Alameda Countywide
Clean Water Program

Contra Costa
Clean Water Program

Fairfield-Suisun
Urban Runoff
Management Program

Marin County
Stormwater Pollution
Prevention Program

Napa Countywide
Stormwater Pollution
Prevention Program

San Mateo Countywide
Water Pollution
Prevention Program

Santa Clara Valley
Urban Runoff Pollution
Prevention Program

Sonoma County
Water Agency

Vallejo Flood &
Wastewater District

B A S M A A

To Whom It May Concern:

We certify under penalty of law that this document was prepared under our direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on our inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of our knowledge and belief, true, accurate, and complete. We are aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

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San Francisco Bay Area
Receiving Water Trash Monitoring

Pilot-Testing of Qualitative and Quantitative Monitoring and Assessment Protocols

PRELIMINARY REPORT

Prepared for:

Bay Area Stormwater Management Agencies Association

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APPLIED marine SCIENCES

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ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agency Association
CCCWP	Contra Costa Clean Water Program
CEDEN	California Environmental Data Exchange Network
FSURMP	Fairfield Suisun Urban Runoff Management Program
MRP	Municipal Regional Permit
NPDES	National Pollution Discharge Elimination System
OVTA	On-land Visual Trash Assessments
OPC	California Ocean Protection Council
PMT	Project Management Team
QAPP	Quality Assurance Project Plan
QAPP	Quality Assurance Program Plan
QA/QC	Quality Assurance/Quality Control
RTA	Rapid Trash Assessment
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
SCCWRP	Southern California Coastal Water Research Project
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFEI	San Francisco Estuary Institute
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SMC	Southern California Monitoring Coalition
SMCWPPP	San Mateo County Water Pollution Prevention Program
SOP	Standard Operating Protocol
WY	Water Year

1 INTRODUCTION

The San Francisco Bay Regional Water Quality Control Board (Regional Water Board) has determined that trash is a pervasive problem near and in receiving waters, such as local creeks, rivers, and the San Francisco Bay Estuary (SFBRWQCB 2015). Trash can cause major impacts to beneficial uses, including recreation, aquatic life and habitat in those waters. Trash can originate on land or through individuals directly dumping/depositing trash into a receiving water or on its banks/shoreline. Eventually, trash present in local water bodies contributes to the global ocean ecosystem, where it can persist in the environment for hundreds of years, concentrate organic toxins, and be ingested by aquatic life. There are also physical impacts, as aquatic species can become entangled and ensnared, and can ingest plastic that looks like prey, losing the ability to feed properly.

Between 2003 and 2005, trash levels and types deposited in local creeks and rivers were measured by the Regional Water Board using the Surface Water Ambient Monitoring Program's (SWAMP) Rapid Trash Assessment (RTA) Protocol. The Regional Water Board reported that data collected by SWAMP indicated that levels of trash in the waters of the San Francisco Bay region were very high (SFBRWQCB 2007). During 85 surveys conducted at 26 sites throughout the Bay Area, an average of almost three pieces of trash were observed per linear foot of creek. As a result of this new information, the Regional Water Board added 26 waterbodies in the region to the 303(d) list for the pollutant trash and concluded that this set of receiving waters was representative of the trash impacts present in all segments of local receiving waters that flow through urbanized watershed areas, and the shoreline of San Francisco Bay (Bay). Additionally, urban stormwater runoff was identified as an important pathway that transports trash from watersheds to these receiving waters. Identifying stormwater as an important pathway necessitated the inclusion of trash load reduction requirements in the Municipal Regional Stormwater NPDES Permit (MRP 2.0), Order No. R2-2015-0049.

MRP 2.0 was issued by the Regional Water Board on November 19, 2015 to 76 cities/towns, counties and special districts (Permittees). MRP 2.0 includes general stormwater management requirements, as well as those associated with specific pollutants. Provision C.10 of MRP 2.0 (Trash Load Reduction) requires Permittees to reduce trash discharged from their municipal separate storm sewer system (MS4) by demonstrable amounts in specific timeframes, install and maintain trash full capture systems, annually cleanup and assess trash hot spots in receiving waters, and conduct monitoring and assessment activities to address specific management questions regarding trash. Provision C.10.b.v entitled "Receiving Water Monitoring" requires Permittees to develop and test a receiving water trash monitoring program plan (Trash Monitoring Plan).

In July 2017, the Bay Area Stormwater Management Agencies Association (BASMAA) submitted the first iteration of the Trash Monitoring Plan to SF Bay Water Board staff for review and comment. The Final Trash Monitoring Plan that addressed all comments was submitted to the SF Bay Water Board staff in October 2017 (BASMAA 2017). Implementation of the Trash Monitoring Plan, initiated in October 2017, represents the "pilot-testing phase" of trash receiving water monitoring in the San Francisco Bay Area, during which the pilot protocols and methods will be evaluated in the field. This evaluation is intended to provide MRP 2.0 Permittees the opportunity to evaluate the validity of proposed monitoring protocols and adapt the methodologies for future iterations of the monitoring program based on the information gained during the MRP 2.0-specified timeframe of October 2017 to July 2020.

The overall goal of the Trash Monitoring Program Plan, as described in the MRP 2.0 Fact Sheet, is to establish:

> *"…the least expensive and simplest to use monitoring methods and protocols that are applicable to the various discharge and receiving water scenarios that accounts for the various receiving waters and watershed, community, and drainage characteristics within Permittees' jurisdictions that affect the discharge of trash and its fate and effect in receiving water(s). These and other factors, such as feasibility, location logistics, types of trash, complexity, and costs provide a means to focus and limit the number of monitoring tools and protocols, and determine spatial and temporal representativeness of the tools and protocols, representativeness of scenarios that will be tested." (Emphasis added)*

The Fact Sheet also indicates that Permittees may include assessment methods based on the *Rapid Trash Assessment Method Applied to Waters of the San Francisco Bay Region: Trash Measurement in Streams* (SFBRWQCB 2007). Additionally, MRP 2.0 specifies that the development of receiving water monitoring tools and protocols and a monitoring program shall be designed, to the extent possible, to answer the following management questions:

1. Have a Permittee's trash control actions effectively prevented trash within a Permittee's jurisdiction from discharging into receiving water(s)?
2. Is trash present in receiving water(s), including transport from one receiving water to another, e.g., from a creek to a San Francisco Bay segment, at levels that may cause adverse water quality impacts?
3. Are trash discharges from a Permittee's jurisdiction causing or contributing to adverse trash impacts in receiving water(s)?
4. Are there sources outside of a Permittee's jurisdiction that are causing or contributing to adverse trash impacts in receiving water(s)?

Receiving water trash monitoring conducted through the Trash Monitoring Plan is intended to address these management questions by collecting initial information on the levels of trash in applicable receiving waters, the importance of site and watershed characteristics on trash levels observed/measured, and the relative contributions from important trash sources and pathways. Information and data collected during the testing phase of the Trash Monitoring Plan is not intended to address compliance issues associated with trash reduction requirements of the MRP. Compliance is achieved through other aspects of Provision C.10, including evaluations of the extent of certified trash full capture system implementation and the trash reduction effects of other management actions measured via On-land Visual Trash Assessments (OVTA) conducted on streets, sidewalks and other watershed land areas.

Provision C.10.b.v of the MRP requires that the results of the testing phase of the Trash Monitoring Plan be submitted to the SF Bay Regional Water Board in two separate reports: 1) Preliminary Report by July 1, 2019; and 2) Final Report by July 1, 2020. This report serves as the Preliminary Report for all MRP 2.0 Permittees and provides a preliminary analysis of approximately 60% of the information/data collected from trash assessments and monitoring conducted through spring 2019. The remaining 40% of the trash assessment/monitoring data will be incorporated with data that are included in this report and the entire dataset will be presented in the Final Report.

2 Background

2.1 Trash Monitoring Plan Overview

2.1.1 Monitoring Plan Development Process

The Trash Monitoring Plan was developed through a collaboration of the BASMAA Project Management Team (PMT), regional stakeholders and scientific peer reviewers. Permittees and SF Bay Regional Water Board staff developed a list of stakeholders who would be potentially interested in providing feedback on the Trash Monitoring Plan. Stakeholders included additional permittee representatives, and staff from environmental non-governmental organizations, USEPA, and Regional and State Water Boards.

BASMAA held three stakeholder meetings at key stages of the project to solicit input and share information. Additionally, stakeholders also had an opportunity to contribute information on existing monitoring tools and protocols. Stakeholders were provided the opportunity to review and provide comments on the Draft Trash Monitoring Plan. In some instances, follow-up discussions were necessary with individual stakeholders (e.g., SF Bay Regional Water Board staff) to obtain clarification and guidance for moving forward with the project. A table of stakeholder comments received and BASMAA responses is provided as an attachment to the Trash Monitoring Plan (BASMAA 2017).

The development of the Trash Monitoring Plan utilized technical experts to review the monitoring tools, protocols and sample design. These peer reviewers were selected by the PMT based on their experience in designing and implementing trash receiving water monitoring programs and/or other types of water quality monitoring. Peer reviewers provided input on key topic areas, which assisted the PMT in developing a successful receiving water trash monitoring program.

2.1.2 Goals/Objectives of Monitoring Plan

The PMT developed specific goals of the Trash Monitoring Plan through the stakeholder engagement process to cost-effectively answer the MRP 2.0 management questions. These goals include:

- Informs management decisions;
- Accounts for different stream and channel types, and considers temporal variability (e.g., to estimate baseline conditions and show change over time) and seasonality;
- Can assess trends over time;
- Helps to assess if the Permittees' trash reduction efforts are resulting in improvement;
- Allows for comparison of trash levels between sites (understand the range of levels of impact);
- Assists in determining relative contributions from different pathways (i.e., wind, illegal dumping, illegal encampments, MS4s);
- Leverages and exhibits consistency with existing monitoring efforts and other water quality monitoring programs, including direct discharge offset provisions (MRP Provision C.10.e); and
- Cost-effective, efficient and feasible (e.g., safe, access to sample locations, can be implemented by volunteer monitoring groups).

2.1.3 Trash Scientific Monitoring Questions

Project goals were used to guide the development of scientific monitoring questions that informed the study design and selection of methodologies used during the pilot-testing phase of the Trash Monitoring Plan. These scientific monitoring questions were developed to begin answering the broader Management Questions listed in Table 2-1.

Table 2-1. Scientific monitoring questions developed to guide the design of the trash monitoring program and the methods used to monitor trash in receiving waters.

Management Question	Scientific Monitoring Question
1. Is trash present in receiving water(s) at levels that may cause adverse water quality impacts?	• What is the current level of trash deposited in flowing waterbodies in each MRP county; the entire MRP area? • Are significantly strong correlations observed between qualitative and quantitative methods? • What is the range of trash levels observed at sites targeted for cleanup? How do these ranges compare to levels in all flowing waterbodies?
2. Have a Permittee's trash control actions effectively prevented trash within a Permittee's jurisdiction from discharging into receiving water(s) (*over time*)?	• What is the current level of trash deposited in flowing waterbodies in each MRP county; the entire MRP area? • Are significantly strong correlations observed between qualitative and quantitative methods? • Do trash levels in flowing waterbodies strongly correlate to trash generation levels depicted on Permittee maps?
3. Are trash discharges from a Permittee's jurisdiction causing or contributing to adverse trash impacts in receiving water(s)?	• What is the current level of trash deposited in flowing waterbodies in each MRP county; the entire MRP area? • Are significantly strong correlations observed between qualitative and quantitative methods? • What is the range of trash levels observed at sites targeted for cleanup? How do these ranges compare to levels in all flowing waterbodies?
4. Are there sources outside of a Permittee's jurisdiction that are causing or contributing to adverse trash impacts in receiving water(s)?	• What percentages of trash observed in receiving waters are attributable to wind/litter, illegal dumping, illegal encampments and other (stormwater/upstream sources)?
5. Is trash (if present) being transported from one receiving water to another, at levels that may cause adverse water quality impacts?	• Do trash levels in flowing waterbodies differ significantly between wet and dry seasons?

2.2 Coordination with State Monitoring Project

In 2015, the State Water Resources Control Board (State Water Board) adopted an Amendment to the Water Quality Control Plan for the Ocean Waters of California (Ocean Plan) to Control Trash and Part 1 Trash Provision of the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries. Together these are referred to as the Trash Amendments. The Trash Amendments prohibit discharge of trash larger than 5 millimeters to state waters from stormwater systems.

The California Ocean Protection Council (OPC) sent a letter to the State Water Board supporting adoption of the Trash Amendments in 2015. The letter expressed the OPC's interest in the use of scientific measures to track and verify program effectiveness. The OPC recognized that there is no agreed-upon scientific method to monitor for trash in receiving waters and that the lack of methods makes assessing progress on reducing trash in state waters difficult. In close partnership with the State Water Board, the OPC employed the Southern California Coastal Water Research Project (SCCWRP) and

San Francisco Estuary Institute (SFEI) to begin evaluating and testing multiple trash monitoring methods with a goal of developing a library of methods with known levels of precision, accuracy, and cross-comparability of results. The methods tested would also be linked to specific management questions. The Trash Monitoring Methods Project sponsored by OPC is intended to provide the research needed to develop scientific measures to monitor macro (>5mm) trash in receiving waters.

The OPC/State Water Board Trash Monitoring Methods Project began subsequent to the finalization of the BASMAA Trash Monitoring Plan. As such, the methods developed via the BASMAA Trash Monitoring Plan were incorporated with other methods being used in Southern California and novel (i.e., aerial photography and machine-learning) methods developed as part of the OPC/State Water Board project. These three methods are currently being tested in coordination with MRP 2.0 permittee efforts described in this report. Additionally, staff representing MRP 2.0 participates on the OPC/State Water Board's Technical Advisory Committee (TAC) to provide further coordination on the testing of trash receiving water monitoring methods. This coordination is planned to continue throughout the term of both projects.

3 Data Collection and Analysis Methods

3.1 Study Area

The pilot-testing phase of the Trash Monitoring Plan focuses on initial evaluations of the extent, magnitude and pathways of trash present/deposited on the surface and banks of local creeks, channels, rivers and lakes/lagoons, and the shorelines of San Francisco Bay and the Pacific Ocean. The study area for the Trash Monitoring Program consists of receiving water bodies that are within the MRP Area, which includes portions of the five participating counties (San Mateo, Santa Clara, Alameda, Contra Costa, Solano) that are subject to MRP 2.0 requirements.

3.2 Monitoring Design

The Trash Monitoring Plan primarily focuses on two types of monitoring designs:

1) **Probabilistic Assessment Sites** – Randomly selected monitoring sites that were previously established for BASMAA's Regional Monitoring Coalition (RMC) Creek Status Monitoring Program. These sites are intended to represent the trash conditions in all creek, channel and riverine sites that flow through the urban Bay Area.

2) **Targeted Monitoring Sites** – Selected sites in urban creeks, channel and river segments and sites along San Francisco Bay shorelines where trash regularly deposits and is periodically removed by MRP Permittees. Includes a small number of targeted locations where trash booms/curtains are deployed to intercept trash prior to transport downstream to the San Francisco Bay.

Together, probabilistic and targeted sites are intended to represent the full range of trash conditions present in all water bodies flowing through the urban Bay Area that are subject to MRP 2.0 trash reduction requirements, and San Francisco Bay shorelines that may be impacted by contributions of trash from these flowing waters (e.g., creeks, channels and rivers). Brief descriptions of each type of monitoring design and the associated sites are provided below, followed by descriptions of the types of monitoring methods deployed at each type of site.

3.2.1 Probabilistic Assessment Sites

Probabilistic trash assessment sites were chosen from the sample frame (i.e., stream network) developed by the RMC in 2012 for the Bay Area Regional Creek Status and Trends Monitoring Program (BASMAA 2012). The RMC sample frame includes all perennial and non-perennial creeks, channels and rivers that run through urban and non-urban areas within the five counties subject to MRP requirements. The sample frame was established using the United State Geological Survey (USGS) National Hydrography Dataset, which covers 3,567 miles of stream length in the five counties.

As part of the RMC's Regional Creek Monitoring Program, a pool of urban and non-urban probabilistic monitoring sites were previously established along the RMC sample frame at an average density of one site per 0.62 mile of stream length (i.e., total of 5,740 sites). Urban and non-urban probabilistic sites were previously selected (randomly) from this pool and monitored for physical, chemical and biological integrity as part of the Regional Creek Monitoring Program (2012-2019). The urban[1] sites previously monitored by the RMC formed the pool of sites for which probabilistic trash assessment sites were selected.[2] Additional details of the RMC sample frame and site selection process are summarized in the *BASMAA Regional Monitoring Coalition Five-Year Bioassessment Report Water Years 2012-2016* (BASMAA 2019).

A total of 125 probabilistic trash assessment sites (approximately 7% of the urban sites in the RMC sample frame) representing urban creek, channel and river segments were selected for pilot-testing the Trash Monitoring Plan (Figure 3-1). Consistent with the Trash Monitoring Plan, Alameda, Contra Costa, San Mateo and Santa Clara counties each selected 30 probabilistic assessment sites, and 5 sites were selected in Solano county. Trash assessments at these probabilistic sites focused on qualitatively observing and documenting trash levels and estimating the contributions of trash from different pathways. Because the vast majority of the trash assessment sites included in the Monitoring Program Plan were previously monitored by Permittees via RMC's Creeks Monitoring Program, these sites generally represent accessible locations where trash assessments could feasibly occur. Probabilistic trash assessment sites were selected and evaluated in the order they appeared in the site pool to determine if each site met requirements outlined in the Trash Monitoring Plan and was physically accessible (including during higher flow conditions in the wet season). Evaluations of potential trash assessment sites were conducted following the methods presented in *Standard Operating Procedures for Ambient Creek Status Monitoring Site Evaluation* (BASMAA 2016).

3.2.2 Targeted Monitoring Sites

In addition to the 125 probabilistic sites, 100 targeted trash receiving water monitoring sites were selected and monitored (Figure 3-1). These targeted sites were generally known by MRP Permittees to accumulate trash. The vast majority of the sites were previously designated as "trash hot spots" and undergo periodic trash removal. These sites include segments of urban creeks, channels and rivers, and shoreline sites along the San Francisco Bay. To the extent possible, targeted trash monitoring sites were selected to represent a wide range of known trash levels in water bodies within a majority of MRP Permittee jurisdictions within each of the five MRP counties. The goal was to establish a pool of sites with a wide range of trash conditions as a basis to evaluate the relationship between qualitative and quantitative trash assessment tools. Consistent with the Trash Monitoring Plan, the following numbers of

[1] Probabilistic sites classified as urban are located within the boundaries of a city or a populated place.

[2] Non-wadeable and tidally influenced probabilistic sites that were originally removed from the site pool during creek status monitoring due to limitations in implementing standardized monitoring protocols at these sites, were added back into the pool of trash assessment sites due to interest in trash levels at these sites.

targeted monitoring sites were selected and monitoring by Permittees in the following MRP counites: Alameda (29), Contra Costa (19), San Mateo (15), Santa Clara (32) and Solano (5).

It is important to note that each county used different criteria to select their targeted monitoring sites. Some counties selected targeted sites that contained illegal encampments with large quantities of trash. Other counties purposefully avoided selecting sites with illegal encampments for practical concerns and safety issues. Due to the discrepancy in the type of targeted sites and associated levels of trash, the quantitative assessment data collected at targeted sites were not compared between counties.

Trash monitoring at targeted sites also included existing trash boom locations. Monitoring consisted of the removal and estimation of trash volumes that accumulated behind the booms during a known period of time. Although trash boom monitoring was not identified as a required component of the Trash Monitoring Plan, MRP 2.0 Permittees agreed to conduct monitoring at these sites to better understand the utility of data from these locations and answer management questions outlined in MRP 2.0. Please note that since the timing of monitoring at trash boom locations did not align with the development of the initial analysis of data presented in this Preliminary Report, results from monitoring conducted at trash boom/curtain locations are not included in this report, but will be included in the Final Report scheduled for completion in July 2020.

3.3 Monitoring Protocols and Data Collection

Standard Operating Procedures (SOPs) and associated field forms (Version 1.0) for conducting qualitative visual trash assessments and quantitative trash monitoring were developed as part of the Trash Monitoring Plan (BASMAA 2017). The SOPs and field forms were refined (Version 2.0) in July 2018 following recommendations by field staff after pre-monitoring calibration events, the initial assessment event at probabilistic sites, and the trainings conducted for field staff. Revisions of the SOPs primarily consisted of supplementing or modifying specific data fields that are associated with site characteristics. Summaries of qualitative and quantitative assessment methods are provided in Sections 3.3.1 and 3.3.2 Full descriptions of these methods are included in Trash Monitoring Plan (BASMAA 2017).

3.3.1 Qualitative Visual Assessments

Qualitative trash assessments are visual surveys of trash levels (i.e., conditions) within a defined assessment area of a receiving water body. Trained personnel assign a **trash condition score** from 1 to 12 (12 being the most trash) to a site based on the level of trash that is observed both within the water body and along its banks or shoreline within a defined assessment area. Field personnel assign trash condition scores based on their first impression of the amount of trash that is visually observed within the entire assessment area.

Trash condition scores (1 to 12) are organized into four **trash condition categories** that include narrative descriptions of trash levels associated with the condition scores (Table 3-1). The four trash condition categories and associated condition scores are: Low (1-3), Moderate (4-6), High (7-9) and Very High (10-12). As part of the pilot testing phase of the Trash Monitoring Plan, trash condition scores will be compared to trash volume data collected during the quantitative assessment (see Section 3.3.2) at targeted sites to validate the less intensive qualitative assessment method.

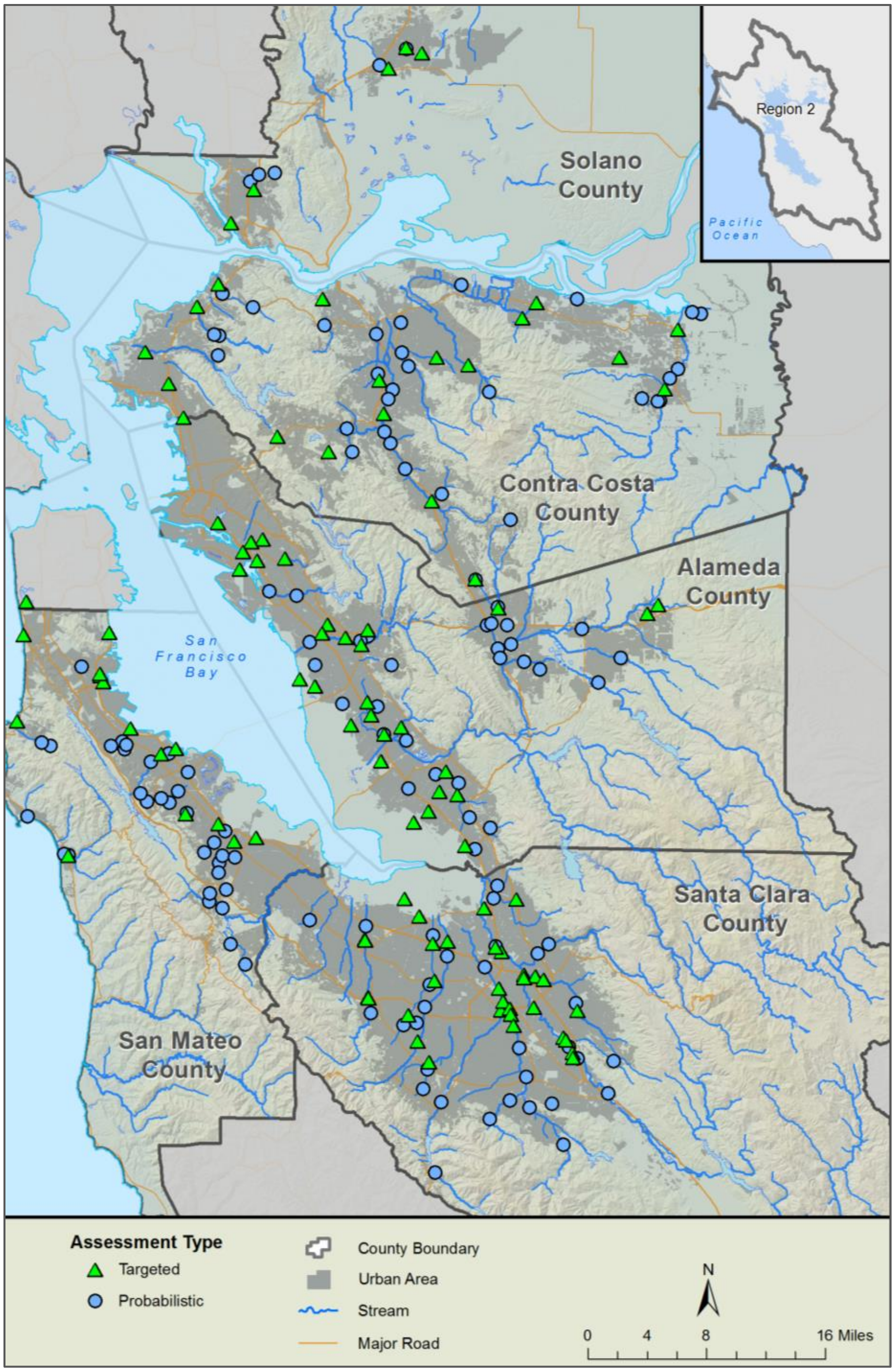

Figure 3-1. Locations of probabilistic and targeted receiving water trash monitoring and assessment sites included in the pilot-testing of the BASMAA Trash Monitoring Plan.

Qualitative visual assessments include documentation of site characteristics within the assessment area that may affect the transport and accumulation of trash. Site characteristic information includes predominant channel type (e.g., armored, levee, natural) and the proportion (%) of bank cover (e.g., grasses, shrubs, trees) and creek/channel cover (e.g., woody debris, aquatic vegetation, open/wet, dry) within the assessment area.

In addition to trash condition scoring, field crews estimated the relative contribution of trash associated with four different trash pathways: 1) Litter/Wind; 2) Illegal Encampment; 3) Illegal Dumping and 4) Other (Stormwater/Upstream Sources). The definition and characteristics for each of these four pathways are presented in Table 3-2.

During the testing of the Trash Assessment SOP, field crews determined that trash directly associated with stormwater and MS4s could not be accurately determined in the field. As a result, the "Other" category was created to include any trash that is transported by water to the assessment area from any upstream sources, including stormwater conveyances. Trash items identified as "Other" were typically small, transportable trash observed in the channel that appeared worn due to exposure from water (Table 3-2).

Because stormwater related trash is a component of the "Other" trash pathway, the amount or percentage of trash from stormwater could not be determined. However, the differences between the "Other" pathway and the remaining three trash pathways, provide useful information for identifying high priority pathways to information management programs.

During qualitative assessments, the contribution of trash from each pathway was visually estimated and assigned a percentage between 0 and 100% (increments of 5%) of the total trash observed in the trash assessment area.

Table 3-1. Narrative descriptions of trash condition categories and scoring ranges for qualitative visual assessments in receiving waters.

Condition Category			
Low	Moderate	High	Very High
• Effectively no or very little trash • On first glance, little or no trash is visible • Little or no trash is evident when streambed and stream banks are closely examined for litter and debris • One individual could easily remove all trash observed within 30 minutes	• Predominantly free of trash except for a few littered areas • On first glance, trash is evident in low levels • After close inspection, small levels of trash are evident in stream bank and/or streambed. • On average, all trash could be cleaned up by two individuals within 30 minutes to one hour. • Approximately 2-3 times more trash than the low condition category	• Predominantly littered except for a few clean areas • Trash is evident upon first glance in moderate levels along streambed and banks • Evidence of site being used by people: scattered cans, bottles, food wrappers, plastic bags, etc. • On average, would take a more organized effort (more than 2 people, but less than 5) to remove all trash from the area. Removal of trash would take 30 mins to 2 hours. • Approximately 2-6 times more trash than the moderate condition category	• Trash is continuously seen throughout the assessment area • Trash distracts the eye on first glance • Substantial levels of litter and debris in streambed and banks • Evidence of site being used frequently by people (e.g., many cans, bottles, food wrappers, plastic bags, clothing; piles of garbage and debris) • On average, would take a large number of people (more than 5) during an organized effort to remove all trash from the area. Removal of all trash would take more than 2 hours. • Approximately 2 or more times trash than the high condition category
1 2 3	4 5 6	7 8 9	10 11 12

Table 3-2. Characteristics of trash associated with each of the four transport pathways.

Pathway	Characteristics	Potential Location in Assessment Area
Litter/Wind	• Light weight • Distributed evenly, recent/not worn	• Adjacent to or under freeways and road crossings • Near roadways, bike or foot paths adjacent to the water body
Illegal Encampments	• Large items • Dense, multiple piles near current or abandoned camping site • No sign of water damage	• Adjacent to camps or trails • Banks, above and below high-water mark • Under bridges
Illegal Dumping	• Large items • Recent • Large piles, adjacent to roads	• Directly upstream or downstream of bridges • Near roadways
Other (Stormwater/Upstream Sources)	• Small, persistent, transportable • Old, worn, water damaged • Integrated with vegetation, debris • Well distributed and mixed with debris	• Wetted channel • Banks below high-water line • Directly below outfalls

3.3.2 Quantitative Monitoring

Quantitative trash monitoring entails removing, sorting and measuring the volume of trash that is found within the assessment area at a targeted site. The collected trash is sorted into the four pathway categories (Table 3-2) and the volume of trash attributable to each pathway is quantified by using buckets or trash bags of known size. The quantified volume of trash for each trash pathway is then combined to establish the total volume of trash collected at each monitoring event. Materials that are too large to be placed in buckets or bags are stacked together (by pathway) and the volume of these materials is visually estimated using units of cubic feet or cubic yards. In addition, field crews identify the five most frequently observed types of trash that are collected.

Both quantitative trash monitoring methods summarized above and the qualitative assessment methods described in the previous section were used at targeted sites to allow for the comparison of qualitative and quantitative approaches. At targeted sites, qualitative monitoring was conducted directly prior to (i.e., within 1-3 days) each corresponding quantitative monitoring event.

The removal of trash at a site via cleanup events that occur direct before or within a few weeks of assessment/monitoring events can potentially result in lower levels of trash observed at a site, in comparison sites where recent cleanup events did not occur. Cleanup activities that occurred prior to a trash assessment/monitoring event were documented at a small number of the targeted monitoring locations. However, most field crews did not document the last known trash clean up event on data collection forms and therefore the data were not normalized to an accumulations period post-cleanup event.

3.3.3 Delineation of Assessment Areas

Trash assessments and monitoring was conducted within a defined assessment area within both probabilistic and targeted sites. A standard assessment length of 300-feet was used for sites located in creeks, channels and rivers. This is consistent with the length generally used by the RMC Creek Status and Trends Monitoring Program and for creek/channel trash hot spot cleanups required by MRP 2.0. For sites on creeks, channels and rivers, the width of the assessment area was specific to each site and extended to the upper portions of the banks where a majority of normal discharges and channel-forming activities take place. This creek/channel width is typically referred to as the "bankfull width" of the receiving water. The width of each trash assessment area on a creek or channel included the distance, as measured by the contour of the bank slope, between three equidistant bankfull locations measured on the opposite banks.

Trash assessments conducted at targeted sites along Bay/Ocean shorelines were typically 600 feet in length, which is consistent with the minimum length for trash hot spots, as described in MRP Provision C.10.c.i. For shoreline monitoring locations, the assessment area width was delineated as appropriate, based on a change in substrate material, presence of upland vegetation or the onset of development.

3.3.4 Field Staff Training and Calibration

Trash assessments were conducted by several entities representing MRP 2.0 Permittees (Table 3-3). For this reason, several field calibration events were conducted for field staff representing Permittees in Alameda, Contra Costa, Santa Clara, San Mateo and Solano Permittees to help standardize field data collection methods. For Santa Clara and San Mateo, additional field training events were conducted to train permittee staff conducting both qualitative and quantitative trash assessments at targeted sites.

Table 3-3. Entities that conducted qualitative and/or quantitative trash assessment/monitoring at probabilistic and targeted receiving water monitoring sites in each county within the MRP Area.

County	Qualitative Assessments at Probabilistic Sites	Qualitative Assessments and Quantitative Monitoring at Targeted Sites
Alameda	Applied Marine Sciences (AMS)	SJ Conservation Corps & Charter School with AMS Supervision
Contra Costa	ADH Environmental	ADH Environmental
Santa Clara	EOA, Inc.	Municipal staff with EOA, Inc. supervision
San Mateo	EOA, Inc.	Municipal staff with EOA, Inc. supervision
Solano	Solano County Resource Conservation District	Solano County Resource Conservation District

3.4 Assessment/Monitoring Frequencies

Regionally, a total of 125 urban creek, channel and riverine probabilistic sites were selected and qualitatively assessed for trash. Qualitative visual trash assessments were conducted at a total of 30 probabilistic sites in Alameda, Contra Costa, Santa Clara and San Mateo Counties, and 5 sites in Solano County (Table 3-4). A total of five assessment events were planned at the probabilistic sites during the pilot testing phase of the Trash Monitoring Plan (October 2017 - March 2020). As described in the Trash Monitoring Plan, assessments are planned during three wet season events and two dry season events. Data collected during both seasons is intended to allow comparisons between dry and wet season trash conditions and accumulation rates in receiving waters. Dry season assessments are intended to provide information about non-stormwater sources and pathways, such as wind and illegal dumping. Wet season assessments provide information on the transport and deposition of trash resulting from stormwater runoff and transport from upstream locations.

Results from a total of 375 qualitative trash assessments, conducted during the first three sampling events (i.e., wet season 2017-18, dry season 2018, wet season 2018-19) are presented in this Preliminary Report. The subsequent two sampling events, scheduled for dry season 2019 and wet season 2019-20, will be incorporated into the results for the Final Report. A total of 129 probabilistic sites[3] were sampled over the three sampling events presented in this report.

In addition to the probabilistic sites, a total of 100 targeted sites were selected for qualitative and quantitative trash assessments. The total number of sites was determined based on population for each County: Santa Clara (32), Alameda (29), Contra Costa (19), San Mateo (15) and Solano (5). Targeted sites included ninety-one (91) sites in urban creeks, channels, rivers and nine (9) sites along the shorelines of San Francisco Bay. Two quantitative monitoring events were planned during the pilot testing phase of the Trash Monitoring Plan; one during the dry season 2018 and one during dry season 2019. Trash assessments results from the dry season 2018 are included in this Preliminary Report.

Trash monitoring was conducted at selected trash boom locations in Alameda, San Mateo and Santa Clara Counties (Table 3-5). All trash boom locations were located at the bottom of the watershed, at the mouth of a creek/channel or the shoreline of lake. Trash monitoring at booms entailed measuring the volume of all trash removed over a known time frame (i.e., between previous boom cleanout and date of the monitoring event). To-date, one or two monitoring events have been conducted at each trash boom/curtain site, between October 2017 and February 2019. All data collected at boom sites will be summarized in the Final Report.

Table 3-4. Total number of sampling sites and events to be conducted during pilot testing phase of Trash Monitoring Plan.

County	Probabilistic Sites (Qualitative Trash Assessments)			Targeted Sites (Qualitative and Quantitative Assessments)			Trash Boom/ Curtain Sites[1]
	# Sites	Frequency	# Events	# Sites	Frequency	# Events	# Sites
Alameda	30	5x	150	29	2x	58	2
Contra Costa	30	5x	150	19	2x	38	--
San Mateo	30	5x	150	15	2x	30	1
Santa Clara	30	5x	150	32	2x	64	3
Solano (Vallejo, Suisun City and Fairfield)	5	5x	25	5	2x	10	--
Total	**125**	**--**	**625**	**100**	**--**	**200**	**6**

[1] The number of sampling events for trash booms will be determined on the availability of municipal/agency staff that is participating in the monitoring project.

[3] 4 of the 125 probabilistic sites were replaced during the dry season 2019 sampling event due to issues related to physical access. Therefore, data exists for 129 sites and is presented in this report.

Table 3-5. Trash boom locations in Alameda, San Mateo and Santa Clara Counties.

County	Jurisdiction	Waterbody	Drainage Area (acres)
San Mateo	San Mateo	Laurel Creek	2,884
Santa Clara	San Jose	Lower Silver Creek	26,261
	Palo Alto	Adobe Creek	8,979
		Matadero Creek	7,997
Alameda	Oakland	Lake Merritt (Outfall 56)	138
		Lake Merritt (Glen Echo Cr)	1,609

3.5 Data Analysis Methods

All statistical, tabular, and graphical analyses were conducted in R Studio, running R version 3.5.0 (R Core Team 2018). The qualitative trash condition scores (1 to 12) defined in the Trash Monitoring Plan were used to evaluate trash data collected at both probabilistic and targeted sites. Four condition categories were used to distinguish these thresholds: “Low” (trash scores 1-3); “Moderate” (trash scores 4-6); “High” (trash scores 7-9); and “Very High” (trash scores 10-12).

To provide a standardized quantitative estimate of trash levels at targeted sites, trash volumes were converted to density (in units of gallons per square foot of assessment area) for all analyses by dividing trash volumes (as a total and by pathway) by the site assessment area.

3.5.1 Estimating the Extent of Trash Levels in all Urban Streams

Cumulative distribution functions (CDFs) of qualitative trash condition scores were generated for probabilistic sites to estimate overall extent of trash levels within the urban portion of the sampling frame. The estimates were weighted based on total stream length of urban sites, divided by the total stream length in the urban area of the sample frame. Non-urban sites that were part of the original RMC creek status monitoring site selection process were excluded from the analyses of trash levels. Therefore, each urban trash monitoring site contributes an equal proportional amount of stream length to the extent estimates. The adjusted sample weights were used to estimate the proportion of stream length represented by trash condition scores regionwide. Condition estimates and 95% confidence intervals were calculated for all probabilistic results averaged across the three qualitative events, as well as for the trash condition scores generated from each seasonal sampling event individually. All calculations were conducted using the R-package *spsurvey* (Kincaid and Olsen 2016).

3.5.2 Boxplots and Descriptive Statistics

Boxplots and scatterplots were used to summarize the distributional characteristics of the data. In each boxplot, the horizontal line represents the median value, the bounds of the upper and lower box represent the interquartile range (representing the middle 50% of the data), and the whiskers represent the upper and lower 25% of the data. ‘Outlier’ values outside the quartiles are shown by points.

Scatterplots are used to evaluate relationships between qualitative (trash condition scores) and quantitative (trash density) results. Linear regression lines were added for perspective only.

3.5.3 Correlation Analysis

Spearman rank correlation statistics (rho) were used to evaluate relationships between trash condition scores or densities and site characteristics (e.g., channel type, channel width, bank cover, channel cover), and pathways of trash. Physical habitat and land use data (e.g., percent impervious, percent urban, road density) previously collected during creek status monitoring at the majority of the probabilistic sites were also evaluated for correlation with trash condition scores. All trash condition data were pooled for analyses and the average trash condition score for each site was developed using data from multiple sampling events. For analyses of trash densities, only data for targeted sites were used. A p-value of < 0.05 was used to determine significance for all correlation analyses.

3.5.4 Ordination Analysis

Principal Components Analysis (PCA) was used to visualize patterns in trash density related to characteristics of bank and channel cover. Prior to analysis, data were transformed to have a mean of zero and scaled to the standard deviation. All results for trash density, channel, and bank cover were used in the *rda function* of the 'vegan' package in R Studio.

4 Preliminary Results and Discussion

<u>The results and discussion presented in this section should be viewed as preliminary and are subject to revision</u> based on the remainder of data collection during the pilot-testing of the BASMAA Trash Monitoring Plan. Final results and conclusions will be presented in the Final Trash Receiving Waters Monitoring Report that will be completed in mid-2020.

Preliminary results are organized by the following sections and are intended to answer specific scientific monitoring questions outlined in the Trash Monitoring Plan:

4.1 Comparison of Qualitative Assessment and Quantitative Monitoring Results

- Are significantly strong correlations observed between qualitative and quantitative trash receiving water monitoring/assessment methods?

4.2 Levels of Trash in Urban Water Bodies in the MRP Area

- What is the current level of trash deposited in flowing waterbodies in each MRP county and the entire MRP urban area?
- Do trash levels in flowing waterbodies differ significantly between wet and dry seasons?
- Do other site and landscape variables correlate with trash levels in flowing waterbodies?
- What trash levels are observed at sites targeted for cleanup? How do these levels compare to levels in all flowing waterbodies?

4.3 Contributions of Trash from Different Pathways

- What percentages of trash observed in receiving waters are attributable to stormwater conveyance systems, direct dumping, wind, and encampments.

4.4 Levels of Trash Observed in Receiving Waters Compared to Trash Discharged by Stormwater Conveyances

- Do trash levels in flowing waterbodies strongly correlate to trash generation levels depicted on Permittee maps?

4.1 Comparison of Qualitative Assessment and Quantitative Monitoring Results

Both qualitative visual assessments and quantitative monitoring of trash volumes and densities were conducted at targeted sites (n=100) to evaluate the correlation between these two receiving water trash monitoring methods. Correlations between qualitative and quantitative results are desired to assist in the validation of the qualitative assessment methodology and the generation of standard trash volumes for qualitative assessment scores. Should correlations between the two methods be adequately established, the less resource-intensive qualitative assessment method may be a viable method for future trash receiving water monitoring efforts.

Significant correlations were observed between the qualitative trash condition scores (1-12) and trash density estimates (volumes) at both the regional and county-wide scale (Table 4-1). Due to the small number of samples at the county-wide scale, outlier sites may potentially have a large influence on the overall correlation. A comparison of trash condition scores and trash densities at the targeted sites is presented in Figure 4-1. Trash densities greater than 0.05 gallons/ft^2 were observed at sites with *high* or *very high* trash condition scores (i.e. $\geq$ 6 condition score). Trash density was lower at sites with *low* or *moderate* scores (i.e. $\leq$ 6 condition score), with the majority exhibiting trash density less than 0.02 gallons/ft^2.

Table 4-1. Correlations between trash densities (volume per unit area) and qualitative trash condition scores (1-12) at targeted urban receiving water monitoring sites (n=100) in the MRP area.

Strata[1]	Targeted Sites	Correlation Coefficient (rho)	p-value
Alameda	29	0.42	0.024
Contra Costa	19	0.62	0.004
San Mateo	15	0.74	0.002
Santa Clara	32	0.80	< 0.001
Regional	**100**	**0.62**	**< 0.001**

[1] Solano County (n=5) is included in the regional evaluation, but with only 5 samples had low statistical power to evaluate correlations at the county scale.

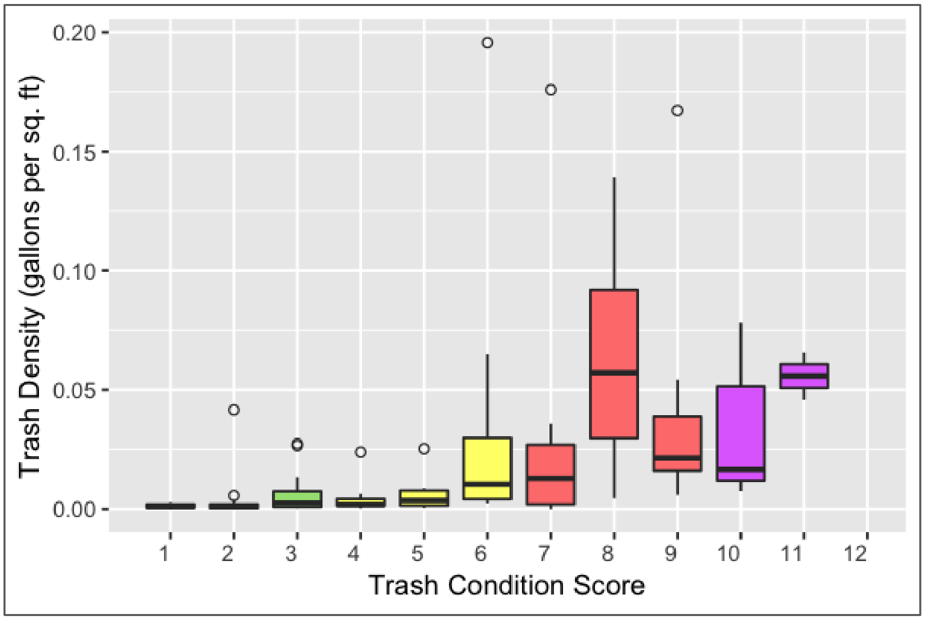

Figure 4-1. Comparison of trash densities (volume per unit area) and qualitative trash condition scores (1-12) at targeted urban receiving water monitoring sites (n=100) in the MRP area. Colors designate trash condition scores (Green = Low, Yellow = Moderate, Red = High, and Purple = Very High)

Organizing the trash condition scores presented in Figure 4-1 into the four broader trash condition categories shows a better relationship with trash density (Figure 4-2), which visually confirms the positive correlations outlined in Table 4-1.

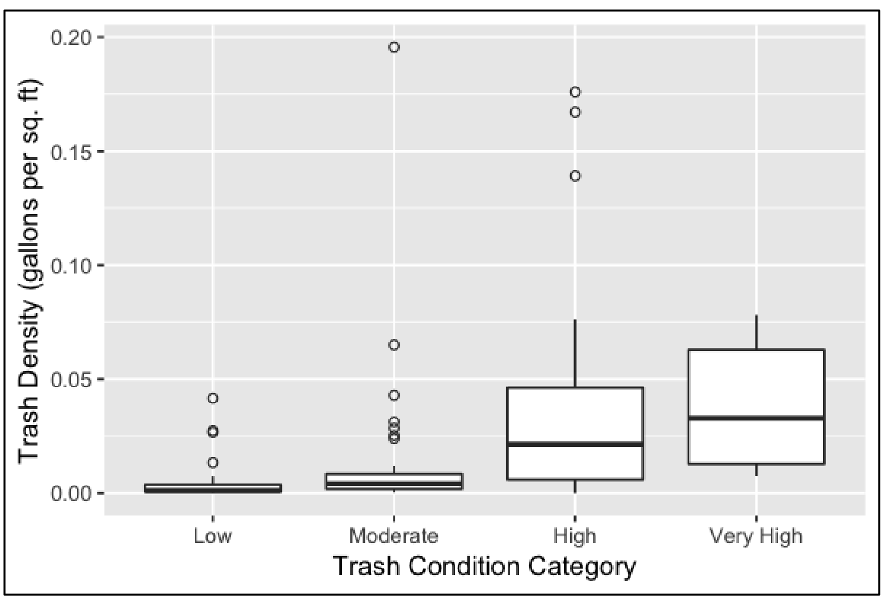

Figure 4-2. Comparison of trash densities and qualitative trash condition categories of 100 targeted receiving water monitoring sites.

Outliers[4] shown (as open circles) in Figures 4-1 and 4-2 indicate results where the trash density was more than 1.5x the interquartile range for the data in each condition score/category. Several sites were outliers at each of the *Low, Moderate*, and *High* categories, suggesting that sites can vary widely in trash density. Closer examination of these outliers provides some insight into the challenges that may occur when applying qualitative and quantitative assessment methods at some sites. For some outliers, the majority of trash was deposited in dense vegetation on the banks or under the water surface of the channel and thus, was not visible during the qualitative assessment. In other cases, high amounts of trash were removed from a single location (e.g., under bridge), but the remaining portions of the assessment area had low levels of trash, and thus received a low trash condition score. In contrast, some sites received a high trash condition score, but some of the visible trash could not physically be removed due to access issues (e.g., deep water, muddy substrate) or safety issues related to illegal encampments. These observations suggest that although correlations between qualitative and quantitative methods appear to be moderately strong, qualitative and quantitative results may not correlate well at every site due to the unique nature of some sites.

4.1.1 Effects of Channel Characteristics on Correlations between Qualitative and Quantitative Methods

Factors that may affect the relationship between qualitative trash condition scores or category and trash density were preliminarily explored to assist with future Monitoring Program design. Figure 4-3 illustrate how channel type may affect this relationship. Although data are limited for certain types of channels (e.g., shorelines), trash condition scores and densities appear to correlate well in different types of channels. Sites with concrete and earthen channels had trash condition scores that ranged between 1 and 10, and exhibited similar relationships to trash density (i.e., slope of regression line ~ 0.005 gal/sq.ft). Sites in natural channels, however, had condition scores that ranged between 2 and 11 and exhibited a different relationship to trash density (i.e., slope of regression line ~0.025 gal/sq.ft). Thus, for sites in natural channels, the trash density was higher at a given trash condition score relative to the other channel types. Although the dataset is limited (n=6), shoreline sites tended to have lower trash condition scores (between 1 and 5), presumably as a consequence of larger assessment areas where trash dispersion is less constrained and can occur further away from the site than trash within stream channels.

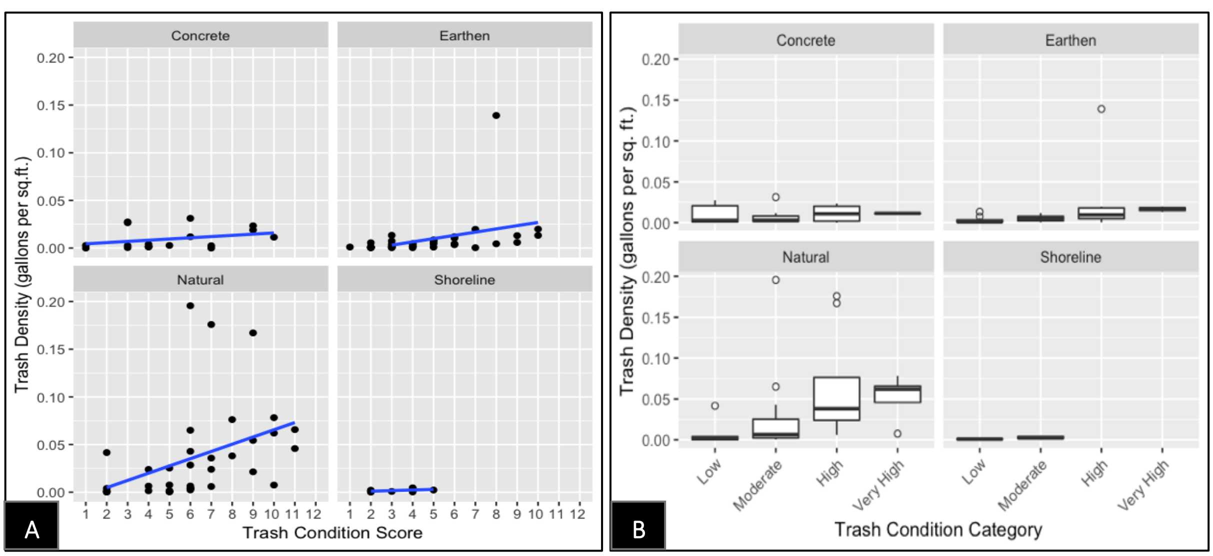

Figure 4-3. Comparison of trash densities and qualitative condition scores (A) and categories (B) observed at 100 targeted receiving water monitoring sites grouped by channel type.

[4] Data from outlier sites were included in the statistical analyses.

Overall, the preliminary comparison of qualitative assessments and quantitative monitoring indicates that the two methodologies are relatable. There are apparent regional differences in the relationships between the two methods, which although likely driven by outliers, suggests further examination of this pattern should be conducted once multiple targeted events are conducted during the pilot-testing of the Trash Monitoring Plan. Additionally, it appears that the relationship was more tenuous at the 1 to 12 scale, compared to categorical scale (i.e., Low, Moderate, High, Very High). There were less obvious delineations in trash levels between consecutive condition scores, compared to the four categories. This pattern may suggest that refinements to the qualitative assessment SOP that reduces (or eliminates) the 1 to 12 scale may be warranted in the future. Alternatively, additional training and calibration of field crews to the current 1 to 12 scale may help improve the relationship to trash densities, along with additional training tools, such as video footage of trash deposition for each of the trash condition categories. Further analysis and recommendations will be included in the Final Receiving Waters Trash Monitoring Report.

4.2 Levels of Trash in Urban Waterbodies in the MRP Area

4.2.1 Qualitative Visual Assessments at Probabilistic and Targeted Sites

Qualitative trash condition scores for the 125 probabilistic receiving water monitoring sites were used to conduct a preliminary evaluation of the extent and magnitude of trash in urban creeks and channels in the MRP area.[5] Table 4-2 illustrates the cumulative distribution results of trash condition scores (averaged over three events) for the regional probabilistic dataset. Condition scores at approximately half (46%) of the urban probabilistic sites were in the *Low* condition category (i.e., condition score < 4) and 39% were in the *Moderate* category (condition score 4 to 6), indicating that approximately 85% (±11%) of the urban stream lengths in the MRP area exhibit low to moderate levels of trash. In contrast, only 1% of the stream-lengths in the urban MRP area had trash levels in the *Very High* trash condition category. It is also notable that none of the 129 sites assessed had an average trash condition score greater than 10.

The cumulative distribution results of the trash condition scores for each of the three sampling events is shown in Appendix A - Table A1. The variability in trash condition scores for each probabilistic site is shown in Appendix A - Table A2. Average trash condition scores at probabilistic stream sites in the region are illustrated in Figure 4-2. Maps illustrating the average trash condition scores for assessment sites in each county are included in Appendix B (Figures B1-B5).

[5] Condition scores from the 100 targeted sites were not used in this evaluation because of the uncertainty in the length of stream represented by these sites, beyond the length of the site. Targeted data were used, however, to compare to condition scores at probabilistic sites to evaluate whether the conditions observed at targeted sites (i.e., trash hot spots) were or were not represented in the probabilistic sample draw.

Table 4-2. Proportion of stream lengths in the MRP urban area with the different average trash condition scores (1 to 12) and within each condition category (Low, Moderate, High and Very High) based on observations at 129 sites within the 5 participating MRP counties.

Trash Condition Score	% of Stream Length (± 95% C.I.)	Trash Condition Category	% of Stream Length (± 95% C.I.)
1	12% (4%)	Low	46% (6%)
2	19% (6%)		
3	15% (6%)		
4	16% (7%)	Moderate	39% (5%)
5	14% (6%)		
6	9% (5%)		
7	7% (4%)	High	14% (1%)
8	6% (2%)		
9	2% (1%)		
10	1% (0%)	Very High	1% (0%)
11	0% (0%)		
12	0% (0%)		

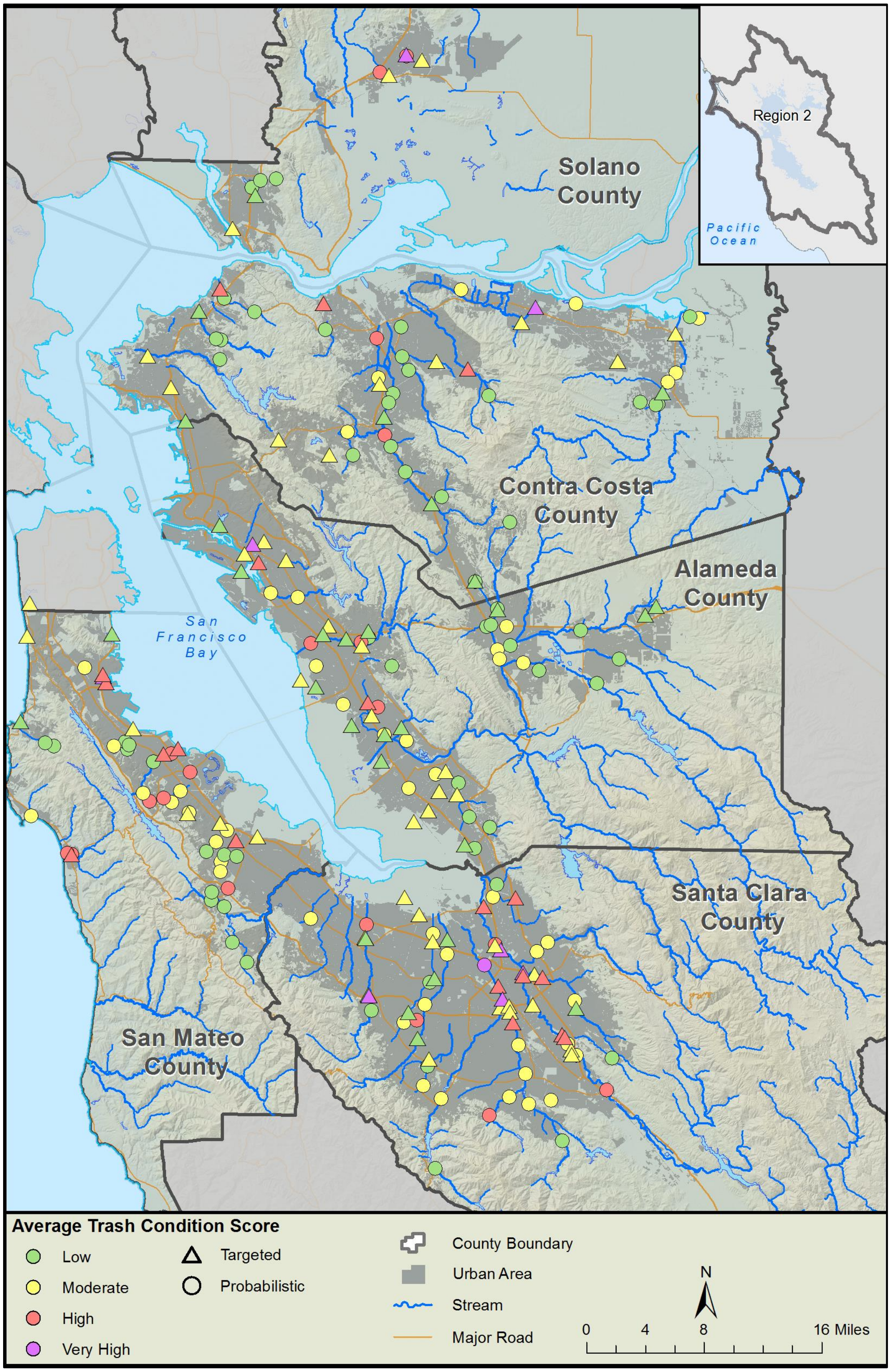

Figure 4-4. Average Trash Condition Scores for 129 probabilistic (average of 3 events) and 100 targeted (1 event) sites in SF Bay Area urban streams and shorelines.

The trash assessment results from the targeted sites were compared to the results from probabilistic sites to determine if the range of conditions were similar between the two sample designs. The percentage of sites within each condition category was used to compare results. As presented in Table 4-3, approximately 16% less targeted sites were in Low trash condition category, compared to the probabilistic sites, and more targeted sites were in the Moderate, High, and Very High condition categories than probabilistic sites. Because targeted sites were selected by MRP Permittees as "trash hot-spots", higher trash scores would generally be expected at targeted sites compared to probabilistic sites. Some of the hot spot locations, however, may have lower than expected trash conditions for variety of reasons, including recent clean-up activities (prior to assessment), exclusion of sites with illegal encampments, and cleaner hot spot locations for some jurisdictional areas.

These preliminary results suggest that MRP Permittees have been successful in identifying receiving water trash hot spot locations. Additionally, these results may suggest that the probabilistic sites assessed via the pilot-testing stage of the Trash Monitoring Plan may not fully represent stream lengths with higher trash accumulation (i.e., trash hot spots). Further analysis of data collected at probabilistic and targeted sites to better assess the representativeness of probabilistic site data to adequately depict overall stream condition will be conducted via the development of the Final Report.

Table 4-3. Percentage of probabilistic and targeted sites in each trash condition category.

Trash Condition Category	Probabilistic Sites		Targeted Sites	
	% of Sites	# of Sites[1]	% of Sites	# of Sites
Low	46%	59	30%	30
Moderate	39%	50	43%	43
High	14%	19	19%	19
Very High	1%	1	8%	8
Totals		129		100

[1] Although 125 probabilistic sites were assessed during each event, 4 sites assessed during the first event were replaced with new sites before the subsequent monitoring events due to access issues.

4.2.2 Associations with Site/Landscape Characteristics

To better understand patterns in the extent and magnitude of trash in receiving waters, all site characteristics (e.g., vegetation cover and channel type) and landscape metrics (e.g., imperviousness in the watershed upstream of the site) were evaluated for their potential association with trash condition scores and trash densities. Spearman correlation analysis, Principal Components Analysis (PCA) and data visualization were used to evaluate the relationship between site/landscape characteristics and qualitative trash condition scores and trash densities at probabilistic and targeted sites, where characteristic data were available. Other categorical type variables (e.g., land use, evidence of public use) were visually evaluated with trash conditions. Evidence of public use showed some association with trash density (Appendix C). Public land use data did not show any association with trash conditions.

Type of Bank and Channel Cover

Spearman correlation results for variables associated with the types of bank and channel cover are shown in Table 4-4. In general, site characteristic variables had slight or no correlations with qualitative trash condition scores. Trash condition scores were slightly correlated ($p < 0.05$, showing the correlation coefficient was non-zero) with the banks that have high proportions of bushes (rho = 0.23), trees (rho = 0.17), and open/wet channels (rho = 0.17) and lower proportions of armored banks (rho = - 0.24) and dry channels (rho = -0.17). Correlations with other variables were not statistically significant (i.e., $p > 0.05$).

Table 4-4. Correlations between bank/channel cover variables and qualitative trash condition scores for all MRP urban sites (probabilistic and targeted). Variables with statistically significant correlations are bolded.

Site Characteristic	Variable	Correlation Coefficient (rho)	p-value
Bank Cover	% Grasses	0.13	0.05
	% Bushes/Shrubs	**0.23**	**< 0.001**
	% Trees	**0.17**	**0.01**
	% Armored	**-0.24**	**< 0.001**
	% Open/Exposed	-0.11	0.1
Channel Cover	**% Open/Wetted Channel**	**0.17**	**0.01**
	% Woody Debris	0.06	0.18
	% Aquatic Veg/Algae	-0.08	0.22
	% Dry Channel	**-0.17**	**0.01**

Principal Components Analysis (PCA) was used to visualize associations among bank cover characteristics and trash density at targeted sites. PCA results yielded similar results to the Spearman correlation analysis presented in Table 4-4, with little to no association between trash density and bank and channel cover variables (see results in Appendix C). Analyses of other site characteristics (i.e., channel width and density of different sizes of outfalls within proximity of the sites) also showed limited or no association to trash density levels and trash condition scores.

Landscape Variables

Correlations between trash condition scores and physical habitat data collected at majority of probabilistic sites during previous creek status monitoring were also evaluated. These physical habitat data include landscape variables (e.g., percent imperviousness and road density) that were calculated for the drainage areas associated with each site. Based on this preliminary analysis, no physical habitat or landscape variables appear to have a statistically significant correlation with trash condition scores (see results in Appendix C).

Overall, the initial evaluation of site and landscape characteristics for receiving water monitoring sites suggests that some bank and channel cover characteristics barely explain the variation in observed trash conditions at probabilistic and targeted sites. The extent of natural vegetation and banks at a site appear to be somewhat positively correlated to trash condition scores, while the extent of armored and exposed/open banks are negatively correlated to condition scores. This is likely because natural channels that have riparian vegetation and diverse instream substrate (both woody debris and varying sizes of substrate) “intercept” trash more effectively than channels with less obstructions. Further evaluation of these relationships will be explored via the development of the Final Report, scheduled for completion in mid-2020.

4.2.3 Effects of Seasonality

Between October 2017 and March 2019, two qualitative trash assessments were conducted at each probabilistic site during the wet season (October – March) and one assessment was conducted at each probabilistic site during the dry season (April – September). As illustrated in Figure 4-5, the rainfall patterns during the 2017-18 and 2018-19 wet seasons differed substantially. During the wet season of 2017-18, storms were infrequent, short and had higher intensity than in 2018-19, when storms were generally more frequent and long term, longer, and less intense. That said, the distributions of trash condition scores were similar between the two wet seasons at probabilistic and targeted sites (Figure 4-6). The median trash condition scores for all probabilistic sites monitored in 2017-18 and 2018-19 was 4 (Moderate) on the 1 to 12 scale. This suggests that either trash levels did not significantly vary between wet seasons, or the trash condition scoring system is insensitive to minor variations in trash levels.

In comparison to the median scores observed during the wet seasons, the median trash condition score (3) for all probabilistic sites during the 2018 dry season was slightly lower than the median score (4) for the wet season events. The median score for targeted sites during the 2018 dry season were slightly higher (5) than the three probabilistic monitoring events. For each season, the interquartile ranges were between 2 and 6 at probabilistic sites and between 3 and 7 at targeted sites.

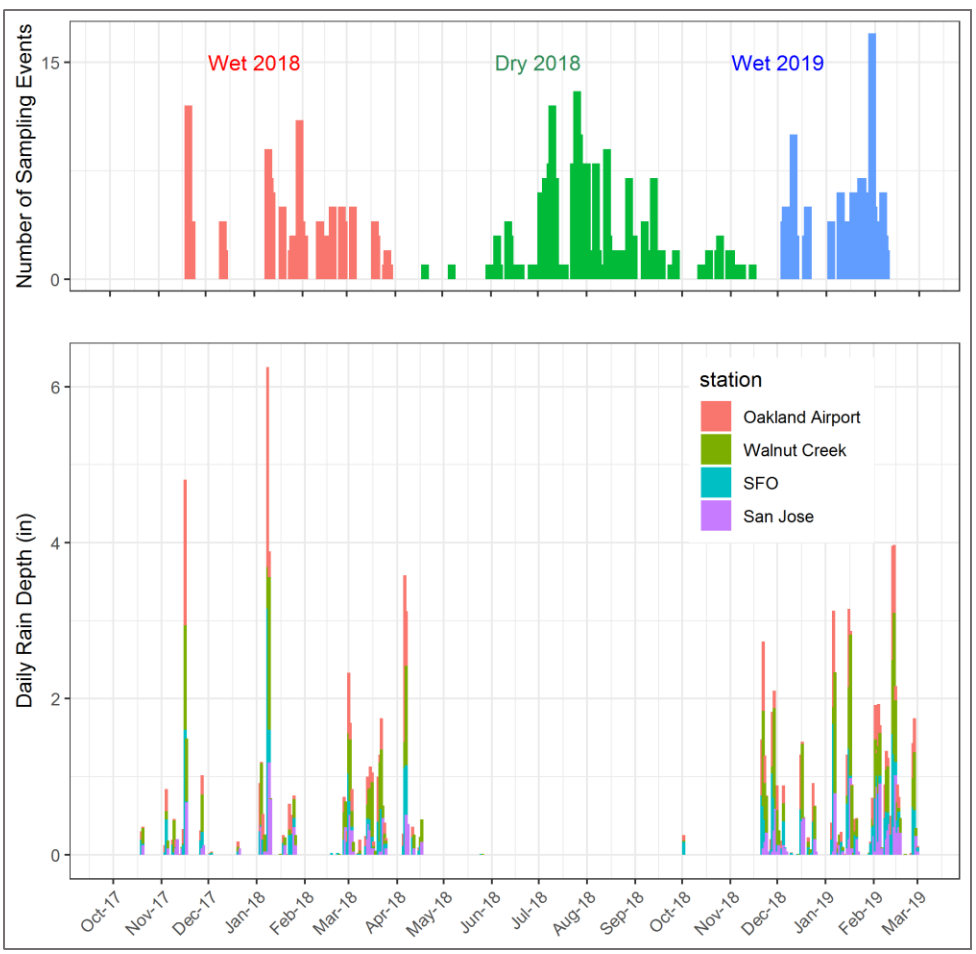

Figure 4-5. Daily precipitation (inches) recorded at four stations across the SF Bay Area from October 2017 through March 2019, and the number of sampling events probabilistic and targeted sites during that timeframe.

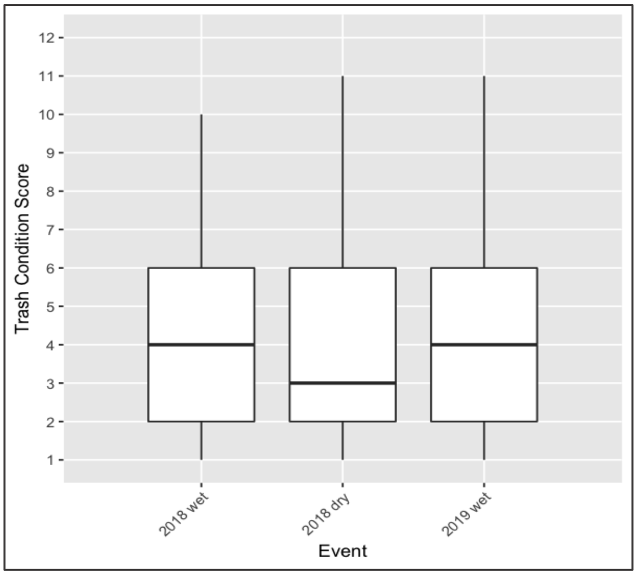

Figure 4-6. Ranges of trash condition scores at probabilistic sites the 2018 and 2019 monitoring events.

At a broader (categorical) scale, the trash condition category observed at each probabilistic site indicated slightly greater trash levels were present during the wet season events, compared to the dry season event. Figure 4-7 illustrates the proportion of probabilistic sites in each of the four trash condition categories for the three events. The proportion of sites in the *High* and *Very High* categories was greater in the 2018 (22% combined) and 2019 (23%) wet season events, compared to the 2018 dry season (15%). Nearly exactly the same number of sites occurred in the *Moderate* condition category for each of the three events (31%, 32% and 31%). The proportion of sites in the *Low* category was greater in the dry season event (53%) relative to either wet season event (47% and 46%).

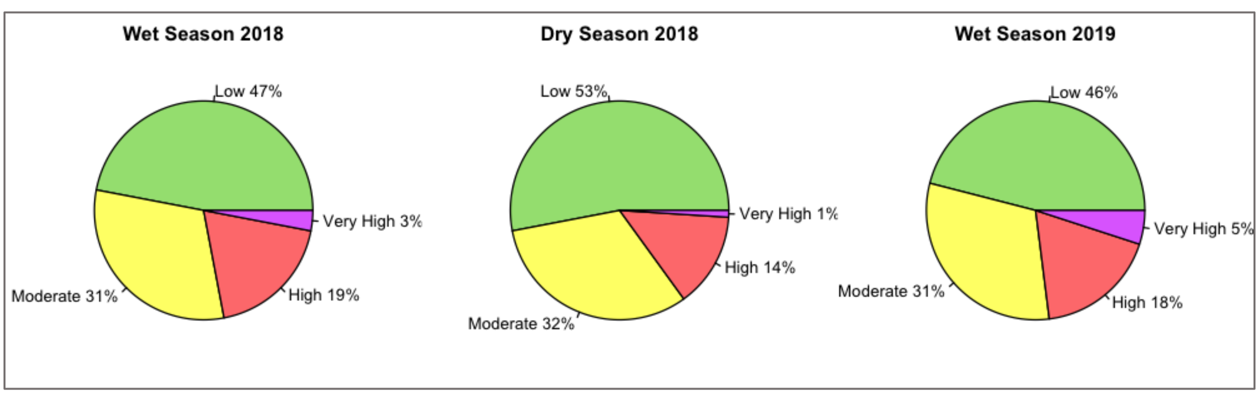

Figure 4-7. Comparison of trash conditions at probabilistic sites for wet and dry season sampling events.

4.3 Contributions of Trash in Receiving Waters from Different Pathways

Trash Monitoring Plan SOPs include the identification of trash pathways at probabilistic and targeted sites. Field personnel qualitatively identified trash pathways at all sites (both probabilistic and targeted) and quantified the volume of trash from each pathway at targeted sites. Contributions from one or more of the following four pathways were documented: 1) litter/wind; 2) illegal dumping; 3) illegal encampments; and 4) other/stormwater. One of the goals for this project was to determine the relative contribution of trash observed at monitoring sites that is associated with the “Other/Stormwater” pathway[6]. The preliminary trash dataset was evaluated to answer the following questions:

- How well do qualitative and quantitative approaches to assessing contributions from different trash pathways compare?
- What are the prevalent pathways of trash observed in receiving waters?
- What are the relationships between trash pathways and trash levels?
- What are key factors that influence trash pathways?

4.3.1 Comparison of Quantitative and Qualitative Approaches

Prior to presenting the information collected on the relative contributions of trash to probabilistic and targeted sites from each of the four pathways, it is important to compare trash pathway contributions that were determined via two different approaches: 1) qualitative visual assessments, and 2) volumetric measurements. Figure 4-8 presents the results of linear regression analyses conducted on data collected at targeted sites (n=100) on the relative (%) contributions by the four pathways using quantitative and qualitative approaches. Based on these analyses, it appears that the quantitative and qualitative approaches correlate rather well ($r^2 > 0.7$) for three (i.e., litter/wind, illegal encampments and other/stormwater) of the four pathways, although the data are highly variable on a site-by-site basis.

Multiple pathways were identified for the vast majority of the targeted sites using both the qualitative and quantitative approaches. Trash items associated with the litter/wind and stormwater pathways are typically light weight and smaller in size(e.g., single-use food ware, plastic bags, cigarettes), and therefore typically contribute smaller proportions of the overall trash volume at sites where the illegal dumping and/or illegal encampment pathways are also present. As a result, it is not surprising that the estimates of trash from the litter/wind and other/stormwater pathways have lower correlations compared to the illegal encampment pathway, which is associated with larger items. Other factors that can explain the moderate correlations include the inherent variability associated with qualitative visual approach. Additional analyses on the accuracy of qualitative approaches will be further evaluated during the development of the Final Report.

[6] “Other/Stormwater” pathway includes trash that appears to be associated with stormwater and unknown upstream sources (i.e., trash transported by flow and deposited further downstream).

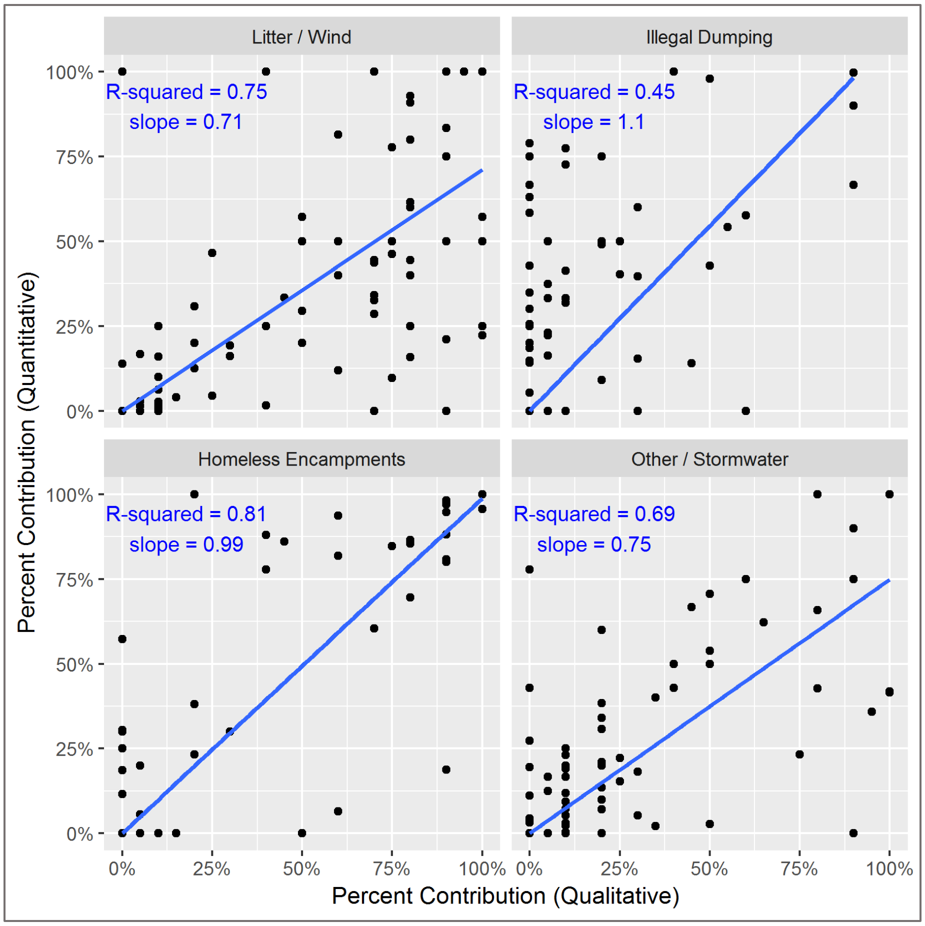

Figure 4-8. Comparisons of quantitative (volume measurements) and qualitative (visual estimate) approaches to identifying the relative contributions of trash from four trash pathways at targeted monitoring sites (n=100).

4.3.2 Prevalent Trash Pathways

The prevalence of each trash pathway was evaluated by assessing whether the pathway was (or was not) identified as a contributor of trash to each site (Table 4-5). The two most common pathways identified as contributors were litter/wind (88.6 % of events) and other/stormwater (76.1 % of events). The illegal encampment pathway was the least represented pathway (19.7 % of events). These preliminary results indicate that trash from the wind/litter and other/stormwater pathways are prevalent at receiving water sites.

Comparing the relative contributions of each pathway between targeted and probabilistic sites indicates that the illegal dumping and illegal encampment pathways are more prevalent at the targeted sites. This result is expected since these sites were originally selected as trash hot spots, locations where significant levels of trash are present in receiving waters.

Table 4-5: Total number and percentage of events at probabilistic and targeted sites when trash from a given pathway was reported as contributing trash to the site.

Type of Site	# of events included in analysis[1]	# of Events where the Pathway was Identified (%)			
		Litter/Wind	Illegal Dumping	Illegal Encampments	Other (Stormwater/Upstream Sources)
Probabilistic	359	324 (90.3 %)	93 (25.9 %)	57 (15.9 %)	283 (78.8 %)
Targeted	97	80 (82.5 %)	35 (36.1 %)	33 (34.0 %)	64 (66.0 %)
Totals	**456**	**404 (88.6 %)**	**128 (28.1 %)**	**90 (19.7 %)**	**347 (76.1 %)**

[1] The number of sites included in this analysis are smaller than the total number of monitoring events because of data quality issues with 16 probabilistic sites and 3 targeted sites.

4.3.3 Relationships Between Trash Pathways and Trash Levels

Although illegal encampments and illegal dumping pathways were less prevalent at targeted and probabilistic sites compared to litter/wind and other/stormwater, these two pathways were associated with much larger volumes of trash. During the targeted monitoring event (dry season of 2018), trash volumes were measured for each of the four pathways. In total, about 14,000 gallons of trash were associated with illegal encampments and illegal dumping, while the litter/wind and other/stormwater pathways together accounted for about 3,000 gallons of trash (Figure 4-9).

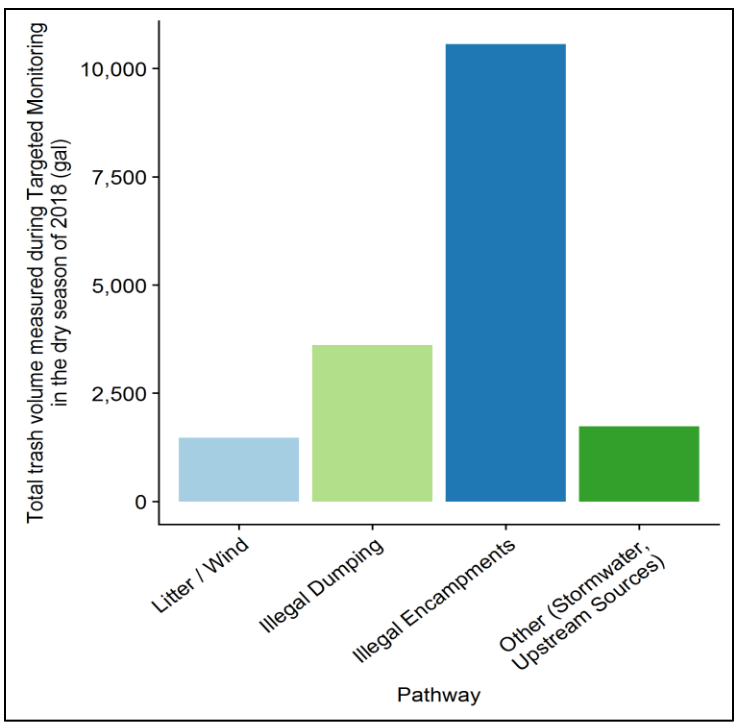

Figure 4-9. Total trash volume for each of the four pathways measured at targeted sites.

The association between illegal encampments and illegal dumping pathways and trash levels was confirmed using statistical correlation tests that compared trash pathway contributions to trash levels. The Spearman correlation analysis presented in Table 4-6 examined correlations between the relative contributions by each trash pathway and the trash condition score observed at the probabilistic and targeted sites. At probabilistic sites, higher trash condition scores were correlated to higher proportions of trash from the illegal encampment and illegal dumping pathways. In contrast, lower condition scores were correlated to proportions of the litter/wind pathway. The contribution of trash from the other/stormwater pathway did not exhibit a correlation to trash condition scores. However, it should be noted that contribution estimates are relative percentages and a negative correlation does not indicate that there is less trash from the litter/wind pathway, but merely that this pathway is becoming less dominant compared to other pathways (i.e., illegal dumping and Illegal encampments). Evaluating the correlations between pathway contributions and measured trash densities at targeted sites (instead of trash condition scores at probabilistic sites) yields similar results, with the exception of the illegal dumping pathway, which was not significantly correlated to trash condition score. Additional information on the results of the analysis of pathway contributions will be included in the Final Report.

Table 4-6. Correlations between qualitative trash condition scores and the qualitative estimation of trash contributed from different pathways at probabilistic (n=129) and targeted (n=100) sites.

	Probabilistic		Targeted	
Pathway	Correlation Coeff. (rho)	p-value	Correlation Coeff. (rho)	p-value
% Litter/Wind	-0.30	< 0.001	-0.42	<0.001
% Illegal Dumping	0.31	< 0.001	0.08	0.45
% Illegal Encampment	0.47	< 0.001	0.44	<0.001
% Other (Stormwater/Upstream Sources)	-0.04	0.559	0.04	0.7

The association between trash condition category and trash pathway contribution for both probabilistic (calculated as an average over all three events) and targeted sites is represented visually in Figure 4-10. Consistent with the statistical analysis results presented in Table 4-6, poor trash conditions are associated with higher proportions of trash from illegal encampments and illegal dumping, and lower proportions of trash from litter/wind. There appears to be little or no association between trash conditions and the other/stormwater pathway.

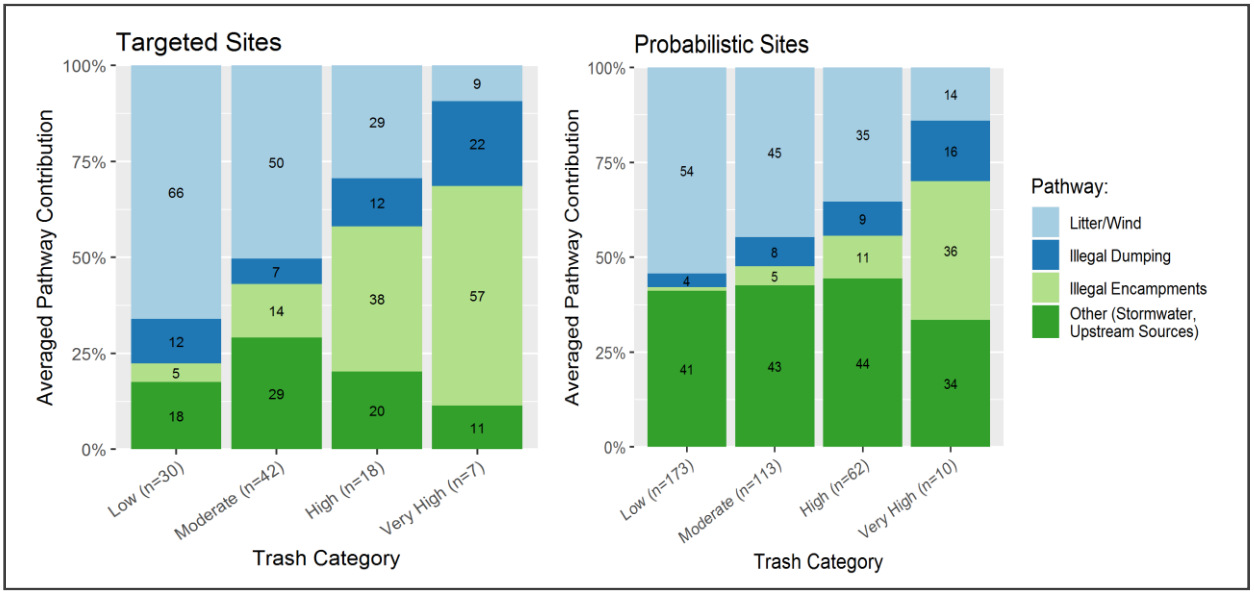

Figure 4-10. Average contributions of trash observed from each pathway to (A) probabilistic and (B) targeted receiving water monitoring sites during monitoring events. Monitoring events are grouped by trash condition categories observed during the monitoring event.

4.3.4 Factors that Influence Trash Pathways

Seasonal differences in the relative contributions of different trash pathways were also evaluated. Based on the data collected at probabilistic sites, the four trash pathways remained relatively consistent across the wet and dry season of 2018 (Figure 4-11). In contrast, the wet season of 2019 shows a higher relative contribution from the other/stormwater pathway (more than 50 % of the trash) and a lower relative contribution from litter/wind pathway, compared to the first two events. As discussed in Section 4.2.1, the 2019 wet season had more frequent storm events compared to the 2018 wet season, potentially resulting in more opportunities for trash to be transported and deposited across sites during the 2019 wet season. More frequent storm events may also have resulted in the transport of significantly more trash associated with the other/stormwater pathway, as illustrated in Figure 4-10.

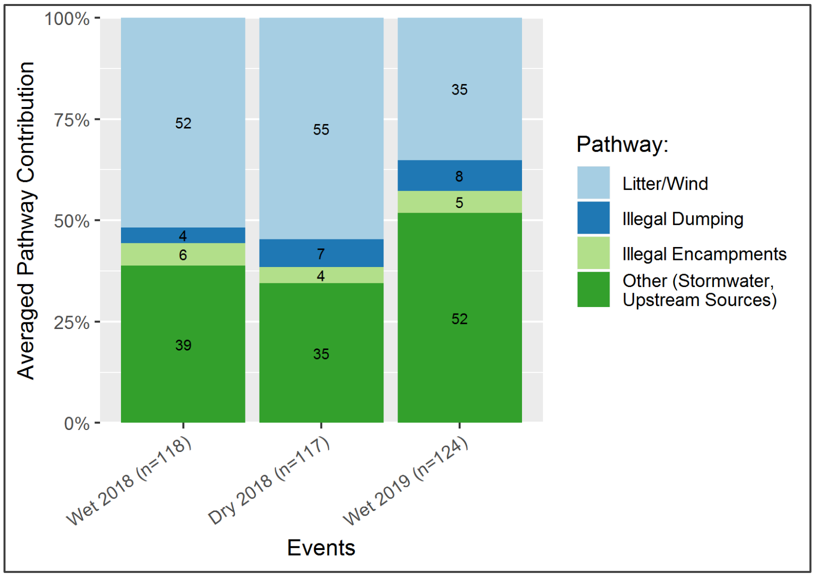

Figure 4-11. Average contributions of trash from each pathway identified during each receiving water trash monitoring event at probabilistic sites.

Overall, the comparison of trash levels amongst seasons suggests that seasonal differences may have an impact on the relative contributions from different trash pathways. In particular, wet seasons with more frequent, runoff-inducing storm events might lead to higher contributions of trash from the other/stormwater pathway. The Final Report will further evaluate the validity of these considerations with additional data, and will consider these differences to suggest an optimal timing of future trash assessments.

4.4 Levels of Trash Observed in Receiving Waters Compared to Trash Discharged by Stormwater Conveyances

In 2012, all MRP Permittees developed *Baseline Trash Generation Maps*[7] that depict the levels (i.e., categories - very high, high, moderate and low) of trash that was annually generated and transported to the Permittee's MS4 in 2009. Using the acres of land area within each baseline trash category (as depicted on Permittee maps) and the average annual volume of trash generated per unit of land area (gallons/acre) (BASMAA 2014), baseline trash loads were estimated for each Permittee. These loads are used by Permittees to compare current levels of trash generation and track progress towards trash reduction goals outlined in the MRP.

The Trash Monitoring Plan identified one scientific monitoring question related to the baseline (2009) levels of trash generation depicted on Permittee maps: *Do trash levels in flowing waterbodies strongly correlate to trash generation levels depicted on Permittee maps?* As described in this Preliminary Report, current trash levels in receiving water bodies are being observed/measured via a combination of qualitative and quantitative approaches at probabilistic and targeted sites during multiple events over the course of 2017-2020. Many of the methods that will be used to answer this question are dependent upon

[7] Some Permittees have refined their baseline maps since initially submitted to the SF Bay Regional Water Board in 2012. As applicable, refinements are documented in Permittee annual reports.

the results of the remaining data collection efforts and the relationships between qualitative trash condition scores and quantitative volumetric measurements that will be established through the analyses of the entire dataset collected through the Trash Monitoring Plan implementation. As such, analyses that will compare the levels of trash in receiving waters and trash discharged via stormwater conveyances will occur following the completion of all data collection efforts. The results of these analyses will be presented in the Final Monitoring Report, which will be completed in July 2020.

5 Summary of Preliminary Results and Next Steps

The following section presents a summary of the results of the preliminary analyses presented in this Preliminary Monitoring Report. The preliminary results are organized by specific scientific monitoring questions outlined in the Trash Monitoring Plan.

<u>Comparison of Qualitative Assessment and Quantitative Monitoring Results</u>

- ***Are significantly strong correlations observed between qualitative and quantitative trash receiving water monitoring/assessment methods?*** - Significant correlations are observed between qualitative trash condition scores (1-12) and trash density (volume per unit area) at both regional and countywide scales. Correlations are more tenuous at the 1 to 12 scale, compared to categorical scale (i.e., Low, Moderate, High, Very High), which may suggest that refinements to the qualitative assessment SOP that reduces (or eliminates) the 1 to 12 scale may be warranted in the future.

<u>Levels of Trash in Urban Water Bodies in the MRP Area</u>

- ***What is the current level of trash deposited in flowing waterbodies in each MRP county and the entire MRP urban area?*** - Trash levels are currently evaluated based on the qualitative trash condition scores (1-12) and categories (i.e., Low, Moderate, High, Very High) observed at probabilistic sites. For the probabilistic sites regionwide, 46% are in the Low condition category and 39% are in the Moderate category, indicating that approximately 85% (+11%) of the urban stream lengths in the MRP area exhibit low to moderate levels of trash. In contrast, only 1% of the stream-lengths have trash levels in the Very High trash condition category.
- ***Do other site and landscape variables correlate with trash levels in flowing waterbodies?*** - Site and landscape characteristics for trash receiving water monitoring sites suggests that some bank and channel cover characteristics partially explain the variation in observed trash conditions. The extent of natural vegetation and banks at a site appear to be somewhat positively correlated to trash condition scores, while the extent of armored and exposed/open banks are negatively correlated to condition scores. This is likely because natural channels that have riparian vegetation and diverse instream substrate (both woody debris and varying sizes of substrate) "intercept" trash more effectively than channels with less obstructions. Landscape variables, such as percent imperviousness, urban area, or road density, did not correlate with trash levels.
- ***Do trash levels in flowing waterbodies differ significantly between wet and dry seasons?*** - Seasonality appears to have little to moderate effects on trash levels observed/measured at receiving water sites. Trash condition categories observed at probabilistic sites indicate slightly greater trash levels during the wet season, compared to the dry season. Variations in trash levels between the two (2018 and 2019) wet season events, however, also illustrates the effects that storm frequencies and intensities can have on trash levels observed at the same sites over time.

- ***What trash levels are observed at sites targeted for cleanup? How do these levels compare to levels in all flowing waterbodies?*** - The trash assessment results from the targeted (hot spot) sites were compared to the results from probabilistic sites to determine if the range of conditions were similar between the two sample designs. Approximately 16% less targeted sites were in Low trash condition category, compared to the probabilistic sites, and more targeted sites were in the Moderate, High, and Very High condition categories than the probabilistic sites. Because targeted sites were selected by MRP Permittees as "trash hot-spots", higher trash scores would be expected at targeted sites compared to probabilistic sites.

<u>Contributions of Trash from Different Pathways</u>

- ***What percentages of trash observed in receiving waters are attributable to stormwater conveyance systems, direct dumping, wind, and encampments -*** At targeted sites, illegal encampments and illegal dumping pathways were associated with much larger volumes of trash. In total, at targeted sites about 14,000 gallons of trash were associated with illegal encampments and illegal dumping, while the litter/wind and other/stormwater pathways together accounted for about 3,000 gallons of trash. Based on comparisons between average pathway contribution and trash condition category, poor trash conditions are associated with higher proportions of trash from illegal encampments and illegal dumping. Although little to no association between trash conditions and the other/stormwater pathway have been observed, contributions of trash from this pathway appear to increase during the wet season, compared to the dry season.

<u>Levels of Trash Observed in Receiving Waters Compared to Trash Discharged by Stormwater Conveyances</u>

- ***Do trash levels in flowing waterbodies strongly correlate to trash generation levels depicted on Permittee maps?*** - Many of the methods that will be used to answer this question are dependent upon the results of the remaining data collection efforts and the relationships between qualitative trash condition scores and quantitative volumetric measurements that will be established through the analyses of the entire dataset collected through the Trash Monitoring Plan implementation. As such, analyses that will compare the levels of trash in receiving waters and trash discharged via stormwater conveyances will occur following the completion of all data collection efforts.

Based on the results of the preliminary data analyses presented in this Preliminary Report, the following next steps will be completed in preparation for completion of the pilot-testing stage of the Trash Monitoring Plan:

- Compile additional data from data collection efforts underway and planned for 2019 and early 2020, consistent with the Trash Monitoring Plan;
- Identify a set of reviewers and conduct a Peer Review of the trash monitoring results and conclusions in early 2020;Collaborate with SFEI to update existing regional data management tools to allow data collected through the BASMAA Trash Monitoring Plan to be made publicly-available via the on-line *Contaminant Data Display and Download (CD3)* tool, which is compatible with California Environmental Data Exchange Network (CEDEN);
- Develop a Final Trash Receiving Water Monitoring Report and submit to the SF Bay Regional Water Board by July 1, 2020; and Submit all data collected via the BASMAA Trash Monitoring Plan to SFEI for uploading to the CD3 tool.

6 References

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APPENDICES

A. Trash Condition Scores for Probabilistic sites over three sampling events (Tables A1-A2)
B. Trash Condition Scores – County Maps (Figures B1-B5)
C. Additional Figure evaluating site characteristics and trash condition scores (Figures C1-C3)
D. Additional Figure evaluating trash density for prevalent pathways (Figure D1)

Appendix A

Trash Condition Scores at Probabilistic Sites over three sampling events

The distribution of trash condition scores by event suggests very similar results to average scores presented in Table 4-1. The majority of streams in the MRP urban area exhibit low levels of trash. Table A1 presents the cumulative distribution results of trash condition scores during each of three events for the entire regional dataset. Table A2 presents the trash condition scores observed at each site during each of the first three sampling events.

Across all three events, the majority of streams exhibited trash condition scores of 1 or 2 (32-38%) and 4 or 5 (20-25%). Less than 25% of the stream length had a condition score of 7 or higher during the 2018 or 2019 wet seasons (22% and 24%, respectively), and only 11% of the stream length had a score of 7 or higher during the dry event.

Table A1. Proportion of stream lengths with different average trash condition scores based on three sets of observations at 125 sites within the five participating MRP counties. Condition categories are represented as follows: Low (green); Moderate (yellow); High(red) and Very High (purple).

Season	WY 2018 Wet Season	WY 2018 Dry Season	WY 2019 Wet Season
Event	1	2	3
Trash Condition Score	Percent of Stream Length (± 95% C.I.)		
1	18% (6%)	15% (5%)	15% (5%)
2	20% (7%)	22% (7%)	17% (7%)
3	9% (7%)	16% (7%)	14% (7%)
4	14% (7%)	10% (7%)	13% (7%)
5	11% (7%)	10% (7%)	11% (7%)
6	6% (6%)	11% (5%)	7% (6%)
7	10% (5%)	6% (4%)	8% (6%)
8	7% (3%)	6% (2%)	6% (5%)
9	2% (2%)	2% (1%)	5% (3%)
10	3% (0%)	1% (0%)	3% (2%)
11	0% (0%)	0% (0%)	2% (0%)
12	0% (0%)	0% (0%)	0% (0%)

Table A2. Trash condition scores at probabilistic sites over three sample events. Condition categories are represented as follows: Low (green); Moderate (yellow); High (red) and Very High (purple).

Site ID	Event 1	Event 2	Event 3
202R00284	2	5	4
202R01308	9	8	4
202R01356	1	1	
202R01612	1	1	1
202R02332			7
204R00020	4	4	2
204R00047	1	2	2
204R00068	3	3	2
204R00084	1	2	4
204R00100	5	2	3
204R00180	2	2	3
204R00191	7	2	3
204R00200	7	7	9
204R00232	6	8	5
204R00244	1	1	1
204R00292	3	6	2
204R00303	10	2	8
204R00327	6	2	6
204R00334	2	2	4
204R00340	2	2	4
204R00356	5	3	7
204R00367	1	6	2
204R00383	5	2	4
204R00388	2	3	2

Site ID	Event 1	Event 2	Event 3
204R02248	6	7	8
204R02312	8	7	8
204R02504	5	3	4
204R02548	7	6	4
205R00026	4	4	8
205R00035	5	7	7
205R00042	4	5	11
205R00067	5	6	5
205R00090	4	4	5
205R00099	4	6	5
205R00110	2	5	3
205R00115	7	6	8
205R00131	8	5	6
205R00154	7	3	6
205R00218	5	5	7
205R00227	2	6	4
205R00234	2	2	3
205R00241	2	3	5
205R00259	10	11	10
205R00279	8	5	9
205R00282	4	3	9
205R00346	5	6	6
205R00355	5	5	6
205R00374	3	4	

Site ID	Event 1	Event 2	Event 3
206R00919	3	1	3
206R00960	3	2	2
206R01024	4	2	3
206R01495	2	2	
207R00027	2	2	2
207R00247	1	1	1
207R00395	5	5	4
207R00428	8	8	10
207R00476	8	7	10
207R00503	1	1	1
207R00567	2	3	5
207R00619	1	1	1
207R00631	7	5	5
207R00688	4	2	4
207R00823	2	1	1
207R00843	3	1	1
207R00880	4	3	5
207R00891	2	1	2
207R01163	9	8	10
207R01227	2	1	1
207R01271	1	1	1
207R01291	8	8	5
207R01447	2	2	3
207R02480	1	1	1

Table A2. continued

Site ID	Event 1	Event 2	Event 3
204R00391	7	2	7
204R00436	2	4	3
204R00447	1	3	2
204R00473	1	3	2
204R00520	5	4	4
204R00575	7	3	5
204R00583	9	6	9
204R00596	8	1	9
204R00639	10	4	11
204R00680	7	9	9
204R00711	4	2	6
204R00712	8	8	8
204R00807	4	7	1
204R00831	7	3	7
204R00852	1	3	2
204R00884	6	4	5
204R01012	4	2	2
204R01256	6	4	6
204R01268	2	6	2
204R01288	4	2	6
204R01460	3	2	2
204R01972	4	4	3
204R02056	6	8	5
204R02228	1	2	1

Site ID	Event 1	Event 2	Event 3
205R00387	4	1	3
205R00419	2	2	2
205R00430	2	4	2
205R00451	10	9	5
205R00474	5	6	5
205R00535	5	5	3
205R00538	6	7	7
205R00547	1	3	1
205R00554	2	6	3
205R00586	1	2	2
205R00602	3	2	7
205R00622	3	5	2
205R00627	6	3	7
205R00659	7	5	7
205R00686	1	7	2
205R00707	4	5	4
205R00714			4
205R00872	1	1	
205R00878	5	3	4
205R00984	1	3	1
205R01704	2	2	3
205R01816	1	1	1
205R02408			1
206R00727			3

Site ID	Event 1	Event 2	Event 3
207R03504	2	1	1
543R00137	2	2	2
544R00025	2	3	1
544R00281	4	4	6
544R00342	8	6	4
544R00464	7	6	3
544R00598	3	1	3
544R01049	1	3	1
544R01305	3	4	8

Appendix B

Trash Condition Scores for Probabilistic and Targeted Sites for Each County

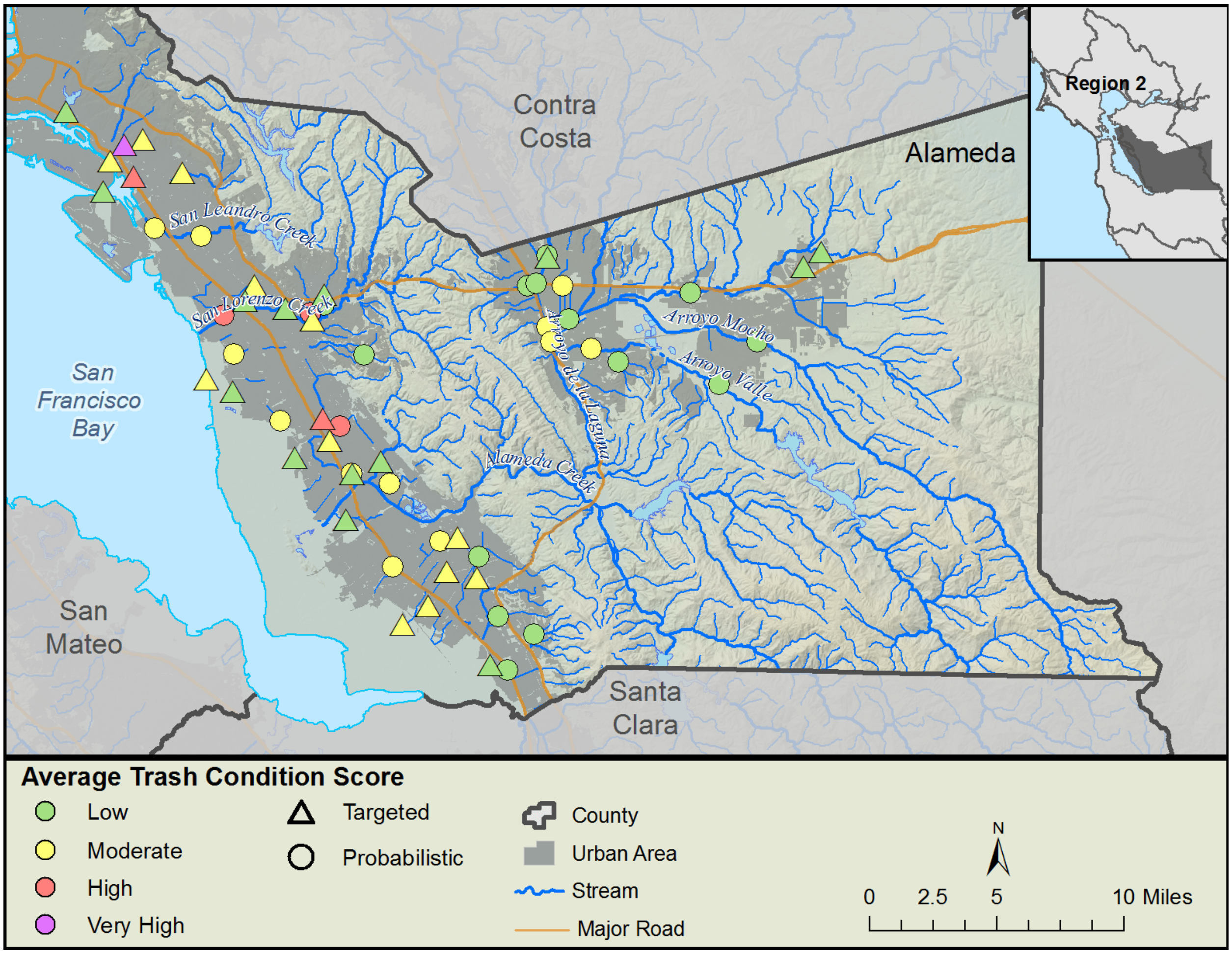

Figure B1. Trash Condition Scores at Probabilistic and Targeted sites in Alameda County.

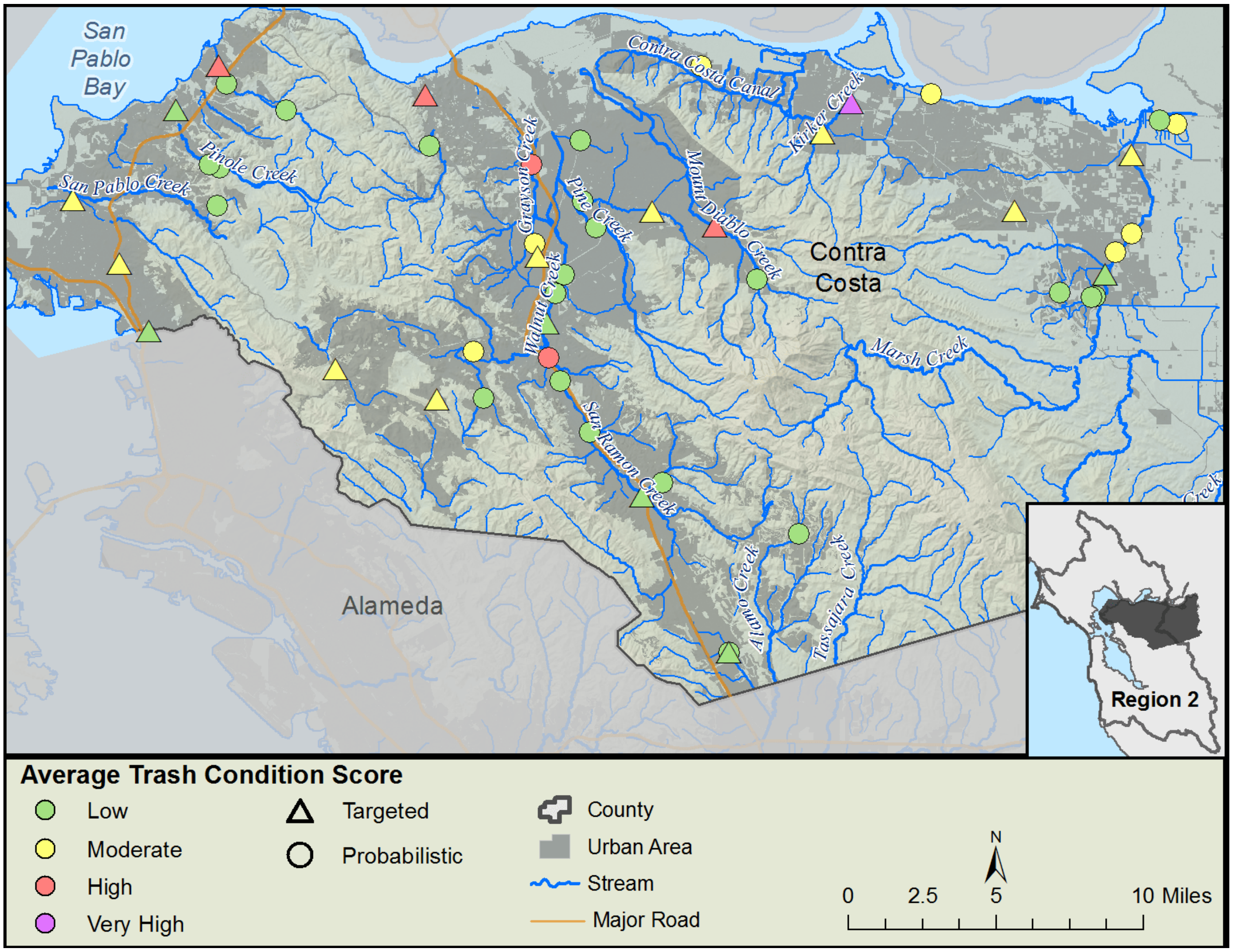

Figure B2. Trash Condition Scores at Probabilistic and Targeted sites in Contra Costa County.

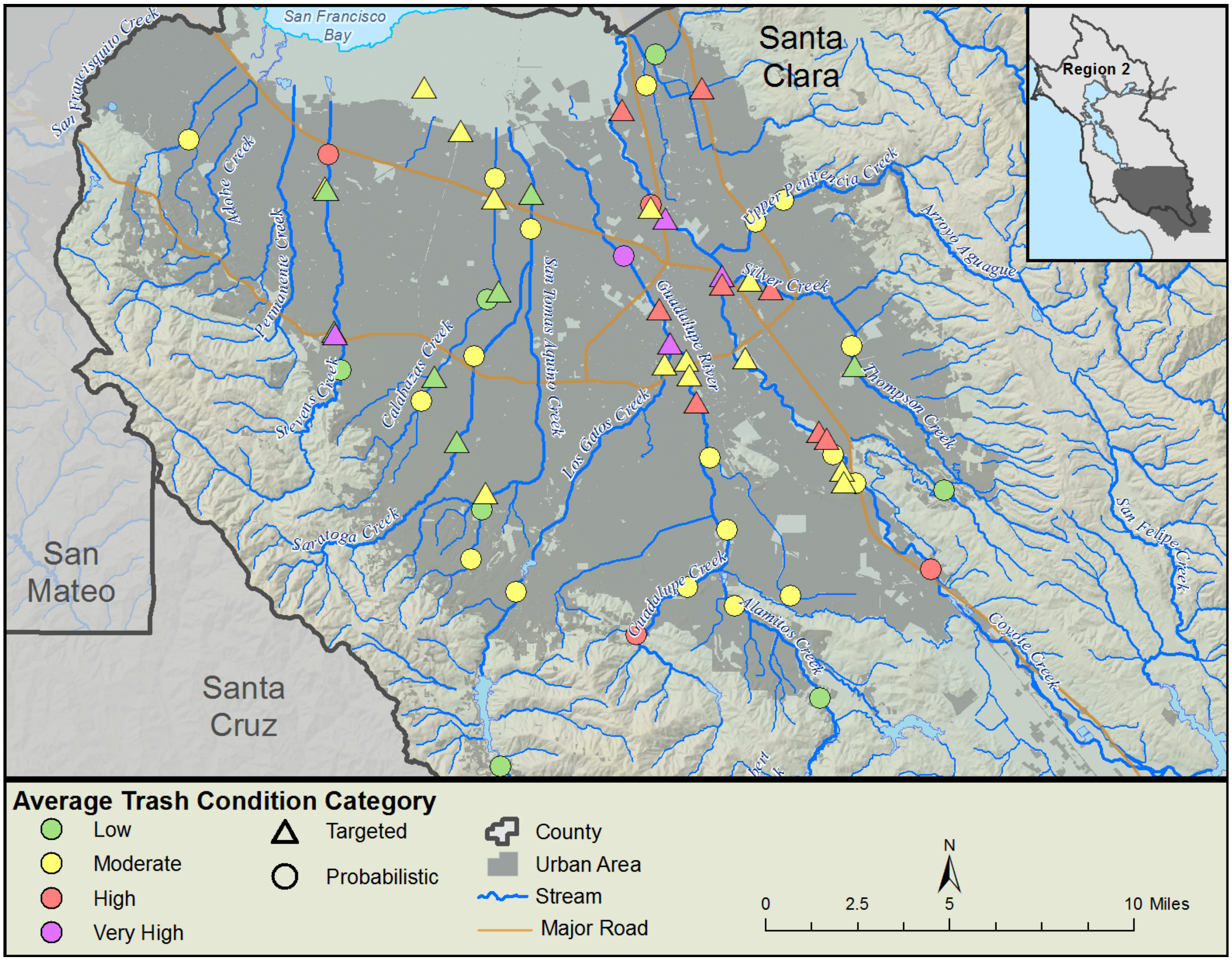

Figure B3. Trash Condition Scores at Probabilistic and Targeted sites in Santa Clara County.

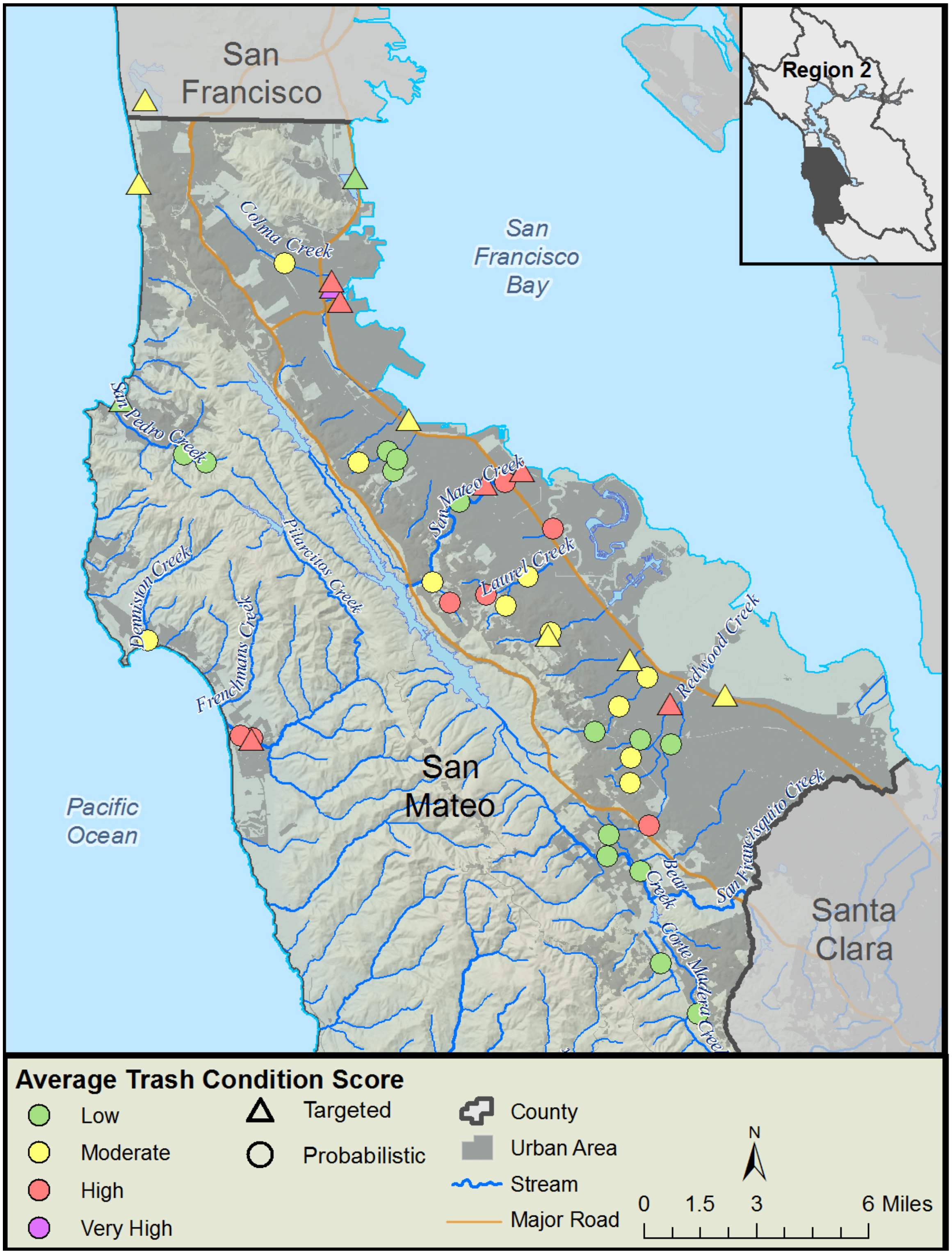

Figure B4. Trash Condition Scores at Probabilistic and Targeted sites in San Mateo County.

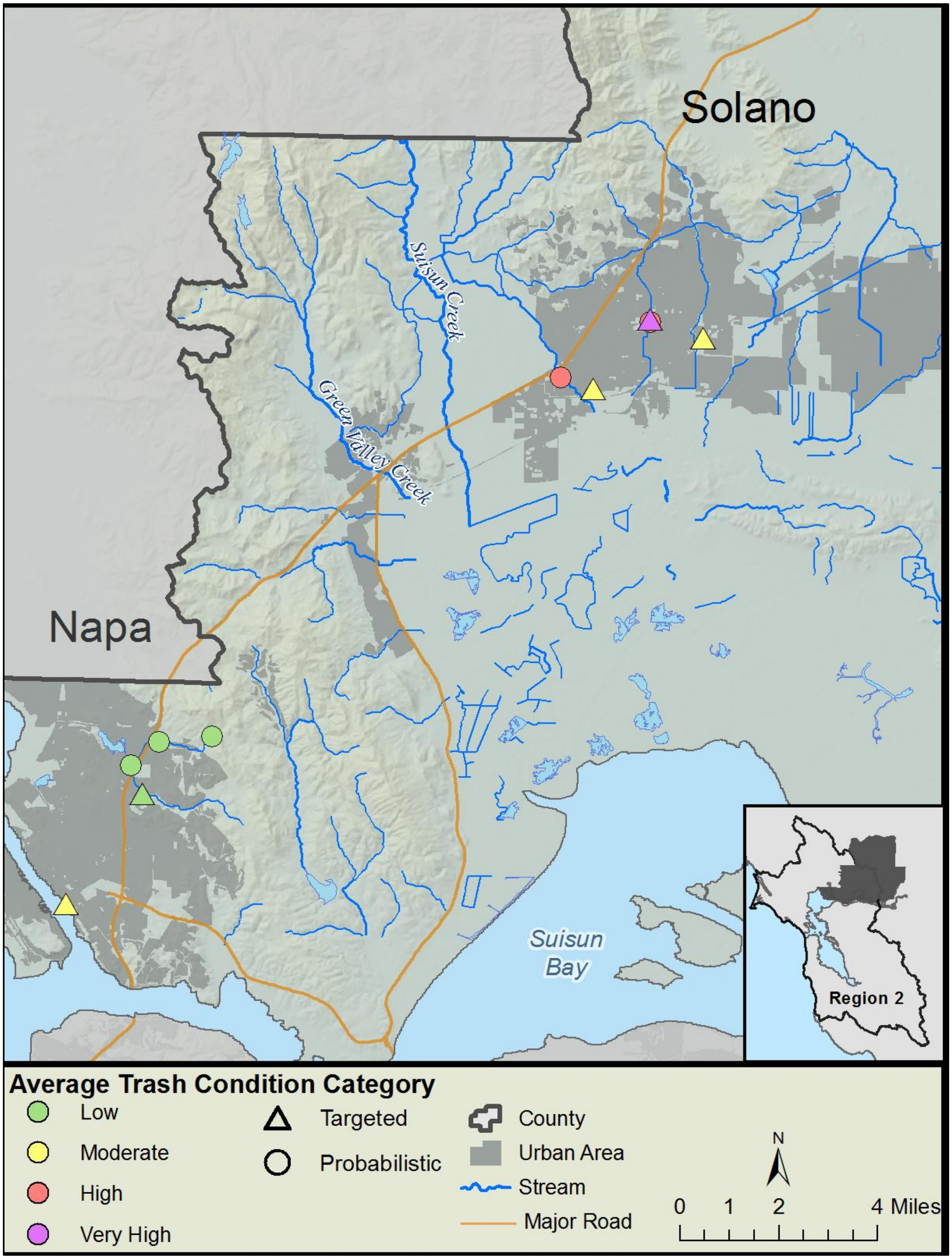

Figure B5. Trash Condition Scores at Probabilistic and Targeted sites in Solano County.

APPENDIX C

ADDITIONAL FIGURES EVALUATING ASSOCIATIONS BETWEEN SITE CHARACTERISTICS AND TRASH CONDITION SCORES

Supplementary data analysis was performed to explore characteristics of sites that may have influenced the trash condition scores.

Using data for all sites combined, Spearman's correlation analysis was conducted for relationships to contiguous stream width and number of outfalls (Table C.1). Bank cover characteristics were evaluated using a Principal Components Analysis (Figure A1.2).

The stream width and number of outfalls were significantly ($p < 0.05$), but weakly (rho < 0.25) correlated with trash condition scores across all sites.

Table C1. Correlation between trash condition scores, contiguous width, and number of outfalls across all sites.

	Contiguous Width	# Outfalls 18-24"	# Outfalls 24-36"	# Outfalls 36-48"	# Outfalls >48"
Trash Condition Score	0.23*	0.14*	0.12*	0.09*	0.07

* p < 0.05

Principal Component Analysis is a multivariate ordination technique commonly used to explore the underlying structure of a dataset to emphasize variables that best explain the variance. Figure C.2 shows the results of an exploratory PCA of all targeted sites, with the sites designated based on the trash condition category. The PCA results indicate that trash density increased with changes in bank cover characteristics along PC1, but did not clearly associate with trash condition categories. The first two principal components (PC1 and PC2) explain 54.6% of the variation in the trash density and bank cover data. To interpret the ordination plot, we would be looking for sites of the same color to group together and eigenvectors to be strongly positive or negative along the X or Y-axes. Using these cues, it is evident that sites of a unique condition category do not group well along either axis, and instead are distributed in multiple quadrants of the ordination. For example, sites characterized in the Low category are more common along the positive quadrants of PC1 and PC2. This pattern suggests trash categories are distributed based on lower trash density (along PC1) and proportion of armored banks (along PC2). Conversely, none of the High or Very High sites occur in the positive quadrants of PC1/PC2 (top right). Conversely, sites in this category occur in all other quadrants of the ordination. This suggests a combination of higher proportion of trees and bushes, lower proportions of grasses, and higher trash density are all contributing to the distribution of the sites in the higher trash condition categories.

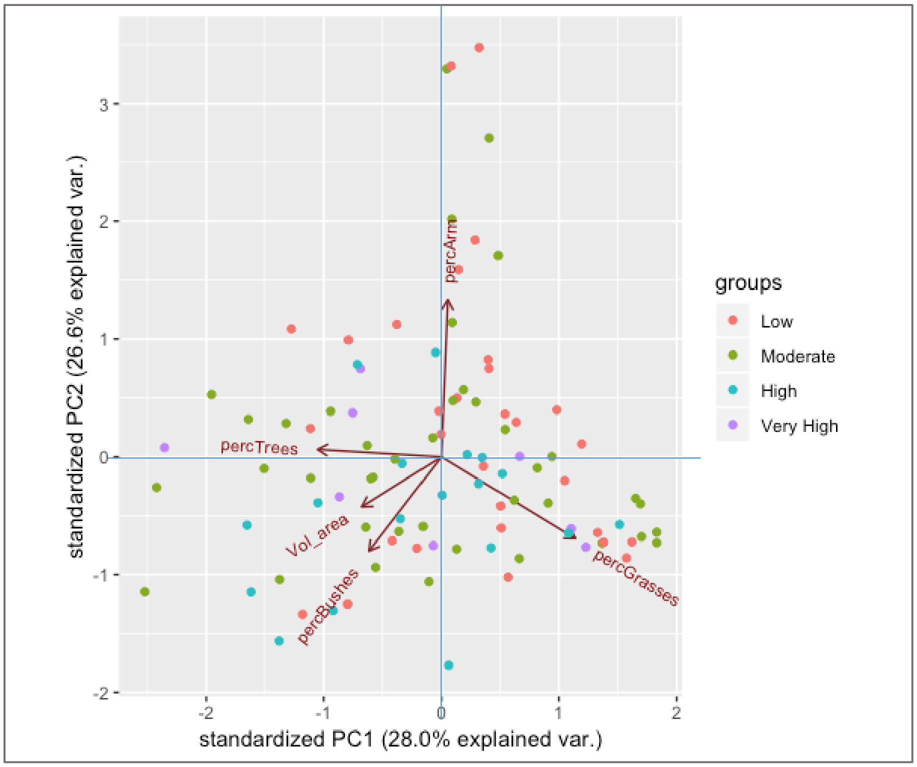

Figure C2. PCA ordination of bank cover and trash density at targeted sites

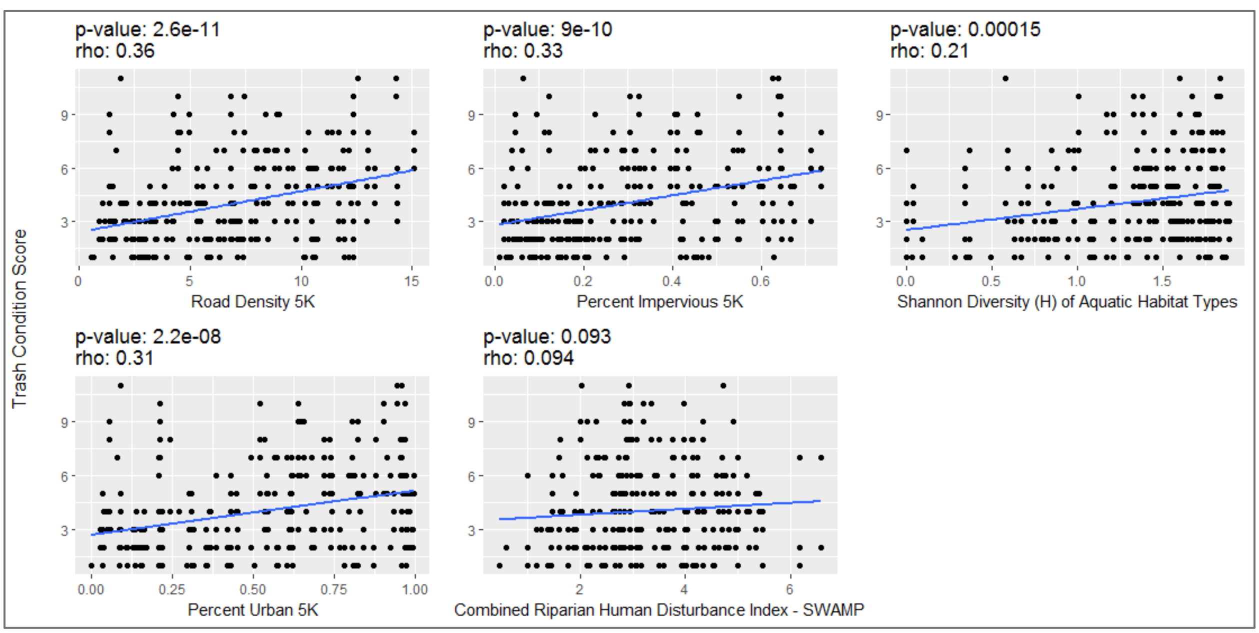

Figure C3. Spearman rank plots of landscape variables and physical habitat data (collected during Creek Status Monitoring) association with trash condition scores.

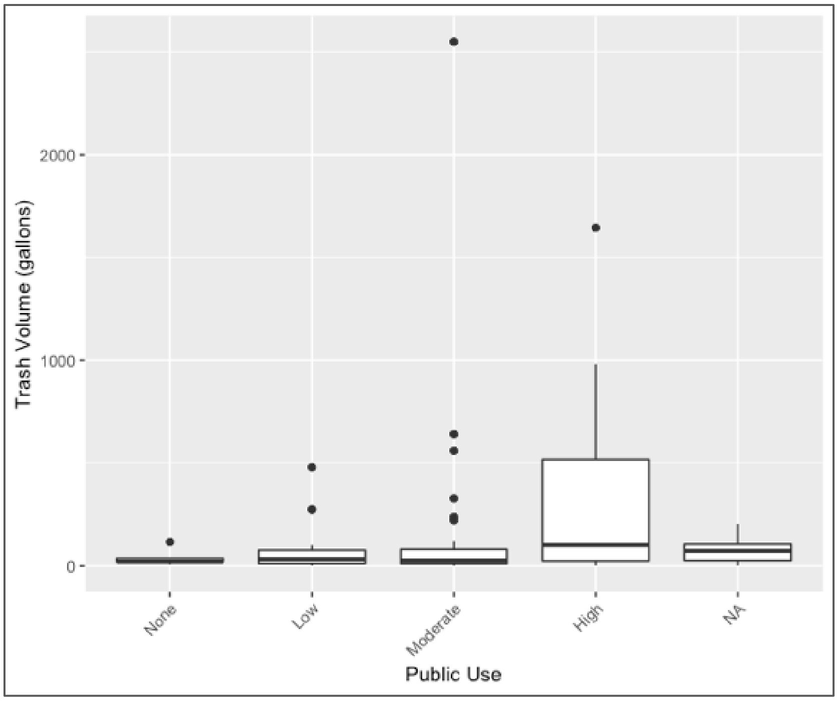

Figure C4. Box plots showing trash density compared to evidence of public use category at all targeted assessment sites.

APPENDIX D – ADDITIONAL FIGURE EVALUATING TRASH PATHWAYS

Based on the relationship between qualitative percentages and actual trash volumes, the average trash density generated by each trash pathway can be estimated. Ideally, sites with a 100% contribution from a given pathway would be used to estimate the mean trash density for a given pathway. However, because of the limited size of this dataset, all sites with a contribution greater than 50% were used. An example calculation is given below:

$$Average\ trash\ density\ for\ the\ Litter - Wind\ Pathway\ at\ a\ given\ site\ =$$

$$\frac{volume\ of\ trash\ from\ Litter - Wind\ (if\ Qualitative\ Percentage\ for\ Litter\ Wind > 50\%)}{\left(\frac{Qualitative\ Percentage\ for\ Litter\ Wind}{100}\right)}$$

Dividing by the qualitative percentage amounts to estimating what the trash density would be if there were a 100% contribution from the Litter Wind pathway.

The results are presented in Figure D1. On average, trash density from illegal dumping and encampment pathways are 5 to 10 times higher than from the two other pathways. Trash items deposited at those locations are typically more variable in size and larger on average (e.g., bikes, appliances, furniture) than those than can be transported by wind or stormwater.

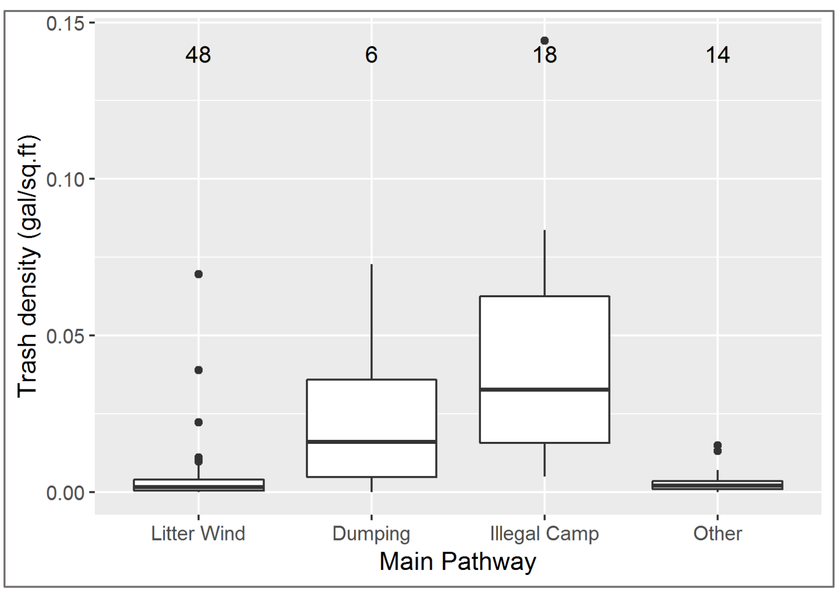

Figure D1. Boxplot of estimated trash density for all 4 main trash-generating pathways at targeted sites; the total number of sites used for each event is shown at the top.