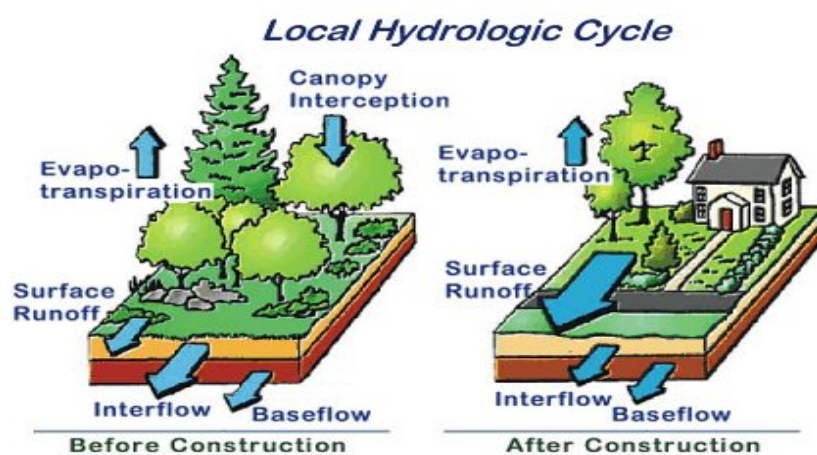


Stormwater Green Infrastructure: Evaluation, Performance and Modeling

Fouad H. Jaber, PhD, PE
Associate Professor and Extension Specialist
Biological and Agricultural Engineering
Texas A&M AgriLife Extension
Dallas Research and Extension Center



Urban vs. Natural



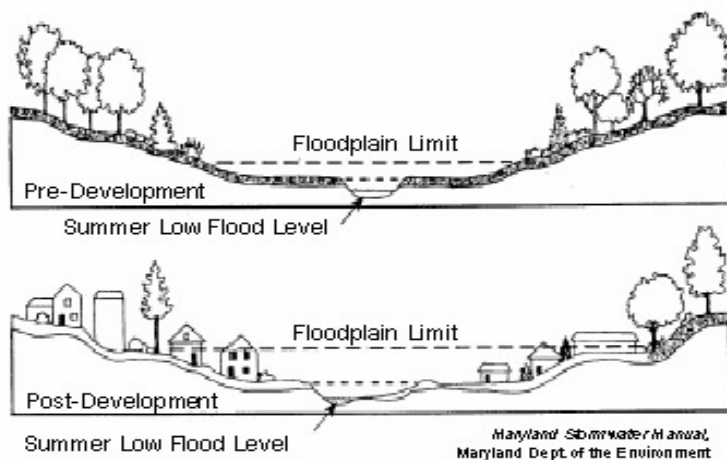
Why is Stormwater a Concern?



Why is Stormwater a Concern?



Why is Stormwater a Concern?



Why is Stormwater a Concern?



Eutrophication

- Impacts due to urbanization:
 - **Impact to aquatic habitat:** Degradation of habitat structure, loss of pool-riffle structure, reduction in base flow, increased stream temperature, and decline in abundance and biodiversity.



Fish kill at Lake Granbury.

Green Stormwater Infrastructure

- Rain garden-bioretenion areas
- Porous pavements
- Green roofs
- Rainwater harvesting



What is a Rain Garden (Bioretention)?

A rain garden is a beautiful landscape feature consisting of a planted shallow depression that collects rainwater runoff from roofs, parking lots and other impervious surfaces.



Home Rain Garden

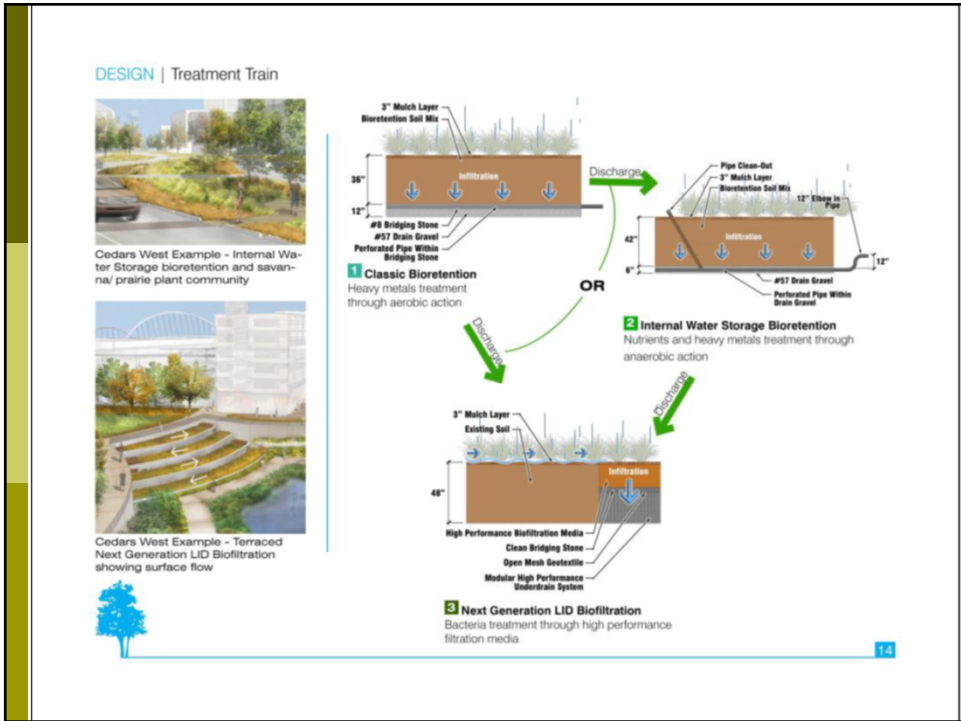
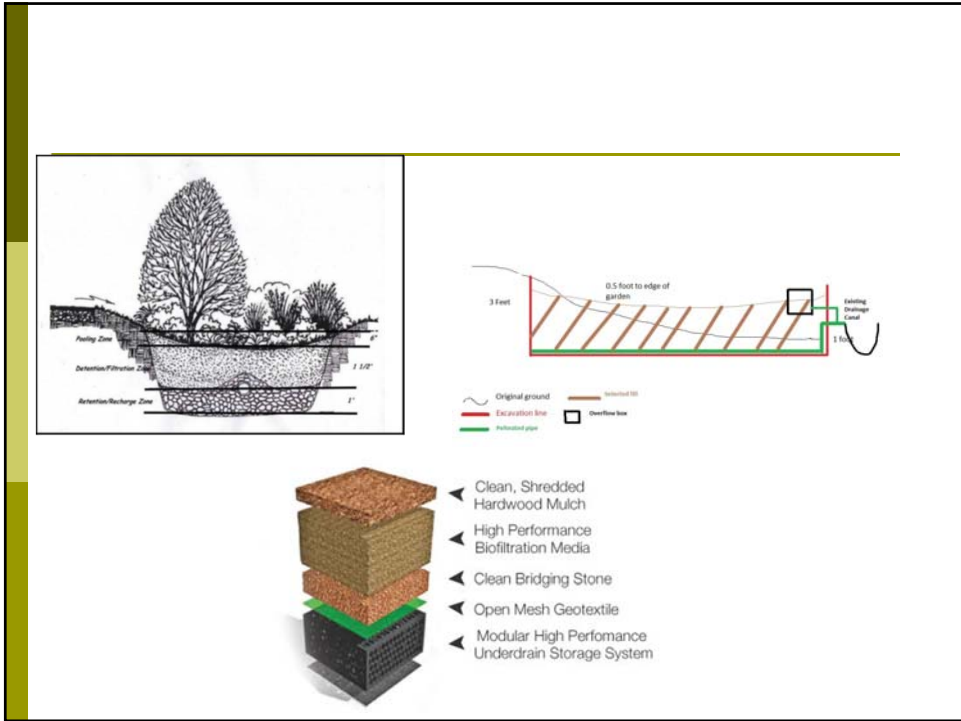


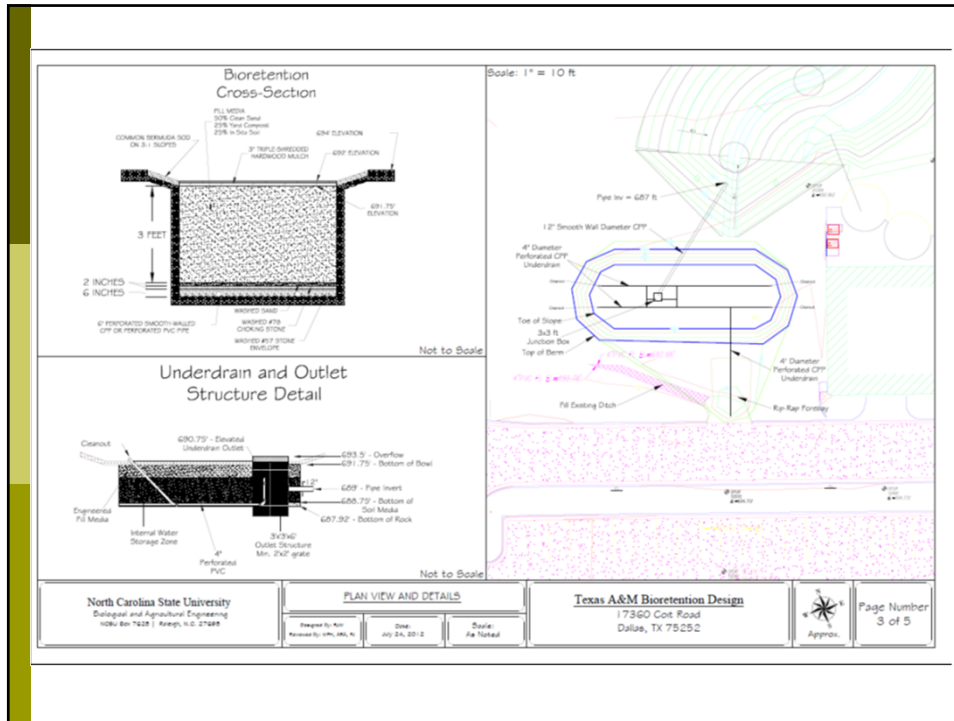
Bioretention in Parking Lot



Bioretention in Road Median



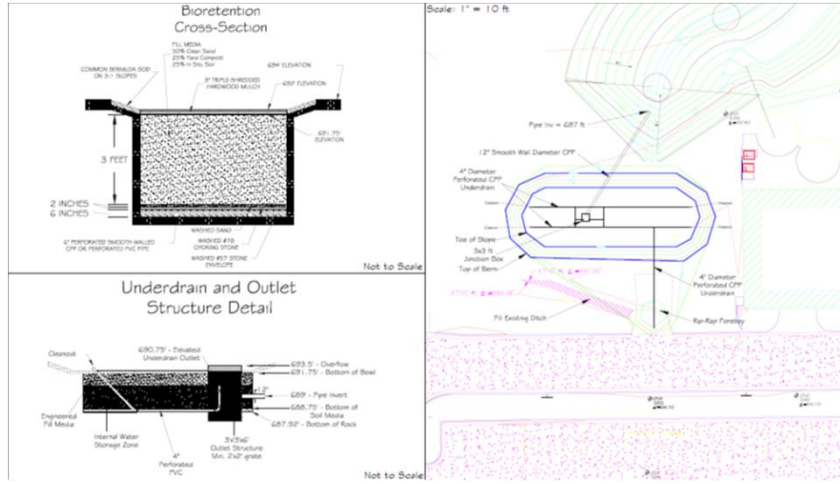




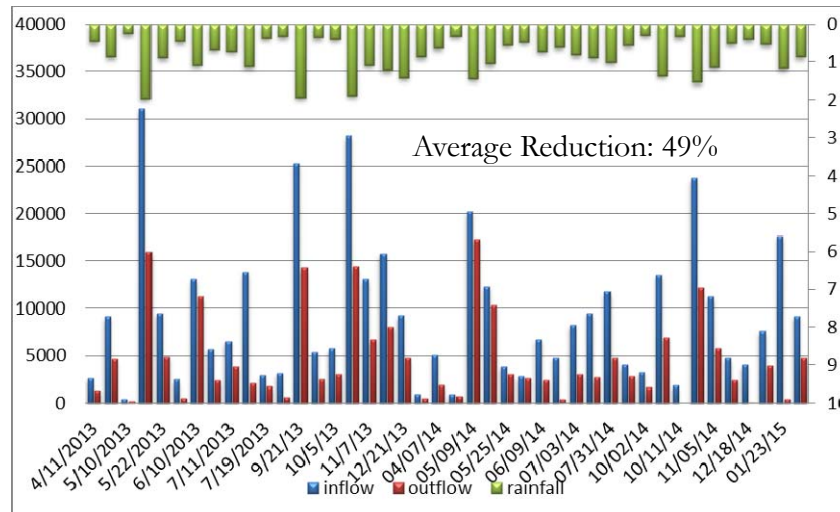
Bioretention Design

- Collected from 37,000 square foot parking lot CN=94
- Include Internal Water Storage (IWS)
- Total Media Depth was 4 feet with 1.75 feet ponding depth
- Media: 25% yard waste compost, 50% sand, 25% native soil
- Planted with native plants
- 4 inch perforated pipe at bottom

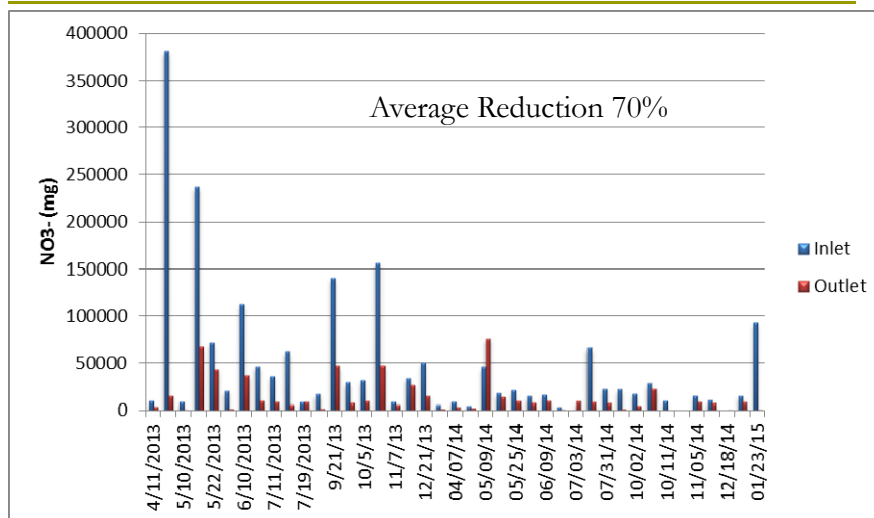
Bioretention Area



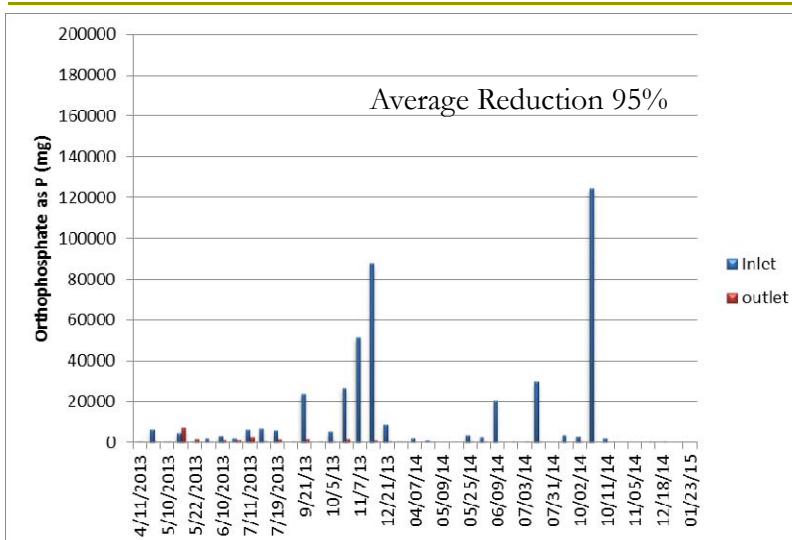
Volume Reduction



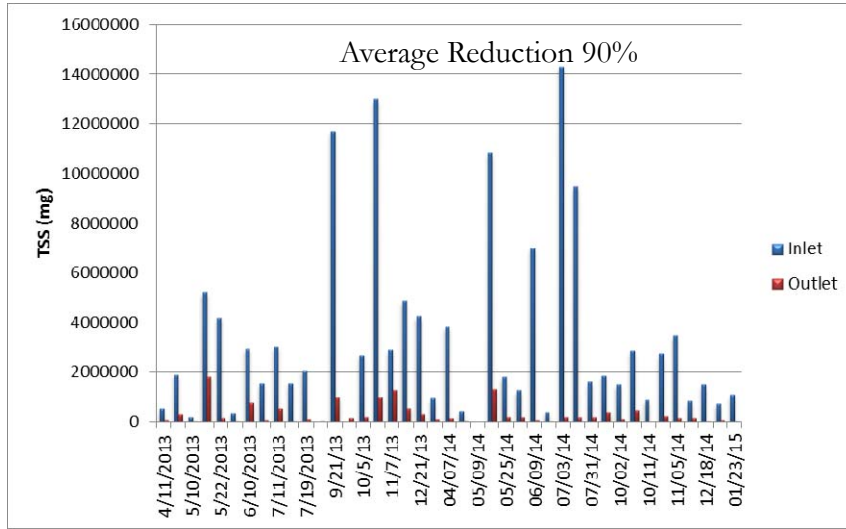
Load Reduction: Nitrate



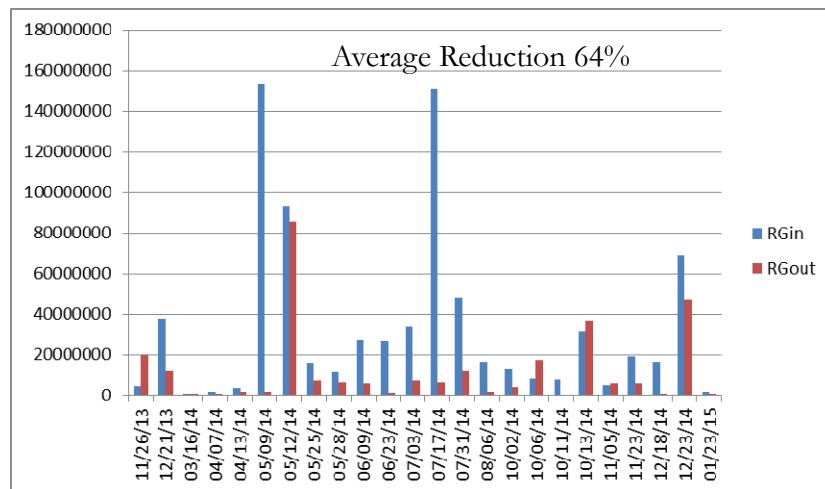
Load Reduction: Orthophosphate



Load Reduction: Sediments



Load Reduction: E. coli





What is Porous Pavement?

- Porous pavement is a permeable pavement surface with a gravel reservoir underneath.
 - it temporarily stores surface runoff before infiltrating it into the subsoil
 - provides water quality treatment
 - often appears as traditional asphalt or concrete but is without "fine" materials
 - could also allow for grass growth

Types of Permeable Pavement



Paver blocks



Porous asphalt



Porous concrete



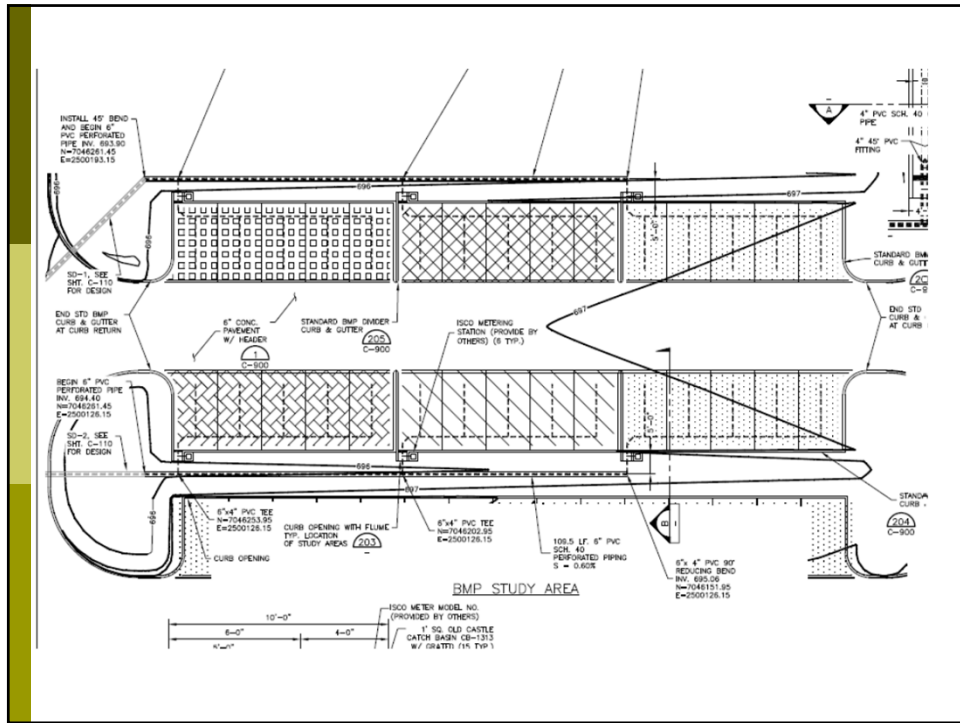
Turf Paver



Expanded shale mix

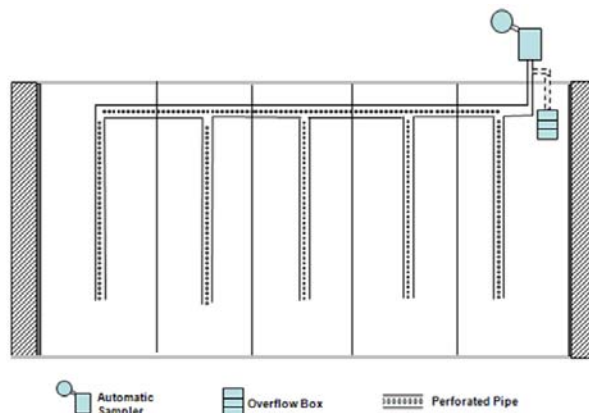
Permeable Pavement

- ▣ Newly constructed parking lot
- ▣ Comparison of 5 types pavement
- ▣ 25 experimental stalls among 52 total functional stalls
- ▣ Perforated underdrain pipes
- ▣ Total thickness = 14 inches
- ▣ Gravel layer
- ▣ Hydrologically separated with concrete curbs

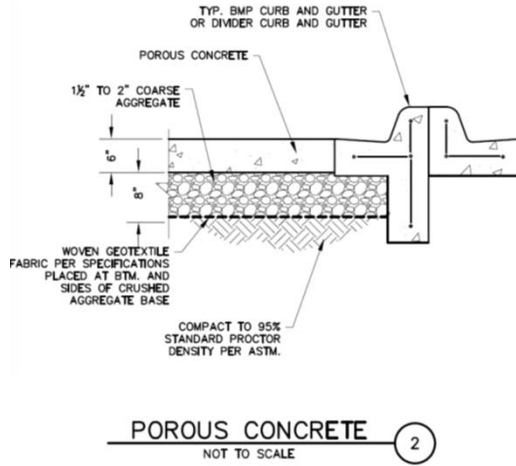


Design and Monitoring

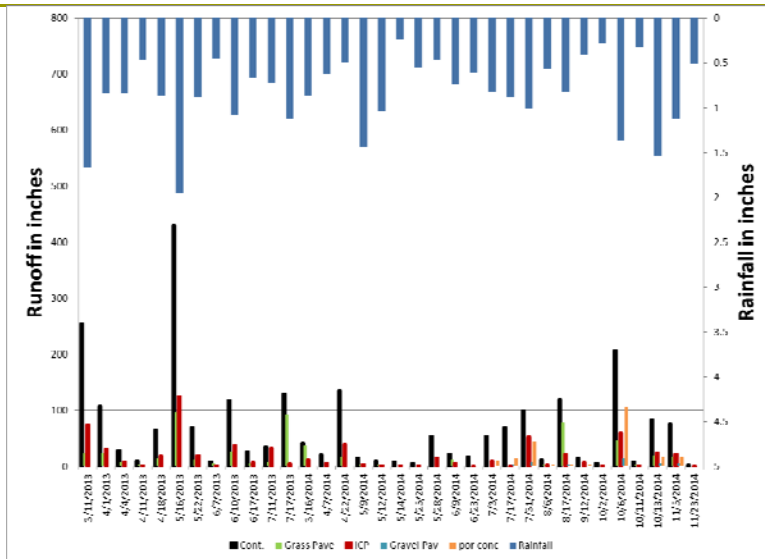
- Stalls: 18'x10'
- ISCO samplers with bubbler flow meters
- Runoff quantity and quality is measured



Pervious Concrete Cross Section



Results: Volume



Volume Reduction Rates

	PICP	Pervious Concrete	Grass Pavers	Gravel Pavers
Reduction Rate	71%	74%	78%	93%

Water Quality

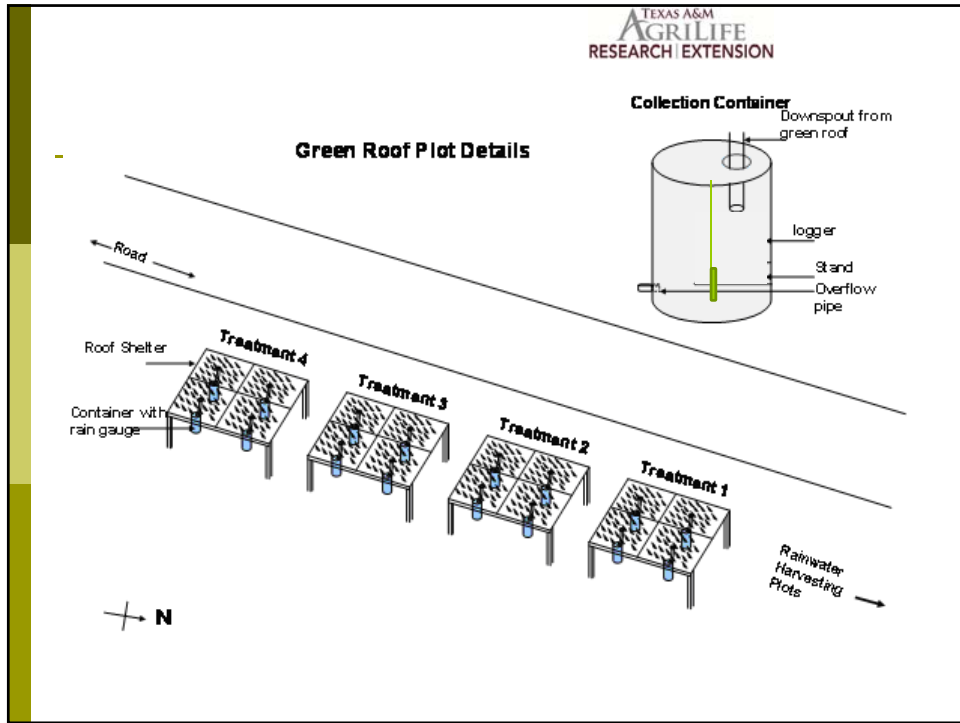
	Control (mg)	Grass Pave (mg)	Grass Pave % reduction	ICP (mg)	% reduction
NO3	221.98	857.55	-286%	654.27	-195%
NH4	272.07	173.43	36%	60.64	78%
TKN	2327.54	1760.51	24%	1023.3	56%
Orthophosphate	2.46	12.08	-391%	20.84	-747%
Total Phosphorus	53.66	85.37	-59%	107.87	-101%
TSS	59833.46	9648.71	84%	32306	48%

TSS Reduction in Per Conc: **57%**
 in Gravel pavers: **48%**



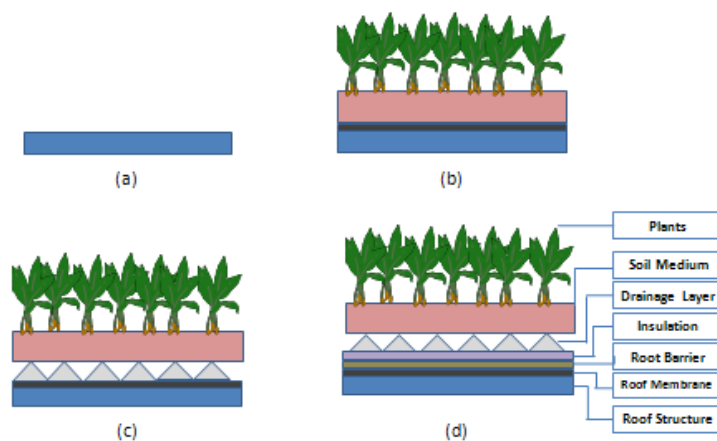
Green Roofs





Growth Medium

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Vegetation

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- ❑ Selected based on location, wind, rainfall, air pollution, height of the building, shade and soil depth.
- ❑ Roof microclimate can be extreme, requiring hardy plants, adapted to the local climate.
- ❑ drought tolerant, have a growth pattern that covers the soil, have very low need for maintenance such as fertilizers, insecticide, herbicides, mowing or trimming, be perennial or self-sowing and be fire resistant



Volume Reduction

Event	Rainfall	C	H	H reduction	S	S reduction	SD	SD Reduction
Date	inches	gals	gals	%	gals	%	gals	%
12/28/12	1.52	13.04	8.67	33.51%	8.40	35.58%	8.62	33.90%
01/10/13	2.61	39.13	25.67	34.40%	23.13	40.89%	28.15	28.06%
02/11/13	0.9	8.40	5.13	38.93%	5.19	38.24%	2.18	74.05%
03/11/13	1.67	19.71	7.02	64.38%	12.51	36.53%	6.31	67.99%
04/01/13	0.84	2.71	0.00	100.00%	0.00	100.00%	0.00	100.00%
04/04/13	0.84	3.51	1.30	62.96%	1.29	63.25%	1.29	63.11%
04/18/13	0.87	6.96	0.70	89.94%	0.00	100.00%	1.18	83.05%
05/16/13	1.96	24.61	5.62	77.16%	2.63	89.31%	7.32	70.26%
05/22/13	0.89	4.25	0.10	97.67%	0.00	0.00%	0.36	91.53%
06/10/13	1.08	7.73	2.42	68.69%	1.18	84.73%	0.67	91.33%
06/17/13	0.67	0.80	0.00	100.00%	0.00	100.00%	0.00	100.00%
07/11/13	0.72	1.72	0.00	100.00%	0.00	100.00%	0.30	82.53%
07/17/13	1.12	9.27	4.07	56.09%	1.60	82.74%	2.86	69.19%
09/21/13	1.93	7.44	5.37	27.82%	1.12	84.95%	2.66	64.25%
10/16/13	1.88	7.26	3.25	55.23%	5.78	20.39%	3.6	50.41%
10/27/13	1.24	5.25	4.43	15.62%	4.25	19.05%	2.83	46.10%
11/05/13	1.08	5.55	2.54	54.23%	0.04	99.28%	2.24	59.64%
11/26/13	1.22	3.89	0.53	86.38%	1	74.29%	0	100.00%
12/21/13	1.42	7.02	4.19	40.31%	4.4	37.32%	6.96	0.85%



Volume Reduction

Event	Rainfall	C	H	H reduction	S	S reduction	SD	SD Reduction
Date	inches	gals	gals	%	gals	%	gals	%
05/09/14	Total Volume Reduction from C			65.39%	76.05%		75.33%	
05/12/14								
06/09/14								
07/03/14	0.82	5	3.4	0.32	0.17	0.97	0.17	0.97
07/17/14	0.89	6.7	1.47	0.78	0.1	0.99	2	0.70
07/31/14	1.01	7.7	6.1	0.21	0.24	0.97	1.18	0.85
08/06/14	0.56	2.7	0	1.00	0	1.00	0.29	0.89
08/17/14	0.83	4.7	1.18	0.75	0	1.00	0.29	0.94
10/06/14	1.37	15.8	5.54	0.65	2.47	0.84	4.1	0.74
10/13/14	1.54	22	11.9	0.46	8.7	0.60	9.3	0.58
10/13/14	1.54	22	11.9	0.46	8.7	0.60	9.3	0.58
11/05/14	1.13	9.02	0.17	0.98	0.35	0.96	0.29	0.97
11/23/14	0.51	2.5	0	1.00	0	1.00	0	1.00
12/23/14	0.53	3.89	0.59	0.85	0.35	0.91	0	1.00
01/12/15	0.63	4.5	0.66	0.85	2.4	0.47	0.94	0.79
01/23/15	1.17	7.58	3.56	0.53	3.63	0.52	3.28	0.57
02/02/15	0.72	35.7	25	0.30	1.12	0.97	0	1.00
02/25/15	2.22	15.58	8.63	0.45	1.36	0.91	5.66	0.64
03/06/15	1.1	2.36	0	1.00	1.35	0.43	0.17	0.93

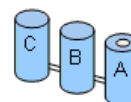
Rainwater Harvesting as a Stormwater BMP

- ❑ Retains water on-site
- ❑ All water applied on high infiltration areas (yard)
- ❑ Reduces total volume and peak flow
- ❑ Conserves water

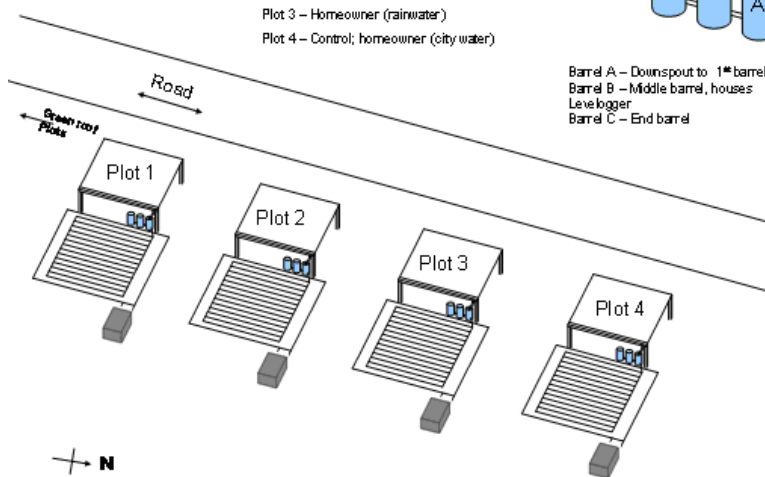


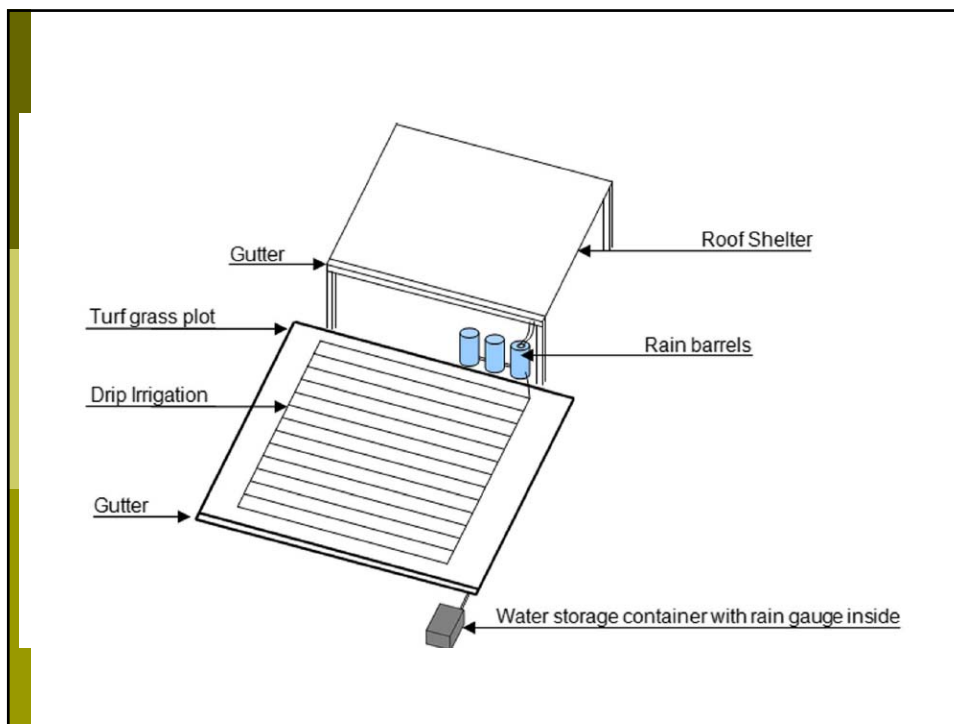
Experimental plot layout

Rainwater Harvesting Treatments
 Plot 1 – Soil Moisture
 Plot 2 – Evapotranspiration
 Plot 3 – Homeowner (rainwater)
 Plot 4 – Control; homeowner (city water)

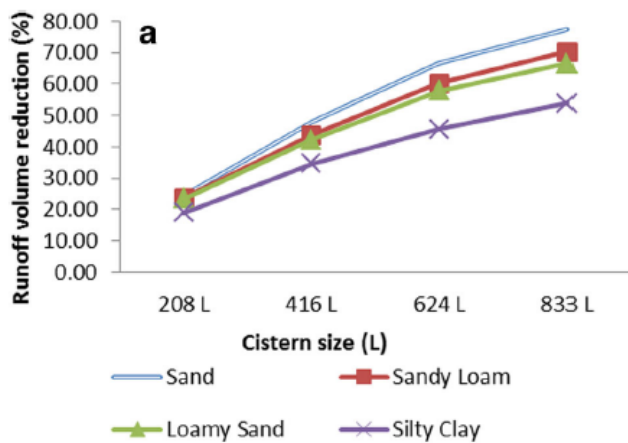


Barrel A – Downspout to 1" barrel
 Barrel B – Middle barrel, houses Levelogger
 Barrel C – End barrel

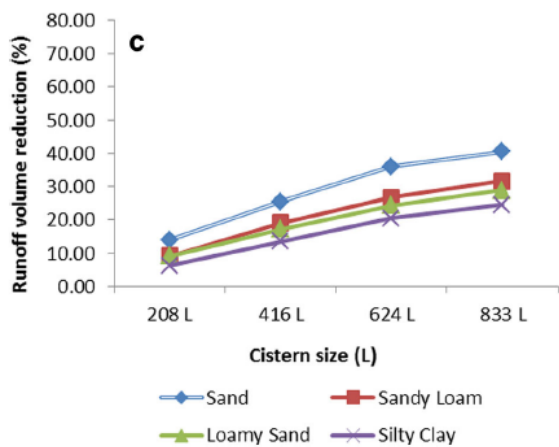




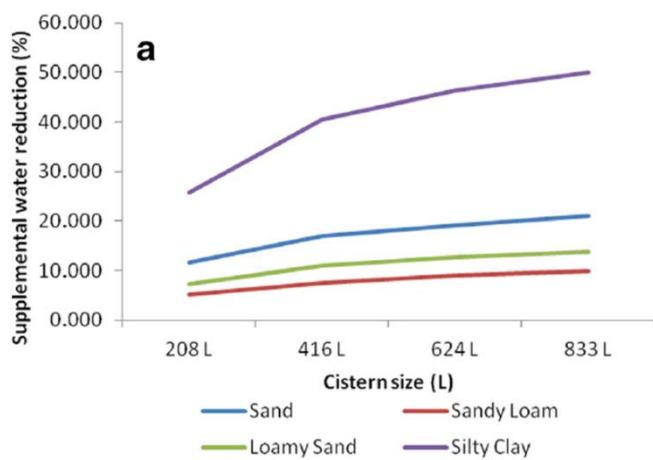
Runoff from time based



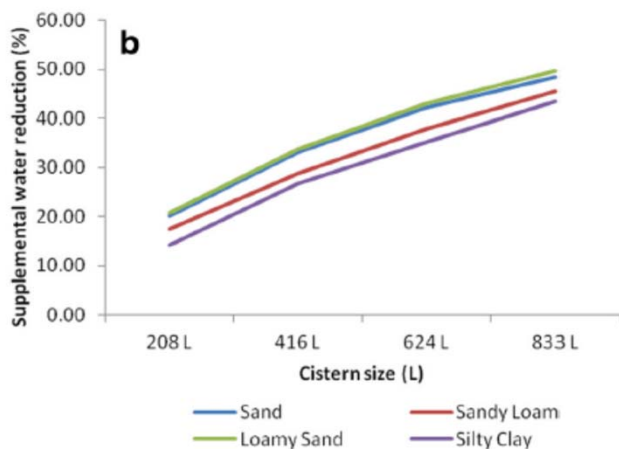
Runoff from ET-based



Water Savings from RWH



Water Savings Soil Moisture



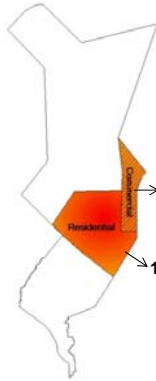
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**Is high density
development an LID
practice?
A modeling study**

Fouad H. Jaber and Mijin Seo

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Urban Land Uses (1. UHD)



Compact high-density urban design

A heavily developed area and maximized site perviousness

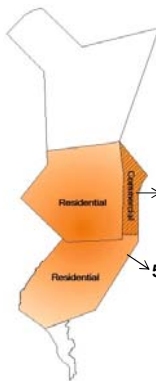
→5% of total area
(0.28 FAR)
→16% of total area
(10 units/ac)



Land use	Urban design	Urban ratio	Impervious/pervious fraction (in %)	
			Residential	Commercial
UHD	Compact urban form with high density	21%	61/39	68/32
UMD	Conventional urban form with medium density	56%	44/56	75/25
UMC	Conservational urban form with medium density	56%	41/59	68/32

Source of designs: League City, designed by Edminster, Hinshaw, Russ and Associates, Inc. (EHRA)

Urban Land Uses (2. UMD)



Conventional medium-density urban design

A typical pattern in the United States

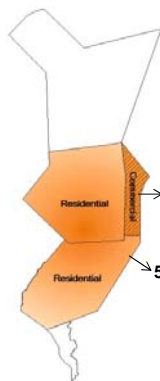
→5% of total area
(0.23 FAR)
→51% of total area
(3 units/ac)



Land use	Urban design	Urban ratio	Impervious/pervious fraction (in %)	
			Residential	Commercial
UHD	Compact urban form with high density	21%	61/39	68/32
UMD	Conventional urban form with medium density	56%	44/56	75/25
UMC	Conservational urban form with medium density	56%	41/59	68/32

Source of designs: League City, designed by Edminster, Hinshaw, Russ and Associates, Inc. (EHRA)

Urban Land Uses (3. UMC)



Conservational medium-density urban design

Include conservational areas under the same base format with conventional urban form



Land use	Urban design	Urban ratio	Impervious/pervious fraction (in %)	
			Residential	Commercial
UHD	Compact urban form with high density	21%	61/39	68/32
UMD	Conventional urban form with medium density	56%	44/56	75/25
UMC	Conservational urban form with medium density	56%	41/59	68/32

Source of designs: League City, designed by Edminster, Hinshaw, Russ and Associates, Inc. (EHRA)

Post-LIDs results

Final result values

Scenario	SURQ (mm)	NO ₃ (kg)	TP (kg)	Difference (% reduction)		
				SURQ (mm)	NO ₃ (kg)	TP (kg)
UHD	374.66	430.92	431.64	52.97	101.37	46.45
UHDLIDs	321.69	329.55	385.19	(14%)	(24%)	(11%)
UMD	473.32	591.87	449.55	135.51	186.03	110.69
UMDLIDs	337.81	405.85	338.86	(29%)	(31%)	(25%)
UMC	462.73	577.19	443.46	117.80	170.51	97.43
UMCLIDs	344.93	406.68	346.03	(25%)	(30%)	(22%)

- SURQ: UMCLIDs > UMDLIDs > UHDLIDs
- NO₃ : UMCLIDs > UMDLIDs > UHDLIDs
- TP : UHDLIDs > UMCLIDs > UMDLIDs



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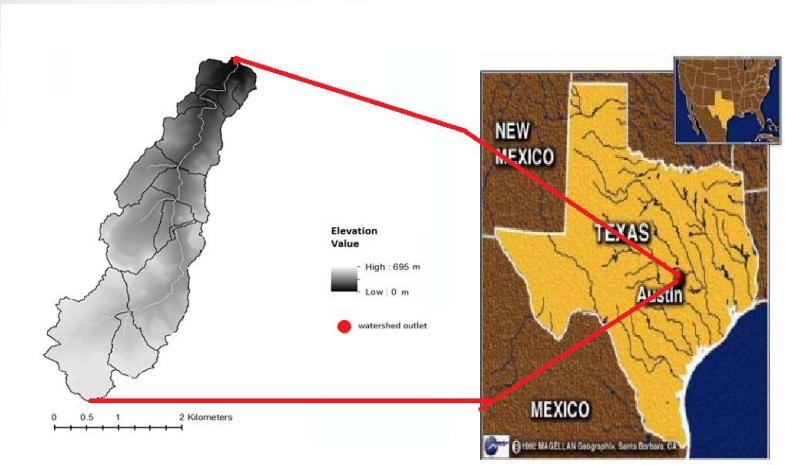
Modeling LID Effect Practices on Stream Health

Fouad H. Jaber, PhD
Associate Professor and Extension Specialist
Sa'd Shannak, PhD
Former Graduate Student Currently at KAPSARC

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BLUNN CREEK WATERSHED- AN OVERVIEW

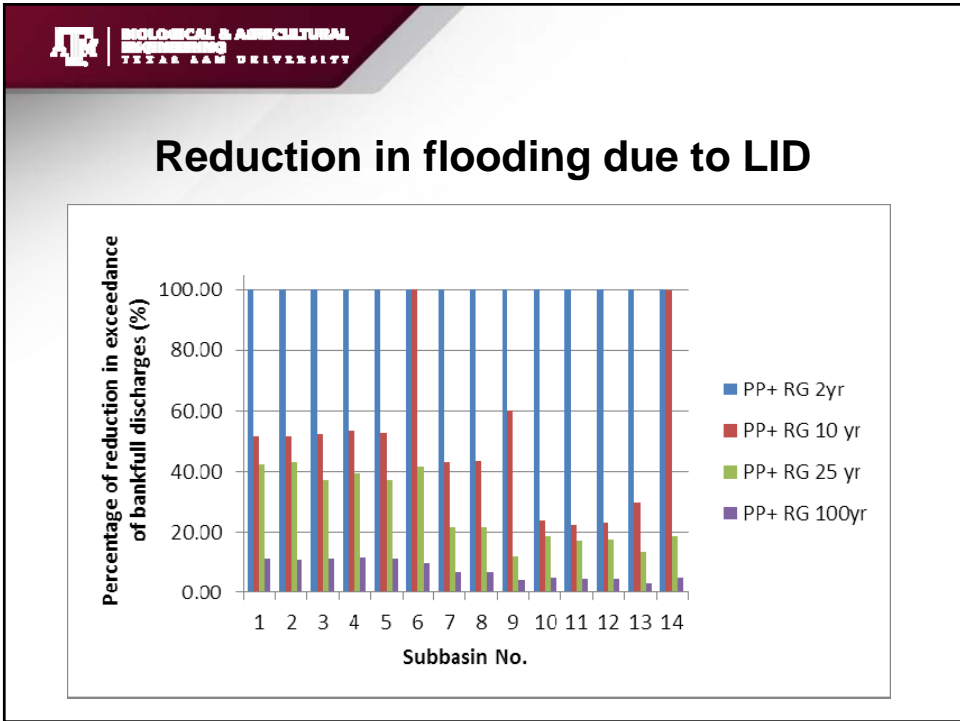
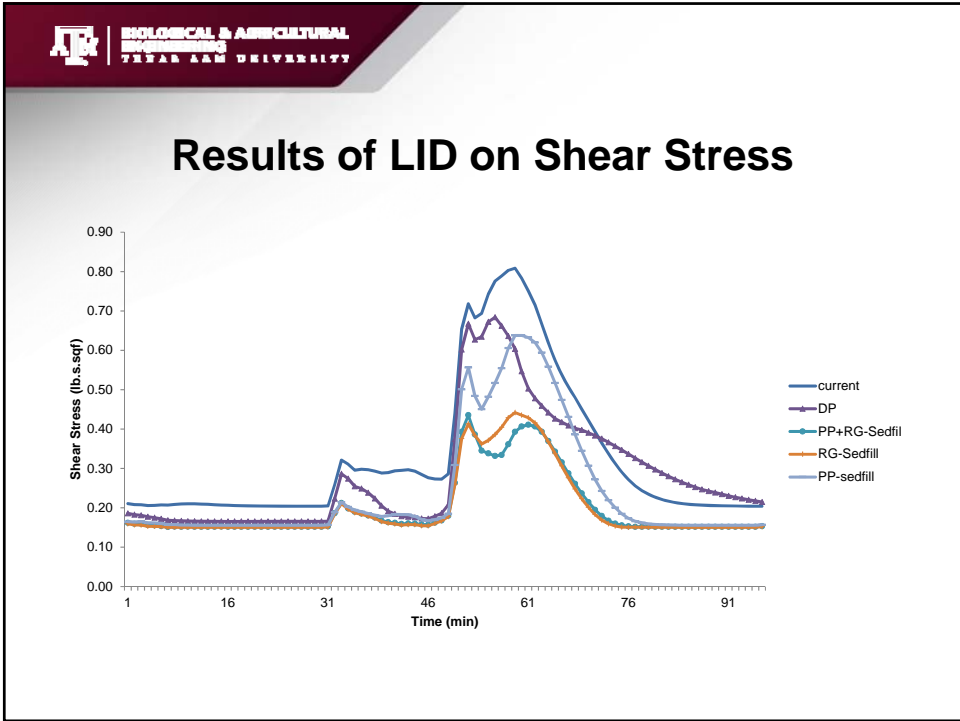


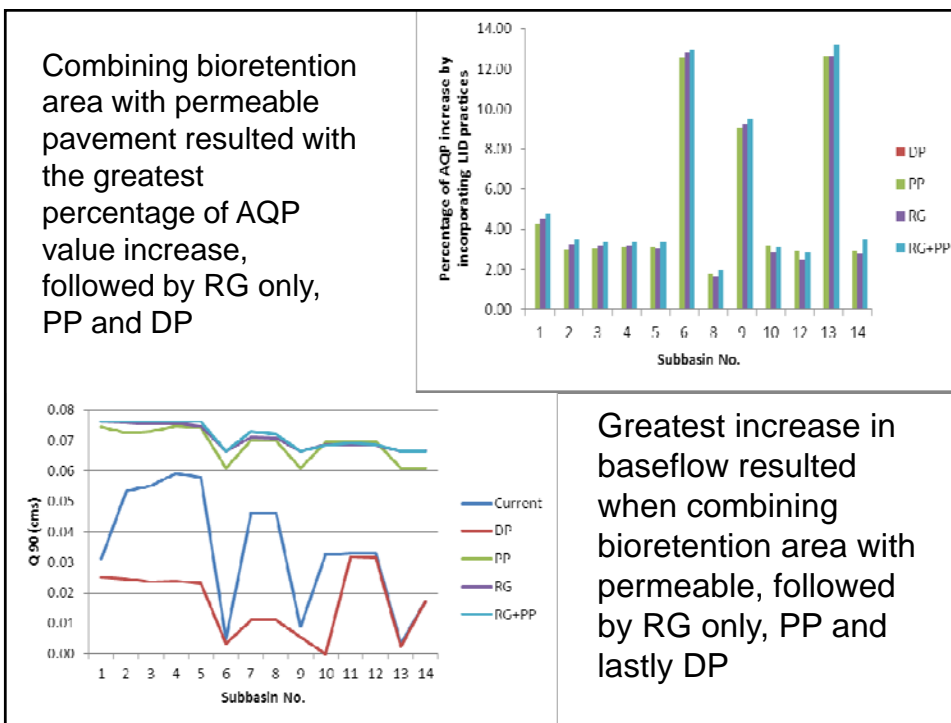
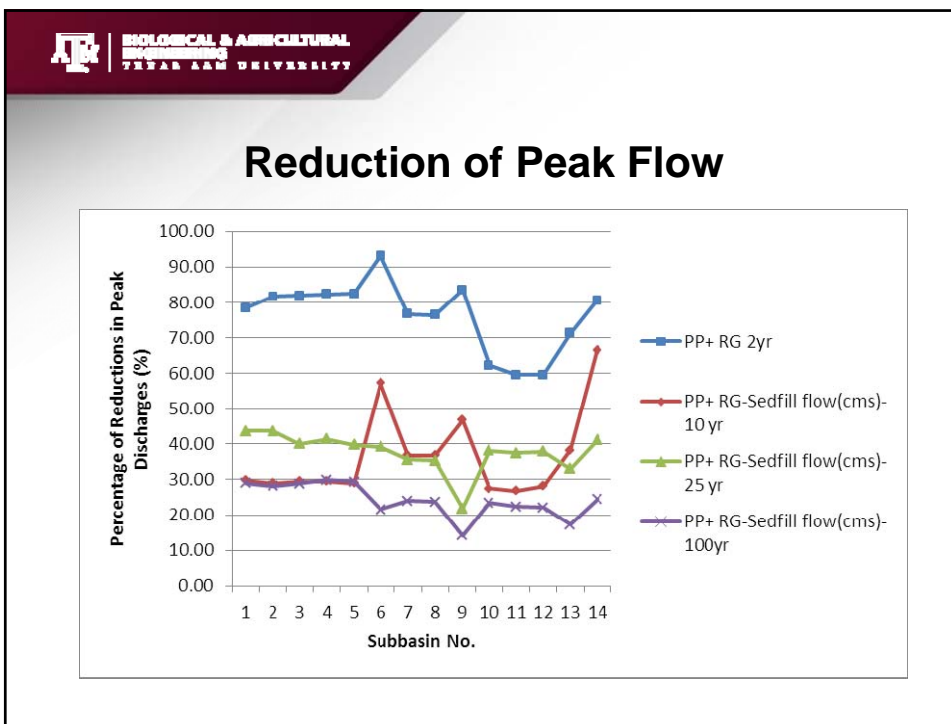
Elevation Value
High: 695 m
Low: 0 m
● watershed outlet

0 0.5 1 2 Kilometers

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TEXAS
Austin
MEXICO

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- ▣ This research was made possible by a CWA 319 (h) NPS grant provided by USEPA and TCEQ
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- ▣ Modeling studies funded by Texas Sea Grant, USEPA, TCEQ and the City of League City, TX



Fouad H. Jaber, PhD, PE

Associate Professor and Extension
Specialist

Biological and Agricultural Engineering
Texas A&M AgriLife Extension
Dallas Research and Extension Center

f-jaber@tamu.edu

972-952-9672



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