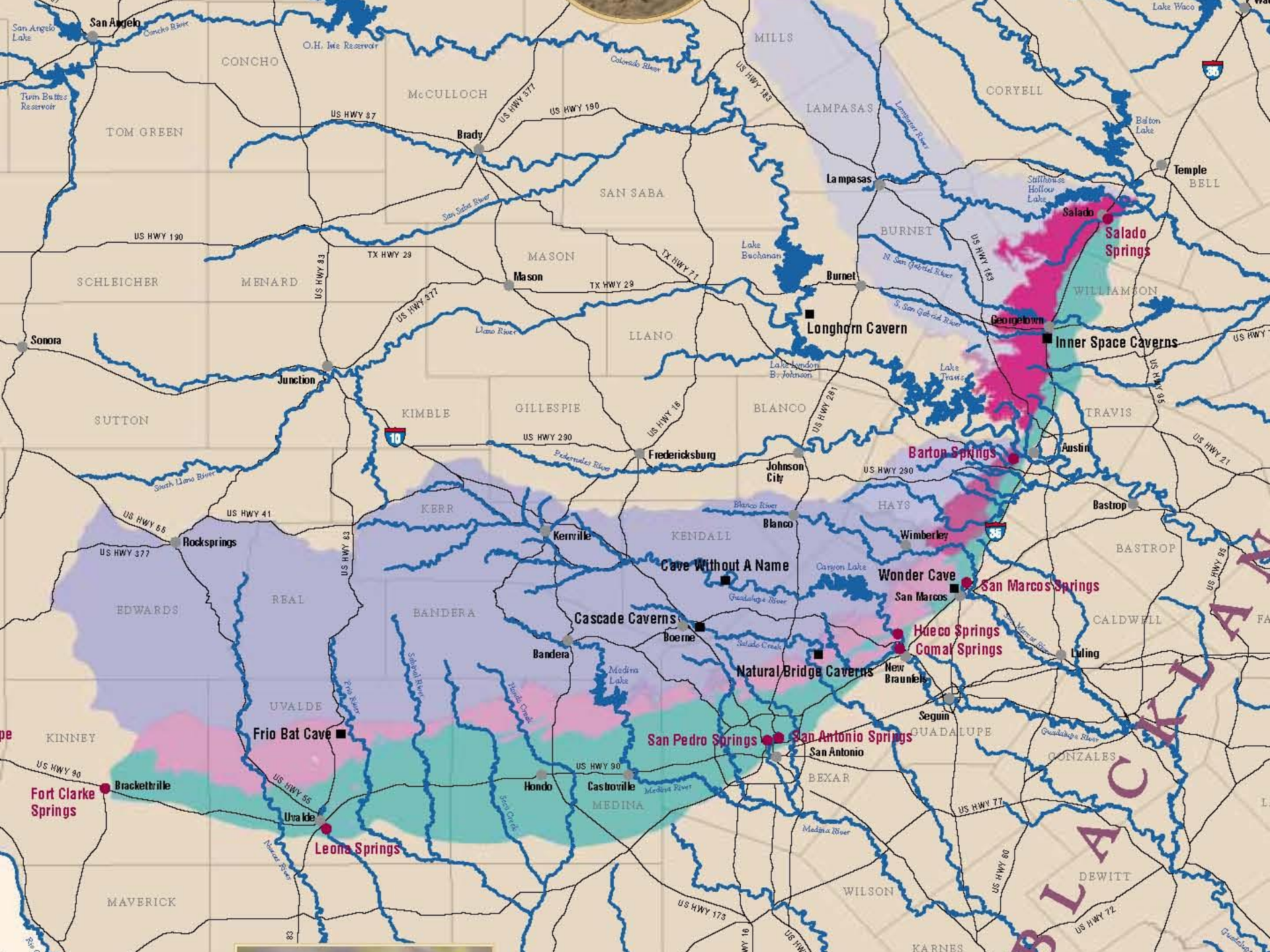
A topographic map of Texas and surrounding regions, showing elevation and terrain. The Edwards Aquifer is highlighted in a bright yellow color, forming a curved shape in the eastern part of Texas. The map includes state boundaries and the Gulf of Mexico to the south.

Managing Natural Resources in the Heart of Texas: Challenges and Opportunities

Annalisa Peace
Greater Edwards Aquifer Alliance



San Angelo

CONCHO

MCCULLOCH

SAN SABA

MILLS

LAMPASAS

CORYELL

TOM GREEN

Brady

US HWY 87

US HWY 577

US HWY 190

La mpasas

LAMPASAS

Salado

Salado Springs

Temple

US HWY 190

SCHLEICHER

MENARD

Mason

MASON

TX HWY 29

TX HWY 29

Burnet

BURNET

US HWY 163

Inner Space Caverns

US HWY 95

Junction

KIMBLE

GILLESPIE

LLANO

BLANCO

Longhorn Cavern

Georgetown

TRAVIS

SUTTON

Fredericksburg

JOHNSON CITY

Barton Springs

Austin

US HWY 21

US HWY 55

US HWY 41

KERR

Kerrville

Cave Without A Name

Blanco

HAYS

Wimberley

San Marcos Springs

BASTROP

US HWY 95

EDWARDS

REAL

BANDERA

Cascade Caverns

Boerne

Wonder Cave

Hico Springs

Comal Springs

Luling

Fort Clarke Springs

Frio Bat Cave

Bandera

Natural Bridge Caverns

New Braunfels

Seguin

GUADALUPE

CONZALES

Brackettrille

Uvalde

Hondo

San Pedro Springs

San Antonio Springs

San Antonio

US HWY 77

US HWY 77

US HWY 95

MAVERICK

Castroville

Medina

BEXAR

US HWY 80

US HWY 72

DEWITT

WILSON

BLACKLANDS

KARNES

US HWY 72

The Texas Commission on Environmental Quality (TCEQ) has designated the Edwards Aquifer as the major aquifer in the state most vulnerable to pollution.

Little to no filtration is provided as water enters directly into the Aquifer through faults, stream beds, and terrain characterized by uniquely porous Edwards limestone.



The Edwards is a uniquely prolific aquifer characterized by rapid groundwater recharge and rapid open channel flow.



This rock also makes the Edwards uniquely prolific.



Surface water across Edwards/Trinity Aquifer region is scarce



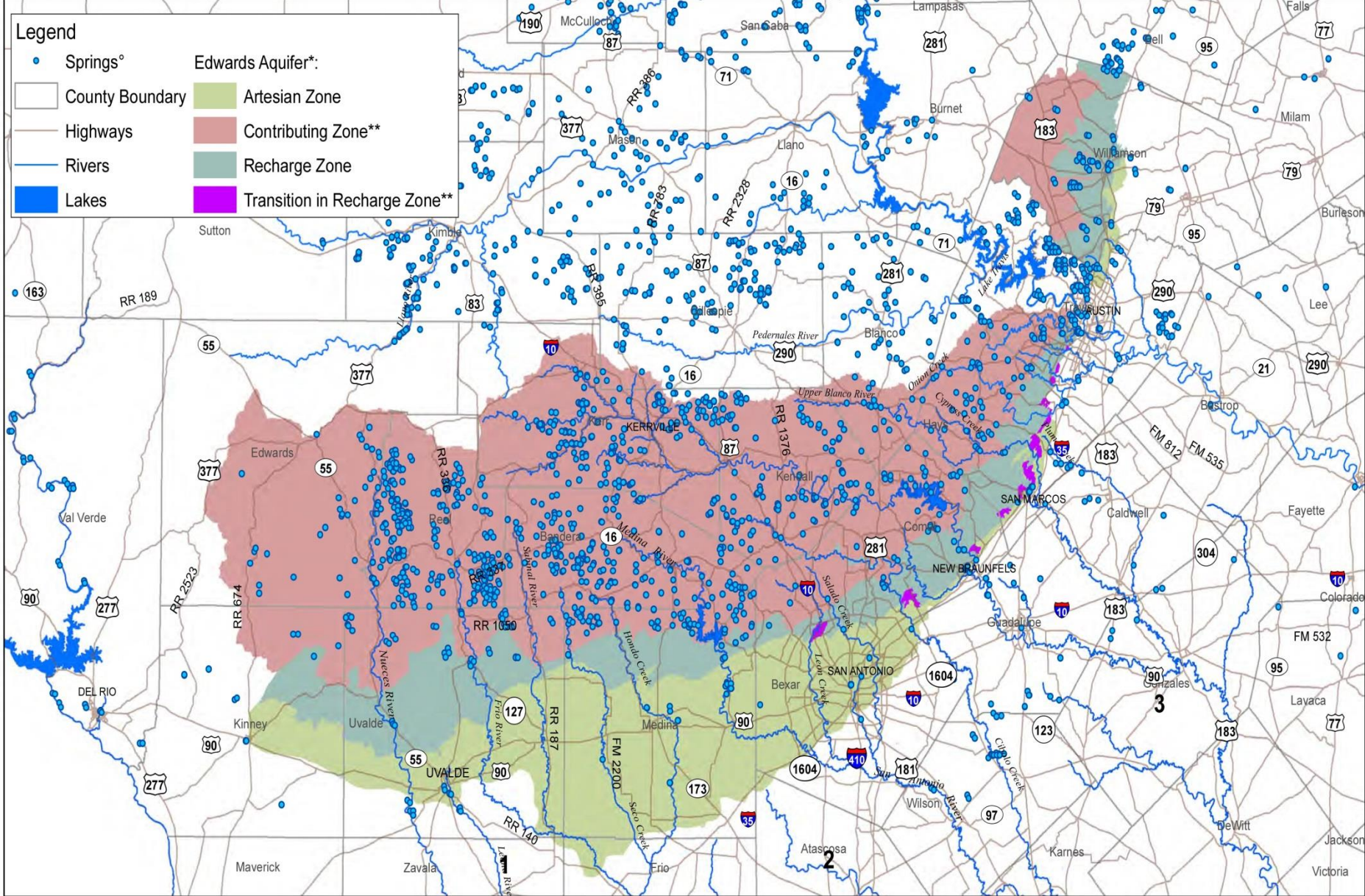
- Surface waters and streams less prevalent in aquifer region
- Streams lose water through fissures as they flow across porous karst
- 75% of aquifer recharge occurs directly through streambeds that cross the Recharge Zone
- Available water derived from groundwater springs and seeps

The Edwards Aquifer is the source of the largest springs in Texas

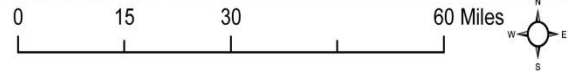
- Largest springs in Texas
- Cities and towns



Springs of the Edwards Aquifer



° Spring data compiled from three sources: 1) USGS (spring location information downloaded from <http://waterdata.usgs.gov/bw/nwis/si> on 7/15/2010), 2) Texas Water Development Board (shapefiles obtained via personal email correspondence with Janie Hopkins, Manager, Groundwater Monitoring Section on 4/27/2010), and Texas Hydrological Innovations (shapefile downloaded from <http://geosites.evans.tstate.edu/g4427/2010/S10/THI/maps.html> on 3/1/2011).
 * Edwards Aquifer base shapefile ("Edwards Aquifer Zone Boundary") downloaded from http://www.edwardsaquifer.org/display_technical_m.php?pg=gs on 01/15/2011.
 ** Modified zone information taken from TCEQ Edwards Aquifer Regulatory Boundary shapefile, originally downloaded from <http://www.tceq.texas.gov/gis/boundary.html> on 12/15/2010.



The Edwards Aquifer
Ecosystem sustains essential
freshwater flows to bays
and estuaries



Guadalupe Estuary – San Antonio Bay



“Our fundamental position is that water in its natural state is entirely dedicated to supporting the environment. There is no surplus. As that water is used for human purposes, its environmental support capability is reduced.

As more of water is used for human purposes, not only is there less water available for environmental support, but there starts to be competition for the water among human needs. There never is a surplus. There is only a willingness by people to claim that certain amounts of water can be placed to human use with certain restraints.

The challenge is in adequately defining the constraints so that adverse social and environmental impacts are minimized.”

Edwards Aquifer Ecosystem

Home to 50 unique species
of plants and animals



Black capped Vireo



Golden cheeked Warbler



Texas Blind salamander
(*Eurycea rathbuni*)



Fountain darters

APRIL 2002 • \$3.95

Texas Monthly

Life & Death
at NASA
by STEPHEN HARRIGAN

hill country FOREVER

by JOHN GRAVES, SUZY BANKS,
and KINKY FRIEDMAN

School Finance
For Dummies
by PAUL BURKA

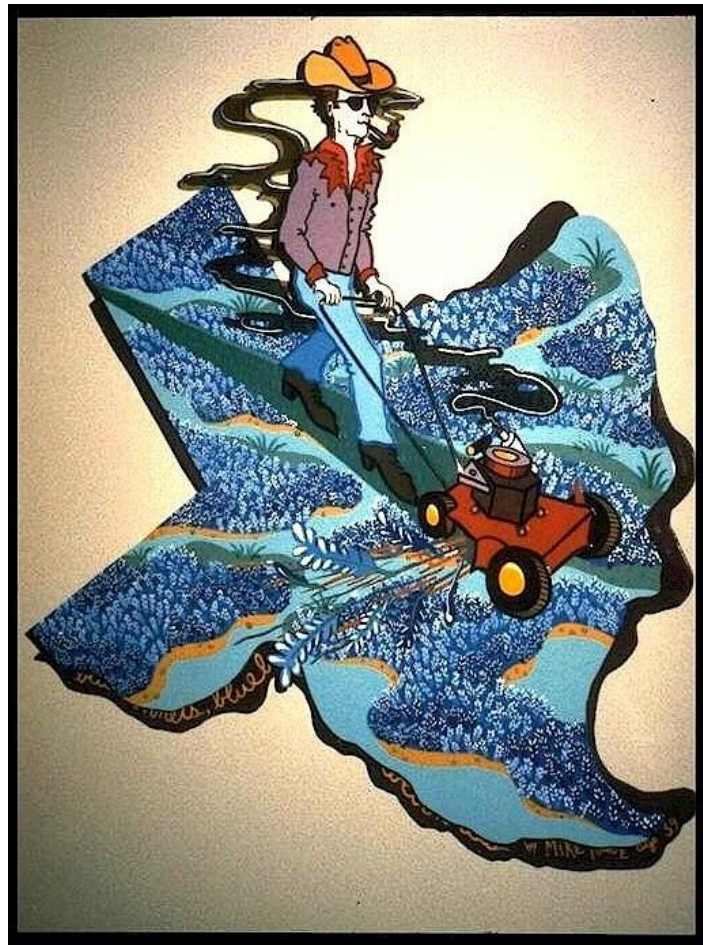
David Koresh Will
Be Resurrected
Any Day Now
by MICHAEL HALL

The Woman Who
Ratted Out Enron
by PAMELA COLLOFF



A poll taken in the 1990's by Texas Monthly found that 80% of Texans want to retire to the Hill Country.

We are literally loving the Hill Country to death.



Mowing Bluebonnets by Mike Pogue

The Texas Hill Country is one of the fastest growing areas in the nation:

Fastest Growing Cities in the Nation (U.S. Census Bureau 2015)

#1: San Marcos – 2015 population growth rate 7.9%

(Since 2010, the city's population has increased by 30 %)

#4: Austin - 2015 Population Growth Rate: 2.5%

#5: San Antonio - 2015 Population Growth Rate: 1.8%

U.S. Census Bureau - Resident Population Estimates for the 100 Fastest Growing U.S. Counties With 10,000 or More Population in 2010: April 1, 2010 to July 1, 2013

#10 – Kendall County	13% growth
#14 – Hays County	12% growth
#17 – Williamson County	11.5% growth
#31 – Travis County	9.4% growth
#34 – Comal County	9.2% growth
#44 – Guadalupe County	8.9% growth



THE WORLD'S POPULATION, CONCENTRATED

If the world's 6.9 billion people lived in one city, how large would that city be if it were as dense as...



PARIS
12,000 square miles
30,000 square kilometers



SAN FRANCISCO
20,000 square miles
52,000 square kilometers



NEW YORK
250,000 square miles
650,000 square kilometers



LONDON
150,000 square miles
390,000 square kilometers



SINGAPORE
17,000 square miles
44,000 square kilometers



HOUSTON
1,000,000 square miles
2,600,000 square kilometers

TCEQ Paves the Way for Shit Creek(s)

State environmental agency rejects science in favor of allowing sewage in creeks

BY JACOB COTTINGHAM, FRI., DEC. 5, 2008



TCEQ administrative law judges recommended allowing the Belterra subdivision to discharge treated effluent into Bear Creek, while the agency's commissioners rejected the city of Austin and BS/EACD's request for a ban on discharge within the watersheds of Barton and Onion creeks.

For a local example of the great "global warming debate," just look at the controversy over discharge of treated effluent – **sewage** in laymen's terms – in the **Edwards Aquifer Watershed**. On one side are the familiar government entities and environmental groups, such as the Barton Springs/Edwards Aquifer Conservation District, the city of Austin, Hays County, and the Save Our Springs Alliance. On the other are development interests and their lawyer, **Andy Barrett**, whose lobby list on file with the Texas Ethics Commission includes water giant Aqua America Inc. and an assortment of development and energy companies. Ostensibly in the middle are the commissioners of the **Texas Commission on Environmental Quality** – all appointed by industry-friendly Gov. Rick Perry. Each side has its own set of scientists, talking points, and convictions, making any environmental topic a lengthy point-counterpoint discussion.

There are three TCEQ-related issues in play, which seem to blend into a single case: One is the contested case of the **Belterra** development in Hays Co. This was a battle before two TCEQ administrative law judges, with each side arguing whether or not to discharge treated effluent from Belterra into Bear Creek, which feeds the recharge zone of the Edwards Aquifer. Following on its heels is the joint petition filed by the city of Austin and the BS/EACD, which asked the TCEQ for a change of rules to prohibit discharge into the Onion or Barton watersheds. A third TCEQ case on the horizon concerns **Jeremiah Venture's** massive residential development in Hays Co., which is seeking a permit to discharge effluent on thin soil covering the recharge zone.

THE SUMMIT AT STONE DOMINON OAK AT CIBOLO CULEBRA CREST



A COMMUNITY OF GENERIC, PIECE O'CRAP **McMANSIONS**

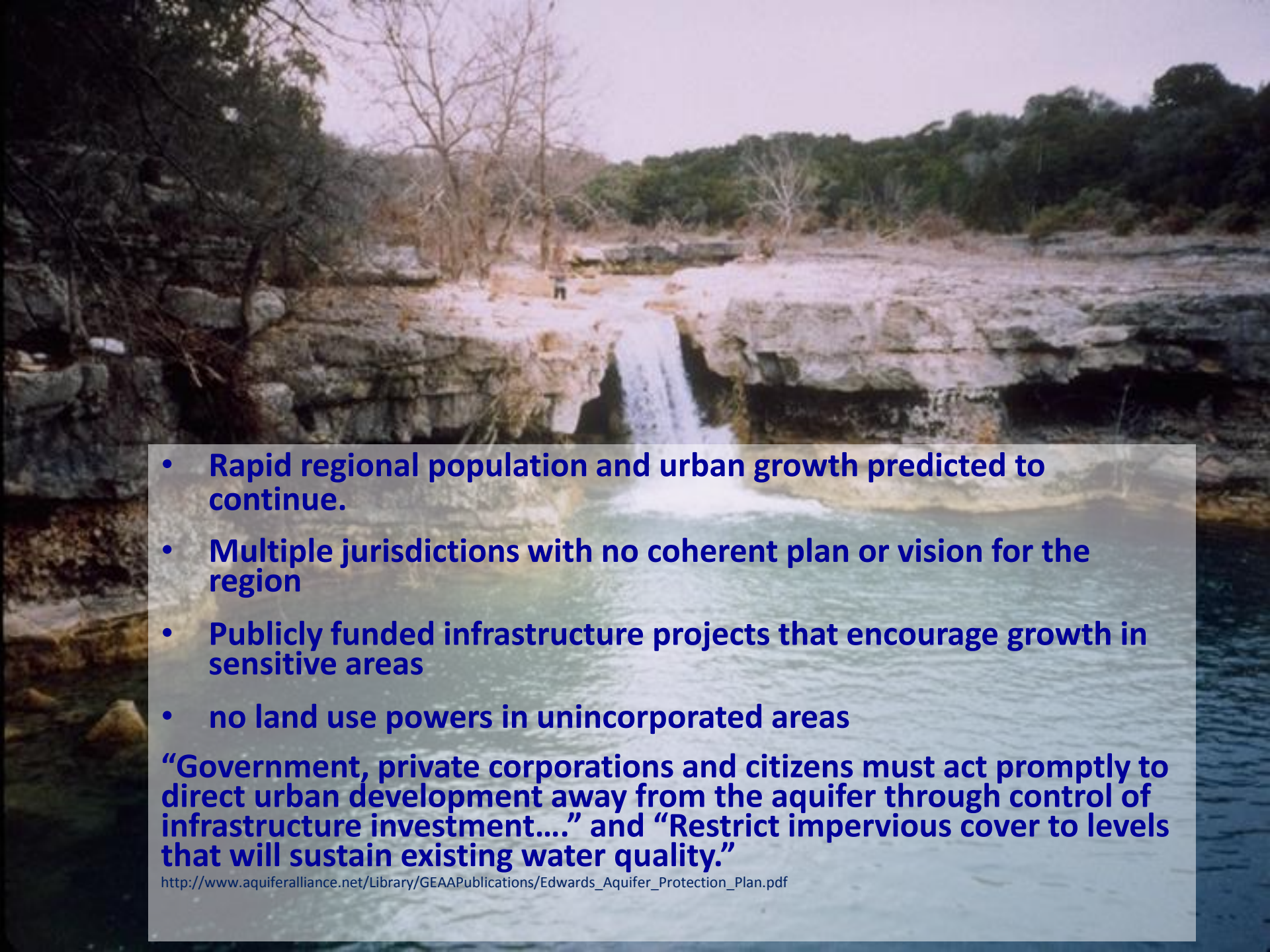
slapped together with cheap materials and shoddy workmanship

RIDICULOUSLY
OVERPRICED

FROM THE LOW \$800's

OFFERED BY
SWEENCO.

(210) 342-3088

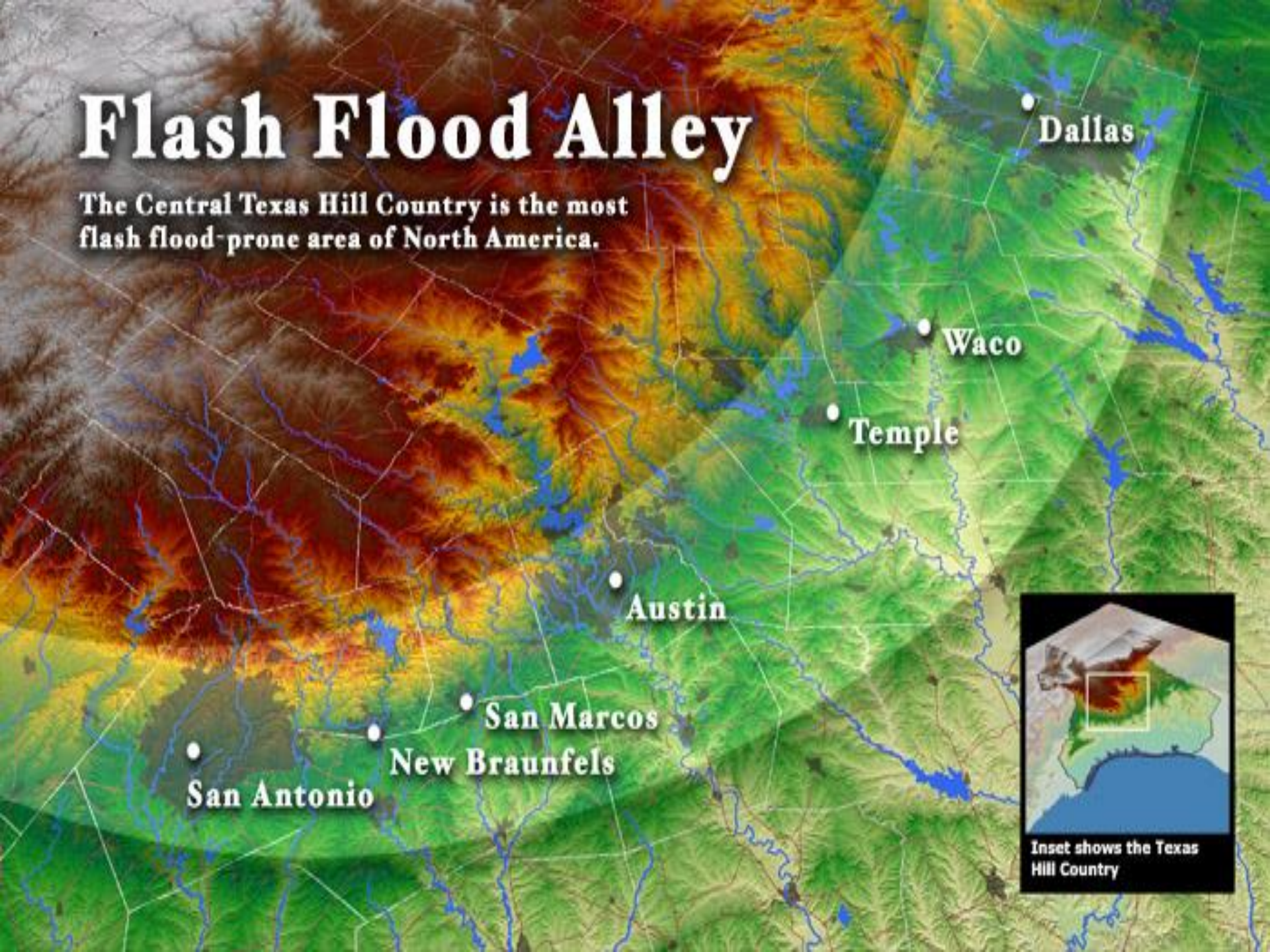
- 
- **Rapid regional population and urban growth predicted to continue.**
 - **Multiple jurisdictions with no coherent plan or vision for the region**
 - **Publicly funded infrastructure projects that encourage growth in sensitive areas**
 - **no land use powers in unincorporated areas**

“Government, private corporations and citizens must act promptly to direct urban development away from the aquifer through control of infrastructure investment....” and “Restrict impervious cover to levels that will sustain existing water quality.”

http://www.aquiferalliance.net/Library/GEAAPublications/Edwards_Aquifer_Protection_Plan.pdf

Flash Flood Alley

The Central Texas Hill Country is the most flash flood-prone area of North America.



Dallas

Waco

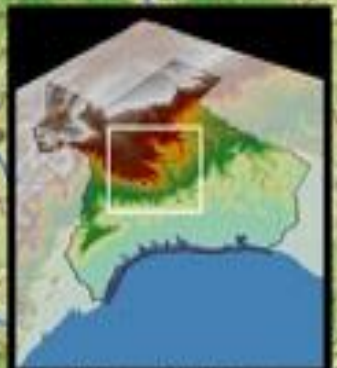
Temple

Austin

San Marcos

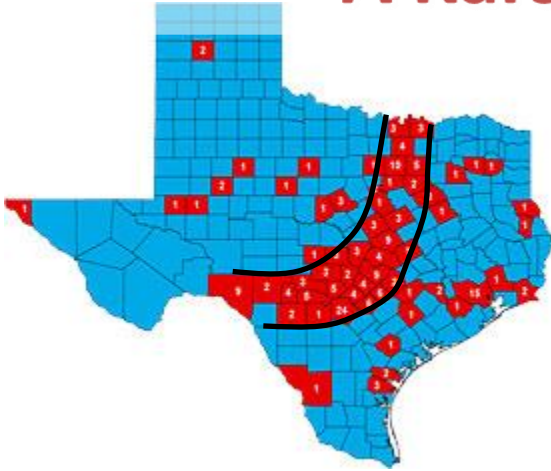
New Braunfels

San Antonio



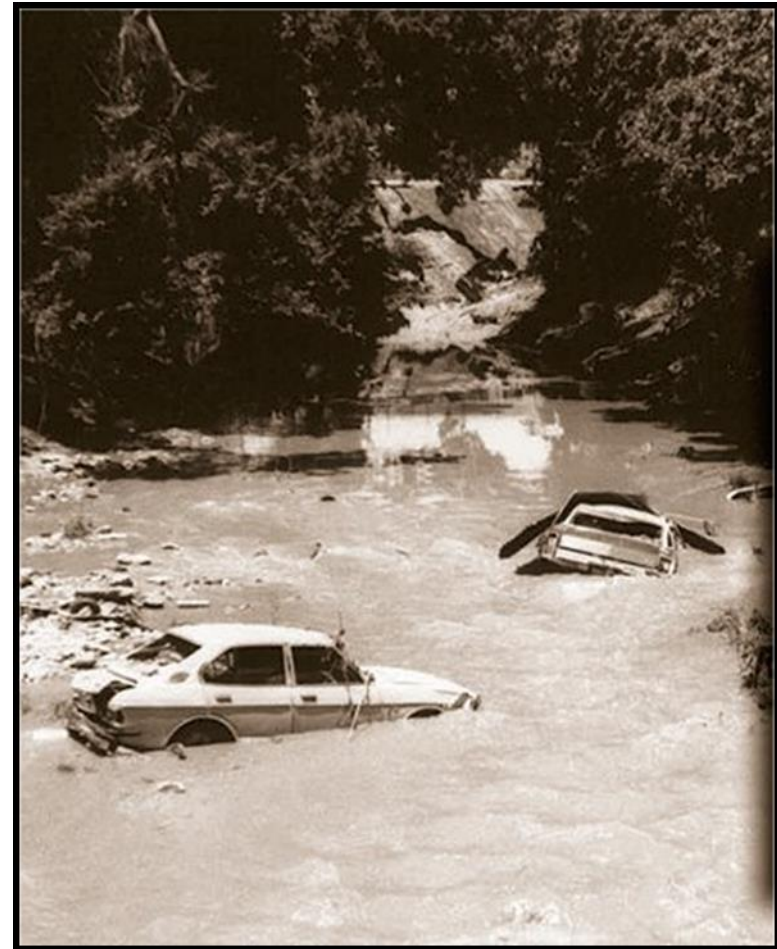
Inset shows the Texas Hill Country

Current Developments Are Usually Not Designed To Maximize Water Infiltration into A Karst Landscape



Since 1996, flash floods have claimed
198 lives in Texas.
(National Weather Service)

Current regulatory measures are inadequate:
Increased Impervious cover on the Edwards Aquifer
Recharge Zone increases storm water flows, erosion,
and flooding, requiring cities to spend billions of
dollars for storm water management projects to
mitigate downstream flooding



Regulations permit extensive site modification thus altering the hydrologic regime



- Sand filter is prevalent BMP across the Edwards/Trinity region
- Edwards Rules treat storm water as a pollutant

On the Edwards Recharge Zone:

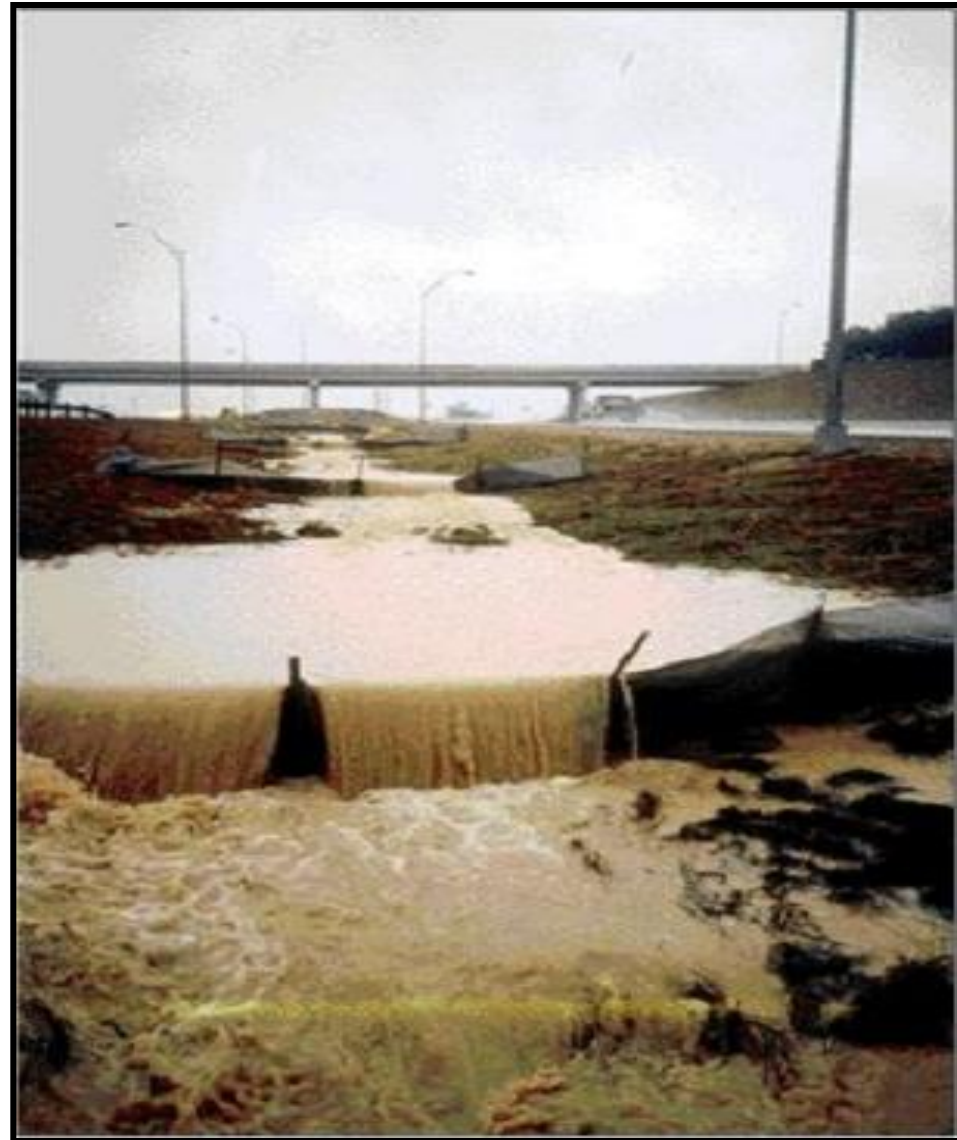
- Up to 85% impervious cover allowed in San Antonio
- Up to 100% impervious cover allowed under State Law

Structural controls often fail to prevent pollution.

A study conducted by GEAA in 2010 on permanent structural controls (BMP's) found that at any given time, approximately 10% - 15% of the 3,000 permanent BMP's in Bexar County do not function sufficiently to achieve the desired result of preventing non-point source pollution from infiltrating the Aquifer.

Temporary BMP's installed to prevent pollution on construction sites frequently fail to achieve this goal.

http://www.aquiferalliance.net/Library/GEAAPublications/BMP_Final.pdf



Pollutants found in Barton Springs or Contributing Stream Sediments Above Levels which are Toxic to Aquatic Life

Heavy Metals

Arsenic
Cadmium
Copper
Lead
Mercury
Silver

Pesticides

P-P'-DDD
P-P'-DDE
P-P'-DDT
Aldrin
Endrin
Heptachlor Epoxide
Beta-BHC
Delta-BHC
Gamma-BHC (lindane)
PCD

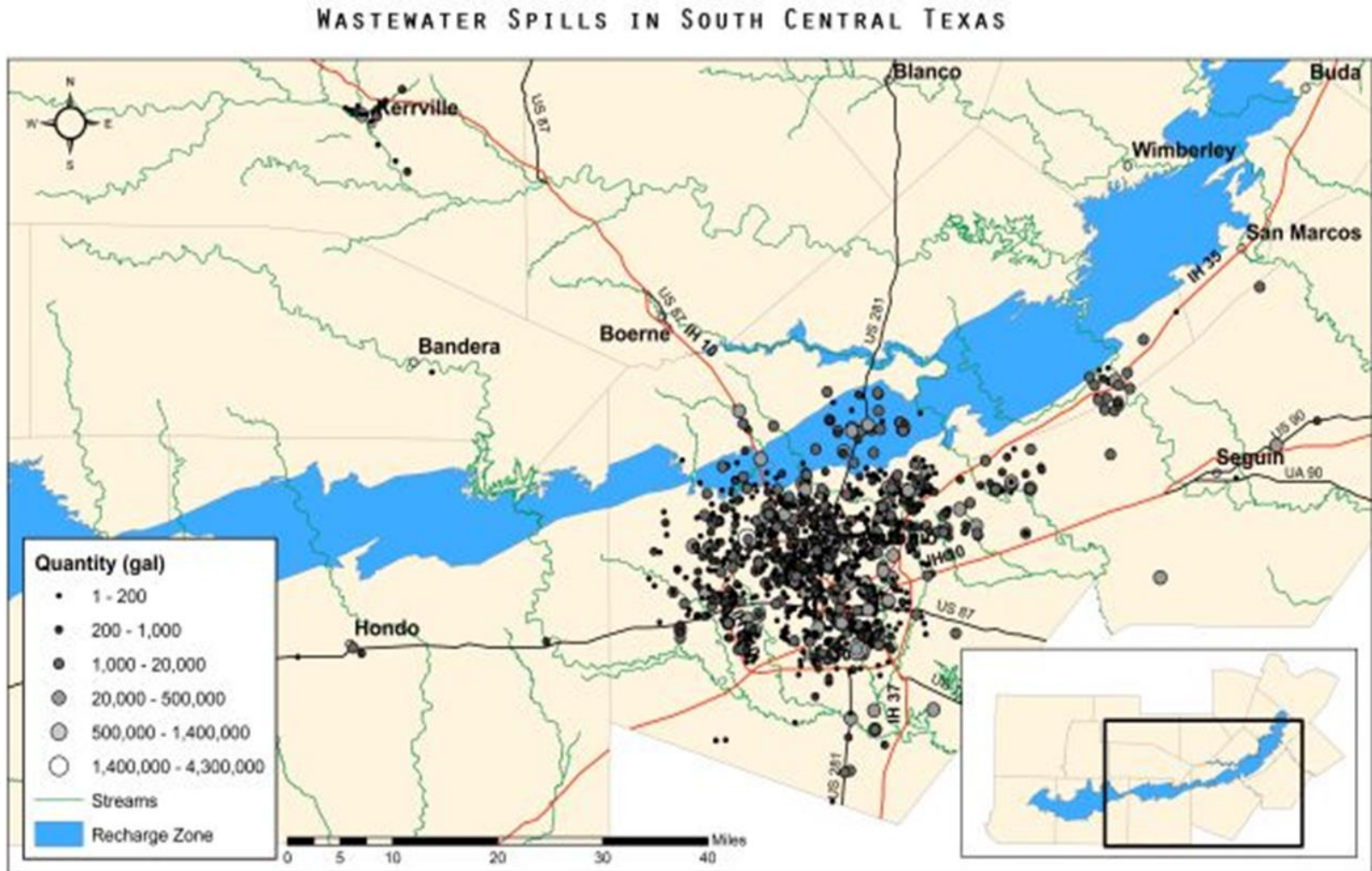
Polyaromatic hydrocarbons

Benzo(A)anthrocene
Benzo(B)fluoranthene
Benzo(K)fluoranthene
Benzo(A)pyrene
Chrysene
Dibenz(AH)anthracene
Fluoranthene
Phenanthrene
Pyrene

Increased Urbanization in the Edwards Aquifer Recharge and Contributing zones is Impairing Water Quality

- Results of EAA well tests (2011 – 2012*) detecting anthropogenic or “emerging” contaminants (pharmaceuticals and personal care products)
- Analytic Method Chemical Name Result Unit AY-68-28-2118/22/11 10:50 AMWS-LC-002217a-Estradiol 1.2ng/L AY-68-28-2118/22/11 10:50 AMWS-LC-0022 Equilenin 3.8ng/L AY-68-28-2118/22/11 10:50 AMWS-LC-0022 Estrone 6.9ng/L AY-68-28-2118/22/11 10:50 AME1694 Triclocarban 2.9ng/L AY-68-28-2118/22/11 10:50 AME1694 Tylosin 2.3ng/L AY-68-28-6088/18/11 10:30 AME1694 Cotinine 1.7ng/L AY-68-28-6088/18/11 10:30 AME1694 Cotinine 1.7ng/L AY-68-28-6088/18/11 10:30 AME1694 Lincomycin 0.51ng/L AY-68-28-6088/18/11 10:30 AME1694 Lincomycin 0.51ng/L AY-68-28-6089/19/12 12:40 PME1694 Diltiazem 7.9ng/L AY-68-29-1128/18/11 1:35 PME1694 Lincomycin 0.42ng/L AY-68-29-1121/11/12 11:05 AME1694 Caffeine 53ng/L AY-68-29-1121/11/12 11:05 AMWS-LC-0022 Estrone 1.6ng/L AY-68-29-1121/11/12 11:05 AME1694 Lincomycin 0.27ng/L AY-68-29-1138/18/11 12:05 PME1694 Lincomycin 0.31ng/L AY-68-29-1138/18/11 12:05 PME1694 Lincomycin 0.31ng/L AY-68-29-1131/10/12 11:25 AMWS-LC-002217a-Estradiol 1.4ng/L AY-68-29-1131/10/12 11:25 AMWS-LC-002217b-Estradiol 1.5ng/L AY-68-29-1131/10/12 11:25 AME1694 Caffeine 320ng/L AY-68-29-1131/10/12 11:25 AME1694 Diltiazem 0.48ng/L AY-68-29-1131/10/12 11:25 AMWS-LC-0022 Estrone 1.3ng/L AY-68-29-1131/10/12 11:25 AME1694 Lincomycin 0.69ng/L AY-68-29-1131/10/12 11:25 AME1694 Triclosan 17ng/L AY-68-29-4181/17/12 9:45 8/16/12 9:50 AME1694 Thiabendazole 24ng/L IDX-68-15-901 Hueco Springs 12/3/12 1:15 PME169817a-Estradiol 1.60ng/L IDX-68-15-901 Hueco Springs 12/3/12 1:15 PME1694 Cotinine 4.85ng/L IDX-68-15-901 Hueco Springs 12/3/12 1:15 PME1694 Diltiazem 0.705ng/L IDX-68-23-301 Comal Springs 8/23/11 8:50 AMWS-LC-002217a-Estradiol 4.3ng/L IDX-68-23-301 Comal Springs 8/23/11 8:50 AMWS-LC-002217b-Estradiol 7.0ng/L IDX-68-23-301 Comal Springs 8/23/11 8:50 AMWS-LC-0022 Equilenin 0.72ng/L IDX-68-23-301 Comal Springs 8/23/11 8:50 AMWS-LC-0022 Estrone 5.8ng/L ILR-67-01-801 Hotel Springs at San Marcos 12/3/12 11:50 AME1694 Cotinine 4.73ng/L ILR-67-01-801 Hotel Springs at San Marcos 12/3/12 11:50 AME1694 Diltiazem 0.451ng/L ILR-67-09-101 12/14/12 12:00 AME1694 Caffeine 250ng/L ILR-67-09-101 12/14/12 12:00 AME1694 Carbamazepine 19ng/L ILR-67-09-101 12/14/12 12:00 AME1694 Sulfamethoxazole 12ng/L
- *excludes results from test well near Cibolo Nature Center
- Lincomycin and sulfamethoxazole are antibiotics · Diltiazem is a blood pressure medication · Carbamazepine is an epilepsy medication . Cotinine is a nicotine metabolite

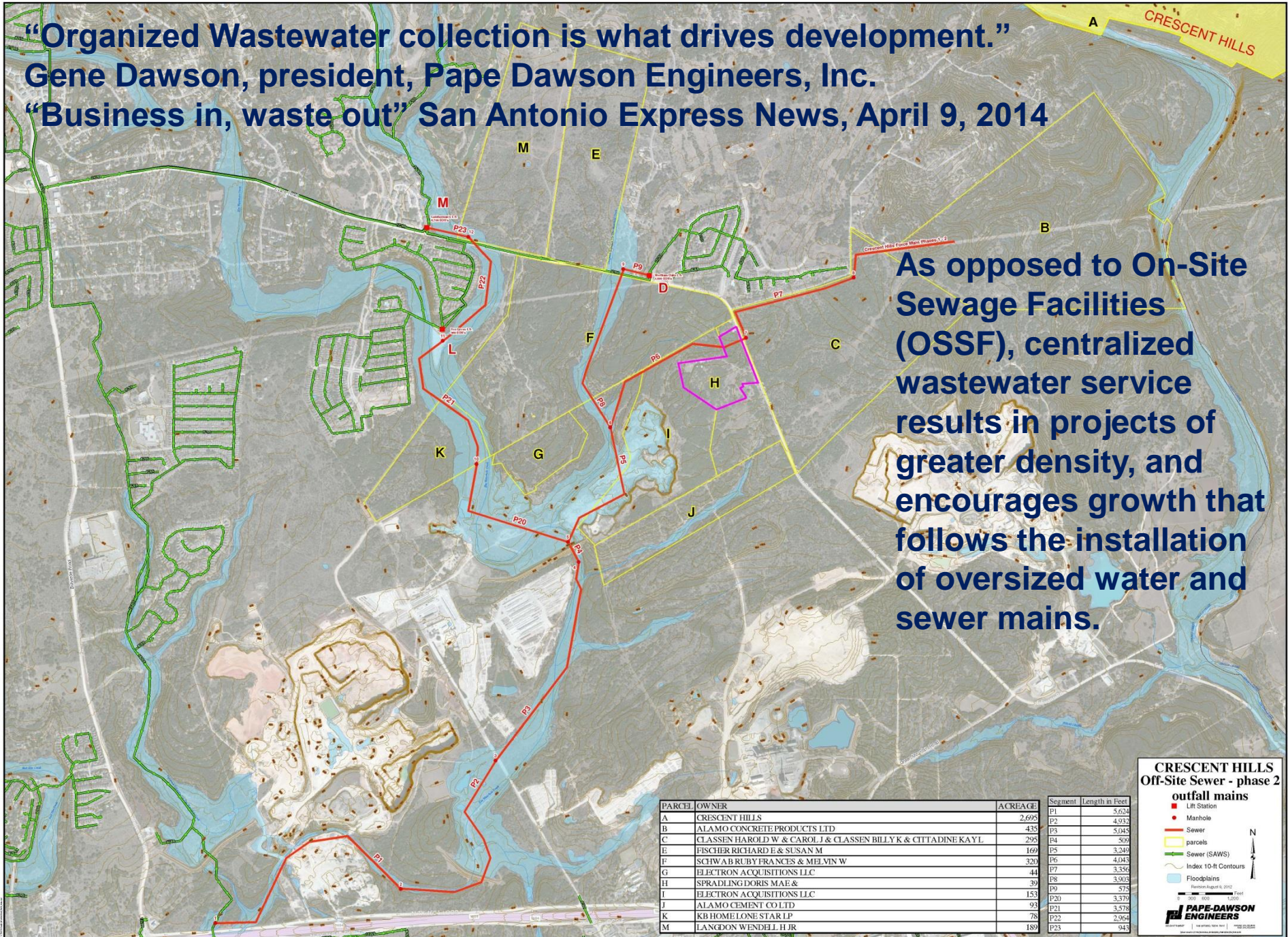
Between January 2008 and May 2012 eighty three spills totaling 809,000 gallons (2.5 acre/feet) of raw sewage occurred on Edwards Aquifer Recharge Zone.



Created by: GeoTex Environmental Solutions
Projection: GCS_North_American_1983

“Organized Wastewater collection is what drives development.”
Gene Dawson, president, Pape Dawson Engineers, Inc.
“Business in, waste out” San Antonio Express News, April 9, 2014

As opposed to On-Site Sewage Facilities (OSSF), centralized wastewater service results in projects of greater density, and encourages growth that follows the installation of oversized water and sewer mains.



PARCEL	OWNER	ACREAGE
A	CRESCENT HILLS	2,695
B	ALAMO CONCRETE PRODUCTS LTD	435
C	CLASSEN HAROLD W & CAROL J & CLASSEN BILLY K & CITTADINE KAY L	295
E	FISCHER RICHARD E & SUSAN M	169
F	SCHWAB RUBY FRANCES & MELVIN W	320
G	ELECTRON ACQUISITIONS LLC	44
H	SPRADLING DORIS MAE &	39
I	ELECTRON ACQUISITIONS LLC	153
J	ALAMO CEMENT CO LTD	93
K	KB HOME LONE STAR LP	78
M	LANGDON WENDELL H JR	189

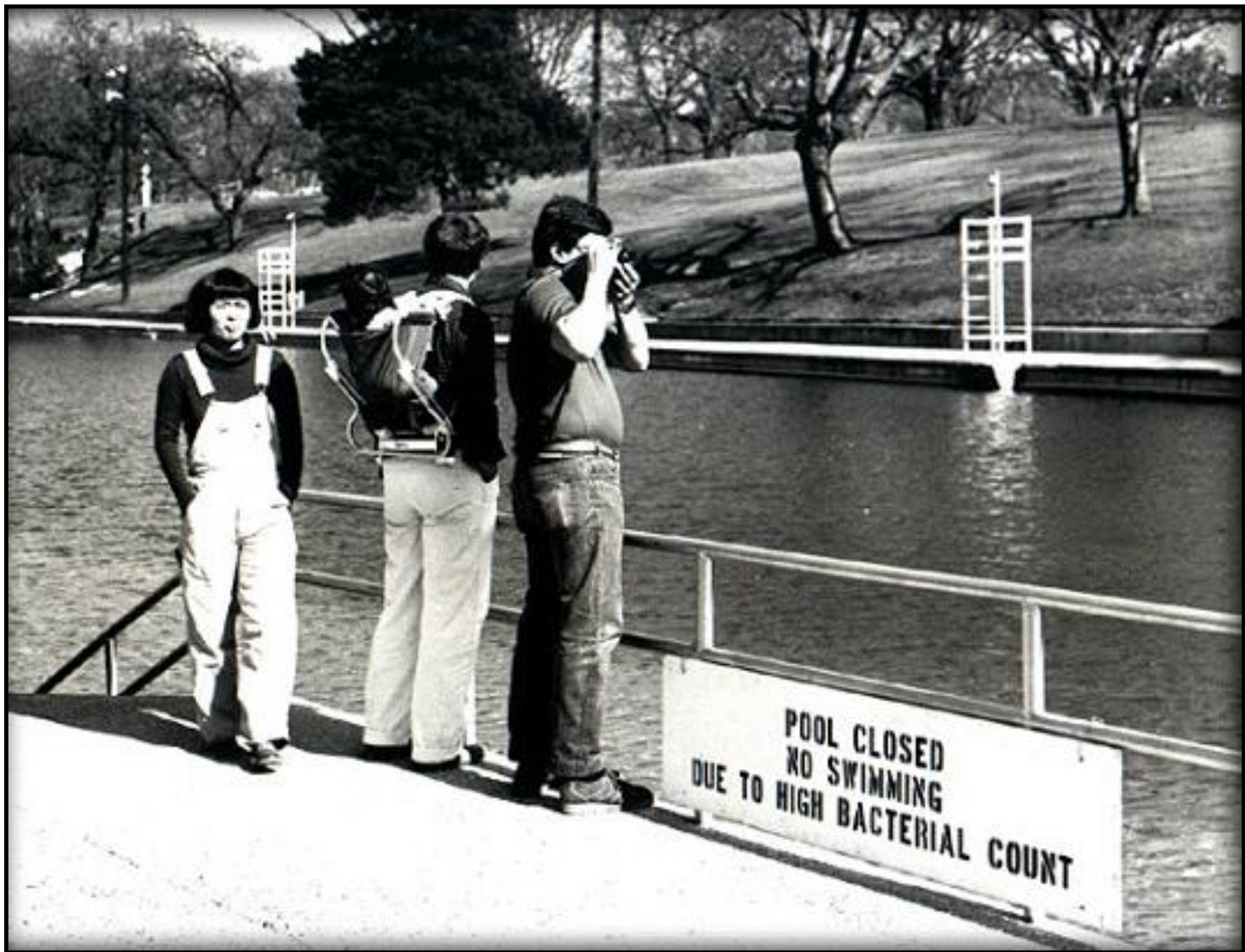
Segment	Length in Feet
P1	5,624
P2	4,932
P3	5,045
P4	509
P5	3,240
P6	4,045
P7	3,358
P8	3,903
P9	575
P20	3,370
P21	3,578
P22	2,964
P23	943

CRESCENT HILLS Off-Site Sewer - phase 2 outfall mains

- Lift Station
- Manhole
- Sewer
- parcels
- Sewer (SAWS)
- Index 10-ft Contours
- Floodplains

Revised August 9, 2012

PAPE DAWSON ENGINEERS



Some issues with protection of Central Texas karst aquifers:

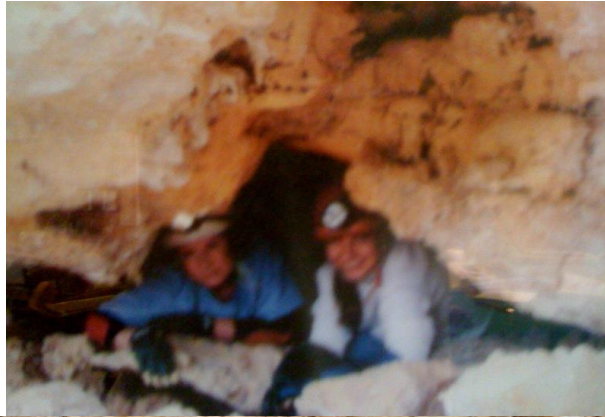
- The State has no density restrictions for the Edwards Aquifer Recharge Zone.
- Neither the State nor municipalities require adequate protection of the Edwards Aquifer Contributing Zone. Most Edwards Aquifer Authority regulations extend protections for five miles into the Contributing Zone.
- The State treats storm water as a pollutant, requiring measures to seal the Aquifer from recharge, or to mitigate water quality through the use of engineered Best Management Practices (BMP's).
- Current engineered structures required by the state to mitigate water quality are often poorly designed and poorly maintained.
- Public investment in infrastructure does not take environmental services of the Edwards and Trinity aquifer watersheds, encouraging growth where it is least appropriate.
- Counties lack the authority to regulate land uses
- The State often grants powers of eminent domain to Municipal Utility Districts and other entities, empowering them to encroach on contiguous privately held land.

Preserving Caves and Recharge Features

Impervious Cover Limits for the Edwards Aquifer Recharge Zone are the best strategy we have to preserve Caves

Other strategies include protections for endangered karst species.

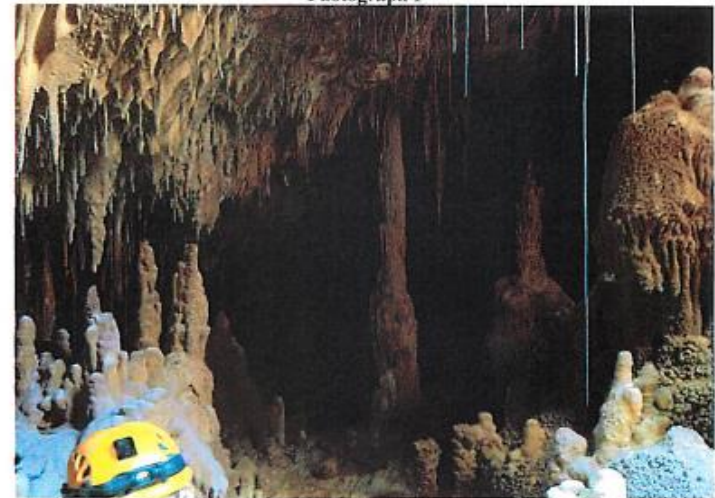
Effective Habitat Conservations Plans are needed.



the Ridge at Lookout Canyon Phase II PUD



Photograph 1



Photograph 2

Incompatible land uses...



Martin Marietta Quarry next to San Antonio Ranch



Infill development is occurring within drainage areas on the Edwards Recharge Zone

Watershed Stewardship for the Edwards Aquifer Region

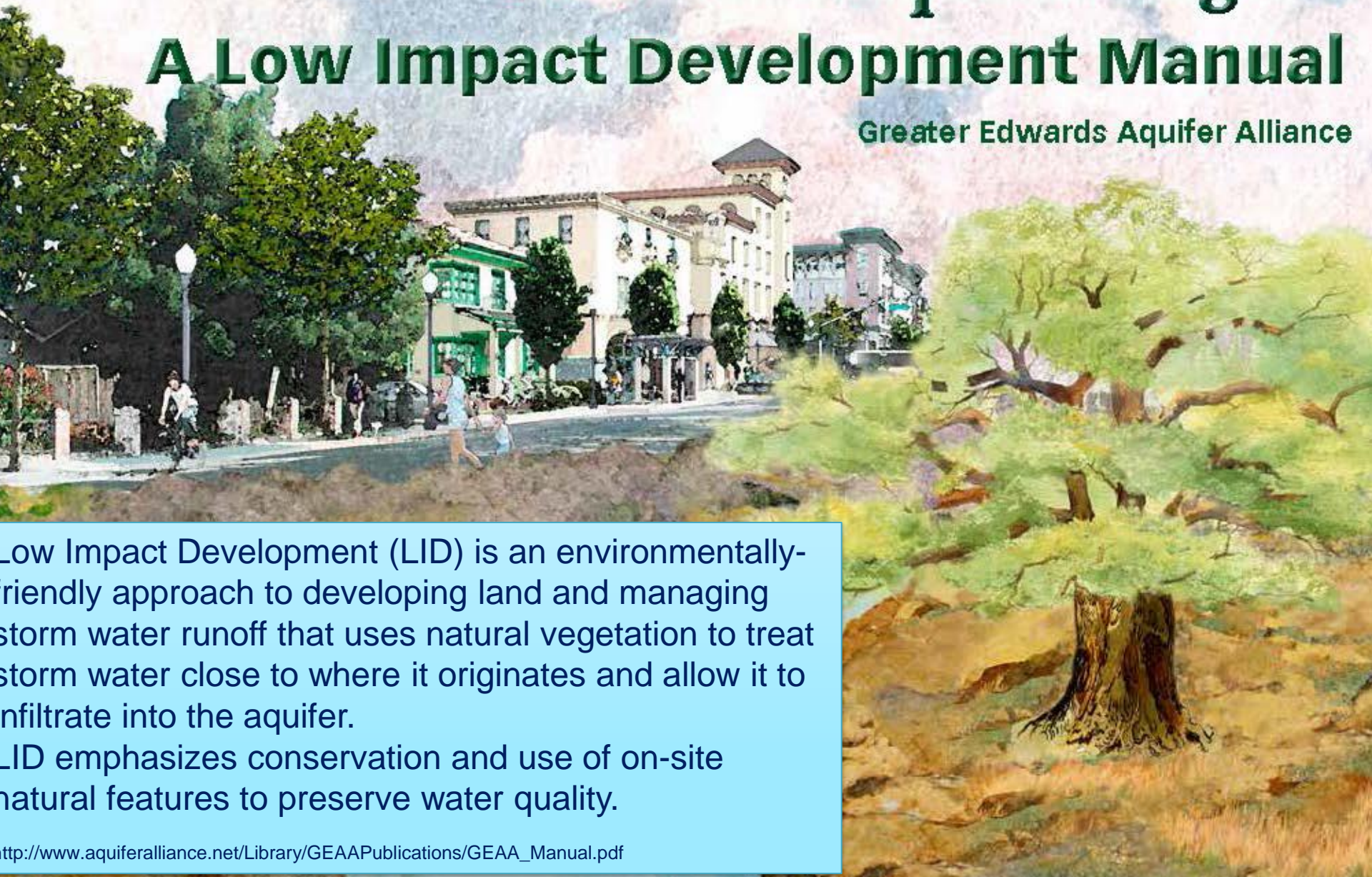
A Low Impact Development Manual

Greater Edwards Aquifer Alliance

Low Impact Development (LID) is an environmentally-friendly approach to developing land and managing storm water runoff that uses natural vegetation to treat storm water close to where it originates and allow it to infiltrate into the aquifer.

LID emphasizes conservation and use of on-site natural features to preserve water quality.

http://www.aquiferalliance.net/Library/GEAAPublications/GEAA_Manual.pdf



TCEQ recommendations for employing LID on the ERZ

- Preserve and mimic the natural runoff system
- Maintain areas of natural vegetation and major trees
- Minimize impervious surface areas
- Use native or adapted plants, minimize turf
- Convey site stormwater through vegetation prior to release or storage
- Surround faults and sinkholes with vegetated buffer 25 feet wide
- Use integrated pest management (IPM) vs. insecticides



We can do much, much better

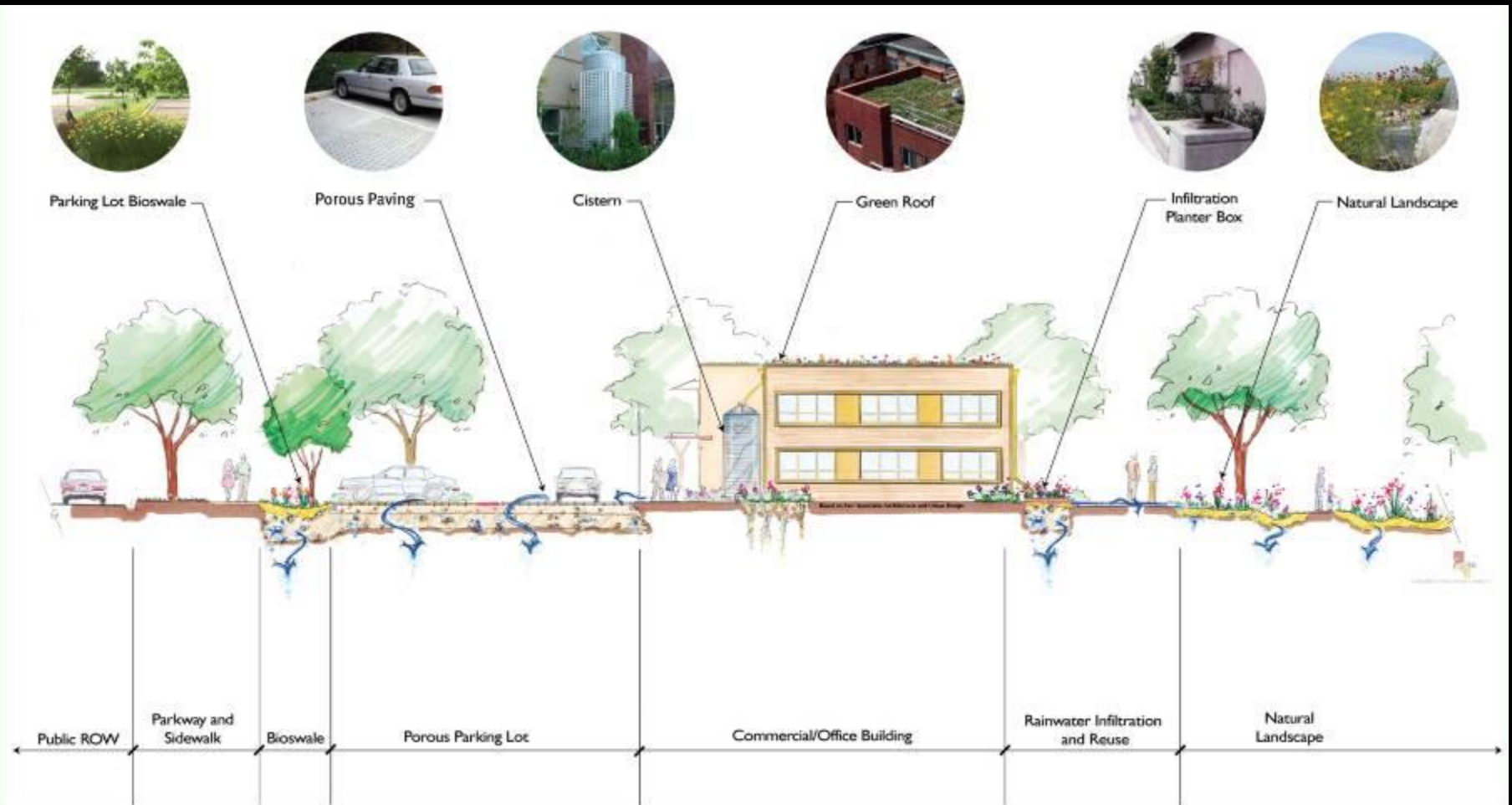


Villanova University traffic island
Portland OR streetscape swale



- Biofiltration may capture up to 100% rainfall
- Filters out 95% pollutants in plant + soil layer
- Special soil mix applied in areas of thin soils
- Applications: parking lot islands, filter strips, pre-treatment swales, rain gardens

LID used in sequence for water quality



“stormwater treatment train” or recharge sequence

The GEAA LID for Karst and Arid Regions Initiative Includes:

- A Landowner's Guide – how to maintain the integrity of your karst landscape
- Technical Guidance Manual for LID Best Management Practices specific to our region for Residential and Commercial Developments
- LID demonstration projects – Our team will work with developers of sites within our region to incorporate LID into the design and build out.
- Workshops for citizens/landowners/city staff and developers. For Kendall County these could be coordinated with the Upper Cibolo WPP
- Seeking funding for these initiatives from Federal and State grants, municipalities, agencies, and other sources

Karst regions have special issues for LID

- Stormwater runoff carries pollutants from impervious roadways and parking lots, which enter aquifer quickly through porous karst.
- Stormwater in urbanizing karst regions tends to concentrate water, eroding and destabilizing limestone bedrock.
- Investigation of subsurface geology and avoidance of known sinkhole areas important if considering use of infiltration

LID principles for Karst Aquifers

- Respect the context of the Edwards Plateau and nearby Texas Hill Country
- Balance growth with preservation of the natural drainage and infiltration system
- Take a systems approach to development, integrating water planning from the onset
- Use every building project as an opportunity to improve groundwater collection, quality and monitoring
- Integrate aquifer management into site programs through LID multiple use projects



ECOREGIONAL CONTEXT: KEY CONCEPTS

The Edwards Aquifer is an irreplaceable resource that has been subjected to significant urban growth and development, resulting in loss of recharge due to impervious cover replacing native landscape cover.

The Edwards is a karst aquifer, a type of aquifer that is especially susceptible to contamination because pollutants from runoff, leaks, spills, lawn treatments, and other sources can reach the water table within minutes and travel quickly through the aquifer with effectively no filtration.

The need exists for an integrated approach to water management over the aquifer that will maintain the natural hydrologic regime to the extent possible, including the need to recharge the aquifer safely.

New GEAA Programs for 2015 – Community Rain Gardens

GEAA proposes to work with Home Owners Associations, schools, and businesses to create Community Rain Gardens, similar to the many community garden programs popular throughout the United States. GEAA will teach homeowners how to maintain existing water quality structures and will engage them in installing Low Impact Development (LID) projects such as swales, rain gardens, and specific plantings to enhance filtration of stormwater before it enters the Aquifer. Landscape architects with expertise in LID will be employed to design and help homeowners to properly install and maintain site specific LID enhancements.

We hope to educate homeowners on the Edwards Aquifer Recharge Zone how to identify and report non-compliant systems, to enhance the function of the systems in their neighborhoods, to understand the need to use drought tolerant plants for water conservation, and to generally educate them on the importance of protecting the Edwards Aquifer.

Under Your Feet Campaign

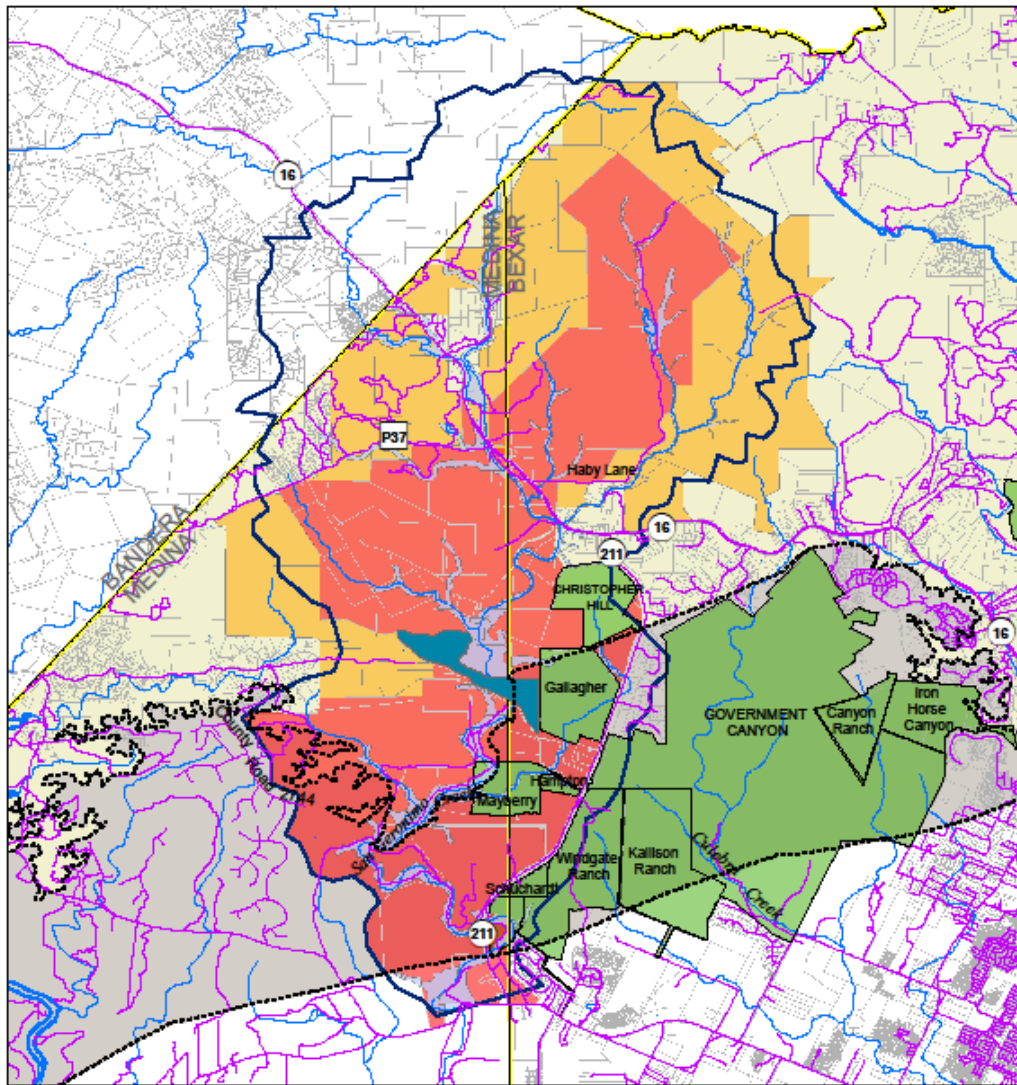
GEAA is contracting Western Kentucky University to produce a campaign to educate people who live on the Recharge Zone on how to protect the Aquifer.



Permanent Protection of the San Geronimo Valley

The San Geronimo Valley is approximately 7,000 acres within Northwest Bexar County and proximal Medina County.

The San Geronimo Creek and significant recharge features found in the upland areas are estimated to contribute approximately seven to fifteen percent of the entire recharge of the San Antonio segment of the Edwards Aquifer. The San Geronimo Valley is under immense pressure from encroaching development, with plans underway to provide roadways and flood control based on the scenario that the entire area will be developed out. Permanent protection of this area through the purchase of conservation easements would preempt plans for development, thus preserving this important region so that it will continue to contribute significant volumes of high quality recharge to the Edwards Aquifer in perpetuity.



**GENERAL LOCATION:
Proposed Gallagher Ranch CE and
Acquisition Priority Zones In
the Upper San Geronimo Valley**



LEGEND	
	Proposed Conservation Easement
	Upper San Geronimo Watershed Boundary
	parcel boundary
	Priority Acquisition ZONE 1
	Priority Acquisition ZONE 2
	Managed Lands COSEA Prop 3 parcels, TNC conservation easements, Government Canyon
	Streets, Roads, and Highways
	Rivers and Streams
	FEMA 100 year floodplain
	County boundary
	Edwards Aquifer
	Contributing Zone
	Recharge Zone

For more information about GEAA
and our member groups visit
www.AquiferAlliance.org

You may contact me:

Annalisa Peace

210-320-6294

annalisa@aquiferalliance.org

