



Assessment of Point Recharge Feature Protective Buffers, Austin, Texas.

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ABSTRACT

Concern for the quality and quantity of water entering the Edwards Aquifer has lead the City of Austin to enact ordinances which require protective buffers for point recharge features such as caves, sinkholes, and solution cavities in the Edwards Recharge Zone. These buffers are described in the Land Development Code and are set aside as undisturbed areas which aim to protect or mitigate impacts on Critical Environmental Features (CEFs) from construction and post-construction activity. Guidelines for determining the size of these protective buffers is defined in the City of Austin Environmental Criteria Manual (ECM). The ECM states that typical buffers are 150 feet in radius, but may be as large as 300 feet or as small as 50 depending on the features topographically defined catchment area (Section 1.10.4) and the extent of the underlying cave. Inspection results on randomly selected point recharge features has revealed that CEF buffers experienced more human disturbance if they were small in size and surrounded by larger amounts of impervious cover.

INTRODUCTION

West of Austin, Texas lies the Balcones Fault Zone. In this area, limestone and dolomite rock formations from the Edwards Group have been uplifted and exposed at the land surface. Caves, sinkholes and solution fractures are characteristic of this area as a result of the dissolution of limestone, forming the karstic Edwards Aquifer. These features act as points of recharge for the Edwards Aquifer and accumulatively make up what is known as the Recharge Zone.

Human development near these points of recharge has the potential to degrade the quality and quantity of water entering the Edwards Aquifer by way of nonpoint source pollution. The application of fertilizers, pesticides and herbicides to managed vegetative areas can also enter these points of recharge and lead to degraded water quality.. Removal or disturbance of groundcover within a feature's catchment basin, particularly during construction activities, may result in erosion. If sediment that is generated by construction-related erosion is transported offsite with stormwater runoff, it may result in clogging a recharge feature. This has been observed in the Austin area at a few locations. Furthermore, if pollutants have been trapped within the sediment, they now pose a threat to water quality if they enter the recharge feature. In order to mitigate the potential decrease in the quantity and quality of recharge, the City of Austin (COA) requires that the existing native vegetation and topography within the catchment basin of a recharge feature remain undisturbed by designating the area as a buffer. In so doing, the area protects the form and function of the catchment basin with the intention of maintaining the quantity and quality of recharge to the Edwards Aquifer.

In 1986, the City of Austin (COA) City Council passed the Comprehensive Watershed Ordinance which defined Critical Environmental Features (CEFs) and prescribed protective buffers for them. As a follow-

up, the COA Environmental Criteria Manual (ECM) was released, containing explanations and descriptions for establishing and protecting CEFs. The ECM defines a standard buffer as 150 feet from the immediate edge of the recharge feature (sinkhole rim, karst feature opening) to protect the catchment area to the point recharge feature. However, if the catchment area extends further, the protective buffer may extend as far as the topographic break up to a maximum distance of 300 feet. In instances where the catchment is less than 50 feet, a minimum buffer of 50 feet (Section 1.10.4). By protecting native vegetation within the protective CEF buffer, it is assumed that the quantity and quality of recharge as well as the form and function of the CEF will be protected and preserved (Section 1.10.2). This assumption is based on the ability of native Central Texas grasses to trap sediment with their thick blade tufts and their common presence in the catchment area of caves and sinkholes. Not only do these native grasses help prevent erosion, they help by reducing the sediment load from entering a recharge feature. The buffer also prevents the alteration of the existing topography within the catchment area. Ideally, this maintains the established drainage pattern that may have characteristics similar to sheet flow with some shallow, concentrated flow paths in an upland setting. The buffer is intended to maintain pre-construction recharge occurrence.

METHODS

Classification and selection of CEFs

There are over 550 karst CEFs points in Watershed Protection Department’s karst database. Critical Environmental Features for this study were classified by the size of the protective buffer and amount of impervious cover located within a 300-foot radius of the feature. Impervious cover and protective CEF buffer areas were calculated through ArcGIS. Within the 300-foot radius of evaluation, the impervious cover and the protective CEF buffer were clipped so that their areas could be recorded. Classification breaks were then made by summing the mean area value of impervious cover polygons (sidewalks, road, rooftops and other) and the protective CEF buffer size individually. As a result, impervious cover and the protective CEF buffer were categorized by the following criteria.

Impervious cover < 22,000 ft ² = Small	CEF buffer < 10,000 ft ² = Small
Impervious cover > 22,000 ft ² = Large	CEF buffer > 10,000 ft ² = Large

The CEF points were then grouped into categories labeled “small impervious cover, small buffer” (SS), “small impervious cover large buffer” (SL), “large impervious cover, small buffer” (LS), and “large impervious cover, large buffer” (LL) which correspond to the size of impervious cover and protective CEF buffer respectively. For each of these categories, a selection of 15 CEF points was made using a random number generator on Microsoft Excel. The final 60 selected CEF points for inspection evenly represent each of the 4 categories as well as roughly 10% of the original sampling population. Of the selected CEFs, 5 were located in Williamson County and within the City of Austin’s extra-territorial jurisdiction, 38 in Travis County and 17 in Hays County.

Form

An inspection form was developed and used to catalog the physical characteristics of CEF buffers as well as the presence of any unauthorized activity, invasive species, infrastructure, water quality indicators, and any other important observations. Figure 1 is an example of a complete buffer inspection for a solution cavity named #3.

City of Austin Watershed Protection / ERM / Key CEF Buffer Inspection

Date: 7/27/16
Time: 9:30 am
Staff: Andy O'Brien, Sylvia Rippe

Feature Name: 413
Feature Type: Suburban Density
MIS Identification No.: 14462
Buffer Size (area in sq. ft.): 80,500 sq. ft.
Buffer Shape (circle, ellipse, rectangle, etc.): *irregular*

Location Coordinates (X, Y): *70, 117*
Physical location (address, subdivision, etc.): *1906 E. Mc-Tu Corporation*
Responsible Party (PCA, owner, agency): *Austin Water Department*
Permit (DCCP, private federal permit, construction easement): *NA*

Map/Hand-drawn Activities
 Vegetation clearing
 Ridge dumping
 Remediation
 Pesticides, herbicides, fertilizer application
 Trash, categories of trash
 Pet droppings or animal soil
 Other: _____

Infrastructure Condition/Damage
 Total present? *NO* *Yes*, condition is: *good* *fair* *poor*
 Damage enhancement structure present? *NO* *Yes*, is it intact? *Yes* *No* *Partial* *Destroyed* *Other* *Not needed?*
 Fencing present? *NO*
 Gate(s) present? *NO*
 Storage present? *NO* *Condition* and *utilizational content* *Yes*, "contaminated area" type which has been made by "fence up wall" at a "garage" (concrete) type. *garage has been built in*

Other Infrastructure
*There is a driveway/entrance and driveway going through buffer area. *garage has been built in**
*presence of *hatched* fence *near* to *entrance* *to* *garage**

Plot Assessment

	1 st Plot	2 nd Plot	3 rd Plot	4 th Plot	TOTAL	Average %
Rock						
Leaf		5%	10%	10%	25%	6.25%
Groundcover	40%	10%	20%	10%	80%	20.0%
Canopy	0%	0%	0%	0%	0%	0.0%
Understory	0%	0%	0%	0%	0%	0.0%
Infrastructure	0%	0%	0%	0%	0%	0.0%

*Vegetation is determined at waist height
 Canopy and understory are separate percentages (3 canopy in direct and from a densiometer reading while 1 canopy shot at knee height) since the densiometer uses the quadrants of within the 10' by 10' plot

Damage to Site
 Active (major disturbance): *unimpaired/undisturbed* *Hardened disturbance*

Invasive species noted: *NA* *quite a lot to some extent, some sightings*
Blackberry, Chinese Elm, Chinese Pistache, Chinese Tallow, Vine
Chimborizo

Understory usually 1:1:1
 Invasive species noted: *NO*
Giant Reed, Bamboo, Phoradendron, Heavily Bamboo/Smother

Groundcover / Herbaceous / Grasses / Vines *Yes*
 Invasive species noted: *NO*
King Ranch Bluegrass, Johnson, Bermuda, Coastal Cabbage, Elephant
Reed, Japanese Honeylocust

Water Quality Indicators
 Declined accumulation and proximity to hard surface *Yes*
 Erosion or signs of concentrated flow: *Source of concentrated flow?*
Yes, along the storm water driveway/driveway path

Other Important Observations (stressor vegetation, predominance of invasives, etc.)
 Specialty Findings:
 - CEF Buffer - entire S/E is mowed/maintained but not
 this long as on 1906
 - rock plot in center of CEF buffer
 - clearing of vegetation along the east end of buffer
 (except to the east road)

*NA - mowed for this
 at edge of buffer to
 allow water flow
 to go into buffer
 but this has
 occurred. We do not
 have a fence
 to keep this out
 but fence
 prevents at
 edge of
 buffer
 point*

Figure 1. Example of a completed Critical Environmental Feature buffer inspection form.

Survey Plot assessments within CEF buffers

To evaluate the CEF buffers, plot assessments were used to quantify the different categories of vegetation and other land cover within CEF buffers. Plot assessments were conducted by dividing the CEF buffer into four equal quadrants using a drawing tool on ArcGIS. For CEF buffers that were not symmetrical, the buffers were divided in such a way as to distribute four quadrants of land within the CEF buffer as evenly as possible. Navigation to the center of each quadrant was done by using GPS through an ArcGIS map. In each quadrant center, a 10-foot by 10-foot plot was measured and staked with survey flags. Inside the plot, the percentage of rock, bare soil, ground cover, leaf cover and manmade infrastructure was recorded using visual estimation with the aid of a comparison chart for estimating percentage composition (Terry and Chilingar, 1955). Afterwards, a separate percentage of canopy cover was recorded using a densiometer held at waist height while pointing north from the center of the quadrant. Finally, the percentage of understory was also recorded as a separate function from both land cover and canopy cover. This procedure was repeated 3 more times in the center of the remaining 3 quadrants. The final values were totaled and averaged to give an estimate of the percentages of each land cover component (rock, bare soil, ground cover, leaf cover, and infrastructure, canopy, understory) throughout the entire CEF buffer.

Classifying vegetation

The following guidelines were used to classify vegetation within a plot:

Groundcover < 18 inches (1.5 feet)
Understory = 1.5 to 10 feet
Canopy > 10 feet

In some cases, vegetation bordered classifications and could be categorized in one of two ways. In this instance, vegetation was classified by considering its functionality with intercepting water as opposed to a botanical classification. For example, if some vegetation was 19 inches tall but was very dense at the base and rooted into the soil, it would be classified as groundcover because it would play a greater role in intercepting overland sheet flow than rainfall. Additionally, since canopy cover is found through the use of a densiometer, it is possible for the densiometer to capture branches and leaves that would originally be defined as understory. For this project, the percentage of canopy cover read through the densiometer is final and represented as the canopy because both the canopy and understory act as agents of branch/leaf interception, not overland sheet flow interception.

Rating Human Disturbance

Almost all CEF buffers indicated some level of human disturbance. Some of the potential threats to water quality that were found are categorized below, according to their respective level of disturbance.

Minimal	Little to moderate levels of trash present, minor vegetation clearing
Moderate	Higher levels of trash and vegetation clearing, road or other infrastructure reduces catchment area and results in partial flow to the recharge feature, presence of detergent bottle, motor oil bottle, fertilizer bag, etc.
Significant	Serious levels of trash and vegetation clearing, untreated runoff/storm water irrigation, large amounts of animal waste, human development inside buffer

RESULTS & DISCUSSION

Of the 60 CEFs selected, 54 inspections were completed. Thirty-eight buffers were listed as having minimal human disturbance, 11 as moderate, and five as significant. The distribution of human disturbance levels between each buffer category can be seen in the pie charts below.

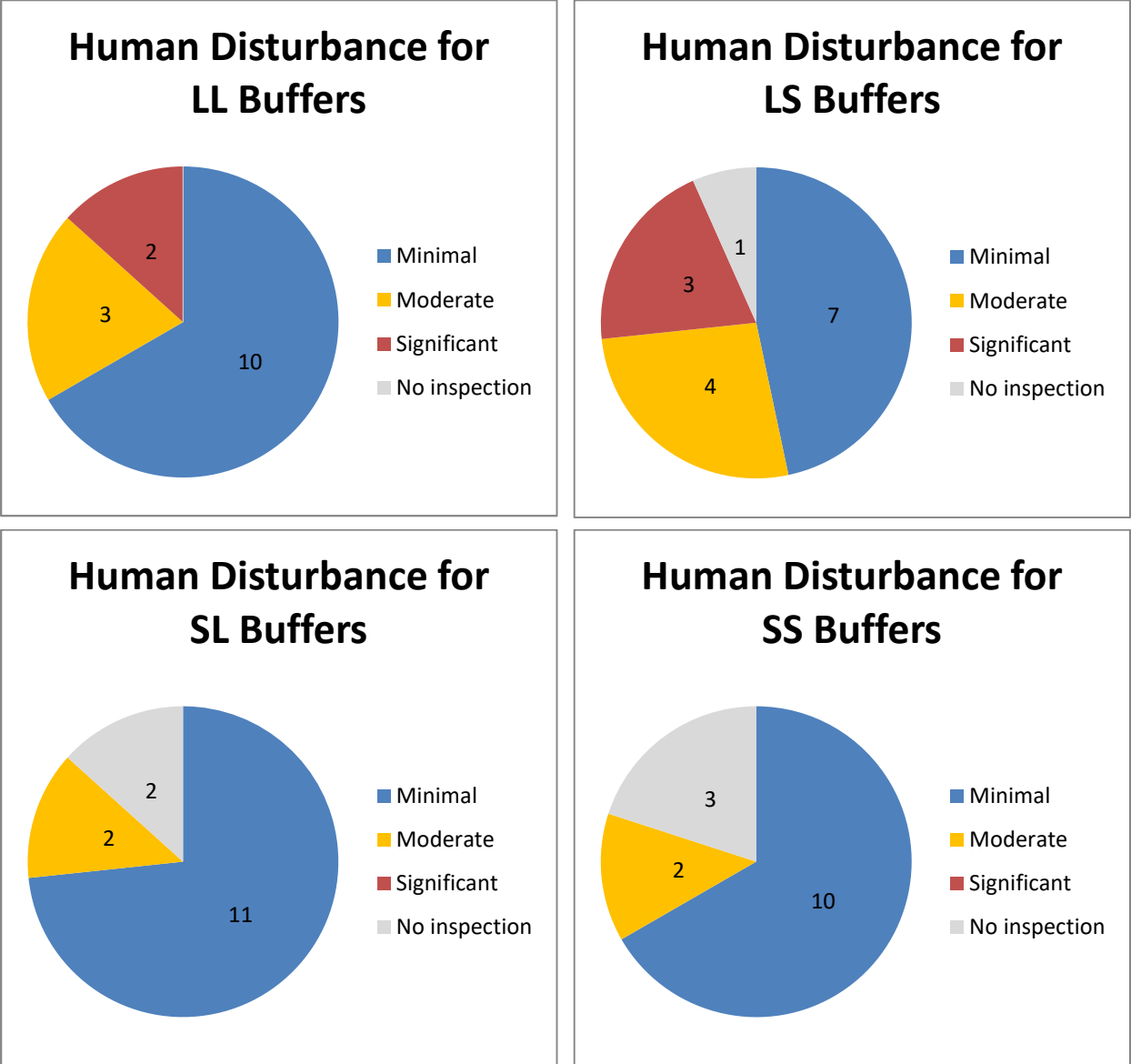


Figure 2. Charts illustrating the levels of disturbance in CEF buffers for each of the four categories. LL means large impervious cover and large buffer. LS means large impervious cover and small buffer. SL means small impervious cover and large buffer. SS means small impervious and small buffer.

General observations

The overall condition of most CEF buffers was good. Human disturbance was minimal and vegetative cover was sufficient enough to allow recharge and prevent sediment accumulation. However, CEF buffers with a large percentage of adjacent impervious cover and small protective buffers (LS) tended to be in worse condition. LS buffers had higher levels of human disturbance than those of large impervious cover and large protective (LL) buffers, possibly due to greater visibility and pedestrian traffic from nearby human development. CEF buffers on City of Austin property, and Water Quality protection lands had some of the lowest levels of human disturbance and were in the best shape.

Invasive plant species were more common in urban but rare in rural areas. When found, the most common invasive species were large leaf privet (*Ligustrum lucidum*), and heavenly bamboo (*Nandina*

domestica). CEF buffers located on ranch land commonly had no invasive plant species other than King Ranch (KR) Bluestem (*Bothriochloa-ischaemum-var-songarica*).

Groundcover

The lowest percentage of groundcover was 1.66% for the buffer around Little Bee Creek Cave. This CEF is somewhat of an outlier in the data collected because it was the only feature that was on the side of a bluff and a significant portion of the protective buffer is a creek bed. The highest percentage of groundcover was 87.5% at a feature named S-1. The average percentage of groundcover for all CEF buffers was 41.67%. By taking the average of groundcover percentages with respect to buffer classification, it was found that the amount of groundcover decreased when there was higher human disturbance. LS buffers had the lowest average of groundcover at 28.77%. LL buffers had the second lowest groundcover average at 38%. SS and SL buffers had 46.45% and 55.38% groundcover respectively. Inspections were conducted in the summer from July to August. Although high temperatures and lack of soil moisture probably influenced the health of groundcover, high rain totals in April and May 2016 most likely contributed to optimal growing conditions early in the summer.

Concentrated flow

Concentrated flow to caves or sinkholes is noted where the topography has distinct drainage channels within the catchment area and/or woody debris and leaf detritus from stormwater runoff reveals an obvious flow path. Features C-1, District Park Cave, #3, Ireland Cave, Divide Swamp Sinkhole, an unnamed sink located near Davis Lane and Central Sink in the Stillhouse Nature Preserve had the only catchment areas within CEF buffers that showed visible signs of concentrated flow (channelized flow). Of these features, C-1, District Park Cave, and Central Sink are the only features that have erosion controls. A rock berm has been installed for C-1 and is functioning properly. At District Park Cave, a wall of gabion baskets have been placed outside of the cave opening in order to exclude large, woody debris from entering the cave during flood events but a heavily used footpath inside of the CEF buffer is creating some concentrated flow inside of the rock berm. This results in eroding the soil and sediment build up within the cave and warrants attention to correct the situation. Erosion control mulch socks installed adjacent to Central Sink have decayed and may not be functioning as intended. This type of temporary erosion control was installed to prevent deposition of soil from a nearby earthen berm that has been revegetated and the mulch from the sock may remain in place. Erosion and sedimentation controls may be deployed within CEF buffers in order to prevent sediment accumulation within caves or sinkholes that may result in a partial or significant reduction in the volume of water recharging the Edwards Aquifer.

Fencing

Most of the CEF buffers had locked, secured fencing around them. More frequently, however, buffers with fencing did not have any particular signage that prohibited trespassing or indicated what was inside. For many cases, this did not seem to be an issue. An exception to this was noted when buffers were located in areas of high human concentration. For example, Lakeline Mall Cave is fenced off but has no signage indicating the importance of the fenced-off area. Moderate levels of trash were found along and inside the fencing as well as inside the cave entrance. One section of the fencing was more bent and flimsy than the rest, indicating that people have been trespassing into the buffer. A common trend for CEF buffers that were located in neighborhoods was that they tended to have unauthorized vegetation clearing if they were behind homeowners' backyard fencing. This was apparent at NW2-NW3, Hang Tree Sink, S-16, Elm Garden Cave, Ireland Cave, and at Nutcracker 1.



Photo 2. Unauthorized vegetation clearing at NW2-NW3



Photo 3. Similar unauthorized vegetation clearing at S-16

Some buffers had no fencing at all despite their proximity to large amounts of impervious cover and human development. For CEF buffers that this was the case, human disturbances were much higher. In fact, four out of the five CEF buffers which experienced significant levels of human disturbance did not have any fencing. The 5th buffer with significant human disturbance, Flea Market Sink, had fencing but no proper lock. Good Thunder Cave and Hang Tree Sink were other features which were surrounded by large impervious cover and had a fence but no proper lock and/or openings in the fencing. In 2014, the City of Austin adopted changes to Section §25-8-281 of the Land Development Code and Section 1.10.5 of the Environmental Criteria Manual that require perimeter fencing of karst feature buffers in order to prevent human disturbance and potential water quality impacts.

Water Quality

Six CEF buffers exhibited conditions that pose minor to severe water quality threats, as noted in the following list.

1. Singletary Cave – Across the parking lot from the buffer is a kennel. Upon visitation, kennel workers walked their dogs into the CEF buffer multiple times to allow them to defecate on the

lawn. It was evident that no excrement is picked by kennel workers based upon how many feces were on the grass. It should be noted that the buffer for this feature had no means of protection and there is no visible sign that a cave exists at that location. The groundcover within the buffer is largely grass which is most likely mowed on a regular basis, based upon its manicured appearance. The CEF itself has been covered with rocks as well. A parking lot and major road have been built in close proximity to the cave, however, a subdivision file document for this tract indicates that the road and parking lot were built within the buffer prior to regulatory requirements to establish a CEF buffer.

2. #3 –A storm water drain/detention area as well as irrigation were found going through the middle of the buffer site. There was no evidence or signage of the storm water runoff being treated before use as irrigation. Signage in front of the un-fenced buffer says “Barton Creek watershed. Storm water irrigation area. Watering times vary. City water is not used for irrigation.” It should be noted that the CEF within this buffer could not be found. It is highly likely that it has been covered by rock and/or debris.
3. Flea Market Sink – An untreated storm water inlet is directed straight into this sinkhole. A fertilizer bag was also found inside this CEF buffer.
4. National Instruments Sink – This CEF buffer is in close proximity to a storm water discharge path as well as potential sheet flow directly from the nearby road.
5. Hang Tree Sink – 2 Castrol motor oil bottles were found within this CEF buffer.
6. Nutcracker 1 – A laundry detergent bottle was found within this CEF buffer.

Other Buffer Notes

1. The un-curbed parking lot edge on the north edge of the buffer for solution cavity #3 allows sheet flow to go into the buffer. Leaf litter has collected 40 feet into the buffer, resulting in the formation of a depression where water ponds. A small wetland has formed in this area, as indicated by the presence of spike rush and other wetland plants. Wetland plants have also been found next to storm water irrigation heads throughout the buffer. It is possible that these wetland plants are mitigating pollutants from untreated runoff from the parking lot.
2. Elm Garden Cave (CEF-7) has one manhole and one storm water inlet inside its CEF buffer.
3. Kretschmarr Cave as well as the buffer for an unnamed sinkhole are located underneath an electrical easement.
4. Powerline Cave is located underneath powerlines.

Recommendations

1. Install fencing for CEF buffers with large, adjacent impervious cover that are currently unfenced.
2. Conduct inspections of remaining CEFs. Those with LS and LL buffer classifications should have first priority on inspections due to a greater risk of human disturbance.
3. Conduct follow-up inspections on fencing, gate conditions, as well as the vegetative state of the CEF buffers established through the City of Austin site development process. Frequency of inspections can be prioritized by previous inspection findings of the buffer conditions.
4. For CEF buffers in areas of high-density residential areas, more explicit signage should be put on buffer fencing. There is a sign on the fence of a CEF buffer at the Arrowwood apartment complex that reads “No Trespassing by Order of the TCEQ.” Higher levels of trash were

observed inside this CEF buffer, as well as bags of pet waste that had to have been thrown inside the fencing. Signage that explains that the protected area is an environmentally sensitive recharge feature for the Edwards Aquifer may deter people from throwing trash and pet waste into a buffer because they are more aware of its importance. Also, it may benefit to address some sort of fine for littering on the signage of these buffers.

5. Conduct a follow up study that compares CEF buffer conditions of karst features located within COA Parks land/Water Quality Protection/Wildlife Management land and those that are located on privately owned land where there is no active management or maintenance. The publically owned agencies typically perform selective clearing of understory and invasive species. It would be helpful to understand to what degree these managed buffers are or are not benefiting from selective clearing. More study is needed to determine if the standard of leaving CEF buffers as undisturbed vegetative areas is beneficial for water quality and quantity.
6. High amounts of tannic acid inside Texas Live Oak leaves make it very difficult for them to break down and decompose. It takes them even longer to break down if they are underneath thick canopy cover. Since leaf litter is ineffective in trapping sediment, CEF buffers with high percentages of leaf litter may not be functioning to their fullest intent. Also, large amounts of leaves can and have been found to fill point recharge features. A follow up study which analyzes recharge/sedimentation for buffers with high amounts of leaf litter may be beneficial to understanding whether or not we should play a greater role in managing buffers.

Issues

- Impervious cover shape files were not up-to-date by several years. Satellite imagery shows that new development/impervious cover has been built. This could have slightly altered classification breaks

CONCLUSIONS

This short-term project was conducted to inspect the land surface and vegetation within Critical Environmental Feature (CEF) buffers of caves and sinkholes on randomly selected sites within the City of Austin's extra-territorial jurisdiction or ownership. The purpose was to qualitatively evaluate whether the CEF buffers were functional for the purpose of protecting the cave or sinkhole and maintaining vegetation for the benefit of water quality. Watershed Protection Department staff are currently working on developing an inspection method and schedule so that the water quality and quantity benefits of CEF buffers are evaluated on a periodic basis.

REFERENCES

City of Austin Environmental Criteria Manual. 2016. Section 1.10.2 – Background. Austin, Texas

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