**MEMORANDUM**

**TO:** Mayor and Council Members

**FROM:** Jorge L. Morales, P.E., CFM, Director, Watershed Protection Department

**DATE:** Aug 17, 2022

**SUBJECT:** Reporting Deliverables - Monitoring & Sources of Trash in Creeks (Resolution No. 20200123-108)

The purpose of this memorandum is to provide reporting deliverables associated with Council Resolution No. 20200123-108. This resolution, in part, directed the City Manager to prepare a study with recommendations to address litter problems in Austin's waterways.

The Trash in Creeks field study, completed in the spring of 2022, documented trash distribution and sources at 19,467 data points in 20 watersheds along 110 miles of streams in Austin. Surprisingly, the intensity of trash had no significant relationship with stream drainage area, land use, population, or proximity to roadways/parks nor to individual point sources such as overflowing dumpsters, illegal dumping, and encampments/etc. This suggests that intensity of trash in creeks is a cumulative influence of the entire community and is primarily spatially influenced by the physical nature of the stream (roughness) rather than observed local sources. Spatial analysis indicates that 76% of the volume is in 10% of the area and the most encountered items were single-use plastic beverage/food containers, which has implications for both site prioritization and source reduction.

The Trash in Creeks benchmarking study reviews trash reduction methods and physical technologies that collect trash actively and passively in watersheds and waterways. Many strategies identified as being effective in peer cities are already being implemented by the City of Austin. Novel technologies and innovative mechanisms to extract trash in waterways around the world show promise, however, most have limitations that may preclude efficient use in Austin's setting. Physical removal is a critical part of the strategy but interception of trash on the landscape, and reduction of items commonly found in the waste stream are more sustainable methods for trash reduction.

These two reports provide insight to the distribution, character, and solution space of trash in creeks that will help our community focus resources and effort towards removal, prevention, and source reduction. The City of Austin is increasing its understanding of trash in creeks and diversifying the toolbox to address the problem. We anticipate testing application of some of the methods identified in the report to provide increased resolution on cost/benefit in our environment. A past deliverable associated with this council resolution was a Program Inventory, Analysis and Outcomes report on June 19, 2020, that helps to provide context for what the City is currently doing. However, the scale and scope of this problem will require increased staff and contractual resources if we as a community want to prioritize reductions of trash in our watersheds and waterways.

In the 110 miles of surveyed creek, WPD found 21 micromobility devices ("scooters") that have since been removed or are currently in the process for removal. WPD will continue to monitor for and respond to scooters in local waterways. Strategies to reduce presence of micromobility devices in creeks that have been created in response to the Council Resolution include:

- Austin Transportation Department (ATD) installed special signage and currently maintains active geofences to prohibit micromobility device parking on bridges and by waterways to limit illegal dumping of devices.
- To streamline reporting and retrieval of devices from waterways, the 311-mobile app was modified so that community members can report micromobility devices in waterways directly to licensed shared micromobility service providers. The providers cooperate in retrieving reported devices in waterways. We have not encountered issues where licensed providers were unable to retrieve a device. Devices that do not belong to a currently licensed provider are retrieved with City assistance. A provider's failure or refusal to recover devices from waterways could result in action directed by ATD, such as suspension of operations or permit revocation.
- A working draft of an update to the *Director Rules* governing dockless transportation systems contains language protective of watershed areas and will soon undergo stakeholder review in September 2022. The target date to present the draft for public comment is later this year.
- As of December 2021, Austin maintains a cap on devices licensed in the downtown area (currently observed at 8,100), so providers may not request to add further devices to their downtown fleets until further notice.

Should you have any questions related to the attached reports on litter in Austin's waterways, please contact Mateo Scoggins, Watershed Protection Manager, Watershed Protection Department at 512-974-1917.

cc: Spencer Cronk, City Manager
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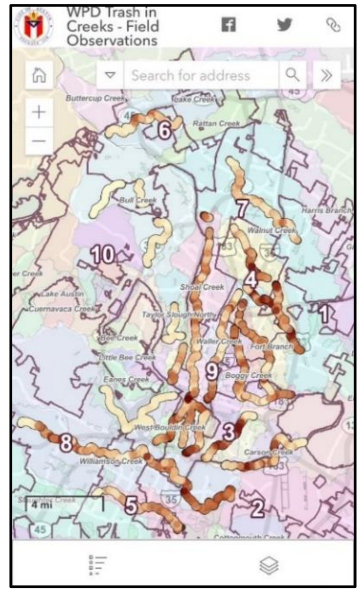
Attachments:

1. Trash In Creeks: A field survey of trash intensity and source types in Austin, Texas
2. Trash in Creeks: Benchmarking solution space and resources
3. Trash in Creeks: Program Inventory, Analysis and Outcomes

# Attachment 1




**https://arcg.is/0z48bj0**

# Trash In Creeks: A field survey of trash intensity and source types in Austin, Texas

**RR-22-01, August 2022**

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## Abstract

*The Watershed Protection Department conducted a field survey to understand distribution and sources of trash in creeks to inform solutions. Data points were collected every 30ft for a total of 19,467 observations in 110 miles along 20 creeks from November 2021 to April 2022. Results show that trash intensity does not correlate well with stream position (upstream-to-downstream) which implies that trash does not move evenly through the system, complicating efforts to quantify the relative impact of different sources. Presence of trash is more strongly influenced by stream roughness (primarily riparian vegetation) than by source inputs which presents an opportunity to use these natural "strainers" as locations to periodically remove trash from the system. ArcGIS attributes and linear regression, at the raw data level and aggregated, were used to evaluate relationships between trash intensity and observed point sources such as overflowing dumpsters, illegal dumping, historic dumping, encampments, as well as land attributes such as population, transportation, and land use (e.g., single family residential, multifamily, commercial, parks, etc.). Surprisingly, there were no strong relationships with any of the sources or watershed attributes. This indicates that culpability of trash in creeks should not be directed specifically at any one source, but rather it is the cumulative influence of the Austin community. Spatial analysis indicates that 76% of the total volume of trash was located at only 10% of the observation points. The most encountered items were single use plastic beverage and food containers resonating a global appeal for reduction. A companion report "Trash in Creeks: Benchmarking Solution Space" (RR-22-02) provides recommendations synthesizing the data from this field survey in the context of international strategies to prevent and abate trash in waterways.*

## Introduction

### *Purpose*

Due in part to public comment asserting an increase of trash in creeks over time, prevalence of scooters thrown in waterbodies and concerns with encampments, the City Council passed Resolution No. 20200123-108 (CIUR 2234) directing the City Manager "to prepare a study with recommendations to improve the ecological health and safety of Austin's rivers, lakes, and creeks by addressing litter problems, prevention, and abatement in our watershed." The resolution further specified a list of deliverables to address litter problems and illegal dumping of electric micro-mobility devices (i.e., "scooters") in waterways. Responsive to one of these deliverables, the Watershed Protection Department (WPD) Environmental

Monitoring and Compliance (EMC) Division completed a review of available data and comparable studies and subsequently implemented a field study quantifying the extent of trash in creeks as well as correlating predetermined sources to trash accumulation in representative locations around Austin.

*Available Data*

Existing in-house data on trash in waterways was determined to be inadequate to provide an immediate response to CIUR 2234. From 1999 – 2022 the City's primary baseline water quality monitoring project called the Environmental Integrity Index program (EII), included the collection of limited qualitative data related to litter in creeks through the sub-index "Non-Contact Recreation" assessment. The most relevant information in this assessment is parameter 316 "litter", for which the data is recorded as a 0-20 score based on an overall condition as defined by a qualitative rubric. Unfortunately, the data cannot be reliably correlated to sources or provide spatial or temporal comparisons because the method does not specify the physical boundaries of the area represented in the score and has therefore inherently been implemented differently through the years. In addition, the method was developed to describe recreational considerations and presence of any amount of glass disproportionately affected the score. For these reasons, the Non-Contact Recreation data is not useful for characterizing litter intensity for the purpose of spatial analysis or other related objectives in this study.

Cognizant of the benefits of citizen science and other volunteer-led initiatives, in 2011 WPD initiated a study called the "Litter Intensity and Sources Index" ("LISI" Project 552 SR-21-06) to determine if volunteer-collected data could effectively and consistently identify composition and sources of litter in creeks based on visual observations using staff-designed field sheets. Data was collected at 15 sites with duplicates and controls. Results of the study (Jackson and Richter 2020) indicate that while visual litter assessment forms may be useful for identifying some sources, volunteer-based data collection based on perception is not recommended due to poor precision and accuracy. Recommendations from the project included use of a limited number of trained personnel rather than an unlimited number of volunteers. This implies that a study focusing on trash in creeks should be implemented by a small number of trained staff recording data using a well-defined method that limits differences in visual perception.

The lake crew of WPD Field Operations Division removes trash from Lady Bird Lake weekly. Until recently, the crew removed both anthropogenic trash and organic matter and conflated the estimates of volume removed. Trend analysis of the data over time is impossible due to the shift in method. Organic matter is estimated to have been the bulk of material removed. Debris removal from Waller Creek Tunnel facilities has been anecdotally described as primarily (as much as ~80%) organic matter.

WPD EMC designed a rapid visual litter assessment method to evaluate success of litter management efforts in the lower Waller Creek watershed over time (Jackson, 2015). The study concluded that:

- there was a significant presence of litter in lower Waller Creek,
- beverage containers were identified to be the most prevalent type of litter, and
- additional data points at each site were needed to better describe baseline conditions.

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Although each of these efforts to characterize trash intensity served a specific purpose, due to their unique limitations they could not be used to characterize trash in creeks/riparian corridors for the purpose of correlating sources and/or spatial trends. A reproducible method with defined observation area boundaries, a less subjective visual method, and a large area and density of data points would be necessary for a city-wide survey.

*Literature Review for Trash Survey Methods*

Municipal, regional, state, national and international efforts to understand, quantify, and reduce trash in waterways are diverse and appear to be increasing over time. However, most available data appears to be from studies that focus on marine litter which typically use volunteer-driven beach clean-ups as a vehicle for data collection (Carpenter & Wolverton 2017, Carson et al. 2013, Hidalgo-Ruz and Theil 2013, Hong et al. 2014, Koelmans et al. 2015, Ryan 2015, van der Velde et al. 2017, Vincent et al. 2017, Xanthos and Walker 2017). Often, beach collection efforts are centered around hot spots and are typically not representative of the baseline litter accumulation in a watershed (EPA TFW 2018). Freshwater litter studies tend to focus on large river/lake systems and/or non-point source production and illegal dumping (Allison et al. 1997, Armitage 2007, Armitage & Rooseboom 2000, BASMAA 2014, Cowger et al. 2019, Jakiel et al. 2019, Kim et al. 2008, Liu et al. 2017, Marais & Armitage 2004, McCormick 2015, McCormick & Hoellein 2016, Santos et al. 2019, Vincent et al. 2017, Weaver 2015). Many studies provided insights for experimental design including:

- Land use: Various land uses such as recreation (Moore et al. 2007, Weaver 2015) can influence litter in aquatic systems (BASMAA 2014, Cowger et al. 2019). Monitoring sites in BASMAA (2014) represented seven different land use types, with a focus on retail and residential trash generation rates. BASMAA (2011) found that retail and residential areas generally had higher litter rates than other land use types. These rates can be explained by higher population density in residential and retail zones (BASMAA 2014).
- Seasons: Seasonality can affect litter trends (BASMAA 2014, City of Los Angeles 2016, Moore et al. 2007) and therefore, repeated site visits are required for studies that seek to address temporal trends, such as accumulation rates (Moore et al. 2007), which can be critical in determining litter sources, and for evaluating management actions.
- Vegetation density: Some studies report a relationship between dense riparian buffers and less trash accumulation in stream beds (Cowger et al 2019, EPA TFW 2018, McCormick 2015). McCormick (2015) found a higher density of litter in riparian zones compared with instream zones due to the buoyancy of the materials found in each zone. High velocity streams are more likely to transport heavy materials, while riparian zones tend to accumulate lighter materials through lower energy transportation methods such as wind or rain events (McCormick 2015).
- Stream width, stream order, catchment area: Stream size is likely to influence transport and retention of different types and categories of litter. Incorporating a variety of stream sizes, for example, can assist in evaluating longitudinal (Moore et al. 2007) and regional trends (Moore et al. 2007, Kiessling et al. 2019). In a study looking at major rivers, tributaries and small streams, Kiessling et al. (2019) speculated that larger rivers, possibly due to better accessibility and recreational areas, may lead to aggregation of both visitors and litter. Moore et al. (2007) included numerous sites per watershed in the San Francisco Bay Area, which allowed for specific longitudinal analyses of watersheds with unique sources of litter.
- Impervious cover (IC): IC is positively correlated to litter accumulation and urban runoff. The storm drain system is a primary source for floatable debris entering a watershed (Armitage 2007, Conley et al. 2019, Cowger et al. 2019, Moore et al. 2007).
- Proximity to major roadways: Trash dispersal can be increased from incidental littering from passengers and unsecured items (Cowger et al. 2019, Jakiel et al. 2019). Cowger et al. (2019) found significant positive correlation between road density and trash accumulation rates.

Two recent methodologies that can be applied to a wide variety of freshwater systems and riparian corridors are: the Rapid Trash Assessment Method (RTAM) applied to waters of the San Francisco Bay region, and the Escaped Trash Assessment Protocol (ETAP) developed by the Environmental Protection Agency Trash Free Waters Program. The RTAM was the first published account of a methodology which met the objectives of quantifying trends and identifying sources of litter in municipal freshwater streams (Moore et.al 2007). The ETAP (EPA TFW 2018) represents the most recently updated version of litter assessments conducted in California intended for development into a national standard for documenting and assessing anthropogenic litter in stream habitats, making it a primary source of guidance for City of Austin litter assessment. The protocols employed by the ETAP were not used in the City of Austin assessment because they were designed for estimating the trash of a large area such as a park, river basin, or large parcel through a detailed assessment of a subsampled area; they were not designed for thin, long, linear systems like Austin's first- and second-order creeks.

WPD water quality monitoring staff have not noted, anecdotally, a significant increase in trash at the ~120 routine water quality monitoring sites over time, however, these monitoring sites may not represent the conditions at other locations within the city. With the unprecedented and sustained accelerated growth that the Austin metropolitan region has experienced it is certainly plausible that trash in creeks is an increasing problem as reported anecdotally by citizens. WPD Field Operation crews dedicated to routinely clearing obstructions in creek culverts and removing trash from Lady Bird Lake cannot document a trend of increasing trash due to the variability in their efforts and methods, however, there is a chronic trash problem in these areas. Just in the first three quarters of FY 2022, the lake crew has removed 22.5 tons of trash from Lady Bird Lake from booms on creek deltas and from the shoreline.

As Austin's population continues to grow and dependence on single use plastics and disposable items increase, so too will the problem of trash in creeks. The City of Austin supports organizations such as Keep Austin Beautiful and The Other Ones Foundation that remove tons of trash from the landscape in addition to facilitating cleanup events such as Its My Park Day (Austin Parks Foundation), Clean Lady Bird Lake and Keep Austin Beautiful Day. In addition, a newly created team of City staff within the Austin Resource Recovery Department (ARR) has begun to focus on removing trash in creeks this year. Sustaining and increasing the effort to remove the trash can be improved by a comprehensive look at the location and sources of trash in our creeks.

# Methods

After an extensive literature review of trash survey methods, existing data and preliminary field reconnaissance, the following methods were developed for Austin-area streams to maximize the potential for identifying source types and understanding spatial patterns of trash intensity.

*Timing of survey*

Inputs of trash into a creek is unlikely to be steady or uniform due to changes in weather, social patterns, and economic changes. The Trash in Creeks study was originally initiated in 2020, however the radical changes in social patterns due to the COVID-19 pandemic, in addition to resulting safety precautions delayed the study until late 2021. The literature review revealed that seasonality is known to affect trash patterns due to changes in storm events and human activity, therefore the field survey was concentrated within a single season to the extent practical. Due to Austin's bimodal rain patterns (increased risk of storms in late spring and early fall) the preferred season for a field survey was either winter or summer to avoid stormflow disturbance and redistribution of trash. Anecdotal observations by WPD Field Operations indicate that the intensity of trash in creeks is more noticeable after drought-breaking storm events.

Staff determined that winter would also be the optimal time frame due to "leaf-off" conditions, when the normally densely vegetated riparian areas would be dormant, providing maximum visibility of the litter items accumulated on the ground. This period was also optimal for safety considerations due to dormant poison ivy and lower water levels. Following preparations, the survey was conducted from 23 Nov 2021 to 12 April 2022 during which time few rain events occurred.

*Survey location selection*

Within the City Limits, there are approximately 217 miles of creek mainstems in the COA regulatory watersheds and thousands of miles of tributaries. These creek lengths almost double when including the

Extra Territorial Jurisdiction. Preliminary surveys in East Bouldin Creek indicated a high amount of variability in trash intensity that did not appear to be related to source locations, so a high number of data points, 30-foot length reaches, was proposed by the study team. More than a hundred miles of creeks were selected to represent the general spatial extent within the city limits (Figure 1) as well as to ensure representation of creeks within all ten council districts (Figure 2). Sample areas included a mix of residential, multifamily, commercial, park, urban, suburban and undeveloped space within twenty watersheds. Sixteen creeks were sampled in their entirety from the headwater to their confluence with the receiving waterway, however, four creeks were only partially sampled because of their large size, access problems, and extent beyond the City of Austin jurisdiction.

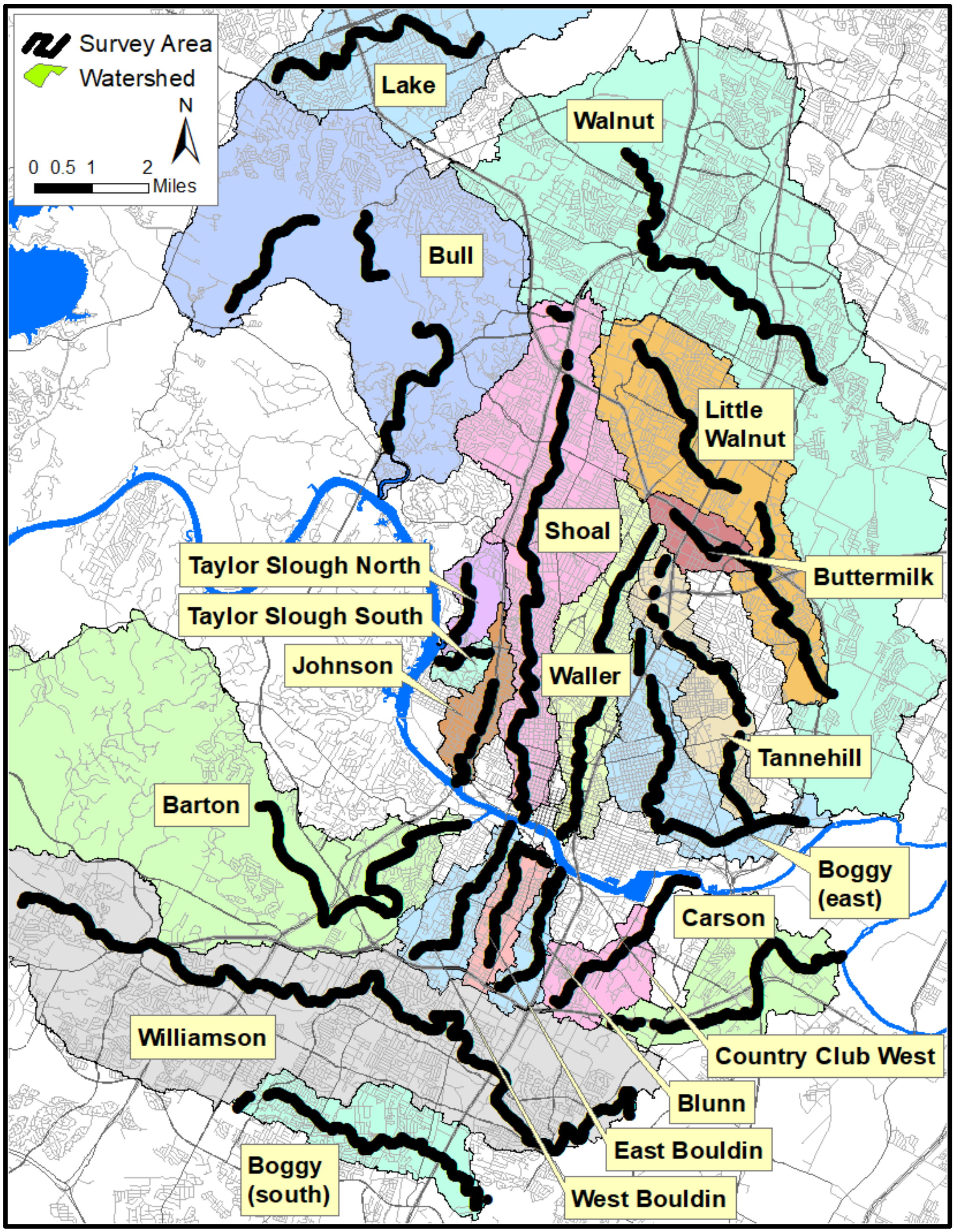


**Figure 1. Survey location within the 20 selected watersheds**

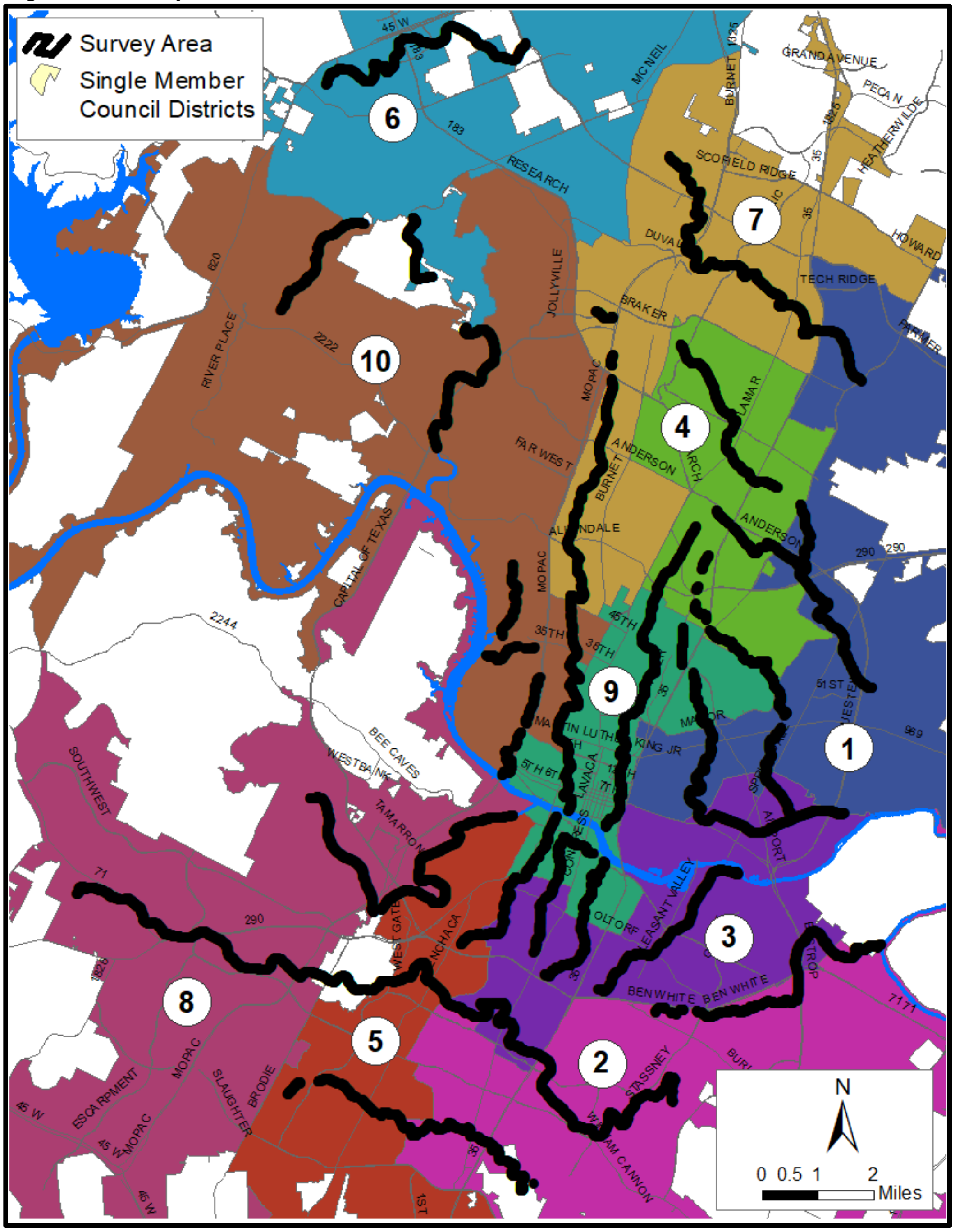



**Figure 2. Survey location within the 10 Single Member Council Districts**

*Assessment Unit*

A standardized unit of 30 ft long stream reaches was selected, as measured along the centerline of the creek. The assessment area extends laterally from the centerline through the stream bed, to beyond the lower banks (bank full) to include the first floodplain bench. This floodplain bench can be assumed to be inundated with less frequency than the channel-forming events (~2yr), but more frequently than a 100-yr event. This area will be characterized by riparian vegetation, notable drift lines from larger storms and floodplain areas where trash and other items are likely to be deposited in or mobilized from. Staff shall use these cues and topographic changes to assess the area that appears to be flooded with frequency between approximately a two-year and ten-year event (Figure 3).

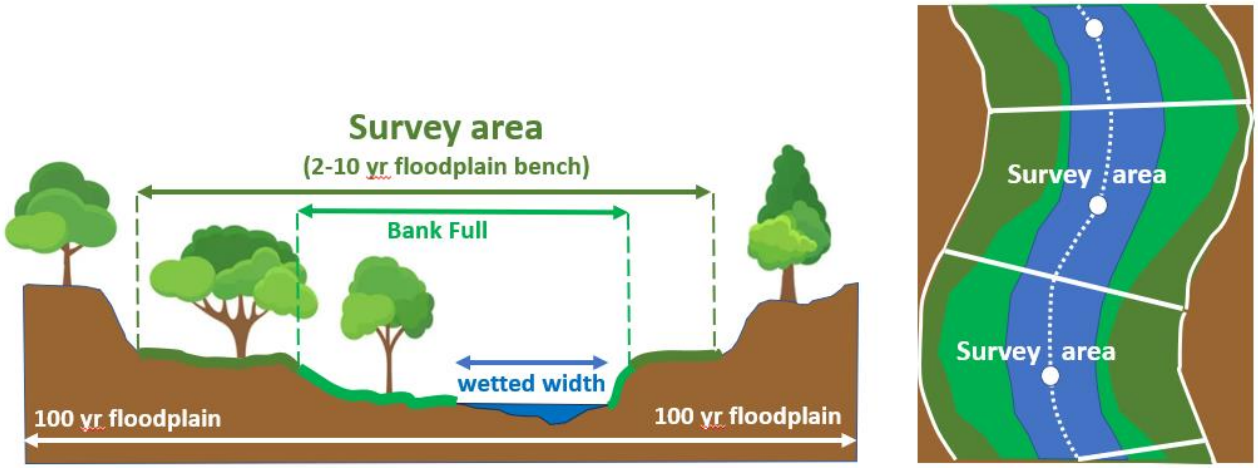



**Figure 3. Survey area cross section and top view. The survey area is 30ft long (15ft on either side of the center point) and extends outward past the bank full into the riparian zone of the low floodplain bench. The 100-year floodplain typically extends beyond the survey area.**

Within each assessment unit the intensity or volume of the trash is evaluated. Although the term "trash" may seem intuitive, certain limitations were drawn to maintain consistency. For this assessment:

"Trash" includes (Figure 4):

- Anthropogenic garbage and/or human possessions that are out of place
- Abandoned shopping carts, scooters, vehicles
- Erosion and stabilization materials (silt fence, matting, etc.) if completely detached from the application area
- Bricks, asphalt chunk, cinder blocks, concrete chunks, rebar, etc. that is has mobilized, and/or is otherwise no longer in its intended place.
- A bag or sack that contains sand/organics (but "trash" does not include the organics)
- Loose possessions or trash on the outside/around an actively used tent or temporary living space
- All items within a tent/camp that is no longer in use

"Trash" *does not* include: (Figure 5):

- Vegetation (e.g., leaf litter, branches, sticks, etc.) whether naturally distributed or dumped
- Failing structures that are still attached (e.g., fence wire, in-place bricks, pipe segments, etc)
- Slumping or failing bank stabilization still in place but vulnerable to mobilization for which removal would compromise integrity of the bank
- Large pieces of concrete or pipe that are no longer in place but could not be removed without heavy equipment
- Sand/organics (leaves, mulch) that are contained within bags/sacks
- An actively used tent or temporary living space

**Figure 4. Objects were considered trash if they were mobilized beyond their intended place**

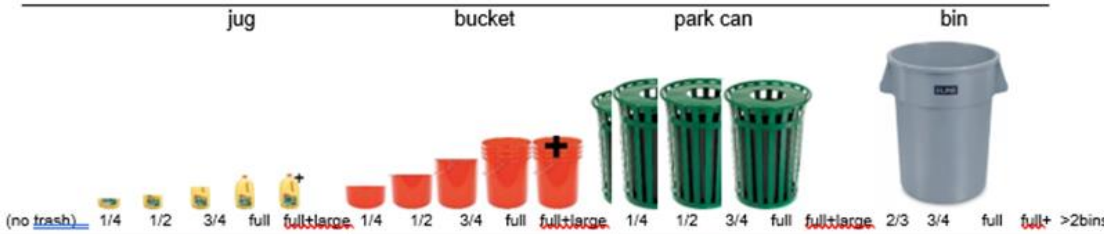
**Figure 5. Objects were not considered trash if they were in process of failing (e.g., fences, utilities, revetments, pipes, etc.), were still attached, were stabilizing a bank, or were too large to be removed by hand.**

*Trash Intensity Method (Rubric)*

A rubric, or matrix, to visually characterize trash intensity for a one-time snapshot of trash in creeks was developed for the purpose of estimating aesthetic intensity, cumulative volume and time necessary to collect. Variability in rubric interpretation, or error, was limited by utilizing a small number of trained and calibrated staff throughout the survey period. The rubric, visual aids and narrative guidance is contained in a creek walk field sheet that was laminated and carried by each team (Figure 6).

## Visual Trash Intensity Rubric for Creek Walk

1) Score is recorded at the center of a 30ft creek segment (15ft upstream and 15ft downstream of point)
2) Survey area extends outward to the high bank (perceived floodplain) visible from the channel banks, to include areas that trash will imminently reach the stream in a storm event even if above high bank
3) Accumulations of dead vegetation will not be considered trash, however if contained in bags, the bags will be considered trash (presume the bag is separated from leaves). Same with sandbags.
4) Immobile abandoned infrastructure (e.g., pipelines in channel, large blocks of concrete) will not be considered trash if infeasible (without heavy equipment) to remove/cleanup by hand), however, portions that could be easily cut off with hand tools (exposed rebar, cables, etc.) and removed will be considered trash. Small construction debris (bricks, cinderblocks, asphalt etc.) that can mobilize during storm events are considered trash. Materials that are in-place but failing are not considered trash (fence sagging, erosion matting dangling, etc.), but can be considered trash if no longer in-place and mobile




| Minimal | | Apparent | Abundant | Dense |
|---|---|---|---|---|
| 0 | 1 2 3 4 5 | 6 7 8 9 10 | 11 12 13 14 15 | 16 17 18 19 20 |
| No litter observed within survey area | **Description:** "good"<br>Few items here or there but not very noticeable. If noticeable, few<br>**Volume**:<br>The cumulative amount could easily fit within a 1-gallon milk jug, however, a single item that is larger than a milk jug (but still fits in a 5-gal bucket) can still be in this category<br>**Effort:**<br>Site could be easily and quickly cleaned by one person (<5 minutes) | **Description:** "not bad"<br>Trash is noticeable but doesn't define the site<br>**Volume**:<br>The cumulative amount could easily fit within a 5-gallon bucket, however, a single item that is larger than a bucket (but still fits in a 25-gallon can) can still be in this category<br>**Effort:**<br>Site could easily be cleaned by one person but not quickly (~5-15 minutes) | **Description:** "bad"<br>Site has obvious and salient accumulation. "Trashy" is forefront<br>**Volume**:<br>The cumulative amount could easily fit within a 25-gallon park trash can, however, a single item that is larger can still be in this category<br>**Effort:**<br>Site looks like a two-person job but could be cleaned by one person (~15-30 minutes) | **Description:** "horrible"<br>Trash defines the site and offends the visitor. Desire for cleanup is overwhelming<br>**Volume**:<br>The cumulative amount requires the big 55-gallon bin(s)<br>**Effort:**<br>Site would take a long time for one person, (~30+ minutes) but site is better suited for a team |

**Figure 6. Field Sheet for evaluating Litter Intensity at each 30ft assessment reach**

The rubric for scoring trash intensity was designed such that the observing team would consider three facets of trash located within the assessment unit area. The first facet was one of four general adjectives for which the area could be described as: Minimal, Apparent, Abundant, Dense. These descriptors represent four "bins" under which the observing team determines the 0-20 score. The "Minimal" category is characterized by a small volume of trash that would fit within a 1-gallon jug and take a single person less than 5 minutes to fully pick up. Apparent, Abundant and Dense categories have increasing volume and time thresholds as described in Figure 6. In the field, the observer team discusses and agrees on the value that best fits the assessment area. The estimated volume of the trash is the primary driver determining the score, and the estimated time to collect can influence the score for better or worse. This method was devised due to the variability of types (size, weight, etc.) and character (distribution, difficulty, etc,) of trash observed during pilot assessments.

*Field Method*

Trash study field crews typically consisted of a team leader and one or two supporting staff from a small pool of individuals that had been trained/calibrated to reduce variability in method application. At each site, the team utilized the following equipment and protocol:

Field equipment:

- iPad for georeferenced data input, Fulcrum mapping application, charger cable, external battery
- waders, first aid, phone, water
- 2 vehicles (one staged upstream, begin survey at downstream site)

Field Protocol:

- Team identifies stream reach that has not already been surveyed
- Team navigates to the first observation point in Fulcrum app
- Team lead stands 15ft upstream of first point, partner stands 15ft downstream of first point
- Team observes the survey area (Figure 3) and determines the trash intensity value (Figure 6) for the 30ft reach and enters the value in Fulcrum app plus any observations of scooters, specific sources, and other comments. If a scooter is observed, company name is recorded in comment field.

At each observation point, additional site attributes were recorded and georeferenced. If a source of trash was obvious and without-question, it was logged within the 30ft reach. Multiple sources were allowed at each observation point, but at no point were speculative "guesses" recorded. For a source to be identified as "present" within the app, trash had to be observed emanating from the source and could not have been deposited by any other method (i.e., stormflow, etc.). The following six trash sources and one stand-alone attribute (scooter) were options for presence/absence in each 30 ft study reach:

- Dumping – known point source
- Dumping – historic dump site
- Dumping – unknown source
- Overflowing dumpster
- Encampment
- Outfall/Tributary
- Property Management
- Scooter

Descriptions of each of the parameters is provided in the Results section. A comment field was also provided to record such information as the name of the scooter company and any other salient information the team deemed important.

## *Geospatial Analysis*

Segmented buffers generated along surveyed creeks were used as the spatial unit to relate trash observation with potential drivers of trash presence (e.g., land use, roads, impervious cover). ESRI ArcGIS Pro 2.9.2 and Safe Software Feature Manipulation Engine 2021 were used to generate segmented buffers. The process was to first buffer creek centerlines to widths of 300 feet and 3000 feet and then cut the buffers into segments every 300 linear feet and 3000 linear feet, respectively (Figures 7 and 8). Segmented buffers generated by software were manually inspected and modified so that segment breaks were roughly perpendicular to creek lines and consistently applied around bends and meanders.

Trash observation points and spatial data representing potential drivers were then associated with the intersecting 300-foot and 3000-foot segments. Trash observation points were each assigned the unique ID values of the intersecting segments. Nine types of drivers were associated with each segment (Table 1).

**Table 1. Potential drivers associated with trash observations via creek buffer segments**

| Driver | Data source | Spatial association, per segment |
|---|---|---|
| Land use | Land Use Inventory Detailed, COA Planning and Zoning Dept. | Overlapping area and percentage cover of parcels intersecting segments, by land use class. |
| Impervious cover | Impervious Cover 2019, COA Watershed Protection Dept.* | Overlapping area and percentage cover of impervious features intersecting segments, by feature type. |
| Street centerlines | Street Segments, COA Transportation Dept. | Linear feet and segment count of street centerlines intersecting segments, by road class. |
| Encampments | Observed by field staff | Attributes of homeless activity points within segments. |
| Points of interest | Open Street Map | Count of ways and nodes intersecting segments, by type. |
| Population | 2020 Decennial Census blocks, US Census Bureau | Population within segment estimated via areal weighted interpolation. |
| Stormwater inlets and headers | Drainage Infrastructure GIS, COA Watershed Protection Dept. | Count of inlet and header points intersecting segments, by type. |
| Water quality pond drainage areas | Drainage Infrastructure GIS, COA Watershed Protection Dept. | Count, overlapping area, and percentage cover of drainage areas intersecting segments. |

* With definition query applied: *FEATURE NOT IN ('Above Ground Pool', 'Compacted Soil', 'Courtyard', 'Golf Course', 'Gravel/Sandpit', 'In Ground Pool', 'Open Space', 'Quarry', 'Unpaved Athletic Field', 'Paved Ditch')*

In addition to analyzing trends by summarizing the area around creeks, several attempts were made to build regressions with spatial associations of adjacency and concentration of land uses and encampments at various drainage area scales (e.g., storm sewer drainage areas, watershed subbasins), that could explain the trash severity scores. Spatial analysis tools in ArcGIS Pro 2.9.1, such as Exploratory Regression and Colocation, did not yield any insights. Dividing land use categories into more specific values (e.g., “fast food” or “convenience store” instead of “commercial”) was considered in hopes that insight could be gained regarding specific sources of trash (such as stores that generate single use items) however, since land use did not end up being a good predictor of trash (i.e., not a significant correlation with increasing trash), further specificity was not thought to offer better resolution.

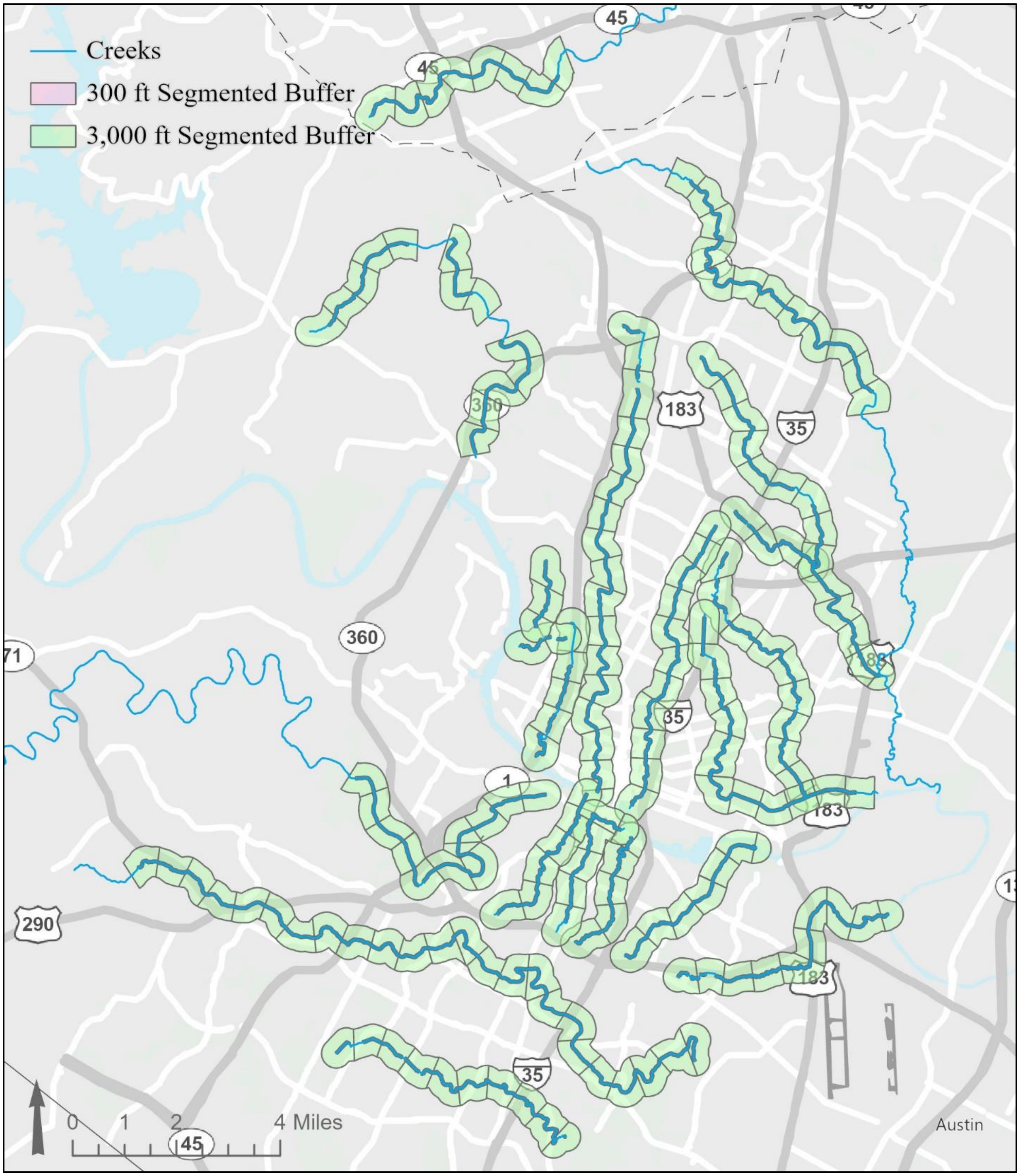


**Figure 7. Geospatial analysis units. Data were aggregated into small (300ft, the thinner blue lines) and large (3,000ft, the larger green buffers) linear segments with polygons created with similar widths to characterize the area surrounding and potentially influencing the creeks (e.g., land use, population, etc.).**


**Figure 8. Within each 300ft (pink) and 3,000ft (green) segment (A), attributes such as population by census block (B), transportation (C), and land use (D) were calculated and correlated to the median value of trash intensity within each respective segment.**

### *Regression Analysis*

Surrounding land use types were evaluated for correlations to trash intensity. Median values for trash scores were used instead of mean values because the data were not normally distributed. Medians were compared to the land use characteristics at two different scales. First, the median of trash volume estimates was calculated for 300 ft and 3,000 ft square segments. Second, the land use percentages for each segment were extracted from City land use GIS layers. Standard land use categories were aggregated to a smaller number that more simply represented potential trash sources. Transportation infrastructure was also represented by using the roadway and right of way areas. Median impervious cover in each unit was also calculated using the 2019 City of Austin data.

It was hypothesized that correlation between land use and trash volume would be an indicator of a possible causal relationship. A simple univariate linear regression analysis was performed using the land use percentages for each category as single independent variables and the estimated trash volume as the dependent variable. Impervious cover was also used as an independent variable.

## Results

*Spatial patterns*

The field investigation included 19,467 observation points in over 110 miles of creek within 20 watersheds. Some anomalies in antecedent conditions at a few sites were apparent due to recent trash collection. Individuals performing creek clean ups such as The Other Ones Foundations (TOOF), Keep Austin Beautiful (KAB), Austin Resource Recovery's Clean Creek Crew, creek-adjacent landowners, other contractors and volunteers may have affected surveyed areas in the preceding days/weeks/months. However, effects of these anomalies on the results are thought to be insignificant due to the large total number of observation points. Over half of the observations were in the "minimal category" (volume ≤ 1gallon) and approximately a quarter were in the "apparent category" (volume that fits in a 5gallon bucket). A surprising 25% of the surveyed area (~28 miles of creek) were characterized to be in the worst two categories "abundant" (requires a 25gallon trash can) and "dense" (requires one or more 55gallon trash bins) (Figure 9). Although the "dense" category was only observed at 10% of all the sites, it accounted for 76% of all the trash by volume.

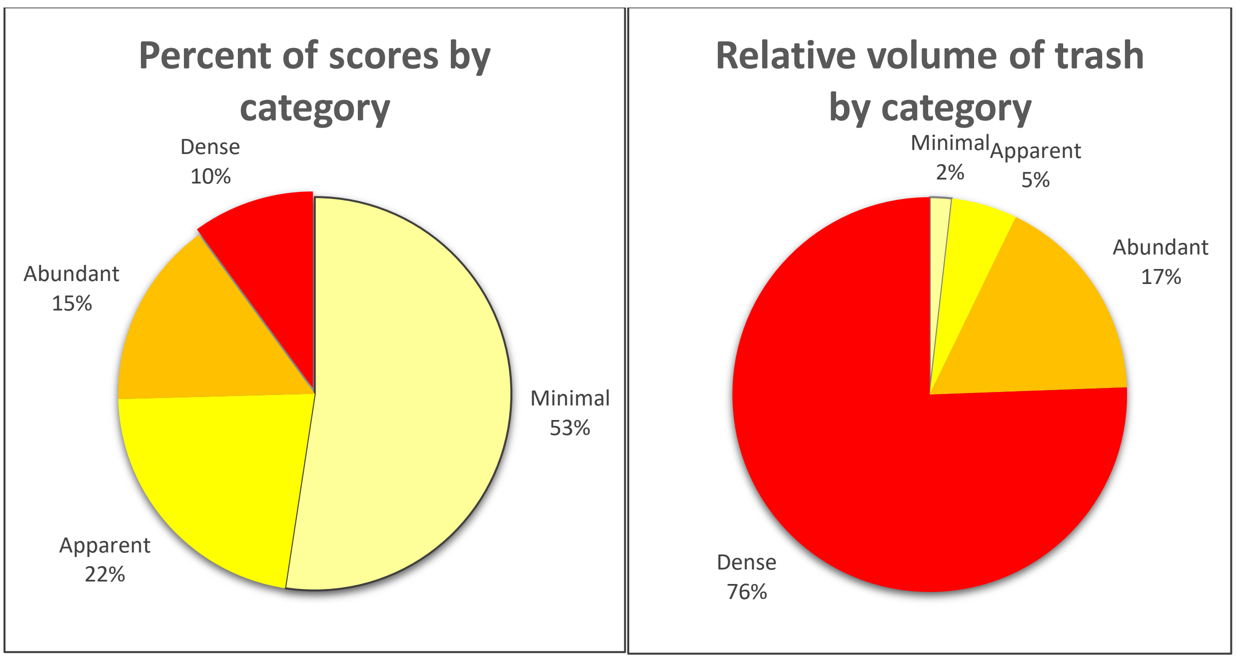



**Figure 9. Trash intensity scores (left) and relative amount (right) of trash by category. Most scores were in the "minimal" category, while roughly a quarter were in the two worst categories "abundant" and "dense". The dense category, 10% of the observations, accounted for 76% of the total trash volume and the combination of these worst two categories accounted for 93% of all the trash by volume.**

Trash intensity scores within the Council Single Member District varied greatly (Figure 10).

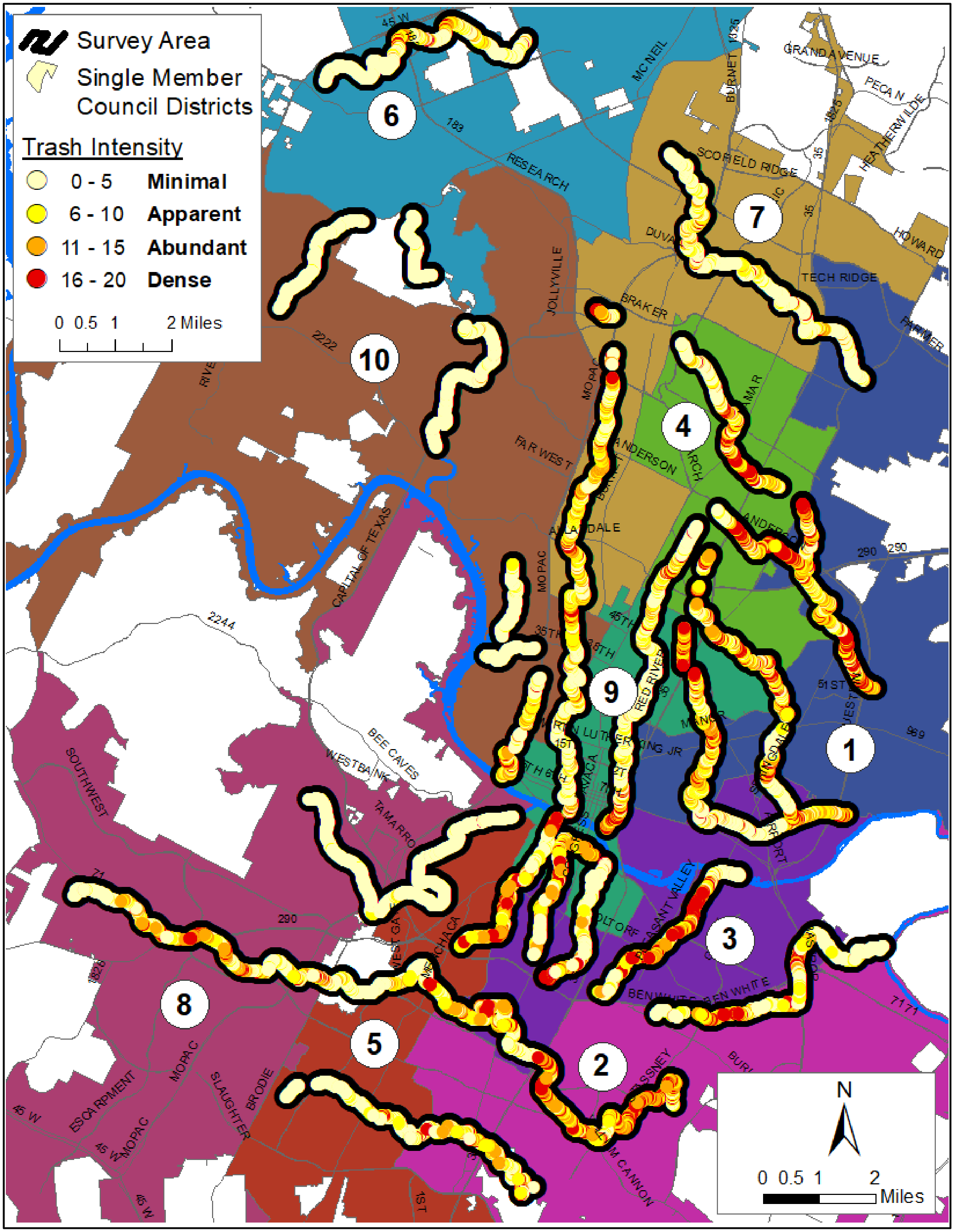



**Figure 10. Overview of trash intensity scores for survey area within Single Member Districts**

Determining the relative contribution of trash from a specific source depends greatly on the conveyance of trash through the stream network system. An experiment that assesses the contribution of a localized trash source could be designed to sample upstream and downstream of the source input to assess relative increase at one point in time, or throughout time. That experiment would require the assumption that all trash travels downstream and travels at a similar rate, otherwise the design will not work. Anecdotal observations by staff senior environmental scientists indicated that trash did not appear to simply move downstream as evenly as one might assume. To test the relationship of trash moving from upstream to downstream, the data points from the survey were normalized by their position in the creek and plotted against the trash intensity score. Normalizing stream position (ordering all observations incrementally from upstream to downstream) enables trend analysis for intensity within a creek as well as comparison to other creeks. If it were true that most trash flows through the creek from upstream to downstream, then as the watershed grows bigger (more land, more tributaries, more outlets), then trash intensity should grow larger downstream.

The rate at which trash is conveyed downstream varies greatly. Mobility is generally dependent on 1) the item (buoyancy, shape, size, weight, etc.), 2) the water (velocity, depth, frequency of storms) and 3) the roughness, or complexity of the stream and riparian corridor. Floatables like beverage bottles may quickly transport down the stream, however, large, irregularly shaped and/or flexible items (fabrics, foam rubber, erosion matting, etc.), can easily become entrained in stream vegetation. Woody vegetation in the stream and riparian corridor provides stability and integrity to the stream system, but with this advantage comes entrainment of trash. This "straining" effect can be seen as a benefit because it keeps some trash from entering the stream and also provides a natural detaining focal area for staff, contractor, or volunteer efforts to extract trash from the system.

This is an important facet of an evaluation of the various source relationships because sources found in the lower watershed may inherently appear to contribute disproportionate amounts of trash as well as the converse. Creeks in which trash intensity increases in a downstream trend should show a trendline upward to the right (increasing score downstream). Creeks in which the inverse is true (trash intensity decreases downstream) will show a trendline down to the right. A flat (or virtually flat) trendline indicates that trash intensity is effectively the same regardless of stream position.

Fortunately, there were no major storms during the survey period for any creek that would have otherwise redistributed trash from upstream to downstream. Although the trend lines may appear to show some relationships, none were very strong. $R^2$ values provide an indication of the strength of the relationship between the driver (stream position) and the response variable (trash score), an $R^2$ of 1.0 is a perfect predictor, >0.7 would be considered strong predictor and <0.4 would be considered weak at best. However, even with some significant relationships in some watersheds, the overall trends were inconsistent, with the same number of creeks showing increasing trends downstream as those showing increasing trends upstream and at least a quarter of the creeks showing no trend at all (Figure 11).

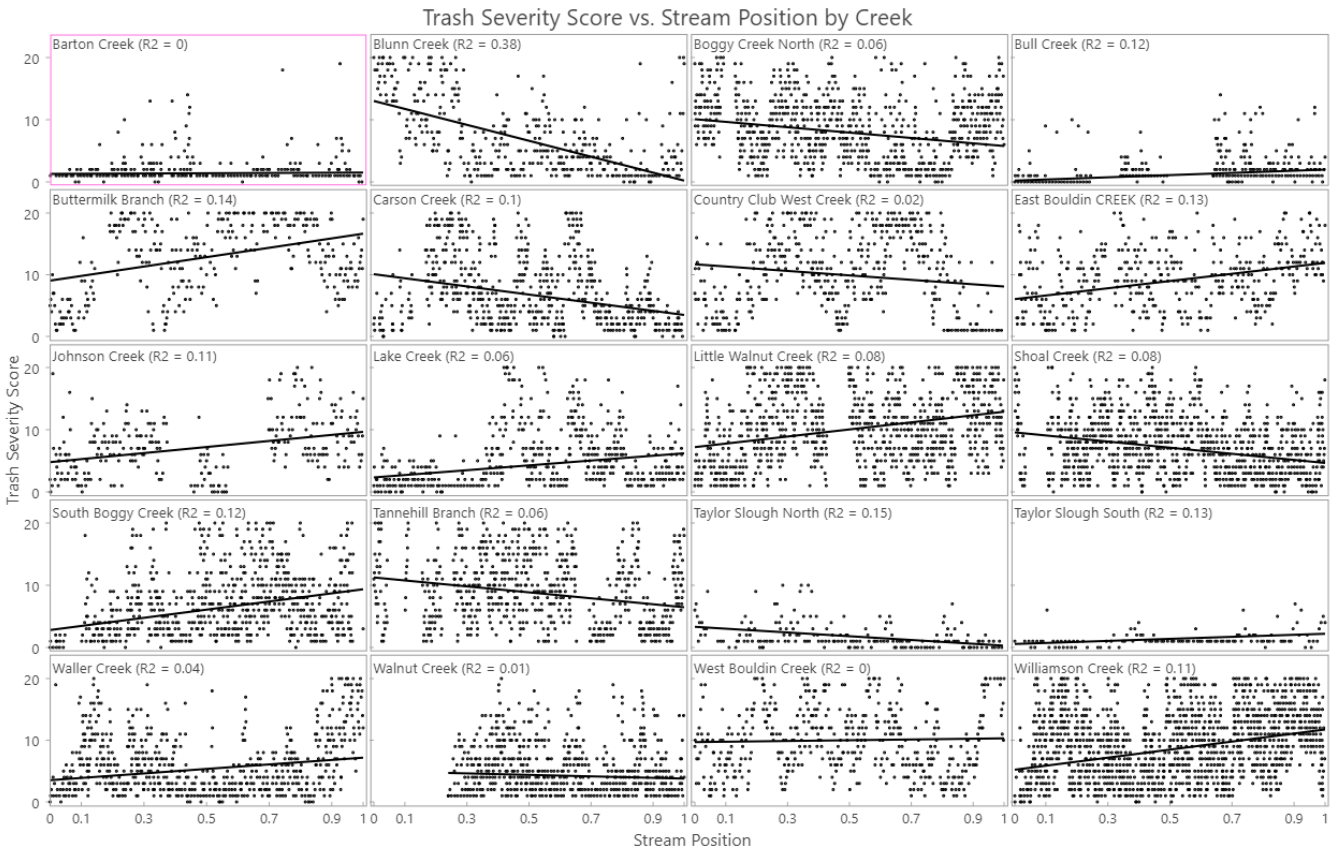



**Figure 11. Trash score is poorly predicted by stream position ($R^2$ 0 - 0.4) in all surveyed watersheds. Scores plotted against creek position (normalized from 0=farthest upstream to 1=farthest downstream) show that 40% of the creeks have a weak trend for increasing trash downstream, 35% of the creeks have a weak trend for increasing trash upstream and 25% of the creeks show no discernable trend. However, none of the relationships were very strong (all $R^2$ <0.40)**

Our results show that stream position does not predict trash intensity. This finding is important because it implies that trash does not flow in such a uniform manner that a particular point source could be evaluated for its effect on a stream by comparing trash upstream and downstream of that point. Further, it implies that trash intensity in a creek is either a result of diffuse or combined local inputs that are typically not mobile and/or that stream roughness might predict trash scores (i.e., trash detained in areas of thick vegetation or rough stream beds).

## *Spatial Distribution of Trash Sources*

Seven types of trash sources were pre-selected for field identification and location including:

- encampments,
- property management,
- overflowing dumpsters,
- outfall/tributary,
- historic dumping,
- recent point source/known dumping, and
- recent unknown dumping

These sources were observed 869 times in the 110 miles of creek that were surveyed. Frequency of occurrence (Figure 12) for each source indicates that encampments (352 observations) were by far the most common source in the survey area. Volume of trash doesn’t necessarily correlate with these sources because of the different physical and anthropogenic characteristics of each source. For example, illegal dumping is a focal point that typically creates a high score in one observation point, but property management may be diffuse and extend for several linear observation points but with lower scores. Regardless, some sources (such as encampments) were very common while other (such as overflowing dumpsters) were not.

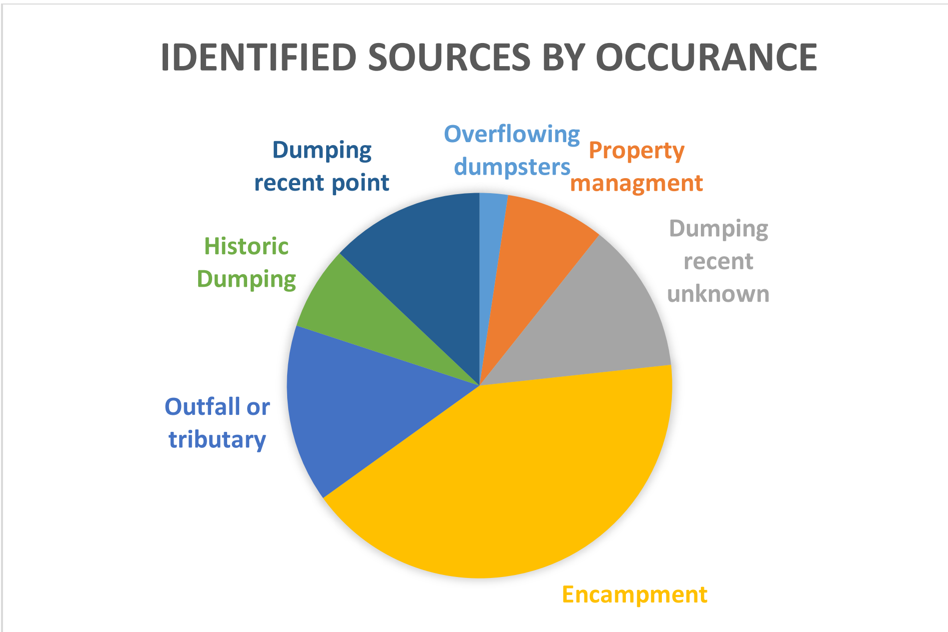



**Figure 12. The seven potential trash sources selected a-priori and logged during field surveys, and their relative frequency of observation.**

The following sections provide a narrative and spatial description of each of the observed seven sources in addition to observations of micromobility devices (i.e. "scooters").

## Scooters

Dumping/abandonment of micromobility devices (herein "scooters") was a concern expressed in CIUR 2234. Scooters provide an inexpensive and low-pollution alternative to traditional transportation, however, when they are dumped in creeks, the scooters effectively become large trash items, obstructing flow and potentially contributing to ancillary pollution through degradation of the various components (e.g., battery, plastics, electronics, etc.). The field survey observed a total of 21 abandoned/dumped scooters in the 110 miles of stream channel (Figure 13). Although this is an average of 1 scooter for every 5 miles of creek, most scooters were in the downtown area. The vendor is responsible to collect abandoned scooters. The location and description (photograph suggested) of an abandoned scooter should be communicated through 311 to the Austin Transportation Department (ATD), or directly to ATD. ATD then contacts the respective vendor who has 24hrs to retrieve the device. A provider's failure or refusal to recover devices from waterways could result in action directed by ATD, such as suspension of operations or permit revocation. To date, ATD indicates that providers have demonstrated cooperation in retrieving reported devices in waterways and ATD has not encountered issues where licensed providers were unable to retrieve a device. Devices that do not belong to a currently licensed provider are retrieved with City assistance.

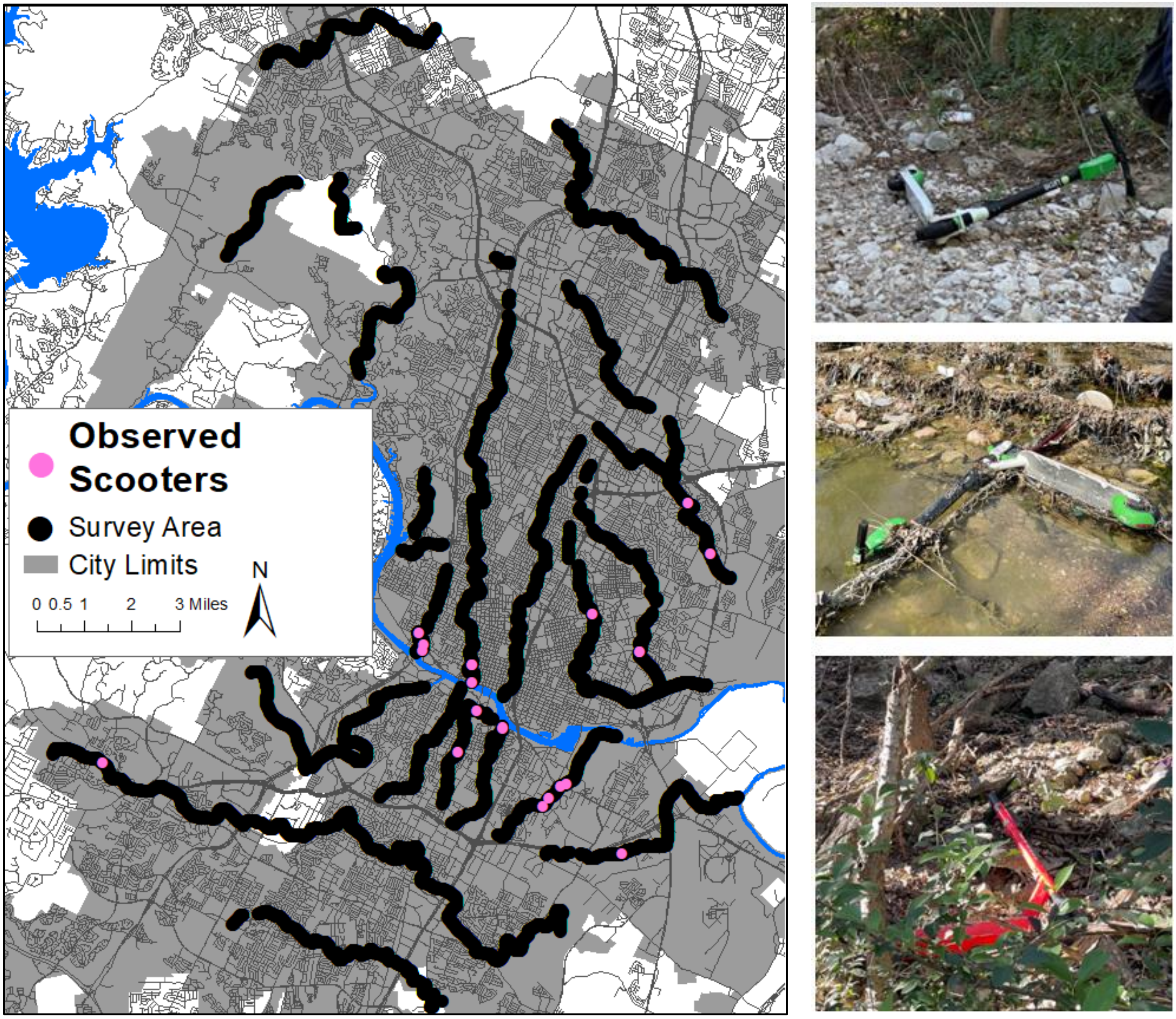



**Figure 13. Observations of micromobility devices ("scooters") abandoned/dumped in the survey area**

## Active/Observed Encampment

Presence of "encampment" was recorded for any site with an active camp site with peripheral trash if they constituted a living space such as sleeping areas, food preparation, storage of possessions, etc. Loitering was not considered "encampment." 352 active encampments were observed in 17 of the 20 watersheds (Figure 14). Bull Creek, Taylor Slough North and Taylor Slough South were the only creeks in which encampments were not observed. Size ranged from single campsites to comingled aggregates of tents/temporary structures. Most encampments were concentrated in urban watersheds, but some extended to the farthest reaches of the survey area indicating that there are no boundaries to the activity. Some encampments were associated with large amounts of floatables, containers, fabrics, possessions, etc. resulting in "Dense" or "Abundant" scores, however, other encampments were virtually clear of trash resulting in "Minimal" or "Apparent" scores. Similarly, survey staff observed people in the encampments actively littering, but also observed people cleaning up trash as well which is indicative of the wide diversity of people experiencing homelessness. Some encampments had been supplied with trash receptacles, and others were in locations inaccessible to these services.

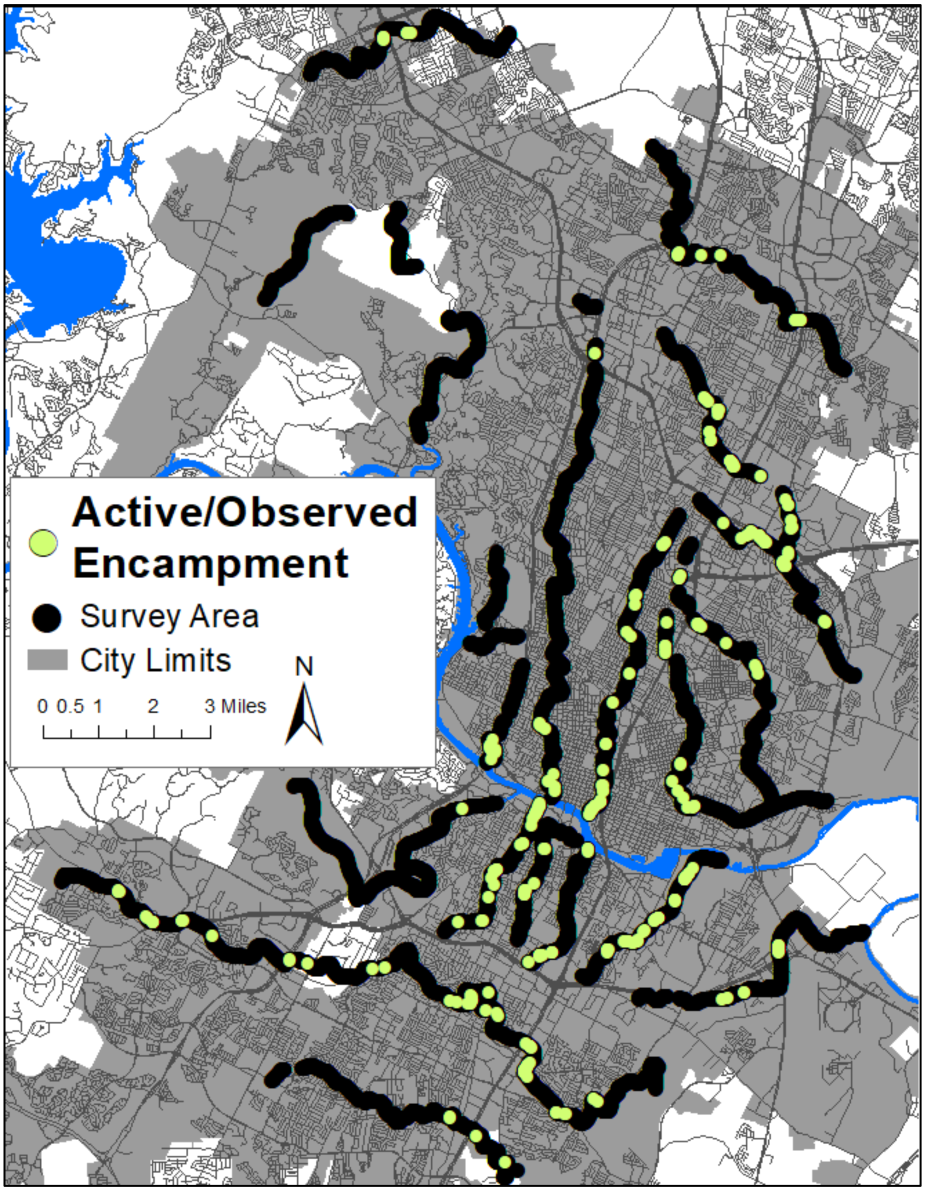



**Figure 14. Observations of encampments with clear and present trash inputs in the survey area**

## Overflowing Dumpsters

Only 20 overflowing dumpsters near creeks were observed (Figure 15). They were often associated with high concentrations of trash but present a seemingly easily preventable problem compared to other sources because they indicate either an undersized capacity or deficient frequency of emptying rather than human disregard for misplaced trash. Overflowing dumpsters that do not have barriers surrounding them are even more likely to contribute to trash in creeks.

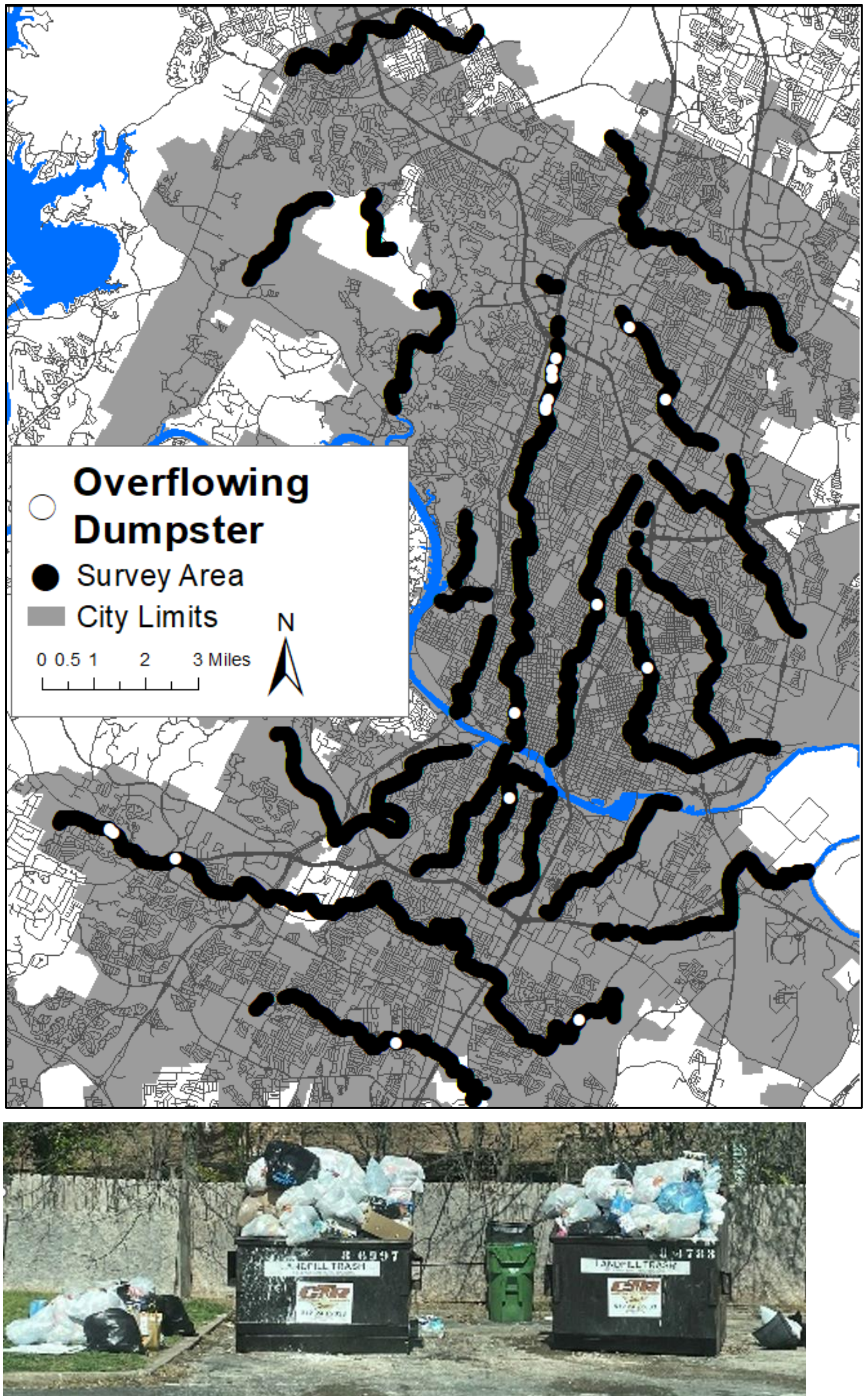


**Figure 15. Observations of overflowing dumpsters in the survey area**

## Outfall or Tributary

Storm drains and tributaries effectively do the same thing: they collect/concentrate stormwater that has washed over the landscape and deliver contents to the creek mainstem. Although all outfalls and tributaries can be sources of trash, there were 126 observations (Figure 16) in which accumulations of trash were notable. Significant amounts of trash emanating from outfalls/tributaries reveal information about the catchment area, such as a lack of stormwater controls, an anomalously large source and/or an opportunity to isolate and address a trash problem.

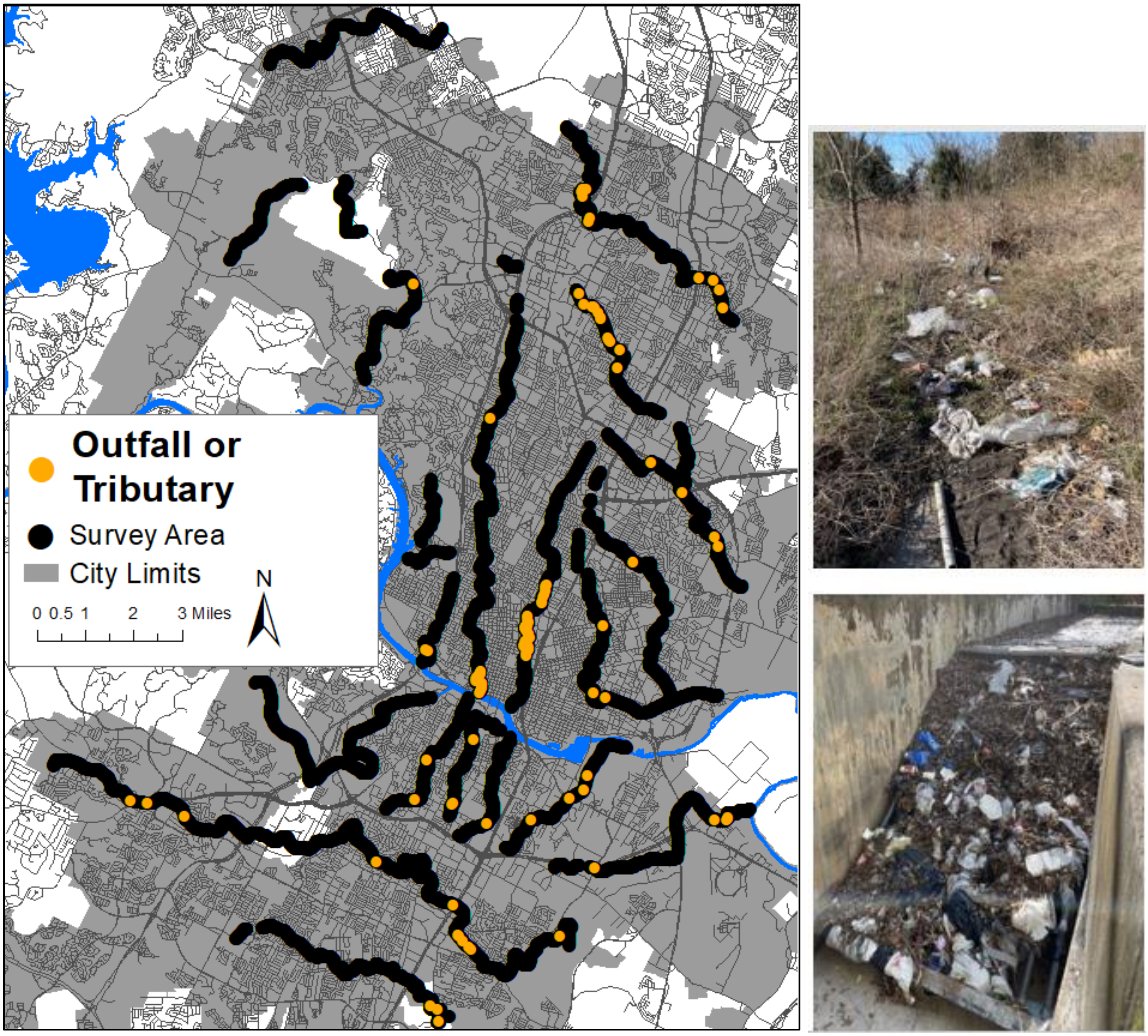



**Figure 16. Observations of outfalls/tributaries with notable trash inputs in the survey area**

## Recent Dumping - Unknown Source

There were 106 observations (Figure 17) of recent illicit disposal for which the responsible party is not apparent. This meets the State definition of "Illegal Dumping" reserved for items that have been knowingly transported from a non-adjacent location. Illegal dumping violations can carry misdemeanor or felony charges (Texas Health and Safety Code and/or the Texas Water Code), however, identifying and convicting a perpetrator is extremely difficult. The ease at which an offender can quickly dump bags of trash or large items over a bridge or slope facilitates this activity. Although it is sometimes possible to sift through the trash for clues to identify the perpetrator, the task is daunting. Sites with illegal dumping may encourage additional dumping, so expeditious removal is important. This type of dumping was absent in 6 watersheds (Figure 17) but was common in others.

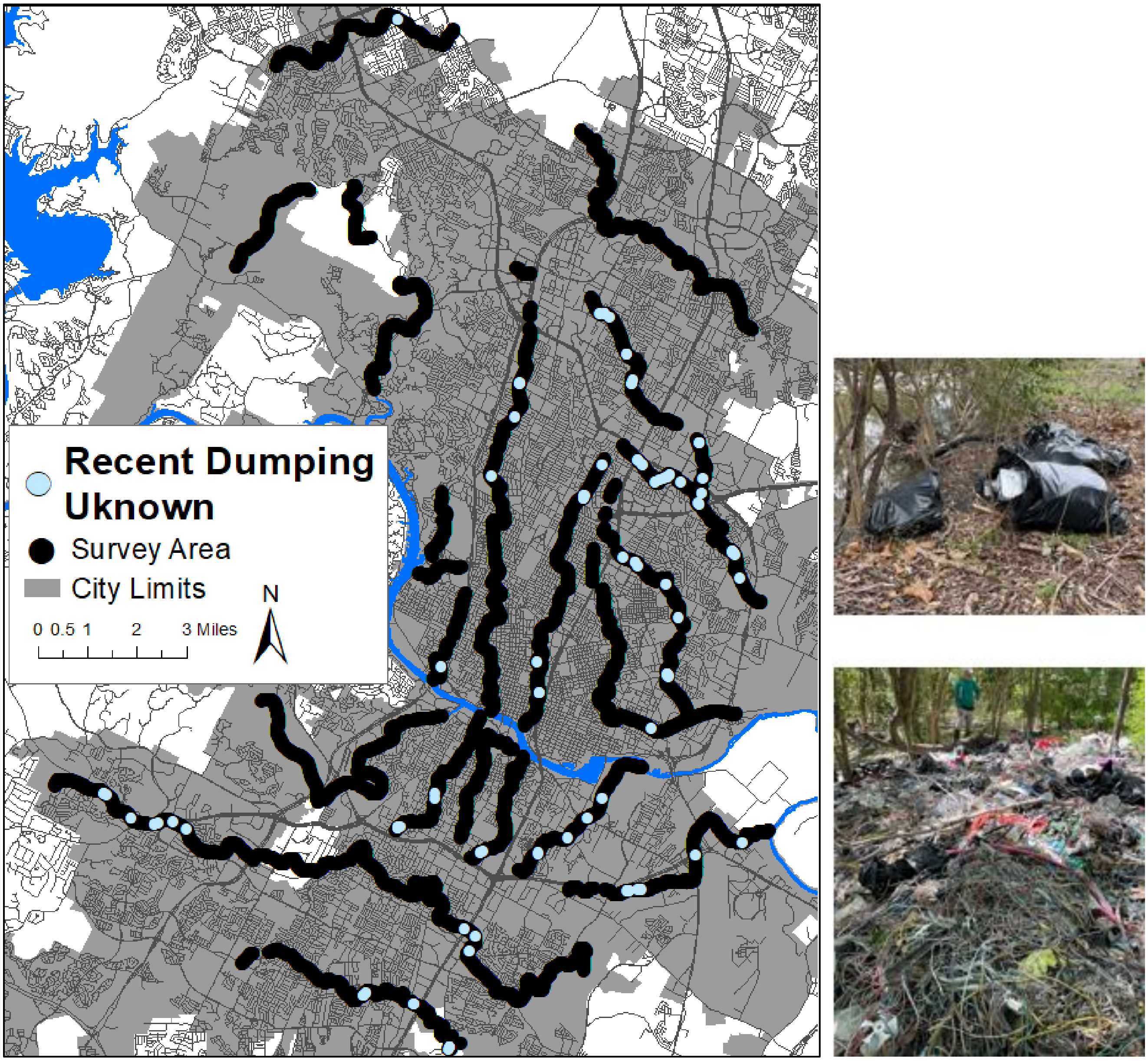


**Figure 17. Observations of recent dumping with unknown sources**

## Recent Dumping – Known or Point Source

Observations of dumping (Figure 18) in which the source of the trash is obvious was as common (109) as unknown sources (106). Recent point sources were intentional disposal of trash by an identifiable residence, commercial entity, or other responsible party. They frequently included construction materials, landscaping/gardening, household waste, fencing, home renovation materials, and industrial refuse. Enforcement action should be feasible. Most locations were in low visibility areas (fence abutting creek). Violations can carry misdemeanor or felony charges (Texas Health and Safety Code or the Texas Water Code) which should be a deterrent, but the threat of potential referral for enforcement may be more effectively used as an incentive for the landowner to clean up the trash even if the responsible party denies culpability.

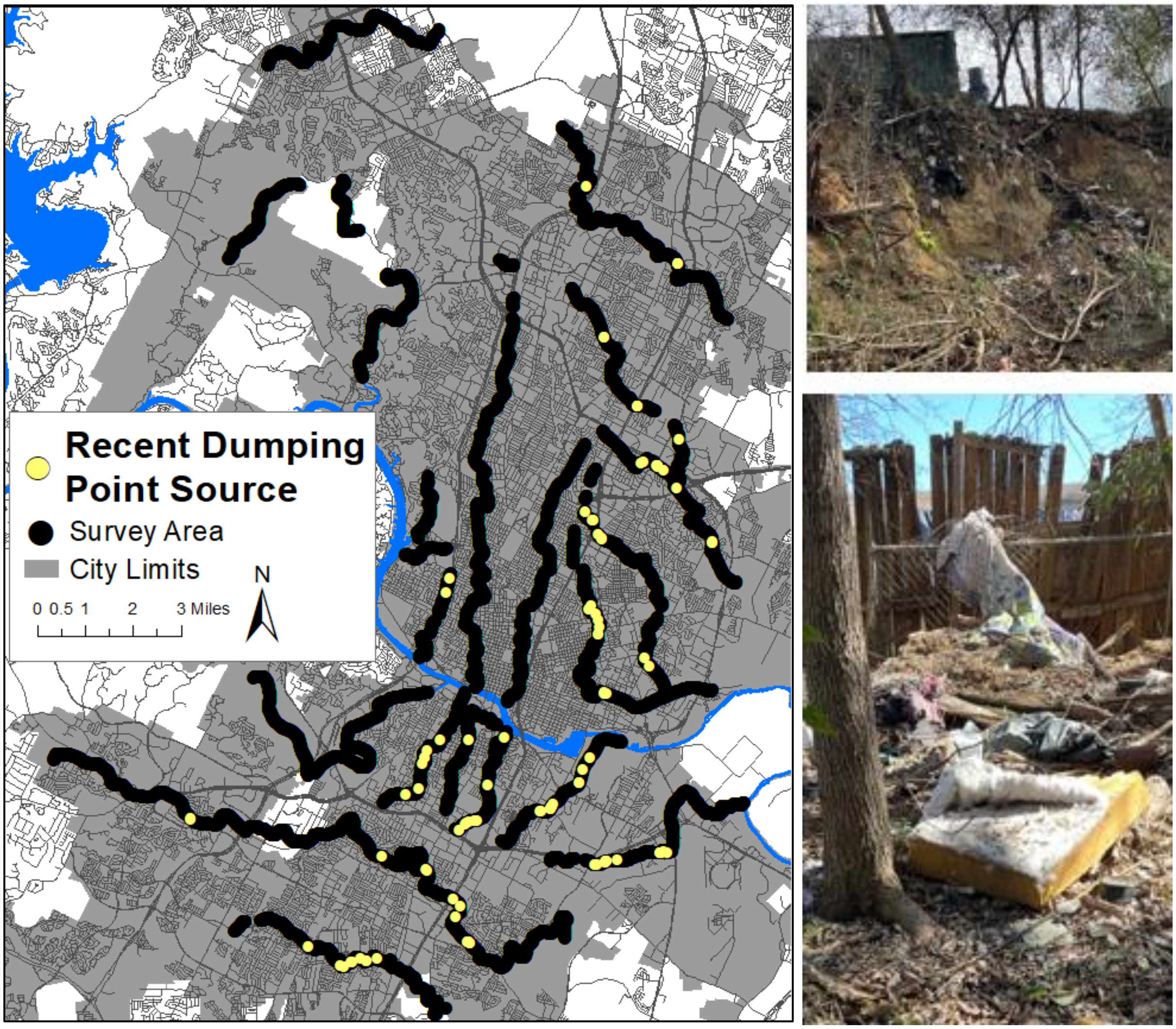



**Figure 18. Observations of recent dumping with identifiable sources**

## Property Management

"Property management" sources are similar to "Recent Dumping- Point Source" but refers specifically to activities that property managers or their contractors do or don't do with respect to trash on their property. Examples include neglected or intentional disposal of items like mattresses, carpet, building materials, maintenance materials, and the inappropriate use of leaf blowers. Improperly disposed of items from apartments and commercial lots were observed 70 times and occurred in half of the creeks of the survey area (Figure 19). Although large items such as furniture, office items and building materials dumped over fences into creeks or on the banks may have been deposited by tenants, it is still the responsibility of the property owner to address. Similarly, the actions of landscaping and maintenance workers that routinely sweep or blow leaves/grass/trash from parking areas into storm-drains and riparian areas are responsible to property owners. Individually, the littering tenant or worker could be responsible for the action and enforced upon (if caught in the act), but ultimately the property owner should monitor/address these issues and implement corrective actions to prohibit or limit the improperly disposed of trash. Physical barriers such as a chain link fence between parking areas and riparian corridors were observed to intercept and retain trash while properties with no physical barriers were observed to have years of blown leaf litter mixed with trash onto the banks of creeks.

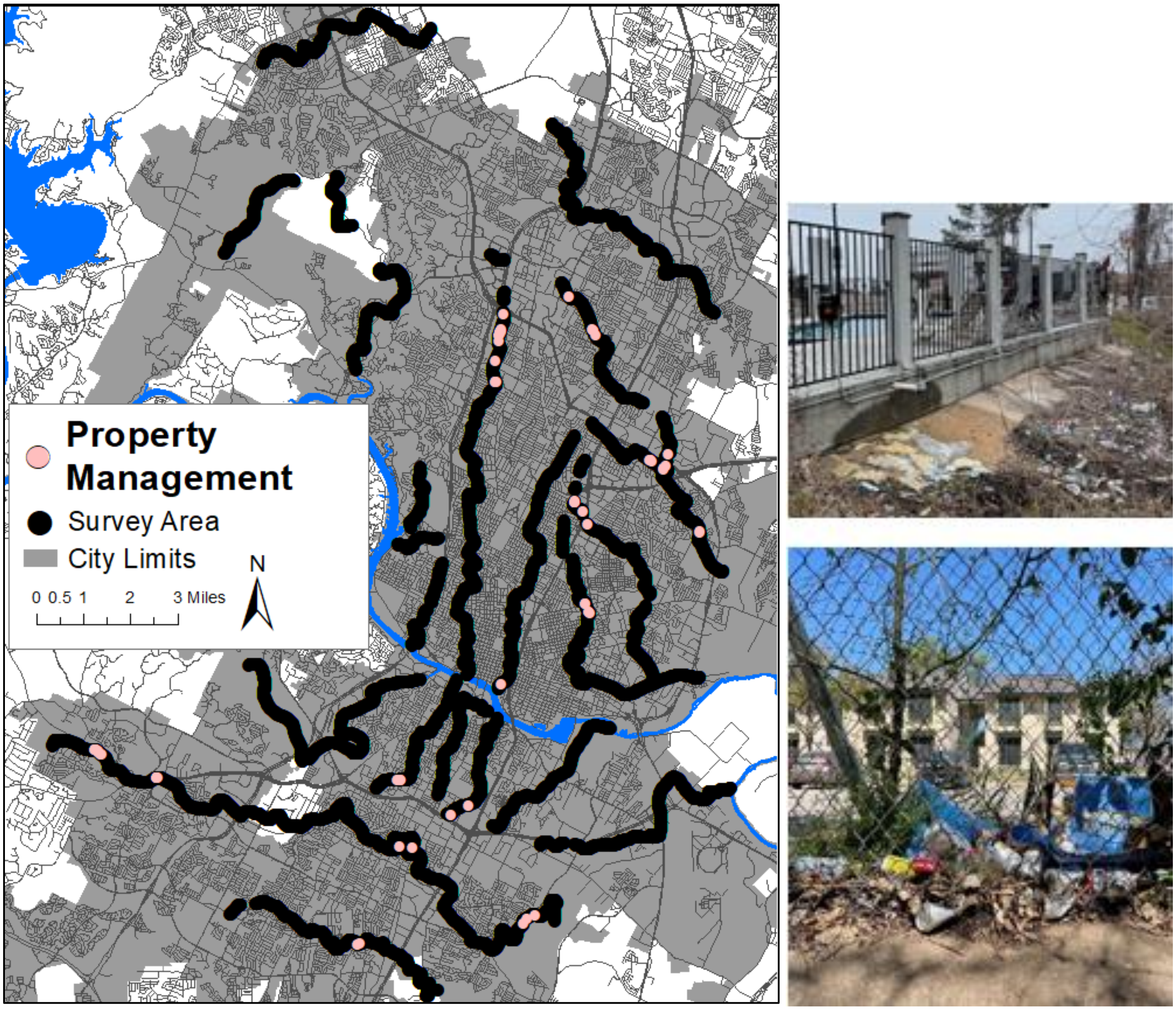


**Figure 19. Observations of property management that resulted in obvious trash inputs**

## <u>Historic Dumping</u>

These location sources were generally items dumped in piles or partially buried in the past, but have more recently been exposed due to erosion or storm events. Age is evident from material degradation, weathering, lichens, moss, etc. Dumping may be small or substantial but does not appear to be currently taking place. Observations of trash that had been improperly disposed of decades ago (either by burial or dumping on slopes/floodplains) were relatively few (Figure 20) compared to other sources. 59 instances of varying degree were either identified by antiquated items degraded by time or revealed by erosion exposing a cross section of buried garbage. Historic dump sites near creeks did not appear to be a significant source of trash relative to the other identified sources but can present a persistent and chronic contribution of trash of all sizes in creeks. In contrast to the current dominant types of trash in creeks (plastics and fabrics), historic dumping is primarily composed of metal and hard building materials (brick/tile/cinderblocks) that have degraded slowly.

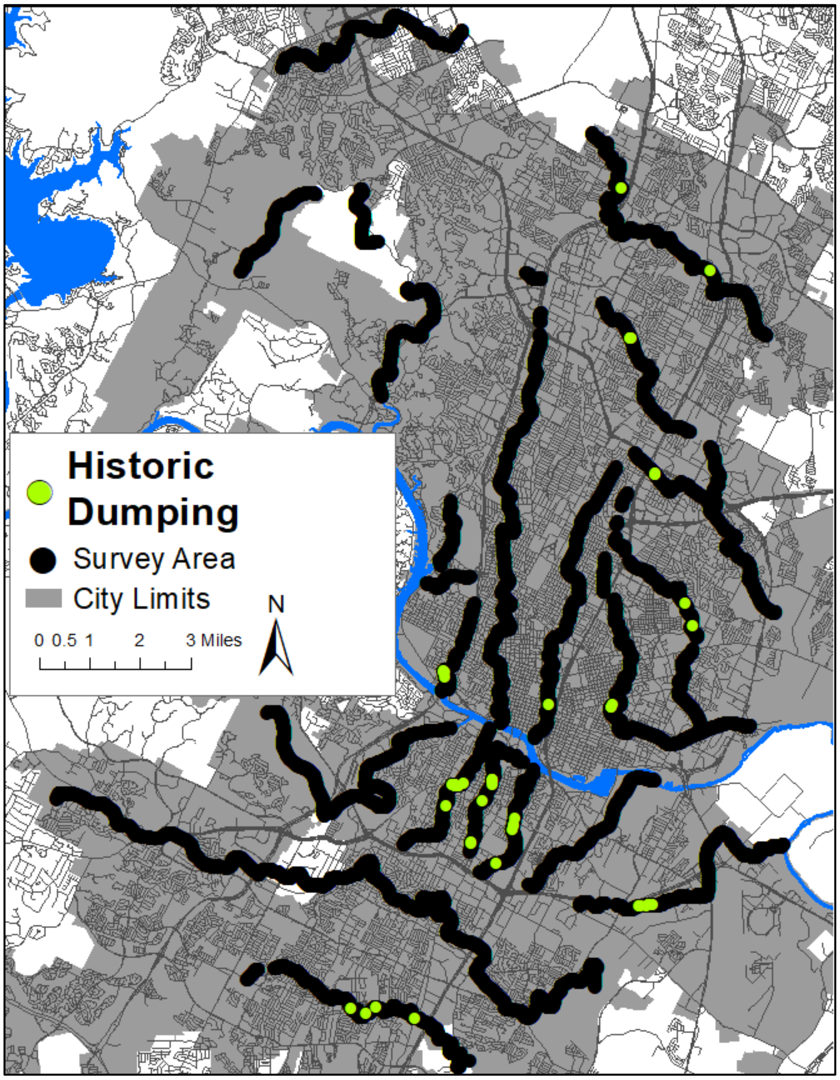



**Figure 20. Observations of historic dumping locations.**

Districts 1, 2 and 4 all shared the highest median score of 9 (out of 20) and higher total volumes of trash, while sources of trash per mile of creek indicated that these high values are due to a combination of different sources, including different dumping types and encampments (Table 2).

**Table 2. Number of surveyed creek miles, median scores, gallons of trash, and average number per mile of trash sources in the ten Council Districts.**

| | | | Average Numbers per unit mile | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| District | survey miles | median score | gallons of trash | dumping historic | dumping recent - point source | dumping recent - unknown | overflowing dumpster | encampment | property management | outfall/ tributary |
| **1** | 10.3 | 9 | 4237 | 0.4 | 1.5 | 2.0 | 0.0 | 2.8 | 1.3 | 0.9 |
| **2** | 12.4 | 9 | 3633 | 1.1 | 2.6 | 1.2 | 0.2 | 3.3 | 0.4 | 1.0 |
| **3** | 15.7 | 7 | 3858 | 0.7 | 2.1 | 0.8 | 0.0 | 6.4 | 0.5 | 0.7 |
| **4** | 8.6 | 9 | 4845 | 0.7 | 1.5 | 3.5 | 0.2 | 6.3 | 1.4 | 1.7 |
| **5** | 7.2 | 2 | 945 | 0.0 | 0.1 | 0.7 | 0.0 | 0.7 | 0.0 | 0.1 |
| **6** | 5.3 | 1 | 947 | 0.0 | 0.0 | 0.0 | 0.0 | 1.7 | 0.0 | 0.0 |
| **7** | 11.5 | 5 | 1139 | 0.2 | 0.3 | 0.4 | 0.7 | 1.0 | 1.3 | 0.6 |
| **8** | 9.8 | 1 | 1518 | 0.0 | 0.2 | 0.8 | 0.4 | 1.6 | 1.4 | 0.3 |
| **9** | 14.2 | 6 | 2584 | 1.3 | 0.5 | 0.3 | 0.3 | 5.2 | 0.2 | 4.4 |
| **10** | 11.7 | 1 | 611 | 0.3 | 0.2 | 0.1 | 0.0 | 0.9 | 0.0 | 0.3 |

Multiplying the estimate of trash volume and clean-up time (provided in the scoring rubric, Figure 6) by each of the 19,467 scores yields an estimate for the total volume and clean-up time for the entire survey area. Assuming the non-surveyed creeks (117 miles of mainstem creeks) within the City of Austin full purpose jurisdiction (city limits) are generally similar to the surveyd creeks, then the total volume and clean-up time can be estimated for the city limits the and extra territorial jurisdiction (Table 3). These estimates would need to be scaled up further if all creeks with CWQZ are desired. There are approximately 628 miles of CWQZ creek in the city limits and an additional 650 miles in the ETJ.

**Table 3. Estimated volume of trash and time to pick-up* trash by each trash score extrapolated to total miles of mainstem creeks** in the City Limits and the Extra Territorial Jurisdiction.**

| | | | Volume (gallons) | | | Time (hours) | | |
|---|---|---|---|---|---|---|---|---|
| | Trash intensity score | Total number of observations | volume of trash in survey area (110mi) | volume of trash in mainstems of city limits (227mi) | volume of trash in mainstems of ETJ (161mi) | Time to pick up trash in the area (110mi) | Time to pick up trash in mainstems of city limits (227mi) | Time to pick up trash in mainstems of ETJ (161mi) |
| Minimal | 0 | 782 | 0 | 0 | 0 | 0 | 0 | 0 |
| Minimal | 1 | 4260 | 1065 | 2198 | 1559 | 71 | 147 | 104 |
| Minimal | 2 | 2007 | 1004 | 2071 | 1469 | 67 | 138 | 98 |
| Minimal | 3 | 1225 | 919 | 1896 | 1345 | 61 | 126 | 90 |
| Minimal | 4 | 1044 | 1044 | 2154 | 1528 | 70 | 144 | 102 |
| Minimal | 5 | 885 | 996 | 2055 | 1457 | 74 | 152 | 108 |
| Apparent | 6 | 1011 | 1106 | 2283 | 1619 | 118 | 243 | 173 |
| Apparent | 7 | 1020 | 2528 | 5216 | 3699 | 153 | 316 | 224 |
| Apparent | 8 | 646 | 3825 | 7893 | 5598 | 118 | 244 | 173 |
| Apparent | 9 | 745 | 3230 | 6666 | 4728 | 161 | 333 | 236 |
| Apparent | 10 | 892 | 4191 | 8648 | 6134 | 223 | 460 | 326 |
| Abundant | 11 | 901 | 4656 | 9609 | 6815 | 451 | 930 | 659 |
| Abundant | 12 | 773 | 11150 | 23010 | 16320 | 387 | 798 | 566 |
| Abundant | 13 | 460 | 16894 | 34863 | 24726 | 230 | 475 | 337 |
| Abundant | 14 | 453 | 19325 | 39880 | 28285 | 227 | 467 | 332 |
| Abundant | 15 | 408 | 14260 | 29427 | 20871 | 204 | 421 | 299 |
| Dense | 16 | 354 | 27379 | 56500 | 40073 | 207 | 426 | 302 |
| Dense | 17 | 243 | 36795 | 75932 | 53855 | 182 | 376 | 267 |
| Dense | 18 | 371 | 49555 | 102264 | 72531 | 371 | 766 | 543 |
| Dense | 19 | 458 | 85030 | 175471 | 124453 | 687 | 1418 | 1006 |
| Dense | 20 | 529 | 101200 | 208840 | 148120 | 1058 | 2183 | 1549 |
| | total | 19467 | 386150 | 796873 | 565183 | 5119 | 10563 | 7492 |

* time estimates only include the approximate time to collect trash one time and do not count time for mobilization, access, delivery to landfill/recycle, sorting, etc. Or repe

**mainstem creeks do not include the thousands of miles of tributaries.

## *Statistical Analysis of Trash Sources*

Box-and-whisker graphs are often used to show summary statistics for large datasets in a distilled and easily comparable way. In the graphs below, the median of the dataset is expressed as a thick horizontal line within a "box" that represents the boundaries of the 25th and 75th percentile for the data (i.e., the "middle half" of the data). The lines extending vertically from the box are an expression of the "range" of the data, but it does not show the full extent, rather it extends 1.5 times the difference between the 25th and 75th percentile and the median. Median was used (rather than mean) because the data was not normally distributed (i.e., the scale for scoring was not linear).

The source type "Dumping Unknown" had both the highest median and highest 25/75 percentile range (Figure 21). The median value for "Encampment" was the second highest, however there was a much wider range of values, which matched the anecdotal observation that there was a wide variety of ancillary trash at encampments, and also the variability of "size" of encampments (e.g., number of residents, intensity of use, etc.). "Outfall/tributary" had the lowest median and range and was the only source for which the bulk of the scores were low. This data summary implies that "Dumping Unknown" is a focal point characterized by the highest intensity of trash compared to the other sources. The other forms of dumping (historic and point source), overflowing dumpster, encampment and property management were all comparable in median scores and 25th/75th range.

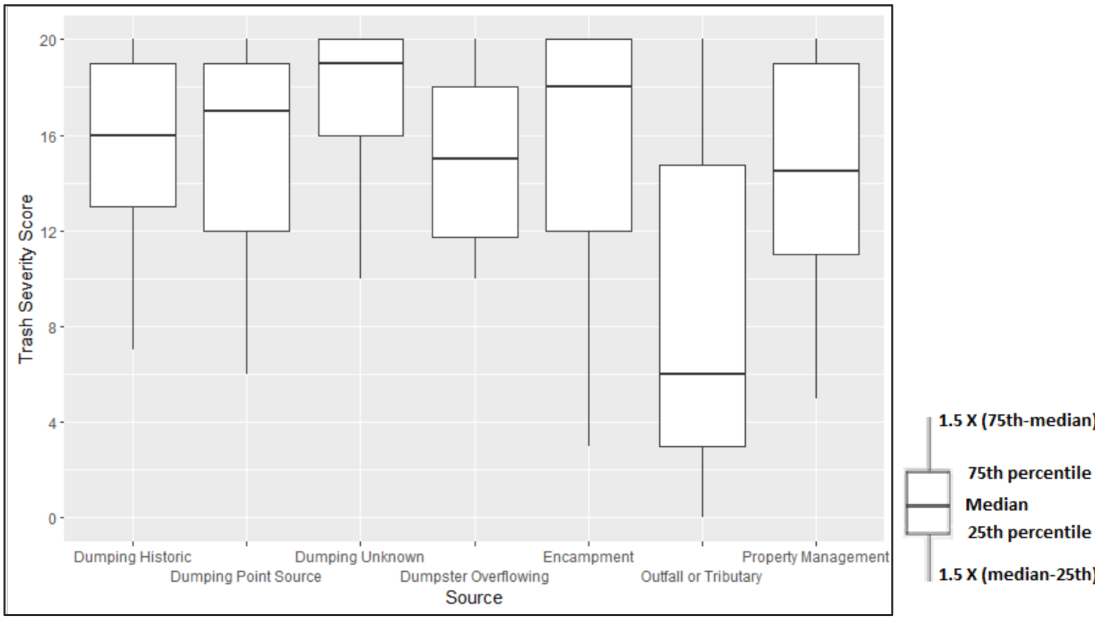



**Figure 21. Trash score medians and 25th/75th percentile by source type. With the exception of "Outfall/Tributary" sources had similar medians with the majority of data points in the Abundant (11-15) and Dense (16-20) score categories.**

Regression analysis can estimate the relationship between a dependent variable (trash intensity) and various independent variables. For example, a hypothesis that a land use is correlated with trash intensity could be assessed by the slope, variance ($R^2$) and "fit" (p-value) of land use vs. trash score plots. A threshold of significance is typically considered to be $p<0.05$. Regression analysis of different land characteristics (land use, population, roads, impervious cover, etc) at different spatial scales (300' and 3000' reaches) yielded no significant relationships (Figure 22 and Table 4).

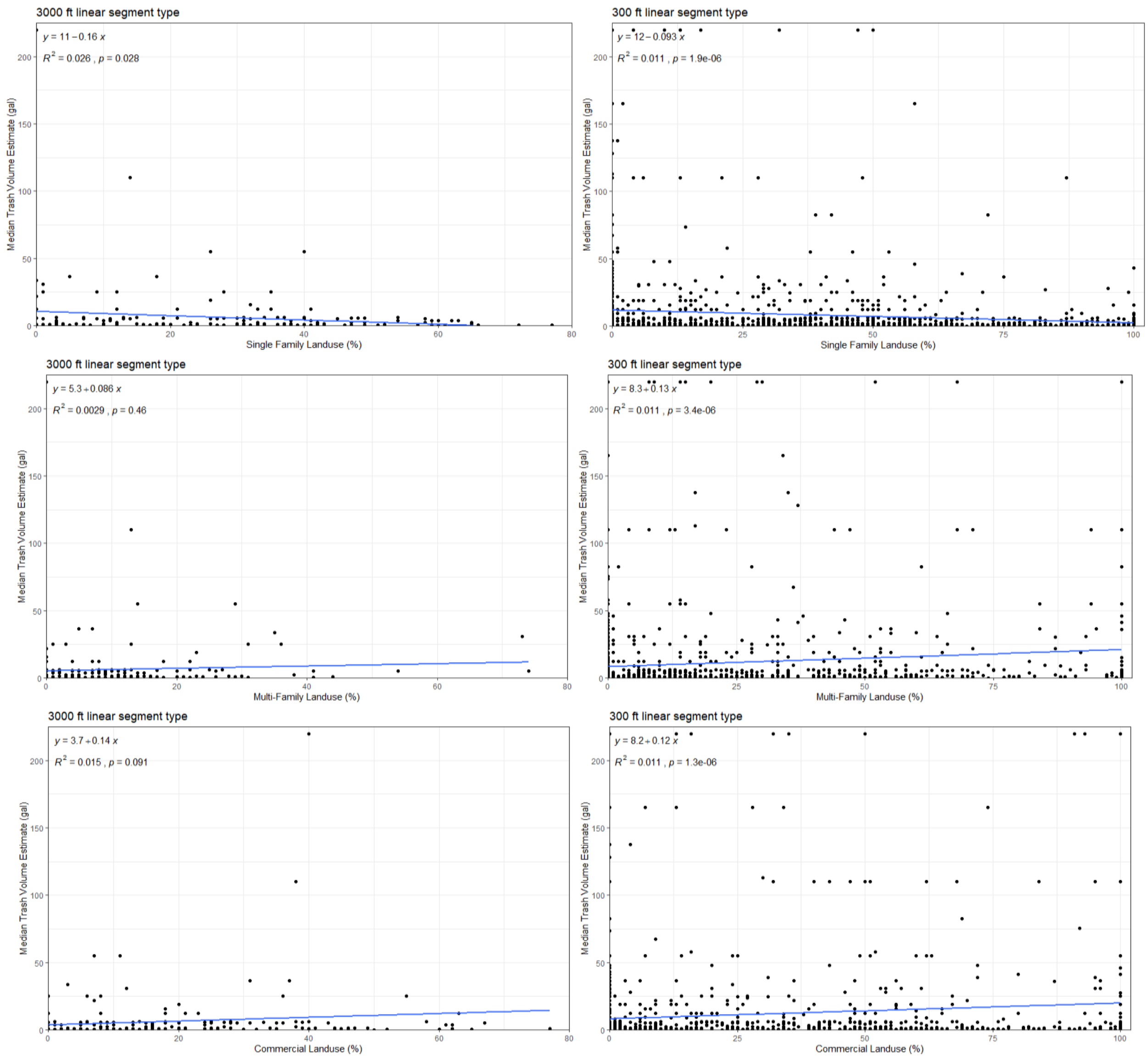



**Figure 22. Examples of regression analysis of 3,000 ft and 300 ft reach lengths for the land use categories of Single Family, Multifamily and Commercial against the total estimated volume of trash (converted from trash score using the scoring rubric, Fig 6)**

Of the seven land characteristics evaluated (Table 4), even the strongest relationships (% Single Family, % Multifamily, and % Commercial) were not good predictors of trash scores explaining less than 3% of the variability in the data ($R^2<0.03$). Some had significant relationships because of the large number of data points ($p<0.05$), but none of these independent land use variables had meaningful relationships with trash volumes

**Table 4. $R^2$ and p-values for regression analysis of surrounding land characteristics vs. trash intensity**

| Independent Variable | 3,000 ft reach length | | 300 ft reach length | |
|---|---|---|---|---|
| | $R^2$ | p-value | $R^2$ | p-value |
| **Single Family Landuse** | 0.026 | 0.03 | 0.011 | 0.0000015 |
| **Multifamily Landuse** | 0.029 | 0.46 | 0.011 | 0.0000034 |
| **Commercial Landuse** | 0.015 | 0.09 | 0.011 | 0.0000013 |
| **Parks Landuse** | 0.007 | 0.25 | 0.002 | 0.029 |
| **Undeveloped Landuse** | 0.008 | 0.23 | 0.004 | 0.0031 |
| **Impervious Cover** | 0.006 | 0.29 | 0.003 | 0.022 |
| **2020 Population** | 0.012 | 0.13 | 0.008 | 0.000061 |
| **Road area (%)** | 0.0003 | 0.94 | 0.002 | 0.065 |

*Trash Characterization by Watershed*

The watershed with the highest median trash score (14) was Buttermilk Creek which includes high (but not the highest) concentration of encampments per mile in addition to high concentration of dumping and property management issues (Table 5). For a detailed presentation of watershed-specific maps and narratives that provide greater context for the variety of trash related issues in Austin's creeks see Appendix.

**Table 5. Trash score summaries, by watershed, from highest (worst) median score to lowest.**

| Watershed | survey miles | median score | Average amounts per unit mile | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | gallons of trash | dumping historic | dumping recent point source | dumping recent unknown | overflowing dumpster | encamp ment | property manage ment | outfall/ tributary |
| Buttermilk | 2.1 | 14 | 10284 | 1.5 | 3.4 | 5.4 | 0.0 | 9.3 | 2.9 | 0.5 |
| Country Club W | 3.7 | 10 | 6170 | 0.0 | 3.5 | 1.3 | 0.0 | 11.3 | 0.0 | 1.1 |
| Little Walnut | 7.9 | 10 | 5710 | 0.4 | 1.3 | 2.8 | 0.3 | 5.7 | 1.1 | 2.0 |
| West Bouldin | 3.5 | 10 | 5788 | 3.7 | 2.0 | 2.0 | 0.0 | 9.7 | 1.1 | 0.6 |
| East Bouldin | 2.9 | 9 | 2554 | 3.1 | 0.3 | 0.0 | 0.3 | 3.4 | 0.0 | 1.0 |
| Tannehill | 5.2 | 8 | 3055 | 0.4 | 1.5 | 2.1 | 0.0 | 2.7 | 1.3 | 0.2 |
| Williamson | 16.9 | 8 | 3360 | 0.0 | 0.8 | 0.7 | 0.3 | 4.1 | 1.1 | 0.7 |
| Boggy (east) | 6.9 | 7 | 2324 | 0.4 | 1.6 | 0.1 | 0.1 | 2.0 | 0.7 | 0.4 |
| Johnson | 1.9 | 7 | 1573 | 2.1 | 1.0 | 0.5 | 0.0 | 5.2 | 0.0 | 1.0 |
| Shoal | 9.8 | 6 | 1538 | 0.0 | 0.0 | 1.0 | 1.6 | 0.2 | 3.0 | 0.2 |
| Blunn | 3.1 | 5 | 3275 | 1.6 | 2.6 | 0.7 | 0.0 | 4.2 | 0.7 | 0.3 |
| Carson | 5.5 | 5 | 2416 | 1.8 | 2.7 | 1.6 | 0.0 | 3.3 | 0.0 | 0.9 |
| South Boggy | 5.7 | 5 | 1899 | 0.7 | 1.6 | 1.6 | 0.2 | 0.7 | 0.3 | 0.5 |
| Waller | 6.1 | 4 | 1556 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Walnut | 7.6 | 3 | 520 | 0.3 | 0.5 | 0.0 | 0.0 | 1.4 | 0.0 | 1.3 |
| Lake | 5.0 | 2 | 1146 | 0.0 | 0.0 | 0.2 | 0.0 | 1.8 | 0.0 | 0.0 |
| Barton | 7.1 | 1 | 96 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bull | 7.6 | 1 | 62 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Taylor Slough N | 1.4 | 1 | 94 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Taylor Slough S | 1.8 | 1 | 62 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Trash scores for the 2022 survey area can be viewed through an interactive online map (**https://arcg.is/0z48bj0**). This map shows trash intensity with a color ramp from light yellow to dark red in the context of Council Districts and other informative options (Figure 23). The map can be used to identify areas that are the highest priority for staff, contractors or volunteer groups. Storms and future cleanups may change the trash scores over time, however, because trash location appears to be largely driven by stream roughness or a highly localized source (like overflowing dumpster or point source) it is likely that "hot spots" will remain locations of high trash intensity. This means that the map may be relevant for years to come.

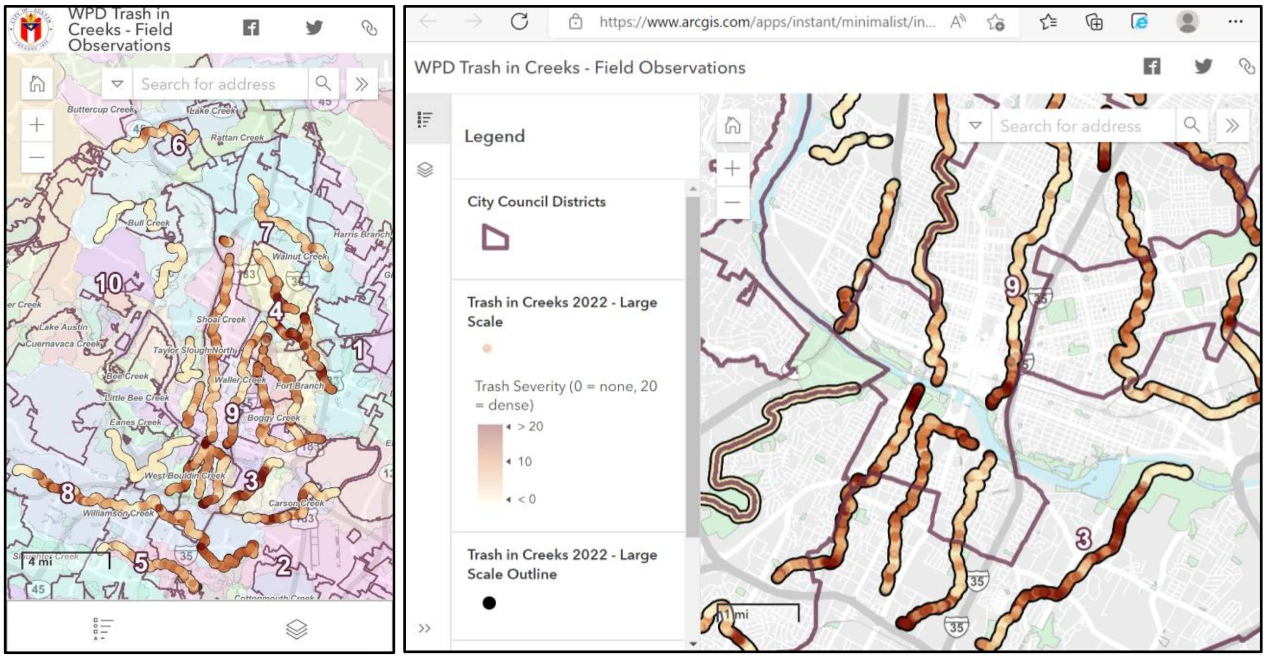



**Figure 23. AGOL online website showing results of the field survey in the context of watersheds and council districts. Access the interactive map here: https://arcg.is/0z48bj0**

## Discussion

Trash in creeks in Austin is a deceptively complex issue. The vision is ugly, the sources are many, the pathways are obscured, and the solutions appear either fleeting or overwhelming. Certainly, increased quantity and number of sources leads to increased trash in creeks, but the dominant factor determining the specific location of trash in a creek is likely stream roughness. Although this factor obscures detection of source and renders it virtually impossible to assign relative contributions to various sources, it does provide a path forward: control the outputs of various sources to the extent practical and implement physical intervention at strategic locations of trash accumulation.

More area does not necessarily mean more trash. Regression analysis indicates that drainage area does not have a strong correlation with trash intensity. The rate at which trash is conveyed downstream varies greatly. Mobility is dependent on 1) the item (buoyancy, shape, size, weight, etc.), 2) the water (velocity, depth, frequency of storms) and 3) the roughness of the stream and riparian corridor. Floatables like beverage bottles may quickly transport down the stream, however, large, irregularly shaped and/or flexible items (fabrics/foam rubber/erosion matting/etc.), can easily become entrained in stream roughness like vegetation. Woody vegetation in the stream and riparian corridor provides stability and integrity to the stream system, but with this advantage comes entrainment of trash. The survey indicates that 76% of all the trash in creeks is located at only 10% of the area, with most intense accumulations occurring at locations which physically strain the trash from storm flow downstream of either high, acute inputs or low, chronic inputs.

By far, the most abundant type of trash encountered in all creeks was single-use plastic beverage and food containers (Figure 24). Even though these items are conveyed quickly through the system by storms, they persist in all parts of all streams as the most common item.

**Figure 24. Single-use plastics are (by far) the most numerous trash type in all watersheds**

Although single use plastics were the most common item, there were several types of trash that warrant mention as they illustrate that the source of the problem is at the community level. No one single source is to blame for the current problem, rather it is a result of homeowners, business owners, customers, children, recreation, accidents, poor property management, people experiencing homelessness, flash flooding, utility work, and a myriad of other daily life activities. Often noted in trash cleanup reports, cigarette butts and "vape" devices were uncommon (~1 every 5 miles) as were observations of hypodermic needles (~1 every

10 miles). These items may be more common to upland areas. Shopping carts were common. Over 500 shopping carts (~5 every mile) in creeks and riparian areas. Although many were clustered in riparian areas near encampments, most were in streambeds, and many were partially buried in the bed. Shopping carts in creeks highlight a financial loss to retail businesses and present a significant amount of trash mass and difficulty in removal. Camping equipment (tents, sleeping bags, pillows, etc.) were common near areas of encampments. However, items used primarily by homeowners (hoses, lawn equipment, appliances, etc) were common across the entire survey area, demonstrating that the problem of trash in creeks is a communal issue. The following photographs and anecdotal observations by field staff help characterize the scope and scale of trash in creeks in Austin (Figures 25-30).

**Figure 25. Transportation construction accoutrements (cones, barriers, signs, etc) were frequently encountered. It is unclear if the pathway for these items were due to roadway flooding, vandalism, dumping, etc. but they represent a municipal loss and expense**

**Figure 26. Toys, specifically foam rubber "nerf" projectiles, balls, and stuffed animals**

**Figure 27. Telecommunication cables were a common, preventable, and significant issue in some stream reaches. Thousands of feet of internet cables were observed in discarded in creeks, some still partially attached, likely disconnected on one end by service contractor during a change in service.**

**Figure 28. Fabrics (primarily clothing and bedding, etc) and foam rubber padding were common and tend to become wrapped around vegetation persisting for as long as the fibers take to completely degrade which may take a very long time such as the carpet in the righthand photo.**

**Figure 29. Erosion and stabilization controls (e.g. silt fence, mulch socks, netting/matting, etc) are vulnerable to becoming trash in creeks when improperly secured or neglected. All were observed as significant large items in creeks.**

**Figure 30. Trash detained by the rack (left) of the stormwater bypass on Johnson Creek indicating how much trash is contributed from the roadway system (headwaters of Johnson) and delivered to the lower part of the creek (right). These two areas (inlet and outlet) present an opportunity for strategic interception/removal of trash.**

## Conclusions

The 110-mile field survey of 20 creeks that collected 19,467 data points resulted in the following conclusions regarding the character, source, and pathways of trash in Austin's creeks:

- Stream position and drainage area do not correlate with trash intensity. This identifies the difficulty in quantifying impacts from source type by invalidating upstream/downstream comparisons and implies that transport of trash through a stream is more strongly controlled by factors such as stream roughness. Areas with high roughness (dense woody vegetation) are natural trash detention "strainers" that keep much trash from entering our lake/river and are opportunities for focal areas of trash removal.
- Of the seven sources identified in this study, trash intensity was highest at locations of illegal dumping. Outfalls/Tributaries was the lowest intensity, and all other sources (overflowing dumpsters, property management, encampments, historic dumping and point source dumping) have similar trash intensity and range of scores.
- Single-use plastic/polystyrene beverage and food containers were the most encountered item.
- Although encampments were the most common of the seven source of trash in waterways, based on the spatial analysis, high trash intensity is also common in areas without an encampment source, indicating that the source of trash in our waterways is a complex, community-generated dynamic.
- Regression analysis indicates that there were no statistically significant correlations between trash intensity and census population, roadways, impervious cover, and land use categories (single family, multifamily, commercial, parks, undeveloped), supporting the hypothesis that location of trash is primarily driven by a physical factor such as stream roughness.
- 76% of the trash is found at 10% of the sites. The map created from the survey can be used to focus/prioritize creek cleanup efforts to extract the most amount of trash in the smallest areas.
- Micromobility devices (e.g. "scooters") in creeks does not appear to be a signification problem in 2022, only 21 scooters were discovered (avg 1 scooter every 5 miles) and there is an active 311 process to have them removed by the vendor.

## Recommendations

(For a comprehensive review of trash program, projects and practices from around the world please see the companion to this study, Trash in Creeks: Benchmarking Solution Space and Resources, Gosselink et al. 2022. In addition, City of Austin staff prepared a Program Inventory of trash related efforts in June of 2020 and can be found here: https://www.austintexas.gov/edims/document.cfm?id=348493)

*Recommendations for future trash surveys*

- Future surveys for trash in creeks should perform fieldwork during the winter leaf-off season, Nov-Apr, for large assessments. Small site assessments can be conducted at any time of year.
- Add the following object observation options to the field sheet: shopping cart, partial shopping cart, pallets, erosion/sedimentation controls, telecommunication lines, as well as a comment field for "top 3 materials".
- Verify/substantiate volume estimates by collecting trash in containers at select sites that represent low to high trash intensity.
- Add the remaining 107 miles of creek to a future assessment rotation where 10% of full rotation gets surveyed every 10 years, to allow for assessment of temporal and spatial trends.
- Conduct a repeat-visit survey at locations representing different parts of the city that looks at accumulations rates after an area has been completely cleared of trash by clean-up crews. This will help understand movement rates and volumes and types of trash that are mobilized vs static.
- Collaborate directly with all City Departments that work in the realm of litter and trash in survey purpose, methods, locations and data interpretation.

*Recommended Strategies to address trash in the creeks (Extraction)*

- Continue creek cleanups with staff, subcontractors and volunteer organizations.
- Target creek cleanups at the locations of highest intensity (Online map: **https://arcg.is/0z48bj0,** Figure 23), especially those of high stream roughness (woody vegetation) that serve as existing natural strainers.
- Target large diameter storm outlets with increased maintenance and potentially novel extraction solutions. For example, the Johnson Creek bypass channel outlet collects a lot of trash after every large storm event. This would be an effective method to collect trash where it is concentrated before it gets to our receiving water body and distributes widely.
- Follow up with enforcement action for each location identified as "Point Source Dumping"
- Increase incentives for Adopt-a-Creek and other programs that encourage citizens to collect trash throughout our stream network using the data and tools generated from this report.

*Recommend Strategies to keep trash from getting into the creeks (Interception and Enforcement)*

- Continue to support and increase waste services to encampments. Develop programs to incentivize proper disposal of trash and recyclables for people experiencing homelessness.
- Review and improve ordinances and enforcement to reduce incidence of overflowing dumpsters. Increase requirements for minimum dumpster size for commercial and multifamily and require secondary containment around the dumpsters (fences, walls, etc).
- All picnic tables (in parks and commercial/multifamily) near creeks should have a waste receptacle near them
- Strengthen City ordinances on telecommunication providers, assess fines for abandoned lines
- Review/study Street Sweeping efficiency/effectiveness in geographically targeted areas
- Improve and promote enforcement programs that report dumping, and other source of trash getting to creeks.
- Evaluate appropriate trash controls within drainage conveyance system. E.g. Trash racks or modification of stormwater controls at outlets to creeks and/or detention facilities.
- Strategies for retail businesses to retain shopping carts onsite are recommended. Some retail businesses in Pennsylvania use bollards to prohibit carts from entering the parking lot, keeping them close to the store. Other retail businesses use shopping carts with sensors that lock wheels at a designated distance from the store. These and other strategies to keep shopping carts on the premises should be considered for promotion and possible support by the City.

*Recommend Strategies to keep trash from reaching the landscape (Source Reduction)*

- Campaigns or strategies to reduce use of single use plastics and polystyrene including, but not limited to continued/increased education/outreach, regulations/bans, and political solutions.
- Expand and improve education and outreach efforts that target the complex path from communities and individuals to trash in creeks.
- Collaborate, strategize, and share data with other departments that are working on litter and trash issues in our watersheds, with the goal of a citywide, integrated trash management effort.

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# Appendix
# Watershed-specific trash scores and sources

**Barton Creek (Figure A)**
Similar to Bull Creek, the Barton watershed is characterized by large preserves, open space, greenbelts and accordingly has less trash. During the survey only one observation of an active encampment was observed near the creek and no other sources or attributes were recorded. Similarly infrequent, there were only two observations of "Dense" trash accumulations, and only eight observations of "Abundant", most of which associated near the crossing of Loop 360. Although there were some "Apparent" trash observations, the overwhelming majority of the survey area was in the "Minimal" category.

**Bull Creek (Figure B)**
Similar to Barton, the Bull Creek watershed is characterized by large preserves/openspace/greenbelts and accordingly has less trash. The apparent dominant type of trash were small single-use plastics, styrenes and other floatables. Within the survey area, no scooters were observed, no encampments, and no dumping. The only source-attribute was observed was an outfall/tributary located near Spicewood Springs and Loop 360. No instances of "Dense" trash accumulations (score 16+) were recorded in the survey area, and only a few instances of "Abundant" trash accumulation (score 10-15) were observed.

**Buttermilk Creek and Little Walnut Creek (C)**
Buttermilk Creek was the worst creek for trash intensity as measured by the highest median value. A variety of sources were noted including and dumping (recent point source and unknown), property management, tributary/outfalls and several encampments. Although the streambed is primarily scoured Austin Chalk limestone, the stream is prone to very high flows or "flash flooding" in which the riparian edges are inundated causing trash to be entrained high up the banks. Numerically single use plastic was by far the most commonly encountered item, however, the most salient trash item in Buttermilk was likely fabrics (clothing, bedding, etc.). Encampments do not explain all of the trash in this creek as dumping appears to be a chronic issue, compounded by the lack of stormwater controls and high impervious cover characteristics of the age it was developed. Little Walnut upstream of the confluence with Buttermilk is similar in trash intensity and source composition, however, downstream of the confluence few sources are apparent, yet trash remains very high.

**Carson Creek and Country Club West Creek (D)**
Carson Creek is a small watershed that is high in impervious cover and dominated by commercial, industrial and transportation (e.g., roads/highway/parking lots). An area of encampments just north of Highway 71 contributes to localized dense accumulations of trash between Highway 71 and Highway 183. An area of similar trash intensity is located in the upper watershed, yet no encampments are associated, rather various forms of dumping are apparent. Country Club West Creek had the second highest median score and is punctuated by apartment complexes with several encampments, however, almost all source types are present, including an inordinate amount of point source dumping. The lower watershed downstream of Krieg Field Complex is heavily influenced by encampments.

**Lake Creek (Figure E)**
The upstream portion of Lake Creek watershed is primarily single family residential, while the downstream portion is largely commercial, but both include a prevalence of manicured (mowed) trapezoid/engineered channels for improved conveyance. Areas of high trash density were typically associated with naturally vegetated (high roughness) corridors just downstream of mowed trapezoid channels. The woody vegetation in these areas act as strainers detaining trash from the upper watershed. There were few encampments in the survey area, but each was associated with uncommonly high concentration of shopping carts, which increase the trash score disproportionately due to their size/weight and difficulty in removal.

**Shoal Creek and Waller (F)**

Although single use plastics were clearly numerically dominant in all watersheds (including Shoal), the most salient aspect of litter in this creek were fabrics (clothing, bedding, etc.). Fabrics along with foam rubber appeared to visually dominate the total mass of trash in Shoal Creek. This prevalence of fabrics was most noticeable in the downstream half of Shoal (south of Beverly Sheffield Park) including primarily clothing and bedding, etc. A reasonable assumption would be the conclusion that these fabrics result from the influence of encampments, however there was only one active encampment observed in the upper half of Shoal (located far in the upper watershed). Several other sources were present in the upper watershed. Overflowing dumpsters and property management issues in upper Shoal Creek may be the source of dense/abundant trash in the upper half of the watershed since no other significant sources (only 1 encampment, no point source dumping, no historic dumping, etc.) were observed. It should be noted that fabrics become entrained in woody vegetation and do not easily migrate downstream, therefore, these items may have simply been accumulating over time through a densely populated part of town with few stormwater controls due to old development. Waller Creek is similar in character to Shoal Creek except for dense encampments in the downtown area and a much higher instance of outfall/tributary sources, likely the result from old development without many stormwater controls.

**Taylor Slough North, Taylor Slough South and Johnson Creek (G)**

No instances of "Dense" or "Abundant" trash scores were recorded in either Taylor Slough North or South, and no sources (dumping, outfalls, encampments) or scooters were observed. Trash in Taylor Sloughs were primarily associated with single use plastics and home construction/renovation. Long strands of detached or partially attached telecommunication cables were common. Construction materials such as lumber, tile, metal, bricks were all common in addition to evidence of labor crews such as ice bags and fast-food containers. Land use is overwhelmingly single family residential in all three watersheds, for which the areas adjacent to the creek were developed long before Critical Water Quality Zones provided a buffer to creeks. Salient trash items indicated refuse from landscaping and home renovation such as an abundance of empty icebags, mulch bags, water bottles, fast food containers/wrappers, building materials, telecommunication cable, etc. The Johnson watershed presents a unique difference compared to other watersheds in that the uppermost portion of the watershed (~275 acres) above the terminus of the natural channel is dominated by roadway (primarily Loop1) and is conveyed to the creek through a large network of underground storm drains and culverts. This drainage system conveys any trash on the roadways directly to the channel and thence to a large stormflow bypass that diverts stormwater (and trash therein) from the upper watershed through a ~1.5-mile tunnel extending all the way to the to the lowest 1/4 of the channel.

**Tannehill Branch and Boggy Creek (H)**

Much like other urban creeks, single use plastic and styrene floatables dominated trash composition. Several of the focal points of trash intensity were associated with clusters of point source dumping. This may be a result of the positive feedback loop dumping tends to cause. Both watersheds have long stretches of historic Corps of Engineers trapezoid concrete channels. These concrete channels have a tendency to show less trash due to the low roughness, however the transition to natural channel and wooded riparian corridors are high in trash concentration.

**Walnut Creek (Figure I)**

Compared to most other watersheds of its size, Walnut had relatively little trash and few sources. Walnut Metro Park stands out as a clean reach with no observed sources. Outfalls/Tributaries were the primary source in Walnut. Most of the watershed is beyond the city limits.

**South Boggy Creek and Williamson Creek (Figure J)**

South Boggy Creek is an example of a watershed that has few encampments, yet many dense trash sites. The intensity of trash in South Boggy is due to a number of other sources underscoring the finding that encampments are not singly to blame for much of the trash in creeks. Williamson Creek was the longest watershed of the survey and included pristine headwaters and horrific sections of dense trash far exceeding other watersheds.  Some areas of encampment were not identified in the survey as they had been recently cleared by the authorities and were no longer active.  An interesting and unexplained observation is the prevalence of tin cans between Oak Hill and IH35.  Tin cans (both historic and recent) were a common item and were described as occurring in most of the survey observation points.  No other creek in the survey shared this characteristic.

**East Bouldin Creek, West Bouldin Creek and Blunn (Figure K)**

West Boulding and East Bouldin had the fourth and fifth highest median values of the survey.  Although the trash composition was diverse in West Bouldin Creek, the total mass was greatly influenced by heavy building materials from construction and renovation.  Bricks, broken concrete, cinderblocks, lumber, tiles, metal and other structure components were prevalent.  The East Bouldin watershed is dominated by single family land use, but the corridor around the creek is largely commercial.  Subdivided largely before the1980's there are few stormwater controls and pervasive encroachment into the areas that is now the Critical Water Quality Zone.  An encampment in Gillis Park was associated with some high scores on East Bouldin. All three watersheds included a higher number of historic dump sites exposed by eroding banks which opens a window to the historic development of south Austin.  Property management in the upper watershed is similar in West Bouldin and Blunn.

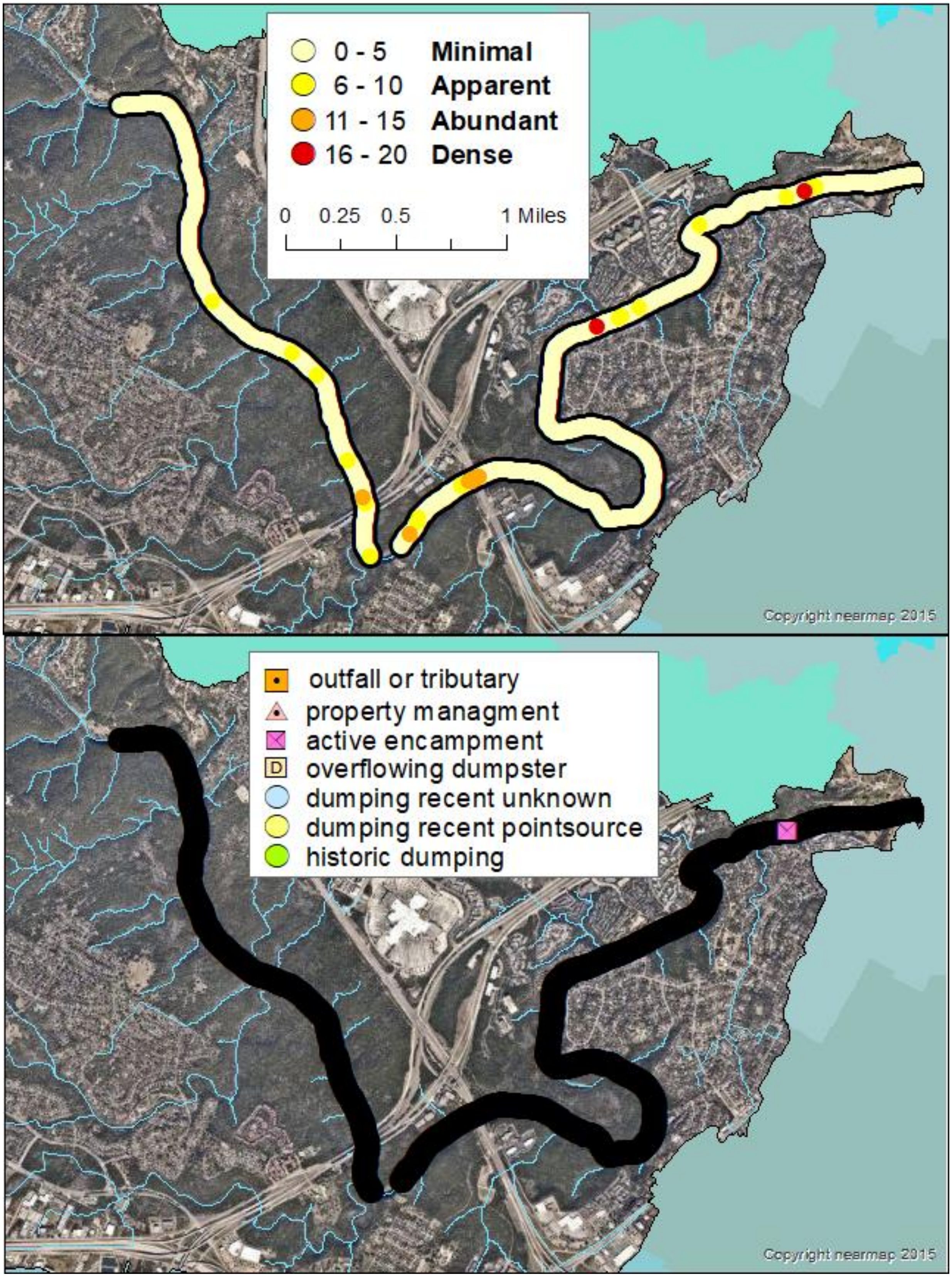


**Figure A. Barton Creek scores and observed source types**

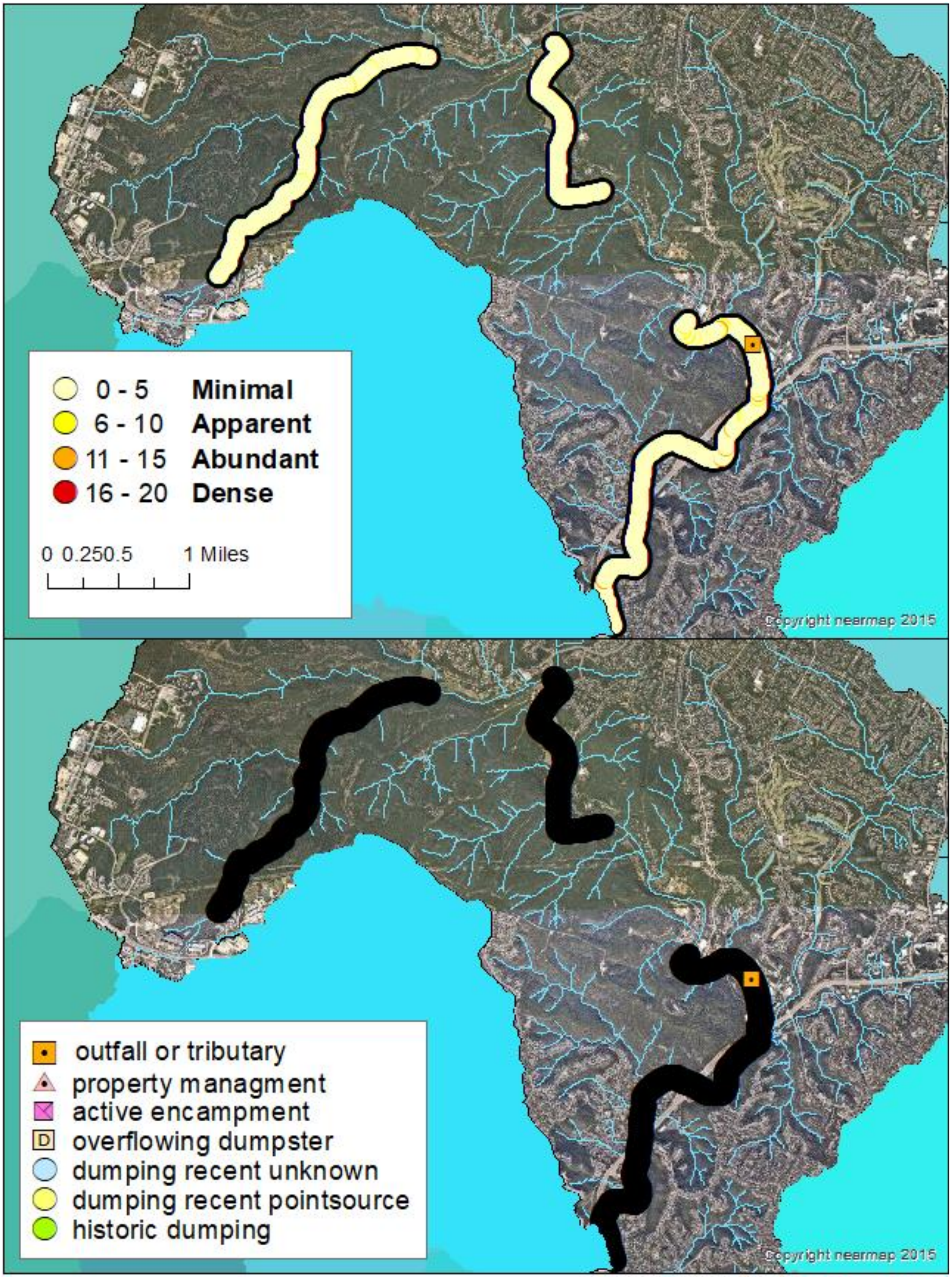


**Figure B. Bull Creek scores and observed source types**

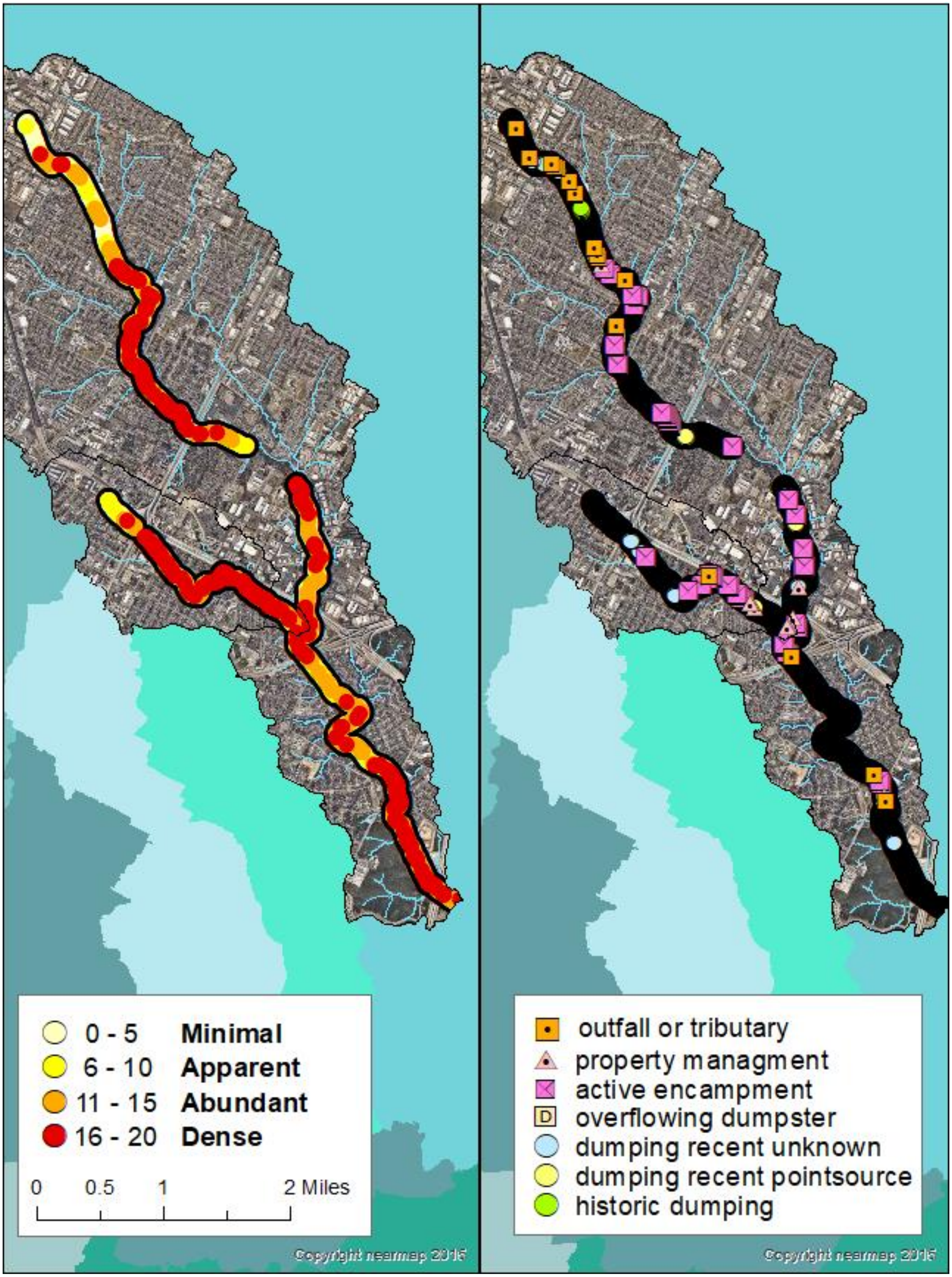


**Figure C. Little Walnut and Buttermilk scores and observed source types**

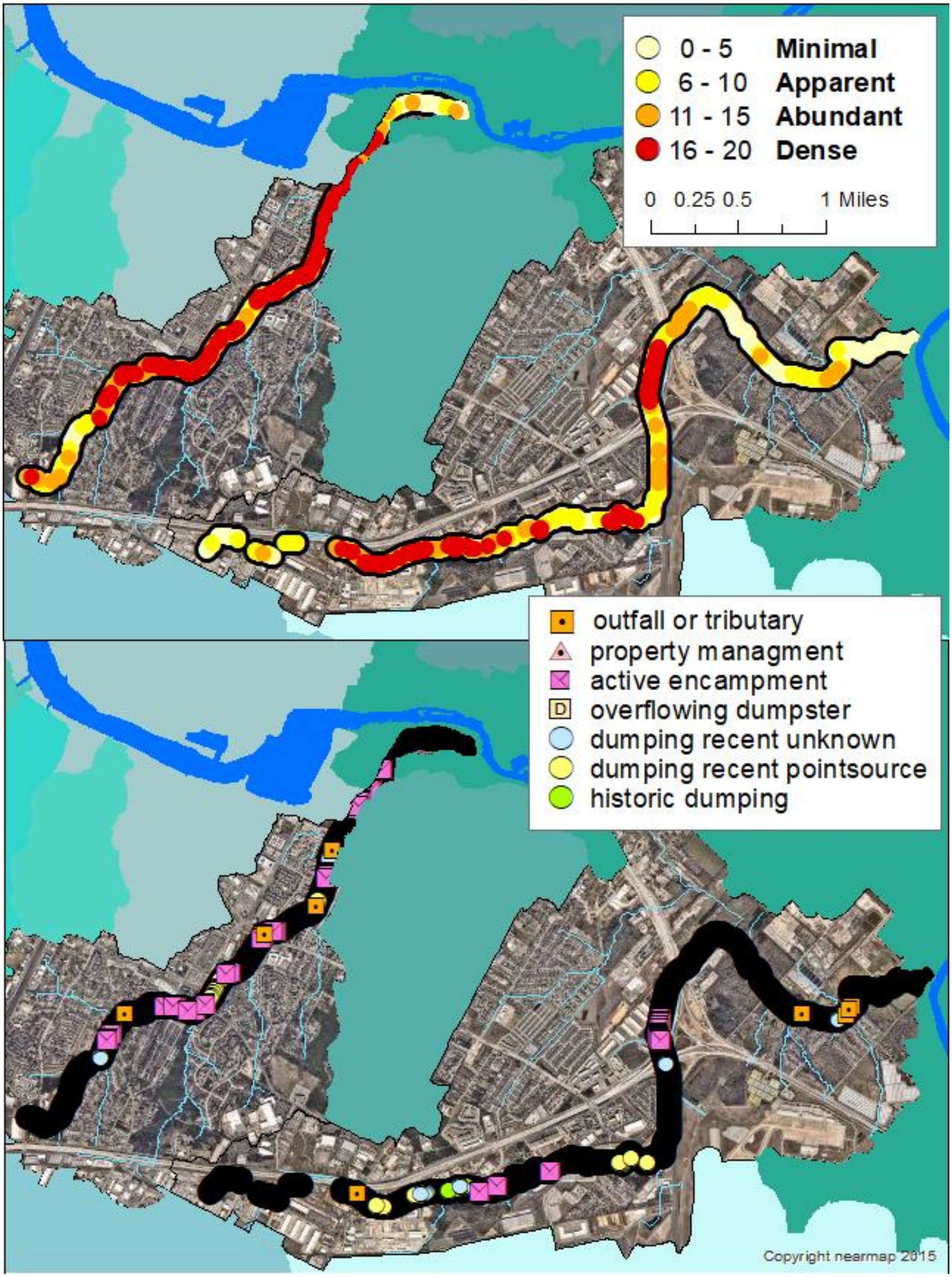


**Figure D. Country Club West and Carson scores and observed source types**

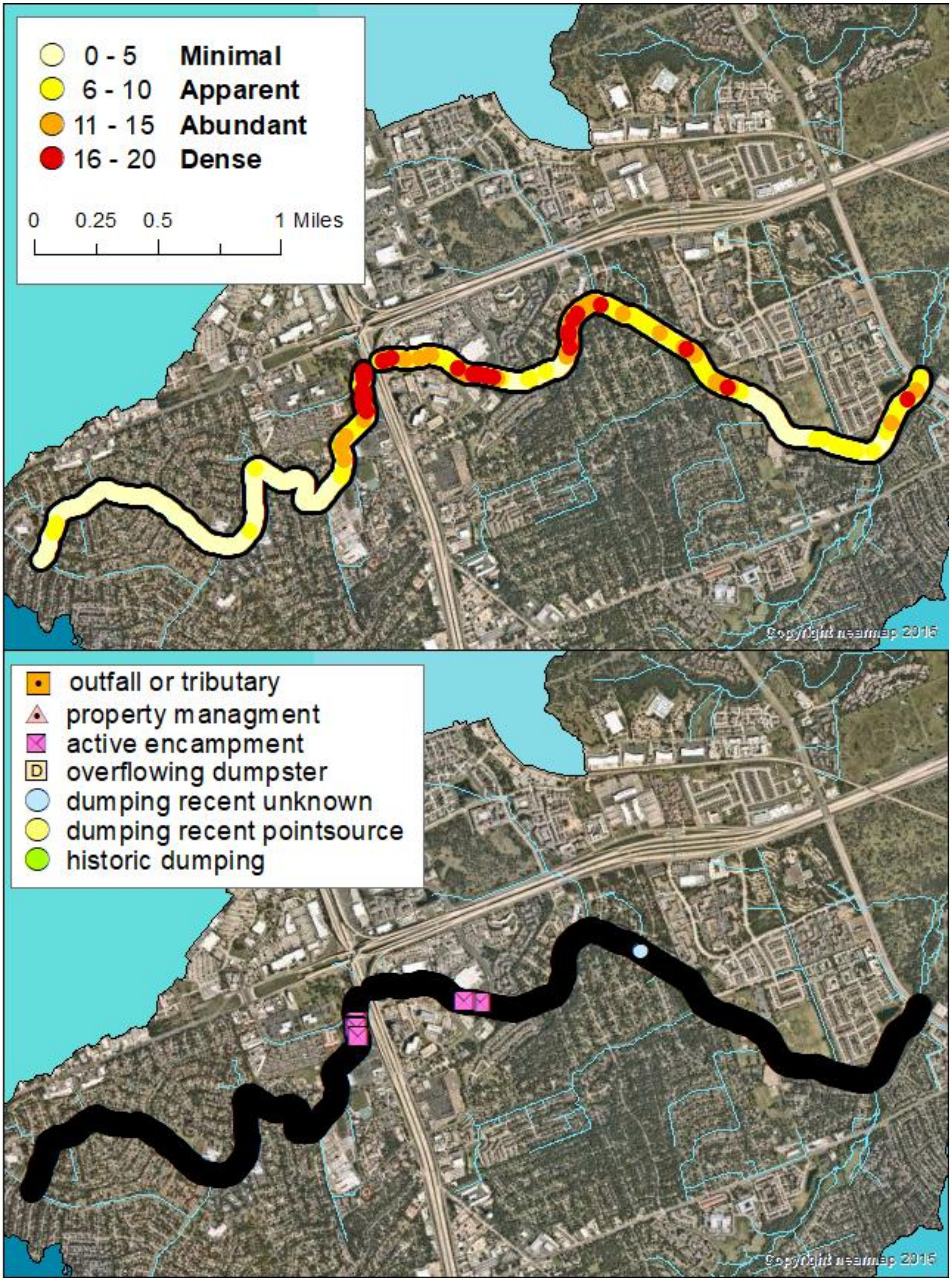


**Figure E. Lake Creek scores and observed source types**

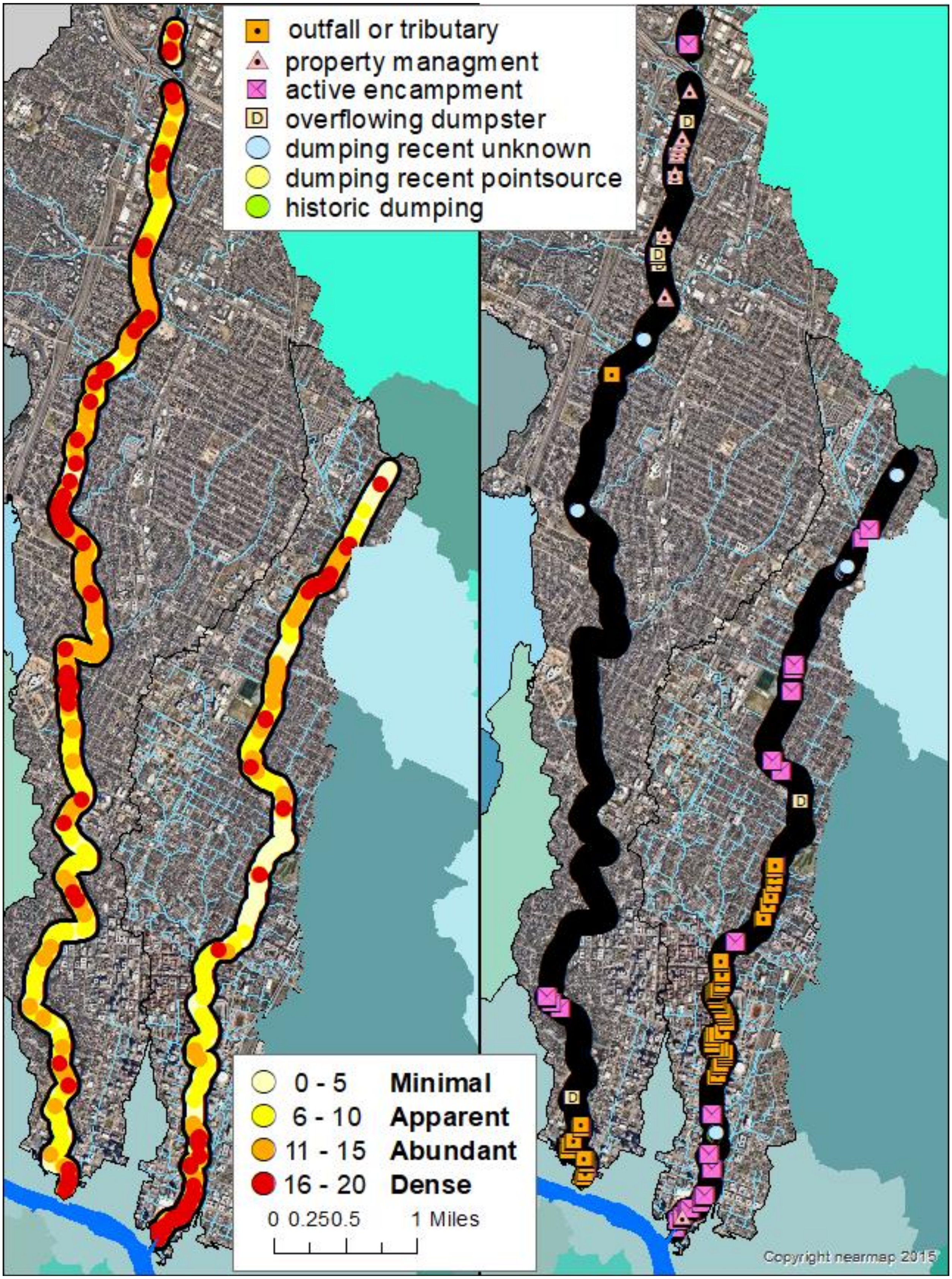


**Figure F. Shoal and Waller Creek scores and observed source types**

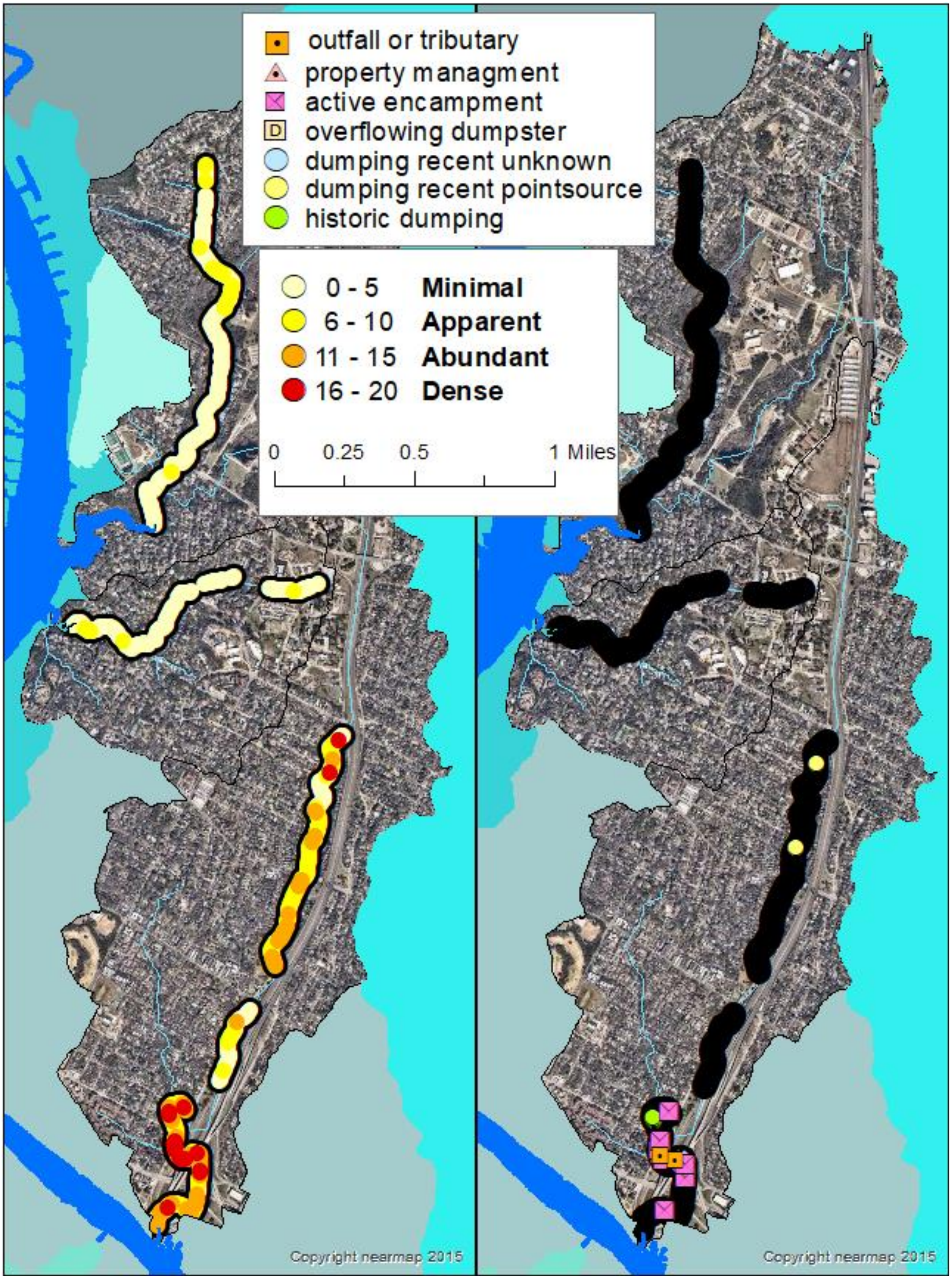


**Figure G. Taylor Slough South, Taylor Slough North, and Johnson Creek scores and source types**

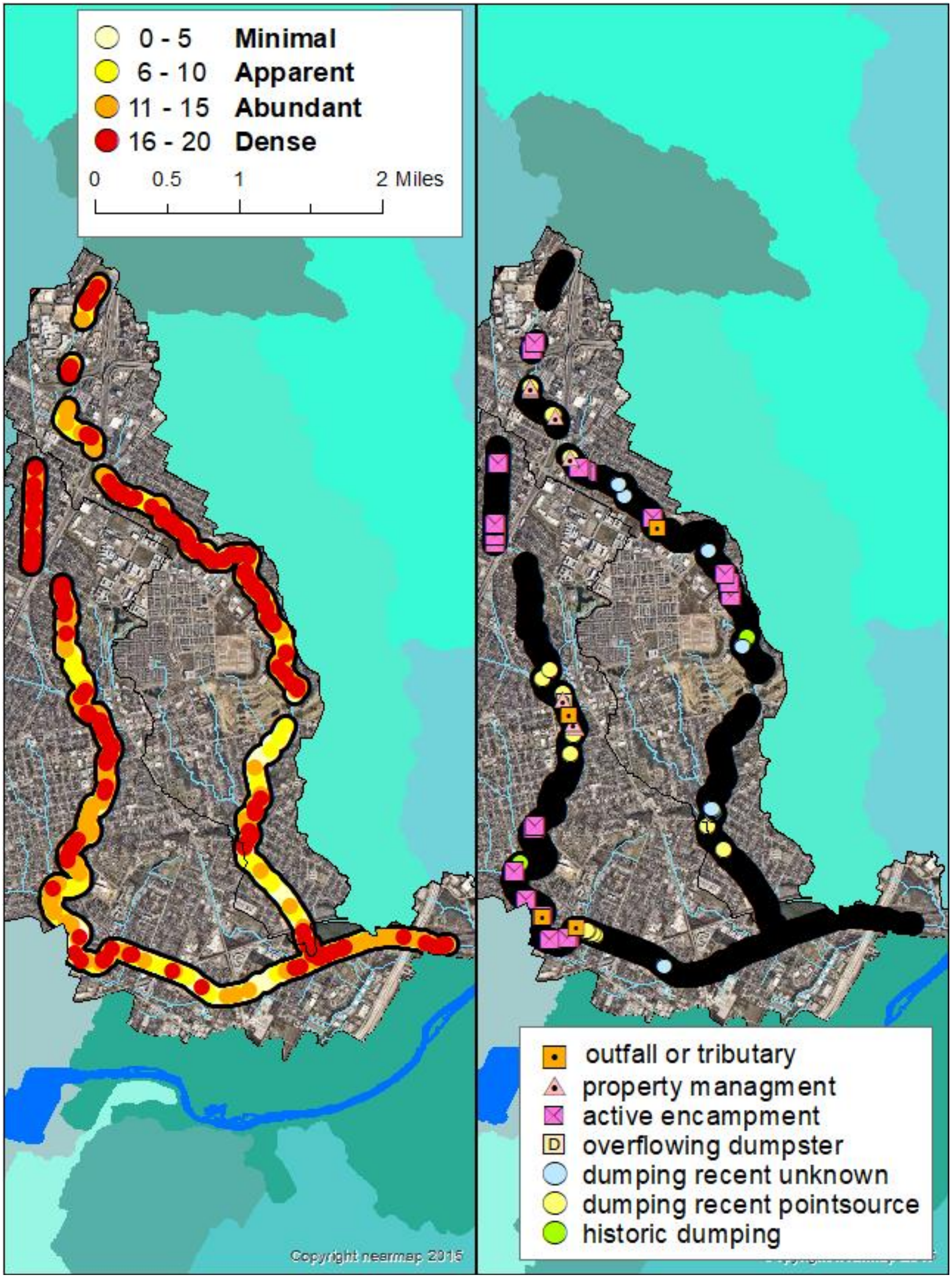


**Figure H. Tannehill and Boggy (East) scores and observed source types**

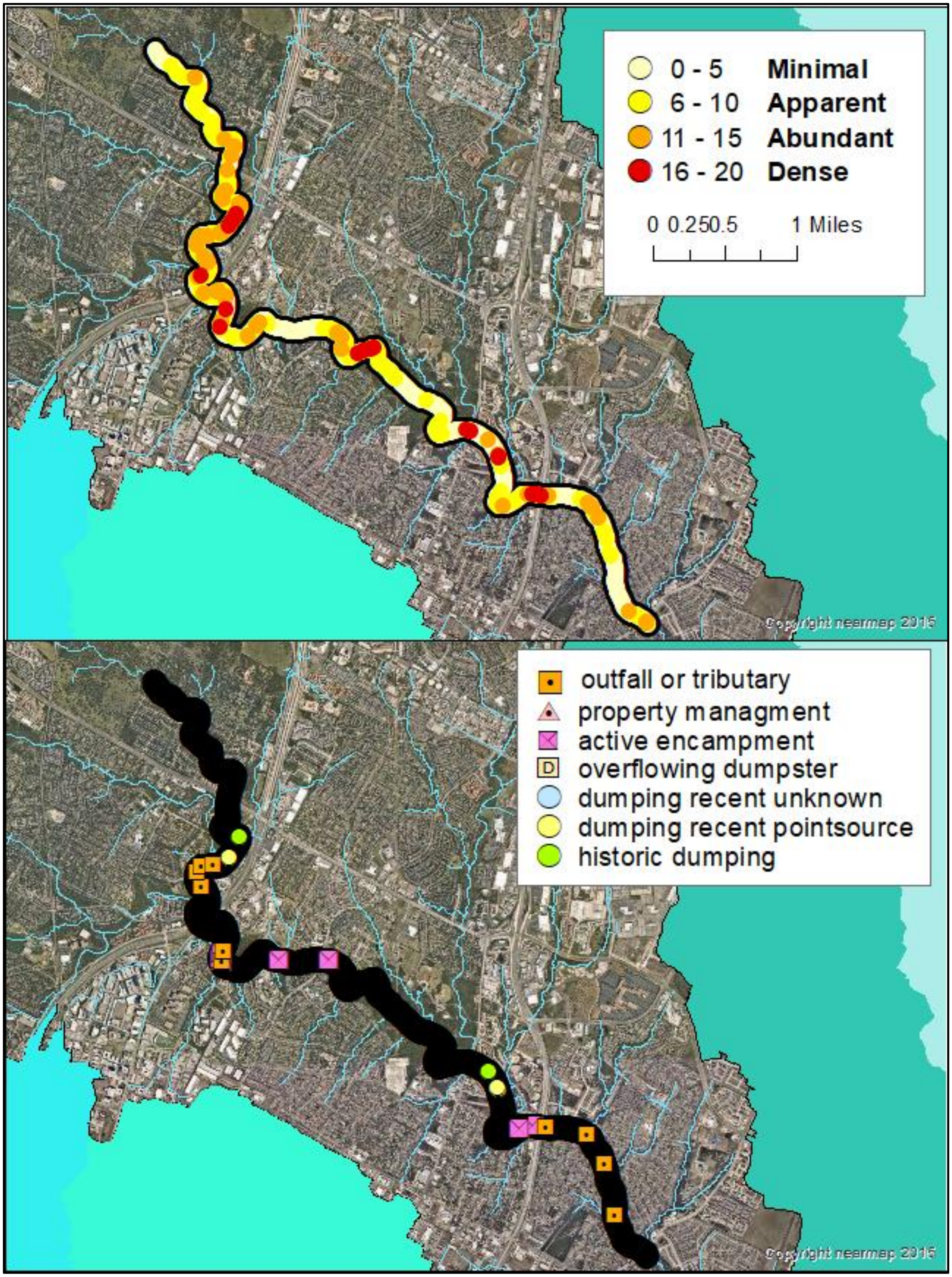


**Figure I. Walnut Creek scores and observed source types**

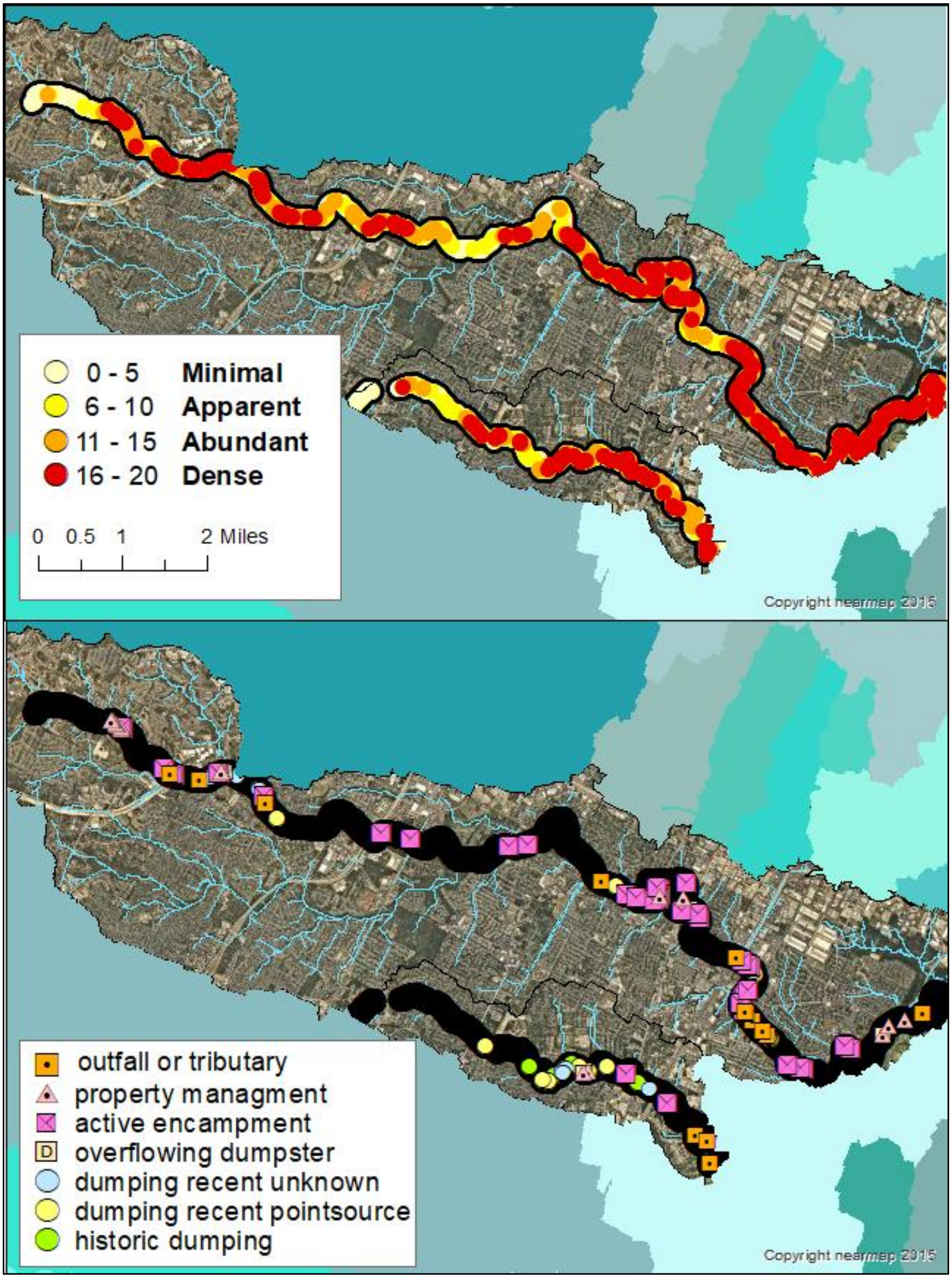


**Figure J. Williamson and Boggy (South) scores and observed source types**

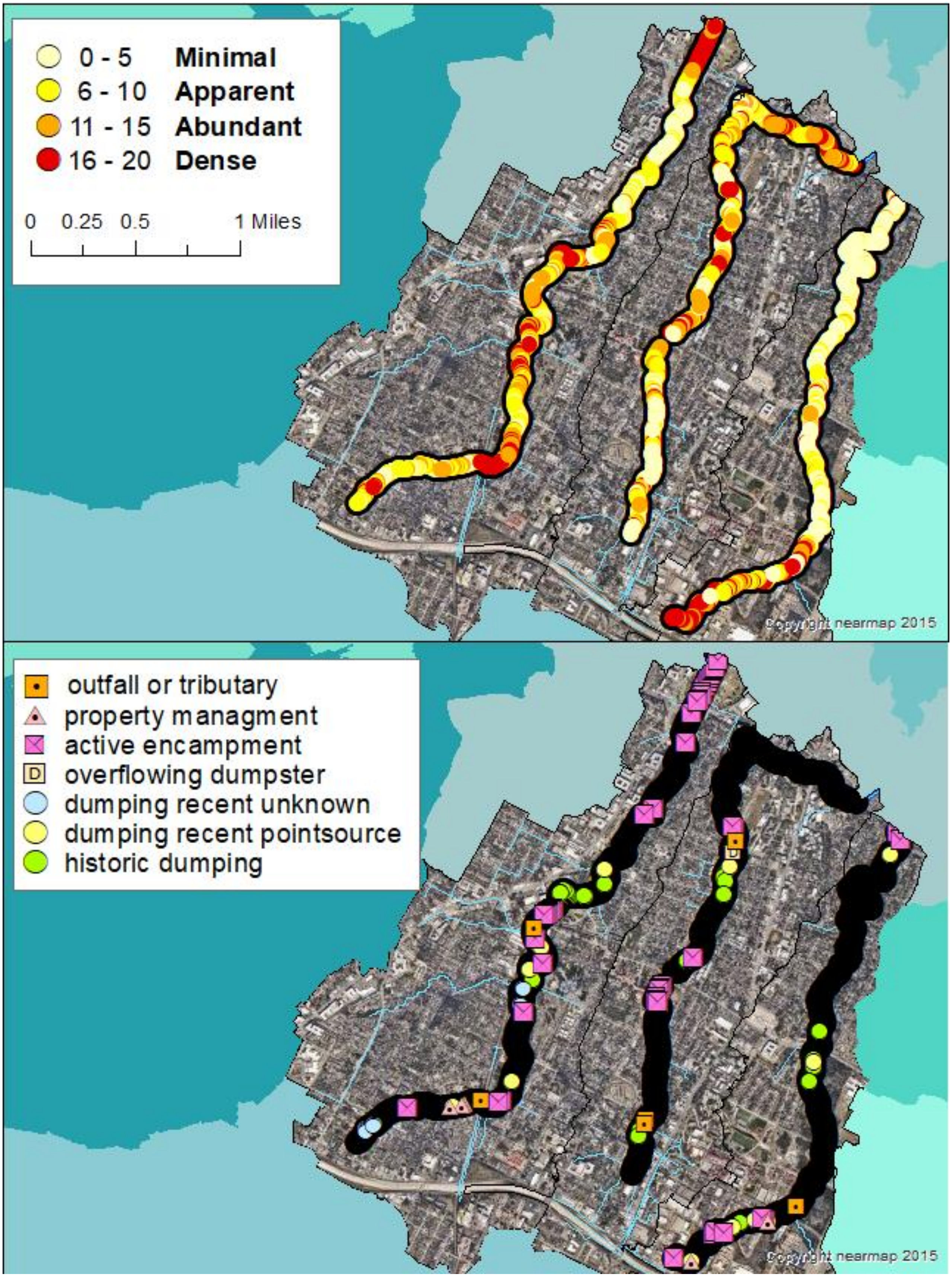


**Figure K. West Bouldin, East Bouldin, and Blunn scores and observed source types**

# Attachment 2

# Trash In Creeks: Benchmarking Solution Space and Resources

**RR-22-02, August 2022**

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## Abstract

*At the request of Austin City Council (CIUR 2234), to address prevention and abatement of trash in waterbodies, the Watershed Protection Department (WPD) researched strategies available in literature and reached out to peer municipalities, organizations, and vendors. The City of Austin already implements many of the strategies employed by others entities. While there are novel technologies for the active and passive collection of trash, most have limitations that preclude efficient use in Austin's setting. Based on the research, recommendations for the City of Austin to address the problem of trash in creeks include a progressive and three-pronged strategy: the physical removal of trash at strategic locations, improved methods to prevent trash from getting to the waterways, and strategies to reduce the quantities of some types of items that typically become trash in our community such as single-use plastics. A companion report "Trash in Creeks: A Field Survey of Trash Intensity and Source Types in Austin, Texas" (RR-22-01) provides a high-resolution characterization of Austin's trash in creeks problem. Recommendations in this report integrate the findings of the Austin field survey with the results of comprehensive benchmarking.*

## Introduction

Due in part to public comments that 1) assert the increase of trash in creeks over time, 2) express concern of micromobility vehicles (i.e. scooters) in waterbodies, and 3) request the reinstatement of the public camping ban, Austin City Council passed Resolution No. 20200123-108 (CIUR 2234) directing the City Manager to "prepare a study with recommendations to improve the ecological health and safety of Austin's rivers, lakes, and creeks by addressing litter problems, prevention, and abatement in our watersheds…". The resolution further specified a list of deliverables to address litter problems and illegal dumping of electric micro-mobility devices in waterways. The Environmental Monitoring and Compliance (EMC) Division of the Watershed Protection Department (WPD), in response to one of these deliverables, committed to a research effort to identify practices by peer cities and organizations (nationally and globally) and provide recommendations for actions that Austin could take to substantially prevent and abate litter in our watersheds.

Litter, overflowing dumpsters at apartments, windblown garbage from the bed of a pickup truck, storm-washed floatables, illegal dumping, encampments in riparian areas, old commercial developments lacking proper stormwater controls, and historic buried trash and debris exposed by erosion are all examples of trash that ends up in waterways. The negative externalities of trash in creeks far exceeds aesthetics and includes many expensive costs (beyond the cost to simply remove) such as:

- Litter can decrease property values in residential areas and decrease customers/sales in commercial areas (Skogan, 1990).
- The risk to human health and safety imposed by trash is increased by sharps and trip hazards, but also includes indirect biological hazards through chemical pollution and increased mosquito habitat.
- Environmental degradation from microplastics, rotting textiles, decaying foam rubbers, paint, metals, etc., is difficult to quantity and may have effects on wildlife habitat, and/or morbidity/mortality to aquatic life.
- Trash can obstruct storm sewers increasing the risk of property damage from flooding and can exacerbate erosion by obstructions in flow paths diverting storm (University of Texas at Austin, 2022).

When fully realized, the cumulative costs to the community of trash in creeks may outweigh the costs of clean up and prevention.

Aesthetic degradation promotes a positive feedback loop that invites apathy and additional littering. A lack of ownership, or a belief that someone else will pick up the litter, or simple disregard because the area is already littered (University of Texas at Austin, 2022) are all reasons for littering. Once litter is in the waterway, it may take years, decades, or even centuries to resolve. The time improperly disposed trash spends in our environment can be staggering. An item as small as a cigarette butt may only take 2-5 years to decompose, but an aluminum can take 200-500 years (*The Brazos River Authority, 2021).*

It is important to evaluate solution opportunities along all parts of the waste stream path. For example, extracting trash once within creeks will only result in the need for additional removal effort if the pathway of the trash is not intercepted. Intercepting the trash before it enters the creek will only result in continued efforts to intercept if the source of the trash does not cease. Instead, reduction of the materials commonly littered is the only method that can reduce the time and expense of interception and removal. To effectively resolve the problem, a multifaceted strategy that attacks the problem from all parts of the waste stream is necessary.

### *Extraction: Removing Trash within the Waterway*

Faced with an ever-increasing volume of trash in common areas and riparian corridors the initial reaction is to lean into the problem and orchestrate clean ups through volunteer organizations, contractors, and additional municipal staff. However, collecting trash within the waterways is extremely time consuming, logistically difficult, often hazardous, and expensive. The economic burden often falls on the local government's budget and ultimately the cost felt by the citizens through increased taxes or a reduction of other services. A 2009 study by Keep America Beautiful found that the U.S. spends about $11.5 billion per year to clean up litter (KAB, 2021); however, this cost is likely spiraling upward due to inflation and increased waste load.

Options for trash removal in creeks are limited in many ways (e.g., physical access, cost, time, labor, hazard, etc.) and typically take the form of hand removal due to the complexity of natural waterways. This intense physical labor is spread over a large area; Austin has hundreds of miles of creeks and thousands of miles of contributing tributaries in its jurisdiction alone. If the trash is submerged or otherwise buried the difficulty in removal is increased. Private property, limited entry points, and the logistics of trash disposal further limits cleanup efforts. Active and passive mechanical devices installed to detain trash still require physical removal by people. Trash booms, trash racks or other devices that detain/extract trash from creek flow are problematic in regions that experience extreme weather such as Central Texas because these mechanisms could cause increased localized flooding and/or exacerbate erosion of the stream bed or banks.

*Interception: Preventing or blocking trash from entering waterways*

Opportunities within a community to intercept trash prior to reaching creeks are available, but often underutilized. Stormwater controls in Austin are designed to capture the "first flush" of a storm event and detain a portion of floodwaters including some interception of trash carried by stormwater. These facilities can be effective at intercepting trash if the controls are regularly maintained but may not detain floatable debris if the storm event is large. Other physical containments such as trash cans/dumpsters are vulnerable to both improper use and overloading. Undersized capacity and/or inadequate emptying frequency can lead to trash overflowing to the landscape and creeks. Increased access to waste receptacles, education and outreach programs, enforced ordinances strengthening the prohibition/consequences of unrestrained trash, and efforts to collect trash on the ground can all reduce the amount of trash mobilizing to waterways.

Individuals and encampments of people experiencing homelessness are frequently a focal point for discussions about trash in and around creeks and were part of the discussion in the development of CIUR 2234. The association of discarded items with homelessness is apparent to observers but not directly linked to larger scale trash patterns. A recent survey identified that encampments were not consistently associated with high volumes of trash in creeks (Clamann et al. 2022). Some encampments in Austin were observed to maintain a clean perimeter and may not contribute significantly to the total load of trash in creeks. Other encampments are riddled with loose items and when located within the floodplain are subject to stormwater mobilization (e.g., tent, fabrics, possessions, trash). Homelessness is a complex and critical issue in Austin that needs to be addressed at many levels, with trash service, disposal and mitigation just one of them.s

Diversion of trash prior to entering the creek is a more effective and less difficult endeavor than physical removal once in the creek. Regardless of the increased efficacy, it still requires constant diligence/expense and adaptation to changing social patterns.

*Source Reduction: Reducing the Supply of Trash in Our Community*

Worldwide, but particularly in cities, there is a trend toward single-use, disposable and overly packaged consumer goods. Even those who ensure their trash follows the proper disposal pathway are unable to avoid the single-use industry and ultimately contribute to the increasing supply of these items entering our creeks and lakes. Although some commercial establishments, with the encouragement of their customers and through Austin's Zero Waste efforts, are switching to compostable alternatives and reusable containers, major reductions in materials most frequently found in the litter stream will require regulatory approaches. While comprehensive regulations are difficult to institute, restrictions on use of non-biodegradable materials and packaging are likely a key tool in keeping trash out of our creeks.

## Methods: Research and Benchmarking

Efforts to benchmark a wide range of potential strategies to the litter problems in Austin began with contacting other large cities in the United States. City representatives were solicited to describe strategies, effectiveness, maintenance, problems, costs, and additional contacts. As in Austin, numerous entities are often involved in litter management efforts, and each entity might focus on only one component (like cleanups). Research efforts evolved from generalized survey questions to a more targeted focus on successful, novel, and innovative strategies/tactics.

Internet research also yielded different methods and evaluations of effectiveness, along with some specific examples of implementation. The US Environmental Protection Agency Trash Free website (US EPA, 2021) provided information on funded programs and a list of municipalities who have identified trash as an impairment of beneficial uses (e.g., recreation) in a water body as part of the water quality assessments required under the Clean Water Act (CWA). In some instances, the EPA has delegated the authority to administer the CWA to the state, as is the case for the state of Texas. Texas has elected not to include trash as a constituent to be assessed and has therefore not identified trash as an impairment. As part of their cooperation with the EPA and the CWA, those states and municipalities that do identify an impairment are required to provide a Total Maximum Daily Load (TMDL) plan to reduce the constituent of concern and the amount that must be removed and have developed comprehensive guides for Best Management Practices (BMPs) for reduction, monitoring success, and identifying gaps.

Types of mechanized and passive trash collection products were grouped by type. Manufacturers of representative products within a type were contacted for information such as purchase cost, maintenance requirements, as well as cities where the product had been implemented and contact information. When provided, customers who had implemented the products for litter control were solicited for opinions on the success/failure, and relative value. Where available, independent published evaluation of device effectiveness was obtained. Some of the most recent mechanical and automated devices have not been implemented yet in the United States, have only been demonstrated but not permanently deployed, and/or have not been in place long enough for a reliable assessment of success.

Benchmarking also included compilation of available cost data. Equipment purchase price or other “up-front cost” was typically available; however, the true cost to implement (maintenance, staffing, ancillary, etc.) was quite difficult to obtain because of the scale of implementation, the level of effort, labor complexity, and frequent overlap with other programs/organizations. For example, labor for maintenance may be provided by a volunteer group, but management of those efforts and any associated risks are born by the governmental agency, but effectively undiscoverable. A breakdown of cost information was impossible to reliably acquire for individual strategies in most cases.

For a perspective of overall funding requirements in other cities, Austin costs were compared to those provided in a Pennsylvania litter study. Nine Pennsylvania cities were examined, but the two largest are shown in Table 1 (Burns & McDonnell, 2020); the complete results are included in Appendix A. Based on their description of the categories, costs for Austin, from the Trash in Creeks Program Inventory, Analysis and Outcomes 2022 were distributed between categories as best as possible.

**Table 1. COA litter program costs ($, except for population) compared to large Pennsylvania municipalities**

| City | Philadelphia* | Pittsburgh | Austin FY20 (avg costs FY18-20) |
|---|---|---|---|
| Population | 1,584,138 | 301,048 | 1,028,225 |
| Litter Prevention (Trash) | 1,217,000 | 2,734,400 | 2,722,203 |
| Dumping Prevention | 2,163,400 | 246,800 | 6,609,111 |
| Education & Outreach | 547,300 | 57,700 | 123,500 |
| Litter Abatement | 36,314,700 | 2,706,900 | 8,384,434 |
| Dumping Abatement | 6,376,800 | 232,400 | 1,017,986 |
| Enforcement | 1,778,300 | 331,300 | 1,990,734 |
| **Total** | 48,397,500 | 6,309,500 | 20,847,968** |
| Cost/Person | $ 30.55 | $ 20.96 | $ 20.28** |
| *Most costs from FY18 (Burns & McDonnell 2020) | | | |
| **Code Enforcement Costs not included. | | | |

Philadelphia created the "Zero Waste and Litter Cabinet" in 2016 which was guided by an Action Plan (City of Pa 2017). Philadelphia used a litter index database, which in conjunction with litter reporting through their 3-1-1 system and surveillance, guides the placement of new public litter cans and optimizes routes for litter collection. The placement of surveillance cameras for illegal dumping and where to build enclosures on parkland for trash containment as well as coordination with their transportation authority is also directed by the index and reporting.

# Results

The strategies explored in this research have been grouped into three categories:

- EXTRACTION: Litter removal from within waterways,
- INTERCEPTION: Preventing or blocking trash from getting to waterways, and
- SOURCE REDUCTION: Stemming the Flow Into our Community

## EXTRACTION: Litter Removal from Within Waterways

### *Current Austin Waterway Cleaning Programs*

The WPD maintains a perennial presence on Lady Bird Lake via the Field Operations Division (FOD) Lady Bird Lake crew which is responsible for removing litter, trash, and debris from the main body of the lake (485 acres) and along the shoreline (14.8 miles). FOD utilizes boats (Figure 1) to remove trash on Lady Bird Lake; some have a collector bin for trash below deck. However, the skimming function with the collector bins cannot be used as designed because it has a deleterious impact on lake vegetation/organic detritus which quickly fills the bin and was discontinued. The boats are currently still used by the lake crew for trash management, but the collector bins are not employed. Austin has installed floating trash booms at the mouths of the urban tributaries to capture litter from the creeks as they discharge into Lady Bird Lake; removal of captured debris from behind the booms is eased by the access provided from the lake itself. A boom, like those at creek mouths has also been installed at in East Austin at 38 ½ street on a small tributary below a shopping center, to facilitate trash removal by unhoused workers employed through "The Other Ones Foundation (TOOF)." Performance and maintenance requirements for this boom can direct whether more of these devices should be deployed in creeks to concentrate trash for cleanup. From October 2021 through July 2022, the Lady Bird Lake crews have removed more than 18 tons of waste material. WPD also uses vendors to provide vegetation and litter management services along more than 80 miles of waterways and over 1,100 stormwater controls.

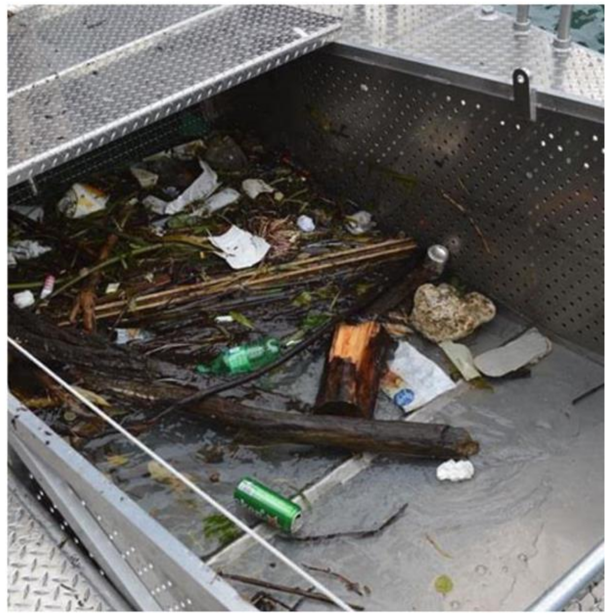

**Figure 1. Elastec Omni Catamaran skimmer boat with collector bin** *(Photos courtesy of Elastec)*

The Clean Creeks Program is a joint effort between Austin Resource Recovery (ARR) and WPD to provide general litter abatement in creeks and waterways. Efforts have been enhanced in the Waller Creek Project area downtown, including providing for screening of trash at the intake structure for the flood control tunnel. Collected litter must be removed from the intake structure screen and the stilling basin pond manually.

Currently, the resources Austin has allocated to trash and litter removal are extensive. All our parks and trail systems and their numerous trash receptacles are maintained through the Austin Parks and Recreation Department (PARD) geographic area. This major effort is supplemented in high use areas, such as downtown and the Waller Creek area, by many other agencies. In the downtown area this includes the Downtown Alliance, the Waterloo Greenway, the operators of concert venues, Adopt-a-Creek volunteer groups, ARR and the WPD, among others.

Several cities are having success with hiring from within the communities of people experiencing homelessness for litter control including Fort Worth, Texas; Portland, Oregon; Pueblo, Colorado; Stockton, California; San Jose, California; Tacoma, Washington and Oakland, California through the nonprofit Downtown Streets Team (individual city contacts and https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2021/10/13/cities-see-trash-cleanup-programs-as-a-way-to-combat-homelessness accessed April 14, 2022). Austin has implemented two specific efforts to both address trash at homeless encampments and simultaneously provide employment. They have contracted through The Other Ones Foundation (TOOF) to employ people from the homeless community to pick up trash. They have also targeted areas for the Violet Bag Program to encourage proper disposal and provide pick up services in and around homeless communities in Austin. Each year since this effort was instituted staff have requested expansion to the program.

If the use of TOOF for boom maintenance is successful, Austin should also consider expanding that program and other incentive-based efforts. Churches or other nonprofits that work with the communities might attempt a trade program where clothing or bedding materials that might be discarded could be traded for clean materials, or these organizations could perhaps be required to collect equivalent waste materials when making donation deliveries. There are several different programs that use the "Trash for Treats" slogan or encourage appropriate disposal, primarily through schools. Smith College handed out 320 desserts during campus moveout and collected six boxes of unwanted clothing and 27 bins of recyclables in 2016 (https://www.smith.edu/about-smith/news/trash-for-treats-2016). However, very few innovative programs were identified that addressed the huge problem of discarded fabric (clothes, blankets, etc).

Solutions for our littered waterways include enhancement of these current City of Austin programs; each budget cycle, funding is requested to expand those programs found to be most effective. Programs and mechanisms used in other cities to remove litter from our waterways are described in the remainder of this section with a discussion of applicability to the City of Austin.

*Volunteer Cleanup Programs for Waterways*

Most cities have volunteer programs, sometimes an affiliate of Keep America Beautiful (KAB-America; an affiliate search is at https://kab.org/search-result/), sometimes as part of City or County efforts, and sometimes through a nonprofit. Many programs, like those in Austin, are providing organization and equipment, and sometimes these programs are the primary effort in less urban areas to address their trash problem. For example, WPD-supported KAB programs "Adopt A Creek" and the "Clean Lady Bird Lake" since 10/01/2021 have removed an additional 4.3 tons of waste material solely from the lake. These volunteer efforts have the added benefit of raising awareness of the litter problem and educating community members about how their product and disposal choices impact the environment.

Many states and areas have cleanup efforts at multiple nested layers, for example, a state chapter of Keep America Beautiful (KAB- America) and an affiliate organization at a county or city level; in Austin those are Keep Texas Beautiful (KTB) and Keep Austin Beautiful (KAB). Many cities, or other jurisdictions, that operate an affiliate program do not limit registration at events, and some provide equipment only "as available" (e.g. Keep Arkansas Beautiful). Sometimes the organization and scheduling of cleanups is left solely to the volunteers, or an organization provides instruction, guidance, and equipment only, similar to KAB-Austin's 'Love Where You Live" program. The KAB-Austin model for the lake appears to benefit from the easy sign-up, provision of equipment and trash hauling service. The one exception is the limitations to the number of people who can be involved. A contract with KAB-Austin with a high level of funding allows negotiations with them on service provided as that contract is renewed. KAB-Austin also provides Austin with regular reports, so the success of equipping a higher number of volunteers would be measurable by the amount of litter collected.

Expanding cooperative efforts with multiple groups is also an approach that other cities have demonstrated can maximize impact (e.g. "Source to Sea"); managing those efforts would require additional staffing and/or funding. Groups could be identified by their goals relative to the environment as well as groups who use the waterways regularly for recreation or exercise. The organization of these types of events and volunteers could be primarily provided by the identified groups, with equipment or other support supplied by Austin. Trash pickup from large cleanup efforts could be requested if enough advance notice is provided, as it is for "Love Your Neighborhood" cleanups. For example, the "Animal Safe Migration" organization reached out to the Watershed Protection Department about coordination of clean up events (details provided in Appendix B). One concept that has been identified is the coordination of clean-up events with a centralized schedule so that efforts are not duplicated, and they achieve as much coverage as possible geographically as well as temporally. KAB-Austin already maintains a calendar of events; the system could be updated to include other efforts such as cleanups by the Trail Foundation, with links provided from the City of Austin's webpage, Chamber of Congress, and social media; increased funding to KAB or the entity managing would be required.

The City of San Marcos reached out to the Leave No Trace (LNT) Center for Outdoor Ethics for a week-long focused river clean-up effort. The Center assisted in getting stakeholders together and equipping them with the tools to effectively educate visitors about being better stewards of the river. The Center held workshops across San Marcos for tubing businesses, Texas State University, local non-profits, and city managers, ending with a cleanup. The City of San Marcos engaged with those efforts with educational tents, having games for children and items like litter bags near launch and take-out points for river goers. Similarly, Austin focuses on the well-known LNT ethic. Many City of Austin Park Rangers have received official LNT training and Austin's Barton Creek Greenbelt was selected as one of a few national LNT Hot Spot locations a few years ago. LNT Hot Spot locations are popular beautiful outdoor areas across the country that have been damaged due to heavy use. The program is designed to help reduce impacts in nature including excessive trash, damage to vegetation, trail erosion and more while allowing community members to enjoy our nation's shared outdoor places. Where signage is provided, as planned for concessionaires on the Lady Bird Lake, it should include links for volunteer efforts, perhaps promoting free canoe/kayaks for those events. Grant funding opportunities might be used to supplement existing programs or test new ones. KAB-America through KAB-Texas has awarded grants for litter control since Texas was an identified focus state from the Keep America Beautiful 2020 National Litter Study (KAB-America 2021). Although most nonprofit and city staff contacted felt that signage became unnoticed after it has been in place awhile, there are some parking areas near trails and lake launch points that might benefit from "Leave No Trace" signage.

Another way to encourage participation is providing incentives for actions. City staff have approached lakeside businesses in the past but had a low success rate in gaining cooperation. Many programs have tried a variety of incentives, usually these require working with local businesses to provide a discount or prizes. Sometimes encouragement can instead be in the form of gamification or drawing on competitive spirit for large cleanup efforts. For example, forming teams, (e.g. sports teams, companies), with each team getting bingo cards for types of trash collected and prizes awarded. The City of San Marcos and Keep San Marcos Beautiful instituted Kudo Coins, where staff award coins for returning full litter bags at education tents at launch and takeout points. The coins can then be passed on to other people the recipient would like to reward when they observe someone contributing to cleanup efforts or redeemed for discounts or rewards at participating merchants. Costs for the coins themselves are minimal, but organization and recruitment for business participation would need to occur. The Chamber of Commerce might assist with coordination, and it could be modeled after or be part of the "Go Local" campaign, which provides discounts or perks at local businesses. Another opportunity for coordination might be with the Austin Chamber of Commerce "chamber bucks". The simplest method would be for Kudo Coin recipients to be able to redeem one or several for a Go Local card (currently they have a cost of $15 for citizens wanting to purchase one).

There were two unique programs identified for litter retrieval from waterbodies by community members and visitors. The Urban Rivers nonprofit in Chicago had the most enthusiastic report on the effectiveness of a program from among all those interviewed. They had built constructed wetlands and were having the common problem of how to extract litter from the vegetation. They instituted a program where free kayaks were provided for volunteers who schedule a regular cleanup time, committing to a regular 1–2 hour time slot once a week; volunteers also collect scientific information on the constructed wetlands. They store kayaks with a crate attached for litter retrieval and grabbers and gloves in a riverside shipping container and provide a place for litter disposal. They report that this almost continuous daily manual cleaning does an excellent job in the focus area. This allows paddlers in the community who may not be able to own a canoe/kayak/SUP or are unable to afford regular rentals, the use of kayaks, and was reported to be a highly effective motivator.

Another program which is beginning to be adopted in a few areas (mostly overseas) is Trash Fishing or Plastic Fishing (Figure 2). In the US, efforts have primarily been individuals or small groups, such as an effort by a father and son in the Detroit River, who encouraged a competitive spirit in their "fishing" cleanups. PETA endorses it as a way of protecting aquatic creatures from the hazards associated with litter in water bodies. In the Netherlands and the UK, the efforts have grown from cleanups to building a boat from discarded plastics. The Canary Wharf College used plastic fishing materials to build a boat. The Plastic Whale Foundation has a method to distribute equipment for online events, hold school educational plastic fishing trips, and Plastic Fishing tours available for anyone who will purchase a ticket. The proceeds are used in their many efforts including the production of furniture from used plastic in a collaborative effort (Plastic Whale – Together for a plastic free land & sea).


**Figure 2. Trash Fishing outing in Amsterdam** *(Photo courtesy of Plastic Whale)*

Finally, while venues, condominiums, and office buildings that are on the shore of a waterbody have a vested interest in beautifying their waterfronts, much of the litter that has already entered the water body is difficult to retrieve. There is often no enforcement for littered shorelines or a way to include shoreline maintenance for new developments. The adoption of waterway segments by businesses through the Adopt-A-Creek program could help with this gap. The adoption program could alternatively be a funding mechanism for City cleanup or contract crews, as it is for Texas Highways where a highway section is "adopted" through a funding mechanism only. The City of Oakland cited success with their "Adopt-A-Drain" program, where over 750 volunteers have adopted over 1,000 storm drains to maintain. Their program was estimated to offset staff time of 10 hours/week to assist with volunteer management after their sign-up website was improved. Equipment layout costs are low at $40-100 to outfit a volunteer. Very recently, in the summer of 2022, Austin began an "Adopt-A-Drain" program (https://www.austintexas.gov/AdoptAStormDrain).

### *Waterway Litter Collection Devices*

Many cities have tried a variety of devices for capturing litter within the waterways themselves.

However, there are many limitations to this approach, including the volatile flow conditions in our creeks and reservoirs. Booms are floating devices that must span the waterway to capture floating materials without obstructing flow (Figure 3); sometimes booms include a curtain or screen below the boom, but those do not function in shallow water bodies where they would also prohibit the movement of aquatic life. The materials entrapped behind booms must be removed manually and can be lost over the top of the boom in higher flows. Booms are also sometimes used to direct floating debris to a passive collection device. Booms do break-away if a large quantity of debris is retained or in high flow conditions; this is often a design feature so they can be reattached rather than replaced. Issues in deploying booms include the aesthetic impact of corralled debris between maintenance, the loss of collected debris in high-flow conditions, and the access within creeks and reservoirs required to manually remove trash.

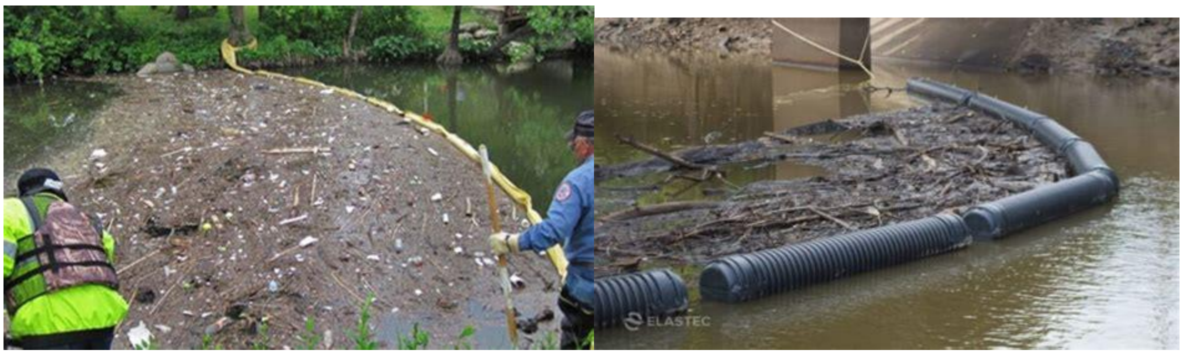

**Figure 3. Trash Booms and Maintenance Crew** *(Photos courtesy of Elastec)*

While WPD deploys floating booms at the mouths of several urban creeks, it is not feasible to install booms that span whole reservoirs or that block areas that boats traverse. For example, at some locations like the mouth of Barton Creek and vicinities near rental vendors, booms would restrict passage of water vessels. Costs of booms vary widely from $3,000-$5,000 per boom and up to $2000/10-foot section for more durable booms (Table 2). Booms can also be paired at creek mouths or deeper sections with traps or capture devices. If the booms at creek mouths could be retrofitted or replaced to incorporate a device like the Elastec bins which can be emptied directly into bins beneath the Lake Crew boats (Table 2, Figure 4), that may prevent the loss of material. However, the cost of the bins can be high (Table 3) .

**Table 2. Trash Containment Booms and Estimated Costs**

| In-Stream Trash Capture Device | Manufacturer Info | Locations Installed | Initial Cost* | Annual maintenance costs** |
|---|---|---|---|---|
| Litter Boom | https://osprey.world/litter-collection-devices | Birmingham, AL (funded with USEPA grant to Freshwater Land Trust) | NA - Contracts included installation and maintenance | $20K-$45K. Osprey maintenance contract for several devices; Mobile, AL |
| Trash Boom - Elastec | https://www.elastec.com/products/floating-boom-barriers/trash-debris-boom/bruteboom/ | San Antonio, TX | $1K-$2k/10-ft section | Medium |

| | | | | |
|---|---|---|---|---|
| WaterGoat Trash Barrier | [https://www.watergoat.org/product-page.html](https://www.watergoat.org/product-page.html) | Tampa Bay, FL; Greenville, SC; Boston - Charles River, MA; Fundraiser for one as teaching tool - Columbus State Univ., GA | $3K-$5K | "The average Watergoat can be cleaned out in less than two hours with three Volunteers. Scoop Nets or Hooking Nets are used to easily remove debris" re manufacturer . |
| *Capital Cost Sources: Manufacturer or Agency installing device.<br>Where range is provided: High = $100K +; Medium = $10K-$100K; Low = <$10K | | | | |
| **Maintenance Cost: Agency who installed the device or estimates from (Shields, 2020)<br>For maintenance, annual costs: High = $80K+; Medium= $20-$80K; Low = <$20K | | | | |


**Figure 4. Skimmer Boat Used to Empty Trash Tra**p *(Photo courtesy of Elastec)*

The more robust group of devices for collection within or at the mouths of creeks function by passively allowing stormwater to carry the litter and debris into a trash trap device, usually a metal trap or mesh, or other sturdy material, that does not impede flow while collecting debris.  Frequently booms are used to funnel floating debris to devices that are narrower than the creek width (Figure 5). The devices basically screen the debris and allow the water to flow through. Most of these devices are quite costly (Table 3) with potentially high maintenance costs, and in some instances where large watersheds are served, they are part of a much larger structure. Many cities install devices and soon revert to contracting with the manufacturer for maintenance.


**Figure 5.   Booms directing Floatables into Trash Traps (***Photos courtesy of Bandalong and Elastec)*

Trash traps typically float so that surface litter is collected in a cage or mesh as creeks rise during storm events.  Some have a breakaway function like that of booms. While that prevents flow obstructions, the device and its captured litter are lost downstream. Damage to the devices can also occur when large debris and branches impact them during storms. While these devices do concentrate the litter, they still require maintenance which is more difficult than for booms because of their more limited capacity and more complicated structure; for some depending on design, a concern has been entrapment of wildlife in the cages if debris prohibits their exit. For smaller structures vandalism has been a problem. Maintenance also requires that they be located where they can be accessed for maintenance; a few of the structures reviewed are deployed only at large culverts with a well-defined cross-section. Near creek mouths, as with the booms, maintenance access is more easily provided from the lake, but the benefit is offset by these locations receiving the highest flows (bottom of a watershed) and provide no benefit within the creeks upstream. Some devices have been installed and maintained by volunteers after storm events in several Alabama waterways (Bates, 2022).  If survey data, reporting and neighborhood requests identify specific locations that may naturally accumulate litter due to the flow patterns, these areas may be locations where testing smaller in-stream capture devices, perhaps with volunteer litter removal, could prevent further litter dispersion downstream.

**Table 3. In-Stream Trash Capture Devices**

| | Manufacturer Info | Locations Installed | Initial Cost* | Annual Maintenance Costs** |
|---|---|---|---|---|
| Bandalong Litter Trap; Stormwater Systems | Bandalong The Original Litter Trap - Storm Water Systems | Waycross, GA; Washington, DC; Little Rock, AK; Australia; Gainesville, GA; Prince George's County, MD; Mt. Rainier, WA; Athens, GA | $50K-$100K | $28K-$40K re District of Columbia SW Management |
| Bandalong-Bandit (small scale) | Introducing The Bandalong Bandit! - Storm Water Systems | Smaller waterways: Chattahoochee River Keeper, TN | $14,000 | Low |
| LitterGitter | https://osprey.world/litter-gitter | Mobile, AL: Mobile Bay National Estuary Program; East Baton Rouge Parish, LA; Birmingham, AL, | Medium | $20K-$45K. Osprey maintenance contract for several devices; Mobile, AL |
| Trash Trout Jr. | https://www.ashevillegreenworks.org/trash-trout.html | Asheville and other cities, NC; St. Louis, MO; Roan Mtn, TN; Elizabethton, TN | Large $25,000 Small (bank width <50 ft.) $7,500 | Low - depending on site installation |
| Elastec Brute Bin Trash Collector | https://www.elastec.com/products/floating-boom-barriers/trash-debris-boom/brute-bin/ | | $26,000 | |
| Trash Cage; Clearwater Mills | https://www.clearwatermills.com/trash-cages.html | Baltimore, MD | $75K-$110K with installation | $5K-$20K |
| *Capital Cost Sources: Manufacturer or Agency installing device. Where range is provided: High = $100K +; Medium = $10K-$100K; Low = <$10K | | | | |
| **Maintenance Cost: Agency who installed the device or estimates from (Shields, 2020) For maintenance, annual costs: High = $80K+; Medium= $20-$80K; Low = <$20K | | | | |

Cities that have a litter reduction requirement as part of their MS4 permits have invested significant resources including installation of a significant number of these types of expensive devices. These cities also can provide evaluation of the devices and their effectiveness. California has an approved list for devices that provide full pollutant capture including floatables, which is included in Appendix C. It is also highly recommended that before a large investment is made, results from testing by cities currently evaluating trash capture devices be reviewed to assess applicability to Austin based on similar flow, climate and topography along with maintenance requirements. As an indication of the interest in litter nationwide, the American Society of Testing and Materials (ASTM) has just announced a new standard test method for trash capture performance of stormwater control measures, E3332 (Standard Test Method for Determining Trash and/or Debris Capture Performance of Stormwater Control Measures (astm.org),

### *Deep Water Litter Collection Devices*

New technologies are being developed for automated removal by machines or robots; these efforts are spurred on by the attention to ocean waste and the profusion of plastics in our environment. Some devices for capturing litter will only function with a minimum water depth, excluding most Austin's creek locations. Many of these were developed for areas with deeper perennial creeks or tributaries entering a bay or are focused on plastic pollution in the ocean. Most automated devices for freshwater litter problems have a limited track record and there is a dearth of information on their effectiveness, ability to retrieve litter among vegetation, maintenance requirements, problems under high flow conditions and vandalism, but they are being demonstrated and tested in many locales. Automated litter collection devices have the same requirement to collect and dispose of collected litter, but they have the added complication of powering the devices. One benefit to consider for some of the more unique devices is the visibility and education value brought to the public, and in particular attention brought to the litter problem.

Another type of floating litter collector, applicable only in a deeper water setting, is a small skimming device like the "Sea Bin" that has been deployed in over 800 harbors and marinas worldwide. It acts as a floating garbage bin skimming the surface of the water by pumping water into the device. The Seabin V5 can intercept floating debris, plastics, and even microfibers with an additional filter. It requires power and thus must be moored to docks or boardwalks. Operational costs are estimated to be about $3/day and the catch bag capacity is about 20 kg; the manufacturer recommends that it be checked twice a day. The SeaBins can collect and transmit data. The USEPA and the Partnership for the Delaware Estuary have just begun (summer 2022) a program to study a network of devices placed in the river for litter removal, data collection, trash monitoring and water quality monitoring. (https://seabinproject.com/seabin-partners-with-us-epa-pde-philadelphia/ accessed June 15, 2022). SeaBins would only be a consideration at docks or on the boardwalk to keep those immediate areas free of litter and debris; they may become more attractive if solar charging for the pump can be incorporated.

There are many efforts to develop more automated litter collection devices (i.e., robotic devices). Most of these systems have been developed outside of the United States. The most fully developed litter robot appears to be the WasteShark. Multiple WasteSharks can be deployed, and plans indicate development of a station for emptying and recharging, but no station information was provided with the specifications from the manufacturer. The specifications indicate that each robot can recover up to 500 kg (1,100 lbs.) of trash per day, with a waste receptacle holding 180 liters (47.5 gallons). The WasteShark (Figure 6) can collect water quality information simultaneously and can be operated manually or autonomously with predefined routes.

Open Ocean Engineering based in Hong Kong has a similar device called a Clearbot which can collect up to 250 kg (550 lbs) of trash/trip and, uniquely, is solar powered. Open Ocean Engineering has recently partnered with the gaming company Razer to develop a detection system to identify trash for pickup. The Clearbot catalogues and categorizes trash as well. The biggest unknown and the biggest challenges for aquatic robots are operational. Most of these devices require recharging, and to facilitate a longer deployment-time the large trash volume capacity makes the devices bulky and difficult to transport. Lake access and variable flow velocities present some logistical issues for retrieving the litter robots for emptying and charging.

**Figure 6. Waste Shark Aquatic Litter Robot and photo to show scale** *(Photos courtesy of RanMarine for Wasteshark photo and IADYS – Interactive Autonomous Dynamic Systems for Jellyfishbot photo)*

Clear Blue Sea, a nonprofit based in Australia, has developed several solar powered prototypes of a "FRED" (Floating Robot for Eliminating Debris). They plan for FRED to be designed to be scaled up, modified, or replicated by anyone interested in improving marine waters. It is currently being piloted, but their plan is that it can be successfully constructed with readily available commercial products, and they will provide the design. Another nonprofit, the Urban Rivers program, has a prototype aquatic trash robot, but software issues and maintenance have been ongoing problems; their plan was that it could be controlled remotely by users online. They have concerns with vandalism and the loss of the robot, thus the implementation of a safety tether and a virtual GPS cage which will limit the area that can be served. Based on these initiatives, it might be worth pursuing sponsoring contests or working with University of Texas engineering students to construct devices.

The Jellyfishbot from an overseas company is now being heavily marketed (Figure 7). An interesting feature of the Jellyfish bot is that it can also be equipped with a sampling net for scientific collection purposes. The makers of the Jellyfishbot have offered to provide a demonstration in Austin.

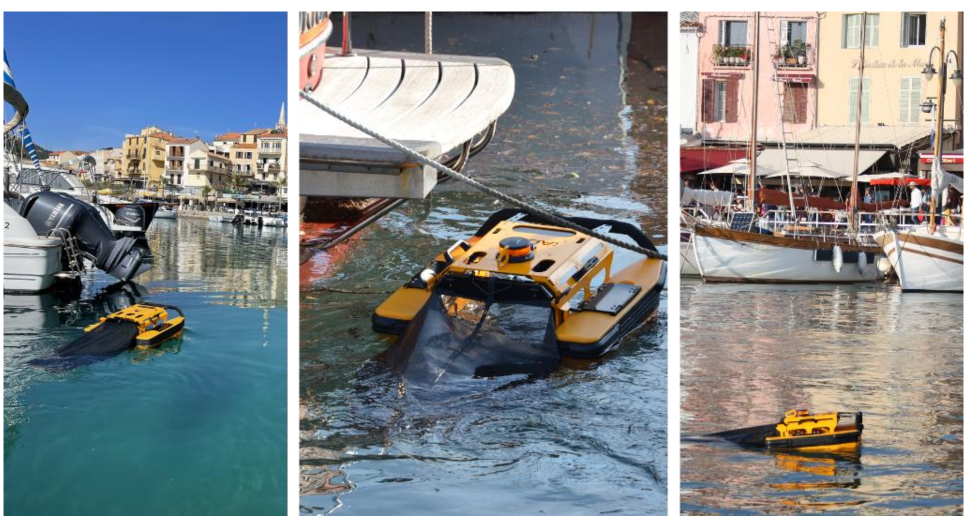

**Figure 7. Trash Robot, Jellyfishbot, deployed in harbor area** *(Photo courtesy of IADYS – Interactive Autonomous Dynamic Systems for Jellyfishbot photo)*

Some cities have piloted litter robots as part of community education campaigns and coordinated with sponsoring companies. IKEA introduced the "Good Ship IKEA" with its store opening in Greenwich, England, and Coca-Cola used pirate themed robotic vessels in London as part of the "Treasure your river campaign"; both had citizens pilot the boats. Implementation of the aquatic litter robots have not been extended on a long-term basis. Examples of other litter robots under development are a Kickstarter for development of a litter robot by the Urban Rivers program in Chicago with the intention of allowing remote online piloting by citizens and a very technologically advanced marine debris system using drones and autonomous robots called SeaClear in Europe

For some municipalities, large scale trash removal devices may offer the least ongoing operational and maintenance efforts, such as "Mr. Trash Wheel" (e.g., Figure 8) in Baltimore, Maryland. Several trash wheels prevent litter from entering the Baltimore harbor area or Chesapeake Bay, and one is proposed for Fort Worth, Texas to protect the Trinity River. Fort Worth intends to fund the initial $600,000 cost as well as $1,000,000 for 10 years of maintenance through donations. Baltimore's Trash Wheel cost was $800,000 with annual operating costs estimated at $130,000. Several restrictions make them impractical for application in Lady Bird Lake. Areas for installation of these devices do not have boat traffic. The stationary device uses water flow to carry the debris to the collection area via large booms that direct floatables to the wheel for removal. In Austin, the tributaries are frequently dry, and there is insufficient space in the creek outflow to station a large device. Attempting to collect trash within the lake itself would require booms that impede recreational watercraft from passing. Additionally, while the manufacturer, Clearwater Mills, has offered to evaluate whether they might be able to scale down such a device (for installation at a location such as the mouth of Shoal Creek), the maintenance access for the volume of trash collected would be difficult. Trash Wheels thus far have been deployed in deep-water locations attached to a dock or other station with access for dumpster removal. In addition, Lady Bird has multiple urban creeks flowing in that contribute to the trash problem so each would need a device to be effective at reducing trash in the lake.

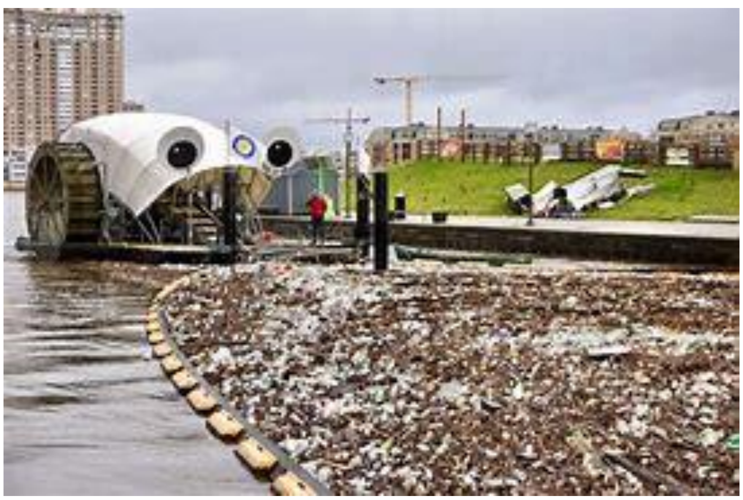

**Figure 8. Mr. Trash Wheel in Baltimore, MD** *(Courtesy of Waterfront Partnership, Baltimore, MD)*

One newly emerging technology to direct litter toward a collection device without obstructing flow uses a submerged air curtain. This technology is being tested in the Netherlands and is not yet available in the United States. This curtain of air might overcome constraints where a boom is not feasible, allowing the waterway to remain navigable yet still be able to divert the litter to a collection device or concentrate the litter in a confined area for collection. These devices, like many passive collection devices still rely on the water movement to transport the litter, so they must be placed in a flow-through system. It works by generating a screen of bubbles that block plastics and direct suspended plastics to the surface. The bubble curtain is placed diagonally across the entire waterway and guides plastic waste to the side and into a catchment system. The benefit to this type of system is that it does not obstruct watercraft or interfere with biological life, it may benefit aquatic life by increasing dissolved oxygen. The primary costs include installation, and energy costs for the pumps that generate the bubblers. One of these systems has been deployed in an Amsterdam canal (Figure 9). The Great Bubble Barrier effectiveness is described in a company newsletter:

> "Based on the results of the pilot at Deltares research institute, it has been calculated that the Great Bubble Barrier captures approximately 70-80% of top-surface floating plastic and 50% of plastic underwater. During the tests in the IJssel we looked at how these results translate in a river. We tested our Bubble Barrier at the IJssel in various weather conditions and came to the conclusion that it caught 86% of the (floating) test material. We can catch plastics with a size of 1mm and bigger, like granulate and Styrofoam. In the pilot at Wervershoof, we are investigating whether we can catch microplastics measuring 20 micrometers up to 500 micrometers (0.5 millimeters)."

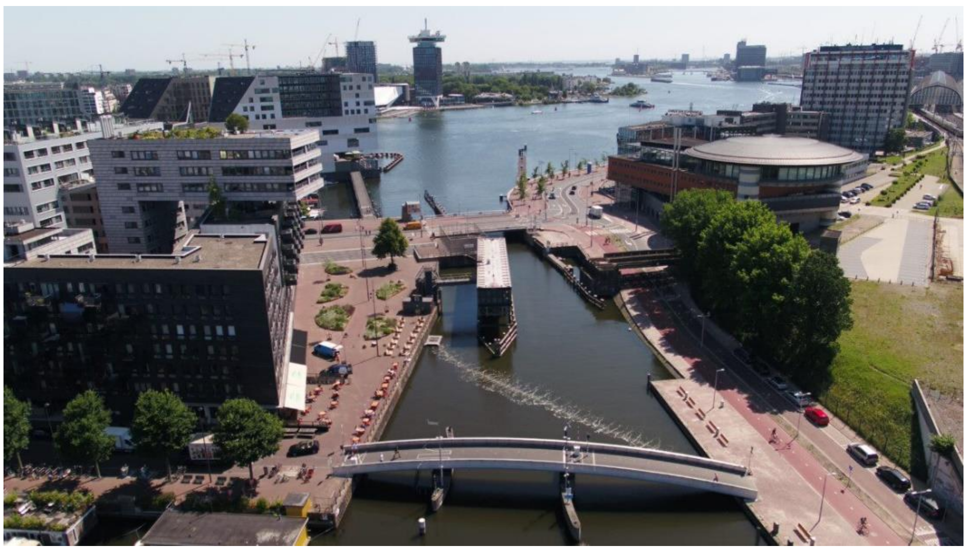

**Figure 9. Bubble barrier diverting flow to Containment Trap, Netherlands** *(Photo courtesy of The Great Bubble Barrier)*

Another similar system is called Azure, by Icthion. The costs of the systems were stated to be highly dependent on local conditions in width, depth, and flow velocity. The systems are comprised of a tube with openings along the bottom of the waterway through which air is pumped; the aeration has the added benefit of increasing oxygen in the water column.

## INTERCEPTION: Preventing or blocking trash from getting to waterways

The City of Austin has sanitation codes to prevent trash from becoming litter as well as protecting our waterways from pet waste (Table 4). Currently in Austin there are several methods to physically intercept the litter before it enters the stormwater system. In new development water quality ponds capture stormwater and intercept trash but may not capture or retain floatables if the storm event is larger than the required water quality volume. Much of central Austin's development occurred before those requirements or space is limited for placing devices. Austin does construct some retrofit facilities using the fee-in-lieu and other capital funds to construct water quality ponds to try and capture untreated flows. The Texas Department of Transportation has an Adopt-A-Highway program in place, and in a few particularly vulnerable crossings in the recharge zone, traps to capture highway spills are in place. These traps are quite effective for capturing litter as they are designed to contain oil which also floats on the water's surface. Observation also indicates they are also very effective at containing cigarette butts. Maintenance of these devices would minimize loss of captured litter, and additional cooperative agreements with TxDOT might allow the installation of trash traps along road swales and easements.

<table>
<tr><th colspan="2">Table 4. Applicable portion of City Code of Ordinances Title 10. Public Health Services and Sanitation and Pet Waste Sign</th></tr>
<tr><td>§ 10-5-42 - LITTERING PROHIBITED<br>(A) A person commits an offense if the person deposits or throws litter on a street, alley, sidewalk, premises, vacant lot, or public property, including a park or playground.<br>(B) A person commits an offense if the person deposits or throws litter along a street, alley, sidewalk, or public property, including a park or playground.<br>(C) A person commits an offense if the person deposits or throws litter from cleaning the interior of a residence, business, or premises on a street, alley, sidewalk, or creek.</td><td rowspan="3">

(Ladybird Lake Trail near Statesman Bat Observation Center)</td></tr>
<tr><td>§ 10-5-43 - LITTER REMOVAL REQUIRED.<br>The owner or occupant of a business or residence adjacent to a street, alley, sidewalk, or public property on which litter is located commits an offense if the owner or occupant fails to remove the litter from the one-half of the street adjacent to the owner or occupant's property not later than 24 hours after the owner or occupant becomes aware of the litter.</td></tr>
<tr><td>§ 10-5-45 – PENALTY<br>A person who violates this article commits a Class C misdemeanor, punishable in accordance with Section 1-1-99 (where this violation is punishable by a fine not to exceed $2000).</td></tr>
</table>

Pathways on the watershed surface can sometimes be identified and litter intercepted before it enters the storm drain system. In the downtown area of Austin, inlet filters are in place to capture large trash in areas most heavily used by tourists and for entertainment. These filters do not capture all trash as an overflow is provided to prevent street flooding. The labor to empty these regularly is quite demanding as they must be manually removed and emptied into collection vehicles. Because they are within the inlet itself this process cannot be mechanized. If the inlet sumps are pumped out on a regular basis, installation of a mesh hood within the inlet would exclude the floatables from moving down into storm sewer pipes. These devices might also increase maintenance requirements to prevent any clogging within the inlets. Trials of several inlet types have led staff to conclude that the filters originally put in place in Austin are preferred for ease of maintenance (pers. comm. John Beachy, WPD). Expanding the area where inlet filters are used is prohibitive due to the intensive manual maintenance requirements and thus, their use is limited to areas of high foot traffic and tourist activity.

*Prevent Litter from Reaching Waterways*

Methods that prevent litter on the watershed surfaces from entering the waterways provide protection not only for the receiving water bodies (reservoirs in Austin) but also the creeks. Ensuring that residents, commercial developments, and construction areas comply with existing regulations is a first line of defense. Philadelphia has instituted the [Streets & Walkways Education and Enforcement Program] (SWEEP) that educates Philadelphia residents, businesses, and property owners about sanitation regulations and enforces code violations. SWEEP officers are trained, uniformed civilians. They educate local businesses and apartment managers about their responsibility for keeping their properties clean, work with communities on outreach efforts, patrol streets to enforce litter laws, and issue warnings and citations. Philadelphia states that their entire SWEEP program, education and enforcement, costs approximately $2.3 million annually. This type of approach to keep watershed surfaces as clean and litter-free as possible, along with interception works to prevent litter from reaching waterways.

Some entities require the retention of litter when using the water bodies for recreation. One highly effective method on the Buffalo River in Arkansas is focused on requiring all river users to follow a set of National Park Service (NPS) rules for litter control (Table 5). Concessionaires on the river must have a permit from the NPS and display and enforce the rules as well as provide mesh litter bags. The provision of requiring mesh litter bags to be on watercrafts not only prevents the loss of trash into the water body but provides a place to contain any extra litter collected while recreating.

| **Table 5. National Park Service Watercraft Rules for Buffalo River, Arkansas** |
|---|
| • **Glass Containers:** The possession or use of glass containers in caves, on trails or waterways within 100 feet (30.48 meters) of any river or stream is prohibited for public safety, except in designated campgrounds, picnic sites, or in vehicles on designated roads and parking areas.<br>• **Mesh Litter Bags:** All canoes, kayaks, tubes, rafts, and other vessels easily susceptible to swamping, tipping, or rolling must have an attached closeable mesh litter bag. All trash must be disposed of safely and legally. A mesh litter bag is not required for people traveling without food or beverages. If you rent your vessel from a park authorized concessioner a litter bag will be provided with each vessel. You may also purchase a litter bag from a concessioner for use in your privately owned vessel. Visit our park's **Canoe Rental** page for a list of park authorized concessioners.<br>• **Fasten Cooler Lids:** If you are transporting food and/or beverages in a vessel on the river, it must be kept in a sealed cooler or container that prevents the contents from spilling into the river.<br>• **Use a Floating Holder (Koozie) for Beverages:** All beverage containers not securely contained in a sealed cooler or mesh litter bag must be held in a floating holder that is designed to prevent it from sinking beneath the surface of the water.<br>• **Foam Coolers:** The possession of polystyrene coolers (commonly known as Styrofoam) is prohibited while floating or camping along the Buffalo River, except in developed campgrounds, picnic areas, landings, roads, and parking lots. This prohibition includes cups, plates, coolers, ice chests, and containers. High-density bait containers, used solely for that purpose, are allowed. |

The City of Austin has similar parks rules, prohibiting concessionaires from selling refreshments in Styrofoam, and prohibiting glass and cigarettes in parks. Unfortunately, these rules do not apply to the waterbodies themselves and many citizens of Austin, but especially visitors, are unaware of the rules. Park rules should be published at parking areas and other access points to parks, creeks, and the river.

Currently the Parks and Recreation Department is working with concessionaires to develop "Leave No Trace" signs. Concessionaires could also be used as a vehicle to distribute mesh litter bags, even if not required, they could be offered. If informational tents are used by the City of Austin or other partners at launch and take-out points during high water traffic times, litter bags could be provided there as well. The link to parks rules on their webpage could benefit from a short rule summary as seen above for the Buffalo River.

One additional type of inlet protection are trash guards or curb inlet screens. Curb inlet guards simply block all trash from entering curb limits with screening or flaps (Figure 10). Curb inlet guards differ from inlet filters as they do not capture or retain the trash, but rather allow stormwater to enter while blocking litter that is then washed down gradient along the street curb, thus avoiding clogging. They were evaluated in California as an alternative to having to provide full capture for trash reduction and achieved a 63–78% reduction in trash (Fusco & Fons, 2019). While these are a low cost retrofit, they must be used in conjunction with a rigorous street cleaning program to collect the litter before entering the waterway through another path. Their benefit is exclusion of trash from inlets, while reducing maintenance difficulty. The disadvantage of these devices is that the street litter would remain visible until cleaned and may just move litter to another location downgradient of areas with inlet protection.


**Figure 10. Custom Curb Inlet Guard, Myrtle Beach and BioClean Curb Guard** *(Photo courtesy City of Myrtle Beach and BioClean)*

Some municipalities require that businesses and residents provide maintenance of sidewalks and adjacent portions of the street surface. New York City inspects and enforces their requirement that both residential and commercial properties clean sidewalks and the surface 18 inches from the curb. Austin has the requirement (Table 4) that the owner or occupant of a property remove litter adjacent to the street centerline but may require a program like the SWEEP program in Philadelphia to educate and monitor compliance. Advertisement of our reporting system (3-1-1) might facilitate those activities, and neighborhoods who are having a problem with excessive litter in commercial areas could be encouraged to use the Austin 311 system.

Austin has an existing street sweeping program; the frequency of street sweeping varies by area type. Some cities have more structured street sweeping programs that post street sweeping dates and times scheduled so that parked vehicles can be relocated. Baltimore posts parking requirements to facilitate daily sweeping in their downtown area, while areas that are swept monthly do not have signs but there is a schedule and residents are encouraged to move their vehicles. Typically, one side of the street at a time is cleaned, enabling cars to be simply switched to the alternate side. New York City also uses an alternate street side parking system, with tickets issued for cars blocking street sweepers; informational signs note schedules. If responses to 3-1-1 litter complaints are too numerous to address, they could be tracked in a geographic database and that information used to target the street sweeping program. Logistics of varying schedules may be difficult to implement, but that may be a project that could use advanced technology and transportation optimization software for future implementation. Increased street sweeping capabilities, including for curb inlet guards, comes at a capital cost of $200,000 for new sweepers and an estimated $60,000 for operating costs.

Other interception devices that were tested in the past that did not meet pollutant removal requirements, might be reconsidered as floatable controls. The devices that capture floatables within the storm drain system include those that can be inserted at junctions in the stormdrain system. A Stormceptor was installed in a storm drain junction in the Rosewood neighborhood for testing its efficiency, and it did not meet requirements for sediment and pollutant removal. If used solely for the trash capture, they could be effective for retaining floatables but the during the City testing the unit became clogged (Glick et al., 2013). Devices like hoods or trash guards within stormwater inlet catch basins can block trash from moving from the catch basin to the stormwater pipes. New York City has hoods installed in the catch basins to retain floatables in the sumps and inspects them on a regular basis or in response to complaints. Capital costs are comparable and maintenance requirements depend on maintenance of inlet catch basin sumps. A manhole must be removed, and the contents pumped out; if catch basin sumps are already being maintained using vactor trucks maintenance should not be significantly increased. If certain storm drains are transporting trash from a highly developed area, a limited number might be employed. Consideration might be given to including them as part of large construction pollution control plans. These sites lead to increased litter in the area with the introduction of numerous trucks carrying supplies. If the closest storm sewer junction downstream of the site was required to have a temporary insert and maintained regularly, it would capture the materials not retained on the site.

Another example of devices which are better for capture of floatables than pollutants are the large underground vaults put in place at the Austin Recreation Center and as pre-treatment to capture litter and debris before discharge of stormwater to the Convention Center Wet Pond. This type of device has also been used at some commercial areas due to lack of sufficient area for above ground ponds. A big issue with underground treatment devices is the tendency to allow maintenance to cease; the lack of visibility of the devices or their condition leads to neglect.

End of pipe solutions considered by Austin for capturing trash at a pipe or other outfall structure suffer similar problems with clogging/increased risk of flooding, access, and maintenance. An example of an outfall capture device that was evaluated in Austin are netting trash traps, essentially netting bags attached to the pipe (Figure 11). The maintenance can be simple if not desiring to sort trash; the entire filled netting attached to a pipe end is removed and discarded as a whole. The capital is relatively small for the first bag ($5,000 each for those tested in Austin) but since that cost must be repeated for each maintenance event, the long-term costs are enormous.

**Figure 11. StormX Netting Trash Traps** *(Photos courtesy of Stormwater Systems)*

Large commercial retail locations with high customer traffic often results in littered parking surface which gets washed into a waterway.  Another alternative or addition to an outfall capture device would be a requirement that these strip malls and large grocery establishments retain their litter on-site. These sites (defined by retail sales with parking area of a certain size) could be required to install fencing or other surface debris control of a specific height to contain blown material around their parking areas. This solution may lead to some unsightly areas of the enclosures, but the business would be required to retain their waste. Contrary to the Texas waste laws, this would be putting the onus of managing their waste on the proper entity rather than on the taxpayer. A requirement like this could be put in place as a development water quality control or it could be a negotiation for a frequently reported litter problem.

Each of these smaller scale solutions has the added benefit of improved litter conditions and the reduction in effort of removing litter after it enters the creeks. But, because these flows paths must be intercepted before reaching creeks,  many more locations must be treated. The most comprehensive litter capture solutions would be locating them at outlets at each drainage area. The large number of locations and thus devices needed, if not instituted for each development, makes the capital cost and maintenance requirements substantial.  Currently, volume exceeding the required capture for water quality ponds, bypasses or flow around the pond.  Wet ponds in particular catch a lot of trash due to their flow-through design.  These ponds do collect trash and must be maintained every 6 months per the Environmental Criteria Manual 1.6.3.  Inspection reports will show if there is a trash/debris deficiency during commercial and residential inspections.  Amending our development code to specify capture and treatment of floatables in all water control devices would be the most effective way to capture litter for new developments.

### *Increase Disposal Convenience*

Trash cans, dumpsters, recycling bins and all manner of trash collection devices are ubiquitous in our urban areas, but they are vulnerable to lack of use and overloading (Figure 12). Their effectiveness is ultimately limited by the diligence of use and frequency of emptying. Convenience and sufficient capacity of trash receptacles can, however, greatly increase their effectiveness. In the 1950's Disney increased the number of trash bins until a can is never more than 30 feet away, based on the distance at which improper disposal increases. Keep America Beautiful (KAB America 2021) found that at the time of improper disposal, the average distance to the nearest receptacle was 29 feet. Littering increases as the distance to a trash receptacle increases and more littering acts occur in areas that already have existing litter. An observation from a recent study on trash in Austin's creeks found that the amount of trash in encampments was highly variable (Clamann et al., 2022); some areas have little to no peripheral trash and others have a dense amount of trash. Areas that did not have much trash were typically near serviced trash receptacles whereas encampments deep in floodplain/greenbelts displayed a dense accumulation of trash.

**Figure 12 (a) Trash near paddling concession, Lady Bird Lake (left) and (b) PARD trash cans near paddling concession (right)** *(Stephen F. Austin Dr. across from Austin High School)*

Concessionaires on City of Austin land could also be required to provide litter bags to customers. Litter bags could also be provided by Austin staff doing "Leave No Trace" education events. The Missouri Department of Conservation's Stream Team Program, provides mesh trash bags to river recreationists, including through canoe-rental operations as part of their "Stash Your Trash" program. The program has an annual operating budget of $80,000 for the purchase of mesh bags to be distributed free of charge for the states more than 1.3 million visitors a year.

The simplest device to prevent trash from becoming litter on Ladybird Lake requires boaters to deposit their trash in a receptacle on the waterway itself. The City of San Marcos, Texas, deploys "Litter Boats" on their rivers during high use periods (Figure 13). Logistics to be considered include locations to avoid restricting boat traffic and maintenance requirements; San Marcos reported emptying boats several times a day during weekends and holidays (Amy Thomaides, City of San Marcos, pers. comm. 5/2/2022). This type of device is only applicable where people are recreating in the water without easy access to land-based trash receptacles. There is some concern that disposal as watercraft float by may miss the receptacles and rather than being retrieved and packed out, contribute to the litter problem.

**Figure 13. Litter Boat in San Marcos, Texas** *(Photo courtesy of Pecan Park Riverside RV Park)*

Potential locations for floating trash bins like the Trash Boats are areas where recreation and alcohol consumption are concentrated. During lake cleanups a high incidence of crushed cans and bottles and other beverage containers are seen below Barton Springs Pool and on the lake bottom where a delta has formed a shallow area as Barton Creek enters Lady Bird Lake. Barton Creek does not have a boom at that location because it would block the entrance of rented watercraft from the Zilker Park canoe/kayak rental venue as well as prohibit the regular recreational use of that lower portion of Barton Creek by standup paddleboarders. For the mouth of Barton Creek, a canoe or trash receptacle might be anchored or attached below Lou Neff Point, allowing emptying from the shore. Providing on-the-water receptacles not only provide a place close to the source for disposal of trash generated while enjoying the water, but also make it more convenient to dispose of other floating litter, thus encouraging litter collection during recreation.

Compacting trash receptacles are devices that have been incorporated in some programs because of their ability to contain 6-8 times as much waste as a regular bin (Figure 14). Austin Resource Recovery (ARR) had a trial of solar powered compacting trash bins on Guadalupe Street due to the problem of overfilling. It was determined that they would no longer be used for two primary reasons. The recycling side filled up quickly, but because of the nature of mixed recycling, the compaction was not ideal. The other reason was that ARR crews were already working on a regular fixed schedule, so the added benefit of a trash can that could alert staff when emptying was needed did not fit with routine maintenance. Philadelphia, incorporated the installation of close to 1000 solar-powered Big Belly trash receptacles throughout downtown and the commercial district. At a cost of over $4,000 per bin, major modifications to current maintenance programs would be required to offset the cost of the bins with any gain in reducing the emptying frequency due to compacting and directing efforts more towards high trash areas. Another added benefit of compactors is eliminating the ability to scavenge for trash. Two companies were identified that market these, both solar powered, Big Belly and Ecube Labs both offer optimization of bin maintenance and deployment.

**Figure 14. Solar Powered Compacting Trash Cans** *(Photo courtesy of Big Belly)*

Another area of frequent overfilling are outdoor eating establishments and other areas used for that purpose (Figure 15). Rules may need to be revisited for these commercial businesses, or requirements through the MS4 program coordinated. One suggested requirement is a lidded garbage receptacle for every picnic table, potentially along with increased dumpster requirements.

**Figure 15. Trash Area of Food Trailer Court** *(Photos from Juniper St., East Austin, TX)*

Some areas tend to have a plethora of litter due to their role as transition areas, where citizens are moving from into an area where smoking, beverages, or food are not allowed. Parking lots of secondary schools and to-go food establishments are areas where trash needs to be discarded and frequently the bins are inconvenient (more than 30' spacing) or overfilled. Schools should be encouraged to maintain their parking areas and bus stops. The City of Austin could work with Austin Independent School District (AISD) to promote environmental efforts from their students. Education programs discussed in the following section would recruit student participation.

Cigarette butts are not as visually obvious in the creeks themselves, but still litter the ground around benches, trash cans, and particularly in transition areas where smokers are going into an area where smoking is prohibited. One device that has been implemented in numerous cities worldwide is a "cigarette butler" or "sidewalk butler", a small disposal container that can be attached to a utility pole that is specifically for cigarette debris. In entertainment districts, these are reported to be effective in keeping the butts off the sidewalk, providing a convenient alternative to "flicking" them into storm drain inlets. Corpus Christi's downtown management district invested in these through a grant awarded by the Council of Governments and the Texas Commission on Environmental Quality (TCEQ). The UK organization Hubbub initiated a #neatstreets program with sectioned "ballot bins" (Figure 16), that "gamifies" cigarette butts by using them to vote on various topics (e.g., their favorite soccer player or sports team). Hubbub is a nonprofit that also provides free resources and campaigns. only asking that they be informed of the projects.

Bus stops are a prime location for cigarette butlers. They would require maintenance but could be emptied with the waste receptacles. Allowing beverages on buses might lead to them being left on the buses but might reduce loss to the environment if a waste container was provided on the buses. Compacting trash cans or, if a bottle bill were instituted in Texas, refund stations for containers at the bus stops are additional alternatives. Several cities have positioned solar powered compacting stations at bus stops including San Francisco and Philadelphia.

Terracycle is an organization to which you can ship tobacco waste (butts, cigarette packaging) and will recycle the waste for free. There is no cost unless you purchase shipping containers from them, but you can use any container. Maintenance coordinated with the Downtown Alliance for the downtown area and south congress would be initial locations to investigate. A successful funding opportunity is a cigarette litter tax; a litter survey and analysis of data collected using the Litterati App was used to justify, and in fact increase, a litter tax for San Francisco (pers. comm Jeff Kirschner, Litterati). Although the state of Texas prohibits any other jurisdiction from charging a cigarette tax (Texas Tax Code Title 2. Subchapter J. Sec. 154.601STATE CODE CITATION). it may be worth pursuing an increase in the state cigarette tax with the proceeds being distributed to municipalities for litter abatement.

Philadelphia also created the "Community Cans" program to place over 50 wire mesh litter cans in the public right-of-way, in partnership with sponsors in commercial districts. Although cleanup at event sites might be sufficient, parking areas such as the Mopac Access Road, north of the river near Zilker Park, and other adjacent event parking areas, might be considered for temporary trash receptacles. Temporary trash receptacles could be coordinated with roadway barrier distribution and pickup after the event. The importance of the provision and maintenance of abundant litter receptacles is emphasized in almost every big city.

**Figure 16. Vote with your Butt London "Neat Streets" project through Hubbub.** *(Photo courtesy of Hubbub)*

Another source of litter is spilled trash during recycle and trash collection, both at commercial and residential locations, and illegal dumping. For commercial facilities, increasing inspection of waste areas may address this as well as reporting. For city collection, it may be another opportunity to coordinate with street sweeping on the same or next day which would also make it easier for residents to remember to relocate street parked vehicles if implemented. The City of New Orleans had a problem with illegal dumping near their ports, so they installed a dumpster in the area, which a contractor removes and replaces every two or three weeks for $200; $7,000 was spent to develop signage directing trucks to the location (USEPA 2016). Travis County funded a comprehensive study to identify strategies to address illegal dumping (TSU 2021). The study found that it is five times more expensive to cleanup than prevent illegal dumping. As a result, the county has established an online tool to help locate disposal methods more easily at www.traviscountyrecycles.com. Texas State University also recommended developing an illegal dumping online reporting tool, collecting data from that effort, and implementing pilot programs for reduced-cost options for waste disposal.

### *Community Education*

The City of Austin has a robust community education strategy with programs in youth education, marketing and technology. The desired result is changing individual behavior patterns to properly dispose of waste and participate in cleanup programs. The Watershed Department has recently used new applications of statistical methods, collaborating with the University of Texas to analyze the response to outreach programs and identify programs that successfully move citizens from awareness of a problem, to gaining their interest and desiring to help, all the way to taking action. Use of that type of analysis would target programs that successfully change citizen and visitor patterns, from awareness to action. More information on this new effort can be obtained through the Data Analysis/Decision Support Team in the Watershed Protection Department.

KAB-America identified 85% of littering as the result of individual attitudes and state that changing individual behavior is key to preventing litter. Every jurisdiction contacted has community education programs and campaigns. Each jurisdiction, however, has consistently offered the opinion that while education in schools is essential to establish a baseline understanding of an individual's impact on the community, anti-litter slogans and campaigns lose their influence over time. Some programs, tap into a community's identification and pride of place. "Don't Mess With Texas" has been repeatedly cited as an example of a highly effective campaign and efforts to replace it have met with resistance. However, enhancements to refresh a campaign, such as using native Texas actor Matthew McConaughey can bring new recognition to the issues. Signs, even those displaying rules, have the same problem of lack of notice when they have been in place for an extended time. Without enforcement action or notice of violations, they soon become ignored.

One program that many municipalities have adopted is marking storm drains. Markers or painted signs on stormdrain inlets inform citizens that anything discarded in the drains ends up in the creek. Austin has a stormdrain marking program that has marked approximately 12,000 stormdrains (Figure 17). This program educates citizens that the items that enter the inlets do not go to a treatment plant, which can be a perception for people from areas with a combined sewer system, that route stormwater and sewage to treatment plants. While these older combined sewer systems are being phased out, the perception that pipes lead to a treatment plant still lingers. In high tourist areas, more eye-catching graphics might be employed to attract attention and prohibit the casual disposal of items into the storm drains and onto the streets. Japan has a street decorated with a paint that is only visible when wet which brings a surprise element to the flow pathways on the street surface leading to the inlets.


**Figure 17. Stormdrain Inlet Art** *(Photos courtesy of Friends of the River, Fort Wayne, IN)*

The Don't mess with Texas campaign has an app to report litterers In Texas and in almost all jurisdictions reported violators receive a notification in the mail (identified by license plate number) stating the law and the potential fine if an officer observes them littering. Representatives from several jurisdictions have communicated that fines are primarily assessed only in the case of illegal dumping, which have higher penalties. When asked how likely it is for someone to get caught or fined because of littering in a Philadelphia study, approximately 80% of respondents said, "Not likely at all" (Pennsylvania Litte Research Study 2020). The City of Austin has incorporated a message about reporting people parking in handicapped spaces on some of their meter pay stations; there may be an opportunity to include the Report A Litterer program information there as well or on metering stations in severely littered areas.

A highly recognized slogan like "Leave No Trace" becomes an ethic that many people adopt and use to call out bad behavior. Incorporation of that nationally recognized slogan into Austin's education campaigns taps already established behaviors associated with the slogan. And although the slogan in the past was used for wilderness camping and hiking, the concepts should carry over to packing out and proper disposal even when visiting an urban trail or water feature as well as enjoying a park.

One enhancement to Austin efforts would encourage reporting of frequently overfilled trash cans. A model that could be used is the "How am I driving" sticker seen on commercial vehicles; a sign could be posted on prioritized trash cans with a QR code for reporting ("Am I too full? Please report here"). An example priority area would be overfilled parkland trash receptacles and concessionaire trash facilities in parks. While contracts with concessionaires require that they manage their own trash, they are frequently overfilled and nearby park receptacles quickly become overfilled as well (Figure 12b). Combined prominent "Leave No Trace" signage (including how to report litter issues) and perhaps even litter fine reminders, would encourage proper disposal.

The City of Austin incorporates litter education into its youth programs at all education levels. These efforts have been expanded, revised, and evaluated over time, from sorting trash to examining waste streams (using a recycling relay game) to watershed models that teach how pollutants move through the watershed (using physical models and Trash Travels posters). One enhancement of the programs would be to encourage more schools to adopt a nearby creek segment or at least include a "Love Where You Live" cleanup as part of their program. Recruitment could be coordinated through school science programs and school clubs and community service hours could be used as an inducement for participation. Schools should be encouraged to provide opportunities and sanction time for students to perform cleanups, design signs, design a program, or even generate an app to help with cleanups. Sports events and litter generated there provide another opportunity for volunteer cleanups (by service clubs or for service hours) and education.

Litter education could also be expanded to include data and even geographic analysis depending on the grade level. Several Apps have been developed that allow the collection and analysis of litter collection data. One of the apps is discussed below, but app use could be incorporated in Austin's environmental education. The City of Austin investigated the use of the Litterati App for their recent Trash in Creeks survey; this App includes a sophisticated program to quantify litter collected by type and even by brand, along with geographic location data. The software has a recognition function that identifies this information from a photograph of each piece of litter collected. Raw data can be downloaded free, but more selective retrieval and in-depth data analysis and visualization is done by Litterati under a contract or cooperative program. Some cities are participating in the efforts, but some have also identified difficulties with using the data. Over time, if many of the participants in cleanup activities entered their data into the same App, the data acquired might approach that achieved by a comprehensive random sampling plan. Some issues of concern are user bias in litter collection (sometimes biodegradable items or smaller fragments are not retrieved). The data may also be heavily weighted for more frequent users or locations that are more frequently visited. Franklin County in North Carolina has a contract with Litterati, but a county representative who works with cleanups noted that the biggest drawback is the substantial increase in time required for cleanups, since each individual cigarette butt or piece of paper is photographed. Most programs track general quantities, like number of trash bags, or for large City efforts pounds collected, which is easily comparable across programs and locations.

Cleanup programs for watershed surfaces are like those for creeks. KAB-Austin has the "Love Where You Live" program that provides equipment and trash pickup, if notified in advance, for individual or group cleanups at any location. A recent trend in the US is to engage people in litter pickup who are out frequently exercising or walking. Sweden began the trend called "plogging" and in Swedish it means pick up and run and it is catching on globally. You can even purchase backpacks and bags, or plogging kits (a bag and a folding grabber). A quick search of the hashtag #plogging on Instagram or social media shows the increasing popularity all over the planet. Some towns have embraced plogging and are organizing events. The Hillsborough Township Community in New Jersey frequently includes the fact that plogging burns about 22% more calories than jogging alone. To highlight and promote this new activity they sponsored events with the first 100 participants receiving plogging litter cleanup kits. Some communities have formed groups to "plog" together at a regularly scheduled time. "Plogging the Keys" meets on the same day each week at a different location. Individuals who prefer to "plog" on their own can still be involved in a community that shares their efforts such as the Facebook group "Plogging in the USA" (which has a #dontmesswithtexas entry). A plogging campaign could kick-off the sport in Austin by providing equipment, perhaps as an extension of KAB-Austin's "Love Where You Live" program. Informational packets could be provided to institutions, schools, the YMCA, and other organizations who might use the activity for team building or as an additional summer camp activity.

As Austin continues to grow, its litter problem reflects the population increase which includes the large influx of visitors. Many of our programs focus on our citizens. More effort may need to be made to prevent improper waste disposal by visitors who don't have the same motivation as citizens to protect the environment they live in. A program expansion might focus on convenience and capacity of visitor areas, with reminders displayed, and highly visible events and cleanups that can be tied with tour activities and new experiences like plastic fishing or plogging. As cleanup efforts that include visitors have increasing participation, results should include not only a cleaner environment, but increased motivation of participants to be more careful to properly dispose of waste in our city.

All the efforts that prevent litter from entering our waterways are a better solution than perennial cleaning. An example of costs of a large-scale campaign was Your Litter Hits Close to Home in Maryland, Virginia and the District of Columbia including advertisement, visuals, communication, and community outreach. Over approximately six years, a total of about $500,000 was spent on implementing the program, fronted by approximately $300,0000 in research and development of the program. A smaller scale example is the Trash Free Schools Project in Maryland and the District of Columbia sponsored by the Ferguson Foundation with an annual budget of $15,000.

The Clean Water Fund developed a technical assistance program that partners with local governments to "ReThink Disposable" packaging. Their program costs are approximately $300,000 per year. They found that the cost to businesses is the purchase of re-useable products with a proven payback period, but they save an average of $3,000 to $4,000 annually after the initial investment. In San Francisco, 112 food businesses and four institutions reduced disposable product usage by over 10 million products and prevented 120,000 pounds of waste. A case study with a high school resulted in annual savings of $6,459 in food ware costs and a reduction of 3,376 pounds of waste. Case Studies can be found at https://rethinkdisposable.org along with resources opportunities to partner.

Even though preventing litter from entering our waterways is a more effective and less difficult than physical removal, it still requires constant diligence and ongoing expense and ultimately may do nothing to affect the flow of single use and disposable items into and throughout our community.

## Source Reduction: Stemming the Flow Into our Community

### *Regulations*

Regulating the production or use of materials or specific products are perhaps the most difficult solutions to implement. Although they may initially seem the least expensive solution with no initial capital investment or ongoing maintenance there are potential large development and implementation costs such as interfacing with impacted business communities and potential legal fees.

The most effective method of reducing litter is to eliminate availability of materials that are most frequently discarded and are most predominantly seen in our waterways. Austin has regulated some materials primarily based on health and safety. Cigarettes and glass are banned in our park system unless otherwise specified or if allowed for certain events. To aid in the litter problem, PARD has also banned the use of Styrofoam containers by concessionaires selling refreshments on City property. WPD's recent Trash in Creeks survey (Clamann et al., 2022) noted that plastics were numerically dominant in all watersheds. Polystyrenes and other floatables were also frequently amongst the most common materials observed. These materials are used to produce most single use containers for beverages and to-go containers. Large fabric materials could, however, dominate the observed litter based on their greater volume. Besides the large physical size of fabric items found, from clothing to sleeping bags and blankets, when saturated in the creeks they become heavy. Their prevalence may be due to their lack of movement as they are weighed down or entangled and trapped on rocks, branches, and bridge structures. Plastic, polystyrenes and other floatables on the other hand are more easily transported through the creeks and to the Colorado River.

Some entities report a reduction in litter in areas that have bans/restrictions. The Marine Conservation Society (MCS), which runs the largest annual cleanup event in the United Kingdom (UK), found that litter on beaches has dropped to the lowest level in more than 20 years, after a ban on a few single-use plastic items (such as plastic bags and cotton ear buds). The reduction was significant even though plastics and polystyrene still made up 75% of all the litter collected (MCS 2014).

Cities and states in the US with various bans in place all reported success in reducing litter. The most banned materials are plastic grocery bags, single-use plastic water or beverage bottles and polystyrene food packaging. California's state agency said that they are seeing a substantial decline in plastic grocery bag litter on beaches, rivers, and parkways after a single-use plastic bag ban; this reduction is supported by data collected from the Coastal Clean-Up Day only a year after the ban went into effect. Sometimes additional measures are needed when only one specific product is banned. The University of Vermont saw an initial increase in consumption of other bottled beverages (Berman & Johnson, 2015); they are continuing their efforts by increasing water stations and stocking them with biodegradable cups. (Berman & Johnson, 2015). The overwhelming opinion of government and nonprofit representatives where bans were in place was that regulations have the most immediate and largest impact on litter. An added impetus for reduction of plastic materials is that they use large amounts of petroleum resources to produce as well as contributing to less visible microplastics in the environment and our drinking water.

Comprehensive bans of multiple litter materials or product types have even been put in place at a national scale. For example, India is banning 19 identified single-use plastics, including polystyrene and "expanded polystyrene" (aka Styrofoam), beginning July 1 of 2022. And, in India in August of 2021 the manufacturing, import, stocking, distribution, sale, and use of identified single-use plastic commodities was phased out because of their low utility and high littering potential. The Indian Environment Minister has said the ban will be strictly enforced with penalties including jail time.

Some jurisdictions have bans on multiple products, as separate or combined laws. Usually the bans were phased in, providing time for the products to be replaced with re-useable or compostable products. The bans that have been in place have faced several issues. For example, the definition of a single-use bag sometimes led to slightly thicker bags or the definition of compostable was not specific and led to containers that could not be accepted into the composting waste stream. The prevalence of single-use plastic/polystyrene beverage and food containers from the Trash in Creeks survey in Austin indicates that any reduction in their use would provide a significant reduction in litter.

### *Single Use Plastic Bags*

The most widespread bans are on single-use plastic bags and on polystyrene products. Single-use plastic bags are used on average for 12 minutes. Humans use 5 trillion plastic bags per year; 160,000 a second; 700/year for every single person on the planet (https://www.theworldcounts.com/challenges/planet-earth/waste/plastic-bags-used-per-year accessed May 20, 2022). Recycling rates at different times and in different areas are cited as only between 1-5%.

If single-use plastic bags don't wind up in a landfill, the bags litter the landscape, clog storm drains, pollute rivers and oceans, and choke and kill wildlife. A six-week study of 80 random sampling points across Austin called Trashblitz by a partnership of organizations found that trash bags were among the top ten most frequently found waste materials (Trashblitz and Litterati 2021). Keep America Beautiful's 2020 National Litter Study cited it in the top twenty most frequent litter items, using a different categorization method. The City of Austin and at least ten other cities in Texas had instituted plastic bag bans or fees for their use. The Texas Supreme Court, however ruled that Laredo's ban conflicted with a 1993 solid-waste disposal state statute thus nullifying those efforts (https://www.texasattorneygeneral.gov/news/releases/ag-paxton-warns-11-cities-their-bag-bans-are-illegal accessed 5/10/2022) . The Texas Solid Waste Disposal Act which states that local governments may not "prohibit or restrict, for solid waste management purposes, the sale or use of a container or package in a manner not authorized by state law" or "assess a fee or deposit on the sale or use of a container or package" was used to preempt local bag laws. This precedent would be hard to overturn for all containers or packaging as well as for fees or taxes used as disincentives. Although a bag ban is no longer an option in Texas it must be noted that it has been highly effective in other parts of the country as reported by representatives from several cities and follow-up studies. In Washington D.C. after institution of their bag bill, 67% of residents and businesses reported seeing fewer plastic bags as litter and 50% of businesses have saved money.

A data map on Plasticbaglaws.org shows that as of October 2021, 2020, 10 states have statewide bans and an additional eleven contain jurisdictional bans without state preemption while 19 states, including Texas, have laws preempting plastic bag laws as discussed above (https://www.plasticbaglaws.org/bagmaps accessed 4/13/2022); there are a total of over 300 municipalities that have banned plastic bags.

Looking at other bans, incentives, and disincentives options, like those provided in the Surfrider Foundation's Plastic Bag Law Activist Toolkit (Romer, 2019), may make alternative products (to plastic) more cost competitive or more attractive. Plastic bags do not have to be single use. They can be reused and the low-density polyethylene plastic (LDPE) they are made of can be recycled or burned with other things to produce energy. The low rates of recycling lead to the discard of 100 billion bags a year. Single use bags are hard to recycle because they jam sorting equipment at recycling facilities, thus requiring hand sorting. One approach suggested would be to require post-consumer recycled content in plastic bags as described in the following excerpt from the Plastic Bag Law Activist Toolkit:

> "Most local bag laws in the U.S. require post-consumer content for paper bags. Post-consumer recycled content is material from products that people or businesses already used (e.g., shipping cartons, plastic bottles) versus pre- consumer recycled content, which is material from the manufacturing process (e.g., scraps left over when envelopes are cut). It's important to require post-consumer recycled content to drive a market for truly recycled materials and divert recyclable materials from landfill. Under most ordinances, paper carryout bags must be 100% recyclable and include a minimum of 40% post-consumer recycled content. Standard-sized paper shopping bags that meet these criteria are now widely available. Requiring post-consumer recycled content for paper bags is important in straight plastic bag bans, because environmental impacts of paper versus plastic bags are closely analyzed. Many ordinances also require that paper bags must contain no old growth fiber.
>
> Until recently, most ordinances did not require post-consumer recycled content for plastic bags because plastic bags containing post-consumer recycled content were difficult to obtain. However, the California statewide law has created a market for post-consumer recycled content film plastic bags. The California statewide bag law requires that bags marketed as reusable that are made from plastic film must be made from a minimum of 20% post-consumer recycled material after January 1, 2016. As more and more jurisdictions require post-consumer content, the

percentage of post-consumer content readily available should be monitored and requirements should be adjusted accordingly."

Other approaches attempting to include disincentives for plastic bags used by retail stores might be adding fees or justifying the required collection of single-use plastic bags by the retail stores using them as part of the City's zero waste efforts. If used in conjunction with requiring recycled content in bags, stores might be more inclined to use alternatives.

### *Polystyrene*

Polystyrene and Styrofoam are problematic for several reasons. They are light and therefore easily transported by wind or water, they are difficult to recycle, brittle and easily break into small pieces that are more difficult to retrieve from the environment and presents a danger to aquatic life. Dangers of polystyrene in the environment come from its ability to pick up contaminants, becoming a toxic material, the ingestion of tiny polystyrene pieces by wildlife, and its potential to cause obstructions to flow. Polystyrene is broken down to microplastics in the environment (Helmberger et al., 2022). These microplastics have now been identified in almost every type of environmental media: soil, air, and water, drinking water supplies, and in human blood. The EPA National Human Adipose Tissue Survey for 1986 identified styrene (used to produce polystyrene) in 100% of all samples of human fat tissue taken in 1982 in the US (El-Ziney et al., 2016).

Twenty-nine countries have regulations against polystyrene; in France and Germany the ban is restricted to foam take-out containers only. In Austin, some highly specific restrictions reduce the localized use of polystyrene such as a prohibition for use by concessionaires in City parks. Austin is prohibited from banning polystyrene containers city-wide due to State law. In the United States, as of 2021 seven states have banned EPS foam, with three of those in effect in 2021 and the others being phased in at later dates. In addition, other smaller jurisdictions have also banned it, including San Marcos, CA, and Washington DC, which banned polystyrene foam take-out containers and then expanded it to include all retail sales. Florida municipalities and counties have attempted to ban polystyrene on beaches, but those rules have been challenged. In September 2021, however, Florida introduced a proposed phaseout of polystyrene foam food packaging. The Florida Legislature will consider the proposed rule this year. (Nikki Fried Press release September 24, 2021). Florida State Commissioner Fried cited the hidden danger to public health from these disposable consumer products citing the link to human and animal health concerns from the chemicals and the long period required for decomposition. The distinction of banning a material for health reasons rather than for the purposes of limiting litter may be important if a ban is pursued to avoid preemption of a ban at the state level. Alternatives to a ban, would be sustainability requirements around packaging and food service containers; an approach like requiring that single-use bags include some percent of recycled material. If packing and food service containers were required to be made of compostable materials, the market would quickly identify materials like the cardboard to-go containers or the mushroom packaging that IKEA has announced to replace its Styrofoam packaging. There are some voluntary programs for reduction. New York City Public Schools through an organization called Cafeteria Culture, instituted "Trayless Tuesdays" in New York Public Schools, diverting 2.4 million plastic foam trays per month from the waste stream (USEPA 2016).

### *Beverage containers*

Some bans have been very specific, banning for instance, plastic water bottles. They are usually smaller scale bans, proposed and enacted in several municipalities and campuses over such concerns as resource wastage, transportation emissions, plastic litter, and damage to affected aquifers.

Some municipalities in Australia and Canada have enacted bottled water bans. The Australian town of Bundanoon offers public drinking fountains and filtered water dispensers,  and stores sell empty reusable bottles (BUNDANOON JOURNAL July 2009). Many municipalities in Canada and some in the U.S. have instead prohibited them only on city property. In Toronto, the ban prohibits the sale and distribution of water bottles in all civic centers, city facilities. and parks. San Francisco has stiff penalties if plastic water bottles are sold at events and are also installing outdoor water bottling refilling stations. In Cape Cod Massachusetts, the ban on city property extends to soft drinks in plastic bottles. Quite a few college campuses and some municipalities have banned the sale of beverages in single-use plastic, though there is some feeling that banning bottled water encourages drinking other less healthy beverages instead. A key component to the success in reducing plastic water bottles is availability of water stations including outside (for example, for the homeless population), and having readily available reusable bottles.  Austin Water Utility is installing twelve water stations (Figure 18) in the Central Business District. Coordinating this increased availability of refill stations with efforts to encourage or provide reusable bottles could reduce one use bottles being discarded in public space.


**Figure 18. New Austin Water Water Stations** *(at Trinity St. and E. Cesar Chavez St.)*

Although the alternative of reusable water bottles and fill stations is a simple solution, in some instances, they are more inconvenient. The discard of plastic water bottles is ubiquitous on Austin's trails and high pedestrian traffic areas. Incentives for travelers to use reusable bottles is an area that needs to be investigated. Tourists use around 30 plastic bottles per person for a two-week trip. Perhaps large events that attract large numbers of participants, like SXSW, could be encouraged to supply both refillable bottles and large drinking water containers in event areas.

Another alternative to single use plastic bottled water is aluminum canned water. Aluminum cans are unique in that they are most often recycled directly, meaning that the average can has a very high percentage of recycled content. This means that aluminum cans have more than three times the recycled content than EPA estimates for glass or plastic, with 70% recycled content on average. Innovative alternatives to plastics continue to emerge. A group of students has managed to create a biodegradable plastic bottle from algae and other natural materials. The implementation and use of a product like this could take a big cut in the use of plastics.

Container deposit legislation mandates a refundable deposit on certain types of recyclable beverage containers. Deposit efforts are effective because it includes an incentive for the user not to discard their container and have been demonstrated to be highly effective, especially in homeless communities. Opinion polls show the public supports bottle bills, but the beverage and packaging industries have blocked bottle bills in nearly 40 states and even the successful programs are still threatened. There are ten U.S. states with these "bottle bills." Studies show that the recycling rate for beverage containers is vastly increased with a bottle bill. The United States' overall beverage container recycling rate is approximately 33%, while states with container deposit laws have a 70% average rate of beverage container recycling. Michigan's recycling rate of 97% from 1990 to 2008 was the highest in the nation, as is its ten-cent deposit (Gitlitz & Franklin, 2006). Studies in seven states show that beverage container legislation has reduced beverage container litter from 69% to 84% and reductions in total roadside litter range from 30% to 64%.

Texas unsuccessfully attempted to introduce a bottle bill in 2011, 2013, and again in 2015. The bill set a redemption goal and deposit rates. Containers made of glass, plastic or aluminum with a capacity of 4 L (1.1 U.S. gal) or less would have been covered. The Texas bottle bill did not gather enough votes (https://en.wikipedia.org/wiki/Container_deposit_legislation_in_the_United_States#Repealed_legislation and https://www.bottlebill.org/index.php/past-campaigns/texas-past-campaigns accessed February 10, 2022). One interesting alternative are machines that entice recyclers to deposit beverage containers for the chance to win a prize, point cards or cash. Tomra Reverse vending (tomra.com) is a company that works with retailers where container deposits are accepted, but also could be used at those transition points on the watershed surface that collect large volumes of litter. And in another example, a McDonalds in Stockholm lets you pay for food with recycled cans (Figure 19).


**Figure 19. McDonalds Stockholm, Food for Cans** *(Photo courtesy of DDB Stockholm Agency)*

Comprehensive bans of specific materials for municipalities in the state of Texas or even container deposit legislation may not be feasible due to the Texas Supreme Court ruling preempting local bans, as described below for single-use plastic bags. However, it may be worth investigating other ways to achieve the same result. The Surf-rider Foundation has a database of over 1,000 regulations that have been in place regarding plastics and toolkits for making policy. Sources of data cited above include lists of those cities and states that have bans or restrictions in place. All the entities contacted that had bans in place reported that they were highly effective in reducing those materials being discarded. Restrictions were frequently described as making the most significant difference in litter.

### *Use Restrictions*

There are a few examples of more comprehensive rules that protect a particular natural resource. These restrictions appear to be more enforceable and sometimes easier to implement, particularly if they are related to health and safety. Beach communities frequently ban glass containers on their beaches. Parks ban alcohol. The State of Texas bans glass in riverbeds in counties within 85 miles of an international border. (Texas Health and Safety Code 365.035). The National Park Service has many parks with specific restrictions, sometimes relating to the wildlife habitat, but also in protecting a particular water body. As cited in Section 3, glass and Styrofoam coolers are banned on the Buffalo River in Arkansas and Denali National Park has extensive Leave No Trace rules.

Disposable items (e.g., cans, plastics, glass, foam or paper) and alcohol are prohibited by law on the Rainbow River in Dunnellon, Florida, however reusable containers are allowed. The City of New Braunfels bans single-use items on the Guadalupe and Comal Rivers, a ban so-called the "Can-Ban". The ordinance also prohibits all glass and Styrofoam, limits cooler size, and assesses a $2 River Management Fee for non-residents. New Braunfels' original 2011 ordinance was challenged in court and suspended, but revived in October 2017, after the Texas Supreme Court refused to strike it down. Fines of $500 are assessed and citations are regularly issued for those that have banned items.

As the population grows, so grows recreation on Lady Bird Lake (Figure 20), leading to increased littering of single use (glass, aluminum, plastic) beverage containers, discarded clothing, polystyrene coolers, and fishing gear, whether intentionally or inadvertently. Structural controls will not address the problem of litter released directly into the lake, and the City already has staff dedicated to cleanup of the surface as well as volunteer efforts. Any new and mechanized/robot devices will still require removal and disposal of the materials collected. Prohibition of single use containers (glass, plastic, and styrenes) would yield a significant decrease in some of the materials seen. If the City were to institute rules solely for Lady Bird Lake or the Colorado River within the city limits, restrictions could be published and enforced at concessions that rent watercraft as well as other launch points. An initial effort to educate local citizens with informational booths at launch points and perhaps staff at concessionaires as well and information provided to hotels and other venues could help inform compliance.

**Figure 20. Recreation levels in Lady Bird Lake at Barton Creek confluence in peak use**
*(Photo courtesy of Texas Monthly, published in July 2022 issue)*

## Conclusions

Solutions were compiled from among those employed across the nation and listed in Tables 6, 7 and 8. The solutions are discussed here in a bottom-up approach, from clean-up in creeks and reservoirs (Table 6, Extraction) to preventing litter from entering our waterways (Table 7, Interception), and finally the most comprehensive approach of reducing litter sources (Table 8, Source Reduction); requirements for supporting actions are also identified. For each solution the first column provides a relative cost and benefit assessment. The cost level ($-$$$ or <$10,000 to >$100,000); a range is provided where the scale of implementation is the determining factor. Although maintenance is not included in cost estimates, an "M" is included to indicate frequent maintenance is required. Finally, a comparative benefit is estimated where "◊◊◊" indicates solutions recommended for implementation or trial, with the number of diamonds indicating the level of confidence. A "♦" is included where a solution is unsuitable for Austin or may cause clogging in storm drains or outfalls. Following each of the tables are some key findings about the most promising solutions, particularly as they relate to Austin.

| **Table 6. Extraction: Solutions to pull litter directly from waterways.** | | | |
|---|---|---|---|
| **Cost/ Benefit** | **Strategy** | **Current/potential use** | **Comments/Obstacles** |
| $$-$$$ ◊ | Increased Manual (paid) cleanup | COA full-time crews plus additional efforts funded through volunteer and subcontractors | Coordination with other entities is lacking, which may be needed to target the critical areas. |

| Table 6. Extraction: Solutions to pull litter directly from waterways. | | | |
|---|---|---|---|
| **Cost/ Benefit** | **Strategy** | **Current/potential use** | **Comments/Obstacles** |
| $$ ◊◊◊ | Violet bag program | COA promotes, distributes and actively uses during cleanups | Provision of trash collection for homeless encampment locations |
| $$$ M ♦ | Trash Wheel | Currently several installed in Baltimore and planned for Fort Worth. | Limited area of effectiveness. Potential for use with "bubble barrier", new technology to divert floating litter without obstructing boat traffic. Maintenance and access issues. |
| $-$$ M ◊ | Trash Booms | COA utilizes in Lady Bird | Trash lost during large storm events and inhibited watercraft access |
| $$ M ◊ | In-Stream Litter Traps [e.g. Litter Gitter, Bandalong] | Trash cages centered in current booms or additional locations to retain captured litter better and ease collection. | Medium Cost; Need to test for animal entrapment, esp. where creeks dry and for ease of emptying and durability in storm events. |
| $$-$$$ M ♦ | Trash Robots | One benefit would be high visibility and could be incorporated into a public campaign like "Treasure Your River" used by Coca Cola in the UK (https://www.hubbub.org.uk/Pages/Category/campaigns?Take=36) | Demonstration to be held August 31, 2022 to acquire additional information. High cost. Insufficient information on capability in highly vegetated areas and maintenance, charging, vandalism concerns and appropriate areal extent. Sales currently only from overseas companies |
| $-$$ ◊/◊◊ | Trash Fishing | Trash Collection as tourist attraction and/or team building exercise | Provides high visibility and awareness with limited litter removal. Establishment of venue may be major effort. |
| $$ M ♦ | Small-scale Litter Skimmer [Sea-Bin] | Trash Collection at stationary location siphoning water into a straining device. Could provide information on devices to concessionaires. | Requires power and continual maintenance. Primarily used in marinas. |
| $-$$ ◊◊ | Volunteer Cleanup Programs | In Place: Funding to Keep Austin Beautiful "Clean Lady Bird Lake" and "Adopt-A-Creek" | Possible enhancements would be to Increase allowed participation and advertisement to tourists, UT, and condominium dwellers; Coordinate with more local agencies like "Animal Safe Migration". Increased efforts would require increased funding depending on effort level. |

| Table 6. Extraction: Solutions to pull litter directly from waterways. | | | |
|---|---|---|---|
| **Cost/ Benefit** | **Strategy** | **Current/potential use** | **Comments/Obstacles** |
| $$<br>◊◊◊ | Free Watercraft for Lake Maintenance | Free kayaks for regular committed volunteers like the Urban Rivers Program | Requires purchase of watercraft and provision of litter disposal, along with advertisement of the program and location to store watercraft and supplies. Maintenance for collected litter removal, some administrative costs. |
| $$<br>◊ | Trash Collection Incentives | Provide rewards or discounts, etc. for cleanup efforts “Kudo Coins” in San Marcos or other alternatives or other contests or gamification. | Incentives would need to be solicited from local businesses. |
| $-$$<br>◊◊ | Use Litter Data for Trash Cleanup Direction | Target the 10% dense trash sites identified by the Trash Survey for cleanup efforts. | Need to revisit to observe whether accumulation returns and whether a device could facilitate collection. Increased staffing required. |

- Cleanup efforts are a particularly effective use of volunteers if manual extraction is required and can be prohibitively expensive if using paid staff. Trials to assess the effectiveness of devices to concentrate trash for pickup should continue.

- Increased participation in volunteer efforts can be encouraged with incentives (like free watercraft), high visibility efforts (e.g. trash fishing) and soliciting cooperative support and publication, through businesses, schools, and other venues in high traffic areas. Approaching businesses for cooperative efforts (installing inlet guards if the business agrees to “adopt-a-drain") could lessen the cost to the City directly.

- The concentration in creeks of 76% of the litter at only 10% of the sites is an opportunity to prioritize those areas for cleanup (Trash in Creeks Study, Clamann et al. 2022, interactive map: **https://arcg.is/0z48bj0**). Include scheduled revisits at strainer locations like the Johnson Creek bypass tunnel.

- Using devices in-stream to concentrate and retain litter, adding traps to booms at creek mouths or putting booms to concentrate litter, can make cleanup easier by creating an artificial “strainer” at a more easily accessible site/

- Extraction efforts can be particularly difficult in creeks due to access issues, difficulty in extraction from the streambed and vegetation, and the widely dispersed nature of our stream networks. In creek cleanups may be reduced if supplemental cleanup addresses high frequency illegal dumpsites and is paired with enforcement action and, if possible, equipment or reporting to identify the offenders.

- Note that trash robots and mechanized collection are only feasible on flat, deep water, like a reservoir or lake, while there are many obstacles to their use: vandalism, charging, and emptying.

- Waste service at encampments should be increased (Violet Bag Program) and discussions held with agencies providing support services.  This may encourage minimizing single use food and beverage containers as well as increase the retrieval of containers that have been provided as well as the clothing and housing materials, to reduce abandonment.

Table 7. Interception: Solutions to Intercept Litter before it Enters Waterways. Costs are scalable to size of area or number of units.

| Cost/ Benefit | **Strategy** | **Current/potential use** | **Comments/Obstacles** |
|---|---|---|---|
| $-$$$<br>◊◊<br>M | Curb Inlet Guards | In high pedestrian traffic and high litter areas. | Would require reprioritization or additional funding for street sweeping. Should be tested and monitored by appropriate City of Austin departments to ensure no clogging. Implementation where frequent street sweeping already occurs could reduce costs of inlet filter maintenance. |
| $$<br>M<br>♦ | Catch Basin Inserts or Swirl Separators | Drop in or constructed insert that separates trash from stormflow within the stormsewer system. Possible temporary installation in high construction areas. | Many have high cost of installation, but primarily maintenance, requiring a vactor truck or manual removal of material after manhole removal.<br>High clogging potential. Functional difficulty found when tested by Watershed (Glick et al. 2013) |
| $$<br>◊ | Enhanced Reporting of Litter Problems | Implement and advertise method to report litter problems through 3-1-1 or another program. | Staffing levels could be high to respond to reports.  Also, response on public vs private locations would need to be addressed. |
| $$-$$$<br>◊◊ | Increased Enforcement for littering: SWEEP (Philadelphia) type Program | Staff with the capability to educate businesses, etc. about trash requirements and authority to issue warnings and citation | Staffing requirements could be high.*<br><br>** Unable to acquire information from Pennsylvania with SWEEP program directly at this time, on staffing levels and whether fines are issued.* |
| $$<br>◊◊ | Refine and Enhance Street Sweeping Program | Prioritization and scheduling for high litter locations and hours when on-road vehicles are absence, or vehicle removal requirements. | Large difficulties in logistics for crew scheduling. Leaf litter during certain times needs to be considered and integrated. |

| Table 7. Interception: Solutions to Intercept Litter before it Enters Waterways. Costs are scalable to size of area or number of units. | | | |
|---|---|---|---|
| Cost/ Benefit | **Strategy** | **Current/potential use** | **Comments/Obstacles** |
| $-$$$<br>♦<br>M | End-of-pipe Nets or Traps at Outfalls | Nets or devices that strain the outflow from stormsewer outfalls at creeks. | High likelihood of obstructing flow causing flooding. High maintenance requirements associated with high flow events. High costs for replaceable nets that ease maintenance. |
| $-$$$<br>◊◊ | Physical Containment at Large Commercial Developments | Fencing or other retention around site to prevent movement of litter for collect if floatable treatment is not provided for stormwater. | Would probably require change in development rules.<br>Include Shopping Cart retention |
| $-$$$<br>◊◊ | Floatable Capture In Water Quality Controls | Amend requirements for new ponds to require capture of floatables that are frequently lost in bypass systems. | Would require change in water quality pond requirements and ongoing maintenance. |
| $$<br>◊◊◊<br>M | Increase litter disposal proximity and capacity. | Evaluate size and distance between litter bins on high use trails and high pedestrian areas; assess relative to 30' guideline. Possibility of bins in heavy parking locations during large events. | Increased costs, especially labor costs for maintenance. Contact Philadelphia re success of Community Cans program. |
| $$<br>◊<br>M | Solar compacting bins | Possible installation only in areas where high use overwhelms capacity. | High costs for installation as well required changes to maintenance scheduling. Difficulty in either adapting current crew scheduling or complete overhaul to optimize the reporting capabilities of the bins. |
| $$$<br>◊ | Provide Additional Water Stations | Encourage use of reusable water bottles, including by homeless citizens, by providing refill stations. Could supplement by providing reusable bottles at hotels and through homeless services. | Austin Water Utility recently installed 12 new stations. No data on the impact on reducing litter.<br>May need an education campaign to discourage provision of single-use containers to homeless population. |
| $<br>◊◊◊ | Lakeside and Park Concession Requirements | Ensure "Leave No Trace" Signage is posted and that sufficient litter disposal required and maintained. | Costs should be borne by concessionaires; Additional inspection may be required. |
| $-$$<br>◊<br>M | Cigarette Butlers | Provide cigarette butlers in transition areas and high pedestrian areas. Evaluate maintenance in cooperation with downtown alliance and others. | Cost of devices, maintenance required. Could be paired with campaign or gamified to attract attention. |

| Table 7. Interception: Solutions to Intercept Litter before it Enters Waterways. Costs are scalable to size of area or number of units. | | | |
|---|---|---|---|
| Cost/ Benefit | **Strategy** | **Current/potential use** | **Comments/Obstacles** |
| $-$$$ ◊◊ | Enhance Current Education Programs | Expand volunteer cleanup opportunities and creek adoptions, particularly through schools, condominiums, organizations | Advertising or information distribution costs can be high. Campaigns need to be refreshed. |
| $-$$ ◊◊ | New education effort or partnership | Specific focus effort. Example: Rethink Disposable with Clean Water Fund. | Staff time might be high for the program to be effective. |
| $$ ◊◊◊ | Encourage landfill disposal | Free dump days, increased enforcement, monitoring (cameras) at frequently used dumping locations | Possible provision of containers for disposal for closed hours or additional locations |
| No Data | Program to retrieve Homeless Materials | Work with nonprofits to retrieve single-use containers and discarded clothing. | Programs using this approach were not identified, and merit further investigation. It may be that some existing programs retrieve materials, but not that we could document. |
| ◊◊◊ | Mesh Litter Bags | Provide or Require Mesh Litter Bags for On-Water Recreation | Distribution and information must be provided at launch locations, as well as sufficient waste disposal for the return of trash. Could be required of lakefront concessionaires. |
| $$ M ◊◊◊ | Trash Boat bin in Ladybird Lake | Moored boats (s) to provide trash receptacle in lake to encourage proper disposal. | Active maintenance required during high use periods. |

- Institutional or programmatic interception methods are already extensive in Austin, but additional focus on visitors, college students, and programs to report litter may provide opportunities for enhancement. High profile efforts at trails encouraging “Leave No Trace” and interactive activities like plogging are some approaches that can be pursued. On our waterways, ensuring that people recreating have a way to retain their trash could be accomplished by providing or requiring mesh litter bags or providing a “litter boat”

- While expensive, increasing waste capacity appears to be the most critical component for encouraging appropriate disposal. Picnic tables (in parks and commercial/multifamily properties) should have sufficient waste receptacles. Based on maintenance, solar compacting bins could be used to increase capacity, where schedules are flexible and locations remote. Maintenace costs are very high to significantly increase the number and capacity of trash cans, but the amount of litter distributed in heavily used pedestrian areas (South Congress), where no trash cans are within sight, shows that they are desperately needed.

- Ordinances and enforcement need to be updated to reduce the incidence of overflowing waste receptacles and dumpsters (similar to Philadelphia's SWEEP program). Improving monitoring of high frequency illegal dumping sites and reporting procedures for litter would result in increased enforcement of severe problem areas, penalties in turn would reduce littering and dumping behaviors. One specific issue to address is abandoned telecommunication lines. Increased funding for Code Enforcement would be required. Another issue is whether water quality ponds need additional control of floatables, or more frequent cleaning.

- Illegal dumping was associated with the highest litter areas in the Trash in Creeks study (Clamann 2022); high priority should be given not only to strategies that reduce dumping, but also those that ease appropriate disposal.

- Site specific solutions may need to be used to prevent trash movement to our creeks from high litter areas, such as combining curb inlet guards with targeted street sweeping or with the adopt-a-drain program. Strategies to retain shopping carts and debris in large retail shopping centers need to be developed.

| Table 8. Source Reduction: Solutions that can reduce the sources of litter that are most frequently found in Austin waterways | | | |
|---|---|---|---|
| **Potential** | **Strategy** | **Current/Potential Use** | **Comments/Obstacles** |
| ◊ | Single use plastic bag ban | Previous failure due to state preemption | State pre-emption without a different goal. |
| ◊◊ | Retail bag post-consumer recycled material requirement | Require that bags that are provided by retailers contain a minimum of post-consumer recycled material. | Potential state challenge. Use of these requirements also increases the market and likelihood that plastic will be recycled. |
| ◊◊ | Single-use Plastic bag recycling bins at retail locations | Require that retailers provide plastic bag recycling opportunity | Legal requirements not determined. |
| ◊ | Ban sales of bottled water | Unusual, usually restricted to a college campus or other small environment. | Mixed results with possibility of other single-use beverage containers replacing plastic water bottles, although water in aluminum cans is more recyclable. |
| ◊ | Restrict sales and/or use of single-use water bottles on City property and/or lake | | Same issue as a ban, replacement with alternatives. Concerns with heat and hydration. |
| ◊ | Container Deposit Legislation | Unsuccessfully proposed in Texas legislature in the past. | |
| ◊◊ | Polystyrene (Styrofoam) Ban | Increasing implementation worldwide. Ban could be comprehensive or specific; only at grocery markets and convenience stores, or only for takeout food containers. | State pre-emption ban could mean it would be challenged, but toxicity concerns may facilitate implemented as Florida has based their proposal. |
| ◊◊◊ | Restrict Use of Polystyrene (Styrofoam) in City Parks and/or Lakes & River | Further restrict current ban of the sale of food in parks in polystyrene to also prohibit possession, particularly of polystyrene coolers. | Education and enforcement would be required, at least initially, but concessionaires could easily ensure polystyrene coolers are restricted there. |
| ◊◊ | Single-Use Container Ban on Lady Bird Lake or River | Ban the Possession of Single-Use Containers | State preemption challenge possible, although New Braunfels ban upheld. Enforcement at concessionaires and at other launch points would be required. |
| ◊◊◊ | Prohibit Glass and Cigarettes on Lady Bird Lake and/or Colorado River | Extend the current prohibition in parks to the Colorado River or Lady Bird Lake. | Will require education, signage and enforcement. |

- Table 8 lists measures other entities have put in place to would limit the use of the materials most frequently found littering our waterways. The relative feasibility of implementing these solutions in Texas are indicated by the number of symbols in the first column; with a greater number indicating a higher possibility that a rule might be put in place. The state of Texas previously overturned a plastic bag ban, and it is anticipated that any bans would face the same challenge. Relative costs are not included because of the potential for high legal costs and unknown costs of enforcing the restrictions.

- Expansion of some current rules for Austin Parks may be most likely to be implemented. The prohibition on glass and cigarettes should be extended to the Colorado River system; safety concerns with glass make this a common ban on rivers, lakes and beaches.

- As the solution reported as most effective where instituted, reducing the materials that are frequently discarded could, even if on a small scale, reduce our litter. Prohibiting polystyrene and glass on the trails and waterways could address the most problematic materials for safety as well as for polystyrene decomposition and toxicity, in the most vulnerable locations (immediately adjacent to waterways with no interception opportunities).

- Recreators who have refreshments should have a mesh litter bag or other way to ensure they will "Leave No Trace". Mesh bags could be provided, could be attached to all rental watercraft, could be encouraged or could be required. Informational booths would be in high traffic areas to educate hikers and boaters about the issue.

Although many bans and container deposit proposals have a low probability of success having previously failed in Austin and most cities in Texas, the two listed below have a some successful precedents and could be reconsidered in the future.

- A ban of polystyrene as food service containers or other appropriate categories (coolers) could be pursued following the example of Florida, basing the need on public health. Lake Austin is a drinking water source and Austin creeks do contribute to the Edwards Aquifer, so polystyrene may impact public health as well as that of the aquatic community.

- A bold regulatory statement would be to follow the precedent set by New Braunfels and prohibit all single use containers in Lady Bird Lake. That ban was upheld by the state appeals court and the Texas Supreme Court denied an appeal, but such a rule would raise a lot of enforcement issues.

Selecting and compiling a suite of measures that pulls from all three solution spaces (Extraction, Interception and Source Reduction) will be necessary for Austin to effectively address the litter problem we are currently facing. Most large municipalities are struggling with the same issues, leading to the development of TMDLs, where appropriate, Action Plans such as Philadelphia's and studies such as the Santa Ana Watershed's Trash Assessment for Homeless Encampments (SAWPA 2021). Table 9 lists some municipal strategies that were used to develop a comprehensive action plan from watershed to river.

| Table 9. Approaches for Comprehensive Litter Action Plan | | |
|---|---|---|
| Approach | Description | Obstacles/Comments |
| Leave No Trace Hot Spot Effort | Solicit Assistance from Leave No Trace Center for Outdoor Ethics | Organization would need to approve; At least a week of multiple staff member time to organize stakeholder meetings, collect information requested. This is just one option for Action Plan Development. |
| Zero Waste and Litter Cabinet (Philadelphia) | A Committee to Take Solutions, Recommend the Phase I and Budgeting and Review Results | Alternatives of Staff Across Departments is an alternative, but either method has coordination, reporting, and evaluation difficulties. |
| Consultant Action Plan Development | Frequently consultants are used to develop a TMDL plan. | High Cost |

The suite of solutions provided will allow layering of approaches to minimize the trash that becomes litter and to remove the litter from our waterways. The Trash Survey results identified large litter volumes associated with illegal dumping and encampments, but also located "hot spots" where cleanup efforts will have the most impact. Efforts using that information for the most short-term impact could begin promptly.

- High Priority Cleanups - The priority should be to extract litter from those areas with the highest volume to prevent further spread throughout our watersheds. It should include plans for follow-up visit at those high litter sites to see if they are an ongoing problem (versus historic dumping sites) .

- Increasing waste disposal convenience and capacity should also begin as soon as possible in high pedestrian activity areas. Current litter cleanup efforts like street sweeping can provide data to identify high litter areas. Possible actions are listed below.
    - If funding is available to increase waste service activities, Austin should provide more or higher volume litter bins in high pedestrian areas, particularly at high use times.
    - City code requirements should be reviewed and compared with those of other municipalities and an informational packet prepared, if not already available, for businesses denoting their responsibilities and possible penalties.
    - A review of enforcement actions taken and any fines assessed would provide information on whether lack of penalties could be a factor in site management litter problems.
    - Identify who would be responsible for street litter, in high pedestrian areas and high-volume parking where no waste receptacles are located.

While addressing opportunities for immediate action, a long-term plan should be developed with solutions identified by geographic area and primary watershed surface litter sources. The plan should consider the time required to implement solutions; for example, code changes or source reduction measures will require policy planning. Development of a plan will assist in coordinating across the multiple departments involved in the efforts and in assessing the success of each component.

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**Appendix A. Litter Abatement Costs, Nine Pennsylvania Cities ([https://www.keeppabeautiful.org/wp-content/uploads/2020/02/KPB-Litter-Cost-Study-013120.pdf](https://www.keeppabeautiful.org/wp-content/uploads/2020/02/KPB-Litter-Cost-Study-013120.pdf) Accessed August 10, 2022).**

| City | Population | Prevention of Litter: Trash Cans & Maintenance | Prevention of Illegal Dumping | Education & Outreach | Litter Abatemen incl. Encampment | Illegal Dumping Abatement | Code** Enforcement | Total | Cost/ Person |
|---|---|---|---|---|---|---|---|---|---|
| Allentown | 121,433 | $1,291,700 | $8,900 | $35,000 | $2,192,100 | $370,200 | $669,300 | $4,567,200 | $37.61 |
| Altoona | 43,702 | $227,300 | $151,800 | $2,300 | $260,700 | $26,000 | $143,500 | $811,600 | $18.57 |
| Erie | 96,471 | $151,100 | $498,600 | $17,300 | $998,400 | $207,900 | $345,700 | $2,219,000 | $23.00 |
| Harrisburg | 49,229 | $73,400 | $34,700 | $102,200 | $1,242,700 | $235,500 | $49,000 | $1,737,500 | $35.29 |
| Lancaster | 59,420 | $20,000 | $1,000 | $5,500 | $1,393,300 | $7,200 | $704,500 | $2,131,500 | $35.87 |
| Philadelphia | 1,584,138 | $1,217,000 | $2,163,400 | $547,300 | $36,314,700 | $6,376,800 | $1,778,300 | $48,397,50 | $30.55 |
| Pittsburgh | 301,048 | $2,734,400 | $246,800 | $57,700 | $2,706,900 | $232,400 | $331,300 | $6,309,500 | $20.96 |
| Reading | 88,495 | $70,500 | $126,500 | $9,400 | $1,437,200 | $404,600 | $29,700 | $2,077,900 | $23.48 |
| **Austin FY20 + Avg FY18-20 Capital Cost** | **1,028,225** | **$2,722,203** | **$6,609,111** | **$123,500** | **$8,384,434** | **$1,017,986** | **$1,990,734** | **$20,847,968** | **$20.28** |
| *Most costs from FY18 (Burns & McDonnell 2020) | | | | | | | | | |
| **Only litter specific Code Enforcement included | | | | | | | | | |

## Appendix B. Offer to Cooperate from “Safe Animal Migration.

Hello,

I am reaching out on behalf of Animal Safe Migration, a local 501 c 3 based here in Austin, TX. Our mission is to create coexistence between human and animal life by way of safe migratory pathways for all wildlife in their natural habitats. Right now we are focusing our efforts on habitat restoration and wildlife conservation. Since mid-December we have been going out with our volunteers and cleaning up Lady Bird Lake every Saturday for a minimum of two hours. You may have seen us along the Ann and Roy Butler Hike-and-Bike Trail. Over the course of our clean-ups we have collected over 500 gallons of trash, and that is only what is found around the lake beds and on the surface of the water closest to shore. In addition to the trash, we have pulled numerous drowned animals out of the water and disposed of dozens of hypodermic needles.
These past few months we have come to realize that the city we all love, is grossly polluted; The water ways that we spend our summers in, are not only polluted with trash, but have toxins in them that are harmful to people and wildlife alike. Our ecosystems are being destroyed, and we are seeing less wildlife because of it.
We have plans to plant native vegetation along the shorelines, reducing the amount of toxins in the water, and to install flood netting on storm drains that run into the lake, preventing garbage from flowing into the water off of the streets. But, we can not do this without your help.
As nature lovers and Austin locals alike, we feel that it is our responsibility to make sure people know their impact. It is our responsibility to educate our community on how they can help, how they can do better. We want to partner with the City of Austin in order to have the ability to continue to improve our community, your community. Would you consider funding our project?

Thank you so much, I hope to hear from you soon.

Best,

Caitlin Phillips
Director of Operations
Animal Safe Migration
www.animalsafemigration.org
caitlin@animalsafemigration.org / 206.355.6893

**Appendix C.**

## California Stormwater Quality Association: Certified Full Capture System List of Trash Treatment Control Devices

**(Last Updated July 7, 2022)**

TABLE 1 - CATCH BASIN INSERTS AND OTHER DEVICES

| Owner / Website | Full Capture System Trash Device Brand Name | Date Application Certified or Fact Sheet Updated | Date Vector Control Accessibility Verified |
|---|---|---|---|
| AbTech Industries | Ultra Urban Filter (UUF) Curb Opening and Drop-In | Application 25<br>5/1/20 | 4/8/2020 |
| Advanced Drainage Systems, Inc.<br>FLEXSTORM Division | FLEXSTORM PURE Full Trash Capture (FTC) Inserts | Application 3<br>3/15/2018<br>Updated 4/21/2021 | 3/30/2021 |
| Advanced Drainage Systems, Inc.<br>FLEXSTORM Division | FLEXSTORM Connector Pipe Screen | ADS-1<br>Updated 6/8/2021 | 3/30/2021 |
| Bio Clean® Environmental Services, Inc. | Curb Inlet and Grate Inlet Filters | Application 4<br>3/15/2018<br>Updated 10/21/2021 | 10/20/2021 |
| Bio Clean® Environmental Services, Inc. | Modular Connector Pipe Trash Screen | BC-3<br>Updated 4/30/2020 | 3/10/2020 |
| BrightWater™ | Connector Pipe Screen | Application 29<br>3/15/2018<br>Updated 12/28/2020 | 11/19/2020 |
| BrightWater™ | Curb Inlet Filter | Application 26<br>6/30/2020 | 4/17/2020 |
| Ecology Control Industries | Debris Dam - Catch Basin Insert for Curb Inlet Design | ECI-1<br>Updated 6/17/2020 | 4/29/2020 |
| Enviropod International: A Stormwater360 Group Company | Enviropod® LittaTrap™ FC | Application 27<br>10/15/2020 | 7/20/2020 |
| Fabco Industries, Inc. | Fabco Connector Pipe Screen | Application 36<br>7/6/2022 | 6/16/2022 |
| Filtrexx Sustainable Technologies | StormExx® Clean | Application 16<br>8/10/2018<br>Updated 11/25/2019 | 12/6/2019 |
| Frog Creek Partners, LLC | Gutter Bin® Channel Filtration System & Mundus Bag® Water Filter | Application 22<br>6/26/2019 | 4/19/2019 |
| Frog Creek Partners, LLC | Gutter Bin® Eco Curb Inlet Filter & Mundus Bag® Water Filter | Application 23<br>2/18/2019 | 10/11/2019 |
| Frog Creek Partners, LLC | Gutter Bin® Eco Drop Inlet Filter & Mundus Bag® Water Filter | Application 24<br>2/18/2020 | 12/6/2019 |

| | | | |
|---|---|---|---|
| G2 Construction, Inc. | G2 CPS-Mod™ and Removable CPS Mod™ Screen | Application 18<br>6/26/2019 | 3/15/2019 |
| G2 Construction, Inc. | G2 GITS™ Grated Inlet Trash Screen | Application 19<br>6/26/2019 | 4/10/2019 |
| Inventive Resources, Inc. | Water Decontaminator | Application 2<br>3/15/2018<br>Updated 2/5/2021 | 4/20/2020 |
| Oldcastle Infrastructure™ | FloGard® + Plus® Catchbasin Trash Screen Insert, Combination Inlet Style Drop in Basket | OI-1<br>Updated 6/9/2021 | 6/9/2021 |
| Oldcastle Infrastructure™ | FloGard® Catchbasin Trash Screen Insert, Flat Grated Inlet Style Drop in Basket | OI-2<br>Updated 6/9/2021 | 6/9/2021 |
| Oldcastle Infrastructure™ | FloGard® Catchbasin Outlet Trash Screen Insert Connector Pipe Screen | OI-3<br>Updated 11/29/2019 | 12/6/2019 |
| Revel Environmental Manufacturing, Inc. | Triton™Bioflex Inlet Trash Guard Catchbasin Polyester Fiber Mesh Trash Filter Insert | REM-1<br>9/10/2021 | 9/7/2021 |
| Revel Environmental Manufacturing, Inc. | Triton™ CPS-FTC (Crescent Pipe Screen) | Application 12<br>7/10/2018 | 3/15/2019 |
| Revel Environmental Manufacturing, Inc. | Triton Perf-FTC Insert | Application 13<br>7/10/18<br>Updated 12/21/2021 | 12/20/2021 |
| Safe Drain Stormwater Holdings Inc. | Storm Vector Guard | Application 30<br>2/11/2021 | 12/17/2020 |
| Stormtek | Stormtek ST3 & STEG Catchbasin Connector Pipe | AS-1, A1S-2<br>Updated 8/12/2021 | 8/4/2021 |
| United Stormwater, Inc. | Connector Pipe Trash Screen | USW-1<br>Updated 1/29/2022 | Updated 1/26/2022 |

TABLE 2 - HIGH FLOW CAPACITY TRASH DEVICES

| Owner / Website | Full Capture System Trash Device Brand Name | Date Application Certified or Fact Sheet Updated | Date Vector Control Accessibility Verified |
|---|---|---|---|
| Advanced Drainage Systems, Inc. | Barracuda Hydrodynamic Separator | Application 21<br>6/26/2019<br>Updated 5/21/2021 | 3/15/2019 |
| AquaShield™, Inc. | Aqua-Swirl® Stormwater Treatment System | Application 1<br>8/4/2017<br>Updated 11/6/2020 | 12/3/2020 |
| Bio Clean® Environmental Services, Inc. | Debris Separating Baffle Box (DSBB) | Application 6<br>3/15/2018 | 7/28/2020 |
| Bio Clean® Environmental Services, Inc. | BioClean Deflective Screening Device (DSD) | Application 20<br>6/26/2019 | 7/28/2020 |
| Bio Clean® Environmental Services, Inc. | Modular Wetland System® (MWS) | Application 15<br>7/10/2018 | 3/15/2019 |
| Coanda Inc. | Coanda Trash Screen and Debris Fence | COA-1<br>Updated 9/10/2021 | 9/7/2021 |
| Contech Engineered Solutions | Continuous Deflective Separator (CDS) Hydrodynamic Separator | CCP-1HF<br>Updated 5/27/2021 | 4/29/2021 |
| Jensen® Stormwater Systems | Jensen® Deflective Separators (JDS) | Application 5<br>3/15/2018 | 12/6/2019 |
| Hydro International® | Downstream Defender (In-Line and Off-Line Configurations) | Application 14<br>7/10/2018 | 3/16/2020 |
| Hydro International® | First Defense® High Capacity Full Trash Capture Device (FDHC FTC) | Application 28<br>10/30/2020 | 8/20/2020 |
| Hydro International® | Hydro DryScreen | Application 10<br>7/10/2018<br>Updated 5/5/2021 | 4/29/2021 |
| Hydro International® | Hydro Up-Flo Filter® | Application 11<br>7/18/2018 | 3/16/2020 |
| Oldcastle Infrastructure™ | FloGard® NetTech | OI-11HF<br>Updated 12/08/2020 | 12/3/2020 |
| Oldcastle Infrastructure™ | Nutrient Separating Baffle Box® (NSBB) | Application 17<br>10/12/2018<br>Updated 7/21/2020 | 5/1/2020 |
| Roscoe Moss Company | Storm Flo® Trash Screen – Linear Radial Gross Solids Removal Device | RMC-1HF<br>Updated 3/30/2021 | 3/11/2021 |
| StormTrap | SiteSaver® | Application 9<br>3/15/2018<br>Updated 2/23/2021 | 3/18/2021 |

| | | | |
|---|---|---|---|
| StormTrap | TrashTrap Net and Fixed Basket In-Line Systems | Application 34<br>6/21/2022 | 5/3/2022 |
| StormTrap | TrashTrap Net and Fixed Basket End-of-Pipe Stormwater Treatment System | Application 35<br>7/6/2022 | 6/1/2022 |

Certified Full Capture System Trash Treatment Control Devices | CASQA - California Stormwater Quality Association

# Attachment 3

**MEMORANDUM**

**TO:** Mayor and Council Members

**FROM:** Jorge L. Morales, P.E., CFM, Director, Watershed Protection Department
Robert Spillar, P.E., Director, Austin Transportation Department

**DATE:** June 19, 2020

**SUBJECT: CIUR # 2234, Trash in Creeks: Program Inventory, Analysis, and Outcomes**

The purpose of this memorandum is to provide an update on interim efforts and outcomes related to Council Resolution No. 20200123-108 (CIUR # 2234), which directed the City Manager to prepare a study with recommendations addressing litter and the dumping of electric micromobility devices in Austin's waterways. For additional background please refer to the March 3, 2020 update. This update is a collaboration between the Watershed Protection Department (WPD), Austin Transportation Department (ATD), Austin Resource Recovery (ARR), Parks and Recreation Department (PARD), and Austin Code Department (Code). In March staff committed to a report that contains an inventory of active programs and funding sources. The results of that report (attached) indicate:

- The primary sources of trash in Austin are littering, illegal dumping, large public events, and homeless encampments;
- The locations of this trash are predominantly along roads, waterways, and parkland; and
- Immediate opportunities exist to reduce the impacts of trash in the key areas of homeless encampment management, to provide long-term solutions for solving homelessness, and to expand community partnerships.

Upon review of the attached report, please direct additional questions to: Mike Kelly, Interim Assistant Director (WPD), 512-974-6591; or Jason JonMichael, Assistant Director (ATD), 512-974-7028.

cc: Spencer Cronk, City Manager
Rey Arellano, Assistant City Manager
Gina Fiandaca, Assistant City Manager
Christopher Shorter, Assistant City Manager
Mike Kelly, P.E., Interim Assistant Director, Watershed Protection Department
Robert Spillar, P.E., Director, Austin Transportation Department
Jason JonMichael, Assistant Director, Austin Transportation Department
Jacob Culberson, Division Manager, Austin Transportation Department
Ken Snipes, Director, Austin Resource Recovery
Richard McHale, Assistant Director, Austin Resource Recovery
Kimberly McNeeley, CPRP, Director, Parks and Recreation Department
Liana Kallivoka, PhD, P.E., Assistant Director, Parks and Recreation Department
José Roig, Acting Director, Austin Code Department
Richard Mendoza, P.E., Director, Public Works Department

Attachments:

- Report: Trash in Creeks: Program Inventory, Analysis, and Outcomes
- City of Austin Clean City Strategy Overview
- Litter Abatement and Prevention Services Funding
- WPD Trash in Creeks Project Work Plan

City of Austin
Founded by Congress, Republic of Texas, 1839
P.O. Box 1088, Austin, Texas 78767

# Trash in Creeks
## Program Inventory, Analysis, and Outcomes

Council Resolution 20200123-108
Litter and micromobility devices
(CIUR # 2234)

**Prepared by**
Watershed Protection Department (WPD)
Austin Code Department (ACD)
Austin Resource Recovery Department (ARR)
Austin Transportation Department (ATD)
Parks and Recreation Department (PARD)
Public Works Department (PWD)

**Publish date**
June 16, 2020

## 1. Analysis of existing data

Trash in Austin waterways comes from diverse sources and tracking them down is difficult. Preliminary analysis of existing data indicates the main categories of trash sources in Austin are:

- Littering
  - Non-point source pollution in the urban environment, in which small amounts of solid waste are discarded into the environment repeatedly by different people, spread over a wide area over time, and moved via rain, wind, and stormwater to our waterways.
- Illegal dumping
  - Unauthorized waste disposal, distinguished from littering by large volumes and commonly more bulky items discarded during a single incident.
- Large events
  - Mass gatherings, which rapidly generate significant volumes of trash that are geographically concentrated and that put a strain on systems for handling typical waste streams.
- Homeless encampments
  - Many people experiencing homelessness do not have access to waste disposal avenues that are available to housed residents in our community.

Existing data shows geographic trends in the concentration of litter, trash, and cleanup efforts across the City of Austin (Figs 1-5). Trash and litter accumulate predominantly along major roads, in waterways, and on parkland. The map layers and figures below provide a more detailed look at these patterns.

Figure 1. Base layer showing the primary networks of major roads (ATD), parklands (PARD), waterways and floodplains (WPD).

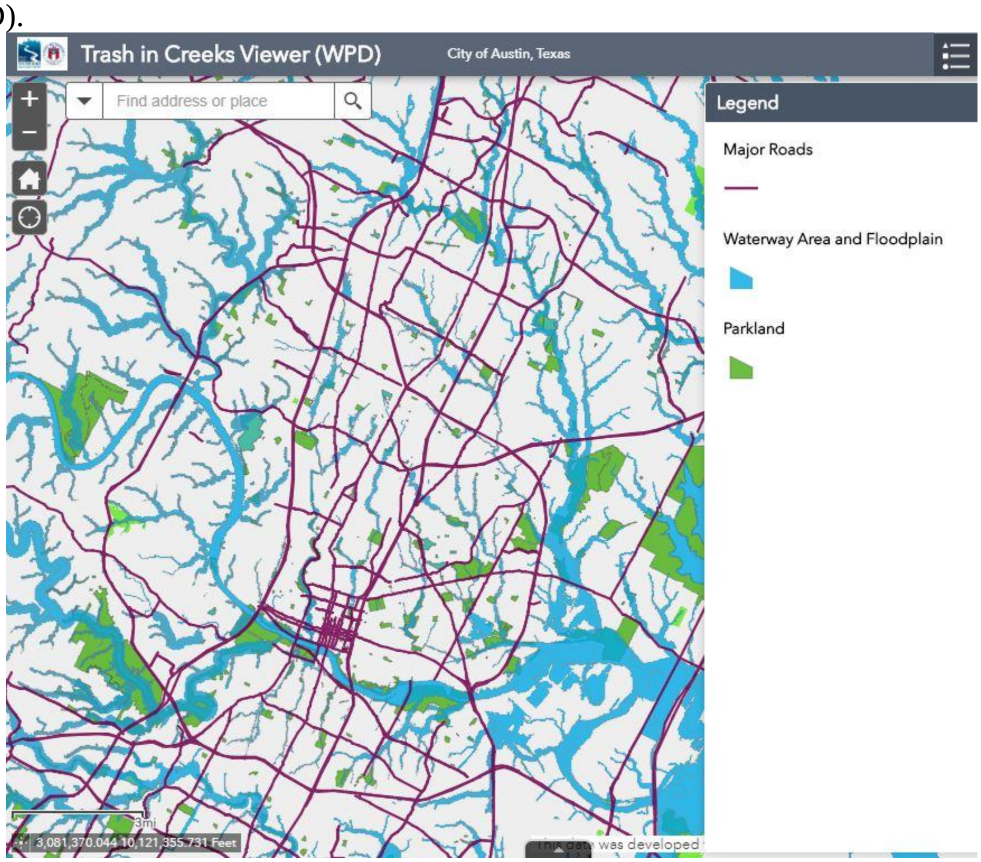


Figure 2. WPD pollution response data shows that there are more trash and litter findings (darker purple) in population-dense areas, along major roads, and along waterways.

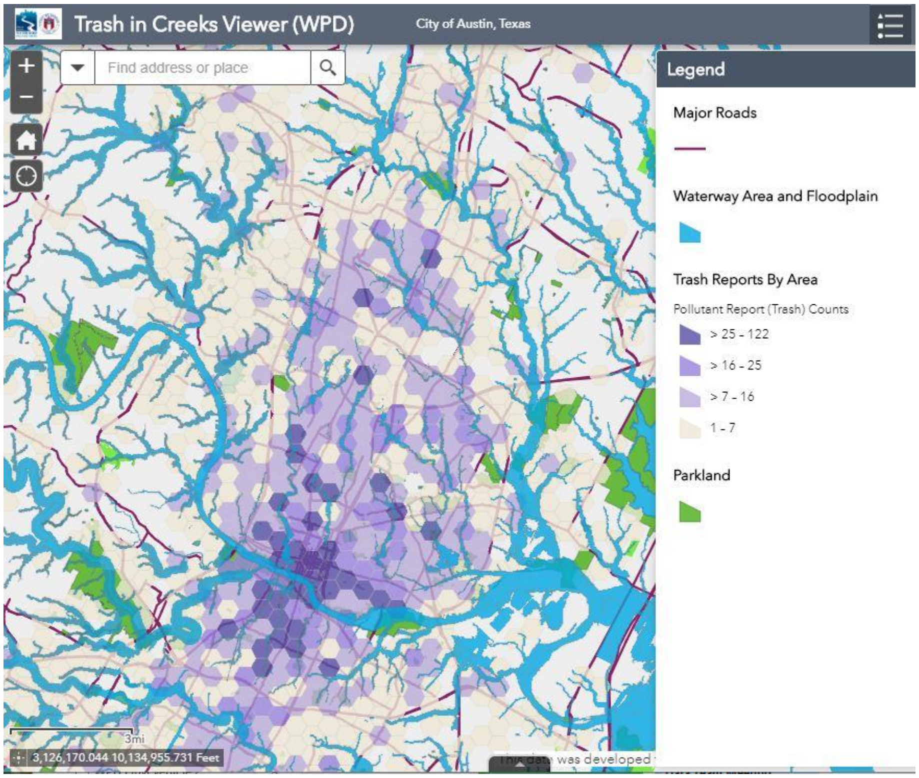



Figure 3. Homeless encampment site visits and cleanups by WPD, ARR, PARD, and PWD predominantly occur along major roads, in population-dense areas, along waterways, and on parkland.

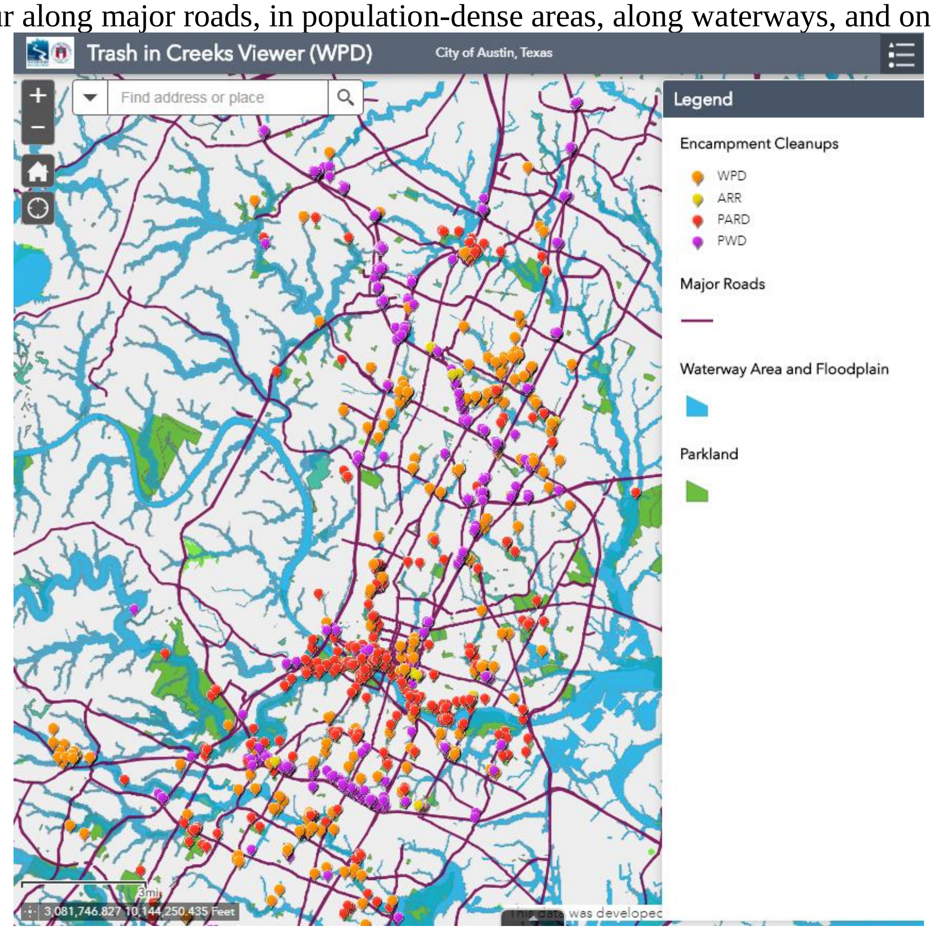


Figure 4. Locations of Illegal Dump sites that have been reported by Austin Resource Recovery.

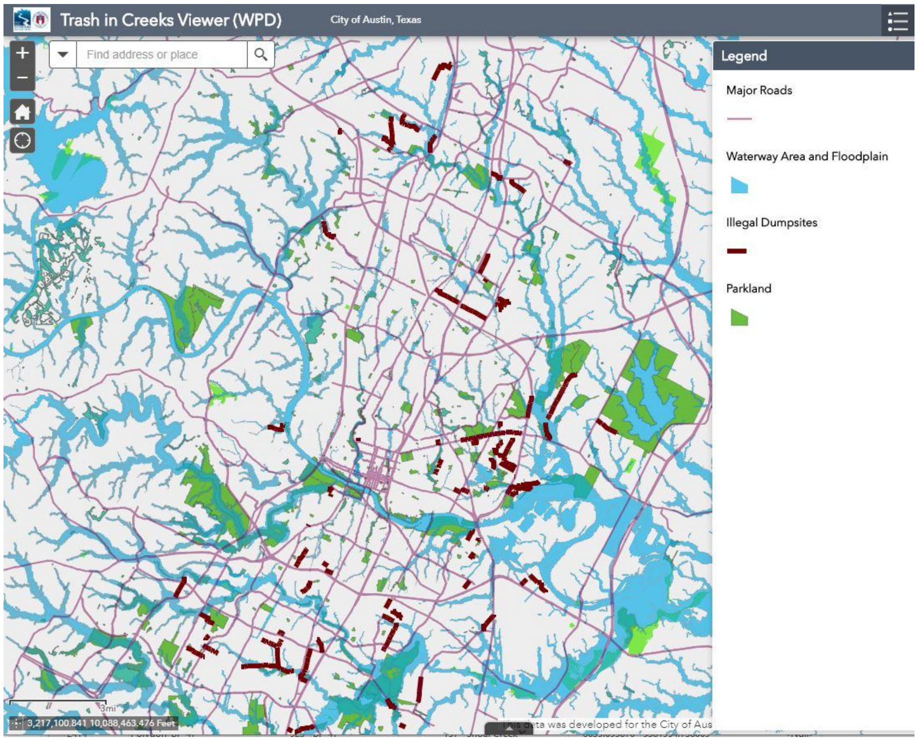
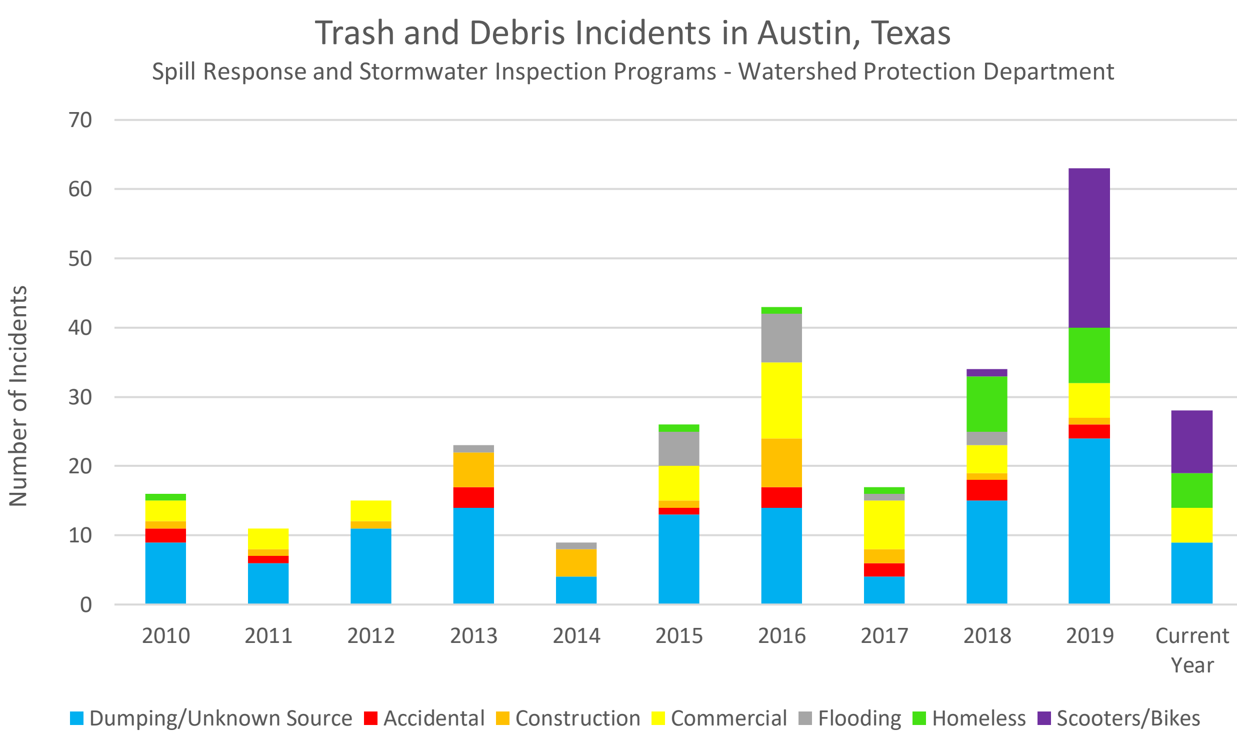



Figure 5. The WPD pollution response database shows dumping and commercial locations as consistent sources over the past ten years, with homeless encampments and scooters/bikes increasing in recent years.



Citywide trash and encampment data suggest that Austin's major transportation infrastructure, waterways, and greenspaces are hotspots for trash accumulation and corresponding clean-up efforts. In addition to near-term recommendations for reducing trash in Austin's waterways, we have provided a high-level overview of existing citywide efforts.

## 2. Existing trash and litter focused programs and initiatives

### *Clean City Strategy and Homeless Encampments*

Homeless encampments are a source of trash in waterways. They are not the only source, but citywide efforts to maintain these encampments show that they are persistent and tend to occur near major roads, in waterways, and on parkland. To reduce the impact of encampments, WPD manages an annual $250,000 contract for encampment cleanup services. In in a seven-week period between January and March 2020, WPD contractors removed 60,000 pounds of debris from encampments across the City. In FY20, PARD has an operating budget of $125,000 for homelessness-related initiatives. PARD cleanup efforts have resulted in the removal of 187,000 pounds of debris from parkland so far this year. For FY21, WPD is requesting a contract expansion to $600,000 for continued encampment cleanup services. PARD will be requesting additional funds to allow for the hiring of another crew to provide cleanup services.

The Underpass Cleanup Contract, jointly funded by PWD, ARR and ATD is also a significant effort being undertaken to reduce the impact of trash in encampments. This contract, funded at $386,000 last year and proposed to increase to $575,000 next year (going to council on July 30th, 2020) has visited 673 sites and removed 440,000 pounds of debris from our bridges and underpasses since the inception of the program.

Encampment management and cleanups are a recurring effort that will continue to use City resources until the causes of homelessness are identified and resolved. When compared to other sources of trash, homeless encampments represent a promising opportunity for the reduction of trash in the environment through the Clean City Strategy (Program overview document attached). We have found that engaging and partnering with people experiencing homelessness is effective in reducing environmental impacts of encampments.

### *Litter Abatement*

City of Austin departments have implemented different programs to reduce and prevent litter as well as protect Austin's waterways. These programs are a joint effort, utilizing City staff, contractors, and volunteers led by community partners. These programs include:

- Austin Resource Recovery Programs
    - Bi-annual brush and bulk collection
    - Daily litter removal and street sweeping in the Central Business District
    - Daily removal of dead animals
    - Sweeping of residential streets six times per year; monthly sweeping of boulevards and protected bike lanes (over 7 million pounds of debris removed so far in FY20)
    - Cleaning of litter from rights-of-way and illegal dumpsites
    - City co-sponsored special event collection
    - Regular cleaning of bulk and brush debris from Clean Austin Program areas
    - Daily collection of litter and small debris from 14 established Violet Bag encampments sites (over 49,900 pounds of material collected through Violet Bag program in FY20).
- Community Partnerships
    - WPD partners with Keep Austin Beautiful (KAB), a local non-profit, to protect Austin's environment through programs such as Clean Creek Campus, Adopt a Creek, Grow Green, and Lady Bird Lake Volunteer Cleanups.
    - ARR partners with Keep Austin Beautiful (KAB) to conduct neighborhood and community clean-ups throughout the year in addition to a large-scale, one-day volunteer cleanup event.

- Lady Bird Lake Floatables Program
  - To reduce trash on Ladybird Lake, WPD established litter collection sites at the mouths of two urban creeks that discharge into the lake. In FY19, these sites successfully removed 12 tons, or 24,000 pounds, of trash and debris from Austin's waterways.
- Vegetation Management Program
  - WPD utilizes several vendors to provide vegetation management and litter collection services along more than 80 miles of waterways and over 1,100 stormwater controls.
- Waller Creek Tunnel Program
  - Trash screening controls are utilized at three of the tunnel facilities, and staff also removes litter along the creek. In FY19, this effort led to the removal of more than 34 tons, or 68,000 pounds, of trash and debris along lower Waller Creek.

### *Illegal Dumping*

Austin Code Department responds to citizen complaints of illegal dumping (Fig 4). More than thirty cameras are placed throughout Austin to monitor chronic dumping locations. Camera locations are prioritized by the number of dumping reports received in a given area. The cameras serve as a deterrent more than as an effective investigation tool. Successful enforcement rates are very low, as there is typically not enough evidence for City attorneys to prosecute.

### *Spill Response Program*

The WPD Spill Response program aims to prevent or minimize pollution impacts from illicit discharges to Austin's creeks and lakes. Pollutant records are most frequently generated as a result of citizen complaints. For incidents involving trash, WPD frequently coordinates with ATD, ARR, PARD and Austin Code toward resolution.

### *Micromobility Devices*

As Figure 5 shows, shared scooters and (dockless) bicycles, or micromobility for short, constitute a newer debris source in waterways since their introduction in 2018. Explanations for micromobility incidents are anecdotal, ranging from weather circumstances to individual malintent. To foster an orderly mobility environment, ATD has planned and communicated with permitted micromobility companies for everyday operations and special events. Communications encompass quick-response processes with permitted companies to retrieve devices from waterways. Although extensive work hasn't been done on environmental risk of scooters abandoned in waterways, the batteries they carry are a significant concern as they leach out a variety of contaminants when submersed in water. Staff is looking into other pollutant risks associated with scooters in waterways, but are focusing currently on ways of locating and removing them from our creeks and reservoirs as quickly as possible.

Moving forward, ATD is pursuing infrastructure and education efforts to prevent and mitigate dumping of micromobility devices. ATD has analyzed map data of reported micromobility issues which are informing future shared mobility planning.

## 3. Funding Sources

Funding for programs that address litter problems comes from several sources, is allocated to different recipients and programs, and routed through various sponsor departments. The combined operating budget of these programs for FY20 is approximately $21.5 million. A detailed cost breakdown is provided in the attached *Litter Abatement and Prevention Services Funding*.

## 4. Recommendations

Capitalizing on existing collaborative efforts, the following focus areas are recommended as major, tangible, and key opportunities that can significantly reduce the impacts of litter on the City's environment and waterways:

- **Create a Citywide centralized cleanup contract and protocol managed by a single department with funding contributions and technical assistance from other impacted departments.**
- Create a dedicated Violet Bag cleanup group and increase site locations
- Increase Leave No Trace education and outreach efforts.
- Continue to develop and expand the Work Force First Program, a partnership with Family Eldercare and The Other Ones Foundation that provides opportunities for those experiencing homelessness to participate in the care of the City's Parks and Open Spaces
- Increase boulevard sweeping efforts to twice-a-month
- Provide long-term housing-focused solutions that reduce the need for transient encampments and corresponding recurring litter problems in waterways and transportation infrastructure.
- Expand community partnerships with volunteer-management and work-force non-profit organizations to increase citizen engagement and reduce litter in the environment.

## 5. Next Steps:

- Departments will identify practical mechanisms for implementing a large citywide encampment cleanup contract.
- ARR and partner departments will identify potential new sites for Violet Bag kiosks.
- PARD and partner departments will review Leave No Trace education data and identify future needs for funding and resources.
- Departments will review the report that the national homelessness consultants will be providing in June regarding housing and other initiative recommendations, and will develop an action plan.
- Departments will coordinate, collaborate, and consolidate trash-related sponsorships and contracts with community partners to improve efficiency, effectiveness and equity.
- ATD will issue a summary report on the peer city survey.
- ATD will continue to install signs on bridges over Lady Bird Lake and other bodies of water about proper micromobility use and provide parking boxes where appropriate at end points of bridges.
- ATD will create and provide a map layer that shows the location of all existing and planned signs and parking boxes.
- Continued testing of monitoring tools (drones, divers, etc.) to identify sunken micromobility devices and other trash in Lady Bird Lake.
- WPD will kick off a quantitative study of trash dynamics in Austin-area watersheds in early FY21, with a report at the end of the year. The *WPD Trash in Creeks Project Work Plan* is attached for detail.

# City of Austin Clean City Strategy

## Pride in our City

Everyone deserves to live in a clean City.  A clean city speaks to hope, it speaks to dignity, for all of our community members and visitors. The City of Austin strives to create pride in our community by administering cleanup programs across multiple departments working to keep our city clean and all residents safe. The Parks and Recreation Department is committed to keeping our parks clean, are stewards of our natural resources, and protect our ecosystem. Watershed Protection Department is dedicated to protecting lives and property by reducing erosion and keeping our streams and waterways clean. Resource Recovery is devoted to serving our neighborhoods and all of our neighbors, and the Public Works Department maintains our infrastructure including our roadways, bridges, and overpasses. The City of Austin is also working collaboratively with the Texas Department of Transportation (TxDOT) to maximize our resources and address as many areas as possible.

## Public Works

Public Works contracts with outside crews that provide once-per-month cleanup services at 34 locations across the city. The department adds or deletes sites based on 3-1-1 calls, information or observations by City staff, or through the collaboration with TxDOT.  Public Works continues to add sites and increases frequency of cleanups as needed.  TxDOT contracts with the same crews to perform cleanups at 17 locations.

If there are residents experiencing homelessness at the site, crews will not remove individuals from these locations—only debris and unattended items. Public Works posts signage at cleanup sites 72 hours of advance to give notice that crews will be coming. Prior to and at the time of cleanups, “be safe – be seen” bags are provided to individuals to store any personal belongings. The cleaning process includes the removal of general solid waste and debris only from directly under bridges in the designated locations.

## Watershed Protection

Watershed Protection assesses homeless encampments on Watershed Protection lands or drainage infrastructure. The department conducts cleanups when there are significant flood or water quality risks. Cleanups are generally conducted through a contractor. The department also makes an effort to connect residents of the encampments to social services prior to a cleanup.

## City Landholding Departments

Departments with publicly accessible land are endeavoring to keep dangerous areas cleared of encampments. Non-dangerous areas still do not allow encampments; a process for contacting and supporting those experiencing homelessness is in place, while also ensuring public spaces are safe and accessible for all.

## Austin Resource Recovery

Austin Resource Recovery (ARR) is expanding to meet the cleanup needs for the City of Austin. The department provides on-demand cleanup support for other city departments, and daily downtown litter abatement activities, in addition to providing its core services of curbside collections street cleaning, and brush and bulk collection. Austin Resource Recovery is also taking 3-1-1 homeless calls, tracking the information, and prioritizing cleanup areas.

**Austin Resource Recovery**

Storage Support for our Neighbors Experiencing Homelessness: For those experiencing homelessness, simply being able to store belongings can be life-altering. Access to storage bins allows those experiencing homelessness to safeguard important documents that can be hard or expensive to replace, as well as protect sentimental items and keepsakes, which can't be replaced at all. Everyday activities are difficult or impossible for anyone who has to protect their belongings around the clock.

Single-Site Storage Facility: A best-practice for providing storage for those experiencing homelessness is using a warehouse that can hold "curbside cart" containers for storing belongings. Each cart is assigned to an individual. The City is evaluating several successful models across the U.S. to support development of the Austin storage program. ARR has conducted a site visit to HealthSouth parking garage to determine if it is a suitable site until a long-term facility is built or acquired. If it is determined a suitable site, we anticipate a late March start date. Costs to secure the site, program management, and operation are still under review.

Current Storage Cart Support: ARR has provided 144 carts to the ARCH to support personal storage. Purple carts have been acquired and designated exclusively for personal asset storage. The designated color establishes a unique identifier that will be easily distinguishable for the designated purpose, which we believe will be a first in the United States.

Citywide Lockers: Creating smaller storage opportunities in strategic locations around the City of Austin will require a lower level of support and provide convenient access. These units will be similar to gymnasium or travel center lockers, and most likely will require some form of staff oversight or third-party support. The City is currently working to acquire a set of low-cost lockers to pilot this option.

Encampment Cleanup Storage: The Parks and Recreation Department (PARD) has purchased a shipping container to store unattended personal items found in City parks. The container will be located at the PARD facility at the Nash Hernandez building adjacent to Lady Bird Lake. The container will also be available to other City departments as space permits. ARR is providing the carts for storage.

**Working together**

Violet bag: The Violet Bag Project provides designated violet bags to homeless encampments to help keep the area clean and focuses on encampments with high volumes of trash. Individuals within the homeless community are encouraged to use these bags to collect garbage for pick-up by Austin Resource Recovery twice a week. Users have expressed appreciation for the ability to keep areas cleaner and safer. The project has been well received in its seven locations and will be expended to three more in the coming weeks.


Workforce solutions: The Parks and Recreation Department (PARD), Austin Public Health, in partnership with The Other Ones Foundation and Family Eldercare, created Workforce First. Workforce First's purpose is to offer people experiencing homelessness extremely low barrier employment opportunities as an alternative to panhandling as well as to pave pathways to stable employment and housing. Participants are given transportation to and from work sites, lunch, and counseling services, and have collectively removed 50 tons of trash from green spaces. The program also provides mobile outreach, job training, connection to banking and saving services, and access to social services.

## Litter Abatement and Prevention Services Funding

**City-funded litter abatement (and litter prevention) services to keep clean our parks, waterways, streets, preserves, and any other similarly serviced public lands or spaces.**

| Department | Program/Project Name | Program Details | One-Time or Ongoing | FY18 Operating Budget | FY 19 Operating Budget | FY20 Operating Budget | FY18, FY19, FY20 Combined Capital Budget | Funding Source |
|---|---|---|---|---|---|---|---|---|
| Austin Resource Recovery | Bulk Collection | The Bulk program provides weekly bulk collection for the City of Austin residential customers. This program collects large bulk items such as furniture, appliances, mattresses, metals and tires. | Mixed | $ 2,795,782 | $ 2,922,438 | $ 3,143,378 | $ 1,670,945 | Clean Community Fee |
| Austin Resource Recovery | Clean Austin Program | The Clean Austin Program consists of the cleanup of areas designated for high volume legal/illegal bulk disposal by members of the public. | Mixed | $ 673,129 | $ 603,263 | $ 525,180 | $ 1,493,353 | Clean Community Fee |
| Austin Resource Recovery | Business Outreach | The program implements and monitors compliance of the adopted ordinances and policies of the department, as well as providing zero waste education and technical assistance to the business community. Stakeholders include multifamily properties, commercial properties, food permit holders, and construction permit holders over five thousand square feet. | Mixed | $ 1,755,592 | $ 1,625,707 | $ 1,743,634 | $ 40,000 | Clean Community Fee |
| Austin Resource Recovery | Residential Street Cleaning | Residential Street Sweeping provides street sweeping for the City of Austin residential customers. Residential streets are swept 6 times per year. | Mixed | $ 1,759,126 | $ 2,013,737 | $ 1,704,580 | $ 1,395,000 | Clean Community Fee |
| Austin Resource Recovery | Litter Control | This program maintains the downtown area 7 days a week. Litter Control sweeps and cleans the CBD, collects litter from the rights of way, cleans up illegal dumpsites and assists with special events. | Mixed | $ 2,947,907 | $ 2,919,952 | $ 2,992,126 | $ 2,055,000 | Clean Community Fee |
| Austin Resource Recovery | Boulevard Sweeping | This program is responsible for sweeping all of the boulevards in the City of Austin. Also, assists with Bike Lanes and Special Events. | Mixed | $ 509,808 | $ 525,030 | $ 544,341 | $ - | Clean Community Fee |
| Austin Resource Recovery | Dead Animal Collection | The Dead Animal Collection Program provides collection of deceased animals from the City of Austin residential customers, rights of way and the Austin Animal Shelter. | Mixed | $ 194,958 | $ 219,080 | $ 252,795 | $ 125,000 | Clean Community Fee |
| Austin Resource Recovery | Household Hazard Waste Facility | This program allows residents to safely dispose of unwanted Household Hazardous Waste (HHW) free of charge. Much of this material can be recycled, or is reusable through the Reuse store. The HHW facility offers a home pickup service to the elderly and disabled. Those that have HHW, but are not able to transport it to the facility can request a home pickup free of charge. | Mixed | $ 1,462,446 | $ 1,349,761 | $ 1,539,973 | $ 30,000 | Clean Community Fee |
| Austin Resource Recovery | Strategic Design and Development | This program plans and develops ARR's Zero Waste programs and ordinances. In addition, the team supports diversion at special events, and manages the Home Composting and Zero Waste Event Rebate programs. This team also leads department-wide research and plan development, such as the ARR Zero Waste Master Plan. | Mixed | $ 942,137 | $ 857,365 | $ 768,857 | $ - | Clean Community Fee |
| Austin Resource Recovery | Resource Recovery Center | This program allows residents to recycle a wide variety of items. Recycled items at the Resource Recovery Center (RRC) consist of: common items - like cardboard, plastic, glass, and aluminum, and uncommon items - like textiles, scrap metal, tires, Styrofoam, and electronics. The RRC manages a Reuse Program, in which reusable items are offered for free to the public at a store. | Mixed | $ 899,496 | $ 1,213,076 | $ 1,339,348 | $ 75,857 | Clean Community Fee |
| Austin Resource Recovery | Brownfields Redevelopment | This program is designed to empower communities and stakeholders in economic redevelopment to work together in a timely manner to prevent, assess, safely clean up, and sustainably reuse brownfields. Brownfields are defined as any property that is underutilized due to the real or perceived presence of contamination (i.e. hazardous chemicals, asbestos, lead-based paint, mold, etc.). | Mixed | $ 376,285 | $ 358,622 | $ 339,916 | $ - | Clean Community Fee |
| Austin Resource Recovery | FM 812 Landfill Closure Care | The landfill activities are based on the required maintenance of the FM 812 per the Texas Commission on Environmental Quality (TCEQ). | Mixed | $ 1,416,701 | $ 1,290,337 | $ 963,422 | $ 1,275,000 | Clean Community Fee |
| Austin Resource Recovery | Circular Economy Program | This program is designed to attract, retain, and grow businesses, non-profits, and entrepreneurs in the zero waste industry in order to create well-paying local jobs, attract investment, and support the necessary infrastructure for a resilient circular economy in Central Texas. | Mixed | $ 511,738 | $ 529,892 | $ 592,775 | $ - | Clean Community Fee |
| Austin Resource Recovery | Commercial Compliance | This program supports education efforts and enforces the Universal Recycling Ordinance (URO). | Mixed | $ - | $ - | $ 210,100 | $ 72,000 | Clean Community Fee |
| Austin Resource Recovery | Homelessness | This program assists with cleanup efforts related to homelessness. | Mixed | $ - | $ - | $ 429,000 | $ - | Clean Community Fee |
| Austin Resource Recovery | Customer Service | Graffiti abatement call intake center | | $ - | $ - | $ - | $ - | |
| Austin Resource Recovery | Public Information Office | Leave No Trace is a nationally recognized anti-litter campaign that focuses on community members leaving public spaces the way that they found them or in better condition. WPD and Austin Resource Recovery (ARR) contribute funding to PARD to unify our message | Ongoing | $ 34,000 | $ 34,000 | $ 34,000 | $ - | |
| Downtown Austin Community Court DACC | Community Services Restitution/Litter abatement | Includes litter pickup, graffiti abatement, abatement of code violations based on Austin Resource Recovery; Code Enforcement; PARD; and other City Departments or citizens requests | Ongoing | $ 210,898 | $ 212,250 | $ 211,971 | $ - | Interdepartment Agreements (?) |
| Economic Development | TIF15 / 2nd St District | Maintenance of 4 downtown blocks per Ordinance #001012-34 (TIF15 Plan) under competitive contract for $100,000 of which a portion is for daily litter pickup | Ongoing | $ 47,520 | $ 47,520 | $ 47,520 | $ - | Funded by Tax Increment Fund |

| Department | Program/Project Name | Program Details | One-Time or Ongoing | FY18 Operating Budget | FY 19 Operating Budget | FY20 Operating Budget | FY18, FY19, FY20 Combined Capital Budget | Funding Source |
|---|---|---|---|---|---|---|---|---|
| Parks & Recreation | Grounds maintenance | The PARD Grounds maintenance units are responsible for the maintenance of parkland. | Ongoing | $ 1,635,376 | $ 2,556,607 | $ 2,722,203 | $ - | General Fund |
| Parks & Recreation | Homeless Response | The PARD Homelessness Response unit created in FY19 to address homelessness response, including coordination of parkland clean-up efforts. In FY18, $50K was transferred to APH to support the Workforce First Program. | Ongoing | $ - | $ 50,000 | $ 238,969 | $ - | General Fund |
| Public Works | Downtown Sidewalk Cleaning | Enhanced cleaning and debris removal of sidewalks within the Central Business District | Ongoing | $ 837,220 | $ 839,235 | $ 596,921 | $ - | Transportation Fee |
| Public Works | Highway underpass cleanup | Contracted services for the removal of debris, cleanup, and clearing out of encampments under bridge overpasses throughout the city. | Ongoing | $ - | $ 64,460 | $ 230,227 | $ - | Transportation Fee |
| Watershed Protection Department | Homeless Encampment cleanup services | The Watershed Protection Department (WPD) is working with multiple other city departments and external stakeholders to identify and implement strategies utilizing a human centered approach that reduce the impacts homelessness encampments have on WPD mission areas. In FY19, WPD piloted an encampment cleanup contract at 9 locations which included integrating social service provider into the process. Additionally, WPD has developed a prioritization process for encampments that can focus resources to the appropriate location. WPD also piloted and education and outreach engagement effort with individuals experiencing homelessness on WPD land with the goals of reduce in the impact of encampments on the environmental and enhancing a support network for individuals as they seek permanent housing options. WPD utilizes the same contracted vendor that performs the litter abatement activities to also perform vegetation control work for other department program initiatives. While the vegetation control work also entails some litter removal, it is supplementary to vegetation control which is the primary purpose of the contract and the budget for litter abatement in this area cannot be separated. | Ongoing | $ - | $ 250,000 | $ 250,000 | $ - | Drainage Utility Fund |
| Watershed Protection Department | Keep Austin Beautiful (KAB) for Clean Creek Campus | The Clean Creek campus program is a youth education program developed by KAB and WPD in 2005 that reaches more than 1,600 students, while also completing 25 service projects, 17 of which are creekside projects. WPD has provided $17,500 in annual funding from FY 2017-2020 for the KAB to fund a Program Coordinator and part-time Environmental Educator to coordinate projects, schedule schools, deliver classroom presentations, and to oversee service projects. | Ongoing | $ 17,500 | $ 17,500 | $ 17,500 | $ - | Drainage Utility Fund |
| Watershed Protection Department | WPD funding to Parks and Recreation Department (PARD) for Leave No Trace program | Leave No Trace is a nationally recognized anti-litter campaign that focuses on community members leaving public spaces the way that they found them or in better condition. WPD and Austin Resource Recovery (ARR) contribute funding to PARD to unify our messaging, and so PARD can localize the national campaign for our Austin area. The WPD and ARR departments each contribute $34,000 annually towards this campaign. The campaign includes advertising (radio, digital, bus advertisements, etc.), social media, signage, media outreach, engagement with local non-profits, and on the ground outreach by the Park Rangers. The campaign targets litter hotspots, which are often creeks like the Barton Creek Greenbelt. | Ongoing | $ 34,000 | $ 34,000 | $ 34,000 | $ - | Drainage Utility Fund |
| Watershed Protection Department | Funding to Keep Austin Beautiful (KAB) for Adopt a Creek and Grow Green Program | The Adopt-a-Creek program developed by KAB and WPD In 2005 as a creek clean-up program to improve water quality in Austin's streams and engage the public in urban water quality issues currently has over 100 active groups with more than 50 miles of streams adopted within the City of Austin. In 2012, WPD established the Grow Zone program to improve water quality, infiltration and base flow in our streams by restoring creekside (riparian) areas utilizing both passive management techniques (e.g., no longer mowing near streams), and proactive methods (e.g., soil stabilization, revegetation, invasive plant management, etc.). As many of the methods employed are well-suited to volunteer participation, KAB also expanded their program to include riparian restoration activities as well, and WPD has collaborated extensively with KAB to educate, train and organize volunteers, as well as coordinate workdays and supply restoration materials. To enhance coordination between the Adopt-a-Creek and Grow Zone programs, from FY 2017-2020 WPD has provided $20,000 in funding for the KAB Program Coordinator to receive training in restoration techniques to lead volunteer training and restoration events; thereby expanding outreach efforts and increasing the number of adopted creek segments in Grow Zones to encourage the transition of adopted creek segments into active restoration areas. | Ongoing | $ - | $ - | $ - | $ 60,000 | Drainage Utility Fund |

| Department | Program/Project Name | Program Details | One-Time or Ongoing | FY18 Operating Budget | FY 19 Operating Budget | FY20 Operating Budget | FY18, FY19, FY20 Combined Capital Budget | Funding Source |
|---|---|---|---|---|---|---|---|---|
| Watershed Protection Department | Funding to Keep Austin Beautiful (KAB) for Lady Bird Lake clean-up program | The Lady Bird Lake Volunteer clean-up program developed by KAB and WPD in 2009 to improve the floatable litter abatement program and incorporate citizen requests for a more robust volunteer program, currently coordinates more than 4,000 volunteers at nearly 150 water-based clean-up events each year; providing all equipment needed for clean-up activities. This program has dovetailed extremely well with Adopt-a-Creek program activities within those watersheds contributing flow into the lake and helping to raise awareness of litter on Lady Bird lake throughout the City. To address both the need for volunteer coordination services and the demand for litter management specific to Lady Bird Lake, from FY 2017-2020 WPD has provided $18,000 in funding to address the pervasive litter issues along Lady Bird Lake. | Ongoing | $ 18,000 | $ 18,000 | $ 18,000 | $ - | Drainage Utility Fund |
| | | | **Totals** | **$ 19,079,619** | **$ 20,551,832** | **$ 21,490,736** | **$ 8,292,155** | |

# Project Work Plan

| | |
|---|---|
| **Project Name** | Trash sources, types and pathways to creeks |
| **Section Program(s)** | Surface Water Health |
| **Timeline** | March, 2020 – June 2022 |
| **Staff Involved** | Mateo Scoggins, Andrew Clamann, Todd Jackson |

## I. Problem statement

Austin's lakes, rivers, creeks, and springs are a cherished natural resource that distinguish Austin and provide immeasurable quality of life, health, ecological, and economic benefits. The exceptional value the Austin community places on our rivers is reflected in Imagine Austin's Environment and Water priority programs. Trash and other physical contaminants are a dynamic pollutant, entering constantly into the stormwater pathway from anywhere in the watershed, and moving at unknown rates, with unknown effects on the health of the overall system. Although there are a wide variety of litter and trash related programs and policies, including Watershed Protection Department routine monitoring of trash, there has never been a comprehensive study of trash dynamics in our watersheds to understand the sources, quantities, and pathways of trash that moves from our uplands to our creeks and receiving water bodies.

## II. Task Outline

WPD would like to initiate a roughly 2-year study that would be broken down into 3 primary components:

**Objective 1:** Complete a background study of currently active programs and policies related to litter and trash in Austin's waterways and analyze available data related to spatial and temporal patterns.

| Task | Deliverable | Start Date | Finish Date |
|---|---|---|---|
| Review and compile all currently active programs and policies related to litter and trash in Austin's waterways, including funding and resources currently or potentially available. | | 03/01/2020 | 06/01/2020 |
| Compile and analyze all available data related to spatial and temporal patterns of litter and trash. | | 06/01/2020 | 08/31/2020 |
| Writing a background report that includes an inventory and review of current COA and external partners efforts with respect to litter and trash in Austin watersheds and a high-level summary of available data, trends, and maps. | Background Report | 03/01/2020 | 9/30/2020 |

**Objective 2:** Develop and implement a field-based empirical study of trash dynamics in Austin's watersheds that will represent the range of spatial and temporal variation that is both comprehensive and feasible.

| Task | Deliverable | Start Date | Finish Date |
|---|---|---|---|
| Planning of the study. Development of appropriate sampling locations, field collection methods, and statistical analysis to use within the project. | Quality Assurance Project Plan | 06/01/2020 | 10/01/2020 |
| Data Collection. | | 10/01/2020 | 07/01/2021 |
| Statistical analysis of collected data and writing the associated report which will include volume, type, source, and pathways of trash in creeks from representative locations around Austin. | Study Report | 07/01/2021 | 10/01/2021 |

**Objective 3:** Benchmark trash and litter related studies, best practices, programs and policies in peer cities around the country to understand the range, scope, and reach of the problems and potential solutions that are available.

| Task | Deliverable | Start Date | Finish Date |
|---|---|---|---|
| Staff to write a Scope of Services for a comprehensive benchmarking and solution analysis study of peer cities and programs around the country. | Scope of Services | 10/5/2020 | 12/04/2021 |
| Selection of consultant. | | 12/07/2020 | 04/02/2021 |
| Phase 1: Consultant to perform benchmarking study of best practices, programs and policies in peer cities around the country. | Preliminary Report to WPD | 04/05/2021 | 07/02/2021 |
| Phase 2: Consultant to develop a list of Austin-specific trash and litter solutions based on results in Objective 1, Objective 2, and the first phase of this benchmarking study. | | 07/01/2021 | 10/01/2021 |
| Phase 3: Consultant to benchmark and analyze costs and resources needed to implement the trash and litter solutions from the second phase of this benchmarking study. | | 10/01/2021 | 01/31/2022 |
| Compilation of a final report that will integrate the background and quantitative COA staff studies mentioned above, into the national context, including estimated costs and time scales for implementation of Austin-specific solutions. | Final Report | 01/31/2022 | 05/27/2022 |

## III. Resources

1. Background Report:
    - This will be researched, analyzed, and published using current WPD staff by re-prioritizing time and resources.
2. Study of watershed trash and litter dynamics in Austin watersheds:

- One Full-Time Equivalent (FTE) position to oversee the development and implementation of the study, including analysis and reporting, and $150,000 in contractuals (temp staff, laboratory analysis, labor, etc).

3. Final Report:
    - Selection of a consultant via a competitive bid process will be managed by the WPD staff noted above (one FTE), and will also include management of the contract and deliverables. This component of the study we estimate to cost $250,000 in contractuals over a 1.5 year period.

## IV. Network folder

Sharepoint: https://cityofaustin.sharepoint.com/sites/TrashInCreeks_CIUR_QAPP