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: November 4, 2020

SUBJECT: Status Update - Monitoring & Sources of Trash in Creeks (Resolution No. 20200123-108)

The purpose of this memorandum is to provide an update on interim updates and outcomes related to 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.

Progress since the last update on June 19, 2020 has focused on the literature review portion of the workplan (Attachment 1). This literature review (Attachment 2) is the first step in the quantitative study of trash (types, characteristics, and sources) in representative locations around Austin. It is also the first step in the preparation of a final report that will compile the analysis of the quantitative study with benchmarking and solution recommendations. The final report is to be completed by June 2022.

Based on the results of the literature review staff determined:

1) All aspects of the project will be completed in-house rather than by a consultant.
2) We shall postpone the primary data-collection phase of the quantitative litter study until after wide-spread vaccination of COVID allows for a return to regular background traffic/commercial/residential/behavior patterns, presumably Spring 2021. In the interim, site selection and benchmarking will continue, and experimental design will be finalized.
3) The study will use draft Environmental Protection Agency protocols for the collection and analysis of longitudinal trash survey data in conjunction with assessment of litter collected during existing City trash management activities.

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

cc: Spencer Cronk, City Manager
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Attachments:
Workplan
Literature Review

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

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

Trash in Creeks

Literature Review – Sources and monitoring of trash in urban watersheds

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

Prepared by
Watershed Protection Department
Austin Transportation Department
Austin Resource Recovery Department
Parks and Recreation Department
Austin Code Department

Publish date
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Introduction

This report provides the results of a literature review of monitoring and source isolation related to trash in creeks in response to Resolution No. 20200123-108 (CIUR # 2234). This resolution, in part, directed the City Manager to prepare a study with recommendations to address litter problems in Austin's waterways. This literature review brings together relevant domestic and international studies to identify themes/gaps and synthesize meaningful results that inform the design of an upcoming quantitative study of trash (types, characteristics, and sources) in representative locations around Austin. It is also the first step in a benchmarking and solution analysis study to be completed by June 2022.

Background

Trash enters creeks either deposited directly, driven by wind, or transported throughout the watershed by storm events. The sources of trash include, but are not limited to:

- incidental pedestrian or vehicular littering
- illegal dumping of large items/garbage assemblage
- large organized events/gatherings
- overflowing garbage containers (both commercial and residential)
- habitation/use of floodplain areas (e.g. backyards, encampments, greenbelts, etc.)

Municipal, regional, state, national and international efforts to understand, quantify, and reduce litter and illegal dumping in aquatic resources are diverse and appear to be increasing over time. Unfortunately, most available data are from studies that focus on marine litter (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). These reports typically use volunteer-driven beach clean-ups as a vehicle for data collection. 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). Beach clean-up and marine trash studies, while useful in contextualizing policy recommendations and source identification, are not a good analog for litter accumulation/abundance/characterization in urban freshwater creeks due to the fundamental differences in transport, source, and material (Carpenter and Wolverton 2017; Thompson et al. 2007). For example, beach debris commonly contains trash related to the fisheries industry such as netting (Hong et al. 2014) and floatable trash which washes ashore from sources thousands of miles away (Carson et al. 2013).

Most of the freshwater litter studies reviewed 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. 2017; Kim et al. 2008; Lui et al. 2017; Marais & Armitage 2004; McCormick 2015; McCormick & Hoellein 2016; Santos et al. 2019; Vincent et al. 2017; Weaver 2015). Scientific examinations of the relationship between trash in waterways and people experiencing homelessness were not found in the literature. Similarly, there was no scientifically meaningful study found that focused on litter generated by large organized events. This may be due, in part, to the difficulty of sampling encampments and special events in a statistically meaningful way. However, it should be noted that the recommended solutions in many studies appear to transcend the source and focus on upstream prevention via bans, biodegradable alternatives, and strategic waste receptacle placement (Weaver 2015; Schnurr et al. 2018).

Of the literature reviewed in this report, two documents rose to the top that were clearly the most relevant in regard to the methods and analysis of an assessment of trash in urban creeks. A Rapid Trash Assessment Method Applied to Waters of the San Francisco Bay Region (Moore et.al 2007) was the first published account of a methodology that was successfully applied to generate a dataset which met the objectives of quantifying trends and identifying sources of litter in municipal freshwater streams. Subsequent work in California was based primarily on that methodology, which was successfully replicated. The Escaped Trash Assessment Protocol (ETAP), developed by the EPA TFW (2018 Draft), represents the most recently updated version of litter assessments conducted in California. The 2018 draft document is intended for development into a national standard for documenting and assessing anthropogenic litter in stream habitats and should therefore be the primary source of guidance for City of Austin staff moving forward with local litter assessments.

Findings

Despite a moderate amount of peer-reviewed literature concerned with general litter monitoring, characterizing and tracking, there is little uniformity in scope, methods and analysis. However, there are common themes in the variety of experimental designs reviewed, resulting in four essential elements for a litter study in urban freshwater systems: Site Selection, Sample Collection, Categorization and Analysis.

Site Selection

There are several site variables that influence the types/sources/transport of litter in freshwater systems and should be considered during the process of site selection. Variables include, but are not limited to:

- Land use: The various urban/suburban/rural and subcategories such as recreation use (Moore et al. 2007; Weaver 2015) will 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. The associated literature review, 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).
- Vegetation density: Some studies proport an inverse relationship between riparian buffers and 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 benthic 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.

- House-hold income: Average house-hold income of an area has been shown to be correlated with litter (Armitage 2007; BASMAA 2011; BASMAA 2014). This may be, in part, because neighborhoods with higher incomes are speculated to have better, more consistent trash services (Armitage and Rooseboom 2000; Liu et al. 2017) or that population density generally decreases as house-hold income increases, resulting in fewer people contributing to trash accumulation (Armitage 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. 2017). Cowger et al. (2019) found significant positive correlation between road density and trash accumulation rates.
- Impervious cover: Impervious cover is positively correlated to litter accumulation and as one would assume, urban runoff (i.e. 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 landfills: Liu et al. (2017) used empirical methods to test factors that induced illegal dumping. The study found that size and capability of landfills as well as dispersion significantly impacts rates of illegal dumping. In other words; the easier a landfill is to access, the less likely an individual is to dump trash illegally (Liu et al. 2017).
- Seasonality can affect litter trends (BASMAA 2014; City of Los Angeles 2016; Moore et al. 2007). 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.

Sample Collection Methods

Litter collection methods in relevant literature span a wide range of techniques:

- Utilization of volunteers or "citizen science" is a popular source for sample collection (Cowger et al. 2019; Carson et al. 2013; Harris 2018; Hidalgo-Ruiz & Theil 2013; Hong et al. 2014; Kiessling et al. 2019; Vincent et al. 2017). Kiessling et al. (2019) stated that "the citizen science approach may have limitations (citing Dickinson et al. 2010), but when these are taken into account and adequate strategies applied (e.g. training of volunteers, simple instructions, and data verification mechanisms (Hidalgo-Ruz and Thiel, 2015), the quality of data contributed by volunteers are able to match that of professional scientists (Zettler et al., 2017)". Kiessling et al. (2019) used only half of the available data (179 of 360 groups submitting data) in a survey of litter in rivers in Germany due to a rigorous data quality screening method. Cowger et al. (2019) investigated sources and hotspots of riparian litter from over 5,000km of streams in Iowa collected by volunteers and sorted/recorded by trained staff (Cowger et al. 2019). Although larger sample sizes are desirable, the simplification of litter categorization used in citizen science surveys can negatively affect comparability to other studies, and the uncertainty introduced by a simplified categorization strategy may undermine assessment of litter categories (Cowger et al. 2019). A recent qualitative litter assessment study by the City of Austin WPD (Jackson and Richter 2020) determined that the use of untrained volunteers for litter categorization was a contributing factor in inconsistent results in visual litter assessments. This study determined that litter characterization data should not be collected by untrained personnel (Jackson and Richter 2020). In the San Francisco Bay area, Moore et al. (2007), using only trained staff (teams of 2 or 3 per visit) for all data collection at 26 locations over two years, completed replicated site visits (93 total) for a robust data set that was consistent and reliable.

- Passive litter collection devices are noted in several studies (Allison et al. 1997; Armitage 2007; BASMAA 2014; Carson et al. 2013; Marais & Armitage 2004) and can be effective in collection of litter, however, efficacy and type-bias complicate their use in studies that seek to characterize all trash in a given area. Passive litter devices placed in stormwater inlets may cause flooding without regular maintenance and/or during high storm flow events (Armitage 2007).
- Trained collection teams were used to hand-pick, count, sort, and weigh litter in several successful studies (New Jersey Clean Communities Council 2020; EPA TFW 2018 Draft; McCormick & Hoellein 2016; Moore et al. 2007; Vincent et al. 2016).
- Visual assessments of roadside litter combined with Bayesian uncertainty estimates can be used in assessments of litter concentrations in waterways (Conley et al. 2019)

Stormflow events and seasonality should inform both site selection and sample collection methodology. High rain volume can damage passive collection devices, rendering them useless (Allison 1997; Carson et al. 2013). A 2007 technical report of the San Francisco Bay Region found that the type of litter collected changed depending on whether collection occurred during the wet season or the dry season (Moore et al. 2007). Moore et al. (2007) found that dry versus wet season data collection identified different source types, and repeat site visits over a two-year time period also allowed for the analysis of litter accumulation rates during different seasonal and weather conditions. Acquiring a litter accumulation rate will be critical in future attempts to evaluate the efficacy of structural, enforcement, education, and policies aimed at reducing litter. Generally, trash deposition is much greater during wet conditions due to increased litter mobility (BAASMA 2014; City of Los Angeles 2016; McCormick & Hoellein 2016; Moore et al. 2007). In a study by Cowger et al. (2019), litter collection was primarily conducted in riparian zones due to high turbidity in the creeks, making it impossible to accurately collect all the litter at a site. The City of Los Angeles Trash Management Report (2016) deliberately designed collection protocols for dry weather conditions, which is defined as a sampling event that occurs a minimum of 72 hours after a rain event. Central Texas is highly variable in weather patterns, however there is typically a bi-modal wet "season" that peaks in both May and September and sample collection should avoid these peaks.

The EPA has recognized a need for uniform collection procedures and has responded by creating the Escaped Trash Assessment Protocol (ETAP) that is "meant to align stakeholders collecting [litter] data by providing one standardized method designed to address existing data gaps" (EPA TFW 2018). The EPA ETAP protocol was based on previously successful litter assessments conducted by municipalities in California, which were themselves developed primarily from a method developed in the San Francisco Bay Area by Moore et al. (2007). Those assessments provided a level of detail that regional or national studies had not. As of August 2020, the ETAP is still in the draft stage but is publicly available on the EPA website and provides a simple procedure for on-land litter collection. Additional on-land litter collection procedures were developed in 2015 by EOA Inc., an environmental consulting firm in the San Francisco Bay area. These protocols were utilized by Conley et al. (2019) and are available on EOA Inc.'s website. Currently no uniform collection procedure for aquatic trash collection exists.

Categorization of Litter

The method for categorization criteria of litter is a critical aspect of experimental design that can greatly influence how the data can/will be used. Properly and consistently categorized, the data can inform recommendations for litter reduction strategies for both preventative and removal measures and provide context for source isolation, impacts to aquatic life, and threats to human health and safety. Currently no uniform categorization procedure for aquatic trash collection exists.

Inconsistency in litter classification criteria between different studies complicates a comparison of results (Cowger et al. 2019), however, the Escaped Trash Assessment Protocol (EPA 2018) includes guidance and references to other successful municipal litter assessment programs and may become the future standard. Litter classifications range from as many as 31 different categories (van der Wal et al. 2015) to as few as one (Conley et al. 2019). Unfortunately, many studies do not provide clarity regarding litter taxonomy, which makes replication and comparison challenging (Allison et al. 1997; Carson et al. 2013) and others do not make a distinction between specific litter types at all.

Moore et al. (2007) and EPA TFW (2018) provide an excellent framework for categorization regarding size, material composition, threat to aquatic life, threat to human health, state of decomposition, and source identification. A recent survey conducted by the City of Austin WPD (Jackson and Richter 2020) used similar categories in a study evaluating the efficacy of volunteer-based visual assessments. This study classified creek litter into both a single "overall condition" as well as an 18-category classification system. Results indicated that 1) visual estimates are not recommended for data collection because these types of estimates cannot be collected in a consistent, replicable, and defensible manner and 2) policy, enforcement, or structural controls that are related to a specific type of litter should be based on empirical and quantified data such as total weight, volume, or item count rather than qualitative visual assessments. The EPA TFW classification system is based on the most frequently encountered items, but the authors recommend that additions be made where local conditions suggest other litter types are present/more frequent.

Clean Water Fund (2011) sought additional resolution in assessing litter sources by quantifying brand points of purchase and brands for specific litter types. The Point-of-Sale was established for only 19% of the litter collected, however, for the remaining litter it was often possible to identify the manufacturer. The EPA TFW (2018) draft protocol includes space for notation for identifying features, such as product or event, but more rigorous assignment may be necessary to replicate the method used by Clean Water Fund.

Several research methods define litter categories by size, however, criteria for size categories is highly variable (Gonzalez et al. 2016) and most studies appear to focus either on "micro" or "macro/meso" which are litter that are easily detectable and identifiable (source, function, material) but not all three categories. The micro size category is primarily useful to determine water quality and biological impacts of trash.

Litter Analysis

Studies that explore the transport of litter typically analyzed the material type and weight (Carson et al. 2013; McCormick 2015; McCormick & Hoellein 2016). Other studies designed to track litter sources were concerned primarily with material type, location, and function (Conley et al. 2019; CFW 2011; Hong et al. 2014), while others yet included assessments of litter size, density, location descriptions, brand-name, count, surface area, volume and more (Allison et al. 1997; Carson et al. 2013; CFW 2011; Cowger et al. 2019; Hong et al. 2014; Marais & Armitage 2004; McCormick 2015; Hoellein et al. 2014). Quantification of surface area is used in some studies (Conley et al. 2019; Jakiel et al. 2017; Hoellein et al. 2014), however a drawback of this metric is that it is time consuming since it requires detailed location records for every piece of trash collected. Some mobile apps, such as Collector for ArcGIS, can reduce labor hours by enabling instantaneous data translation into GIS (Conley et al. 2019). Volumetric quantification is another method of quantifying amount of trash and can be accomplished rapidly with several methods (bag/bin/truckload/dumpster, etc), however results can be complicated and potentially misleading due to variable compaction, breakage, and void space.

Despite this wide variety of quantification, most studies typically included a measurement of mass, count, and material type. Although mass would appear to be a logistically simple method to quantify litter, the added water-weight typical in creek litter is problematic. Mass may also be misleading since much litter of concern is small and lightweight (EPA 2002; Moore 2007).

Moore et al. (2007) and some municipalities in California utilized both quantitative data from surveys and qualitative scoring metrics to analyze spatial and temporal trends in litter composition and accumulation. The draft protocol provided by EPA TFW (2018) incorporated these analytical elements as well, relying heavily on type (litter category) and count (number of discrete items). Type and count provide an efficient/effective method for actionable, comparable and reproducible assessments of litter in creeks.

Discussion

This literature review serves as the first step in developing an experimental design for characterizing trash in creeks in Austin. While current litter research spans a breadth of topics, from marine to terrestrial, behavioral to chemical, comparatively little has been published on trash dynamics in freshwater systems (Vincent et al. 2007). What is known is simply that there is an existing global freshwater litter problem which presents a threat to environmental and human health and research dealing with litter in freshwater systems is an emerging science (BASMAA 2014; Carpenter & Wolverton 2017; Carson et al. 2013; City of Los Angeles 2016; CFW 2011; EPA 2002; EPA TFW 2018 Draft; Gonzalez et al. 2016; Koelmans et al. 2015; Liu et al. 2017; McCormick & Hoellein 2016; Moore 2007; Schnurr et al. 2018). Multiple experimental designs have been employed, but with varying results due to errors related to data collection methods, sample size, timing of sampling, categorical assignment, or resolution with regard to specificity of identification. A smaller set of publications have identified methods that are repeatable and defensible, which can inform experimental design moving forward.

Based on the literature reviewed, essential facets of a future study by the City of Austin to assess litter in streams include:

- Data collection method should align with Moore et.al (2007) and/or the EPA TFW Escaped Trash Assessment Protocol (2018) to include longitudinal surveys recoding litter type (bottles, food packaging, tires, etc.) and count (discrete occurrence).
- Repeated site visits are necessary to determine accumulation rates and temporal trends. An initial site visit informs what has collected in a stream during an unknown period,

however, one or more follow-up visits can inform rate of change and establish baseline conditions for future evaluations of change and/or effectiveness of solution implementation.

- Rigorous scrutiny of site selection can strategically isolate areas of interest (land use/encampments/etc.) and bracket (upstream/downstream) subsequent impacts.
- Trained personnel should be used to sort/categorize and/or supervise the sorting/categorization of litter for analysis.
- Volunteer-led creek cleanups can provide an inexpensive method for gathering voluminous data but are limited in resolution and may only reflect known hot spots rather than characterize a watershed.

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