CHEMICAL CHARACTERISTICS OF DITCH CLEANINGS IN FLORIDA

FINAL REPORT

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Report #

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KEYWORDS

Ditch cleanings, Florida, heavy metals, polycyclic aromatic hydrocarbon

EXECUTIVE SUMMARY

INTRODCUTION

Drainage ditches help controlling the flow direction of stormwater and preventing flooding. There are three types of drainage ditches: open ditches, concrete ditches and culverts. Drainage ditches are maintained as and when necessary to provide optimum water flow. Ditch cleaning includes cleaning and reshaping of ditches such as loading, hauling, and disposing of excess materials usually by excavation or the removal of overgrown vegetation. Such cleanings and maintenance generate huge quantity of solid wastes in every city and county across the state of Florida. However, there are concerns about the presence of heavy metals and organic contaminants in the ditch cleaning wastes.

OBJECTIVES

1) Collect representative and typical ditch cleaning samples throughout Florida;
2) Characterize the wastes chemically including the contents of selected 503 metals and selected organic contaminants;
3) Evaluate the potential adverse impacts on water quality and cost-effective ways of managing these wastes.

MATERIALS AND METHODS

Number of samples

The ditch cleaning samplings for heavy metals and organic contaminants were collected based on a designed sampling program. A total 78 samples were collected: 39 from Clay County and 39 from 8 different zones across the state.

Sample collections

Half (39) of the samples were collected through the public works or other appropriate departments of various counties/cities across the state. A sampling kit, which consists of a cooler, a stainless steel scoop, a sample container, a sampling protocol describing collection and mailing procedure, and an information sheet, was sent via FedEx to the cooperators over a period of 4 weeks. The cooperators were instructed to return the sample back to UF on the same or next day using prepaid FedEx overnight service. All samples were received in an ice-packed cooler to meet the requirement for the analyses of organic contaminants. The samples received were immediately split into two halves: one for metal analysis and one for organic analysis.

The other half (39) of the samples were collected by the investigators via on-site sampling through the active cooperation from the public works department of Clay County located in the Northeast district. The collected samples were carried to the laboratory in an ice-packed cooler to meet the requirement for the analyses of organic contaminants.

Sample analyses

Ditch cleaning samples were dried and ground before metal analyses. They were analyzed for heavy metals including As, Cd, Cr, Cu, Pb, Mo, Ni, Se and Zn using ICP-OES after digestion using the Hot Block Digestion System (EPA SW-846 Method 3050B). Total concentrations of PAHs were determined using reverse-phase HPLC equipped with UV/Fluorescence detectors after extraction using EPA Method 3550.

RESULTS

The average pH of all 78 samples was 6.5, which is 1.5 to 2 units higher than typical Florida soils (Chen et al., 1999). The average pH value (6.5) of the mailed samples was close to that (6.6) of the collected samples from Clay County. While some of the samples were acidic with pH≤6.0, more than 50% of the sample had pH between 6.1 and 7.0. Further, more than 25% of samples were a slightly alkaline with pH values ranging from 7.1 to 8.0. However, none of the sample had pH≥8.1.

The geometric mean concentrations and the concentration range of the nine 503-metals in the ditch cleaning samples were as follows: As = 0.61 (0 - 4.08), Cd = 1.14 (0 - 3.82), Cr = 2.05 (0 - 202), Cu = 2.98 (0 - 246), Pb = 3.88 (0 - 86.7), Mo = 1.04 (0 - 5.46), Ni = 0.50 (0 - 0.50), Se = 1.19 (0 - 11.0), and Zn = 15.3 (3.16 - 659) mg kg^{-1}. The geometric mean concentrations of all nine metals were lower than their corresponding FDEP residential and industrial Soil Cleanup Target Levels (SCTLs). Comparing the results to the background concentrations of metals in Florida soil (Chen et al., 1999), the geometric mean concentrations of As, Cd, Cu, Mo, Se and Zn were all lower than their respective background concentrations. However, the concentrations of Cr, Ni and Pb were higher than the background values. Also, with except for As, for which the residential SCTL (R-SCTL) was just 3.5 times higher than the mean detected value, all R-SCTL for the studied metals were much greater than the detected values, ranging from 50 times for Cu to 1702 times for Zn.

This implies that the ditch cleaning samples were relatively clean with little contamination in heavy metals.

Out of the 78 samples tested for arsenic, 10 samples had detectable concentration and six of the detected concentrations were above the R-SCTL for As (2.1 mg kg^{-1}), representing 8% of the total samples analyzed. For Cu, only one sample was higher than the R-STCL even though 61 out of 78 samples tested (78% of the total) had detectable level of Cu. For the rest of metals excluding As and Cu, the detectable concentrations in all samples were below the corresponding R-SCTL. This again implies that the ditch cleaning samples we collected from Florida were relatively clean.

When the ditch cleanings results were compared with those of Townsend et al. (2002), it appeared that the average concentrations, especially of Cr, Cu, Pb, and Zn, were the highest in street sweepings. Though the concentrations decreased remarkably in the ditch cleanings, they again increased in the stormwater system sediments, and catch basin sediments. The street sweepings and highway soils are expected to be rich in contaminants since they are exposed to contamination through various ways. Given the fact that ditches allow continuous flow of stormwater, hence settling of only coarser particles is expected in the ditches, while finer particles may travel long distance and settle as sediments in the stormwater ponds and catch basin. Thus, ditch cleaning wastes are mostly coarse particles and they are continuously exposed to a wash away effect of stormwater flow, and hence had lower average metal concentrations. In contrast, the higher average metal concentration in stormwater system sediments and catch basin sediments reflect the fact that metals originated from streets and highways were predominantly bound with colloidal particles, which travelled long distance through the ditches and deposited as sediments in stormwater ponds and catch basins.

All the 16 PAHs investigated were detected in measurable quantities most of the 67 samples analyzed. The number of detects for PAHs ranged from 18 detects for pyrene to 63 detects for benzo(a)pyrene. The large number of detects in this study was partially due to the low detection limits offered by the HPLC equipped with UV/fluorescence detectors, which is lower than those of previous studies where GC-MS was used. With the exception of benzo(a)pyrene, all PAHs measured in the 67 samples were lower than their respective R-SCTL and industrial SCTL (I-SCTLs). In the case of benzo(a)pyrene, 11 values exceeded R-SCTLs. Two measured values (1.01 and 0.85 mg kg^{-1}) were 1.4 and 1.2 times higher than the I-SCTL of 0.7 mg kg^{-1}. The other 9 exceeding benzo(a)pyrene concentration values were between 1.3 to 6.7 times higher than the R-

SCTL, however they were lower than their corresponding I-SCTLs. In spite of this, the geometric mean concentrations of benzo(a)pyrene (0.012 mg kg^{-1}) was lower than both R-SCTL and I-SCTL. The R-SCTL and I-SCTL were 8.3 and 58 times higher than the geometric means concentration of benzo(a)pyrene. The geometric mean concentrations of all the other 15 PAHs investigated were lower than their corresponding R-SCTL and I-SCTL. Also, the calculated 99% UCL (upper confidence level) for all PAHs were lower than both SCTLs. There is, therefore, a 99% confidence that the geometric mean does not exceed the UCL, which is in turn lower than the SCTLs.

CONCLUSIONS

Based on our analysis of nine 503 metals (As, Cd, Cr, Cu, Pb, Mo, Ni, Se and Zn), except for arsenic, there seems little concern of contamination for the other 8 metals, which were all substantially lower than the corresponding Florida SCTLs and slightly higher than the background metal concentrations in Florida soils. Six samples (8%) had arsenic concentrations exceeding the Florida R-SCTL of 2.1 mg kg^{-1}. However, considering the total samples collected, the arsenic concentrations in the ditch cleanings were low, with arithmetic mean concentration of 0.76 mg kg^{-1} and geometric mean concentration of 0.61 mg kg^{-1}. The corresponding numbers for Florida surface soil are 1.34 and 0.42 mg kg^{-1} (Chen et al., 1999).

All 16 PAHs investigated were detected in measurable quantities in some of the 67 samples analyzed. Except for benzo(a)pyrene, all PAHs measured in the 67 samples lower than their respective R-SCTL and I-SCTL. In the case of benzo(a)pyrene, 11 values exceeded the SCTL. Two measured values (1.01 and 0.85 mg kg^{-1}) were 1.4 and 1.2 times higher than the I-SCTL. The other 9 exceeding benzo(a)pyrene concentration values were between 1.3 to 6.7 times higher than the R-SCTL. However, the geometric mean concentrations of benzo(a)pyrene (0.012 mg kg^{-1}) was lower than both R-SCTL and I-SCTL. The Florida R-SCTL and I-SCTL were 8.3 and 58.3 times respectively higher than the geometric means concentration of benzo(a)pyrene. The geometric mean concentrations of all the other 15 PAHs investigated were lower than their corresponding R-SCTL and I-SCTL. Also, the calculated 99% UCL (upper confidence level) for all PAHs were lower than R-SCTL and I-SCTL.

2 INTRODUCTION

1.1 Drainage Ditches

Various agricultural, urban and industrial non-point pollution may impact water quality via runoff, drainage, leaching, aerial deposition and drift (Margoum et al., 2006). Different measures have been developed to minimize such a potential transfer of pollutants. For example, street sweeping has been used to minimize pollutant export to receiving waters. These cleaning practices are designed to remove sediment, debris, and other pollutants from road and parking lot surfaces that are a potential source of pollution impacting urban waterways. In addition, interface areas such as buffer strips and small ditches are used to reduce diffuse pollutant transfer into water body. However, sediments accumulated in drainage ditches still contain different levels of pollutants. Much research has been conducted documenting the impacts of drainage ditch in agricultural and forest areas (Twisk et al., 2000; Diaz et al., 2005); however, information on drainage ditches located in industrial and urban areas is rather limited.

Generally speaking, drainage ditches provide a means for controlling the flow direction of storm water and help to prevent flooding. According to City of San Diego, a drainage ditch is defined as an open graded or lined ditch, which is 8 feet or less in width across the bottom (City of San Diego, 1978). According to Florida Department of Transportation (FDOT), a drainage ditch should have a front slope and with a back slope of at least 6 inches. There are three types of drainage ditches: open ditches, concrete ditches and culverts. Drainage ditches are maintained as and when necessary to provide optimum water flow (Center for Environmental Excellence, 2007). Ditch cleaning includes cleaning and reshaping of ditches such as loading, hauling, and disposing of excess materials usually by excavation or the removal of overgrown vegetation. **Figures 1 to 4** below show some typical ditches and their cleaning.

Figure 1. Roadside storm water entrance to a ditch

Figure 2. A concrete ditch with soil and plant hindering storm water flow (requires cleaning)

Figure 3. A ditch with standing water (top) and a nearby storm water retention pond (bottom)

Figure 4. Ditch cleaning operation in by Bradford county public works

Studies conducted by EPA indicate that polluted stormwater is a leading cause of impairment to the nearly 40% of the surveyed water bodies in the country, therefore stormwater runoff is considered as the number one threat to our fresh water supply today (EPA, 1995). Runoff from drainage ditches is similar to stormwater in nature and is supposed to carry pollutants as rainwater washes off roads, bridges, parking lots, rooftops, and other impermeable surfaces. For example, pollutants from vehicles and activities associated with road and highway construction and maintenance are washed off from roads and roadsides when it rains. As rainwater flows over these surfaces, it picks up dirt and dust, rubber and metal deposits from tire wear, antifreeze and engine oil that has dripped onto the pavement, pesticides and fertilizers, and etc. As runoff flows in a drainage ditch, the pollutants may either settle down in the ditch (i.e. end up in ditch cleanings) or keep suspended in the water (i.e. end up in nearby aquatic system). Hence, it is important to characterize ditch cleanings to determine its appropriate disposal or reuse options.

1.2 Previous study by Townsend et al. (2002)

Townsend et al. (2002) conducted a comprehensive study characterizing three types of solid wastes including street sweepings (SS), stormwater system sediments (SSS), and catch basin sediments (CBS) in an attempt to evaluate their disposal and reuse option in Florida. More than 300 samples were collected from 20 different locations throughout Florida, and analyzed for total and/or SPLP (Synthetic Precipitation Leaching Procedure) volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, herbicides, metals, and inorganic ions. The results were compared to FDEP Soil Cleanup Target Levels (SCTLs) or Groundwater Cleanup Target Levels (GWCTLs) as appropriate.

Total concentrations of eleven 503-metals (i.e., Ag, As, Ba, Cd, Cr, Cu, Hg, Ni, Pb, Se, and Zn) were analyzed. Concentrations of Ag, Cd, Hg, and Se in the majority of the samples were below the detection limits. Barium, Cr, Cu, Ni, Pb, and Zn were detected in more than half of the samples but their concentrations were generally below the SCTLs. Arsenic was detected in 178 samples with 35 samples exceeding the residential SCTL of 2.1 mg/kg and 3 samples being above the industrial SCTL of 12 mg/kg. SPLP metals in the majority of samples were less than GWCTLs. In short, among the 11 metals determined in these solid wastes, concentrations of As, Ba, Cr, Cu, and Pb in some samples exceeded the FDEP SCTLs. Those exceed the residential SCTLs are marked with * and those exceed industrial SCTLs are marked with ** (**Table 1**).

Of 74 EPA target compounds of VOCs tested, 12 were detected in a few samples with none exceeding the SCTLs. Of 116 EPA target compounds of SVOCs tested, 17 were found in a few samples. 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 (<2% of the samples). One sample 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 that of indeno(1,2,3-cd)pyrene was above both residential and industrial SCTLs. No phthalate compounds detected exceeded the respective SCTLs.

Of 43 EPA target compounds of pesticides, 14 were detected in a number of samples. Two OCl Pesticides, 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. No nitrogen-phosphorus pesticides were found above the detection limit (0.25 mg/kg) in any of the samples.

In summary, 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 occasionally exceed their respective GWCTLs.

Based on this study, FDEP (2004) developed a guidance document on proper management of street sweepings (SS), catch basin sediments (CBS) and stormwater system sediments (SSS). However, ditch cleanings was not included in the document.

1.3 Previous studies by other investigators

Several studies were carried out by other states to characterize these solid wastes as well as stormwater and highway runoff. **Table 1** was compiled based on the data from these studies.

Table 1. Metal concentrations in solid wastes from different sources compared with FDEP SCTLs

Metals	**SCTLs**		**Townsend (2002)**			**Crowser (2000)**			**Mathisen (1999)**		**T & M (2003)**
	R	**I**	**SS**	**SSS**	**CBS**	**SS**	**SSS**	**CBS**	**SS**	**CBS**	**HS**
Ag	**410**	**8.2k**	18-130	12-18	--	0.5-1.1	0.04		ND	ND	
As	**2.1**	**12**	0.5-14**	0.5-13**	0.6-25**	1.2-4.4*	2.7	0.4-56**	2.9-8.2*	2.9-16**	
Ba	**120**	**130k**	5.0-130*	3.0-98	8.1-1019*	43-56	50		12-26	12-71	210-720*
Cd	**82**	**1.7k**	46-54	--	5.3-5.3	0.2-0.4	0.3	0.2-5.0	0-1.4	0-1.1	
Cr	**210**	**420**	2.4-552**	6.2-51	5.8-175	20-26	23	5.9-241*	4.8-56	4.8-75	39-220*
Cu	**150**	**89k**	2.5-372*	5.5-398*	4.5-90	21-41	25	12-730*		ND	4-180*
Hg	**3**	**17**	--	--	--	0.1-0.1	0.2	0.02-0.2	ND		
Ni	**340**	**35k**	2.4-70	2.5-31	5.4-40						35-68
Pb	**400**	**1.4k**	2.7-386	6.4-1060*	5.6-196	10-34	35	4-850*	15-77	18-540*	15-820*
Se	**440**	**11k**	11-11	7.4-7.4	7.5-14	0.3-0.6	2.0	14-86	ND	0-1.8	
Zn	**26k**	**630k**	4.0-1080	9.1-956	5.4-711	60-140	240	50-2000			26-390

***** exceeds R-SCTL and ****** exceeds I-SCTL; **R**=residential; **I**=industrial; **ND**=non detect; **SS**=street sweeping; **CBS**=catch basin sediment; **SSS**=Stormwater system sediment; **HS**=highway soil

A study carried out Washington Dept of Ecology (Washington Dept of Ecology, 2005) found 19 of the EPA's 121 priority pollutants present in the runoff from Seattle streets. The most frequently detected pollutants were pesticides, phenols, phthalates, and PAHs. Concentrations of heavy metals such as As, Cr, Cu, and Pb in CBS from Seattle exceed FDEP's SCTLs (see **Table 1**). A study for the Alaska Department of Transportation & Public Facilities (Crowser, 2000) evaluated both SS and CBS as Anchorage for metal and organic pollutants. Except for As, none of the metals exceeded the FDEP's SCTLs (**Table 1**) and except for benzo(a)pyrene, none of the organic pollutants exceeded the EPA limit. A study for the Office of Environmental Affairs of Massachusetts (Mathisen, 1999) characterized SS and CBS from Worcester. While those of As and Pb in the samples exceed FDEP's SCTLs (**Table 1**), those of PAHs and PCBs are all low. Results from different sources are consistent with Townsend et al. (2002) in that the solid wastes SS, CBS and SSS contain elevated concentrations of metals and PAHs, although the levels of these concentrations do not exceed FDEP's SCTLs in most cases.

Though research reports on ditch cleanings are available only on a limited scale, much research has been conducted documenting metal contamination in soils near roadsides (Li et al., 2001; Dilek, 2005; Nabulo et al., 2006). Since many of the ditches are located along highway, characteristics of highway runoff and soils will shed light on ditch cleanings characteristics. Sansalone and Buchberger (1997) sampled lateral pavement sheet flow from a study area along I-75 in Cincinnati, OH and found that Cd, Cu, Pb, and Zn often exceeded surface water quality discharge standards during rainfall events. They also found that Cd, Cu, and Zn were mostly in dissolved form, whereas Al, Fe, and Pb were particulate-bound in storm water. Their study suggests that metals coming from highways can be an unsuspected but a significant source of metal contamination in streams. While metal concentrations in soils near highway from West Bank are low (Swaileh et al., 2004), they are elevated in highway soil samples collected from Texas and Ohio (Turer and Barry, 2003), with Ba, Cr, Cu and Pb in some samples exceeding FDEP's SCTLs (**Table 1**). Thus, it seems that concentrations of only five metals, i.e. As, Ba, Cr, Cu and Pb, are of concerns in SS, SSS and CBS and highway soils.

1.4 Identified information gap and project objectives

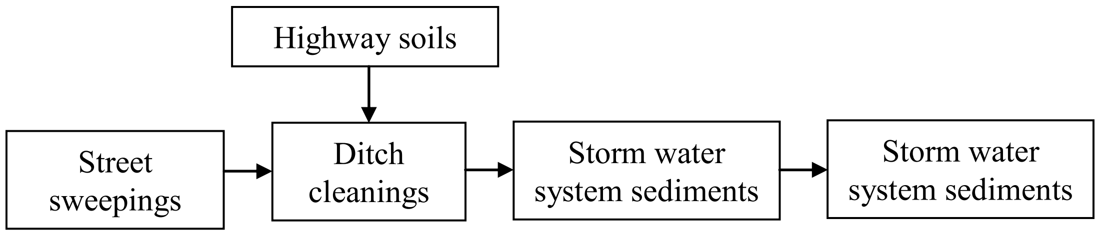

Figure 5. Source and sink of stormwater-borne contaminants

Even though considerable research information about the concentrations of metals and organic contaminants in SS, SSS, CBS, and highway soils are available, such information on the ditch cleanings are clearly lacking despite the fact that cleaning of ditches generate significant quantity of solid waste in every city/county, which is also an important sink of stormwater-borne contaminants and exist in between SS/Highway-soils and SSS **(Figure 5)**. To bridge this information gap, it is important to characterize ditch cleanings. The information would serve two major purposes:

1) Understand contaminant flow in the SS/Highway-soils to CBS system, and
2) Help determine appropriate disposal or reuse options for this solid waste.

1.5 Objectives

Built upon previous studies discussed above, this research was to collect and characterize ditch cleanings across the state of Florida to evaluate their disposal and reuse options. The overall objective of this research task was to recommend proper management practices to handle the wastes based on our results.

The specific objectives of this project were:

1) Collect representative and typical ditch cleaning samples throughout Florida;
2) Characterize the wastes chemically and physically including the contents of selected 503 metals and selected organic contaminants;
3) Evaluate the potential adverse impacts on water quality and most cost-effective ways of managing these wastes

2. METHODOLOGY

2.1 Sample Location

The ditch cleaning samples were collected from eight Florida districts (**Figure 6**) as well as from different divisions of Clay County (**Figure 7**). The different districts include Northwest, North Central, Northeast, Central West, Central, Central East, Southwest, and Southeast. Sampling locations and number of samples collected from different districts are summarized in **Table 2**.

2.2 Sample Collection

2.2.1 Samples Obtained via Mail

Half (39) of the samples were collected through the public works or other appropriate department of various counties/cities across the state. For this channel of procuring samples, we established a total of 120 cooperators covering all eight districts of the state through telephonic discussion about the background, methodology, and expected output of the project. Out of these 120, only those cooperators who were interested in this research and technically capable of collecting and sending a sample were placed in the final list. There were 60 cooperators in the final list.

A sampling kit consisting of a cooler, a stainless steel scoop, a sample container, a sampling protocol describing collection and mailing procedure, and an information sheet was sent via FedEx to these 60 cooperators over a period of 4 weeks. The samplers were instructed to return the sample back to UF on the same or next day using prepaid overnight FedEx. All samples were received in an ice-packed cooler to meet the requirement for the analyses of organic contaminants. The samples received were immediately split into two halves: one for metal analysis and one for organic analysis.

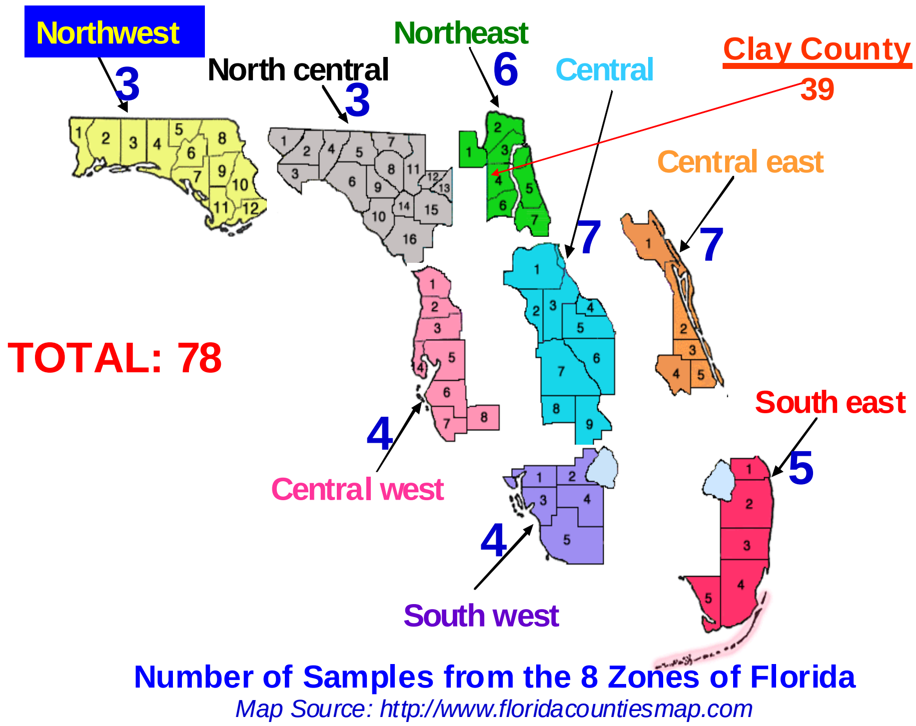

Figure 6. Number of ditch cleaning samples collected from each district

2.2.2 Samples Collected by the Investigators

Through the active cooperation of the public works department of Clay County located in the Northeast district, the other half (39) of the samples were collected by the investigators via on-site sampling. Samples were collected from 4 divisions of Clay County (**Figure 7**) with the aid of County public work crews.

Composite samples were collected from the selected ditches and placed in glass containers. The composite sample collection was accomplished by randomly collecting sub-samples from the site, thoroughly mixing the combined sub-samples in a stainless steel bowl. The composite samples generated were transferred into glass bottles with Teflon coated caps. The collected samples were carried to the laboratory in ice-packed coolers to meet the requirement for the analyses of organic contaminants.

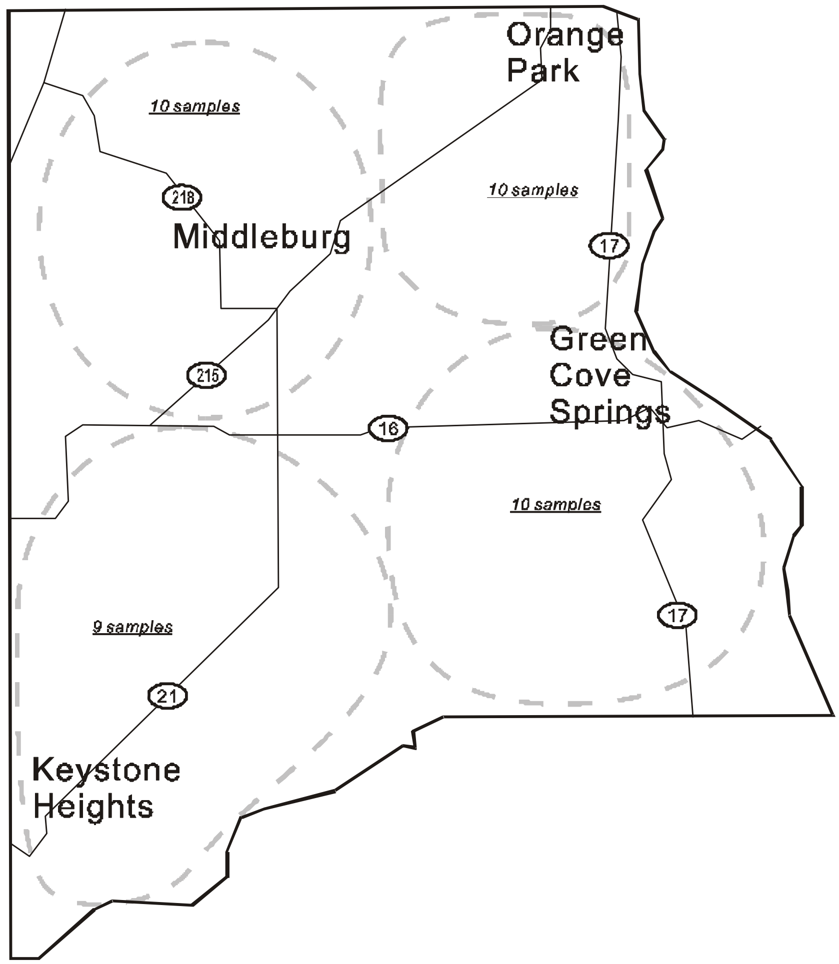

Figure 7. Number of samples collected from each division of Clay County

Table 2. Number of ditch cleanings samples collected from each district.

Districts	# of Samples	County	City	Provider	Collected from
Northwest	3	Escambia	Pensacola	City	Ditches
		Okaloosa	Fort Walton Beach	City	Ditches
		Franklin	Apalachicola	City	Ditches
North Central	3	Alachua	Gainesville	City	Pile (screened)
		Alachua	Gainesville	City	Pile (unscreened)
		Bradford	N/A[§]	County	Ditches
North East	6	St. Jhons	N/A	County	Not available
		Putnam	N/A	County	Ditches
		Flagler	Palm Coast	City	Ditches
		Flagler	Palm Coast	City	Swale
		Flagler	Palm Coast	City	Swale
Central West	4	Hernando	N/A	County	Pile
		Pinellas	Clearwater	City	Pile
		Manatee	Palmetto	City	Ditches
		Sarasota	North Port	City	ditches
Central Zone	7	Marion	N/A	County	Ditches
		Marion	Ocala	City	Pile
		Orange	Orlando	City	Ditches
		Orange	Winter Park	City	Ditches
		Osceola	St Cloud	City	Ditches
		Polk	County Contacted	City	Not available
		Polk	City of Lakeland	City	Ditches
Central East	7	Volusia	Daytona Beach	City	Ditches
		Volusia	Holly Hill	City	Ditches
		Bevard	Palm Bay	City	Ditches
		Indian River	N/A	County	Pile
		Indian River	Sebastian	City	Ditches
		St. Lucie	N/A	County	Pile
		St. Lucie	Port St. Lucie	City	Pile
South West	4	Charlotte	N/A	County	Pile
		Lee	Fort Myers	City	Ditches
		Collier	N/A	County	Ditches
		Collier	Marco Island	City	Ditches
South East	5	Martin	N/A	County	Pile
		Martin	Stuart	City	Ditches
		Palm Beach	Boca Raton	City	Ditches
		Broward	Hollywood	City	Ditches
		Broward	Margate	City	Not available
North East	39	Clay			Ditches
	10		Middleburg		
	10		Orange Park		
	10		Green Cove Spring		
	9		Keystone height		
TOATAL	**78**				

[§]N/A= Not applicable

2.3 Sample Analyses

For pH and metal analyses, samples were air-dried in a sample preparation laboratory for 2 weeks. The air-dry samples were gently ground in an agate mortar. The samples were analyzed for metals and pH measured using procedures described later.

For organic analysis, samples collected/received from the field were used for analysis without drying to preserve volatile compounds. The extraction and analytical procedures are described later.

2.3.1 pH

The pH of the samples was measured in water (1:20 sample/water ratio) after equilibration for 1 h using a combined pH & ISE meter (Model 225, Denver Instrument, CO).

2.3.2 Heavy metals

Approximately 0.5 g (i.e., 0.5±0.01 g) of air-dried ground samples were digested using HNO_3/H_2O_2 in a Hot Block Digester using USEPA Method 3050B. The resulting solution was diluted to 50 ml and analyzed with an inductively coupled plasma – optical emission spectroscopy (ICP-OES) (Perkin Elmer Optima 3200 RL, Massachusetts, MA).

All reagents used for analysis were trace metal grade (Fisher Scientific, Pittsburgh PA 15275). Stock standard solution was Spex Certiprep (SPEX Certiprep, NJ 08840). NIST traceable Certified Reference Material (Soil) was analyzed. ICP-OES was used for metal analysis.

2.3.3 Organic Analyses

Ditch cleaning samples collected from all over Florida and Clay County were used for organic analysis. Upon receipt in the laboratory, collected samples were thoroughly mixed and extracted to ensure that recommended sample holding time of 2 weeks is not exceeded. Target organic compounds were extracted from 30 grams of wet samples with a total of 300 mL of methylene chloride using ultra-sonic extraction technique (USEPA Method 3550). A surrogate compound (Benzo-b-chrysene) was added to all samples prior to extraction with methylene chloride. The extract was filtered through Watman # 1 filter paper containing anhydrous sodium sulfate. The volume of extracted samples was reduced to 5 mL using the nitrogen-blowdown technique as described in Method 3550. Samples were stored in a freezer prior to cleaning. It is noted that organic materials under consideration in this research are polycyclic aromatic hydrocarbons (PAH). Since wet samples were used for analysis, moisture content of each sample was separately measured.

The crude extract contains other substances other than PAHs that could interfere with analytical determination. The gel-permeation cleanup (GPC) technique was employed (USEPA Method 3640b) to separate the PAHs from undesired compounds. The procedure involved filling a glass chromatography column (600 mm X 25 mm ID) with a slurry prepared by mixing bio beads (200-400 mesh, BioRad Laboratory) with methylene chloride. The prepared gel-permeation column (GPC) was connected to the HPLC unit as depicted in **Figure 8**. The retention times of a composite PAH peak were identified using the PAH standards (Ultra Scientific, Rhode Island) and the cleaned samples fraction was collected from the beginning to ending of the retention time of PAH peak. **Figure 9** shows the example of a gel-permeation chromatogram of the PAH standards that include 16 PAH components.

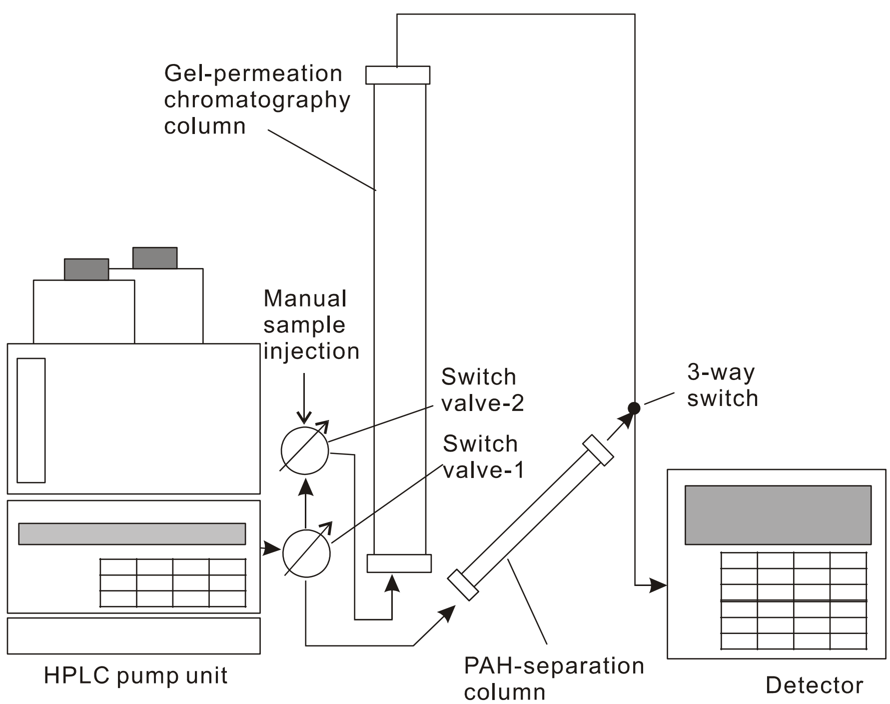

Figure 8. HPLC unit connected with GPC and PAH separation column

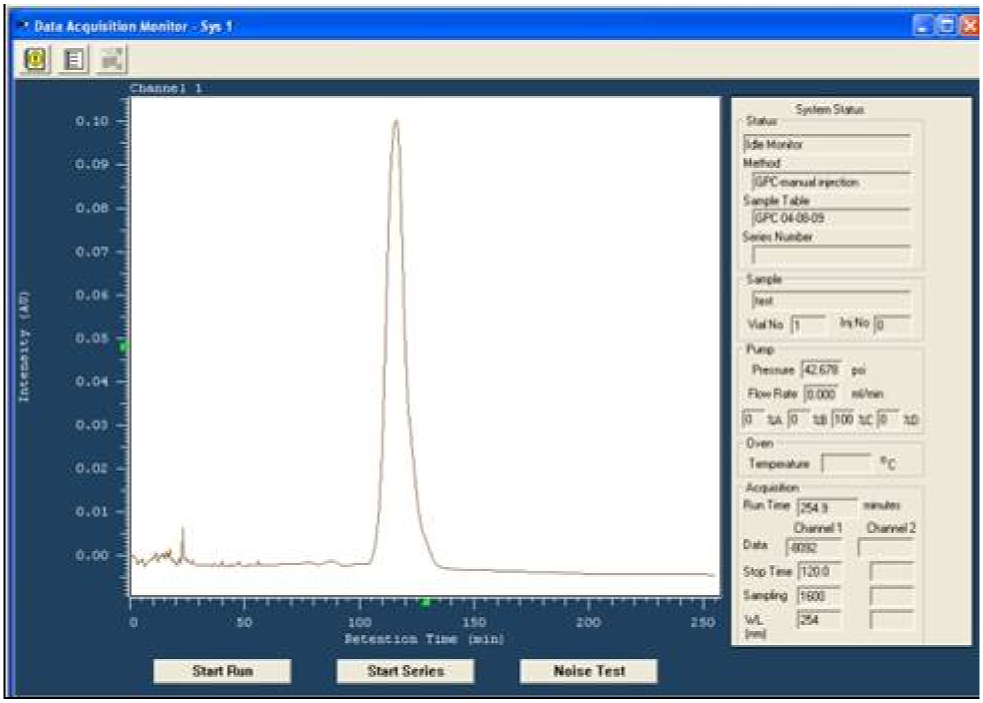

Figure 9. Composite peak of 16 PAH components shown on the gel-permeation chromatogram

The cleaned samples were concentrated to 3-6 mL using the nitrogen blow method and the solvent exchanged from methylene chloride to acetonitrile using micro K-D apparatus (USEPA Method 8310). The final cleaned sample volume for analysis was 1 mL. The analysis of the extracted sample for PAHs chemicals was conducted employing the use of a reverse - phase high performance chromatography system (Hitachi) consisting of L-7100 pump coupled with L-7200 autosampler, L-7400 UV detector and L-7485 Fluorescence detector. The list of PAH components and HPLC operation conditions were summarized in **Table 3** and **Table 4**.

Table 3. List of PAH components under consideration in this research

Polycyclic aromatic carbon components
Acenophthene
Acenophthylene
Anthracene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(g,h,I)perylene
Benzo(k) Fluoranthene
Chrysene
Dibenzo(a,h)anthracene
Fluorene
Fluorranthene
Indeno(1,2,3,cd)pyrene
Naphthalene
Phenanthrene
Pyrene

Table 4. HPLC operation condition for GPC and PAH analysis

Parameters	Operation conditions
Gel permeation chromatography (GPC)	
Carrier liquids	Methylene chloride
Flow rate	3 mL/min.
Range of retention time for PAH collection	95 min. through 150 min.
Manual Injection volume (mL)	5
PAH analysis	
Carrier liquids	Acetonitrile and water (ratio was gradually changed from 40%:60% to 100%:0%)
Column flow rate	0.7 mL/min.

3 RESULTS AND DISCUSSION

The results for both metal and organic analysis were checked for normality. Non normal data set were normalized by employing log transformation. The geometric and arithmetic means of results were determined. The 95% upper confidence levels (UCL) for the mean of organic contaminants were calculated using equation below (EPA 2002).

$$UCL_{0.95} = \exp\left(\mu_y + 0.5\delta^2 + \delta . \frac{H_{0.95}}{\sqrt{n-1}} \right)$$

μ_y = arithmetic mean of log transformed data

δ = Standard deviation of log transformed data

n = Number of samples

$H_{0.95}$ = H-statisti table for 95% UCL

3.1 Quality Control/Quality Assurance

3.1.1 Heavy Metal Analysis

USEPA approved quality assurance/ quality control (QA/QC) plan involving spikes, duplicates, blanks and certified reference materials was followed. **Table 5** to **Table 9** show the precision and accuracy of the analyses of various QC samples in the adopted QA/QC protocol. The measured values of metals showed good precision and accuracy, which was within $\pm$20% in most cases with few exception.

3.1.2 Organic Analysis

The percentage of recovery of each PAH component is presented in **Table 10**. The average recovery for the 16 target PAHs was 88.7%. Although the recoveries of acenophthylene, pyrene and benzo(a)anthracene were less than 70%, the rest ranged between 72.9% and 125%. The method detection limits for all PAHs are presented in **Table 11**. Surrogate compound added to 70% of samples yielded an average recovery of 139%.

3.2 Results of pH Analysis

The average pH of all 78 samples was 6.54 (**Figure 10**), which is 1.5-2 units higher than typical Florida soils (Chen et al., 1999). The mean pH value (6.5) of the mailed samples was close to that (6.6) of the collected samples from Clay County. The frequency distribution of pH of all samples is given in **Figure 10**. While some of the samples were acidic with pH≤6.0, more than 50% of the sample had pH between 6.1 and 7.0. More than 25% of samples were slightly alkaline with pH values ranging from 7.1 to 8.0. However, none of the sample had pH≥8.1.

Table 5. Precision in duplicate digestion and analysis of metals in ditch cleaning samples

Sample ID	Relative percentage difference (RPD) for duplicate digestion and analysis								
	As	**Cd**	**Cr**	**Cu**	**Mo**	**Ni**	**Pb**	**Se**	**Zn**
10	nd#	nd	nd	nd	nd	nd	10.9	nd	3.68
30	nd	nd	nd	3.91	nd	nd	32.4	11.6	24.1
50	19.0	1.00	1.00	4.72	14.3	nd	10.2	13.6	2.09
70	12.0	0.79	12.2	12.1	nd	nd	16.7	19.2	11.2

#RPD is not available in the cases of non-detects

Table 6. Precision in duplicate analysis of metals on the same digests of ditch cleaning samples

Digest ID	Relative percentage difference (RPD) for duplicate analysis								
	As	**Cd**	**Cr**	**Cu**	**Mo**	**Ni**	**Se**	**Pb**	**Zn**
Ma-DC-10	nd#	nd	nd	nd	13.3	nd	nd	11.1	3.75
Ma-DC-20	nd	nd	nd	nd	nd	nd	nd	nd	0.91
Ma-DC-30	nd	nd	nd	nd	nd	nd	nd	nd	1.09
Ma-DC-40	nd	nd	nd	nd	nd	nd	nd	15.4	0.33
Ma-DC-50	nd	nd	nd	nd	nd	nd	nd	nd	3.17
Ma-DC-60	9.52	0.00	4.08	2.82	10.2	nd	14.9	17.5	1.10
Ma-DC-70	18.2	3.77	2.06	0.00	3.51	nd	4.32	0.46	0.26
Ma-DC-80	nd	0.00	7.69	7.23	nd	nd	8.25	15.4	1.48
Ma-DC-90	nd	3.64	0	3.08	nd	nd	18.6	1.77	1.08
Ma-DC-98	2.12	0.48	0.08	0.05	1.77	2.05	2.71	0.21	0.62

#RPD is not available in the cases of non-detects

Table 7. Accuracy of metal analysis on analytical QC samples

QC	% Recovery									
	Measure #	**As**	**Cd**	**Cr**	**Cu**	**Mo**	**Ni**	**Pb**	**Se**	**Zn**
1 ppm	1	99	95	97	101	107	98	98	99	97
1 ppm	2	113	112	115	119	115	114	116	115	117
1 ppm	3	95	98	99	99	101	100	98	104	99
1 ppm	4	88	87	88	86	85	87	87	90	89
1 ppm	5	106	101	101	105	119	103	102	106	103
1 ppm	6	91	91	88	90	90	90	93	91	93
1 ppm	7	106	100	101	102	107	105	103	105	102
1 ppm	8	109	106	107	107	104	108	109	110	109
2.5 ppm	1	99	97	99	101	101	99	99	97	99
2.5 ppm	2	113	112	112	116	113	112	113	114	114
2.5 ppm	3	98	99	99	99	98	99	98	100	99
2.5 ppm	4	84	85	85	84	83	84	84	84	85
2.5 ppm	5	101	100	99	101	104	101	101	99	100
2.5 ppm	6	84	87	82	85	85	85	86	85	86
2.5 ppm	7	97	99	99	100	101	101	100	101	99
2.5 ppm	8	103	102	101	102	102	102	103	101	102

Table 8. Recovery of metals in spiked samples

Spiked Sample ID	Spike Recovery (%)									
	Digestion ID§	**As**	**Cd**	**Cr**	**Cu**	**Mo**	**Ni**	**Pb**	**Se**	**Zn**
1	Ma-DC-2 & -3	81	83	89	101	86	80	89	92	97
21	Ma-DC-26 & -27	87	82	87	84	84	87	86	84	85

§ Ma-DC-3 and Ma-DC-27 are spiked digests corresponding to Ma-DC-2 and Ma-DC-26, respectively.

Table 9. Recovery of metals in 8 certified reference materials (CRM)

CRM ID	% Recovery								
	As	**Cd**	**Cr**	**Cu**	**Mo**	**Ni**	**Pb**	**Se**	**Zn**
CRM-1 (Soil-54)	96	106	110	117	108	8	112	124	122
CRM-2 (Soil-55)	71	87	85	84	77	16	86	94	89
CRM-3 (Soil-56)	77	83	79	82	82	50	80	87	82
CRM-4 (Soil-57)	81	98	94	96	85	nd	99	92	98
CRM-5 (Soil-59)	78	88	91	90	78	58	94	90	97
CRM-6 (Soil-61)	94	96	95	94	86	36	95	91	96
CRM-7 (Soil-63)	94	97	98	94	91	70	97	94	105
CRM-8 (Soil-65)	79	93	97	101	84	59	98	96	104

Table 10. Recovery of PAH components in spiked ditch cleaning samples

PAH components	**Mean Recovery [a] (%)**	**RSD (%)**
Naphthalene	83.3	5.32
Acenophthylene	61.2	12.9
Acenophthene	114	14.5
Fluorene	119	14.7
Phenanthrene	98.9	0.36
Anthracene	81.6	1.04
Fluorranthene	125	6.77
Pyrene	50.1	#
Benzo(k)fluoranthene	112	0.89
Chrysene	72.9	19.2
Benzo(g,h,I)perylene	121	2.04
Benzo(a)pyrene	92.6	3.66
Benzo(a)anthracene	51.6	#
Dibenzo(a,h)anthracene	72.9	1.19
Benzo(b)fluoranthene	73.8	0.23
Indeno(1,2,3,cd)pyrene	87.7	0.19

[a] Mean of 3 replicate extractions , [#] Only 1 out of 3 extractions was identified.

Table 11. Method detection limits of PAH components

PAH components	SCTL - direct exposure (mg/kg)		Method detection limits
	Residential	Industrial	μg/kg
Naphthalene	55	300	2.5
Acenaphtylene	1800	20000	2.5
Acenaphthene	2400	20000	4.9
Fluorene	2600	33000	0.5
Phenanthrene	2200	36000	0.2
Anthracene	2100	300000	0.1
Fluoranthene	3200	59000	0.2
Pyrene	2400	45000	0.5
Benzo[k]fluoranthene	#	#	0.1
Chrysene	#	#	0.2
Benzo[ghi]perylene	2500	52000	0.4
Benzo[a]pyrene	0.1	0.7	0.2
Ben[a]anthracene	#	#	0.2
Dibenz[a,h]anthracene	#	#	1.0
Benzo[b] fluoranthene	#	#	0.1
Ideno[1,2,3-cd] pyrene	#	#	0.2

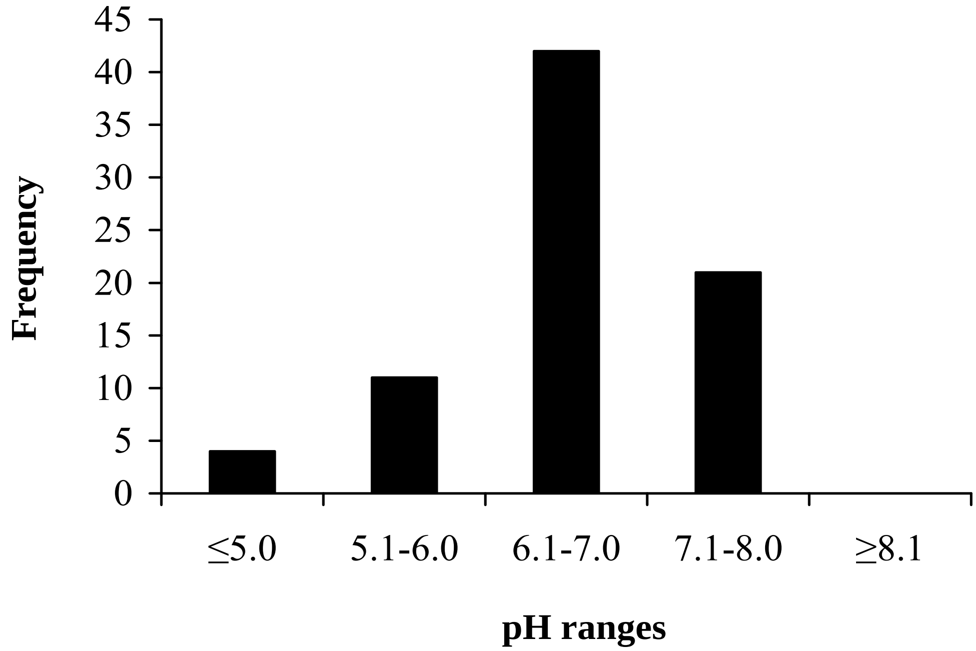

Figure 10. pH frequency distribution of 78 ditch cleaning samples.

3.3 Results of Metal Analysis

3.3.1 Total Metal Concentrations in Ditch Cleanings

Both geometric and arithmetic mean concentrations of nine 503-metals As, Cd, Cr, Cu, Pb, Mo, Ni, Se and Zn in the 78 ditch cleaning samples are presented in **Table 12**. However, geometric mean concentrations were used to compare with FDEP R-SCTLs and I-SCTLs because metal concentrations in soils are usually not normally distributed, and hence geometric mean is a better representation for the data (Chen et al., 1999).

Detected geometric mean concentrations of all nine metals were lower than their corresponding FDEP R-SCTLs and I-SCTLs. However, except for Cr, Ni and Pb, the geometric mean concentrations of other six metals were slightly higher than the corresponding geometric mean concentrations of metals in Florida soils (Chen et al., 1999).

With the exception of arsenic, for which the SCTL-R was 3.5 times higher than the mean detected value, SCTL-R for all other studied metals were far higher than detected values ranging from 50 times in the case of Cu to 1702 times in the case of Zn. This suggests that the ditch cleaning samples were relatively clean with little contamination of heavy metals. Out of the 78 samples tested for arsenic, 10 samples had detectable concentration (**Table 12**) with six being above the R-SCTL for As of 2.1 mg kg^{-1}, representing 8% of the total samples. For Cu, only one sample exceeded the R-STCL even though 61 samples or 78% of the samples had detectable level of Cu.

Comparing the results to the background geometric mean concentrations of metals in Florida soil (Chen et al., 1999), the concentrations of As, Cd, Cu, Mo, Ni, Se and Zn were all lower than their respective background concentrations. However, the concentrations of Cr, Ni and Pb were 4.1, 18 and 1.4 times respectively higher than the background values. This again suggests that the ditch cleaning samples we collected from Florida were relatively clean.

Table 12. Mean concentrations of nine metals in 78 ditch cleaning samples compared to Florida SCTLs

Metal	Number of Samples	Number of Detects	Concentration Range (mg/kg)	Mean Concentration (mg/kg)		R-SCTL (mg/kg)	I-SCTL (mg/kg)	Number of Samples Exceeding[§]	
				Geometric	Arithmetic			R-SCTL	I-SCTL
As	78	10	nd[¶] - 4.08	0.61	0.76	2.1	12	**6**	0
Cd	78	38	nd - 3.82	1.14	1.59	82	1700	0	0
Cr	78	55	nd - 202	2.05	5.55	210	470	0	0
Cu	78	61	nd - 246	2.98	7.85	150	89,000	**1**	0
Mo	78	33	nd - 5.46	1.04	1.60	440	11,000	0	0
Ni	78	0	nd	0.50	0.50	340	35,000	0	0
Pb	78	66	nd - 86.7	3.88	8.98	400	1400	0	0
Se	78	34	nd - 11.0	1.19	2.20	440	11,000	0	0
Zn	78	78	3.16 - 659	15.3	31.2	26,000	630,000	0	0

[§]SCTL=Soil Clean-up Target Level; R=Residential; I=Industrial

[¶]nd=not detected; nd was taken as 0.5 mg/kg (i.e., half of limit of quantification, which is 1.0 mg/kg) for mean calculation

3.3.2 Frequency Distribution of Metal Concentrations in Ditch Cleanings

In addition to mean metal concentrations, the frequency distribution of metal concentrations for As, Cd, Cr, Cu, Pb, Mo, Ni, Se and Zn are presented in **Figures 11-19**.

Among the 9 metals studied, arsenic (in six samples) was the one of the two metals exceeded the Florida R-SCTL.

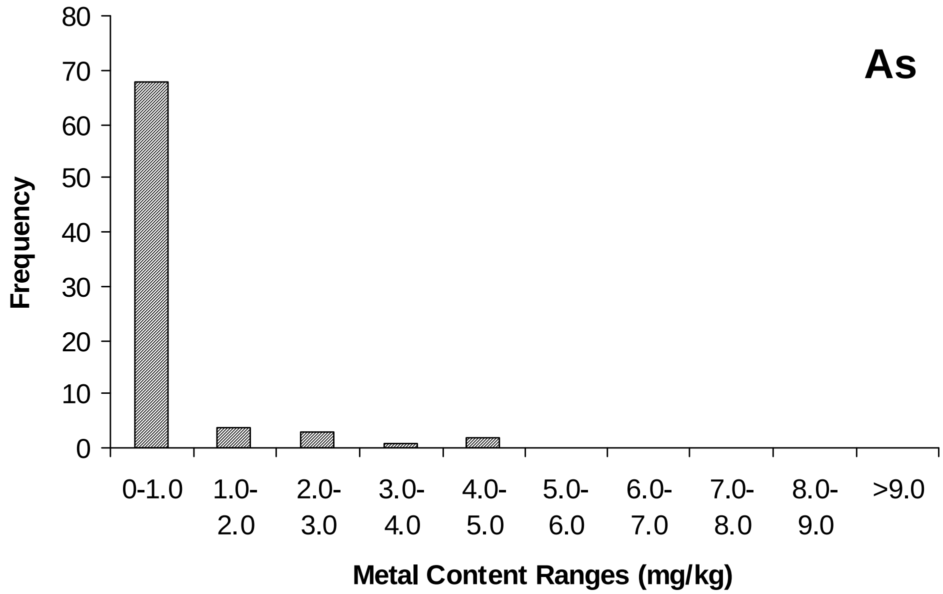

Figure 11. Frequency distribution of arsenic concentrations in 78 ditch cleaning samples

As expected, arsenic concentrations in the 78 ditch cleaning samples were low, with 68 samples (87%) being ≤1 mg kg^{-1} (**Figure 11**), similar to arsenic concentrations in Florida soils (Chen et al., 1999). The geometric mean concentration of arsenic in the ditch cleaning samples was 0.61 mg kg^{-1} with a concentration range of 0 to 4.08 mg kg^{-1} (**Table 12**). The corresponding numbers for background concentration in Florida surface soils are 0.42 mg kg^{-1} with a concentration range of 0.01 to 50.6 mg kg^{-1}. There were 6 samples exceeding R-SCTL for As of 2.1 mg kg^{-1}, which accounts for 8% of total samples collected. Based on our data, there was little contamination of arsenic in the ditch cleaning samples.

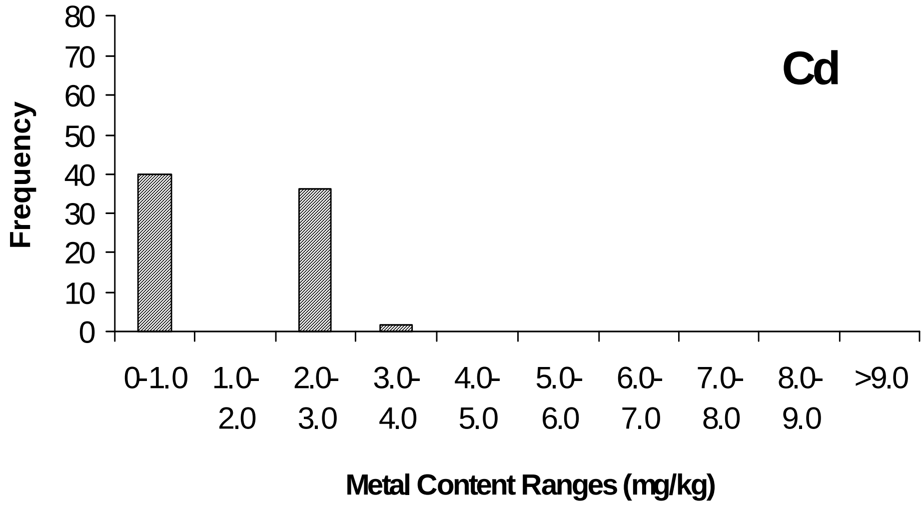

Figure 12. Frequency distribution of cadmium concentrations in 78 ditch cleaning samples

Unlike As, Cd concentrations in ditch cleaning samples were relatively low, with none exceeding Florida R-SCTL in all 78 samples (**Figure 12**). The geometric mean concentration of Cd was 1.14 mg kg^{-1} with a concentration range of 0 to 3.82 mg kg^{-1} (**Table 12**) The corresponding numbers for Cd background concentration in Florida surface soils are 0.01 mg kg^{-1} with a concentration range of 0.01 to 2.80 mg kg^{-1} (Chen et al., 1999).

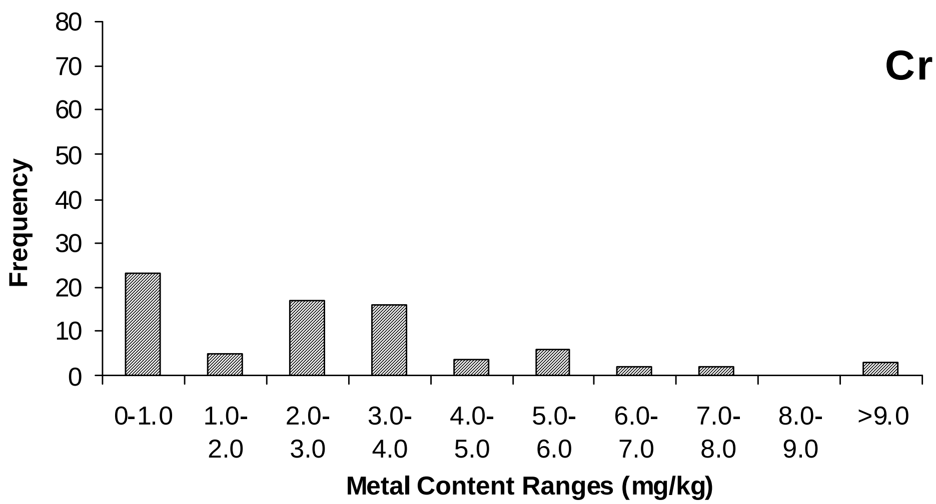

Figure 13. Frequency distribution of chromium concentrations in 78 ditch cleaning samples

Compared to Cd, Cr concentrations in the ditch cleaning samples were slightly higher, with 13 samples exceeding 5 mg kg^{-1} and 3 samples exceeding 9 mg kg^{-1} (**Figure 13**). The geometric mean concentration of Cr was 2.05 mg kg^{-1} with a concentration range of 0 to 202 mg kg^{-1} (**Table 12**). The corresponding numbers for Cr background concentration in Florida surface soils are 8.45 mg kg^{-1} with a concentration range of 0.02 to 447 mg kg^{-1} (Chen et al., 1999). As a group, Cr concentrations were much lower than the Florida SCTL and the background concentration in Florida soils and hence it is of little environmental concern in the ditch cleanings.

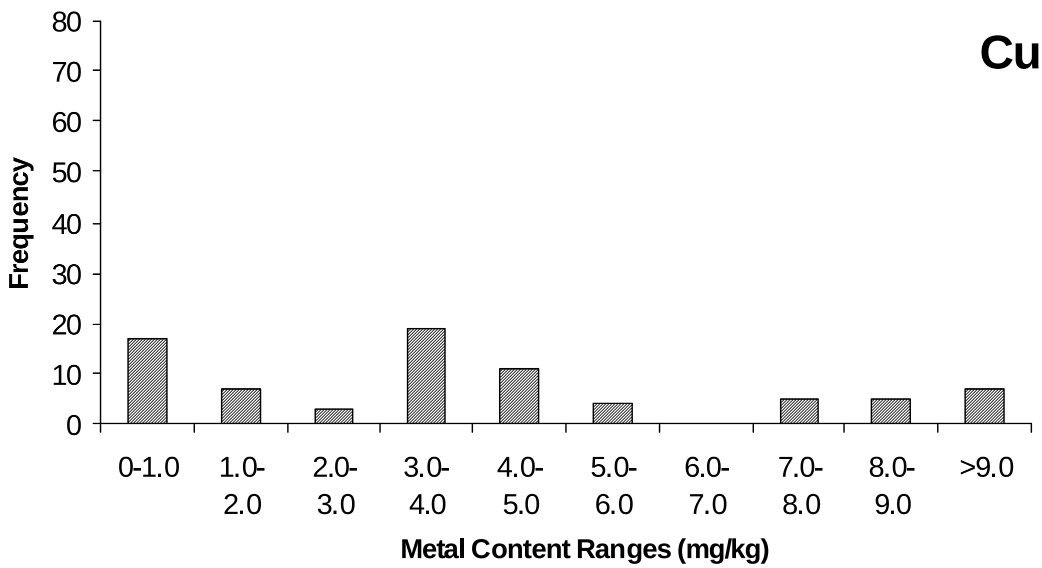

Figure 14. Frequency distribution of copper concentrations in 78 ditch cleaning samples

Similar to Cr, Cu concentrations in ditch cleaning samples were slightly higher than Cd with 21 samples exceeding 5 mg kg^{-1} and 7 samples exceeding 9 mg kg^{-1} (**Figure 14**). The geometric mean concentration of Cu was 2.98 mg kg^{-1} with a concentration range of 0 to 246 mg kg^{-1} (**Table 12**). The corresponding numbers for Cu background concentration in Florida surface soils are 2.21 mg kg^{-1} with a concentration range of 0.1 to 318 mg kg^{-1} (Chen et al., 1999). As a group, copper concentrations were much lower than the Florida SCTL and hence it is of little environmental concern in ditch cleanings.

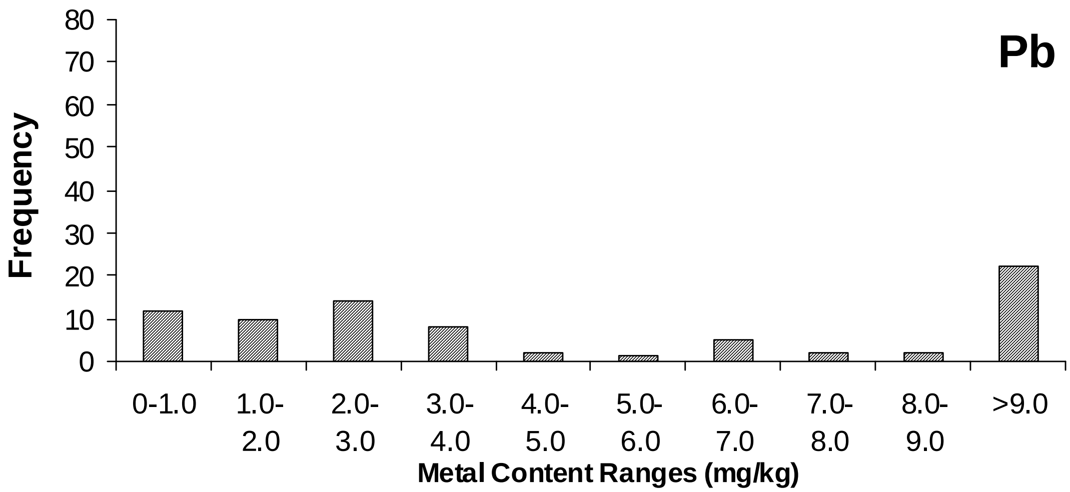

Figure 15. Frequency distribution of lead concentrations in 78 ditch cleaning samples

Compared to Cu and Cr, Pb concentrations in ditch samples were slightly higher with as many as 32 samples exceeding 5 mg kg^{-1} and 22 samples exceeding 9 mg kg^{-1} (**Figure 15**). It is possible that the elevated lead may be associated with Pb emitted by automobiles and Pb-battery. The geometric mean concentration of Pb was 3.88 mg kg^{-1} with a concentration range of 0 to 86.7 mg kg^{-1} (**Table 12**). The corresponding numbers for Pb background concentration in Florida surface soils are 5.38 mg kg^{-1} with a concentration range of 0.28 to 290 mg kg^{-1} (Chen et al., 1999). As a group, lead concentrations were much lower than the Florida SCTL and Florida background concentration in Florida soils and hence it is of little environmental concern in ditch cleanings.

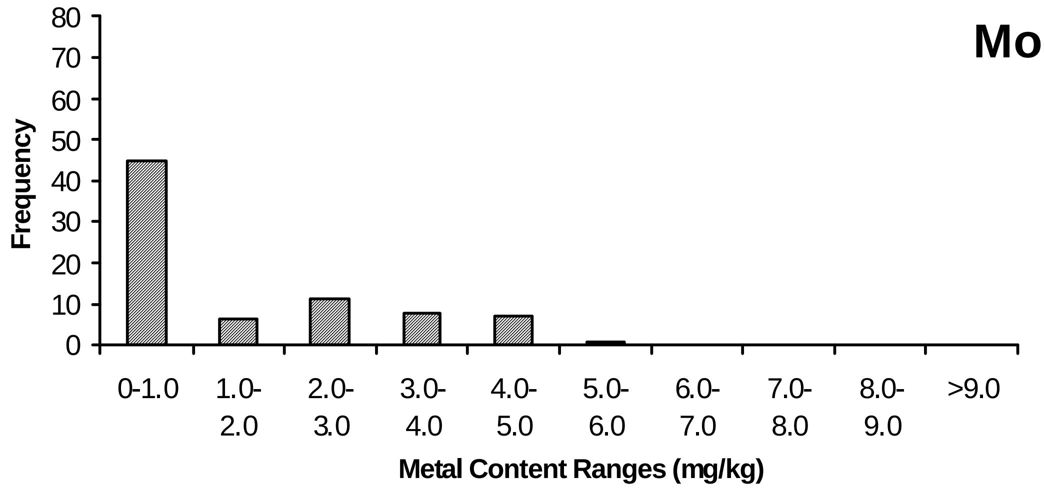

Figure 16. Frequency distribution of molybdenum concentrations in 78 ditch cleaning samples

The Mo concentrations in ditch cleaning samples were relatively low with as many as 45 samples being ≤1 mg kg^{-1} (**Figure 16**). The geometric mean concentration of Mo was 1.04 mg kg^{-1} with a concentration range of 0 to 5.46 mg kg^{-1} (**Table 12**). The corresponding numbers for Mo background concentration in Florida surface soils are 0.95 mg kg^{-1} with a concentration range of 0.04 to 14.1 mg kg^{-1} (Chen et al., 1999). As a group, molybdenum concentrations were much lower than the Florida SCTL and it is of little environmental concern in ditch cleanings.

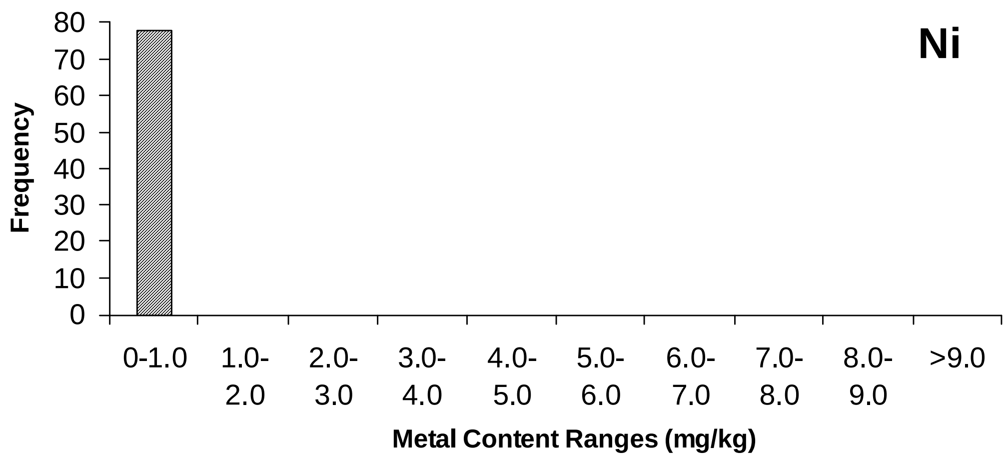

Figure 17. Frequency distribution of nickel concentrations in 78 ditch cleaning samples

Nickel concentrations in all 78 ditch cleaning samples below the detection limit of 1 mg kg^{-1} (**Figure 17**). The geometric mean concentration of Ni was 0.50 mg kg^{-1} with a concentration range of 0 to 0.5 mg kg^{-1} (**Table 12**). The corresponding numbers for Ni background concentration in Florida surface soils are 9.08 mg kg^{-1} with a concentration range of 0.04 to 375 mg kg^{-1} (Chen et al., 1999). Hence, nickel is of little environmental concern in ditch cleanings.

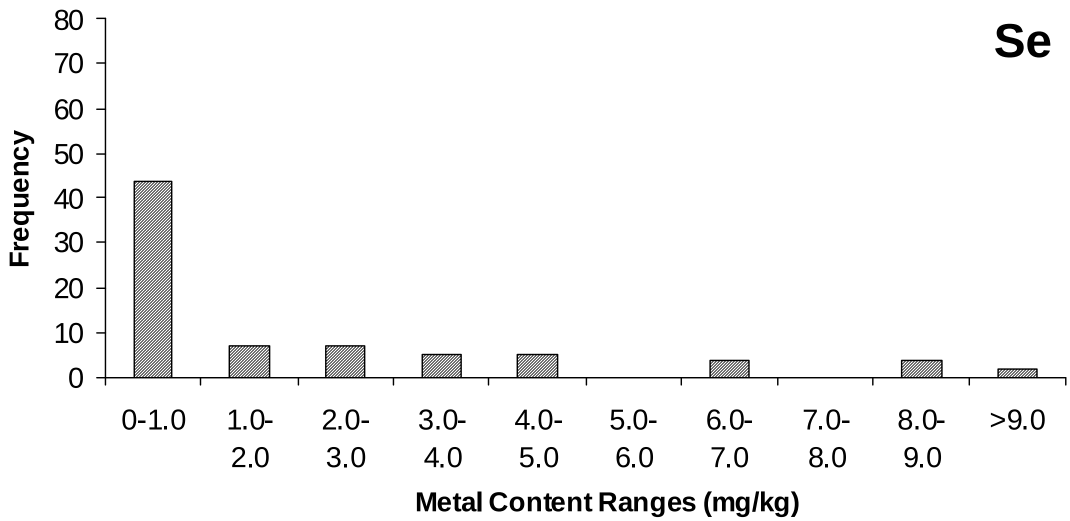

Figure 18. Frequency distribution of selenium concentrations in 78 ditch cleaning samples

Selenium concentrations in ditch cleaning samples were relatively low with as many as 44 samples being ≤1 mg kg^{-1} (**Figure 18**). There were 10 samples exceeding 5 mg kg^{-1} and 2 samples exceeding 9 mg kg^{-1}. The geometric mean concentration of Se was 1.19 mg kg^{-1} with a concentration range of 0 to 11.0 mg kg^{-1} (**Table 12**). The corresponding numbers for Se background concentration in Florida surface soils are 0.10 mg kg^{-1} with a concentration range of 0.01 to 4.62 mg kg^{-1} (Chen et al., 1999). Overall selenium concentrations were much lower than the Florida SCTL and it was of little environmental concern in ditch cleanings.

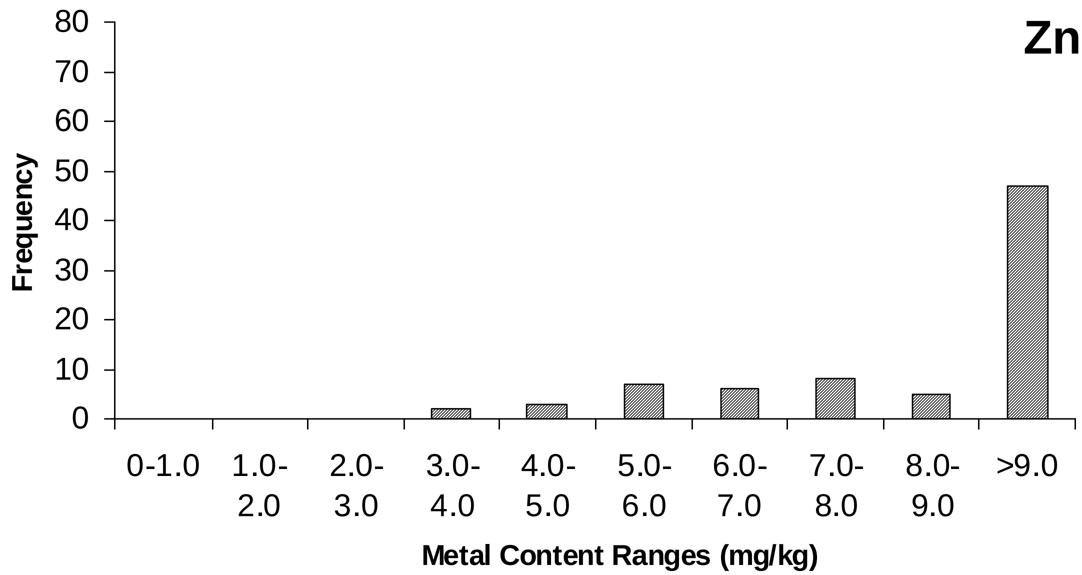

Figure 19. Frequency distribution of zinc concentrations in 78 ditch cleanings samples

Unlike Se, Zn concentrations in ditch cleaning samples were relatively higher with as many as 47 samples (60%) exceeding 9 mg kg^{-1} (**Figure 19**). The geometric mean concentration of Zn was 15.3 mg kg^{-1} with a concentration range of 3.16 to 659 mg kg^{-1} (**Table 12**). The corresponding numbers for Zn background concentration in Florida surface soils are 5.12 mg kg^{-1} with a concentration range of 0.9 to 169 mg kg^{-1} (Chen et al., 1999). As a group, zinc concentrations were much lower than the Florida SCTL and hence it is of little environmental concern in ditch cleanings.

3.3.3 Metal concentrations in ditch cleanings from different districts

To have a better understanding of metal concentrations in ditch cleanings in Florida, we have grouped the data into 8 districts (**Table 13; Figure 18**).

Based on **Table 13** and **Figure 18**, it doesn't seem there is a trend for metal concentrations in ditch cleanings in the 8 districts. However, the overall mean concentrations of the four metals were relatively high with the order of Zn > Pb > Cu > Cr.

Table 13. Arithmetic mean metal concentrations of the ditch cleaning samples in the eight districts of Florida

District/County	Number of Samples	pH	Mean Metal Content (mg/kg)								
			As	Cd	Cr	Cu	Mo	Ni	Pb	Se	Zn
Northwest	3	5.51	0.50[¶]	0.50	1.32	5.21	1.48	0.50	**12.2***	0.90	**20.9**
North Central	3	6.64	0.50	0.50	3.11	3.01	1.59	0.50	**21.0**	0.50	**29.6**
North East	6	6.39	0.50	0.50	0.50	1.11	1.02	0.50	**1.73**	0.73	**24.1**
Central West	4	6.33	0.50	1.33	53.0	**63.1**	2.06	0.50	23.4	0.50	**184**
Central	7	6.40	0.50	0.50	5.44	5.22	1.06	0.50	**17.2**	0.50	**38.1**
Central East	7	6.64	0.50	0.50	1.49	6.89	0.50	0.50	**8.59**	0.66	**27.7**
South west	4	6.93	0.50	0.50	**2.60**	0.50	0.50	0.50	1.28	0.50	**15.9**
South east	5	6.61	0.50	0.50	3.78	5.34	0.50	0.50	**4.62**	0.85	**78.5**
Samples (mailed)	39	6.46	0.50	0.59	7.85	10.19	1.00	0.50	**10.6**	0.64	**50.0**
Clay County (collected)	39	6.62	1.02	2.60	3.26	5.51	2.19	0.50	**7.39**	3.74	**12.4**
All	**78**	6.54	0.76	1.59	5.55	7.85	1.60	0.50	**8.98**	2.20	**31.2**

[¶] non detect cases were taken as 0.5 mg/kg (i.e., half of limit of quantification) for mean calculation

* The highest two metal concentrations among the 6 districts were highlighted in bold.

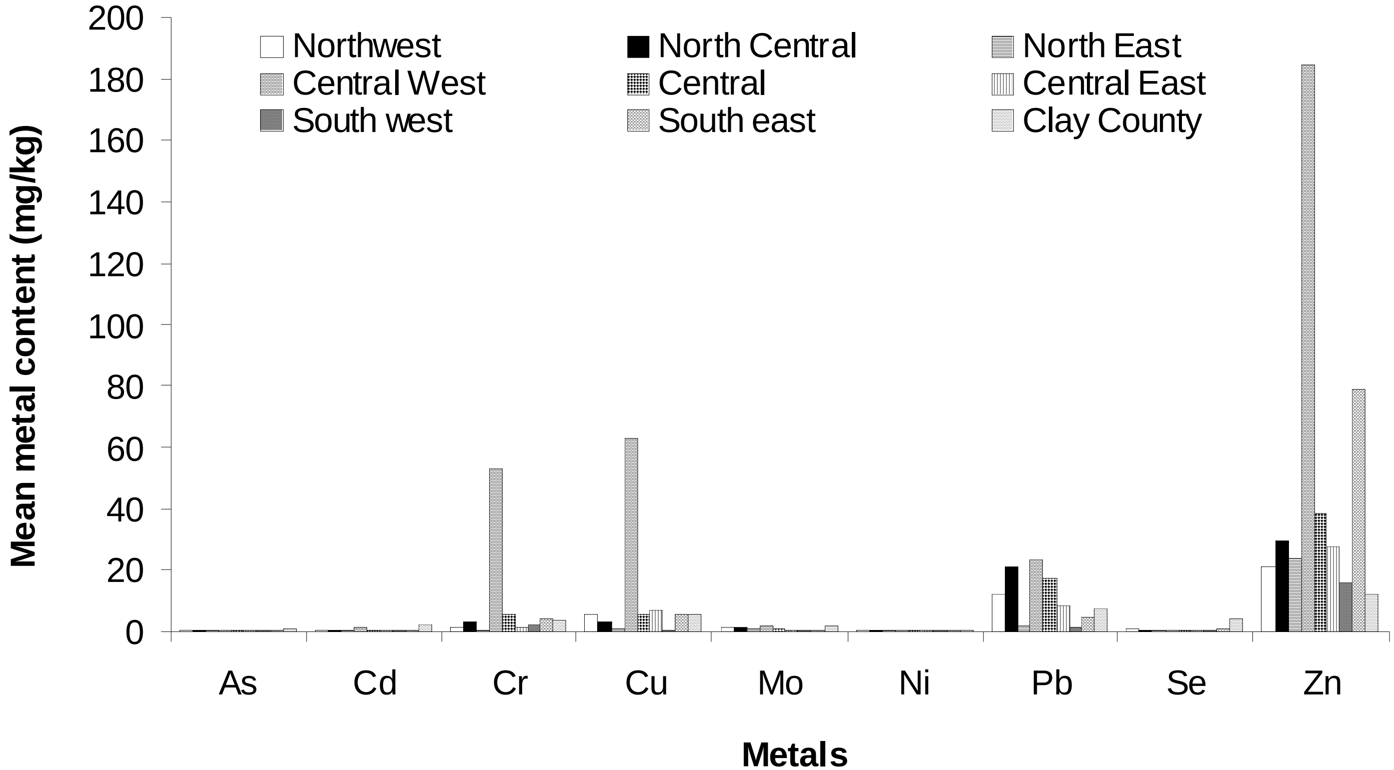

Figure 18. Arithmetic mean metal concentrations in ditch cleaning samples in eight Florida districts

3.3.4 Comparison of metal contents of ditch cleanings with other solid wastes and soils

The ranges of metal concentrations in the 78 ditch cleaning samples of the present study along with those of some other solid wastes and natural soils of Florida are given in **Table 14.** The corresponding arithmetic mean values are plotted in **Figure 19**.

As shown in **Table 14**, the highest concentrations of all metals except for Cd, Se, and Zn in the ditch cleaning samples of the present study were lower than the corresponding highest concentrations of Florida soils (Chen et al., 1999). Except for Cr, Cu, and Se, the highest concentrations of all other metals were higher than those in street sweepings. Their concentrations were much lower in ditch cleanings, but again increased in stormwater system sediments (SSS) and catch basin sediments (CBS).

The average metal concentrations in the ditch cleanings of the present study were either comparable to or lower than Florida soils for all metals except for Zn (**Figure 19.** Comparison of average metal contents of Florida soils and various solid wastes.). Compared to ditch cleanings, Cu, Cr, Pb, and Zn in Florida soils were higher. Interestingly, the average metal concentrations, especially the four metals, were the highest in street sweepings and the lowest in ditch cleanings, with those in stormwater system sediments and catch basin sediments in the middle (**Figure 5**).

If we carefully consider the positions of these four wastes and highway soils as shown in **Figure 5**, it is understood that particulate materials from the streets and highways, carried by stormwater, flow through the ditches and stormwater ponds to the catch basins. During this flow, the contaminants (metals and organics) may exist as bound to particulate materials or dissolved in stormwater. The street sweepings and highway soils are logically rich in contaminants, since they are exposed to contamination through various ways. Given the fact that ditches allow continuous flow of stormwater, we expect settling of only coarser particles in the ditches, while finer particles travel long distance and settle as sediments in the stormwater ponds and catch basin. Thus, ditch cleaning wastes are mostly coarse particles and they are continuously exposed to a wash away effect of stormwater flow, and hence had lower average metal concentrations. The high average metal concentration in stormwater system sediments and catch basin sediments reflect the fact that metals originated from streets and highways were predominantly bound with colloidal particles, which travelled longer distance through the ditches and deposited as sediments in stormwater ponds and catch basins.

Table 14. Comparison of the ranges of metal contents in Florida soils and various solid wastes[§]

Metal	Conc. Range (mg/kg)					
	Florida Soils	Yard Trash	Street Sweepings	Ditch Cleanings	Stormwater System Sediments	Catch Basin Sediments
As	0.16-6.00	nd[¶]-9.98	nd-13.6	nd-4.08	nd-24.8	nd-12.7
Cd	0.004-2.80	0.28-3.44	nd-54.1	nd-3.82	nd-5.3	nd
Cr	0.02-447	nd-18.1	nd-552	nd-202	nd-174.5	nd-50.8
Cu	0.1-318	2.57-11.6	nd-372	nd-246	4.5-90.4	5.5-398
Mo	0.04-14.1	nd-4.88	na[†]	nd-5.46	na	na
Ni	0.04-375	0.38 - 8.27	nd-69.9	nd	5.4-40.4	2.5-30.7
Pb	0.18-290	nd- 67.2	nd-386	nd-86.7	nd-196	nd-1060
Se	0.01-4.62	nd-6.27	nd-10.6	nd-10.9	nd-14.1	nd-7.4
Zn	0.90-169	4.01-270	4.3-1080	3.16-659	5.4-711	9.1-956

[§]Metal contents of yard trash are from Ma et al. (2009) and those of street sweepings, storm water system sediments, and catch basin sediments are from Townsend et al. (2002).
[¶]nd=not detected; nd was taken as 0.5 mg/kg (i.e., half of limit of quantification, which is 1.0 mg/kg) for mean calculation

[†]na=not available

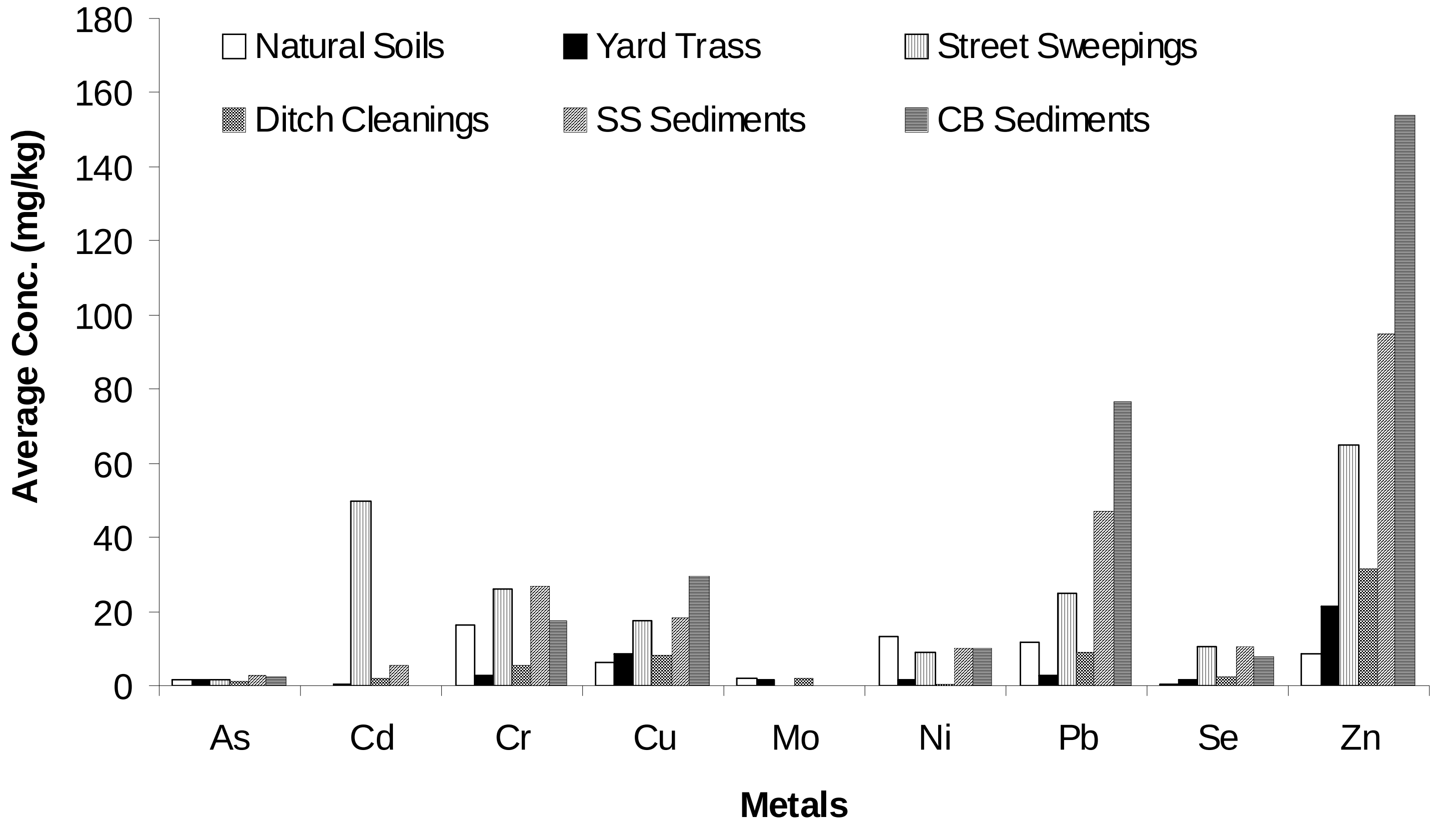

Figure 19. Comparison of average metal contents of Florida soils and various solid wastes.

Notes: SS = Stormwater System; CB = Catch Basin; Metal contents of yard trash are from Ma et al. (2009) and those of street sweepings, storm water pond sediments, and catch basin sediments are from Townsend et al. (2002).

3.4 Results and Discussion of Organics Analysis

The results of organics analysis in ditch cleaning samples are summarized in **Table 15**. All analytical data including surrogate recovery percentage of each sample are presented in **Table 21** through **Table 29** in the Appendix. Total number of samples analyzed for PAH was 67. Eleven samples received by mail were not analyzed for PAHs because the holding time for PAH containing samples, which is 14 days, was exceeded by the time these samples were delivered to the laboratory. Unlike the metal analysis, wet samples were used for organic analysis to prevent lose of target PAHs during drying. Measured moisture content was used to convert result to dry weight basis. The moisture contents of ditch cleaning samples used for organic analysis are presented in **Table 30** in Appendix.

All the 16 PAHs investigated were detected in measurable quantities in some of the 67 samples analyzed. The number of detects of PAHs observed ranged from 18 detects for pyrene to 63 detects of benzo(a)pyrene. The large number of detects in this study is due to the fact that HPLC equipped with UV/Fluorescence detectors was employed in the analyses. This ensured the achievement of lower detection limit compared to previous studies discussed later in this report where GC-MS was the analytical instrument.

With the exception of benzo(a)pyrene, all PAHs measured in the 67 samples lower than both their respective residential and industrial Florida soil cleanup target levels (SCTLs) (Table 15). In the case of benzo(a)pyrene, 11 values exceeded the SCTLs. Two measured values (1.01 mg/kg and 0.85 mg kg^{-1}) were 1.4 and 1.2 times higher than I-SCTL of 0.7 mg kg^{-1}. The other 9 exceeding benzo(a)pyrene concentration values were between 1.3 to 6.7 times higher than the residential SCTL, however, they were lower than the I-SCTL. In spite of this, the geometric mean concentration of benzo(a)pyrene (0.012 mg kg^{-1}) was lower that both R-SCTL and I-SCTL. The Florida residential and industrial SCTL are 8.3 and 58.3 times respectively higher than the geometric means concentration of benzo(a)pyrene. Considering the other 15 PAHs investigated, their geometric mean concentrations were lower than their corresponding residential and industrial SCTLs. Also, the calculated 99% UCL (Upper confidence level) for all PAHs were lower than both residential and industrial SCTLs (**Table 15**). There is therefore a 99% confidence that the geometric mean does not exceed the UCL, which is in turn lower than the SCTLs.

Comparing results to previous work on similar waste streams conducted in Florida and Massachusetts (Townsend et al ,2002, Miles and Delfino, 1999, and Shiaris and Jambard-Sweet, 1986), the current study values are lower (**Table 16**). As part of effort to evaluate possible disposal and management option for street sweeping, stormwater sediment, and catch basin sediment, chemical characterization of these samples was performed (Townsend et al, 2002). A total of 300 samples collected from 20 different sampling locations throughout Florida were analyzed for selected pollutants including 16 priority PAHs. Five compounds, benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3,c,d)pyrene were detected in some of the samples above R-SCTLs or both R-SCTLs and I-SCTLs. For example, benzo(a)pyrene concentrations were 9.2 mg/kg and 34.3 mg/kg, which were 92 and 69 times higher than the R-SCTL and I-SCTL of 0.1 mg/kg and 0.5 mg/kg, respectively (**Table 16**).

Miles and Delfino (1999) investigated priority PAHs in Florida sediments. Sediment samples from freshwater and estuarine sites close to potential pollutant sources across Florida were sampled. A total of 31 sites were sampled and analyzed for 82 organic pollutants, including 16 priority PAHs. Results showed that PAH compounds from molecular weight 178 (phenanthrene and anthracene) through molecular weight 252 (benz(a)anthracene and benzo(bk)fluoranthene were found most frequently. Mean measured concentrations ranged from 0.54 mg/kg acenophthylene to 33 mg/kg naphthalene. The mean concentrations of benzo(a)pyrene and dibenzo(a,h)anthracene, which are of much concern, were 1.4 mg/kg and 0.59 mg/kg and concentration ranges of 0.18-9.50 mg/kg (benzo(a)pyrene) and 0.36-1.00 mg/kg (dibenzo(a,h)anthracene) were reported (**Table 16**).

Investigation of PAH loading in sediments of Boston Harbor, Massachusetts, USA by Shiaris and Jambard-Sweet (1986) reveled the presence of PAH compounds. Twenty sites were sampled and analyzed for PAHs. High PAH concentration (>10 mg/kg) were detected in samples from some sites (**Table 16**). The maximum measured values of this research are lower than their corresponding measured concentrations reported in the literature. For example, the maximum measured benzo(a)pyrene concentration is just 2.9%, 1.1% and 11% of the corresponding value reported by Townsend et al (2002), Shiaris and Jambard-Sweet (1986), and Miles and Delfino (1999) respectively.

The box plot of selected PAH components are presented in **Figure 22** to **Figure 24**. In whisker diagrams, the box itself indicates the middle 50% of data and upper and lower hinges of the box indicate 75^{th} and 25^{th} percentile. The horizontal line positioned in the box indicate the median of PAH concentrations. As mean values are shown in **Table 15**, except for benzo(a)pyrene, the median and 75^{th} percentile of PAH concentrations were substantially lower than the Florida SCTL.

Table 15. Summary of polycyclic aromatic hydrocarbon analysis results of ditch cleaning samples.

	Number of samples	Number of detects	Max conc. (mg/kg)	99 % UCL conc. (mg/kg)	Mean (mg/kg)		SCTL (mg/kg)		Number of samples exceeding R-SCTL (I-SCTL exceedance)
					Geometric mean	Arithmetic mean	Residential	Industrial	
Acenophthene	67	27	1.51	0.078	0.010	0.074	2400	20000	0
Acenophthylene	67	27	0.43	0.028	0.005	0.029	1800	20000	0
Anthracene	67	48	0.43	0.028	0.002	0.035	2100	300000	0
Benzo(a)anthracene	67	52	0.98	0.043	0.004	0.033	#	#	0
Benzo(a)pyrene	67	63	1.01	0.079	0.012	0.099	0.1	0.7	**9 (2)**
Benzo(b)fluoranthene	67	41	0.23	0.015	0.001	0.009	#	#	0
Benzo(g,h,I)perylene	67	59	3.95	0.239	0.024	0.251	2500	52000	0
Benzo(K) Fluoranthene	67	43	0.13	0.008	0.001	0.009	#	#	0
Chrysene	67	48	1.12	0.062	0.005	0.096	#	#	0
Dibenzo(a,h)anthracene	67	25	0.67	0.041	0.002	0.040	#	#	0
Fluorene	67	32	1.97	0.098	0.001	0.071	2600	33000	0
Fluoranthene	67	38	10.5	0.425	0.004	0.304	3200	59000	0
Indeno(1,2,3,cd)pyrene	67	53	0.68	0.049	0.002	0.050	#	#	0
Naphthalene	67	47	2.02	0.172	0.036	0.270	55	300	0
Phenanthrene	67	44	0.27	0.016	0.001	0.017	2200	36000	0
Pyrene	67	18	1.21	0.048	0.001	0.030	2400	45000	0

† For calculations above, half the method detection limit (MDL) was used for results where measured concentrations were below MDL.

Table 16. Concentration of polycyclic aromatic hydrocarbon in sediments and street sweepings.

	Miles and Delfino (1999) Florida (mg/kg)	Shiaris and Jambard (1986) Massachusettes (mg/kg)	Townsend et al (2002) Florida (mg/kg)	This Research (mg/kg)
Acenophthene	0.08 – 262			<0.0049 - 1.514
Acenophthylene	0.08 – 3.00			<0.0025 - 0.425
Anthracene	0.04 – 11.0	<0.010 – 0.51	12.9	<0.0001- 0.429
Benzo(a)anthracene	0.04 – 11.0		14.5 – 39.9	<0.0002 - 0.976
Benzo(a)pyrene	0.18 – 9.50	<0.007 – 95.0	9.2 – 34.3	<0.0002 - 1.007
Benzo(b)fluoranthene		<0.070 – 4.10	13.2 – 104	<0.0001 - 0.233
Benzo(g,h,I)perylene	4.5 – 10.6		7.6 – 48.5	<0.0004 - 3.951
Benzo(K) Fluoranthene			22.2	<0.0001 - 0.133
Chrysene	0.04 – 13.0		56.3	<0.0002 - 1.119
Dibenzo(a,h)anthracene	0.36 – 1.00			<0.001 - 0.668
Fluorene	0.07 – 128		6.5	<0.0005 - 1.971
Fluoranthene	0.06 – 85.0	<0.005 – 84.5	5.4 – 59.3	<0.0002 - 10.549
Indeno(1,2,3,cd)pyrene	0.72 – 9.50		47.2	<0.0002 - 0.676
Naphthalene	0.26 – 226	<0.01 – 43.6		<0.0025 - 2.019
Phenanthrene	0.05 – 228	0.045 – 63.7	7.5 – 29.1	<0.0002 - 0.267
Pyrene	0.05 – 78.0	0.158 – 66.8	11.6 – 111	<0.0005 - 1.206

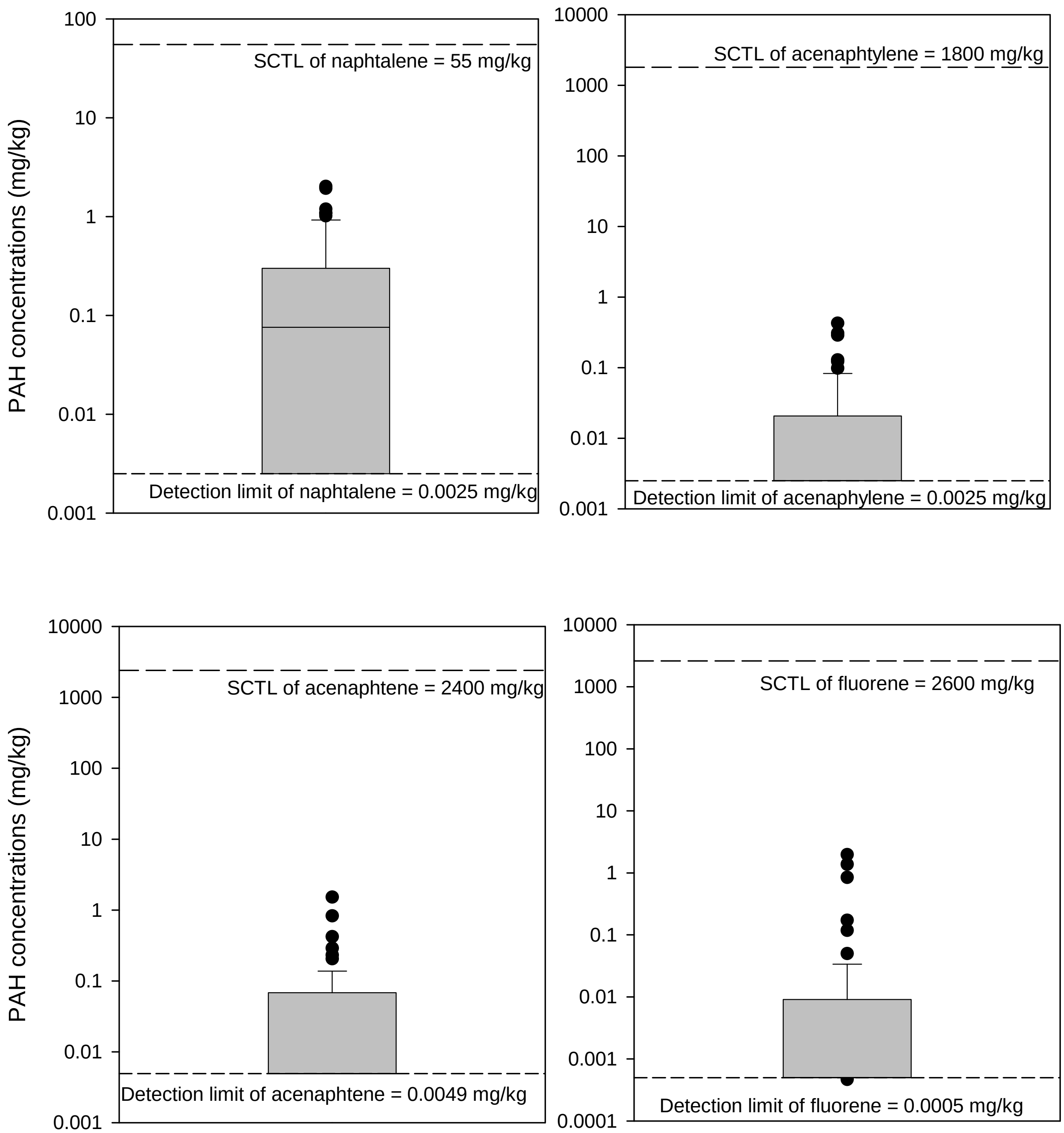

Figure 20. Concentration distribution of selected PAH components (naphthalene, acenaphylene, acenaphthene and fluorene) in ditch cleaning samples

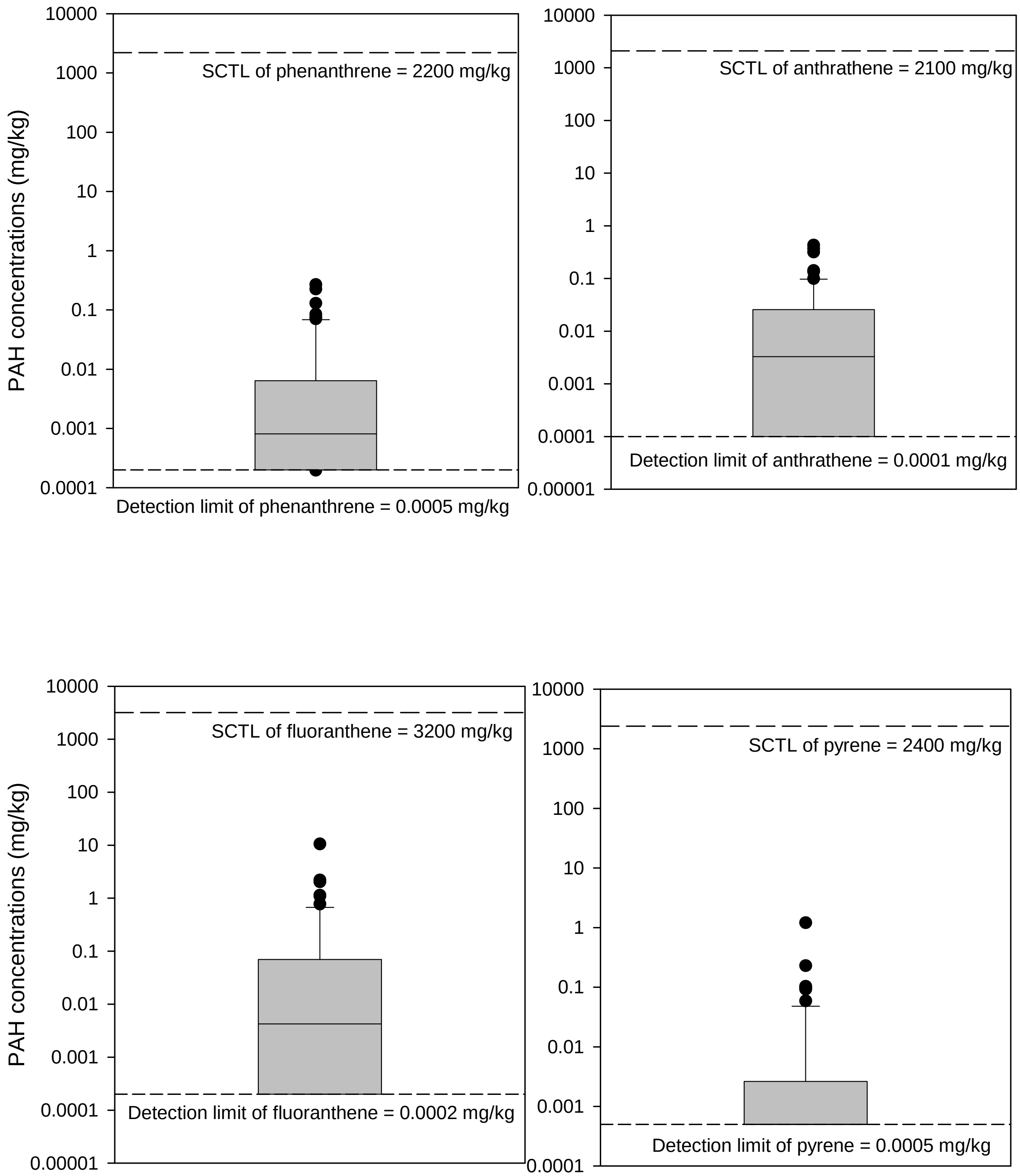

Figure 21. Concentration distribution of selected PAH components (phenanthrene, anthrathene, fluoranthene, and pyrene) in ditch cleaning samples

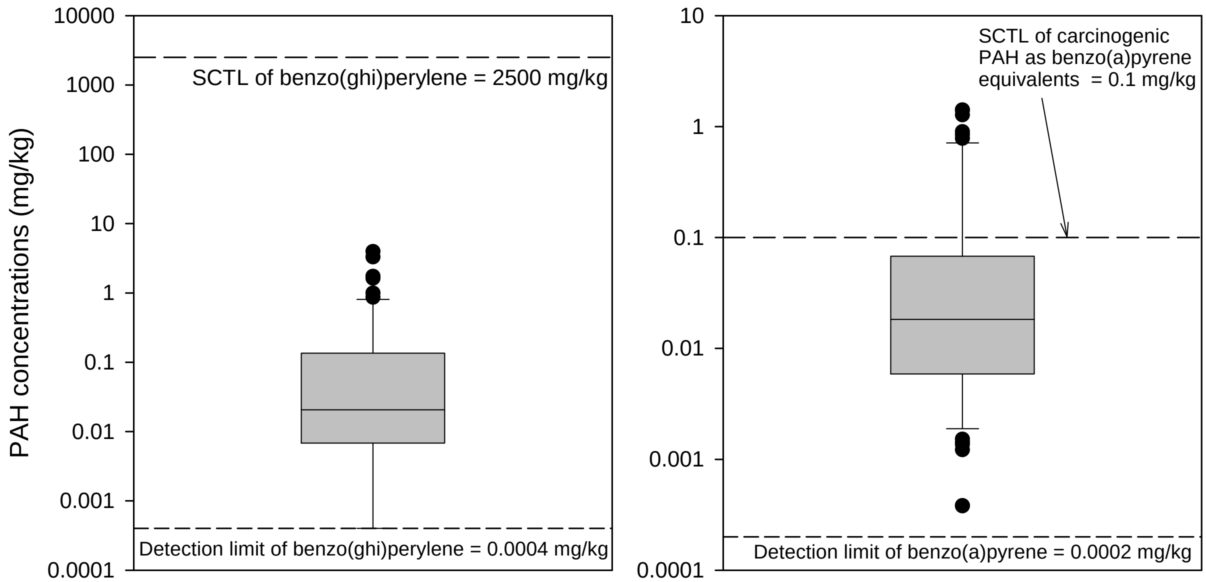

Figure 22. Concentration distribution of selected PAH components (benzo (ghi) perylene and carcinogenic PAH) in ditch cleaning samples.

4. SUMMARY AND CONCLUSION

To address potential concerns of metals and organic contaminants in ditch cleanings in Florida, we collected 78 representative samples (39 across the state of Florida and 39 from Clay County) for analyses of metals and organic contaminants.

Based on our analysis of nine 503 metals (As, Cd, Cr, Cu, Pb, Mo, Ni, Se and Zn), except for arsenic, there seems no concern of contamination for the other 8 metals, which were all substantially lower that the corresponding Florida SCTLs as well as metal concentrations in Florida soils.

However, 6 samples (8%) had arsenic concentrations exceeding the Florida R-SCTL for residential soil of 2.1 mg kg^{-1}. This may suggest that 1 in 12 ditch cleaning samples may have slightly elevated arsenic levels. However, as a group, the arsenic concentrations in the ditch cleanings were low, with arithmetic mean concentration of 0.76 mg kg^{-1} and geometric mean concentration of 0.61 mg kg^{-1}.

Total 67 samples were analyzed for PAH. Among 16 PAHs under consideration, except for benzo(a)pyrene, all PAHs measured in the 67 samples lower than both their respective residential and industrial Florida SCTLs. In the case of benzo(a)pyrene, 11 values exceeded the SCTLs. Two measured values (1.01 and 0.85 mg kg^{-1}) were 1.4 and 1.2 times higher than I-SCTL of 0.7 mg kg^{-1}. The other 9 exceeding benzo(a)pyrene concentration values were between 1.3 to 6.7 times higher than the residential SCTL, however, they were lower than the I-SCTL. In spite of this, the geometric mean concentrations of benzo(a)pyrene (0.012 mg kg^{-1}) was lower that both R-SCTL and I-SCTL. The Florida residential and industrial SCTL were 8.3 and 58 times respectively higher than the geometric means concentration of benzo(a)pyrene. Considering the other 15 PAHs investigated, their geometric mean concentrations were lower than their corresponding residential and industrial SCTLs. Also, the calculated 99% UCL (upper confidence level) for all PAHs were lower than both SCTLs (**Table 15**). There is therefore a 99% confidence that the geometric mean does not exceed the UCL, which is in turn lower than the SCTLs.

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6. APPENDICES

To provide more detailed information about pH, and metal and PAHs concentrations in the 78 ditch cleaning samples, we have grouped the individual data into 8 districts for the 39 samples obtained via mail. The pH and metal concentrations in the 39 mailed samples are presented in **Tables 17 to 19**. The individual data for pH and metal concentrations in the 39 samples collected from Clay County of Northeast district are given in **Table 20**. Similarly, PAHs concentrations in the 39 ditch cleaning samples collected from Clay Country were presented in **Tables 21-24**, while those grouped into 8 districts are presented in **Tables 26 to 29**. The moisture contents in the 39 samples collected from Clay County are presented in **Table 30**.

Table 17. pH and metal contents of the 12 ditch cleaning samples from north Florida.

District	Sample ID	pH	Metal Content (mg/kg)								
			As	Cd	Cr	Cu	Mo	Ni	Pb	Se	Zn
Northwest (3 samples)	1	5.58	nd[§]	nd	2.95	7.66	2.36	nd	18.0	nd	28.0
	2	5.65	nd	nd	nd	7.47	1.59	nd	16.3	1.69	29.9
	3	5.31	nd	nd	nd	nd	nd	nd	2.26	nd	4.92
North Central (3 samples)	4	6.75	nd	nd	5.38	4.18	2.09	nd	22.0	nd	38.0
	5	6.92	nd	nd	3.45	3.16	1.58	nd	23.4	nd	32.6
	6	6.26	nd	nd	nd	1.69	1.09	nd	17.7	nd	18.3
North East (6 samples)	7	6.10	nd	nd	nd	1.98	2.08	nd	1.19	nd	24.7
	8	6.78	nd	nd	nd	nd	1.38	nd	2.77	nd	15.5
	9	6.07	nd	nd	nd	nd	nd	nd	2.18	nd	6.73
	10	5.76	nd	nd	nd	nd	nd	nd	1.87	nd	58.3
	11	6.69	nd	nd	nd	1.87	1.18	nd	1.08	nd	18.2
	12	6.94	nd	nd	nd	1.28	nd	nd	1.28	1.87	21.2

[§]nd= not detected

Table 18. pH and metal contents of the 18 ditch cleaning samples from central Florida.

District	Sample ID	pH	Metal Content (mg/kg)								
			As	Cd	Cr	Cu	Mo	Ni	Pb	Se	Zn
Central West (4 samples)	13	7.19	nd	nd	7.4	nd	3.9	nd	nd	nd	27.7
	14	6.42	nd	nd	2.2	5.6	nd	nd	11.2	nd	38.5
	15	6.15	nd	3.8	202	246	3.3	nd	79.8	nd	659
	16	5.57	nd	nd	nd	nd	nd	nd	2.1	nd	10.7
Central (7 samples)	17	6.67	nd	nd	4.3	1.4	1.6	nd	19.2	nd	37.4
	18	7.01	nd	nd	24.2	3.8	3.3	nd	34.1	nd	35.6
	19	5.86	nd	nd	nd	nd	nd	nd	nd	nd	36.6
	20	6.28	nd	nd	nd	10.7	nd	nd	17.8	nd	47.2
	21	6.31	nd	nd	nd	8.0	nd	nd	nd	nd	31.7
	22	6.53	nd	nd	7.6	8.9	nd	nd	27.5	nd	56.4
	23	6.15	nd	nd	nd	3.2	nd	nd	20.8	nd	22.1
Central East (7 samples)	24	6.27	nd	nd	nd	nd	nd	nd	nd	nd	9.0
	25	6.81	nd	nd	5.0	32.2	nd	nd	32.7	nd	83.0
	26	7.14	nd	nd	2.3	nd	nd	nd	nd	nd	11.7
	27	6.83	nd	nd	nd	3.7	nd	nd	7.6	nd	24.9
	28	5.94	nd	nd	nd	1.6	nd	nd	15.5	nd	23.8
	29	6.93	nd	nd	1.1	1.6	nd	nd	1.6	nd	24.1
	30	6.54	nd	nd	nd	8.1	nd	nd	1.8	nd	17.6

[§]nd = not detected

Table 19. pH and metal contents of the 9 ditch cleaning samples from south Florida.

District	Sample ID	pH	Metal Content (mg/kg)								
			As	Cd	Cr	Cu	Mo	Ni	Pb	Se	Zn
South West (4 samples)	31	6.74	nd	nd	5.31	nd	nd	nd	nd	nd	11.4
	32	6.86	nd	nd	nd	nd	nd	nd	3.60	nd	30.3
	33	7.15	nd	nd	4.10	nd	nd	nd	nd	nd	18.1
	34	6.98	nd	nd	nd	nd	nd	nd	nd	nd	3.89
South East (5 samples)	35	6.62	nd	nd	1.48	nd	nd	nd	1.97	nd	15.3
	36	5.60	nd	nd	nd	nd	nd	nd	nd	1.30	7.38
	37	6.66	nd	nd	nd	2.45	nd	nd	2.65	1.47	12.2
	38	6.92	nd	nd	12.5	19.1	nd	nd	17.5	nd	324
	39	7.24	nd	nd	3.88	4.18	nd	nd	nd	nd	33.8

[§]nd= not detected

Table 20. pH and metal contents of the 39 ditch cleaning samples from Clay County, Northeast Florida.

Collector's ID	Lab ID	pH	Metal Content (mg/kg)								
			As	Cd	Cr	Cu	Mo	Ni	Pb	Se	Zn
CL-HM-001	40	7.20	nd[§]	nd	1.19	nd	nd	nd	nd	nd	10.2
CL-HM-002	41	4.67	nd	nd	nd	nd	nd	nd	nd	nd	3.17
CL-HM-003	42	7.00	nd	2.68	1.88	8.93	5.46	nd	2.08	8.53	6.94
CL-HM-004	43	7.15	nd	2.58	3.08	7.44	4.96	nd	2.48	3.57	5.56
CL-HM-005	44	7.45	nd	2.48	2.38	5.84	4.55	nd	2.18	4.65	7.23
CL-HM-006	45	7.32	nd	2.68	2.39	5.27	4.27	nd	2.58	nd	6.86
CL-HM-007	46	7.46	nd	2.58	2.88	4.56	4.56	nd	2.38	2.08	5.26
CL-HM-008	47	6.81	4.07	3.27	2.08	4.66	2.88	nd	1.29	nd	4.86
CL-HM-009	48	7.23	nd	2.55	2.46	3.93	3.54	nd	2.65	2.85	5.70
CL-HM-010	49	7.04	nd	2.55	3.05	3.93	3.83	nd	1.77	4.42	6.68
CL-HM-011	50	5.71	2.18	2.57	2.38	3.56	2.77	nd	3.07	2.18	9.01
CL-HM-012	51	7.01	nd	2.69	3.89	4.49	4.19	nd	3.29	4.39	5.39
CL-HM-013	52	4.93	1.58	2.57	1.39	3.56	2.77	nd	2.18	3.07	4.65
CL-HM-014	53	4.94	3.66	2.67	3.56	4.06	2.67	nd	6.14	2.48	17.5
CL-HM-015	54	5.07	2.67	2.57	3.06	3.36	2.96	nd	6.52	3.95	6.23
CL-HM-016	55	6.60	nd	2.67	2.38	3.56	3.07	nd	7.82	2.97	7.23
CL-HM-017	56	6.54	nd	2.66	2.17	3.25	3.55	nd	2.27	6.31	7.10
CL-HM-018	57	6.72	1.28	2.57	2.87	3.06	2.57	nd	3.66	6.23	5.43
CL-HM-019	58	6.46	1.79	2.68	4.77	4.37	2.88	nd	86.7	nd	38.4
CL-HM-020	59	6.85	nd	2.56	3.55	3.85	3.75	nd	4.24	2.96	18.3
CL-HM-021	60	7.10	nd	2.67	4.84	8.60	4.74	nd	1.58	1.28	24.5
CL-HM-022	61	6.66	nd	2.60	5.81	4.20	4.10	nd	2.20	nd	38.0
CL-HM-024	62	7.16	1.06	2.79	3.56	8.27	2.41	nd	6.25	8.47	8.18
CL-HM-025	63	7.22	nd	2.96	6.70	10.45	nd	nd	12.0	8.97	38.0

Continued to next page

Table 20 (*Continued*)

Collector's ID	Lab ID	pH	Metal Content (mg/kg)								
			As	Cd	Cr	Cu	Mo	Ni	Pb	Se	Zn
CL-HM-026	64	6.79	nd	2.89	3.49	4.78	nd	nd	4.09	1.40	8.27
CL-HM-027	65	5.55	2.84	2.74	3.53	7.44	nd	nd	8.42	10.97	7.34
CL-HM-028	66	6.29	nd	2.78	2.68	4.27	nd	nd	10.7	10.02	6.75
CL-HM-029	67	6.88	nd	2.78	2.09	2.78	nd	nd	3.38	8.45	5.77
CL-HM-030	68	6.88	nd	2.99	5.38	22.8	nd	nd	21.9	2.49	65.4
CL-HM-031	69	7.13	nd	2.72	2.92	3.99	nd	nd	3.11	nd	7.97
CL-HM-032	70	4.77	nd	2.78	3.68	25.2	nd	nd	13.5	4.08	13.1
CL-HM-033	71	6.93	nd	2.75	3.34	4.72	nd	nd	8.45	nd	16.1
CL-HM-034	72	6.36	4.08	2.78	2.58	3.38	nd	nd	6.96	6.86	5.57
CL-HM-035	73	6.66	nd	2.87	6.52	3.46	nd	nd	6.82	6.52	7.81
CL-HM-036	74	7.15	nd	2.65	3.24	3.24	nd	nd	5.50	4.62	9.14
CL-HM-037	75	7.16	nd	2.77	3.36	3.36	nd	nd	3.16	3.75	8.30
CL-HM-043	76	7.00	nd	2.87	2.87	3.07	nd	nd	9.11	3.46	8.91
CL-HM-044	77	7.10	nd	2.78	5.06	5.26	nd	nd	13.5	nd	16.4
CL-HM-045	78	7.38	nd	2.78	3.68	2.78	nd	nd	3.38	nd	7.36

[§]nd= not detected

Table 21. PAH concentrations (mg kg^{-1}) of ditch cleaning samples collected from Clay County (CL-1 to -9)

Lab ID PAH components	CL-1	CL-2	CL-3	CL-4	CL-5	CL-6	CL-7	CL-8	CL-9
Acenaphthene	<0.0049	<0.0049	<0.0049	<0.0049	<0.0049	0.0345	<0.0049	<0.0049	0.0871
Acenaphthylene	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	0.0790	<0.0025
Anthracene	<0.0001	<0.0001	0.0003	<0.0001	<0.0001	0.0003	0.0009	0.0065	<0.0001
Benzo(a)anthracene	0.0015	<0.0002	0.0027	<0.0002	<0.0002	<0.0002	0.0019	0.0100	0.0047
Benzo(a)pyrene	0.0152	0.0059	0.0464	0.0039	<0.0002	<0.0002	0.0163	0.0144	0.0647
Benzo(b)fluoranthene	0.0033	0.0026	0.0028	<0.0001	<0.0001	0.0026	0.0055	<0.0001	<0.0001
Benzo(ghi)perylene	0.0318	<0.0004	0.1476	0.0131	<0.0004	0.0303	0.0068	0.0475	<0.0004
Benzo(K)fluoranthene	<0.0001	<0.0001	0.0010	<0.0001	0.0008	0.0005	0.0012	0.0021	<0.0001
Chrysene	0.0092	0.0026	0.0241	0.0020	0.0161	0.0195	0.0152	0.0330	<0.0002
Dibenzo(a,h)anthracene	0.0217	<0.001	0.0109	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Fluorene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0057
Fluoranthene	0.0042	<0.0002	0.0077	<0.0002	0.0038	0.0040	0.0120	0.0947	0.2111
Indeno(1,2,3,cd)pyrene	0.0050	<0.0002	0.0089	<0.0002	<0.0002	0.0010	0.0118	0.0001	<0.0002
Naphthalene	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	0.0275	0.8987	0.0060
Phenanthrene	0.0014	0.0024	0.0010	<0.0002	<0.0002	<0.0002	0.0044	0.0003	<0.0002
Pyrene	0.0018	<0.0005	0.0097	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
B(a)P equivalency	0.0155	0.0652	0.0093	0.0331	0.0096	0.6809	0.0404	0.0171	0.0077
Surrogate Recovery %	136%	N/A	183%	N/A	80.8%	180%	159%	136%	133%

Table 22. PAH concentrations (mg kg^{-1}) of ditch cleaning samples collected from Clay County (CL-10 to -19)

Lab ID PAH components	CL-10	CL-11	CL-12	CL-13	CL-14	CL-15	CL-16	CL-17	CL-18	CL-19
Acenaphthene	<0.0049	<0.0049	0.1173	<0.0049	<0.0049	<0.0049	0.0135	0.1111	<0.0049	<0.0049
Acenaphthylene	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	0.3074	<0.0025	<0.0025	<0.0025	0.0671
Anthracene	<0.0001	0.0008	<0.0001	<0.0001	0.0458	<0.0001	0.0007	0.0256	0.3163	<0.0001
Benzo(a)anthracene	0.0030	<0.0002	0.0009	0.0091	0.0102	0.0104	0.0026	0.0016	0.0209	<0.0002
Benzo(a)pyrene	0.0022	0.0193	0.0080	0.6781	0.0136	0.0158	0.0010	0.0045	0.0180	0.0120
Benzo(b)fluoranthene	0.0008	0.0038	0.0017	0.0082	0.0095	<0.0001	0.0008	0.0036	0.0067	<0.0001
Benzo(ghi)perylene	0.0030	<0.0004	0.0044	0.3064	0.0375	0.0117	0.1346	0.0993	0.1052	0.7871
Benzo(k)fluoranthene	0.0046	0.0005	<0.0001	<0.0001	0.0142	0.0130	0.0058	0.1302	0.0160	<0.0001
Chrysene	<0.0002	0.0417	0.0126	0.3966	<0.0002	<0.0002	0.0522	0.0083	<0.0002	0.0181
Dibenzo(a,h)anthracene	0.0066	0.0121	<0.001	<0.001	0.0243	<0.001	0.0061	<0.001	<0.001	<0.001
Fluorene	<0.0005	<0.0005	0.0112	<0.0005	1.9706	0.0091	0.0030	0.0155	0.1177	1.3673
Fluoranthene	<0.0002	0.0046	0.1938	0.0224	<0.0002	0.2840	0.0631	<0.0002	<0.0002	0.2061
Indeno(1,2,3,cd)pyrene	0.0017	0.0125	0.0136	0.0060	0.0037	0.0020	0.0018	0.0231	0.0137	0.0004
Naphthalene	<0.0025	<0.0025	0.2204	<0.0025	0.5242	0.2997	0.1524	0.0049	0.1581	0.1882
Phenanthrene	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0007	0.0025	<0.0002	0.0008
Pyrene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
B(a)P equivalency	0.0086	0.0223	0.0120	0.0216	0.0075	0.0012	0.0181	0.0049	0.0020	0.0030
Surrogate Recovery %	N/A	127%	106%	N/A	184%	170%	128%	182%	162%	52.2%

Table 23. PAH concentrations (mg kg^{-1}) of ditch cleaning samples collected from Clay County (CL-20 to -29)

Lab ID PAH components	CL-20	CL-21	CL-22	CL-23	CL-24	CL-25	CL-26	CL-27	CL-28	CL-29
Acenaphthene	<0.0049	<0.0049	0.0681	0.0882	0.2311	0.0195	<0.0049	0.0562	<0.0049	<0.0049
Acenaphthylene	<0.0025	0.0074	0.0253	0.1287	0.0041	<0.0025	0.0246	0.0108	0.4253	0.0320
Anthracene	0.1418	<0.0001	0.0195	0.0125	0.0283	0.0123	0.0028	0.0120	0.0624	<0.0001
Benzo(a)anthracene	0.0439	0.0087	0.0063	0.0039	0.0117	0.0101	0.0045	0.0080	0.0014	0.0054
Benzo(a)pyrene	0.0147	0.0059	0.0005	0.0016	0.0032	0.0009	0.0025	0.0023	0.0011	0.0023
Benzo(b)fluoranthene	0.0118	<0.0001	<0.0001	0.0010	<0.0001	<0.0001	<0.0001	0.0030	<0.0001	<0.0001
Benzo(ghi)perylene	0.1013	0.0569	0.0048	0.0200	0.0206	0.0242	0.0048	0.0193	0.0199	0.0101
Benzo(K)fluoranthene	<0.0001	0.0387	<0.0001	0.0051	0.0098	0.0043	<0.0001	<0.0001	0.0076	<0.0001
Chrysene	0.0402	<0.0002	0.0048	<0.0002	<0.0002	0.0441	0.0055	0.0074	<0.0002	0.0019
Dibenzo(a,h)anthracene	<0.001	<0.001	<0.001	0.0160	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Fluorene	0.0241	0.0236	<0.0005	0.0011	0.0002	<0.0005	<0.0005	<0.0005	0.0499	0.0122
Fluoranthene	<0.0002	0.6489	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.1207	<0.0002
Indeno(1,2,3,cd)pyrene	0.0132	0.0039	0.0012	<0.0002	0.0049	<0.0002	0.0012	0.0007	<0.0002	0.0006
Naphthalene	0.0312	0.2264	<0.0025	0.2860	0.0422	0.2569	0.0396	0.1388	2.0194	0.6024
Phenanthrene	0.0074	<0.0002	0.0045	0.0005	<0.0002	0.0005	<0.0002	0.0113	0.0075	0.0007
Pyrene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
B(a)P equivalency	0.0034	0.0014	0.0029	0.0182	0.0014	0.0082	0.0041	0.0030	0.0091	0.0021
Surrogate Recovery %	89.9%	174%	152%	172%	188%	165%	175%	152%	149%	153%

Table 24. PAH concentrations (mg kg^{-1}) of ditch cleaning samples collected from Clay County (CL-30 to -39)

Lab ID PAH components	CL-30	CL-31	CL-32	CL-33	CL-34	CL-35	CL-36	CL-37	CL-38	CL-39
Acenaphthene	<0.0049	0.0838	0.0671	0.0370	<0.0049	<0.0049	0.0206	0.0737	0.0949	0.1198
Acenaphthylene	0.0255	0.0108	<0.0025	<0.0025	0.0659	0.0979	<0.0025	<0.0025	0.0106	0.0479
Anthracene	0.0145	0.0236	0.0171	0.0077	0.0005	0.0320	0.0485	0.0136	0.0180	0.0073
Benzo(a)anthracene	0.0082	0.0074	0.0142	0.0103	0.0157	0.0110	0.0088	0.0073	0.0096	0.0115
Benzo(a)pyrene	0.0172	0.0006	0.0013	0.0027	0.0014	0.0028	0.0010	0.0008	0.0033	0.0141
Benzo(b)fluoranthene	<0.0001	<0.0001	0.0004	0.0007	<0.0001	<0.0001	<0.0001	<0.0001	0.0009	0.0038
Benzo(ghi)perylene	0.0164	0.0410	0.0195	0.0077	0.0005	0.0040	0.0137	0.0040	0.0084	0.0394
Benzo(K)fluoranthene	<0.0001	0.0031	0.0007	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0017
Chrysene	0.0048	<0.0002	0.0096	0.0034	<0.0002	<0.0002	<0.0002	0.0018	0.0074	0.0601
Dibenzo(a,h)anthracene	<0.001	<0.001	0.0052	<0.001	<0.001	0.0051	<0.001	<0.001	<0.001	0.0485
Fluorene	0.0033	0.0043	0.0012	<0.0005	0.0142	0.0250	0.0295	0.0062	0.0053	0.0276
Fluoranthene	0.0436	<0.0002	0.0698	<0.0002	0.0444	<0.0002	<0.0002	0.0562	<0.0002	0.1355
Indeno(1,2,3,cd)pyrene	0.0017	<0.0002	0.0019	0.0028	<0.0002	0.0010	0.0023	<0.0002	0.0033	0.0002
Naphthalene	0.5182	0.3937	0.5558	1.0163	1.1904	1.0904	0.6902	0.6274	0.6224	0.1256
Phenanthrene	0.0009	0.0026	0.0060	0.0064	0.0004	<0.0002	<0.0002	0.0011	0.0030	0.0002
Pyrene	<0.0005	<0.0005	<0.0005	0.0170	0.0163	<0.0005	<0.0005	<0.0005	0.0926	<0.0005
B(a)P equivalency	0.0015	0.0046	0.0642	0.3976	0.2224	0.0089	0.0591	0.8981	0.0118	0.8454
Surrogate Recovery %	130%	177%	129%	N/A	118%	N/A	87.0%	49.7%	50.8%	98.0%

Table 25. PAH concentrations (mg kg^{-1}) of ditch cleaning samples collected from Central district

Lab ID PAH components	DC 6	DC 7	DC 11	DC 22	DC 25	DC 27	DC 28
Acenaphthene	<0.0049	<0.0049	<0.0049	0.0221	<0.0049	<0.0049	<0.0049
Acenaphthylene	0.0353	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Anthracene	0.0009	<0.0001	<0.0001	0.0056	0.0805	0.0156	<0.0001
Benzo(a)anthracene	<0.0002	<0.0002	0.0151	0.1473	0.0138	<0.0002	<0.0002
Benzo(a)pyrene	0.0109	0.8454	0.0740	0.3221	0.0657	<0.0002	0.0252
Benzo(b)fluoranthene	0.0013	<0.0001	0.0029	0.0796	0.0238	<0.0001	0.0595
Benzo(ghi)perylene	0.1104	<0.0004	0.0115	1.6156	0.1876	<0.0004	0.1509
Benzo(K)fluoranthene	0.0030	<0.0001	0.0007	0.0296	0.0011	0.0090	0.0051
Chrysene	0.0045	0.0617	0.0144	0.4147	0.0745	<0.0002	<0.0002
Dibenzo(a,h)anthracene	<0.001	<0.001	<0.001	0.3959	0.0088	<0.001	<0.001
Fluorene	<0.0005	<0.0005	<0.0005	0.0032	<0.0005	<0.0005	<0.0005
Fluoranthene	<0.0002	0.0885	<0.0002	1.1303	<0.0002	0.0903	<0.0002
Indeno(1,2,3,cd)pyrene	0.0073	<0.0002	<0.0002	0.3842	0.0538	0.0819	<0.0002
Naphthalene	0.0191	<0.0025	<0.0025	0.2304	0.1125	<0.0025	<0.0025
Phenanthrene	0.0011	0.0181	0.0022	0.1294	0.0278	0.0706	<0.0002
Pyrene	0.0128	0.1034	0.0082	<0.0005	<0.0005	0.2287	<0.0005
B(a)P equivalency	0.0379	0.0062	0.0588	0.0039	0.0000	0.0004	0.0183
Surrogate Recovery %	141%	N/A	N/A	122%	182%	N/A	N/A

Table 26. PAH concentrations (mg kg^{-1}) of ditch cleaning samples collected from Northwest district

Lab ID PAH components	DC 1	DC 3	DC 5	DC 12	DC 2	DC 4	DC 20
Acenaphthene	0.4198	<0.0049	<0.0049	<0.0049	<0.0049	<0.0049	0.2895
Acenaphthylene	<0.0025	<0.0025	<0.0025	0.0266	0.0094	<0.0025	0.1220
Anthracene	0.0996	0.0006	<0.0001	<0.0001	0.0007	0.0034	0.4293
Benzo(a)anthracene	0.0409	<0.0002	0.1920	<0.0002	0.0353	0.0340	0.0617
Benzo(a)pyrene	0.3526	0.0085	0.4874	<0.0002	0.1724	0.0440	0.6473
Benzo(b)fluoranthene	0.0410	<0.0001	0.1605	<0.0001	0.0039	0.0148	0.1781
Benzo(ghi)perylene	0.5036	<0.0004	1.7308	0.0163	0.0690	0.1370	3.2914
Benzo(K)fluoranthene	0.0205	0.0009	<0.0001	<0.0001	<0.0001	0.0057	0.0376
Chrysene	0.2019	0.0196	<0.0002	0.0045	0.0135	0.0560	0.7060
Dibenzo(a,h)anthracene	0.0361	<0.001	0.3189	<0.001	0.0459	0.0067	0.6679
Fluorene	<0.0005	0.0075	0.8420	0.0005	<0.0005	<0.0005	<0.0005
Fluoranthene	0.0289	<0.0002	10.5485	<0.0002	0.0069	0.0485	2.0311
Indeno(1,2,3,cd)pyrene	0.0031	0.0036	0.5649	0.0037	0.0016	0.0338	0.6763
Naphthalene	0.2074	0.0617	<0.0025	<0.0025	0.0212	0.0795	1.0735
Phenanthrene	0.0679	<0.0002	<0.0002	0.0005	0.0061	0.0157	0.2253
Pyrene	0.0232	<0.0005	<0.0005	<0.0005	0.0026	0.0588	<0.0005
B(a)P equivalency	0.0382	0.1683	0.0193	0.0758	0.0004	0.0148	0.0918
Surrogate Recovery %	93.7%	N/A	156%	74.5%	176%	N/A	168%

Table 27. PAH concentrations (mg kg^{-1}) of ditch cleaning samples collected from South district

Lab ID PAH components	DC 8	DC 9	DC 10	DC 19
Acenaphthene	<0.0049	0.0906	<0.0049	0.0496
Acenaphthylene	0.0072	<0.0025	<0.0025	0.0207
Anthracene	<0.0001	0.1345	0.0003	0.0004
Benzo(a)anthracene	0.0048	0.0131	<0.0002	<0.0002
Benzo(a)pyrene	0.0376	0.1276	0.0186	0.0727
Benzo(b)fluoranthene	0.0008	0.0217	<0.0001	0.0010
Benzo(ghi)perylene	0.0039	0.3336	0.0890	0.0142
Benzo(K)fluoranthene	0.0007	0.0245	0.0013	0.0004
Chrysene	0.0003	0.1737	<0.0002	0.0408
Dibenzo(a,h)anthracene	<0.001	0.0267	<0.001	0.0091
Fluorene	<0.0005	<0.0005	<0.0005	<0.0005
Fluoranthene	0.0018	0.7756	0.0050	0.0050
Indeno(1,2,3,cd)pyrene	0.0010	0.1007	0.0061	0.0013
Naphthalene	0.0513	0.0471	<0.0025	<0.0025
Phenanthrene	0.0002	0.0763	<0.0002	0.0007
Pyrene	<0.0005	<0.0005	<0.0005	<0.0005
B(a)P equivalency	0.0236	0.0545	1.2676	0.0617
Surrogate Recovery %	159%	N/A	N/A	N/A

Table 28. PAH concentrations (mg kg^{-1}) of ditch cleaning samples collected from Southeast district

Lab ID PAH components	DC 14	DC 15	DC 16	DC 21	DC 23	DC 24
Acenaphthene	0.2050	0.0403	<0.0049	0.1067	<0.0049	<0.0049
Acenaphthylene	0.0068	0.0137	<0.0025	0.2884	<0.0025	<0.0025
Anthracene	0.0548	0.0016	<0.0001	0.0967	0.0749	0.0738
Benzo(a)anthracene	0.0195	0.0090	<0.0002	0.0684	0.9758	0.0131
Benzo(a)pyrene	0.0896	0.0225	0.0545	0.0847	1.0066	0.0155
Benzo(b)fluoranthene	<0.0001	0.0007	<0.0001	0.0274	0.2331	0.0023
Benzo(ghi)perylene	0.0078	0.0164	0.1735	0.2305	0.8614	0.0574
Benzo(K)fluoranthene	<0.0001	0.0030	0.0008	0.0044	0.1329	0.0123
Chrysene	<0.0002	0.0011	0.0057	0.1362	1.1189	<0.0002
Dibenzo(a,h)anthracene	<0.001	<0.001	<0.001	0.0722	0.2284	0.0108
Fluorene	0.0080	0.0052	0.0122	<0.0005	<0.0005	0.0078
Fluoranthene	<0.0002	0.0042	<0.0002	<0.0002	1.0981	<0.0002
Indeno(1,2,3,cd)pyrene	0.0028	0.0008	<0.0002	0.0640	0.5450	0.0125
Naphthalene	0.1007	0.0069	<0.0025	0.1498	1.9288	0.0076
Phenanthrene	<0.0002	<0.0002	<0.0002	0.0846	0.2669	0.0023
Pyrene	<0.0005	0.0171	<0.0005	0.0174	1.2062	<0.0005
B(a)P equivalency	0.0820	1.4079	0.1731	0.7798	1.4128	0.0292
Surrogate Recovery %	157%	N/A	N/A	N/A	N/A	131%

Table 29. PAH concentrations (mg kg^{-1}) of ditch cleaning samples collected from Southwest district

Lab ID PAH components	DC 13	DC 17	DC 18	DC 26
Acenaphthene	<0.0049	1.5139	<0.0049	0.8265
Acenaphthylene	<0.0025	<0.0025	0.0191	<0.0025
Anthracene	0.0031	0.3691	0.0033	0.0160
Benzo(a)anthracene	0.0167	0.2066	0.0140	0.0308
Benzo(a)pyrene	0.0116	0.5971	0.0449	0.3484
Benzo(b)fluoranthene	0.0029	0.1418	0.0130	0.0080
Benzo(ghi)perylene	<0.0004	3.9508	0.0461	0.9905
Benzo(K)fluoranthene	0.0042	0.0380	0.0011	0.0088
Chrysene	0.0364	0.5623	0.0794	0.0544
Dibenzo(a,h)anthracene	<0.001	0.5765	0.0106	0.0633
Fluorene	<0.0005	0.1715	<0.0005	<0.0005
Fluoranthene	0.0330	2.1999	0.0392	0.0044
Indeno(1,2,3,cd)pyrene	0.0117	0.5820	0.0342	0.0085
Naphthalene	<0.0025	0.2220	0.0758	0.7875
Phenanthrene	0.0158	0.0046	0.0147	0.0197
Pyrene	0.0203	<0.0005	0.0451	0.0981
B(a)P equivalency	0.0838	0.4167	0.0083	0.0312
Surrogate Recovery %	173%	139%	N/A	141%

Table 30. Moisture contents of ditch-cleaning samples

Lab ID	Collection site	MC
CL-1	Clay	10.7%
CL-2	Clay	35.0%
CL-3	Clay	19.3%
CL-4	Clay	24.2%
CL-5	Clay	17.2%
CL-6	Clay	19.6%
CL-7	Clay	6.70%
CL-8	Clay	18.4%
CL-9	Clay	18.7%
CL-10	Clay	25.2%
CL-11	Clay	30.1%
CL-12	Clay	14.9%
CL-13	Clay	22.9%
CL-14	Clay	31.1%
CL-15	Clay	27.5%
CL-16	Clay	7.60%
CL-17	Clay	15.5%
CL-18	Clay	15.0%
CL-19	Clay	35.2%
CL-20	Clay	20.8%
CL-21	Clay	22.8%
CL-22	Clay	4.20%
CL-23	Clay	7.20%
CL-24	Clay	20.4%
CL-25	Clay	16.1%
CL-26	Clay	18.7%
CL-27	Clay	22.9%
CL-28	Clay	21.2%
CL-29	Clay	20.2%
CL-30	Clay	17.8%
CL-31	Clay	5.80%
CL-32	Clay	6.50%
CL-33	Clay	7.00%
CL-34	Clay	17.1%

Lab ID	Collection site	MC
CL-35	Clay	3.90%
CL-36	Clay	6.80%
CL-37	Clay	4.20%
CL-38	Clay	2.10%
CL-39	Clay	3.60%
DC 1	NE	23.9%
DC 2	NW	22.4%
DC 3	NE	28.6%
DC 4	NW	22.8%
DC 5	NE	9.50%
DC 6	C	11.2%
DC 7	C	30.0%
DC 8	S	3.60%
DC 9	S	9.10%
DC 10	S	21.5%
DC 11	C	11.4%
DC 12	NE	21.6%
DC 13	SW	1.80%
DC 14	SE	22.7%
DC 15	SE	6.90%
DC 16	SE	19.3%
DC 17	SW	68.7%
DC 18	SW	21.8%
DC 19	S	32.7%
DC 20	NW	31.1%
DC 21	SE	19.4%
DC 22	C	30.7%
DC 23	SE	16.0%
DC 24	SE	12.3%
DC 25	C	5.20%
DC 26	SW	3.80%
DC 27	C	26.9%
DC 28	C	12.4%