



CITY OF AUSTIN URBAN KARST FEATURE WATER QUALITY EVALUATION AND MITIGATION

Olivia Bramlet, P.E.

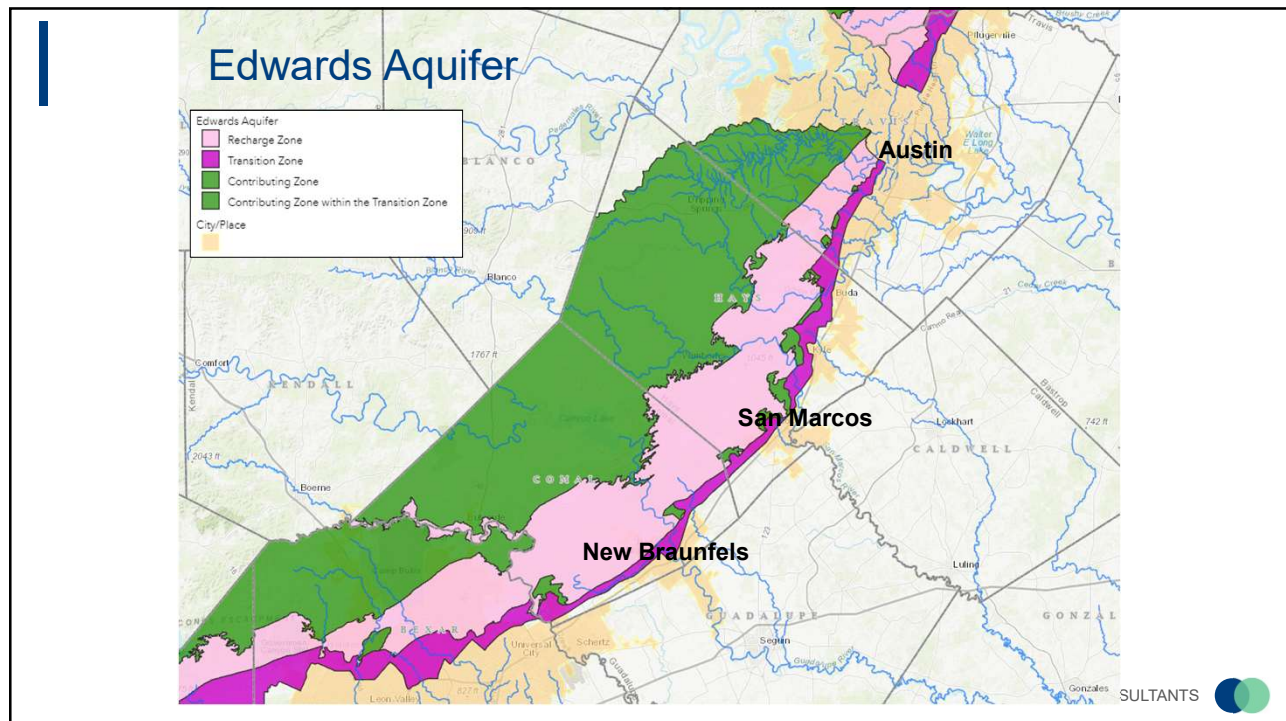
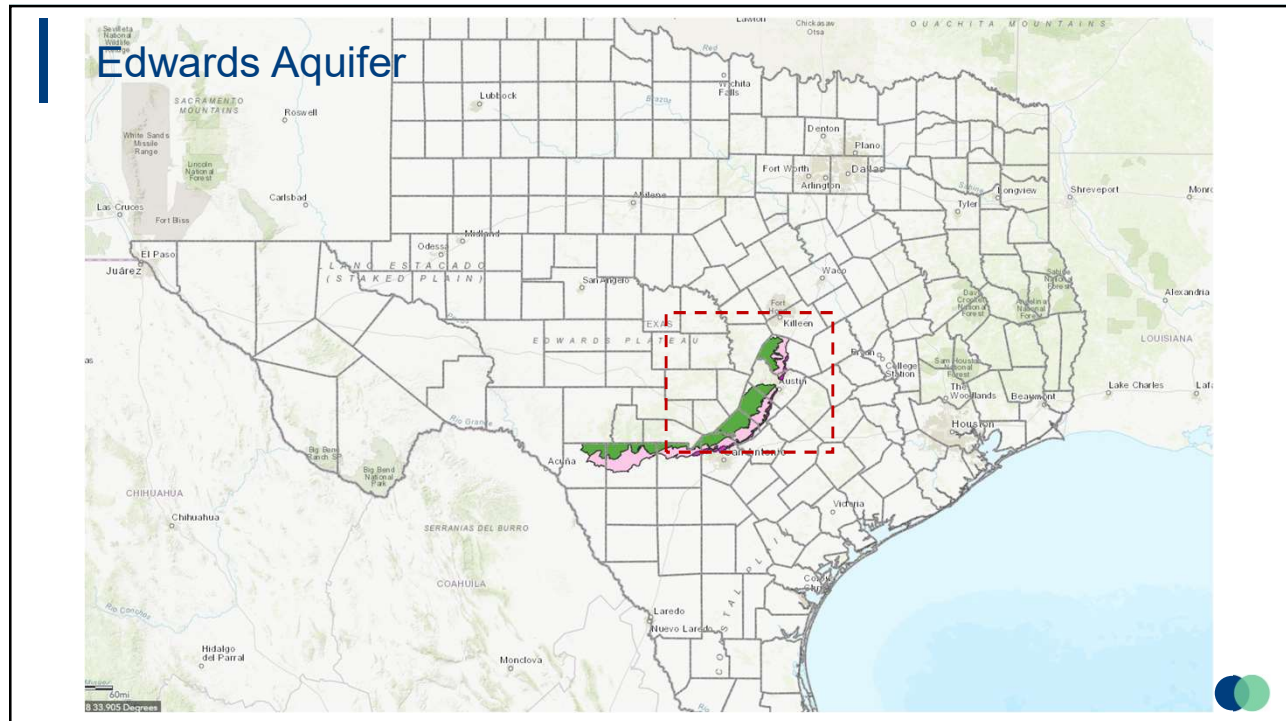
March 28, 2023

AGENDA

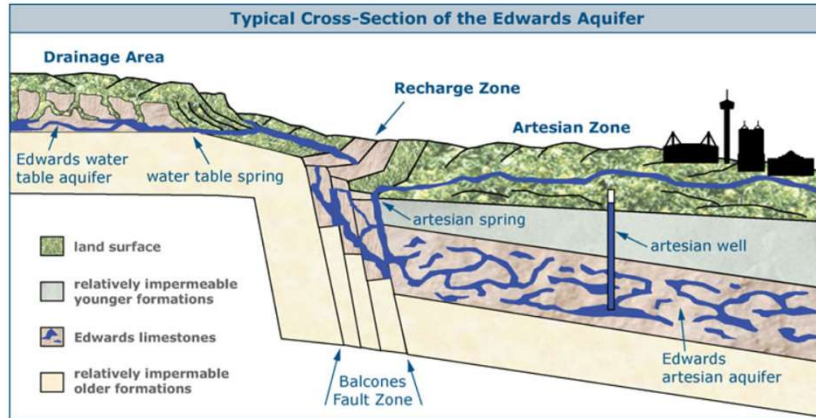


- Edwards Aquifer Recharge Zone
- Urban Karst Feature Project Introduction and Scope
- Evaluation
 - Geologic Assessment
 - Drainage Area and Land Use for Spill Risk Assessment
 - Pollutant Loads and Recharge Volume
 - Karst Feature Prioritization
 - Mitigation Strategies
- Path Forward

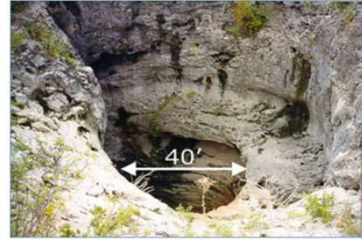




Edwards Aquifer Recharge Zone... what is a sinkhole???



The Valdina Farms / Seco Creek Sinkhole



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Environmentally Sensitive Aquifer



Recreation



Water Supply



Endangered Species

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Save Our Springs Ordinance

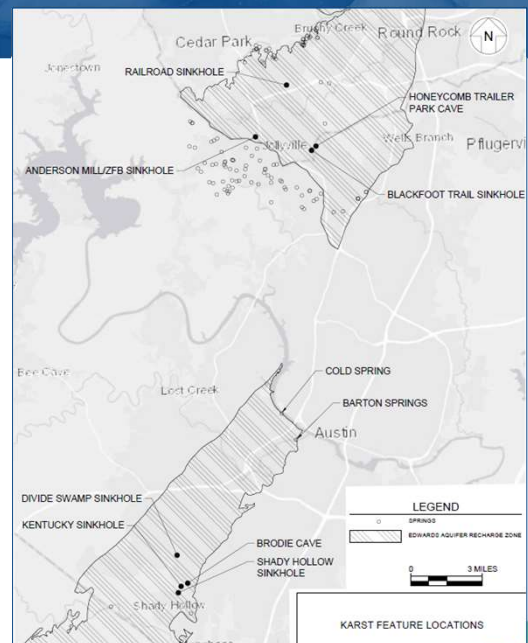
- Local rule adopted 1992 for new development over the recharge zone
- “Non-degradation” rule
 - No increase in annual loading for:
 - TSS
 - E. coli
 - Total Nitrogen
 - Total phosphorus
 - Dissolved phosphorous
 - Total lead
 - Total zinc
- Led to widespread implementation of Retention-Irrigation systems (i.e., on-site retention of ~95% of average annual runoff volume)
- Runoff from many older developments remain untreated or undertreated

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City of Austin Urban Karst Feature Project Scope

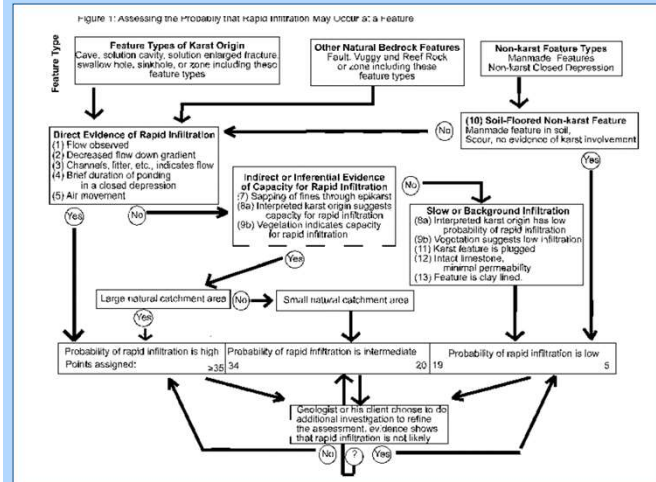
- Watershed Protection Department identified 8 karst features (i.e., sinkholes and caves) currently receiving untreated or undertreated runoff in the recharge zone
- Geosyntec Scope
 - Assess geologic sensitivity of karst features
 - Evaluate karst feature drainage areas and land use to assess spill risk
 - Estimate annual pollutant loads and recharge volumes to features
 - **Prioritize karst features based on relative risk to aquifer**
 - **Conceptualize and evaluate strategies to mitigate risk**



Karst Feature Geologic Assessment

- Assess Geologic Sensitivity
- Based on:
 - Feature size
 - Estimate of relative infiltration rate
 - Connectivity to impervious cover
- All 8 features were determined to be highly sensitive
- Assign a **geologic sensitivity score** to use in prioritization matrix

Flowchart for Determining Relative Infiltration Rate



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Karst Feature Geologic Assessment



Honeycomb Trailer Park Cave

- Located within Honeycomb Trailer Park
- Walnut Creek Watershed
- Recharges Northern Edwards Aquifer
- DA = 27 ac; IC = 38%; single family res, offices, undeveloped land
- Runoff from 15 ac receives treatment



Blackfoot Trail Sink

- Intersection of Blackfoot Tr./McNeil Dr.
- Walnut/Brushy Creek Watersheds
- Recharges Northern Edwards Aquifer
- DA = 9 ac; IC = 19%; single family res, commercial, undeveloped land
- No runoff receives treatment

Karst Feature Geologic Assessment



Divide Swamp Sink

- Located north of W Slaughter Ln and east of Mopac
- Slaughter Creek Watershed
- Recharges Barton Springs Edwards Aquifer
- DA = 58 ac; IC = 27%; single family res, undeveloped land
- Runoff from 48 ac receives treatment



Brodie Cave

- Located on an undeveloped tract near Brodie/Slaughter Ln
- Slaughter/Williamson Creek Watershed
- Recharges Barton Springs Edwards Aquifer
- DA = 556 ac; IC = 20%; single family res, apts, commercial, utility development
- Runoff from 165 ac receives treatment

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Karst Feature Geologic Assessment



Kentucky Sink

- Located on an undeveloped tract near Brodie Ln
- Slaughter Creek Watershed
- Recharges Barton Springs Edwards Aquifer
- DA = 21 ac; IC = 11%; single family res, undeveloped land
- No runoff receives treatment



Shady Hollow Sink

- Located on private property in neighborhood
- Slaughter Creek Watershed
- Recharges Barton Springs Edwards Aquifer
- DA = 17 ac; IC = 11%; single family res
- No runoff receives treatment



Karst Feature Geologic Assessment



Railroad Sink

- Located adjacent to CapMetro ROW
- Brushy Creek Watershed
- Recharges Northern Edwards Aquifer
- DA = 12 ac; IC = 0%; railroad ROW
- No runoff receives treatment



Photo 2
Feature S-1 - Smaller Sinkhole that is approximately 15 feet in diameter within Watershed Sinkhole (possible cave but not accessible)
Position Lat/Long NAD83:
N30° 26' 54.5" W97° 47' 40.4"

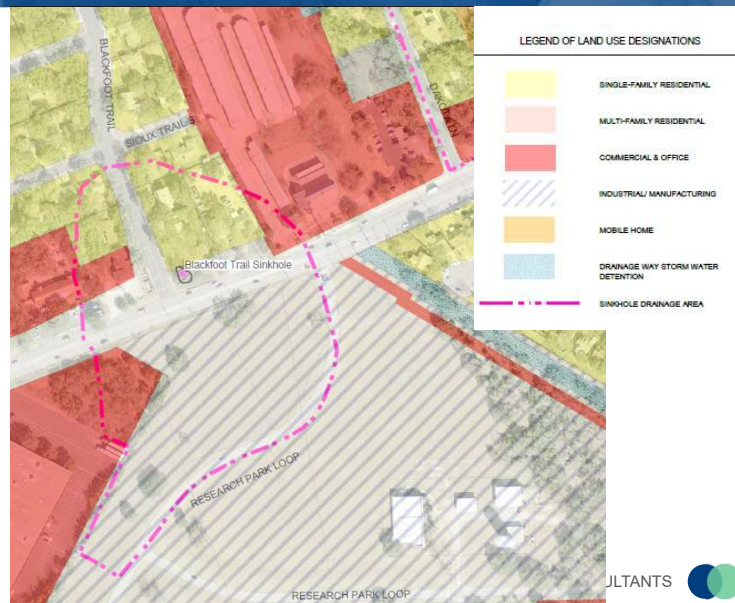
Anderson Mill/ZFB Sink

- Located on private property, access not granted by owners
- Lake Creek Watershed
- Recharges Northern Edwards Aquifer
- DA = 29 ac; IC = 50%; church, gas station, roadway, undeveloped land
- Runoff from 16 ac receives treatment



Spill Risk Assessment – Drainage Area and Land Use Evaluation

- Verify drainage area
- Verify land use
- Identify spill risks in drainage area
 - Major roads
 - Railroads
 - Hot spots (e.g., gas stations)
- Developed a **spill risk score** to use in prioritization matrix



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Pollutant Load & Recharge Volume Assessment

- **Annual runoff volumes and load**
 - Estimated using City tool (SLAT)
 - Drainage area
 - Impervious cover
 - Existing stormwater ponds
- **Conditions**
 - Developed (existing)
 - Undeveloped (natural)
- **Pollutants**
 - Total suspended solids
 - Total nitrogen
 - Total lead
- **Developed pollutant load and recharge volume increase scores to use in prioritization matrix**

SLAT STORMWATER LOAD ANALYSIS TOOL 2.0

Quick Guide:

1. Enable macros in the worksheet.
2. Click "Restore Defaults" button to the right.
3. Fill in yellow cells with project specifics, moving from top to bottom.
4. Click "View Full Results" button.
5. Project passes if green "COMPLIANT" button appears.

Find the full user manual at: slat@usdot.fhwa.gov or slat@usdot.fhwa.gov

Questions? Email: slat@usdot.fhwa.gov

Click Here To: [Restore Defaults](#) [View Results](#)

KEY: Required (Yellow), User Input (Blue), Internal Calculation (Green), Error (Red), Calculator Output (Grey), Does Not Apply (Light Grey)

Step 1: Input site characteristics in yellow highlighted cells

Brodie Cave Virginia Palacios 8/12/2019 SLAT 2.0 - 30000

Is your site within the Elbert Springs Zone (ESZ)? Yes

How many drainage areas, n_{DA} , does your site have? 3

Drainage Area A	Drainage Area B	Drainage Area C
72.25	93.15	227.61
59.0	49.0	10.0
59.0	49.0	10.0

Drainage area to the control, A_c (acres)

Bag impervious cover of the drainage area, C_p (%)

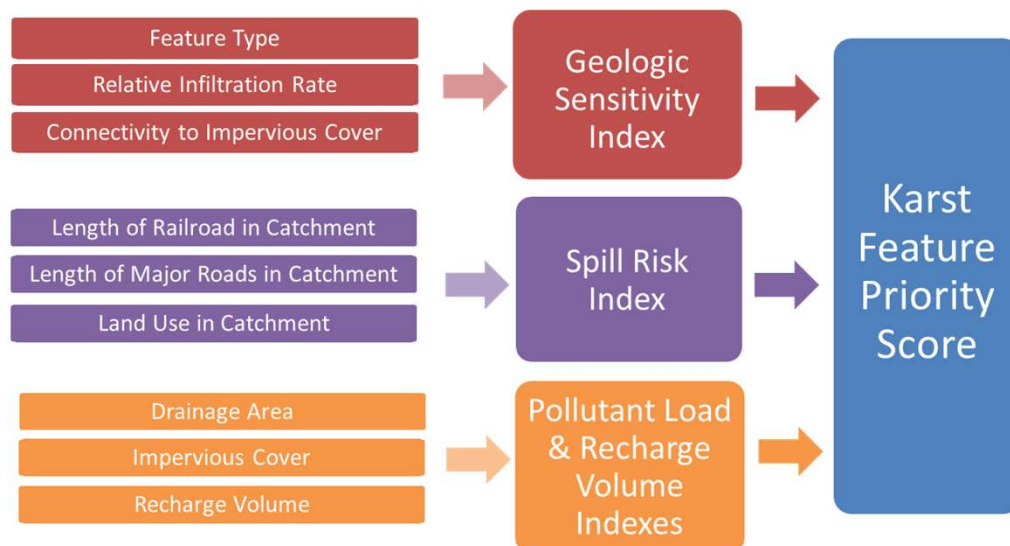
Developed impervious cover of the drainage area, C_d (%)

Step 2: Input SCM characteristics in yellow highlighted cells

SCM 1 (First in Series)

Drainage Area A	Drainage Area B	Drainage Area C
SCM A1	SCM B1	SCM C1
sedimentation/filtration	Retention Basin	None
Yes (Off-Line)	Yes (Off-Line)	None
What is the Water Quality Volume, WQV (acres-ft) (aka Capture Depth)	0.89	1.5
Minimum water quality volume allowed (in)	0.89	0.79
SCM 1 Actual Volume (in)	23916	69720
Do you know the drawdown time or the flow rate?	Drawdown Time	Drawdown Time
Drawdown Time, T_{DD} (hrs)	48	60
Flow Rate (gpm) (use only for "alternative" control)	0.008	0.025
Treatment Rate, T_R (in/hr)	No	No
Do you already know the runoff capture efficiency?	No	No
Use Groundwater Capture Efficiency, RCE (%)	94.0%	96.2%
Runoff Capture Efficiency, RCE (%)	94.0%	96.2%
Conveyance	Gravity Drained	Pumped
How is effluent from SCM 1 discharged?	Gravity Drained	Pumped
Delay after end of rainfall before discharging SCM 1 (hrs)	0	12
SCM A2	SCM B2	
None	Infiltration Field	
Do you know the infiltrated or reused water quantity?	No, infiltrate all routed water	
User-entered infiltr. water quality volume, WQV_{in} (in)		
-CR- Percent of yearly runoff infiltrated, RCE_{in} (%)		
Soil infiltration rate (in/hr)	0.1	
Ratio of drawdown time / irrigation time, for any zone	2	
Approximate Minimum Field Area (Ac)	46.58	


Karst Feature Prioritization



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Karst Feature Prioritization Matrix

Karst Feature Name	Geological Sensitivity Index	Spill Risk Index	Pollutant Load Index	Recharge Loss Index	Karst Feature Priority Score	Karst Feature Priority Rank	
Brodie Cave	1.00	1.00	1.00	-0.97	0.51	1	 <i>Poses largest relative risk to ground water quality</i>
Anderson Mill/ZFB Sinkhole	0.72	1.00	0.23	-0.14	0.45	2	
Railroad Sinkhole	0.72	0.67	0.06	-0.02	0.36	3	
Kentucky Sinkhole	0.72	0.33	0.05	-0.01	0.27	4	
Blackfoot Trail Sinkhole	0.72	0.33	0.05	-0.03	0.27	5	
Shady Hollow Sinkhole	0.78	0.00	0.17	-0.04	0.23	6	
Honeycomb Trailer Park Cave	0.78	0.00	0.17	-0.09	0.22	7	
Divide Swamp Sinkhole	0.61	0.00	0.00	0.03	0.16	8	

Mitigation Strategies

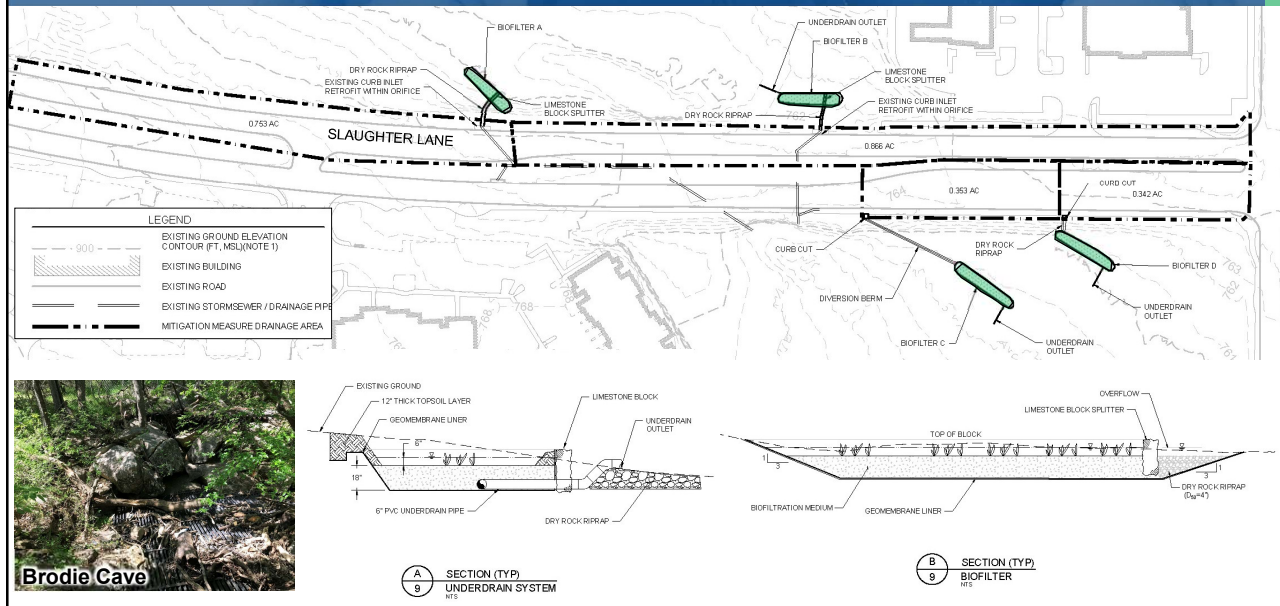
Identify	Identify specific opportunities for up to 24 mitigation strategies
Screen	Screen strategies in terms of relative feasibility, effectiveness, and cost
Select	Select up to 12 mitigation projects for further consideration.

Potential Strategies

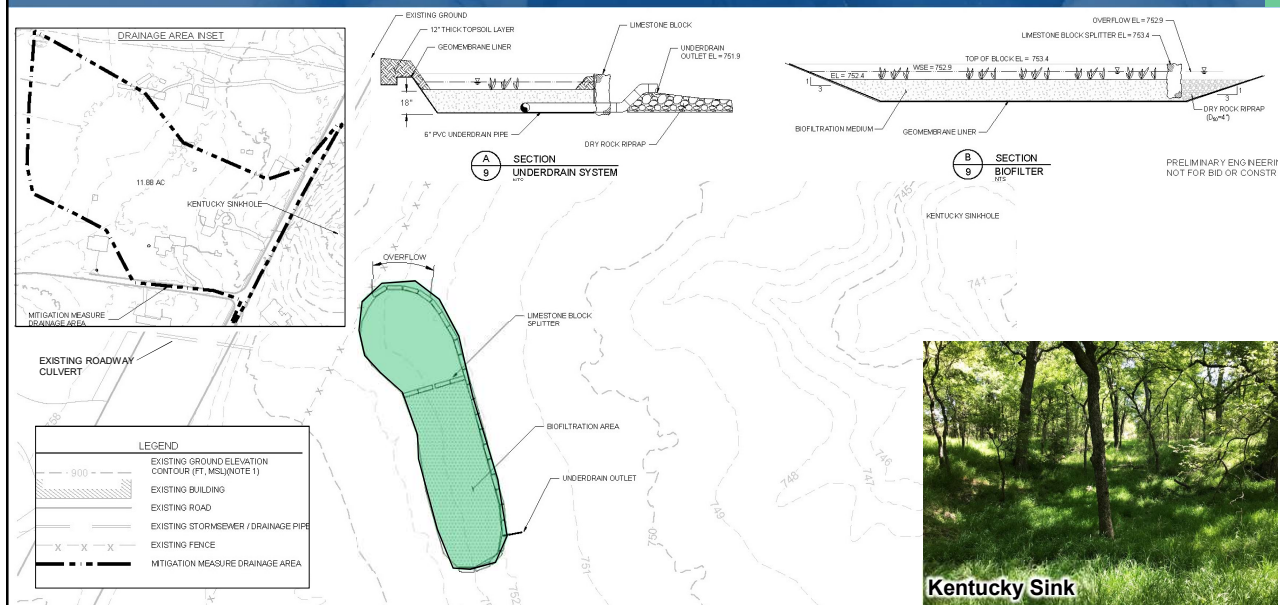
- Land acquisition
- Decentralized runoff treatment
- Centralized runoff treatment
- Karst feature protection structures
- Plugging and sealing
- Redirecting storm sewer
- Surface runoff diversions

Strategies identified on case-by-case basis depending on the calculated screening score that was assigned based on the magnitude of threat, effectiveness of strategy, and relative rating of feasibility and cost

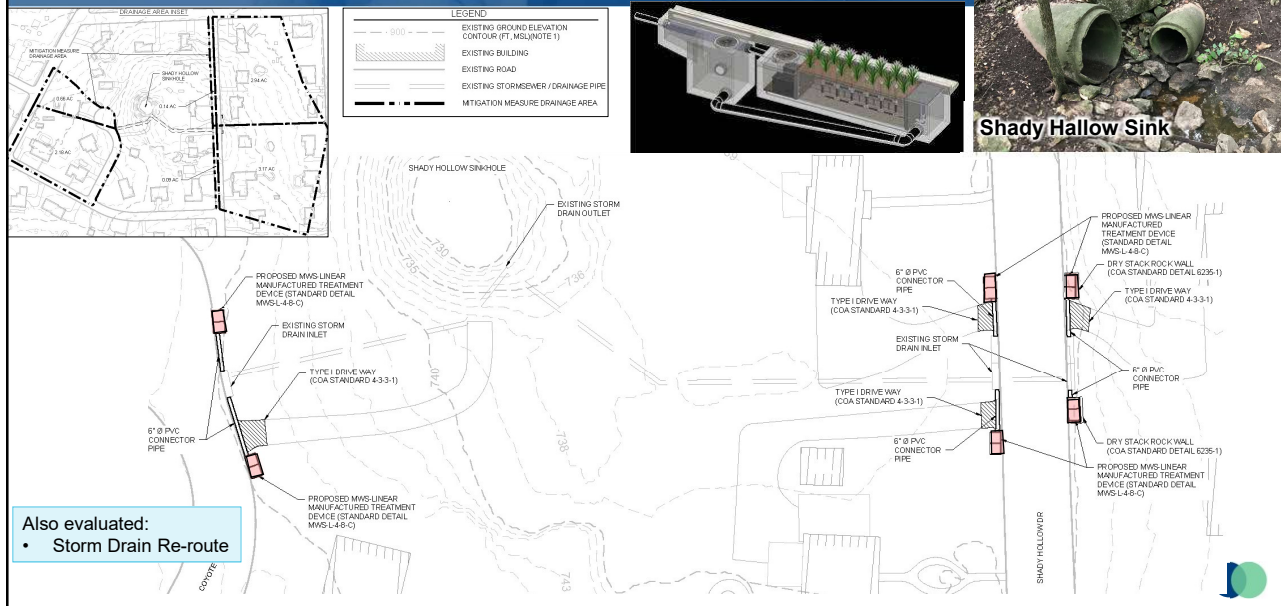
Brodie Cave Biofilter



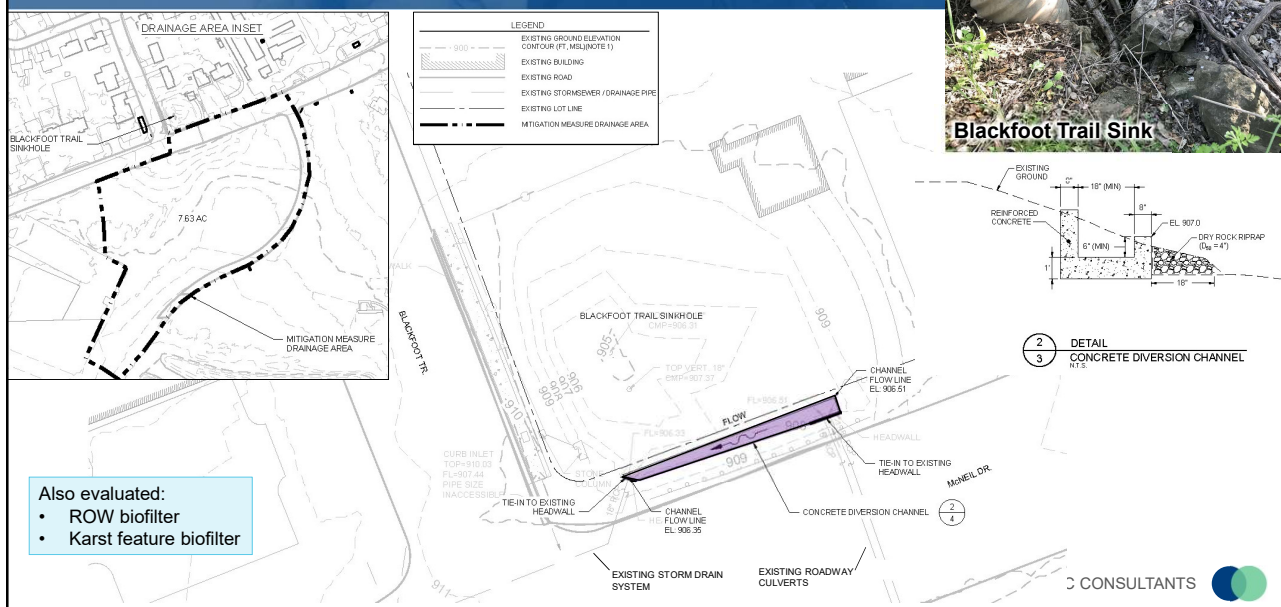
Kentucky Sink Biofilter



Shady Hollow Sinkhole Manufactured Treatment Devices



Blackfoot Trail ROW Diversion Channel



Path Forward

- **Brodie Cave Biofilter**
 - Design phase as part of Slaughter Road corridor improvements
- **Kentucky Sink Biofilter**
 - Design phase in progress by City
- **Shady Hollow Manufactured Devices**
 - Design phase on hold
 - Reconsidering related flood mitigation project
- **Blackfoot Diversion Channel**
 - Planning to incorporate storm drain improvements with future McNeil Road corridor improvements project

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Thank you! Questions?

Olivia Bramlet, P.E.
obramlet@geosyntec.com

Geologic Assessment Summary

Karst Feature Name	Date of Site Visit	Feature		Dimensions of Opening	Infill	Relative Infiltration Rate		Structural Notes	Cave Extent	Connectivity to Impervious Cover		Geologic Sensitivity Score (Type, Infiltration Rate, Connectivity to IC)		Geologic Sensitivity Index	Notes
		Type	Points			Description	Points			Rating	Points	Score	Rating		
Railroad Sinkhole	No site visit	Cave	30	Unknown. Unable to determine the size of the opening. Based on information from City staff, the feature is assumed to be a cave.	Unknown	High based on large drainage area	35	Unknown	Unknown	Low, surrounded by relatively large buffer based on aerial imagery	0	65	High	0.72	Access to the feature was not granted by CapMetro
Anderson Mill/2FB Sinkhole	No site visit	Cave	30	20 ft wide, based on 3/4/2019 phone conversation with Bill Fohl (owner)	Unknown	High based on large drainage area and vegetative cover observed from aerial photos.	35	Unknown	Greater than 60' long based on phone conversation with owner	Low, relatively large vegetative buffer based on aerial imagery	0	65	High	0.72	Contacted Bill Fohl 3/4/2019 via Fohl Brown Associates. Mr. Fohl did not provide site access and expressed concern that providing access to the sinkhole for the project could potentially risk development to his property through additional cost or time delay. Mr. Fohl indicated he has spent \$150K studying the cave including dye trace.
Honeycomb Trailer Park Cave	3/26/2019	Cave	30	Surface opening filled with 26-in. diam. corrugated metal pipe. At approx. 4 ft below ground, the cave opening is approx. 2-ft by 2-ft.	No infill observed in the cave. The depressed area around the cave opening is vegetated with grass.	High - Trailer park manager indicated that drainage to cave does not back up even during heavy rain events.	35	Appears structurally stable.	Unknown	Moderate, surrounded by grass	5	70	High	0.78	Cave opening is covered with a metal gate.
Blackfoot Trail Sinkhole	3/26/2019	Sinkhole	20	Two 18-in. diam. corrugated metal standpipes. Standpipe appear to extend 10-15 feet below ground surface.	Surface covered with leaves, sticks, and soil. Trees and shrubs appear healthy.	High based on drainage features	35	Appears structurally stable.	Unknown	High, storm drain routed to feature.	10	65	High	0.72	Standing water at bottom of standpipes. Storm main on top of standpipes clogged with leaves and sticks. Some displacement of material surrounding standpipes.
Divide Swamp Sinkhole	3/26/2019	Sinkhole	20	Approximately 25-ft by 10-ft surface depression, 3 to 4 ft deep. No visible opening.	Filled with broken boulder-sized rocks and soil.	High (1,500 to 1,900 gpm) based on City measurements and video taken by City staff in October 2018.	35	Appears structurally stable.	Unknown	Low, surrounded by exclusion berm.	0	55	High	0.61	Broken rocks evidence of historical infilling, surrounded by earthen berm.
Brodie Cave	3/26/2019	Cave	30	Sinkhole opening measures approximately 25-ft by 20-ft at grate, approximately 10 feet below threshold. Dimensions of cave opening greater than 3 ft.	Partial infilling with leaves, woody debris and logs, and smaller rocks.	High based on large opening, very large drainage area, no standing water.	50	Unknown structural stability. No apparent instabilities.	Unknown	High, located in stream bed	10	90	High	1.00	Cave is located in stream bed and protected with horizontal grate and gate. Chain link fence surrounding cave was damaged, evidently by past high stream flows debris. Extensive deposits of cobbles and boulders in stream bed indicative of high energy intermittent flow.
Kentucky Sinkhole	3/26/2019	Sinkhole	20	2 small approximately 1-ft diameter animal burrow holes at bottom of sinkhole. Sinkhole is approximately 10 to 15 ft deep and approximately 50-ft by 50-ft wide at bottom.	Filled with soil and leaves. Trees and grasses appear healthy.	High based on feature dimensions, large drainage area, and healthy vegetation (evidence of subsequent standing water).	40	Appears structurally stable.	Unknown	Moderate, channelized drainage from west, relatively large vegetative buffer.	5	65	High	0.72	Very well developed, prominent surface expression bounded by roads with surface drainage towards sink.
Shady Hollow Sinkhole	5/31/2019	Sinkhole	20	Sinkhole is approximately 10 ft deep and approximately 50-ft by 50-ft wide at bottom.	Filled with soil and leaves. Trees and grasses appear healthy.	High based on presence of storm drain pipes, large drainage area, and healthy vegetation (evidence of subsequent standing water).	40	Appears structurally stable.	Unknown	High, storm drain pipes routed to feature.	10	70	High	0.78	Sinkhole located behind private fence. Sinkhole partially visible from Coyote Court. Storm drain pipes are connected to sinkhole.

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Spill Risk Summary

Karst Feature Name	Roads		Railroad		Industrial/Gas Station Land Uses		Spill Risk Index				
	Length of Major Roads (ft)	Points (Note 1)	Length of Railroad (ft)	Points (Note 1)	Land Use Type	Points (Note 2)	Weighted Road Points Weight Factor = 2	Weighted Railroad Points Weight Factor = 2	Weighted Other Land Use Points Weight Factor = 1	Spill Risk Score	Spill Risk Index
Railroad Sinkhole	0	0	2,726	10	N/A	0	0	20	0	20	0.67
Anderson Mill Sinkhole	2,219	10	0	0	Gas Station	10	20	0	10	30	1.00
Honeycomb Trailer Park Cave	0	0	0	0	N/A	0	0	0	0	0	0.00
Blackfoot Trail Sinkhole	657	5	0	0	N/A	0	10	0	0	10	0.33
Divide Swamp Sinkhole	0	0	0	0	N/A	0	0	0	0	0	0.00
Brodie Cave	2,588	10	0	0	Gas Station	10	20	0	10	30	1.00
Kentucky Sinkhole	782	5	0	0	N/A	0	10	0	0	10	0.33
Shady Hollow Sinkhole	0	0	0	0	N/A	0	0	0	0	0	0.00

Notes:

1. Road and railroad point scale: No major roads or railroads = 0, length of major roads and railroads <1000 ft = 5, length of major roads and railroads > 2000ft = 10
2. Land use point scale: absence of industrial/gas station = 0 and presence of industrial/gas station = 10.

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Pollutant Load Summary

Karst Feature Name	Developed Conditions Annual Pollutant Load (lb/yr)			Natural Conditions Annual Pollutant Load (lb/yr)			Excess Annual Pollutant Load (lb/yr)			Normalized Excess Pollutant Load			Pollutant Load Index
	TSS	TN	Pb	TSS	TN	Pb	TSS	TN	Pb	TSS	TN	Pb	Average
Railroad Sinkhole	1,993	26.65	0.08	599	4.29	0.02	1,394	22.4	0.06	0.11	0.05	0.03	0.06
Anderson Mill Sinkhole	4,198	108.29	0.51	1,434	10.28	0.04	2,764	98.0	0.47	0.22	0.20	0.26	0.23
Honeycomb Trailer Park Cave	3,664	78.57	0.36	1,311	9.40	0.03	2,353	69.2	0.33	0.19	0.14	0.18	0.17
Blackfoot Trail Sinkhole	1,646	22.02	0.07	569	4.08	0.01	1,077	17.9	0.05	0.09	0.04	0.03	0.05
Divide Swamp Sinkhole	0	0.00	0.00	2,852	20.44	0.07	-2,852	-20.4	-0.07	-0.23	-0.04	-0.04	0.00
Brodie Cave	31,782	616.86	2.31	19,266	138.11	0.50	12,516	478.7	1.81	1.00	1.00	1.00	1.00
Kentucky Sinkhole	1,966	26.29	0.06	906	6.50	0.02	1,059	19.8	0.04	0.08	0.04	0.02	0.05
Shady Hollow Sinkhole	4,291	57.39	0.22	818	5.87	0.02	3,473	51.5	0.20	0.28	0.11	0.11	0.17

Notes:
TSS = Total Suspended Solids
TN = Total Nitrogen
Pb = Lead

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Recharge Volume Summary

Karst Feature Name	Recharge Volume (acre-in/year)			Recharge Loss Index
	Developed Conditions	Natural Conditions	Recharge Increase	
Railroad Sinkhole	52.95	15.91	37.04	-0.02
Anderson Mill Sinkhole	355.22	38.10	317.12	-0.14
Honeycomb Trailer Park Cave	236.78	34.85	201.93	-0.09
Blackfoot Trail Sinkhole	75.03	15.12	59.90	-0.03
Divide Swamp Sinkhole	0.00	75.78	-75.78	0.03
Brodie Cave	2,751.61	511.96	2239.65	-0.97
Kentucky Sinkhole	52.24	24.09	28.15	-0.01
Shady Hollow Sinkhole	114.04	21.74	92.30	-0.04

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