration with complementary datasets, including with parking ordinance.

Thank You.

Kathy Jack, Ph.D. ,
The Nature Conservancy
kathy.jack@tnc.org

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