TARGETED AGGRESSIVE STREET SWEEPING PILOT PROGRAM PHASE III MEDIAN SWEEPING STUDY

FINAL REPORT

TASK ORDER #18 DOC ID# CSD-RT-10-URS18-02

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PROGRAM ASSESSMENT SERVICES
BMP DEVELOPMENT & ENGINEERING
ASSET MANAGEMENT SERVICES
ENVIRONMENTAL ASSESSMENT & PERMITTING
STRATEGIC PLANNING
MONITORING & INVESTIGATIONS

MWH URS

CITY OF SAN DIEGO

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List of Acronyms and Abbreviations

BMPs	Best Management Practices
CA	California
City	City of San Diego
EPA	Environmental Protection Agency
GIS	Geographical Information System
GPS	Global Positioning System
HSP	Health and Safety Plan
JURMP	Jurisdictional Urban Runoff Management Plan
MDL	Method Detection Limit
MEP	Maximum Extent Practicable
MRL	Method Reporting Limit
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NURP	Nationwide Urban Runoff Program
O&M	Operations and Maintenance
OP	Organophosphorous Pesticides
Permit	RWQCB Order NO. R9-2007-0001
Phase I	Sweeping Frequency Study of the City of San Diego's Targeted Aggressive Street Sweeping Pilot Program
Phase II	Sweeping Machine Technology Study of the City of San Diego's Targeted Aggressive Street Sweeping Pilot Program
Phase III	Median Sweeping Study of the City of San Diego's Targeted Aggressive Street Sweeping Pilot Program
Phase IV	Speed Sweeping Study of the City of San Diego's Targeted Aggressive Street Sweeping Pilot Program
QA/QC	Quality Assurance/Quality Control
Report	Median Sweeping Study, Phase III of the City's Targeted Aggressive Street Sweeping Pilot Program Report
RWQCB	San Diego Regional Water Quality Control Board
Route 1	Miramar Area Median Sweeping Route
Route 2	Clairemont Area Median Sweeping Route
Route 3	Mission Valley Area Median Sweeping Route
Route 4	Tijuana River Area Median Sweeping Route
SWRCB	State Water Resources Control Board
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
URS	URS Corporation
US	United States
WMA	Watershed Management Area
Work Plan	Street Sweeping Route Optimization Work Plan (CSD-RT-10-URS18-01)
WURMP	Watershed Urban Runoff Management Program

EXECUTIVE SUMMARY

The City of San Diego (City) manages a large Municipal Separate Storm Sewer System (MS4) that discharges stormwater and urban runoff to creek, bay, and ocean receiving waters throughout the City limits. The San Diego Regional Water Quality Control Board (RWQCB) regulates the discharge of urban runoff through the City's MS4 under the National Pollutant Discharge Elimination System (NPDES) permit program. In response to NPDES permit obligations and as a result of other program drivers, the City has engaged in a multi-faceted urban runoff management program that includes studies to determine the most cost-effective and efficient methods to implement water quality improvements.

As part of the Targeted Aggressive Street Sweeping Pilot Program, the City has developed a phased series of pilot projects designed to evaluate the feasibility, potential water quality benefits, and cost-effectiveness of modifications to its current street sweeping effort. Phases I and II of this pilot program assessed the relative pollutant removal and cost-efficiency of increased sweeping frequency and advanced sweeper equipment technologies. The purpose of the Phase III Median Sweeping Study was to evaluate sweeping of roadway medians adjacent to high volume roadways in order to determine the water quality benefits and feasibility of sweeping the median sweeping routes. These areas are not included in the current City street sweeping routes and are not typically swept during routine sweeping activities.

Phase III included four median routes located in urbanized areas of watershed management areas (Los Peñasquitos, Mission Bay and La Jolla, San Diego River, San Diego Bay and adjacent to the Tijuana River) throughout the City. Median types included barrier (typically a heavy physical barrier that prevents vehicle passage), raised medians (which include a curb and gutter and vary in width and the presence of vegetation) and painted medians (which typically include double yellow or broken double yellow lines defining median sections and/or turn lanes). Mechanical broom sweepers were used to conduct street sweeping operations along the four study routes at three week intervals over approximately 3 months. Street sediment samples from sweeping event were analyzed for common roadway constituents with potential water quality impacts including metals, general chemistry, pesticides and hydrocarbons. In addition, a limited hand-sweeping pilot was conducted by using hand sweeping (manual) methods to assess constituents present in the impervious area on top of raised medians. These areas were pilot tested using manual methods because they are logistically and operationally difficult for traditional City mechanical sweepers to access. As part of Phase III, a literature review of available national, regional and local street sweeping studies was also conducted. Key results of the literature review include:

- Bi-weekly to monthly sweeping frequencies have been shown to be a cost effective approach in some studies. The specific frequency at which sweeping operations most effectively remove pollutants in a given area will depend on numerous site-specific pollutant loading, operational costs, and other factors.
- Regenerative air sweepers and vacuum-assisted sweepers are consistently more effective than mechanical broom sweepers.
- High efficiency sweepers (that use a combination of a mechanical and vacuum action to dislodge settled debris and remove it by vacuuming it from the pavement) are more effective than others at picking up fine particulate matter (PM-10 particulates).

- Knowledge of baseline (pre-sweeping) and post-sweeping road conditions are critical to accurately compare results of sweeper efficiency testing programs.

Phase III study results indicate that median sweeping has potential to remove significant amounts of street debris and roadway constituents. Key results include:

- The initial median sweeping event collected 3-5 times greater amounts of debris than subsequent 3-week interval sweeping events. This suggests significant buildup of roadway debris occurs adjacent to median areas. Extrapolation of data allowed an estimate of 32,000 pounds of material to be removed by a single annual sweeping event or up to 140,000 pounds of material to be removed annually from sweeping median areas at 3-week intervals.
- Metals, nutrients, and hydrocarbon constituents were all detected in median street debris and the hand-swept samples in varying concentrations which may impact downstream water quality. These results suggest that median sweeping may provide a significant benefit for controlling input of constituents with potential water quality impacts to the City MS4.
- Operational capacity limitations are likely to limit potential implementation of median sweeping activities to quarterly or even less frequent intervals. Examination of relatively infrequent implementation scenarios using the project data indicated that approximately 3 pounds of copper, 0.75 pounds of lead, and 3.5 pounds of zinc may be removed from City streets by median sweeping. Periodic manual sweeping of raised medians will likely result in additional removal of street debris and associated roadway constituents.

SECTION 1 INTRODUCTION

The California State Water Resources Control Board (SWRCB) and nine Regional Water Quality Control Boards regulate the waste discharge requirements for discharges of urban runoff from Municipal Separate Storm Sewer Systems (MS4s) under the National Pollutant Discharge Elimination System (NPDES) permit program. The City of San Diego (City) manages a large MS4 that discharges stormwater and urban runoff to creek, bay, and ocean receiving waters throughout the City limits. The San Diego Regional Water Quality Control Board (RWQCB) regulates the discharge of urban runoff through the City's MS4 and the City is identified as a discharger (or "Copermittee") under the RWQCB Order No. R9-2007-0001 (Permit) (RWQCB 2007). Under the Permit, the City must reduce the discharge of pollutants in urban runoff to the Maximum Extent Practicable (MEP) through a combination of pollution prevention, source control, and treatment control Best Management Practices (BMPs).

The City is committed to making clean water a priority by improving the quality of creeks, streams, rivers, bays, and beaches throughout the City's jurisdiction. Urban runoff, also called stormwater, has been identified as a major contributor of pollutants to receiving waters both locally and regionally. The City has developed a phased series of pilot projects designed to evaluate the feasibility, potential water quality benefits, and cost-effectiveness of modifications to its current street sweeping effort. As part of these efforts, the Targeted Aggressive Street Sweeping Pilot Program was initiated to optimize the City's current street sweeping programs to efficiently remove pollutants from road surfaces. Phases I and II of this pilot program assessed the relative pollutant removal and cost-efficiency of increased sweeping frequency and advanced sweeper equipment technologies. The purpose of Phase III is to increase street sweeping routes to include roadway medians and other non-traditionally swept thoroughfares adjacent to high volume roadways in order to determine the water quality benefits and feasibility of the additional sweeping. The following sections describe the pilot project design, implementation strategy, and results for the Phase III study.

1.1 BACKGROUND

Stormwater runoff, which can accumulate particulates and other pollutants from roadways and other impervious surfaces in urban areas, is a known contributor to water quality problems throughout the United States. Street sweeping is a common source control BMP used by municipalities nationwide to remove potential water pollutants from roadways. The City's Permit specifically requires Sweeping of Municipal Areas as follows:

> Each Copermittee shall implement a program to sweep improved (possessing a curb and gutter) municipal roads, streets, highways, and parking facilities. The program shall include the following measures:
>
> (a) Roads, streets, highways, and parking facilities identified as consistently generating the highest volumes of trash and/or debris shall be swept at least two times per month.
>
> (b) Roads, streets, highways, and parking facilities identified as consistently generating moderate volumes of trash and/or debris shall be swept at least monthly.

(c) Roads, streets, highways, and parking facilities identified as consistently generating low volumes of trash and/or debris shall be swept as necessary, but no less than once per year.

Table 1-1 presents a description of each completed or planned phase of the Targeted Aggressive Street Sweeping Pilot Program. The City's overall goal in performing these pilot programs is to identify and implement the most cost-efficient combination of street sweeping practices and technology that will maximize pollutant load reductions.

Table 1-1. Phases of the Targeted Aggressive Street Sweeping Pilot Program

Pilot Program Phase	Description of Pilot	Status
Phase I	Sweeping Frequency Study	Complete
Phase II	Sweeping Machine Technology Study	Complete
Phase III	Median Sweeping Study	Complete
Phase IV	Speed Sweeping Study	Planned Fiscal Year 2011
Phase V	Posted/Non-posted Route Study	Planed Fiscal Year 2012

The City conducted the first two phases of the Targeted Aggressive Street Sweeping Pilot Program (Phases I and II) in fiscal years 2008 and 2009, respectively. Phase I of the project assessed the relative effect of increased street sweeping frequency in removing pollutants. Phase II of the project compared the efficiency of three types of street sweeping machine technologies. Phases I and II were conducted in the La Jolla Shores, Tecolote, and Chollas Creek watersheds. The street sweeping frequency comparison consisted of sweeping routes once per week and twice per week. The efficiency assessment of the sweeper types compared mechanical, regenerative air, and vacuum-assisted sweepers. The three different types of sweepers were used to sweep routes with different land uses and terrain to compare their street debris and pollutant removal effectiveness.

The City performs street sweeping on many routes City-wide in a variety of areas with different adjacent land use types (including residential, commercial, and other dominant land use types), traffic patterns, and other factors that potentially impact the water quality of urban runoff. It is generally accepted that many particulate pollutants tend to accumulate on the shoulders of roadways (typically near curb areas), adjacent to where traffic most often travels. Accordingly, the City's street sweeping program preferentially targets the curb and gutter areas to facilitate removal of roadway street debris. Higher traffic volume streets, often with mixed commercial and residential adjacent land uses, can often include raised or painted median areas that separate opposing traffic lanes. Raised medians often include a curb and gutter configuration surrounding grass, trees, pavement or, other material. Painted medians are level with the adjacent landscape and use a yellow painted striped area to separate opposing lanes of traffic. It is presumed that roadway street debris and other particulate pollutants accumulate adjacent to raised medians and within painted median areas in the same way it accumulates along curbs and in gutters. However, the City does not currently have pre-defined street sweeping routes that target either raised or painted median areas.

In addition, casual observation of raised median areas on high traffic roadways indicates, in some cases, significant build-up of trash, litter and course- and fine-grained particulates. Previous special studies in the City have indicated that street debris often contains high concentrations of metals constituents (Weston 2009) and aerial deposition of metals and other materials is likely a significant contributor to annual loads of metals discharged via stormwater (Weston 2009). Given the logistical challenges of using traditional street sweeping machine technology to sweep raised median areas (e.g. few access points for machines to access raised curb areas, limited space for machine maneuvering, and numerous potential obstacles), raised medians provide a potential area where non-traditional street sweeping techniques may be utilized to reduce pollutant loads.

Phase III of the City's Targeted Aggressive Street Sweeping Pilot Program took place within the City's jurisdictional boundaries. The City's boundaries encompass more than 324 square miles and include six watershed management areas (WMA): San Dieguito River, Los Peñasquitos, Mission Bay and La Jolla, San Diego River, San Diego Bay, and adjacent toTijuana River. The four street sweeping routes studied in Phase III were chosen based on traffic volume, differing adjacent land use, and are generally located within five different watershed management areas as presented in Table 1-2. Further information regarding the designated beneficial uses for the major receiving waters and land use within these watersheds, is presented in the project Work Plan (CSD-RT-10-URS18-01).

Table 1-2. Phase III Route Areas and Associated Watershed Management Areas

Route Area	Watershed Management Area
Miramar Area	Los Peñasquitos/Mission Bay and La Jolla
Clairemont Area	Mission Bay and La Jolla/San Diego River
Mission Valley Area	San Diego River/San Diego Bay
Tijuana River Area	San Diego Bay/Tijuana River

1.2 OBJECTIVE

The purpose of Phase III is to document and assess the effectiveness of the methods used during the street sweeping pilot study to answer the specific management questions developed for this project. Phase III assessed the following project-specific management questions:

Cost-efficiency:

- What is the relative cost-efficiency of integrating median sweeping into the City's overall street sweeping program?

Water Quality Benefits:

- What level and type of street debris may be removed by street sweeping in medians?

Logistical Constraints:

- What is the optimum sweeping frequency to maximize street debris removal in medians?
- What lessons learned from Phase I and II of the street sweeping optimization program can be identified?
- What are considerations for procedures to efficiently conduct a Phase IV, which would be a sweeping speed study, based on the lessons learned from Phases I, II, and III?

In addition to assessing the feasibility, potential water quality benefits, community impact, and cost effectiveness of this study, an evaluation of the data requirements for the study was also conducted. The evaluation was to assess whether this study was an effective BMP in reducing the pollutant load within the watersheds.

1.3 GENERAL SCOPE OF ACTIVITIES

This Median Sweeping Study, Phase III of the City's Targeted Aggressive Street Sweeping Pilot Program Report (Report) documents a general review of City reports, route maps, and other relevant information specific to median sweeping operations with respect to impacts on stormwater quality. This information was evaluated to assess the opportunities and constraints of proposed additions to the City's street sweeping program. The following methods were used to evaluate the information: desktop reviews, field reconnaissance of potential routes; interviews with the City Storm Water Department, Operations and Maintenance (O&M), Parking Enforcement, and other City staff; and a literature search to assess potential specialized equipment requirements. A literature review was also conducted in order to determine if similar studies have been undertaken in other areas, and if so, the outcomes of such studies.

In addition to the review of existing information, three main types of data collection activities were conducted for the study:

- Baseline Route Samples

  Samples were collected to provide the estimated historical accumulation of street sediment and pollutant load present in each of the four street sweeping routes. To establish a baseline sample, City staff performed sweeping of all four routes and street sediment samples were collected, composited, and sent to the laboratory for analysis. Baseline sample collection was performed February 26, 2010.

- Route Samples

  Samples were collected to assess the amount of street sediment and pollutant load present, and contaminants removed in each of the four respective median street sweeping routes during the sampling period. Composite street sediment samples were collected every three weeks from the four routes and analyzed. A total of 16 samples were collected during four events from March 9, 2010 through May 22, 2010.

- Hand Swept Route Samples

Samples were collected to provide the estimated amount of street sediment and pollutant load present on representative raised medians in each respective street sweeping route area during the sampling period. Hand swept street sediment sampling included manual collection of debris from 1 square yard of undisturbed area on an exposed raised median route. Hand swept sample collection was performed May 21, 2010.

Upon receipt of sampling results, data were reviewed and an assessment on the effectiveness of pollutant removal was conducted. The project results are presented in Section 4. The effectiveness assessment of Phase III of the City's Targeted Aggressive Street Sweeping Pilot Program is discussed in Section 5.

1.4 PROJECT ORGANIZATION AND RESPONSIBILITES

The project team for this project consists of staff representing the City, URS Corporation (URS), and MWH. The City Project Coordinator for this project is Clement Brown. The URS Task Order Manager is Bryn Evans. Sara Carroll served as the URS project lead overseeing coordination and assessment efforts. The MWH project lead was Christine Nancarrow.

1.5 DOCUMENT ORGANIZATION

This document is organized into the following sections:

Section 1 — *Introduction*: Summarizes the project background information including objectives, general scope of activities, study objectives, and project organization and responsibilities. This section describes the goals of Phase III for the City's Targeted Aggressive Street Sweeping Pilot Program and the methods and results of the effectiveness assessment.

Section 2 — *Site Characteristics*: Describes the routes selected within each watershed.

Section 3 — *Field Observations and Data Collection Methods*: Describes the monitoring methodology that was used to measure the effectiveness of the modifications to the street sweeping program. This section identifies the data that was collected to perform the effectiveness assessment and data analysis approach. This section also identifies the types of comparisons and procedures used to evaluate the effectiveness of the street sweeping program.

Section 4 — *Project Results*: Presents the results of the street sweeping data analysis.

Section 5 — *Project Effectiveness Assessment*: This section summarizes an effectiveness assessment for the street sweeping program regarding the potential water quality benefits of increased street sweeping frequency and inclusion of roadway medians and areas adjacent to high traffic thoroughfares.

Section 6 — *Summary*: Summarizes key components of the Phase III Median Sweeping Study.

Section 7 — *References*: Provides a summary of report references.

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SECTION 2 SITE CHARACTERISTICS

The project area identified for Phase III covers the jurisdictional area of the City's existing street sweeping programs. Currently, the City actively sweeps over 2,700 miles of traffic lanes. A review of existing City street sweeping route data was conducted in order to identify suitable median routes. Based on the efficient use of O&M staff resources, siting and other criteria discussed in the project Work Plan (CSD-RT-10-URS18-01), four representative median routes were chosen for Phase III. Table 2-1 summarizes the chosen median sweeping routes. The Phase III median routes are geographically identified on Figure 2-1 along with adjacent existing sweeping routes for the City.

A description of each median route project area is discussed in the subsequent sections of this Report.

Table 2-1. Phase III Median Sweeping Routes

Route	Watershed Management Area	Location	Description
Route 1-Miramar Area	Los Peñasquitos/ Mission Bay and La Jolla	Sorrento Valley/ Mira Mesa/ Miramar	Miramar Road and La Jolla Village Dr.
Route 2-Clairemont Area	Mission Bay and La Jolla/San Diego River	Bay Park/ Clairemont Mesa	Genesee Avenue, Clairemont Mesa Boulevard, and Morena Boulevard.
Route 3-Mission Valley Area	San Diego River/ San Diego Bay	Mission Valley Area	Friars Road, Mission Gorge Road, Montezuma Road.
Route 4-Tijuana River Area	San Diego Bay/Tijuana River	Imperial Beach/ San Ysidro	Beyer Boulevard, Coronado Avenue, and Palm Avenue.

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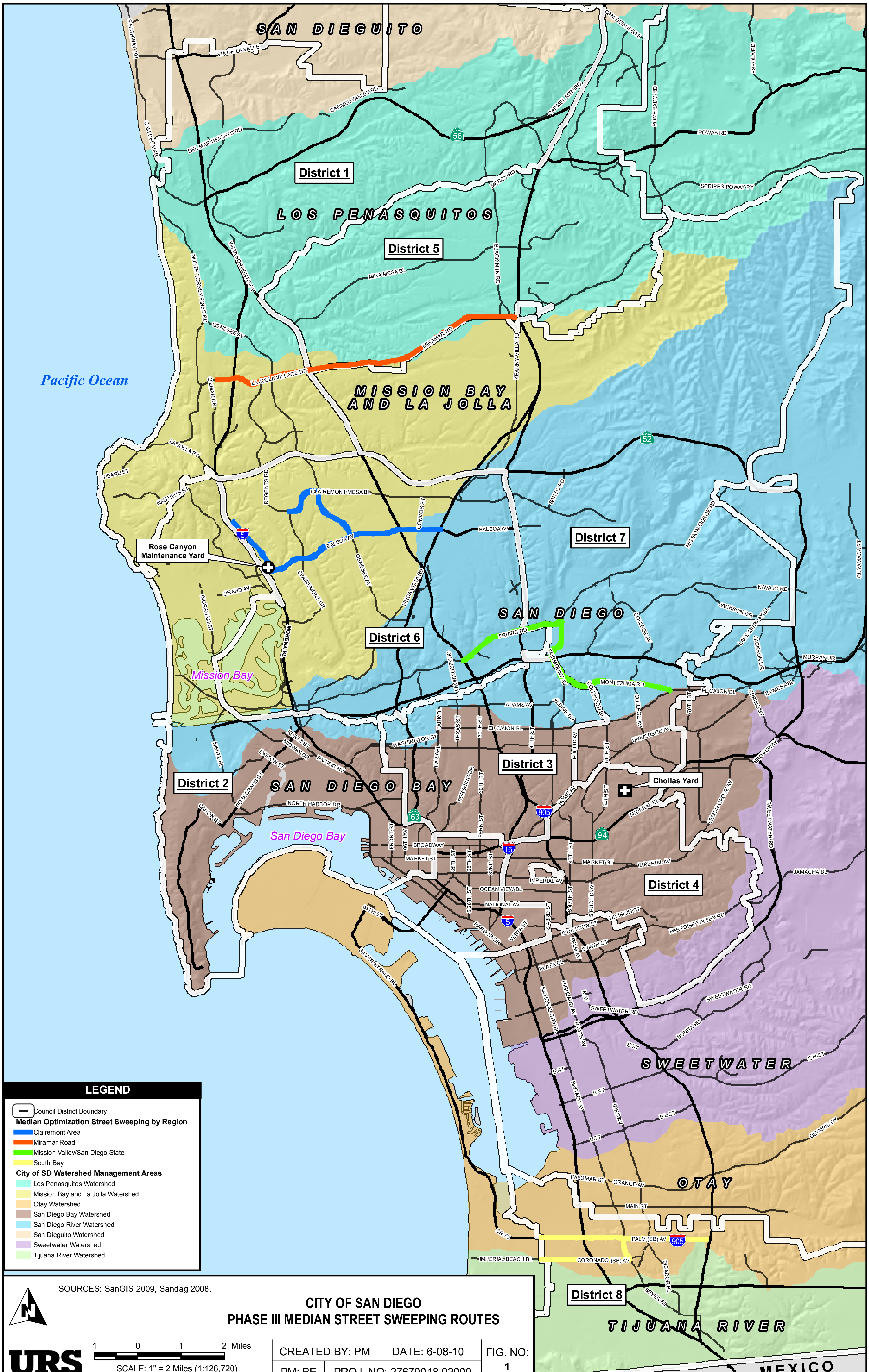

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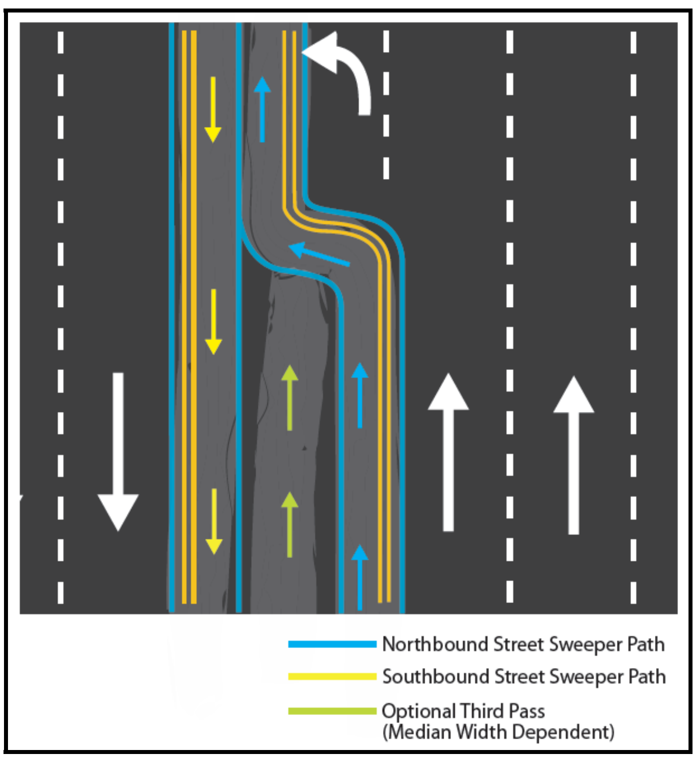
2.1 STREET SWEEPING ROUTE SPECIFIC INFORMATION

To conduct representative median sampling throughout the City's jurisdiction and watershed areas, a global positioning system (GPS) analysis of currently swept City streets was conducted to document higher traffic volume routes configured with either a raised or painted median. Field teams were sent into the field with a GPS unit in which they drove each route and mapped the land use, median type and length. The information was then taken and downloaded into geographical information system (GIS). Figure 2-4, Figure 2-6, Figure 2-8 and Figure 2-10 are representative of the types of medians found on each of the routes.

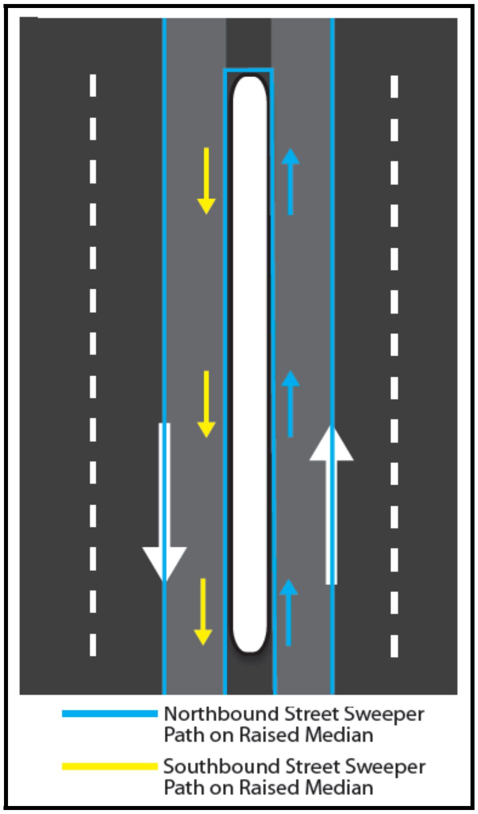
Observed median configurations were documented as barrier, raised or painted. Barrier medians generally consist of a physical barrier along the center of a street through an intersection which prohibits left turns and through traffic from the intersecting street (ITE, 2000). Raised medians often include a curb and gutter configuration surrounding pavement (referred to as 'raised no vegetation') or grass, trees, or other material (raised vegetation). Painted medians include medians defined by yellow lines on both sides as well as breaks in the yellow lines for turning lanes. Depending on the width of the painted median, the median area may have required several sweeper passes to fully sweep the median area. As indicated in Figure 2-2, the median area, referred to as 'painted skinny', was swept just over the yellow line on both edges of the median (yellow and blue arrows in Figure 2-2), and in instances of wider medians, referred to as 'painted wide', an additional pass through the middle of the median (green arrow in Figure 2-2) was conducted. Phase III utilized mechanical sweeping machines for the barrier, painted medians, and curb and gutter sweeping along the edges of raised medians.

Figure 2-2. Painted Median Sweeping Pattern



Areas with raised medians were swept along the curb and gutter in order to capture any street debris along the street level edges of the median (Figure 2-3). This street level area along the curb of the raised median is where pollutants tend to collect along roadways and where stormwater runoff from the street is conveyed.

Figure 2-3. Raised Median Sweeping Pattern



Observed land uses in this study were documented as residential, commercial/office, industrial, parks and recreation, public facilities and utilities, and roadways and transportation. A Nationwide Urban Runoff Program (NURP) study conducted by the Environmental Protection Agency (EPA) from 1978 to 1983 evaluated the characteristics of urban runoff including the similarities or differences among urban land uses (USEPA, 1983). Although the NURP study did not indicate statistically significant differences in pollutant concentrations from different land uses (i.e., residential, commercial, and mixed), the data did show a significant difference between urban and non-urban sites as shown in Table 2-2. The routes selected for Phase III were all in urban settings.

Table 2-2. Environmental Protection Agency Stormwater Pollutant Concentrations

Pollutant	Units	Residential		Mixed		Commercial		Open Space/ Non-urban	
		Statistical Median	CV	Statistical Median	CV	Statistical Median	CV	Statistical Median	CV
Total Lead	ug/L	144	0.75	114	1.35	104	0.68	30	1.52
Total Copper	ug/L	33	0.99	27	1.32	29	0.81	-	-
Total Zinc	ug/L	135	0.84	154	0.78	226	1.07	195	0.66
TKN	ug/L	1,900	0.73	1,288	0.50	1,179	0.43	965	1.00
Nitrate + Nitrite	ug/L	736	0.83	558	0.67	572	0.48	543	0.91
Total Phosphorus	ug/L	383	0.69	263	0.75	201	0.67	121	1.66

Notes/abbreviations:

CV = Coefficient of variation = standard deviation/mean; TKN = total Kjeldahl nitrogen = organic nitrogen + ammonia nitrogen, - = insufficient data.

Source: USEPA, 1983.

2.1.1 Miramar Area Median Sweeping Route (Route 1)

The Miramar Area (Miramar Road and La Jolla Village Drive) Median Sweeping Route (Route 1) is located within the Los Peñasquitos, Mission Bay and La Jolla WMAs. Specific watershed characteristics and beneficial uses are presented in the Work Plan (CSD-RT-10-URS18-01). Route 1 is 14.6 miles in length covering both sides of the median. Table 2-3 represents the median designations that were found along the route. Raised non-vegetated medians comprise the highest percentage median type located along the route. Table 2-4 describes the type of land uses that are along Route 1.

Table 2-3. Route 1 Median Designation

Median Type	Length of Route (miles)[1]	Percent (%) of Route
Barrier	0.552	7.6
Intersection	0.427	5.8
Painted Skinny	0.458	6.3
Painted Wide	2.170	29.7
Raised Non-Vegetated	3.131	42.9
Raised Vegetated	0.561	7.7

Notes:

[1] Length of the route is one way.

Table 2-4. Route 1 Estimated Land Use

Land Use[1]	Percent (%) of Route
Residential	8
Commercial and Office	34
Industrial	7
Parks and Recreation	28
Public Facilities and Utilities	6
Agriculture	0
Roadways and Transportation	10
Vacant and Undeveloped	7

Notes:
[1] Route is calculated as a total of 14.6 miles in length. Estimations were made as to the land use that exists along the route.


OVERVIEW MAP
San Diego County
City of San Diego Boundary
Map Extent
MIRAMAR ROAD
MIRA MESA BL
BLACK MTN RD
POMERADO RD
MIRAMAR RD
LA JOLLA VILLAGE DR
GENESEE AV
GOVERNOR DR
REGENTS RD
LA JOLLA COLONY DR
GILMAN DR
5
805
15
52
RAISED MEDIAN STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path on Raised Median
Southbound Street Sweeper Path on Raised Median
DOUBLE YELLOW LINE STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path
Southbound Street Sweeper Path
Optional Third Pass (Median Width Dependent)
LEGEND
Median Type
Barrier
Painted Skinny
Painted Wide
Raised No Veg
Raised Veg
SOURCES: SanGIS 2009, RWQCB 2006
SANDAG 2008
CITY OF SAN DIEGO
MEDIAN STREET SWEEPING ROUTE
MIRAMAR ROAD (7.3 MILES)
URS
750 0 750 1500 2250 Feet
SCALE: 1" = 1250' (1:15,000)
SCALE CORRECT WHEN PRINTED AT 22X34
CREATED BY: PM
DATE: 6-07-10
PM: BE
PROJ. NO: 27679018.00000
FIG. NO: 2

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OVERVIEW MAP
San Diego County
City of San Diego Boundary
Map Extent
MIRAMAR ROAD
LA JOLLA VILLAGE DR
MIRAMAR RD
POMERADO RD
MIRA MESA BL
BLACK MTN RD
KEARNY VILLA RD
GENESEE AV
GOVERNOR DR
REGENTS RD
LA JOLLA COLONY DR
GILMAN DR
5
805
15
52
RAISED MEDIAN STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path on Raised Median
Southbound Street Sweeper Path on Raised Median
DOUBLE YELLOW LINE STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path
Southbound Street Sweeper Path
Optional Third Pass (Median Width Dependent)
LEGEND
Median Street Sweeping Route
Landuse
Residential
Commercial and Office
Industrial
Parks and Recreation
Public Facilities and Utilities
Agriculture
Roadways and Transportation
Vacant and Undeveloped
SOURCES: SanGIS 2009, RWQCB 2006
SANDAG 2008
CITY OF SAN DIEGO
MEDIAN STREET SWEEPING ROUTE WITH LANDUSE
MIRAMAR ROAD (7.3 MILES)
URS
750 0 750 1500 2250 Feet
SCALE: 1" = 1250' (1:15,000)
SCALE CORRECT WHEN PRINTED AT 22X34
CREATED BY: PM
DATE: 6-07-10
PM: BE
PROJ. NO: 27679018.00000
FIG. NO: 3

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2.1.2 Clairemont Area Median Sweeping Route (Route 2)

The Clairemont Area (Balboa Avenue, Genesee Avenue, Morena Boulevard, and Clairemont Mesa Boulevard) Median Sweeping Route (Route 2) is located primarily within the Mission Bay and La Jolla WMA. Specific watershed characteristics and beneficial uses are presented in the Work Plan (CSD-RT-10-URS18-01). Route 2 is 15.9 miles in length covering both sides of the median. Table 2-5 represents the median designations that are found along the route. Raised non-vegetated medians comprise the highest percentage median type located along the route. Table 2-6 describes the type of land uses that exist along Route 2.

Table 2-5. Route 2 Median Designation

Median Type	Length of Route (mile)[1]	Percent (%) of Route
Barrier	1.267	15.9
Intersection	0.442	5.6
Painted Skinny	0.724	9.1
Painted Wide	1.864	23.4
Raised Non-Vegetated	2.744	34.5
Raised Vegetated	0.914	11.5

Notes:
[1] Length of the route is one way.

Table 2-6. Route 2 Estimated Land Use

Land Use[1]	Percent (%) of Route
Residential	71
Commercial and Office	11
Industrial	0
Parks and Recreation	4
Public Facilities and Utilities	4
Agriculture	0
Roadways and Transportation	9
Vacant and Undeveloped	1

Notes:
[1] Route is calculated as a total of 15.9 miles in length. Estimations were made as to the land use that exists along the route.

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OVERVIEW MAP
San Diego County
City of San Diego Boundary
Map Extent
RAISED MEDIAN STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path on Raised Median
Southbound Street Sweeper Path on Raised Median
DOUBLE YELLOW LINE STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path
Southbound Street Sweeper Path
Optional Third Pass (Median Width Dependent)
CLAIREMONT MESA BLVD
GENESSEE AVENUE
MORENA BLVD
BALBOA AVENUE
Mission Bay
LEGEND
Median Type
Barrier
Painted Skinny
Painted Wide
Raised No Veg
Raised Veg
SOURCES: SanGIS 2009, RWQCB 2006
SANDAG 2008
CITY OF SAN DIEGO
MEDIAN STREET SWEEPING ROUTE
CLAIREMONT AREA (7.95 MILES)
750 0 750 1500 2250 Feet
SCALE: 1" = 1250' (1:15,000)
SCALE CORRECT WHEN PRINTED AT 22X34
URS
CREATED BY: PM
DATE: 6-07-10
PM: BE
PROJ. NO: 27679018.00000
FIG. NO: 4

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OVERVIEW MAP
San Diego County
City of San Diego Boundary
Map Extent
RAISED MEDIAN STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path on Raised Median
Southbound Street Sweeper Path on Raised Median
DOUBLE YELLOW LINE STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path
Southbound Street Sweeper Path
Optional Third Pass (Median Width Dependent)
CLAIREMONT MESA BLVD
GENESSEE AVENUE
MORENA BLVD
BALBOA AVENUE
Mission Bay
LEGEND
Median Street Sweeping Route
Landuse
Residential
Commercial and Office
Industrial
Parks and Recreation
Public Facilities and Utilities
Agriculture
Roadways and Transportation
Vacant and Undeveloped
SOURCES: SanGIS 2009, RWQCB 2006
SANDAG 2008
CITY OF SAN DIEGO
MEDIAN STREET SWEEPING ROUTE WITH LANDUSE
CLAIREMONT AREA (7.95 MILES)
URS
750 0 750 1500 2250 Feet
SCALE: 1" = 1250' (1:15,000)
SCALE CORRECT WHEN PRINTED AT 22X34
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DATE: 6-07-10
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FIG. NO: 5

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2.1.3 Mission Valley Area Median Sweeping Route (Route 3)

The Mission Valley Area (Montezuma Road, Fairmont Avenue, and Friars Road) Median Sweeping Route (Route 3) is located primarily within the San Diego River WMA. Specific watershed characteristics and beneficial uses are presented in the Work Plan (CSD-RT-10-URS18-01). Route 3 is 14.4 miles in length covering both sides of the median. Table 2-7 represents the median designations that are found along the route. Raised non-vegetated medians comprise the highest percentage of median type that is located along the route. Table 2-8 describes the type of land uses that occur along Route 3.

Table 2-7. Route 3 Median Designation

Median Type	Length of Route (mile)[1]	Percent (%) of Route
Barrier	1.067	15.3
Intersection	0.441	6.3
Painted Barrier	0.010	0.2
Painted No Median	0.452	6.5
Painted Skinny	0.453	6.5
Painted Vegetated	0.127	1.8
Painted Wide	1.312	18.7
Raised Mixed	0.132	1.9
Raised Non-Vegetated	2.694	38.5
Raised Vegetated	0.310	4.3

Notes:
[1] Length of the route is one way.

Table 2-8. Route 3 Estimated Land Use

Land Use[1]	Percent (%) of Route
Residential	24
Commercial and Office	18
Industrial	1
Parks and Recreation	30
Public Facilities and Utilities	12
Agriculture	0
Roadways and Transportation	7
Vacant and Undeveloped	8

Notes:
[1] Route is calculated as a total of 14.4 miles in length. Estimations were made as to the land use that exists along the route.

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CITY OF SAN DIEGO
MEDIAN STREET SWEEPING ROUTE
MISSION VALLEY AREA (7.22 MILES)
SOURCES: SanGIS 2009, RWQCB 2006
SANDAG 2008
URS
750 0 750 1500 2250 Feet
SCALE: 1" = 1250' (1:15,000)
SCALE CORRECT WHEN PRINTED AT 22X34
CREATED BY: PM
DATE: 6-07-10
PM: BE
PROJ. NO: 27679018.00000
FIG. NO:
6
OVERVIEW MAP
San Diego County
City of San Diego Boundary
Map Extent
LEGEND
Median Type
Undetermined
Barrier
Painted No Median
Painted Skinny
Painted Veg
Painted Wide
Raised Mixed
Raised No Veg
Raised Veg
City of San Diego Boundary
FRIARS ROAD
MISSION GORGE ROAD
MONTEZUMA ROAD
Chollas Yard
RAISED MEDIAN STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path on Raised Median
Southbound Street Sweeper Path on Raised Median
DOUBLE YELLOW LINE STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path
Southbound Street Sweeper Path
Optional Third Pass (Median Width Dependent)
163
8
805
15
FRIARS RD
MONTEZUMA RD
EL CAJON BL
ADAMS AV
UNIVERSITY AV
COLLEGE AV
FAIRMOUNT AV
EUCLID AV
MISSION CENTER RD
QUALCOMM WY
PARK BL
30TH ST
40TH ST
43RD ST
54TH ST
70TH ST
WARING RD
NAVAJO RD
LAKE MURRAY BL
SAN DIEGO RIVER

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CITY OF SAN DIEGO
MEDIAN STREET SWEEPING ROUTE WITH LANDUSE
MISSION VALLEY AREA (7.22 MILES)

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PM: BE | PROJ. NO: 27679018.00000

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2.1.4 Tijuana River Area Median Sweeping Route (Route 4)

The Tijuana River Area (Palm Avenue, Beyer Boulevard, and Coronado Avenue) Median Sweeping Route (Route 4) is located primarily within the San Diego Bay WMA. A goal for the Phase III study was to include a route in the Tijuana River WMA. However the street configuration in the Tijuana River WMA did not contain a high enough density of median areas to meet other study parameters. Specific watershed characteristics and beneficial uses are presented in the Work Plan (CSD-RT-10-URS18-01). Route 4 is 12.8 miles in length covering both sides of the median. Table 2-9 represents the median designations that are found along the route. Painted wide medians comprise the highest percentage median type that is located along the route. Table 2-10 describes the type of land uses that occur along Route 4.

Table 2-9. Route 4 Median Designation

Median Type	Length of Route (mile)[1]	Percent (%) of Route
Barrier	0.074	1.2
Intersection	0.388	6.1
Painted No Median	0.290	4.5
Painted Skinny	0.096	1.5
Painted Wide	2.893	45.3
Raised Mixed	0.819	12.8
Raised Mixed Railroad Intersection	0.031	0.5
Raised Mixed Vegetated Fence	0.238	3.7
Raised Non-Vegetated	1.556	24.4

Notes:
[1] Length of the route is one way.

Table 2-10. Route 4 Estimated Land Use

Land Use[1]	Percent (%) of Route
Residential	72
Commercial and Office	12
Industrial	0
Parks and Recreation	2
Public Facilities and Utilities	3
Agriculture	0
Roadways and Transportation	11
Vacant and Undeveloped	0

Notes:
[1] Route is calculated as a total of 12.8 miles in length. Estimations were made as to the land use that exists along the route.

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OVERVIEW MAP
San Diego County
City of San Diego Boundary
Map Extent
PALM AVENUE
BEYER BLVD
CORONADO AVENUE
PALM (SB) AV
CORONADO (SB) AV
IMPERIAL BEACH BL
MAIN ST
PALOMAR ST
ORANGE AV
E ORANGE AV
BROADWAY
BEYER WY
PICADOR BL
TOCAYO AV
SMYTHE AV
BEYER BL
EAST BEYER BL
SR-75
5
805
905
OTAY RIVER
TIJUANA RIVER
MEXICO
RAISED MEDIAN STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path on Raised Median
Southbound Street Sweeper Path on Raised Median
DOUBLE YELLOW LINE STREET SWEEPER EXAMPLE
Northbound Street Sweeper Path
Southbound Street Sweeper Path
Optional Third Pass (Median Width Dependent)
LEGEND
City of San Diego Boundary
Median Type
Undetermined
Barrier
Painted No Median
Painted Skinny
Painted Veg
Painted Wide
Raised Mixed
Raised No Veg
Raised Veg
SOURCES: SanGIS 2009, RWQCB 2006
SANDAG 2008
CITY OF SAN DIEGO
MEDIAN STREET SWEEPING ROUTE
TIJUANA RIVER VALLEY AREA (6.4 MILES)
URS
750 0 750 1500 2250 Feet
SCALE: 1" = 1250' (1:15,000)
SCALE CORRECT WHEN PRINTED AT 22X34
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PROJ. NO: 27679018.00000
FIG. NO: 8

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SOURCES: SanGIS 2009, RWQCB 2006
SANDAG 2008

CITY OF SAN DIEGO
MEDIAN STREET SWEEPING ROUTE WITH LANDUSE
TIJUANA RIVER VALLEY AREA (6.4 MILES)

URS

750 0 750 1500 2250 Feet
SCALE: 1" = 1250' (1:15,000)
SCALE CORRECT WHEN PRINTED AT 22X34

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SECTION 3 FIELD OBSERVATION AND DATA COLLECTION METHODS

This section describes the field observation and data collection methods that were performed in the field. Field observations include the methods that were utilized by the field teams while collecting samples, the Health and Safety Plan that was followed, and the preparation of field data sheets for every sample collected. Data collection describes the techniques used to collect samples, the constituents that were tested, and the Quality Assurance/Quality Control (QA/QC) performed by the laboratory. Sampling events included the collection of 6 composite samples per site using the "Clean Hands/Dirty Hands" sampling technique.

3.1 HEALTH AND SAFETY

The monitoring program utilized for this study required careful consideration of health and safety. The project area is located within a highly urbanized section of the watershed and there are numerous areas where natural and anthropogenic hazards provided the potential for injury. Field teams were required to wear the proper personal protective equipment during sampling events. This included, but was not limited to: Nitrile gloves, safety glasses, steel-toe boots, and dust masks. Field teams were also provided various forms of sanitary solutions to thoroughly clean their hands once sampling was complete. The Health and Safety Plan (HSP) for this project is documented within the Work Plan (CSD-RT-10-URS18-01), and was adhered to throughout the course of the study.

3.2 SWEEPER STREET DEBRIS COLLECTION

Mechanical broom sweepers were used to conduct street sweeping operations once every three weeks along each of the four study routes. Sweeping operations consisted of sweeping median areas on each side of the roadway. Street sweepers were operated at 6 to 12 miles per hour. Broom miles swept ranged from 11 to 22 miles per route, which includes the sweeper collecting up to two pilot routes per night.

After sweeping a route, the City sweeper operator would empty collected sweeper street debris into designated bins at a City operations yards. Route 1 and 2 sweepers emptied at the City Rose Canyon Operation Yard and the Route 3 and 4 sweepers emptied street debris at the City Chollas Operation Yard as shown in Table 3-1.

Table 3-1. Sample Collection Events

Event Disposal Location	Collection Events
Chollas Operation Yard	2/26/2010 3/20/2010 4/10/2010 5/1/2010 5/22/2010
Rose Canyon Operation Yard	2/26/2010 3/20/2010 4/10/2010 5/1/2010 5/22/2010

The loaded weight and tare weight of each bin were recorded during street debris disposal to determine the mass of street debris collected (Appendix D). Composite samples were collected by URS field personnel from each of the four bins the Saturday morning following the conclusion of sweeper operations. A total of 24 street debris composite samples were collected during field activities. The following sections describe procedures that were utilized in the collection of those samples, including where and when the samples were collected, how composite samples were produced, and sample collection methods.

Sample handling and designation procedures are included to provide project-specific QA/QC measures. In addition to the above, the following sub-sections describe project-specific QA/QC procedures.

3.3 GRAB SAMPLING AND FIELD OBSERVATIONS

This section describes the sample methods and field observations for the street debris samples and the hand swept samples.

3.3.1 Street Debris Sample Methods

Field teams collected grab samples once every three weeks from the Chollas Operations yard and the Rose Canyon Operations yard. Field teams followed the protocol outlined in the Work Plan (CSD-RT-10-URS18-01). Each street sweeping collection was placed in a dumpster that was labeled by the City with the route posted on the front of the dumpster. Field teams collected six grab samples from each bin containing each route's collected street debris, taking samples from all four corners of the waste piles and two samples from the middle. Samples were collected and sifted to remove gross solids (i.e., litter, leaves, etc) by using a No.4 sieve per the stormwater-borne solids classification protocol developed by the Water Environmental Research Foundation and according to the American Society of Civil Engineers nomenclature. Street sediment samples were collected into jars provided by the laboratory, labeled and shipped to the lab via FedEx for analysis.

Street sweeping was conducted on Friday nights, and sampling activities were conducted every Saturday morning following the Friday evening collection. Field observations were documented in the field data sheets (Appendix C). The first entry at the beginning of each sheet includes the date and time, field personnel on site, and location. Additional information recorded on the sheets includes:

- Sampling methods and field equipment used.
- Number of samples collected.
- Sample Identification.
- Volume of sample collected.
- Number of samples collected in each composite sample.
- Additional sampling observations including: sieved street debris noted, street debris volume, and any QA/QC samples collected.

3.3.2 Hand Swept Samples

The purpose of the hand swept sample collection was to provide a preliminary estimate of the relative pollutant concentration of the accumulated trash, litter and course- and fine-grained particulates present on raised median surfaces. Given significant logistical challenges prevent the use of traditional street sweeping machine technology to sweep raised median areas (e.g. few access points for machines to access raised curb areas, limited space for machine maneuvering, and numerous potential obstacles), alternative manual sweeping methods were utilized for the sample collection. While it is recognized that the results of the hand swept sample collection provide a preliminary estimate of the relative pollutant load present on raised median surfaces that may be compared to street debris sample data, the application of these data to current street sweeping operational practices may be limited.

Hand swept samples were collected by a field team manually sweeping one square yard of median using clean brooms and dustpans. Sediment samples were collected in a bucket and filtered through a No.4 sieve. The composited sediment samples were collected in jars and submitted to the lab for analysis.

3.4 STREET SEDIMENT SAMPLE COMPOSITING PROCEDURES

Four baseline and sixteen representative street sediment composite samples were collected over the study period once every three weeks beginning on February 26, 2010 and ending May 22, 2010. All street sediment samples were collected with a decontaminated, stainless steel post hole digger, sieved with a No. 4 sieve and contained in a bucket. A representative composite sweeper sample is comprised of six grab samples that were collected from a route specific bin, one from each corner and two from the middle, which were then sieved with a No. 4 sieve and combined. Samples were then composited in a bucket for sample collection. Large particles, leaves and trash were recorded and then returned to the bin. Hand swept street sediment samples were collected using a manual sweeping technique. Field teams were instructed to visit each route and sample a square yard of median. Field teams swept all the street debris into a No. 4 sieve, then compositing the street sediment into two jars. All representative street sediment samples collected were sent to the lab to perform the same analysis as the composited samples collected from the street sweeping routes.

To prevent potential sample contamination, grab samples were collected and composited using the "Clean Hands/Dirty Hands" sampling technique. This technique consists of two-person sampling teams where one individual ("clean hands") is responsible for all actions involving direct contact with the sample bottle and transfer of the sample from the collection device to the sample bottle. The second individual ("dirty hands") is responsible for all sampling activities that do not involve direct contact with the sample, such as operation of the sample collection device.

Once collected, street sediment samples were transferred to Pat-Chem Laboratories in Moorpark, CA for analysis. Samples were analyzed for the constituents listed in Table 3-2.

Table 3-2. Analytical Constituents

Analyte	Analytical Procedure	Reporting Limits"	Units
% Solids	% calculation	0.1	%
Metals			
Aluminum	EPA 6010B	5	mg/kg
Antimony	EPA 6010B	1	mg/kg
Arsenic	EPA 6010B	1	mg/kg
Barium	EPA 6010B	1	mg/kg
Beryllium	EPA 6010B	1	mg/kg
Cadmium	EPA 6010B	1	mg/kg
Chromium	EPA 6010B	1	mg/kg
Cobalt	EPA 6010B	1	mg/kg
Copper	EPA 6010B	1	mg/kg
Iron	EPA 6010B	1	mg/kg
Lead	EPA 6010B	1	mg/kg
Manganese	EPA 6010B	1	mg/kg
Mercury	EPA 7471A	0.05	mg/kg
Molybdenum	EPA 6010B	1	mg/kg
Nickel	EPA 6010B	1	mg/kg
Selenium	EPA 6010B	1	mg/kg
Silver	EPA 6010B	1	mg/kg
Thallium	EPA 6010B	1	mg/kg
Tin	EPA 6010B	5	mg/kg
Titanium	EPA 6010B	1	mg/kg
Vanadium	EPA 6010B	1	mg/kg
Zinc	EPA 6010B	1	mg/kg

Analyte	Analytical Procedure	Reporting Limits"	Units
General Chemistry			
Ammonia as N	SM 4500-NH3 G	0.5	mg/kg
Nitrate as N	EPA 353.2	0.5	mg/kg
Nitrite as N	EPA 353.2	0.5	mg/kg
Phosphorus, Total as P	EPA 365.4	1	mg/kg
Total Kjeldahl Nitrogen	EPA 351.2	1	mg/kg
Pesticides			
1,2-Dibromoethane (EDB)	EPA 8260B	0.1	ug/kg
1,2-Dichloroethane	EPA 8260B	0.1	ug/kg
Allethrin	EPA 8081A	2	ug/kg
Asana (Esfenvalerate)	EPA 8081A	2	ug/kg
Atrazine	EPA 8141	50	ug/kg
Azinphos methyl	EPA 8141	50	ug/kg
Bifenthrin	EPA 8081A	2	ug/kg
Bioresmethrin	EPA 8081A	2	ug/kg
Bolstar	EPA 8141	50	ug/kg
Chlorpyrifos	EPA 8141	50	ug/kg
cis-Permethrin	EPA 8081A	2	ug/kg
Coumaphos	EPA 8141	50	ug/kg
Cyfluthrin	EPA 8081A	2	ug/kg
Cyhalothrin	EPA 8081A	2	ug/kg
Cypermethrin	EPA 8081A	2	ug/kg
Deltamethrin	EPA 8081A	2	ug/kg
Demeton-o	EPA 8141	50	ug/kg
Demeton-s	EPA 8141	50	ug/kg
Diazinon	EPA 8141	50	ug/kg
Dichlorvos	EPA 8141	50	ug/kg
Disulfoton	EPA 8141	50	ug/kg
EPN	EPA 8141	50	ug/kg
Ethoprop	EPA 8141	50	ug/kg
Fenpropathrin	EPA 8081A	2	ug/kg
Fensulfothion	EPA 8141	50	ug/kg
Fenthion	EPA 8141	50	ug/kg

Analyte	Analytical Procedure	Reporting Limits"	Units
Fluvalinate	EPA 8081A	2	ug/kg
Malathion	EPA 8141	50	ug/kg
Merphos	EPA 8141	50	ug/kg
Methyl parathion	EPA 8141	50	ug/kg
Mevinphos	EPA 8141	50	ug/kg
Naled	EPA 8141	50	ug/kg
Parathion	EPA 8141	50	ug/kg
Phorate	EPA 8141	50	ug/kg
Prallethrin	EPA 8081A	2	ug/kg
Ronnel	EPA 8141	50	ug/kg
Sanmarton (Fenvalerate)	EPA 8081A	2	ug/kg
Simazine	EPA 8141	50	ug/kg
Stirophos	EPA 8141	50	ug/kg
Strontium	EPA 6010B	1	mg/kg
Sulfotep	EPA 8141	50	ug/kg
TEPP	EPA 8141	50	ug/kg
Tert-amyl methyl ether	EPA 8260B	0.1	ug/kg
Tert-butyl alcohol	EPA 8260B	0.4	ug/kg
Tokuthion (Prothiofos)	EPA 8141	50	ug/kg
trans-Permethrin	EPA 8081A	2	ug/kg
Trichloronate	EPA 8141	50	ug/kg
Hydrocarbons			
Benzene	EPA 8260B	0.1	ug/kg
Diesel	EPA 8015DRO	2.5	mg/kg
Di-isopropyl ether	EPA 8260B	0.1	ug/kg
Dimethoate	EPA 8141	50	ug/kg
Ethyl tert-butyl ether	EPA 8260B	0.1	ug/kg
Ethylbenzene	EPA 8260B	0.1	ug/kg
Gasoline	EPA 8015M	0.05	mg/kg
Methyl tert-butyl ether	EPA 8260B	0.1	ug/kg
m,p-Xylene	EPA 8260B	0.1	ug/kg
Oil & Grease (HEM)	EPA 1664	50	mg/kg
o-Xylene	EPA 8260B	0.1	ug/kg
Toluene	EPA 8260B	0.1	ug/kg

3.4.1 Quality Control Sampling

Field and laboratory QA/QC samples were required to assess performance of the project team in the collection and analysis of street debris samples. Field QA/QC sampling consisted of the collection of field blank samples prior to sample collection at a subset of the sampling events. The field blank sample consisted of a sample jar filled with glass beads that was provided by the lab. Field blanks were taken to each sample location, labeled, and shipped to the lab for analysis. Field blank samples were collected on April 10, 2010 and May 22, 2010.

3.4.2 Sample Containers and Preservation

The analytical lab provided certified clean, 8 ounce, sample collection containers. Sample container quality protocols were strictly enforced and assured by the laboratory. The laboratory will retain certificates of analyses for a period of at least 5 years. Sample containers were kept closed until used and only handled by the "clean hands" individual of the collection team.

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SECTION 4 PROJECT RESULTS

The following section presents the project results for median sample collection and activities associated with the Phase III assessment monitoring events. The Phase III baseline, street sediment composite and hand-swept sampling results were evaluated in a two step process. First, a literature review of 19 selected articles, studies and documents discussing various aspects of street sediment removal on public roadways was conducted. Various components of each study were reviewed, including sweeper types, frequency of sweeping, environmental media collected, constituents analyzed, and baseline sample collection. The purpose of the literature review was to provide a basis of comparison for the Phase III analytical results, data presentation structure and data assessment methodology. The data assessment methodology described in the literature review was then used to conduct the second step, a determination of the effectiveness of the street debris removal and pollutant load reduction directly associated with Phase III, as presented in Section 5. The Literature Review is provided in Appendix B. All analytical data is provided in Appendix F.

4.1 KEY FINDINGS FROM LITERATURE REVIEW

The selected literature focused on national, regional and local projects with street sweeping pilot or project data found to be comparable to previous and current activities completed by the City. Reviewed literature included topics such as the efficiency of available motorized street sweeping equipment, adequacy of street debris removal, effects of sweeping activities on street debris contaminant load, and potential water quality benefits including reduction in metals loading, as a result of routine sweeping.

Key findings that correlate to the results of Phase III are included in this section. Findings that offer insights into the interpretation of data collected in this study and present considerations for future pilot studies and other potential implementation efforts are discussed in Sections 5 and 6, respectively.

Common findings from the literature that relate to the City Targeted Aggressive Street Sweeping Program include:

- As stormwater permitting and regulations are likely to become more stringent, street sweeping is considered a cost effective non-point source pollutant control method.
- Bi-weekly to monthly sweeping frequencies have been shown to be a cost effective approach in some studies. In general, debris removal effectiveness increases with increasing sweeping frequency. Sweeping weekly or every other week is most effective in reducing the amount of sediment and associated constituents on city streets; however, the specific operating costs for the sweeping operations can vary due to a variety of factors. Accordingly, the specific frequency at which sweeping operations most effectively remove pollutants in a given area will depend on numerous site-specific pollutant loading, operational costs, and other factors.
- Street sweeping has the potential to be more cost effective at pollutant removal than either catch basin cleaning or treatment of stormwater discharges.
- Regenerative air sweepers and vacuum-assisted sweepers are consistently more efficient than mechanical broom sweepers.

- High efficiency sweepers are more effective than others at picking up fine particulate matter (PM-10 particulates). High efficiency sweepers use a combination of a mechanical and vacuum action that is able to dislodge settled debris and remove it by vacuuming it from the pavement. This removes more debris than sweepers with only broom action.
- Trace metal concentrations are generally greatest on fine-grained particles. However, coarse-grained particles generally account for the greatest mass of trace metals due to the greater total mass of coarse-grained particles in debris collected by mechanical and vacuum type sweepers.
- High efficiency sweeping with annual catch basin cleaning was found to be the most efficient sweeping-BMP combination.
- Knowledge of baseline (pre-sweeping) and post-sweeping conditions is critical to accurately compare results of sweeper efficiency testing programs.

4.2 ANALYTICAL RESULTS

This section presents the analytical results for street sediment samples collected during Phase III.

4.2.1 Metals

Metals are of concern with regards to stormwater pollution due to their relative solubility in natural waters, affinity for complexation with humic substances, and potentially toxic effects on bioaccumulation in biota and aquatic organisms (Driscoll, 1994). Typically, copper, zinc, cadmium, and lead are the primary metals monitored because they are generally detected at elevated concentrations in most urban roadway runoff locations, and they display similar transport characteristics to other metals (Driscoll, 1994; Strecker, 1994). Common sources of metals in street sediment pollution include: brake pads (copper and lead), vehicle tires (zinc and cadmium), and paints (copper and lead) (Sansalone et al, 1997).

Several local monitoring efforts in San Diego were investigated to determine which metals should be evaluated during Phase III. Consistency with other local efforts such as regional monitoring programs and TMDLs were considered to be an important factor in determining the constituents that would provide the most meaningful basis for evaluation.

In its 2009 Baseline Effectiveness Assessment Monitoring Report (Weston, 2009), the City evaluated the effectiveness of three different BMPs. In all cases, analysis for metals, pesticides and bacteria levels were conducted as part of the evaluation of BMP effectiveness. The metals analysis for this study included monitoring for copper, lead and zinc. The findings may be used for planning future phases of the City street sweeping program to more cost effectively comply with the NPDES permit as well other regulatory action related to water quality improvement such as TMDLs and Areas of Special Biological Significance special protections.

The RWQCB has developed metals TMDLs for several waterbodies within the San Diego region. TMDLs for dissolved copper, lead, and zinc for the lower portion of Chollas Creek were approved by EPA in late 2008. In addition, the SWRCB approved the Shelter Island Yacht Basin TMDL for dissolved copper (Resolution No. R9-2005-0019) (RWQCB, 2005) in 2005. Copper has also been identified as a significant constituent/stressor in the *Fiscal Year 2008-2009 San Diego Bay Watershed Urban Runoff Management Program (WURMP) Annual Report.* This report identified two water bodies, the San Diego Bay Shoreline at Coronado Cays and the San Diego Bay Shoreline at Glorietta Bay (City of San Diego, et. al. 2010), where copper was a significant constituent/stressor. TMDLs have not been developed for either of these identified locations.

Other local studies related to street sweeping that also evaluated metals include the *Street Sweeping BMP Effectiveness Monitoring Work Plan* (Weston, 2008) and the *Interim Report for the City of San Diego Aggressive Street Sweeping Program* (Weston, 2009). In the latter program, metals results for copper, lead, and zinc were analyzed. During Phases I and II of the Targeted Aggressive Street Sweeping Pilot Program, constituents of concern for the Chollas Creek, Tecolote Creek and La Jolla Shores Coastal Watersheds were targeted. These constituents were initially identified using the *San Diego County Municipal Co-permittees 2005–2006 Urban Runoff Monitoring Report* (Weston, 2007b) and the SWRCB 303(d) List of Impaired Waters (SWRCB, 2006). Both of these documents address constituents of concern for the San Diego region, and identify copper, lead and zinc as the primary metals impacting water quality.

Based upon the review of the literature, including reports from local monitoring efforts, it was determined that data analysis for copper, lead and zinc are appropriate measures to evaluate the effectiveness of Phase III. The street sediment samples collected in Phase III were analyzed for the California Title 22 metals suite and are presented below.

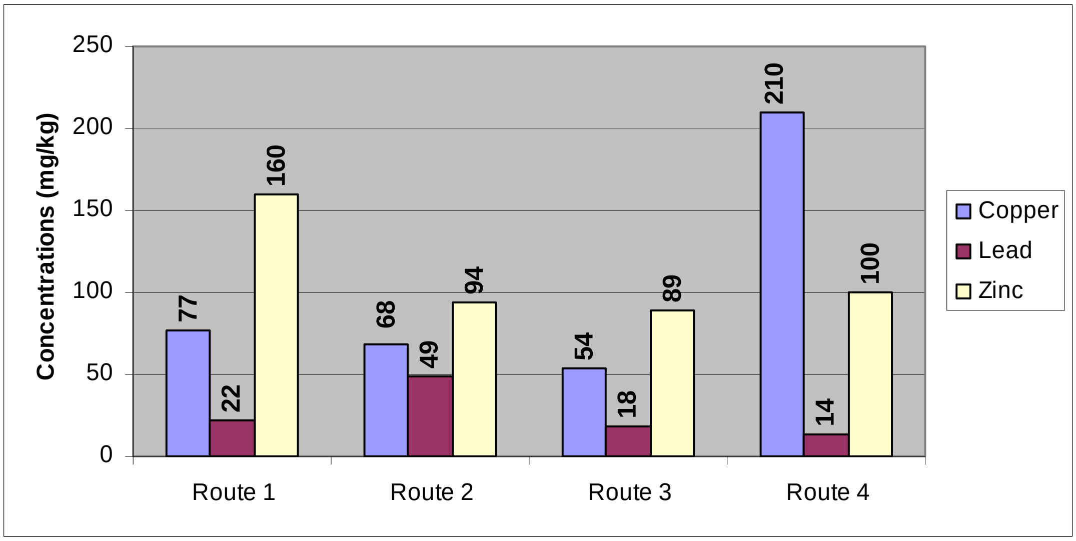
4.2.1.1 Baseline Sample

Up to 16 of the 22 priority metals were detected above the reporting limits in the four baseline samples collected on February 26, 2010. Samples collected in the first sweeping event are referred to as the baseline samples. Copper was detected in all four baseline samples with concentrations ranging from 54 to 210 mg/kg. Lead was detected in all four baseline samples with concentrations ranging from 14 to 49 mg/kg. Zinc was detected in all four baseline samples with concentrations ranging from 89 to 160 mg/kg. Except for lead, the baseline metals concentration for debris from Route 3 was the lowest of the four routes. Results are presented below in Table 4-1 and Figure 4-1.

Table 4-1. Baseline Sample Metals Concentrations

Baseline	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Route 1	77	22	160
Route 2	68	49	94
Route 3	54	18	89
Route 4	210	14	100
Average Concentration	**102**	**25.8**	**111**

Figure 4-1. Baseline Sample Metals Concentration



4.2.1.2 Composited Street Sediment Samples

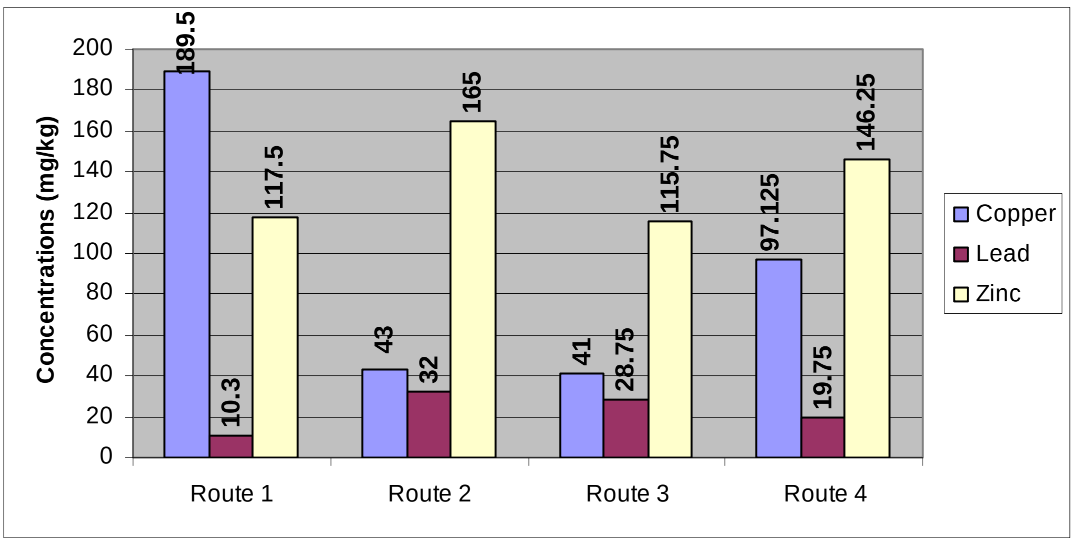
Up to 20 of the 22 priority pollutant metals were detected above the reporting limits in the 16 composited street sediment samples that were collected over an approximate three month period. Beryllium and silver were not detected in any of the samples. Copper, lead and zinc concentrations for each sample event are reported in Table 4-2 and Figure 4-2. Average concentrations of zinc were higher than the other metals for three of the four routes. For Route 1 the average detected copper concentration was higher than that of other three routes; this appears to be due in large part to the high copper concentration detected in the Route 1 sample collected on 5/22/2010. The limited sampling data collected as part of this project do not provide sufficient statistical confidence to determine if the observed data point is an outlier or provide an indication of the potential cause of this result. However, generally metals concentrations detected in samples collected on 5/22/2010 at all four routes are higher than concentrations detected in earlier samples.

Table 4-2. Average Composite Metals Concentration

Route	Sample Date	Copper(mg/kg)	Lead(mg/kg)	Zinc(mg/kg)
Route 1	3/20/2010	37	18	90
Route 1	4/10/2010	30	5.1	110
Route 1	5/1/2010	41	8.8	110
Route 1	5/22/2010	650	9.3	160
Average Route 1 Concentration	**-**	**190**	**10.3**	**118**
Route 2	03/20/10	33	13	110
Route 2	04/10/10	38	70	110
Route 2	05/01/10	22	19	120
Route 2	05/22/10	79	26	320

Route	Sample Date	Copper(mg/kg)	Lead(mg/kg)	Zinc(mg/kg)
Average Route 2 Concentration	**-**	**43**	**32**	**165**
Route 3	03/20/10	34	61	93
Route 3	04/10/10	32	11	120
Route 3	05/01/10	46	10	110
Route 3	05/22/10	52	33	140
Average Route 3 Concentration	**-**	**41**	**28.8**	**116**
Route 4	03/20/10	120	16	130
Route 4	04/10/10	150	11	180
Route 4	05/01/10	8.5	18	75
Route 4	05/22/10	110	34	200
Average Route 4 Concentration	**-**	**97.1**	**19.8**	**146**
Overall Average Concentration		**92.7**	**22.7**	**136**

Figure 4-2. Average Composite Street Sediment Sample Metals Concentration



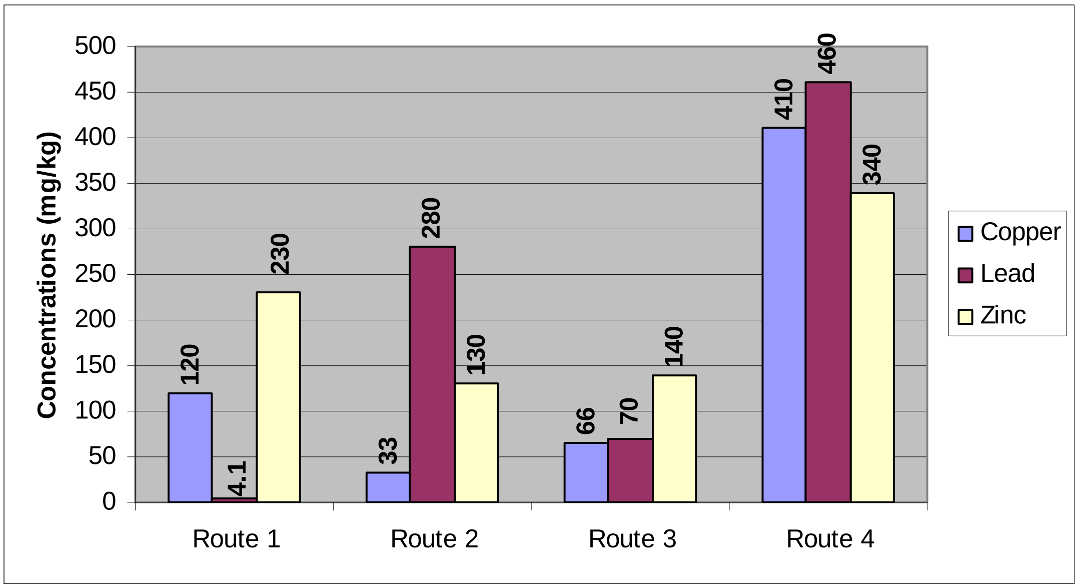
4.2.1.3 Hand-Swept Sample

Eighteen of the 22 priority metals were detected above the method detection limit (MDL)/method reporting limit (MRL) in the hand-swept sample. In addition to beryllium and silver, mercury and selenium were not detected in the hand-swept sample. Copper, lead and zinc concentrations are reported in Table 4-3 and Figure 4-3. Copper, lead, and zinc concentrations detected in the hand-swept samples were on average higher than those detected in the sweeper samples. Unlike the sweeper samples where average lead concentrations detected were always lower than copper and zinc concentrations, average detected lead concentrations in the hand-swept samples were higher than copper concentrations and approximately equal to average detected zinc concentrations.

Table 4-3. Hand-Swept Sample Metals Concentrations

Hand-Swept Sample	Copper(mg/kg)	Lead(mg/kg)	Zinc(mg/kg)
Route 1	120	4.1	230
Route 2	33	280	130
Route 3	66	70	140
Route 4	410	460	340
Average Concentration	**157**	**204**	**210**

Figure 4-3. Hand-Swept Metals Concentrations



4.2.2 Pesticides

Pesticides are a significant street sediment and urban runoff pollution concern due to their current and historic widespread application in both residential and commercial landscape areas. Residential lawns and gardens, roadsides, utility right-of-ways, commercial and industrial landscaped areas, and soil wash-off, are all common sources of potential pesticide stormwater pollution (NCHRP, 2006). As stated in the Phase I and II Final Report (Weston 2010) there has been an observable shift in pesticide use from organophosphorus pesticides (OP) (e.g., Diazinon and Malathion) to synthetic pyrethroid pesticide use (e.g., Bifenthrin and Cypermerthrin), presumably due to use of OP being banned. Over the course of the two years spent on the Phase I and II studies Weston only detected OP in three street debris samples (Chlorpyrifos and Malathion), while measureable quantities of the synthetic pyrethroids, Bifenthrin and Cypermerthrin, were detected in sweeper street debris samples from all three study routes.

No OP or synthetic pyrethroid pesticides were detected above reporting limits in the baseline, composited street sediment samples, or hand-swept samples collected in Phase III.

4.2.3 General Chemistry/Nutrients

Nutrients are a common urban runoff constituent particularly in residential, agricultural, and heavily landscaped areas. Common nutrient sources include fertilizers, leaves, other tree debris, automobile exhaust, and decaying organic matter. Elevated nitrogen and phosphorus levels may over-stimulate biological growth and lead to detrimental water-quality conditions (e.g., eutrophication and hypoxia) (Strecker, 1994). Results are presented in Table 4-4 and Table 4-5.

Table 4-4. General Chemistry/Nutrient Results

Route	Sample Date	TKN (mg/kg)	TP (mg/kg)
Route 1	3/20/2010	430	162
	4/10/2010	280	154
	5/1/2010	400	185
	5/22/2010	750	189
Average Route 1 Concentration	**-**	**465**	**173**
Route 2	03/20/10	400	164
	04/10/10	240	191
	05/01/10	410	179
	05/22/10	730	154
Average Route 2 Concentration	**-**	**445**	**172**
Route 3	03/20/10	540	190
	04/10/10	340	206
	05/01/10	510	190
	05/22/10	820	265
Average Route 3 Concentration	**-**	**553**	**213**
Route 4	03/20/10	470	328
	04/10/10	580	220
	05/01/10	250	162
	05/22/10	770	244
Average Route 4 Concentration	**-**	**518**	**239**
Average Concentration (Sweeper)	**-**	**495**	**199**

4.2.3.1 Hand-Swept Sample

Both average detected Total Kjeldahl Nitrogen (TKN) and total phosphorus (TP) concentrations were higher in the hand-swept sample than average concentrations detected in sweeper samples. Generally, the hand swept sample results for nutrients were inline with results observed in the sweeper samples with the exception of a relatively high concentration of TKN was observed for the Route 2 hand swept sample. The limited sampling data collected as part of this project do not provide sufficient statistical confidence to determine if the observed data point is a statistically significant outlier.

Table 4-5. Hand Swept General Chemistry/Nutrient Results

Hand-Swept Sample	TKN (mg/kg)	TP (mg/kg)
Route 1	320	208
Route 2	1500	340
Route 3	380	196
Route 4	680	236
Average Concentration	**720**	**245**

4.2.4 Hydrocarbons

Petroleum hydrocarbons are common roadway pollutants that are typically sorbed onto street sediments due to their hydrophobic nature. There are numerous potential sources of hydrocarbon pollution including automobiles and roadway materials. Results are presented in Table 4-6. The average detected gasoline range hydrocarbon concentration was consistently higher on all four routes for the sample collected on 5/1/2010 than that of the other three sample dates. The high results observed during this sample event are 2-3 orders of magnitude greater than the other sample values and significantly skew the average values. Given the limited sampling data collected as part of this project this data point should be interpreted with caution.

Table 4-6. Average Composite Hydrocarbon Concentrations

Route	Sample Date	Gasoline Range (mg/kg)	Diesel Range (mg/kg)	Oil & Grease (mg/kg)
Route 1	3/20/2010	0.091	310	6160
	4/10/2010	0.016	ND	4420
	5/1/2010	64.7	ND	4300
	5/22/2010	0.065	190	3770
Average Route 1 Concentration	**-**	**16.2**	**250**	**4663**
Route 2	03/20/10	0.042	160	6920
	04/10/10	0.57	ND	6000
	05/01/10	144	ND	5360
	05/22/10	0.25	210	6740
Average Route 2 Concentration	**-**	**36.2**	**185**	**6255**
Route 3	03/20/10	0.01	140	5120
	04/10/10	0.096	ND	4490
	05/01/10	118	150	3920
	05/22/10	0.16	160	5370

Route	Sample Date	Gasoline Range (mg/kg)	Diesel Range (mg/kg)	Oil & Grease (mg/kg)
Average Route 3 Concentration	**-**	**29.6**	**150**	**4725**
Route 4	03/20/10	0.2	160	5700
	04/10/10	0.15	ND	6030
	05/01/10	72.3	ND	4290
	05/22/10	0.16	150	5590
Average Route 4 Concentration	**-**	**18.2**	**155**	**5403**
Average Concentration (Sweeper)		**25.1**	**185**	**5261**

Note:
Non-detections not factored into average concentrations.

4.2.4.1 Hand-Swept Sample

Average detected gasoline range hydrocarbons, diesel range hydrocarbons, and oil and grease concentrations were lower in the hand-swept sample than average concentrations detected in sweeper samples.

Table 4-7. Hand Swept Hydrocarbon Results

Hand-Swept Sample	Gasoline Range(mg/kg)	Diesel Range(mg/kg)	Oil & Grease(mg/kg)
Route 1	0.16	280	3490
Route 2	0.026	71	3820
Route 3	0.15	93	5360
Route 4	0.19	ND	3920
Average Concentration	**0.132**	**148**	**4148**

Note:
Non-detections not factored into average concentrations.

Sampling was conducted for BTEX compounds (benzene, toluene, ethylbenzene, and xylenes); however, none were detected above the reporting limits in the baseline, composited street sediment or hand-swept samples.

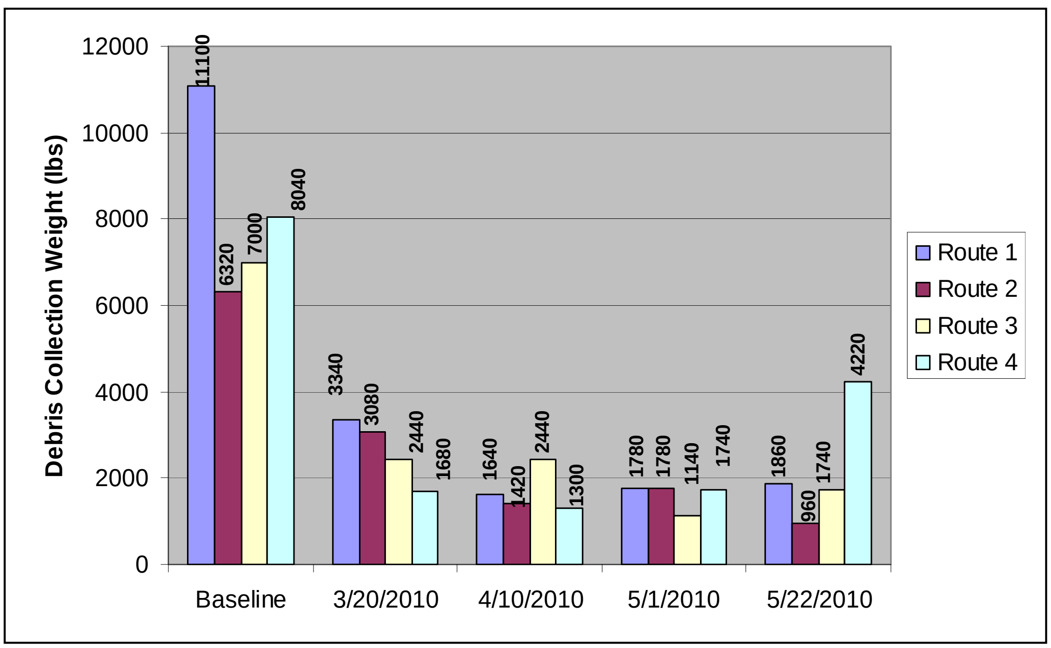
4.3 STREET DEBRIS REMOVAL RESULTS

The street debris removal monitoring generated quantitative information regarding the amount of accumulated waste collected during the Phase III sampling events. A review of sweeper daily reports provided total mileage swept, water used, street debris collected in cubic feet, and maintenance requests, if applicable. Weight of street debris collected in pounds and cost of disposal information were obtained from the Street Debris Disposal Records included as Appendix D. The detailed sweeper daily reports are presented in Appendix E. The following types of data were collected during each sampling event:

- Total mileage traveled.
- Total mileage swept.
- Mileage to disposal facility.
- Amount of water used.
- Amount of street debris collected (cubic feet) per route.
- Weight of street debris collected (pounds) per route.
- Types of items disposed.
- Cumulative cubic yards of street debris disposed.
- Cost of disposal.

A summary of the weight of street debris collected during Phase III is presented in Figure 4-4. Table 4-8 and Table 4-9 show the bin weight for each sampling event, the length of each route, and the pounds per broom miles swept. Analysis of the quantity of street debris removed allowed a comparison of the relative amount of street debris accumulation between sampling events.

Figure 4-4. Weight of Collected Street Debris



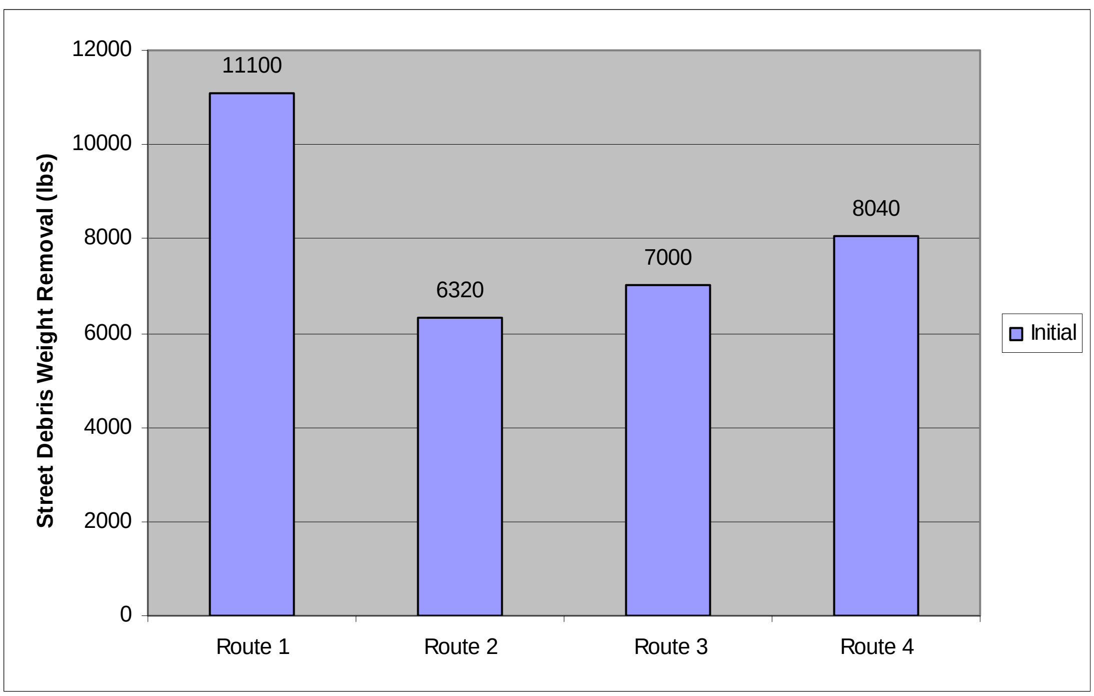
4.3.1 Baseline Sample Street Debris Removal

A baseline sweep of the four routes was performed on February 26, 2010. Sweeping of the medians along the four designated routes had not previously been conducted. The average weight of debris removed during the sweeping of these routes was 8,115 pounds/route. The least amount of debris was removed from Route 2 (6,320 pounds) while the highest amount of debris was removed from Route 1 (11,100 pounds). The average pounds of debris removed per broom-mile swept was 568. Debris removal rates ranged from 397 to 760 pounds/broom-mile as presented in Table 4-8 and Figure 4-5.

Table 4-8. Baseline Sample Debris Removal

Dumping Date	Debris Weight (pounds)	Route Identification	Broom Miles (miles)	Debris Removed (pounds/broom mile)
2/26/2010	11100	Route 1	14.6	760
2/26/2010	6320	Route 2	15.9	397
2/26/2010	7000	Route 3	14.4	484
2/26/2010	8040	Route 4	12.8	628
Average pounds per broom mile				**568**

Figure 4-5. Weight of Debris Removed in Baseline Sweeping Event



4.3.2 Composited Street Sediment Removal

After the baseline street sweeping, the four routes were swept at a frequency of once every three weeks over an approximate three month period, allowing median sweeping debris weight data to be compiled (Table 4-9). It should be noted that the Route 4 sample event on 5/22/10 resulted in the highest weight of debris removal of all sample dates and sites. The limited sampling data collected as part of this project do not provide sufficient statistical confidence to determine if the observed data point is an outlier or provide an indication of the potential cause of this result.

Table 4-9. Composited Street Sediment Debris Removal

Route	Route Identification	Debris Weight (Pounds)	Route Length (Broom miles)	Debris Removed (Pounds/ broom mile)
3/20/2010	Route 1	3340	14.6	229
4/10/2010	Route 1	1640	14.6	112
5/1/2010	Route 1	1780	14.6	122
5/22/2010	Route 1	1860	14.6	127
Route 1 Average Removal		**2155**	**--**	**148**
3/20/2010	Route 2	3080	15.9	194
4/10/2010	Route 2	1420	15.9	89.3
5/1/2010	Route 2	1780	15.9	122
5/22/2010	Route 2	960	15.9	60.3
Route 2 Average Removal		**1810**	**--**	**116**
3/20/2010	Route 3	2440	14.4	169
4/10/2010	Route 3	2440	14.4	169
5/1/2010	Route 3	1140	14.4	79.0
5/22/2010	Route 3	1740	14.4	121
Route 3 Average Removal		**1940**	**--**	**134**
3/20/2010	Route 4	1680	12.8	131
4/10/2010	Route 4	1300	12.8	102
5/1/2010	Route 4	1740	12.8	136
5/22/2010	Route 4	4220	12.8	330
Route 4 Average Removal		**2235**	**--**	**175**
Composite Average Debris Removed				**143**
Annual Median Sweeping Removal				**2431**

The project data may be used to calculate the annual estimated weight of debris removed by median sweeping at the four locations. In order to perform this calculation, the average weight of debris removed per broom mile for each route was calculated using the debris weight and route mileage data collected during the three week sample intervals (*Equation 1*).

Equation 1:

$$RADR = (DW_{\text{Sample date 1}} + DW_{\text{Sample date 2}} + DW_{\text{Sample date 3}} + DW_{\text{Sample date 4}}) / 4 * (RL)$$

Where:

RADR = Route Average Debris Removed (units: pounds per broom mile).

DW = Debris Weight (units: pounds).

RL = Route Length (units: miles).

The route average debris removed along each route was then used to calculate a composite estimate of debris removed by median sweeping activities using data collected at the four route locations (*Equation 2*).

Equation 2:

$$CADR = (RADR_{\text{Route 1}} + RADR_{\text{Route 2}} + RADR_{\text{Route 3}} + RADR_{\text{Route 4}}) / 4$$

Where:

CADR = Composite Average Debris Removed (units: pounds per broom mile).

RADR = Route Average Debris Removed (units: pounds per broom mile).

Given that a three week sweeping interval equates to approximately 17 annual sweeping events, the composite average debris removed was used to estimate of the annual amount of material that may be removed by median sweeping activities (*Equation 3*).

Equation 3:

$$AMSR = (CADR * 17)$$

Where:

AMSR = Annual Median Sweeping Removal (units: pounds per broom mile)

CADR = Composite Average Debris Removed (units: pounds per broom mile).

It should be noted that given the total combined route length for the four median sweeping routes is 57.7 miles, the estimated annual median sweeping removal value of 2,431 pounds of material per broom mile equates to approximately 140,269 pounds of material removed annually if the medians of these four routes are swept every three weeks. A comparison of the baseline sample data (Table 4-8) to the three week interval data (Table 4-9) provides a preliminary indication that less frequent sweeping (represented by the baseline data) will result in higher amounts of debris removal per sweeping event. However a greater amount of debris can be removed per year with more frequent sweeping. The limited data collected as part of this pilot study do not allow calculation of an optimal median sweeping frequency to maximize debris removal.

4.3.3 Hand-Swept Sample Results

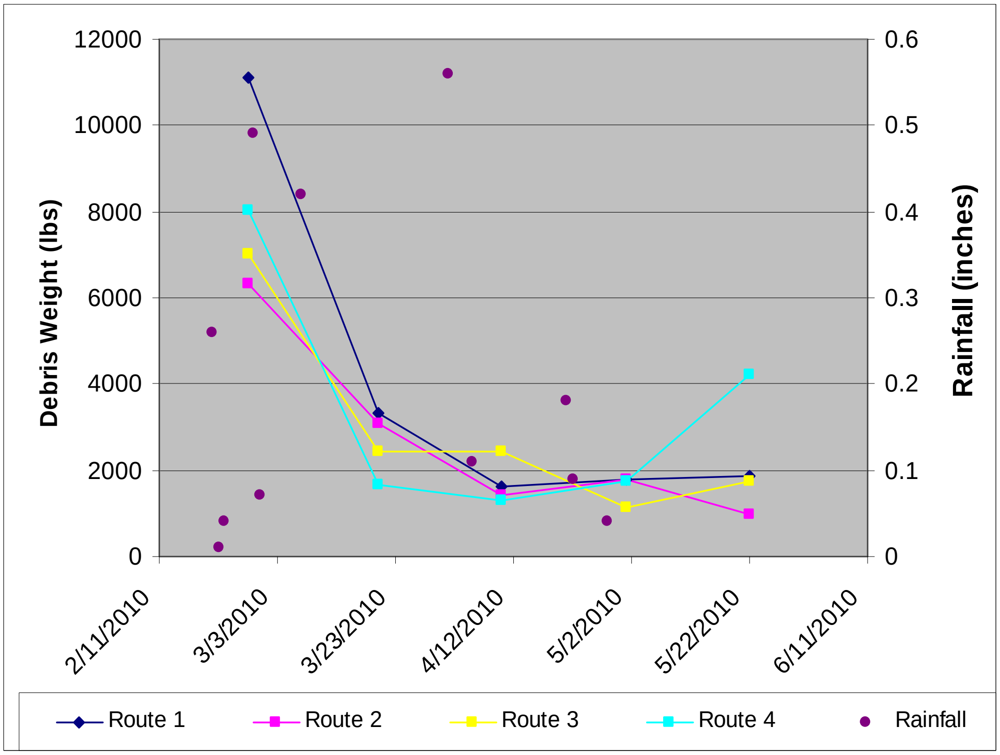
The purpose of conducting the hand-sweeping was to gather preliminary data regarding the concentration of constituents on raised medians. Current City street sweeping practices do not include sweeping of raised medians due to operational capacity and logistical constraints.

Hand-sweeping of a representative area of each route was conducted on May 21, 2010. Due to a project communication error, the weight of debris removed during the hand-sweeping was not documented. However, given the expected site-specific variability of debris present on raised medians and the limited sample collection area size (~1 square yard) relative to the total raised median surface area, it is recognized that the concentration of constituents presented above (Sections 4.2.1.3, 4.2.3.1, 4.2.4.1) as compared to the street debris data was the primary interest of this pilot effort.

4.4 STREET DEBRIS ACCUMULATION RESULTS

Analysis of the quantity of street debris removed and street sediment deposition rate allowed evaluation of the relative change in the amount of street debris accumulation between sampling events. All four routes showed a significant reduction in the amount of street debris collected after the baseline sample. Street debris deposition for all routes decreased over time up to the third sampling event (4/12/2010). After the third sampling event, street sediment deposition increased slightly for three of the four routes. Route 3 was the exception, and continued to show a decrease in street sediment deposition. As shown in Figure 4-6, a significant increase in street debris weight is noted for Route 4 between the May 1 and May 22 sampling events. The weight of street debris collected doubled between the two sampling events. No significant rainfall event occurred during this period and the cause of this increase in street sediment deposition may be influenced by local factors that were not identified during the study.

Figure 4-6. Collected Street Debris Weight Per Event and Rainfall



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SECTION 5 PROJECT EFFECTIVENESS ASSESSMENT

This section provides a summary of the assessment of the effectiveness of sweeping the medians associated with four major San Diego thoroughfares. Consideration was given to the feasibility, potential water quality benefits, and relative cost-effectiveness of modifying or increasing street sweeping routes to include roadway medians and areas adjacent to high traffic thoroughfares. Previous and current work in the City, other municipalities and private entities were used for comparison of the sample collection attributes and methodology, and the reduction of pollutant load levels in the street sediment samples collected (Weston, 2009). The street debris results indicate that implementing median sweeping assists in the reduction of metals from streets that could potentially reach the storm drain and effect downstream water quality

5.1 ESTIMATED POLLUTANT REDUCTION EFFECTS

5.1.1 Annual Sweeping Pollutant Reduction Effect

The baseline sampling data are demonstrative of the potential benefit of the City performing one median sweeping event per year, expressed in pounds of pollutant (copper, lead, and zinc) removed per broom mile. Given known operational and logistical constraints, a reasonable implementation option may be for the City to perform a single annual median sweeping event prior to the start of the rainy season to reduce pollutant loads. It may be also reasonable to assume the actual amount removed by a single annual sweeping event may be higher than the values measured in the baseline (February 26, 2010) event of this pilot as there had been several rainfall events prior to the baseline sampling event.

The data suggest that if the City were to implement a single annual median sweeping event, an estimated 0.058 pounds of copper, 0.015 pounds of lead, and 0.063 pounds of zinc per broom mile of street swept may be removed (Table 5-1). Furthermore, if the City were to expand median sweeping to other high traffic thoroughfares additional pollutant load reductions could be achieved.

Table 5-1. Estimated Annual Median Sweeping Pollutant Load Removal

Constituent	Constituent Concentration[1]	Debris Removed[2]	Estimated Amount of Constituent Removed[3]	Constituent Amount Removed Via Annual Median Sweeping[4]
	(mg/kg)	(pounds/broom mile)		(pounds/year)
Copper	102	568	0.058	3.3
Lead	26		0.015	0.87
Zinc	111		0.063	3.6

Notes:
[1] Constituent concentration derived from baseline sample collection (Table 4-1).
[2] Debris weight derived from baseline median sweeping (Table 4-8).
[3] Calculated using observed constituent concentration multiplied by weight of debris removed.
[4] Calculated using estimated amount of constituent removed multiplied by total median sweeping route length distance (57.7 miles).

5.1.2 Estimated Quarterly Sweeping Pollutant Reduction Effect

The composited sampling data from the March 20, April 10, May 1, and May 22, 2010 sampling events are demonstrative of the pollutant removal that could be anticipated (in pounds/ per broom mile (copper, lead, zinc)) if median sweeping is performed every three weeks on a continuous basis. It is understood however that budgetary and/or logistical constraints may make a lower sweeping frequency (i.e., quarterly) a more feasible implementation approach for median sweeping. Given the relatively similar constituent concentrations in the baseline and the composited samples, which represent more frequent sweeping events, it is likely that the median debris contains relatively static concentrations of constituents. Accordingly, a main driver in the relative amount of constituents removed from medians by more frequent sweeping events is the amount of debris removed during each sweeping event. As presented in Table 4-8 and Table 4-9, there was a 3-5 fold decrease in amount of debris removed between the baseline and composited sweeping events, suggesting there is potential for significant build-up of debris material between longer interval sweeping events. In addition, environmental impacts such as wind and precipitation may impact debris accumulation rates between sweeping events. Given the data collection limitations of this pilot study, the relative effect of sweeping frequency on debris accumulation in median areas is unable to be assessed. However, for planning purposes, a conservative estimate of the potential pollutant removal benefit of quarterly sweeping was developed. The quarterly sweeping frequency estimate utilized the measured amount of debris removed per broom mile during the three week sweeping interval to scale the potential annual benefit of quarterly median sweeping implementation. A potential limitation of this approach is that the amount of debris removed during quarterly sweeping events may be underestimated. As presented in Table 5-2, the data suggest that quarterly median sweeping may allow removal of an estimated 3.06 pounds of copper, 0.75 pounds of lead, and 4.49 pounds of zinc per broom mile of street swept per year.

Table 5-2. Estimated Quarterly Median Sweeping Pollutant Load Removal

Constituent	Average Constituent Concentration[1]	Estimated Median Sweeping Debris Removal[2]	Average Constituent Removed per Sweeping Event[3]	Constituent Amount Removed Via Quarterly Median Sweeping[4]
	(mg/kg)	(pounds/broom mile)		(pounds/year)
Copper	92.7	143	0.013	3.06
Lead	22.7		0.003	0.75
Zinc	136		0.002	4.49

Notes:
1 Constituent concentration derived from composited sample collection (Table 4-1)
2 Debris weight derived from composited median sweeping (Table 4-9).
3 Calculated using observed constituent concentration multiplied by weight of debris removed.
4 Calculated using average constituent removed per sweeping event multiplied by total median sweeping route length distance for four quarterly sweeping events (57.7 miles x 4 events).

5.1.3 Estimated Annual Hand-Sweeping Pollutant Reduction Effect

City street sweeping equipment is not designed to remove debris from raised medians. One means to remove this source of potential stormwater pollution is to use manual methods to hand sweep the raised medians, provided there is a sufficient pollutant removal benefit to do so. In order to assess the potential pollutant removal benefit of manual sweeping for raised medians, hand sweeping was performed for a small area in four raised median areas adjacent to the project median sweeping routes. Hand-swept samples were collected from raised medians to characterize constituent concentrations of deposited debris collected on medians. The constituent concentration data support the argument that additional constituents could be removed from stormwater runoff if hand sweeping were to occur on a regular basis.

The concentrations of copper, lead and zinc in the hand-swept samples as compared to the metals concentrations in the baseline and composite sediment samples from the street sweepers are presented in Table 5-3.

Table 5-3. Comparison of Metals Concentrations in Baseline, Composite and Hand-Swept Collected Samples

Constituent	Average Baseline Concentration (1) (mg/kg)	Composite Average Concentration (2) (mg/kg)	Average Hand-Swept Concentration (3) (mg/kg)
Copper	102	92.7	157
Lead	25.8	22.7	204
Zinc	111	136	210

Notes:
1 Data derived from Table 4-1
2 Data derived from Table 4-2
3 Data derived from Table 4-3

The concentrations of copper, lead and zinc in the hand-swept samples were consistently higher than the average concentrations measured in the baseline and composited sediment samples from the street sweepers. While these results are based on a limited amount of data, it is reasonable to expect higher concentrations in the hand-swept samples. Metals have a greater affinity to adsorb onto smaller versus larger particulates and hand-swept samples may generally include fine particulate matter that is often left behind by conventional street sweeping equipment (Law, DiBlasi, and Ghosh, 2008). Therefore, higher metals concentrations in hand-swept samples should be expected and benefits may be anticipated by removing this source of pollution by incorporating annual hand sweeping.

5.2 ESTIMATED POLLUTANT REMOVAL EFFECTS

The following section provides a comparison of current City street sweeping pollutant reduction rates and three alternative sweeping practices the City may consider implementing. This evaluation is part of the overall Targeted Aggressive Street Sweeping Pilot Program.

5.2.1 Option A: Use of a Vacuum Sweeper (Weston, 2010)

The City Targeted Aggressive Street Sweeping Pilot Study Effectiveness Assessment (Weston, 2010) analyzed the relative efficiencies of three types of street sweepers at removing metals and other constituents of concern from City roadways. The study was conducted in three pilot areas, utilizing mechanical, vacuum and regenerative air sweepers. The different sweeper types were operated at frequencies of once and twice per week along the same routes, over different time periods. Volumes of removed street debris and pollutant concentrations within the removed debris were compared to determine relative pollutant removal efficiencies. The vacuum sweeper was generally found to be the most effective at removing debris and pollutants from the routes. In addition, it was found that variability in route characteristics (i.e., steeper grades and inadequate curb and gutter in La Jolla Shores) potentially lead to site-specific differences in sweeper performance. Based on these findings it was recommended that when considering modifications to the current fleet of City street sweepers, the City maintain at least as many vacuum sweepers as mechanical sweepers. This recommendation was made to optimize the potential to reduce constituent loads along relatively flat routes where the vacuum sweeper performed significantly better than the other two sweepers, while maintaining the versatility of the current fleet (Weston, 2010).

It was also recommended that the City purchase a vacuum sweeper as a means of reducing the current pollutant load to the City's MS4. Weston reported the pounds of pollutant removal rates per sweeper type presented in Table 5-4.

Table 5-4. Pollutant Removal by Sweeper Type

Pollutant Removed	Current: Mechanical Sweeper		Option A: Vacuum Sweeper	
	Weekly	Yearly	Weekly	Yearly
	(pounds/broom mile)			
Copper	0.002	0.125	0.004	0.229
Lead	0.001	0.047	0.002	0.122
Zinc	0.009	0.493	0.120	0.615

Note:
Analytical Data values were obtained from the Targeted Aggressive Street Sweeping Pilot Study Effectiveness Assessment - Final Report (Weston, 2010). Values were reported in (g/broom mile) at a sweeping frequency of 1x week. Grams/broom mile were converted to pounds/broom mile and multiplied by 52 weeks to allow for a yearly concentration comparison.

5.2.2 Option B: Annual Median Sweeping

The baseline sweeping event completed as part of Phase III demonstrated that pollutants can be removed if the medians of four major thoroughfares are swept once a year. Table 5-5 presents data to suggest the benefit of adding such an annual sweep to the City's current street sweeping program.

Table 5-5. Option B: Annual Pollutant Removal by Adding One Annual Median Sweep to Current City Practice

Pollutant Removed	Median Pollutant Removal [1]	Current: Traffic Lane Pollutant Removal [2]	Option B: Total Potential Pollutant Removal
	(pounds/broom mile/year)		
Copper	0.058	0.125	0.183
Lead	0.015	0.047	0.062
Zinc	0.063	0.493	0.556

Notes:

1. Average pollutant removal rates are calculated and provided in Table 5-1.
2. Analytical Data values were obtained from the Targeted Aggressive Street Sweeping Pilot Study Effectiveness Assessment - Final Report (Weston, 2010). Values were reported in (g/broom mile) at a sweeping frequency of 1x week. Grams/broom mile were converted to pounds/broom mile and multiplied by 52 weeks to allow for a yearly concentration comparison.

5.2.3 Option C: Annual Pollutant Removal by Adding Four Quarterly Median Sweeps to Current City Practice

The composite sediment sweeping samples collected as part of Phase III demonstrate that pollutants can be removed if the medians of four major thoroughfares are swept every three weeks. It is assumed a similar rate of pollutant removal would be observed if median sweeping were to occur quarterly. Table 5-6 presents data to suggest the benefit of adding such quarterly sweeping to the City's current street sweeping program. It should be noted that for planning purposes, conservative estimate of the potential pollutant removal benefit of quarterly sweeping was developed using available three week frequency data. Quarterly sweeping frequency constituent removal utilized scaled estimates of debris removed per broom mile during the three week sweeping interval. A potential limitation of this approach is that the amount of debris and associated constituents removed during quarterly sweeping events may be underestimated.

Table 5-6. Option C: Annual Pollutant Removal by Adding Quarterly Median Sweeps to Current City Practice

Pollutant Removed	Median Pollutant Removal [1]		Current: Traffic Lane Pollutant Removal [2]	Option C: Total Potential Pollutant Removal
	Quarterly	Yearly Average		
	(pounds/broom mile)			
Copper	0.013	0.052	0.125	0.177
Lead	0.003	0.012	0.047	0.059
Zinc	0.002	0.008	0.493	0.501

Notes:

1. Data derived from Table 5-2
2. Analytical Data values were obtained from the Targeted Aggressive Street Sweeping Pilot Study Effectiveness Assessment - Final Report (Weston, 2010). Values were reported in (grams/broom mile) at a sweeping frequency of 1x week. Grams/broom mile were converted to pounds/broom mile and multiplied by 52 weeks to allow for a yearly concentration comparison.

5.2.4 Evaluation of Options A, B, and C

The data presented in Table 5-7 suggest that the City could increase the amount of metals collected via current street sweeping practices by implementing Option A, B or C, or a combination thereof.

Table 5-7. Comparison between Options A, B, and C

Pollutant Removed	Current Traffic Lane Sweeping Pollutant Removal [1]	Option A: Vacuum Sweeper	Constituent Removal Improvement (%)	Option B: Current + Annual Median	Constituent Removal Improvement (%)	Option C: Current + Qtrly Median	Constituent Removal Improvement (%)
	(pounds/broom mile/year)						
Copper	0.125	0.229	83%	0.185	48%	0.177	42%
Lead	0.047	0.122	160%	0.057	21%	0.059	29%
Zinc	0.493	0.615	25%	0.553	12%	0.501	1%

Note:

1 Analytical Data values were obtained from the Targeted Aggressive Street Sweeping Pilot Study Effectiveness Assessment - Final Report (Weston, 2010). Values were reported in (g/broom mile) at a sweeping frequency of 1xweek. Grams/broom mile were converted to pounds/broom mile and multiplied by 52 weeks to allow for a yearly concentration comparison.

Option A appears more effective than Option B in removing pollutants. Option B and C, which differ in the frequency of implementation of median sweeping activity (annual and quarterly sweeping frequency, respectively) appear to provide relatively equivalent constituent removal benefit. It should be noted however that a conservative estimate of the potential pollutant removal benefit of quarterly sweeping was developed using available three week frequency data. Based on comparison of the baseline sample (which demonstrates annual or less frequent median sweeping activity) and composited sample (which demonstrate conservative estimates for more frequent quarterly median sweeping activity), it is assumed that more debris per sweeping event would be removed with less frequent median sweeping activity. Accordingly, the relative constituent removal benefit of implementation of quarterly sweeping events is likely to be underestimated for Option C.

5.2.5 Option D: Additional Hand-Sweeping Sampling on Raised Medians

As presented in Section 5.1.4, constituents including copper, lead and zinc were detected in the hand-swept samples at concentrations measurably higher than those collected by a sweeper. Given the potential logistical difficulties in the use of sweeping machines on raised medians and operational capacity issues associated with employment of manual sweeping techniques on raised median areas, this concept may be considered a potential pollution/prevention source control opportunity for the City. A potential hand sweeping approach could include opportunities for partnership with local watershed stakeholders and/or nonprofit groups to perform median hand sweeping activities. This type of program may also be able to be supported by nonpoint source or other grant programs.

5.3 COMMUNITY IMPACT PERSPECTIVE

The City has been conducting a community impact assessment as a follow-up effort to the Phase I and II street sweeping studies. Due to the Phase III project configuration and sample collection parameters, community feedback was not solicited. Engaging the community was not considered necessary due to the median sweeping being conducted along commercial and/or non-residential high traffic roadways at night. The Phase III median sweeping activities also did not result in parking impacts to businesses and residents adjacent to the project sweeping routes. It is anticipated that additional community assessment will also be conducted during Phases IV and V of the Targeted Aggressive Street Sweeping Pilot Program.

5.4 COST-EFFECTIVENESS

A critical component to understanding and assessing the effectiveness of pollution prevention, source control and other potential stormwater BMP activities is determining the cost-effectiveness of the given program. Oftentimes, the cost-effectiveness will drive implementation feasibility considerations and allow planners, water quality managers and others to make informed decisions on how to best allocate available resources to improve water quality. Unfortunately, accurate cost estimates and the effectiveness of a given pollution prevention or source control BMP can be difficult in large, complex watershed systems with many confounding variables. However, the thoughtful use of available program effectiveness data and direct or comparable cost information may allow informed decisions as to how specific programs or program components may be utilized to reduce or eliminate problems which cause or contribute to water quality impairment. This section describes recommended variables that would be useful in the evaluation of the estimated costs of routine median sweeping and vacuum sweeper sweeping.

5.4.1 Debris Disposal Cost

There is a total of approximately 2700 miles of City streets currently being swept. Of those 2700 miles, approximately 304 miles of streets are considered major roadways. Those major roadways have medians associated with them, all varying in median type. This is equal to 11 percent of the streets swept in the City.

Figure 5-1 depicts the disposal costs per sweeping event. Table 5-8 shows the actual costs of each sweeping event's dumping costs. As is shown in the figure and corresponding table, as more frequent sweeping events occurred, the costs decreased. Disposal costs are driven solely by amount of material being disposed.

Figure 5-1. Collected Street Debris Disposal Cost Per Event

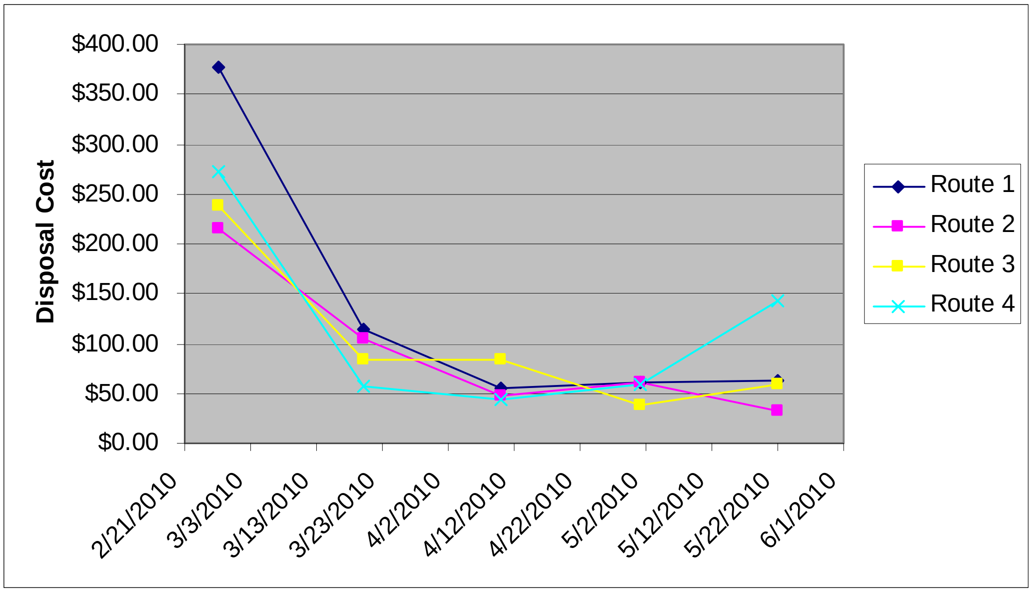


Table 5-8. Waste Disposal Dumping Costs

Route Identification	Dumping Date	Ticket No.	Disposal Cost
1	Baseline	8224953	$378.00
	3/20/10	8248898	$114.00
	4/10/10	8266160	$56.00
	5/1/10	8297950	$61.00
	5/22/10	8321521	$63.00
2	Baseline	8225127	$215.00
	3/20/10	8249441	$104.00
	4/10/10	8272981	$48.00
	5/1/10	8297950	$61.00
	5/22/10	83211716	$33.00
3	Baseline	8225386	$238.00
	3/20/10	8250930	$83.00
	4/10/10	8272765	$83.00
	5/1/10	8298103	$39.00
	5/22/10	8321144	$59.00
4	Baseline	8224824	$273.00
	3/20/10	8250806	$57.00
	4/10/10	8272569	$44.00
	5/1/10	8297825	$59.00
	5/22/10	8321305	$143.00

Based on the rates of the dump slips, and the amount of waste that was collected over the sampling period, Table 5-9 depicts the estimated disposal costs for yearly median sweeping of each of the four routes, as well as the estimated disposal cost of sweeping all four routes on a continual yearly basis every three weeks.

Table 5-9. Average Weekly Disposal Cost per Route

Route Identification	Average Weekly Street Debris Deposition (pounds)	Average Weekly Disposal Cost Estimate ($)	Average Yearly Disposal Cost Estimate ($)
Route 1	718	24.40	422.30
Route 2	605	20.60	356.40
Route 3	647	22.00	380.60
Route 4	745	25.30	437.70
Average	**679**	**23.10**	**399.60**
Total Cost of 4 Routes Combined	2715	92.30	1,598.80

Note:
Costing estimates are based on the average disposal cost ($1.00 per 29.41 pounds of disposal material). Average yearly cost based on sweeping every 3 weeks as was conducted in this study.

5.4.2 Overall Cost Effectiveness

In addition to the data presented in Section 5.4.1, preliminary City street sweeping program cost data has been gathered and is shown in Table 5-8 of the Targeted Aggressive Street Sweeping Pilot Study Report (Weston, 2010). However, as is noted in that report, the current data is not sufficient to provide an accurate cost assessment and should not be used for City-wide planning. In order to make fully informed decisions regarding potential improvements to and expansions of the City's street sweeping program, accurate cost information should be utilized in addition to pollutant removal efficiency data.

If the City decided to pursue Option A, as recommended by the Targeted Aggressive Street Sweeping Pilot Study Report (Weston, 2010), the following information would have to be gathered in order to accurately evaluate costs:

- Purchase price of buying new vacuum sweepers
- Staff training on the use, operation and maintenance of the new sweepers
- Broom miles to be swept
- Fuel costs associated with operating the vacuum sweepers
- Vacuum sweeper maintenance and repair costs
- Project management and operations man-hours
- Disposal costs of collected street debris

If the City decided to pursue Option B, the following information would have to be gathered in order to accurately evaluate its related costs:

- Project management and operations man-hours (including additional operation man-hours associated with sweeping the median at a frequency of once per year)
- Broom miles to be swept (traffic lane and median)
- Fuel costs associated with operating the current mechanical sweepers (including additional fuel costs associated with sweeping the median at a frequency of once per year)
- Mechanical sweeper maintenance and repair costs
- Disposal costs of collected debris

The above data collected for Option B could be normalized to a median sweeping frequency of four times per year in order to assess the costs of Option C. It should also be noted that the debris accumulation rate for median areas is currently unknown. The project data provided an estimate of an annual or less frequent sweeping program (baseline) and three week interval sweeping activities (composited samples). For planning purposes, the amount of material (and associated constituent weight) removed from quarterly sweeping activities was estimated using available data collected as part of this study. The actual amount of debris and associated constituents removed from quarterly sweeping activities are anticipated to be greater than the planning level estimate provided in this report. As a result, additional data may be required to provide a more refined estimate of Option C.

Once the above information is gathered an accurate cost assessment can be performed for Options A, B and C. At that point a cost-benefit analysis can be performed comparing the effectiveness of each option, and the cost-benefits of maintaining the street sweeping program as is currently implemented. It is expected that the capital costs (vehicle purchase and training) of Option A will be higher than Options B and C; while the fuel, project management and man-hour costs (due to increase broom miles swept caused by median sweeping) of Options B and C will be higher than those of Option A. Sufficient information is not available to determine whether or not maintenance and repair costs associated with vacuum sweepers (Option A) would be higher or lower than those associated with mechanical sweepers (Options B and C).

In addition to Options A, B, and C, it has been discussed that hand sweeping of the raised medians could potentially be an additional opportunity for pollutant removal. Analytical data of samples collected from the raised medians (Table 4-3) has shown pollutant concentrations (including copper, lead and zinc) detected above the MDL/MRL. In order to conduct an accurate assessment of the potential pollutant reduction benefit from hand sweeping of the raised median, additional quantitative data would need to be gathered in addition to cost data. In order to perform that evaluation the following information would have to be gathered:

- Raised median sediment loading rates
- Miles of raised median to be swept
- Equipment costs (e.g., brooms, dust pans, transportation vehicles).
- Project management and man-hour costs
- Manual sediment removal rate and cost per area swept

SECTION 6 SUMMARY

This section summarizes the results of the Phase III future median sweeping study.

6.1 SUMMARY OF RESULTS

The City has developed a series of pilot projects under the Targeted Aggressive Street Sweeping Pilot Program designed to evaluate the feasibility, potential water quality benefits, and cost-effectiveness of modifications to its current street sweeping program. Phases I and II of this program assessed the relative pollutant removal and cost-efficiency of increased sweeping frequency and advanced sweeper equipment technologies. The purpose of Phase III was to evaluate a pilot project which increased street sweeping routes to include roadway medians and other non-traditionally swept thoroughfares adjacent to high volume roadways. The Phase III pilot included four median street sweeping routes distributed throughout the City's jurisdictional watersheds along relatively high traffic volume roadways with somewhat similar adjacent land use.

The four selected Phase III street sweeping routes varied according to median type and City jurisdictional watershed (Table 6-1). Median types included barrier (typically a heavy physical barrier that prevents vehicle passage), raised medians (which include a curb and gutter and vary in width and the presence of vegetation) and painted medians (which typically include double yellow or broken double yellow lines defining median sections and/or turn lanes).

Table 6-1. Phase III Route Descriptions

Route	Watershed Management Area	Length (miles)	Median Type (%)			
			Raised	Painted	Barrier	Other
Route 1-Miramar Area	Los Peñasquitos/ Mission Bay and La Jolla	14.6	50.6	36	7.6	5.8
Route 2-Clairemont Area	Mission Bay and La Jolla/San Diego River	15.9	46	32.5	15.9	5.6
Route 3-Mission Valley Area	San Diego River/ San Diego Bay	14.4	44.7	33.7	15.3	6.3
Route 4-Tijuana River Area	San Diego Bay/Tijuana River	12.8	41.4	51.3	1.2	6.1

Route 4 is located in the Tijuana River area, but is primarily contained in the San Diego Bay WMA. A goal for the Phase III study was to include a route in the Tijuana River WMA, however, the street configuration in this WMA did not contain a high enough density of median areas to meet other study parameters. Land use adjacent to the targeted routes varied, but included (in various proportions among the four routes) residential, commercial, parks and recreation, and roadways and transportation uses. Previous studies have evaluated the similarities or differences among urban land uses and various characteristics of urban runoff, including pollutant load (EPA 1983). Although data from these studies did not indicate statistically significant differences in pollutant concentrations from different land uses (i.e. residential, commercial and mixed-use), the data did indicate a significant difference between urban and non-urban sites (Driscoll, 1990). Accordingly, given the relatively similar urban nature of the four selected routes for this Phase III study, it was expected that the collected median constituent load data would allow meaningful planning-level estimates of median sweeping effectiveness in urban areas.

Mechanical broom sweepers were used to conduct street sweeping operations along the four study routes at three week intervals over an approximate 3 month period. Median routes were swept by the street sweepers traveling along the roadway edge of barrier medians, along the curb and gutter of raised median areas, and along the median edge of painted median areas. These areas are not included in the current City street sweeping routes and are not typically swept by City street sweeper machines during routine sweeping activities. At the conclusion of each median route sweep, sweepers dumped the street debris in marked disposal bins at City operations yards (Chollas and Rose Canyon). Field teams collected representative grab samples from each street debris bin. The samples were sifted using a number 4 sieve and submitted to a certified laboratory for analysis of metals, pesticides, nutrients, and petroleum hydrocarbon constituents. In addition, a limited hand-sweeping pilot data collection effort was conducted at each of the four median routes. A small standardized area of raised median was swept using hand sweeping (manual) methods to assess the level of constituents present in the impervious area on top of raised medians, which was not mechanically swept as part of this study. These areas were pilot tested using manual methods because they are logistically and operationally difficult for traditional City mechanical sweepers to access.

As study part of the Phase III study, a literature review of available national, regional and local street sweeping studies was conducted. Various components of 19 studies were reviewed, including sweeper types, frequency of sweeping, environmental media collected, constituents analyzed, and baseline sample collection. The studies were also examined to provide a basis of comparison for Phase III pilot study results; to identify insights into the interpretation of data collected in this study, and present considerations for future pilot studies and other potential implementation efforts. Key findings from the literature review to consider when evaluating the City's Targeted Aggressive Street Sweeping Program include:

- As stormwater permitting and regulations are likely to become more stringent, street sweeping is considered a cost effective non-point source pollutant control method.
- Bi-weekly to monthly sweeping frequencies have been shown to be a cost effective approach in some studies. In general, debris removal effectiveness increases with increasing sweeping frequency. Sweeping weekly or every other week is most effective in reducing the amount of sediment and associated constituents on city streets; however, the specific operating costs for the sweeping operations can vary due to a variety of factors. Accordingly, the specific frequency at which sweeping operations most effectively remove pollutants in a given area will depend on numerous site-specific pollutant loading, operational costs, and other factors.
- Regenerative air sweepers and vacuum-assisted sweepers are consistently more effective than mechanical broom sweepers.
- High efficiency sweepers are more effective than others at picking up fine particulate matter (PM-10 particulates). High efficiency sweepers use a combination of a mechanical and vacuum action that is able to dislodge settled debris and remove it by vacuuming it from the pavement. This removes more debris than sweepers with only broom action.

- Trace metal concentrations are generally greatest on fine-grained particles. However, coarse-grained particles generally account for the greatest mass of trace metals due to the greater total mass of coarse-grained particles in debris collected by mechanical and vacuum type sweepers.
- High efficiency sweeping combined with annual catch basin cleaning was found to be the most efficient sweeping-BMP combination.
- Knowledge of baseline (pre-sweeping) and post-sweeping conditions is critical to accurately compare results of sweeper efficiency testing programs.

Results from the Phase III study indicate that median sweeping has potential to remove significant amounts of street debris and constituents commonly associated with potential water quality impacts. The initial median sweeping (baseline) event resulted in a significant amount of debris collection, likely due to the fact that median areas are infrequently swept or cleaned of debris (Figure 6-1). Subsequent median sweeping events (composited) performed at three week intervals collected approximately 3-5 times less total weight of street debris along each route.

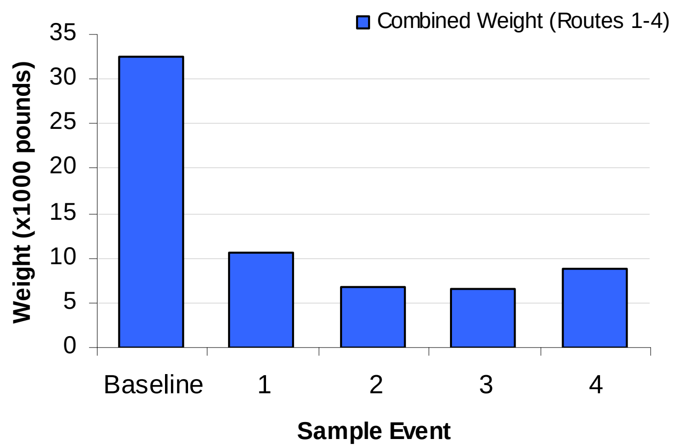


Figure 6-1. Median Sweeping Debris Weights

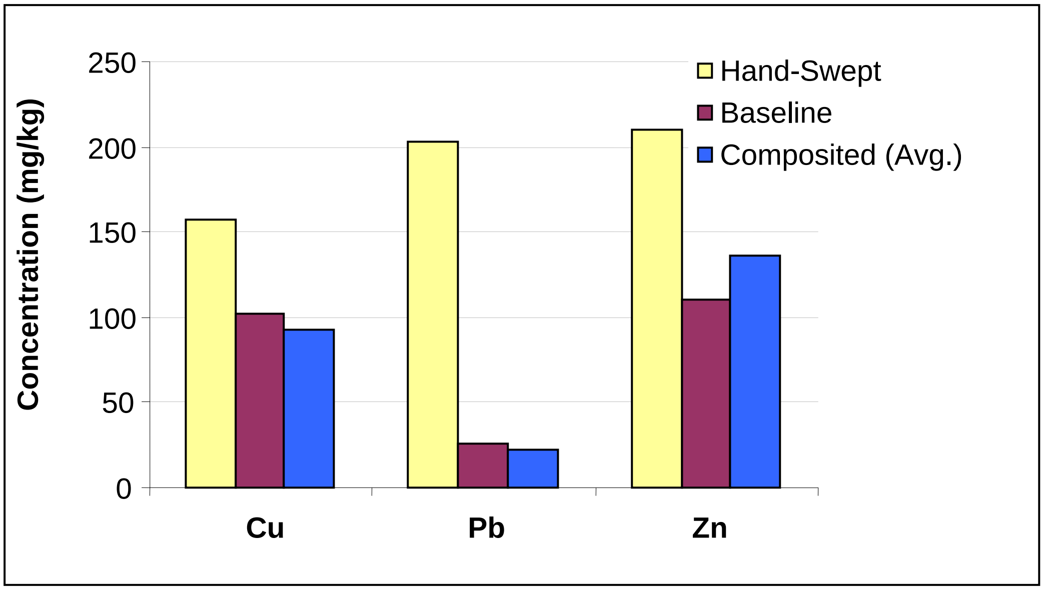
Constituent concentrations in street debris collected by the broom sweepers remained relatively static throughout the baseline and subsequent sampling events (Table 6-2), with a few isolated exceptions. A single copper result for the sample collected from Route 1 debris on 5/22/10 was 10 times greater than the result for previous samples collected at that site. The limited sampling data collected for this project do not allow for the potential cause of this high result to be identified. It should be noted however, that the copper result for all four routes for the sweeping event that occurred on 5/22/10 were greater than previous results at each of the respective route locations. Pesticides were not detected in the baseline or composited samples. Similar to the metals results, a single sample event that occurred on 5/1/10 resulted in significantly higher observed concentrations of gasoline range hydrocarbons at all four of the routes as compared to the other sampling events. The limited sampling and ancillary data collected for this project do not allow the cause of these high results to be identified.

Table 6-2. Composite Sample Average Constituent Concentrations

Constituent	Average Concentration (mg/kg)				
	Route 1	Route 2	Route 3	Route 4	Combined Average
Cu	190	43	41	97.1	92.7
Pb	10.3	32	28.8	19.8	22.7
Zn	118	165	116	146	136
TKN	465	445	553	518	495
TP	173	172	213	239	199
Gasoline Range	16.2	36.2	29.6	18.2	25.1
Diesel Range	250	185	150	155	185
Oil & Grease	4,663	6,255	4,725	5,403	5,261
Pesticides	-	-	-	-	-

Results from the hand-swept sampling indicated that there are relatively high concentrations of metals and other constituents in street debris accumulated on raised medians. While there was some variation among the sites, average copper, lead and zinc concentrations in the hand-swept sample exceeded both the baseline and average composited sample concentration results (Figure 6-2). Similarly, average nutrient concentrations in the hand-swept samples exceeded the composite average for the sweeper-collected street debris samples. The pattern for petroleum hydrocarbon constituents was reversed; higher average concentrations were found in the sweeper-collected debris samples than the hand-swept samples collected on raised medians. These results suggest that development of a cost-effective means to remove accumulated debris on raised medians adjacent to high-traffic areas may provide a significant benefit for controlling input of constituents with potential water quality impacts to the City MS4.

Figure 6-2. Average Metals Results for Hand-Swept, Baseline and Composited Samples



The weight of street debris removed during the baseline median sweeping effort was 3-5 times greater than subsequent 3-week median sweeping intervals. This indicates that in the absence of sweeping, there is significant build-up of street debris in the raised median curb and gutter and the painted median areas. Extrapolation of the data collected as part of Phase III allowed an estimate of approximately 32,000 pounds of material to be removed by a single annual sweeping event or up to 140,000 pounds of material to be removed annually from sweeping median areas at 3-week intervals (equivalent to 17 annual events).

Analyses of several potential sweeping options to efficiently perform median sweeping in the City were presented in Section 5. Based on review of operational capacity of the City Storm Water Department Operations and Maintenance Division, it was recognized that potential implementation of median sweeping activities are likely to be limited to quarterly or even less frequent intervals. Accordingly, the project results were used to estimate constituent removal for both annual and quarterly median sweeping implementation scenarios (Table 6-3). Given the relatively similar constituent concentrations observed between the baseline and composited samples, the main driver for the difference between these two estimates is the amount of debris removed during each sweeping event. As discussed above, the baseline median sweeping effort resulted in a 3-5 times greater amount of debris collected than the subsequent shorter interval sweeping events. In order to estimate the optimum sweeping frequency to maximize the debris and associated constituent weights removed from median areas, the long-term rate of accumulation of median debris must be determined.

Table 6-3. Comparison of Median Sweeping Frequency Constituents Removed

Sweeping Frequency	Estimated Debris Collected (pounds)[1]	Constituent Amount Removed (pounds/year)		
		Cu	Pb	Zn
Annual	32,774	3.3	0.87	3.6
Quarterly	33,004	3.1	0.75	4.5

Notes: [1] Calculation derived from Table 5-1 and Table 5-2.

As a final step in evaluation of the Phase III median sweeping effort relative to other components of the Targeted Aggressive Street Sweeping Pilot Program, a preliminary evaluation of the relative efficiencies for three potential street sweeping optimization implementation options were considered. One option considered was the use of vacuum sweepers rather than mechanical broom sweepers. Two additional options evaluated a) the addition of an annual median sweeping effort, and b) addition of quarterly median sweeping effort to the current mechanical sweeping effort. Based on this preliminary evaluation, implementation of vacuum-assisted sweepers on current street sweeping routes is expected to be the most effective for improving removal of copper, lead and zinc on City streets. The Phase III data indicate that implementation of limited median sweeping with mechanical sweepers will likely also result in improved constituent removal over current sweeping efforts. A limitation of this preliminary comparison of potential sweeping optimization options is that it does not consider the capital costs for vacuum or other sweeper purchases. The comparison also does not account for potential increases in operational capacity required to implement these options. Additional potential logistical cost and/or operational considerations which may impact the overall efficiency of each option may also need to be evaluated.

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SECTION 7 REFERENCES

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Appendix A City of San Diego Efficiency Assessment Framework Document

<table>
<tr><td>Project Title:</td><td colspan="2">Phase III – City of San Diego Targeted Aggressive Street Sweeping Program</td></tr>
<tr><td>Watershed:</td><td colspan="2">Los Peñasquitos, Mission Bay. La Jolla, San Diego River, and Otay.</td></tr>
<tr><td colspan="2">Efficiency Assessment</td><td>Compliance Assessment</td></tr>
<tr><td colspan="2">Overview: The fundamental management question the City of San Diego is working to answer in its efficiency assessment program is: “What is the most efficient combination of storm water programs and activities that will maximize pollutant load reductions most cost-effectively?”

Therefore, to answer this question the City is working to answer two program-wide management questions:
1. Has each individual program or activity optimized its efficiency (i.e., pollutant load reduction/cost)?
2. What is the optimal efficiency of each program or activity, so that the City can direct resources to the most efficient programs?
To answer these program-wide questions, the City identifies project-specific management questions to be evaluated as part of targeted watershed activities. The project-specific management questions are detailed below.</td><td>Overview: A description of the project’s effectiveness assessment, as required by the Municipal Permit, is provided below.</td></tr>
<tr><td colspan="3">Part I: Development of Project Specific Management Questions (to be completed by City)</td></tr>
<tr><td>Project Specific Management Questions</td><td>1.) What is the relative cost-efficiency of integrating median sweeping into the City street sweeping program?
2.) What level and type of street debris may be removed by street sweeping in medians?
3.) What is the optimum sweeping frequency to maximize street debris removal in medians?
4.) What lessons learned from Phase I and II of the Targeted Aggressive Street Sweeping Pilot Program can be identified?</td><td>MS4(D.3.a(5))
Each Copermittee shall implement a program to sweep improved (possessing a curb and gutter) municipal roads, streets, highways, and parking facilities. The program shall include the following measures:

Roads, streets, highways, and parking facilities identified as consistently generating the highest volumes of trash and/or debris shall be swept at least two times per month.

Roads, streets, highways, and parking facilities identified as consistently generating moderate volumes of trash and/or debris shall be swept at least monthly.

Roads, streets, highways, and parking facilities identified as consistently generating low volumes of trash and/or debris shall be swept as necessary, but no less than once per year.</td></tr>
<tr><td colspan="3">Part II: Development of Assessment Methodology (to be completed by Consultant)</td></tr>
</table>

Assessment Methodology	**Targeted Measurable Outcome(s)**	a.) Public Awareness (Level 2) b.) Implementation of Aggressive Street Sweeping (Level 3) c.) Load Reduction (Level 4) d.) Change in Urban Runoff Quality (Level 5)	a.) Provide data for public awareness for City's efficient use of resources for pollutant removal on roadways. b.) Identify medians on roadways that have high measurable pollutants. c.) Estimate pounds of debris removed. d.) Calculate amount of pollutants removed.
	Assessment Method(s)	Initial, Composite, and Hand Sweeping	Estimate % load reduction. Estimate % debris removal. Estimate % pollutant load reduction. Estimate % potential pollutant removal from hand sweeping.
	Data	Initial	Initial Average concentration Cu (mg/kg) (102), Pb (25.8), and Zn (111)
		Composite	Composite Average concentration (mg/kg) Cu (92.7), Pb (22.7), and Zn (136)
		Hand	Manual Average concentration (mg/kg) Cu (157), Pb (204), and Zn (210)
		Program Implementation / O&M Costs	Average disposal costs are estimated to at $400 per year. Specific O&M costs to implement median sweeping is dependent on frequency and current operational capacity.
		Average debris removal/lbs broom mile	Average of 568 lbs of debris removed per broom mile swept for Phase III.

Part III: Project Scorecard

A: Technical Feasibility

Pollutant Load Reductions						Annual Average Pollutant Reduction (lbs/broom mile/yr) (copper, lead, zinc)	Overall Project Cost¹					Average Efficiency Rating
Sweeping Routes	Average Debris Removed (lbs/broom mile)	**Copper** (mg/kg)	**Lead** (mg/kg)	**Zinc** (mg/kg)			Planning	Education & Outreach	Implementation	Operation & Maintenance	Typical Programmatic Cost per Year	
Initial	568	102	25.8	111		0.058,0.015,0.063	-	0				
Composited Samples	2483	92.7	22.7	136		0.230, 0.056, 0.338	-	0	$1,599[2]	Data not available[3]	Current Data not available at this time[3]	Moderate
Manual	-	157	204	210		N/A[1]	-	0				

[1] Manual sweeping was done as a pilot, the amount of debris removed is similar to median sweeping and the pollutant removal was similar.
[2] Assumes cost of debris disposal only, other administrative and associated costs not included in this estimate due to current data unavailable at this time.
[3] Implementation of a median sweeping program is dependent on number of routes, and operational capacity of the Storm Water Department.

Technical Feasibility?	All programs are technically feasible.

Assumptions: *(Consultant to provide assumptions for calculating avg. pollutant load reduction & avg. efficiency rating)*

Average debris removal rate was calculated by adding up all the sample debris weights and dividing them by 4 to account for quarterly sweeping.
Grams per broom mile swept were converted to pounds per broom mile to calculate yearly concentrations.
Phase I and II data and assumptions assisted in calculations for average broom mile swept as well as cost-effectiveness.
Assumes average debris removal conducted over the four routes.

¹ Estimated project cost for implementation across program implemented City-wide for one year.

If Project is technically feasible, complete section B

B: Non-quantifiable Factors *(do not change 1-4)*

1. Level of public support?	Public support for sweeping operations has been considered in a previous study and is still under review. Public support for median sweeping is likely to be high based on an anticipated minimal impact to parking and other publicly available City amenities.
2. Opportunities for partnering leveraging?	Possible partnership opportunities could be considered when performing manual median sweeping with non-profits or other interested groups.
3. Additional benefits derived from Project implementation?	Project data provides opportunity for the City to present measurable improvements in pollutant load reduction and street sweeping optimization techniques with minimal public impact.

4. Overriding factors?	None.	
5. Other? *(to be added by Consultant as needed)*	None.	
Overall Project Rating:	Ease of implementation	Minimal impacts; don't have to buy new sweepers, night operations so little to no community impact. Should be easy to implement.
	Overall efficiency	Median sweeping may provide an efficient way to optimize the current City street sweeping program provided that operational capacity is available to incorporate high traffic routes.
Assuming the Project is technically feasible, and after analyzing the Project's non-quantifiable factors, Consultant to provide bulleted recommendations for optimizing the Project		

C: Project Optimization Improvements & Recommendations *(Consultant to provide anticipated cost savings, if any, resulting from full-scale implementation of the Project)*

Phase III study results indicate that median sweeping has potential to remove significant amounts of street debris and roadway constituents. Key results include:

- The initial median sweeping event collected 3-5 times greater amounts of debris than subsequent 3-week interval sweeping events. This suggests significant buildup of roadway debris occurs adjacent to median areas. Extrapolation of data allowed an estimate of 32,000 pounds of material to be removed by a single annual sweeping event or up to 140,000 pounds of material to be removed annually from sweeping median areas at 3-week intervals.
- Metals, nutrients, and hydrocarbon constituents were all detected in median street debris and the hand-swept samples in varying concentrations which may impact downstream water quality. These results suggest that median sweeping may provide a significant benefit for controlling input of constituents with potential water quality impacts to the City MS4.
- Operational capacity limitations are likely to limit potential implementation of median sweeping activities to quarterly or even less frequent intervals. Examination of relatively infrequent implementation scenarios using the project data indicated that approximately 3 pounds of copper, 0.75 pounds of lead, and 3.5 pounds of zinc may be removed from City streets by median sweeping. Periodic manual sweeping of raised medians will likely result in additional removal of street debris and associated roadway constituents.

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Appendix B Literature Review

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List of Tables

Tables

List of Acronyms and Abbreviations

BMP	best management practice
City	City of San Diego
CWP	Center for Watershed Protection
MS4	municipal separate storm sewer system
PAH	poly-aromatic hydrocarbon
PCB	polychlorinated biphenyls
PSD	particle size distribution
SIMPTM	Simplified Particulate Transport Model
SLAMM	Source Loading and Management Model
SPLP	Synthetic Precipitation Leaching Procedure
SVOC	semi-volatile organic compound
TDS	total dissolved solids
TKN	total kjeldahl nitrogen
TPH	total petroleum hydrocarbons
TSS	total suspended solids
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	volatile organic compound

SECTION 1 INTRODUCTION

1.1 PURPOSE

The purpose of this document was to perform a literature review of selected available articles, studies and documents discussing various aspects of street sediment removal on public roadways through the use of motorized street cleaning machines known as “sweepers”. Currently, the City of San Diego (City) is in Phase III of its Targeted Aggressive Street Sweeping Pilot Program. Selected literature focused on national, regional and local projects with street sweeping pilot or project data found to be comparable to previous and current activities completed by the City was reviewed. Reviewed literature included topics such the efficiency of available motorized street sweeping equipment, adequacy of street debris removal, effects of sweeping activities on street debris contaminant load, and potential water quality benefits including reduction in metals loading, as a result of routine sweeping. The results of the literature review were intended to verify Phase III data as well as plan for future pilot studies and other potential implementation efforts. A comparison of the reviewed literature to City pilot program activities is provided in Section 3.

1.2 DEFINITIONS

The following terms are utilized throughout the Literature Review:

- Sweeping machines –A type of street cleaning equipment. For the purposes of this review, all sweepers are motorized, also referred to as ‘Sweeper”.
- Street debris or Sweeper Waste– Material including litter and soil collected by sweepers as a result of the cleaning of City streets, gutters, alleys, parking lots, and other areas as assigned.
- Street sediment – Fragments of organic or inorganic solid material deposited on roads, highways and driveways (ex. silt, sand, gravel), also referred to as “Street Dirt”.
- Sweeper type - Street sweeper equipment utilizing different means of street debris collection (e.g., vacuum, regenerative air, brush).
- Sweeping frequency – the rate at which sweeping events occur, or the number of sweeping occurrences in a given time period (i.e., weekly, bi-monthly, or monthly).
- Sweeping duration – the length of time repetitive sampling events occur over a period (i.e., monthly sampling for 12 months).

SECTION 2 LITERATURE REVIEW

A total of 17 studies were reviewed. Each of the reviewed studies were conducted for different purposes, utilized different methods, and resulted in different outcomes. The sections below present summaries of each study reviewed within these three main groups:

A comparison to City of San Diego street sweeping programs is presented in Section 3.

2.1 MULTICOMPONENT STUDIES

2.1.1 Seattle, Washington (SPU and Herrera, 2009)

In 2006 Seattle Public Utilities and the Seattle Department of Transportation conducted a study on street sweeping and its potential impacts on pollutant loads discharged to receiving water bodies. The study was conducted over a one year period in the city of Seattle, Washington. *"Seattle Street Sweeping Pilot Study, Monitoring Report"* was prepared by Seattle Public Utilities and Herrera Environmental Consultants on April 22, 2009. The purpose of this report was to determine if street sweeping significantly reduced the volume of sediment entering the storm drain system, and to determine the effect on pollutant levels in storm drain discharge by expanding or improving street sweeping programs. In this study, regenerative air street sweepers were used by sweeping each side of a street from the curb to a width equal to the sweeper (single pass, 11.5 feet wide). Street sediment samples (collected prior to and after sweeping), sweeper waste, and catch basin sediment samples, were collected every four weeks for chemical analysis. Additionally, composite street sediment samples were collected once a quarter for chemical analysis. Samples were analyzed for numerous constituents including: metals, SVOCs, PCBs, PSD, TSS, phosphorus, and TKN. Data was kept on acreage swept, mileage swept, and quantity of debris removed. A sweeping frequency of once every other week was used. Results from swept areas were compared with control (unswept) areas to determine street sweeping efficiency.

Results indicated that sweeping every other week was effective in reducing the amount of sediment and associated pollutants collected from city streets. Initial chemical analysis results showed that numerous contaminants were present in street sediment, sweeper waste, and catch basin sediments, at concentrations above Washington State sediment/soil standards and guidelines. Test results showed that street sweeping did not affect the amount or rate of sediment accumulation in the test area catch basins. As a result, it was recommended that further investigation of both the effect of street sweeping on catch basin sediment accumulation and required cleaning frequency be conducted. Also, it was recommended that the City of Seattle pursue an expanded street sweeper program. An additional finding of the report was that street sweeping has the potential to be more cost-effective at sediment/pollutant removal than either catch basin cleaning or treatment of stormwater discharge. The following uncertainties were recommended as topics of future research: evaluate sweeping effectiveness on curbless streets, evaluate how routes with differing characteristics (ex. surrounding land use, traffic volume, etc.) effect mass removal rates, and continued evaluation of the effectiveness of street sweeping at reducing drainage system maintenance costs (SPU and Herrera, 2009).

2.1.2 Madison, Wisconsin (Selbig and Bannerman, 2007)

The U.S. Geological Survey, in cooperation with the City of Madison and the Wisconsin Department of Natural Resources, conducted an evaluation of three street sweeper technologies. The evaluation was conducted from 2002 through 2006 in three residential sub-watershed basins in the city of Madison, Wisconsin. *"Evaluation of Street Sweeping as a Stormwater-Quality-Management Tool in Three Residential Basins in Madison, Wisconsin"* was written by William R. Selbig and Roger T. Bannerman in 2007 for the U.S. Department of the Interior and the U.S. Geological Survey. The purpose of this report was to measure relative efficiencies of several types of street sweepers in different sub-watershed areas. Regenerative air, vacuum-assisted, and mechanical broom street sweepers were operated at a sweeping frequency of once per week (high-frequency) in separate residential basins in Madison, WI, to measure each sweepers ability to not only reduce street sediment yield, but also improve the quality of stormwater runoff. A second mechanical broom sweeper, operating at a frequency of once per month (low-frequency), was also evaluated to measure reductions in street sediment yield only. Street sediment (before and after sweeping) and stormwater samples were collected for physical and chemical analysis. Samples were analyzed for PSD, TSS, TDS, and constituents including metals, chloride, phosphorus, and nutrients. A paired-basin study design was used to compare street sediment and stormwater quality samples during a control (no sweeping) and a treatment period (weekly sweeping).

Results discussed in the report were that street sediment yield was reduced by an average of 76, 63, and 20% in the regenerative air, vacuum-assisted, and mechanical broom basins, respectively. The low-frequency broom basin showed no significant reductions in street sediment yield. The regenerative air and vacuum-assisted sweepers had similar pickup efficiencies of 25 and 30%, respectively. The mechanical broom sweeper operating at high-frequency was considerably less efficient, removing an average of 5% of street sediment yield. This study noted difficulty in detecting significant changes in constituent stormwater quality loads; this was attributed in part to the large amount of variability in the data. Coefficients of variation for the majority of constituent loads were greater than 1, indicating substantial variability. It was determined that the ability to detect changes in constituent stormwater quality loads may have been due to an inadequate number of samples in the dataset. Total solids, TSS, and TKN results were not considered reliable and therefore were eliminated from statistical interpretation (Selbig and Bannerman, 2007).

2.1.3 New Bedford, Massachusetts (Breault, Smith, and Sorenson, 2005)

The U.S. Geological Survey, in cooperation with the U.S. Environmental Protection Agency, Massachusetts Department of Environmental Protection, and the City of New Bedford Department of Public Works, conducted a study to determine street dirt accumulation rates in residential areas, the chemical composition of the street dirt, and the relative removal efficiencies of two different types of street sweepers. The study was conducted from 2003 through 2004 in residential areas in the city of New Bedford, Massachusetts. *"Residential Street-Dirt Accumulation Rates and Chemical Composition, and Removal Efficiencies by Mechanical- and Vacuum-Type Sweepers, New Bedford, Massachusetts, 2003-04"* was prepared by Robert F. Breault, Kirk P. Smith, and Jason R. Sorenson. Sediment accumulation rates were determined for one, two, and three day intervals, and sediments were collected with a handheld vacuum for chemical analysis for trace metals and PAHs. Sweeper efficiencies were measured by known mass of sediment to the ground and measuring the amount removed by mechanical- and vacuum-type sweepers.

Accumulation rates for all particle sizes tested ranged from 2.1 to 41 g/curb-m/d (grams per curb meter per day), and averaged approximately 14 g/curb-m/d for both streets for the 1-, 2-, and 3-day experiments. Trace metal and PAH concentrations were generally greatest on fine-grained particles; however, coarse-grained particles generally accounted for the greatest mass of trace metals and PAHs due to the greater total mass of coarse-grained particles. Street sweeper efficiencies ranged from 20 to 31 percent for the mechanical sweeper and 60 to 92 percent for the vacuum sweeper. The vacuum sweeper was at least 1.6 and as much as 10 times more efficient than the mechanical sweeper depending on the particle size (Breault, Smith, and Sorenson, 2005).

2.1.4 Chesapeake Bay (Law et al., 2008)

The Center for Watershed Protection, in coordination with the City of Baltimore Department of Public Works, Baltimore County Department of Environmental Protection and Resource Management, and the Department of Civil and Environmental Engineering at the University of Maryland-Baltimore County, conducted a research project to gather information to support pollutant removal efficiencies of street sweeping and storm drain cleanout activities. This project included a literature review, municipal survey of current street sweeping practices within the Chesapeake Bay Basin, and a field monitoring program utilizing locations in Baltimore County, Maryland. The field monitoring program consisted of a 15-month pre-treatment period, from September 2004 through December 2005, to establish baseline study area conditions, and a treatment (sweeping) period lasting 19 months, from January 2006 through July 2007.

"Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping and Storm Drain Cleanout Programs in the Chesapeake Bay Basin" was prepared by Neely L. Law, Katie DiBlasi, and Upal Ghosh. The report was prepared by the Center for Watershed Protection as fulfillment of the U.S. EPA

Chesapeake Bay Program grant CB-973222-01 in September of 2008. This monitoring study was completed to provide locally-derived pollutant removal reductions for street sweeping and storm drain cleanout practices. The monitoring program included chemical and physical monitoring of water quality, flow, bedload, first-flush runoff, precipitation, source area street particulate matter, and storm drain inlet accumulation. Collected samples were analyzed for characteristics and constituents including: PSD, metals, total solids, TSS, phosphorus, and nitrogen. Mechanical and regenerative air street sweepers were studied operating at weekly and monthly sweeping frequencies. A "before-and-after" study design was used due to the inability to find a suitable control catchment to implement a paired-watershed study design.

The study concluded that the pollutant removal efficiency of the regenerative air sweepers was greater than that of the mechanical sweepers. In addition, removal efficiencies were found to increase with increasing sweeping frequency. It was found that additional pollutant contributions came from areas other than public streets and roadways for which pollutant loading is unaffected by street sweeping. Recommendations issued in this report were that analysis of catch basin sediments be expanded, alternative stormwater sampling techniques be researched and developed, adoption of whole water sampling as a method to measure sediment in stormwater as an initial step to reduce bias, and quantify bedload contributions to the total stormwater pollutant load. Analysis showed that an insufficient number of samples were collected given the conditions experienced during the study period to statistically detect differences in the street sweeping treatment on water quality. Monitoring efforts, however, did reveal key findings to determine factors contributing to the effectiveness of street sweeping and storm drain cleanout practices such as the particle size distribution of the street particulate matter picked-up by sweeping and its chemical composition (Law, DiBlasi, and Ghosh, 2008).

2.1.5 Delaware State (Walch, 2006)

The Delaware Department of Transportation, while in the process of upgrading its street sweeping program by increasing sweeping frequencies and replacing older mechanical broom sweepers with regenerative air sweepers, began collecting and analyzing waste characterization samples of debris produced by the program. Samples were collected over a time period from 2003 to 2005 with the dual purpose of assessing street sweeping effectiveness and exploring alternative means of disposing of the increased volumes of waste produced by the program. *"Monitoring of Contaminants in Delaware Street Sweeping Residuals and Evaluation of Recycling/Disposal Options"* was written by Marianne Walch for the Delaware Department of Transportation. The purpose was to implement a monitoring program that included physical and chemical analyses of sweeper wastes in order to assess the effectiveness of street sweeping as a stormwater best management practice. The monitoring program included analysis of removed debris and debris leachate for numerous pollutants including: metals, TPH, VOCs, SVOCs, and sediment. Quantity of removed debris was measured from roadways of varying traffic loads. Additionally, analysis was conducted to determine disposal and/or recycling options for the removed debris.

The report concluded that street waste can contain high sediment loads, oil and petroleum products, PAHs, pesticides, fertilizers, bacteria, metals, and other toxic materials. The main contaminants detected were metals, PAHs, phthalates, and methyl acetate. Statistically significant differences in physical and chemical properties of collected street debris were observed in roadways of differing traffic loads.

Exceptions were zinc, chromium, and TPH (higher concentrations observed on higher traffic roads) and nitrogen (higher concentrations observed on lower traffic roads) (Walch, 2006).

2.1.6 Montgomery County, Maryland (Curtis, 2002)

The Montgomery County Maryland Department of Environmental Protection collected information of the volumes of street dirt and debris removed from Montgomery County roadways by street sweeping activities during the year 2000. In 2001, a literature review was conducted to assess relative sweeper efficiencies and probable street dirt pollutant load levels. *"Street Sweeping for Pollutant Removal"* was prepared by Meosotis C. Curtis for the Montgomery County, Maryland Department of Environmental Protection in February of 2002. The purpose of this report was to document the current status of street sweeping in Montgomery County, evaluate pollutant removal from street sweeping based on the literature review, and make recommendations for the County's street sweeping program to maximize pollutant removal at the lowest possible cost. The literature review was used to evaluate the relative effectiveness of mechanical, vacuum-assisted, and regenerative air sweepers at removing pollutants TSS and nitrogen. The assumed sweeping frequency was once per week.

The report indicated that the data compiled by the Center for Watershed Protection (CWP) showed that vacuum-assisted sweepers produce the greatest reduction in TSS and nitrogen; methodology for the collection of this data was not provided in this report. The report stated that slightly less than 2,500 tons of debris was removed in 2000 by the sweeping program. Using the median metals concentrations in storm drain inlet sediment (developed by Mineart and Singh in 1994) and the mass of debris removed, it was determined that 348 pounds of copper, 468 pounds of lead, and 2,371 pounds of zinc were removed from streets by the street sweeping program in 2000 (Curtis, 2002).

2.1.7 Baltimore, Maryland (Stack et al., date unknown)

The City of Baltimore Water Quality Management Section conducted a pilot street sweeping program in the Moores Run Watershed area. It is unclear from the reviewed literature when and over what duration of time this study was conducted. *"Baltimore City Pilot Street Sweeping Program"* was prepared by William P. Stack, Norman Seldon, and Daisuke Matsuo for the City of Baltimore Water Quality Management Section. The purpose of this pilot program was to conduct a study of the effects of street sweeping on stormwater quality prior to its implementation as a city-wide stormwater BMP. Determinations of the effects of sweeping on stormwater quality were made by comparing water quality samples collected at a wet weather monitoring station during storm events before and after the implementation of the street sweeping program. Samples were analyzed for copper, total phosphorus and total nitrogen. Roadways were swept at a frequency of twice per month.

Stack et. al. concluded that the copper and total nitrogen concentrations detected in the wet weather monitoring decreased after implementation of street sweeping, while total phosphorus concentrations did not appear affected. Due to variability, definitive conclusions could not be drawn as to the actual effect street sweeping had on water quality. The study recommended continuing to collect water quality data and potentially increase sweeping frequency to reduce variability. (Stack, Seldon, Matsuo, unknown date).

2.1.8 Ramsey-Washington Metro Area (Schilling, 2005)

"Street Sweeping" is a series of three reports published in June 2005 prepared by Joel Schilling, principal with Schilling Consulting Services, for the Ramsey-Washington Metro Watershed District with the purpose of advancing efforts to improve water quality and serve as an educational tool for members of the Ramsey-Washington Public Works Forum.

The purpose of *"Street Sweeping – Report No. 1: State of the Practice"* was to summarize and analyze recent literature, WEB search reviews, personal communications with industry experts, and ongoing street sweeping research projects. This report indicates that stormwater permitting and regulation will likely become more stringent and that street sweeping is looked at favorably as a cost-effective non-point source pollutant control method.

The purpose of *"Street Sweeping – Report No. 2: Survey Questionnaire Results and Conclusions"* was to conduct a web-survey regarding the street sweeping programs of other jurisdictions in Minnesota as well as from other states and Canada. Results of the survey were that municipalities within Minnesota were much more likely to use mechanical broom sweepers instead of newer technologies, reported sweeping frequencies were lower for location within Minnesota than locations outside of the state, and a lower percentage of jurisdictions within Minnesota than those without identified water quality improvement at a very important reason for sweeping.

The purpose of *"Street Sweeping – Report No. 3: Policy Development and Future Implementation Options for Water Quality Improvement"* was to examine the conclusions developed in Report Nos. 1 and 2 with respect to the Ramsey-Washington Metro Watershed District and make recommendations for future street sweeping and stormwater quality improvement programs. The reports indicated sweeping is more cost-effective than structural BMPs; high-efficiency sweepers may increase percent of total solids removal from 30-70% (vs. mechanical sweeper); and biweekly to monthly sweeping frequencies have been shown to be the most effective frequencies. The following topics were recommended areas of future research: high-efficiency sweeping and water quality improvement, street sweeping as a component in sub-watershed modeling, disposal of street sweepings and recycling practices, life cycle costing of street sweeping practices, and integration of street sweeping practices into local government MS4 permits (Schilling, 2005a; 2005b; 2005c).

2.2 INDIVIDUAL COMPONENT STUDY

2.2.1 Street Cleaner Performance Testing (Sutherland, 2008)

Pacific Water Resources, Inc. conducted "real world" street sweeper efficiency testing of four different street sweepers models in July of 2008. It was determined that a controlled study which closely mimics real world conditions was required to accurately evaluate street sweeper efficiency. This was necessary due to problems associated with typical street sweeper testing protocol, including the facts that "before and after" sampling programs often cover a period of days between "before" sampling and "after" sampling, forward sweeping speed (closely related to sweeping efficiency) is usually not specifically monitored and observed, and common sweeping area issues such as parked cars often arise. *"Real World Street Cleaner Pickup Performance Testing"* was prepared by Roger Sutherland, and his company Pacific

Water Resources, Inc., as an independent sweeper efficiency test for four different Elgin street sweeper models. The Elgin sweeper models tested were the high-efficiency Crosswind NX, regenerative air Crosswind, vacuum Whirlwind MV, and mechanical Waterless Eagle FW. Each sweeper was given one pass over a track set up to simulate real-world conditions. Additionally, the sweeper was timed to determine speed and photos were taken throughout the process. A known quantity of sediment (with known particle size distribution) was applied evenly to the closed track, after the sweeper run a shop-vac was used to remove remaining sediment. The sediment collected was weighed and sent to a lab for PSD analysis. The high-efficiency sweeper (Crosswind NX) removed the largest percentage of street dirt at 97.5% removal. Other vehicles removed from 81.0 to 96.4% of sediment (Sutherland, 2008).

2.3 MODELING STUDIES

Rather than observations, sample collection, and physical and chemical analysis, several studies used a form of "calibrated" modeling to answer question related to street sweeping topics such as relative sweeper efficiencies, street sweeping effect on stormwater quality, and the effect of sweeping frequency on pollutant load removal. The most commonly used model is the Simplified Particulate Transport Model (SIMPTM) developed by Roger Sutherland and Seth Jelen.

The SIMPTM model is calibrated to a specific location using sediment accumulation data (accumulation rates, physical/chemical characteristics, etc.), along with monitored rainfall data, for that location. Specifically, representative locations are chosen and sediment accumulation on roads, parking lots and other paved areas, and in catch basins, is monitored over an extended period (usually a full year). Physical and chemical analysis of this sediment is conducted regularly, and precipitation is monitored hourly. Current and historic precipitation data is used to calculate an average rainfall year; the average rainfall year is combined with the collected sediment accumulation data and used to calibrate the SIMPTM model. After calibration the model is used to predict the accumulation and runoff via stormwater of urban street sediment and the appropriate interaction that certain BMPs have in the removal and/or capture of this material and its associated pollutants. The SIMPTM model accounts for variables such as sediment deposition, armoring, and the resuspension process (Sutherland and Jelen, 2002).

A variety of literature utilizing the SIMPTM model was reviewed. The documents containing a modeling component are summarized below.

2.3.1 Western Washington State (Geosyntec, 2008)

A series of white papers were produced to assist the Washington State Department of Transportation in evaluating the highway runoff water quality and the effectiveness of various best management practices. *"BMP Effectiveness Assessment for Highway Runoff in Western Washington"* was prepared in March 2008 by Geosyntec with the purpose to evaluate the effectiveness of available BMPs in managing highway runoff pollutants and quantity, specifically addressing potential stressors that may impact Endangered Species Act-listed species (Geosyntec, 2008). Conclusions regarding street sweeping as a BMP were gathered from a review of outside studies rather than observations and data collection.

It was the conclusion of the Geosyntec paper that, with respect to highway runoff, monitoring studies have failed to measure benefits to stormwater quality from street sweeping. Calibrated modeling, such as the SIMPTM developed by Sutherland and Jelen and the Source Loading and Management Model (SLAMM) developed by Pitt and Voorhees, was found to suggest that street sweeping (in particular with high efficiency sweepers) would benefit road and highway runoff quality; however, these benefits were based on frequent sweeping (weekly or twice monthly) and other specific operating conditions. These operating conditions were determined unlikely to be met on highways (Geosyntec, 2008).

2.3.2 Urban Runoff Load Estimation (Sutherland and Jelen, 2002)

Pacific Water Resources, Inc., in coordination with Hubble, Roth, and Clark, Inc., and Tetra Tech/MPS, conducted a pollutant load estimation study for two separate projects. The first project was for the City of Livonia's portion of the Bell Branch and Tarabusi Creek subwatershed of the Rouge River in southeastern Michigan, and the second project was for the City of Jackson and Jackson County's portion of the Grand River in southwestern Michigan. Both studies included an initial baseline data collection period of at least six months; the Livonia baseline study was conducted from October 1999 through May 2000, and the Jackson baseline study was conducted from April 2000 through September 2000. *"A Technique for Accurate Urban Runoff Load Estimation"* was prepared by Roger Sutherland and Seth Jelen in 2002. This report applies the SIMPTM model to the two study locations in Michigan and combines the results with economic production theory; marginal cost analysis was used to determine the optimal mix of BMP practices. Five different sweeper types were tested at sweeping frequencies ranging from daily to bimonthly. It was determined that high-efficiency sweeping with annual catch basin cleaning was the most efficient sweeping BMP combination. This was followed closely by regenerative air sweeping and annual catch basin cleaning. A sweeping frequency of biweekly to monthly was determined to be the most cost-effective. These methods were shown to be able to reduce TSS loadings by up to 80% annually (Sutherland and Jelen, 2002).

2.3.3 Street Sweeping as an Effective BMP (Sutherland and Jelen, 1997)

Roger Sutherland and Seth Jelen prepared a study with the purpose of displaying that, contrary to studies conducted in the 1970s and 1980s, street sweeping could effectively reduce urban runoff pollutant loads. Calibrated modeling was applied to two stormwater sites. *"Contrary to Conventional Wisdom, Street Sweeping can be an Effective BMP"* (Chapter 9 of *Advances in Modeling the Management of Stormwater Impacts – Vol. 5*) was prepared by Sutherland and Jelen in 1997. The report applies the SIMPTM model to two street sweeping studies conducted in the Portland, Oregon area (the actual studies themselves were not available for review). The model was used to compare the relative sweeping efficiencies of five different sweeper types: older mechanical models, newer mechanical models, tandem sweeping (mechanical followed by a vacuum sweeper), regenerative air, and high-efficiency sweepers. Modeling showed that reductions of up to 80% of annual TSS and associated pollutant washoff might be achieved using bimonthly to weekly sweeping. The high-efficiency sweeper (Enviro Whirl I) was generally the most efficient at reducing TSS and removing finer grained particulates. Order of relative efficiencies of other sweepers used (from most to least efficient) were regenerative air, tandem sweeping, newer mechanical, and older mechanical (Sutherland and Jelen, 1997).

2.3.4 Stormwater Treatment Alternatives (Sutherland, Jelen, and Minton, 1998)

Kurahashi and Associates was contracted by the City of Seattle with the purpose of evaluating the stormwater pollutant removal effectiveness of high-efficiency sweepers in combination with sediment trapping catch basins, and to determine if this BMP combination would be equivalent to pollutant removal efficiencies of wet vaults, that were at the time the only stormwater BMP deemed technically feasible and approved by the Washington State Department of Ecology for use at marine terminals. The baseline sampling and data collection program ran for a two month period, from May 31, 1996 to July 30, 1996. During this program 39 sediment samples were collected and rain gauges were monitored. *"High-Efficiency Sweeping as an Alternative to the Use of Wet Vaults for Stormwater Treatment"* (Chapter 18 of *Advances in Modeling the Management of Stormwater Impacts – Vol. 6*) was prepared by Roger Sutherland, Seth Jelen, and Gary Minton in 1998 for the Port of Seattle. Representative areas were manually swept and vacuumed to determine pollutant load levels and sediment deposition rate. Sweeper, catch basin, and wet vault sediment removal was modeled using the SIMPTM model. The SIMPTM model predicted that for marine cargo handling and storage facilities, the pollutant removals associated with high-efficiency sweeping at a weekly frequency in combination with normal catch basin inlets, cleaned annually, are essentially equivalent to wet vault removals. Additionally, while wet vaults are ineffective at soluble pollutant removal, sweepers were found to be successful due to removal the soluble fraction in sediment removed during dry periods (Sutherland, Jelen, and Minton, 1998).

2.3.5 The Ideal Sweeper for Particulates (Minton, Lief, and Sutherland, 1998)

In 1998, Pacific Water Resources, Inc. conducted an evaluation to display how the use of high-efficiency sweepers could play an important part in a successful salmon recovery plan. The evaluation was conducted in part to show how pollution control in developed and urbanized areas was as important as, if not more than, pollution control in developing areas. *"Stormwater Treatment Northwest: High-Efficiency Sweeping or Clean a Street, Save a Salmon"* was prepared by Gary Minton, Bill Lief, and Roger Sutherland in 1998 as a review of previously conducted street sweeper studies to determine a model of street sweeper that would effectively remove the finer grained particulates that pollute urban runoff and negatively impact the local salmon population. Studies conducted in the northwest United States were reviewed. The studies used the SIMPTM model as a means of comparing five different sweeper types (older mechanical, newer mechanical, tandem, regenerative air, and high-efficiency) at sweeping frequencies ranging from twice weekly to monthly. Results of the discussed studies were that the high-efficiency sweeper (Schwarze EV1) was the most effective at TSS removal. Weekly and biweekly street cleaning were determined to be the optimal sweeping frequencies. Using SIMPTM modeling, a 60% reduction of TSS would result in a 45-55% reduction in total metals, 25-35% reduction in nutrients, and a 35-45% reduction in oxygen demand (chemical and biological) (Minton, Lief, and Sutherland, 1998).

2.3.6 Stormwater BMP Options for Reduction of TSS (Bannerman and Fries, 2003)

The State of Wisconsin Department of Natural Resources and the City of Madison, in cooperation with the U.S. Geological Survey, conducted a study with the overall goal of demonstrating a combination of stormwater BMPs which would reduce the TSS load in the Lake Wingra watershed (Madison, WI) by 40%. The study was conducted in response to a new state rule (NR151) administered by the State of

Wisconsin Department of Natural Resources that contains performance standards aimed at reducing stormwater-related pollutant impacts in urban established and developing areas; the new rule was stated to be potentially affecting over 200 cities in the State of Wisconsin. Two calibrated models were used in the course of this evaluation. *"Source Area and Regional Stormwater Treatment Practices: Options for Achieving Phase II Retrofit Requirements in Wisconsin"* was prepared by Roger Bannerman and Greg Fries in 2003 with the purpose of using urban stormwater runoff modeling to compare the cost-effectiveness of different source area and regional stormwater treatment practices. The urban runoff model SLAMM indicated that parking lots and streets were the most important TSS source areas. SLAMM was chosen over other models, including SIMPTM, due to its ability to easily produce TSS loads for each source area. Calibration of the SLAMM model requires collection of storm event related flow and TSS concentrations at the end of a stormwater pipe; the model of this paper was calculated using data collected by the USGS in Madison, WI. SLAMM modeling indicated that nine different BMP combinations could achieve the desired TSS load reduction of 40%; high-efficiency sweeping by itself was projected to reduce overall TSS load by 17%. It was noted in this report that in a previous study SIMPTM modeling showed that high-efficiency street sweepers should be able to reduce TSS loads by approximately 60 and 45% for residential streets and freeways, respectively (Bannerman and Fries, 2003).

SECTION 3 LITERATURE EVALUATION

A Phase I and Phase II Street Sweeping BMP Effectiveness Monitoring Program was conducted on behalf of the City of San Diego by Weston Solutions. The literature reviewed and summarized in Section 2 of this memorandum revealed characteristics both similar and different to what has been previously completed by the City. Differences observed include the types of sweepers studied, sweeping frequency, environmental media sampled, and parameters used in analysis. A comparison between the City Phase I and II Sweeper investigations and the studies evaluated during the literature review are discussed below.

3.1 SWEEPER TYPES

The City Phase I and II studies evaluated the efficiency of different sweeper types to remove street debris by comparing mechanical, vacuum, and regenerative air sweepers. This comparison was conducted by each vehicle type sweeping the same route with the same frequency over a period of time. Each sweeper type was tested along a given route for one week to four months with a sweeping frequency of once per week; this schedule was "modified and re-projected on a weekly basis based on the serviceability of sweepers, standard City procedures (no sweeping on holidays or 5th weeks), weather, etc." (Weston, 2010). After each run, the sweeper debris was physically and chemically analyzed. Results of the analysis were compared to determine relative sweeper efficiencies. Comparatively, from the literature reviewed and summarized in Section 2, no other study evaluated sweeper debris as a means of relative sweeping efficiency of different sweeper types as presented in Table 3-1. It was determined from the literature review that analysis of removed sweeper debris was not an accurate way of determining sweeper efficiency due to numerous variables unaccounted for such as fugitive dust lost during sweeping (Sutherland, 2008), street sediment remaining within in sweeper (in filters, brushes, etc.), and pieces of asphalt removed from the road by sweeper brushes (Walch, 2006).

Based on the literature reviewed, calibrated modeling studies indicate the order of sweeper types (from most to least efficient at street debris collection) were regenerative air, tandem sweeping, newer mechanical, and older mechanical. (Sutherland and Jelen, 1997). Additionally, it was determined that the vacuum sweeper was at least 1.6 and as much as 10 times more efficient than the mechanical sweeper depending on the particle size. (Breault, Smith, and Sorenson, 2005). An alternative method referred to as "tandum" sweeping utilizing a mechanical followed by a vacuum sweeper, was found to be more effective than each respective sweeper type on its own (Minton, Lief, and Sutherland, 1998; Sutherland and Jelen, 1997 and 2002). A controlled environment evaluation affirms the calibrated modeling data conclusion that high-efficiency sweepers were determined to be the most efficient and cost-effective model when evaluated against other types (Sutherland, 2008). Furthermore, field studies also determined that street sediment yield was reduced by an average of 76, 63, and 20% in the regenerative air, vacuum-assisted, and mechanical broom basins, respectively (Selbig and Bannerman, 2007). The City has not attempted to evaluate the vacuum sweeper as part of tandem sweeping operation.

Table 3-1. Sweeper Model Type Comparison

STUDY	MODELS OF STREET SWEEPERS					
	Older Mechanical	Newer Mechanical	Tandem Sweepers	Vacuum	Regenerative Air	High-Efficiency
Memorandum Re: June 2009 Interim Report for the City of San Diego Aggressive Street Sweeping Program. June 30, 2009. (Weston Solutions, 2009)		X		X	X	
Study 2.1.1					X	
Study 2.1.2		X		X	X	
Study 2.1.3		X		X		
Study 2.1.4		X			X	
Study 2.1.5					X	
Study 2.1.6		X		X	X	
Study 2.1.7						
Study 2.1.8	X	X	X	X	X	X
Study 2.2.1		X		X	X	X
Study 2.3.1						
Study 2.3.2	X	X	X	X	X	X
Study 2.3.3	X	X	X	X	X	X
Study 2.3.4						
Study 2.3.5	X	X	X		X	X
Study 2.3.6						X

3.1.1 Efficiency Testing Methods

Several studies also evaluated sweeper efficiency by comparing alternative characteristics. Selbig and Bannerman (2007) compared swept areas to pre-determined street sediment baselines developed for those areas. They used a paired-basin study design in which four separate basins are put through a calibration period (no sweeping) and a treatment period (sweeping), each basin testing a different sweeper type or sweeping frequency. This allowed for statistical analysis of sweeper efficiencies against a control as well as a comparison of relative efficiencies between variables (sweeper types and frequencies).

Alternatively, several studies compared environmental media in one area before and after sweeping. One method of comparison chemically analyzed the street sediment in place after the sweeping of a predetermined area where a known amount of sediment had been applied evenly (Breault, Smith, and Sorenson, 2005; Sutherland, 2008). Alternatively, Law, DiBlasi, and Ghosh (2008) analyzed multiple forms of environmental media including stormwater, first-flush runoff, street sediment, catch basin sediments, and bedload before and after sweeping events. It was concluded that the analysis of alternative environmental media rather than sweeper debris allowed for the before-and-after view of conditions. Other studies compared street sweeper types and their relative efficiencies through calibrated modeling (Sutherland and Jalen, 1997; Minton, Lief, and Sutherland, 1998) or literature review (Curtis, 2002; Schilling, 2005).

3.2 SWEEPER FREQUENCY

One objective of the City Phase I and II studies was to evaluate the effect of sweeping frequency on removal of street sediment and contaminants of concern. This evaluation was conducted by comparing the sediment removal rates as a result of weekly and biweekly mechanical sweeping activity. This comparison was accomplished by sweeping two lengths of the same road at different frequencies over the same period of time and comparing the physical and chemical characteristics of removed sweeper debris.

Of the literature reviewed, the effect of sweeping frequency on contaminant loading was evaluated through a calibrated modeling program or by data comparison. Sweeping frequency is also presented in Table 3-2 below. Based on documents summarized in Section 2.3, the SIMPTM model determined weekly (high frequency) or biweekly (medium frequency) sweeping would benefit road and highway runoff quality (Geosyntec, 2008), but that biweekly and monthly sweeping is the most cost effective (Sutherland and Jalen, 2002). Studies that evaluated sweeper frequency by data comparison either compared swept areas to pre-determined sediment baselines (Selbig and Bannerman, 2007) or evaluated the before-and-after effects of sweeping (Law, DiBlasi, and Ghosh, 2008). Similar to the modeled conclusions, it was determined that biweekly, or medium frequency (SPU and Herrera, 2009) and monthly sweeping, or low frequency (Law, DiBlasi, and Ghosh, 2008), were the most efficient and cost-effective (Schilling, 2005). The City did not conduct medium or low frequency sweeping during Phase I or II.

Sutherland also noted that the highest rate of accumulation occurred immediately following a cleaning or significant wash off of material (Sutherland, 2008). The importance of sampling duration was also noted in order to obtain a statistically significant number of samples, a reasonable level of uncertainty, and to address issues such as seasonal variability (SPU and Herrera, 2009; Selbig and Bannerman, 2007; Law, DiBlasi, and Ghosh, 2008).

Table 3-2. Sweeper Frequency Comparison

STUDY	SWEEPING FREQUENCY						
	2x/week	1x/week	2x/month	1x/month	Quarterly	Semi-annual	Annual
Memorandum Re: June 2009 Interim Report for the City of San Diego Aggressive Street Sweeping Program. June 30, 2009. (Weston Solutions, 2009)	X	X					
Study 2.1.1			X				
Study 2.1.2		X		X			
Study 2.1.3							
Study 2.1.4		X		X			
Study 2.1.5					X	X	X
Study 2.1.6		X					
Study 2.1.7			X				
Study 2.1.8							
Study 2.2.1							
Study 2.3.1							
Study 2.3.2							
Study 2.3.3		X	X				
Study 2.3.4				X			
Study 2.3.5	X	X	X	X			
Study 2.3.6		X					

3.3 ENVIRONMENTAL MEDIA

Environmental media analyzed in the City of San Diego Phase I and II street sweeping studies consisted of physical and chemical analysis of the sweeper debris. Soil and leachate (via Synthetic Precipitation Leaching Procedure [SPLP]) analysis of this debris was performed. Soil analysis of the sweeper debris was conducted with the purpose of obtaining an accurate representation of the volume collected, and physical and chemical characteristics of the street sediment removed by street sweeping.

It is noted in the Weston June 2009 Memorandum (Weston, 2009) that a combination of collecting of sweeper debris leachate sampling and wet weather monitoring would be used to evaluate the impact of street sweeping on contaminants of concern in runoff rather than the simulated rain assessment described in the work plan. The only other reviewed report which conducted sweeper debris leachate analysis (Walch, 2006) did so for waste characterization and disposal purposes, this is not the reason it was conducted in the Phase I and II studies.

As part of the Phase I and II studies, wet weather monitoring was conducted during three storm events at three locations in the Chollas Creek Subwatershed. Of the literature reviewed, collection of stormwater to evaluate the impact of street sweeping on contaminants of concern in runoff was determined to be not feasible for two reasons; due to high variability, and the costs associated with collecting and analyzing a sufficient number of samples to produce statistically significant results with a reasonable level of uncertainty. In 2005, a baseline stormwater quality investigation was conducted to determine if it was feasible to collect the numbers of samples needed to obtain statistically significant results for a pilot study (SPU and Herrera, 2009). It was determined that due to variability in stormwater quality, 30 samples over a two and a half year period would produce an unacceptably high level of uncertainty. Analysis by Law, DiBlasi and Ghosh (2008) showed that an insufficient number of samples were collected during the study period to statistically detect differences on water quality as a result of street sweeping. The ability to detect changes in constituent stormwater quality loads was determined to be likely hampered by an inadequate number of samples in the dataset (Law, DiBlasi, and Ghosh, 2008).

Difficulty in detecting significant changes in constituent stormwater quality loads has also been attributed, in part, to the large amount of variability in the data (Selbig and Bannerman, 2007). Coefficients of variation for the majority of constituent loads were greater than 1, indicating substantial variability. The three aforementioned studies conducted stormwater sampling over a period of at least one year. The City conducted monitoring over one wet weather season, and not concurrent with any of the street sweeping operations conducted for the Phase I and II studies.

In addition to the above described environmental media, sediment collected from catch basins that received runoff from sweeper study locations were analyzed. Sampling catch basin sediment was determined to be an alternative way to monitor the effects of street sweeping on runoff quality. Two components were monitored including: how street sweeping effected sediment volumes, and composition migrating to catch basins to display the effects of street sweeping on runoff water quality (SPU and Herrera, 2009; Law, DiBlasi, and Ghosh, 2008).

A comparison of environmental media discussed in the Literature Review is presented in Table 3-3.

Table 3-3. Environmental Media and Constituents Analyzed

STUDY	ENVIRONMENTAL MEDIA ANALYZED									CONSTITUENTS ANALYZED																																							
	Removed Debris	Debris Leachate	Stormwater	First Flush	Street Dirt	After Sweep Debris	Catch Basin Sed.	Bedload	Statistical Model	Acreage Swept	Mileage Swept	Quantity removed	Particle Size	Metals (Dry)	Metals (total/dis.)	Copper (water)	Lead (water)	Hardness	Total Alkalinity	pH	Chloride (Dissolved)	Pesticides	Synthetic Pyrethroids	TPH	VOCs	PAHs	Phthalate, SVOCs	PCBs	Pest/Herb	Ca and Mg	Indicator Bacteria	TOC	Total Solids	TSS	TDS	TVS	Suspended Sediment	Conductivity	Total Phosphorus	Phosphorus (Diss.)	Orthophosphorus	Sulfates	Nutrient	Total Nitrogen	Nitrate and Nitrite	TKN	Ammonia	BOD	COD	Fecal Coliform
Memorandum Re: June 2009 Interim Report for the City of San Diego Aggressive Street Sweeping Program. June 30, 2009. (Weston Solutions, 2009)	X											X	X	X																																				
		X											X		X			X																																
Study 2.1.1	X				X	X	X			X	X	X	X	X												X	X	X				X		X		X			X							X				
Study 2.1.2			X		X	X						X	X		X			X	X	X	X									X				X	X		X	X	X		X				X	X	X			
Study 2.1.3					X						X	X	X													X																								
Study 2.1.4			X	X						X			X																				X						X					X						
					X	X	X						X	X	X																		X	X					X		X				X	X		X	X	
								X					X	X																									X	X		X			X	X				
Study 2.1.5	X												X	X							X			X	X	X	X	X															X							X
		X													X									X	X	X	X		X																					
Study 2.1.6																																		X										X						
Study 2.1.7			X							X						X																							X					X						
Study 2.1.8																																																		
Study 2.2.1					X	X						X	X																																					
Study 2.3.1																																																		
Study 2.3.2									X				X	X	X																			X					X										X	
Study 2.3.3													X																					X																
Study 2.3.4					X					X		X	X		X																			X					X											
									X	X		X	X																																					
Study 2.3.5									X								X																	X					X							X		X	X	
Study 2.3.6									X																									X																

3.4 CONSTITUENTS ANALYZED

The environmental media collected during the City Phase I and II street sweeping studies were subject to laboratory physical and chemical analysis. Physical characteristics of sweeper debris were determined by using techniques including weighing, particle size distribution, and lab analysis for constituents of concern such as metals, total suspended solids, and forms of nitrogen. Debris leachate samples were also prepared and analyzed for PSD, hardness, and total and dissolved metals. Similar sampling suites were utilized in several of the reviewed studies (Law, DiBlasi, and Ghosh, 2008; Sutherland and Jelen, 2002; SPU and Herrera, 2009); the constituents chosen are common stormwater pollutants. Studies which did not analyze sampled environmental media for full constituent suites generally derived pollutant loads from grain size distribution analysis combined with the generally accepted idea that finer sized grains contain a relatively larger pollutant load than larger particles.

3.5 BASELINE DATA

The City Phase I and II studies monitored individual sampling events to evaluate contaminate detection trends in street sediment over time. Reviewed literature found that baseline (pre-sweeping) conditions need to be known in order to accurately compare results. Baseline conditions may be obtained by monitoring investigation location parameters for an extended period prior to sampling commencement (Selbig and Bannerman, 2007), sampling environmental media immediately prior to sweeping (Law, DiBlasi, and Ghosh, 2008), or by estimation based on data collected at control locations with similar characteristics to investigation locations (SPU and Herrera, 2009). Similarly, modeling programs require the evaluation of baseline conditions in order to calibrate the model.

3.6 SIMILAR STUDIES

Sweeper waste, differing routes, and variable sweeping frequency were components utilized by the City Phase I and II studies, but evaluated differently by Walch (2006) and Curtis (2002). Sweeper waste analytical data has been utilized for waste disposal characterization (Walch, 2006) and to monitor the potential impact on stormwater quality (Weston, 2009; Curtis, 2002). Sweeper waste was analyzed by the City to illustrate the pollution reducing benefits of street sweeping. Alternatively, a 2002 study performed by Curtis combined sweeper debris removal volumes with a literature review to determine potential pollutant removal benefits of street sweeping. Previously determined pollutant load levels from an alternate location were utilized to calculate the volume of copper, lead and zinc removed by street sweeping activities. It remains unclear what effect the calculated quantity of removed metals would have on stormwater quality.

The City Phase I and II studies utilized different routes in order to evaluate the efficiency of street sweeper machinery. Differing routes were also used to determine composition and waste volume differences between routes with varying levels of traffic and street use (Walch, 2006).

As discussed in Section 3.2, sweeping frequency was observed ranging from weekly to biweekly (Weston, 2009) to quarterly, semi-annually, and annually (Walch, 2006).

SECTION 4 CONCLUSIONS AND RECOMMENDATIONS

As discussed in Section 3, differences were noted between literature reviewed and the Phase I and II Targeted Aggressive Street Sweeping Pilot Program conducted on behalf of the City. Differences include the types of sweepers studied, sweeping frequency, environmental media sampled, and parameters used in analysis. Recommendations for interpreting the data collected during the Phase III effort and potential parameters to consider in future studies are included in the attached report.

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Appendix C Field Observation Notes

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 02/26/2010 – 8:00

Initials of field crew members: SEC, TCP

Operations yard location: CHOLLAS OPERATION YARD

Sampling methods/gear used: Grab with post hole

Number of samples collected (soil/sediment/tissue): 12

Sample ID/number: 3-1002260800-000, 4-1002260820-000

Volume of sample collected (soil/sediment/tissue): 240 mL glass jars

Number of samples in composite (if individual samples are composited): 6 of 3-1002260800-000, 6 of 4-1002260820-000

Notes:

Thomas # 619-527-3472

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 02/26/2010 9:00-9:15

Initials of field crew members: SEC, TCP

Operations yard location: Rose Canyon Operation Yard

Sampling methods/gear used: grab with post hole

Number of samples collected (soil/sediment/tissue): 12

Sample ID/number: 1-1002260915-000, 2-1002260900-000

Volume of sample collected (soil/sediment/tissue): 240 mL glass jars

Number of samples in composite (if individual samples are composited): 6 of 1-1002260915-000, 2-1002260900-000

Notes:

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 3/20/10

Initials of field crew members: TP, CE

Operations yard location: Rose Canyon

Sampling methods/gear used: Pole Digger, bucket - grab sample

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 2-100320095 9-000

Volume of sample collected (soil/sediment/tissue): 1440 mL

Number of samples in composite (if individual samples are composited): 6

Notes:

1/4 of previous visit on 2/26. Dead cat.

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 3/20/10 9:41

Initials of field crew members: TP, CE

Operations yard location: Rose Canyon

Sampling methods/gear used: Pole digger, bucket - grab sampling

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 1-100320 0941-000

Volume of sample collected (soil/sediment/tissue): 1440 mL

Number of samples in composite (if individual samples are composited): 6

Notes:

Sediment collected by street sweeper is approx. 1/5 less than what previously observed 2/26. Dead Possum.

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 3/20/10 8:48

Initials of field crew members: TP, CE

Operations yard location: Chollas

Sampling methods/gear used: Pole digger & bucket, grab sample

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 4-1003200848-000

Volume of sample collected (soil/sediment/tissue): 1440 mL

Number of samples in composite (if individual samples are composited): 6

Notes:

Approx 1/5 of 2/26 observations. Dead possum

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 3/20/10 8:19

Initials of field crew members: TP, CE

Operations yard location: Chollas

Sampling methods/gear used: Pole Digger, bucket - grab sample

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 3-1003200819-000

Volume of sample collected (soil/sediment/tissue): 1440 mL

Number of samples in composite (if individual samples are composited): 6

Notes:

1/6 of previous visit.

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 4/10/10

Initials of field crew members: TCP, SEC

Operations yard location: Chollas

Sampling methods/gear used: Post-Hole Digger, bucket - grab sample

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 4-1004100756-000

Volume of sample collected (soil/sediment/tissue): 1440 mL

Number of samples in composite (if individual samples are composited): 6

Notes:

Took 1 blank -
4-1004100756-600

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 4/10/10

Initials of field crew members: TCP, BEC

Operations yard location: Chollas

Sampling methods/gear used: Post-hole digger, bucket - grab sample

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 3-1004100745-000

Volume of sample collected (soil/sediment/tissue): 1440 mL

Number of samples in composite (if individual samples are composited): 6

Notes:

smaller than last sampling event.

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 4/10/10

Initials of field crew members: TCP, SEC

Operations yard location: Rose Canyon

Sampling methods/gear used: Post-hole digger-bucket - grab sample

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 1-1004100840-000

Volume of sample collected (soil/sediment/tissue): 1440 mL

Number of samples in composite (if individual samples are composited): 6

Notes:

Took 1 blank -
1-1004100840-600

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 04/10/10

Initials of field crew members: TCP, SEC

Operations yard location: Rose Canyon

Sampling methods/gear used: Post-Hole, bucket - grab sample

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 2-1004100830-000

Volume of sample collected (soil/sediment/tissue): 144 mL

Number of samples in composite (if individual samples are composited): 6

Notes:

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 5/1/10 9:23

Initials of field crew members: Christine Eary & Rino Bortolin

Operations yard location: Rose Canyon

Sampling methods/gear used: Same as previous events

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 1-100501093-000

Volume of sample collected (soil/sediment/tissue): 8 oz.

Number of samples in composite (if individual samples are composited):

Notes:

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 5/1/10

Initials of field crew members: Christine Eary + Rino Bartolin

Operations yard location: Rose Canyon

Sampling methods/gear used: Same as previous events

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 2-100500931-000

Volume of sample collected (soil/sediment/tissue): 8 oz.

Number of samples in composite (if individual samples are composited):

Notes:

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 5/1/10

Initials of field crew members: Christine Eany + Rino Bartolin

Operations yard location: Chollas

Sampling methods/gear used: Same as previous events

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 03-1005011010 -000

Volume of sample collected (soil/sediment/tissue): 8 oz.

Number of samples in composite (if individual samples are composited):

Notes:

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 5/1/10

Initials of field crew members: Christine Gary + Rino Bortolin

Operations yard location: Chollas

Sampling methods/gear used: Same as previous events

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 4-1005011015-000

Volume of sample collected (soil/sediment/tissue): 8 oz.

Number of samples in composite (if individual samples are composited):

Notes:

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 5/22/2010

Initials of field crew members: SC & CE

Operations yard location: Rose Canyon

Sampling methods/gear used: Same as previous events

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 1-1005220825-000

Volume of sample collected (soil/sediment/tissue):

Number of samples in composite (if individual samples are composited):

Notes:

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 5/22/2010

Initials of field crew members: SC & CE

Operations yard location: Rose Canyon

Sampling methods/gear used: Same as previous events

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 2-1005220825-000

Volume of sample collected (soil/sediment/tissue):

Number of samples in composite (if individual samples are composited):

Notes:

Field Blank ~~Duplicate~~ taken at this location

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 5/22/2010

Initials of field crew members: SC & CE

Operations yard location: Chollas

Sampling methods/gear used: Same as previous events

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 3-1005220737-000

Volume of sample collected (soil/sediment/tissue):

Number of samples in composite (if individual samples are composited):

Notes:

Field Blank taken at this location

TO-18 Street Sweeping Grab Sample Field Form

Date and time of sampling: 5/22/2010

Initials of field crew members: SC & CE

Operations yard location: Chollas

Sampling methods/gear used: Same as previous events

Number of samples collected (soil/sediment/tissue): 6

Sample ID/number: 4-1005220750-000

Volume of sample collected (soil/sediment/tissue):

Number of samples in composite (if individual samples are composited):

Notes:

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Appendix D Street Debris Disposal Records

ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
(858) 694-7000

5180 CONVOY STREET
SAN DIEGO, CA 92111

835-001
GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8225386
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44954, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 3/5/2010 11:36:34
Scale Operator: AGC
Incoming /FB 03

	LBS	TONS
Gross Weight	34400.00	17.20
Tare Weight	27400.00	13.70
Net Weight	7000.00	3.50

Tip Fee	$ 203.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 35.00
Total	**$ 238.00**

Price increase effective July 1, 2009. All hand unload vehicles must be in the gate before 4 PM.All VEHICLES MUST EXIT THE LANDFILL BY 5 PM

FEB. 25TH FRIARS RD.

SIGNATURE

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
(858) 694-7000

5180 CONVOY STREET
SAN DIEGO, CA 92111

835-001
GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8225127
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44203, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 3/5/2010 09:57:10
Scale Operator: J9G
Incoming /FB 01

	LBS	TONS
Gross Weight	34080.00	17.04
Tare Weight	27760.00	13.88
Net Weight	6320.00	3.16

Tip Fee	$ 183.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 32.00
Total	**$ 215.00**

Price increase effective July 1, 2009. All hand unload vehicles must be in the gate before 4 PM.All VEHICLES MUST EXIT THE LANDFILL BY 5 PM

FEB. 25TH CLAIREMONT

SIGNATURE

ES-072 (REV. 5-09)

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
(858) 694-7000

5180 CONVOY STREET
SAN DIEGO, CA 92111

835-001
GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8224953
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44217, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY

Hauler Type:	08/CITY OTHER DEPTS
Vehicle Type:	030/A - 20 CY OR LESS
Material Type:	004/DEMO
Origin:	001/SAN DIEGO CITY
Special Fees:	

Date: 3/5/2010 08:56:52
Scale Operator: TIR
Incoming /FB 02

	LBS	TONS
Gross Weight	39140.00	19.57
Tare Weight	28040.00	14.02
Net Weight	11100.00	5.55

Tip Fee	$ 322.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 56.00
Total	**$ 378.00**

Price increase effective July 1, 2009. All hand unload vehicles must be in the gate before 4 PM.All VEHICLES MUST EXIT THE LANDFILL BY 5 PM

FEB. 25TH MIRAMAR RD.

[signature]
SIGNATURE

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REFUSE DISPOSAL DIVISION
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5180 CONVOY STREET
SAN DIEGO, CA 92111

835-001
GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8224824
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44953, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 3/5/2010 07:49:56
Scale Operator: AGC
Incoming /FB 03

	LBS	TONS
Gross Weight	35660.00	17.83
Tare Weight	27620.00	13.81
Net Weight	8040.00	4.02

Tip Fee	$ 233.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 40.00
Total	**$ 273.00**

Price increase effective July 1, 2009. All hand unload vehicles must be in the gate before 4 PM.All VEHICLES MUST EXIT THE LANDFILL BY 5 PM

FEB. 25TH PALM AVE.

SIGNATURE

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
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5180 CONVOY STREET
SAN DIEGO, CA 92111

GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8249441
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44203, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 3/27/2010 11:55:16
Scale Operator: J9G
Incoming /FB 03

	LBS	TONS
Gross Weight	30840.00	15.42
Tare Weight	27760.00	13.88
Net Weight	3080.00	1.54

Tip Fee	$ 89.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 15.00
Total	**$ 104.00**

Price increase effective July 1, 2009. All hand unload vehicles must be in the gate before 4 PM.All VEHICLES MUST EXIT THE LANDFILL BY 5 PM

6 ~~12~~ 5.5

3/19

ClaiRemont. Drew

SIGNATURE

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
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5180 CONVOY STREET
SAN DIEGO, CA 92111

835-001
GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8248898
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44217, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 3/27/2010 07:53:59
Scale Operator: CCX
Incoming /FB 02

	LBS	TONS
Gross Weight	31380.00	15.69
Tare Weight	28040.00	14.02
Net Weight	3340.00	1.67

Tip Fee	$ 97.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 17.00
Total	**$ 114.00**

Price increase effective July 1, 2009. All hand unload vehicles must be in the gate before 4 PM.All VEHICLES MUST EXIT THE LANDFILL BY 5 PM

3/19

Miramar [signature] Drew

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
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(858) 694-7000

5180 CONVOY STREET
SAN DIEGO, CA 92111

835-001
GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8250930
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44954, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 3/28/2010 14:31:59
Scale Operator: VMJ
Incoming /FB 03

	LBS	TONS
Gross Weight	29840.00	14.92
Tare Weight	27400.00	13.70
Net Weight	2440.00	1.22

Tip Fee	$ 71.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 12.00
Total	**$ 83.00**

Price increase effective July 1, 2009. All hand unload vehicles must be in the gate before 4 PM.All VEHICLES MUST EXIT THE LANDFILL BY 5 PM

3/19
friars rd
Drew

SIGNATURE

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5180 CONVOY STREET
SAN DIEGO, CA 92111

Transaction #: 8250806
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44953, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 3/28/2010 13:21:11
Scale Operator: BS2
Incoming /FB 02

835-C01
GENERAL SERVICES
STREET SWEEPING
940554

	LBS	TONS
Gross Weight	29300.00	14.65
Tare Weight	27620.00	13.81
Net Weight	1680.00	0.84

Tip Fee	$ 49.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 8.00
Total	**$ 57.00**

Price increase effective July 1, 2009. All hand unload vehicles must be in the gate before 4 PM.All VEHICLES MUST EXIT THE LANDFILL BY 5 PM

3/19 Palm Ave

Drew

SIGNATURE

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
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5180 CONVOY STREET
SAN DIEGO, CA 92111

835-001
GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8272765
Account #: 940554/STREET SWEEPING
Decal #: 41346, 44954, 0
Fleet #: 835002 Tag #: 1167889
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 4/17/2010 09:20:24
Scale Operator: AGC
Incoming /FB 02

	LBS	TONS
Gross Weight	23800.00	11.90
Tare Weight	21360.00	10.68
Net Weight	2440.00	1.22

Tip Fee	$ 71.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 12.00
Total	**$ 83.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

4-9-10 sweep

Friars

SIGNATURE

ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
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5180 CONVOY STREET
SAN DIEGO, CA 92111

SERVICES
SWEEPING

Transaction #: 8272569
Account #: 940554/STREET SWEEPING
Decal #: 41346, 44953, 0
Fleet #: 835002 Tag #: 1167889
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 4/17/2010 07:30:07
Scale Operator: TIR
Incoming /FB 03

	LBS	TONS
Gross Weight	22880.00	11.44
Tare Weight	21580.00	10.79
Net Weight	1300.00	0.65

Tip Fee	$ 38.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 6.00
Total	**$ 44.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

4-9-10 Sweep

PALm

ES-072 (REV. 5-09)

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
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5180 CONVOY STREET
SAN DIEGO, CA 92111

835-001
GENERAL SERVICES
STREET SWEEPING

Transaction #: 8272981
Account #: 940554/STREET SWEEPING
Decal #: 41346, 44203, 0
Fleet #: 835002 Tag #: 1167889
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 4/17/2010 10:51:16 940554 -
Scale Operator: RTA
Incoming /FB 03

	LBS	TONS
Gross Weight	23140.00	11.57
Tare Weight	21720.00	10.86
Net Weight	1420.00	0.71

Tip Fee	$ 41.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 7.00
Total	**$ 48.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

4-9-10 sweep

Clairemont

SIGNATURE

ES-072 (REV. 5-09)

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
(858) 694-7000

5180 CONVOY STREET
SAN DIEGO, CA 92111

835-001
GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8266160
Account #: 940554/STREET SWEEPING
Decal #: 41346, 44217, 0
Fleet #: 835002 Tag #: 1167889
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 4/11/2010 08:55:40
Scale Operator: VMJ
Incoming /FB 03

	LBS	TONS
Gross Weight	23640.00	11.82
Tare Weight	22000.00	11.00
Net Weight	1640.00	0.82

Tip Fee	$ 48.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 8.00
Total	**$ 56.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

WK OF 5TH (FRI. 4/9/10)
MIRAMAR RD.

SIGNATURE

ES-072 (REV. 5-09)

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
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5180 CONVOY STREET
SAN DIEGO, CA 92111

835-001
GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8298103
Account #: 940554/STREET SWEEPING
Decal #: 41346, 44954, 0
Fleet #: 835002 Tag #: 1167889
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 5/9/2010 11:20:16
Scale Operator: P3K
Incoming /FB 02

	LBS	TONS
Gross Weight	22500.00	11.25
Tare Weight	21360.00	10.68
Net Weight	1140.00	0.57

Tip Fee	$ 33.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 6.00
Total	**$ 39.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

(WK OF APR. 30TH)
FRIARS RD.

SIGNATURE

ES-072 (REV. 5-09)

Printed on recycled paper

This information is available in alternative formats upon request.

ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
(858) 694-7000

5180 CONVOY STREET
SAN DIEGO, CA 92111

835-001
GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8297950
Account #: 940554/STREET SWEEPING
Decal #: 41346, 44217, 0
Fleet #: 835002 Tag #: 1167889
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 5/9/2010 09:29:46
Scale Operator: AGC
Incoming /FB 01

	LBS	TONS
Gross Weight	23780.00	11.89
Tare Weight	22000.00	11.00
Net Weight	1780.00	0.89

Tip Fee	$ 52.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 9.00
Total	**$ 61.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

(WK OF APR. 30TH)
MIRAMAR RD.

SIGNATURE

ES-072 (REV. 5-09)

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This information is available in alternative formats upon request.

THE CITY OF SAN DIEGO
ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
(858) 694-7000

5180 CONVOY STREET
SAN DIEGO, CA 92111

835001
GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8297904
Account #: 940554/STREET SWEEPING
Decal #: 41346, 44203, 0
Fleet #: 835002 Tag #: 1167889
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 5/9/2010 08:37:12
Scale Operator: PJ4
Incoming /FB 01

	LBS	TONS
Gross Weight	23520.00	11.76
Tare Weight	21720.00	10.86
Net Weight	1800.00	0.90

Tip Fee	$ 52.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 9.00
Total	**$ 61.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

(WK OF APR. 30TH)
CLAIREMONT

SIGNATURE

ES-072 (REV. 5-09)

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
(858) 694-7000

5180 CONVOY STREET
SAN DIEGO, CA 92111

GENERAL SERVICES
STREET SWEEPING
940554 -

Transaction #: 8297825
Account #: 940554/STREET SWEEPING
Decal #: 41346, 44953, 0
Fleet #: 835002 Tag #: 1167889
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 5/9/2010 07:37:26
Scale Operator: CYN
Incoming /FB 02

	LBS	TONS
Gross Weight	23320.00	11.66
Tare Weight	21580.00	10.79
Net Weight	1740.00	0.87

Tip Fee	$ 50.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 9.00
Total	**$ 59.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

(WK OF APR. 30TH)
PALM AVE.

SIGNATURE

ES-072 (REV. 5-09)

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THE CITY OF SAN DIEGO
ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
(858) 573-1420

MIRAMAR LANDFILL
5180 CONVOY STREET
SAN DIEGO, CA 92111

Transaction #: 8321144
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44954, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 5/29/2010 07:44:19
Scale Operator: PJ4
Incoming /FB 01

SUPVX
TRANSPORTATION
STREET
0U0554

	LBS	TONS
Gross Weight	29140.00	14.57
Tare Weight	27400.00	13.70
Net Weight	1740.00	0.87

Tip Fee	$ 50.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 9.00
Total	**$ 59.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

Frias

Drew
SIGNATURE

ES-072 (REV. 1-00)

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
(858) 694-7000

5180 CONVOY STREET
SAN DIEGO, CA
TRANSPORTATION
STREET
940554 -

Transaction #: 8321305
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44953, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 5/29/2010 09:07:11
Scale Operator: CYN
Incoming /FB 01

	LBS	TONS
Gross Weight	31840.00	15.92
Tare Weight	27620.00	13.81
Net Weight	4220.00	2.11

Tip Fee	$ 122.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 21.00
Total	**$ 143.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

palm

Dren

SIGNATURE

ES-072 (REV. 5-09)

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THE CITY OF SAN DIEGO
ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
(858) 694-7000

MIRAMAR LANDFILL
5180 CONVOY STREET
SAN DIEGO, CA 92111

SUPVX
TRANSPORTATION
STREET

940554 -

Transaction #: 8321521
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44217, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 5/29/2010 10:47:54
Scale Operator: CCX
Incoming /FB 02

	LBS	TONS
Gross Weight	29900.00	14.95
Tare Weight	28040.00	14.02
Net Weight	1860.00	0.93

Tip Fee	$ 54.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 9.00
Total	**$ 63.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

Miramar LD

SIGNATURE

ES-072 (REV. 5-09)

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ENVIRONMENTAL SERVICES DEPARTMENT
REFUSE DISPOSAL DIVISION
9601 RIDGEHAVEN CT., SUITE 310 • SAN DIEGO, CA 92123-1636
(858) 694-7000

5180 CONVOY STREET
SAN DIEGO, CA 92111

SUPVX
TRANSPORTATION
STREET
940554 -

Transaction #: 8321716
Account #: 940554/STREET SWEEPING
Decal #: 32566, 44203, 0
Fleet #: 806016 Tag #:
Transaction Type: 08/CITY OTHER DEPTS
Payment Type: CT/CITY
Hauler Type: 08/CITY OTHER DEPTS
Vehicle Type: 030/A - 20 CY OR LESS
Material Type: 004/DEMO
Origin: 001/SAN DIEGO CITY
Special Fees:

Date: 5/29/2010 12:07:49
Scale Operator: CYN
Incoming /FB 01

	LBS	TONS
Gross Weight	28720.00	14.36
Tare Weight	27760.00	13.88
Net Weight	960.00	0.48

Tip Fee	$ 28.00
Spec Fee	$ 0
RCBus Tax	$ 0
Recycle	$ 5.00
Total	**$ 33.00**

All hand unloads must be in gate before 4:00. All VEHICLES MUST EXIT THE LANDFILL BY 5 P.M.

Clairemont

SIGNATURE

ES-072 (REV. 5-09)

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Appendix E Daily Sweeper Reports

SWEEPER DAILY REPORT

Date: 2/26/10			Equipment #: 718.038		Operator: FAIAI .D	
01. Route/Job No.	SPC.1	SPC.2	10.19			Grand Total
02. Complete Incomplete	COMP.	COMP.				
03. Speedometer Stop	14958	14978	14993			
04. Speedometer Start	14914	14958	14978			
05. Total Mileage	44	20	15			79
06. Broom Meter Stop	14958	14978				
07. Broom Meter Start	14935	14959				
08. Total Broom Mileage	17	18				35
09. Total Travel Mileage	21	1	15			37
10. Dump Milage (Information only)	6	1				7
11. Equipment/ Manual Hours						
12. Maintenance Hours						
13. Breaks						
14. Down Time						
15. Total Hours						
16. Water Usage (cubic feet)	500	500				1000
17. Debris Collected (cu. ft.)	4	3				7

Dump Location	Cubic Yards
ROSE CANYON Spc.1 MB-2	4
Spc.2 ORANGE EAST	3

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

Spc.1 - MIRA MAR CENTER ISLAND RT. DEBRIS DUMPED IN MB-2 BIN

Spc 2 - CLAIREMONT CENTER ISLAND RT. " " " ORANGE EAST

SWEEPER DAILY REPORT

Date: 2/26/2010 | Equipment #: 718-038 | Operator: LO

							Grand Total
01. Route/Job No.	MIRAMAR ROAD	CLAIRMONT MESA AREA					
02. Complete Incomplete	COMPL →	→					
03. Speedometer Stop	55027						
04. Speedometer Start	54944						
05. Total Mileage	83						
06. Broom Meter Stop	86	12					83
07. Broom Meter Start	66	93					
08. Total Broom Mileage	20	19					
09. Total Travel Mileage	22	7	15				39
10. Dump Milage (Information only)	/						43
11. Equipment/ Manual Hours	4.0	4.0					/
12. Maintenance Hours	0						8.0
13. Breaks	0						0
14. Down Time	0						0
15. Total Hours	8.0						0
16. Water Usage (cubic feet)	800	650					8.0
17. Debris Collected (cu. ft.)	5.0	3.5					1450
							8.5

Dump Location	Cubic Yards
ROSE CANYON	8.5

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

MIRAMAR RT. IN MB-2 BIN

CLAIREMONT RT. IN ORANGE EAST BIN

SWEEPER DAILY REPORT

Date: 2-25-2010			Equipment #: 718-057		Operator: Ethridge		
01. Route/Job No	South Bay	Friars					Grand Total
02. Complete Incomplete	comp	comp					comp.
03. Speedometer Stop	13167	13187					
04. Speedometer Start	13124	13167					
05. Total Mileage	43	20					63
06. Broom Meter Stop	13154	13182					
07. Broom Meter Start	13144	13175					
08. Total Broom Mileage	10	7					17
09. Total Travel Mileage	20	8					28
10. Dump Milage (Information only)	13	5					18
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours							
16. Water Usage (cubic feet)	200	175					375
17. Debris Collected (cu. ft.)	3	2.5					5.5

Dump Location	Cubic Yards
Chollas	5.5

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

South Bay Debri In South Bin
Friars In North Bin

SWEEPER DAILY REPORT

Date: 2/26/10			Equipment #: 718-055		Operator: [signature]	
01. Route/Job No.		Southbay @ I-805	Montezuma + Friars rd.			Grand Total
02. Complete Incomplete		C	C			
03. Speedometer Stop	11013					
04. Speedometer Start	10953					
05. Total Mileage	60					60
06. Broom Meter Stop		977	005			
07. Broom Meter Start		969	997			
08. Total Broom Mileage		8	8			16
09. Total Travel Mileage						44
10. Dump Milage (Information only)						
11. Equipment/ Manual Hours						
12. Maintenance Hours						
13. Breaks						
14. Down Time						
15. Total Hours						
16. Water Usage (cubic feet)		425	450			875
17. Debris Collected (cu. ft.)		2.5	2.5			5

Dump Location	Cubic Yards
Chollas	5

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

Note: Southbay center islands swept @ Palm ave. + I-805 to Imperial Beach city limits.
Montezuma center islands swept @ Montezuma + El Cajon blvd. to Auto Circle.

TF-101 (REV. 1-96)

SWEEPER DAILY REPORT

OTAY & Friars

(22) SPECIAL 4154903 | SPECIAL 4154904 | SPECIAL 4154905 | SPECIAL 4154906

Date: 3-~~19~~-2010 | Equipment #: 718 057 | Operator: Ethridge, J

							Grand Total
01. Route/Job No.	8B	8A	6I	3I	10.19		
02. Complete Incomplete	Comp	Comp	Comp	Comp			Comp
03. Speedometer Stop	13630	15654	13669	13674	13679		
04. Speedometer Start	13608	13630	13654	13669	13674		
05. Total Mileage	22	24	15	5	5	41.1	71
06. Broom Meter Stop	15630	15636	13669	13674			
07. Broom Meter Start	13629	13630	13666	13669			
08. Total Broom Mileage	1	6	3	5		15.3	15
09. Total Travel Mileage	21	Ø	12	Ø	5		38
10. Dump Milage (Information only)	Ø	18	Ø	Ø			18
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours	.25	2.50	1.25	2			
16. Water Usage (cubic feet)	25	145	50	125			345
17. Debris Collected (cu. ft.)	1.0	1.5	1.0	1			4.5

Dump Location	Cubic Yards
Chollas	4.5

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

Otay - W Friars

SWEEPER DAILY REPORT

SPECIAL 4155108 | SPECIAL 4155110 | SPECIAL 4155112

Date: 3/20/10 | Equipment #: 718-049 | Operator: Bryant [signature]

01. Route/Job No.		8B	3I	6I			Grand Total
02. Complete Incomplete		C	C	C			
03. Speedometer Stop	47168						
04. Speedometer Start	47111						
05. Total Mileage	57					64.7	57
06. Broom Meter Stop		135	158	160			
07. Broom Meter Start		127	154	158			
08. Total Broom Mileage		8	4	2		18.7	14
09. Total Travel Mileage							43
10. Dump Milage (Information only)							
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours		3.5	1.75	.75			
16. Water Usage (cubic feet)		700	150	150			600
17. Debris Collected (cu. ft.)		1	.5	.5			2

Dump Location	Cubic Yards
Chollas	2

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

SWEEPER DAILY REPORT

20 OVERTIME SPECIAL 4154908 SPECIAL 4154909 SA 6C

Date: 3/19/10			Equipment #: 718.058	Operator: FA141.D			
01. Route/Job No	MIRAMAR RD.	CLAIRE-MONT	10.19				Grand Total
02. Complete Incomplete	Comp.	Comp.					
03. Speedometer Stop	15503	15522	15537				
04. Speedometer Start	15460	15503	15522				
05. Total Mileage	43	19	15			77.2	77
06. Broom Meter Stop	15503	15522					
07. Broom Meter Start	15480	15508					
08. Total Broom Mileage	8	13				21.9	21
09. Total Travel Mileage	20	5	15				40
10. Dump Milage (Information only)	15	1					16
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours	2.25	3.75					
16. Water Usage (cubic feet)	250	300					550
17. Debris Collected (cu. ft.)	2	2					4

Dump Location	Cubic Yards
ROSE CANYON	4

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

ROUTES COMPLETE

SWEEPER DAILY REPORT

20 SPECIAL 4154938 SPECIAL 60 4154965

Date: 3/19/2010 .5A			Equipment # 718-038	Operator: LC		
01. Route/Job No	MIRAMAR RD	~~Clairemont~~ (DelBea) - 6D				Grand Total
02. Complete Incomplete	COMP →	→				
03. Speedometer Stop	55685					
04. Speedometer Start	55627					
05. Total Mileage	58				53.0	58
06. Broom Meter Stop	50	66				
07. Broom Meter Start	40	56				20
08. Total Broom Mileage	10	10			16.1	~~10~~
09. Total Travel Mileage	13	6	19			38
10. Dump Milage (Information only)						
11. Equipment/ Manual Hours	4	4				8
12. Maintenance Hours						
13. Breaks						
14. Down Time						
15. Total Hours	8					8
16. Water Usage (cubic feet)	600	600				1200
17. Debris Collected (cu. ft.)	2	2				4.0

Dump Location	Cubic Yards
ROSE CANYON	4.0

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

19
19
38

TF-101 (REV. 1-96)

SWEEPER DAILY REPORT

SPECIAL 4156331 | SPECIAL 4156332

Date: 4/10/2010			Equipment #: 718-038		Operator: LC	
01. Route Name	5A MIRAMAR RD	6B MORENA BLVD				Grand Total
02. Complete Incomplete	compl	*INC – completed by other operator – Faiai				
03. Speedometer Stop	56292					
04. Speedometer Start	56241					
05. Total Mileage	51					
06. Broom Meter Stop	66	76			47.4	51
07. Broom Meter Start	57	72				
08. Total Broom Mileage	9	4				
09. Total Travel Mileage	16	6	16		11.9	13
10. Dump Milage (Information only)						38
11. Equipment/ Manual Hours	3	1.5				4.5
12. Maintenance Hours						
13. Breaks						
14. Down Time						
15. Total Hours	8.0					
16. Water Usage (cubic feet)	4.25 700	1.75 300				8.0
17. Debris Collected (cu. ft.)	3	1.5				1,000 4.5

Dump Location	Cubic Yards
RC	4.5

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

In complete second nought Due to rear ended

J.T.
Center Island

SPECIAL 4156479

SPECIAL 4156481

SWEEPER DAILY REPORT

4/10/10

Date: ~~4/9/10~~	5A	6D	Equipment #: 718.058		Operator: FAIAI. D		
01. Route/Job No	MIRA MAR RD.	CLAIRE-MONT	⟶	⟶	10.19		Grand Total
02. Complete Incomplete	CENTER ISLANDS	⟶	⟶	⟶			
03. Speedometer Stop	16088	16096	16101	16106	16124		
04. Speedometer Start	16045	16088	16096	16101	16106		
05. Total Mileage	43	8	5	5	18	81	79
06. Broom Meter Stop	16088	16096	16101	16106			
07. Broom Meter Start	16065	16091	16096	16101			
08. Total Broom Mileage	8	5	5	5		25.1	23
09. Total Travel Mileage	20	3	Ø	Ø	18		41
10. Dump Milage (Information only)	15	Ø	Ø	Ø			15
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours	2	4					
16. Water Usage (cubic feet)	250	100	100	100			550
17. Debris Collected (cu. ft.)	2	.5	.5	.5			3.5

Dump Location	Cubic Yards
ROSE CANYON (BIN MIRA MAR)	2
" " (BIN CLAIREMONT)	1.5

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

ROUTES COMPLETE!

SWEEPER DAILY REPORT

- SPECIAL - 4156324
- SPECIAL - 4156325
- SPECIAL - 4156326

4-10-10

Date: ~~4/9/10~~		Equipment #: 48045		Operator: [signature]		
01. Route/Job No		8B	3I	6I			Grand Total
02. Complete / Incomplete		C	C	C			
03. Speedometer Stop	46616						
04. Speedometer Start	46560						
05. Total Mileage	56					53.9	56
06. Broom Meter Stop		583	606	609			
07. Broom Meter Start		575	602	606			
08. Total Broom Mileage		8	4	3			15
09. Total Travel Mileage							41
10. Dump Milage (Information only)							
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours		3.25	1.50	1.25			
16. Water Usage (cubic feet)		350	150	100		(600)	~~550~~
17. Debris Collected (cu. ft.)		.5	.5	.5			1.5

Dump Location	Cubic Yards
Chollas	1.5

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

8A
8B Otay

3I
6I Friars

TF 101 (REV. 1-96)

SWEEPER DAILY REPORT

4-10-10 SPECIAL 4156327 SPECIAL 4156328 SPECIAL 4156329 SPECIAL 4156330

Date: ~~4.9.10~~ | Equipment #: 718-050 | Operator: Baker

							Grand Total
01. Route/Job No	8B	8A	6I	3I			
02. Complete Incomplete	Comp.	Comp.	Comp	Comp.			Comp.
03. Speedometer Stop	674	677	703	711			
04. Speedometer Start	58655	58674	58677.	58703			
05. Total Mileage	19	3	26	8		64.5	36
06. Broom Meter Stop	674	677	703	707			
07. Broom Meter Start	58672	58674	58700	58703			
08. Total Broom Mileage	2	3	23	4			
09. Total Travel Mileage	17	0	3	4		15	32 24
10. Dump Milage (Information only)			15				
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours	.50	.50	4.25	.75			
16. Water Usage (cubic feet)	100	100	150	150			500
17. Debris Collected (cu. ft.)	1YD	1YD	1YD	2YDS			5YDS

Dump Location	Cubic Yards
Chollas	5yds

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

TF-101 (REV 1-96)

SWEEPER DAILY REPORT

OVERTIME

Date: 5/01/10			Equipment #: 718·058		Operator: FAIA I.D		
01. Route/Job No.	1B	5A	6D	6C	6E	10·19	Grand Total
02. Complete Incomplete	LAJOLLA VILLAGE DR	MIRAMAR RD.	BALBOA AVE.	CLAIRE-MONT MESA	BALBOA AVE		
03. Speedometer Stop	16600	16620	16628	16631	16637	16655	
04. Speedometer Start	16578	16600	16620	16628	16631	16637	
05. Total Mileage	22	20	8	3	6	18	77
06. Broom Meter Stop	16600	16620	16628	16631	16637		
07. Broom Meter Start	16598	16600	16623	16628	16631		
08. Total Broom Mileage	2	6	5	3	3		19
09. Total Travel Mileage	20	Ø	3	Ø	Ø	18	41
10. Dump Milage (Information only)	Ø	14	Ø	Ø	3		17
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours							
16. Water Usage (cubic feet)	50	100	100	50	50		350
17. Debris Collected (cu. ft.)	.5	1	1	.5	.5		3.5

Dump Location	Cubic Yards
ROSE CANYON BIN	
MIRAMAR	1.5
CLAIREMONT	2

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

ROUTES COMPLETE!

SWEEPER DAILY REPORT

Date: 4.31.10			Equipment #: 718-050		Operator: BOOKER		
01. Route/Job No	5A	1B	6B	6D			Grand Total
02. Complete Incomplete	Comp.	Comp.	Comp.	Comp.			Comp.
03. Speedometer Stop	137	138	146	169			52
04. Speedometer Start	59117	59137	59138	59146			
05. Total Mileage	20	1	8	23			
06. Broom Meter Stop	137	138	146	153			
07. Broom Meter Start	59131	59137	59145	59146			
08. Total Broom Mileage	6	1	1	7			15
09. Total Travel Mileage	14	—	7	16			37
10. Dump Milage (Information only)							
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours							
16. Water Usage (cubic feet)	150	50	50	150			400
17. Debris Collected (cu. ft.)	1YD	1/2YD	1/2YD	1YD.			3YDS

Dump Location	Cubic Yards
ROSE CANYON	3YDS

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

TF-101 (REV 1-96)

SWEEPER DAILY REPORT

Date: 4 - 30 - 2010		Equipment #: 718 057		Operator: Ethridge, T		
01. Route/Job No	8 B	8A	6 I	3 I	6 I	10.19	Grand Total
02. Complete Incomplete	Comp	Comp	Comp	Comp	Comp		
03. Speedometer Stop	14734	14754	14766	14771	14776	14782	
04. Speedometer Start	14718	14734	14754	14766	14771	14776	
05. Total Mileage	16	20	12	5	5	6	64
06. Broom Meter Stop	14734	14740	14766	14771	14776		
07. Broom Meter Start	14733	14734	14762	14766	14771		
08. Total Broom Mileage	1	6	4	5	5		21
09. Total Travel Mileage	15	0	8	0	0	6	29
10. Dump Milage (Information only)	0	0 14	0	0	0		14
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours							
16. Water Usage (cubic feet)	25	100	50	120	125		430
17. Debris Collected (cu. ft.)	.5	1	1	.5	1		4

Dump Location	Cubic Yards
Chollas	4

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

TP-101 (REV. 1-96)

SWEEPER DAILY REPORT

Date: 4/30/10			Equipment #: 718045		Operator: [signature]		
01. Route/Job No		8B	3I	6I			Grand Total
02. Complete Incomplete		C	IC	IC			
03. Speedometer Stop	47255						
04. Speedometer Start	47205						
05. Total Mileage	50						50
06. Broom Meter Stop		229	250	/			
07. Broom Meter Start		220	247				
08. Total Broom Mileage		9	3	0			12
09. Total Travel Mileage							38
10. Dump Milage (Information only)							
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours							
16. Water Usage (cubic feet)		250	/	/			250
17. Debris Collected (cu. ft.)		.5					.5

Dump Location	Cubic Yards
Chollas	.5

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

Elevator needs adjustment.
E.T completed Route 3I and 6I

SWEEPER DAILY REPORT

SPECIAL 41597786 | SPECIAL 41597787 | SPECIAL 41597788 | SPECIAL 41597789

Date: 5.22.2010			Equipment #: 718-049		Operator: A Todd		
01. Route / Job No	8B	8A	6I	3I			Grand Total
02. Complete Incomplete	C	C	C	C			
03. Speedometer Stop	Otay	Otay	Friars	Friars			
04. Speedometer Start	48471						48518
05. Total Mileage							48471
06. Broom Meter Stop	48484	48489	48509	48513		71.2	47
07. Broom Meter Start	48482	48484	48506	48509			/
08. Total Broom Mileage	2	5	3	4			/
09. Total Travel Mileage						22.2	14
10. Dump Milage (Information only)							33
11. Equipment / Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours	.75	2.25	1.25	1.75			
16. Water Usage (cubic feet)	150	150	150	150			600
17. Debris Collected (cu. ft.)	1	2	1	1			5

Dump Location	Cubic Yards
Chollas	

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

OTAY & Friars

TP-101 (REV. 1-96)

SWEEPER DAILY REPORT

SPECIAL 4159735 SPECIAL 415973

Date: 5.21.10			Equipment #: 718-7050		Operator: Booker		
01. Route/Job No	1B	5A	1B				Grand Total
02. Complete Incomplete	Comp.	Comp.	Comp.				Comp.
03. Speedometer Stop	26	037	040				
04. Speedometer Start	60003	60026	600037				
05. Total Mileage	23	11	3			85.7	37
06. Broom Meter Stop	26	037	040				
07. Broom Meter Start	60024	60026	60037				
08. Total Broom Mileage	2	11	3			38.2	16
09. Total Travel Mileage	21	0	0				21
10. Dump Milage (Information only)	—	—	4				
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours	.25	2	.50				
16. Water Usage (cubic feet)	50	300	50				400
17. Debris Collected (cu. ft.)	1 1/2	1	1 1/2				4YDS

Dump Location	Cubic Yards
ROSE CANYON	4YDS

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

5A - Miranar

1B - C/m

TF-101 (REV 1-96)

SWEEPER DAILY REPORT

SPECIAL C 4159729 | SPECIAL C 4159731 | SPECIAL C 4159731 | SPECIAL C 4159732

Date: 5.24.10			Equipment #: 718-050		Operator: BOOKER		
01. Route / Job No	6B	6E	6D	6C	6D	6E	Grand Total
02. Complete Incomplete	comp.	Comp	Comp.	Comp.	Comp.	Comp	Comp.
03. Speedometer Stop	047	056	058	060	062	080	
04. Speedometer Start	60046	60047	600 56	60058	60060	60062	
05. Total Mileage	1	9	2	2	2	18	34
06. Broom Meter Stop	047	056	058	60060	062	063	
07. Broom Meter Start	60046	60047	60056	60058	60060	60062	
08. Total Broom Mileage	1	9	2	2	2	1	17
09. Total Travel Mileage	—	—	—	—	—	17	17
10. Dump Milage (Information only)							
11. Equipment/ Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours	.25	2	.25	.25	.25	.25	
16. Water Usage (cubic feet)	50	200	50	50	50	50	450
17. Debris Collected (cu. ft.)	1/2	1	1/2	1/2	1/2	1/2	3 1/2 YDS

Dump Location	Cubic Yards
ROSE CANYON	3YDS

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

All C/m area

SWEEPER DAILY REPORT

SPECIAL 4159783 SPECIAL 4159784 SPECIAL 4159785

Date: 5/21/10			Equipment #: 718-058		Operator: Bryant [signature]		
01. Route / Job No.		8B	3I	6I			Grand Total
02. Complete Incomplete		C	C	C			
03. Speedometer Stop	17454	OTAY	Friars	Friars			
04. Speedometer Start	17396						
05. Total Mileage	58					58.6	58
06. Broom Meter Stop		422	444	447			
07. Broom Meter Start		413	440	444			
08. Total Broom Mileage		9	4	3		16.5	16
09. Total Travel Mileage							42
10. Dump Milage (Information only)							
11. Equipment / Manual Hours							
12. Maintenance Hours							
13. Breaks							
14. Down Time							
15. Total Hours		3.25	1.5	1.25			
16. Water Usage (cubic feet)		300	150	150			600
17. Debris Collected (cu. ft.)		1	.5	.5			2

Dump Location	Cubic Yards
Chollas	2

REMARKS: (reason for down time, unusual conditions of route, location of special job, etc.)

OTAY & Friars

TP-101 (REV 1-96)

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Appendix F Analytical Results

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Baseline Street Sediment Collection Results

	Miramar Area	Clairemont Area	Mission Valley Area	Tijuana River Area	Units
% Solids	95.1	96.9	93.1	92.8	%
Metals					
Aluminum	4,700	7,400	4,600	4,800	mg/kg
Antimony	-	3	-	-	mg/kg
Arsenic	4	5.3	1.2	2.4	mg/kg
Barium	48	60	52	44	mg/kg
Chromium	23	18	27	24	mg/kg
Cobalt	3.9	2.1	1.8	2.5	mg/kg
Copper	77	68	54	210	mg/kg
Iron	17,000	15,000	11,000	16,000	mg/kg
Lead	22	49	18	14	mg/kg
Manganese	150	210	180	160	mg/kg
Molybdenum	5.9	6.8	4.5	5.1	mg/kg
Nickel	11	5.4	15	6.5	mg/kg
Strontium	25	26	35	65	mg/kg
Thallium	3	-	-	-	mg/kg
Titanium	-	500	370	320	mg/kg
Vanadium	22	28	20	25	mg/kg
Zinc	160	94	89	100	mg/kg
General Chemistry					
Ammonia as N	8	18.6	13.1	7.51	mg/kg
Nitrate as N	-	0.6	-	-	mg/kg
Phosphorus, Total as P	231	157	184	194	mg/kg
Total Kjeldahl Nitrogen	620	350	560	670	mg/kg
Hydrocarbons					
Diesel	88	78	99	110	mg/kg
Oil & Grease (HEM)	2,300	3,570	2,880	2,280	mg/kg
Toluene-d8	230	228	229	210	mg/kg

Hand-Swept Sweeping Collection Results

	Miramar Area	Clairemont Area	Mission Valley Area	Tijuana River Area	Units
	Route 1	Route 2	Route 3	Route 4	
Sample Date	5/21/2010 14:20	5/21/2010 14:55	5/21/2010 15:45	5/21/2010 13:25	
% Solids	99	99	99	99	%
Metals					
Aluminum	4900	5500	4400	4900	mg/kg
Antimony	0	0	0	7	mg/kg
Arsenic	5	7	6	8	mg/kg
Barium	70	49	63	140	mg/kg
Chromium	35	19	46	98	mg/kg
Cobalt	6	4	4	5	mg/kg
Copper	120	33	66	410	mg/kg
Iron	20000	15000	16000	27000	mg/kg
Lead	4.1	280	70	460	mg/kg
Manganese	250	210	230	410	mg/kg
Molybdenum	7	5	5	5	mg/kg
Nickel	8	6	25	38	mg/kg
Strontium	19	17	25	61	mg/kg
Thallium	0	1	0	1	mg/kg
Tin	21	21	42	86	mg/kg
Titanium	340	230	340	310	mg/kg
Vanadium	24	22	29	42	mg/kg
Zinc	230	130	140	340	mg/kg
General Chemistry					
Ammonia as N	25	34	20	28	mg/kg
Nitrate as N	9	4	7	3	mg/kg
Phosphorus, Total as P	208	340	196	236	mg/kg
Total Kjeldahl Nitrogen	320	1500	380	680	mg/kg
Hydrocarbons					
Diesel	280	71	93	0	mg/kg
Gasoline	0.2	0	0.2	0.2	mg/kg
Oil & Grease (HEM)	3490	3820	5360	3920	mg/kg

Street Debris Sediment Collection Results

	Miramar Area				Clairemont Area				Mission Valley Area				Tijuana River Area			
	Route 1				Route 2				Route 3				Route 4			
SAMPDATE	03/20/2010 09:41:00	04/10/2010 08:40:00	05/01/2010 09:23:00	05/22/2010 08:25:00	03/20/2010 09:59:00	04/10/2010 08:30:00	05/01/2010 09:31:00	05/22/2010 08:25:00	03/20/2010 08:19:00	04/10/2010 07:45:00	05/01/2010 10:10:00	5/22/2010 7:37	03/20/2010 08:48:00	04/10/2010 07:56:00	05/01/2010 10:15:00	05/22/2010 07:50:00
% Solids	96	0.8	1.8	97	97	2	1.8	95	96	2.5	2.3	96	95	4.5	1.9	98
Metals																
Aluminum	4,800	5,800	4,700	4,200	6,000	9,300	6,700	4,300	4,000	6,800	4,400	3,900	6,500	9,300	6,000	5,700
Arsenic	2.5	120	6.5	6	4.2	7.9	12	3.6	1.5	5.2	7.5	4.9	3.9	6.6	9.6	4.6
Barium	45	57	45	55	42	56	42	42	49	69	53	59	52	53	36	62
Chromium	15	13	30	330	15	34	15	15	24	22	39	30	22	25	17	33
Cobalt	3.9	3.6	4	4.6	3.5	4.5	4.5	12	3.4	4.3	4.1	3.6	3.8	5.7	3.7	5.7
Copper	37	30	41	650	33	38	22	79	34	32	46	52	120	150	8.5	110
Iron	14,000	15,000	13,000	1,5000	11,000	15,000	15,000	11,000	11,000	15,000	13,000	12,000	17,000	18,000	12,000	18,000
Lead	18	5.1	8.8	9.3	13	70	19	26	61	11	10	33	16	11	18	34
Manganese	180	260	180	200	170	230	220	150	170	260	170	180	220	260	170	190
Mercury	-	-	-	0.051	-	-	-	-	-	-	-	-	-	-	-	-
Molybdenum	4.9	5.6	4.3	30	5.2	4.1	5.7	3.5	3.6	3.9	5.9	3.8	2.9	2.9	2.9	3.3
Nickel	8	7.8	8.3	240	7.7	8.4	6.6	8.8	11	9.6	8.4	11	17	10	6.9	15
Selenium	-	-	-	-	1.9	-	1.4	-	-	-	-	-	-	-	-	-
Strontium	24	69	37	190	22	33	22	29	43	50	34	55	29	31	18	55
Thallium	-	1.1	-	-	-	-	1.2	-	-	-	1.5	-	-	-	-	3.1
Tin	19	5.8	11	390	17	31	-	13	24	14	29	25	15	17	-	21
Titanium	360	470	320	250	380	530	400	200	320	530	320	220	310	550	340	230
Vanadium	22	24	21	21	24	35	25	20	18	26	20	20	28	33	25	34
Zinc	90	110	110	160	110	110	120	320	93	120	110	140	130	180	75	200

SAMPDATE	Miramar Area				Clairemont Area				Mission Valley Area				Tijuana River Area			
	Route 1				Route 2				Route 3				Route 4			
	03/20/2010 09:41:00	04/10/2010 08:40:00	05/01/2010 09:23:00	05/22/2010 08:25:00	03/20/2010 09:59:00	04/10/2010 08:30:00	05/01/2010 09:31:00	05/22/2010 08:25:00	03/20/2010 08:19:00	04/10/2010 07:45:00	05/01/2010 10:10:00	5/22/2010 7:37	03/20/2010 08:48:00	04/10/2010 07:56:00	05/01/2010 10:15:00	05/22/2010 07:50:00
General Chemistry																
Ammonia as N	18.5	6.92	-	23.8	24.9	3.02	11.7	12.1	17.3	21.8	3.41	29.4	29.3	30.2	-	11.4
Nitrate as N	-	3	2.8	4.7	0.9	2.4	1.7	-	0.8	2.2	0.9	3.3	-	1.1	0.6	6.8
Nitrite as N	-	0.6	-	-	-	0.7	-	-	-	0.7	-	-	-	0.7	-	-
Phosphorus, Total as P	162	1.2	185	189	164	191	179	154	190	206	190	265	328	220	162	244
Total Kjeldahl Nitrogen	430	-	400	750	400	240	410	730	540	340	510	820	470	580	250	770
Hydrocarbons																
Diesel	310	-	-	190	160	-	-	210	140	-	150	160	160	-	-	150
Gasoline	0.091	-	0.065	0.065	-	0.57	0.14	0.25	-	0.096	0.12	0.16	0.2	0.15	0.072	0.16
Oil & Grease (HEM)	6,160	-	4,300	3,770	6,920	6,000	5,360	6,740	5,120	4,490	3,920	5,370	5,700	6,030	4,290	5,590
Toluene	-	-	-	27.4	-	-	-	-	-	-	-	-	-	-	-	-
Toluene-d8	43.3	44.4	251	53.5	46	230	261	50.2	48.6	221	254	44.7	44.4	248	249	48.3