# Community Science-informed Local Policy: a Case Study in Pinole Creek Litter Assessment

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### Abstract

California is one of the only states actively managing trash in its rivers. Several community groups in the Pinole, CA and a scientist collaborated on a Thriving Earth Exchange community science project. Its purpose was to assess the trash in Pinole Creek and identify policy opportunities for the Pinole City Council. The key scientific questions were: how much trash was in the creek, what types of trash were most abundant, and where were areas of highest concern? The team enlisted additional community volunteers at in-person local events and local nonprofit listservs. We used a randomized sampling design and a community science adapted version of The Trash Monitoring Playbook, to survey the trash in the creek. We estimated there were 37 m 3 and 47,820 pieces of total trash in the creek channel with an average concentration of 2 m 3 per km 2697 pieces per kilometer. This gave the community an understanding of the scale of the problem and the resources needed to address it. Plastic and single-use trash were most abundant, and the community members expressed high concern about plastic single-use food packaging and tobacco-related waste. The community used the data to identify locations in the creek where trash was abundant and prioritize follow-up study locations. Seven new policies were recommended to the Pinole City Council. The City Council unanimously voted for the proposed policies to be reviewed by the Municipal Code Ad-Hoc Committee. And that is when community science turned to policy.


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# Title

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# Keywords

Thriving Earth Exchange, Litter, Trash, Water Quality, Plastic Pollution, Assessment, Community Science

# Key Points

- Created a framework for conducting rigorous policy informing community science research on trash in rivers through the Thriving Earth Exchange.
- Assessed river trash data in collaboration with the community who led the research priorities and collected the data.
- Used community science to inform local City Council policy.

# Abstract

California is one of the only states actively managing trash in its rivers. Several community groups in the Pinole, CA and a scientist collaborated on a Thriving Earth Exchange community science project. Its purpose was to assess the trash in Pinole Creek and identify policy

opportunities for the Pinole City Council. The key scientific questions were: how much trash was in the creek, what types of trash were most abundant, and where were areas of highest concern? The team enlisted additional community volunteers at in-person local events and local nonprofit listservs. We used a randomized sampling design and a community science adapted version of The Trash Monitoring Playbook, to survey the trash in the creek. We estimated there were 37 $m^3$ and 47,820 pieces of total trash in the creek channel with an average concentration of 2 $m^3$ per km 2697 pieces per kilometer. This gave the community an understanding of the scale of the problem and the resources needed to address it. Plastic and single-use trash were most abundant, and the community members expressed high concern about plastic single-use food packaging and tobacco-related waste. The community used the data to identify locations in the creek where trash was abundant and prioritize follow-up study locations. Seven new policies were recommended to the Pinole City Council. The City Council unanimously voted for the proposed policies to be reviewed by the Municipal Code Ad-Hoc Committee. And that is when community science turned to policy.

# Introduction

## Community

### Community Motivation

In the fall of 2019, over coffee at a local shop, three stakeholders, Lisa Anich, Watershed Manager, Contra Costa Resource Conservation District (CCRCD); Norma Martinez-Rubin, Community member and Pinole Council member; and Ann Moriarty, Board member, Friends of Pinole Creek Watershed, met to discuss how they might work together and address an ongoing set of problems: trash in Pinole Creek and unconsolidated local action. The aforementioned members are referred to as "The Core Community Team" throughout. When "The Community" is mentioned it is to refer to The Core Community Team and their networks and partners in Pinole. The Core Community Team, composed of environmentally conscious and civically oriented volunteers, saw the value in using a standardized methodology to survey trash in the creek, using a method that would later be defensible among others. The group decided to submit a proposal to Thriving Earth Exchange for support and assistance in direction. Thriving Earth Exchange (TEX), an initiative and program within the American Geophysical Union (AGU), strives to unite communities, scientists, partners, and stakeholders to engage in a community science process that addresses community-level issues related to natural hazards, natural resources, and climate change. The group formalized their project with Thriving Earth Exchange with the title "Engaging community to protect the Pinole Creek Watershed: Assessment of trash impacts to promote a thriving ecosystem."

## Pinole Creek Trash Policies

As a Municipal Separate Storm Sewer System (MS4) permittee, Pinole is responsible for compliance with the state of California Trash Amendments (State Water Resources Control Board, 2015). Pinole opted to use track 1 compliance which requires the City to identify locations of priority (high waste generation) on the roadsides and capture trash that runs into the storm drain system using "Total Trash Capture Devices." Total trash capture devices are metal grates inside the storm drain that filter trash out of the storm drains down to 5 mm in size and are periodically cleaned out. Before this project began, Pinole was in full compliance with the trash amendments but at one point was the subject of a Grand Jury Report that revealed they were out of compliance, which they subsequently corrected (Nakano, 2019). In addition to the trash amendment regulations, Pinole is active in trash abatement and supports community-run cleanup service days, organizes annual "dumpster days" in partnership with its trash hauling franchisee, operates a street sweeper, and has an ordinance that bans Styrofoam. A Pinole beautification ad-hoc committee, composed of council members and planning commissioners, recommended targeted placement of solar-powered trash bins at popular recreational sites. Pinole is an exemplary permittee in this regard, going above and beyond to improve its water quality.

### Community Objectives

The Core Community Teams' primary goals were to improve the Pinole Creek Watershed's environmental stewardship and make it as clean as possible. Critical to the success of these goals was using a sound methodology to collect data to inform the creation of new policies at the Pinole City Council.

## Scientific

### Stream Trash Research Background

Riparian river trash research is still nascent (Emmerik & Schwarz, 2020). We know that there is variability in the abundance of trash from river to river (Baldwin et al., 2016) and that trash abundance correlates with urban land use near the stream and within the entire watershed upstream from the river corridor (Cowger et al., 2019). We also know that there can be some variation in the trash composition from reach to reach of the same river, but the mechanisms controlling litter composition within a river are not clearly understood (McCormick & Hoellein, 2016). Areas of concern (i.e., highly abundant locations of trash) exist due to river process (Hoellein & Rochman, 2021) and variation in human input processes (Meijer et al., 2021) and are commonly prioritized as locations for mitigation of trash in rivers (Helinski et al., 2021). Trash composition and concentration are highly variable; therefore priorities for mitigation should be acted on locally (Rochman et al., 2020). To apply science in its fullest sense, scientists must work with community members during the scientific process (McKinley et al., 2017; Watkins, 2022). Plastic pollution research has a long history of community collaboration on data collection (Cârstea et al., 2022; Cook et al., 2021; Rambonnet et al., 2019). Still, much of this appears to be driven by researchers, not the community itself, as in this project. We want to make a clear distinction that this research project was not led by the scientists involved, The Community led it. We will go into more detail about this paradigm in our methodology and results to demonstrate what we mean by community science. At the start of the Pinole litter assessment, we were not aware of other cases where community driven science on river trash was leveraged to inform local policies focused on reducing river trash. We aim for this study to lay the groundwork for similar studies elsewhere.

## Trash Monitoring Playbook

The Community decided that they wanted to survey for trash using the most robust standardized methodology available. By doing so they could compare their results with other studies in California and have results that would be publishable in scientific literature. River trash methodologies are recently beginning to be standardized. The Trash Monitoring Playbook was designed and published in 2021 by the San Francisco Estuary Institute to allow for a California-wide assessment of trash in rivers in a way that is rapidly compared with other studies throughout the state (Moore et al., 2020). We aim for this study to improve the utility of the Trash Monitoring Playbook for community science projects by modifying it for community use (Rambonnet et al., 2019).

### Scientific Questions

The Community identified three scientific questions to guide data collection: 1) How much trash was in the creek at the time of the study? 2) What types of trash were most abundant? 3) Where should the Community be most concerned about trash in the creek?

# Methods

## Community

### Project Team Meetings and Roles

Project leader meetings happened twice a month starting on March 8, 2021 and ending on June 30, 2022. Lisa Anich represented the Contra Costa Resource Conservation District (CCRCD) which provides staff support for the Friends of Pinole Creek Watershed and conducts trash assessments for Contra Costa County's Watershed Program. Itzel Gomez represented Earth Team, introducing youth to the environment and previously conducted many cleanups with youth. Norma Martinez-Rubin was city mayor and acted in the capacity of a concerned citizen while also functioning as a liaison between the groups and city staff to facilitate communication and presentations. Ann Moriarty represented Friends of Pinole Creek Watershed which engages with The Community to improve the watershed health of Pinole creek. Todd Harwell was the Community Science Fellow who convened the meetings and kept the group progressing toward its goals. Win Cowger was the Scientist who developed the scientific methodology based on The Community objectives and conducted the data analysis. All aforementioned members are referred to as "The Thriving Earth Team" or "We" throughout.

## Public Engagement Strategy

Pinole is an ethnically diverse community; to engage volunteers in assessing trash,The Core Community Team employed several strategies. They set up a table at the local Coastal Cleanup Day in September 2020 and took down names and contact information. They met cars bringing trash to a Dumpster Day, asking for contact info, and passing out flyers. They reached out to two local elementary schools adjacent to the creek. Lastly, they gave presentations to city commissions and other political groups.

## Fieldwork Preparation

The fieldwork was relatively inexpensive to conduct. We purchased waders, buckets, trash grabbers, and gloves for project participants and paid for transportation to the field site and meetings. The estimated total cost for the fieldwork was $9,500 which was funded by the Thriving Earth Exchange.

The Trash Monitoring Playbook included useful resources for planning, equipping, and training trash assessment teams but was not specifically designed for community members who may not all be experts in fieldwork or research. We modified and expanded these materials to suit our unique training and assessment situations by creating simplified layperson variations of the materials along with detailed instructions for use (Supplemental Information).

Assessment sites were each evaluated by the project team by conducting site visits and taking photos to ensure accessibility and safety for the volunteers. Evaluations assessed how accessible each site was, how safe it was, and if it was on private or public property. Private landowners were contacted when possible to discuss entering their property. Any sites deemed inaccessible, unsafe, or illegal to enter were removed from the list of sites to visit.

The COVID-19 pandemic restrictions were in constant flux throughout the project due to local and state regulations. We adapted to them while prioritizing the health and safety of The Community. We primarily conducted outdoor site meetings with groups of 5-6 people. Workshops were virtual due to restrictions on having many people indoors.

## Council Engagement

We wanted the Pinole City Council as a partner in the project. Two presentations about the project were given to the City Council. The first presentation was given on October 19, 2021, to introduce the City Council to the project and seek their input on directions at early project onset. On April 22, 2022, a presentation was given to the City Council where we presented the final results of the study and The Community joined to provide verbal testimony and support for the proposed policies.

## Community Workshop

Before a presentation to the City Council, a workshop conducted via Zoom was conducted to share the study results with The Community. The workshop's goal was to form policy recommendations based on the study findings in collaboration with The Community members that participated in the study and others. The Thriving Earth Exchange team presented the study findings and the entire group broke into small groups to discuss policies that might prevent or mitigate the problems we observed. Groups highlighted areas for further research. Afterward, policy recommendations were finalized by the Pinole Thriving Earth Exchange team.

# Scientific

## Site Description

The Pinole Creek watershed is a small (39 $km^2$) coastal watershed that hosts a perennial stream (Figure 1). The climate in Pinole is Mediterranean with most of the rainfall occurring in the winter and dry hot summers. Pinole creek is the 18 km mainstem of the watershed and is home to steelhead trout. Pinole Creek flows directly into the San Pablo Bay without dams or other impeding structures. Approximately one-quarter (10 $km^2$) of the creek watershed is within the Pinole city limits. Pinole city is 13 $km^2$ so most of the City is within the Pinole creek watershed. The rest of the creek watershed upstream is in county jurisdiction. Approximately 19,343 people live in Pinole. Most of the City is contained within the bottom highly urbanized quarter of the watershed with the top three-quarters being rural county land with low population density and agriculture. Pinole conducts street sweeping, trash capture in priority storm drains, and streetside collection of waste to prevent trash from entering the creek.

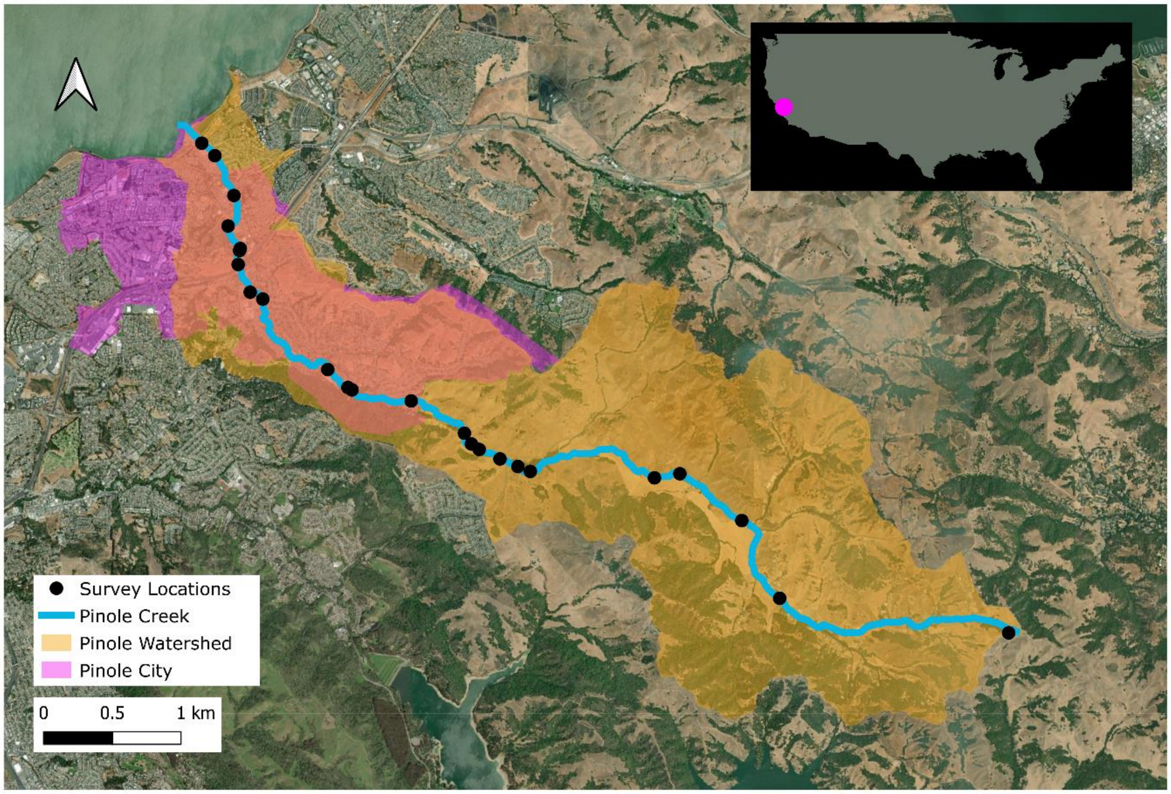


Figure 1: Pinole Watershed outlined in orange. 23 Sample locations were randomized across the Pinole creek channel.

## Description of Trash Monitoring Playbook Methodology

The Trash Monitoring Playbook method consists of 4 tiers of methodologies: qualitative, quantitative, semi-quantitative, and drone imaging. Using the playbook, a project team will choose the suite of methods that help them achieve their study objectives. We decided that the quantitative and semi-quantitative approaches would be the most useful to address The Community's questions because we felt that quantitative data provided the most detailed information about the source of the trash. The quantitative approach would provide a count of the trash and the semi-qualitative would provide its volume, both metrics were thought important.

These methods include surveying a 30 m stretch of the river corridor from high water line to high water line in the water and outside of the water in the adjacent floodplain. The survey is conducted to assess the entire area within the high water line for trash. Trash was categorized using the terms established in the Trash Monitoring Playbook. Three volunteers worked together to measure and flag the assessment area, the bankfull width and transect cross sections, to take photos, and record coordinates. The other volunteers were tasked with documenting vegetation, storm drains, and encampments. All team members collected and tallied trash. Trash was tallied when found and collected if not submerged or embedded in soil or substrate. If objects were present in number larger than 10 then counts they were allowed to be estimated as between 11-100 or between 100-200 and this happened on 4 occasions. Those counts were estimated afterward using a uniform probability density function. Collected trash was sorted into the categories used for volume assessment in the Trash Monitoring Playbook using buckets. Buckets were visually assessed for volume using the semi-quantitative methodology. Large items were estimated for volume visually.

## Randomized Sampling

Survey locations were randomized throughout the Pinole creek main channel. Tributaries in the watershed were not assessed because access was too difficult in these smaller channels, they were mostly either on private property or overgrown. 23 locations were selected based on available effort from the volunteers. There is no guidance currently on the minimum number of survey locations to sample for a given river but we felt this was adequate for a single channel based on the variability that had been observed in other studies (Moore et al., 2016). Randomized locations were created along Pinole creek using QGIS (version 2.24.3) and the random points along line function. Another randomized site was generated and assessed if a site was deemed unsuitable or inaccessible to survey. Six locations were moved a maximum of

295 meters, in line with the recommendations from the Trash Monitoring Playbook, to increase accessibility since the other randomized locations were on private property.

### Trash Abundance

Mean trash abundance was assessed by dividing the number of pieces of trash found at each site by the total site length and taking the mean from all sites. This was used to calculate the total trash volume in the whole river by multiplying the mean abundance by the total river length. Mean trash abundance was bootstrapped with replacement (n = 10,000) to derive the confidence intervals around the total and mean abundance of trash in Pinole creek.

### Composition

Trash composition was categorized using the categories defined in the Trash Monitoring Playbook. Mean trash composition proportions were assessed using bootstrapping of the trash composition proportions at each site (resampling with replacement n = 10,000). Trash compositions were determined distinguishable if confidence intervals did not overlap.

### Areas of Concern

The random locations were visually assessed for areas of concern (i.e., areas with elevated levels of trash) by looking for locations where trash was elevated above other nearby locations and where high concentrations were close together. We wanted a unit that could account for count and volume concentration simultaneously, so we min-max normalized the count and volume concentrations separately and then multiplied them. We visualized these values as quantiles (n = 5) on a map and drew bounding boxes around regions that appeared amplified. These regions would be recommended for future targeted research and management.

# Results and Discussion

## Community

### New Community Science Materials Developed

The Friends of Pinole Creek Watershed and CCRCD trained adult volunteers to conduct assessments. Earth Team trained high school student interns to conduct assessments; interns also planned and supervised an assessment engaging elementary students. For the adult team, we created a double-sided handout illustrating two types of roles for volunteers. We also streamlined the Trash Monitoring Playbook's trash tally spreadsheet for use as both field worksheet (hard copy) and data tabulation (online) (Supplemental Material). Materials were adapted from the trash monitoring playbook to make them simpler without compromising the richness or compatibility of the data.

### Data-informed Policy Recommendations and Proposed Actions

The Pinole City Council's involvement was on October 19, 2021 ("Pinole City Council Meeting," 2021) and April 22 2022 ("Pinole City Council Meeting," 2022) as an audience to project presentations. During the October 19, 2021 meeting, the council expressed support for the project and interest in a follow-up presentation when the team had results to share. At its April 19, 2022 meeting, the consensus among the Council was that ordinance-related recommendations presented by the Pinole Thriving Earth Exchange Project team members be considered by its Municipal Code Ad-Hoc Committee. Other recommended actions, listed below, await future City Council deliberation and decisions to become publicly funded items and/or operational policies.

Recommended Actions

- Develop and/or update city food packaging and cigarette ordinances.
- Characterize areas of concern and address the problem.
- Create a city-owned trash bin inventory. Use our data to inform new trash bin locations in areas of concern.
- Initiate monthly trash cleanups harnessing the power of community groups.
- Institute an "Adopt-a-Street" or "Adopt-a-Spot" Program (Create Pinole Creek Allies).
- Initiate litter-awareness outreach & educational programs in schools and community (creative media campaign).
- Fund a follow-up trash assessment in 5 years (2026).

# Scientific

## Abundance

Trash abundance was first assessed as the mean count and volume of trash at each site surveyed (Figures 2 & 3). Mean trash count was 2697 (95% CI 1237-4890) pieces of trash per kilometer. Mean trash volume was 2 (95% CI 0.7 - 4) cubic meters per kilometer. We estimated that there were 47820 (21933-86712) pieces and 37 (13 - 68) cubic meters of trash in the creek in 2021-2022. Some of the highest count concentrations were located within the city limits, while some of the highest volume concentrations were found above the city limits (Figures 4 & 5). Both spatial relationships had high variability.

Using this information, The Community learned that the amount of waste in Pinole Creek was not a situation of everyone throwing all their waste into it. Divided by the entire population of Pinole, the waste was only 2 L per person. Additionally, dumping (high volume concentration) was less often observed in the city limits. These facts encouraged proposing and supporting policies that targeted littering processes.

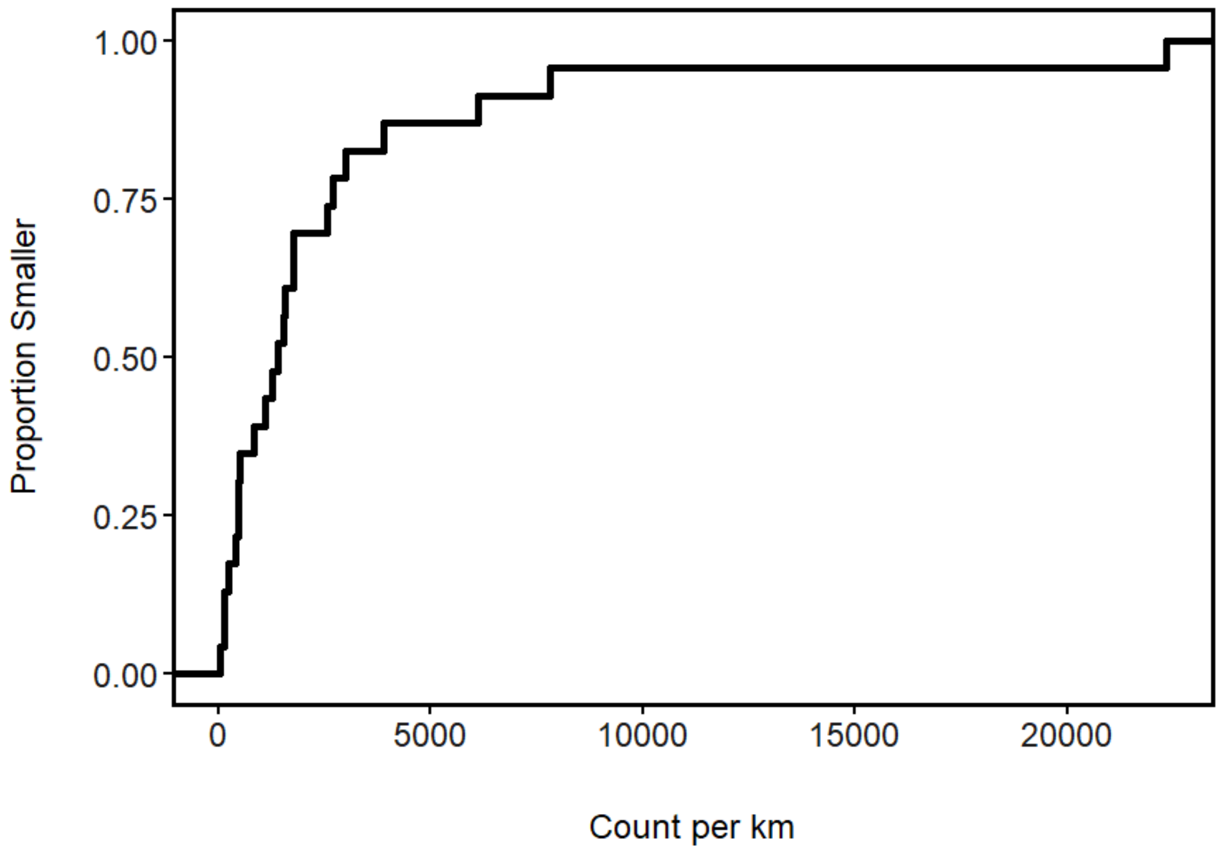


Figure 2: The cumulative density function for the counts of trash per kilometer found at each site. The X-axis is the count concentration. The y-axis is the proportion of sites with lower concentrations. The line connects the continuous values at the sites.

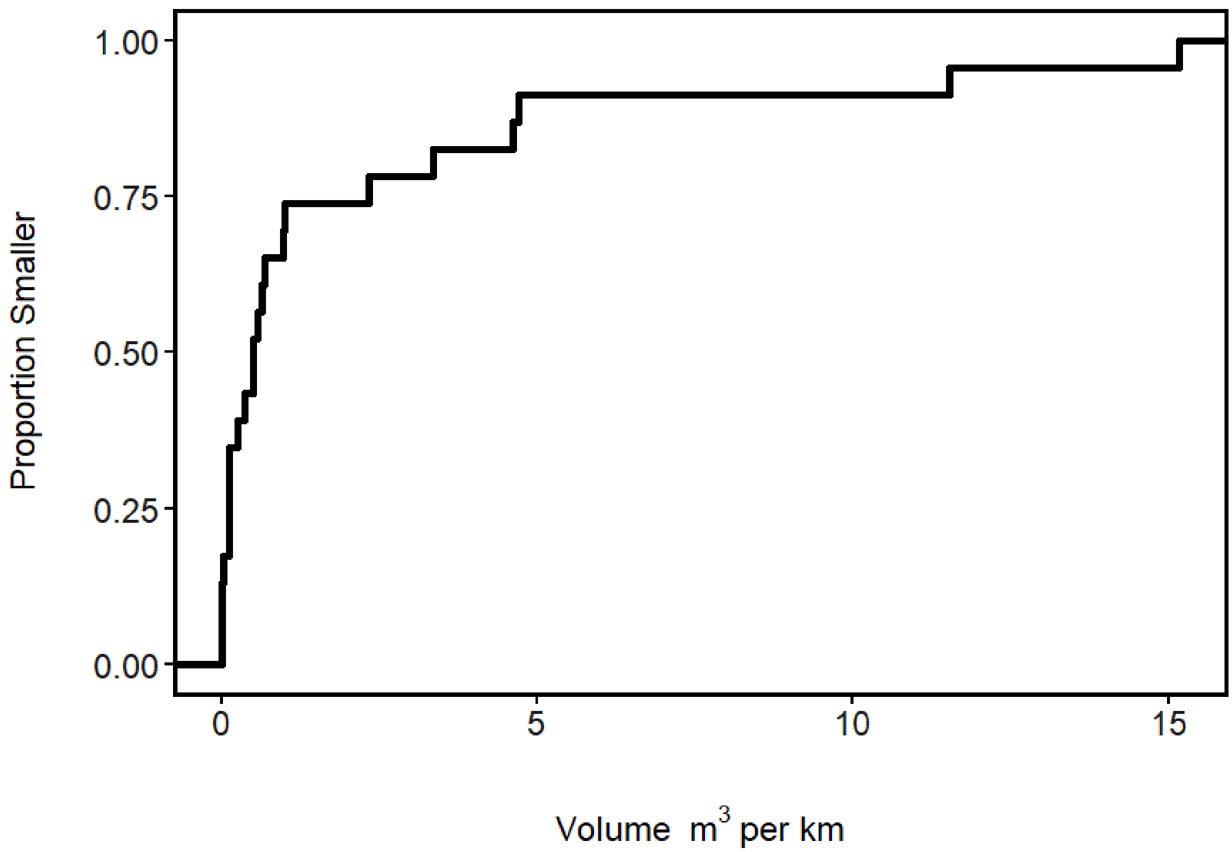


Figure 3: The cumulative density function for the volume of trash in cubic meters per kilometer at sites. The X-axis is the volume concentration, the y-axis is the proportion of sites with lower concentrations. The line connects the continuous values at the sites.

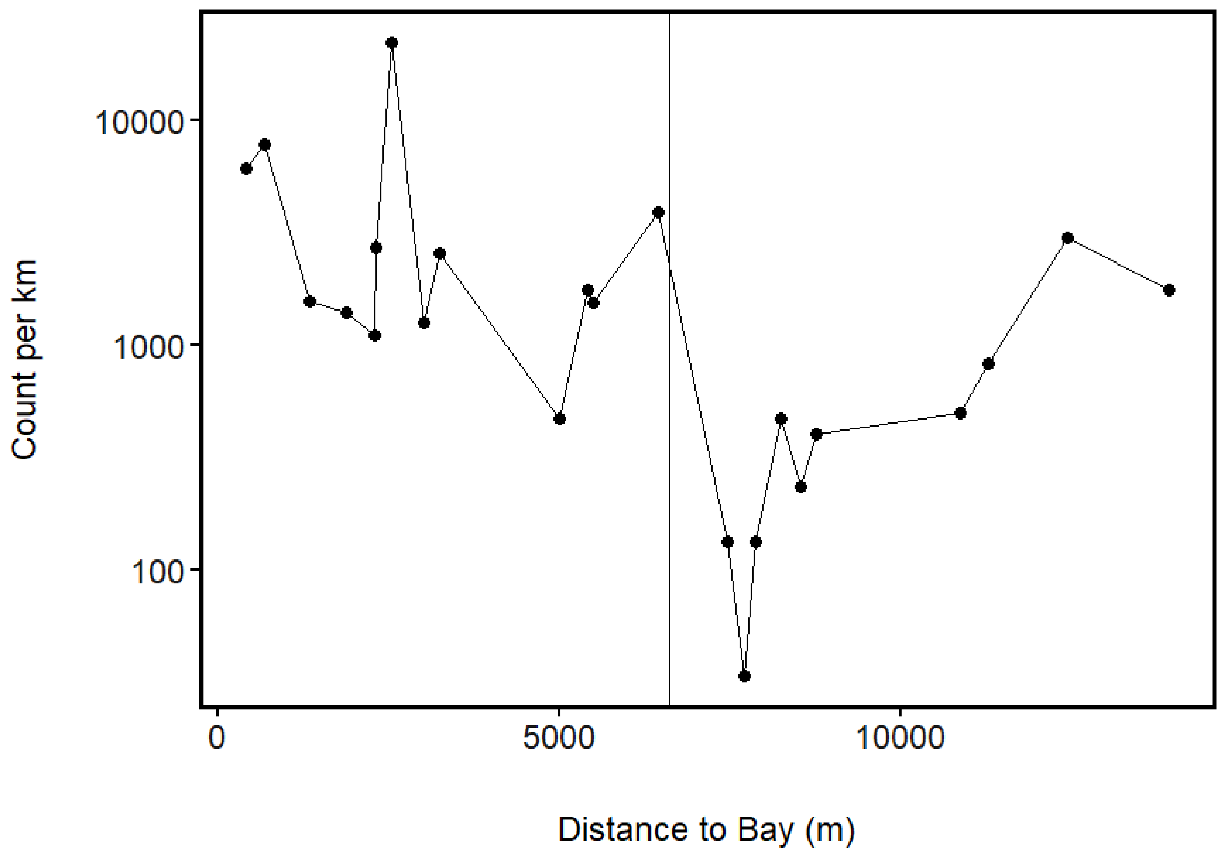


Figure 4: Litter count per kilometer at each of the sites. The x-axis is the distance the survey location is from the outlet at the bay. The y-axis is the count concentration of trash at the site. The points are the values at the sites. The line connects the sites as a tool for visual interpolation. Everything to the left of the line is within the city limits; everything to the right is above the city limits.

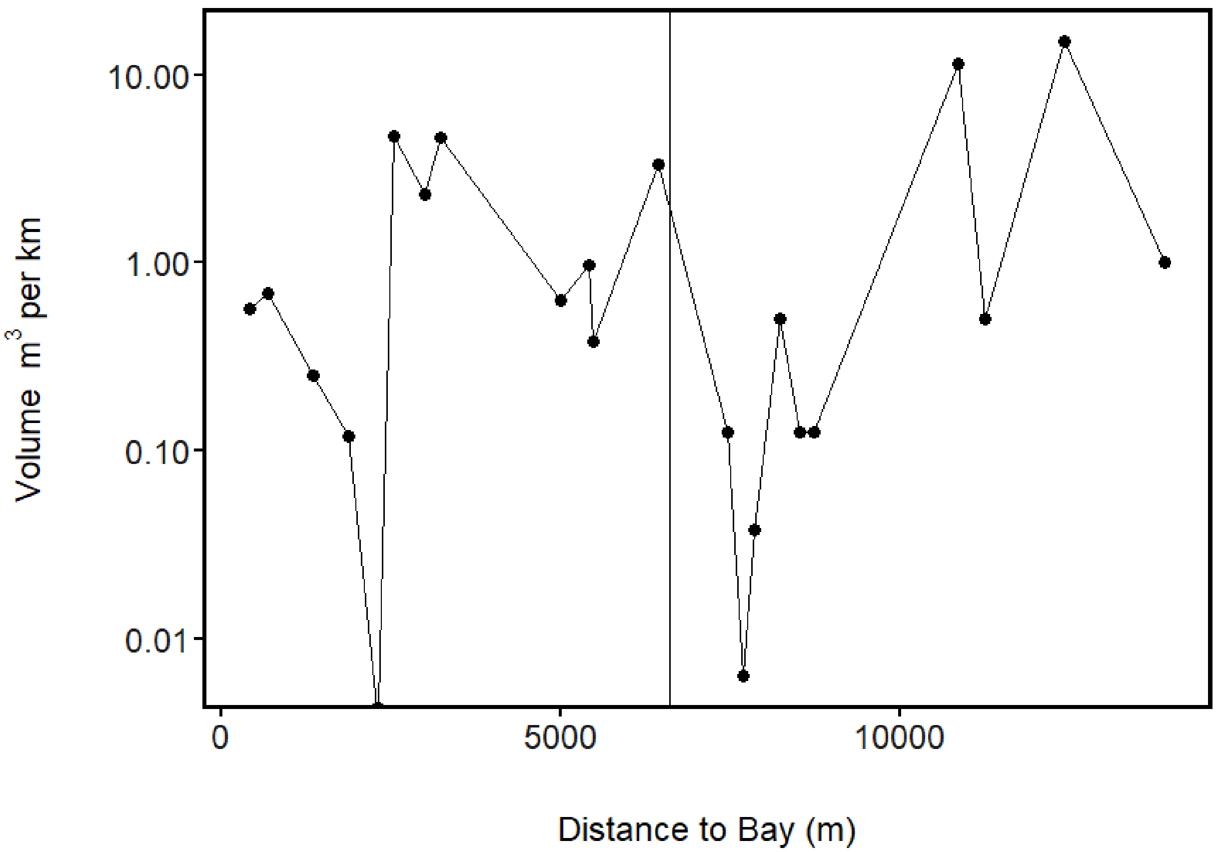


Figure 5: Volume per kilometer at each of the survey locations. The x-axis is the distance the survey location is from the outlet at the bay. The y-axis is the volume concentration of trash at the site. The points are the values at the sites. The line connects the sites as a tool for visual interpolation. Everything to the left of the line is within the city limits and everything to the right is above.

## Composition

Trash composition was assessed to identify the sites' most common types of trash by bootstrapping the mean count proportions for each type of trash (Figure 6). The most prevalent morphologies were fragments of bags, wrappers, foam, glass, and soft plastic. Generally, there is wide variability around the mean estimates and few comparisons between the morphology types are significantly different. By material type, plastic stood out as the most prevalent material for count and volume proportions.

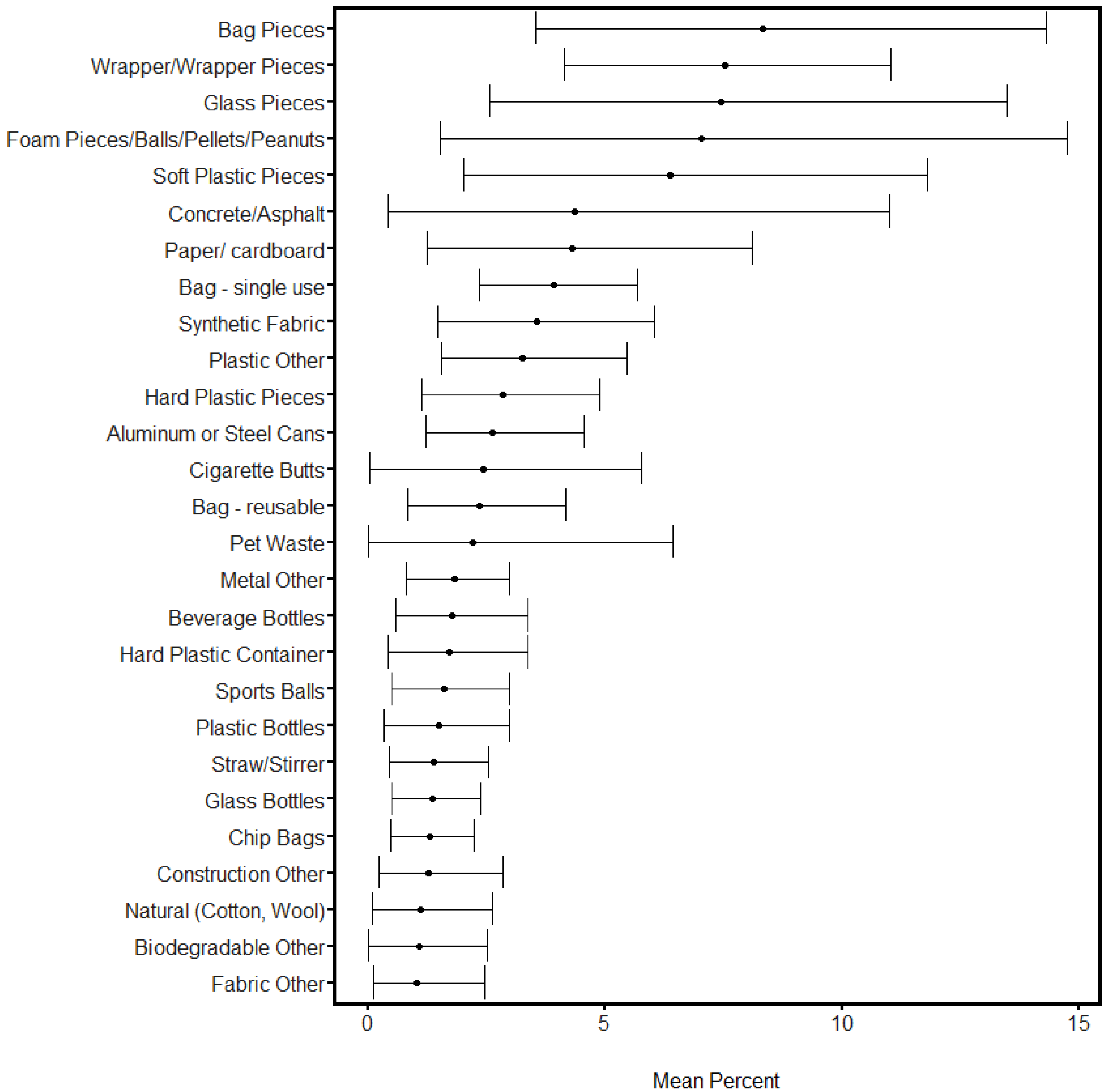


Figure 6: Morphology composition by mean count percent. Highly abundant trash types in Pinole Creek by morphology type. Error bars represent uncertainty around the mean percent of these trash types (bootstrapped 95% confidence intervals). The x-axis represents each morphology's mean percent from all the survey sites. The y-axis is the morphology type.

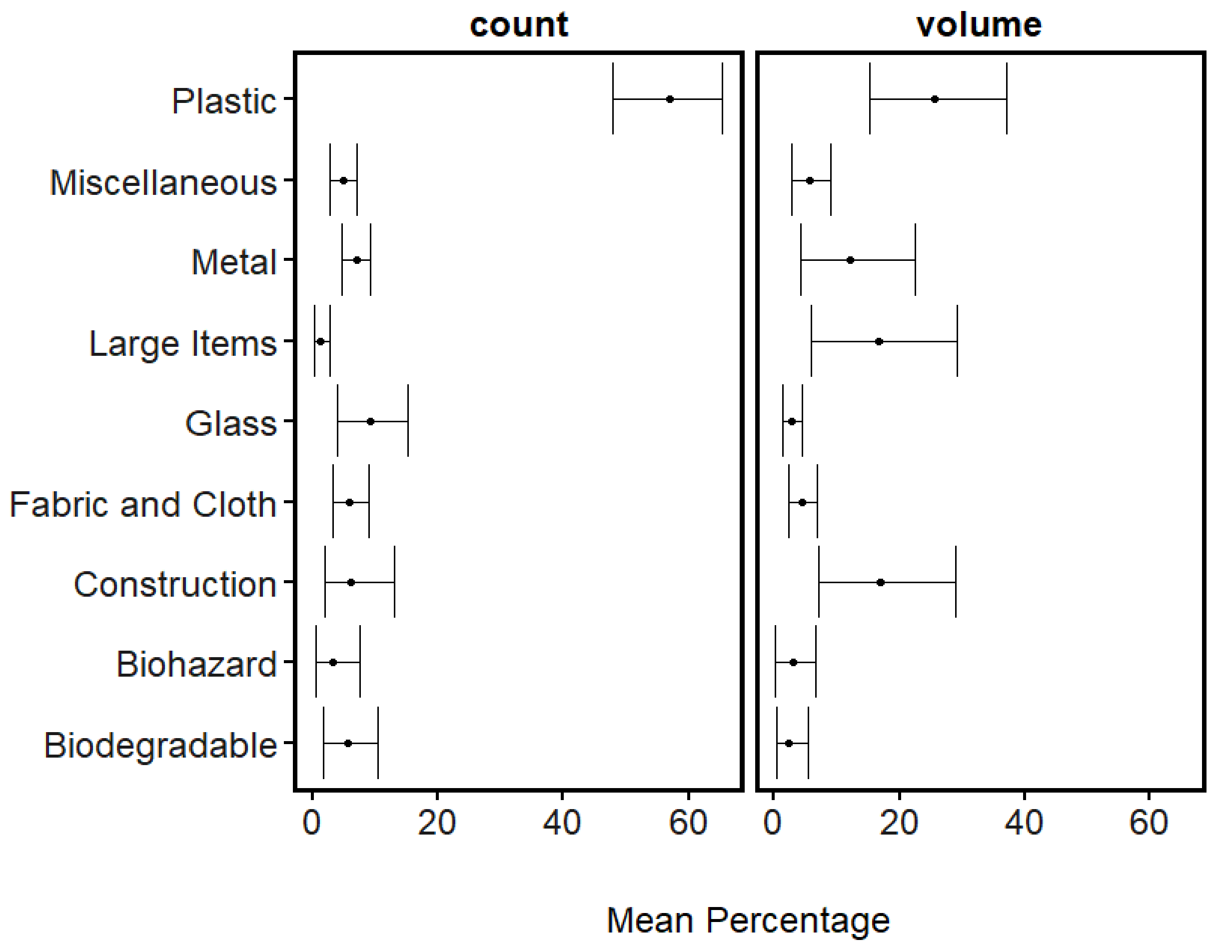


Figure 7: Material composition by count and volume. X-axis is the mean percent of the material type at all sites. Y-axis is the material type. Top axis is the data split up by count or volume respectively. The point is the mean and the whiskers are the 95% confidence intervals from the bootstrap simulation.

The Community determined that their top priorities were to reduce cigarette-related litter and single-use plastic food packaging, which seemed prevalent by material and morphological type (Figures 6 & 7). We produced spatial graphs for each of these categories so that The Community could identify regions where preventative measures would likely be successful due to focus on elevated levels of litter (Figures 8 & 9). We did not observe a specific region where single-use food packaging was most abundant, it was prevalent throughout the watershed. This suggested that broad-scale measures like bans might be successful in reducing waste. However, we did observe elevated levels of tobacco product waste isolated near the mouth of the creek. The Community decided that combining cleanup/education activities focused on those locations and updated cigarette ordinances would likely be the most effective at improving environmental and human health.

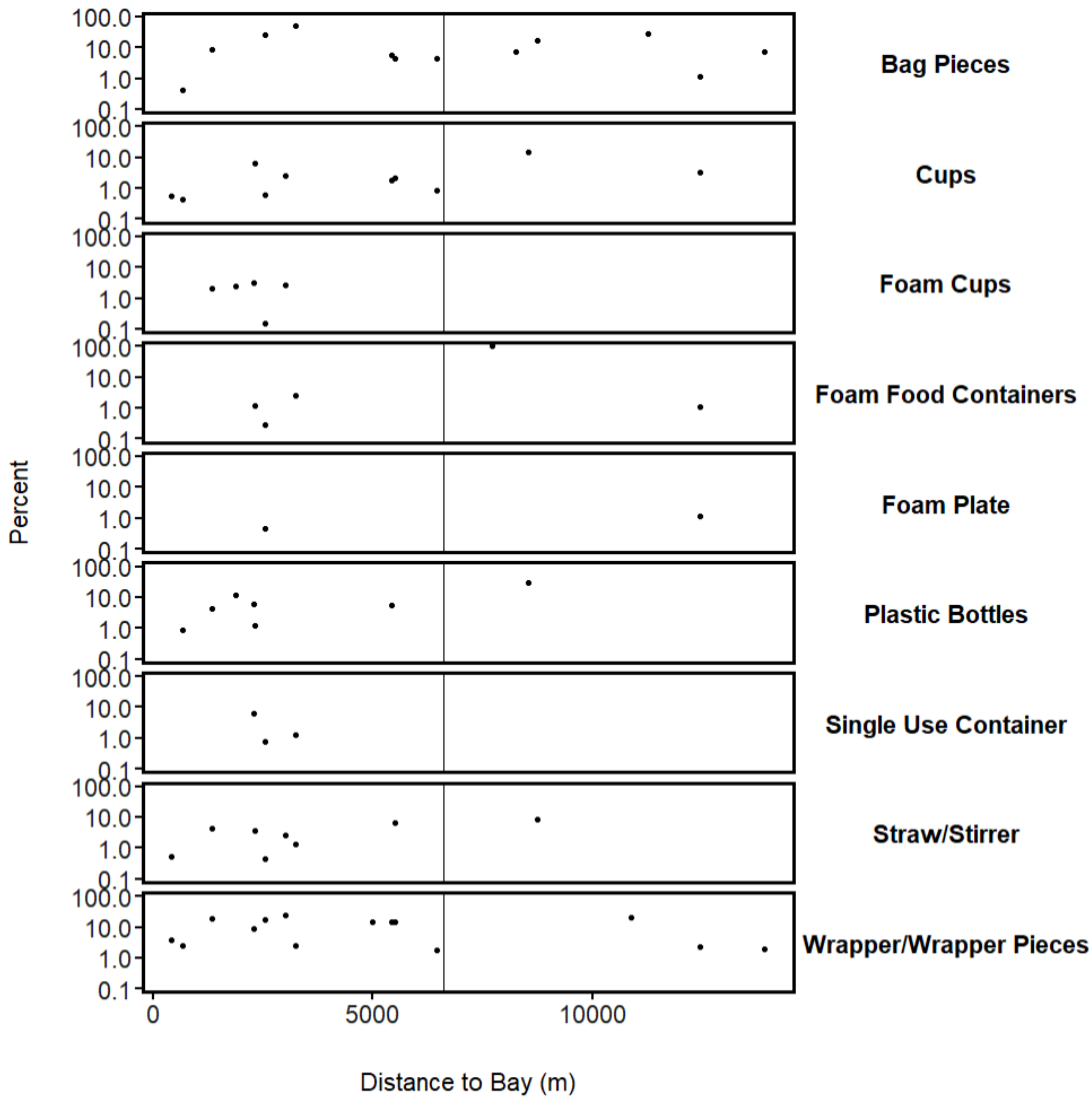

Figure 8: Food related morphologies and their percent found in the creek. X axis is the distance in meters upstream from the outlet at the bay. Y axis is the percentage of all morphologies found that were in the category listed on the right axis. Points are survey locations. Vertical line is the city limits. Everything to the left is in the City and everything to the right is outside of the City.

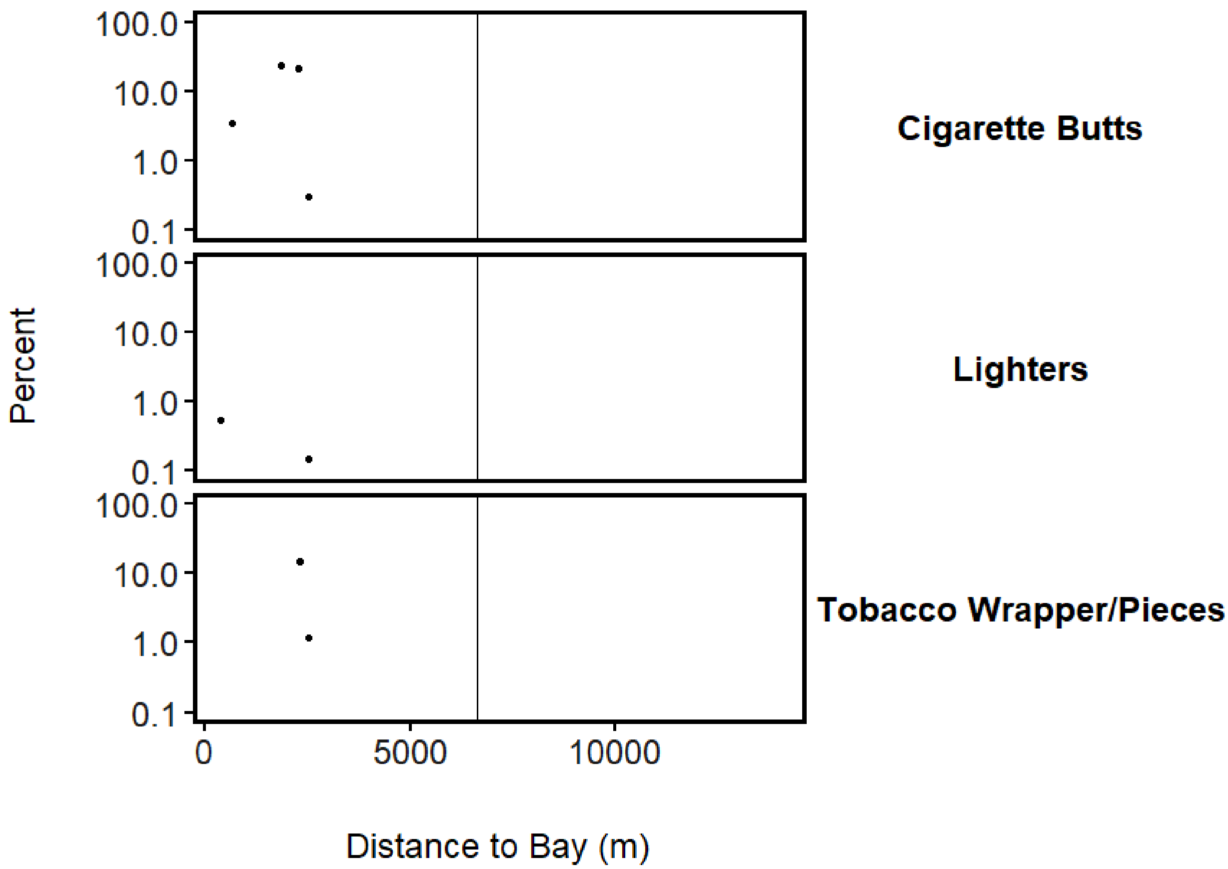


Figure 9: Tobacco related morphologies found at the survey locations. X axis is the distance in meters upstream from the outlet at the bay. Y axis is the percentage of all morphologies found in the category listed on the right axis. Points are survey locations. The vertical line is the city limits. Everything to the left is in the City and everything to the right is outside of the City.

## Areas of Concern

The Community wanted to identify areas of concern with high litter load in the creek that they could prioritize for future mitigation and policy efforts (Figure 10). We identified near the mouth of the stream, near where the highway intersects the creek, and near the top of the city limit as locations with elevated concentrations of count and volume combined. The Community recommended these sites to be further investigated in future studies and prioritized by the City Council for mitigation activities. Sites above the city limits also could be classified as areas of concern but were not focused on for this study because we did not have a policy partner with jurisdiction there.

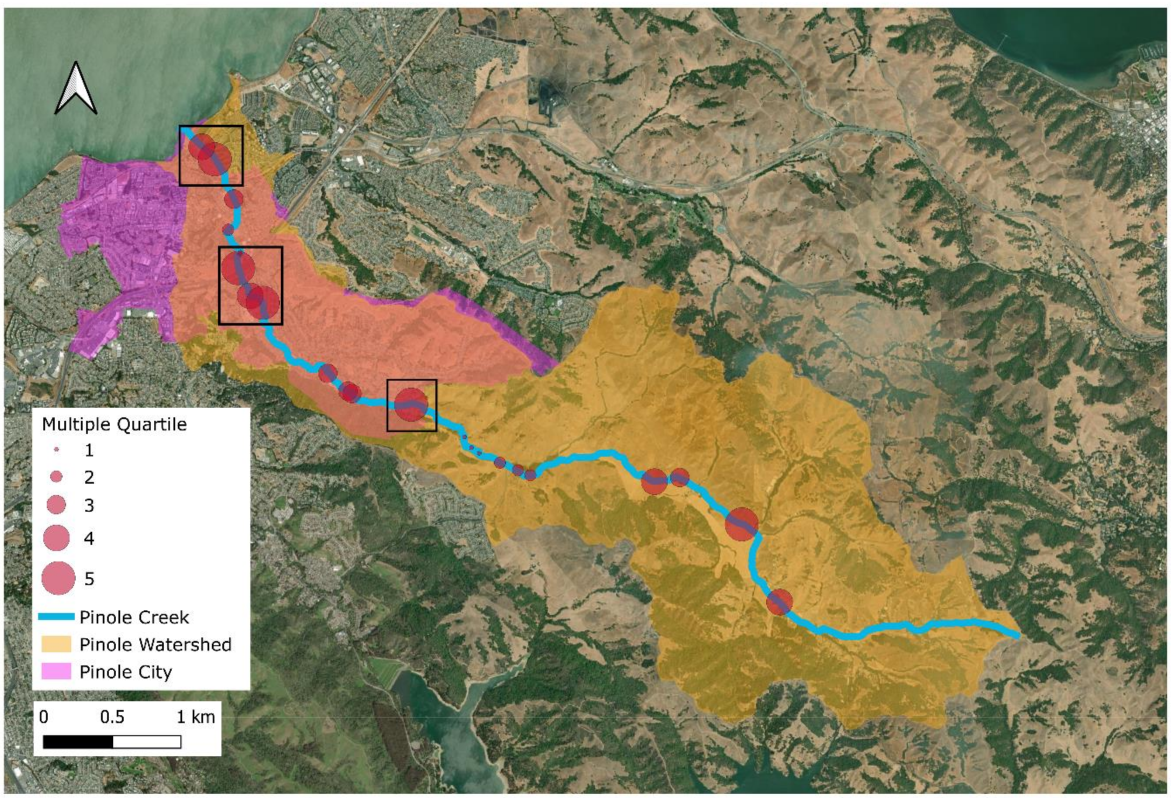


Figure 10: Areas of concern were identified by transforming count and volume concentrations using maximum normalization, multiplying them together, and mapping the 5 quartiles as different-sized circles (multiple quartile). Blue line is the Pinole Creek mainstem. Yellow area is

the Pinole watershed. Pink area is the Pinole city limits. Both areas are slightly transparent, so their overlap can be visualized in the orange area. Locations with large circles near each other were outlined with a black box and described as an area of concern that warrants future investigation. Basemap is satellite imagery from QGIS basemaps. North arrow points to the top of the image.

# Next Steps

## Community

### Continued community - policy engagement

The work is certainly not over after this initial assessment. The Core Community Team will follow up with City Council, Public Works Director, and staff to request policy recommendations be put in the City's Capital Improvement Plan (CIP). This plan aligns projects with public funding by the City and other agency partners and assists in collaborative decision-making. At the time of this writing, the CIP included recommendations made years prior by the Pinole Beautification Ad-hoc committee. It recommended the installation of new solar-powered trash bins for a budget of approximately $425,000 and a community education program with a budget of approximately $60,000. The group continues to be active in Pinole, engaging through presentations to local nonprofits and scientific conferences, and conducting multiple cleanups monthly.

Although we assessed land on county property outside of the City's jurisdiction, we could not adequately engage with management at the county to propose policies for that level of government. Community members noted elevated levels of illegal dumping on the county property compared to the city property. This was reflected in the data (Figure 5). Litter there ultimately flows to Pinole City creeks. Therefore, The Community would welcome a collaborative relationship with county management. Community members recommend the Pinole City Council's policy actions as examples the county could follow to improve litter conditions on county property.

## Scientific

### Follow-up study in 5 years

We know that trash conditions in creeks can change over time. Those changes could inform us about how effective the policy actions were at improving the creek quality. The Community recommended a follow-up study to be conducted in 5 years to assess changes resulting from the policy actions.

### Targeted focus on areas of concern and sources

A limitation of the study design was not being able to thoroughly assess the trash sources at some of the most problematic areas of concern. For example, the location near the highway had homeless encampments, highway runoff, parking lot windblown trash, and upstream sources all interacting at that location. To identify the most important sources at that site, we would need to conduct a site-specific study. In such a study, we would look at the composition of the trash coming from each source and compare that to the trash in the creek.

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# Open Research

All training, survey, and data collection resources mentioned in the text are available on OSF at https://osf.io/ghswp/. All raw data and data analysis from the survey is available on Github at https://github.com/wincowgerDEV/pinole_creek.

# References

Baldwin, A. K., Corsi, S. R., & Mason, S. A. (2016). Plastic Debris in 29 Great Lakes Tributaries: Relations to Watershed Attributes and Hydrology. *Environmental Science and Technology*, *50*(19), 10377–10385. https://doi.org/10.1021/acs.est.6b02917

Cârstea, E. M., Popa, C. L., & Donțu, S. I. (2022). Citizen Science for the Danube River—Knowledge Transfer, Challenges and Perspectives. In A. Negm, L. Zaharia, & G. Ioana-Toroimac (Eds.), *The Lower Danube River* (pp. 527–554). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-03865-5_18

Cook, S., Abolfathi, S., & Gilbert, N. I. (2021). Goals and approaches in the use of citizen science for exploring plastic pollution in freshwater ecosystems: A review. *Freshwater Science*, *40*(4), 567–579. https://doi.org/10.1086/717227

Cowger, W., Gray, A. B., & Schultz, R. C. (2019). Anthropogenic litter cleanups in Iowa riparian areas reveal the importance of near-stream and watershed scale land use. *Environmental Pollution*, *250*, 981–989. https://doi.org/10.1016/j.envpol.2019.04.052

Emmerik, T., & Schwarz, A. (2020). Plastic debris in rivers. *WIREs Water*, *7*(1). https://doi.org/10.1002/wat2.1398

Helinski, O. K., Poor, C. J., & Wolfand, J. M. (2021). Ridding our rivers of plastic: A framework for plastic pollution capture device selection. *Mar. Pollut. Bull.*, *165*, 112095.

Hoellein, T. J., & Rochman, C. M. (2021). The “plastic cycle”: a watershed-scale model of plastic pools and fluxes. *Frontiers in Ecology and the Environment*, *19*(3), 176–183. https://doi.org/10.1002/fee.2294

McCormick, A. R., & Hoellein, T. J. (2016). Anthropogenic litter is abundant, diverse, and mobile in urban rivers: Insights from cross-ecosystem analyses using ecosystem and community ecology tools. *Limnol. Oceanogr.*, *61*(5), 1718–1734.

McKinley, D. C., Miller-Rushing, A. J., Ballard, H. L., Bonney, R., Brown, H., Cook-Patton, S. C., et al. (2017). Citizen science can improve conservation science, natural resource management, and environmental protection. *Biol. Conserv.*, *208*, 15–28.

Meijer, L. J. J., van Emmerik, T., van der Ent, R., Schmidt, C., & Lebreton, L. (2021). More than 1000 rivers account for 80\% of global riverine plastic emissions into the ocean. *Sci Adv*, *7*(18).

Moore, S., Sutula, M., Von Bitner, T., Lattin, G., & Schiff, K. (2016). Southern California Bight 20 Regional Monitoring Program: Volume {III}. Trash and Marine Debris.

Moore, S., Hale, T., Weisberg, S. B., Flores, L., & Kauhanen, P. (2020). *California Trash Monitoring Methods and Assessments Playbook*.

Nakano, R. (2019). *Stormwater Trash Reduction Are We Doing All That We Can?* (Grand Jury Report). Contra Costa County Grand Jury. Retrieved from https://pleasanthill.granicus.com/MetaViewer.php?view_id=&clip_id=1663&meta_id=126584

Pinole City Council Meeting. (2021, October 19). Retrieved from http://pinole.granicus.com/MediaPlayer.php?view_id=2&clip_id=1891

Pinole City Council Meeting. (2022, April 22). Retrieved from http://pinole.granicus.com/MediaPlayer.php?view_id=2&clip_id=1950&meta_id=54685

Rambonnet, L., Vink, S. C., Land-Zandstra, A. M., & Bosker, T. (2019). Making citizen science count: Best practices and challenges of citizen science projects on plastics in aquatic environments. *Marine Pollution Bulletin*, *145*, 271–277. https://doi.org/10.1016/j.marpolbul.2019.05.056

Rochman, C. M., Munno, K., Box, C., Cummins, A., Zhu, X., & Sutton, R. (2020). Think Global, Act Local: Local Knowledge Is Critical to Inform Positive Change When It Comes to Microplastics. *Environ. Sci. Technol.*

State Water Resources Control Board. (2015). *Amendment to the Water Quality Control Plan for the Ocean Waters of California to Control Trash and Part 1 Trash Provisions of the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California*.

Watkins, L. (2022). *Quantifying Plastic Pollution: An assessment of traditional and community science methods*. Cornell University Library. Retrieved from https://hdl.handle.net/1813/111811