Results of a Retail Gasoline Outlet And Commercial Parking Lot Storm Water Runoff Study

This study was funded by the Western States Petroleum Association (WSPA) and the American Petroleum Institute

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EXECUTIVE SUMMARY

This report presents the results of a two-part study of constituents present in simulated storm water runoff from six retail gasoline outlets (RGOs) and four commercial parking lots. The objective of the study is to characterize storm water runoff from RGOs and to compare the results with runoff from commercial parking lots and published urban "background" values. The study was funded by the Western States Petroleum Association (WSPA) and the American Petroleum Institute (API).

The study demonstrates that for the constituents analyzed, median event mean concentrations (EMCs) in storm water runoff from normally operated and maintained RGOs are no higher than those in runoff from commercial parking lots. Additionally, median EMCs of total suspended solids, copper, lead, and zinc in runoff from RGOs and parking lots are no higher than background levels present in urban runoff as established by the National Urban Runoff Program. Furthermore, there are no significant differences in median EMCs in runoff from RGO pump islands and driveways for the constituents analyzed. These results indicate that fueling activities at normally operated and maintained RGOs do not contribute additional significant concentrations of measured constituents in storm water runoff.

In 1987, Section 402(p) was added to the Clean Water Act to establish a framework for addressing storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program. Storm water discharges from commercial facilities, such as RGOs and parking lots, are not included under the initial regulations. However, regulations are to be promulgated that are expected to increase the number and types of dischargers required to obtain NPDES permit coverage for storm water discharges. EPA, in a report to Congress (EPA, 1993), identified several business categories that are not currently regulated by NPDES permits. Automotive service facilities, including RGOs, are included on EPA's list of potential Phase II permittees.

GEOMATRIX

RESULTS OF A RETAIL GASOLINE OUTLET AND COMMERCIAL PARKING LOT STORM WATER RUNOFF STUDY

1.0 INTRODUCTION

This report presents the results of a two-part study of simulated storm water runoff from six retail gasoline outlets (RGOs) and four commercial parking lots. Part I was conducted by Hart Crowser, Inc. (Hart Crowser) and characterized simulated storm water runoff from five RGOs. Part II was conducted by Geomatrix Consultants, Inc. (Geomatrix) and characterized simulated storm water runoff from four commercial parking lots and one RGO. The study was funded by the Western States Petroleum Association (WSPA) and the American Petroleum Institute (API).

1.1 Objective

The objective of this study is to characterize storm water runoff from RGOs and to compare the results with runoff from commercial parking lots and published urban "background" values.

1.2 Background

In 1972, the Federal Water Pollution Control Act (also known as the Clean Water Act or CWA) was amended to provide that any discharge of pollutants from a point source to Waters of the United States is effectively prohibited unless it is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit.

As more significant sources of water pollution were brought under control, the impact of pollutants in storm water became more noticeable. Water quality studies conducted in the 1970s and 1980s identified urban runoff as a source of pollution. In response to these studies, the 1987 amendments to the Water Quality Act added Section 402(p). This section established a comprehensive two-phased approach for the U.S. Environmental Protection Agency (EPA) to follow in addressing storm

water discharges. Five types of storm water discharges are covered under the Phase I program. Dischargers within these five categories, listed below, were required to obtain permit coverage before October 1, 1992:

A) A discharge for which a permit has been issued prior to February 4, 1987;

B) A discharge associated with industrial activities;

C) A discharge from a municipal separate storm sewer system serving a population of 250,000 or more;

D) A discharge from a municipal separate storm sewer system serving a population of 100,000 or more, but less than 250,000; or

E) A storm water discharge determined by the EPA Administrator or the State to contribute to a violation of a water quality standard or to be a significant contributor of pollutants to the waters of the United States.

Discharges from commercial facilities, such as RGOs and parking lots, are not included under the Phase I regulations. However, Phase II regulations to be promulgated are expected to increase the numbers and types of dischargers that are required to obtain NPDES permit coverage for storm water discharges. EPA, in a draft Phase II report to Congress (EPA, 1993), identified several business categories that are not currently regulated by NPDES permits. Automotive service facilities, including RGOs, are included on EPA's list of potential Phase II permittees. It should be noted that, according to the EPA draft Phase II report, the list of potential permittees was created using limited reliable data on storm water problems associated with Phase II sources nationwide. In order to provide data regarding storm water runoff from potential Phase II facilities, WSPA and API commissioned this study.

1.3 Other Studies

This study utilized the results from a recently published RGO runoff study titled *Action Plan Demonstration Project, Demonstration of Gasoline Fueling Station Best Management Practices, Phase 1 Report* (September, 1993), prepared by Uribe & Associates and Larry Walker Associates for the County of Sacramento, Water Resources Division. Another storm water runoff study used for the WSPA/API study described herein is the *Final Report of the Nationwide Urban Runoff Program* (December 30, 1983) prepared by the Water Planning Division of EPA. These storm water studies are described in the following sections.

1.3.1 Sacramento County's Action Plan Demonstration Project

Sacramento County's Action Plan Demonstration Project characterized storm water runoff from RGOs and identified potential best management practices (BMPs) to reduce storm water runoff pollution. EPA provided funding of the study by a grant through the San Francisco Estuary Project and the Sacramento County Water Resources Division. The report presents the analytical results of samples collected from storm water runoff from three RGOs in Sacramento County.

The Sacramento County project selected high-volume (over 200,000 gallons per month), self-service RGOs with convenience markets and without automobile repair service bays for the study. The selected RGOs are located less than 2 miles apart.

Within each RGO, a single representative sampling point was selected where station runoff leaves the property and includes drainage from the fueling and auxiliary services areas. Uribe collected samples during six storm events during the 1992/93 wet season. For five of the storms, the sample collection procedure consisted of placing a 1 liter sampling bottle into a below-grade concrete sump. A portion of the storm water discharge flowed over the lip of the sump directly into a sampling bottle. Samples were collected in this manner for each 0.05 inch increment of measured rainfall. The samples were composited immediately into a 5-liter borosilicate bottle until the 5-liter bottle was filled. The one exception to this sample collection method occurred during the first storm event, when only grab samples were collected.

The initial analytical program for the collected samples included analyses for oil and grease, total suspended solids, metals (13 EPA priority pollutant metals plus aluminum and iron), polycyclic aromatic hydrocarbons (PAHs), and petroleum hydrocarbons. However, some of the metals, petroleum hydrocarbons, and PAHs were consistently not detected in samples collected from the first three storm events. On the basis of these results, the following parameters were selected for the final three sampling events:

- oil and grease
- total suspended solids
- heavy metals (cadmium, chromium, copper, lead, and zinc)

Pertinent results of Sacramento County's Action Plan Demonstration Project are discussed in Sections 3 and 4 of this report.

1.3.2 National Urban Runoff Program

The National Urban Runoff Program (NURP) was conducted from 1978 through 1983 with funding and guidance provided by EPA. NURP characterized the chemicals present in discharges from separate storm sewers that drain residential, commercial, and light industrial areas. NURP included 28 projects across the nation, conducted separately at the local level, but centrally reviewed, coordinated, and guided. The overall objective of the program was to collect information from a national perspective that could be used to characterize urban runoff, assess the impact of non-point source urban runoff on the quality of the receiving waters, and assist decision makers in developing control measures to limit its impact. The results of NURP provide insight on what can be considered background levels for urban runoff.

The resultant NURP data represent a cross section of regional climates, land use types, and ground surface conditions. The sites sampled during NURP included 81 sites that were unaffected by hydraulic devices, such as detention basins, that would modify runoff. A total of more than 2300 separate storm events were sampled from these sites during the project. Samples collected from these sites were tested for the following standard pollutants:

- total suspended solids
- biochemical oxygen demand
- chemical oxygen demand
- total phosphorus
- soluble phosphorus
- total Kjeldahl nitrogen
- nitrite and nitrate as N
- heavy metals (copper, lead, and zinc)

Pertinent results of NURP are discussed in Sections 3 and 4 of this report.

2.0 WSPA/API PART I AND PART II STORM WATER RUNOFF STUDIES

This section describes both parts of the WSPA/API runoff study. Part I, conducted by Hart Crowser, characterized simulated storm water runoff from five RGOs. Part II, conducted by Geomatrix, characterized simulated storm water runoff from four commercial parking lots and one RGO.

2.1 Literature Search

As part of this WSPA/API study, Hart Crowser conducted a literature search to assess whether analytical results from prior RGO runoff studies were available for this study. The search was conducted using the Dialog Information Database and included a search of the following databases:

NTIS (National Technical Information Service)
COMPENDEX (Engineering Information Inc.)
APILIT (American Petroleum Institute)
Pollution Abstracts/Cambridge Scientific Abstracts
Water Resources Abstracts
WATERNET (American Water Works Association)
CA SEARCH (Chemical Abstracts)

The database search did not disclose prior RGO storm water runoff studies.

2.2 Selection of RGOs and Test Sites

In selecting the RGOs to be used for the study, the following characteristics were evaluated for a number of potential RGO sites:

- monthly throughput
- site location
- anticipated level of use by commercial vehicles
- age and general appearance
- types of ancillary services provided including on-site vehicle service, car washes, or convenience stores
- on-site drainage patterns and adjacent property usage.

On the basis of this evaluation, six RGOs, all located in Southern California, were selected for the study. The six RGOs provide a representative cross section of typical RGOs in Southern California. Site characteristics for each RGO are summarized in Table 1. Each of the selected RGOs was considered "normally operated and maintained". For the purposes of this study, "normally operated and maintained" signifies that the RGOs utilize Best Management Practices (BMPs) to minimize the buildup of potential storm water contaminants on exposed areas. These BMPs include regular sweeping of exposed areas, regular site inspections, and standardized spill response procedures.

Hart Crowser and Geomatrix conducted the simulated rainfall application and sample collection at a pump island and driveway approach area within each RGO. These areas were selected to provide results that are representative of discharge from the entire RGO. A summary of pavement types and conditions of each test site location is presented in Table 2.

A simulated gasoline spill was performed at RGO 5 to provide data regarding the effectiveness of standardized spill response procedures. One quart of regular unleaded gasoline from a pump nozzle was discharged onto the pump island pavement. Absorbent material was applied to the spill after one

minute. The absorbent material was then swept up after it appeared to have absorbed the spilled liquid, and the simulated runoff test was conducted.

2.3 Selection of Parking Lots and Test Sites

Commercial parking lots for the second part of the study were evaluated using the following criteria:

- site use
- relative parking duration
- traffic and parking volume
- pavement type, condition, and visual appearance
- cleaning methods and frequency
- on-site drainage patterns.

On the basis of this evaluation, Geomatrix and WSPA selected four commercial parking lots, all located in Southern California, for the study. The selected parking lots were associated with a grocery store, bank, office complex, and restaurant.

Simulated rainfall was applied and samples were collected at two locations at each of the four parking lots for a total of eight test sites. The test locations included one high-use and one moderate-use parking area. The high-use area was generally closer to the commercial facility entrance, and was occupied more frequently than the moderate-use area. Each of the parking lots used scheduled sweeping as a good housekeeping BMP. Parking lot test locations, conditions, and BMPs are summarized in Table 3.

2.4 Testing Methodology

To minimize test variability caused by differing rainfall intensities and durations, both parts of the WSPA/API runoff study used a simulated rainfall method to induce runoff from the study sites. The water-dispensing system and sampling procedures were identical for both the RGO and commercial

parking lot sites. The water-dispensing system was designed to apply water uniformly over the test area and create sheet flow.

During the test, potable water was distributed uniformly over an approximate 400-square-foot area using a network of perforated 1-inch-diameter, schedule 80 polyvinyl chloride (PVC) pipes elevated approximately 4 feet above the pavement surface. A schematic of the simulated rainfall system is shown on Figure 1.

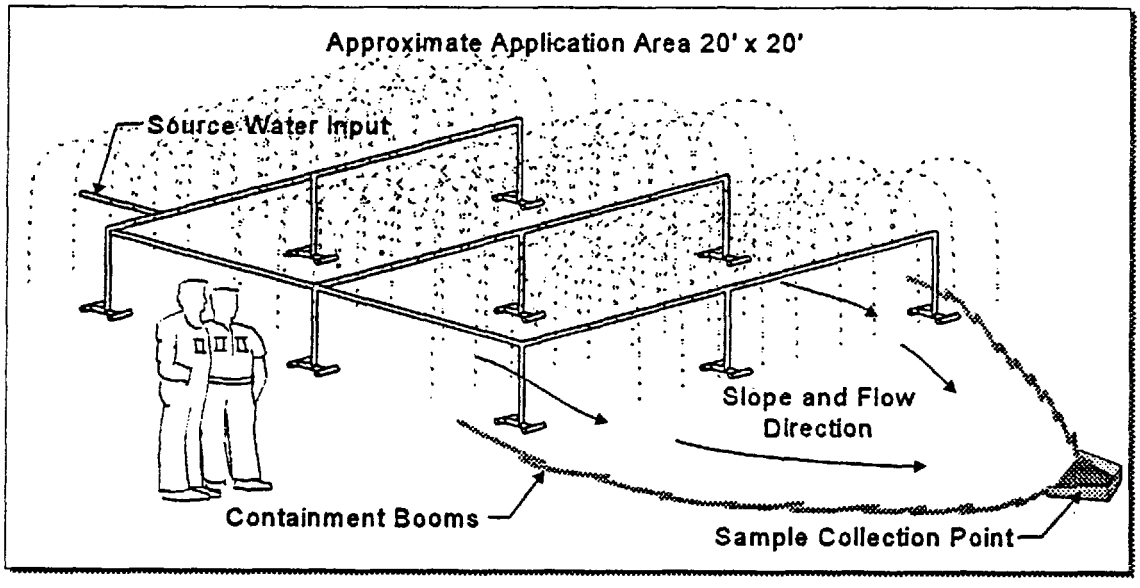

Figure 1. Schematic of Simulated Rainfall System

The water was applied at a rate of approximately 2.0 gallons per minute (gpm) for the duration of the 45-minute test. This rate represents a rainfall rate of approximately 0.008 inch per minute or 0.12 inch every 15 minutes over the test application area.

The runoff from the simulated rainfall application was channeled by gravity and sand-filled polyethylene tubing containment berms to a collection point. The runoff was diverted into a stainless steel collection trough and was pumped into a poly-lined 55-gallon steel drum.

2.5 Sampling Procedures

Sampling procedures for both Part I and II studies follow the sampling protocol established by SW-846, "Test Methods for Evaluating Solid Waste" (including surface and groundwater).

The following samples were collected at each test site.

- A discrete grab sample from the collection trough every 15 minutes during the 45 minute test
- One composite sample from the runoff pumped into the 55-gallon drum.

In addition to these samples, a background sample of the on-site water supply was collected at the point of discharge from the simulated rainfall application apparatus, and a duplicate oil and grease sample was collected at each test site. Samples were obtained using cleaned sampling equipment and were placed into laboratory-supplied and certified "clean" sampling containers. Collected samples were labeled, placed on ice in a cooler, and maintained under proper chain-of-custody procedures. A trip blank sample was included in each of the sample coolers used for this study.

2.6 Analytical Testing

GTEL Environmental Laboratories, a state-certified analytical laboratory located in Torrance, California analyzed samples from RGOs 1 through 5. Del Mar Analytical, a state-certified laboratory located in Irvine, California analyzed samples from RGO 6 and all four parking lots.

Laboratory analyses were conducted in accordance with appropriate EPA methods. The constituents, analytical test methods, and detection limits used for the WSPA/API study are listed in Table 4.

2.7 Quality Assurance and Quality Control

Both parts of the WSPA/API study described herein developed and implemented field and laboratory quality assurance/quality control (QA/QC) procedures. Field QA/QC includes following strict sampling protocols as specified in the project work plans and standard operating procedures. These

procedures include an evaluation of cross-contamination through the analysis of trip blanks. Laboratory QA/QC addressed the following:

- Accuracy (analysis of matrix spike recoveries on each batch of samples and regular analysis of certified samples)
- Precision (analysis of matrix spike duplicates)
- Contamination (analysis of method and filter blanks)
- Holding Time (specified holding times associated with each chemical method)
- Certified Methods of Analysis (EPA or State certified methods of analysis) .

3.0 RESULTS AND DISCUSSION

The following sections present the results of the WSPA/API simulated runoff study and provide summaries of analytical data from Sacramento County's Action Plan Demonstration Project and NURP. Also presented are data plots that provide comparisons between the pump islands and driveway RGO results and between RGOs, parking lots, and NURP.

3.1 Analytical Results

The analytical results of simulated runoff samples collected from RGOs as part of this study are summarized in Tables 5a and 5b. These tables present the results of both the Part I study conducted by Hart Crowser (RGOs 1 through 5) and the Part II study conducted by Geomatrix (RGO 6). Tables 6a and 6b summarize the results of laboratory analyses of simulated runoff samples from commercial parking lots. Tables 7 and 8, respectively, summarize the results from Sacramento County's Action Plan Demonstration Project and median concentrations reported in NURP.

3.2 Data Comparisons

This report compares analytical data from the WSPA/API RGOs and parking lots, the Action Plan Demonstration Project, and NURP using a series of box plots, Figures 3 through 24. Box plots are a simple and useful method of data comparison because they effectively describe the characteristics of single groups of data and reveal differences between groups. The components of a typical box plot are presented on Figure 2. Shown on this figure are the 25th and 75th percentiles of the data, which form the top and bottom of the box. Therefore, by definition, 25 percent of the data have a value equal to or less than the bottom line of the box, and 75 percent have a value equal to or less than the top of the box. The middle horizontal line within the box is the median, or 50th percentile (one-half of the data values are equal to or less than the median, and one-half are equal to or greater). Lines (called whiskers) extend vertically from the top and bottom of each box to the maximum and minimum data values.

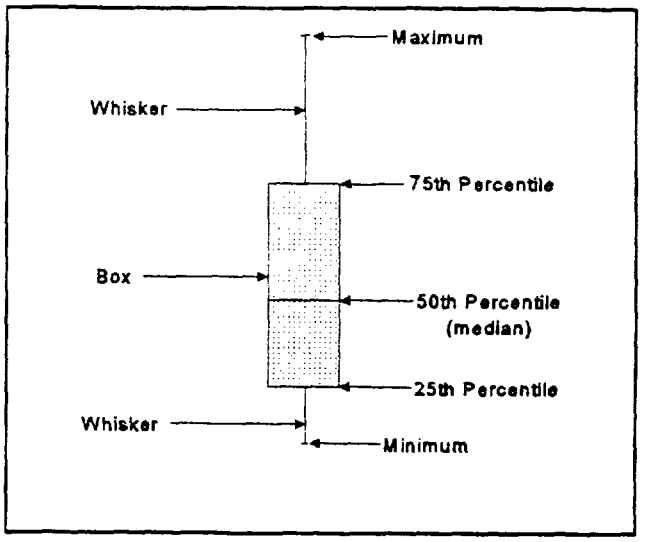

Figure 2. Components of a Typical Box Plot

In many cases, the boxes shown on Figures 3 through 24 are collapsed into a single horizontal line without a whisker extending to the minimum value. The principal reason for the shape of these plots is the presence of a large number of non-detect values in the data set. When this occurs, a single horizontal line is drawn at the detection limit, and the whisker and box segments below the reporting limit are masked.

Although Hart Crowser and Geomatrix collected and analyzed both discrete and composite samples for this study, only the composite results are used for comparison purposes in this report. Composite results are normally considered more meaningful than individual discrete results when evaluating pollutant loading in storm water discharges. It should be noted that the composite sampling

methodology used for the WSPA/API study is equivalent to the event mean concentration (EMC) reported in NURP (EPA, 1983), which is defined as the total constituent mass discharged divided by the total runoff volume. In addition, the flow weighted sampling method used for the Action Plan Demonstration Project (Uribe, 1993) provides an estimate of EMC. To provide consistency in comparisons between these studies, the EMC will be used when describing composite discharge concentrations for the remainder of this report.

The following sections discuss comparisons between the pump island and driveway results from the WSPA/API RGOs, and between the RGOs, parking lots, and NURP.

3.2.1 Comparison of Results from RGO Pump Islands and Driveways

Figures 3 through 9 present box plots that compare EMC results between the pump islands and driveways from the WSPA/API RGOs for total suspended solids, oil and grease, total petroleum hydrocarbons as gasoline (TPHg) and benzene, toluene, ethyl benzene, and total xylenes (BTEX). On the basis of these box plots, there is no significant difference in median EMCs in runoff from pump islands and driveways for these constituents. In each case, the median EMCs from pump islands and driveways are either at or very near the detection limit. Toluene, ethyl benzene, and total xylenes were detected more frequently in samples from pump islands, primarily the result of the simulated spill on the RGO 5 pump island. However, the EMCs of these chemicals were significantly below the Maximum Contaminant Levels (MCLs) for drinking water established by EPA and California Department of Health Services (Marshack, 1993).

3.2.2 Comparison of Results from RGOs, Parking Lots, and NURP

Figures 10 through 24 present box plots that compare the EMC results for RGOs and parking lots. The median EMC results from NURP are also presented on the data plots for total suspended solids, copper, lead, and zinc (Figures 10, 20, 22, and 24, respectively). On the basis of these box plots, there is no significant difference in median EMCs between RGOs and parking lots for these constituents. In addition, the box plots for total suspended solids, copper, and zinc indicate that for these constituents, there is no significant difference in median EMCs between RGOs, parking lots,

and background runoff levels established by NURP. The box plots for lead, Figure 22 indicate that the median and range of EMCs from RGOs and parking lots are significantly less than the background values reported in NURP.

4.0 CONCLUSIONS

The results of this study demonstrate that for the constituents analyzed in this report, median EMCs in storm water runoff from normally operated and maintained RGOs are no higher than those in runoff from commercial parking lots. Additionally, median EMCs of total suspended solids, copper, lead, and zinc in runoff from RGOs and parking lots are no higher than background levels present in urban runoff as established by NURP. Furthermore, there are no significant differences in median EMCs in runoff from RGO pump islands and driveways for the constituents analyzed. In all cases, the fueling related constituents (TPHg and BTEX) from pump islands were either not detected or below applicable Maximum Contaminant Levels (MCLs). These results indicate that fueling activities at normally operated and maintained RGOs do not contribute additional significant concentrations of measured constituents in storm water runoff.

5.0 REFERENCES

U.S. Environmental Protection Agency, 1993. Storm Water Discharges Potentially Addressed by Phase II of the National Pollutant Discharge Elimination System Storm Water Program, Report to Congress, dated October, 1993.

Uribe & Associates and Larry Walker Associates, 1993. Action Plan Demonstration Project Demonstration of Gasoline Fueling Station Best Management Practices, Phase 1 Report, dated September 1993.

U.S. Environmental Protection Agency, Water Planning Division, 1983. Final Report of the Nationwide Urban Runoff Program, dated December 30, 1983.

Marshack, 1993. A Compilation of Water Quality Goals, Staff Report of the California Regional Water Quality Control Board Central Valley Region, dated May, 1993.

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TABLES

TABLE 1
SUMMARY OF RETAIL GASOLINE OUTLET CHARACTERISTICS AND BEST MANAGEMENT PRACTICES
WSPA/API STORM WATER RUNOFF STUDY

Characteristic	RGO 1	RGO 2	RGO 3	RGO 4	RGO 5	RGO 6
Age of Facility	New	New	Older	Older	Older	Older
Location/Use	Urban, Little to No Commercial	Urban, Little to No Commercial	Inner City, Light Commercial	Urban, Light Commercial	Inner City, High Commercial	Urban, Little to No Commercial
Adjacent Property	Shopping Center	Fast Food	Residential /Retail	Shopping Center	Industrial /Retail	Residential /Retail
Throughput (gallons/month)	>250,000	>250,000	150,000 to 250,000	150,000 to 250,000	<150,000	>250,000
Carwash	Yes	Yes	No	No	No	No
Convenience Store	No	Yes	No	No	No	Yes
Mechanic's Bays	No	No	Yes	Yes	Yes	Yes
Structural BMPS						
Berms	Yes	Yes	No	No	No	No
Fuel Island Covered	Yes	Yes	Yes	Yes	Yes	Yes
Good Housekeeping BMPs						
Concrete Area Swept Daily	Yes	Yes	Yes	Yes	Yes	Yes
Inspect & Clean Spots Weekly	Yes	Yes	Yes	Yes	Yes	Yes
Monthly Washdown of Area	No	No	Yes	No	Yes	No

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TABLE 2
SUMMARY OF RETAIL GASOLINE OUTLET TEST LOCATIONS AND SURFACE CONDITIONS
WSPA/API STORM WATER RUNOFF STUDY

Test Site	Location	Pavement Type	Pavement Condition	Surface Condition
RGO 1	Pump Island	Portland Cement Concrete	Good	Minor Staining
RGO 1	Driveway Approach	Portland Cement Concrete	Good	No Staining
RGO 2	Pump Island	Portland Cement Concrete	Good	Minor Staining
RGO 2	Driveway Approach	Portland Cement Concrete	Good	Moderate Staining
RGO 3	Pump Island	Portland Cement Concrete	Degraded	Heavy Staining
RGO 3	Driveway Approach	Asphaltic Concrete	Degraded	Heavy Staining
RGO 4	Pump Island	Portland Cement Concrete	Degraded	Moderate Staining
RGO 4	Driveway Approach	Asphaltic Concrete	Good	Moderate Staining
RGO 5	Pump Island	Portland Cement Concrete	Degraded	Moderate Staining
RGO 5	Driveway Approach	Asphaltic Concrete	Degraded	Moderate Staining
RGO 6	Pump Island	Portland Cement Concrete	Good	Moderate Staining
RGO 6	Driveway Approach	Asphaltic Concrete	Good	Moderate Staining

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TABLE 3
SUMMARY OF PARKING LOT TEST LOCATIONS, CONDITIONS, AND BEST MANAGEMENT PRACTICES
WSPA/API STORM WATER RUNOFF STUDY

Test Site	Site Use	Location and Traffic/Parking Condition	Traffic/Parking Frequency	Pavement Type and Condition	Best Management Practices
TS-1	Grocery Store Parking Lot	Near Store Entrance	High Volume of Traffic/Parking Spaces Normally Occupied During Business Hours	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-2	Grocery Store Parking Lot	Located in Perimeter Parking Area	Moderate Traffic Volume/Area Used For Overflow Parking, Spaces Only Used During Peak Periods	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-3	Bank Parking Lot	Near Bank Entrance/Parking	High Volume of Traffic/Parking Spaces Normally Occupied	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-4	Bank Parking Lot	Located in Perimeter Parking Area	Moderate Traffic Volume/Spaces Only Used During Peak Periods	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-5	Office Complex Parking Lot	Near Office Entrance	High Volume of Traffic/Parking Spaces Normally Occupied	Asphaltic Concrete, Good Condition	Daily Sweeping
TS-6	Office Complex Parking Lot	Located in Perimeter Parking Area	Moderate to High Traffic Volume/Spaces Normally Filled During Business Hours	Asphaltic Concrete, Slightly Degraded Condition	Daily Sweeping
TS-7	Restaurant Parking Lot	Near Restaurant Entrance	High Traffic Volume/Parking Spaces Normally Occupied During Business Hours	Asphaltic Concrete, Moderately Degraded Condition	Sweeping Every Other Day, Occasional Washdown
TS-8	Restaurant Parking Lot	Located in Perimeter Parking Area	Moderate to High Traffic Volume	Asphaltic Concrete, Moderately Degraded Condition	Sweeping Every Other Day, Occasional Washdown

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TABLE 4
ANALYTICAL CONSTITUENTS, TEST METHODS, AND DETECTION LIMITS
WSPA/API STORM WATER RUNOFF STUDY

Constituent	Test Method	Detection Limit[1] (ppm unless otherwise noted) RGOs 1 -5	RGO 6 and Parking Lots
Volatile Organic Compounds	EPA Method 8020		
Benzene		0.0003	0.0003
Toluene		0.0003	0.0003
Ethyl Benzene		0.0003	0.0003
Total Xylenes		0.0006	0.0006
Total Petroleum Hydrocarbons	EPA Method 8015 (gasoline)	0.1	0.05
Total Suspended Solids	EPA Method 160.2	10.0	5.0
Total Recoverable Oil and Grease	EPA Method 413.2	1.0	1.0
Aluminum	EPA Method 6010	NA	0.5
Iron	EPA Method 6010	NA	0.05
Specific Conductance	EPA Method 120.1	NA	1 umhos/cm
pH	EPA Method 150.1	NA	–
Title 26 Metals			
Antimony	EPA Method 204.2	0.04	0.005
Arsenic	EPA Method 7060	0.1	0.01
Barium	EPA Method 6010	0.02	0.05
Beryllium	EPA Method 210.2	0.01	0.001
Cadmium	EPA Method 6010	0.03	0.005
Chromium (VI)	EPA Method 7196	0.04	0.005
Cobalt	EPA Method 6010	0.02	0.05
Copper	EPA Method 6010	0.2	0.01
Lead	EPA Method 7421	0.1	0.001
Mercury	EPA Method 7470	1.0	0.002
Molybdenum	EPA Method 6010	0.02	0.1
Nickel	EPA Method 6010	0.1	0.1
Selenium	EPA Method 7740	0.04	0.01
Silver	EPA Method 6010	0.05	0.05
Thallium	EPA Method 279.2	0.4	0.001
Vanadium	EPA Method 6010	0.2	0.05
Zinc	EPA Method 6010	0.1	0.001

[1] In some cases higher detection limits were required due to matrix effects caused by foaming.

NA - Not Analyzed

GEOMATRIX

TABLE 5a

Summary of Analytical Results for Non-metal Constituents of Simulated Runoff from Retail Gasoline Outlets
WSPA/API Storm Water Runoff Study

RGO Designation	Location	Sample Type	Sampling Date	pH	Conductance (umhos/cm)	Total Suspended Solids (mg/l)	Oil and Grease (mg/l)	TPH (ug/l)	Benzene (ug/l)	Toluene (ug/l)	Ethyl Benzene (ug/l)	Total Xylenes (ug/l)
RGO 1	Source	Background	09/04/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 1	Pump Island	15 minute	09/04/92	NA	NA	ND(10)	1	ND(100)	ND(0.3)	0.5	ND(0.3)	0.7
RGO 1	Pump Island	30 Minute	09/04/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	0.6	ND(0.3)	0.8
RGO 1	Pump Island	45 Minute	09/04/92	NA	NA	ND(10)	1	ND(100)	ND(0.3)	0.8	ND(0.3)	1.4
RGO 1	Pump Island	Composite	09/04/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	0.8	ND(0.3)	1.3
RGO 1	Driveway	15 minute	09/04/92	NA	NA	ND(10)	2	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 1	Driveway	30 Minute	09/04/92	NA	NA	ND(10)	1	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 1	Driveway	45 Minute	09/04/92	NA	NA	ND(10)	2	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 1	Driveway	Composite	09/04/92	NA	NA	ND(10)	1	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Source	Background	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Pump Island	15 minute	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Pump Island	30 Minute	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Pump Island	45 Minute	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Pump Island	Composite	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Driveway	15 minute	09/10/92	NA	NA	ND(10)	1	ND(100)	1.5	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Driveway	30 Minute	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Driveway	45 Minute	09/10/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 2	Driveway	Composite	09/10/92	NA	NA	ND(10)	1	ND(100)	0.4	ND(0.3)	ND(0.3)	ND(0.6)
RGO 3	Source	Background	09/03/92	NA	NA	11	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 3	Pump Island	15 minute	09/03/92	NA	NA	13	8	ND(1000)	ND(3)	7.9	ND(3)	20
RGO 3	Pump Island	30 Minute	09/03/92	NA	NA	ND(10)	3	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 3	Pump Island	45 Minute	09/03/92	NA	NA	ND(10)	2	ND(100)	ND(0.3)	0.4	ND(0.3)	1.1
RGO 3	Pump Island	Composite	09/03/92	NA	NA	ND(10)	3	ND(100)	ND(0.3)	0.3	ND(0.3)	1.1
RGO 3	Driveway	15 minute	09/03/92	NA	NA	ND(10)	1	ND(1000)	ND(3)	ND(3)	ND(3)	ND(6)
RGO 3	Driveway	30 Minute	09/03/92	NA	NA	ND(10)	ND(1)	ND(1000)	ND(3)	ND(3)	ND(3)	ND(6)
RGO 3	Driveway	45 Minute	09/03/92	NA	NA	ND(10)	1	ND(100)	0.5	4.5	1.1	12
RGO 3	Driveway	Composite	09/03/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	0.8	ND(0.3)	3.4
RGO 4	Source	Background	09/09/92	NA	NA	14	15	ND(100)	ND(0.3)	0.3	ND(0.3)	7.1
RGO 4	Pump Island	15 minute	09/09/92	NA	NA	ND(10)	4	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 4	Pump Island	30 Minute	09/09/92	NA	NA	ND(10)	2	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 4	Pump Island	45 Minute	09/09/92	NA	NA	ND(10)	8	ND(100)	ND(0.3)	0.4	ND(0.3)	1.5
RGO 4	Pump Island	Composite	09/09/92	NA	NA	13	1	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	1.4
RGO 4	Driveway	15 minute	09/09/92	NA	NA	11	2	ND(1000)	ND(3)	ND(3)	ND(3)	ND(6)
RGO 4	Driveway	30 Minute	09/09/92	NA	NA	10	1	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 4	Driveway	45 Minute	09/09/92	NA	NA	12	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 4	Driveway	Composite	09/09/92	NA	NA	ND(10)	ND(1)	130	ND(0.3)	ND(0.3)	ND(0.3)	ND(.6)
RGO 5	Source	Background	09/17/92	NA	NA	ND(10)	ND(1)	ND(100)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
RGO 5	Pump Island	15 minute	09/17/92	NA	NA	ND(10)	9	ND(1000)	ND(3)	9.5	ND(3)	19
RGO 5	Pump Island	30 Minute	09/17/92	NA	NA	ND(10)	7	ND(1000)	ND(3)	14	5	37
RGO 5	Pump Island	45 Minute	09/17/92	NA	NA	ND(10)	9	180	1	13	6.3	41
RGO 5	Pump Island	Composite	09/17/92	NA	NA	ND(10)	34	ND(1000)	ND(3)	9.5	3.4	22
RGO 5	Driveway	15 minute	09/17/92	NA	NA	ND(10)	9	ND(2500)	ND(7.5)	ND(7.5)	ND(7.5)	ND(15)
RGO 5	Driveway	30 Minute	09/17/92	NA	NA	ND(10)	11	ND(1000)	ND(3)	ND(3)	ND(3)	ND(6)
RGO 5	Driveway	45 Minute	09/17/92	NA	NA	13	6	ND(2500)	ND(7.5)	ND(7.5)	ND(7.5)	ND(15)
RGO 5	Driveway	Composite	09/17/92	NA	NA	ND(10)	29	ND(2500)	ND(7.5)	ND(7.5)	ND(7.5)	ND(15)
RGO 6	Driveway	Source	05/04/94	7.6	960	ND(5)	ND(1)	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Driveway	15 minute	05/04/94	7.6	1000	28	2.1	NA	NA	NA	NA	NA
RGO 6	Driveway	30 Minute	05/04/94	7.8	990	14	1.7	NA	NA	NA	NA	NA
RGO 6	Driveway	45 Minute	05/04/94	7.9	1000	13	ND(1)	NA	NA	NA	NA	NA
RGO 6	Driveway	Composite	05/04/94	7.9	1000	19	2.6	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Driveway	Duplicate	05/04/94	NA	NA	NA	6	NA	NA	NA	NA	NA
RGO 6	Driveway	Trip Blank	05/04/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Pump Island	15 minute	05/04/94	8.0	1000	21	3	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Pump Island	30 Minute	05/04/94	8.1	1000	ND(5)	3	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Pump Island	45 Minute	05/04/94	8.1	960	ND(5)	1.7	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Pump Island	Composite	05/04/94	8.1	1000	16	9.6	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)
RGO 6	Pump Island	Duplicate	05/04/94	NA	NA	NA	4.8	NA	NA	NA	NA	NA
RGO 6	Pump Island	Trip Blank	05/04/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.5)

NA Not analyzed.
ND(10) Not detected at specified detection limit.
Note: Increased analytical method detection limit was caused by matrix effect (foaming).

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TABLE 5b
Summary of Analytical Results for Metal Constituents of Simulated Runoff from Retail Gasoline Outlets
WSPA/API Storm Water Runoff Study

RGO Designation	Location	Sample Type	Sampling Date	Aluminum (mg/l)	Antimony (mg/l)	Arsenic (mg/l)	Barium (mg/l)	Beryllium (mg/l)	Cadmium (mg/l)	Chromium (VI) (mg/l)	Chromium (mg/l)	Cobalt (mg/l)	Copper (mg/l)	Iron (mg/l)	Lead (mg/l)	Mercury (mg/l)	Molybdenum (mg/l)	Nickel (mg/l)	Selenium (mg/l)	Silver (mg/l)	Thallium (mg/l)	Vanadium (mg/l)	Zinc (mg/l)
RGO1	Pump Island	15 minute	09/04/92	NA	ND(04)	ND(1)	0.13	ND(01)	ND(03)	NA	ND(04)	ND(02)	ND(2)	NA	ND(.1)	ND(001)	ND(02)	ND(1)	ND(04)	ND(05)	ND(4)	ND(2)	ND(1)
RGO 2	Pump Island	15 minute	09/10/92	NA	ND(04)	ND(1)	ND(02)	ND(01)	ND(03)	NA	ND(04)	ND(02)	ND(2)	NA	ND(.1)	ND(001)	ND(02)	ND(1)	ND(04)	ND(05)	ND(4)	ND(2)	ND(1)
RGO 3	Pump Island	15 minute	09/03/92	NA	ND(04)	ND(1)	0 06	ND(01)	ND(03)	NA	ND(04)	ND(02)	ND(2)	NA	ND(1)	ND(001)	ND(02)	ND(1)	ND(04)	ND(05)	ND(4)	ND(2)	0 2
RGO 4	Pump Island	15 minute	09/09/92	NA	ND(04)	ND(1)	0 06	ND(01)	ND(03)	NA	ND(04)	ND(02)	ND(2)	NA	ND(1)	ND(001)	ND(02)	ND(1)	ND(04)	ND(05)	ND(4)	ND(2)	0 2
RGO 5	Pump Island	15 minute	09/17/92	NA	ND(04)	ND(1)	0 08	ND(01)	ND(03)	NA	ND(04)	ND(02)	0 2	NA	ND(1)	ND(001)	ND(02)	ND(1)	ND(04)	ND(05)	ND(4)	ND(2)	0 6
RGO 6	Driveway	Source	05/04/94	ND(5)	ND(005)	ND(01)	0 11	ND(001)	ND(005)	ND(025)	ND(005)	ND(05)	0 009	ND(05)	0 004	ND(002)	ND(1)	ND(05)	ND(01)	ND(05)	ND(001)	ND(05)	0 027
RGO 6	Driveway	15 minute	05/04/94	ND(5)	NA	NA	NA	NA	ND(005)	NA	ND(005)	NA	0 017	0 41	0 008	NA	NA	ND(05)	NA	NA	NA	NA	0 2
RGO 6	Driveway	30 minute	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Driveway	45 minute	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Driveway	Composite	05/04/94	ND(.5)	NA	NA	NA	NA	ND(005)	NA	ND(005)	NA	0 028	0 5	0 009	NA	NA	ND(05)	NA	NA	NA	NA	0 18
RGO 6	Driveway	Duplicate	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Driveway	Test Blank	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Pump Island	15 minute	05/04/94	ND(.5)	ND(005)	ND(01)	0 098	ND(001)	ND(005)	ND(025)	ND(005)	ND(05)	0.014	0 21	0 004	ND(002)	ND(1)	ND(05)	ND(01)	ND(05)	ND(001)	ND(05)	0 16
RGO 6	Pump Island	30 minute	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Pump Island	45 minute	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Pump Island	Composite	05/04/94	ND(.5)	ND(005)	ND(01)	0 1	ND(001)	ND(005)	ND(025)	ND(005)	ND(05)	0 012	0 27	0 006	ND(002)	ND(1)	ND(05)	ND(01)	ND(05)	ND(001)	ND(05)	0 18
RGO 6	Pump Island	Duplicate	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RGO 6	Pump Island	Test Blank	05/04/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA Not analyzed.
ND(10) Not detected at specified detection limit
Note Increased analytical method detection limit was caused by matrix effect (foaming)

GEOMATRIX

TABLE 6a
Summary of Analytical Results for Non-metal Constituents of Simulated Runoff from Parking Lots
WSPA/API Storm Water Runoff Study

Test Site	Sample Type	Sampling Date	pH	Total Suspended Solids (mg/l)	Conductance (umhos/cm)	Oil and Grease (mg/l)	TPH (8015-G) (ug/l)	Benzene (ug/l)	Toluene (ug/l)	Ethyl benzene (ug/l)	Total Xylenes (ug/l)
TS-1	Source	01/12/94	7.8	ND (5)	1100	ND(1)	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-1	15	01/12/94	7.6	250	1200	820	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-1	30	01/12/94	7.8	10	1100	23	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-1	45	01/12/94	7.8	10	1100	24	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-1	Composite	01/12/94	7.7	6	1200	11	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-1	Duplicate (20)	01/12/94	NA	NA	NA	230	NA	NA	NA	NA	NA
TS-1	Trip Blank (20)	01/12/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-2	15	01/12/94	7.7	170	1200	13	NA	NA	NA	NA	NA
TS-2	30	01/12/94	7.4	46	1200	7.4	NA	NA	NA	NA	NA
TS-2	45	01/12/94	7.8	25	1100	3.5	NA	NA	NA	NA	NA
TS-2	Composite	01/12/94	7.7	77	1200	7	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-2	Duplicate (20)	01/12/94	NA	NA	NA	24	NA	NA	NA	NA	NA
TS-2	Trip Blank (20)	01/12/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-3	15	01/12/94	7.7	110	1100	24	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	0.74
TS-3	30	01/12/94	7.9	13	1100	6.2	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-3	45	01/12/94	7.8	ND (5)	1100	5.3	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-3	Composite	01/12/94	7.9	14	1100	4.1	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-3	Duplicate (20)	01/12/94	NA	NA	NA	25	NA	NA	NA	NA	NA
TS-3	Trip Blank (20)	01/12/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-4	Source	01/12/94	7.8	ND (5)	1100	ND(1)	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-4	15	01/12/94	7.7	290	1200	3.7	NA	NA	NA	NA	NA
TS-4	30	01/12/94	7.8	53	1100	2.5	NA	NA	NA	NA	NA
TS-4	45	01/12/94	7.8	55	1100	2.9	NA	NA	NA	NA	NA
TS-4	Composite	01/12/94	7.7	90	1200	2.2	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-4	Duplicate (20)	01/12/94	NA	NA	NA	7.1	NA	NA	NA	NA	NA
TS-4	Trip Blank (20)	01/12/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-5	Source	01/13/94	7.9	ND (5)	1100	ND(1)	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-5	15	01/13/94	7.8	140	1100	3.8	ND(50)	ND(0.3)	0.45	ND(0.3)	0.63
TS-5	30	01/13/94	7.8	160	1100	11	ND(50)	ND(0.3)	0.36	ND(0.3)	ND(0.6)
TS-5	45	01/13/94	7.9	52	1100	5.1	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-5	Composite	01/13/94	7.8	62	1100	4.1	ND(50)	ND(0.3)	0.4	ND(0.3)	ND(0.6)
TS-5	Duplicate (20)	01/13/94	NA	NA	NA	3.5	NA	NA	NA	NA	NA
TS-5	Trip Blank (20)	01/13/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-6	15	01/13/94	7.7	63	1200	3.2	NA	NA	NA	NA	NA
TS-6	30	01/13/94	7.7	17	1100	1.8	NA	NA	NA	NA	NA
TS-6	45	01/13/94	7.8	13	1100	1.6	NA	NA	NA	NA	NA
TS-6	Composite	01/13/94	7.8	39	1100	1.9	ND(50)	ND(0.3)	0.33	ND(0.3)	ND(0.6)
TS-6	Duplicate (20)	01/13/94	NA	NA	NA	3.5	NA	NA	NA	NA	NA
TS-6	Trip Blank (20)	01/12/94	NA	NA	NA	NA	ND(50)	ND(0.3)	ND(0.3)	ND(0.5)	ND(0.5)
TS-7	Source	01/17/94	7.7	ND (5)	780	ND(1)	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-7	15	01/17/94	7.9	27	830	4.3	NA	NA	NA	NA	NA
TS-7	30	01/17/94	7.9	23	810	NA	NA	NA	NA	NA	NA
TS-7	45	01/17/94	7.9	25	800	4	NA	NA	NA	NA	NA
TS-7	Composite	01/17/94	7.9	86	830	6.3	ND(50)	ND(0.3)	0.46	ND(0.3)	ND(0.6)
TS-7	Duplicate (20)	01/17/94	NA	NA	NA	4.5	NA	NA	NA	NA	NA
TS-8	15	01/17/94	7.9	120	740	7.9	ND(50)	ND(0.3)	0.31	ND(0.3)	ND(0.6)
TS-8	30	01/17/94	7.9	79	700	9.4	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-8	45	01/17/94	8.0	62	690	12	ND(50)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.6)
TS-8	Composite	01/17/94	8.0	120	720	5.1	ND(50)	ND(0.3)	0.31	ND(0.3)	ND(0.6)
TS-8	Duplicate (20)	01/17/94	NA	NA	NA	6.8	NA	NA	NA	NA	NA

ND(.001) Not detected at specified detection limit.
NA Not analyzed.

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TABLE 6b
Summary of Analytical Results for Metal Constituents of Simulated Runoff from Parking Lots
WSPA/API Storm Water Runoff Study

Test Site	Sample Type	Sampling Date	Aluminum (mg/l)	Antimony (mg/l)	Arsenic (mg/l)	Barium (mg/l)	Beryllium (mg/l)	Cadmium (mg/l)	Chromium (VI) (mg/l)	Chromium (mg/l)	Cobalt (mg/l)	Copper (mg/l)	Iron (mg/l)	Lead (mg/l)	Mercury (mg/l)	Molybdenum (mg/l)	Nickel (mg/l)	Selenium (mg/l)	Silver (mg/l)	Thallium (mg/l)	Vanadium (mg/l)	Zinc (mg/l)
TS-1	Source	01/12/94	ND(0 5)	ND(0 005)	ND(0 01)	0 14	ND(0 001)	ND(0 005)	ND(0 025)	ND(0 005)	ND(0 05)	0 011	ND(0 05)	ND(0 001)	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 01)	ND(0 05)	ND(0 001)	ND(0 05)	ND(0 001)
TS-1	15	01/12/94	2	ND(0 005)	ND(0 01)	0 13	ND(0 001)	0 062	ND(0 025)	0 011	ND(0 05)	0 032	2 3	0 026	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 02)	ND(0 05)	ND(0 001)	ND(0 05)	0 66
TS-1	30	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-1	45	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-1	Composite	01/12/94	0 53	ND(0 005)	ND(0 01)	0 13	ND(0 001)	ND(0 005)	ND(0 025)	0 006	ND(0 05)	0 021	0 38	0 004	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 01)	ND(0 05)	ND(0 001)	ND(0 05)	0 35
TS-1	Duplicate (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-1	Trip Blank (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-2	15	01/12/94	2 6	NA	NA	NA	NA	ND(0 005)	NA	0 007	NA	0 028	3 1	0 02	NA	NA	ND(0 1)	NA	NA	NA	NA	0 25
TS-2	30	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-2	45	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-2	Composite	01/12/94	1 7	NA	NA	NA	NA	ND(0 005)	NA	0 008	NA	0 026	1 9	0 016	NA	NA	ND(0 1)	NA	NA	NA	NA	0 17
TS-2	Duplicate (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-2	Trip Blank (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-3	15	01/12/94	2 3	ND(0 005)	ND(0 01)	0 18	ND(0 001)	ND(0 005)	ND(0 025)	0 009	ND(0 05)	0 056	2 8	0 026	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 01)	ND(0 05)	ND(0 001)	ND(0 05)	0 45
TS-3	30	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-3	45	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-3	Composite	01/12/94	0 63	ND(0 005)	ND(0 01)	0 12	ND(0 001)	ND(0 005)	ND(0 025)	ND(0 005)	ND(0 05)	0 021	0 51	0 005	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 01)	ND(0 05)	ND(0 001)	ND(0 05)	0 1
TS-3	Duplicate (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-3	Trip Blank (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-4	Source	01/12/94	ND(0 5)	ND(0 005)	ND(0 01)	0 12	ND(0 001)	ND(0 005)	ND(0 025)	ND(0 005)	ND(0 05)	0 02	ND(0 05)	0 002	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 01)	ND(0 05)	ND(0 001)	ND(0 05)	ND(0 001)
TS-4	15	01/12/94	2 8	NA	NA	NA	NA	ND(0 005)	NA	0 009	NA	0 021	3 6	0 026	NA	NA	ND(0 1)	NA	NA	NA	NA	0 25
TS-4	30	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-4	45	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-4	Composite	01/12/94	2 1	NA	NA	NA	NA	ND(0 005)	NA	0 006	NA	0 021	ND(0 05)	0 015	NA	NA	ND(0 1)	NA	NA	NA	NA	0 21
TS-4	Duplicate (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-4	Trip Blank (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-5	Source	01/13/94	ND(0 5)	ND(0 005)	ND(0 01)	0 14	ND(0 001)	ND(0 005)	ND(0 025)	ND(0 005)	ND(0 05)	0 021	ND(0 05)	0 002	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 01)	ND(0 05)	ND(0 001)	ND(0 05)	ND(0 001)
TS-5	15	01/13/94	2 4	ND(0 005)	ND(0 01)	0 15	ND(0 001)	ND(0 005)	ND(0 025)	0 006	ND(0 05)	0 034	3	0 017	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 01)	ND(0 05)	ND(0 001)	ND(0 05)	0 2
TS-5	30	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-5	45	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-5	Composite	01/13/94	1 7	ND(0 005)	ND(0 01)	0 14	ND(0 001)	ND(0 005)	ND(0 025)	ND(0 005)	ND(0 05)	0 026	2 3	0 011	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 01)	ND(0 05)	ND(0 001)	ND(0 05)	0 17
TS-5	Duplicate (20)	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-5	Trip Blank (20)	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-6	15	01/13/94	1 5	NA	NA	NA	NA	ND(0 005)	NA	ND(0 005)	NA	0 024	1 8	0 011	NA	NA	ND(0 1)	NA	NA	NA	NA	0 12
TS-6	30	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-6	45	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-6	Composite	01/13/94	1 3	NA	NA	NA	NA	ND(0 005)	NA	ND(0 005)	NA	0 018	1 2	0 007	NA	NA	ND(0 1)	NA	NA	NA	NA	0 072
TS-6	Duplicate (20)	01/13/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-6	Trip Blank (20)	01/12/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-7	Source	01/17/94	ND(0 5)	ND(0 005)	ND(0 01)	0 11	ND(0 001)	ND(0 005)	ND(0 025)	ND(0 005)	ND(0 05)	0 016	ND(0 05)	ND(0 001)	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 01)	ND(0 05)	ND(0 001)	ND(0 05)	ND(0 001)
TS-7	15	01/17/94	0 81	NA	NA	NA	NA	ND(0 005)	NA	ND(0 005)	NA	0 015	1 1	0 0054	NA	NA	ND(0 1)	NA	NA	NA	NA	0 21
TS-7	30	01/17/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-7	45	01/17/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-7	Composite	01/17/94	1 4	NA	NA	NA	NA	ND(0 005)	NA	ND(0 005)	NA	0 012	1 5	0 008	NA	NA	ND(0 1)	NA	NA	NA	NA	0 22
TS-8	15	01/17/94	3 7	ND(0 005)	ND(0 01)	0 15	ND(0 001)	ND(0 005)	ND(0 025)	0 008	ND(0 05)	0 034	5 8	0 033	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 01)	ND(0 05)	ND(0 001)	ND(0 05)	0 46
TS-8	30	01/17/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-8	45	01/17/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TS-8	Composite	01/17/94	1 7	ND(0 005)	ND(0 01)	0 092	ND(0 001)	ND(0 005)	ND(0 025)	ND(0 005)	ND(0 05)	0 017	2 1	0 012	ND(0 002)	ND(0 1)	ND(0 1)	ND(0 01)	ND(0 05)	ND(0 001)	ND(0 05)	0 24

ND(.001) Not detected at specified detection limit.
NA Not analyzed.

GEOMATRIX

Table 7

Analytical Results reported in "Action Plan Demonstration Project, Phase 1 Report"

Station	Date Sampled	Oil and Grease (mg/l)	Aluminum (mg/l)	Cadmium (mg/l)	Chromium (mg/l)	Copper (mg/l)	Iron (mg/l)	Lead (mg/l)	Nickel (mg/l)	Zinc (mg/l)
X	10/29/92	2.7	NA	0.00038	0.0043	0.03	NA	0.034	0.0052	0.69
Y	10/29/92	6.9	NA	0.0014	0.011	0.068	NA	0.15	0.0094	0.41
Z	10/29/92	1.2	NA	0.00054	0.0074	0.0093	NA	0.015	ND(.001)	2.4
X	12/06/92	15	0.8	0.0018	0.0067	0.026	1.3	0.028	0.0051	0.5
Y	12/06/92	7.8	0.81	0.00071	0.0041	0.031	1	0.028	0.0031	0.19
Z	12/06/92	14	0.91	0.00056	0.0029	0.026	1.3	0.028	0.0031	0.2
X	12/10/92	ND(.5)	2.3	0.0019	0.0094	0.0097	2.7	0.017	0.011	0.43
Y	12/10/92	1	0.57	0.00031	0.0026	0.006	0.6	0.017	ND(.001)	0.059
Z	12/10/92	0.8	0.14	0.00011	ND(.001)	0.006	0.19	0.007	0.0031	0.053
X	01/06/93	5.4	NA	0.00042	ND(.001)	0.0052	0.34	0.0082	NA	0.18
Y	01/06/93	0.6	NA	0.00025	0.0018	0.0076	0.11	0.016	NA	0.082
Z	01/06/93	2	NA	0.00039	ND(.001)	0.0092	0.85	0.015	NA	0.084
X	03/16/93	12	NA	0.00077	0.0041	0.02	NA	0.054	NA	0.43
Y	03/16/93	5	NA	0.0006	0.0055	0.045	NA	0.063	NA	0.13
Z	03/16/93	3.9	NA	0.00053	0.004	0.037	NA	0.032	NA	0.15
X	03/23/93	1.9	0.94	0.00054	0.003	0.013	NA	0.015	NA	0.55
Y	03/23/93	1	0.31	0.00027	0.0026	0.02	NA	0.024	NA	0.091
Z	03/23/93	1.2	0.68	0.00045	0.0025	0.085	NA	0.05	NA	0.2

ND(.001) Not detected at specified detection limit.
NA Not analyzed.

Source: Uribe & Associates, Larry Walker Associates (1993), Action Plan Demonstration Project Demonstration of Gasoline Fueling Stat Best Management Practices, September, Table 5.5 and 3.1.

GEOMATRIX

TABLE 8

Analytical Results Reported in NURP
Event Mean Concentrations (Median Results)

Category	Site	Total Suspended Solids (mg/l)	Copper (ug/l)	Lead (ug/l)	Zinc (ug/l)
Residential	1	265	25	137	151
	2	129	20	143	165
	3	232	22	210	158
	4	39	--	--	151
	5	90	33	200	106
	6	38	27	--	76
	7	122	63	191	--
	8	1247	81	128	596
	9	29	--	--	--
	10	45	88	592	573
	11	26	296	69	113
	12	63	20	77	81
	13	88	34	218	340
	14	32	--	--	--
	15	57	--	52	
	16	88	--	27	312
	17	196	--	144	327
	18	150	--	--	--
	19	101	--	136	114
	20	243	--	77	63
	21	141	--	90	69
	22	34	6	53	55
	23	82	--	--	--
	24	206	--	200	--
	25	42	15	123	81
	26	43	34	184	48
	27	119	--	--	--
	28	138	33	169	--
	29	492	52	376	354
	30	100	21	159	107
	31	211	36	396	--
	32	16	7	26	38
	33	14	25	--	76
	34	380	45	351	295
	35	200	43	227	189
	36	128	104	225	236
	37	135	33	182	138
	38	39	72	160	210
	39	38	28	130	75
Urban Open and Nonurban	1	551	55	159	160
	2	341	25	39	91
	3	113	--	11	306
	4	6	--	8	--
	5	22	--	22	--
	6	51	--	18	322
	7	26	--	--	--
	8	149	--	--	--
Mixed	1	208	45	147	525
	2	43	61	176	112
	3	199	37	380	--
	4	52	13	75	110
	5	48	25	227	138
	6	302	--	424	303
	7	154	100	307	225
	8	30	96	143	174
	9	98	76	91	200
	10	43	--	11	--
	11	134	--	47	--
	12	48	48	--	99
	13	81	--	50	--
	14	131	13	99	140
	15	59	--	--	--
	16	1004	--	254	--
	17	171	65	351	231
	18	23	5	35	78
	19	27	5	65	37
	20	354	59	278	471
Commercial	1	122	25	187	247
	2	107	61	296	474
	3	112	--	42	517
	4	161	--	148	94
	5	38	103	152	430
	6	99	36	140	289
	7	167	--	98	125
	8	34	39	--	368
	9	14	10	32	28
	10	296	--	310	234

Source: US Environmental Protection Agency (1983) Final Report of the Nationwide Urban Runoff Program, Table 6-1, 6-8, 6-9, and 6-10.

GEOMATRIX

FIGURES
(Figures 1 and 2 Presented in Text)

GEOMATRIX

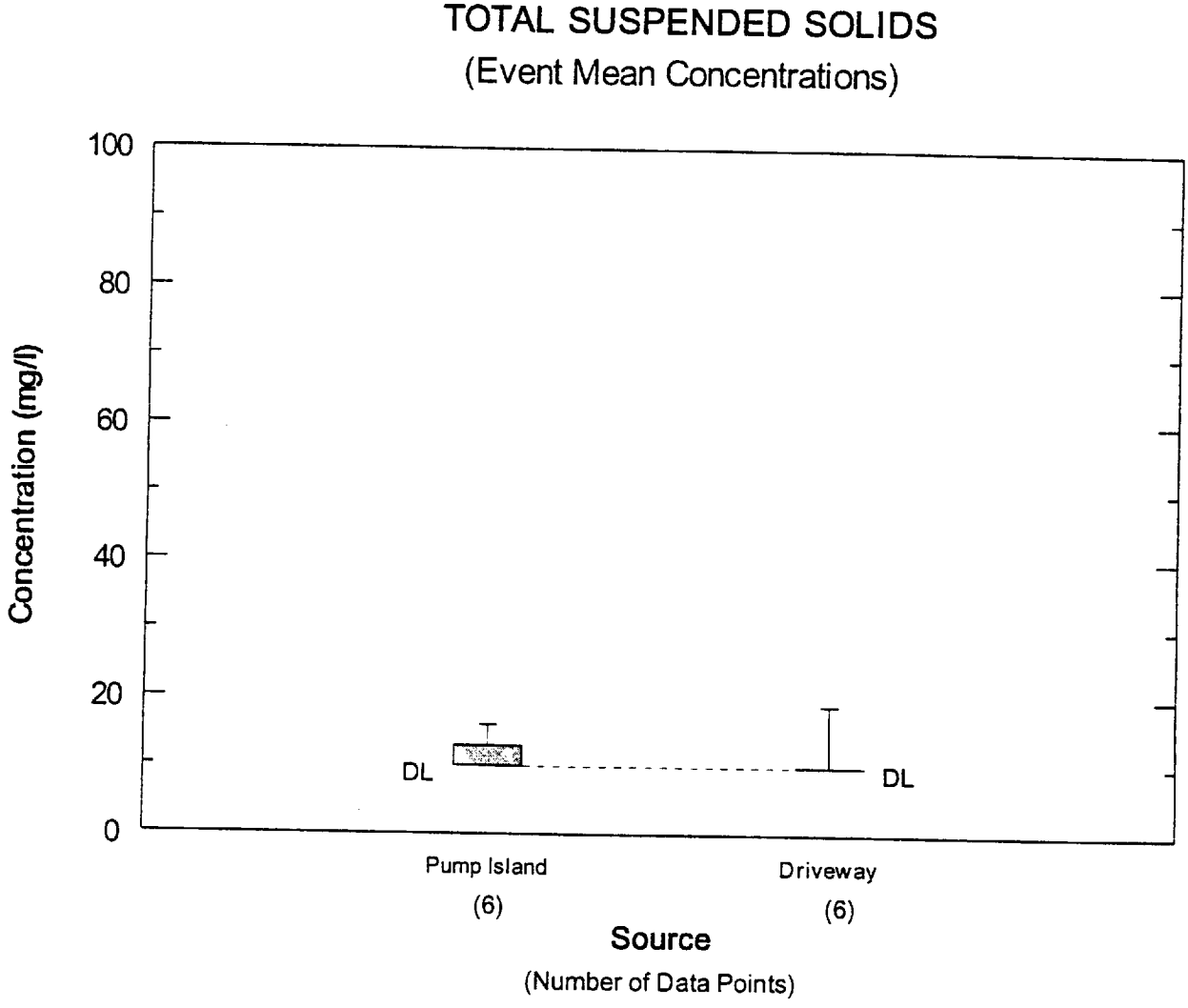


FIGURE 3

GEOMATRIX

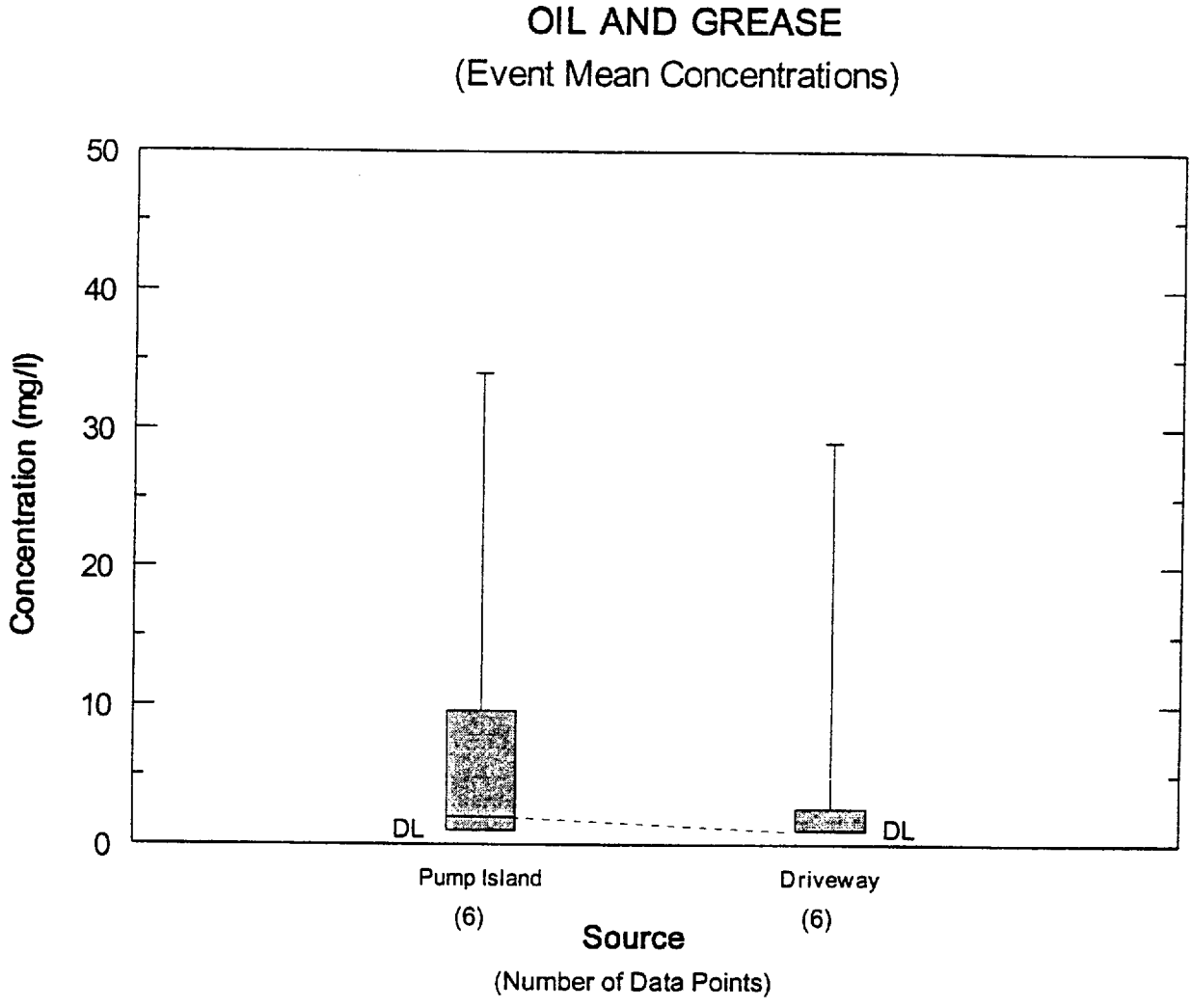
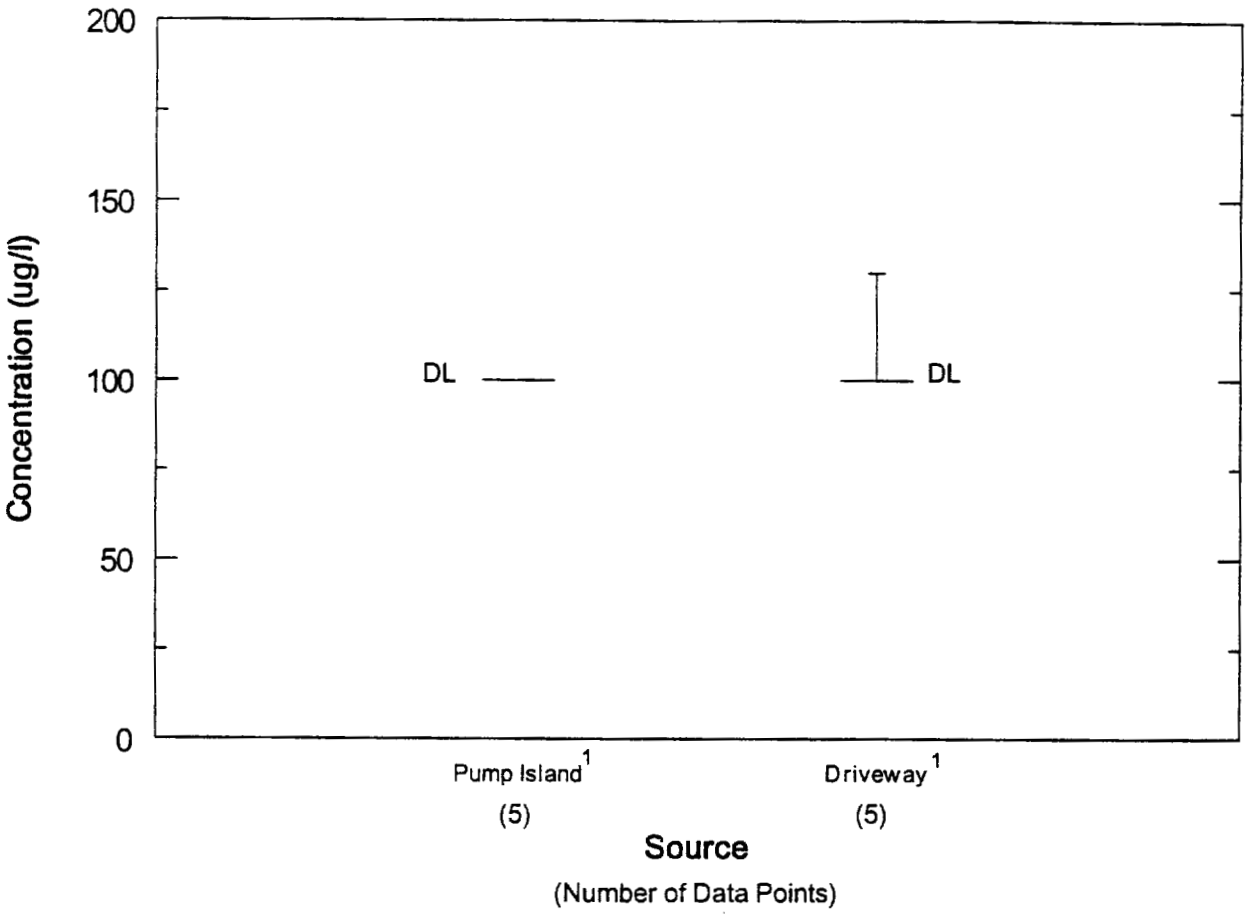


FIGURE 4

GEOMATRIX

TOTAL PETROLEUM HYDROCARBONS

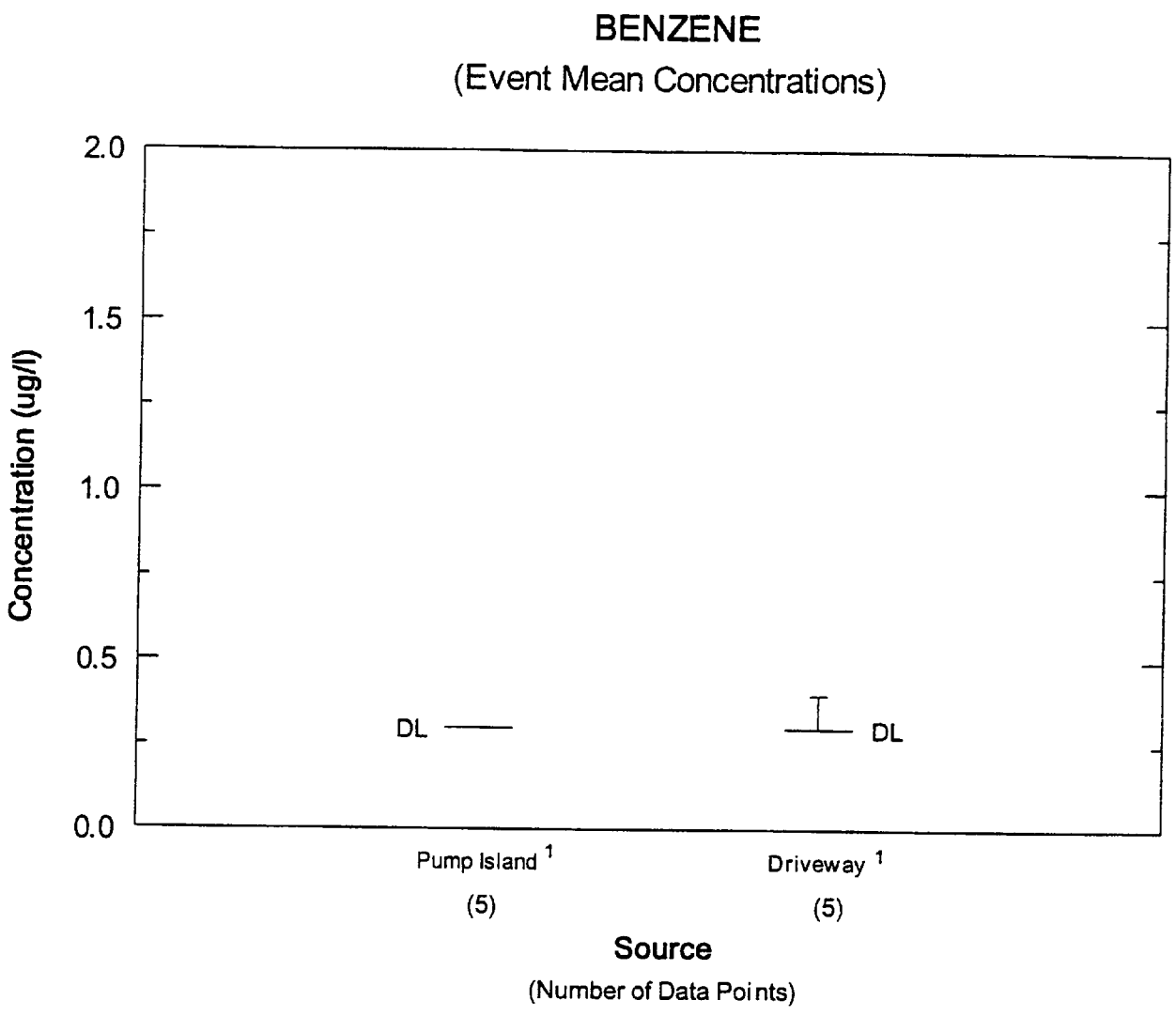
(Event Mean Concentrations)



[1] Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 5

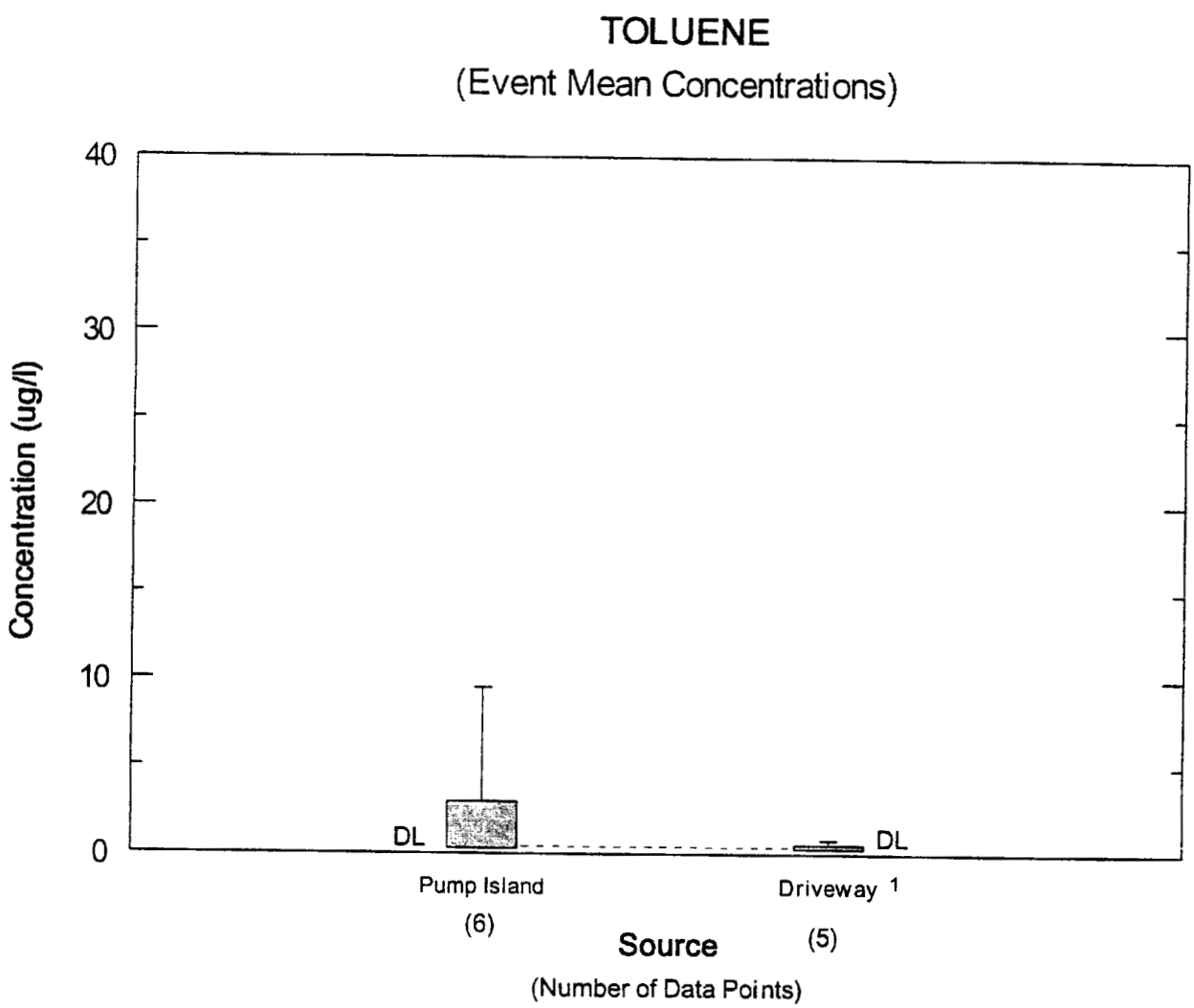
GEOMATRIX



[1]Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 6

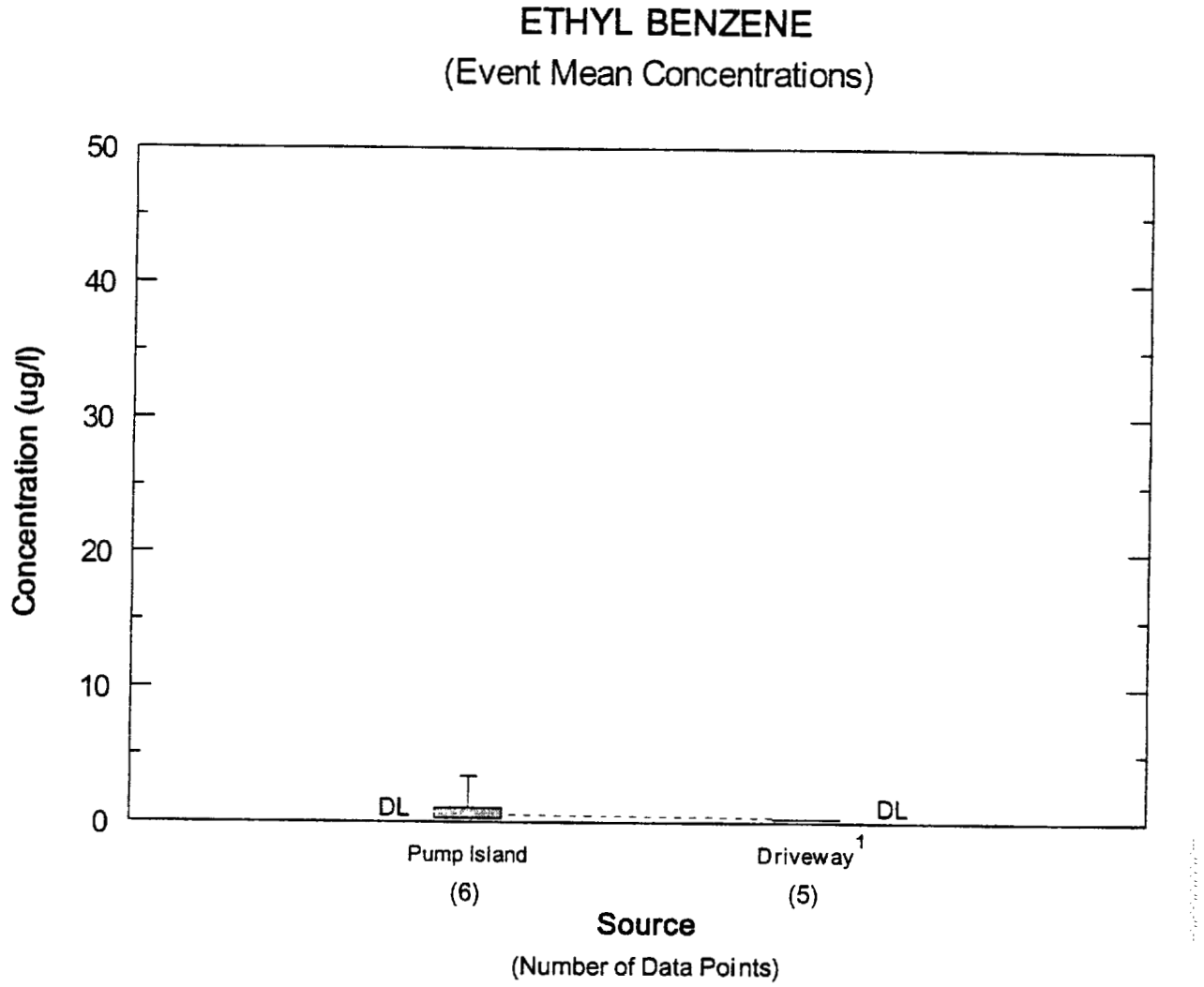
GEOMATRIX



[1] Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 7

GEOMATRIX

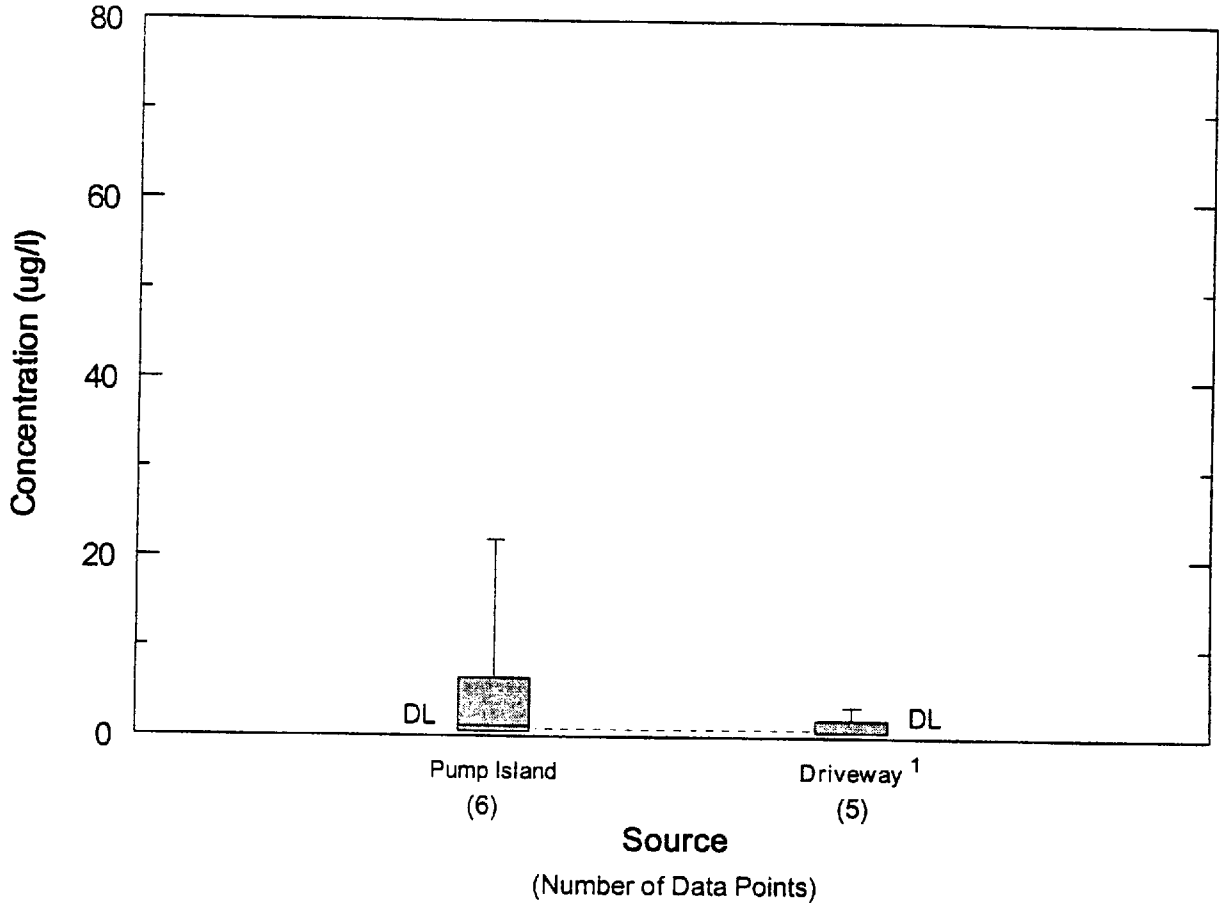


[1] Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 8

GEOMATRIX

TOTAL XYLENES
(Event Mean Concentrations)



[1] Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 9

GEOMATRIX

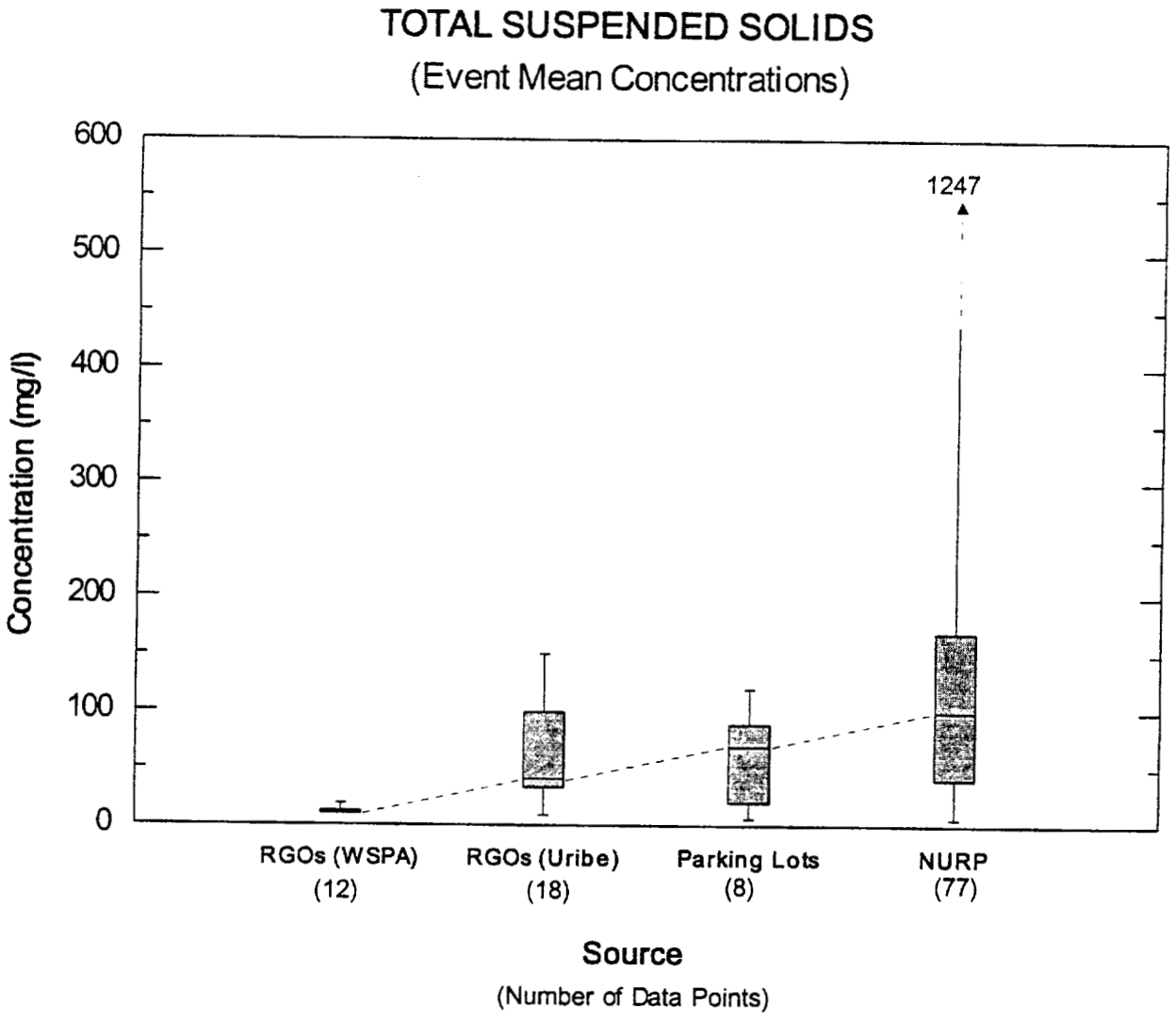


FIGURE 10

GEOMATRIX

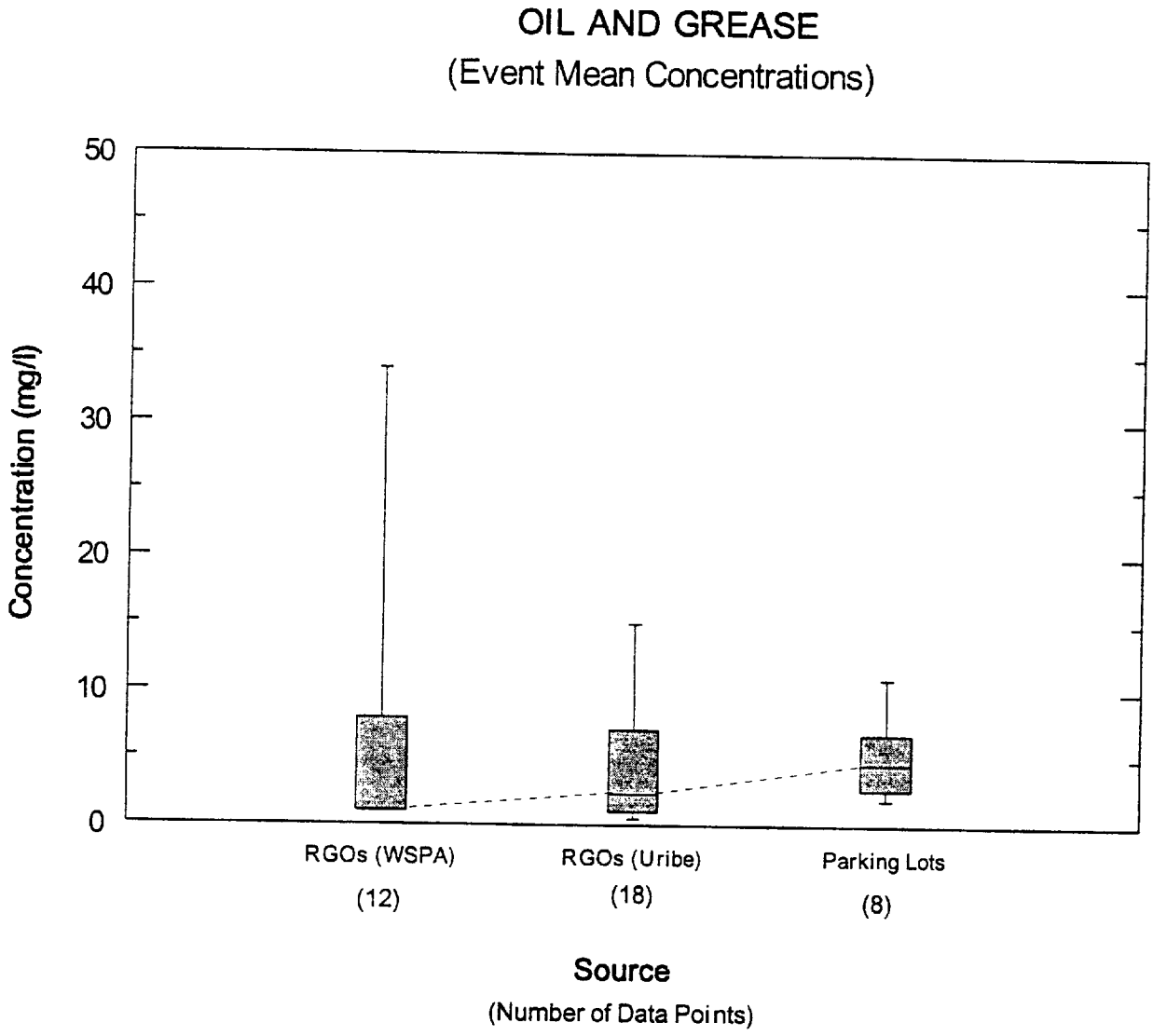
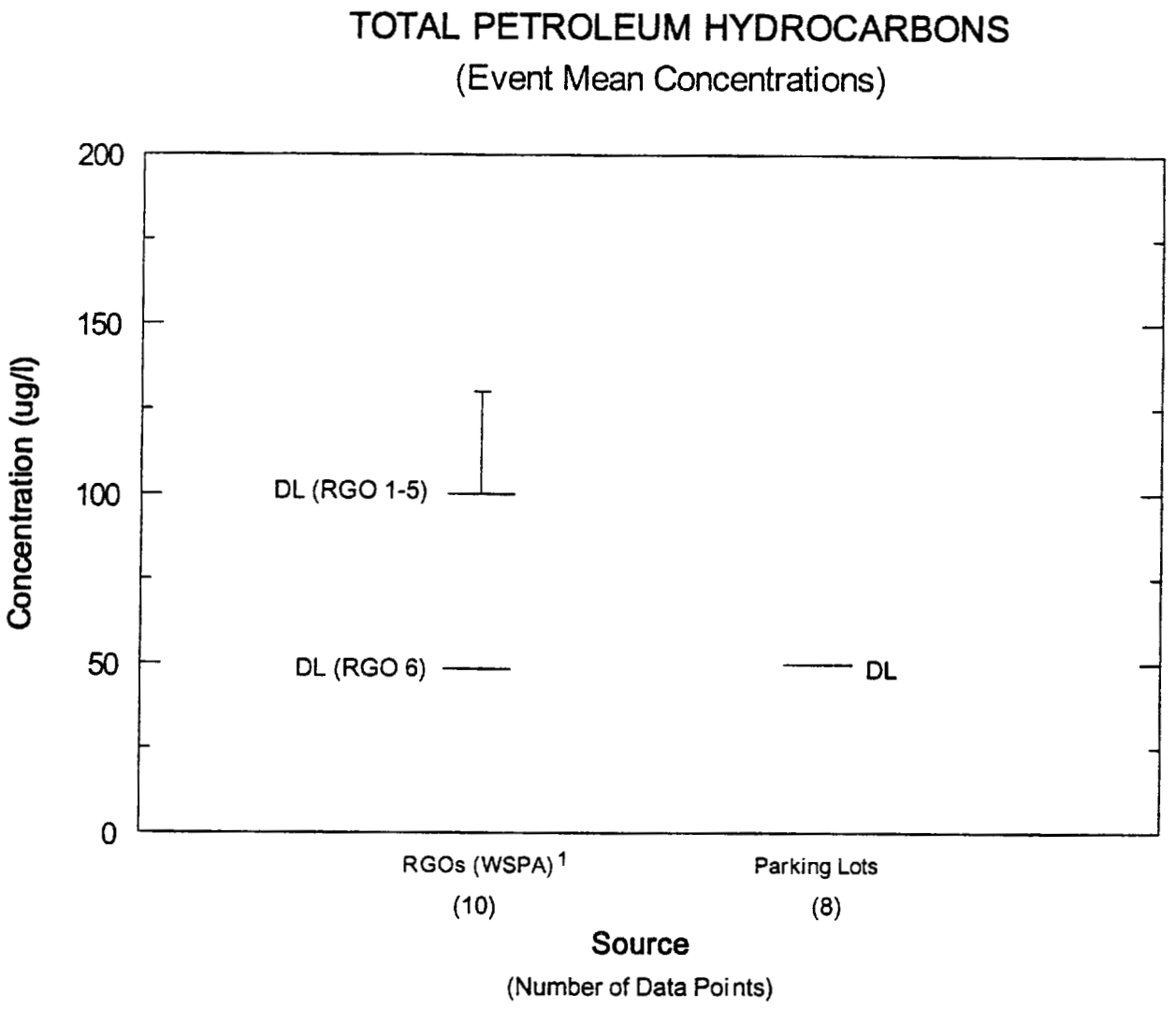


FIGURE 11

GEOMATRIX



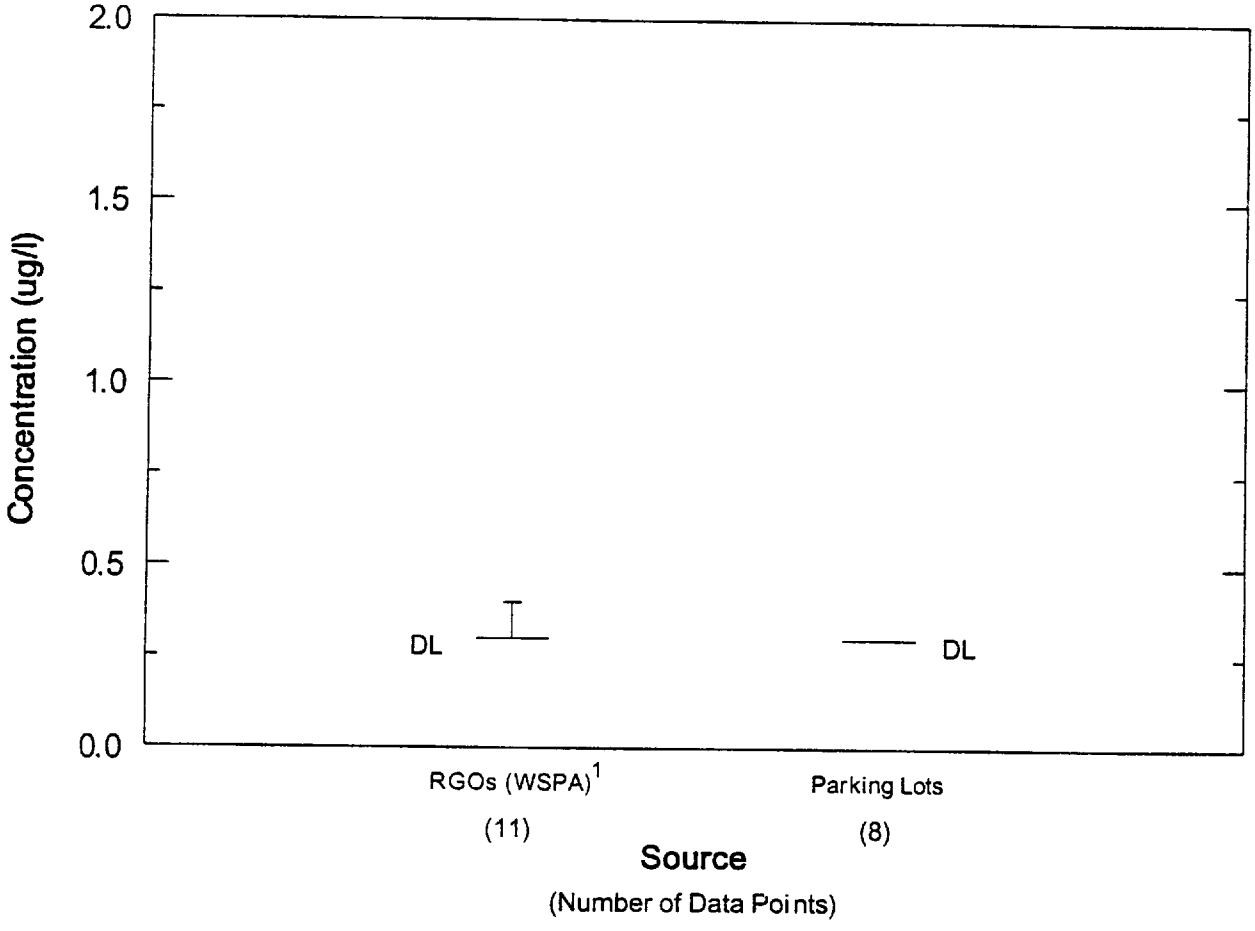
[1] Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 12

GEOMATRIX

BENZENE

(Event Mean Concentrations)



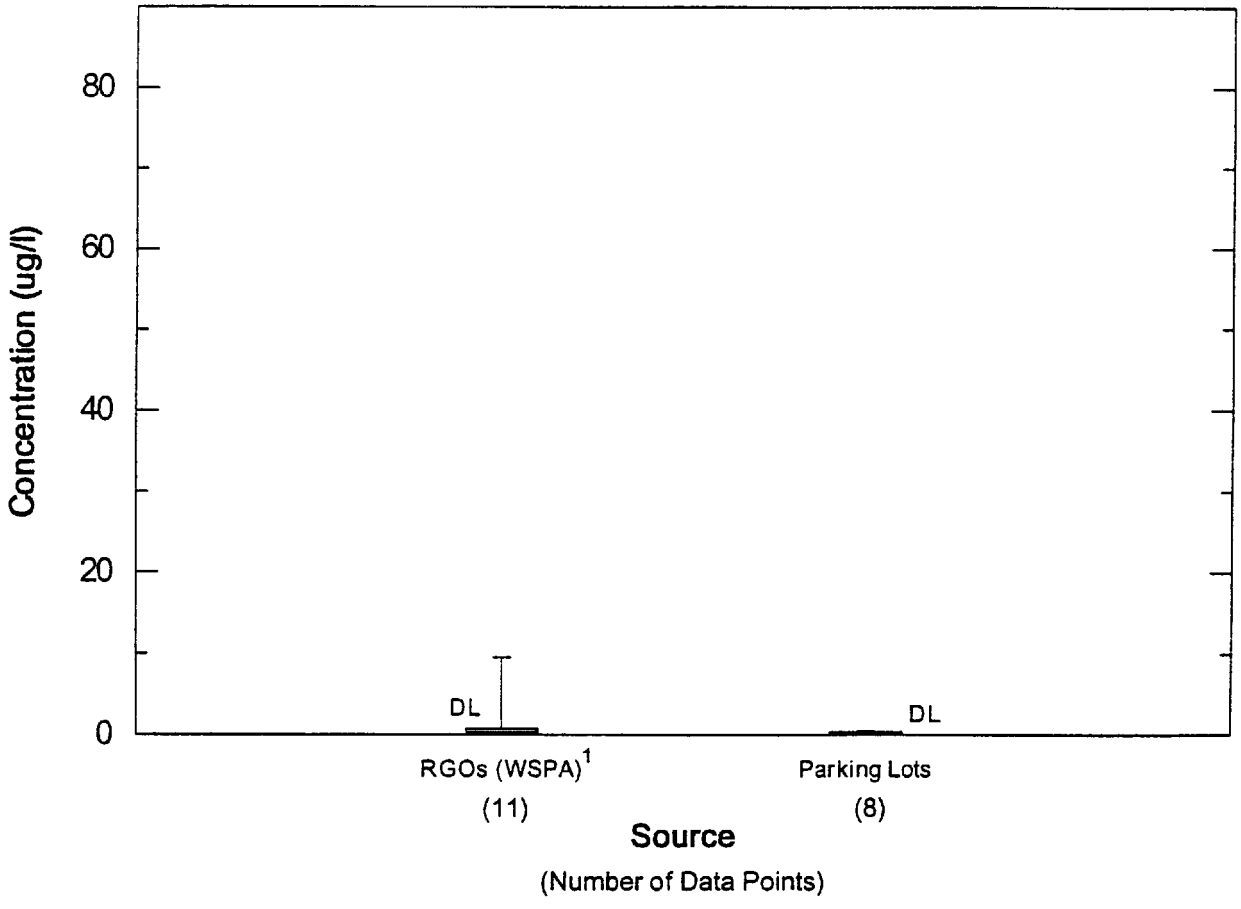
[1]Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 13

GEOMATRIX

TOLUENE

(Event Mean Concentrations)



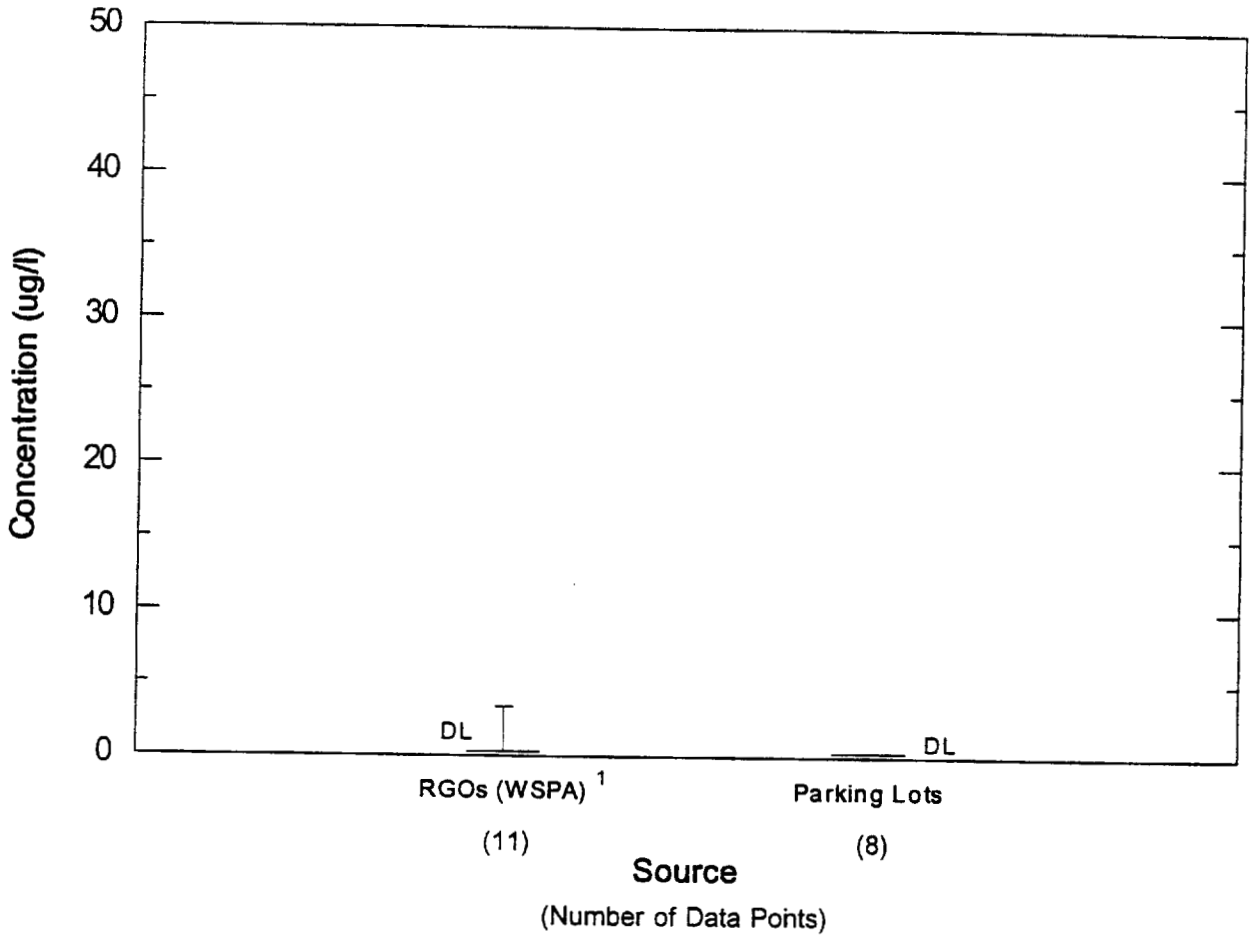
[1] Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 14

GEOMATRIX

ETHYL BENZENE

(Event Mean Concentrations)



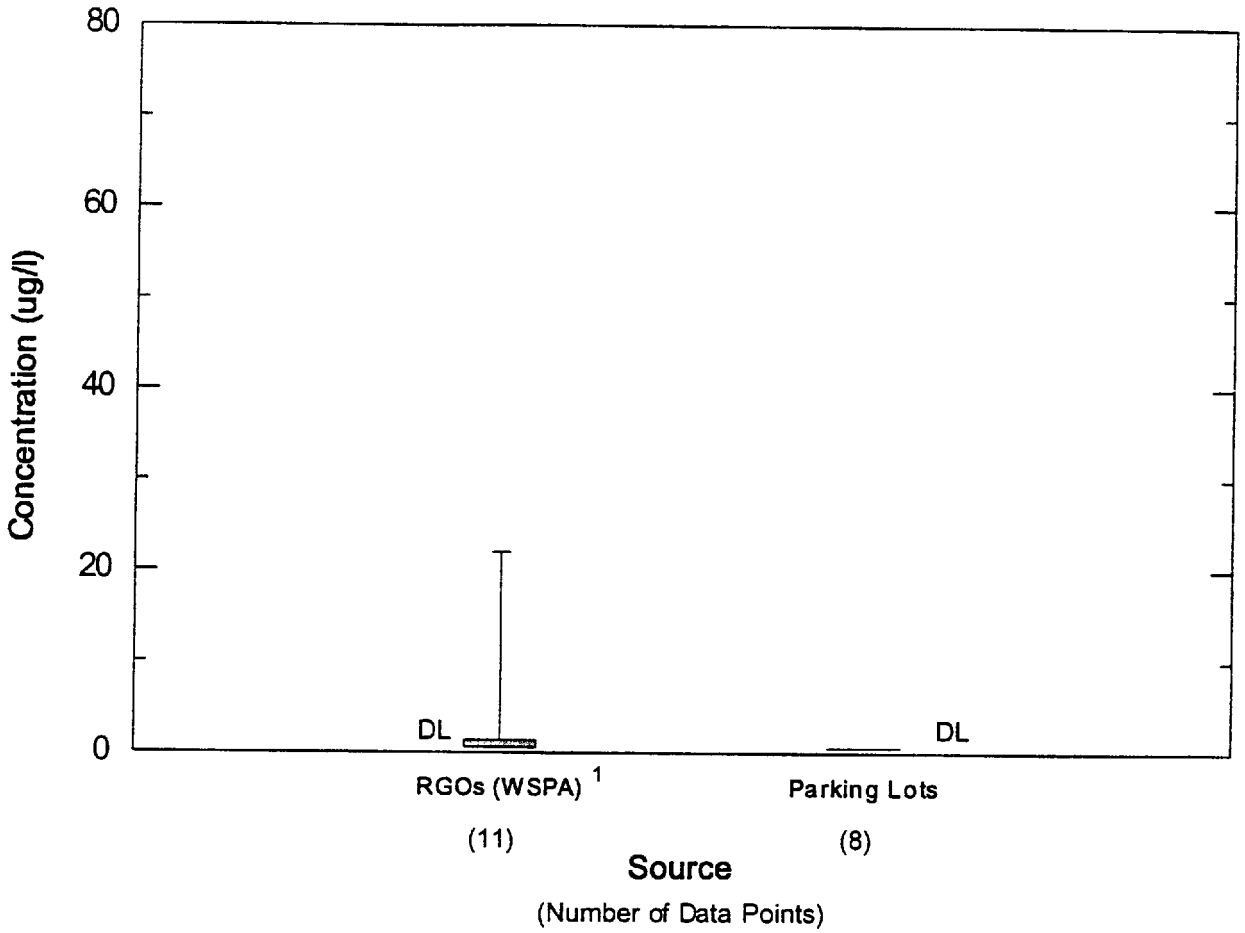
[1]Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 15

GEOMATRIX

TOTAL XYLENES

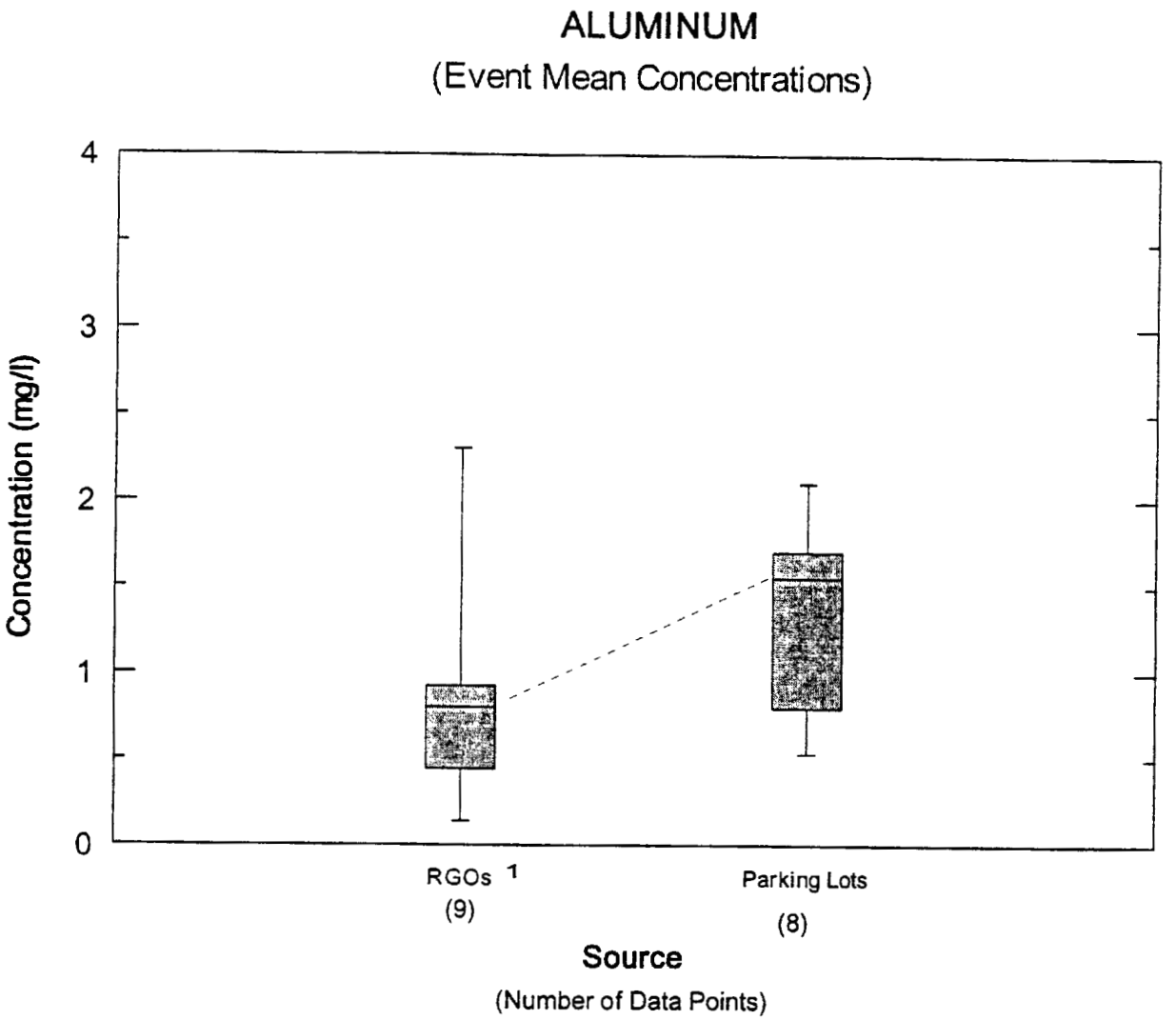
(Event Mean Concentrations)



[1] Excludes data from simulated spill sample at RGO 5 because of elevated limit of detection.

FIGURE 16

GEOMATRIX



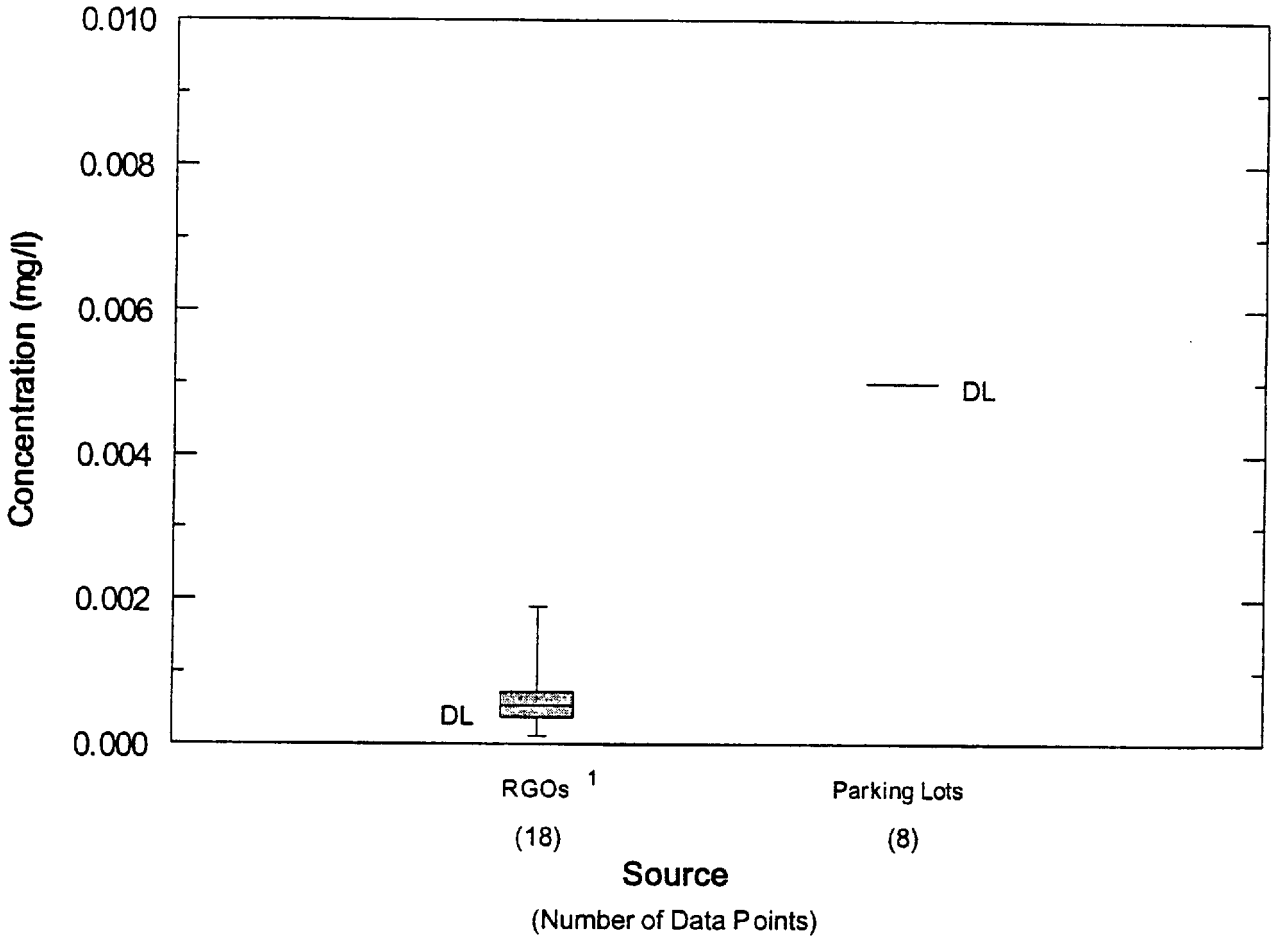
[1] Results from Uribe (1993) only.

FIGURE 17

GEOMATRIX

CADMIUM

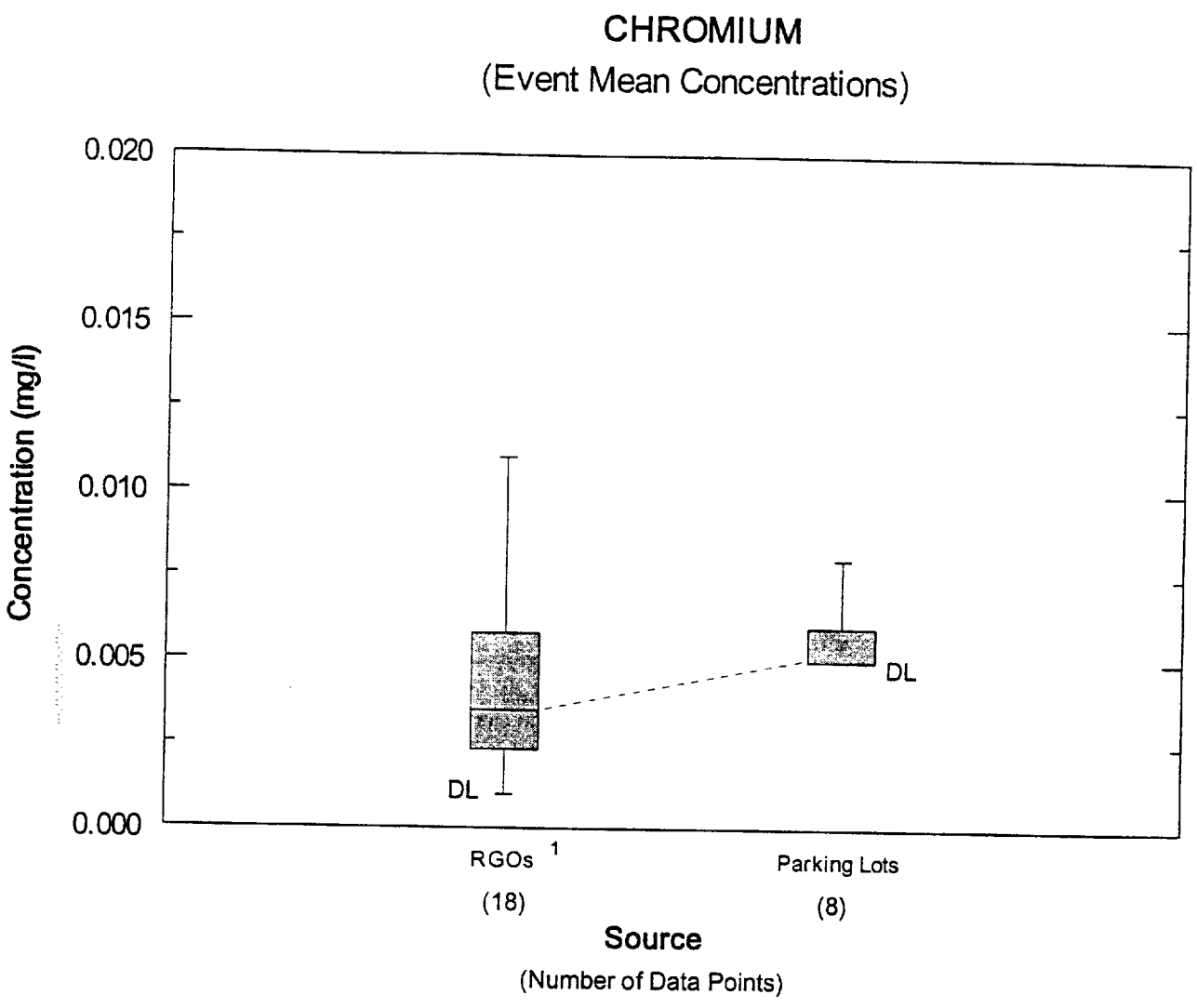
(Event Mean Concentrations)



[1] Results from Uribe (1993) only.

FIGURE 18

GEOMATRIX



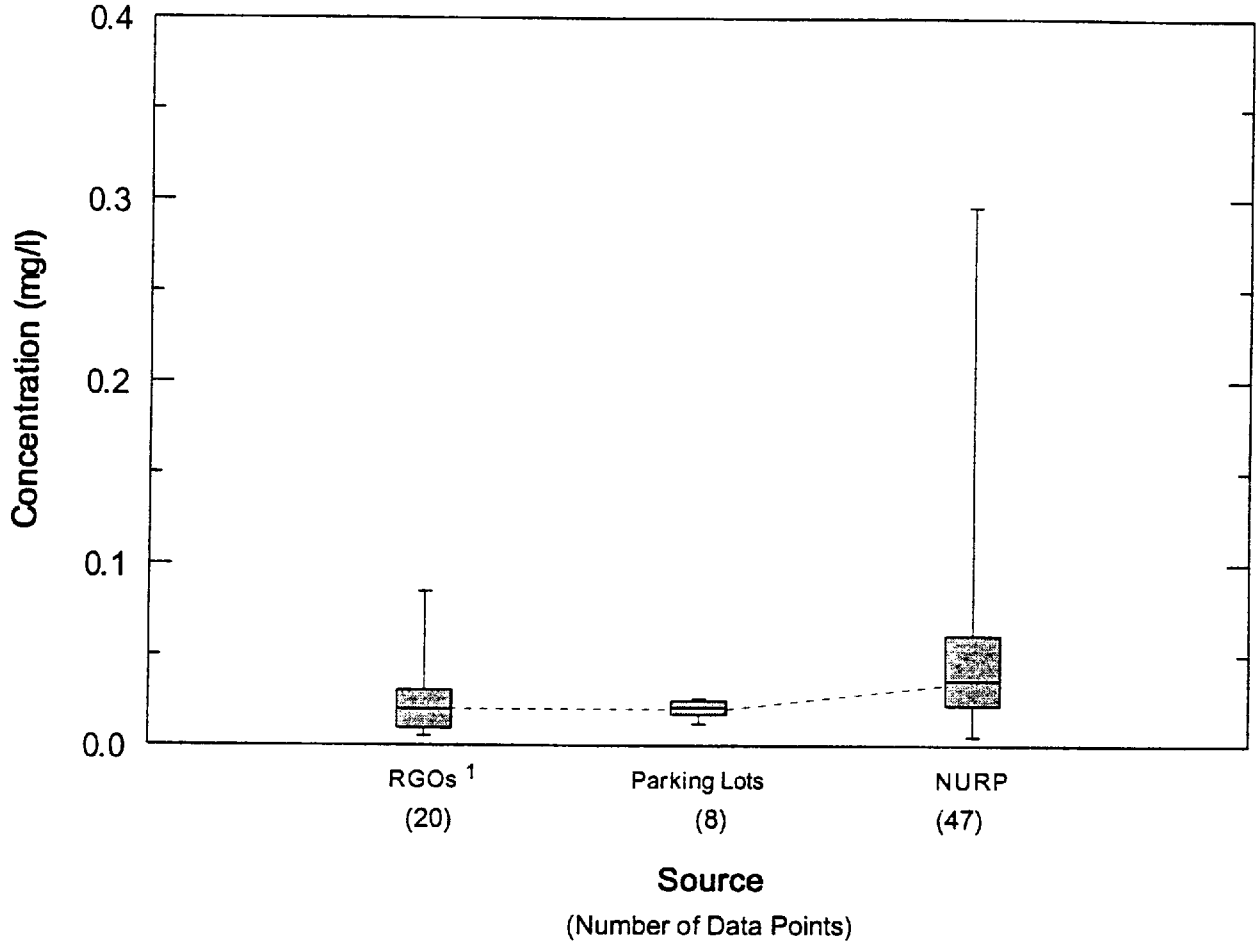
[1] Results from Uribe (1993) only.

FIGURE 19

GEOMATRIX

COPPER

(Event Mean Concentrations)

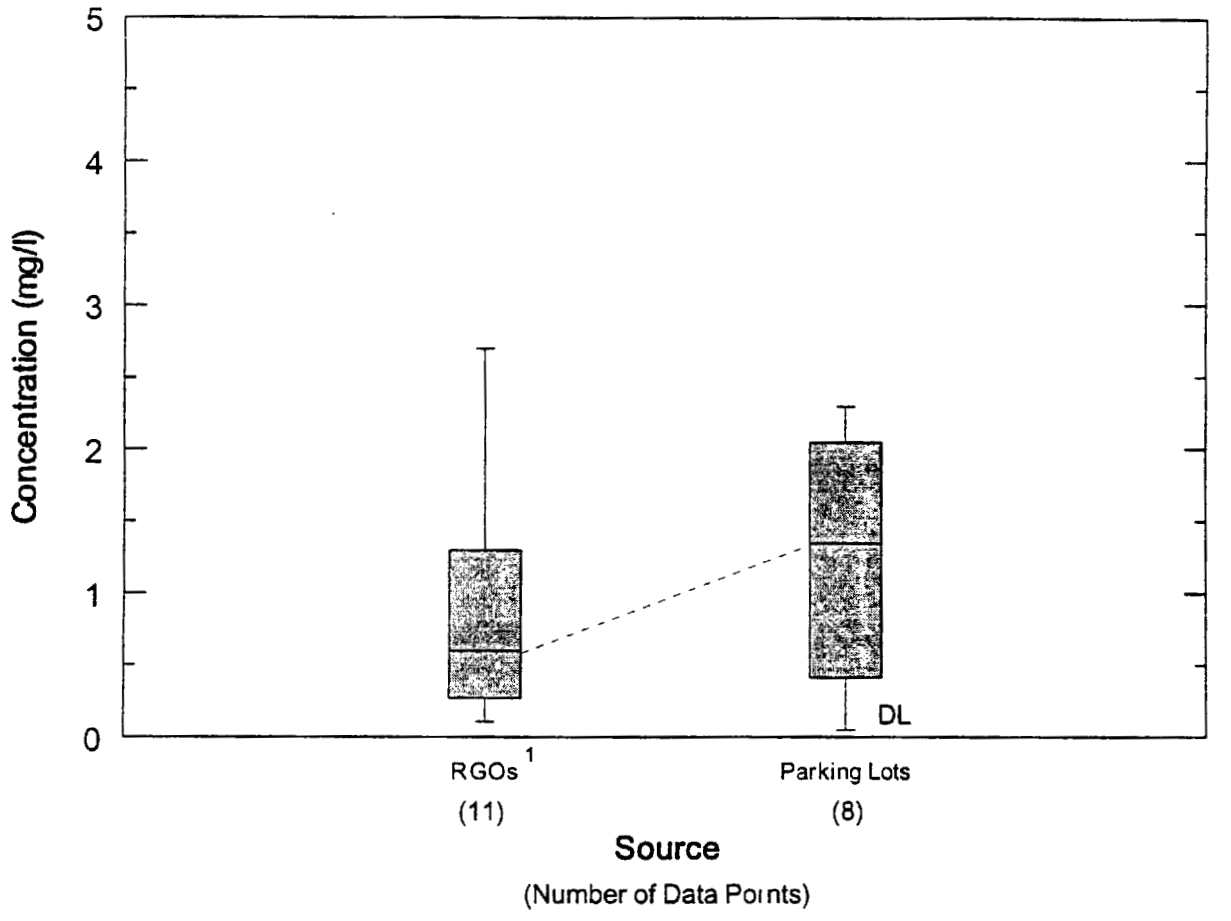


[1] Includes WSPA and Uribe (1993) results.

FIGURE 20

GEOMATRIX

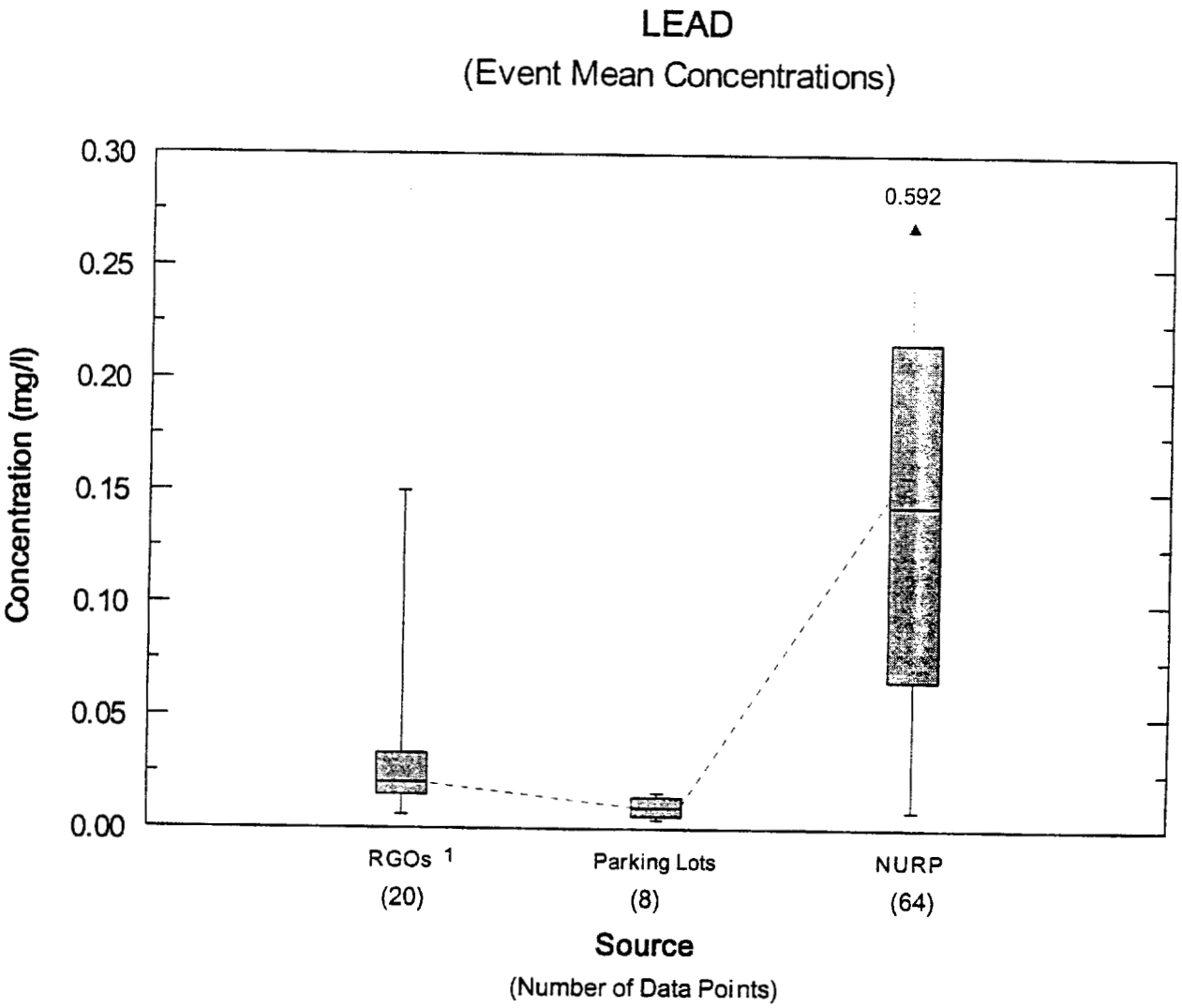
IRON
(Event Mean Concentrations)



[1] Includes WSPA and Uribe (1993) results.

FIGURE 21

GEOMATRIX



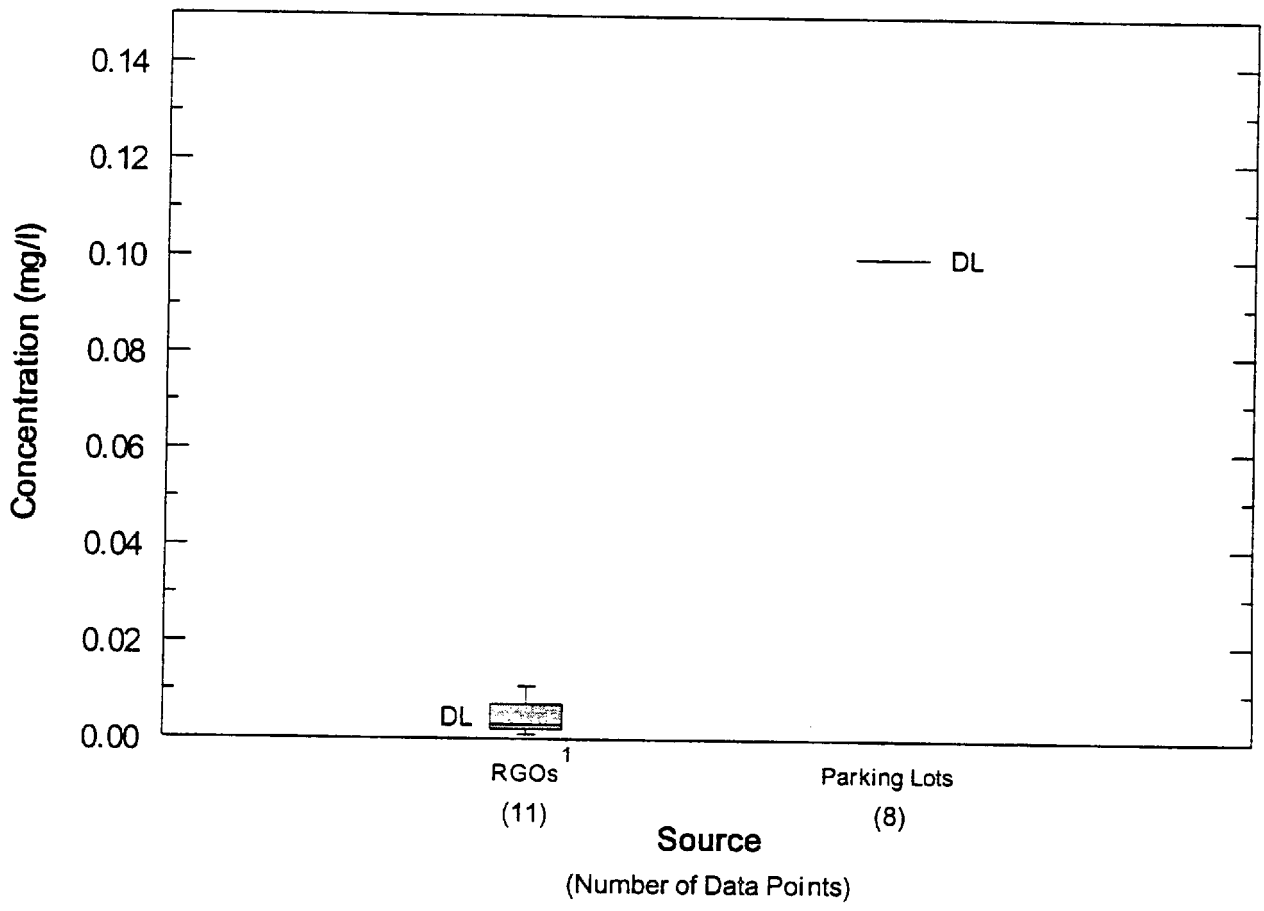
[1] Includes WSPA and Uribe (1993) results.

FIGURE 22

GEOMATRIX

NICKEL

(Event Mean Concentrations)



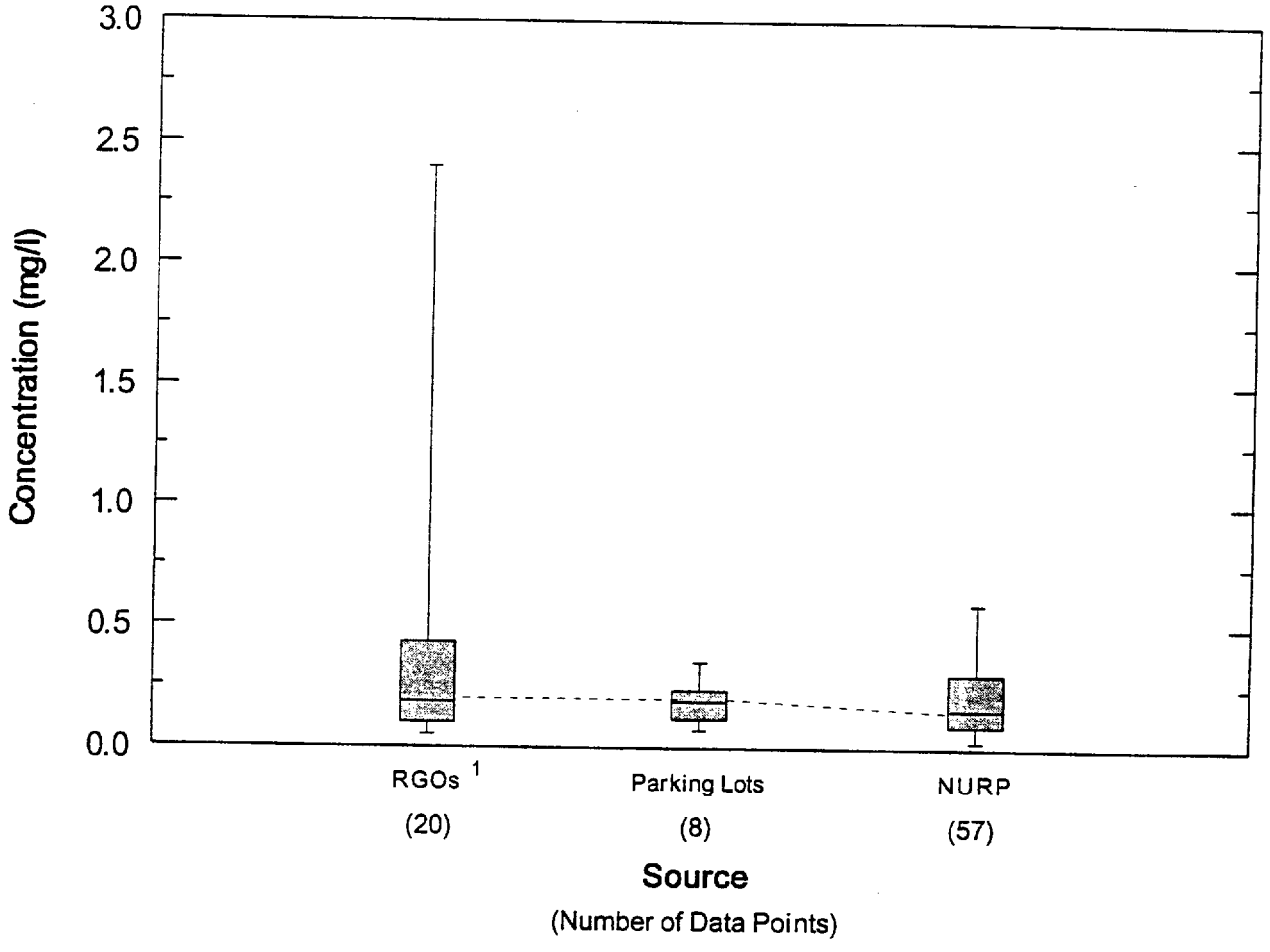
[1] Results from Uribe (1993) only.

FIGURE 23

GEOMATRIX

ZINC

(Event Mean Concentrations)



[1] Includes WSPA and Uribe (1993) results.

FIGURE 24

1-01400—12/94—0.6C ( )

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