Water Quality of Storm Runoff and Comparison of Procedures for Estimating Storm-Runoff Loads, Volume, Event-Mean Concentrations, and the Mean Load for a Storm for Selected Properties and Constituents for Colorado Springs, Southeastern Colorado, 1992

by Paul von Guerard and William B. Weiss

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CONVERSION FACTORS AND RELATED INFORMATION

Multiply	By	To obtain
cubic foot (ft^3)	0.028317	cubic meter
cubic foot per second (ft^3/s)	0.028317	cubic meter per second
foot (ft)	0.3048	meter
gallon (gal)	3.785	liter
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
pound (lb)	0.454	kilogram
quart (qt)	0.9464	liter
square mile (mi^2)	2.590	square kilometer

Degree Fahrenheit (°F) can be converted to degree Celsius (°C) by using the following equation:

$$°C = 5/9\ (°F-32).$$

Degree Celsius (°C) can be converted to degree Fahrenheit (°F) by using the following equation:

$$°F = 9/5\ (°C + 32).$$

The following terms and abbreviations also are used in this report:

colonies per 100 milliliters (col/100 mL)

microsiemens per centimeter at 25 degrees Celsius (µS/cm)

milligram per liter (mg/L)

microgram per liter (µg/L)

Water Quality of Storm Runoff and Comparison of Procedures for Estimating Storm-Runoff Loads, Volume, Event-Mean Concentrations, and the Mean Load for a Storm for Selected Properties and Constituents for Colorado Springs, Southeastern Colorado, 1992

By Paul von Guerard *and* William B. Weiss

Abstract

The U.S. Environmental Protection Agency requires that municipalities that have a population of 100,000 or greater obtain National Pollutant Discharge Elimination System permits to characterize the quality of their storm runoff. In 1992, the U.S. Geological Survey, in cooperation with the Colorado Springs City Engineering Division, began a study to characterize the water quality of storm runoff and to evaluate procedures for the estimation of storm-runoff loads, volume and event-mean concentrations for selected properties and constituents.

Precipitation, streamflow, and water-quality data were collected during 1992 at five sites in Colorado Springs. Thirty-five samples were collected, seven at each of the five sites. At each site, three samples were collected for permitting purposes; two of the samples were collected during rainfall runoff, and one sample was collected during snowmelt runoff. Four additional samples were collected at each site to obtain a large enough sample size to estimate storm-runoff loads, volume, and event-mean concentrations for selected properties and constituents using linear-regression procedures developed using data from the Nationwide Urban Runoff Program (NURP). Storm-water samples were analyzed for as many as 186 properties and constituents. The constituents measured include total-recoverable metals, volatile-organic compounds, acid-base/neutral organic compounds, and pesticides.

Storm runoff sampled had large concentrations of chemical oxygen demand and 5-day biochemical oxygen demand. Chemical oxygen demand ranged from 100 to 830 milligrams per liter, and 5-day biochemical oxygen demand ranged from 14 to 260 milligrams per liter. Total-organic carbon concentrations ranged from 18 to 240 milligrams per liter. The total-recoverable metals lead and zinc had the largest concentrations of the total-recoverable metals analyzed. Concentrations of lead ranged from 23 to 350 micrograms per liter, and concentrations of zinc ranged from 110 to 1,400 micrograms per liter.

The data for 30 storms representing rainfall runoff from 5 drainage basins were used to develop single-storm local-regression models. The response variables, storm-runoff loads, volume, and event-mean concentrations were modeled using explanatory variables for climatic, physical, and land-use characteristics. The r^2 for models that use ordinary least-squares regression ranged from 0.57 to 0.86 for storm-runoff loads and volume and from 0.25 to 0.63 for storm-runoff event-mean concentrations. Except for cadmium, standard errors of estimate ranged from 43 to 115 percent for storm-runoff loads and volume and from 35 to 66 percent for storm-runoff event-mean concentrations. Eleven of the 30 concentrations collected during rainfall runoff for total-recoverable cadmium were censored (less than) concentrations. Ordinary least-squares regression should not be used with censored data; however, censored data can be included with uncensored data using tobit regression. Standard errors of estimate for storm-runoff load and event-mean concentration for total-recoverable cadmium, computed using tobit regression, are 247 and 171 percent.

Estimates from single-storm regional-regression models, developed from the Nationwide Urban Runoff Program data base, were compared with observed storm-runoff loads, volume, and event-mean concentrations determined from samples collected in the study area. Single-storm regional-regression models tended to overestimate storm-runoff loads, volume, and event-mean concentrations. Therefore, single-storm local- and regional-regression models were combined using model-adjustment procedures to take advantage of the strengths of both models while minimizing the deficiencies of each model.

Procedures were used to develop single-storm regression equations that were adjusted using local data and estimates from single-storm regional-regression equations. Single-storm regression models developed using model-adjustment procedures had standard errors of estimate smaller than the standard errors of estimate for the regional-regression equations. Reduction of standard error in percent ranged from –1,980 to –10.

Regression models that had been developed from the Nationwide Urban Runoff Program data base for estimating the mean load for a storm were evaluated. Mean load for a storm was estimated for selected constituents. Ninety-percent confidence intervals were computed for each mean load estimate. Estimated mean load for a storm was compared to mean load of a storm that was computed based on daily mean water discharge and land-use characteristics and was compared to the mean load from six samples collected during rainfall runoff. Generally, mean load for a storm, computed based on daily mean water discharge and land-use characteristics and on mean load from samples collected during rainfall runoff, was near or within the 90-percent confidence intervals for estimates of mean load for a storm.

INTRODUCTION

Urbanization usually increases the impervious area of a watershed, which increases storm-runoff rates and, subsequently, total volume of storm runoff. Associated with storm runoff are properties and constituents that can cause the degradation of water quality locally and in receiving waters downstream. Because of concerns about the effects of urban runoff on water quality, the Water Quality Act of 1987 contains provisions that specifically address storm-runoff discharges. The U.S. Environmental Protection Agency, under section 319 of the Water Quality Act of 1987, requires that States "assess the nature and extent of nonpoint sources of pollution." Section 402(p) of the same act requires that municipalities that have a population of 100,000 or greater obtain National Pollutant Discharge Elimination System (NPDES) permits to improve the quality of storm runoff.

Final rules published by the U.S. Environmental Protection Agency (1990) require that municipalities prepare permit applications to include, among other information, the following:

1. Characterization of the quantity and quality of storm runoff for three or more major storms at selected storm-water-discharge sites that represent different combinations of commercial, industrial, and residential land uses.
2. Estimates of annual-pollutant loads and event-mean concentrations for selected constituents for the cumulative discharges of storm-runoff discharge points in the study area.

In 1992, the U.S. Geological Survey, in cooperation with the Colorado Springs City Engineering Division, began a study to characterize the water quality of storm runoff in Colorado Springs and to compare techniques for the estimation of storm-runoff loads, volume, event-mean concentrations, and mean load for a storm for selected properties and constituents.

Purpose and Scope

This report presents water-quality data collected during 1992 to characterize the water quality of storm runoff in Colorado Springs. These data were collected to help meet the requirements of the NPDES permitting process. Precipitation, streamflow, and water-quality data were collected during 1992 at five sites in Colorado Springs (fig. 1, table 1). This report presents procedures for estimating storm-runoff loads, volume, and event-mean concentrations for selected properties and constituents at unmonitored sites in Colorado Springs and to make a comparison of several procedures for estimating storm-runoff loads, volume, and event-mean concentrations. In addition, the report presents estimates of a mean load for a storm.

Thirty-five samples were collected, seven at each of the five sites. At each site, three samples were collected for NPDES permitting purposes; two of these samples were collected during rainfall runoff, and one sample was collected during snowmelt runoff. Four additional samples were collected at each site to obtain a large enough sample size to estimate storm-runoff

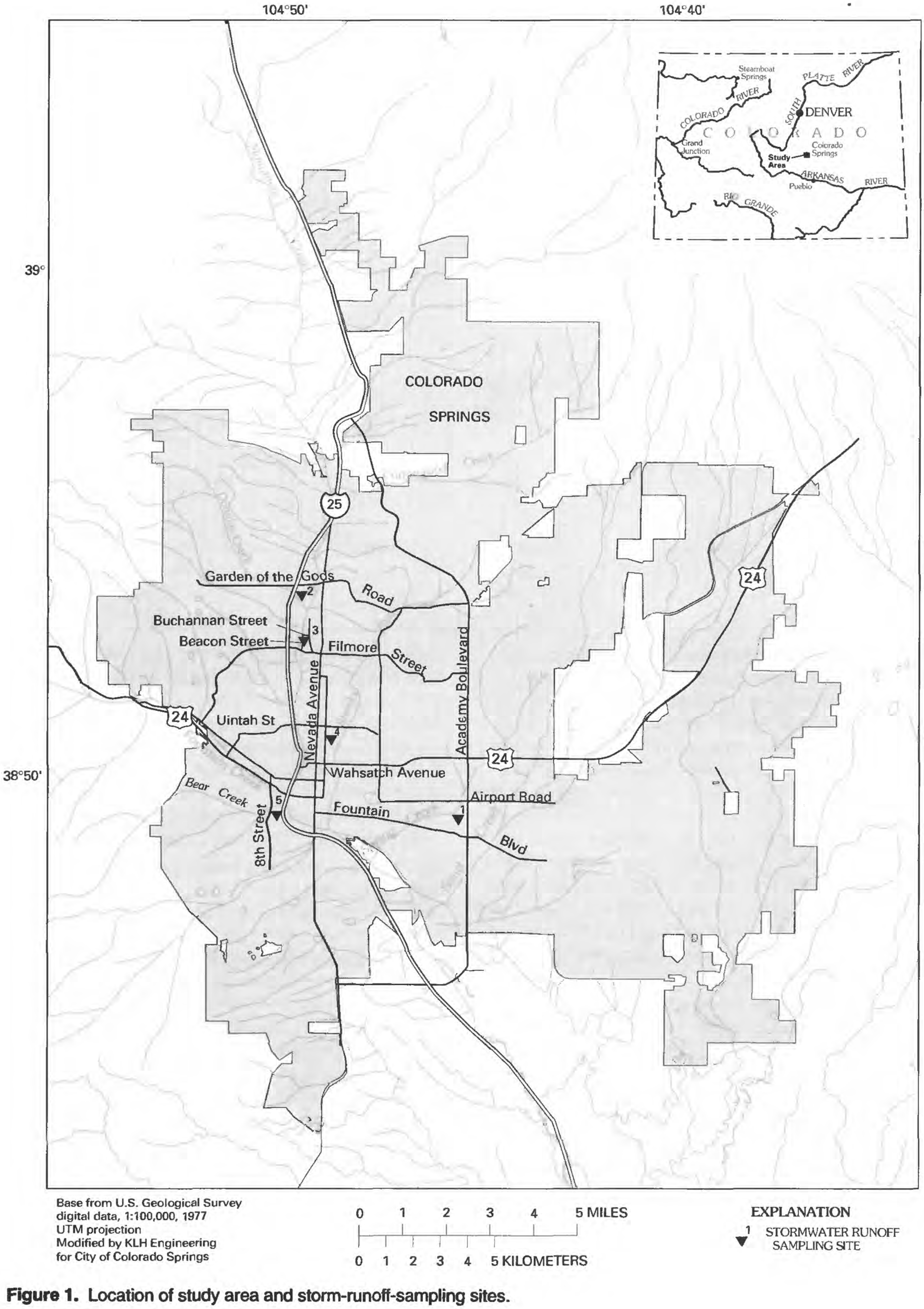


Figure 1. Location of study area and storm-runoff-sampling sites.

Table 1. *Description of and selected land-use data for storm-runoff-sampling sites in Colorado Springs*

Site number (fig. 1)	Site name	Latitude and longitude	Drainage-basin area (square miles)	Impervious area (percent)	Land use	Percentage of total drainage basin
1	Sixteenth Hole, Valley-Hi Golf Course	38°49′18″	0.125	58.1	Commercial	61.1
		104°45′42″			undeveloped	23.0
					residential	15.9
2	Chestnut Street at Douglas Creek	38°53′47″	.165	37.5	Industrial	54.7
		104°50′06″			undeveloped	35.9
					residential	8.5
					commercial	0.9
3	Beacon Street at Buchanan Street	38°52′40″	.173	55.9	Industrial	79.5
		104°49′36″			commercial	17.8
					residential	2.7
4	Wahsatch Street at Cross Lane	38°51′18″	.327	34.2	Residential	79.4
		104°48′58″			commercial	9.3
					public	8.3
					undeveloped	3.0
5	Walmart at Eighth Street	38°49′35″	.049	40.1	Undeveloped	43.0
		104°50′15″			commercial	39.9
					industrial	10.3
					residential	6.8

loads, volume, and event-mean concentrations for selected properties and constituents using linear-regression procedures developed using data from the Nationwide Urban Runoff Program (NURP). Storm-water samples were analyzed for as many as 186 properties and constituents (tables 16–21 in the "Supplemental Data" section at the back of this report). Some of the properties and constituents measured include pH, specific conductance, water temperature, chemical oxygen demand, biochemical oxygen demand, bacteria, dissolved and suspended solids, major ions, nutrients, residual chlorine, total-recoverable metals, oil and grease, phenols, volatile-organic compounds, acid-base/neutral organic compounds, and pesticides.

Computed, hereinafter called observed, values for storm-runoff loads, volume, and event-mean concentrations are compared by using root-mean-square error with the results from regional-regression models developed from data collected for the NURP (Ellis and others, 1984; Driver and Tasker, 1990). Procedures are presented for using local data to adjust estimates from single-storm regional-regression models.

Description of Study Area and Sampling Sites

The study area, the city of Colorado Springs, is located in and along the eastern slope of the southern Rocky Mountains (fig. 1). The climate of the study area is semiarid. Annual precipitation for 1948–87 at the Colorado Springs airport ranged from 8.6 to 25.4 in. Mean annual precipitation at the airport was 15.2 in. Convective thunderstorms contribute most of the rainfall during May through September. Thunderstorms occur an average of 70 days each year (U.S. Geological Survey, 1970). Mean air temperatures are about 29°F in January and 70°F in July (Hansen and others, 1978).

Soils in the study area tend to be sandy, moderately deep to deep, and well drained to excessively well drained. The study area is underlain mainly by sandstone and shale and by alluvial and windlain deposits. The landform dominating the study area is the Colorado Piedmont. A more detailed description of the study area is discussed in von Guerard (1989). Another important aspect of the study area is the rate of growth associated with Colorado Springs. Population increased from 45,472 in 1950 to 281,140 in 1990. Additionally, total area of Colorado Springs increased from 9.4 mi^2 in 1950 to 181.4 mi^2 in 1990 (Christine Lytle, Colorado Springs City Engineering Division, written commun., 1992).

Each of the sampling sites, except for site 4, is located near the outfall of a drainage basin. Drainage-basin areas range from 0.049 to 0.327 mi^2, and a predominant land use can be attributed to each basin (table 1). However, all sites have a mixture of land uses, which is typical of Colorado Springs. For the purposes of this report, a drainage basin is defined by the local municipal storm-sewer network and is not necessarily delineated by the topography of the drainage basin. Selected descriptive data for the five drainage basins are listed in table 1. Except for site 4, all sites discharge into another part of the Colorado Springs storm-sewer system. Site 4 discharges directly into Monument Creek.

Site 1 is in southeastern Colorado Springs (fig. 1). The sampling site is in a 60-in. reinforced concrete pipe (RCP) and is accessed by a manhole. The manhole is located about 200 ft upstream from Spring Creek along the southern boundary fence of the Valley-Hi Golf Course and is south of the sixteenth hole. The sampling site is directly upstream from an 18-in. side drain entering the RCP from the south. Site 1 has a drainage-basin area of 0.125 mi^2, of which 58.1 percent is impervious area (table 1). Predominant land use in the drainage basin is commercial (table 1) and includes retail stores and two automobile dealerships that have repair facilities.

Site 2 is in northwest Colorado Springs (fig. 1). The sampling site is in a 72-in. RCP accessed by a manhole. The manhole is located about 100 ft southeast of the intersection of Garden of the Gods Road and Chestnut Street and is about 200 ft upstream from Douglas Creek. Site 2 has a drainage-basin area of 0.165 mi^2, of which 37.5 percent is impervious area (table 1). Predominant land use is industrial and includes tool and machine forging, computer software, heating and air-conditioning manufacturing, and metallurgy companies.

Site 3 is located in north-central Colorado Springs (fig. 1). The sampling site is in a 48-in. RCP and is accessed by a manhole. The manhole is located on the northwest corner of Beacon Street at Buchanan Street and is about 400 ft east of Monument Creek. Site 3 has a drainage-basin area of 0.173 mi^2, of which 55.9 percent is impervious area. Land use predominantly is industrial (table 1) and includes auto repair, machining, manufacturing, food-processing, welding, computer software, metal-fabrication, and paper-distribution companies.

Site 4 is in central Colorado Springs (fig. 1). The sampling site is in a 66-in. RCP accessed by a manhole. The manhole is about 0.7 mi upstream from Shooks Run and 75 ft from the southeast corner of Wahsatch Street and Cross Lane. Site 4 has a drainage-basin area of 0.327 mi^2, of which 34.2 percent is impervious area. Land use primarily is low-density residential (table 1) but includes some commercial businesses.

Site 5 is in southwest Colorado Springs (fig. 1). The sampling site is in a 42-in. RCP and is accessed by a manhole. The manhole is located about 30 ft upstream from a drainage channel leading to Bear Creek and is about 300 ft east of the southeast corner of a retail store. The sampling site is directly upstream from an 18-in. side drain entering the RCP from the northwest. Site 5 has a drainage-basin area of 0.049 mi^2 of which 40.1 percent is impervious area (table 1). Land use in the drainage basin predominantly is undeveloped (43 percent); however, commercial land use composes 39.9 percent of the drainage-basin area (table 1). The undeveloped area is in the upper part of the drainage basin and did not contribute runoff during the events sampled; therefore, runoff sampled is considered to be representative of commercial land use. Commercial land use includes two automobile dealerships that have repair facilities, a gas station, and several retail stores.

Acknowledgments

The authors appreciate the support and cooperation provided by Christine Lytle, Leonard Miller, and Bruce Thorson of the city of Colorado Springs. The authors thank Daniel Bunting, El Paso County Regional Floodplain Administrator, for providing precipitation duration data. The authors also thank Seth Bacon, Evan Howe, and Dennis Young, student employees of the U.S. Geological Survey, for their untiring efforts in collecting and processing stormwater samples.

DATA-COLLECTION TECHNIQUES, WATER-QUALITY-SAMPLING PROCEDURES, AND QUALITY-ASSURANCE PROCEDURES

Collection of storm-runoff data in the urban environment and for the purposes of NPDES requires specialized techniques and procedures. The following is a description of the data-collection techniques and sampling procedures used for this study.

Precipitation and Flow Data-Collection Techniques

Two to four precipitation storage gages were installed in each drainage basin. These gages were inspected at least daily from May 25 to August 16, 1992, and periodically, thereafter, until the completion of the snowmelt sampling. Precipitation for each drainage basin was area weighted using Thiessen polygons (Chow, 1964). In addition to providing total precipitation for each storm sampled, data collected at precipitation storage gages were used to determine precipitation conditions for 6 to 72 hours prior to the collection of a sample. To meet NPDES requirements for sampled storms, precipitation could not exceed 0.10 in. during the 72 hours preceding the collection of samples. For the four additional samples collected for selected properties and constituents, precipitation could not exceed 0.05 in. during the 6 hours preceding sample collection.

The hydraulics of flow in storm-sewer systems is extremely complex, and when coupled with the safety and logistical problems associated with accessing storm sewers, the complex hydraulics make the accurate measurement of storm-water discharge difficult. Palmer-Bowles flumes were installed at each site to measure flow in the storm sewers (Kilpatrick and others, 1985). The Palmer-Bowles flume causes flow in the RCP to be subcritical at the flume approach and forces flow through critical depth in the flume throat. Kilpatrick and others (1985) developed calibration curves for the Palmer-Bowles flumes. These calibration curves are within ±10 percent of measured flow. Depth of flow in the RCP was measured using a gas-purge conoflow pressure-regulating system and a pressure transducer. Flow depth was recorded using dataloggers.

Water-Quality-Sampling Procedures

Thirty samples were collected during rainfall runoff, and five samples were collected during snowmelt runoff. Prior to sample collection, all sample-collection bottles were washed using a nonphosphate detergent and were rinsed using tap water, 1-percent hydrochloric acid solution, and pesticide-grade methanol. Initially, and after each storm was sampled, pumping-sampler-intake lines were cleaned, using the procedure just described; in addition, the lines were given a final rinse of organic-free water. Glass mason jars used for the collection of samples for bacteria analysis were sterilized using an autoclave.

Storm-runoff samples were obtained by manually collecting grab samples and by using automatic-pumping samplers. Grab samples were collected for pH, bacteria, residual chlorine, total-recoverable cyanide, oil and grease, phenols, and volatile-organic compounds. Water temperature was measured from a grab sample immediately after collection. Grab samples were collected as depth-integrated point samples and were collected using Teflon USDH-81 samplers (Federal Inter-Agency Sedimentation Project, written commun., 1992) that were equipped with 1-qt glass jars. At all sites and at all flow depths, flow in the RCP was turbulent and well mixed.

Composite samples were collected for chemical oxygen demand, biochemical oxygen demand, specific conductance, alkalinity, dissolved and suspended solids, major ions, nutrients, total-recoverable metals, acid-base/neutral organic compounds, and pesticides. Composite samples were first collected discretely using automatic-pumping samplers equipped with Teflon intake lines and four 1-gal glass bottles. The samplers were activated by the datalogger when a predetermined flow in the RCP was exceeded. After the sampler was activated, samples were collected at intervals of 5 to 30 minutes, depending on the flow in the RCP. Samples were collected until the water level in the RCP dropped below the sampler orifice. After the bottles were filled, they were capped with Teflon-lined lids, put on ice, and transported to a field laboratory for flow-weight compositing. Flow-weighted aliquots were split from the sample into a stainless-steel Teflon-lined churn, using a Teflon cone-splitter that was equipped with Teflon tubing. The aliquot needed from each discrete sample used for flow weighting was determined using an arithmetic weighting formula:

$$Sv = (QSAMP*TVSR)/TQSC \quad (1)$$

where

Sv = the aliquot from a particular discrete sample;

QSAMP = instantaneous flow when the particular discrete sample was collected;

TVSR = the total volume of flow-weighted sample needed for processing; and

TQSC = is the sum of instantaneous flows for all discrete samples from which aliquots will be drawn.

After compositing, samples were shipped to the U.S. Geological Survey National Water-Quality Laboratory in Arvada, Colorado, for analysis.

The concentration of the flow-weighted composite sample is used to represent the storm-runoff event-mean concentration. Storm-runoff load, in pounds, was computed by multiplying the event-mean concentration by the volume of storm runoff for the storm sampled and by a unit conversion constant.

Quality-Assurance Procedures

Trip blanks and field-equipment blanks were collected and analyzed for all properties and constituents to evaluate potential field contamination. Trip blanks are sample bottles filled with water devoid of any organic or inorganic constituents. Field and laboratory spikes were used to evaluate recovery and potential loss of concentration of organic compounds. Field and laboratory spikes are sample water spiked with a constituent of a known concentration.

Trip blanks were collected to evaluate any possible contamination occurring during transport of the sample from the field to the analytical laboratory. Values and concentrations in trip blanks were almost equal to or less than the analytical detection limit for all properties and constituents. Values and concentrations in field-equipment blanks were almost equal to or less than the analytical detection limits for every property and constituent except for chemical oxygen demand and total-organic carbon indicating there was little or no field contamination.

Field and laboratory spikes for organic compounds were done to evaluate potential analytical recoveries and possible degradation of constituents from the time of collection to when samples were analyzed. Average percent recoveries for volatile organic compounds were 43 percent for field spikes and 67 percent for lab spikes. The percent recoveries of less than 100 percent for the spikes indicate some loss of constituent concentration between sample collection and analysis. Average percent recoveries for acid-base/neutral organic compounds were 80 percent for field spikes and 97 percent for laboratory spikes. For pesticide compounds, average percent recoveries were 80 percent for field spikes and 82 percent for laboratory spikes. Generally, recovery of constituents was less than 100 percent, especially for volatile organic compounds. However, percent recovery was greater than 100 percent for certain constituents. This large percent recovery can be accounted for by the possible matrix effects on certain spiked concentrations and by the precision of the analytical technique used in the analysis (Mary Olsen, U.S. Geological Survey, oral commun., 1993).

WATER QUALITY OF STORM RUNOFF

Storm-runoff water-quality data were collected at sites that represent commercial (sites 1 and 5), industrial (sites 2 and 3), and residential (site 4) land uses (table 1). The water-quality properties and constituents collected can be separated into the following major categories:

1. Properties—pH, specific conductance, temperature, chemical oxygen demand, and biochemical oxygen demand,
2. Bacteria—fecal coliform and fecal streptococci,
3. Dissolved and suspended solids and major ions,
4. Nutrients—nitrogen and phosphorus,
5. Total-recoverable metals,
6. Total-organic carbon,
7. Organic compounds—volatile, acid-base/neutral, and pesticides.

Three samples were collected at each site for NPDES permitting purposes. Four additional samples were collected for selected constituents that also were collected for NPDES purposes. The additional four samples were collected to provide a large enough sample size (seven samples per site) to estimate storm-runoff loads and event-mean concentrations for selected constituents using linear-regression procedures developed using data from the NURP. These data are summarized in table 2.

Median concentrations of chemical and 5-day biochemical oxygen demand were highest for site 4 (table 2); the median concentration for chemical oxygen demand for site 4 was 330 mg/L and for 5-day biochemical oxygen demand was 86 mg/L. Storm runoff generally had a neutral pH. The median value of pH for commercial sites was 7.5, for industrial sites was 7.3, and for the residential site was 7.4. Specific conductance of storm runoff was largest for samples collected during snowmelt runoff. Median specific conductance for all samples collected during snowmelt runoff was 385 µS/cm; during rainfall runoff, the median specific conductance was 104 µS/cm. Water temperatures ranged from 0.0 (during snowmelt runoff) to 24.5°C (table 17).

The maximum counts of fecal coliform and fecal streptococci were measured at sites 1 and 4 (table 17). Median counts for all samples at sites 1 and 4 were 4,900 and 17,000 col/100 mL. However, largest median counts for bacteria were in samples from site 4 at 4,900 col/100 mL for fecal coliform and 20,500 col/100 mL for fecal streptococci.

Dissolved-solids concentrations ranged from 34 to 4,240 mg/L (table 19) for all land uses, and the range of concentrations was similar for all sites. The largest concentrations of dissolved solids were measured from snowmelt samples. The largest concentration of suspended solids, 1,400 mg/L, was measured for site 5 (table 19). The largest median concentration of suspended solids was 826 mg/L at site 5.

Table 2. Summary statistics for selected constituents in storm runoff for storm-runoff-sampling sites in Colorado Springs

[mg/L, milligrams per liter; µg/L, micrograms per liter; -, not available due to censored data]

Summary statistic	Constituent													
	Oxygen demand, chemical (high level) (mg/L)	Oxygen demand, biochemical, 5-day (mg/L)	Solids, dissolved (mg/L)	Solids, suspended (mg/L)	Nitrogen, ammonia, total as nitrogen (mg/L)	Nitrogen, ammonia plus organic, total, as nitrogen (mg/L)	Nitrogen, nitrite, total, as nitrogen (mg/L)	Nitrogen, nitrate plus nitrite, total, as nitrogen (mg/L)	Phosphorus, total, as phosphorus (mg/L)	Phosphorus, dissolved, as phosphorus (mg/L)	Cadmium, total recoverable (µg/L)	Copper, total recoverable (µg/L)	Lead, total recoverable (µg/L)	Zinc, total recoverable (µg/L)
							Sixteenth Hole, Valley-Hi Golf Course (site 1)							
Number of samples	7	5	7	7	7	7	7	7	7	7	7	7	7	7
Minimum	100	19	63	121	0.28	0.9	0.02	0.40	0.12	0.08	<1	9	23	140
Maximum	310	53	202	524	0.98	2.4	.11	1.00	.45	.28	1	17	170	300
Mean	200	34	108	284	0.60	1.8	.05	.73	.28	.13	-	13	81	204
Median	180	29	93	274	0.67	1.7	.04	.80	.29	.12	<1	12	64	190
							Chestnut Street at Douglas Creek (site 2)							
Number of samples	7	6	7	7	7	7	7	7	7	6	7	7	7	7
Minimum	100	14	34	198	0.23	.90	.03	.45	.09	.06	<1	12	47	230
Maximum	420	80	256	1280	1.10	2.4	.08	1.10	.72	.21	2	99	350	1400
Mean	240	36	94	595	0.49	1.4	.04'	.80	.24	.11	-	39	189	730
Median	230	31	63	464	0.43	1.1	.04	.87	.17	.09	1	19	150	570
							Beacon Street at Buchanan Street (site 3)							
Number of samples	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Minimum	120	26	54	101	0.48	1.6	.03	.66	.16	.10	<1	12	23	150
Maximum	300	74	168	340	1.50	4.0	.07	1.40	.58	.51	2	24	97	400
Mean	210	51	100	220	1.01	2.9	.05	.95	.36	.23	-	16	63	270
Median	200	51	87	220	.99	2.9	.04	1.00	.33	.18	2	14	55	280

Table 2. Summary statistics for selected constituents in storm runoff for storm-runoff-sampling sites in Colorado Springs--Continued

Summary statistic	Constituent													
	Oxygen demand, chemical (high level) (mg/L)	Oxygen demand, biochemical, 5-day (mg/L)	Solids, dissolved (mg/L)	Solids, suspended (mg/L)	Nitrogen, ammonia, total as nitrogen (mg/L)	Nitrogen, ammonia plus organic, total, as nitrogen (mg/L)	Nitrogen, nitrite, total, as nitrogen (mg/L)	Nitrogen, nitrate plus nitrite, total, as nitrogen (mg/L)	Phosphorus, total, as phosphorus (mg/L)	Phosphorus, dissolved, as phosphorus (mg/L)	Cadmium, total recoverable (µg/L)	Copper, total recoverable (µg/L)	Lead, total recoverable (µg/L)	Zinc, total recoverable (µg/L)
						Wahsatch Street at Cross Lane (site 4)								
Number of samples	7	5	6	7	7	7	7	7	7	5	7	7	7	7
Minimum	190	29	74	116	0.16	1.6	.03	.36	.22	.11	<1	8	32	110
Maximum	500	140	908	848	1.00	5.3	.08	.88	1.20	.38	2	22	130	310
Mean	310	84	229	472	0.49	3.8	.05	.59	.75	.26	-	13	89	200
Median	330	86	100	512	0.39	3.8	.05	.47	.72	.27	1	12	110	220
						Walmart at Eighth Street (site 5)								
Number of samples	7	7	6	7	7	7	7	7	7	6	7	7	7	7
Minimum	160	29	67	388	.41	1.2	.03	.69	.21	.09	1	15	85	210
Maximum	830	260	4240	1400	3.90	7.4	.31	1.80	1.00	.34	21	70	350	730
Mean	340	94	790	846	1.30	3.3	.09	1.20	.60	.19	5	28	220	440
Median	260	67	110	826	1.00	2.3	.06	1.20	.59	.17	2	18	200	340

Samples were collected to characterize concentrations of nutrients (nitrogen and phosphorous) in storm runoff. Sites 3 and 5 had the largest median concentrations for ammonia as nitrogen and nitrate plus nitrite as nitrogen, 1.0 and 1.2 mg/L. Site 4 had the largest median concentrations for total ammonia plus organic nitrogen as nitrogen, and total and dissolved phosphorus at 3.8, 0.72, and 0.27 mg/L.

Generally, concentrations of total-recoverable metals were similar for all sites (table 19). Concentrations of total-recoverable lead were largest for sites 2 and 5 and had a median concentration of 180 µg/L. Concentrations of total-recoverable copper, nickel, and zinc were largest for sites 2 and 5 and had median concentrations of 18.0, 16.0, and 500 µg/L.

The largest median concentration of total-organic carbon was 100 mg/L at site 4. The median concentration of total-organic carbon for sites 1, 2, 3, and 5 was 52 mg/L.

Each sample collected for volatile-organic compounds (VOC) was analyzed for 61 constituents. The largest number of VOC's detected were 21 at site 4 and 31 at site 5. The number of VOC's detected, the number of samples collected, and the number of times each VOC was detected are listed for each site in table 3. Generally, volatile organic compounds were detected more often in samples collected during snowmelt runoff than in samples collected during rainfall runoff. A possible explanation for the higher number of detections of volatile organic compounds in snowmelt-runoff samples is that these samples were collected at a lower temperature than were the samples collected during rainfall runoff. Volatile organic compounds volatilize at a slower rate at the lower temperatures during snowmelt runoff. The volatile organic compounds detected generally were associated with gasoline and other petroleum products.

Each sample collected for acid-base/neutral organic compounds was analyzed for 57 constituents. The largest number of acid-base/neutral organic compounds detected was 21 at sites 1 and 3 and 26 at site 2. The number of acid-base/neutral compounds detected, the number of samples collected, and the number of times each compound was detected is listed in table 3. Except for chlordane in the sample collected at site 4 on June 12, concentrations of pesticides were less than the analytical detection limits for all samples.

PROCEDURES FOR ESTIMATING SINGLE-STORM-RUNOFF LOADS, VOLUME, AND EVENT-MEAN CONCENTRATIONS

The NPDES permitting process requires the estimation of total annual pollutant loads and event-mean concentrations for 12 properties and constituents. The 12 properties and constituents are chemical oxygen demand (COD), 5-day biochemical oxygen demand (BOD), dissolved solids (DS), suspended solids (SS), total nitrogen (TN), total ammonia plus organic nitrogen as nitrogen (TKN), total phosphorus (TP), dissolved phosphorus (DP), total-recoverable cadmium (CD), total-recoverable copper (CU), total-recoverable lead (PB), and total-recoverable zinc (ZN). In a simplistic assessment, seasonal or annual storm-runoff loads, volume, and event-mean concentrations could be estimated using mean concentrations of properties and constituents from the set of sampled storms. However, better estimates of single-storm-runoff loads and event-mean concentrations can result by using multiple-regression analysis to relate these response variables to climatic, physical, and land-use characteristics (Driver and Tasker, 1990). These regression models could be used with precipitation data and physical and land-use information to estimate single-storm-runoff loads, volume, and event-mean concentrations for individual storms at ungaged storm-runoff sites.

The form of the regression equation used for estimating single-storm-runoff loads, volume, and event-mean concentrations is a linear function of the logarithmic-transformed variables:

$$\log Y = \log B_0 + B_1 \log X_1 + B_2 \log X_2 + \ldots + B_N \log X_N \qquad (2)$$

Taking the antilogs, the equation becomes:

$$Y = B_0 X_1^{B1} X_2^{B2} \ldots\ldots X_N^{BN}, \qquad (3)$$

where

Y	= estimated storm-runoff load, volume, or event-mean concentration (response variable);
B_0, B_1, B_2, B_N	= regression coefficients;
$X_1, X_2, \ldots, X_N$	= climatic, physical, or land-use variables (explanatory variables); and
N	= number of climatic, physical, and land-use variables in the regression model.

A transformation bias is produced when logarithms of the estimated mean response (log of the response variable) is retransformed (equation 3). This transformation bias usually results in the underestimation of the estimated mean response. However, the major part of this transformation bias may be eliminated by multiplying the estimated mean response by a correction factor (Duan, 1983):

$$BCF = \frac{1}{n} \sum_{i=1}^{n} 10^{e_i} \qquad (4)$$

Table 3. Summary of detections of organic compounds in storm runoff for storm-runoff-sampling sites in Colorado Springs

[All compounds in micrograms per liter]

Site	Constituent	Number of samples	Number of detections
	VOLATILE-ORGANIC COMPOUNDS		
Sixteenth Hole, Valley-Hi Golf Course (site 1)	Benzene, total	10	1
	Ethyl-benzene, total	10	1
	Naphthalene, total	10	3
	Toluene, total	10	2
	Xylene, water, whole, total recoverable	10	3
	1,2,4-trimethyl benzene, water, whole, recoverable	10	2
	1,3,5-trimethyl benzene, water, whole, recoverable	10	1
	ACID-BASE/NEUTRAL ORGANIC COMPOUNDS		
	Benzogh-i-perylenel, 12-benzo perylene, total	3	1
	Benzo-b-flouranthene, total	3	2
	Bis (2-ethylhexyl) phthalate, total	3	3
	Chrysene, total	3	2
	Di-n-butyl phthalat, total	3	3
	Fluoranthene, total	3	3
	Indeno (1,2,3-cd) pyrene, total	3	1
	Phenanthrene, total	3	3
	Pyrene, total	3	3
	VOLATILE-ORGANIC COMPOUNDS		
Chestnut Street at Douglas Creek (site 2)	Naphthalene, total	7	3
	Toluene, total	7	3
	Xylene, water, whole, total recoverable	7	4
	1,2,4-trimethyl benzene, water, whole, recoverable	7	2
	ACID-BASE/NEUTRAL ORGANIC COMPOUNDS		
	Anthracene, total	3	2
	Benzo-a-anthracenel, 2-benzanthracene, total	3	2
	Benzo-a-pyrene, total	3	2
	Benzogh-i-perylenel, 12-benzo perylene, total	3	1
	Benzo-b-fluoranthene, total	3	2
	Benzo-k-fluoranthene, total	3	2
	Bis (2-ethylhexyl) phthalate, total	3	3
	Chrysene, total	3	2
	Fluoranthene, total	3	3
	Indeno (1,2,3-cd) pyrene, total	3	2
	Phenanthrene, total	3	2
	Pyrene, total	3	3

Table 3. Summary of detections of organic compounds in storm runoff for storm-runoff-sampling sites in Colorado Springs --Continued

Site	Constituent	Number of samples	Number of detections
	VOLATILE-ORGANIC COMPOUNDS		
Beacon Street at Buchanan Street (site 3)	Dichlorobromomethane, total	8	1
	Naphthalene, total	8	6
	Toluene, total	8	1
	Xylene, water, whole, total recoverable	8	2
	1,2,4-trimethyl benzene, water, whole, recoverable	8	1
	1,3,5-trimethyl benzene, water, whole, recoverable	8	1
	ACID-BASE/NEUTRAL COMPOUNDS		
	Anthracene, total	3	1
	Benzo-a-anthracenel, 2-benzanthracene, total	3	1
	Benzo-a-pyrene, total	3	2
	Benzogh-i-perylenel, 12-benzo perylene, total	3	1
	Benzo-b-flouranthene, total	3	2
	Benzo-k-fluoranthene, total	3	2
	Bis (2-ethylhexyl) phthalate, total	3	3
	Chrysene, total	3	2
	Fluoranthene, total	3	2
	Indeno (1,2,3-cd) pyrene, total	3	1
	Phenanthrene, total	3	2
	Pyrene, total	3	2
	VOLATILE-ORGANIC COMPOUNDS		
Wahsatch Street at Cross Lane (site 4)	Benzene, total	8	1
	Ethyl-benzene, total	8	1
	Naphthalene, total	8	4
	P-isopropyl toluene, water, whole, recoverable	8	1
	Toluene, total	8	6
	Xylene, water, whole, total recoverable	8	4
	1,2,4-trimethyl benzene, water, whole, recoverable	8	3
	1,3,5-trimethyl benzene, water, whole, recoverable	8	1
	ACID-BASE/NEUTRAL ORGANIC COMPOUNDS		
	Benzo-a-pyrene, total	3	1
	Benzo-b-fluoranthene, total	3	1
	Benzo-k-fluoranthene, total	3	1
	Bis (2-ethylhexyl) phthalate, total	3	3
	Chrysene, total	3	1
	Fluoranthene, total	3	2
	Phenanthrene, total	3	2
	Pyrene, total	3	2

Table 3. Summary of detections of organic compounds in storm runoff for storm-runoff-sampling sites in Colorado Springs

Site	Constituent	Number of samples	Number of detections
	PESTICIDE COMPOUNDS		
Wahsatch Street at Cross Lane (site 4) --Continued	Chlordane, total	3	1
	VOLATILE-ORGANIC COMPOUNDS		
Walmart at Eighth Street (site 5)	Benzene, total	9	1
	Chloroform, total	9	5
	Cis-1,2-dichloroethene, water, total	9	1
	Ethyl benzene, total	9	1
	N-butyl benzene, water, whole, recoverable	9	1
	N-propyl benzene, water, whole, recoverable	9	1
	Naphthalene, total	9	6
	Toluene, total	9	5
	Xylene, water, whole, total recoverable	9	4
	1,1,1-trichloroethane, total	9	2
	1,2,4-trimethyl benzene, water, whole, recoverable	9	3
	1,3,5-trimethyl benzene, water, whole, recoverable	9	1
	ACID-BASE/NEUTRAL ORGANIC COMPOUNDS		
	Anthracene, total	3	1
	Bis (2-ethylhexyl) phthalate, total	3	3
	Di-n-octyl phthalate, total	3	1
	Di-n-butyl phthalate, total	3	2
	Fluoranthene, total	3	3
	N-butyl benzyl phthalate, total	3	2
	Phenanthrene, total	3	2
	Pyrene, total	3	3

where

BCF = the bias correction factor,
n = the number of observations in the data set, and
e_i = least-squares residual for observation i from the calibration data set, in log units.

Single-Storm Local-Regression Models

Using data collected for 30 rainfall-runoff storms, single-storm local-regression models were developed for the Colorado Springs area for estimating storm-runoff loads for the 12 NPDES properties and constituents and for estimating storm-runoff volume and event-mean concentrations for the 12 NPDES properties and constituents. The data for 30 storms from 5 drainage basins (6 storms in each drainage basin) are listed in tables 16 and 19. Data collected for snowmelt samples (the November and December samples) were not available at the time of this analysis and, thus, were not included in the development of the local-regression models. Also, techniques for estimating storm-runoff loads, volumes, and event-mean concentrations were developed using data for rainfall-runoff conditions (Ellis and others, 1984; Driver and Tasker, 1990), and the snowmelt samples represent different hydrologic processes and need to be considered separately. The models were developed using ordinary least-squares regression, except for total-recoverable cadmium (CD). The CD data set had 11 of the 30 analyses reported as less than (censored) values. Ordinary least-squares regression should not be used with censored data. However, censored data can be included with uncensored data using tobit regression, which is similar to least-squares regression, in which the parameter estimates are fit using maximum-likelihood estimation (Helsel and Hirsch, 1992). Except for two, all CD concentrations were 3 µg/L or less (table 19); however, the CD concentration of 21 µg/L was not included in this analysis because it is not considered representative of storm runoff in the study area. Storm-runoff loads, volume, and event-mean concentrations (response variables) were modeled using the following climatic, physical, and land-use characteristics (explanatory variables):

1. Total rainfall (TRN), in inches,
2. Total contributing drainage-basin area (DA), in
3. Impervious area (IA), as a percent of total contributing drainage-basin area,
4. Industrial land use (LUI), as a percent of total contributing drainage-basin area,
5. Commercial land use (LUC), as a percent of total contributing drainage-basin area,
6. Residential land use (LUR), as a percent of total contributing drainage-basin area,
7. Nonurban land use (LUN), as a percent of total contributing drainage-basin area,
8. Period (in days) preceding collection of a sample having less than 0.10 in. of precipitation (DD).

The RSQUARE procedure (Statistical Analysis System Institute, Inc., 1990) was used to determine which combination of explanatory variables composed the most suitable regression model. The RSQUARE procedure performs all possible linear regressions for all possible combinations of explanatory variables and determines the subsets of explanatory variables that have the largest r^2 value (Statistical Analysis System Institute, Inc., 1990). For the models to have a hydrologic and physiographic basis, only subset regression models including the explanatory variables TRN and DA were evaluated. The most suitable regression model was selected on the basis of the statistical significance of explanatory variables in the regression, the values of r^2, and checked using other model selection criteria (Statistical Analysis System Institute, Inc., 1990). An r^2 value is the proportion of the total variation of the response variable that is explained by the explanatory variables. For certain properties and constituents, all of the possible regressions included explanatory variables that were not significant at the 5-percent confidence level. Therefore, some regression models that were selected as the most suitable included explanatory variables that were not significant at the 5-percent confidence level (tables 4 and 5). However, inclusion of these variables in the models improved the computed r^2 and were considered useful predictors of the dependent variables. For event-mean concentrations for BOD, the local-regression model was not significant at the 5-percent confidence level (table 5). For evaluating all possible regression models (RSQUARE procedure) for storm-runoff loads and for event-mean concentrations for CD, only uncensored data were used (19 of the 30 values for CD were uncensored).

Plots of residual (observed values minus estimated values) compared to estimated values were analyzed to evaluate the constant variance (homoscedasticity) of the residuals. Residual plots for all of the most suitable models indicate that the variance of the residuals generally is constant throughout the entire

Table 4. Summary of single-storm local-regression models for storm-runoff loads and volume for storm-runoff-sampling sites in Colorado Springs

[Bo, the regression coefficient that is the intercept in the regression model; B_1 and B_n, regression coefficients; TRN, total rainfall; DA, total contributing drainage-basin area; IA, impervious area; LUI, industrial land use; LUC, commercial land use; LUR, residential land use; LUN, nonurban land use; DD, period preceding collection of a sample having less than 0.10 inch of precipitation; BCF, bias correction factor; r^2, the coefficient of determination; COD, chemical oxygen demand, in pounds; BOD, 5-day biochemical oxygen demand, in pounds; DS, dissolved solids, in pounds; SS, suspended solids, in pounds; TN, total nitrogen, in pounds; TKN, total ammonia plus organic nitrogen as nitrogen, in pounds; TP, total phosphorus, in pounds; DP, dissolved phosphorus, in pounds; CD, total-recoverable cadmium, in pounds; CU, total-recoverable copper, in pounds; PB, total-recoverable lead, in pounds; ZN, total-recoverable zinc, in pounds; RUN, storm-runoff volume, in cubic feet; asterisk (*) indicates the explanatory variable is not significant at the 5 percent level; dashes indicate that the variable is not included in the model; ln, natural log; NA, not applicable; the form of regression equation is:

$$Y = B_o X_1^{B1} \ldots X_n^{Bn}(BCF)$$

Response variable	Bo	Explanatory variables								BCF	r^2	Standard error of estimate	
		TRN (inches)	DA (square miles)	IA + 1 (percent)	LUI + 1 (percent)	LUC + 1 (percent)	LUR + 1 (percent)	LUN + 1 (percent)	DD (days)			Percent	Log
COD	17,167	0.92	2.51	--	--	0.63	-0.81	0.86	--	1.13	0.76	61	0.244
BOD	1,000	.64	0.66	--	-0.30	--	--	--	--	1.14	.78	63	.259
DS	188,799	.70	1.51	--	-.66	--	-1.30	.38	--	1.10	.78	54	.218
SS	1,812	1.36	.17*	--	--	--	--	.38	--	1.23	.65	88	.330
TN	0.48	.89	.05*	2.15	--	--	.55	--	--	1.07	.81	59	.191
TKN	.0001	.69	9.34	--	2.77	4.64	--	3.51	--	1.10	.78	52	.214
TP	5.98	1.00	.24*	--	-.33	--	--	--	--	1.14	.80	58	.235
DP	1.89*	.86	.39*	--	-.19	--	--	--	--	1.22	.60	79	.303
CD[1]	-5.09	1.46	-.087	.10	--	--	--	--	--	1.14	NA	247	.608
CU	.00003	1.06	7.56	--	2.32	3.59	--	2.99	--	1.13	.76	61	.244
PB	750	1.36	-.78	--	-.95	-1.15	-1.16*	--	--	1.29	.66	101	.365
ZN	359	1.01	3.20	--	--	.58	-1.70	1.30	--	1.27	.57	115	.398
RUN	32.5	.98	7.86	--	2.24	3.80	--	2.92	--	1.07	.86	43	.178

[1]equation form is $y = e^{Bo} + e^{\ln TRN^{B_1}} + e^{\ln DA^{B_2}} + e^{\ln(IA+1)^{B_3}} BCF.$

Table 5. Summary of single-storm local-regression models for storm-runoff event-mean concentrations for storm-runoff-sampling sites in Colorado Springs

[Bo, the regression coefficient that is the intercept in the regression model; B_1 and B_n, regression coefficients; TRN, total rainfall; DA, total contributing drainage-basin area; IA, impervious area; LUI, industrial land use; LUC, commercial land use; LUR, residential land use; LUN, nonurban land use; DD, period preceding collection of a sample having less than 0.10 inch of precipitation; BCF, bias correction factor; r^2, the coefficient of determination; COD, chemical oxygen demand, in milligrams per liter (mg/L); BOD, 5-day biochemical oxygen demand, in mg/L; DS, dissolved solids, in mg/L; SS, suspended solids, in mg/L; TN, total nitrogen, in mg/L; TKN, total ammonia plus organic nitrogen as nitrogen, in mg/L; TP, total phosphorus, in mg/L; DP, dissolved phosphorus, in mg/L; CD, total-recoverable cadmium, in micrograms per liter (µg/L); CU, total-recoverable copper, in µg/L; PB, total-recoverable lead, in µg/L; ZN, total-recoverable zinc, in µg/L; asterisk (*) indicates the explanatory variable is not significant at the 5 percent level; dashes indicate that the variable is not included in the model; ln, natural log; NA, not applicable; the form of regression equation is:

$$Y = B_o X_1^{B1} ... X_n^{Bn}(BCF)$$

Response variable	Bo	Explanatory variables								BCF	r^2	Standard error of estimate	
		TRN (inches)	DA (square miles)	IA + 1 (percent)	LUI + 1 (percent)	LUC + 1 (percent)	LUR + 1 (percent)	LUN + 1 (percent)	DD (days)			Percent	Log
COD	6,558	-0.02*	-2273	--	-.92	-1.46	--	-1.02	--	1.13	0.25	41	0.172
BOD[1]	115,432	-.35*	-6.64	--	-2.24	-3.52	--	-2.59	--	1.14	.43	65	.258
DS	35.5	-.37	.04*	--	--	--	--	0.19	--	1.05	.31	35	.148
SS	242,384	.36*	-0.57	-1.80	--	--	--	--	--	1.14	.44	62	.248
TN	.88*	-.16*	-.36	--	--	--	0.35	-.24	--	1.04	.42	32	.136
TKN	.06	-.28	-.12*	.49*	--	--	--	--	--	1.05	.38	35	.149
TP	.0055	.02*	-1.98	--	--	-.34	-1.27	-.72	--	1.06	.56	55	.224
DP	.0046	-.22*	-1.41	--	--	-.25	.93	-.60	.28	1.06	.63	38	.161
CD[2]	-.097*	.26*	-.22	--	--	-.148	--	--	--	1.05	NA	171	.508
CU	15	.02	-.43	--	--	-.30	--	--	.17	--	.50	44	.181
PB	39,346	.57	-.73	-1.65	--	--	--	--	--	1.14	.49	66	.250
ZN	347	.12*	-.65	--	--	-.43	--	--	--	1.08	.60	44	.183

[1]regression model significant at the 20 percent level.

[2]equation form is $y = e^{Bo} + e^{\ln TRN^{B_1}} + e^{\ln DA^{B_2}} + e^{\ln LUC+1^{B_3}} BCF.$

range of prediction. Because hydrologic data usually are skewed when using parametric statistical techniques, such as RSQUARE, data need to be transformed to minimize the heteroscedasticy of residuals and to linearize the x,y relation. Response and explanatory variables used in the RSQUARE procedure were log transformed (base 10).

The local-regression models for storm-runoff loads, volume, and event-mean concentrations and the corresponding BCF, r^2 values, and the standard error of estimate are listed in tables 4 and 5. The standard error of estimate is an estimate of the standard deviation about the regression. The smaller the standard error of estimate, the more precise will be the predictions (Driver and Tasker, 1990). The standard error of estimate, in percent, was calculated for all the local-regression models using the following equation (Driver and Tasker, 1990):

$$SE = 100 \{ [e^{(mse \times 5.302)} - 1] \}^{0.5} \qquad (5)$$

where

SE = the standard error of estimate, in percent;

mse = the mean square error, in log (base 10) units; and

5.302 = the square of the conversion of log base-10 values to natural logs.

The values of r^2 that use ordinary least-squares regression ranged from 0.57 to 0.86 for storm-runoff loads and volume (table 4) and from 0.25 to 0.63 for storm-runoff event-mean concentrations (table 5). Except for CD, standard errors of estimate range from 43 to 115 percent for storm-runoff loads and volume and 32 to 66 percent for storm-runoff event-mean concentrations (tables 4 and 5). Standard errors of estimate for storm-runoff load and event-mean concentration for CD were 247 (table 4) and 171 percent (table 5). The accuracy of the load, volume, and concentration models cannot be compared on the basis of standard error of estimate because the units of the response variable for each model are different (Hoos and Sisolak, 1993).

The explanatory variables generally had signs (positive or negative) that were hydrologically logical. However, occasionally, the signs on individual explanatory variables seem to be counter intuitive. Driver and Tasker (1990) list the following explanations for why the signs of some regression coefficients (explanatory variables) may be counter intuitive:

1. Significant cross-correlation between explanatory variables causes multicollinearity problems in the local-regression models, however, this is accounted for in the RSQUARE procedure.
2. The process involving the effect of the explanatory variables on the water-quality constituent is not well understood.
3. The explanatory variable is a surrogate for another variable.
4. The apparent significance of an explanatory variable may be due to chance and, therefore, the relation may be spurious.

Use of the local-regression models listed in tables 4 and 5 need to be limited to the ranges of climatic, physical, and land-use (explanatory) variables listed in table 6. If values outside these ranges are used in the local- regression models, the standard errors may be considerably larger than the values reported in tables 4 and 5. As the local-regression models are applied to drainage-basin areas and to storms larger than the average drainage-basin area or storm volume of the observation sites, the accuracy of estimates of storm-runoff loads, volume, and event-mean concentrations decreases.

Single-Storm Regional-Regression Models

Procedures for estimating single-storm runoff loads, volume, and event-mean concentrations were developed by Ellis and others (1984) and Driver and Tasker (1990) for 11 of the 12 properties and constituents required for the permitting process. Regional-regression equations for BOD were not developed. Linear-regression equations were developed from data collected by the NURP. Equations developed by Ellis and others (1984) were developed using NURP data collected in the Denver metropolitan area. The Driver and Tasker (1990) equations were developed from the NURP data base and include sets of equations for three geographically distinct regions delineated by mean annual rainfall. The Colorado Springs area is included in Region 1. Comparison of estimates from these regional-regression models with observed storm-runoff loads, volume, and event-mean concentrations for samples collected in the study area will be useful in selecting the most appropriate method for estimating single-storm runoff loads, volume, and event-mean concentrations.

Comparison of Observed and Estimated Single-Storm-Runoff Loads, Volume, and Event-Mean Concentrations

Storm-runoff loads, volume, and event-mean concentrations estimated from single-storm regional-

Table 6. Ranges of values of each explanatory values of each explanatory variable used in single-storm local- and regional-regression models

[TRN, total rainfall, in inches; DA, total contributing drainage area, in square miles; IA, impervious area, in percent; DRN, duration of rainfall, in minutes; COD, chemical oxygen demand; DS, dissolved solids; SS, suspended solids; TN, total nitrogen; TKN, total ammonia plus organic nitrogen as nitrogen; TP, total phosphorus; DP, dissolved phosphorus; CD, total-recoverable cadmium; CU, total-recoverable copper; PB, total-recoverable lead; ZN, total-recoverable zinc; RUN, volume of runoff in cubic feet; dashes, no data available]

Response variable	Explanatory variable	Minimum	Maximum	Mean	Median
		Local-regression model for storm-runoff-sampling sites in Colorado Springs			
([1])	TRN	0.05	0.41	0.17	0.14
([1])	DA	.049	.327	.17	.16
([1])	IA	34.2	58.1	45.2	40.1
SS	DRN	7.00	39.3	62.1	35.0
		Driver and Tasker (1990) regression model			
COD	TRN	.02	1.99	.36	.26
COD	DA	.05	17.50	1.18	.12
COD	IA	--	--	--	--
DS	TRN	.02	1.23	.36	.28
DS	DA	.01	80.5	4.92	.12
DS	IA	11	98.9	60.6	57
SS	TRN	.03	1.99	.39	.29
SS	DA	.05	17.50	1.45	.12
SS	IA	--	--	--	--
SS	DRN	10	2,220	358	231
TN	TRN	.03	1.99	.41	.29
TN	DA	.01	80.5	6.37	.11
TN	IA	--	--	--	--
TKN	TRN	.03	1.99	.37	.28
TKN	DA	.05	80.5	4.79	.12
TKN	IA	--	--	--	--
TP	TRN	0.03	1.99	0.38	0.28
TP	IA	--	--	--	--
DP	TRN	.03	1.99	.39	.28
DP	DA	.01	4.00	.50	.11
DP	IA	--	--	--	--
CD	TRN	.03	.93	.26	.22
CD	DA	0.01	3.03	0.36	0.12
CD	IA	--	--	--	--
CU	TRN	.02	1.99	.37	.27
CU	DA	.01	4.00	.55	.12
CU	IA	--	--	--	--
PB	TRN	.02	1.99	.39	.28
PB	DA	.004	4.00	.47	.11
PB	IA	--	--	--	--
ZN	TRN	.02	1.99	.39	.28
ZN	DA	.01	4.00	.53	.12
ZN	IA	--	--	--	--

Table 6. Ranges of values of each explanatory values of each explanatory variable used in single-storm local- and regional-regression models--Continued

Response variable	Explanatory variabla	Minimum	Maximum	Mean	Median
RUN	TRN	.02	1.99	.36	.26
RUN	DA	.004	80.5	2.93	.11
RUN	IA	0	98.9	56.7	57
		Small basins [Ellis and others (1984)] regression model			
([2])	TRN	.03	1.99	.35	--
([2])	DA	.09	.63	.20	.12
([2])	IA	.60	91	36.7	38
		Small and large basins [Ellis and others (1984)] regression model			
([2])	TRN	--	--	--	--
([2])	DA	0.09	24.7	6.1	0.20
([2])	IA	.6	91	31.8	24

[1]Includes storm-runoff load and event-mean concentration for chemical oxygen demand, dissolved solids, suspended solids, total nitrogen, total ammonia plus organic nitrogen as nitrogen, total phosphorus, dissolved phosphorus, total-recoverable cadmium, total-recoverable copper, total-recoverable lead, total-recoverable zinc, and volume of runoff for RUN.

[2]Includes storm-runoff load for chemical oxygen demand, suspended solids, total nitrogen, total phosphorus, total-recoverable lead, total-recoverable zinc, and volume of runoff for RUN.

regression models were compared to observed values from data collected at five sites in the study area in 1992 (fig. 1, table 1). The response variables estimated by Driver and Tasker (1990) are storm-runoff loads for COD, SS, DS, TN, TKN, TP, DP, CD, CU, PB, and ZN; storm-runoff volume, and event-mean concentrations for COD, SS, DS, TN, TKN, TP, DP, CD, CU, PB, and ZN. The response variables estimated by Ellis and others (1984) are storm-runoff loads for COD, SS, TN, TP, PB, and ZN and storm-runoff volume. Driver and Tasker (1990) developed two sets of single-storm regional-regression models for storm-runoff loads and volume. The first set of models was based on a stepwise regression analysis of 13 explanatory variables including TRN, DA, IA, land-use, and regional climatic variables. The second set of models was based on three explanatory variables—TRN, DA, and IA. The single-storm regional-regression models for storm-runoff event-mean concentrations are based on stepwise regression analysis of the same 13 explanatory variables used to develop models for storm-runoff load and volume. Single-storm regional-regression models developed by Ellis and others (1984) for storm-runoff loads and volume were based on three explanatory variables—TRN, DA, and IA.

Comparisons of observed and estimated storm-runoff loads, volume, and event-mean concentrations were made using the root-mean-square error (RMSE) of estimate from the equation:

$$\mathrm{RMSE} = \left[\frac{1}{n}\sum_{i=1}^{n}(\log O_i - \log E_i)^2\right]^{\frac{1}{2}} \qquad (6)$$

where

RMSE = the root-mean-square error in log units (base 10);
O_i = ith observed value;
E_i = ith estimated value from the regional-regression model; and
n = the number of observations in the data set.

Generally, when compared to observed values, the 3-variable models that were developed by Driver and Tasker (1990) for estimating storm-runoff loads had the smallest RMSE (table 7). For estimates of storm-runoff volume, when compared to observed values, the multivariate model developed by Driver and Tasker (1990) had the smaller RMSE (table 7).

An evaluation of residuals from a comparison of observed and estimated storm-runoff loads, volume, and event-mean concentrations can be used to determine the direction of bias of estimated values compared to observed values. Compared to observed values, most regional-regression models tended to overestimate (negative sign in table 8) storm-runoff loads, volume, and event-mean concentrations. However, the direction of bias was not consistent for all properties and constituents and runoff volume (table 8).

Table 7. Root-mean-square error from comparison of observed storm-runoff loads and volumes and estimated storm-runoff loads and volumes from single-storm regional-regression models

[COD, chemical oxygen demand, in pounds; DS, dissolved solids, in pounds; SS, suspended solids, in pounds; TN, total nitrogen, in pounds; TKN, total ammonia plus organic nitrogen as nitrogen, in pounds; TP, total phosphorus, in pounds; DP, dissolved phosphorus, in pounds; CD, total-recoverable cadmium, in pounds; CU, total-recoverable copper, in pounds; PB, total-recoverable lead, in pounds; ZN, total-recoverable zinc, in pounds; RUN, volume, in cubic feet; dashes indicate not available]

Response variable	Root-mean-square error in log units			
	Regional-regression models from Driver-Tasker (1990)		Regional-regression models from Ellis and others (1984)	
	3-variable model[1]	Multivariate model[2]	Small drainage basins[3]	Small and large drainage basins[4]
COD	0.353	0.738	0.421	0.384
DS	.396	.423	--	--
SS	.463	3.70	.490	.549
TN	.256	.669	.336	.279
TKN	.960	1.11	--	--
TP	.598	1.13	.461	.469
DP	.637	1.12	--	--
CD[5]	.409	.626	--	--
CU	.666	1.15	--	--
PB	.668	.708	.782	.583
ZN	.421	.494	.517	.495
RUN	--	.332	.375	.354

[1]Equations from table 3 in Driver and Tasker (1990).
[2]Equations from table 1 in Driver and Tasker (1990).
[3]Equations from table 19 in Ellis and others (1984).
[4]Equations from table 20 in Ellis and others (1984).
[5]Root-mean-square error computed withont censored data.

Differences between the observed and estimated storm-runoff loads, volume, and event-mean concentrations can be explained by the following:

1. Hydrologic conditions controlling the detection of properties and constituents specific to Colorado Springs are not explained by the Driver and Tasker (1990) models.
2. Data collected for certain properties and constituents for the NURP studies might not be representative of the Colorado Springs area.
3. Regional-regression models were developed using a larger range of drainage-basin areas than the drainage-basin areas used for this study (tables 1 and 6). Therefore, regional-regression models might be biased and might be overestimating storm-runoff loads, volume, and event-mean concentrations for smaller drainage basins.

Procedures for Adjustment of Estimates from Single-Storm Regional-Regression Models Using Local Data

When compared to observed data, single-storm regional-regression models tended to overestimate storm-runoff loads, volume, and event-mean concentrations. As a result, single-storm local-regression models would be the preferred method for estimating storm-runoff loads, volume, and event-mean concentrations because the single-storm local-regression models were developed using local data based on the climatic, physical, and land-use characteristics of the Colorado Springs area. However, only a small number of observations (30--snowmelt samples not included) were available for the development of the single-storm local-regression models, and the use of the single-storm local-regression models need to be limited to estimates within the ranges of the explanatory variables used to develop the model (table 6). Single-storm regional-regression models are based on a large number of observations (65 to 348), and the explanatory variables have a wider range than the explanatory vari-

Table 8. Summary of residual values for observed minus estimated values of storm-runoff loads, volume, and event-mean concentrations

[DT1, regional-regression model from table 1 in Driver and Tasker (1990); DT3, regional-regression model from table 3 in Driver and Tasker (1990); EL19, regional-regression model from table 19 in Ellis and others (1984); EL20, regional regression model from table 20 in Ellis and others (1984); DT5, regional-regression model from table 5 in Driver and Tasker (1990); load, storm-runoff loads, in pounds; mg/L, storm-runoff event-mean concentration, in milligrams per liter; µg/L, storm-runoff event-mean concentration, in micrograms per liter; dashes indicate not data available; negative number in the table means the estimated value from the regional regression model is greater than the observed value; positive number in the table means the estimated value from the regional-regression model is less than the observed value]

Response variable	Regression model	Residual values				
		Minimum	Maximum	75th percentile	Median	Mean
Chemical oxygen demand (COD)	DT1 load	–2,525	1,179	–1.4	–175	–347
	DT3 load	–349	1,188	39	–18	16
	El19 load	–455	1,138	44	6	–13
	El20 load	–323	12,155	60	11	20
	DT5 mg/L	–1,275	265	–28	–433	–443
Dissolved solids (DS)	DT1 load	–85	226	48	12.4	33
	DT3 load	–124	206	36	–0.05	18
	DT5 mg/L	–126	49	–7.4	–62	–48
Suspended solids (SS)	DT1 load	27	2,130	756	310	448
	DT3 load	–1,021	1,064	148	–31	13
	El19 load	–678	1,396	372	36	159
	El20 load	–1,019	1,144	326	22	87
	DT5 mg/L	–489	702	193	–82	–34
Total nitrogen (TN)	DT1 load	0.43	79	8.5	4.0	4.7
	DT3 load	.39	7.09	2.8	2.1	1.8
	El19 load	.44	12.3	3.9	2.6	2.2
	El20 load	.55	9.52	2.8	1.9	1.9
	DT5 mg/L	.71	22	12	5.4	4.4
Total ammonia plus organic nitrogen as nitrogen (TKN)	DT1 load	–42	1.5	–1.4	–3.8	–7.6
	DT3 load	–16	–.72	–1.7	–4.0	–5.0
	DT5 mg/L	–34	–1.2	–2.3	–10	–12
Total phosphorus (TP)	DT1 load	–22	.95	–0.12	–.60	–3.1
	DT3 load	–1.9	.22	–.13	–.47	–0.60
	El19 load	.04	2.6	.91	.63	.72
	El20 load	.04	2. 7	.92	.65	.74
	DT5 mg/L	–8.3	.63	–.21	–2.4	–3.1
Dissolved phosphorus (DP)	DT1 load	–9.6	.31	–.06	–.24	–1.5
	DT3 load	–.95	.06	–.12	–.31	–.33
	DT5 mg/L	–4.6	.13	–.02	–.75	–1.6

Table 8. Summary of residual values for observed minus estimated values of storm-runoff loads, volume, and event-mean concentrations--Continued

Response variable	Regression model	Residual values: Minimum	Maximum	75th percentile	Median	Mean
Total-recoverable cadmium (CD)[1]	DT1 load	–0.02	0.001	–0.0002	–0.0006	–0.002
	DT3 load	–.002	.002	.0003	–.00006	–.0003
	DT5 µg/L	–2.8	.71	–.07	–.69	–.82
Total-recoverable copper (CU)	DT1 load	–.77	–.02	–.06	–.09	–.15
	DT3 load	–.13	.02	–.01	–.03	–.03
	DT5 µg/l	–168	–30	–46	–77	–82
Total-recoverable lead (PB)	DT1 load	–.66	.47	.11	–.06	–.08
	DT3 load	–.62	.43	–.002	–.09	–.12
	EI19 load	–1.1	.36	.03	–.11	–.21
	EI20 load	–.35	.63	.07	–.02	–.003
	DT5 µg/L	–315	200	18	–124	–90
Total-recoverable zinc (ZN)	DT1 load	–.64	1.1	.19	–.009	.02
	DT 3 load	–.69	.95	.14	–.007	.03
	EI19 load	–.87	1.0	.14	–.009	–.04
	EI20 load	–.76	1.0	.15	–.006	–.01
	DT5 µg/L	–651	869	–133	–288	–238
Volume of runoff (RUN)	DT1 cubic feet	–31,592	51,359	4,483	445	1,439
	EI19 cubic feet	–48,818	35,965	2,417	138	–4,928
	EL20 cubic feet	–32,342	47,411	4,794	964	1,028

[1]Computed using uncensored data.

ables used in the single-storm local-regression models (table 6). It would be useful if single-storm local- and regional-regression models could be combined to take advantage of the strengths of both regression models while minimizing the respective deficiencies of the regression models.

Hoos (1991) presented a procedure to adjust single-storm regional-regression models using local data. Hoos and Sisolak (1993) evaluated different model-adjustment procedures (MAP's) and established criteria for selecting the appropriate MAP. The MAP is in the form of a regression analysis. Local data are used as the calibration data set. In one MAP (MAP-R-P), log-transformed local (observed) data (response variables) are regressed against the log-transformed estimates from the single-storm regional-regression models (explanatory variables). The resulting equations are the adjusted regression models used to predict storm-runoff loads, volume, or event-mean concentrations at an unmonitored site. Another form of MAP (MAP-W) is simply the weighting of log-transformed estimates from local- and regional-regression models. The equations for the two MAPs for adjusting the regional-regression equations are Hooş and Sisolak, (1993):

1. MAP-R-P calibration equation:

$$\log O_i = \log B_o + B_1 \log R_{Ei} \quad (7)$$

where

O_i = the observed value of storm-runoff load, volume, or event-mean concentration at site *i*;

B_o and B_1 = coefficients fitted from a simple linear-regression analysis of the calibration data set (observed data); and

R_{Ei} = the regional estimate; estimated value of storm-runoff load, runoff volume, or event-mean concentration from the unadjusted single-storm regional-regression model at site *i*.

The adjusted regional-regression model (from the detransformation of eq. 7) is then:

$$AR_{Ei} = B_0 R_{Ei}^{B1} (BCF) \quad (8)$$

where

AR_{Ei} = the adjusted single-storm regional-regression estimate.

2. MAP-W calibration equation:

$$\log O_i = \{ (J \times \log RE) [(1\text{-}J) \times \log LOC] \} \quad (9)$$

where

$$J = \{ (SEloc^2) / [(SEloc^2) + (SEreg^2)] \} \quad (10)$$

where

SEloc = the standard error of estimate, in log units for the single-storm local-regression model;

SEreg = the standard error of estimate, in log units as reported in Driver and Tasker (1990) for the single-storm regional-regression model; and

LOC = estimated value from the single-storm local-regression equation.

The weighted single-storm regional-regression model (the detransformation of eq. 10) then is:

$$WE = \{ (RE^J) \times (LOC^{(1\text{-}J)}) \} \times BCF, \quad (11)$$

where

WE = adjusted (weighted) single-storm regional-regression estimate.

Selection of the appropriate MAP needs to be made based on whether or not observed and estimated data are correlated and on if there is a consistent bias between the local-data (observed) and estimated-data pairs (fig. 2, step 3). Correlation between observed and estimated data was evaluated by analyzing the significance of Spearman's rho (Iman and Conover, 1983), and bias was determined using the signed-rank test on the paired data (Iman and Conover, 1983). If the null hypothesis (a significant correlation does not exist between observed and estimated values or a consistent bias does not exist between observed and estimated values) for either test is not rejected at a selected level of significance, then correlation between observed data and explanatory variables is determined by examining correlation coefficients, r^2 (fig. 2, step 4) (Hoos and Sisolak, 1993).

After evaluating Spearman's rho and the signed-rank test for the Colorado Springs data set, the appropriate MAPs were selected for adjusting the regional-regression models using local data based on the flow chart in figure 2. The RMSE was large for all comparisons between observed values and values estimated using single-storm regional-regression equations (tables 7, 9, and 10). Because observed values and estimated values from single-storm regional-regression equations were highly correlated and had a consistent direction of bias, MAP-R-P (fig. 2, steps 2 and 3) was selected for adjusting storm-runoff-load equations for TN, TKN, TP, DP, CU, and PB and for adjusting the storm-runoff event-mean concentration equations for TP, CU, and PB. Observed and estimated values for the remaining storm-runoff loads and event-mean concentrations of the remaining constituents were not highly correlated or did not have a consistent direction of bias, or both; however, the remaining observed values were significantly correlated with some explanatory variables. Therefore, MAP-W (fig. 2, step 3) was selected for adjusting storm-runoff-load equations for COD, DS, SS, CD, and ZN; for adjusting equations for estimating volume of runoff; and for adjusting event-mean concentration equations for COD, DS, SS, TN, TKN, DP, CD, and ZN.

When compared to observed storm-runoff loads and volume, the three-variable single-storm regional-regression models for storm-runoff loads and the multivariate single-storm regional-regression models for storm-runoff volume that were developed by Driver and Tasker (1990) had the smallest RMSE of all of the single-storm regional-regression models tested. These models and the 13-variable single-storm regional-regression models for event-mean concentration were adjusted using MAPs.

The MAP's decreased model error in estimating storm-runoff loads, volume, and event-mean concentrations, except for the equation for event-mean concentration for CD. Reduction of error, in percent, ranged from -1,980 to -10 percent (based on data in tables 9 and 10). The effect of MAP's on estimated storm-runoff loads and event-mean concentrations can be illustrated by plotting observed values, estimates from regional-regression models, and estimates from regional-regression models adjusted using MAPs. Two examples from site 2 are presented, one for each MAP—MAP-R-P (TP) and MAP-W (TKN) (figs. 3 and 4). In both cases, the estimates of storm-runoff load and event-mean concentration obtained using MAP-R-P (fig. 3) and MAP-W (fig. 4) were closer to the observed value than the estimate from the regional-regression equation. Adjusted models, developed using MAP-R-P and MAP W, for estimating storm-runoff loads, volume, and event-mean concentrations are listed in tables 11 and 12.

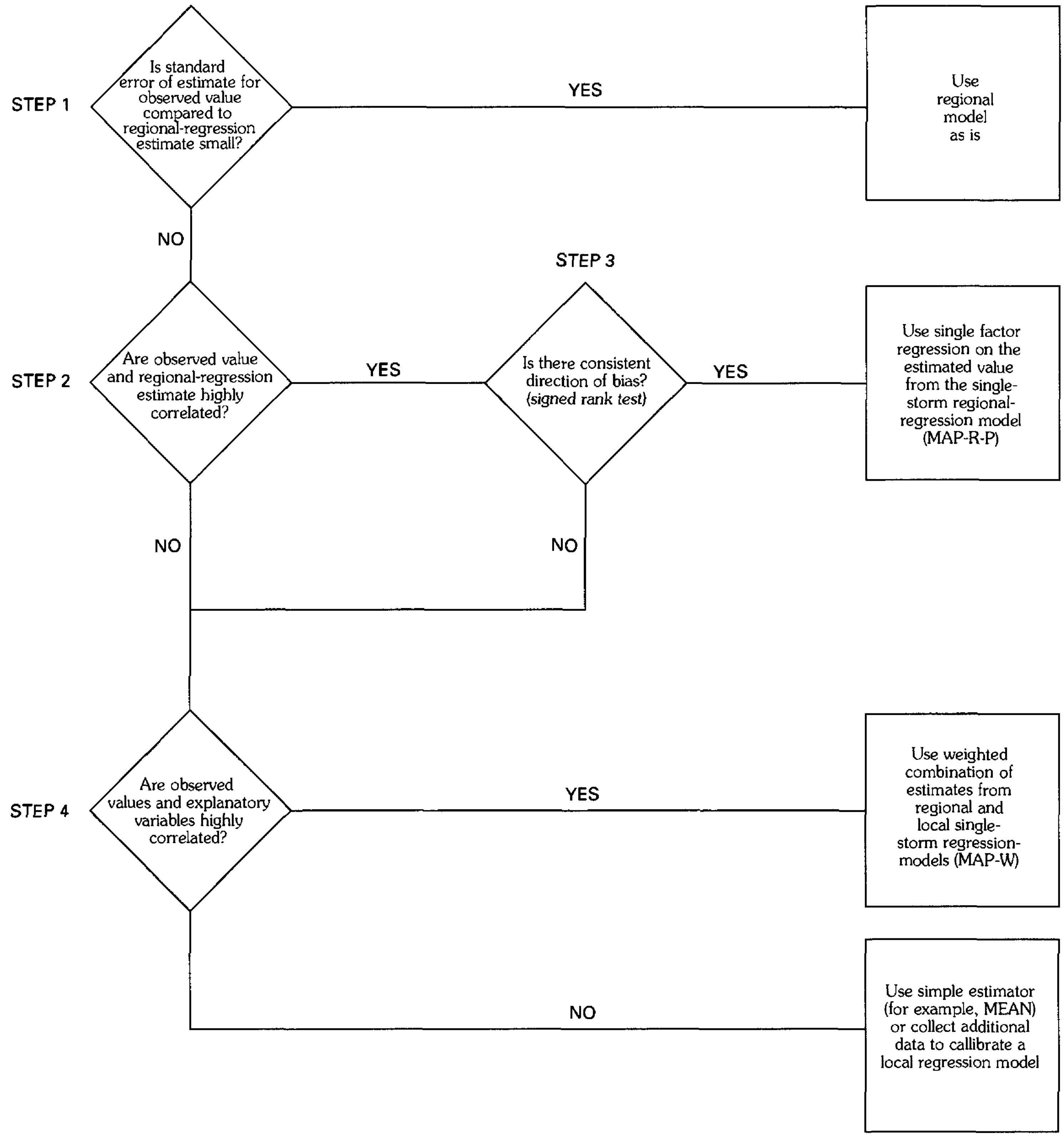


Figure 2. Flowchart for selection of model adjustment procedures (modified from Hoos and Sisolak, 1993).

Table 9. Effect of model-adjustment procedures on root-mean-square error and standard error of estimate for storm-runoff loads and volume

[MAP-R-P, observed data regressed against the regional estimate; MAP-W, the weighted combination of local-regression estimate and regional-regression estimate; COD, chemical oxygen demand; DS, dissolved solids; SS, suspended solids; TN, total nitrogen; TKN, total ammonia plns organic nitrogen as nitrogen; TP, total phosphorus; DP, dissolved phosphorus; CD, total-recoverable cadmium; CU, total-recoverable copper; PB, total-recoverable lead; ZN, total-recoverable zinc; RUN, volume; dashes indicate no data]

Response variable	Root-mean-square error				Standard error of estimate			
	Regional-regression model from Driver-Tasker (1990)				MAP-R-P		MAP-W	
	3-variable models[1]		13-variable models[2]					
	(percent)	(log units)	(percent)	(log units)	(percent)	(log units)	(percent)	(log units)
COD	97	0.353	--	--	--	--	65	0.258
DS	114	.396	--	--	--	--	59	.237
SS	145	.463	--	--	--	--	102	.366
TN	68	.256	--	--	19	0.283	--	--
TKN	1,147	.960	--	--	106	.377	--	--
TP	238	.598	--	--	109	.384	--	--
DP	276	.637	--	--	95	.348	--	--
CD[3]	119	.409	--	--	--	--	81	.308
CU	308	.666	--	--	116	.402	--	--
PB	311	.668	--	--	191	.538	--	--
ZN	125	.421	--	--	--	--	115	.398
RUN	--	--	89	.332	--	--	29	.124

[1]Equations from table 3 in Driver and Tasker (1990).

[2]Equations from table 1 in Driver and Tasker (1990).

[3]Computed without censored data.

Table 10. Effect of model-adjustment procedures on standard error of estimate for storm-runoff event-mean concentrations

[MAP-R-P, local data regressed against the regional estimate; MAP-W, the weighted combination of local-regression estimate and regional-regression estimate; COD, chemical oxygen demand; DS, dissolved solids; SS, suspended solids; TN, total nitrogen; TKN, total ammonia plus organic nitrogen as nitrogen; TP, total phosphorus; DP, dissolved phosphorus; CD, total-recoverable cadmium; CU, total-recoverable copper; PB, total-recoverable lead; ZN, total-recoverable zinc; dashes indicate not applicable]

Response variable	Root-mean-square error		Standard error of estimate			
	[1]Regionel-regression model from Driver and Tasker (1990)		MAP-R-P		MAP-W	
	(percent)	(log units)	(percent)	(log units)	(percent)	(log units)
COD	201	0.553	--	--	41	0.172
DS	69	.272	--	--	45	.188
SS	74	.286	--	--	64	.253
TN	282	.643	--	--	40	.168
TKN	2,078	1.07	--	--	98	.356
TP	1,398	.998	73	0.285	--	--
DP	1,220	.972	--	--	176	.516
CD[2]	86	.322	--	--	238	.598
CU	459	.764	54	.219	--	--
PB	186	.531	70	.273	--	--
ZN	121	.413	--	--	44	.183

[1]Equations from table 5 in Driver and Tasker (1990).

[2]Computed without censored data.

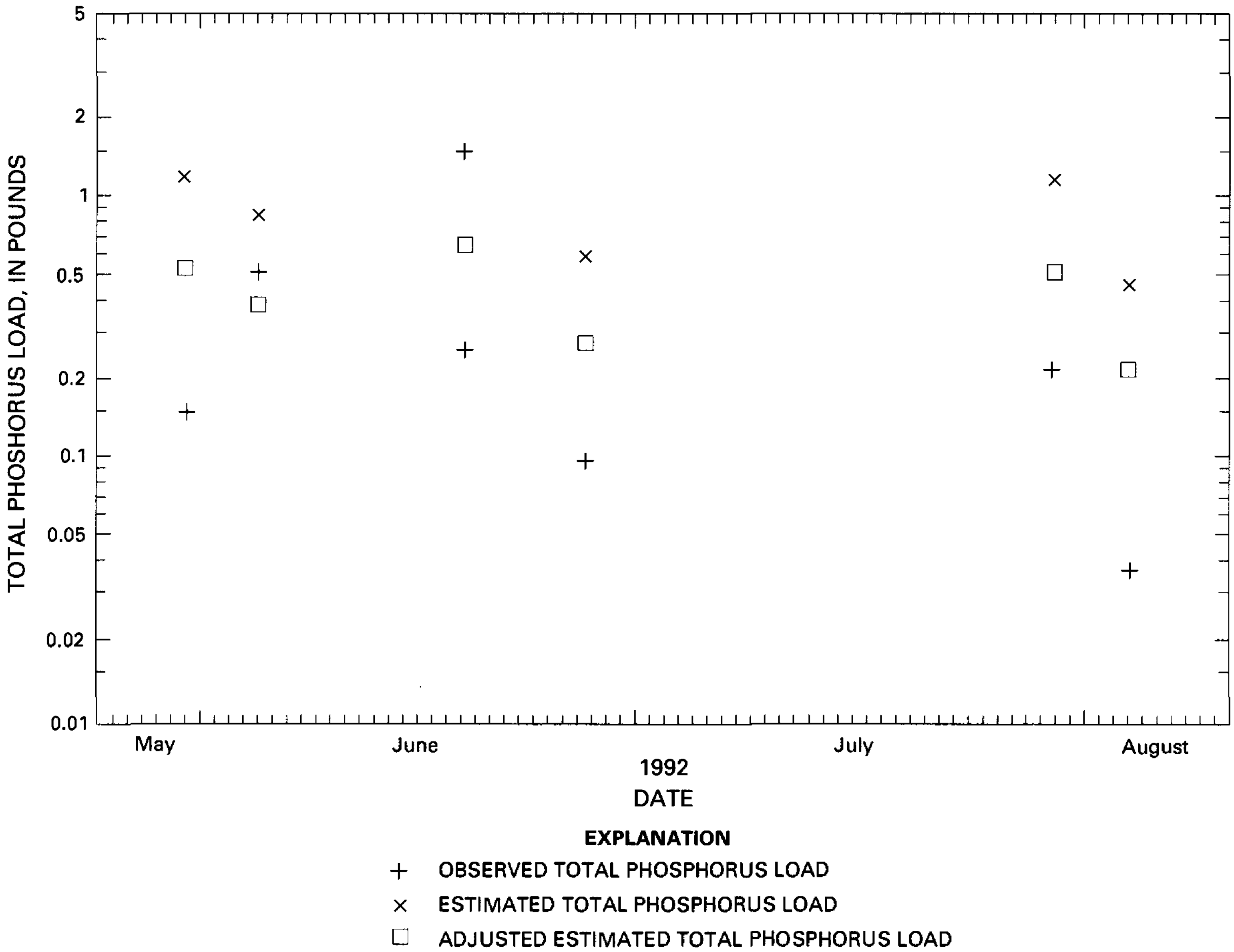
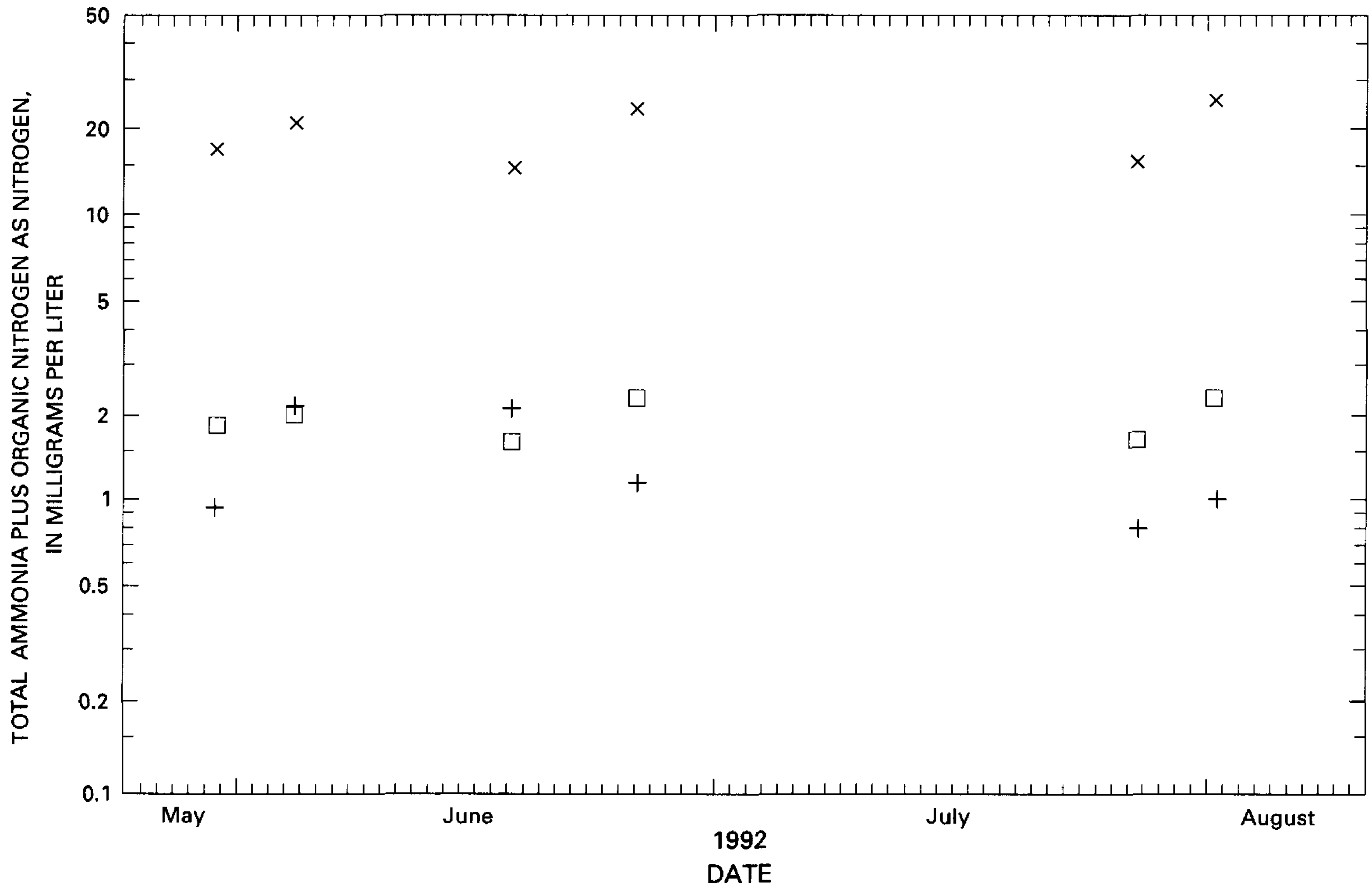


Figure 3. Observed total-phosphorus, estimated total-phosphorus, and adjusted estimates of total-phosphorus loads for storm-runoff load at site 2.



EXPLANATION

+ OBSERVED TOTAL AMMONIA PLUS ORGANIC NITROGEN AS NITROGEN

× ESTIMATED TOTAL AMMONIA PLUS ORGANIC NITROGEN AS NITROGEN

□ ADJUSTED ESTIMATES TOTAL AMMONIA PLUS ORGANIC NITROGEN AS NITROGEN

Figure 4. Observed total ammonia plus organic nitrogen as nitrogen, estimated total ammonia plus organic nitrogen as nitrogen, and adjusted estimates of total ammonia plus organic nitrogen as nitrogen for storm-runoff event-mean concentrations at site 2.

Table 11. Summary of adjusted models for storm-runoff loads and volume

[MAP-R-P, regression of observed data against regional-regression; MAP-W, weighted combination of local-regression estimate and regional-regression estimate; Bo, B1, coefficients fitted from a simple linear regression analysis of the calibration data set (local data base); BCF, the bias correction factor; J, weighting factor; COD, chemical oxygen demand loads; DS, dissolved-solids load; SS, suspended-solids load; TN, total nitrogen load; TKN, total ammonia plus organic nitrogen load; TP, total phosphorus load; DP, dissolved phosphorus load; CD, total-recoverable cadmium load; CU, total-recoverable copper load; PB, total-recoverable lead load; ZN, total-recoverable zinc load; RUN, storm-runoff volume; dashes indicate not applicable; y, response variable; RE, estimate from regional regression; LOC, estimate from local regression]

Response variable	Model-adjustment procedure					
	MAP-R-P[1]			MAP-W[2]		
	Bo	B1	BCF	J	1-J	BCF
COD	--	--	--	0.27	0.73	1.13
DS	--	--	--	.35	.65	1.14
SS	--	--	--	.23	.77	1.24
TN	0.82	0.71	1.23	--	--	--
TKN	.23	.61	1.40	--	--	--
TP	.33	.91	1.35	--	--	--
DP	.24	.82	1.32	--	--	--
CD	--	--	--	.85	.15	1.14
CU	.14	.77	1.42	--	--	--
PB	.20	.69	1.80	--	--	--
ZN	--	--	--	.42	.58	1.18
RUN	--	--	--	.24	.76	1.04

[1]Form of equation is $y = BoR_{Ei}{}^{B1}BCF$.

[2]Form of equation is $y = (REG^{J})\ (LOC^{\ (1\text{-}J)})\ BCF$.

Table 12. Summary of adjusted models for storm-runoff event-mean concentrations

[MAP-R-P, regression of local data against regional estimate; MAP-W, weighted combination of local-regression estimate and regional-regression estimate; Bo, B1, coefficients fitted from a simple linear regression analysis of the calibration data set (local data base); BCF, bias correction factor; J, weighting factor; COD, chemical oxygen demand event-mean concentration; DS, dissolved-solids event-mean concentration; SS, suspended-solids event-mean concentration; TN, total nitrogen event-mean concentration; TKN, total ammonia plus organic nitrogen event-mean concentration; TP, total phosphorus event-mean concentration; DP, dissolved phosphorus event-mean concentration; CD, total-recoverable cadmium event-mean concentration; CU, total-recoverable copper event-mean concentration; PB, total-recoverable lead event-mean concentration; ZN, total-recoverable zinc event-mean concentration; dashes indicate not applicable; y, response variable; RE, estimate from regional model; LOC, estimate from local model]

Rasponse variable	Model-adjustment procedure					
	MAP-R-P[1]			MAP-W[2]		
	Bo	B1	BCP	J	1-J	BCF
COD	--	--	--	0.33	0.67	1.08
DS	--	--	--	.18	.82	1.05
SS	--	--	--	.24	.76	1.14
TN	--	--	--	.33	.67	1.07
TKN	--	--	--	.28	.72	1.06
TP	0.48	-0.26	1.2	--	--	--
DP	--	--	--	.22	.78	1.10
CD	--	--	--	.78	.22	1.05
CU	1.52	.54	1.16	--	--	--
PB	886,692	-1.69	1.18	--	--	--
ZN	--	--	--	.25	.75	1.08

[1]Form of equation is $y = Bo \times REG^{B1}\ BCF$.

[2]Form of equation is $y = (RE^{J})\ (LOC)^{(1\text{-}j)}\ BCF$.

ESTIMATES OF A MEAN LOAD FOR A STORM

In addition to developing single-storm regional-regression models for storm-runoff loads, volume, and event-mean concentrations, Driver and Tasker (1990) developed regression models for estimating the mean load for a storm, hereafter called mean load. Mean load is the estimate of mean load for a particular drainage basin. With the estimate of mean load, seasonal or annual loads for a particular drainage basin can be estimated by multiplying the mean load by the average number of storms for the season or year. Regression models for estimating mean load were based on drainage-basin area, percent of impervious area, mean annual rainfall, mean minimum January temperature, and a variable (dummy variable) indicating whether commercial and industrial land uses exceeded or did not exceed 75 percent of the drainage-basin area (Driver and Tasker, 1990). Regression models for estimating mean load were developed for COD, DS, SS, TN, TKN, TP, DP, CU, PB, and ZN. These regression models were developed from the NURP data base and are based on rain storms. The range of explanatory variables used in the regression models for estimating mean load are listed in table 13. In general, use of the models to estimate mean load at sites that have characteristics much beyond the range of values listed in table 13 need to be avoided (Driver and Tasker, 1990). Using the Driver and Tasker (1990) models, mean loads were estimated for COD, DS, SS, TN, TKN, TP, DP, CU, PB, and ZN for sites 1 through 5. A 90-percent confidence interval was computed for each mean load of a storm estimated using the models from Driver and Tasker (1990) (table 14). For example, there is a 90-percent confidence level that the true mean load for TP for all storms at site 1 lies between 0.06 and 0.87 lb (table 14). Confidence intervals were not computed for single-storm regression models because matrix information was unavailable.

Estimated mean loads from the Driver and Tasker (1990) models (MLDT) were compared to mean loads estimated for 1992, based on daily mean water discharge and land-use characteristics, hereafter referred to as MLDWD, and on loads that are the mean storm-runoff load of the six storms sampled at each of the five sites in 1992 (table 14).

Linear regression was used for estimating mean loads based on daily mean water discharge. The most suitable regression models for estimating mean load from daily mean water discharge were selected using the procedures described in the section "Single-Storm Local-Regression Models." Values of r^2 ranged from 0.59 to 0.84, and standard error of estimate, in percent, for the regression models, ranged from 45 to 93 (table 15).

Table 13. Ranges of values of explanatory variables used in development of regression models for mean load for a storm (modified from Driver and Tasker, 1990)

[DA, total contributing drainage area; IA, impervious area; MAR, mean annual rainfall; MJT, mean minimum January temperature; COD, chemical oxygen demand; DS, dissolved solids; SS, suspended solids; TN, total nitrogen; TKN, total ammonia plus organic nitrogen as nitrogen; TP, total phosphorus; DP, dissolved phosphorus; CU, total-recoverable copper; PB, total-recoverable lead; ZN, total-recoverable zinc]

Response variable (mean seasonal or mean annual load)	Explanatory variables							
	DA (square miles)		IA (percent)		MAR (inches)		MJT (degrees Fahrenheit)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
COD	0.019	0.707	4	100	8.38	62.00	3.2	58.7
DS	.020	.450	19	99	10.24	37.61	11.4	35.8
SS	.019	.707	4	100	8.38	49.38	3.2	50.1
TN	.019	.830	4	100	11.83	62.00	3.2	58.7
TKN	.019	.707	4	100	8.38	62.00	3.2	58.7
TP	.019	.830	4	100	8.38	62.00	3.2	58.7
DP	.020	.707	4	99	8.38	46.18	10.8	35.8
CU	.014	.830	6	99	8.38	62.00	15.3	58.7
PB	.019	.830	4	100	8.38	62.00	3.2	58.7
ZN	.019	.830	13	100	8.38	62.00	11.4	58.7

Table 14. Comparison of computed mean load for a storm based on daily mean water discharge and land-use characteristics, estimated mean load for a storm, and average of samples collected during rainfall runoff

[MLDWD, mean load estimated based on daily mean water discharge and land-use characteristics; MLDT, estimated mean load, from Driver and Tasker (1990) models; CI, 90-percent confidence interval; n, number of storms occurring as rain, January through December 1992; COD, chemical oxygen demand; DS, dissolved solids; SS, suspended solids; TN, total nitrogen; TKN, total ammonia plus organic nitrogen as nitrogen; TP, total phosphorus; DP, dissolved phosphorus; CU, total-recoverable copper; PB, total-recoverable lead; ZN, total-recoverable zinc]

Response variable (as load)	Mean load of a storm (pounds)				Mean of six storms in 1992 (pounds)
	MLDWD	MLDT Regression models in Drivar and Tasker (1990)			
		Estimated	Lower CI	Upper CI	
		Sixteenth Hole, Valley-Hi Golf Conrse Site 1 n=54			
COD	756	172	41	430	492
DS	232	294	58	947	201
SS	927	168	18.2	666	716
TN	4.3	6.63	1.24	19.5	3.7
TKN	2.4	2.16	0.43	6.68	2.3
TP	0.73	0.31	.06	0.87	0.71
DP	.28	.20	.03	.60	.24
CU	.03	.12	.02	.38	.03
PB	.54	.28	.05	.84	.27
ZN	.57	.42	.09	1.11	.49
		Chestnnt Street at Donglas Creek Site 2 n =48			
COD	523	172	41	430	217
DS	77	400	77	1,330	60
SS	1,349	203	22.1	809	603
TN	1.9	6.04	1.15	17.6	1.3
TKN	.90	1.94	.38	6.11	.76
TP	.33	.40	.08	1.12	.21
DP	.14	.23	.04	.72	.10
CU	.07	.15	.02	.47	.04
PB	.36	.25	.04	.77	.24
ZN	1.42	.39	.08	1.02	.76
		Beacon Street at Buchanan Street Site 3 n=50			
COD	312	223	53	560	92
DS	71	424	81	1,410	37
SS	433	210	22.9	837	107
TN	2.0	2.9	0.49	9.7	1.2
TKN	0.80	0.97	.16	3.66	0.40
TP	.26	.42	.09	1.17	.16
DP	.17	.24	.04	.74	.12
CU	.02	.16	.03	.49	.007
PB	.19	.35	.06	1.07	.03
ZN	.24	.55	.12	1.43	.12

Table 14. Comparison of computed mean load for a storm based on daily mean water discharge and land-use characteristics, estimated mean load for a storm, and average of samples collected during rainfall runoff--Continued

Response variable (as load)	Mean load of a storm (pounds)				Mean of six storms in 1992 (pounds)
	MLDWD	MLDT Regression models in Driver and Tasker (1990)			
		Estimated	Lower CI	Upper CI	
		Wahsatch Street at Cross Lane Site 4 n=50			
COD	465	357	83.3	906	378
DS	117	1,060	173	4,140	140
SS	929	372	39.7	1,510	747
TN	4.7	10.8	2.01	31.9	5.2
TKN	.74	3.42	.66	10.9	.76
TP	1.22	.88	.18	2.5	1.20
DP	.36	.40	.06	1.32	.46
CU	.02	.30	.05	.95	.02
PB	.31	.54	.09	1.67	.14
ZN	.31	.80	.17	2.13	.31
		Walmart at Eighth Street Site 5 n=51			
COD	339	76	18	190	58
DS	45	136	27	432	26
SS	407	103	11.1	416	237
TN	0.89	3.12	0.58	9.22	0.64
TKN	.65	1.02	.19	3.26	.27
TP	.20	.16	.03	0.46	.15
DP	.09	.13	.02	.40	.05
CU	.01	.07	.01	.22	.005
PB	.12	.12	.02	.36	.06
ZN	.20	.17	.04	.45	.11

Table 15. Summary of r^2 values and standard error of estimate for regression models used to estimate mean load, in pounds, of a storm based on daily mean water discharge and land-use characteristics

[r^2, is the coefficient of determination]

Response variable	r^2	Standard error of estimate	
		Percent	Log units
Chemical oxygen demand	0.75	57	0.229
Dissolved solids	.82	45	.188
Suspended solids	.68	83	.313
Total nitrogen	.81	47	.195
Total ammonia plus organic nitrogen	.78	47	.193
Total phosphorus	.75	66	.262
Dissolved phosphorus	.59	81	.308
Total-recoverable copper	.84	49	.200
Total-recoverable lead	.65	93	.344
Total-recoverable zinc	.81	55	.225

Records of daily mean water discharge were collected at all sites from about June 1 to December 6, 1992. For periods of missing record, daily mean water discharge was estimated using the following equation:

$$DMWD = 19{,}941 TRN^{1.08} LUI^{-1.26} LUC^{-0.98} LUR^{-1.78} 1.25 \qquad (12)$$

where

DMWD = daily mean water discharge, in cubic feet per second;
TRN = total rainfall, in inches;
LUI = industrial land use, in percent;
LUC = commercial land use, in percent; and
LUR = residential land use in percent.

For this equation, the value of r^2 was 0.77, and the standard error of estimate was 78 percent.

Generally, MLDWD were within the 90-percent confidence intervals of MLDT (table 14). However, estimates of COD, DS, SS, and CU, at selected sites were not within the 90-percent confidence intervals from Driver and Tasker (1990) mean load equations. At sites 1, 2, and 5, estimates of MLDWD for COD exceeded the upper 90-percent confidence interval (table 14); and at sites 1 and 2, MLDWD for SS exceeded the upper 90-percent confidence limit (table 14). At sites 3 and 4, estimates of MLDWD for DS and CU were less than the 90-percent confidence interval, and at site 2, estimates of mean load based on daily mean water discharge for ZN exceeded the upper 90-percent confidence interval (table 14).

At all sites, estimates of MLDWD for COD and SS were larger than MLDT (table 14). At all sites, estimates of MLDWD for DS, TN, and CU were less than MLDT (table 14). Estimates of MLDWD for TKN, TP, DP, PB, and ZN based on daily mean water discharge when compared to MLDT had no consistent direction of bias (table 14).

Differences between the two types of estimates of mean load may be explained by the following:

1. Hydrologic conditions controlling the occurrence of properties and constituents, especially COD and SS, that are specific to Colorado Springs are not accounted for in the Driver and Tasker (1990) models.
2. Data collected for certain properties and constituents for the NURP studies may not be representative of the Colorado Springs area.

Generally, the mean load of six storms at each site was within the 90-percent confidence interval of the Driver and Tasker (1990) mean load equations (table 14). The mean load of the six storms exceeded the upper 90-percent confidence interval for COD and SS at site 1 (table 14). The mean load of the six storms was less than the lower 90-percent confidence interval for DS at sites 2, 3, 4, and 5; for CU at sites 3, 4, and 5; and for PB at site 3 (table 14).

The mean load of the six storms at each site compared well with the estimates derived using the Driver and Tasker (1990) mean load equations. However, these mean loads represent only 6 storms, whereas the Driver and Tasker (1990) models were developed using between 200 and 1,000 storms that represent drainage basins having a wider range of drainage-basin area and percent impervious area (table 6). Therefore, the Driver and Tasker (1990) mean load equations might provide a better estimate of annual and seasonal loads for ungaged drainage basins in Colorado Springs.

COMPARISON OF PROCEDURES FOR ESTIMATING STORM-RUNOFF LOADS, VOLUMES, EVENT-MEAN CONCENTRATIONS, AND THE MEAN LOAD FOR A STORM

Various procedures for estimating storm-runoff loads, volume, and event-mean concentrations have been discussed in this report. The following is a more concise comparison of the value and limitations of these procedures. The procedures discussed include:

1. Single-storm local-regression models for storm-runoff loads, volume, and event-mean concentration (tables 4 and 5).
2. Single-storm regional-regression models for storm-runoff loads, volume, and event-mean concentration (Ellis and others, 1984; Driver and Tasker, 1990).
3. Adjustment of single-storm regional-regression models for storm-runoff loads, volume, and event-mean concentration using local data (tables 11 and 12) (Hoos and Sisolak, 1993).
4. Estimates of mean load (table 14).

The use of single-storm local-regression models needs to be limited to the ranges of explanatory variables (table 6) used to develop the model. If values outside these ranges are used in the single-storm local-regression models, the standard errors may be considerably larger than the values reported in tables 4 and 5. As the single-storm local-regression models are applied to drainage-basin areas and to storm volumes larger than the values from the observation sites, the accuracy of estimates of storm-runoff loads, volume, and event-mean concentrations decreases.

Single-storm regional-regression models were developed using explanatory variables that have a wider range than the single-storm local-regression models (table 6). When compared to observed data, single-storm regional-regression models tended to overestimate storm-runoff loads, volumes, and event-mean concentrations (table 8). Model adjustment procedures (MAPs), which use local data to decrease the model error, were applied to selected single-storm regional-regression models. The MAPs decreased model error in estimating storm-runoff loads, volume, and event-mean concentrations—model error decreased from –1,980 to –10 percent (based on data in tables 9 and 10).

A prediction of annual or seasonal storm-runoff loads, volume, and event-mean concentration at an unmonitored site can be obtained by applying the single-storm models described to a series of storms and producing a synthetic record of storm loads and volume. Values of storm characteristics used as explanatory variables listed in table 6 and in Ellis and others (1984) and Driver and Tasker (1990) may be determined for a series of storms from the long-term rainfall record for a station near an unmonitored site. The synthesized record of storm loads may be reduced to an estimate of mean annual or mean seasonal load by summing loads from each storm, then dividing by the number of years in the period of the synthetic record.

The mean load estimated for individual sites for selected constituents generally compared well to mean load estimated based on daily mean water discharge and land-use characteristics and to the mean load of six storms, for each site, sampled in 1992 (table 14). The use of the mean load procedure should be limited to the range of values of variables used to develop the models (table 13). However, the mean load procedure can be applied to larger drainage basins by dividing the drainage basin into segments that fall into the range of drainage-basin areas used to develop the mean load model and computing the mean load for each drainage-basin segment. The mean load for the drainage basin would be the sum of the loads computed for each drainage-basin segment. Annual or seasonal loads could be computed by multiplying the estimated mean load by the average, or total for a specific year, number of storms for a drainage basin.

SUMMARY

The U.S. Environmental Protection Agency requires that municipalities that have a population of 100,000 or greater obtain National Pollutant Discharge Elimination System permits to control the quality of storm runoff. In 1992, the U.S. Geological Survey, in cooperation with the Colorado Springs City Engineering Division, began a study to characterize the water quality of storm runoff and to compare techniques for the estimation of storm-runoff loads, volume, and event-mean concentrations for selected properties and constituents.

Precipitation, streamflow, and water-quality data were collected during 1992 at five sites in Colorado Springs. Thirty-five samples were collected, seven at each of the five sites. At each site, three samples were collected for National Pollutant Discharge Elimination System permitting purposes; two of the samples were collected during rainfall runoff, and one sample was collected during snowmelt runoff. Four additional samples were collected at each site to obtain a large enough sample size to estimate storm-runoff loads, volume, and event-mean concentrations for selected properties and constituents using linear-regression procedures developed using data from the Nationwide Urban Runoff Program (NURP). Storm-water samples were analyzed for as many as 186 properties and constituents. Some of the properties and constituents measured include pH, specific conductance, water temperature, chemical oxygen demand, biochemical oxygen demand, bacteria, dissolved and suspended solids, major ions, nutrients, residual chlorine, total-recoverable metals, oil and grease, phenols, volatile-organic compounds, acid-base/neutral organic compounds and pesticides.

Storm runoff sampled had large concentrations of chemical oxygen demand and 5-day biochemical oxygen demand. Chemical oxygen demand ranged from 100 to 830 mg/L, and 5-day biochemical oxygen demand ranged from 14 to 260 mg/L. Total-organic carbon concentrations ranged from 18 to 240 mg/L. The total-recoverable metals lead and zinc had the largest concentrations of the total-recoverable metals analyzed. Concentrations of lead ranged from 23 to 350 μg/L, and concentrations of zinc ranged from 110 to 1,400 μg/L.

Single-storm local-regression models for estimating storm-runoff loads, volume, and event-mean concentrations were developed. Results from these models and observed values for storm-runoff loads, volume, and event-mean concentrations are compared with the results from regional-regression models developed from the Nationwide Urban Runoff Program for the purposes of determining which regression models provide the best estimates of storm-runoff loads, volume, and event-mean concentrations.

Single-storm local-regression models were developed for estimating storm-runoff loads and event-mean concentrations for the 12 National Pollutant Discharge Elimination System properties and constituents and for estimating storm-runoff volume. The data for

30 storms representing rainfall runoff from 5 drainage basins were used in this analysis. Except for total-recoverable cadmium, the models were developed using ordinary least-squares regression. Because some cadmium concentrations were censored (less than values), tobit regression, which is similar to ordinary least-squares regression, was used to estimate storm-runoff load and event-mean concentration for total-recoverable cadmium. The response variables, which are storm-runoff loads, volume, and event-mean concentrations, were modeled using climatic, physical, and land-use characteristics.

The values of r^2 for models that use ordinary least-squares regression ranged from 0.57 to 0.86 for storm-runoff loads and volume and from 0.25 to 0.63 for storm-runoff event-mean concentrations. Standard errors of estimate ranged from 43 to 115 percent for storm-runoff loads and volume and from 32 to 66 percent for storm-runoff event-mean concentrations. Standard errors of estimate for storm-runoff load and event-mean concentration for total-recoverable cadmium were 247 and 171 percent.

Single-storm linear-regression models for estimating storm-runoff loads, volume, and event-mean concentrations were developed for 11 of the 12 properties and constituents required for the National Pollutant Discharge Elimination System permitting process. Regional-regression equations for BOD were not developed. Linear-regression equations were developed from data collected by the NURP. Equations were developed from the NURP data base and include sets of equations for three geographically distinct regions delineated by mean annual rainfall. The Colorado Springs area is included in Region I. Estimates from these regression models were compared with observed storm-runoff loads, volume, and event-mean concentrations from samples collected in the study area.

Single-storm regional-regression models tended to overestimate storm-runoff loads, volume, and event-mean concentrations observed at the five Colorado Springs sites. Because regression models developed using local data are based on the climatic, physical, and land-use characteristics of the Colorado Springs area, single-storm local-regression models would be the preferred method for estimating storm-runoff loads, volume, and event-mean concentrations. As a result, single-storm local-regression models would be the preferred method for estimating storm-runoff loads, volume, and event-mean concentrations because the single-storm local-regression models were developed using local data based on the climatic, physical, and land-use characteristics of the Colorado Springs area. However, only a small number of observations (30) were available for the development of the single-storm local-regression models, and the use of the single-storm local-regression models needs to be limited to estimations within the ranges of the explanatory variables used to develop the model. Although the single-storm regional-regression models tended to overestimate storm-runoff loads, volume, and event-mean concentrations, these single-storm regional-regression models are based on a large number of observations (65 to 348), and the explanatory variables have a wider range than the explanatory variables used in the single-storm local-regression models. Single-storm local- and regional-regression models were combined using model-adjustment procedures to take advantage of the strengths of both models while minimizing the respective deficiencies of the models.

When compared to observed storm-runoff loads and volume, the adjusted three-variable single-storm regional-regression models for storm-runoff loads and the multivariate regional-regression model for volume of runoff had the smallest root-mean-squared error of all of the single-storm regional-regression models tested. These models and the single-storm regional-regression models for event-mean concentration were adjusted using model-adjustment procedures.

Except for the equation for event-mean concentration of total-recoverable cadmium, all model-adjustment procedures decreased the error for models estimating storm-runoff loads, volume, and event-mean concentrations. Reduction of standard error, in percent, ranged from –1,980 to –10 percent.

In addition to developing single-storm regional-regression models for storm-runoff loads, volume, and event-mean concentrations, regression models for estimating mean load for a storm were developed for ten of the National Pollutant Discharge Elimination System properties and constituents. With the estimate of the mean load, seasonal or annual loads can be estimated by multiplying the mean load by the mean number of storms for the season or year. These regression models were developed from the NURP data base and are based on rain storms.

Mean loads were estimated for ten of the National Pollutant Discharge Elimination System properties and constituents for sites 1 through 5. Estimated mean loads from the regional-regression equations were compared to mean loads estimated for 1992, based on daily mean water discharge, and on loads that are the mean storm-runoff load of the six storms sampled at each of the five sites in 1992.

Except for selected estimates of chemical oxygen demand, dissolved solids, suspended solids, and total-recoverable copper, mean loads based on daily mean water discharge were within the 90-percent confidence interval of results from the mean load equations. At sites 1, 2, and 5, estimates of mean load based on daily mean water discharge for chemical oxygen demand, and at sites 1 and 2, estimates of mean load based on daily mean water discharge for suspended solids exceeded the upper 90-percent confidence intervals. At sites 3 and 4, estimates of mean load based on daily mean water discharge for dissolved solids and total-recoverable copper were less than the 90-percent confidence interval.

At all sites, estimates of mean load based on daily mean water discharge for chemical oxygen demand and suspended solids were larger than mean loads estimated by the mean load equations. At all sites, estimates of mean load based on daily mean water discharge for dissolved solids, total nitrogen, and total-recoverable copper were smaller than mean loads estimated by the equations. Estimates of mean load for total ammonia plus organic nitrogen as nitrogen, total phosphorus, dissolved phosphorus, total-recoverable lead, and total-recoverable zinc based on daily mean water discharge when compared to mean loads estimated by the mean load equations had no consistent direction of bias. Generally, the mean load of six storms was within the 90-percent confidence interval of the mean load equations. The mean load of the six storms for each site exceeded the upper 90-percent confidence interval for chemical oxygen demand and suspended solids at site 1. The mean load of the six storms was less than the lower 90-percent confidence interval for dissolved solids at sites 2, 3, 4, and 5; for total-recoverable copper at sites 3, 4, and 5; and for total-recoverable lead at site 3.

The mean load of the six storms at each site compared well with the estimates derived using the mean load equations. However, these mean loads represent only 6 storms, whereas the equations were developed using between 200 and 1,000 storms that represent drainage basins having a wider range of drainage-basin area and percent impervious area. Therefore, the mean load equations might provide a better estimate of mean loads, and hence annual and seasonal load, for ungaged drainage basins in Colorado Springs.

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(page 37 follows)

SUPPLEMENTAL DATA

Table 16. Precipitation and runoff characteristics for samples collected at storm-runoff sites in Colorado Springs

[--, not available]

Date	Total precipitation (inches)	Runoff (cubic feet)	Duration of runoff (minutes)	Peak flow (cubic feet per second)	Period that has less than 0.10 inch of precipitation (days)	Duration of precipitation (minutes)
			384918104454201 - Sixteenth Hole, Valley-Hi Golf Conrse (Site 1)			
06-03-92	0.21	46,100	155	37.1	2.0	110
06-23-92	.07	26,800	170	8.57	2.0	101
06-26-92	.13	14,900	125	16.8	.5	50
07-02-92	.08	16,400	240	7.19	3.0	--
[1]07-25-92	.33	78,500	325	22.3	9.0	127
[1]08-10-92	.20	45,900	395	20.5	7.0	240
[1]11-21-92	.78	34,600	560	2.99	8.0	--
			385347104500601 - Chestnnt Street at Douglas Creek (Site 2)			
[1]05-31-92	.22	20,500	545	6.06	3.0	100
06-05-92	.15	11,400	115	12.1	5.0	15
[1]06-19-92	.29	16,400	395	15.2	14.0	118
06-27-92	.10	8,330	70	8.11	.5	25
07-29-92	.23	23,200	195	20.5	5.0	10
08-03-92	.08	7,920	115	4.92	5.0	39
[1]11-21-92	.25	10,200	620	0.87	8.0	--
			385240104493601 - Beacon Street at Bnchanan Street (Site 3)			
[1]06-05-92	.12	3,470	125	2.78	5.0	15
[1]06-19-92	.29	15,800	355	4.92	8.0	115
06-23-92	.14	5,770	210	1.24	4.0	120
06-27-92	.08	3,960	205	2.59	2.0	--
08-02-92	.06	3,450	165	2.14	5.0	15
08-03-92	.14	7,030	265	3.72	1.0	13
[1]11-11-92	.24	3,620	515	0.50	10.0	--
			385118104485801 - Wahsatch Street at Cross Lane (Site 4)			
05-26-92	.30	10,400	195	3.19	1.0	120
06-03-92	.25	9,400	160	10.2	3.0	15
[1]06-12-92	.10	6,030	150	3.82	3.0	15
06-26-92	.32	41,400	285	15.4	1.0	45
[1]07-25-92	.41	48,900	285	13.9	8.5	95
07-29-92	.19	22,600	175	13.9	4.0	10
[1]11-21-92	.27	6,670	545	0.72	8.0	--
			384935104501501 - Walmart at Eighth Street (Site 5)			
06-10-92	.10	6,890	115	8.58	1.0	10
06-26-92	.05	1,560	60	2.87	3.0	35
[1]07-17-92	.15	5,990	205	9.59	9.0	7
[1]08-03-92	.10	2,990	70	5.35	6.0	20
08-04-92	.05	1,440	70	1.92	0.8	35
08-05-92	.17	6,400	105	5.09	1.1	35
[1]12-06-92	.15	345	210	0.10	15.0	--

[1]Samples required for storm-water permit.

Table 17. Values for instantaneous water discharge, pH, specific conductance, water temperature, fecal coliform, fecal streptococci, residual chlorine, cyanide, oil and grease, and phenols for storm-runoff sites in Colorado Springs

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius, deg C, degrees Celsius; cols./100 mL, colonies per 100 milliliters; K, nonideal count; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; dashes indicate no data]

Date	Time	Instantaneous water discharge (ft^3/s)	pH (standard units)	Specific conductance (µS/cm)	Temperature, water (deg C)	Fecal coliform (cols./100 mL)	Fecal streptococci (cols./100 mL)	Total residual chlorine (mg/L)	Total cyanide (mg/L)	Total recoverable oil and grease (mg/L)	Gross phenols (µg/L)
384918104454201 - Sixteenth Hole, Valley-Hi Golf Course (Site 1)											
07-25-92	1424	7.0	7.3	--	19.0	--	--	0	<0.01	2	13
07-25-92	1442	20	8.7	--	18.5	--	--	0	<.01	5	8
07-25-92	1553	2.2	7.5	--	19.5	--	--	0	<.01	<1	9
08-10-92	0910	6.2	6.7	--	19.0	1,300	K22,000	0	<.01	3	8
08-10-92	0955	.31	7.5	--	17.0	K223,000	53,000	0	<.01	<1	9
08-10-92	1050	.18	7.8	--	15.0	60,000	K103,000	0	<.01	<1	8
08-24-92	0825	.40	--	--	--	1,900	9,100	--	--	--	--
11-21-92	0935	.40	7.2	380	3.5	K175	2,980	0	--	--	--
11-21-92	1311	2.55	8.1	240	4.5	--	--	0	<.01	10	11
11-21-92	1540	.51	7.7	260	4.0	K75	1,070	0	--	--	--
385347104500601 - Chestnut Street at Douglas Creek (Site 2)											
05-31-92	1330	.43	7.3	385	19.0	840	9,300	0	<.01	4	4
05-31-92	1430	1.71	6.7	68	15.5	K873	K28,000	0	<.01	<1	4
05-31-92	1535	3.10	7.8	52	13.5	K1,150	4,800	0	<.01	4	5
06-19-92	1731	15.2	6.5	--	22.5	21,000	K12,000	0	<0.01	6	6
06-19-92	1830	.74	7.4	--	20.0	23,000	K13,000	0	<.01	5	6
11-21-92	0920	.04	--	--	.5	K100	1,950	0	--	--	--
11-21-92	1050	.21	7.9	390	2.0	--	--	0	<.01	2	14
11-21-92	1220	.61	8.3	750	2.0	K67	K1,400	0	--	--	--
11-21-92	1345	.74	8.3	450	2.0	--	--	0	--	--	--
11-21-92	1635	.07	8.0	290	3.5	K50	K1,070	0	--	--	--
385240104493601 - Beacon Street at Buchanan Street (Site 3)											
06-05-92	1300	1.0	6.7	92	20.5	480	27,000	--	<.01	5	10
06-05-92	1310	.50	6.7	92	20.5	1,375	7,500	--	<.01	4	9
06-19-92	1740	3.1	6.3	135	22.0	2,900	5,600	0	<.01	4	7
06-19-92	1800	4.3	7.2	76	19.5	3,500	K14,000	0	<.01	6	7
06-19-92	1835	.88	7.2	71	20.5	K2,100	K15,000	0	<.01	5	7
11-11-92	0805	.15	--	--	5.0	K20,000	59,000	0	--	--	--
11-11-92	1020	.43	7.9	--	4.0	--	--	0	<.01	7	11
11-11-92	1245	.09	7.9	--	8.0	K31,000	K36,600	--	--	--	--

Table 17. Values for instantaneous water discharge, pH, specific conductance, water temperature, fecal coliform, fecal streptococci, residual chlorine, cyanide, oil and grease, and phenols for storm-runoff sites in Colorado Springs--Continued

Date	Time	Instantaneous water discharge (ft^3/s)	pH (standard units)	Specific conductance (μS/cm)	Temperature, water (deg C)	Fecal coliform (cols./100 mL)	Fecal streptococci (cols./100 mL)	Total residual chlorine (mg/L)	Total cyanide (mg/L)	Total recoverable oil and grease (mg/L)	Gross phenols (μg/L)
385118104485801 - Wahsatch Street at Cross Lane (Site 4)											
06-12-92	1507	3.4	7.6	--	23.0	5,400	43,000	0	<.01	8	12
06-12-92	1540	1.3	6.7	--	24.5	K11,000	K100,000	0	<.01	1	8
07-25-92	1410	5.6	7.1	68	19.0	--	--	0	<.01	10	10
07-25-92	1430	10.7	7.0	91	20.0	--	--	0	<.01	5	11
07-25-92	1610	1.3	7.4	84	20.5	--	--	--	<.01	<1	6
08-16-92	2050	3.6	--	--	--	3,070	24,000	--	--	--	--
11-21-92	1005	.01	--	--	5.5	K600	2,950	0	--	--	--
11-21-92	1230	.12	7.7	--	5.0	K131,000	1,070	0	<.01	6	11
11-21-92	1415	.68	6.9	--	1.0	--	--	0	--	--	--
11-21-92	1700	.09	7.4	--	2.0	4,900	K17,000	0	--	--	--
11-21-92	1730	.05	7.4	--	2.0	--	--	0	--	--	--
384935104501501 - Walmart at Eighth Street (Site 5)											
07-17-92	0255	4.7	6.5	87	15.5	--	--	0	<0.01	3	2
07-17-92	0325	.14	7.1	116	15.5	--	--	0	<.01	1	3
07-17-92	0415	.08	7.8	146	15.0	--	--	0	<.01	<1	2
08-03-92	1719	4.72	6.4	93	22.0	286	31,000	0	<10	6	10
08-03-92	1733	.68	6.8	121	22.5	143	33,000	0	<10	7	8
08-03-92	1750	.06	7.2	174	22.0	675	32,000	0	<10	3	10
08-16-92	2030	--	--	--	--	K7,000	12,200	--	--	--	--
12-06-92	1120	.01	7.2	5850	0.0	K225	K667	0	.02	6	26
12-06-93	1240	.04	--	--	.0	--	--	0	--	--	--
12-06-92	1400	.01	7.8	6060	4.0	K275	2,000	--	--	--	--

Table 18. Selected volatile-organic compounds for storm-runoff sites in Colorado Springs

[All constituents in micrograms per liter; <, less than]

Date	Time	Acrolein, total	Acrylonitrite, total	Benzene, total	Bromobenzene, water, whole, total	Bromoform, total	Carbon tetrachloride, total	Chlorobenzene, total	Chlorodibromomethane, total	Chloroethane, total	Chloroform, total
384918104454201 - Sixteenth Hole, Valley-Hi Golf Course (Site 1)											
07-25-92	1424	<20	<20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
07-25-92	1442	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	1500	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	1553	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	0910	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	0955	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	1050	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	0935	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	1311	<20	<20	.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	1540	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Date	Methylchloride, total	Cis-1,2-dichloroethene, water, total	Cis-1,3-dichloropropene, total	Dibromochloropropene, water, whole, total recoverable	Dibromomethane, water, whole, total recoverable	Dichlorobromomethene, total	Dichlorodifluoromethane, total	Ethylbenzene, total	Hexachlorobutadiene, total	Isopropylbenzene, water, whole, recoverable
07-25-92	<0.2	<0.2	<0.2	<1.0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
07-25-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	.3	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Selected volatile organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Methyl-bro-mide, total	Methyl-ene chlo-ride, total	N-butyl-benzene, water, whole, recov-ereble total	N-propyl-benzene, water, whole, recov-erable total	Neph-thalene, total	P-Iso-propyl-toluene, water, whole, recov-erable	Sec-butyl-benzene, water, whole, recov-erable, total	Styrene, total	Tetra-chloro-ethylene, total	Toluene, total
384918104454201 - Sixteenth Hole, Valley-Hi Golf Conrse (Site 1)--Continned										
07-25-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	0.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	.6	<.2	<.2	<.2	<.2	2.2
[1]11-21-92	<.2	<.2	<.2	<.2	.5	<.2	<.2	<.2	<.2	.7

Date	Cis-1,3-di-chloro-pro-pene, total	Trans-1,3 di-chloro-pro-pene, total	Tri-chloro-ethyl-ene, total	Tri-chloro-fluoro-meth-ane, total	Vinyl-chlo-ride, total	Tert-butyl-ben-zene, water, whole, recov-erable, total	Xylene, water, whole, recov-erable, total	1,1-di-chloro-pro-pene, water, whole, total	1,1-di-chloro-ethane, total	1,1-di-chloro-ethyl-ene, total	1,1,1-tri-chloro-ethane, total
07-25-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	0.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	2.3	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	.8	<.2	<.2	<.2	<.2

Table 18. Selected volatile organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	1,1,1,2-tetra-chloro-ethane, water, whole, total	1,1,2-tri-chloro-ethane, total	1,1,2,2-tetra-chloro-ethane, total	1,2-di-bromo-ethane, water, whole, total	0-chloro-benzene, 1,2-di-chloro-benzene, total	1,2-di-chloro-ethane, total	1,2-di-chloro-propane, total	0-chloro-toluene, water, whole, total	1,2-trans-di-chloro-ethylene, total	1, 2, 3-tri-chloro-benzene, water, whole recov-erable total
384918104454201 - Sixteenth Hole, Valley-Hi Golf Course (Site 1)--Continued										
07-25-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Date	1,2,3-tri-chloro-propane, water, whole, total	1,2,4-tri-chloro-benzene, total	1,2,4-tri-methyl-benzene, water, whole, recov-erable, total	1,3-di-chloro-benzene, total	1,3-di-chloro-propane, water, whole, total	1,3,5-tri-methyl-benzene, water, whole, recov-erable	Para-chloro-toluene, water, whole, total	1,4-di-chloro-benzene, total	2-chloro-ethyl-vinyl-ether, total	2,2-di-chloro-propane, water, whole, total
07-25-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<0.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
08-10-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]11-21-92	<.2	<.2	.6	<.2	<.2	.2	<.2	<.2	<1.0	<.2
[1]11-21-92	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2	<1.0	<.2

Table 18. Selected volatile organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Time	Acro-lein, total	Acrylo-nitrite, total	Benzene, total	Bromo-benzene, weter, whole, total	Bromo-form, total	Carbon-tetra-chloride, total	Chloro-benzene, total	Chloro-di-bromo-methene, total	Chloro-ethane, total	Chloro-form, total
				385347104500601 - Chestnut Street at Douglas Creek (Site 2)							
05-31-92	1330	<20	<20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
05-31-92	1535	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	1731	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	1830	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	1050	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	1345	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	1635	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Date	Methyl-chloride, total	Cis-1,2-di-chloro-ethene, water, total	Cis,-1,3-di-chloro-propene, total	Di-bromo-chloro-propane, water, whole, total-recov-ereble	Di-bromo-methane, water, whole, recov-erable	Di-chloro-bromo-methane, total	Di-chloro-di-fluoro-methane, total	Ethyl-benzene, total	Hexa-chloro-buta-diene, total	Iso-propyl-benzene, water, whole, recov-erable
05-31-92	<0.2	<0.2	<0.2	<1.0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
05-31-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2

Date	Methyl-bromide, total	Methyl-ene chloride, total	N-butyl-benzene, water, whole, recov-erable	N-propyl benzene, water, whole, recov-erable	Neph-tha-lene, total	P-iso-propyl-toluene, water, whole, recov-erable	Sec-butyl-benzene, water, whole, recov-erable	Styrene, total	Tetre-chloro-ethylene, total	Toluene, total
05-31-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
05-31-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.4
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	.4	<.2	<.2	<.2	<.2	.2
[1]11-21-92	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2	<.2	.2

Table 18. Selected volatile organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Cis-1,3-di-chloro-pro-pene, total	Trans-1,3-di-chloro-pro-pane, total	Tri-chloro-ethyl-ene, total	Tri-chloro-fluoro-meth-ane, total	Vinyl-chlo-ride, total	Tert-butyl-benzene, water, whole, recov-erable	Xylene, water, whole, total recov-erable	1,1-di-chloro-pro-pene, water, whole, total	1,1-di-chloro-ethyl-ene, total	1, 1-di-chloro-ethyl-ene, total	1,1,1-tri-chloro-ethane, total
385347104500601 - Chestnut Street at Douglas Creek (Site 2)--Continued											
05-31-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
05-31-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	.7	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2	<.2

Date	1,1,1,2 tetra-chloro-ethane, water, whole, total	1,1,2-tri-chloro-ethane, total	1,1,2,2-tetra-chloro-ethane, total	1,2-di-bromo-ethane, water, whole, total	1,2-di-chloro-benzene, total	1,2-di-chloro-ethane, total	1,2-di-chloro-propane, total	0-chloro-toluene, water, whole, total	1,2-trans di-chloro-ethylene, total	1,2,3-tri-chloro-benzene, water, whole, recov-erable
05-31-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
05-31-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Date	1,2,3-tri-chloro-propane, water, whole, total	1,2,4-tri-chloro-benzene, total	1,2,4-tri-methy-benzene, water, whole, recov-erable	1,3-di-chloro-benzene, total	1,3-di-chloro-propane, water, whole, total	1,3,5-tri-methyl-benzene, water, whole, recov-erable	Para-chloro-toluene, water, whole, total	1,4-di-chloro-benzene, total	2-chloro-ethyl-vinyl-ether, total	2,2-di-chloro-propane, water, whole, total
05-31-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<0.2
05-31-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]11-21-92	<.2	<.2	.4	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]11-21-92	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2

Table 18. Selected volatile organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Time	Acrolein, total	Acrylonitrile, total	Benzene, total	Bromobenzene, water, whole, total	Bromoform, total	Carbontetrachloride, total	Chlorobenzene, total	Chlorodibromomethane, total	Chloroethane, total	Chloroform, total
385240104493601 - Beacon Street at Buchanan Street (Site 3)											
06-05-92	1300	<20	<20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
06-05-92	1310	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	1740	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	1800	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	1835	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	0805	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	1020	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	1245	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Date	Methylchloride, total	Cis-1,2-dichloroethene, water, total	Cis-1,3-dichloropropene, total	Dibromochloropropane, water, whole, total-recoverable	Dibromomethane, water, whole, recoverable	Dichlorobromomethane, total	Dichlorodifluoromethane, total	Ethylbenzene, total	Hexachlorobutadiene, total	Isopropylbenzene, water, whole recoverable
06-05-92	<0.2	<0.2	<0.2	<1.0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
06-05-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	<.2	<.2	<.2	<1.0	<.2	.2	<.2	<.2	<.2	<.2

Date	Methylbromide, total	Methylenechloride, total	N-butylbenzene, water, whole, recoverable	N-propylbenzene, water, whole, recoverable	Naphthalene, total	P-isopropyltoluene, water, whole, recoverable	Sec-butylbenzene, water, whole, recoverable	Styrene, total	Tetrachloroethylene, total	Toluene, total
06-05-92	<0.2	<0.2	<0.2	<0.2	1.0	<0.2	<0.2	<0.2	<0.2	<0.2
06-05-92	<.2	<.2	<.2	<.2	1.1	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	.4	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	<.2	<.2	<.2	<.2	.6	<.2	<.2	<.2	<.2	.2
[1]11-11-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	<.2	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2

Table 18. Selected volatile organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Cis-1,3-di-chloro-pro-pane, total	Trans-1,3-di-chloro-pro-pene, total	Tri-chloro-ethyl-ene, total	Tri-chloro-fluoro-meth-ane, total	Vinyl-chlo-ride, total	Tert-butyl-ben-zene, water, whole, recov-erable	Xylene, water, whole, total, recov-erable	1,1-di-chloro-pro-pene, water, whole, total	1,1-di-chloro-ethane, total	1,1-di-chloro-ethyl-ene, total	1,1,1-tri-chloro-ethane, total
385240104493601 - Beacon Street at Bnchanan Street (Site 3)--Continned											
06-05-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
06-05-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2
[1]11-11-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	<.2	<.2	<.2	<.2	<.2	<.2	.5	<.2	<.2	<.2	<.2

Date	1,1,1,2-tetra-chloro-ethane, water, whole, total	1,1,2-tetra-chloro-ethane, total	1,1,2,2-tetra-chloro-ethane, total	1,2 di-bromo-ethane, water, whole, total	1,2 di-chloro-benzene, total	1,2 di-chloro-ethane, total	1,2 di-chloro-propane, total	O-chloro-toluene, water, whole, total	1,2-trans-di-chloro-ethylene, total	1,2,3-tri-chloro-benzene, water, whole, recov-erable
06-05-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
06-05-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-11-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Date	1,2,3-tri-chloro-pro-pane, water, whole, total	1,2,4-tri-chloro-ben-zene, total	1,2,4-tri-methyl-ben-zene, water, whole, recov-erable	1,3-di-chloro-ben-zene, total	1,3-di-chloro-pro-pene, water, whole, total	1,3,5-tri-methyl-ben-zene, water, whole, recov-erable	Pere-chloro-toluene, water, whole, total	1,4-di-chloro-ben-zene, total	2 chloro-ethyl-vinyl-ether, totel	2,2-di-chloro-pro-pane, weter, whole, total
06-05-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<0.2
06-05-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
06-19-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]11-11-92	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]11-11-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]11-11-92	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2	<1.0	<.2

Table 18. Selected volatile organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Time	Acrolein, total	Acrylonitrile, total	Benzene, total	Bromobenzene, water, whole, total	Bromoform, total	Carbontetrachloride, total	Chlorobenzene, total	Chlorodibromomethane, total	Chloroethane, total	Chloroform, total
385118104485801 - Wahsatch Street at Cross Lane (Site 4)											
06-12-92	1507	<20	<20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
06-12-92	1540	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	1410	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	1430	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	1610	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	1230	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	1415	<20	<20	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	1730	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Date	Methylchloride, total	Cis-1,2-dichloroethene, water, total	Cis-1,3 dichloropropane, total	Dibromochloropropene, water, whole, total recoverable	Dibromomethane, water, whole, recoverable	Dichlorobromomethane, total	Dichlorodifluoromethane, total	Ethylbenzene, total	Hexachlorobutadiene, total	Isopropylbenzene, water, whole, recoversble
06-12-92	<0.2	<0.2	<0.2	<1.0	<0.2	<0.2	<0.2	0.2	<0.2	<0.2
06-12-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2

Dste	Methylbromide, total	Methylenechloride, total	N-butylbenzene, water, whole, recoverable	N-propylbenzene, water, whole, recoverable	Naphthalene, total	P-laopropyltoluene, water, whole, recoverable	Sec-butylbenzene, water, whole, recoverable	Styrene, total	Tetrachloroethylene, total	Toluene, total
06-12-92	<0.2	<0.2	<0.2	<0.2	0.3	0.2	<0.2	<0.2	<0.2	0.5
06-12-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.6
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2	<.2	1.2
[1]11-21-92	<.2	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2	1.1
[1]11-21-92	<.2	<.2	<.2	<.2	.4	<.2	<.2	<.2	<.2	.3

Table 18. Selected volatile organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Cis-1,3-di-chloro-pro-pene, total	Trans-1,3-di-chloro-pro-pene, total	Tri-chloro-ethyl-ene, total	Tri-chloro-fluoro-meth-ane, total	Vinyl-chlo-ride, total	Tert-butyl-ben-zene, water, whole, recov-erable	Xylene, water, whole, total recov-erable	1,1-di-chloro-pro-pene, water, whole, total	1,1-di-chloro-ethane, total	1,1-di-chloro-ethyl-ene, total	1,1,1-tri-chloro-eth-ane, total
					385118104485801 - Wahsatch Street at Cross Lane (Site 4)--Continued						
06-12-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.5	<0.2	<0.2	<0.2	<0.2
06-12-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	.7	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2

1,1,1,2-tetra-chloro-ethane, water, whole, total	1,1,2-tri-chloro-ethane, total	1,1,2,2-tetra-chloro-ethane, total	1,2-di-bromo-ethane, water, whole, total	1,2-di-chloro-ben-zene, total	1,2-di-chloro-ben-zene, total	1,2-di-chloro-ethene, total	1,2-di-chloro-propane, total	O-chloro-toluene, water, whole, total	1,2-trans-di-chloro-ethyl-ene, total	1,2,3-tri-chloro-ben-zene, water, whole, recov-erable
06-12-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
06-12-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Date	1,2,3-tri-chloro-pro-pane, water, whole, total	1,2,4-tri-chloro-ben-zene, total	1,2,4-tri-methyl-ben-zene, water, whole, recov-erable	1,3-di-chloro-ben-zene, total	1,3-di-chloro-propane, water, whole, total	1,3,5-tri-methyl-ben-zene, water, whole, recov-erable	Para-chloro-toluene, water, whole, total	1,4-di-chloro-ben-zene, total	2-chloro-ethyl-vinyl-ether, total	2-2-di-chloro-propane, water, whole, total
06-12-92	<0.2	<0.2	0.9	<0.2	<0.2	0.3	<0.2	<0.2	<1.0	<0.2
06-12-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
07-25-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]11-21-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]11-21-92	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]11-21-92	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2

Table 18. Selected volatile organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Time	Acrolein, total	Acrylonitrile, total	Benzene, total	Bromobenzene, water, whole, total	Bromoform, total	Carbontetrachloride, total	Chlorobenzene, total	Chlorodibromomethane, total	Chloroethane, total	Chloroform, total
384935104501501 - Walmart at Eighth Street (Site 5)											
07-17-92	0255	<20	<20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2.1
07-17-92	0325	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.9
07-17-92	0415	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	2.0
08-03-92	1719	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-03-92	1733	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-03-92	1750	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]12-06-92	1120	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]12-06-92	1240	<20	<20	.3	<.2	<.2	<.2	<.2	<.2	<.2	.7
[1]12-06-92	1400	<20	<20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	1.1

Date	Methylchloride, total	Cis-1,2-dichloroethene, water, total	Cis-1,3-dichloropropene, total	Di-bromochloropropane, water, whole, total recoverable	Dibromomethane, water, whole, recoverable	Dichlorobromomethane, total	Dichlorodifluoromethane, total	Ethylbenzene, total	Hexachlorobutadiene, total	Isopropylbenzene, water, whole, recoverable
07-17-92	<0.2	0.2	<0.2	<1.0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
07-17-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
07-17-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
08-03-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
08-03-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
08-03-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]12-06-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]12-06-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	<.2
[1]12-06-92	<.2	<.2	<.2	<1.0	<.2	<.2	<.2	.3	<.2	<.2

Date	Methylbromide, total	Methylene, chloride, total	N-butylbenzene, water, whole, recoverable	N-propylbenzene, water, whole, recoverable	Naphthalene, total	P-isopropyltoluene, water, whole, recoverable	Sec-butylbenzene, water, whole, recoverable	Styrene, total	Tetrachloroethylene, total	Toluene, total
07-17-92	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2
07-17-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-17-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-03-92	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2
08-03-92	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2	<.2	.3
08-03-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]12-06-92	<.2	<.2	<.2	<.2	4.7	<.2	<.2	<.2	<.2	.2
[1]12-06-92	<.2	<.2	.4	.3	1.6	<.2	<.2	<.2	<.2	1.7
[1]12-06-92	<.2	<.2	<.2	<.2	1.1	<.2	<.2	<.2	<.2	.2

Table 18. Selected volatile organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Cis-1,3-di-chloro-pro-pene, total	Trsns-1,3-di-chloro-pro-pene, total	Tri-chloro-ethyl-ene, total	Tri-chloro-fluoro-meth-ane, total	Vinyl-chlo-ride, total	Tert-butyl-benzene, water, whole, recov-erable	Xylene, water, whole, total recov-erable	1,1-di-chloro-pro-pene, water, whole, total	1,1-di-chloro-ethane, total	1,2-di-chloro-ethyl-ene, total	1,1,1-tri-chloro-ethane, total
384935104501501 - Walmart at Eighth Street (Site 5)—Continued											
07-17-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
07-17-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.7
07-17-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3
08-03-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-03-92	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2	<.2
08-03-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]12-06-92	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2	<.2	<.2	<.2
[1]12-06-92	<.2	<.2	<.2	<.2	<.2	<.2	4.4	<.2	<.2	<.2	<.2
[1]12-06-92	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2	<.2	<.2	<.2

Date	1,1,1,2-tetra-chloro-ethane, water, whole, total	1,1,2-tri-chloro-ethane, total	1,1,2,2-tetra-chloro-ethane, total	1,2-di-bromo-ethane, water, whole, total	1,2-di-chloro-ben-zene, totel	1,2-di-chloro-ethane, total	1,2-di-chloro-pro-pane, total	O-chloro-toluene, water, whole, total	1,2-trans-di-chloro-ethyl-ene, total	1,2,3-tri-chloro-ben-zene, water, whole, recov-erable
07-17-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
07-17-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
07-17-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-03-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-03-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
08-03-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]12-06-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]12-06-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
[1]12-06-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Date	1,2,3-tri-chloro-pro-pane, water, whole, total	1,2,4-tri-chloro-ben-zene, total	1,2,4-tri-methyl-ben-zene, water, whole, recov-erable	1,3-di-chloro-ben-zene, total	1,3-di-chloro-pro-pane, water, whole, total	1,3,5-tri-methyl-ben-zene, water, whole, recov-erable	Para-chloro-toluene, water, whole, total	1,4-di-chloro-ben-zene, total	2-chloro-ethyl-vinyl-ether, total	2,2-di-chloro-pro-pane, water, whole, total
07-17-92	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<0.2
07-17-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
07-17-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
08-03-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
08-03-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
08-03-92	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]12-06-92	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2	<1.0	<.2
[1]12-06-92	<.2	<.2	2.8	<.2	<.2	.9	<.2	<.2	<1.0	<.2
[1]12-06-92	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2	<1.0	<.2

[1]Snowmelt-runnoff sample.

Table 19. Chemical oxygen demand, 5-day biochemical oxygen demand, specific conductance, alkalinity, dissolved solids, suspended solids, major ions, nutrients, and total-recoverable metals for storm-runoff sites in Colorado Springs

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; µg/L, micrograms per liter; lab, laboratory; dashes indicate no data; <, less than]

Date	Time	Oxygen demand, chemical, high level (mg/L)	Oxygen demand, biochemical, 5-day (mg/L)	Specific conductance (µS/cm)	Alkalinity, lab (mg/L)	Solids, dissolved (mg/L)	Solids, suspended (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sodium, dissolved (mg/L)
				384918104454201 - Sixteenth Hole, Valley-Hi Golf Course (Site 1)							
06-03-92	1410	100	--	114	--	63	321	--	---	--	--
06-23-92	2030	170	53	147	--	107	121	--	--	--	--
06-26-92	1453	140	24	107	--	71	372	--	--	--	--
07-02-92	1459	210	47	--	--	202	136	--	--	--	--
07-25-92	1423	310	29	105	37	75	242	9.9	2.4	1.2	5.2
08-10-92	0840	180	19	133	53	93	524	13	2.9	1.9	5.4
11-21-92	0930	270	--	256	52	143	274	14	3.6	1.8	25

Date	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Nitrogen, ammonia, total, as nitrogen (mg/L)	Nitrogen, ammonia plus organic, total, as nitrogen (mg/L)	Nitrogen nitrite, total, as nitrogen (mg/L)	Nitrogen, nitrate plus nitrite, total, as nitrogen (mg/L)	Phosphorus, total, as phosphorus (mg/L)	Phosphorus, dissolved, as phosphorus (mg/L)	Antimony, total-recoverable (µg/L)	Arsenic, total (µg/L)	Beryllium, total-recoverable (µg/L)
06-03-92	--	--	0.98	1.7	0.03	0.80	0.14	0.08	--	--	--
06-23-92	--	--	.88	2.2	.08	1.00	.29	.15	--	--	--
06-26-92	--	--	.28	1.6	.03	.52	.33	.08	--	--	--
07-02-92	--	--	.73	2.4	.11	.97	.36	.28	--	--	--
07-25-92	1.0	21	.28	1.5	.02	.40	.29	.12	<10	2	<10
08-10-92	.1	2.2	.67	2.1	.04	.98	.45	.14	<10	3	<10
11-21-92	32	27	.41	.9	.07	.46	.12	.08	<10	1	<10

Date	Cadmium, total-recoverable (µg/L)	Chromium, total-recoverable (µg/L)	Copper, total-recoverable (µg/L)	Lead, total-recoverable (µg/L)	Mercury, total-recoverable (µg/L)	Nickel, total-recoverable (µg/L)	Selenium, total (µg/L)	Silver, total-recoverable (µg/L)	Thallium, total (µg/L)	Zinc, total-recoverable (µg/L)	Carbon, organic, total (mg/L)
06-03-92	<1	--	10	140	--	--	--	--	--	180	--
06-23-92	<1	--	9	23	--	--	--	--	--	140	--
06-26-92	<1	--	15	60	--	--	--	--	--	190	--
07-02-92	<1	--	13	30	--	--	--	--	--	190	--
07-25-92	<1	43	12	170	0.1	5	<1	<1	<5	180	32
08-10-92	1	20	12	77	<.1	11	1	<1	<5	300	36
11-21-92	1	14	17	64	<.1	9	<2	<1	<5	250	29

Table 19. Chemical oxygen demand, 5-day biochemical oxygen demand, specific conductance, alkalinity, dissolved solids, suspended solids, major ions, nutrients, and total-recoverable metals for storm-runoff sites in Colorado Springs--Continued

Date	Time	Oxygen demand, chemical (high level) (mg/L)	Oxygen demand, biochemical, 5 day (mg/l)	Specific conductance (µS/cm)	Alkalinity, lab (mg/L)	Solids, dissolved (mg/L)	Solids, suspended (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sodium, dissolved (mg/L)
38534710450061 - Chestnut Street at Douglas Creek (Site 2)											
05-31-92	1255	230	14	385	80	68	396	--	--	--	--
06-05-92	1230	420	39	63	--	63	1280	--	--	--	--
06-19-92	1724	280	80	--	65	121	764	14	1.1	3.1	3.3
06-27-92	1705	310	--	70	--	55	198	--	--	--	--
07-29-92	1350	150	34	85	--	34	832	--	--	--	--
08-03-92	2050	100	28	77	--	60	234	--	--	--	--
11-21-92	0910	190	22	497	57	256	464	13	0.95	1.8	77

Date	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Nitrogen, ammonia, total, as nitrogen (mg/L)	Nitrogen, ammonia plus organic, total, as nitrogen (mg/L)	Nitrogen nitrite, total, as nitrogen (mg/L)	Nitrogen, nitrate plus nitrite, total, as nitrogen (mg/L)	Phosphorus, total, as phosphorus (mg/L)	Phosphorus, dissolved, as phosphorus (mg/L)	Antimony, total-recoverable (mg/L)	Arsenic, total (mg/L)	Beryllium, total recoverable (mg/L)
05-31-92	2.9	6.4	0.43	1.0	0.04	0.93	0.12	--	<10	5	<10
06-05-92	--	--	.24	2.4	.03	.61	.72	0.12	--	--	--
06-19-92	2.1	6.6	1.10	2.3	.03	1.10	.25	.21	<10	8	<10
06-27-92	--	--	.49	1.3	.06	1.10	.20	.07	--	--	--
07-29-92	--	--	.23	.90	.03	.57	.16	.10	--	--	--
08-03-92	--	--	.56	1.1	.04	.87	.09	.08	--	--	--
11-21-92	130	4.2	.36	1.1	.08	.45	.17	.06	<10	<1	<10

Date	Cadmium, total-recoverable (µg/L)	Chromium, total-racoverable (µg/L)	Copper, total-recoverable (µg/L)	Lead, total-recoverable (µg/L)	Mercury, total-recoverable (µg/L)	Nickal, total-recoverable (µg/L)	Selenium, total (µg/L)	Silver, total-recoverable (µg/L)	Thallium, total (µg/L)	Zinc, total-recoverable (µg/L)	Carbon, organic, total (mg/L)
05-31-92	1	27	19	150	<0.1	8	<2	<1	<10	700	48
06-05-92	2	--	99	350	--	--	--	--	--	1400	--
06-19-92	2	51	74	290	.1	22	<2	<1	<10	1400	52
06-27-92	<1	--	12	47	--	--	--	--	--	290	--
07-29-92	2	--	37	290	--	--	--	--	--	550	--
08-03-92	<1	--	18	86	--	--	--	--	--	570	--
11-21-92	1	28	17	110	<.1	8	<2	<1	<10	230	32

Table 19. Chemical oxygen demand, 5-day biochemical oxygen demand, specific conductance, alkalinity, dissolved solids, suspended solids, major ions, nutrients, and total-recoverable metals for storm-runoff sites in Colorado Springs--Continued

Date	Time	Oxygen demand, chemical (high level) (mg/L)	Oxygen demand, biochemical, 5 day (mg/l)	Specific conductance (µS/cm)	Alkalinity, lab (mg/L)	Solids, dissolved (mg/L)	Solids, suspended (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sodium, dissolved (mg/L)
					385240104493601 - Beacon Street at Bnchanan Street (Site 3)						
06-05-92	1240	170	33	92	40	74	330	13	0.86	2.2	2.9
06-19-92	1735	300	66	101	44	103	340	13	.91	3.1	2.9
06-23-92	2044	200	42	110	--	87	101	--	--	--	--
06-27-92	1712	160	51	99	--	77	162	--	--	--	--
08-02-92	1845	270	74	133	--	168	220	--	--	--	--
08-03-92	2055	120	26	59	--	54	272	--	--	--	--
11-11-92	0759	260	62	238	41	137	116	13	1.0	2.6	25

Date	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Nitrogen, ammonia, total, as nitrogen (mg/L)	Nitrogen, ammonia plus organic, total, as nitrogen (mg/L)	Nitrogen nitrite, total, as nitrogen (mg/L)	Nitrogen, nitrate plus nitrite, total, as nitrogen (mg/L)	Phosphorus, total, as phosphorus (mg/L)	Phosphorus, dissolved, as phosphorus (mg/L)	Antimony, total-recoverable (mg/L)	Arsenic, total (mg/L)	Beryllium, total recoverable (mg/L)
06-05-92	3.4	8.5	0.76	2.9	.04	0.84	0.30	0.13	<20	1	<10
06-19-92	2.9	6.4	1.30	3.5	.04	1.00	.58	.51	<10	<1	<10
06-23-92	--	--	.99	2.7	.07	1.10	.27	.17	--	--	--
06-27-92	--	--	1.50	3.7	.06	1.00	.46	.20	--	--	--
08-02-92	--	--	1.50	4.0	.04	1.40	.44	.30	--	--	--
08-03-92	--	--	.48	1.6	.03	.66	.16	.10	--	--	--
11-11-92	42	5.3	.57	1.8	.07	.68	.33	.18	<10	1	<10

Date	Cadmium, total-recoverable (µg/L)	Chromium, total-recoverable (µg/L)	Copper, total-recoverable (µg/L)	Lead, total-recoverable (µg/L)	Mercury, total-recoverable (µg/L)	Nickel, total-recoverable (µg/L)	Selenium, total (µg/L)	Silver, total-recoverable (µg/L)	Thallium, total (µg/L)	Zinc, total-recoverable (µg/L)	Carbon, organic, total (mg/L)
06-05-92	2	18	17	85	<0.1	12	<2	<1	<5	280	68
06-19-92	2	27	24	83	<.1	17	<2	1	<10	350	83
06-23-92	<1	--	13	23	--	--	--	--	--	160	--
06-27-92	<1	--	13	42	--	--	--	--	--	150	--
08-02-92	2	--	22	53	--	--	--	--	--	400	--
08-03-92	2	--	12	97	--	--	--	--	--	340	--
11-11-92	1	8	14	55	<.1	6	<2	<1	<10	200	52

Table 19. Chemical oxygen demand, 5-day biochemical oxygen demand, specific conductance, alkalinity, dissolved solids, suspended solids, major ions, nutrients, and total-recoverable metals for storm-runoff sites in Colorado Springs--Continued

Date	Time	Oxygen demand, chemical (high level) (mg/L)	Oxygen demand, biochemical, 5 day (mg/l)	Specific conductance (µS/cm)	Alkalinity, lab (mg/L)	Solids, dissolved (mg/L)	Solids, suspended (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sodium, dissolved (mg/L)
385118104485801 - Wahsatch Street at Cross Lane (Site 4)											
05-26-92	1945	250	--	--	--	--	116	--	--	--	--
06-03-92	1405	230	--	84	--	74	754	--	--	--	--
06-12-92	1504	500	86	--	84	132	660	20	1.3	5.6	3.3
06-26-92	1619	360	72	84	--	60	848	--	--	--	--
07-25-92	1408	330	140	82	54	106	266	11	1.1	5.3	2.2
07-29-92	1401	340	92	110	--	93	512	--	--	--	--
11-21-92	1010	190	29	1740	40	908	148	20	1.6	3.7	300

Date	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Nitrogen, ammonia, total, as nitrogen (mg/L)	Nitrogen, ammonia plus organic, total, as nitrogen (mg/L)	Nitrogen nitrite, total, as nitrogen (mg/L)	Nitrogen, nitrate plus nitrite, total, as nitrogen (mg/L)	Phosphorus, total, as phosphorus (mg/L)	Phosphorus, dissolved, as phosphorus (mg/L)	Antimony, total-recoverable (mg/L)	Arsenic, total (mg/L)	Beryllium, total recoverable (mg/L)
05-26-92	--	--	1.00	5.0	0.05	0.38	1.20	--	--	--	--
06-03-92	--	--	.53	4.9	.06	.88	.47	0.26	--	--	--
06-12-92	3.0	6.5	.72	5.3	.07	.83	1.10	.38	<10	5	<10
06-26-92	--	--	.27	3.8	.04	.47	.95	.28	--	--	--
07-25-92	2.1	5.6	.16	3.1	.03	.37	.72	.27	<10	3	<10
07-29-92	--	--	.35	2.8	.04	.83	.60	--	--	--	--
11-21-92	470	4.5	.39	1.6	.08	.36	.22	.11	<10	<1	<10

Date	Cadmium, total-recoverable (µg/L)	Chromium, total-recoverable (µg/L)	Copper, total-recoverable (µg/L)	Lead, total-recoverable (µg/L)	Mercury, total-recoverable (µg/L)	Nickel, total-recoverable (µg/L)	Selenium, total (µg/L)	Silver, total-recoverable (µg/L)	Thallium, total (µg/L)	Zinc, total-recoverable (µg/L)	Carbon, organic, total (mg/L)
05-26-92	<1	--	9	41	--	--	--	--	--	110	--
06-03-92	1	--	12	120	--	--	--	--	--	220	--
06-12-92	2	18	22	130	<0.1	11	<2	<1	<10	300	100
06-26-92	1	--	15	130	--	--	--	--	--	310	--
07-25-92	<1	8	11	57	<.1	4	<1	<1	<5	140	100
07-29-92	1	--	17	110	--	--	--	--	--	240	--
11-21-92	<1	7	8	32	<.1	4	<2	<1	<10	110	18

Table 19. Chemical oxygen demand, 5-day biochemical oxygen demand, specific conductance, alkalinity, dissolved solids, suspended solids, major ions, nutrients, and total-recoverable metals for storm-runoff sites in Colorado Springs--Continued

Date	Time	Oxygen demand, chemical (high level) (mg/L)	Oxygen demand, biochemical, 5 day (mg/l)	Specific conductance (µS/cm)	Alkalinity, lab (mg/L)	Solids, dissolved (mg/L)	Solids, suspended (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sodium, dissolved (mg/L)
					384935104501501 - Walmart at Eighth Street (Site 5)						
06-10-92	1625	160	67	--	--	93	1400	--	--	--	--
06-26-92	1712	310	260	132	--	127	388	--	--	--	--
07-17-92	0250	200	35	100	51	70	662	10	1.1	2.2	6.2
08-03-92	1717	390	38	122	64	138	872	14	1.4	2.7	4.9
08-04-92	1729	260	71	142	--	--	516	--	--	--	--
08-05-92	1700	200	29	91	--	67	826	--	--	--	--
12-06-92	1115	830	160	7010	219	4240	1260	59	16	3.2	1300

Date	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Nitrogen, ammonia, total, as nitrogen (mg/L)	Nitrogen, ammonia plus organic, total, as nitrogen (mg/L)	Nitrogen nitrite, total, as nitrogen (mg/L)	Nitrogen, nitrate plus nitrite, total, as nitrogen (mg/L)	Phosphorus, total, as phosphorus (mg/L)	Phosphorus, dissolved, as phosphorus (mg/L)	Antimony, total-recoverable (mg/L)	Arsenic, total (mg/L)	Beryllium, total recoverable (mg/L)
06-10-92	--	--	0.58	1.2	0.06	1.0	0.21	0.14	--	--	--
06-26-92	--	--	.52	1.8	.10	.71	.41	.34	--	--	--
07-17-92	6.9	9.2	.41	2.2	.03	.69	.59	.19	<10	5	<10
08-03-92	6.7	15	1.00	2.3	.04	1.20	.35	.24	<10	7	<10
08-04-92	--	--	1.70	4.2	.08	1.80	.63	--	--	--	--
08-05-92	--	--	1.00	3.8	.04	1.20	1.00	.15	--	--	--
12-06-92	2000	190	3.90	7.4	.31	1.60	1.00	.09	<10	13	<10

Date	Cadmium, total-recoverable (µg/L)	Chromium, total-recoverable (µg/L)	Copper, total-recoverable (µg/L)	Lead, total-recoverable (µg/L)	Mercury, total-recoverable (µg/L)	Nickel, total-recoverable (µg/L)	Selenium, total (µg/L)	Silver, total-recoverable (µg/L)	Thallium, total (µg/L)	Zinc, total-recoverable (µg/L)	Carbon, organic, total (mg/L)
06-10-92	3	--	18	340	--	--	--	--	--	500	--
06-26-92	1	--	18	85	--	--	--	--	--	210	--
07-17-92	2	35	15	200	0.1	16	<2	<1	<5	330	69
08-03-92	21	52	26	300	.2	21	2	<1	<5	630	77
08-04-92	1	--	17	120	--	--	--	--	--	340	--
08-05-92	2	--	30	180	--	--	--	--	--	330	--
12-06-92	4	88	70	350	.1	33	<2	<1	<5	730	240

Table 20. Selected acid-base/neutral organic compounds for storm-runoff sites in Colorado Springs

[All concentrations in micrograms per liter; <, less than]

Date	Time	Acenaphthylene, total	Acenaphthene, total	Anthracene, total	Benzidine, total	Benzo-a-anthracenel, 2-benzanthracene, total	Benzo-a-pyrene, total	Benzogh-iperylenel, 12-benzoperylene, total	Benzo-b-fluoranthene, total	Benzo-k-fluoranthene, total	Bis (2-ethylhexyl) phthalate, total	Bis 2-chloroethylether, total	Bis (2-chloroethoxy) methane, total
384918104454201 - Sixteenth Hole, Valley-Hi Golf Course (Site 1)													
07-25-92	1423	<5.0	<5.0	<5.0	<40.0	<10.0	<10.0	<10.0	10.0	<10.0	14.0	<5.0	<5.0
08-10-92	0840	<5.0	<5.0	<5.0	<40.0	<10.0	<10.0	11.0	11.0	<10.0	11.0	<5.0	<5.0
11-21-91	0930	<5.0	<5.0	<5.0	<40.0	<10.0	<10.0	<10.0	<10.0	<10.0	30.0	<5.0	<5.0

Date	Bis (2-chloro-isopropyl) ether, total	Chrysene, total	Di-ethyl-phthalate, total	Di-methyl-phthalate, total	Di-n-octyl-phthalate, total	Di-n-butyl-phthalate, total	Fluoranthene, total	Fluorene, total	Hexachlorobenzene, total	Hexachloro-butadiene, total
07-25-92	<5.0	11.0	<5.0	<5.0	<10.0	5.0	21.0	<5.0	<5.0	<5.0
08-10-92	<5.0	12.0	<5.0	<5.0	<10.0	6.0	25.0	<5.0	<5.0	<5.0
11-21-92	<5.0	<10.0	<5.0	<5.0	<10.0	15.0	11.0	<5.0	<5.0	<5.0

Date	Hexachloroethane, total	Indeno (1,2,3-cd) pyrene, total	Isophorone, total	Naphthalene, total	N-butyl benzyl phthalate, total	Nitrobenzene, total	N-nitrosodi-n-propylamine, total	N-nitrosodimethylamine, total	N-nitrosodiphenylamine, total	Para-chloro-meta-cresol, total	Pentachlorophenol, total	Phenanthrene, total
07-25-92	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	14.0
08-10-92	<5.0	13.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	14.0
11-21-92	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	7.0

Table 20. Selected acid-base/neutral organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Phenol, total	Pyrene, total	Benzene-o-chloro-water, unfiltered, recoverable	1,2-diphenylhydrazine, water, total-recoverable	Benzene, 1,2,4-trichlorobenzene, unfiltered, recoverable	Benzene, 1,2-dichloro-water, unfiltered, recoverable	Benzene, 1,3-dichloro-water, unfiltered, recoverable	Benzene, 1,4-dichloro-water, unfiltered, recoverable	1,2,5,6-dibenzanthracene, total	2-chloronaphthalene, total	2-chlorophenol, total	2-nitrophenol, total
384918104454201 - Sixteenth Hole, Valley-Hi Golf Course (Site 1)--Continued												
07-25-92	--	17.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
08-10-92	--	19.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
11-21-92	<5.0	8.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0

Date	2,4-dichlorophenol, total	2,4-dimethylphenol, total	2,4-dinitrophenol, total	2,4,6-trichlorophenol, total	2,4-dinitrotoluene, total	2,6-dinitrotoluene, total	3,3-dichlorobenzidine, total	4-bromophenylphenol, ether, total	4-chlorophenylphenol, ether, total	4-nitrophenol, total	4,6-dinitro-ortho-cresol, total
07-25-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0
08-10-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0
11-21-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0

Date	Time	Acenaphthylene, total	Acenaphthene, total	Anthracene, total	Benzidine, total	Benzo-a-anthracenel, 2-benzanthracene, total	Benzo-a-pyrene, total	Benzogh-i-perylenel, 12-benzoperylene, total	Benzo-b-fluoranthene, total	Benzo-k-fluoranthene, total	Bis (2-ethylhexyl) phthalate, total	Bis 2-chloroethylether, total	Bis (2-chloroethoxy) methane, total
385347104500601 - Chestnut Street nt Douglas Creek (Site 2)													
05-31-92	1255	<5.0	<5.0	6.0	<40.0	18.0	22.0	<10.0	31.0	25.0	9.0	<5.0	<5.0
06-19-92	1724	<5.0	<5.0	10.0	<40.0	37.0	46.0	14.0	73.0	90.0	24.0	<5.0	<5.0
11-21-92	0910	<5.0	<5.0	<5.0	<40.0	<10.0	<10.0	<10.0	<10.0	<10.0	24.0	<5.0	<5.0

Table 20. Selected acid-base/neutral organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Bis (2-chloro-iso-propyl) ether, total	Chrysene, total	Di-ethyl-phthalate, total	Di-methyl-phthalate, total	Di-n-octyl-phthalate, total	Di-n-butyl-phthalate, total	Fluor-anthene, total	Fluorene, total	Hexa-chloro-benzene, total	Hexa-chloro-buta-diene, total
				385347104500601 - Chestnut Street at Douglas Creek (Site 2)--Continued						
05-31-92	<5.0	34.0	<5.0	<5.0	<10.0	<5.0	69.0	<5.0	<5.0	<5.0
06-19-92	<5.0	61.0	<5.0	<5.0	<10.0	<5.0	120	<5.0	<5.0	<5.0
11-21-92	<5.0	<10.0	<5.0	<5.0	<10.0	<5.0	8.0	<5.0	<5.0	<5.0

Date	Hexa-chloro-ethane, total	Indeno (1,2,3-cd) pyrene, total	Iso-phorone, total	Naph-thalene, total	N-butyl benzyl phthal-ate, total	Nitro-benzene, total	N-nitro-sodi-n-propyl-amine, total	N-nitro-sodi-methyl-amine, total	N-nitro-sodi-phenyl-amine, total	Para chloro-meta-cresol, total	Penta-chloro-phenol, total	Phenan-threne, total
05-31-92	<5.0	12.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	40.0
06-19-92	<5.0	19.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	67.0
11-21-92	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	<5.0

Date	Phenol, total	Pyrene, total	Benzene-o-chloro-water unfilt-ered, recov-erable	1,2-di-phenyl-hydra-zine, water, total-recov-erable	Benzene, 1,2,4-tri-chloro-benzene, unfil-tered, recov-erable	Benzene, 1,2-di-chloro-water, unfil-tered, recov-erable	Benzene, 1,3-di-chloro-water, unfil-tered, recov-erable	Benzene, 1,4-di-chloro-water, unfil-tered, recov-erable	1,2,5,6-di-benz-anthra-cene, total	2-chloro-naphtha-lene, total	2-chloro-phenol, total	2-nitro-phenol, total
05-31-92	--	52.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
06-19-92	--	94.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
11-21-92	<5.0	6.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0

Date	2,4-di-chloro-phenol, total	2,4-di-methyl-phenol, total	2,4-di-nitro-phenol, total	2,4,6-tri-chloro-phenol, total	2,4-di-nitro-toluene, total	2,6-di-nitro-toluene, total	3,3-di-chloro-benzi-dine, total	4-bromo-phenyl-phenol, ether, total	4-chloro-phenyl-phenol, ether, total	4-nitro-phenol, total	4,6-di-nitro-ortho-cresol, total
05-31-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0
06-19-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0
11-21-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0

Table 20. Selected acid-base/neutral organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Time	Ace-naph-thylene, total	Ace-naph-thene, total	Anthra-cene, total	Benzi-dine, total	Benzo-a-an-thra-cenel, 2-benz-anthra-cene, total	Benzo-a-pyrene, total	Ben-zogh-i-peryl-enei, 12-benzo-peryl-ene, total	Benzo-b-fluor-anthene, total	Benzo-k-fluor-anthene, total	Bis (2-ethyl-hexyl) phthal-ate, total	Bis 2-chlo-ro-ethyl-ether, total	Bis (2-chloro-ethoxy) methane, total
385240104493601 - Beacon Street at Buchanan Street (Site 3)													
06-05-92	1240	<5.0	<5.0	5.0	<40.0	<10.0	12.0	31.0	17.0	14.0	14.0	<5.0	<5.0
06-19-92	1735	<5.0	<5.0	<5.0	<40.0	10.0	15.0	<10.0	26.0	30.0	14.0	<5.0	<5.0
11-11-92	0759	<5.0	<5.0	<5.0	<40.0	<10.0	<10.0	<10.0	<10.0	<10.0	9.0	<5.0	<5.0

Date	Bis (2-chloro-iso-propyl) ether, total	Chrysene, total	Di-ethyl-phthalate, total	Di-methyl-phthalate, total	Di-n-octyl-phthalate, total	Di-n-butyl-phthalate, total	Fluor-anthene, total	Fluorene, total	Hexa-chloro-benzene, total	Hexa-chloro-butadiene, total
06-05-92	<5.0	22.0	<5.0	<5.0	<10.0	<5.0	45.0	<5.0	<5.0	<5.0
06-19-92	<5.0	23.0	<5.0	<5.0	<10.0	<5.0	45.0	<5.0	<5.0	<5.0
11-11-92	<5.0	<10.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0

Date	Hexa-chloro-ethane, total	Indeno (1,2,3-cd) pyrene, total	Iso-phorone, total	Naph-thalene, total	N-butyl benzyl phthalate, total	Nitro-benzene, total	N-nitro-sodi-n-propyl-amine, total	N-nitro-sodi-methyl-amine, total	N-nitro-sodi-phenyl-amine, total	Para-chloro-meta-cresol, total	Penta-chloro-phenol, total	Phenan-threne, total
06-05-92	<5.0	38.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	31.0
06-19-92	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	25.0
11-11-92	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	<5.0

Date	Phenol, total	Pyrene, total	Benzene-o-chloro-water unfilt-ered, recov-erable	1,2-di-phenyl-hydra-zine, water, total-recov-erable	Benzene, 1,2,4-tri-chloro-benzene, unfil-tered, recov-erable	Benzene, 1,2-di-chloro-water, unfil-tered, recov-erable	Benzene, 1,3-di-chloro-water, unfil-tered, recov-erable	Benzene, 1,4-di-chloro-water, unfil-tered, recov-erable	1,2,5,6-di-benz-anthra-cene, total	2-chloro-naphtha-lene, total	2-chloro-phenol, total	2-nitro-phenol, total
06-05-92	--	32.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
06-19-92	--	32.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
11-11-92	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0

Date	2,4-di-chloro-phenol, total	2,4-di-methyl-phenol, total	2,4-di-nitro-phenol, total	2,4,6-tri-chloro-phenol, total	2,4-di-nitro-toluene, total	2,6-di-nitro-toluene, total	3,3-di-chloro-benzi-dine, total	4-bromo-phenyl-phenol, ether, total	4-chloro-phenyl-phenol, ether, total	4-nitro-phenol, total	4,6-di-nitro-ortho-cresol, total
385240104493601 - Beacon Street at Buchanan Street (Site 3)--Continued											
06-05-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0
06-19-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0
11-11-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0

Date	Time	Ace-naph-thylene, total	Ace-naph-thene, total	Anthra-cene, total	Benzi-dine, total	Benzo-a-an-thra-cenel, 2-benz-anthra-cene, total	Benzo-a-pyrene, total	Ben-zogh-i-peryl-enel, 12-benzo-peryl-ene, total	Benzo-b- fluor-anthene, total	Benzo-k-fluoran-thene, total	Bis (2-ethyl-hexyl) phthal ate, total	Bis 2-chloro-ethyl-ether, total	Bis (2-chloro-ethoxy) meth-ane, total
385118104485801 - Wahsatch Street at Cross Lane (Site 4)													
06-12-92	1504	<5.0	<5.0	<5.0	<40.0	<10.0	11.0	<10.0	15.0	14.0	13.0	<5.0	<5.0
07-25-92	1408	<5.0	<5.0	<5.0	<40.0	<10.0	<10.0	<10.0	<10.0	<10.0	7.0	<5.0	<5.0
11-21-92	1010	<5.0	<5.0	<5.0	<40.0	<10.0	<10.0	<10.0	<10.0	<10.0	13.0	<5.0	<5.0

Date	Bis (2-chloro-iso-propyl) ether, total	Chrysene, total	Di-ethyl-phthalate, total	Di-methyl-phthalate, total	Di-n-octyl-phthalate, total	Di-n-butyl-phthalate, total	Fluor-anthene, total	Fluorene, total	Hexa-chloro-benzene, total	Hexa-chloro-butadiene, total
06-12-92	<5.0	17.0	<5.0	<5.0	<10.0	<5.0	32.0	<5.0	<5.0	<5.0
07-25-92	<5.0	<10.0	<5.0	<5.0	<10.0	<5.0	11.0	<5.0	<5.0	<5.0
11-21-92	<5.0	<10.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0

Date	Hexa-chloro-ethane, total	Indeno (1,2,3-cd) pyrene, total	Iso-phorone, total	Naph-thalene, total	N-butyl benzyl phthal-ate, total	Nitro-benzene, total	N-nitro-sodi-n-propyl-amine, total	N-nitro-sodi-methyl-amine, total	N-nitro-sodi-phenyl-amine, total	Para chloro-meta-cresol, total	Penta-chloro-phenol, total	Phenan-threne, total
06-12-92	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	23.0
07-25-92	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	7.0
11-21-92	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	<5.0

Table 20. Selected acid-base/neutral organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Phenol, total	Pyrene, total	Benzene-o-chloro-water unfilt-ered, recov-erable	1,2-di-phenyl-hydra-zine, water, total-recov-erable	Benzene, 1,2,4-tri-chloro-benzene, unfil-tered, recov-erable	Benzene, 1,2-di-chloro-water, unfil-tered, recov-erable	Ben-zene, 1,3-di-chloro-water, unfil-tered, recov-erable	Benzene, 1,4-di-chloro-water, unfil-tered, recov-erable	1,2,5,6-di-benz-anthra-cene, total	2-chloro-naphtha-lene, total	2-chloro-phenol, total	2-nitro-phenol, total
385118104485801 - Wahsatch Street and Cross Lane (Site 4)--Continued												
06-12-92	--	24.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
07-25-92	--	9.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
11-21-92	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0

Date	2,4-di-chloro-phenol, total	2,4-di-methyl-phenol, total	2,4-di-nitro-phenol, total	2,4,6-tri-chloro-phenol, total	2,4-di-nitro-toluene, total	2,6-di-nitro-toluene, total	3,3-di-chloro-benzi-dine, total	4-bromo-phenyl-phenol, ether, total	4-chloro-phenyl-phenol, ether, total	4-nitro-phenol, total	4,6-di-nitro-ortho-cresol, total
06-12-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0
07-25-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0
11-21-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0

Date	Time	Ace-naph-thylene, total	Ace-naph-thene, total	Anthra-cene, total	Benzi-dine, total	Benzo-a-anthra-cenel, 2-benz-anthra-cene, total	Benzo-a-pyrene, total	Ben-zogh-i-peryl-enel, 12-benzo-peryl-ene, total	Benzo-b-fluor-anthene, total	Benzo-k-fluor-anthene, total	Bis (2-ethyl-hexyl) phthal-ate, total	Bis 2-chlo-ro-ethyl-ether, total	Bis (2-chloro-ethoxy) meth-ane, total
384935104501501 - Walmart at Eighth Street (Site 5)													
07-17-92	0250	<5.0	<5.0	<5.0	<40.0	<10.0	<10.0	<10.0	<10.0	<10.0	18.0	<5.0	<5.0
08-03-92	1717	<5.0	<5.0	<5.0	<40.0	<10.0	<10.0	<10.0	<10.0	<10.0	41.0	<5.0	<5.0
12-06-92	1115	<5.0	<5.0	9.0	<40.0	<10.0	<10.0	<10.0	<10.0	<10.0	100.0	<5.0	<5.0

Table 20. Selected acid-base/neutral organic compounds for storm-runoff sites in Colorado Springs--Continued

Date	Bis (2-chloro-iso-propyl) ether, total	Chrysene, total	Di-ethyl-phthalate, total	Di-methyl-phthalate, total	Di-n-octyl-phthalate, total	Di-n-butyl-phthalate, total	Fluor-anthene, total	Fluorene, total	Hexa-chloro-benzene, total	Hexa-chloro-butadiene, total
384935104501501 - Walmart at Eighth Street (Site 5)--Continued										
07-17-92	<5.0	<10.0	<5.0	<5.0	<10.0	<5.0	10.0	<5.0	<5.0	<5.0
08-03-92	<5.0	<10.0	<5.0	<5.0	<10.0	7.0	14.0	<5.0	<5.0	<5.0
12-06-92	<5.0	<10.0	<5.0	<5.0	11.0	6.0	11.0	<5.0	<5.0	<5.0

Date	Hexa-chloro-ethane, total	Indeno (1,2,3-cd) pyrene, total	Iso-phorone, total	Naph-thalene, total	N-butyl benzyl phthal-ate, total	Nitro-benzene, total	N-nitro-sodi-n-propyl-amine, total	N-nitro-sodi-methyl-amine, total	N-nitro-sodi-phenyl-amine, total	Para chloro-meta-cresol, total	Penta-chloro-phenol, total	Phenan-threne, total
07-17-92	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	5.0
08-03-92	<5.0	<10.0	<5.0	<5.0	6.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	9.0
12-06-92	<5.0	<10.0	<5.0	<5.0	11.0	<5.0	<5.0	<5.0	<5.0	<30.0	<30.0	<5.0

Date	Phenol, total	Pyrene, total	Benzene-o-chloro-water unfil-tered, recov-erable	1,2-di-phenyl-hydra-zine, water, total-recov-erable	Benzene, 1,2,4-tri-chloro-benzene, unfil-tered, recov-erable	Benzene, 1,2-di-chloro-water, unfil-tered, recov-erable	Benzene, 1,3-di-chloro-water, unfil-tered, recov-erable	Benzene, 1,4-di-chloro-water, unfil-tered, recov-erable	1,2,5,6-di-benz-anthra-cene, total	2-chloro-naphtha-lene, total	2-chloro-phenol, total	2-nitro-phenol, total
07-17-92	--	8.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
08-03-92	--	12.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0
12-06-92	<5.0	10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0

Date	2,4-di-chloro-phenol, total	2,4-di-methyl-phenol, total	2,4-di-nitro-phenol, total	2,4,6-tri-chloro-phenol, total	2,4-di-nitro-toluene, total	2,6-di-nitro-toluene, total	3,3-di-chloro-benzi-dine, total	4-bromo-phenyl-phenol, ether, total	4-chloro-phenyl-phenol, ether, total	4-nitro-phenol, total	4,6-di-nitro-ortho-cresol, total
07-17-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0
08-03-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0
12-06-92	<5.0	<5.0	<20.0	<20.0	<5.0	<5.0	<20.0	<5.0	<5.0	<30.0	<30.0

Table 21. Selected pesticide compounds for storm-runoff sites in Colorado Springs

[All concentrations in micrograms per liter; <, less than]

Date	Time	Aldrin, total	BHC Alpha, total	Aroclor, PCB, total						
				1016	1221	1232	1242	1248	1254	1260
38491810445201 - Sixteenth Hole, Valley-Hi Golf Course (Site 1)										
07-25-92	1423	<0.04	<0.03	<0.1	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1
08-10-92	0840	<.04	<.03	<.1	<1.0	<.1	<.1	<.1	<.1	<.1
11-21-92	0930	<.04	<.03	<.1	<1.0	<.1	<.1	<.1	<.1	<.1

Date	Beta-benzene, hexa-chloride, total	Chlor-dane, cis, water, whole, total	Chlor-dane, total	Chlor-dane, trans, water, whole, total	Delta, benzene, hexa-chloride, total	Di-eldrin, total	Endo-sulfan-beta, total	Endo-sulfan I, Alpha, water, whole, recov-erable	Endo-sulfan, sulfate, total
07-25-92	<0.03	<0.10	<0.1	<0.10	<0.09	<0.02	<0.04	<0.10	<0.60
08-10-92	<.03	<.10	<.1	<.10	<.09	<.02	<.04	<.10	<.60
11-21-92	<.03	<.10	<.1	<.10	<.09	<.02	<.04	<.10	<.60

Date	Endrin, alde-hyde, total	Endrin water, unfilt-ered, recov-erable	Gamma, BHC, Lindane, total	Hepta-chlor, total	Hepta-chlor-epoxide, total	Tox-aphene, total	p,p' DDD, total	p,p' DDE, totsl	p,p' DDT, total
07-25-92	<0.20	<0.06	<0.03	<0.03	<0.80	<2	<0.10	<0.04	<0.10
08-10-92	<.20	<.06	<.03	<.03	<.80	<2	<.10	<.04	<.10
11-21-92	<.20	<.06	<.03	<.03	<.80	<2	<.10	<.04	<.10

Table 21. Selected pesticide compounds for storm-runoff sites in Colorado Springs--Continued

Date	Time	Aldrin, total	BHC Alpha, total	Aroclor, PCB, total 1016	1221	1232	1242	1248	1254	1260
				385347104500601 - Chestnnt Street at Donglas Creek (Site 2)						
05-31-92	1255	<0.04	<0.03	<0.1	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1
06-19-92	1728	<.04	<.03	<.1	<1.0	<.1	<.1	<.1	<.1	<.1
11-21-92	0910	<.04	<.03	<.1	<1.0	<.1	<.1	<.1	<.1	<.1

Date	Beta-benzene, hexa-chloride, total	Chlor-dane, cis, water, whole, total	Chlor-dane, total	Chlor-dane, trans, water, whole, total	Delta, benzene, hexa-chloride, total	Di-eldrin, total	Endo-sulfan-beta, total	Endo-sulfan I, Alpha, water, whole, recov-erable	Endo-sulfan, sulfate, total
05-31-92	<0.03	<0.10	<0.1	<0.10	<0.09	<0.02	<0.06	<0.10	<0.60
06-19-92	<.03	<.10	<.1	<.10	<.09	<.02	<.04	<.10	<.60
11-21-92	<.03	<.10	<.1	<.10	<.09	<.02	<.04	<.10	<.60

Date	Endrin, alde-hyde, totel	Endrin water, unfil-tered, recov-erable	Gamma, BHC, Lindane, total	Hepta-chlor, total	Hepta-chlor-epoxide, total	Tox-aphene, total	p,p' DDD, total	p,p' DDE, total	p,p' DDT, total
05-31-92	<0.20	<0.06	<0.03	<0.03	<0.80	<2	<0.10	<0.04	<0.10
06-19-92	<.20	<.06	<.03	<.03	<.80	<2	<.10	<.04	<.10
11-21-92	<.20	<.06	<.03	<.03	<.80	<2	<.10	<.04	<.10

Table 21. Selected pesticide compounds for storm-runoff sites in Colorado Springs--Continued

Date	Time	Aldrin, total	BHC Alpha, total	Aroclor, PCB, total						
				1016	1221	1232	1242	1248	1254	1260
385240104493601 - Beacon Street at Buchanan Street (Site 3)										
06-05-92	1240	<0.04	<0.03	<0.1	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1
06-19-92	1735	<.04	<.03	<.1	<1.0	<.1	<.1	<.1	<.1	<.1
11-11-92	0759	<.04	<.03	<.1	<1.0	<.1	<.1	<.1	<.1	<.1

Date	Beta-benzene, hexa-chloride, total	Chlor-dane, cis, water, whole, total	Chlor-dane, total	Chlor-dane, trans, water, whole, total	Delta, benzene, hexa-chloride, total	Di-eldrin, total	Endo-sulfan-beta, total	Endo-sulfan I, Alpha, water, whole, recov-erable	Endo-sulfan, sulfate, total
06-05-92	<0.03	<0.10	<0.1	<0.10	<0.09	<0.020	<0.04	<0.10	<0.60
06-19-92	<.03	<.10	<.1	<.10	<.09	<.020	<.04	<.10	<.60
11-11-92	<.03	<.10	<.1	<.10	<.09	<.020	<.04	<.10	<.60

Date	Endrin, alde-hyde, total	Endrin water, unfil-tered, recov-erable	Gamma, BHC, Lindane, total	Hepta-chlor, total	Hepta-chlor-epoxide, total	Tox-aphene, total	p,p′ DDD, total	p,p′ DDE, total	p,p′ DDT, total
06-05-92	<0.20	<0.06	<0.03	<0.03	<0.80	<2	<0.10	<0.04	<0.10
06-19-92	<.20	<.06	<.03	<.03	<.80	<2	<.10	<.04	<.10
11-11-92	<.20	<.06	<.03	<.03	<.80	<2	<.10	<.04	<.10

Table 21. Selected pesticide compounds for storm-runoff sites in Colorado Springs--Continued

Date	Time	Aldrin, total	BHC Alpha, total	Aroclor, PCB, total						
				1016	1221	1232	1242	1248	1254	1260
385118104485801 - Wahsatch Street at Cross Lane (Site 4)										
06-12-92	1504	<0.040	<0.03	<0.1	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1
07-25-92	1408	<.040	<.03	<.1	<1.0	<.1	<.1	<.1	<.1	<.1
11-21-92	1005	<.040	<.03	<.1	<1.0	<.1	<.1	<.1	<.1	<.1

Date	Beta-benzene, hexa-chloride, total	Chlor-dane, cis, water, whole, total	Chlor-dane, total	Chlor-dane, trans, water, whole, total	Delta, benzene, hexa-chloride, total	Di-eldrin, total	Endo-sulfan-beta, total	Endo-sulfan I, Alpha, water, whole, recov-erable	Endo-sulfan, sulfate, total
06-12-92	<0.03	<0.10	0.2	<0.10	<0.09	<0.02	<0.04	<0.10	<0.60
07-25-92	<.03	<.10	<.1	<.10	<.09	<.02	<.04	<.10	<.60
11-21-92	<.03	<.10	<.1	<.10	<.09	<.02	<.04	<.10	<.60

Date	Endrin, alde-hyde, total	Endrin water, unfil-tered, recov-erable	Gamma, BHC, Lindane, total	Hepta-chlor, total	Hepta-chlor-epoxide, total	Tox-aphene, total	p,p′ DDD, total	p,p′ DDE, total	p,p′ DDT, total
06-12-92	<0.20	<0.06	<0.03	<0.03	<0.80	<2	<0.10	<0.04	<0.10
07-25-92	<.20	<.06	<.03	<.03	<.80	<2	<.10	<.04	<.10
11-21-92	<.20	<.06	<.03	<.03	<.80	<2	<.10	<.04	<.10

Table 21. Selected pesticide compounds for storm-runoff sites in Colorado Springs--Continued

Date	Time	Aldrin, total	BHC Alpha, total	Aroclor, PCB, total 1016	Aroclor, PCB, total 1221	Aroclor, PCB, total 1232	Aroclor, PCB, total 1242	Aroclor, PCB, total 1248	Aroclor, PCB, total 1254	Aroclor, PCB, total 1260
				384935104501501 - Walmart at Eighth Street (Site 5)						
07-17-92	0250	<0.04	<0.03	<0.1	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1
08-03-92	1717	<.04	<.03	<.1	<1.0	<.1	<.1	<.1	<.1	<.1
12-06-92	1115	<.04	<.03	<.1	<1.0	<.1	<.1	<.1	<.1	<.1

Date	Beta-benzene, hexa-chloride, total	Chlor-dane, cis, water, whole, total	Chlor-dane, total	Chlor-dane, trans, water, whole, total	Delta, benzene, hexa-chloride, total	Di-eldrin, total	Endo-sulfan-beta, total	Endo-aulfan I, Alpha, water, whole, recov-erable	Endo-sulfan, sulfate, total
07-17-92	<0.20	<0.060	<0.030	<0.030	<0.80	<0.02	<0.10	<0.04	<0.10
08-03-92	<.03	<.10	<.1	<.10	<.09	<.02	<.04	<.10	<.60
12-06-92	<.03	<.10	<.1	<.10	<.09	<.02	<.04	<.10	<.60

Date	Endrin, alde-hyde, total	Endrin water, unfil-tered, recov-erable	Gamma, BHC, Lindane, total	Hepts-chlor, total	Hepta-chlor-epoxide, total	Tox-aphene, total	p,p′ DDD, total	p,p′ DDE, total	p,p′ DDT, total
07-17-92	<0.20	<0.06	<0.03	<0.03	<0.80	<2	<0.10	<0.04	<0.10
08-03-92	<.20	<.06	<.03	<.03	<.80	<2	<.10	<.04	<.10
12-06-92	<.20	<.06	<.03	<.03	<.80	<2	<.10	<.04	<.10

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