CHARACTERIZATION OF STREET SWEEPINGS, STORMWATER SEDIMENTS, AND CATCH BASIN SEDIMENTS, IN FLORIDA FOR DISPOSAL AND REUSE

Final Report

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, ACRONYMS, AND UNITS OF MEASUREMENT

BDL	Below Detection Limit
CompQAP	Comprehensive Quality Assurance Plan
FCSHWM	Florida Center for Solid and Hazardous Waste Management
FDEP	Florida Department of Environmental Protection
g	gram
GC	Gas Chromatography
GC-ECD	Gas Chromatography Electron Capture Detector
GC-MS	Gas Chromatography Mass Spectrometer
GFAA	Graphite Furnace Atomic Absorption
GWCTLs	Groundwater Cleanup Target Levels
HPLC	High Pressure Liquid Chromatography
ICP	Inductively Couple Plasma
mg/kg	milligram per kilogram
mg/L	milligrams per liter
mm	millimeter
MQL	Minimum Quantitation Limit
OCl Pest	Organochlorine Pesticides
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
SCTLs	Soil Cleanup Target Levels

SPLP	Synthetic Precipitation Leaching Procedure
SVOC	Semi-Volatile Organic Compounds
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
US EPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compounds
ZHE	Zero Headspace Extraction Vessel
µg/kg	microgram per kilogram
µg/L	microgram per liter

KEYWORDS

Street Sweepings

Catch Basin Sediments

Stormwater Pond Sediments

Leaching

Synthetic Precipitation Leaching Procedure (SPLP)

Soil Cleanup Target Levels (SCTLs)

Groundwater Cleanup Target Levels (GWCTLs)

Beneficial Use

ABSTRACT

Research was performed to examine the chemical characteristics of street sweepings, stormwater pond sediments, and catch basin sediments. Large amounts of these materials are produced as part of routine maintenance activities by many utilities and public/private agencies. These materials, referred to collectively here as "residuals," are solid wastes. Generators have historically practiced several different strategies for their management (e.g., landfill disposal, reuse as fill material). As with any solid waste, the occurrence and concentration of pollutants in the residuals dictate which management options are most appropriate. For example, the choice of whether residuals must be disposed in a lined landfill versus an unlined landfill depends on the propensity of the materials to "leach" pollutants into the groundwater. When residuals are beneficially reused in a fashion where direct human contact is possible, the risk of exposure to pollutants must be assessed. Thus, a necessity for proper decision-making is a thorough understanding of typical chemical characteristics.

Street sweepings, stormwater pond sediments, and catch basin sediments samples were collected from 20 different locations throughout Florida. The samples were analyzed for the following chemical parameters: volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, herbicides, metals, and leachable inorganic ions. The analytical methods followed established U.S. Environmental Protection Agency (US EPA) methods and other standardized analytical procedures. Both the total concentrations (mg/kg) and the leachable concentrations (mg/L) were measured. Results were compared to Florida Department of Environmental Protection soil cleanup target levels (SCTLs) and groundwater cleanup target levels (GWCTLs). Comparison to target levels is a standard practice when evaluating risk to human health and the environment associated with the reuse or disposal of a solid waste.

The results of metal concentrations of more than 300 total samples found that arsenic concentrations in 105 samples exceeded the residential SCTLs for direct exposure (0.8 mg/kg). All other metals typically fell below the analytical detection limits or were detectable but less than the SCTLs. Metal leaching was evaluated using the synthetic precipitation leaching procedure (SPLP). Metals in the majority of the SPLP extracts were found at concentrations less than GWCTLs. For the most part, the total concentrations of organic compounds were not a prevailing concern in regard to SCTLs for direct exposure. Organic leaching limits were exceeded in only a few samples. Secondary water quality parameters were also examined in several SPLP leachates, and aluminum, iron, and pH were found on occasion to exceed their respective GWCTLs.

The information gathered greatly adds to the existing knowledge of the types and typical concentrations of pollutants occurring in street sweepings, stormwater pond sediments, and catch basin sediments. This information should prove valuable for those charged with developing policies for the appropriate management of these residuals.

EXECUTIVE SUMMARY

Introduction

The management of residuals created by the maintenance of paved roads (street sweepings), stormwater ponds, and catch basins has been raised as an issue in Florida. These materials are collectively referred to here as "residuals." The two management practices most commonly employed for residuals management are direct landfilling and stockpiling for future use or disposal. The large soil content of these materials has prompted the desire to beneficially use them in an application such as clean fill. This objective, coupled with costs associated with landfill disposal, provides incentive to explore reuse options. Prior to reuse via land application, the chemical properties of the residuals must be assessed to determine the potential environmental impacts when land-applied or reused. The University of Florida's Department of Environmental Engineering Sciences was contracted by the Florida Department of Environmental Protection (FDEP), the Florida Center for Solid and Hazardous Waste Management (FCSHWM), and a consortium of public agencies to perform the chemical characterization of residuals in Florida. This report presents the results of chemical analyses conducted on residuals collected throughout Florida.

Methodology

Thirteen sampling trips were conducted over fifteen months (January 2001–March 2002) to facilities that produce residuals or to locations where these materials could be collected directly. Twenty different sampling locations were visited. In all cases, street sweepings were collected from piles (or roll-off containers) deposited by individual sweepers or dump trucks containing street sweepings. Pond sediments were collected directly from the stormwater ponds. Catch basin sediments were collected from materials emptied from vacuum collection vehicles; in some cases they were collected from the catch basins themselves. The land use category contributing to the residuals was noted where possible (e.g., residential, industrial).

Total content analyses (mg/kg) for metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc) and organics (volatile organics, semi-volatile organics, herbicides, and pesticides) were performed. When applicable, the results of total content analyses were compared to the Florida SCTLs. Target levels are not regulatory standards with respect to land application of solid waste, but they represent a set of risk-based goals used in the assessment of waste site cleanup. Furthermore, the levels can be used voluntarily in lieu of a risk assessment by those who want to land-apply solid waste. A synthetic precipitation leaching procedure (SPLP) test was also performed to determine leachability of pollutants such as metals, organics, and secondary water quality parameters. The concentrations of chemicals detected in the SPLP extracts were compared to the Florida GWCTLs to assess potential leaching risks to groundwater. Some SPLP leachates were also analyzed (in addition to heavy metals and organic pollutants) for secondary water quality parameters. Leaching tests were performed on approximately one-half of the collected samples.

Results

Results for both total and leaching analyses of street sweepings, stormwater pond sediments, and catch basin sediments are summarized as follows:

1. More than 300 residual samples were collected and analyzed (306 for Ag, 355 for As, 306 for Ba, 354 for Cd, 306 for Cr, 354 for Cu, 303 for Hg, 354 for Ni, 354 for Pb, 354 for Se, and 354 for Zn). The majority of the total sample concentrations (mg/kg) of silver, cadmium, mercury, and selenium fell below the instrument detection limits. Barium, chromium, copper, nickel, lead, and zinc were detected in more than half of the total samples but generally below the SCTLs. In almost half of the total samples analyzed, arsenic (178 samples) was detected, and 105 samples exceeded the arsenic SCTL for residential areas (0.8 mg/kg). Of the arsenic samples detected, 11 samples were above the industrial SCTL of 3.7 mg/kg.

2. Three hundred and two samples were analyzed for the total concentration (mg/kg) of volatile organic compounds (VOCs). Of 74 VOCs target compounds tested, 12 compounds were detected in a few of the samples. None of the compounds in the samples exceeded the SCTLs for either residential or industrial settings.

3. The total concentrations (mg/kg) of semi-volatile organic compounds (SVOCs) were analyzed for 300 residual samples. Of 116 SVOCs tested, 17 compounds (primarily polycyclic aromatic hydrocarbons [PAHs] and phthalates) were found in a few. Three PAHs (benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene) were detected above the SCTLs for residential and industrial limits in two samples (one sample from street sweepings and one from catch basin sediments). The sample from catch basin sediments also contained other PAHs, such as anthracene, benzo(ghi)perylene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene. The concentration of benzo(k)fluoranthene in the sample exceeded the SCTLs for residential areas, and the concentration of indeno(1,2,3-cd)pyrene was found above both residential and industrial SCTLs. No phthalate compounds detected exceeded the respective SCTLs.

4. The total concentrations (mg/kg) of organochlorine pesticides (OCl Pest) were analyzed for 323 samples. Of 43 target pesticide compounds, 14 were detected in a number of samples. Two OCl Pests, 4,4'-DDT and Endosulfan II, were found in 66 and 44 samples, respectively. Neither compound exceeded their respective SCTL. Only one compound, dieldrin, exceeded the SCTLs in four samples; three exceeded the residential SCTL limit of 70 μg/kg, and one exceeded the industrial SCTL limit of 300 μg/kg.

5. No nitrogen-phosphorus pesticides were found above the detection limit (0.25 mg/kg) in any of the 314 total samples.

6. SPLP leaching tests were performed to examine the "leachable" concentration (mg/L) of 11 metals (arsenic, barium, cadmium, copper, chromium, lead, mercury, nickel, selenium, silver and zinc). At a minimum, 150 SPLP leachate samples were analyzed for each metal (150 for Ag, 185 for As, 150 for Ba, 178 for Cd, 150 for Cr, 184 for Cu, 169 for Hg, 184 for

Ni, 184 for Pb, 154 for Se, and 184 for Zn). Four metals (arsenic, barium, lead, and zinc) were detected above the respective detection limits in a number of samples (27 for As, 78 for Ba, 50 for Pb, and 44 for Zn). Of 50 samples detected for lead, eight exceeded the GWCTL for lead (0.015 mg/L). None of the other three metals exceeded its respective GWCTL. Cadmium, chromium, copper, and nickel were detected above the detection limits in a few samples (3 for Cd and Cr, 2 for Cu, and 3 for Ni). One out of three detected samples exceeded the GWCTL for cadmium (0.005 mg/L). Of 184 samples, nickel was found in three samples, all of which exceeded the GWCTL limit of 0.1 mg/L.

7. A SPLP tests were also performed to examine leachability of organic compounds (VOCs, SVOCs, OCl Pests, nitrogen-phosphorus pesticides, chlorinated herbicides, and N-methylcarbamates). One hundred and fifty-five SPLP leachates were analyzed for VOCs. Nine VOC compounds were detected in three samples above the detection limit of 5.0 μg/L. Four compounds (1,4-dichlorobenzene, naphthalene, 1,3,5-trimethylbenzene, and o-xylene) were found in two samples above the GWCTLs of their respective analytes. Several solvents used in the SVOC and pesticide analysis were detected in the SPLP leachates, but these were also found in many of the blanks and are thus believed the result of contamination.

8. One hundred and forty-seven SPLP leachates were analyzed for SVOCs. No acid and base/neutral SVOC compounds were detected above the detection limit of 10 μg/L in any of the samples. No nitrogen-phosphorus pesticides and N-methylcarbamates were found in any of the SPLP extracts from 132 samples and 176 samples, respectively.

9. One hundred and sixty-six leaching samples were analyzed for OCl Pests. Out of 43 target OCl Pests, three compounds were detected above the detection limit of 0.05 μg/L in a few samples: 4,4'-DDT in 13 samples, beta-BHC in 7 samples, and Endosulfan II in 1 sample. The concentrations of 4,4'-DDT in all detected samples exceeded the GWCTL of 0.1 μg/L. No GWCTLs are available for the other two detected compounds.

10. Thirty SPLP leachate samples were analyzed for secondary water quality parameters. The secondary parameters included aluminum, chloride, copper, ethylbenzene, fluoride, iron, manganese, pH, silver, sulfate, toluene, total dissolved solids (TDS), xylenes, and zinc. Aluminum was detected above the detection limit in 20 leaching samples, all of which exceeded the secondary standard for drinking water (0.2 mg/L). Iron concentrations, detected in 8 samples, exceeded the secondary standard concentration of 0.3 mg/L. The concentrations of iron ranged from 0.32 to 2.22 mg/L, with an average concentration of 0.88 mg/L. Results of pH in leaching samples ranged from 7.00 to 9.11, with an average of 7.99. Nine samples showed greater pH than the secondary standard of pH 6.5 to 8.5. No other ions, organics, or other metals exceeded the secondary standard limits for drinking water. Several samples of natural soil were collected and leached using the SPLP. Many of these samples showed concentrations of Al and Fe above their respective GWCTLs. The source of these metals likely was the soil in the residuals.

1 INTRODUCTION

The management of residuals created by the maintenance of paved roads (street sweepings), stormwater ponds, and catch basins has been raised as an issue in Florida. These materials are collectively referred to here as "residuals." The two most common management practices employed for residuals management are direct landfilling and stockpiling for future use or disposal. The large soil content of these materials has prompted the desire to beneficially use them in an application such as clean fill. This objective, coupled with costs associated with landfill disposal, provides incentive to explore reuse options. Prior to reuse via land application, the chemical properties of the residuals must be assessed to determine the potential environmental impacts when land-applied or reused. The University of Florida's Department of Environmental Engineering Sciences was contracted by the Florida Department of Environmental Protection (FDEP), the Florida Center for Solid and Hazardous Waste Management (FCSHWM), and a consortium of public agencies to perform the chemical characterization of residuals in Florida.

The objectives of this study were as follows:

1) Collect samples of street sweepings, stormwater pond sediments, and catch basin sediments throughout Florida and analyze the samples for the total concentration (mg/kg) of a variety of different chemical constituents.

2) Conduct leaching tests on many of these samples to measure the leachable concentration (mg/L) of contaminants using the synthetic precipitation leaching procedure (SPLP).

3) Compare the results of total and leaching analyses with soil cleanup target levels (SCTLs) and groundwater cleanup target levels (GWCTLs).

4) Review the data results and provide recommendations that would help develop beneficial reuse options.

This report is divided into six chapters. Chapter 2 presents an overview of the sampling trips conducted throughout the state and the sampling methodology. Chapter 3 discusses laboratory procedures, including total and leachable constituent analysis, extraction and digestion procedures, and target analytes. Chapter 4 presents and discusses the results. All the results of total and leaching concentrations of the materials produced from street sweepings, stormwater pond sediments, and catch basins are provided for metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), herbicides, and pesticides. Chapter 4 also briefly discusses the comparison of the analytical results to the SCTLs and the GWCTLs. Chapter 5 summarizes these comparisons and briefly discusses the implications. Several appendices present sample information (e.g., samples type and source, analysis date), raw data, and quality control and quality assurance data.

2 SAMPLING METHODOLOGY

2.1 Sample Locations

Samples of street sweepings, stormwater pond sediments, and catch basin sediments were collected from 20 different sampling locations throughout the state of Florida (Figure 2.1). The facilities selected for this study were recommended by FDEP. The types of samples collected depended on the sampling sites.

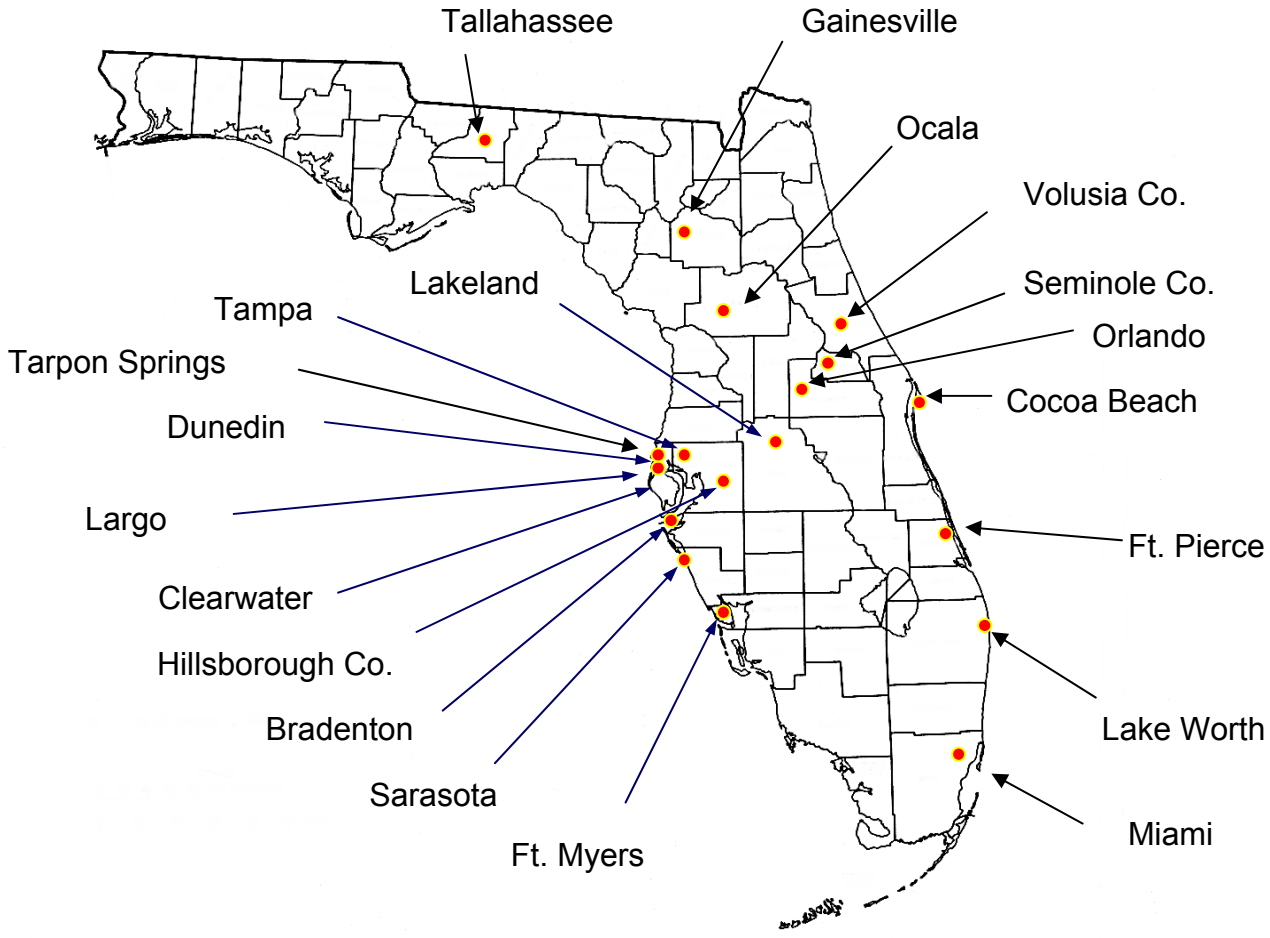

Figure 2.1 Sampling Locations in Florida.

2.2 Sampling Trips

Thirteen sampling trips for street sweepings, stormwater pond sediments, and catch basin sediments were made during this study. Table 2.1 presents locations, sampling date, and types of samples for each trip.

Table 2.1 Summary of Sampling Trips.

Trip	Location	Date	Sampling Type
1	Orlando	1/10/01	Stormwater Pond Sediments
2	Tallahassee	2/7/01	Street Sweepings, Stormwater Pond Sediments, Catch Basin Sediments
	Lakeland	2/8/01	Street Sweepings and Catch Basin Sediments
3	Lakeland	4/11/01	Street Sweepings and Catch Basin Sediments
	Tarpon Spring	4/12/01	Street Sweepings and Stormwater Pond Sediments
	Tampa	4/12/01	Street Sweepings
4	Ft. Pierce	5/7/01	Street Sweepings
	Cocoa Beach	5/8/01	Stormwater Pond Sediments and Catch Basin Sediments
	Seminole County	5/8/01	Street Sweepings and Catch Basin Sediments
5	Tarpon Spring	5/24/01	Street Sweepings
	Tampa	5/24/01	Street Sweepings
	Lakeland	5/24/01	Street Sweepings
	Ft. Myers	5/25/01	Street Sweepings
	Seminole County	5/25/01	Street Sweepings
	Orlando	5/25/01	Street Sweepings
	Ft. Pierce	5/25/01	Street Sweepings
6	Bradenton	6/11/01	Street Sweepings
	Lakeland	6/11/01	Street Sweepings
	Dunedin	6/12/01	Street Sweepings and Catch Basin Sediments
	Clearwater	6/12/01	Street Sweepings and Catch Basin Sediments
	Hillsborough County	6/12/01	Street Sweepings
7	Gainesville	6/25/01	Street Sweeping
	Dunedin	6/25/01	Street Sweeping
	Lakeland	6/25/01	Street Sweeping and Catch Basin Sediments
	Ft. Pierce	6/26/01	Street Sweeping and Catch Basin Sediments
	Cocoa Beach	6/26/01	Street Sweeping and Catch Basin Sediments
	Volusia County	6/26/01	Catch Basin Sediments
	Orlando	6/26/01	Street Sweeping
	Lake Worth	6/27/01	Street Sweeping

Table 2.1 Summary of Sampling Trips.

Trip	Location	Date	Sampling Type
8	Gainesville	7/5/01	Catch Basin Sediments
	Bradenton	7/9/01	Street Sweepings
	Ft. Myers	7/12/01	Street Sweepings
	Sarasota	7/12/01	Catch Basin Sediments
	Largo	7/13/01	Street Sweepings and Catch Basin Sediments
	Dunedin	7/13/01	Catch Basin Sediments
	Clearwater	7/13/01	Catch Basin Sediments
	Tallahassee	7/16/01	Street Sweepings and Catch Basin Sediments
9	Miami	9/18/01-9/19/01	Catch Basin Sediments
10	Gainesville	10/3/01	Stormwater Pond Sediments
	Ocala	10/3/01	Stormwater Pond Sediments
	Hillsborough County	10/4/01	Street Sweepings
	Gainesville	10/8/01	Catch Basin Sediments
11	Gainesville	11/15/01-11/19/01	Street Sweepings, Stormwater Pond Sediments Catch Basin Sediments
12	Tampa	02/14/02	Street Sweepings
	Tarpon Springs	02/14/02	Street Sweepings and Stormwater Pond Sediments
	Clearwater	02/14/02	Street Sweepings and Catch Basin Sediments
	Sarasota	02/14/02	Street Sweepings
	Lakeland	02/15/02	Street Sweepings and Catch Basin Sediments
	Orlando	02/15/02	Street Sweepings
	Seminole County	02/15/02	Street Sweepings
13	Hillsborough County	03/14/02	Street Sweepings
	Sarasota	03/14/02	Street Sweepings
	Ft. Pierce	03/15/02	Street Sweepings
	Gainesville	03/15/02	Street Sweepings

2.3 Sample Collection

Three hundred and fifty-nine samples for total analysis and a half of total samples for leaching analysis were collected from street sweeping management facilities, stormwater ponds, and catch basin management facilities throughout the state according to quality assurance project plan (QAPP # WM 755) (Table 2.2). The sampling plan was approved by FDEP for laboratory operations and sample collection activities. Different sampling methodologies were used to collect the samples, depending upon the nature of the sample types (i.e., street sweepings, stormwater pond sediments, catch basins).

Table 2.2 Number of Samples of Street Sweepings, Stormwater Pond Sediments, and Catch Basins.

Sampling Month	Street Sweepings	Stormwater Pond Sediments	Catch Basin Sediments
Jan 2001	--	30	--
Feb 2001	20	4	3
Apr 2001	20	6	2
May 2001	46	4	7
June 2001	35	--	14
July 2001	7	8	12
Sept 2001	--	--	28
Oct 2001	16	6	8
Nov 2001	6	14	7
Feb 2002	23	2	3
Mar 2002	28	--	--
Total	201	74	84

Street sweeping samples were collected from piles at transfer stations, maintenance yards, or storage yards. The size of the pile was determined, and quadrant sampling was used if the volume was less than 300 square feet. Each pile was sectioned into quarters, and the surface of the street sweeping pile was removed. Some portions of each section were randomly taken and sieved quickly using sieve size #4 (pore size 4.75 mm) to remove any large materials (e.g., twigs, leaves). The materials that passed through the sieve were collected using stainless steel scoops and mixed in stainless steel bowls. Approximately 5 g of street sweeping sample for VOCs were collected first from the mixed sample and placed into 40-mL VOC vials (I-Chem. Corp.) equipped with Teflon-lined septa. Ten milliliters of deionized water were initially added to the vials before sampling. Samples for other organics and metals were collected in 2-liter glass jars with Teflon-lined lids.

For stormwater pond sediments, sampling was conducted using a stainless steel auger. The size of the stormwater pond was first measured, and sampling points were randomly selected to collect sediment samples. Since sediments typically start building up in inlet and outlet pipes at stormwater ponds, samples were taken mainly from areas surrounding both inlet and outlet structures, if any sediment piles were present. Some stormwater ponds contained a significant amount of sediment accumulated throughout the pond area. In this case, a random grid sampling technique was employed to obtain representative samples from the area. A sediment sample was taken using the stainless steel auger at a depth of approximately 6 inches below the surface. After removal, the sample was placed in a stainless steel bowl for mixing with the other two cores from the sampling area. Decontamination of the auger was carried out following the standardized decontamination procedure described in the QAPP. The samples were stored below

4°C in an iced container and transported to a cold room (below 4°C) located at the University of Florida Solid and Hazardous Waste Laboratory prior to analysis.

Two different techniques were used for sampling catch basin sediments. The first sampling technique was to collect sediment samples directly from the catch basins. Direct sampling of catch basin sediments was done for the following locations: Cocoa Beach, Gainesville, and Miami. Catch basins were randomly selected and collected from two types of areas: residential areas and non-residential areas. The manhole cover was removed from the catch basin, and a visual inspection was performed to determine the presence of catch basin sediments. If sediments were present in the catch basin and easily accessible, a sample was collected with either a posthole digger or a stainless steel scoop into a stainless steel bowl. Approximately 5 g of a catch basin sample for VOCs were collected first from the mixed sample in the bowl and placed into a 40-mL VOC vial (I-Chem. Corp.) containing 10 mL of deionized water. The remaining sediment was mixed in the bowl and placed into a two-liter glass container for laboratory analyses. Another sampling technique involved the collection of samples from the sediments pile, which was dumped by vacuum trucks during catch basin sediment cleanup processes. The sample collection procedures from the pile of catch basin sediements resembled the street sweeping sampling, as mentioned previously.

To implement quality assurance (QA) practices in the field, trip blanks, field blanks, equipment blanks, and duplicate samples were carried or collected during sampling trips. The QA samples were analyzed during laboratory work to determine whether any contamination occurred in the field or during the trips.

3 CHEMICAL ANALYSES OF STREET SWEEPINGS, STORMWATER POND SEDIMENTS, AND CATCH BASIN SEDIMENTS

3.1 Overview of Sample Analysis

Samples collected from street sweepings, stormwater pond sediments, or catch basin sediments were mixed in the laboratory with a stainless steel scoop to obtain a representative sample before a number of chemical analyses were carried out.

Sample analysis was performed using approved FDEP and U.S. Environmental Protection Agency (US EPA) analytical methods, and according to the researcher's FDEP Comprehensive Quality Assurance Plan (CompQAP # 960218) and the QAPP. A number of analytical procedures were performed on street sweepings, stormwater pond sediments, and catch basin sediments collected from throughout the state of Florida. The analytical procedures are as follows:

Total Analysis

- Total heavy metal concentrations (Ag, As, Ba, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn)
- Total VOC concentrations
- Total SVOC concentrations
- Organochlorine pesticides (OCl Pest)
- Nitrogen-phosphorus pesticides
- Chlorinated herbicides
- N-Methylcarbamates

Leaching Analysis

- Leachable heavy metal concentrations (Ag, As, Ba, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn)
- Leachable VOC concentrations
- Leachable SVOC concentrations
- Leachable OCl Pests
- Leachable polychlorinated biphenyls (PCBs)
- Leachable nitrogen-phosphorus pesticides
- Leachable chlorinated herbicides
- N-Methylcarbamates
- Secondary standards for drinking water (Al, Br^-, Cl^-, F^-, Fe, Mg, SO_4^{2-}, total dissolved solids (TDS))

Table 3.1 presents the analytical methods used for the sample analyses during this study. The following sections detail the analyses of metals and organics performed on street sweepings, stormwater pond sediments, and catch basin sediments.

Table 3.1 Analytical Methods.

Analyte group		Total	Leaching
VOCs		EPA SW 846 Method 5030B/8260B	EPA SW 846 Method 1312/5030B/8260B
SVOCs		EPA SW 846 Method 3550[1]/8270C	EPA SW 846 Method 1312/3510C/8270C
OCl Pest		EPA SW 846 Method 3550[1]/8041A	EPA SW 846 Method 1312/3510C/8041A
Nitrogen-phosphorus pesticides		EPA SW 846 Method 3550[1]/8041A	EPA SW 846 Method 1312/3510C/8041A
Chlorinated herbicides		EPA SW 846 Method 3550[1]/8151A	EPA SW 846 Method 1312/8151A
N-Methylcarbamates		EPA SW 846 Method 8318	EPA SW 846 Method 1312/8318
Metals	Ag	EPA SW 846 Method 3051A/6010B	EPA SW 846 Method 1312/3015/6010B
	As	EPA SW 846 Method 3051A/7060A	EPA SW 846 Method 1312/3015/7060A
	Ba	EPA SW 846 Method 3051A/6010B	EPA SW 846 Method 1312/3015/6010B
	Cd	EPA SW 846 Method 3051A/6010B	EPA SW 846 Method 1312/3015/7131A
	Cr	EPA SW 846 Method 3051A/6010B	EPA SW 846 Method 1312/3015/6010B
	Cu	EPA SW 846 Method 3051A/6010B	EPA SW 846 Method 1312/3015/6010B
	Hg	EPA SW 846 Method 7471	EPA SW 846 Method 1312/7470A
	Ni	EPA SW 846 Method 3051A/6010B	EPA SW 846 Method 1312/3015/6010B
	Pb	EPA SW 846 Method 3051A/6010B	EPA SW 846 Method 1312/3015/7421
	Se	EPA SW 846 Method 3051A/6010B	EPA SW 846 Method 1312/3015/7740
	Zn	EPA SW 846 Method 3051A/6010B	EPA SW 846 Method 1312/3015/6010B
Secondary Parameters	Inorganic Ions (Cl^-, F^-, and SO_4^{2-})		EPA SW 846 Method 1312/9056
	TDS		Standard Method 1312/2540C
	Al		EPA SW 846 Method 1312/3015/7020
	pH		Standard Method 1312/4500-H^+
	Fe		EPA SW 846 Method 1312/3015/7380
	Mn		EPA SW 846 Method 1312/3015/7460

[1] Sonication extraction method 3550 was used for samples collected Trips 5 through 12. Microwave extraction method 3546 was applied to the samples collected from Trips 1 through 4.

3.1.1 Total Analysis

3.1.1.1 Metals

All of the total metal samples except for mercury were digested using a microwave. Approximately 0.5 g of samples from stormwater pond sediments, catch basin sediments, or street sweepings were weighed into a Teflon vessel in a fume hood, to which 10 mL of concentrated nitric acid or, alternatively, 9 mL of concentrated nitric acid and 3 mL concentrated hydrochloric acid were added. The addition of hydrochloric acid was intended to stabilize certain analytes, such as silver, barium, and selenium. The vessel was vented of any gases present for 5 minutes. The vessel was then sealed with a cap and placed on a rack in the microwave (CEM Corp. Model: CEM MARS X®). The sample was digested for 10 minutes using the microwave heating. The temperature rose to 175 °C in less than 5.5 minutes and remained between 170 and 180 °C for less than 3 minutes. The pressure for the sample was less than 6 atmospheres. At the end of the microwave program, the sample was allowed to cool down for 5 minutes and filtered using filter paper (Whatman 41). The volume of the filtered samples was brought to 50 mL with deionized water. After digestion, the extracts were analyzed by either inductively coupled plasma-atomic emission spectroscopy (ICP-AES, Thermo Jarrell Ash Corp. Model 95970) or an atomic absorption spectrophotometer (Perkin-Elmer Model 5100), depending on the target metals. Samples with high concentrations of metals were diluted to fit within the linear region of the calibration curve. Total mercury concentrations in samples were measured using a cold-vapor atomic absorption technique (US EPA SW 846 Method 7471). This method is based on the absorption of radiation at the 253-nm wavelength by mercury vapor (Perkin Elmer).

3.1.1.2 VOCs

VOC total analysis was carried out using a purge-and trap concentrator (Tekmar 3100) attached to a gas chromatography mass spectrometer (Finnegan, Model GCQ and GCQ-Mass Spectrometer). Table 2.3 presents the analyzed VOCs. VOC vials collected from street sweepings, stormwater pond sediments, or catch basin sediments in the field were purged with an inert gas (helium) at 40 mL/min to transfer the volatile components from the aqueous phase to the vapor phase, where they were swept through an adsorbent trap (Supelco Type K). After purging (11 minutes), the sorbent trap was heated at 250°C and back flushed with the inert gas to desorb trapped sample components. The desorbed analytes were transferred onto the capillary column (JW DB-VRX 75 m x 0.45mm ID, 2.55 m film). The analytes were detected with a mass spectrometer interfaced to the GC**.**

Table 3.2 Target VOC Compounds.

1,1,1,2-Tetrachloroethane	1,4-Dichlorobenzene	Chloroethane	n-Butylbenzene
1,1,1-Trichloroethane	2,2-Dichloropropane	Chloroform	o-Xylene
1,1,2,2-Tetrachloroethane	2-Butanone (MEK)	Chloromethane	Pentachloroethane
1,1,2-Trichloroethane	2-Chlorotoluene	cis-1,2-Dichloroethene	p-Isopropyltoluene
1,1-Dichloroethane	2-Hexanone	cis-1,3-Dichloropropene	Propionitrile
1,1-Dichloroethene	4-Chlorotoluene	cis-1,4-Dichloro-2-butene	Propylbenzene
1,1-Dichloropropene	4-Methyl-2-pentanone (MIBK)	Dibromochloromethane	sec-Butylbenzene
1,2,3-Trichlorobenzene	Acetone	Dibromomethane	Styrene
1,2,3-Trichloropropane	Acetonitrile	Dichlorodifluoromethane	tert-Butylbenzene
1,2,4-Trichlorobenzene	Acrylonitrile (2-Propeneni	Ethyl Methacrylate	Tetrachloroethene
1,2,4-Trimethylbenzene	Alkyl Chloride (3-Chloro-1	Ethyl benzene	Toluene
1,2-Dibromo-3-chloropropane	Benzene	Hexachlorobutadiene	trans-1,2-Dichloroethene
1,2-Dibromoethane	Bromobenzene	Iodomethane	trans-1,3-Dichloropropene
1,2-Dichlorobenzene	Bromodichloromethane	Isopropylbenzene (Cumene)	trans-1,4-Dichloro-2-butene
1,2-Dichloroethane	Bromoform	m,p-Xylenes	Trichloroethene
1,2-Dichloropropane	Bromomethane	Methacrylonitrile	Trichlorofluoromethane
1,3,5-Trimethylbenzene	Carbon Disulfide	Methyl Methacrylate	Vinyl Chloride
1,3-Dichlorobenzene	Carbon Tetrachloride	Methylene Chloride	
1,3-Dichloropropane	Chlorobenzene	Naphthalene	

3.1.1.3 SVOCs and Pesticides

For samples collected during Trips 1 through 4, a microwave extraction technique was used to extract SVOCs and pesticides. Both SVOC and pesticide extraction procedures were identical except for surrogate and matrix spikes used. A 2-g sample was weighed and placed into a microwave vessel with 25 mL of acetone/hexane (1:1 by vol.). An appropriate surrogate standard spike was added to the vessel before the microwave extraction started (SW-846 Method 3546). After the microwave extraction, the sample was filtered through filter paper (Whattman 41) containing anhydrous sodium sulfate. After filtration, a solvent evaporation apparatus (Turbovap® II, Zymark Inc.) was used to reduce the solvent volume to 1.0 mL using a gentle stream of clean, dry nitrogen gas. The sample was transferred to an auto sampler vial for gas chromatography (GC) or gas chromatography mass spectrometer (GC-MS) analysis.

For samples collected during Trips 5 through 12, an ultrasonic extraction technique (US EPA SW-846 Method 3550A, Sonicator™ Model W-375, Heat Systems-Ultrasonics, Inc.) was used for extracting SVOCs and pesticides from street sweepings, stormwater pond sediments, and catch basin sediments. The ultrasonic process ensures intimate contact of the sample matrix with an extraction solvent of 1:1 methylene chloride/acetone (by vol.). A 30-g sample was weighed into a 400-mL Erlenmeyer flask with 100 mL of the solvent. Appropriate surrogate standards were added to each sample, while matrix spike standards were spiked into every

20 samples in duplicate. The flask was moved into the sonicator. The bottom surface of the tip of the disruptor horn was placed approximately 0.5 inch below the surface of the solvent but above the solid sample layer. The sample was sonicated for 3 minutes with the output control knob set at 10, the mode switch on Pulse, and the percent-duty cycle knob set at 50%. The extract was then filtered through anhydrous sodium sulfate to remove water from the extract. The sonication and filtration processes were repeated twice. After filtration, the remaining process was the same as described above. Tables 3.3 and 3.4 present a list of target SVOC and pesticide compounds, respectively.

Table 3.3 Target SVOC Compounds.

1,2,4,5-Tetrachlorobenzene	4-Aminobiphenyl	Chlorobenzilate	Methyl_Parathion
1,2,4-Trichlorobenzene	4-Bromophenyl_phenyl_ether	Chrysene	Naphthalene
1,2-Dichlorobenzene	4-Chloro-3-methylphenol	Diallate	Nitrobenzene
1,3,5-Trinitrobenzene	4-Chloroaniline	Dibenz(a,h)anthracene	N-Nitrosodiethylamine
1,3-Dichlorobenzene	4-Chlorophenyl_phenyl_ether	Dibenz(a,j)acridine	N-Nitrosodi-n-butylamine
1,4-Dichlorobenzene	4-Methylphenol	Dibenzofuran	N-Nitrosodi-n-propylamine
1,4-Naphthoquinone	4-Nitroaniline	Diethyl_phthalate	N-Nitrosomorpholine
1-Napthylamine	4-Nitrophenol	Dimethoate	N-Nitrosopyrrolidine
1-Nitrosopiperidine	4-Nitroquinoline-1-oxide	Dimethyl_phthalate	O,O,O-Triethyl_Phosphorothioate
2,3,4,6-Tetrachlorophenol	5-Nitro-o-toluidine	Di-n-butyl_phthalate	o-Toluidine
2,4,5-Trichlorophenol	7,12-Dimethylbenz(a)anthracene	Di-n-octyl_phthalate	Parathion
2,4,6-Trichlorophenol	Acenaphthylene	Dinoseb	p-Dimethylaminoazobenzene
2,4-Dichlorophenol	Acenaphthene	Diphenylamine	Pentachlorobenzene
2,4-Dimethylphenol	Acetophenone	Disulfoton	Pentachloronitrobenzene
2,4-Dinitrophenol	Aniline	Ethyl_Methanesulfonate	Pentachlorophenol
2,4-Dinitrotoluene	Anthracene	Famphur	Phenacetin
2,6-Dinitrotoluene	Aramite	Fluoranthene	Phenanthrene
2-Acetylaminofluorene	Benzidine	Fluorene	Phenol
2-Chloronapthalene	Benzo(a)anthracene	Hexachlorobenzene	Phorate
2-Chlorophenol	Benzo(a)pyrene	Hexachlorobutadiene	p-Phenylenediamine
2-Methylnapthalene	Benzo(b)fluoranthene	Hexachlorocyclopentadiene	Pronamide
2-Methylphenol	Benzo(g,h,i)perylene	Hexachloroethane	Pyrene
2-Napthylamine	Benzo(k)fluoranthene	Hexachloropropene	Safrole
2-Nitroaniline	Benzoic_Acid	Indeno(1,2,3-cd)pyrene	Silvex
2-Nitrophenol	Benzyl_Alcohol	Isodrin	Sulfotepp
3,3'-Dichlorobenzidine	Bis(2-chloroethoxy)methane	Isophorone	Thionazin
3,3'-Dimethylbenzidine	Bis(2-chloroethyl)ether	Isosafrole	
3-Methylcholanthrene	Bis(2-chloroisopropyl)ether	Kepone	
3-Nitroaniline	Bis(2-ethylhexyl)_phthalate	m-Dinitrobenzene	
4,6-Dinitro-2-methylphenol	Butyl_benzy_phthalate	Methapyrilene	

Table 3.4 Target Chlorinated Pesticides and Nitrogen/Phosphorus Pesticides.

Chlorinated Pesticides		*Nitrogen/Phosphorus Pesticides*	
1,2-Dibromo-3-chloropropane	Endrin	Aspon	Fensulfothion
4,4'-DDD	Endrin Aldehyde	Azinphos ethyl	Fenthion
4,4'-DDE	Endrin Ketone	Azinphos methyl (guthion)	Fonofos
4,4'-DDT	Etridiazole (terrazole)	Bolstar	Leptophos
Alachor	gamma-BHC (Lindane)	Carbophenothion	Malathion
Aldrin	gamma-Chlordane	Chlorfenvinphos	Merphos
alpha-BHC	Heptachlor	Chlorpyrifos	Methyl parathion
alpha-Chlordane	Heptachlor Epoxide	Chlorpyriphos methyl	Mevinphos
beta-BHC	Hexachlorobenzene	Coumaphos	Monocrotophos
Captafol	Hexachlorocyclopentadiene	Crotoxyphos	Naled
Chlorobenzilate	Isodrin	Demeton	Parathion
Chloroneb	Methoxychlor	Diazinon	Phorate
Chloropropylate	Mirex	Dichlofention	Phosmet
Chlorothalonil	Nitrofen	Dichlorvos	Phosphamidon
DCPA (dacthal)	Pentachloronitrobenzene (PCNB)	Dicrotophos	Ronnel
delta-BHC	Permetrins	Dimethoate	Stirofos
Diallate	Perthane	Dioxathion	Sulfotepp
Dichlone	Propachlor	Disulfoton	TEPP
Dicofol (keltane)	trans-Nonachlor	EPN	Terbuphos
Dieldrin	Trifluralin	Ethion	Thionazin
Endosulfan I		Ethoprop	Tokuthion
Endosulfan II		Famphur	Trichlorfon
Endosulfan Sulfate		Fenitrothion	Trichloronate

3.1.1.4 N-methylcarbamate

A 20-g sample was placed into a 250-mL Erlenmeyer flask with 50 mL of acetonitrile. The sample was shaken for two hours with a shaker. After mixing, the mixture was allowed to separate into layers for 10 minutes. The solvent layer was decanted to a 250-mL centrifuge tube. This process was repeated twice with 20 mL of acetonitrile and one hour of shaking each time. The combined sample was centrifuged at 200 rpm for 10 minutes. The supernatant was decanted into a 100-mL volumetric flask and diluted to 100 mL with acetonitrile. Twenty milliliters of extract were transferred via pipette into a 200-mL glass vial containing 0.1 mL of ethylene glycol. The solvent was evaporated until only ethylene glycol remained in the tube. The ethylene glycol residue was dissolved with 1 mL of methanol and then passed through a pre-washed C-18 cartridge (VARIAN Bondelute C-18). The eluant was collected into a 5-mL volumetric flask. The final extract was filtered through 0.45-μm filter paper and then transferred into an auto sampler vial for high-pressure liquid chromatography (HPLC) analysis. The following N-methylcarbamate compounds was analyzed: aldicarb, aldicarb sulfone, carbaryl, carbofuran, dioxacarb, 3-hydroxycarbofuran, methiocarb, methomyl, promecarb, and propoxur (baygon).

3.1.1.5 Chlorinated Herbicides

The herbicide extraction technique was the same as for SVOC and pesticides except for the addition of 5 drops of concentrated hydrochloric acid. After the volume reduction process, the sample was derivatized to form methyl esters. A 0.5-mL derivatized sample was then transferred to an auto sampler vial before gas chromatography electron capture detector (GC-ECD) analysis (US EPA SW846 Method 8151A). The following 10 compounds were targeted during herbicide analysis: 2,4-D, dalapon, 2,4-DB, dicamba, dichlorprop, dinoseb, MCPA, and MCPP.

3.1.2 Leaching Test and Analysis

Leaching tests for street sweepings, stormwater pond sediments, and catch basin sediments were performed using the SPLP (US EPA SW-846 Method 1312, US EPA 1998). The SPLP test simulates leaching of contaminants resulting from land-disposed wastes under conditions of slightly acidic rainfall. Detailed leaching test procedures are described in US EPA SW-846 Method 1312, depending upon the type of analytes or element of interest. All chemicals in total analysis were also analyzed in leaching samples.

3.1.2.1 Metal

A 100-g sample was placed in a 2-liter Teflon-coated glass container. A SPLP leaching solution of pH 4.20 (± 0.05) was prepared to simulate slightly acidic rainwater by adding a 60/40 weight percent mixture of sulfuric and nitric acids. Two liters of the SPLP solution were then added to the container. The container was placed in a rotary extractor and leached for 18 ± 2 hours at 30 rpm. After tumbling, the mixture was filtered using a pressurized filtration apparatus with a 1.0-µm glass fiber toxicity characteristic leaching procedure (TCLP) filter. A sample of 45 mL SPLP extract was placed into a microwave extraction vessel, with 5 mL of concentrated nitric acid or 4 mL of concentrated nitric acid and 1 mL of concentrated hydrochloric acid, for 20 minutes using the microwave. The temperature of the sample-acid mixture was ramped to 170 ± 5°C in 10 minutes and maintained at that temperature for another 10 minutes to accelerate the leaching process. The vessel was sealed and heated in the microwave unit under pressure. After cooling, the sample was filtered through filter paper (Whattman 41). The filtered sample was then preserved with nitric acid (pH<2) and analyzed using either graphite furnace atomic absorption (GFAA) or inductively couple plasma (ICP), as described previously in total analysis.

3.1.2.2 VOC

Leaching tests for volatile organics from street sweepings, stormwater pond sediments, or catch basin sediments were carried out using a zero headspace extraction vessel (ZHE) (Analytical Testing Corporation). A sample of 25 g in VOC vials collected from the field site was placed in the ZHE. To prevent the loss of VOCs, sample loading was performed in a refrigerated room below 4°C. Approximately 500 mL of nano-pure water was then added to the ZHE. The ZHE unit was placed in a rotary extractor and rotated for 18 ± 2 hours at 30 rpm at room temperature. After tumbling, the filtered leachate was collected into a VOC vial using a

glass syringe (Hamilton Gastight™ Syringe). The sample was analyzed by GC-MS following US EPA SW846 Method 8260A.

3.1.2.3 SVOC

Leaching tests for SVOCs followed the same procedures as the metal leaching test. The filtered leachate was extracted following liquid-liquid extraction (US EPA SW846 Method 3510B, 1995). A 500-mL sample was placed into a 1-liter separatory funnel, into which surrogate standard spiking solution was added. Matrix spike standard solution, if needed, was added every 15 samples. The pH of the sample was adjusted with concentrated sulfuric acid, lowering to a pH of less than 2. The sample was extracted with 30 mL of methylene chloride by hand shaking for 2 minutes. The sample was allowed to separate the solvent layer for 10 minutes. Only the solvent layer was collected into a 250-mL flask. The extraction process was repeated twice. The sample pH was adjusted with 10-N sodium hydroxide at a pH of greater than 11. The high pH extraction process was the same as for the acidic extraction. The extracted sample was combined and filtered through anhydrous sodium sulfate to remove water. The solvent evaporation apparatus (Turbovap® II, Zymark Inc.) was then used to reduce the extracted solvent volume to approximately 0.5 ml using a gentle stream of clean, dry nitrogen gas. After the volume reduction process, the SVOC extracted sample was analyzed by GC-MS (US EPA SW846 Method 8270A).

3.1.2.4 Pesticides

The 500-mL extract from the SPLP test for street sweepings, stormwater pond sediments, or catch basin sediments was transferred to a 1-liter separatory funnel. The pesticides surrogate and matrix spike solutions were added to the funnel. The sample in the funnel was extracted with 30 mL of methylene chloride by hand shaking for 2 minutes. The methylene chloride layer in the funnel was collected into a 250-mL Erlenmeyer flask after 10 minutes for separation between the sample and the solvent layer. This extraction process was repeated twice. The collected solvent was filtered with anhydrous sodium sulfate to remove water. The filtered sample was placed in a 250-mL glass concentrator tube and reduced to 1 mL using the solvent evaporation apparatus. Approximately 50 mL of solvent (hexane) were added to the concentrator tube. The solvent in the tube was further concentrated to 10 mL using the evaporation apparatus. A 0.5-mL sample was transferred to an auto sampler vial for pesticides analysis using GC following US EPA SW846 Method 8041.

3.1.2.5 N-methylcarbamate

A 1-liter separatory funnel contained 100 mL of leachate (or extract) from the SPLP test for street sweepings, stormwater pond sediments, or catch basin sediments. The sample in the funnel was extracted with 30 mL of methylene chloride three times, as described previously. Ten milliliters of the extract were pipetted into a concentrator tube containing 0.1 mL of ethylene glycol. The solvent was evaporated until only ethylene glycol remained in the tube. The ethylene glycol residue was dissolved with 1 mL of methanol. The final extract was filtered

through filter paper (Whattman 41) and then transferred into an auto sampler vial for HPLC analysis following US EPA SW846 Method 8318.

3.1.2.6 Herbicides

Before extraction for herbicides, all glassware was rinsed with 1:1 sulfuric acid followed by deionized water. An aliquot of SPLP leachate (500 mL) was placed into a one-liter separatory funnel. Approximately 8.5 mL of cold (4°C) 12 N sulfuric acid were added to the sample to lower pH. The sample was extracted with 60-mL ethyl ether by hand shaking for 2 minutes. The sample was allowed to separate the two layers (solvent and sample) for 10 minutes. The ethyl ether phase was collected in an Erlenmeyer flask. This extraction process was repeated three times. Five grams of acidified sodium sulfate were added to the extract in the flask to remove water either for more than two hours or overnight. The solvent was concentrated to 1 mL during the evaporation process. The concentrated extract was diluted with 1 mL of isooctane and 0.5 mL of methanol. The final volume was brought to 4 mL with ethyl ether. The final extract was then derivatized to form methyl esters before GC analysis (US EPA SW846 Method 8151A).

3.1.2.7 Anion Analysis

Anions such as fluoride, chloride, bromide, and sulfate were also measured in the SPLP extracts to determine whether the secondary drinking water standards would be a concern when disposed. A Dionex DX 500 Ion Chromatograph was utilized to measure the concentrations of inorganic ions in the extracts (US EPA SW-846 Method 9056, US EPA 1998).

3.2 Quality Assurance and Quality Control

To meet the requirements for Quality Assurance and Quality Control (QA/QC) for this study, matrix spike standard was added to every 15 samples. Two matrix spikes and duplicates were taken from samples. Blank spike samples for metals were digested using clean sand. To calculate the matrix recovery, the equation below was used (sample calculations are located in Appendix A). All QA/QC data can be found in Appendix B.

$$R = \frac{X_2 - X_1}{C} * 100$$

Where R= % recovery

X_1= sample concentration (mg/L or mg/kg –dry weight)

X_2=sample spike concentration (mg/L or mg/kg – dry weight)

C=spiked concentration (mg/L or mg/kg – dry weight)

4 RESULTS AND DISCUSSIONS

4.1 Results of Total Analysis

4.1.1 Metals

Where appropriate, the total metal concentrations were compared to Florida SCTLs for direct exposure (both residential and industrial settings). Table 4.1 presents average concentrations for all metals from all types of samples (i.e., street sweepings, stormwater pond sediments, and catch basin sediments). Most of the samples for silver, cadmium, mercury, and selenium were below the detection limits for the analytical instruments used in this study (inductively coupled plasma-atomic emission spectroscopy or atomic absorption spectrophotometer). Total metal concentrations by sample type are shown in Tables 4.2 through 4.4. Out of 359 samples collected, some samples were not included in the numbers of the samples analyzed because of lower spike recovery. The following subsections discuss each metal. Some of the total metal results are plotted as histograms to illustrate the distribution of sample concentrations. All metal raw data of total analysis can be found in Appendix C.

Table 4.1 Total Metal Concentrations of Samples from Street Sweepings, Stormwater Pond Sediments, and Catch Basin Sediments.

Element	No. of Samples	No. of Detects	Ave. Concentration (mg/kg)	Max.	Min.	Standard Deviation	No. of Exceedance (Resid)	No. of Exceedance (Ind.)	Residential SCTLs (mg/kg)	Industrial SCTLs (mg/kg)	Detection Limit (mg/kg)
Ag	306	6	37.5	130.2	12.3	54.5	0	0	390	9100	0.80
As	355	178	1.7	24.8	0.5	1.4	105	10	0.8	3.7	0.50
Ba	306	279	32.5	1019	3.0	17.9	9	0	110	87000	1.35
Cd	354	4	38.6	54.1	5.3	4.0	0	0	75	1300	0.37
Cr	306	225	23.7	552.0	2.4	70.4	1	2	210 (Cr VI)	420 (Cr VI)	1.34
Cu	354	353	20.2	398.4	2.5	31.5	4	0	110	76000	1.84
Hg	303	0	--	--	--	--	0	0	3.4	26	0.02 (µg/kg)
Ni	354	350	9.4	69.9	2.4	7.8	0	0	110	28000	1.72
Pb	354	246	40.8	1060	2.7	36.0	1	1	400	920	1.43
Se	354	6	10.0	14.1	7.4	--	0	0	390	10000	0.25
Zn	354	354	91.8	1080	4.3	86.5	0	0	23000	560000	1.35

Note: Average concentration and standard deviation were calculated using only the detected samples.

Table 4.2 Total Metal Concentrations of Samples from Street Sweepings.

Element	No. of Samples	No. of Detects	Ave. Concentration (mg/kg)	Max.	Min.	Standard Deviation	No. of Exceedance (Resid)	No. of Exceedance (Ind.)	Residential SCTLs (mg/kg)	Industrial SCTLs (mg/kg)	Detection Limit (mg/kg)
Ag	171	4	48.7	130.2	17.7	54.52	0	0	390	9100	0.80
As	199	94	1.2	13.6	0.5	1.49	45	1	0.8	3.7	0.50
Ba	171	152	18.9	130	5.0	17.97	1	0	110	87000	1.35
Cd	199	3	49.8	54.1	46.0	4.06	0	0	75	1300	0.37
Cr	171	118	25.6	552.0	2.4	70.42	1	2	210 (Cr VI)	420 (Cr VI)	1.34
Cu	199	198	17.1	372.4	2.5	31.57	3	0	110	76000	1.84
Hg	157	0	--	--	--	--	0	0	3.4	26	0.02 (µg/kg)
Ni	199	195	8.9	69.9	2.4	7.82	0	0	110	28000	1.72
Pb	199	144	25.0	386	2.7	36.02	0	0	400	920	1.43
Se	199	1	10.6	10.6	10.6	--	0	0	390	10000	0.25
Zn	199	199	65.1	1080	4.3	86.51	0	0	23000	560000	1.35

Note: Average concentration and standard deviation were calculated using only the detected samples.

Table 4.3 Total Metal Concentrations of Sediment Samples from Stormwater Ponds.

Element	No. of Samples	No. of Detects	Ave. Concentration (mg/kg)	Max.	Min.	Standard Deviation	No. of Exceedance (Resid)	No. of Exceedance (Ind.)	Residential SCTLs (mg/kg)	Industrial SCTLs (mg/kg)	Detection Limit (mg/kg)
Ag	68	0	--	--	--	--	0	0	390	9100	0.80
As	74	43	2.4	24.8	0.6	3.90	30	5	0.8	3.7	0.50
Ba	68	61	72.8	1019	8.1	144.6	8	0	110	87000	1.35
Cd	73	1	5.3	5.3	5.3	--	0	0	75	1300	0.37
Cr	68	50	26.6	174.5	5.8	29.88	0	0	210 (Cr VI)	420 (Cr VI)	1.34
Cu	73	73	18.3	90.4	4.5	17.03	0	0	110	76000	1.84
Hg	68	0	--	--	--	--	0	0	3.4	26	0.02 (µg/kg)
Ni	73	73	10.3	40.4	5.4	4.86	0	0	110	28000	1.72
Pb	73	46	46.8	196	5.6	47.78	0	0	400	920	1.43
Se	73	4	10.5	14.1	7.5	2.91	0	0	390	10000	0.25
Zn	73	73	94.9	711	5.4	136.1	0	0	23000	560000	1.35

Note: Average concentration and standard deviation were calculated using only the detected samples.

Table 4.4 Total Metal Concentrations of Sediment Samples from Catch Basins.

Element	No. of Samples	No. of Detects	Ave. Concentration (mg/kg)	Max.	Min.	Standard Deviation	No. of Exceedance (Resid)	No. of Exceedance (Ind.)	Residential SCTLs (mg/kg)	Industrial SCTLs (mg/kg)	Detection Limit (mg/kg)
Ag	67	2	15.0	17.7	12.3	3.82	0	0	390	9100	0.80
As	82	41	2.0	12.7	0.5	2.55	30	4	0.8	3.7	0.50
Ba	67	66	26.5	98	3.0	19.9	0	0	110	87000	1.35
Cd	82	0	--	--	--	--	0	0	75	1300	0.37
Cr	67	57	17.2	50.8	6.2	10.2	0	0	210 (Cr VI)	420 (Cr VI)	1.34
Cu	82	82	29.4	398.4	5.5	45.8	1	0	110	76000	1.84
Hg	78	0	--	--	--	--	0	0	3.4	26	0.02 (µg/kg)
Ni	82	82	10.0	30.7	2.5	4.51	0	0	110	28000	1.72
Pb	82	56	76.3	1060	6.4	169.8	1	1	400	920	1.43
Se	82	1	7.4	7.4	7.4	--	0	0	390	10000	0.25
Zn	82	82	153.9	956	9.1	159.4	0	0	23000	560000	1.35

Note: Average concentration and standard deviation were calculated using only the detected samples.

4.1.1.1 Arsenic

Arsenic was analyzed in 355 samples and detected in 178 samples. Figure 4.1 illustrates the distribution of arsenic sample concentrations. The arsenic concentration ranged from 0.5 to 24.8 mg/kg, with an average of 1.7 mg/kg. The average concentration was above the arsenic SCTLs for residential setting but below the industrial limit of 3.7 mg/kg.

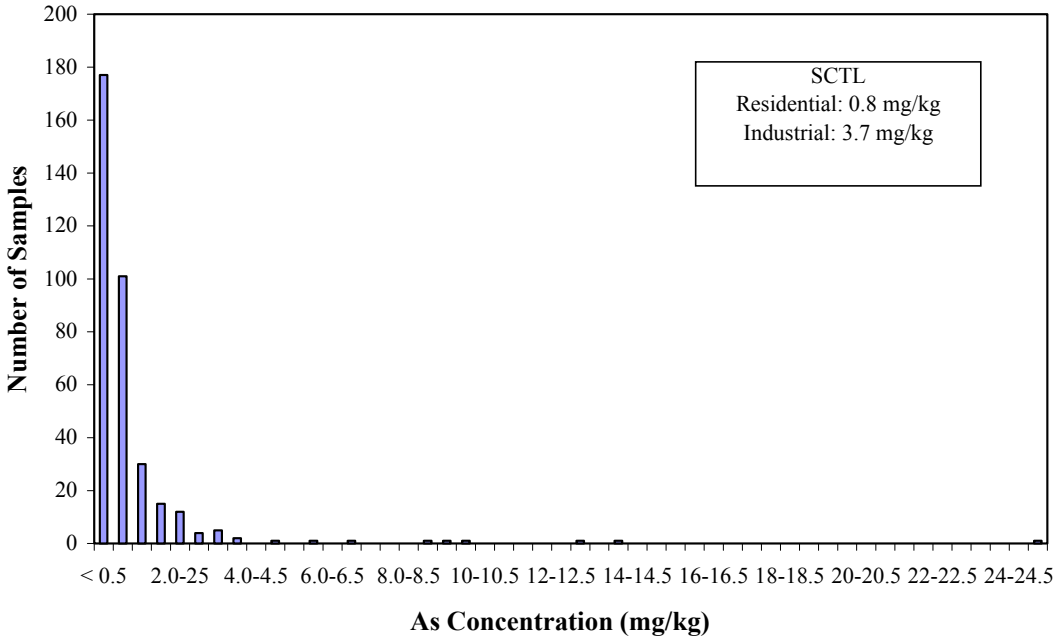

Figure 4.1 Distribution of As Concentrations for Total Metal Samples.

4.1.1.2 Barium

Barium were analyzed in 306 samples and detected above the detection limit (1.35 mg/kg) in 279 samples. The concentrations ranged from 3.0 to 1,019 mg/kg, with an average of 18.0 mg/kg. The average of all the samples is below both the residential and industrial SCTL limits (110 mg/kg and 87,000 mg/kg, respectively). While only one sample out of 172 street sweeping samples exceeded the residential SCTL limit, the concentrations of barium in eight sediment samples from stormwater ponds were higher than the residential SCTL limit but lower than the industrial SCTL limit. No barium was found above the SCTL limits in catch basins sediment samples that mostly contained barium.

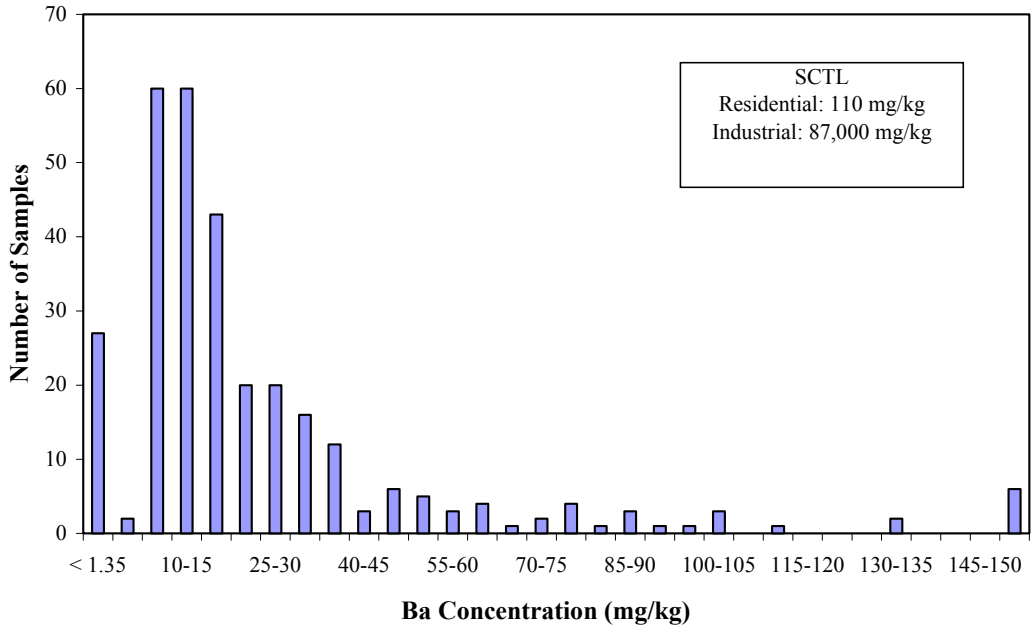

Figure 4.2 Distribution of Ba Concentrations for Total Metal Samples.

4.1.1.3 Cadmium

Cadmium was analyzed in 354 samples and detected in only four samples (three samples from street sweepings and one sample from stormwater pond sediments). The average concentration of the detected samples was 38.6 mg/kg, which was less than both the residential and industrial SCTL limits (75 mg/kg and 1,300 mg/kg, respectively).

4.1.1.4 Chromium

Chromium was analyzed in 306 samples and detected above the detection limit of 1.34 mg/kg in 225 samples. The concentrations ranged from 2.4 to 552 mg/kg with an average of 70.4 mg/kg. The average concentration was less than both the residential and industrial limits (210 mg/kg for Cr^{+6} and 420 mg/kg for Cr^{+6}, respectively). Out of 199 street sweeping samples, three samples exceeded the SCTL limit: two above the industrial limit and one above the residential limit. No hexavalent chromium was measured in any of the samples. The distribution of chromium sample concentrations is shown in Figure 4.3.

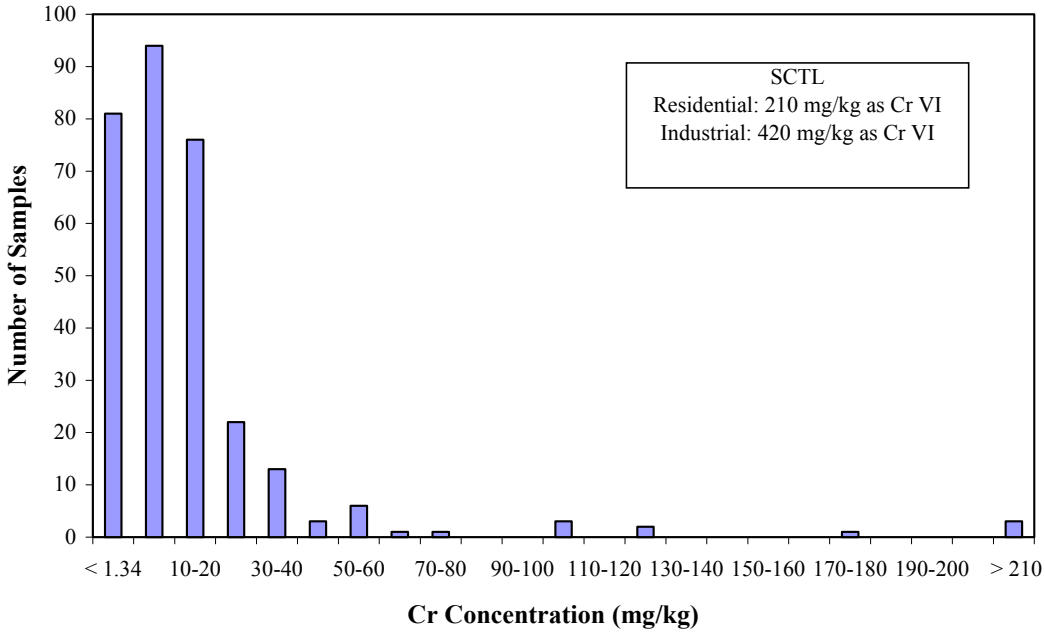

Figure 4.3 Distribution of Cr Concentrations for Total Metal Samples

4.1.1.5 Copper

Copper was analyzed in 354 samples and detected above the detection limit of 1.8 mg/kg in all samples with the exception of one sample. The average concentration of copper for all of the detected samples (20.2 mg/kg) did not exceed the SCTLs for either residential or industrial SCTL limits (110 mg/kg and 76,000 mg/kg, respectively). Four samples (three from street sweeping samples and one from catch basin samples) were found above the residential SCTL limit. Figure 4.4 presents the distribution of copper concentrations in all samples analyzed.

4.1.1.6 Lead

Lead was analyzed in 354 samples and detected above the SCTL in only two samples (one above the residential limit of 400 mg/kg and one above the industrial limit of 920 mg/kg). The source of the two samples that exceeded the limits was catch basin sediments in residential areas. The average concentration for all detected samples was 40.8 mg/kg, within the range of 2.7 to 1,060 mg/kg. The distribution of arsenic sample concentrations is shown in Figure 4.5.

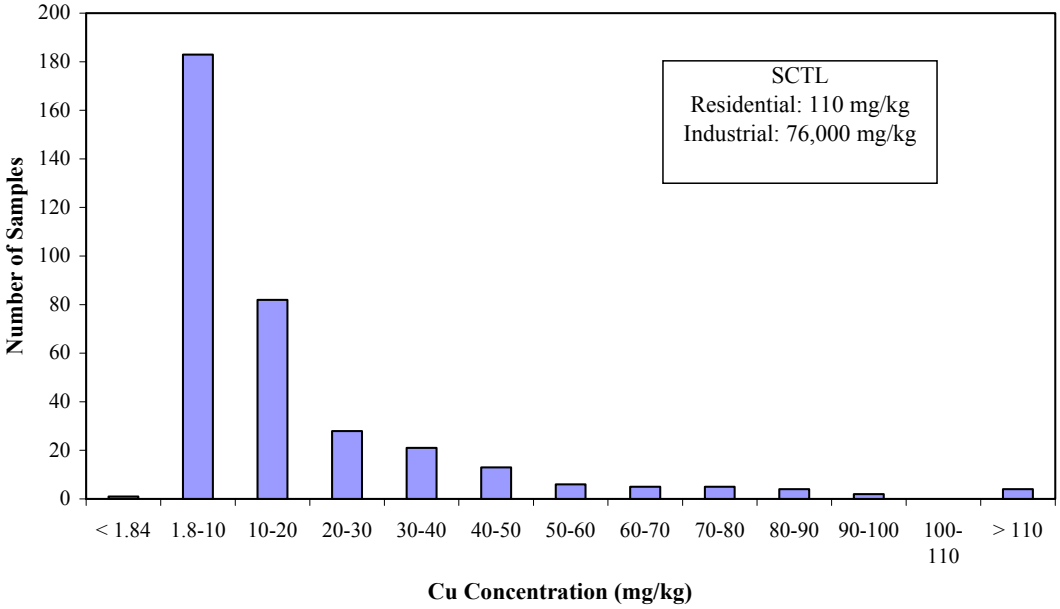

Figure 4.4 Distribution of Cu Concentrations for Total Metal Samples.

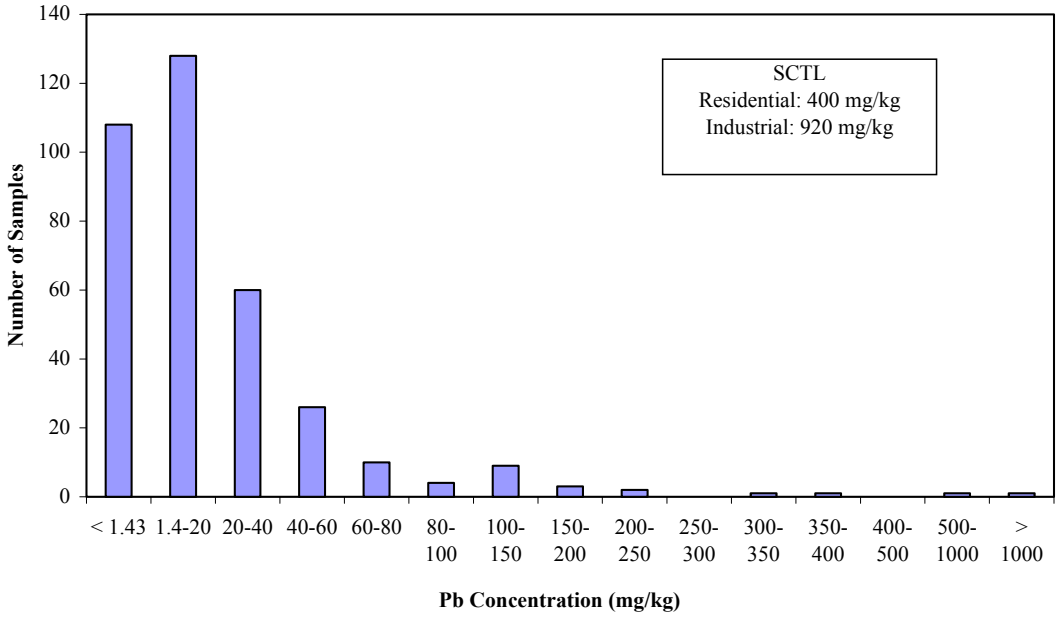

Figure 4.5 Distribution of Pb Concentrations for Total Metal Samples.

4.1.1.7 Mercury

Mercury was analyzed in 157 of street sweeping samples, 68 of stormwater pond sediments, and 78 of catch basin sediments. None of the samples were detected above the detection limit of 0.02 µg/kg.

4.1.1.8 Nickel

Nickel was analyzed in 354 samples and detected above the detection limit of 1.7 mg/kg in 350. Nickel concentrations ranged from 2.4 to 69.9 mg/kg, with an average of 9.4 mg/kg. None of the samples exceeded the SCTL limit for nickel. Figure 4.6 shows the distribution of nickel concentrations.

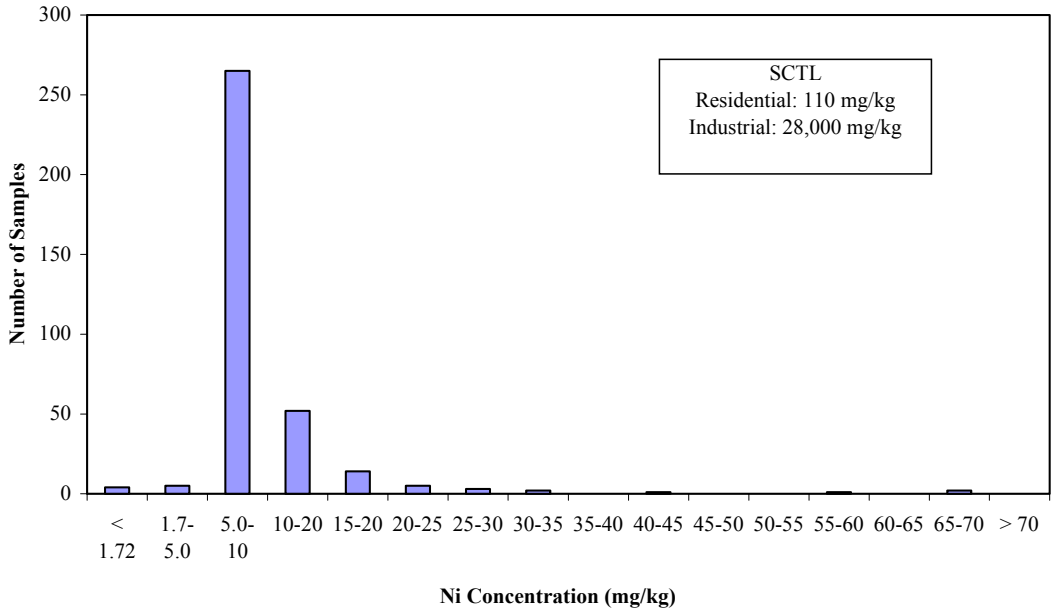

Figure 4.6 Distribution of Ni Concentrations for Total Metal Samples.

4.1.1.9 Selenium

Selenium was analyzed in 354 samples. Most of the samples were found below the detection limit of 0.25 mg/kg. Only a few samples were detected above the detection limit: four samples from stormwater pond sediments, one from street sweepings, and one from catch basin sediments. None of the samples detected exceeded the selenium SCTLs for either residential or industrial settings.

4.1.1.10 Silver

Silver was analyzed in 306 samples. Most of the samples were below the detection limit of 0.8 mg/kg. Only six samples were detected above the limit. None of the samples detected exceeded the silver SCTLs for either residential or industrial settings.

4.1.1.11 Zinc

Zince was analyzed in 354 samples. All samples were above the detection limit of 1.35 g/kg. Zinc concentrations ranged from 4.3 to 1,080 mg/kg, with an average of 91.8 mg/kg. None of the samples exceeded the SCTLs for either residential or industrial settings. Figure 4.7 illustrates the distribution of zinc total concentrations.

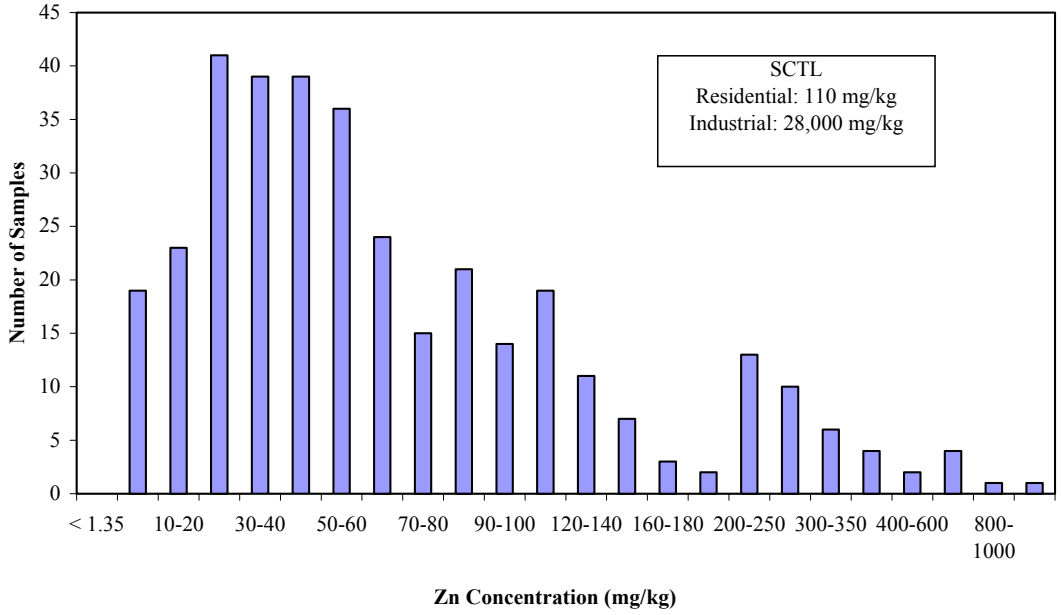

Figure 4.7 Distribution of Zn Concentrations for Total Metal Samples.

4.1.2 Organic Compound Analysis

A number of organic compounds, VOCs, SVOCs, OCl Pest, nitrogen-phosphorus pesticides (N-P Pest), chlorinated herbicides, and N-methylcarbamates, were analyzed in more than 300 samples. Table 4.5 presents number of samples analyzed for three different waste streams: street sweepings, stormwater pond sediments, and catch basin sediments. No nitrogen-phosphorus pesticides, chlorinated herbicides, or N-methylcarbamates were found in any of the samples. The following subsections discuss the results of the total analysis for organic compounds in the samples collected from street sweepings, stormwater pond sediments, and catch basin sediments. Appendix D contains all raw data of organic total analysis.

Table 4.5 Number of Samples Analyzed.

Waste Type	VOC	SVOC	OCl Pest	Nitrogen-Phosphorus Pesticides	Chlorinated Herbicides	N-methylcarbamates
Street Sweepings	169	169	193	185	188	202
Stormwater Pond Sediments	68	65	65	61	69	73
Catch Basin Sediments	65	66	65	68	66	79
Total	302	300	323	314	323	354

4.1.2.1 VOCs

VOCs were analysized in 302 samples. The target VOCs are listed in Table 4.6. Out of 74 VOCs, 12 compounds were detected in a few of the samples. Table 4.6 presents the results of VOC total analysis. None of the compounds in the samples exceeded the SCTLs for either residential or industrial settings. Three volatile compounds, acetone, methylene chloride, and acetonitrile, were commonly detected in the samples during VOC total analysis. These chemicals are commonly used as organic solvents for laboratory glassware cleaning and organic extraction. Laboratory blanks also contained these chemicals above detection levels (5 μg/kg). The source of the chemicals was most likely laboratory contamination.

Table 4.6 Results of VOC Total Analysis for Street Sweepings, Stormwater Pond Sediments, and Catch Basin Sediments.

unit: µg/kg

Analytes	No. of Samples	No. of Detects	Type of waste	Conc. Ranges	No. of Exceedance	SCTLs (Residential)	SCTLs (Industrial)
acrylonitrile	302	5	all stormwater	12.1 – 197.2	0	300	500
n-butylbenzene	302	1	--	86.0	--	NA	NA
isopropylbenzene	302	7	4 street sweepings, 3 catch basins	6.7 – 378.5	--	NA	NA
isopropyltoluene	302	4	all street sweepings	6.7 – 12.2	--	NA	NA
toluene	302	3	all catch basins	30.0 – 37.2	0	$3.8*10^5$	$2.6*10^6$
1,2,3 trimethylbenzene	302	1	catch basin	228.4	0	13000	89000
1,2,4 trimethylbenzene	302	1	catch basin	60.7	0	13000	88000
1,3,5 trimethylbenzene	302	2	street sweeping, catch basin	12.4 – 36.3	0	11000	74000
xylene	302	1	street sweeping	14.8	0	$5.9*10^6$	$4.0*10^7$

4.1.2.2 SVOCs

SVOCs were analyzed in 300 samples. Target organic analytes for SVOCs are listed in Table 3.4. Table 4.7 summarizes the results of SVOC total analyses. Out of 116 SVOCs, 17 compounds, mainly polycyclic aromatic hydrocarbons (PAHs) and base/neutral SVOCs, were found in a number of samples. Three compounds, benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene, were detected in two samples above the SCTLs for residential and industrial limits: one sample from residential street sweeping and one from catch basin sediment in a commercial area. The sample from catch basin sediment also contained other PAHs, such as anthracene, benzo(ghi)perylene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene. The concentrations of two compounds (benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) in the sample exceeded the SCTLs for residential area only for benzo(k)fluoranthene and both residential and industrial limits for indeno(1,2,3-cd)pyrene. No base/neutral compounds detected exceeded the respective SCTLs.

Table 4.7 Results of SVOC Total Analysis for Street Sweepings, Stormwater Pond Sediments, and Catch Basin Sediments.

unit: mg/kg

Analytes	No. of Samples	No. of Detects[1]	Type of waste	Conc. Ranges	No. of Exceedance (Residential)	No. of Exceedance (Industrial)	SCTLs (Residential)	SCTLs (Industrial)
Anthracene	300	1	Catch basin	12.9	0	0	18000	$2.6*10^5$
Benzo(a)anthracene	300	2	Street sweeping, Catch basin	14.5 – 39.9	2	2	1.4	5.0
benzo(a)pyrene	300	2	Street sweeping, Catch basin	9.2 – 34.3	2	2	0.1	0.5
benzo(b)fluoranthene	300	2	Street sweeping, Catch basin	13.2 – 104.1	2	2	1.4	4.8
benzo(k)fluoranthene	300	1	Catch basin	22.2	1	0	15	52
benzo(g,h,i)perylene	300	2	Street sweeping, Catch basin	7.6 – 48.5	0	0	2300	41000
bis(2-ethylhexyl)phthalate	300	4	All street sweeping	5.4 – 14.9	0	0	76	280
chrysene	300	1	Catch basin	56.3	0	0	140	450
di-n-butyl phalate	300	15	13 Street sweeping, 2 Catch basin	5.1 – 15.7	0	0	7300	$1.4*10^5$
di-n-octyl phalate	300	1	Street sweeping	29.0	--	--	NA	NA
fluoranthene	300	12	3 Street sweeping, 5 Catch basins, 4 Stormwater	5.4 – 59.3	0	0	2900	48000
fluorene	300	1	Catch basin	6.5	0	0	2200	28000
indeno(1,2,3-cd)pyrene	300	1	Catch basin	47.2	1	1	1.5	5.3
phenanthrene	300	5	2 Catch Basins, 3 Stormwater	7.5 – 29.1	0	0	2000	30000
pyrene	300	17	9 Street sweeping, 2 Catch basins, 6 Stormwater	11.6 – 111.2	0	0	2200	37000

[1] Detection limit is 5.0 mg/kg

4.1.2.3 OCl Pest

OCl Pest was analyzed in 323 samples. Target OCl Pest can be seen in Table 3.4. Out of 43 pesticides, 14 were detected in a number of samples. Results of OCl Pest found in the samples are shown in Table 4.8. Two OCl Pests, 4,4'-DDT and Endosulfan II, were found in 69 and 47 samples, respectively. Neither compound exceeded the respective SCTL limits. Only one compound, dieldrin, in four samples, exceeded the SCTLs; three exceeded the residential

limit of 70 μg/kg, and one the industrial limit of 300 μg/kg. The sources of the four samples were as follows: two from residential street sweepings, one from stormwater pond sediments in residential and state roads, and one from catch basin sediment in a residential area.

4.1.2.4 Nitrogen-Phosphorus Pesticides

Nitrogen-phosphorus pesticides were analyzed in 314 samples. No nitrogen-phosphorus pesticides were found above the detection limit (0.25 mg/kg) in any of the samples.

Table 4.8 Results of OCl Pest Total Analysis in Street Sweepings, Stormwater Pond Sediments, and Catch Basin Sediments.

unit: μg/kg

Analytes	No. of Samples	No. of Detects	Type of waste	Conc. Ranges	No. of Exceedance (Residential)	No. of Exceedance (Industrial)	SCTLs (Residential)	SCTLs (Industrial)
4,4'-DDD	323	14	7 SS, 4 CB, 3 SW	28.7 – 785.6	0	0	4600	18000
4,4'-DDE	323	10	3 SS, 4 CB, 4 SW	43.6 – 234.2	0	0	3300	13000
4,4'-DDT	323	69	34 SS, 12, CB, 23 SW	25.1 – 785.6	0	0	3300	13000
aldrin	323	1	1 SW	41.0	0	0	70	300.0
alpha-BHC	323	6	1 SS, 5 SW	33.8 – 141.0	--	--	NA	NA
alpha-chlordane	323	15	4 SS, 2 CB, 9 SW	25.5 – 230.4	0	0	3100[2]	12000[2]
beta-BHC	323	9	2 SS, 7 SW	28.1 – 145.2	--	--	NA	NA
delta-BHC	323	2	2 SW	35.9 – 36.3	--	--	NA	NA
Dieldrin	323	9	4 SS, 1 CB, 4 SW	33.8 – 494.6	3	1	70	300
endosulfan II	323	47	35 SS, 4 CB, 8 SW	43.6 - 2817	--	--	NA	NA
endosulfan sulfate	323	1	1 CB	36.3	--	--	NA	NA
Endrin	323	8	4 SS, 1 CB, 3 SW	78.6 – 463.6	0	0	21000	$3.4*10^5$
endrin aldehyde	323	2	2 SS	94.0 – 214.1	--	--	NA	NA
gamma-chlordane	323	14	6 SS, 5 CB, 3 SW	26.4 – 326.1	0	0	3100[2]	12000[2]

[1] SS: Street sweeping, CB: Catch basin, SW: Stormwater Sediment.
[2] SCTL limit for Chlordane.
[3] Detection limit: 25 μg/kg.

4.1.2.5 N-methylcarbamate

N-methylcarbamate analytes were analyzed in 354 samples. No n-methylcarbamate analytes were found above the detection limit (0.1 mg/kg) in any of the samples during total analysis.

4.1.2.6 Chlorinated Herbicides

Chlorinated herbicides were analyzed in 323 samples. No chlorinated herbicides were detected above the detection limit (0.5 mg/kg) in any of total samples.

4.2 Leaching Results

Samples were subjected to a leaching test using the SPLP. The SPLP test utilizes a leaching solution that was designed to simulate slightly acidic rainwater. The leaching concentrations of chemicals are compared to Florida GWCTLs to determine whether any problematic contaminants are present due to leaching. For Trips 11 and 12, SPLP leachate samples were additionally analyzed for drinking water secondary parameters (e.g., fluoride, iron, pH, sulfate) that may cause groundwater to be contaminated. While secondary standards are not always appropriate comparisons, the results would be valuable when beneficial reuse of such waste streams is considered. The results of leaching analysis are presented as follows. All metal leaching raw data were attached to Appendix E.

4.2.1 Metals

The results of leaching analysis for metals are presented in Table 4.9. Four metals (arsenic, barium, lead, and zinc) were detected from a number of samples. Samples of other metals were below the detection limits. One sample, from stormwater pond sediment in a residential area, exceeded the GWCTL for cadmium. Out of 184 samples, nickel was found in three samples, all of which exceeded the GWCTL limit of 0.1 mg/L. The sources of the samples were as follows: two from street sweepings in residential areas and in residential and commercial areas, and one from stormwater pond sediment in a residential area. Out of 50 samples detected for lead, eight exceeded the GWCTL for lead (0.015 mg/L). Tables 4.10 through 12 present a summary of SPLP results for each waste stream. The following subsections discuss each metal that was found in the samples.

Table 4.9 SPLP Results of Samples from Street Sweepings, Stormwater Pond Sediments, and Catch Basin Sediments.

Element	Number of Samples	Number of Detects	Average Detected (mg/L)	Maximum Detected (mg/L)	Minimum Detected (mg/L)	No of Exceedance	GWCTLs[1] (mg/L)	Detection Limits (mg/L)
Ag	150	0	--	--	--	0	0.1	0.082
As	185	27	0.010	0.045	0.003	0	0.05	0.0025
Ba	150	78	0.078	0.122	0.055	0	2.0	0.054
Cd	178	3	0.004	0.009	0.001	1	0.005	0.0005
Cr	150	3	0.090	0.099	0.077	0	0.1	0.054
Cu	184	2	0.190	0.211	0.169	0	1.0	0.069
Hg	169	0	--	--	--	0	0.002	0.0003
Ni	184	3	0.680	1.071	0.189	3	0.1	0.074
Pb	184	50	0.117	3.295	0.003	8	0.015	0.0025
Se	154	0	--	--	--	0	0.05	0.025
Zn	184	44	0.342	2.689	0.055	0	5.0	0.054

[1.] GWCTLs in Florida (FAC 62-777, 1999). Note: Average concentration and standard deviation were calculated using only the detected samples.

Table 4.10 SPLP Results for Street Sweepings.

Element	Number of Samples	Number of Detects	Average Detected (mg/L)	Maximum Detected (mg/L)	Minimum Detected (mg/L)	No of Exceedance	GWCTLs (mg/L)	Detection Limits (mg/L)
Ag	67	0	--	--	--	0	0.1	0.082
As	96	14	0.007	0.016	0.003	0	0.05	0.0025
Ba	68	41	0.078	0.115	0.055	0	2.0	0.054
Cd	96	0	--	--	--	0	0.005	0.0005
Cr	68	1	0.077	0.077	0.077	0	0.1	0.054
Cu	95	2	0.190	0.211	0.169	0	1.0	0.069
Hg	84	0	--	--	--	0	0.002	0.0003
Ni	95	2	0.926	1.071	0.780	2	0.1	0.074
Pb	95	25	0.011	0.064	0.003	4	0.015	0.0025
Se	69	0	--	--	--	0	0.05	0.025
Zn	95	29	0.407	2.689	0.056	0	5.0	0.054

Note: Average concentration and standard deviation were calculated using only the detected samples.

Table 4.11 SPLP Results for Stormwater Pond Sediments

Element	Number of Samples	Number of Detects	Average Detected (mg/L)	Maximum Detected (mg/L)	Minimum Detected (mg/L)	No of Exceedance	GWCTLs (mg/L)	Detection Limits (mg/L)
Ag	38	0	--	--	--	0	0.1	0.082
As	39	10	0.010	0.019	0.003	0	0.05	0.0025
Ba	38	18	0.080	0.122	0.056	0	2.0	0.054
Cd	38	1	0.009	0.009	0.009	1	0.005	0.0005
Cr	38	1	0.093	0.093	0.093	0	0.1	0.054
Cu	39	0	--	--	--	0	1.0	0.069
Hg	38	0	--	--	--	0	0.002	0.0003
Ni	39	1	0.189	0.189	0.189	1	0.1	0.074
Pb	39	8	0.694	3.295	0.003	2	0.015	0.0025
Se	38	0	--	--	--	0	0.05	0.025
Zn	39	8	0.240	1.043	0.057	0	5.0	0.054

Note: Average concentration and standard deviation were calculated using only the detected samples.

Table 4.12 SPLP Results for Catch Basin Sediments.

Element	Number of Samples	Number of Detects	Average Detected (mg/L)	Maximum Detected (mg/L)	Minimum Detected (mg/L)	No of Exceedance	GWCTLs (mg/L)	Detection Limits (mg/L)
Ag	45	0	--	--	--	0	0.1	0.082
As	50	3	0.020	0.045	0.003	0	0.05	0.0025
Ba	44	19	0.076	0.107	0.059	0	2.0	0.054
Cd	44	2	0.002	0.002	0.001	0	0.005	0.0005
Cr	44	1	0.099	0.099	0.099	0	0.1	0.054
Cu	50	0	--	--	--	0	1.0	0.069
Hg	47	0	--	--	--	0	0.002	0.0003
Ni	50	0	--	--	--	0	0.1	0.074
Pb	50	18	0.008	0.021	0.003	2	0.015	0.0025
Se	47	0	--	--	--	0	0.05	0.025
Zn	50	7	0.186	0.624	0.055	0	5.0	0.054

4.2.1.1 Arsenic

Arsenic was analyzed in 185 SPLP leaching samples and detected above the detection limit of 2.5 µg/L (Figure 4.8) in 27 samples. The concentrations ranged from 3 to 45 µg/L, with an average of 10 µg/L. None of the samples detected exceeded the GWCTL for As (50 µg/L). However, US EPA might lower the current drinking water limit for arsenic (50 µg/L) to 10 µg/L; 11 samples were above the proposed limit.

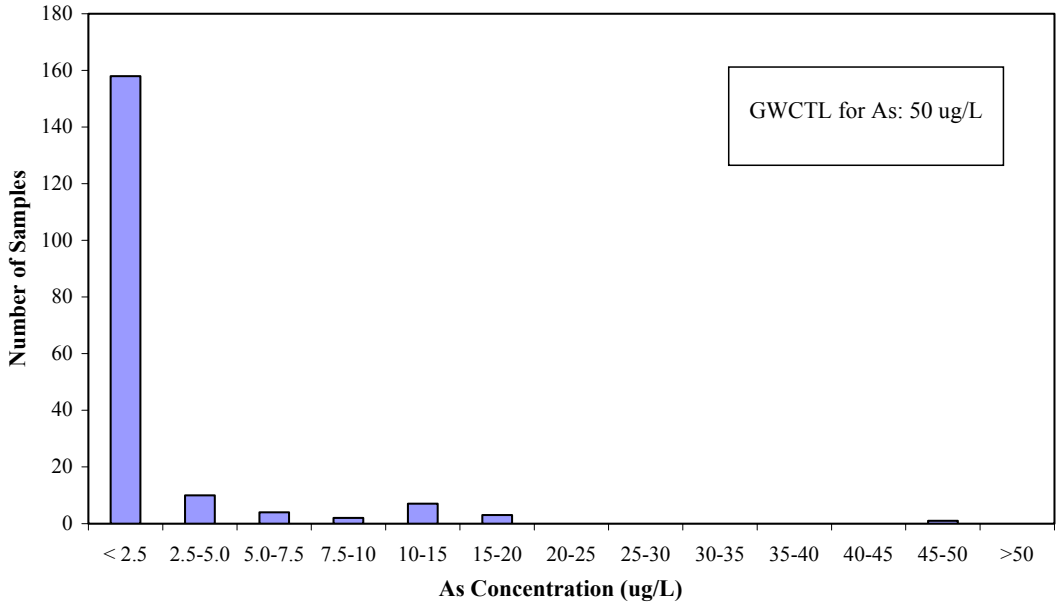

Figure 4.8 Distribution of As Concentrations for SPLP Leaching Samples.

4.2.1.2 Barium

Barium was analyzed in 150 SPLP leaching samples and detected in almost half of the samples (Figure 4.9). The concentrations ranged from 0.06 mg/L to 0.12 mg/L. None of the samples exceeded the GWCTL for Ba (2.0 mg/L). The average concentration of the detected samples was 0.08 mg/L.

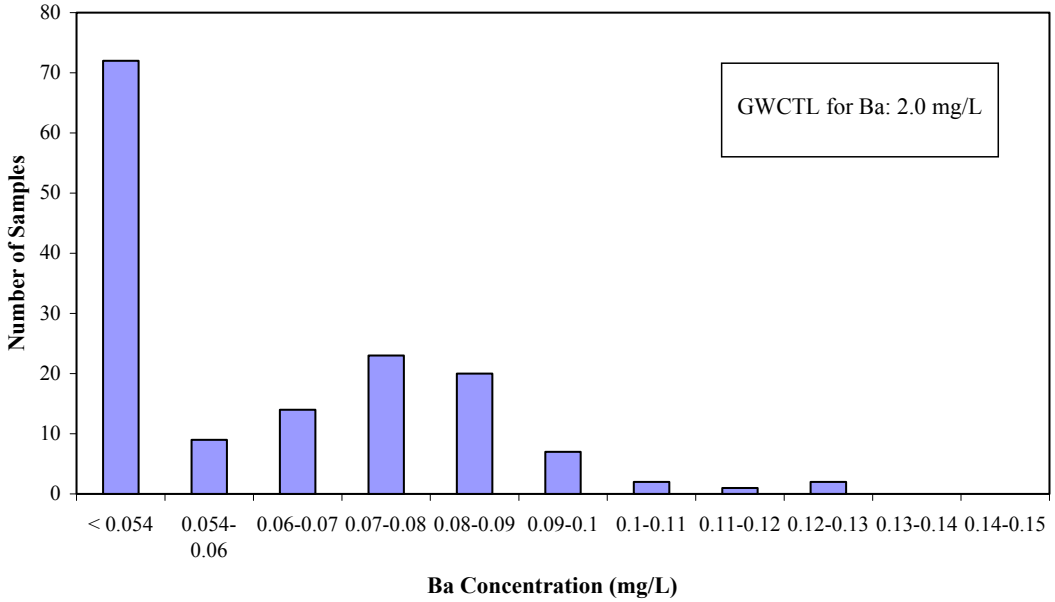

Figure 4.9 Distribution of Ba Concentrations for SPLP Leaching Samples.

4.2.1.3 Cadmium

Cadmium was analyzed in 178 SPLP leaching samples and detected above the detection limit of 0.5 µg/L in three samples. Of the three samples detected, one sample from stormwater pond sediment in a residential area exceeded the GWCTL for cadmium (5 µg/L).

4.2.1.4 Chromium

Chromium was analyzed in 150 SPLP leaching samples and detected above the detection limit of 0.054 mg/L in three samples, but none exceeded the GWCTL for chromium (0.1 mg/L).

4.2.1.5 Copper

Copper was analyzed in 184 SPLP leaching samples and detected above the detection limit of 0.054 mg/L in only two samples, but neither exceeded the GWCTL for copper (1.0 mg/L).

4.2.1.6 Lead

Lead was analyzed in 184 SPLP leaching samples and detected above the detection limit of 0.0025 mg/L in 50 samples. The concentration of the detected samples widely ranged from 0.003 mg/L to 3.3 mg/L, with an average of 0.12 mg/L. Figure 4.10 illustrates the distribution of the sample concentrations for lead.

Leaching samples from two stormwater pond sediments in commercial areas showed relatively high levels of lead. Four samples out of 25 detected street sweeping samples for lead exceeded the GWCTL of 0.015 mg/L. The source of the samples was street sweepings in residential areas. Out of 50 catch basin sediment samples, 18 were detected above the detection limit. Two samples from residential and commercial areas exceeded the GWCTL.

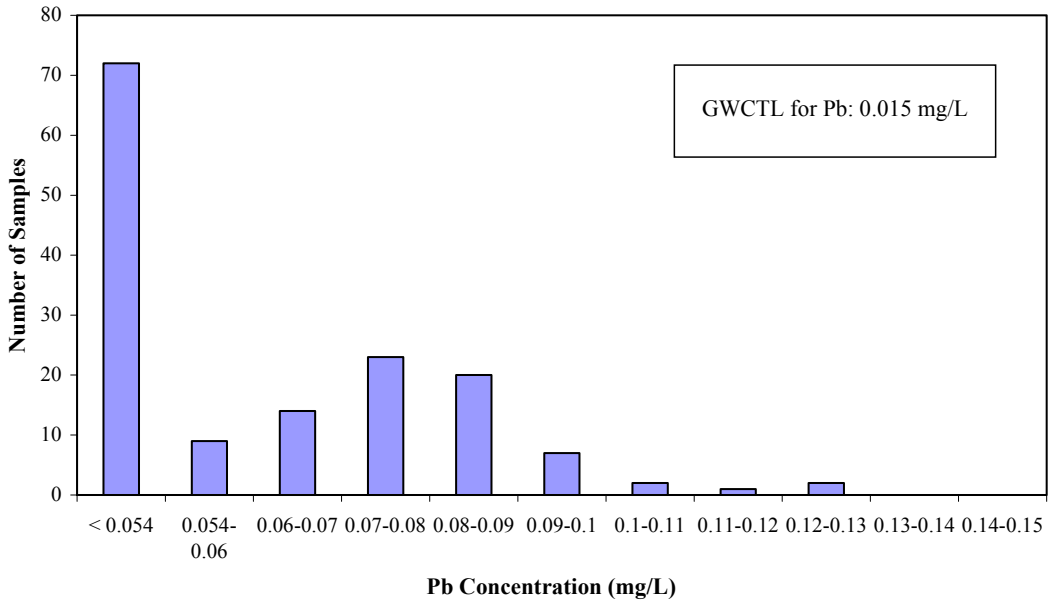

Figure 4.10 Distribution of Pb Concentrations for SPLP Leaching Samples.

4.2.1.7 Mercury

Mercury was analyzed in 169 SPLP leaching samples and detected in none of the samples above the detection limit of 0.3 μg/L for mercury.

4.2.1.8 Nickel

Nickel was analyzed in 184 SPLP leaching samples and was detected in only three samples, all of which exceeded the GWCTL of 0.1 mg/L. The sources of the exceeded samples are one sample from stormwater pond sediment in residential area and two from street sweepings in residential and commercial areas. The average concentration of the detected samples is 0.68 mg/L.

4.2.1.9 Selenium

Selenium was analyzed in 154 SPLP leaching samples and detected in none of the samples above the detection limit of 0.025 mg/L for selenium.

4.2.1.10 Silver

Silver was analyzed in 150 SPLP leaching samples and detected in none of the samples above the detection limit of 0.08 mg/L for silver.

4.2.1.11 Zinc

Zinc was analyzed in 184 SPLP leaching samples and was detected in 44 samples. Figure 4.11 presents the distribution of zinc sample concentrations. The zinc concentrations ranged from 0.05 to 2.7 mg/L, with an average of 0.34 mg/L. All of the detected samples fell below the GWCTL for zinc (5.0 mg/L).

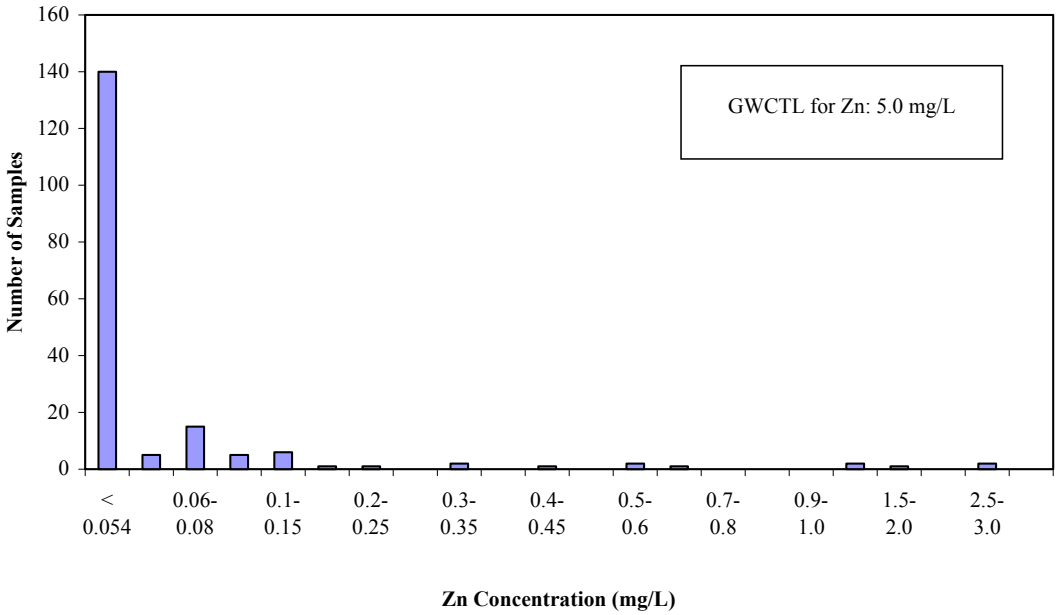

Figure 4.11 Distribution of Zn Concentrations for SPLP Leaching Samples.

4.2.2 Organic Compounds

Target organic groups were VOCs, SVOCs, OCl Pest, nitrogen-phosphorus pesticides, chlorinated herbicides, and N-methylcarbamates, which is the same as for total analyses. The SPLP leaching test was performed to examine leachability of organic compounds. The concentrations of leaching samples were compared to GWCTLs where appropriate. Table 4.13 shows number of the samples analyzed by waste type. The following subsections discuss the leaching results for organic compounds in street sweepings, stormwater pond sediments, and catch basin sediments. Appendix D contains all raw data of organic leaching analysis.

Table 4.13 Number of Leaching Samples Analyzed.

Waste Type	VOC	SVOC	OCl Pest	N-P Pest	Herbicides	Carbamates
Street Sweepings	91	94	88	92	78	94
Stormwater Pond Sediments	36	28	33	32	34	36
Catch Basin Sediments	28	25	45	8	8	46
Total	155	147	166	132	120	176

4.2.2.1 VOCs

Using the SPLP VOC leaching test with a ZHE, 155 SPLP leaching samples were analyzed. Table 4.14 presents the results of organic leaching analysis. Out of 74 target VOCs, 9 were detected above the detection limit of 5.0 μg/L. The source of all the samples was from catch basin sediments in residential areas. Four VOCs (1,4-dichlorobenzene, naphthalene, 1,3,5-trimethylbenzene, and o-xylene) were found above the GWCTLs in two samples. No comparisons were made for the other two compounds (n-but butyl benzene and p-isopropyltoluene) found in one sample, because no GWCTL limits had been set for the compounds. Two volatile organic analytes, acetone and methylene chloride, were commonly found in many samples. Laboratory blanks also contained such compounds above the detectable level. These organic solvents were used for organic extraction in the laboratory. Therefore, the compounds likely may have resulted from laboratory contamination, as discussed previously.

Table 4.14 Results of VOC Analysis for Leaching Samples.

unit: µg/L

Analytes	No. of Samples	No. of Detects	Type of Waste	Conc. Ranges	No. of Exceedance	GWCTL
n-butyl benzene	155	1	Catch basin	142	0	--
1,4-dichlorobenzene	155	2	2 Catch basins	90.3 - 142	2	75.0
naphthalene	155	1	Catch basin	890	1	20.0
p-isopropyltoluene	155	1	Catch basin	17.1	--	NA
1,3,5-trimethylbenene	155	1	Catch basin	12.4	1	10
o-xylene	155	1	Catch basin	594	1	20

Detection limit: 5.0 µg/L

4.2.2.2 SVOCs

SVOC analysis was conducted on 147 SPLP leaching samples produced from the SPLP test. No SVOCs were detected above the detection limit (10.0 µg/L) in any of the leaching samples.

4.2.2.3 OCl Pests

OCl Pest was analyzed in 166 SPLP leaching samples. Leaching results for OCl Pest are shown in Table 4.15. Out of 43 target OCl Pests, three compounds were detected above the detection limit of 0.05 µg/L: 4,4'-DDT in 13 samples, beta-BHC in 7 samples, and Endosulfan II in one sample. The concentrations of 4,4'-DDT in all the detected samples exceeded the GWCTL of 0.1 µg/L. The sources of the samples are mainly from stormwater sediments and street sweepings. No GWCTLs were available for the other two detected compounds.

4.2.2.4 Nitrogen-Phosphorus Pesticides

Nitrogen-phosphorus pesticides were analyzed in 132 SPLP leaching samples. No nitrogen-phosphorus pesticides were found above the detection limit (0.5 µg/L) in any of the samples.

4.2.2.5 N-methylcarbamate

N-methylcarbamate analytes were analyzed in 176 SPLP leaching samples. No n-methylcarbamate analytes were found above the detection limit (50 µg/L) in any of the samples during leaching analysis.

Table 4.15 Results for OCl Pest in Leaching Samples.

unit: µg/L

Analytes	No. of Samples	No. of Detects[1]	Type of Waste	Conc. Ranges	No. of Exceedance	GWCTL
4,4'-DDT	166	13	3 street sweeping, 10 stormwater sediment	0.13 - 0.22	13	0.1
beta-BHC	166	7	7 stormwater sediment	0.1 - 0.24	--	NA
endrin	166	1	1 street sweeping	0.18	--	NA
Endosulfan II	166	1	1 street sweeping	0.45	--	NA

1. Detection limit: 0.05 µg/L

4.2.2.6 Chlorinated Herbicides

Chlorinated herbicides were analyzed in 120 SPLP leaching samples. No chlorinated herbicides were detected above the detection limit (1.0 mg/kg) in any of SPLP leaching samples.

4.2.3 Secondary Parameters for Drinking Water

Thirty SPLP leachate samples were additionally analyzed for secondary water quality parameters. Secondary parameters refer to those compounds whose GWCTL was based on Safe Drinking Water Act Secondary Drinking Water Standards. Secondary drinking water standards address compounds that impact the aesthetic quality of the water, such as taste, color, and odor. The secondary parameters were as follows: aluminum, chloride, copper, ethylbenzene, fluoride, iron, manganese, pH, silver, sulfate, toluene, TDS, xylenes, and zinc. Some of the parameters such as copper, zinc, and organic compounds were previously discussed in the leaching results. Results of other parameters only are presented and discussed (Table 4.16).

Aluminum was detected in SPLP leachates from 20 samples, all of which exceeded the GWCTL of 0.2 mg/L. The maximum concentration of aluminum, 11.9 mg/L, was detected in a residential street sweepings sample. The average concentration of aluminum was 1.4 mg/L. Iron was detected in 8 samples above the detection limit of 0.3 mg/L, which is equivalent to GWCTL. The concentrations of iron ranged from 0.32 to 2.22 mg/L with an average concentration of 0.88 mg/L. SPLP leachate pH ranged from 7.0 to 9.1 with an average of 7.99. Nine samples showed a pH outside the range GWCTL range of 6.5 to 8.5. None of the other ions (chloride, fluoride, and sulfate), organic compounds (ethylbenzene, toluene, and xylenes) and metals (copper, manganese, silver, and zinc) exceeded their respective GWCTL.

Table 4.16 Results of Secondary Standard Parameters for Drinking Water for SPLP Leaching Samples.

Sample Name	Aluminum	Chloride	Fluoride	Iron	Manganese	pH	Sulfate	TDS
021402 TAM S1A	0.59	6.45	BDL	BDL	BDL	7.14	9.62	135
021402 TAM S2A	BDL	4.99	BDL	BDL	BDL	7.25	4.96	290
021402 TAM S3A	0.42	4.99	BDL	BDL	BDL	7.10	7.67	125
021402 TAR S1A	BDL	7.80	BDL	BDL	BDL	7.22	6.29	NA
021402 TAR S2A	0.55	7.00	BDL	0.58	BDL	7.25	8.38	NA
021402 TAR P1A	0.22	5.62	BDL	BDL	BDL	8.88	25.75	NA
021402 CLW S1A	0.21	4.66	BDL	BDL	BDL	8.80	5.24	390
021402 CLW C1A	0.78	4.60	BDL	0.39	BDL	7.82	12.77	530
021402 CLW C2A	1.02	6.50	BDL	BDL	BDL	7.00	12.95	320
021402 SAR S1A	0.66	4.90	BDL	BDL	BDL	8.12	6.30	100
021502 LAK S1A	0.32	5.37	BDL	BDL	BDL	7.51	7.59	75
021502 LAK S2A	0.27	5.11	BDL	BDL	BDL	7.32	5.64	230
021502 LAK S5A	BDL	5.11	BDL	BDL	BDL	7.10	5.33	175
021502 LAK C1A	0.41	5.44	BDL	BDL	BDL	7.42	8.06	120
021502 ORL S1A	11.86	5.51	BDL	BDL	BDL	9.11	6.12	NA
031402 HIL S1A	BDL	2.54	BDL	BDL	BDL	8.96	4.06	65
031402 HIL S3A	BDL	2.38	BDL	BDL	BDL	8.15	4.89	72
031402 HIL S5A	0.34	2.43	BDL	0.33	BDL	8.12	7.35	350
031402 HIL S6A	0.23	2.41	BDL	2.22	BDL	8.88	2.51	80
031402 HIL S8A	0.29	2.78	BDL	BDL	BDL	7.80	4.02	BDL
031402 HIL S10A	BDL	2.14	BDL	BDL	BDL	8.20	2.32	3100
031402 HIL S12A	BDL	2.21	BDL	BDL	BDL	7.82	2.83	130
031402 HIL S13A	0.61	2.58	BDL	1.07	BDL	7.96	5.28	110
031402 HIL S14A	5.93	2.10	BDL	1.39	BDL	8.85	4.62	BDL
031402 HIL S16A	1.36	2.57	BDL	BDL	BDL	8.71	5.68	BDL
031402 SAR S2A	BDL	3.04	BDL	BDL	BDL	7.78	3.55	BDL
031502 FTP S1A	BDL	5.27	BDL	0.32	BDL	7.13	2.98	BDL
031502 FTP S2A	0.60	3.00	BDL	BDL	BDL	8.43	6.30	200
031502 FTP S4A	1.43	3.11	BDL	0.71	BDL	8.89	6.16	110
031502 FTP S5A	BDL	2.52	BDL	BDL	BDL	8.84	4.16	300
Secondary Groundwater Standard	**0.2**	**50.0**	**2.0**	**0.3**	**0.05**	**6.5-8.5**	**250**	**500**

[1] Detection limits: 0.2 mg/L for aluminum, 1.0 mg/L for chloride and fluoride, 0.3 mg/L for iron, 0.05 mg/L for manganese, 1.0 mg/L for sulfate. [2] Note: Average concentration and standard deviation were calculated using only the detected samples.

4.2.3.1 Analysis of Aluminum and Iron in Soils

An additional study was performed to examine whether the source of aluminum and iron might be natural soil. Aluminum and iron are naturally-occurring and often abundant elements in soil. Six different natural soils from four different locations in Florida were collected in July 2002. To the best of the researcher's abilities, the following soils were not impacted by any previous contamination or industrial activity:

1. Sand sample collected from a borrow pit Archer, Florida (designated as *Alachua soil*);

2. Soil samples collected south of the Opalocka Airport in Miami-Dade County (designated as *Miami soil*);

3. Soil samples collected from a borrow pit near Raiford, Florida (designated as *NRL soil*);

4. Soil (sandy) collected from Gainesville, Florida (designated as *Sand*);

5. Soil (sand clay loam soil) collected from Gainesville, Florida (designated as *Clay*); and

6. Soil (organic soil) collected from Gainesville, Florida (designated as *Organic*).

Total and leachable concentrations of aluminum and iron were measured in the soils following the standardized analytical methods (US EPA SW 846 Method 3051A/6010B and Method 1312/3015/6010B).

Table 4.17 presents total and leachable concentrations of aluminum and iron measured in the soil samples for this study. The SPLP results of the soils show that all samples exceeded the GWCTLs (or secondary drinking water standards) for aluminum and iron (0.2 mg/L and 0.3 mg/L, respectively), with the exception of the soil sample from the Archer site. The sample exceeded the limit of aluminum only. Total concentrations of aluminum in soil samples ranged from 813 to 55,000 mg/kg, and the range of iron concentrations was from 781 to 11,630 mg/kg.

Table 4.17 Summarized Results of Total and Leachable Aluminum and Iron from Soil Samples.

Soil	Aluminum			Iron		
	Ave. Conc.	Min.	Max.	Ave. Conc.	Min.	Max.
Leachable (mg/L)						
Alachua Soil (2 samples)	0.30	<0.2	0.33	<0.3	<0.3	<0.3
Miami Soil (2 samples)	0.82	0.73	0.91	0.86	0.85	0.87
NRL Soil (4 samples)	0.41	<0.2	0.90	0.38	<0.3	0.85
GAI Clay (4 samples)	1.40	0.38	2.82	0.46	<0.3	0.66
GAI Organic (4 samples)	1.91	0.60	3.27	0.63	0.32	0.96
GAI Sand (4 samples)	5.38	1.30	7.03	1.20	0.37	1.70
Total Content (mg/kg)						
Alachua Soil (2 samples)	3,570	2,990	4,150	930	806	1,050
Miami Soil (1 sample)	813	--	--	3,600	--	--
NRL Soil (2 samples)	19,940	16,890	23,000	4,020	3,310	4,750
GAI Clay (1 sample)	55,000	--	--	11,630	--	--
GAI Organic (1 sample)	3,900	--	--	1,350	--	--
GAI Sand (2 samples)	3,690	3,280	4,100	781	718	845

Note. Secondary limit: 0.2 mg/L for Al and 0.3 mg/L for Fe.

4.2.3.2 Additional Aluminum and Iron Results of SPLP Tests

To explore the Fe and Al leaching issue further, additional 40 residuals samples (from those samples already collected and not leached for Al and Fe) were leached with the SPLP. The sole purpose was to analyze the leachable concentration of Al and Fe. These 40 samples were composed of 15 street sweepings samples, 15 stormwater sediment samples, and 10 catch basin sediment samples and were all collected in October and November 2001.

Table 4.18 presents the aluminum and iron concentrations found in the 40 SPLP leachates. Aluminum was detected in 29 samples out of a total of 40 samples above the detection limit (0.2 mg/L). All the detected samples leached aluminum above the GWCTL of 0.2 mg/L. Iron was detected in 22 out of 40 samples above the detection limit (0.3 mg/L). All the detected samples leached iron above the GWCTL of 0.3 mg/L.

Table 4.18 SPLP Results of Street Sweepings, Stormwater Pond Sediments, and Catch Basin Sediments.

Stormwater Pond Sediment Sample	Al	Fe	Catch Basin Sediments Sample	Al	Fe	Street Sweeping Sample	Al	Fe
111601 MILP1A	0.28	BDL	100801 GAIC1A	0.32	0.56	100401 HILS1	0.20	BDL
111601 MILP2A	BDL	BDL	100801 GAIC4A	0.39	0.35	100401 HILS3	BDL	BDL
111601 MILP3A	BDL	BDL	100801 GAIC7A	0.35	0.53	100401 HILS4	BDL	BDL
111601 MILP4A	1.16	0.32	111501 GAIC1A	BDL	BDL	100401 HILS7	0.65	1.91
111601 MILP5A	2.03	0.47	111501 GAIC2A	0.30	0.35	100401 HILS9	BDL	BDL
111601 MILP6A	1.00	0.52	111501 GAIC3A	BDL	BDL	100401 HILS11	0.75	0.37
111601 HDPP1A	4.50	1.76	111501 GAIC4A	0.31	BDL	100401 HILS13	0.44	0.52
111601 HDPP2A	BDL	BDL	111501 GAIC5A	0.86	0.65	100401 HILS15	0.36	0.36
111601 HDPP1B	1.09	0.55	111501 GAIC6A	0.34	BDL	100401 HILS16	0.52	BDL
111601 HDPP1C	0.44	0.46	111501 GAIC7A	0.35	0.54	111501 GAIS1A	BDL	BDL
111601 HDPP1D	4.58	1.76				111501 GAIS2A	0.36	0.32
111601 HDPP1E	BDL	BDL				111501 GAIS3A	BDL	BDL
100301 HMDP1C	3.69	0.56				111501 GAIS4A	1.48	0.55
100301 SCOP1A	0.22	BDL				111901 GAIS1A	0.49	0.30
100301 SCOP3A	0.71	BDL				111901 GAIS2A	0.52	0.48
Average	1.79	0.73	Average	0.40	0.45	Average	0.58	0.60
Std. Dev.	1.67	0.60	Std. Dev.	0.19	0.17	Std. Dev.	0.35	0.54
Min.	<0.2	<0.3	Min.	0.09	0.05	Min.	<0.2	<0.3
Max.	4.58	1.76	Max.	0.86	0.65	Max.	1.48	1.91

Table 4.19 presents the comparison of the SPLP results for the natural soil samples with those of the 40 residuals samples. The results show that the average concentrations of aluminum and iron from the residuals SPLP leachates generally fell within the range of the soil SPLP concentrations. This is illustrated graphically in Figures 4.12 and 4.13.

Table 4.19 Comparison of SPLP Results with Soil SPLP Samples.

	Aluminum (mg/L)				Iron (mg/L)			
Matrix type	Mean	Std.dev.	Min.	Max.	Mean	Std.dev.	Min.	Max.
Pond sediments (15 samples)	1.79	1.67	<0.2	4.58	0.80	0.55	<0.3	1.76
Catch Basin sediments (10 samples)	0.40	0.19	<0.2	0.86	0.50	0.19	<0.3	0.65
Street Sweepings (15 samples)	0.58	0.35	<0.2	1.48	0.60	0.45	<0.3	1.91
Alachua Soil (2 samples)	0.30	0.35	0.27	0.33	--[1]	--	<0.3	<0.3
Miami Soil (2 samples)	0.82	0.12	0.73	0.91	0.86	0.02	0.85	0.87
NRL Soil (4 samples)	0.70	0.30	<0.2	0.90	0.85	--[2]	<0.3	0.85
Clay (4 samples)	1.40	1.02	0.38	2.82	0.59	0.08	<0.3	0.66
Organic (4 samples)	1.91	1.15	0.60	3.27	0.63	0.33	0.32	0.96
Sand (4 samples)	5.38	2.74	1.30	7.03	1.20	0.61	0.37	1.70

[1.] All samples are below the detection limit (0.3 mg/L). [2.] Three samples are below the detection limit (0.3 mg/L).

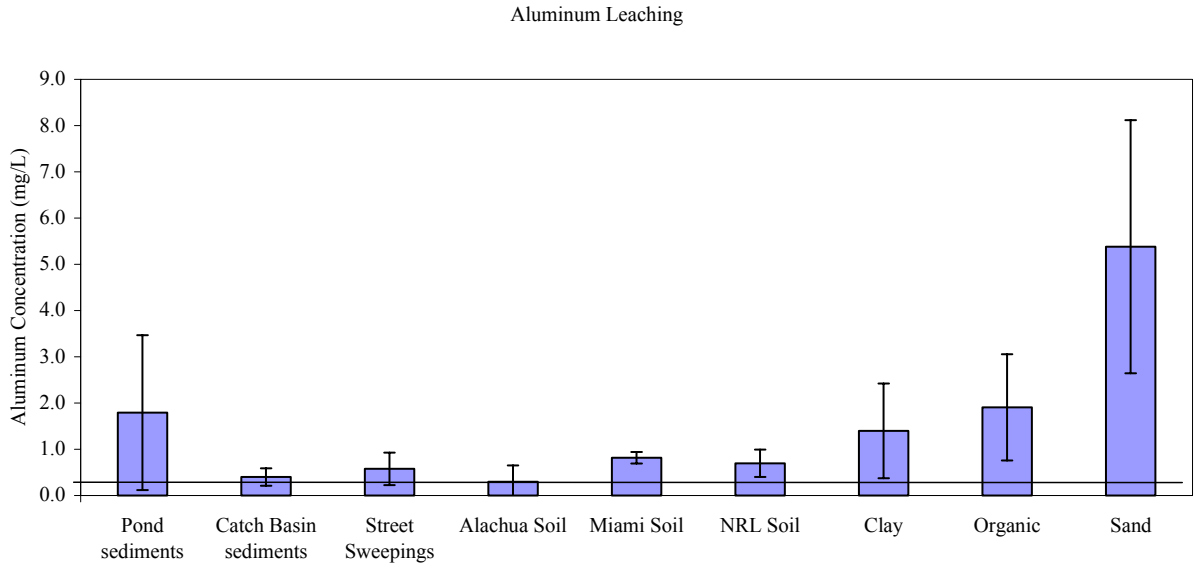

Figure 4.12 Aluminum Leaching Results from Street Sweepings, Stormwater Pond Sediments, Catch Basin Sediments.

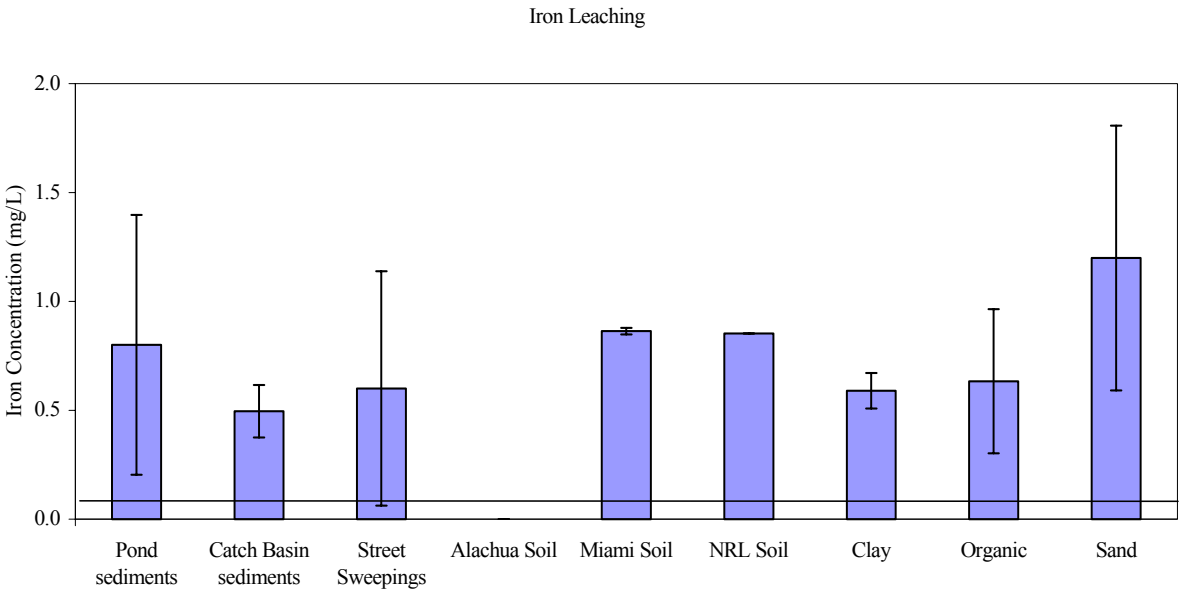

Figure 4.13 Iron Leaching Results from Street Sweepings, Stormwater Pond Sediments, Catch Basin Sediments.

5 DATA SUMMARY

5.1 Total Analysis

Risk-based SCTLs have been commonly used for results of total analysis to evaluate potential threat to human health and the environment. In this study, the results of total analysis for street sweeping samples, stormwater pond sediment samples, and catch basin sediment samples were compared to SCTLs for residential and industrial settings. The total analyses were performed for 11 metals (RCRA 8 metals plus silver, copper, and zinc) and a number of organic compounds (VOCs, SVOCs, pesticides, and herbicides).

5.1.1 Total Metals

For the total metal analysis (more than 300 sample analyses), most of the samples for silver, cadmium, mercury, and selenium were below the detection limits. Barium, chromium, copper, nickel, lead, and zinc were detected above the detection limits in more than a half of total samples but did not exceed the respective SCTLs, in general. Out of 355 arsenic samples analyzed, 178 samples were detectable and commonly exceeded the arsenic SCTL for residential area (0.8 mg/kg). Out of 178 arsenic samples detected, 11 samples were above the industrial SCTL limit of 3.7 mg/kg.

5.1.2 Total Organics

More than 300 samples were collected and analyzed for total organic content including VOCs, SVOCs, OCl Pests, nitrogen-phosphorus pesticides, chlorinated herbicides, and N-methylcarbamates. No nitrogen-phosphorus pesticides, chlorinated herbicides, or N-methylcarbamates were found in any of the samples.

VOCs were analyzed in 302 samples. Out of 74 VOCs, 12 compounds were detected in a few of the samples. None of the compounds in the samples exceeded the SCTLs for either residential or industrial settings. Three VOCs (acetone, methylene chloride, and acetonitrile) were commonly found in a number of samples, probably because of the use of the chemicals for glassware cleaning and organic extractions in the laboratory.

SVOCs were analyzed for 300 samples. Target SVOCs (116 compounds) included phenolic SVOCs (e.g., phenol, 2-nitrophenol, and pentachlorophenol), phthalates (e.g., di-n-butyl phthalate, diethyl phthalate), and polyaromatic hydrocarbons (e.g., anthracene, pyrene). Out of 116 SVOCs, 17 compounds, mainly PAHs and phthalates, were found in a few samples. Three PAHs (benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene) were detected in two samples above the SCTLs for residential and industrial limits: one sample from residential street sweeping and one from catch basin sediment in a commercial area. The sample from catch basin sediment also contained other PAHs, such as anthracene, benzo(ghi)perylene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene. The concentrations of two compounds, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene, in the sample exceeded the SCTLs for residential area only for benzo(k)fluoranthene, and both residential and industrial limits for indeno(1,2,3-cd)pyrene. No phthalate compounds detected exceeded the respective SCTLs.

OCl Pesticides were analyzed in 323 samples. Out of 43 target pesticides, 14 were detected in a number of samples. Two OCl Pests, 4,4'-DDT and Endosulfan II, were found in 66 and 44 samples, respectively. Neither compound exceeded the respective SCTL limits. Only one compound, dieldrin, exceeded the SCTLs in four samples: three exceeded the residential SCTL limit of 70 μg/kg and one the industrial SCTL limit of 300 μg/kg.

No nitrogen-phosphorus pesticides (46 analytes) were found above the detection limit (0.25 mg/kg) in any of the 314 total samples of street sweepings, stormwater pond sediments, and catch basin sediments.

N-methylcarbamates, including 10 target analytes, were analyzed in 354 samples. None of the carbamate analytes were detected above the detection limit of 0.1 mg/kg.

Chlorinated herbicides were analyzed in 323 samples. No chlorinated herbicides were found above the detection limit of 0.5 mg/kg in any of the samples.

5.2 Leaching Analysis

A SPLP leaching test was performed to determine leachability of a number of metals (arsenic, barium, cadmium, copper, chromium, lead, mercury, nickel, selenium, silver and zinc) and organics (VOCs, SVOCs, pesticides, carbamates, and herbicides) from all samples collected from street sweepings, stormwater pond sediments, and catch basin sediments. The SPLP leachate concentrations of the chemicals were compared to GWCTLs for Florida. Sixty samples were additionally analyzed for secondary standards for drinking water. The secondary parameters included in this study were as follows: aluminum, chloride, copper, ethylbenzene, fluoride, iron, manganese, pH, silver, sulfate, toluene, TDS, xylenes, and zinc. Some of the parameters such as fluoride, toluene, and xylenes are also public health related primary standards.

5.2.1 Leaching Metals

More than 150 samples were analyzed for 11 metals. Four metals (arsenic, barium, lead and zinc) were detected above the respective detection limits in a number of samples: 27 out of 185 samples for arsenic, 78 out of 150 samples for barium, 50 out of 184 samples for lead, and 44 out of 184 samples for zinc. Out of 50 samples detected for lead, eight exceeded the GWCTL for lead (0.015 mg/L). None of the other three metals commonly detected (i.e., arsenic, barium, and zinc) exceeded its respective GWCTL.

Four metals (from 178 samples for cadmium, 150 samples for chromium, 184 samples for copper, and 184 samples for nickel) were detected above the detection limits in a few samples. One out of 3 detected samples exceeded the GWCTL for cadmium (0.005 mg/L). Out of 184 samples, nickel was found in three samples, all of which exceeded the GWCTL limit of 0.1 mg/L.

5.2.2 Leaching Organics

A SPLP test for street sweeping, stormwater pond sediment, and catch basin sediment samples was carried out to examine leachability of organic compounds. The organic compounds targeted in this study included VOCs, SVOCs, OCl Pests, nitrogen-phosphorus pesticides, chlorinated herbicides, and N-methylcarbamates, which is the same as for total analyses.

VOCs were analyzed in 155 leaching samples. Out of 74 target VOCs, 9 were detected above the detection limit of 5.0 μg/L in only three samples. Four compounds (1,4-dichlorobenzene, naphthalene, 1,3,5-trimethylbenzene, and o-xylene) in two samples were found above the GWCTLs of their respective analytes. No comparisons were made for another two compounds in one sample, n-butyl benzene and p-isopropyltoluene, because no GWCTL limits had been set for the compounds. Two volatile organic analytes, acetone and methylene chloride, were found in a number of samples. Laboratory blanks also contained such chemicals above the detectable level. Since these chemicals were used as solvents for glassware cleaning and organic extraction in the laboratory, the presence of these compounds may likely have resulted from laboratory contamination.

No acid and base/neutral SVOC compounds were detected above the detection limit of 10 μg/L in any of the 147 SPLP leaching samples. No nitrogen-phosphorus pesticides or N-methylcarbamates were found in any of the SPLP extracts from 132 nitrogen-phosphorus pesticide samples and 176 N-methylcarbamate samples.

OCl Pesticides were analyzed in 166 leaching samples. Out of 43 target OCl Pests, three compounds were detected above the detection limit of 0.05 μg/L in some samples: 4,4'-DDT in 13 samples, beta-BHC in 7 samples, and Endosulfan II in one sample. The concentrations of 4,4'-DDT in all of the detected samples exceeded the GWCTL of 0.1 μg/L. No GWCTLs were available for the other two detected compounds

5.3 Secondary Parameters

Thirty SPLP leachate samples were also analyzed for secondary parameters to examine any potential threat to drinking water (i.e., groundwater in Florida) when beneficial reuse of street sweeping, stormwater pond sediments, and catch basin sediments is considered. The secondary parameters included some metals (aluminum, copper, iron, manganese, and zinc), inorganic ions (chloride, fluoride, and sulfate), organics (ethylbenzene, toluene, xylenes), and other standards (pH, TDS).

Aluminum was detected above the detection limit in 20 leaching samples, all of which exceeded the secondary standard for drinking water (0.2 mg/L). The average concentration of aluminum was 1.4 mg/L. Iron concentrations detected in 8 samples exceeded the secondary standard concentration of 0.3 mg/L. The concentrations of iron ranged from 0.32 to 2.22 mg/L with an average concentration of 0.88 mg/L. Results of pH measurement in leaching samples ranged from 7.00 to 9.11 with an average of 7.99. Nine samples showed greater pH than the secondary standard (pH 6.5 to 8.5). None of the other ions, organics, or other metals exceeded the secondary standard limits for drinking water. For SPLP tests for soil samples (6 samples

collected from four different locations in Florida), all samples exceeded the secondary drinking water standards for aluminum and iron (0.2 mg/L and 0.3 mg/L, respectively), with the exception of one soil sample. Aluminum and iron in street sweepings, stormwater pond sediments, and catch basin sediments may have resulted from natural soils. A further study should be conducted on the sources of aluminum and iron in such waste streams.

6 REFERENCES

U.S. Environmental Protection Agency (1998), *Test Methods for Evaluating Solid Waste. U.S. EPA SW-846*, Office of Solid Waste, Washington D.C.

American Public Health Association (APHA); American Water Works Association (AWWA); Water Environment Federation (WEF), (1995), *Standard Method for the examination of water and wastewater,* 19th Ed., Washington, D.C.

7 APPENDICES

Provided upon request. Contact Dr. Tim Townsend at ttown@ufl.edu.