KNOXVILLE, TENNESSEE PART 2 NPDES STORM WATER PERMIT APPLICATION

MAY 1993

CDM

CAMP DRESSER & MCKEE INC.

environmental engineers, scientists,
planners & management consultants

SIGNATURE and CERTIFICATION

STORMWATER PERMIT APPLICATION
MUNICIPAL PART 2 SUPPLEMENT

FOR: CITY OF KNOXVILLE, TENNESSEE

Federal regulations, 40 CFR 122.22 (a) (3) and 122.22 (d), require the application for a NPDES permit to be signed and certified as follows:

For a municipality, State, Federal, or other public facility, by either a principal executive officer or ranking elected official.

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

xxxxxxx xxxxxxx — 5-13-93

Victor H. Ashe — Date
Mayor

xxxxxxx xxxxxxx — 5-11-93

Samuel L. Parnell, Jr., P.E. — Date
Director of Engineering

xxxxxxx xxxxxxx — 5-13-93

Thomas A. Varlan — Date
Law Director

xxxxxxx xxxxxxx — 5-13-93

Randolph B. Vineyard — Date
Finance Director

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 GENERAL INFORMATION

The City of Knoxville covers about 82 sq mi located in the northeastern portion of the State of Tennessee and has a population of approximately 165,000. Knoxville lies in the Ridge and Valley Physiographic Province of the Appalachian region and receives an average annual rainfall of about 46 inches. Sixteen major streams flow through or near the City, defining the major watersheds delineated on Map No. 1 submitted with the Part 1 permit application. Most of the major streams discharge directly into the Tennessee River. The three exceptions are Ten Mile Creek, which drains to a sinkhole; Woods Creek, and Love Creek which drain to the Holston River. The Tennessee River begins at the confluence of the French Broad River and Holston River near the eastern end of Knoxville. Flow in the Tennessee River through Knoxville is regulated by TVA dams, which cause the river downstream of Knoxville to behave more like a reservoir than a river. The portion of the Tennessee River around Knoxville is known as the Fort Loudoun Lake.

Drainage patterns in the Knoxville area are somewhat unique due to the Karst terrain in the region, areas of limestone terrain characterized by sinks, ravines, and underground streams. Unlike most areas where storm water flow in drainage channels discharges directly into a receiving water (i.e., a lake, river, or ocean), storm water flows from approximately 17 percent of Knoxville drain directly to sinkholes. Sinkholes form when the limestone dissolves due to water action, resulting in a direct connection between surface drainage and underground streams.

In general, most local drainage in Knoxville is conveyed by roadside ditches or gutters into larger open channels, with very few areas containing storm sewer networks consisting of more than 2,000 ft of pipe.

Slopes in Knoxville vary from flat to extremely steep (over 25 percent), with much of the City having moderate slopes ranging from 1 percent to 5 percent. Similarly, the depth to bedrock varies considerably throughout the City, with depths ranging from 0 to greater than 20 ft. The depth to bedrock is greater than 5 ft in over half of the City and less than 20 inches in nearly a third of the City.

The differing soils in Knoxville lie in several bands that run in a general northeast to southwest direction, characteristic of the underlying geologic formations. The predominant soil association is the Fullerton-Dewey- Dunmore-Sequoia association. Most soil textures range from loam to silty clay loam, and the predominant hydrologic soil groups are B and C.

Historically, most of Knoxville has not been prone to major flooding problems for several reasons, including the regulation of flow in the Tennessee River, the well-defined channel sections of the major streams, and the lack of development in the floodplains. The most notable major flooding problem is along First Creek, where some remedial action has been pursued. The majority of the flooding problems in Knoxville are local or nuisance problems generally caused by improper design or maintenance.

Table 1-1 presents pertinent data concerning applicant name, address, contact persons and ownership status. The City does not own or maintain storm water systems associated with the interstates, federal facilities, and state facilities. In addition, the City does not own or maintain a number of private storm water systems that convey drainage from privately-owned facilities.

Table 1-1

GENERAL INFORMATION

CITY OF KNOXVILLE, TENNESSEE

Individual Application __x__	Joint Application _____
Name of Applicant:	City of Knoxville, Tennessee
Contact Persons:	1. Samuel L Parnell Jr., P.E. Director of Engineering 2. Ted Schuler, P.E. Chief Planning Engineer
Address:	City of Knoxville Department of Engineering City County Building P.O. Box 1631 400 Hill Avenue Knoxville, Tennessee 37901
Telephone No:	(615) 521-2148
Ownership Status:	City owns majority of storm sewer system with exception of major highways, state and federal facilities, and some private systems.

2.0 LEGAL AUTHORITY

2.1 INTRODUCTION

As indicated in Section 2.0 of the Part 1 NPDES Stormwater Permit application submitted by the City, through the City Charter and enabling authority provided by the State Code, the City possesses the power to establish by ordinance, the minimum legal authority to meet the requirements of the NPDES permitting regulations for stormwater discharges.

These regulations [CFR 122.26(d)(2)(i)] require "*A demonstration that the applicant can operate pursuant to legal authority established by statute, ordinance, or series of contacts which authorizes or enables the applicant at a minimum to:*

(A) control through ordinance, permit, contract, order or similar means, the contribution of pollutants to the municipal storm sewer by stormwater discharges associated with industrial activity and the quality of stormwater discharged from sites of industrial activity;

(B) prohibit through ordinance, order or similar means, illicit discharge to the municipal separate storm sewer;

(C) control through ordinance, order or similar means the discharge to a municipal separate storm sewer of spills, dumping or disposal of materials other than stormwater;

(D) control through interagency agreements among coapplicants the contribution of pollutants from one portion of the municipal system to another portion of the municipal system;

(E) require compliance with conditions in ordinances, permits, contracts or orders; and

(F) carry out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with permit conditions including the prohibition on illicit discharges to the municipal separate storm sewer."

This Section presents a summary of the existing State and City legal authority, a proposed stormwater ordinance to satisfy the criteria in the NPDES regulations, and a schedule to implement the new ordinance.

2.2 STATE ENABLING AUTHORITY

2.2.1 GENERAL POWERS OF MUNICIPALITIES

The State has provided municipalities with general grants of authority to regulate land development and storm drains within the Corporate limits. This general grant of power to the municipality is located in Sections 6-2-201 (General Powers under Mayor - Aldermanic Charter) of the Tennessee Code Annotated:

- Power to regulate the collection and disposal of drainage, sewage or other waste and to regulate the use of storm drains and sanitary sewers

- Power to regulate land development and require any alteration or changes to ensure that buildings, structures, and lands are healthful, clean, and safe

- Power to define, prohibit, abate, suppress, prevent and regulate all acts, practices, conduct, business, use of property and all other things whatsoever detrimental, or liable to be detrimental, to the health, morals, comfort, safety, convenience or welfare of the inhabitants of the municipality, and exercise general police powers;

In addition, specific authority to regulate land development is presented in Title 13 of the Tennessee Code, Annotated (e.g., authority for regulations covering the subdivision of land is included in Sections 13-3-101 through 13-3-304 and Sections 13-3-401 through 13-3-411).

2.2.2 TENNESSEE WATER QUALITY CONTROL ACT OF 1977

Sections 69-3-101 through 69-3-129 of the Tennessee Code Annotated Constitute the Tennessee Water Quality Control Act of 1977, including the 1987 amendments, which is the State's enabling legislation that provides the legal authority to identify and assess penalties to violators of state issued permits and violators of state water quality standards. This legal authority provides the basis for the State's Compliance assurance and Enforcement Program.

In summary, the State has the authority to assess a civil penalty of $10,000 per day to any person who does any of the following acts or omissions:

(A) Violates an effluent standard or limitation or a water quality standard established under this part;

(B) Violates the terms or conditions of a permit;

(C) Fails to complete a filing requirement;

(D) Fails to allow or perform an entry, inspection, monitoring or reporting requirement;

(E) Violates a final determination or order of the board, panel, or commissioner;

(F) In the case of an industrial user of a publicly owned treatment works, fails to pay user or cost recovery charges or violates pretreatment standards or toxic effluent limitations established as a condition in the permit of the treatment works; or

(G) Violates any other provision of this part or any rule or regulation promulgated by the board.

A copy of Sections 69-3-101 through 69-3-129 of the Tennessee Code, Annotated can be found in Appendix A of the Part 1 NPDES permit submittal.

2.2.3 SENATE BILL NO. 68, HOUSE BILL NO. 56

This bill authorizes municipalities having a population of not less than 100,000 to regulate stormwater discharges in order to facilitate compliance to EPA permit applications. Municipalities will be allowed to establish a system of drainage and flood control facilities. Municipalities will be able to construct, extend, enlarge or acquire stormwater facilities or flood control improvements inside its corporate boundaries. A municipality also has the power to widen, straighten, or relocate stream, surface waters, or water courses.

The bill authorizes the municipality to establish a user fee system and to enter into a contract with any public or private corporation or municipal utilities board for the collection of fees. The municipalities may establish a system of civil penalties between $50 and $5,000 per day per violation and assess damages caused by violations

2.3 CITY CHARTER AND ORDINANCES

The City possesses the general authority through the City Charter and City Ordinances to regulate water quality flowing through the municipal storm sewer systems as well as the waters located within the boundaries of the City. The following is a summary of the relevant sections of both the charter and relevant city ordinances.

2.3.1 CITY CHARTER

The Knoxville City Charter incorporates the general powers which are not expressly prohibited by the constitution or other laws granted by the State. Under the Charter, the City has broad powers to enact ordinances that will promote the general welfare of the City and will secure the general health, welfare, safety, and morals of its inhabitants.

The City Charter also conveys the general powers to prevent, abate and remove nuisances, including the power to declare by ordinance what constitutes a nuisance and provide for the abatement thereof.

To carry out the full intent and meaning of the City Charter, the City is granted the power to enact all ordinances necessary for the health convenience, safety and general welfare of its inhabitants, including the provision for fines, forfeitures and penalties for the violation of any such ordinances.

2.3.2 ENGINEERING ORDINANCES

The primary engineering ordinances affecting stormwater management are the Stormwater Detention Ordinance and the Alteration of Natural Drainage Ordinance. These ordinances focus on establishing standards for stormwater system design and maintenance.

Stormwater Detention Ordinance (City Code, Article VII, Sections 6-171 through 6-183)

The purpose of the stormwater detention ordinance is: (1) to minimize increases in peak flows from urban development and (2) to establish procedures to ensure that appropriate measures are implemented which adequately control increases in peak flows due to development. The ordinance applies to the following:

- road construction of 1 acre or more,
- commercial development of 1 acre or more,
- industrial development of 1 acre or more,
- educational development of 1 acre or more,
- institutional development of 1 acre or more,
- recreational development of 1 acre or more,
- multi-family residential development of 2 acres or more, and
- single family residential development of 5 acres and/or 5 lots or more.

Under the ordinance, stormwater detention requirements may be waived if the developer supplies hydrologic and hydraulic computations to support exclusion. In addition, stormwater detention is not required in areas that discharge directly to the Tennessee River.

All hydrologic and hydraulic computations must be prepared by a registered engineer proficient in these areas and licensed in the State of Tennessee. Computations, which must be submitted with the design information, are required to be in accordance with those outlined in the United States Department of Agriculture, Soil Conservation Service Technical Release No. 55 (TR55), unless an alternate method is approved by the Director of Engineering. The performance standard for detention ponds states that the post-development peak flow cannot be greater than the pre-development peak flow for the 10-year 24-hour storm event. Maintenance of detention facilities is the responsibility of the property owner. A copy of the appropriate sections of the City Code defining this ordinance were submitted in Appendix B of the Part 1 stormwater permit application.

Alteration Of Natural Drainage Ordinance (City Code Section 19-162)

This ordinance mandates that a detailed drainage plan be submitted to the Director of Engineering before any person may "excavate, grade, dump, move, or fill dirt or any other material so as to divert, construct, increase, or change in any manner the natural or existing flow of any stream, or the natural or existing drainage of any area. Under this ordinance, the City may halt construction if deemed necessary. The drainage plan must show proposed drainage for the area, including erosion control during and after site disturbance. The ordinance also empowers the Director of Engineering to require a performance bond equal to the amount to be performed in compliance with the drainage plan. A copy of the appropriate sections of the City Code defining this ordinance also can be found in Appendix B of the Part 1 permit application.

2.3.3 PLANNING ORDINANCES

The primary planning regulation and ordinances affecting stormwater management are the Flood Damage Protection Ordinance, the Knoxville-Knox County Minimum Subdivision Regulations, and the Zoning Ordinance for Knoxville. These ordinances set standards for development and establish some general requirements that must be satisfied by developers.

Flood Damage Protection Ordinance (City Code Chapter 12)

The City was required by the Federal Emergency Management Agency (FEMA) to adopt the Flood Damage Protection Ordinance in order to participate in the National Flood Insurance Program. The ordinance applies to all areas of special flood hazard in Knoxville as defined by the 1981 FEMA study. Like the Flood Fringe Area requirement, this ordinance requires the bottom floor elevation to be certified and to be at least 1 ft above the 500-year flood elevation. Where areas of special flood hazard have not been defined, it is up to the City to define them. Very little definition of floodplains outside of those defined by FEMA has been accomplished to date. Like the Floodway requirement in the Zoning Ordinance, this ordinance disallows any encroachment, fill, construction, etc. that will increase the 500-year flood elevation or increase the floodway width. A copy of the appropriate sections of the City Code defining this ordinance were submitted in Appendix B of the Part 1 permit application.

Knoxville-Knox County Minimum Subdivision Regulations (Appendix A of the City Code)

Similar to the Zoning Ordinance, the Knoxville-Knox County Minimum Subdivision Regulations contain elements that can have an impact on stormwater management, such as setback requirements, minimum rights-of-way, etc. The regulations for storm drainage in the Design Standards (Section 65) and Required Improvements (Section 75) sections are of the greatest importance to stormwater management. The regulations in these two sections state that the developer must provide a drainage system adequate to carry flow from the developed area to an established City/County drain or natural watercourse. The cost of the drainage system is borne by the developer. A stormwater drainage plan must be provided by the developer showing the existing and proposed system. The regulations also give specifications and procedures for the submission of plats. However, there is no requirement that the developer ensure that increased runoff from his property does not result in increases in downstream flooding. Appendix B of the Part 1 permit application includes a copy of the appropriate sections of the City Code defining this ordinance.

Zoning Ordinance of the City of Knoxville, Tennessee (Appendix B of the City Code)

The Zoning Ordinance of the City of Knoxville, Tennessee (Zoning Ordinance) empowers the City Council to regulate the use of land by dividing the municipality into a number of zones and imposing restrictions within those zones such as limiting the size of buildings and the percentage of the lot that may be occupied. The Zoning Ordinance also establishes an appeals process, an enforcement mechanism, and a penalty for violators of the provisions.

Many aspects of the Zoning Ordinance have an implicit impact on stormwater management. Most notable are the portions that establish such items as intensity of use, minimum buffer zones and maximum lot coverage, because these items have an impact on imperviousness of the development. Imperviousness generally governs the amount of runoff that can be expected from an area. While these items impact the level of imperviousness, they do not impose an upper limit on imperviousness.

The two sections of the ordinance dealing directly with stormwater are the F-1 Floodway District section and the Flood Fringe Area section. The floodway is established to protect the channels and floodplains from encroachment so that flood levels and flood damages will not be increased for the 500-year return period storm. Any construction or disturbance of land in the floodway must be permitted by the Department of Engineering. Before a permit can be issued, proof that the construction will not increase 500-year flooding must be supplied. Standards are established to prevent encroachment into the floodway which endangers life and property.

The flood fringe is the area lying outside the floodway and below the 500-year flood elevation as defined by the 1984 Flood Insurance Study (FIS). Buildings constructed in the flood fringe are required to be at least 1 ft above the 500-year flood elevation, and fill in the flood fringe must extend at least 25 ft beyond any structure. Any structure outside the floodway but within 100 ft of a main channel or sinkhole must be approved by the Department of Engineering. No structure may be within 10 ft of the top of bank of any stream. The Zoning Ordinance does not specifically require that the locations of floodways, floodplains, or streambanks be shown on development plans. A copy of the appropriate sections of the City Code defining this ordinance were submitted in Appendix B of the Part 1 stormwater permit application.

2.4 PROPOSED STORMWATER ORDINANCE

Although existing ordinances and codes do cover some of the minimum criteria presented in the regulations, it will be appropriate to develop a new city ordinance to specifically address the issues and criteria related to the NPDES stormwater permitting program.

A model ordinance has been prepared for this permit application. The Storm Sewer Discharge Ordinance is structured to address the criteria of the regulations and to be consistent with the proposed stormwater management program. The model ordinance acts to enforce the program requirements developed to meet the NPDES stormwater regulations. The overall objective is to adopt an ordinance as part of the City's stormwater management program in order to prevent certain non-stormwater discharges to, and improper disposal of substances in, the storm sewer system so as to reduce, to the maximum extent practicable, pollutants that may be present in discharges from the storm sewer systems. The model ordinance is included in Appendix A.

2.5 IMPLEMENTATION SCHEDULE FOR STORMWATER ORDINANCE

The State Legislature approved the Stormwater Bill in April 1993. This will facilitate the passage of a Stormwater Ordinance by the City of Knoxville. A model ordinance is located in Appendix A. It is projected that the City will create a stormwater ordinance or modify the model ordinance within the first six months of the permit term. The Ordinance could be enacted soon thereafter.

3.0 SOURCE IDENTIFICATION

3.1 INTRODUCTION

The Part 2 NPDES stormwater regulations [CFR 122.26 (d)(2)(ii)] require the applicant to identify:

> *"The location of any major outfall that discharges to the waters of the United States that was not reported under paragraph (d)(1)(iii)(B)(1) of this section. Provide an inventory, organized by watershed of the name and address, and a description (such as SIC codes) which best reflects the principal products or services provided by each facility which may discharge, to the municipal separate storm sewer, storm water associated with industrial activity;"*

This Section addresses the two requirements defined above. An update to the outfall database is described first, followed by an industrial facility inventory.

3.2 UPDATE OUTFALL DATABASE

The City of Knoxville has not identified any additional outfalls that discharge to waters of the United States that were not reported under paragraph (d)(1)(iii)(1) of 40 CFR 122.26, as part of its Part 1 stormwater permit application.

3.3 IDENTIFICATION OF INDUSTRIAL FACILITIES

The City has compiled an inventory of industrial facilities which may discharge to the municipal separate storm sewer system. This inventory is categorized into three types of industrial facilities: facilities which have industrial NPDES stormwater discharge permits with the State (or have submitted a Notice of Intent (NOI) to obtain one), facilities which have been identified on the Environmental Protection Agency's (EPA) FINDS database, and facilities which have applied to the EPA for a group stormwater permit. These three categories have been organized by watershed and include either an SIC code or a description of the facility.

3.3.1 FACILITIES WITH NPDES STORMWATER PERMITS

Facilities which have obtained, or submitted an NOI to obtain, a NPDES industrial stormwater permit are shown in Table 3-1 and Table 3-2. The list of facilities shown in Table 3-1 was acquired from the Tennessee Department of Environmental Conservation (TDEC), and represents the inventory of facilities which were presented in the Part 1 permit application. The list of facilities in Table 3-2 which have submitted a NOI to obtain an individual stormwater permit was received from TDEC in April 1993 and has not been completely reviewed by TDEC staff. State regulations require that industrial facilities which apply for an NPDES stormwater discharge permit with the State, and which discharge stormwater to a municipal storm sewer system, must submit a signed copy of the NOI to the operator of the system. To date, compliance with this regulation has been minimal. However, the new Stormwater Ordinance should also require industrial facilities which hold industrial NPDES stormwater discharge permits to submit copies to the Knoxville Engineering Department. Under the new ordinance, the City will have the authority to ensure submittal of NOIs, and therefore will be able to maintain its industrial database.

3.3.2 FACILITIES ON THE EPA "FINDS" DATABASE

FINDS is an acronym for Facility INDex System, which is a computerized database obtained through the Freedom of Information Act. The database is an inventory of facilities which are monitored or regulated by the EPA. The sites listed in the database relate to permit applications, inspection reports, or Superfund sites, which does not necessarily mean that they pose an environmental or health threat. A list of these facilities, arranged by watershed, is presented in Table 3-3.

3.3.3 FACILITIES ON THE EPA GROUP STORMWATER PERMIT LIST

The list presented in Table 3-4 presents industrial facilities which have applied to the EPA to be covered under a group stormwater permit. This table was provided by TDEC in April 1993 and has not been completely reviewed by TDEC staff.

Table 3-1
NPDES Permitted Industrial Facilities

WATERSHED	NPDES PERMIT*	FACILITY NAME/OWNER	ADDRESS	SIC CODE
East Fork Third Creek	TN0002011	SO Cast Stone Company, Inc.	2000 Southerland Ave.	3272
East Fork Third Creek	TN0002682	Rohm and Haas Tennessee, Inc.	730 Dale Avenue	2821
East Fork Third Creek	TN0027804	Florida Steel Company	1919 Tennessee Avenue	3312
East Fork Third Creek	Status Unknown	Consolidated Freightways	3614 Pleasant Ridge	4213
First Creek	TN0064378	Kingston Pike Texaco	4607 Kingston Pike	5541
First Creek	TN0064190	Fountain City Service Station	4816 N. Broadway St.	5541
First Creek	TN0066826	Lay Packing Company, Inc.	400 E. Jackson St.	2013
Fort Loudoun	TN0022225	Star Enterprise	701 Langford Avenue	5171
Fort Loudoun	TN0022535	Union Oil Co.	1720 Island Home Ave.	5171
Fort Loudoun	TN0023574	Fourth Creek STP	1500 Lyons Bend Road	4952
Fort Loudoun	TN0023582	Kuwahee STP	2015 Neyland Drive	4952
Fourth Creek	TN0026662	Publix Oil Co.	5405 Middlebrook Pike	5171
Holston River	TN0055433	Volunteer Asphalt - Knoxville	3111 McClure Lane	2911
Loves Creek	TN0066869	Pilot Station #191	5402 Rutledge Pike	5541
Loves Creek	Applied Group	Liquid Transportes, Inc.	3125 Central Street NW	4213
Second Creek	Applied	Safety-Kleen Corp.	826 Stewart Street	5172
Second Creek	Applied Group	NSRR - Coster Shop	3125 Central Street NW	4011
Third Creek	TN0001554	Shell Oil	5001 Middlebrook Pike	5171
Third Creek	TN0002216	Exxon Company, USA	5009 Middlebrook Pike	5171
Third Creek	TN0022411	Citgo Petroleum Corp.	2409 Knott Road	5171
Third Creek	TN0029769	BP Oil, Inc.	1908 Third Creek Road	5171
Third Creek	TN0057525	Marathon Oil	2501 Knott Road	5171
Third Creek	TN0057959	Robertshaw Controls Co.	2318 Kingston Pike, SW	3429
Third Creek	TN0058483	Chevron USA	5100 Middlebrook Pike	4226
Third Creek	TN0060402	Cummins Terminal, Inc.	4715 Middlebrook PIke	5171
Third Creek	TN0060429	Amoco Oil, Inc.	5101 Middlebrook Pk., NW	5171
Third Creek	TN0066842	Conoco, Inc.	4801 Middlebrook Pike	5171
Third Creek	Applied Group	Fleet Transport Co. Inc.	5207 Middlebrook Pike	4213
Third Creek	Status Unknown	Con-Way Southern Express	5204 Middlebrook Pike	4213
Third Creek	Status Unknown	Roadway Express	1212 Hilton Road	4200
Woods Creek	TN0003352	Dixie Cement Co., Inc.	6212 Cement Plant Lane	3241

TABLE 3-2
Industrial Facilities with Notice of Intent
for Individual Stormwater Permit Applications*

WATERSHED	NPDES PERMIT	FACILITY NAME/OWNER	ADDRESS	SIC CODE
Beaver Creek	TNR000258	P&S Engineered Plastics Inc.	2661 Byington-Solway Rd	3079
Beaver Creek	TNR000697	Thilmany IP Knox Convert Plant	2530 Westcott Blvd	2671
East Fork Third Creek	TNR000686	Knoxville Steel Mill Div.	1919 Tennessee Ave	3312
First Creek	TNR000040	Nolen Products, Inc. - Plant 1	912 Forsythe St., NE	2431
First Creek	TNR000041	Nolen Products, Inc. - Plant 2	4135 McKinley St.	2431
First Creek	TNR000346	CAE Vanguard Inc.	1500 Ninth Ave	3743
French Broad River	TNR000145	Chapman Enterprises Inc.	8028 Chapman Hwy	5015
French Broad River	TNR000304	Rail Bearing Service	5336 Counsellor Lane	3743
French Broad River	TNR000484	Precision Disc Corp.	5055 S. National Drive	3425
French Broad River	TNR000548	Briggs Industries Inc.	5040 South National Drive	NA
French Broad River	TNR000935	Lowe's Auto Parts Inc	1015 Hendron Chapel Road	5015
Ft. Loudoun Lake	TNR000584	JBM Inc.	2651 Scottish Pike	3444
Ft. Loudoun Lake	TNR000146	Smith's Auto Salvage & Parts	202 Seaman St.	5015
Ft. Loudoun Lake	TNR000828	Don Payne Trucking Co, Inc	1749 Riverside Dr.	4
Holston River	TNR000407	Coster Shop	3125 Hopkins Street	3541
Holston River	TNR000408	J. Sevier Yard (landfill)	Old Rutledge Pike	4011
Knob Creek	TNR000943	John's Story Salvage Co., Inc.	117 Stone Road	5015
Second Creek	TNR000099	Jennmar Corp. of Tenn.	201 W. Quincy Ave.	3452
Second Creek	TNR000147	Frank's Part Mart Inc.	5622 Clinton Hwy	5015
Third Creek	TNR000128	Cummins Terminal, Inc.	4715 Middlebrook Pike	5171
Third Creek	TNR000376	W. J. Savage Co.	2501 Hopkins St.	3541
Tolls Creek	TNR000197	Koch Materials	3017 McClure Lane	2951
Turkey Creek	TNR000148	Moon's Used Parts	9922 Hall Dr.	5015
Turkey Creek	TNR000459	Plexco/Spirolite Div. Chevron	10420 Lexington Drive	3084
Turkey Creek	TNR000465	Water Services Inc.	856 Lovell Road	2898
Whites Creek	TNR000585	Greenway Chemical Co.	4320 Greenway Drive	28
Woods Creek	TNR000549	Stowwers Machinery Corp	6301 Rutledge Pike	39
NA	TNR000310	East Tennessee White GMC	6614 Wilbanks Road	7538
NA	TNR000382	Kay's Ice Cream of Knox.	3600 Pleasant Ridge Road	2024
NA	TNR000706	Candora	4405 Candora	2951
NA	TNR000708	Watt Road	NA	2951
NA	TNR000792	Enterprise Waste Oil	5201 N Middlebrook Pike	4613
NA	TNR000816	Pemberton Truck Lines, Inc.	2530 Mitchell St	4
NA	TNR000863	Roddy Coca-Cola Co	5723 Middlebrook Pk	2086
NA	TNR000865	Roddy Coca-Cola Bottling Co., Inc.	2200 Leslie St.	2086
Unnamed Tibutary	TNR000006	Rail Bearing Service Inc.	5336 Cousellor Lane	3743
Unnamed Tributary	TNR000206	Keller Foundry	1010 East Jackson	3321
Unnamed Tributary	TNR000328	Aqua-Chem Inc.	3001 East John Sevier Hwy	3443
Unnamed Tributary	TNR000621	Comtrans	1116 Dutch Valley Rd	4213
Unnamed Tributary	TNR000723	Vinylex Corp	2636 Byington-Solway Rd	3082

NA = Not available

* Source: Data received from TDEC April 1993

Table 3-3
Knoxville EPA FINDS Report

Watershed	Facility Name	Address	Zip Code	Description or SIC Code
First Creek	Alert Transmission	4333 N. Broadway	37917	Automobile Repairs
First Creek	Auto-Chlor System of Knoxville	716 Magnolia Ave.	37917	Chemical Supplies
First Creek	BBC Inc Park Hosiery	1134 Broadway	37917	Knitting Mill
First Creek	BP Oil Co.	1704 Broadway	37917	Gasoline Service Station
First Creek	Brooks Dry Cleaners	801 E. 5th Avenue	37917	Dry Cleaning/Laundry
First Creek	Cabinet Craft Corp.	1116 N. Sixth Ave.	37917	Cabinet Shop
First Creek	Clapp Car Care Center Inc.	2405 Magnolia Avenue	37917	Automobile Repairs
First Creek	Coopers, Inc.	5611 N Broadway Street	37918	Automobile Repairs
First Creek	C&S Laundry Company, Inc.	1200 East Magnolia Ave.	37917	Dry Cleaning/Laundry
First Creek	Diversified Waste Managment, Inc.	1717 N. Broadway	37917	Hazardous Waste Management
First Creek	Exxon Oil Co.	5306 N Broadway	37918	Gasoline Service Station
First Creek	Fine Print & Graphic	4609 Old Broadway	37921	Printer
First Creek	Gaf Corp. Chemical Division	1705 Boone St	37901	Chemical Suplies
First Creek	Hope Battery Shop	2243 Martin Luther King Jr. Ave.	37915	Battery Shop
First Creek	Independent Fleet Service, Inc	1124 Dutch Valley Road	37917	Trucking
First Creek	Industrial Colliods & Chemicals	127 W. Jackson Ave.	37901	Chemical Supplies
First Creek	Judy's Dry Cleaners	2135 Magnolia Ave	37917	Dry Cleaning/Laundry
First Creek	Keller Foundry Co.	1010 East Jackson Ave.	37915	Foundry
First Creek	Knoxville Co. Board of Education	101 East 5th Avenue	37901	Office
First Creek	Knoxville Generator	308 Randolph St	37917	Electric Equipment Dealer
First Creek	K-Trans	1135 Magnolia	37917	Bus Maintenance and Storage
First Creek	Levi Strauss & Co.	2700 Hoitt Avenue	37917	SIC Code 2325
First Creek	Marshall's Transmission	1603 Washington Ave	37912	Automobile Repairs
First Creek	PB&S Chemical Co.	1705 Boone Street	37902	Chemical Supplies
First Creek	Penske Truck Leasing Co	1525 Cherry Street	37917	Truck Leasing
First Creek	Phillips Petroleum Co Station	4801 N Broadway	37918	Gasoline Service Station
First Creek	Rail Bearing Service Inc	1600-R Magnolia Ave	37917	Rail Bearings
First Creek	Sherwin Williams Co	2904 Broadway NE	37917	Paint Store
First Creek	Skil Corp Service Center	2002 East Magnolia Street	37917	Tool Sales
First Creek	Super Kleen Laundry	409 E Glenwood	37917	Dry Cleaning/Laundry
First Creek	Tennessee Press	1501 Washington Ave	37917	Printer
First Creek	Transport America, Inc	3214 Tazewell Pike	37918	Trucking Office
First Creek	TVA	415 Walnut Street	37902	Engineering Office
First Creek	X-Pert Tune	4419 N Broadway	37917	Automobile Repairs
First/White's Creek	Knoxville Utilities Board	4624 Mockingbird Drive	37918	Water Tank

Table 3-3 (continued)
Knoxville EPA FINDS Report

Watershed	Facility Name	Address	Zip Code	Description or SIC Code
First/White's Creek	TVA Knoxville Store Stores	4124 Greenway Drive	37902	Engineering Office/Warehouse
Second Creek	A. J. Melter Hauling & Rigging	117 Chicamauga Ave	37917	Crane and trucking
Second Creek	BP Oil Co.	100 Broadway at Jackson	37917	Gasoline Service Station
Second Creek	Burgin Dodge Inc.	4500 Clinton Hwy	37912	Automobile Sales
Second Creek	Clayton Motors Inc.	4600 Clayton Highway	37912	Automobile Sales
Second Creek	Coloninal Cleaners	109 W. Anderson Avenue	37917	Dry Cleaning/Laundry
Second Creek	East Tennessee Management Co.	4101 Clinton Hwy	37950	Automobile Sales
Second Creek	Exxon Oil Co.	315 Merchants Drive	37912	Gasoline Service Station
Second Creek	Ingersoll-Rand Equipment	4726 Clinton Hwy	37912	Equipment Sales
Second Creek	Kel-San Products Company, Inc.	2107 Grand Ave.	37916	Cleaning Products
Second Creek	Knoxville Co. Assoc. for Retarded	3000 N Central	37917	Light Manufacturing
Second Creek	Knoxville Lincoln Mercury Inc	4701 Clinton Hwy	37912	Automobile Sales
Second Creek	Knoxville Metals Corp.	110 Ramsey Street	37921	Scrap Dealer
Second Creek	Norfolk Southern RR	Heiskel Ave.	37917	SIC Code 4011
Second Creek	Rankin Sign Co Inc	916 Katherine Ave	37921	Sign Company
Second Creek	Rodell Inc DBA Mr. Transmission	1012 Merchants Drive	37912	Automobile Repairs
Second Creek	Safety-Clean Corp	626 Stewart	37917	SIC Code 5172
Second Creek	Sanitary Laundry & Dry Clean	625 North Broadway	37917	Dry Cleaning/Laundry
Second Creek	Silver Furniture Co Inc	2742 Hancock Street	37917	Furniture Sales
Second Creek	South Central Bell	410 Magnolia Ave	37917	Telephone Company
Second Creek	Southern RR Coster Shop	3125 N Central Street	37917	SIC Code 4011
Second, First Creeks	St Mary's Medical Center Inc	900 Oak Hill Ave	37917	Hospital
Second Creek	Tamko Asphalt Products	2506 Johnton Street	37921	Asphalt Company
Second Creek	Tennessee Armature & Electric	308 W Jackson Ave	37901	Electric Equipment Dealer
Second Creek	Tracy Photography	1420 Linden Ave	37917	Photographer
Second Creek	W. T. Thrasher Termite Co.	2212 N Central Ave	37918	Pest Control
Third Creek	Air & Hydraulic Equipment	3901 Paperwill Drive	37919	Hydraulics
Third Creek	Aztec Enterprises	5222 Middlebrook Pike	37950	Gasoline Service Station
Third Creek	CSX Transportation, Inc.	2200 Volunteer Blvd.	37916	Railroad
Third Creek	Cumberland Estates Cleaners	5753 Western Ave.	37921	Dry Cleaning/Laundry
Third Creek	Exxon Oil Co.	2201 Cumberland Ave	37916	Gasoline Service Station
Third Creek	Exxon Oil Co.	4709 Kingston Pike	37902	Gasoline Service Station
Third Creek	Fleet Transportation Co. Inc.	5207 Middlebrook Pike	37921	SIC Code 4213
Third Creek	Fort Sanders Medical Center	1901 Clinch Ave.	37916	Hospital
Third Creek	Knoxville Utilities Board	4517 Middlebrook Pike	37921	Utility Warehouse

Table 3-3 (continued)
Knoxville EPA FINDS Report

Watershed	Facility Name	Address	Zip Code	Description or SIC Code
Third Creek	Merritt Holland Co	200 Liberty Street	37919	Welding Equipment
Third Creek	Midsouth Ice & Cold Storage	4611 Webb Lane	37921	Ice House
Third Creek	Pepsi-Cola South Sales & Distrib.	3501 Middlebrook Pike	37921	Soft Drink Distributor
Third Creek	RMJ Inc DBA Super Wash House	3909 Western Ave	37923	Dry Cleaning/Laundry
Third Creek	Robinson Freight Lines	3600 Papermill Road	37919	Trucking
Third Creek	Sanitary Laundry & Dry Clean	4515 Kingston Pike	37919	Dry Cleaning/Laundry
Third Creek	Sherwin Williams Co	4427 Kingston Pike	37919	Paint Store
Third Creek	South Central Bell	3401 Henson Road	37909	Telephone Company
Third Creek	Union Carbide Corp Linde Div	Liberty & Southern Sts.	37919	Industrial Gases
Third Cr., Ft Loudoun	Univ of Tenn Agricultural Exp Sta	Center Drive	37901	College
Third Creek	Univerity of Tenn. Electric	2233 Volunteer Blvd	37916	Steam Power Plant
Third Creek	University of Tennessee	2111 Terrace Ave	37938	Police Station
Third Creek	Van Slyke Nissan Inc	5800 Clinton Hwy	37912	Automobile Sales
E. Fork Third Creek	Bobby Toole Site	Gap Road	37912	Closed Landfill
E. Fork Third Creek	Christianberry Trucking	3621 Pleasant Ridge Road	37921	Trucking
E. Fork Third Creek	City of Knoxville Engineering Facility	1400 Loraine Street	37921	Engineering Office
E. Fork Third Creek	Commercial Hydraulics	3527 Pleasant Ridge	37921	Hydraulics
E. Fork Third Creek	Knoxville College	301 College Street	37921	College
E. Fork Third Creek	Knoxville Porcelain Corp	2706 Mynders Ave	37921	Porcelain Manufacturer
E. Fork Third Creek	Lamar Advertising of Tennessee	3009 W. Industrial Parkway	37900	Sign Company
E. Fork Third Creek	Lays Cleaners & Laundry	1724 Tennessee Ave	37921	Dry Cleaning/Laundry
E. Fork Third Creek	Long John & Co.	1504 Proctor Street	37921	Machinery Manufacturing
E. Fork Third Creek	Penske Truck Leasing Co	1608 Sanderson Road	37917	Truck Leasing
E. Fork Third Creek	Post Trailer Repair Co	1901 Sutherland Ave	37921	Trailer Repair
E. Fork Third Creek	Roddy Manufacturing Company	2200 Leslie Street	37901	Soft Drink Bottler
E. Fork Third Creek	US Dept. of Labor Knoxville	621 Dale Ave	37921	School
Fourth Creek	Allied Signal Inc. Automotive	1601 Midpark Drive	37921	Automobile Parts Manufacturer
Fourth Creek	Capper Inc.	520 Bearden Park Circle	37919	Color Separators
Fourth Creek	Cherokee Porcelain Enamel Co.	5300 Homberg Drive	37919	Enameling
Fourth Creek	Control Technology Inc.	5734 Middlebrook Pike	37921	Computer Service
Fourth Creek	Crown Cleaners	5300 Kingston Pike	37919	Dry Cleaning/Laundry
Fourth Creek	C&S Laundry Company, Inc.	5961 Kingston Pike	37917	Dry Cleaning/Laundry
Fourth Creek	Enterprise Waste Oil Co.	5201 N Middlebrook Pike	37921	Waste Oil Collector
Fourth Creek	Exxon Oil Co.	5115 Kingston Pike	37919	Gasoline Service Station
Fourth Creek	Exxon Oil Co.	7523 Kingston Pike	37919	Gasoline Service Station

Table 3-3 (continued)
Knoxville EPA FINDS Report

Watershed	Facility Name	Address	Zip Code	Description or SIC Code
Fourth Creek	Federal Express Corp.	1701 Louisville Drive	37921	Shipping
Fourth Creek	Fin-Clair Corp.	1737 Louisville Road	37921	Metal Plating
Fourth Creek	Genuine Parts Co.	5937 Middlebrook Pike	37950	Automobile Parts Sales
Fourth Creek	Helton Dry Cleaners	6724 Papermill Road	37919	Dry Cleaning/Laundry
Fourth Creek	Highway Transportation Inc.	1500 Amherst Road	37919	Shipping
Fourth Creek	I. T. Stewart Site	5815 Middlebrook Pike	37921	Hazadous Waste Management
Fourth Creek	John Banks Buick Motors	6430 Papermill Road	37919	Automobile Sales
Fourth Creek	Johnson Controls Inc.	6101 Industrial Heights Drive	37909	Industrial Controls
Fourth Creek	Kenkaye Cleaners	7421 Northshore Dr	37919	Dry Cleaning/Laundry
Fourth Creek	Maaco Auto Painting & Body	6416 Kingston Pike	37923	Automobile Repairs
Fourth Creek	Phillips Petroleum Co Station	7300 Middlebrook Pike	37909	Gasoline Service Station
Fourth Creek	Redi-Rentals	203 Northshore Drive	37919	Equipment Rentals
Fourth Creek	Rental Uniform Inc	5901 Middlebrook Pike	37921	Laundry
Fourth Creek	Screen Art Inc	1801 Midpark Drive	37919	Printer
Fourth Creek	Sherwin Williams Co	6201 Baum Dr	37919	Paint Store
Fourth Creek	United Parcel Service	1440 Amherst Road	37909	Shipping
Fourth Creek	Zeliweger Uster	456 Troy Circle	37919	Special Instrument Lab
Ft. Loudoun	American Limestone Co. Inc.	2209 Blount Avenue	37920	Concrete Plant
Ft. Loudoun	ASARCO Co./American Limestone	2209 Blount Avenue	37914	Concrete Plant
Ft. Loudoun	Corner Cabinet Shop	1600 Island Home Ave	37920	Cabinet Shop
Ft. Loudoun	Dixie Barrel and Drum Company	2120 Jones Street	37920	Barrel Sales
Ft. Loudoun	Federal Sign Corp.	1901 Jones Street	37920	Sign Company
Ft. Loudoun	First Image Management Co.	900 East Hill Ave.	37915	Computer Service
Ft. Loudoun	Gen Shale Products	1740 Riverside Drive	37901	Brick Yard
Ft. Loudoun	Holston Gases Inc.	222 Council Street	37917	Industrial Gases
Ft. Loudoun	Kern's Bakeries Inc.	2110 Chapman Hwy	37920	Bakery
Ft. Loudoun	Knoxville Co. School Board	400 W. Main Ave.	37902	School Supplies
Ft. Loudoun	Knoxville Glove Corp	444 Blount Ave	37901	Glove Manufactoring
Ft. Loudoun	Lakeshore Mental Health Institution	5908 Lyons View Drive	37919	Mental Institution
Ft. Loudoun	Service Body Shop Inc	2612 Blount Ave	37920	Automobile Repairs
Ft. Loudoun	Signal MTN Cement	2318 Neyland Drive	37916	Concrete Plant
Ft. Loudoun	Southern States Asphalt	1808 Jones Street	37920	Asphalt Company
Ft. Loudoun	Tennessee School for the Deaf	2725 Island Home Blvd.	37901	School
Ft. Loudoun	Tenn. Dept. of Health & Environment	1522 Cherokee Trail	37901	Office
Ft. Loudoun	University of Tenn Medical Center	1924 Alcoa Highway	37920	Hospital

Table 3-3 (continued)
Knoxville EPA FINDS Report

Watershed	Facility Name	Address	Zip Code	Description or SIC Code
Ft. Loudoun	University of Tenn. Physical Plant	1617 Lake Loudoun Blvd	37936	Steam Power Plant
Goose Creek	David Witherspoon Inc	901 Old Maryville Pike	37920	Scrap Metals
Goose Creek	Knoxville One Hour Cleaners	3106 Chapman Hwy	37920	Dry Cleaning/Laundry
Goose Creek	Patent Plastics Inc.	638 Maryville Pike SW	37920	Plastics
Goose Creek	Phillips Petroleum Co Station	3925 Chapman Hwy	37920	Gasoline Service Station
Goose Creek	Sanitary Laundry & Dry Clean	3914 Chapman Hwy	37920	Dry Cleaning/Laundry
Goose Creek	Tennessee Asphalt Co	4405 Candora Ave	37901	Asphalt Company
Knob Creek	Chapman Hwy Cleaners	5622 Chapman Hwy	37920	Dry Cleaning/Laundry
Knob Fork	Audio Animation Inc.	6632 Central Ave. Pike	37912	Video Producer
Love Creek	Acme Diesel	4724 Rutledge Pike	37914	Engine Sales
Love Creek	Aikins Son Transmissions	4001 E. Magnolia Ave.	37914	Automobile Repairs
Love Creek	APAC - Tennessee Inc.	1301 Springhill Road	37914	Contractors Street Paving
Love Creek	Ashland Oil Co.	1301 Spring Hill Road	37914	Contractors Street Paving
Love Creek	Cummins Cumberland, Inc.	1211 Ault Road	37914	Gas Engine Sales
Love Creek	C&S Laundry Company, Inc.	4108 Asheville Highway	37917	Dry Cleaning/Laundry
Love Creek	Exxon Oil Co.	5420 Asheville Hwy	37914	Gasoline Service Station
Love Creek	Frieghtliner of Knoxville Inc.	1429 Ault Road	37914	Shipping
Love Creek	King Business Forms Corp.	1500 Galway Street	37917	Printer
Love Creek	Landmark International Park	4550 Rutledge Pike	37914	Truck Terminal
Love Creek	Levi Strauss & Co.	1808 N. Cherry Street	37917	SIC Code 2325
Love Creek	Perma-Chink Systems Inc	1605 Prosser Road	37914	Log Home Builder
Love Creek	Peterbilt of Knoxville	5218 Rutledge Pike	37924	Truck Sales
Love Creek	Ready-Mix Concrete Co.	1104 Spring Hill Road	37914	Concrete Plant
Love Creek	Renfro Const Office & Shop	4817 Rutledge Pike	37901	Contractor's Office
Ten Mile Creek	Carrier Service Center	8705 Unicorn Drive	37923	Contractor's Office
Ten Mile Creek	Dutch Girl Cleaners	8515 Kingston Pike	37423	Dry Cleaning/Laundry
Ten Mile Creek	Exxon Oil Co.	9200 Kingston Pike	37922	Gasoline Service Station
Ten Mile Creek	Harper's Porche/Audi	120 Gallaher View Road	37919	Automobile Sales
Ten Mile Creek	Harper's Volkswagen	8810 Kingston Pike	37923	Automobile Sales
Ten Mile Creek	Jim Goodill Dodge Company	8544 Kingston Pike	37923	Automobile Sales
Ten Mile Creek	Mr. Transmission	8024 Kingston Pike	37919	Automobile Repairs
Ten Mile Creek	Phillips Petroleum Co Station	9004 Kingston Pike	37923	Gasoline Service Station
Ten Mile Creek	Rice Oldsmobile	8330 Kingston Pike	37919	Automobile Sales
Ten Mile Creek	Rogers Cadillac Inc	8360 Kingston Pike	37919	Automobile Sales
Ten Mile Creek	Suburban Center Cry Cleaners	7907 Kingston Pike	37919	Dry Cleaning/Laundry

Table 3-3 (continued)
Knoxville EPA FINDS Report

Watershed	Facility Name	Address	Zip Code	Description or SIC Code
Ten Mile Creek	Ted Russell Ford	8501 Kingston Pike	37923	Automobile Sales
Ten Mile Creek	The Home Depot	9361 Kingston Pike	37922	Hardware Store
Ten Mile Creek	Toyota of Knox, Inc	8854 Kingston Pike	37930	Automobile Sales
William's Creek	Exxon Oil Co.	929 NE Cherry Street	37917	Gasoline Service Station
William's Creek	Exxon Oil Co. #57137	2561 Magnolia	37914	Gasoline Service Station
William's Creek	Ideal Cleaners	2742 Martin Luther King Jr. Ave.	37914	Dry Cleaning/Laundry
William's Creek	Knoxville Bumper Exchange Ind	2216 Mohawk Ave	37915	Automobile Parts Sales
William's Creek	Knoxville Plating Works Inc.	2327 Martin Luther King Jr. Ave.	37915	Metal Plating
William's Creek	Knoxville Rod & Bearing Co.	915 Cherry Street	37917	Automobile Parts Sales
William's Creek	Parrott Joe Screen Printing	2007 Riverside Drive	37915	Printer

TABLE 3-4
Industrial Facilities on EPA List
for Group Stormwater Permit Applications*

GROUP #	ID #	FACILITY NAME/OWNER	SIC CODE
0355	0130	Knoxville Concrete Pipes	NA
0406	0140	ABF Freight Systems, Inc	NA
0817	0004	AJ Melter Hauling & Rigging	4231
0426	0028	APAC, Inc.	2951
0790	0045	AWS of Knoxville	4231
0820	0081	Airborne Freight Corp.	4513
0690	0003	Ashland Chamical, Inc.	5169
0836	0018	Averitt Express, Inc	4213
0624	0103	Beverly Steel, Inc.	3441
0644	0036	Browning Ferris Indusries	NA
0645	0101	Browning Ferris Indusries	NA
0647	0029	Browning Ferris Indusries	5093
0968	1627	Burkhart Enterprises, Inc.	NA
0962	0096	Burkhart Enterprises, Inc.	4213
0953	0044	Clayton Homes	2451
0657	0265	CSX Transportation	40
0478	0026	Callaway Building Produsts	3449
0362	0007	Chevron Chemical Co.	3082
0979	0011	Consolidated Freightways	4213
0797	0010	Conway Southern Express	4213
0066	0039	Dana Corporation	NA
0596	0523	David Witherspoon, Inc.	NA
0596	0524	David Witherspoon, Inc.	NA
0656	0231	Downtown Island Airport	4581
0478	0055	Enco Materials, Inc.	3449
1221	0337	Fireproof Storage & Van	4221
0790	0280	Fleet Transport Co., Inc.	4231
0790	0280	Fleet Transport Co., Inc.	4231
0817	0082	Fredrickson Motor Express	4231
1026	0035	General Shale Products	3251
0151	0012	Greyhound Lines, Inc.	4131
0355	0113	Hermitage Concrete Pipe	NA
0790	0385	Highway Transport, Inc.	4231
0790	0385	Highway Transport, Inc.	4231
0962	0017	Humbolt Express, Inc.	4231
0353	0051	Jackson Utility Division	NA
0275	0135	Jefferson Smurfit Corp	2653
0596	0781	Knox Metals Corp	NA
0791	0030	Knoxville Downtown Island Airport	4581
0790	0557	Liquid Transporters, Inc	4231

* Source: Data recieved from TDEC, April 1993.

TABLE 3-4 (continued)
Industrial Facilities on EPA List
for Group Stormwater Permit Applications*

GROUP #	ID #	FACILITY NAME/OWNER	SIC CODE
0656	0261	McGhee Tyson Airport	4581
0962	0025	Milan Express Co., Inc.	4231
0771	0027	Military Dept., National Guard	4212
0658	0021	Norfolk Southern Railroad	40
0657	0271	Norfolk Southern Railroad	40
0657	0272	Norfolk Southern Railroad	40
0659	0035	Norfolk Southern Railroad	40
0008	0068	Overnite Transportation	4212
0275	0159	Packaging Corp of America	2653
0962	0036	Petro Express, Inc.	4231
0962	0035	Petro Express, Inc.	4231
0624	0130	Pip's Iron Works, Inc.	3441
0247	0007	Rock Tenn Co.	5093
0920	0065	Ready Mix Concrete Co. of Knoxville	3273
0832	0224	Roadway Express, Inc.	4231
0774	0038	Rock Tenn Co.	2657
0925	0226	Silver Furniature Co	2511
0179	0009	Swift-Eckrich Inc.	NA
0195	0110	Safety-Kleen	5093
0195	0154	Safety-Kleen	5093
1088	0105	Sea Ray Boats, Inc	NA
1088	0113	Sea Ray Boats, Inc	NA
1088	0087	Sea Ray Boats, Inc	NA
0962	0041	Service Transportation, Inc.	4213
0683	0136	Simerly Vault, Inc.	3272
0634	0096	Southern Cast Stone Co., Inc.	NA
0596	1067	Southern Foundry Supply, Inc.	NA
0962	0051	System 81 Express, Inc.	4213
0013	0066	Tom's Foods	NA
0243	0150	US Postal Service	4311
0958	0250	United Bus Owners of America	4151
0693	0409	United Parcel Service, Inc.	4215
0009	0010	Vulcan Materials	NA
1260	0081	Waste Management of Tenn	4212
0968	0928	West Wood Enterprises, Inc.	5015
1153	0163	Yellow Freight Systems, Inc.	4213
0809	0026	Zellweger Uster, Inc.	3552

* Source: Data recieved from TDEC, April 1993.

4.0 CHARACTERIZATION DATA

4.1 INTRODUCTION

Regulations presented in CFR 122.26 (d)(2)(iii) detail the requirements which must be followed in obtaining data characterizing the quality and quantity of pollutant discharges covered in the permit application. These requirements are as follows:

Characterization data. When "quantitative data" for a pollutant are required under paragraph (d)(a)(iii)(A)(3) of this paragraph, the applicant must collect a sample of effluent in accordance with 40 CFR 122.21(g)(7) and analyze it for the pollutant in accordance with analytical methods approved under 40 CFR part 136. When no analytical method is approved the applicant may use any suitable method, but must provide a description of the method. The applicant must provide information characterizing the quality and quantity of discharges covered in the permit application, including:

(A) Quantitative data from representative outfalls designated by the Director (based on the information received in part 1 of the application, the Director shall designate between five and ten outfalls or field screening points as representative of the commercial, residential and industrial land use activities of the drainage area contributing to the system, or where there are less than five outfalls covered in the application, the Director shall designate all outfalls) developed as follows:

(1) For each outfall or field screening point designated under this subparagraph, samples shall be collected of storm water discharges from three storm events occurring at least one month apart in accordance with the requirements at § 122.21 (g)(7) (the Director may allow exemptions to sampling three storm events when climactic conditions create good cause for such exemptions);

(2) A narrative description shall be provided of the data and duration of the storm event(s) sampled, rainfall estimates of the storm event which generated the sampled discharge and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event;

(3) For samples collected and described under paragraphs (d)(2)(iii)(A)(1) and (A)(2) of this section, quantitative data shall be provided for: the organic pollutants listed in Table II; the pollutants listed in Table III (toxic metals, cyanide, and total phenols) of appendix D of 40 CFR part 122, and for the following pollutants:

- *Total suspended solids (TSS)*
- *Total dissolved solids (TDS)*
- *COD*
- *BOD_5*
- *Oil and grease*
- *Fecal coliform*
- *Fecal streptococcus*
- *pH*
- *Total Kjeldahl nitrogen*
- *Nitrate plus nitrite*
- *Dissolved phosphorus*
- *Total Ammonia plus organic nitrogen*
- *Total phosphorus*

(4) Additional limited quantitative data required by the Director for determining permit conditions (The Director may require that quantitative data shall be provided for additional parameters, and may establish sampling conditions such as the location, season of sample collection, form of precipitation (snow melt, rainfall) and other parameters necessary to insure representativeness);

(B) Estimates of the annual pollutant load of the cumulative discharges to the waters of the United States from all identified municipal outfalls and the event mean concentration of the cumulative discharges to waters of the United States from all identified municipal outfalls during a storm event (as described under § 122.21(c)(7)) for BOD_5, COD, TSS, dissolved solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, cadmium, copper, lead, and zinc. Estimates shall be accompanied by a description of the procedures for estimating constituent loads and concentrations, including any modelling, data analysis, and calculation methods;

(C) A proposed schedule to provide estimates for each major outfall identified in either paragraph (d)(2)(ii) or (d)(1)(iii)(B)(1) of this section of the seasonal pollutant load and of the event mean concentration of a representative storm for any constituent detected in any sample required under paragraph (d)(2)(iii)(A) of this section; and

(D) A proposed monitoring program for representative data collection for the term of the permit that describes the location of outfalls or field screening points to be sampled (or the location of instream stations), why the location is representative, the frequency of sampling, parameters to be sampled, and a description of sampling equipment.

The purpose of this section is to characterize the discharge to the municipal storm sewer system corresponding to the requirements presented in the regulations above.

4.2 QUANTITATIVE DATA FROM REPRESENTATIVE OUTFALLS

The task addressing quantitative data from representative outfalls was completed by the United States Geological Survey (USGS) under separate contract with the City of Knoxville. The USGS monitoring program describes quantitative data from three storms at five stations representative of five separate land uses. These land uses are low density residential, high density residential, concentrated commercial, light industrial/warehousing, and chemical industrial. Table 4-1 presents the results of the representative monitoring program for each of the 15 station-storms required by the regulations. This table represents the data as received from the USGS in February 1993. A summary report of the quantitative data prepared by the USGS is presented in Appendix B.

4.3 ANNUAL POLLUTANT LOADS AND EVENT MEAN CONCENTRATIONS

Estimates of the average annual pollutant load and associated event mean concentration (EMC) of the cumulative discharges from the City of Knoxville's municipal outfalls to the waters of the United States were developed for the following 12 water quality parameters:

- Five-day biochemical oxygen demand (BOD_5)
- Chemical oxygen demand (COD)
- Total suspended solids (TSS)
- Dissolved solids (TDS)
- Total nitrogen (TN)
- Total ammonia plus organic nitrogen (total Kjeldahl nitrogen (TKN))
- Total phosphorus (TP)
- Dissolved phosphorus (DP)
- Cadmium (Cd)
- Copper (Cu)
- Lead (Pb)
- Zinc (Zn)

Table 4-1
CITY OF KNOXVILLE
NPDES PART 2 WET WEATHER MONITORING RESULTS

PARAMETER	UNITS	DETECTION LIMIT	STATION AND STORM EVENT					
			#03495905 Low Dens Resid 4/19/91	#03495905 Low Dens Resid 3/06/92	#03495905 Low Dens Resid 4/15/92	Chisholm Trail #03499193 High Dens Res 8/14/91	Chisholm Trail #03499193 High Dens Res 7/31/92	Chisholm Trail #03499193 High Dens Res 9/18/92
DRAINAGE AREA	(sq.mi.)		0.23	0.23	0.23	0.27	0.27	0.27
DIRECTLY CONNECT IMPERV. AREA	%							
SINGLE FAMILY RESIDENTIAL	%		55%	55%	55%	26%	26%	26%
MULTIPLE FAMILY RESIDENTIAL	%		7%	7%	7%	26%	26%	26%
COMMERCIAL LAND USE	%					5%	5%	5%
INDUSTRIAL LAND USE	%		22%	22%	22%			
PUBLIC/INSTITUTIONAL LAND USE	%							
STREETS/HIGHWAYS	%		16%	16%	16%	8%	8%	8%
FOREST LAND USE	%							
OPEN LAND USE	%					35%	35%	35%
GENERAL								
pH				8.70	7.70	7.70	7.70	8.00
BIOCHEM. OXYGEN DEMAND (5 DAY	(mg/L)		8	36	27	8	26	24
TOTAL SUSPENDED SOLIDS	(mg/L)		100	220	186	1	23	21
TOTAL DISSOLVED SOLIDS	(mg/L)		38	59	85	89	117	38
CHEMICAL OXYGEN DEMAND	(mg/L)		77	92	130	32	84	37
OIL & GREASE	(mg/L)	1.0	BDL	BDL	1	BDL	1	BDL
FECAL COLIFORM	(#/100 ml)		24,000	# 17,000	56,000	22,000	690,000	28,000
FECAL STREPTOCOCCUS	(#/100 ml)		22,000	41,000	48,000	69,000	67,000	110,000
NITRATE-NITRITE	(mg/L)		0.32	0.32	1.50	0.99	1.80	0.36
TOTAL KJELDAHL NITROGEN	(mg/L)		1.20	1.10	1.70	0.70	1.80	0.50
NH3	(mg/L)		0.19	0.11	0.40	0.12	0.17	0.05
TOTAL PHOSPHORUS	(mg/L)		0.320	0.300	0.330	0.090	0.140	0.140
DISSOLVED PHOSPHORUS	(mg/L)		0.170	0.100	0.240	0.050	0.090	0.070

NOTES:
NA = NOT AVAILABLE
ND = NO DATA AVAILABLE
BDL = BELOW DETECTION LIMIT

11-May-93

Table 4-1 (continued)
CITY OF KNOXVILLE
NPDES PART 2 WET WEATHER MONITORING RESULTS

PARAMETER	UNITS	DETECTION LIMIT	STATION AND STORM EVENT #03495905 Low Dens Resid 4/19/91	#03495905 Low Dens Resid 3/06/92	#03495905 Low Dens Resid 4/15/92	Chisholm Trail #03499193 High Dens Res 8/14/91	Chisholm Trail #03499193 High Dens Res 7/31/92	Chisholm Trail #03499193 High Dens Res 9/18/92
METALS, CYANIDE, AND TOTAL PHENOLS								
ARSENIC, TOTAL	(ug/L)	1	2.0	1.0	2.0	BDL	BDL	2.0
ANTIMONY, TOTAL	(ug/L)	10	1	BDL	BDL	BDL	BDL	BDL
BERYLLIUM, TOTAL	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL
CADMIUM, TOTAL	(ug/L)	1	BDL	BDL	BDL	BDL	BDL	BDL
CHROMIUM, TOTAL	(ug/L)	1	8.0	12.0	6.0	BDL	7.0	BDL
COPPER, TOTAL	(ug/L)		6.0	6.0	12.0	3.0	6.0	3.0
LEAD, TOTAL	(ug/L)		54	64	40	ND	5	5
MERCURY, TOTAL	(ug/L)	0.1	BDL	BDL	BDL	BDL	BDL	BDL
NICKEL, TOTAL	(ug/L)		6	6	3	2	10	1
SELENIUM, TOTAL	(ug/L)	2	BDL	BDL	BDL	BDL	BDL	BDL
SILVER, TOTAL	(ug/L)	1	BDL	BDL	BDL	BDL	BDL	BDL
THALLIUM, TOTAL	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL
ZINC, TOTAL	(ug/L)		110	130	90	20	50	50
CYANIDE	(mg/L)	0.01	BDL	BDL	BDL	BDL	0.01	0.01
PHENOLS, TOTAL	(mg/L)	5	BDL	3.00	6.00	1.00	3.00	4.00
VOLATILES								
ACROLEIN	(ug/L)	20	ND	BDL	BDL	ND	BDL	BDL
ACRYLONITRILE	(ug/L)	20	ND	BDL	BDL	ND	BDL	BDL
BENZENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
BROMOFORM	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
CARBON TETRACHLORIDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
CHLOROBENZENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
CHLORODIBROMOMETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
CHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
2-CHLOROETHYLVINYL ETHER	(ug/L)	1	BDL	BDL	BDL	BDL	BDL	BDL
CHLOROFORM	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
DICHLOROBROMOMETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL

11-May-93

Table 4-1 (continued)
CITY OF KNOXVILLE
NPDES PART 2 WET WEATHER MONITORING RESULTS

PARAMETER	UNITS	DETECTION LIMIT	STATION AND STORM EVENT #03495905 Low Dens Resid 4/19/91	#03495905 Low Dens Resid 3/06/92	#03495905 Low Dens Resid 4/15/92	Chisholm Trail #03499193 High Dens Res 8/14/91	Chisholm Trail #03499193 High Dens Res 7/31/92	Chisholm Trail #03499193 High Dens Res 9/18/92
1,1-DICHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	ND	BDL	BDL
1,2-DICHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
1,1-DICHLOROETHYLENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
1,2-DICHLOROPROPANE	(ug/L)	0.2	BDL	BDL	BDL	ND	BDL	BDL
1,3-DICHLOROPROPENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
ETHYLBENZENE	(ug/L)	0.2	0.4	BDL	BDL	BDL	BDL	BDL
METHYL BROMIDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
METHYL CHLORIDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
METHYLENE CHLORIDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	0.3	BDL
1,1,2,2,-TETRACHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
TETRACHLOROETHYLENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
TOLUENE	(ug/L)	0.2	1.2	BDL	BDL	BDL	0.3	BDL
1,2-TRANS-DICHLOROETHENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
1,1,1-TRICHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2-TRICHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
TRICHLOROETHYLENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
VINYL CHLORIDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
ACID COMPOUNDS								
2-CHLOROPHENOL	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
2,4-DICHLOROPHENOL	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
2,4-DIMETHYLPHENOL	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
4,6-DINITRO-O-CRESOL	(ug/L)	30	BDL	BDL	BDL	BDL	BDL	BDL
2,4-DINITROPHENOL	(ug/L)	20	BDL	BDL	BDL	BDL	BDL	BDL
2-NITROPHENOL	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
4-NITROPHENOL	(ug/L)	30	BDL	BDL	BDL	BDL	BDL	BDL
P-CHLORO-M-CRESOL	(ug/L)	30	BDL	BDL	BDL	BDL	BDL	BDL
PENTACHLOROPHENOL	(ug/L)	30	BDL	BDL	BDL	BDL	BDL	BDL
PHENOL	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
2,4,6-TRICHLOROPHENOL	(ug/L)	20	BDL	BDL	BDL	BDL	BDL	BDL

11-May-93

Table 4-1 (continued)
CITY OF KNOXVILLE
NPDES PART 2 WET WEATHER MONITORING RESULTS

PARAMETER	UNITS	DETECTION LIMIT	STATION AND STORM EVENT #03495905 Low Dens Resid 4/19/91	#03495905 Low Dens Resid 3/06/92	#03495905 Low Dens Resid 4/15/92	Chisholm Trail #03499193 High Dens Res 8/14/91	Chisholm Trail #03499193 High Dens Res 7/31/92	Chisholm Trail #03499193 High Dens Res 9/18/92
BASE/NEUTRAL								
ACENAPHTHENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
ACENAPHTHYLENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
ANTHRACENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
BENZIDINE	(ug/L)	40	ND	BDL	BDL	BDL	BDL	BDL
BENZO(A)ANTHRACINE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL
BENZO(A)PYRENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL
3,4 BENZOFLUORANTHENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL
BENZO(GHI)PERYLENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL
BENZO (K) FLUORANTHENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL
BIS(2-CHLOROETHOXY)METHANE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
BIS(2-CHLOROETHYL)ETHER	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
BIS(2-CHLOROISOPROPYL)ETHER	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
BIS(2-ETHYLHEXYL)PHTHALATE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
4-BROMOPHENYL PHENYL ETHER	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
BUTYLBENZYL PHTHALATE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
2-CHLORONAPHTHALENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
4-CHLOROPHENYL PHENYL ETHER	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
CHRYSENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL
DIBENZO (A,H) ANTHRACENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL
1,2-DICHLOROBENZENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
1,3-DICHLOROBENZENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
1,4-DICHLOROBENZENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
3,3'-DICHLOROBENZIDINE	(ug/L)	20	ND	BDL	BDL	BDL	BDL	BDL
DIETHYL PHTHALATE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
DIMETHYL PHTHALATE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
DI-N-BUTYL PHTHALATE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
2,4-DINITROTOLULENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
2,6-DINITROTOLULENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
DI-N-OCTYL PHTHALATE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL

11-May-93

Table 4-1 (continued)
CITY OF KNOXVILLE
NPDES PART 2 WET WEATHER MONITORING RESULTS

PARAMETER	UNITS	DETECTION LIMIT	STATION AND STORM EVENT #03495905 Low Dens Resid 4/19/91	#03495905 Low Dens Resid 3/06/92	#03495905 Low Dens Resid 4/15/92	Chisholm Trail #03499193 High Dens Res 8/14/91	Chisholm Trail #03499193 High Dens Res 7/31/92	Chisholm Trail #03499193 High Dens Res 9/18/92
1,2-DIPHENYLHYDRAZINE	(ug/L)	5	ND	BDL	BDL	ND	BDL	BDL
FLURORANTHENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
FLOURENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
HEXACHLOROBENZENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
HEXACHLOROBUTADIENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
HEXACHLOROCYCLOPENTADIENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
HEXACHLOROETHANE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
INDENO(1,2,3-CD)PYRENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL
ISOPHORONE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
NAPTHALENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
NITROBENZENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
N-NITROSODIMETHYLAMINE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
N-NITROSODI-N-PROPYLAMINE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
N-NITROSODIPHENYLAMINE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
PHENANTHRENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
PYRENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
1,2,4-TRICHLOROBENZENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL
PESTICIDES								
ALDRIN	(ug/L)	0.04	BDL	BDL	BDL	BDL	BDL	BDL
ALPHA-BHC	(ug/L)	0.03	BDL	BDL	BDL	BDL	BDL	BDL
BETA-BHC	(ug/L)	0.03	BDL	BDL	BDL	BDL	BDL	BDL
GAMMA-BHC	(ug/L)							
DELTA-BHC	(ug/L)	0.09	BDL	BDL	ND	BDL	BDL	BDL
CHLORDANE	(ug/L)	0.1	0.1	BDL	BDL	BDL	BDL	BDL
4,4'-DDT	(ug/L)	0.1	BDL	BDL	BDL	BDL	BDL	BDL
4,4'-DDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
4,4'-DDD	(ug/L)	0.1	BDL	BDL	BDL	BDL	BDL	BDL
DIELDRIN	(ug/L)	0.02	0.01	BDL	BDL	BDL	BDL	BDL
ALPHA-ENDOSULFAN	(ug/L)	0.01	BDL	BDL	ND	BDL	BDL	BDL

11-May-93

Table 4-1 (continued)
CITY OF KNOXVILLE
NPDES PART 2 WET WEATHER MONITORING RESULTS

PARAMETER	UNITS	DETECTION LIMIT	STATION AND STORM EVENT #03495905 Low Dens Resid 4/19/91	#03495905 Low Dens Resid 3/06/92	#03495905 Low Dens Resid 4/15/92	Chisholm Trail #03499193 High Dens Res 8/14/91	Chisholm Trail #03499193 High Dens Res 7/31/92	Chisholm Trail #03499193 High Dens Res 9/18/92
BETA-ENDOSULFAN	(ug/L)	0.04	BDL	BDL	BDL	BDL	BDL	BDL
ENDOSULFAN SULFATE	(ug/L)	0.6	BDL	BDL	BDL	BDL	BDL	BDL
ENDRIN	(ug/L)	0.06	BDL	BDL	BDL	BDL	BDL	BDL
ENDRIN ALDEHYDE	(ug/L)	0.2	ND	BDL	BDL	BDL	BDL	BDL
HEPTACHLOR	(ug/L)	0.03	BDL	BDL	BDL	BDL	BDL	BDL
HEPTACHLOR EPOXIDE	(ug/L)	0.8	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1242	(ug/L)	0.01	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1254	(ug/L)	0.01	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1221	(ug/L)	1	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1232	(ug/L)	0.01	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1248	(ug/L)	0.01	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1260	(ug/L)	0.01	0.1	BDL	BDL	BDL	BDL	BDL
PCB-1016	(ug/L)	0.1	BDL	BDL	BDL	BDL	BDL	BDL
TOXAPHENE	(ug/L)	2	BDL	BDL	BDL	BDL	BDL	BDL

11-May-93

Table 4-1 (continued)
CITY OF KNOXVILLE
NPDES PART 2 WET WEATHER MONITORING RESULTS

PARAMETER	UNITS	DETECTION LIMIT	Tank Farms #03497041 Industrial/Chem 3/12/92	Tank Farms #03497041 Industrial/Chem 4/27/92	Tank Farms #03497041 Industrial/Chem 2/13/92	Acker Place #03497103 Light Industrial 3/27/91	Acker Place #03497103 Light Industrial 11/20/91	Acker Place #03497103 Light Industrial 8/20/92	#034971055 Conc. Commer. 4/08/91	#034971055 Conc. Commer. 11/01/91	#034971055 Conc. Commer. 3/18/92
			STATION AND STORM EVENTS								
DRAINAGE AREA	(sq.mi.)		0.55	0.55	0.55	0.91	0.91	0.91	0.58	0.58	0.58
DIRECTLY CONNECT IMPERV. AREA	%										
SINGLE FAMILY RESIDENTIAL	%		14%	14%	14%	10%	10%	10%	18%	18%	18%
MULTIPLE FAMILY RESIDENTIAL	%										
COMMERCIAL LAND USE	%		9%	9%	9%	3%	3%	3%	55%	55%	55%
INDUSTRIAL LAND USE	%		18%	18%	18%	48%	48%	48%			
PUBLIC/INSTITUTIONAL LAND USE	%		16%	16%	16%	8%	8%	8%	16%	16%	16%
STREETS/HIGHWAYS	%										
FOREST LAND USE	%										
OPEN LAND USE	%		43%	43%	43%	31%	31%	31%	11%	11%	11%
GENERAL											
pH			7.50	7.90	8.40	8.20	7.40	8.50	7.00	6.70	7.60
BIOCHEM. OXYGEN DEMAND (5 DAY	(mg/L)		72	10	270	72	21	52	20	370	13
TOTAL SUSPENDED SOLIDS	(mg/L)		87	143	200	285	10,100	330	43	75	23
TOTAL DISSOLVED SOLIDS	(mg/L)		129	100	225	56	135	54	48	157	110
CHEMICAL OXYGEN DEMAND	(mg/L)		220	98	250	89	100	71	130	650	110
OIL & GREASE	(mg/L)	1.0	BDL	1	BDL	BDL	3	BDL	4	12	5
FECAL COLIFORM	(#/100 ml)		220	2,500	480	3,100	9,700	ND	3,900	# 6,000	6,000
FECAL STREPTOCOCCUS	(#/100 ml)		870	7,400	2,100	8,200	6,400	ND	45,000	> 1,000,000	28,000
NITRATE-NITRITE	(mg/L)		0.61	0.46	1.10	0.40	0.92	0.49	0.36	1.60	1.60
TOTAL KJELDAHL NITROGEN	(mg/L)		2.20	1.30	3.00	1.10	1.40	0.30	2.10	2.70	1.60
NH3	(mg/L)		0.41	0.21	0.67	0.15	0.37	0.15	0.25	0.64	0.60
TOTAL PHOSPHORUS	(mg/L)		1.500	1.000	2.500	0.380	0.530	0.100	0.210	0.720	0.160
DISSOLVED PHOSPHORUS	(mg/L)		0.910	0.560	1.600	0.040	0.380	0.040	0.110	0.520	0.120
METALS, CYANIDE, AND TOTAL PHENOLS											
ARSENIC, TOTAL	(ug/L)	1	14.0	2.0	14.0	3.0	2.0	2.0	BDL	BDL	12.0
ANTIMONY, TOTAL	(ug/L)	10	1	1	BDL	1	BDL	BDL	3	BDL	BDL
BERYLLIUM, TOTAL	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CADMIUM, TOTAL	(ug/L)	1	1.00	2.00	2.00	1.00	BDL	BDL	BDL	2.0	BDL
CHROMIUM, TOTAL	(ug/L)	1	6.0	10.0	11.0	14.0	6.0	6.0	3.0	28.0	3.0
COPPER, TOTAL	(ug/L)		11.0	14.0	23.0	8.0	ND	5.0	9.0	28.0	13.0
LEAD, TOTAL	(ug/L)		15	23	29	25	18	14	17	14	12
MERCURY, TOTAL	(ug/L)	0.1	0.20	BDL	BDL	0.1	BDL	BDL	BDL	0.1	BDL
NICKEL, TOTAL	(ug/L)		2	11	6	8	9	4	3	10	4
SELENIUM, TOTAL	(ug/L)	2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
SILVER, TOTAL	(ug/L)	1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
THALLIUM, TOTAL	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ZINC, TOTAL	(ug/L)		150	200	210	350	240	150	170	340	150
CYANIDE	(mg/L)	0.01	BDL	BDL	0.01	BDL	BDL	BDL	BDL	0.01	BDL
PHENOLS, TOTAL	(mg/L)	5	120.00	33.00	150.00	BDL	8.00	3.00	5.00	11.00	14.00

11-May-93

Table 4-1 (continued)
CITY OF KNOXVILLE
NPDES PART 2 WET WEATHER MONITORING RESULTS

PARAMETER	UNITS	DETECTION LIMIT	STATION AND STORM EVENTS Tank Farms #03497041 Industrial/Chem 3/12/92	Tank Farms #03497041 Industrial/Chem 4/27/92	Tank Farms #03497041 Industrial/Chem 2/13/92	Acker Place #03497103 Light Industrial 3/27/91	Acker Place #03497103 Light Industrial 11/20/91	Acker Place #03497103 Light Industrial 8/20/92	#034971055 Conc. Commer. 4/08/91	#034971055 Conc. Commer. 11/01/91	#034971055 Conc. Commer. 3/18/92
VOLATILES											
ACROLEIN	(ug/L)	20	ND	ND	BDL	ND	BDL	BDL	ND	BDL	BDL
ACRYLONITRILE	(ug/L)	20	ND	ND	BDL	ND	BDL	BDL	ND	BDL	BDL
BENZENE	(ug/L)	0.2	2	92.0	160.0	BDL	BDL	BDL	BDL	BDL	BDL
BROMOFORM	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CARBON TETRACHLORIDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CHLOROBENZENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CHLORODIBROMOMETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
2-CHLOROETHYLVINYL ETHER	(ug/L)	1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CHLOROFORM	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DICHLOROBROMOMETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1-DICHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-DICHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1-DICHLOROETHYLENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-DICHLOROPROPANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,3-DICHLOROPROPENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ETHYLBENZENE	(ug/L)	0.2	1.8	BDL	0.7	BDL	BDL	BDL	BDL	0.2	BDL
METHYL BROMIDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
METHYL CHLORIDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
METHYLENE CHLORIDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	0.2	BDL	BDL	BDL	BDL
1,1,2,2,-TETRACHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
TETRACHLOROETHYLENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	0.5	BDL	ND	1.7	BDL
TOLUENE	(ug/L)	0.2	8	100.0	190.0	BDL	BDL	BDL	BDL	2.3	BDL
1,2-TRANS-DICHLOROETHENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,1-TRICHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	1.0	BDL	BDL	BDL	BDL
1,1,2-TRICHLOROETHANE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
TRICHLOROETHYLENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
VINYL CHLORIDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ACID COMPOUNDS											
2-CHLOROPHENOL	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
2,4-DICHLOROPHENOL	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
2,4-DIMETHYLPHENOL	(ug/L)	5	5.0	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
4,6-DINITRO-O-CRESOL	(ug/L)	30	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
2,4-DINITROPHENOL	(ug/L)	20	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
2-NITROPHENOL	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
4-NITROPHENOL	(ug/L)	30	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
P-CHLORO-M-CRESOL	(ug/L)	30	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
PENTACHLOROPHENOL	(ug/L)	30	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
PHENOL	(ug/L)	5	BDL	5.0	10.0	BDL	BDL	BDL	BDL	ND	BDL
2,4,6-TRICHLOROPHENOL	(ug/L)	20	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL

11-May-93

Table 4-1 (continued)
CITY OF KNOXVILLE
NPDES PART 2 WET WEATHER MONITORING RESULTS

PARAMETER	UNITS	DETECTION LIMIT	STATION AND STORM EVENTS								
			Tank Farms #03497041 Industrial/Chem 3/12/92	Tank Farms #03497041 Industrial/Chem 4/27/92	Tank Farms #03497041 Industrial/Chem 2/13/92	Acker Place #03497103 Light Industrial 3/27/91	Acker Place #03497103 Light Industrial 11/20/91	Acker Place #03497103 Light Industrial 8/20/92	#034971055 Conc. Commer. 4/08/91	#034971055 Conc. Commer. 11/01/91	#034971055 Conc. Commer. 3/18/92
BASE/NEUTRAL											
ACENAPHTHENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
ACENAPHTHYLENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
ANTHRACENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
BENZIDINE	(ug/L)	40	ND	ND	BDL	ND	BDL	BDL	ND	ND	BDL
BENZO(A)ANTHRACINE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
BENZO(A)PYRENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
3,4 BENZOFLUORANTHENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
BENZO(GHI)PERYLENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	16.0
BENZO (K) FLUORANTHENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
BIS(2-CHLOROETHOXY)METHANE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
BIS(2-CHLOROETHYL)ETHER	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
BIS(2-CHLOROISOPROPYL)ETHER	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
BIS(2-ETHYLHEXYL)PHTHALATE	(ug/L)	5	5.0	BDL	17.0	BDL	BDL	BDL	5.0	ND	ND
4-BROMOPHENYL PHENYL ETHER	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
BUTYLBENZYL PHTHALATE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
2-CHLORONAPHTHALENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
4-CHLOROPHENYL PHENYL ETHER	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
CHRYSENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
DIBENZO (A,H) ANTHRACENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
1,2-DICHLOROBENZENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,3-DICHLOROBENZENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,4-DICHLOROBENZENE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
3,3'-DICHLOROBENZIDINE	(ug/L)	20	ND	ND	BDL	ND	BDL	BDL	ND	ND	BDL
DIETHYL PHTHALATE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
DIMETHYL PHTHALATE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
DI-N-BUTYL PHTHALATE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
2,4-DINITROTOLULENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
2,6-DINITROTOLULENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
DI-N-OCTYL PHTHALATE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
1,2-DIPHENYLHYDRAZINE	(ug/L)	5	ND	ND	ND	ND	BDL	BDL	ND	ND	ND
FLURORANTHENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	9.0	ND	8.0
FLOURENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
HEXACHLOROBENZENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
HEXACHLOROBUTADIENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
HEXACHLOROCYCLOPENTADIENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
HEXACHLOROETHANE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
INDENO(1,2,3-CD)PYRENE	(ug/L)	10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	19.0
ISOPHORONE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
NAPTHALENE	(ug/L)	5	BDL	BDL	ND	BDL	BDL	BDL	BDL	0.6	BDL
NITROBENZENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
N-NITROSODIMETHYLAMINE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
N-NITROSODI-N-PROPYLAMINE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
N-NITROSODIPHENYLAMINE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
PHENANTHRENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ND	BDL
PYRENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	6.0	ND	BDL
1,2,4-TRICHLOROBENZENE	(ug/L)	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

11-May-93

Table 4-1 (continued)
CITY OF KNOXVILLE
NPDES PART 2 WET WEATHER MONITORING RESULTS

PARAMETER	UNITS	DETECTION LIMIT	STATION AND STORM EVENTS								
			Tank Farms #03497041 Industrial/Chem 3/12/92	Tank Farms #03497041 Industrial/Chem 4/27/92	Tank Farms #03497041 Industrial/Chem 2/13/92	Acker Place #03497103 Light Industrial 3/27/91	Acker Place #03497103 Light Industrial 11/20/91	Acker Place #03497103 Light Industrial 8/20/92	#034971055 Conc. Commer. 4/08/91	#034971055 Conc. Commer. 11/01/91	#034971055 Conc. Commer. 3/18/92
PESTICIDES											
ALDRIN	(ug/L)	0.04	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ALPHA-BHC	(ug/L)	0.03	BDL	BDL	BDL	0.1	BDL	BDL	BDL	BDL	BDL
BETA-BHC	(ug/L)	0.03	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
GAMMA-BHC	(ug/L)										
DELTA-BHC	(ug/L)	0.09	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CHLORDANE	(ug/L)	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
4,4'-DDT	(ug/L)	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
4,4'-DDE	(ug/L)	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
4,4'-DDD	(ug/L)	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DIELDRIN	(ug/L)	0.02	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ALPHA-ENDOSULFAN	(ug/L)	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
BETA-ENDOSULFAN	(ug/L)	0.04	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ENDOSULFAN SULFATE	(ug/L)	0.6	ND	ND	BDL	ND	BDL	BDL	BDL	BDL	BDL
ENDRIN	(ug/L)	0.06	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
ENDRIN ALDEHYDE	(ug/L)	0.2	ND	ND	BDL	ND	BDL	BDL	BDL	BDL	BDL
HEPTACHLOR	(ug/L)	0.03	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
HEPTACHLOR EPOXIDE	(ug/L)	0.8	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1242	(ug/L)	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1254	(ug/L)	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1221	(ug/L)	1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1232	(ug/L)	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1248	(ug/L)	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
PCB-1260	(ug/L)	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.3	BDL
PCB-1016	(ug/L)	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
TOXAPHENE	(ug/L)	2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

11-May-93

This subsection presents the cumulative pollutant loads and EMCs for the City of Knoxville from the 17 individual major watersheds defined in the City's Part 1 storm water NPDES permit application.

Estimates of the EMC for each of the pollutant parameters, together with estimates of annual runoff were used to calculate the average annual storm water pollution loadings and the corresponding event mean concentrations for each pollutant parameters. The methodology employed to determine these values is presented below.

4.3.1 METHODOLOGY

Average annual loading estimates for the City of Knoxville were determined using the Watershed Management Model (WMM) developed by Camp Dresser and McKee (CDM). The WMM is a spreadsheet model that calculates annual per-acre pollutant loadings discharged to receiving waters in a watershed based upon land use types, and their associated EMC values and percent imperviousness. The model also calculates annual weighted EMC values based on land use distribution. Specific attributes of the model include:

- Lotus 1-2-3 as the spreadsheet shell program
- Estimates of annual runoff pollution load based upon EMCs, land use, associated annual runoff coefficient, percent imperviousness, and annual rainfall for the 12 pollutant parameters defined previously.
- Estimates of runoff pollutant load reduction due to partial or full scale implementation of site or regional BMPs.
- Estimates of reduction in runoff pollutant load due to uptake or removal in stream courses.
- Estimates of annual pollution loads from stream baseflow.

Data required to use the model include: land use, soil types (runoff coefficients), and Best Management Practice (BMP) types and coverages within each watershed; EMCs for each land use and pollutant type; BMP pollutant removal efficiencies for each pollutant type; and average annual precipitation, average annual baseflow, and average baseflow pollutant concentrations within the city. Methodologies and assumptions used to compile this data for the City of Knoxville are described below.

Land Use

Seventeen major watersheds in the City of Knoxville were defined in the Part 1 NPDES storm water permit application. Land use distribution within each watershed was based upon 16 major categories. The WMM model is configured to determine the storm water pollutant loadings for 12 fixed land use categories and three optional land use categories. Land use categories for the City of Knoxville were converted into WMM equivalent categories as shown in Table 4-2. This table also presents the percent imperviousness for the land use categories and the reference source for determining the event mean concentrations (EMCs) for each land use. Percent imperviousness and event mean concentrations are discussed later under "Rainfall/Runoff Relationship" and "Nonpoint Pollution Event Mean Concentration", respectively.

Estimates of the drainage area for each land use category within each watershed was calculated using colored land use maps maintained by the Knoxville/Knox County Metropolitan Planning Commission (MPC). Estimates of land use areas were used to calculate average runoff coefficients and average percent imperviousness for each watershed. Details about these calculations are presented in the next section "Rainfall/Runoff Relationship". Land use area estimations and average percent imperviousness for each watershed are presented in Table 4-3.

Rainfall/Runoff Relationship

Land use acreage for a watershed are the basis for storm water pollution loading computations in the WMM. Pollutant loads are projected by applying nonpoint pollution loading factors (lbs/acre/year) to each land use type within the watershed. Nonpoint pollution loading factors for different land use categories are based upon annual runoff volumes and EMCs for different pollutants. The EMC is defined as the average of individual measurements of storm pollutant mass loading divided by the storm runoff volume.

TABLE 4-1

WMM Land Use Conversion and EMC Sources

WMM Land Use	% Imperv	Knoxville Land Use	% Imperv	EMC Source*
Forest/Open	5	Agricultural/Forest/Vacant Public Parks Vacant >10 Acres	1 1 5	NURP (open/non-urban)
Agricultural/Pasture	5			
Cropland	5			
Low Density Res.	10	Rural Residential	20	TVA (R2)
Med. Density Res./ Institutional	25	Single Family Residential Church	25 40	TVA (R1)
High Density Res.	45	Multi-Family Residential. Institutional	40 50	TVA (R1)
Commercial	90	Commercial	85	TVA (SC)
Office/Light Indust.	65	Office/Services	60	TVA (CBD)
Heavy Industrial	80	Manufacture/Wholesale	72	TVA (CBD)
Water	100			
Wetlands	100			
Major Highway	90	Transportation/Utilities/ Communication Major Roads/Highways	85 95	FHWA
Optional 1		Public Recreation	35	TVA (R1)
Optional 2		Public Land	35	TVA (R1)

* EMC Sources

NURP - USEPA (1983) NURP Table 6-12

TVA - TVA (1984) Tables V4-V7
- R1 - Medium Density Residential
- R2 - Low Density Residential
- SC - Strip Commercial
- CBD - Central Business District

FWHA - FHWA (1990) Table 5

Table 4-2
Summary Land Use and Runoff Coefficient For Each Watershed

Watershed	Agri./ For./Vac.	Public Parks	Vacant (>10 ac)	Rural Res	Single Family Res.	Private Recreat.	Public Land	Multi-Family Res.	Church	Institut.	Mining	Off./ Serv.	Manuf./ Wholsale	Commer.	Transp./ Utilit/ Commun.	Major Roads/ Highways	Total Area (ac)	Average % Imperv.
First & Whites Creeks	1,094	416	222	1,053	7,120	42	0	776	139	873	0	443	526	623	194	332	13,852	35%
Second Creek	441	124	257	244	1,632	0	0	299	51	317	0	138	239	469	143	244	4,597	41%
Third Creek	1,555	225	766	1,442	2,625	45	0	439	259	1,183	0	518	428	698	518	563	11,266	37%
Fourth Creek	1,016	306	326	665	1,596	150	0	541	182	541	0	215	267	430	104	176	6,515	33%
Baker Creek	351	0	110	74	734	0	0	74	6	147	0	0	36	36	0	0	1,568	26%
Ft. Loudoun Lake	771	15	149	154	1,528	0	0	154	10	1,742	0	60	114	114	119	45	4,977	33%
Goose Creek	754	119	85	132	665	0	0	146	27	76	0	72	76	79	13	0	2,245	23%
Holston River	613	10	51	102	1,020	195	0	12	10	10	0	0	0	12	0	0	2,036	21%
Knob Creek	1,975	0	51	862	634	0	0	177	24	114	0	12	0	75	12	0	3,935	15%
Knob Fork	1,083	0	598	342	910	0	0	87	56	312	0	56	0	173	87	56	3,762	23%
Love Creek	1,567	10	289	524	1,337	5	39	113	113	225	0	39	20	372	20	225	4,897	27%
Sinking Creek	855	0	199	7	1,888	0	0	128	28	57	0	114	28	192	36	28	3,562	28%
Ten Mile Creek	2,471	0	496	38	4,942	0	0	506	57	162	0	124	10	544	86	105	9,540	27%
Toll Creek	567	0	26	84	285	0	0	77	20	1	0	4	69	36	2	0	1,171	21%
Turkey Creek	3,312	0	521	60	2,262	0	0	119	74	201	0	260	30	409	104	89	7,442	22%
Williams Creek	382	5	250	71	518	0	0	49	24	129	0	7	15	174	17	51	1,692	29%
Woods Creek	1,415	16	128	385	398	0	0	123	0	0	0	0	66	58	31	0	2,620	15%
Total	20,224	1,246	4,525	6,239	30,093	437	39	3,819	1,080	6,091	0	2,062	1,925	4,496	1,486	1,915	85,677	

Annual Runoff. To determine the annual runoff volumes associated with each watershed, the WMM multiplies the average annual rainfall volume (46.08 inches at McGhee Tyson Airport) by pervious and impervious runoff coefficients and land use-specific impervious and pervious areas. For non-urban land uses, the pervious fraction of the area represents the major source of runoff or streamflow, while impervious areas are the predominant contributor for the most urban land uses.

It was assumed for each watershed that 95 percent of the rainfall from the impervious fraction, and 15 percent of the rainfall from the pervious fraction of each land use was converted to runoff. Therefore the impervious runoff coefficient and the pervious runoff coefficient were assumed to be 0.95 and 0.15, respectively. For example, based upon an average annual rainfall volume of 46.08 inches/year, the average annual runoff from a single family residential land use (25% impervious) is 16.13 in/yr (46.08*[(0.15*0.75)+(0.95*0.25)]). The runoff coefficient for a single land use is the sum of the impervious percentage multiplied times the impervious runoff coefficient plus the pervious percentage multiplied by the pervious runoff coefficient. For the previous example, the average runoff coefficient is for the single family residential land use is 0.35 ([0.15*0.75]+[0.95*0.25]). For a watershed, the average runoff coefficient is an area weighted average of each land use runoff coefficients times the percentage the area of each land use.

Nonpoint Pollution Event Mean Concentration

Event mean concentrations (EMCs) used in the WMM are presented in Table 4-4. These EMCs are lognormally (base e) distributed and were calculated from median values reported in the literature. The EMCs presented in Table 4-4 are based on several sources including national median EMC statistics from the USEPA National Urban Runoff Program (NURP) study (EPA 1983), Knoxville median EMC statistics from the 1984 TVA report "The Relationship of Urban Runoff to Land Use and Groundwater Resources" (part of the USEPA NURP study), and runoff data reported by Federal Highway Administration (FHWA, 1990).

TABLE 4-3
KNOXVILLE NPDES PART2 PERMIT
MEAN EMCS USED IN WATERSHED MANAGEMENT MODEL

Land Use	% Impervious	mg/L: Oxygen Demand & Sediment: BOD	COD	TSS	TDS	Nutrients: TP	DP	TKN	NO23	Heavy Metals: Pb	Cu	Zn	Cd
Forest/Open	5.0%	8.0	51	216	100	0.23	0.06	1.36	0.73	0.00	0.00	0.00	0.000
Agriculture/Pasture	5.0%	8.0	51	216	100	0.23	0.06	1.36	0.73	0.00	0.00	0.00	0.000
Cropland	5.0%	8.0	51	216	100	0.23	0.06	1.36	0.73	0.00	0.00	0.00	0.000
LDSF	10.0%	8.5	54	133	62	0.28	0.13	0.57	0.41	0.17	0.04	0.12	0.001
MDSF/Institutional	25.0%	17.4	148	614	107	0.78	0.15	1.47	0.49	0.46	0.07	0.42	0.002
HDR	45.0%	17.4	148	614	107	0.78	0.15	1.47	0.49	0.46	0.07	0.42	0.002
Commercial	90.0%	13.5	74	100	68	0.45	0.19	0.83	0.50	0.29	0.05	0.17	0.001
Office/Light Industrial	65.0%	12.6	70	116	90	0.21	0.05	0.63	0.60	0.16	0.05	0.30	0.001
Heavy Industrial	80.0%	12.6	70	116	90	0.21	0.05	0.63	0.60	0.16	0.05	0.30	0.001
Water	100.0%	9.7	61	91	100	0.24	0.10	1.28	0.63	0.13	0.04	0.33	0.002
Wetlands	100.0%	9.7	61	91	100	0.24	0.10	1.28	0.63	0.13	0.04	0.33	0.002
Major Highway	90.0%	9.7	94	104	30	0.33	0.17	1.65	0.74	0.26	0.04	0.24	0.002
Optional Land Use #1	35.0%	17.4	148	614	107	0.78	0.15	1.47	0.49	0.46	0.07	0.42	0.002
Optional Land Use #2	35.0%	17.4	148	614	107	0.78	0.15	1.47	0.49	0.46	0.07	0.42	0.002

These reference sources provide EMCs which were applied to the WMM land use categories as presented in Table 4-2 and as described below. Knoxville was selected as one of the 28 project sites for the NURP project because of its unique location within the ridge and valley province of the eastern United States and because it is characterized by extensive carbonate geology. As a result of this study, the city has an available database of local water quality measurements which were used to estimate local EMCs and to project annual loadings to the waters of the United States.

The TVA's median EMC data were the primary source of EMC data for the WMM program. There were only four land use groups considered in the TVA study: medium density single family residential (R1), low density residential (R2), strip commercial (SC) and central business district (CBD). For each land use group, EMCs were determined for 34 water quality parameters. The 12 parameters required for this program were among the 34 presented in the report.

Median EMC NURP data from the "Open/Non-urban" land use group were the source of EMC data for the "Agricultural/Forest/Vacant", "Public Parks", and "Vacant >10 acres" land uses from the City of Knoxville. Median event mean concentrations presented in Table 4-4 for storm water runoff from major highways are from research published by the Federal Highway Administrations (FHWA). These concentrations are applied to major roadways within the city.

EMC monitoring data collected by TVA, NURP, and FHWA were determined to be lognormally (base e) distributed. The lognormal distribution allows the EMC data to be described by two parameters. These parameters are a measure of central tenancy (i.e., mean or median), and a measure of dispersion or spread of the data (i.e., the standard deviation or coefficient of variation). The coefficient of variation is the standard deviation divided by the mean. The median value should be used for comparisons between EMCs for individual sites or groups of sites because it is less influenced by a few large values which are typical of lognormally distributed data. For computations of annual mass loads it is more appropriate to use the mean value since the large infrequent events can comprise a significant portion of the annual pollutant load.

To estimate annual pollutant loads discharged to receiving waters from a municipality, median EMCs are converted to mean values (USEPA, 1983; Novotny, 1992) by the following relationship:

$$M = T*SQRT(1+CV^2) \quad \text{(Equation 1)}$$

Where: M = arithmetic mean
T = median
CV = coefficient of variation

The mean EMC values determined from the statistical transformation of the median values were applied as the EMCs for the equivalent land use categories in the WMM model. EMCs from TVA land use category "R1" were applied to the "Medium Density Residential/Institutional", "High Density Residential", "Optional 1" (Public Recreation), and "Optional 2" (Public Land) land use categories. EMCs developed from TVA category "CBD" were applied to the "Office/Light Industrial", and "Heavy Industrial" WMM categories. EMCs from "R2" were applied to the "Low Density Residential" category, and EMCs from TVA category "SC" were applied to the WMM "Commercial" land use category. Mean EMCs from NURP "Open/Non-urban" data were applied to the "Forest/Open" WMM category, and mean EMCs from the FHWA data were applied to WMM "Major Highway" land use category.

The calculated mean EMCs for each WMM land use category and pollutant parameter are presented in Table 4-4.

Monitoring data collected by the United States Geological Survey (USGS) as part of the Part 2 NPDES representative monitoring program were compared to the TVA data and are presented in Table 4-5. The TVA values are presented as 90th and 10th percentile high/low

TABLE 4-4

COMPARISON OF TVA AND KNOXVILLE EVENT MEAN CONCENTRATIONS*

PARAMETER	EMCs (mg/L)											
	Low Density Residential Land Use			Medium Density Residential Land Use			Commercial Land Use			Office/Light Industrial Land Use		
	TVA		KNOX	TVA		KNOX	TVA		KNOX	TVA		KNOX
	90th Pctl.	10th Pctl.	Mean	90th Pctl.	10th Pctl.	Mean	90th Pctl.	10th Pctl.	Mean	90th Pctl.	10th Pctl.	Mean
Biochemical Oxygen Demand	13.0	4.7	23.7	26.7	9.7	19.3	19.0	8.7	134.0	17.7	8.2	48.0
Chemical Oxygen Demand	91	24	100	251	67	51	112	43	297	106	40	87
Total Suspended Solids	270	34	169	1248	157	15	196	30	47	227	34	3572
Total Dissolved Solids	126	16	61	218	27	81	133	20	105	176	27	82
Total Phosphorus	0.51	0.10	0.32	1.43	0.29	0.12	0.82	0.17	0.36	0.38	0.08	0.34
Soluble Phosphorus	0.20	0.07	0.17	0.23	0.08	0.07	0.35	0.07	0.25	0.09	0.02	0.15
Total Kjeldahl Nitrogen	1.06	0.20	1.33	2.74	0.51	1.00	1.29	0.45	2.13	0.98	0.34	0.93
NO2 + NO3	0.79	0.12	0.71	0.95	0.15	1.05	0.81	0.25	1.19	0.97	0.30	0.60
Lead	0.310	0.060	0.052	0.870	0.160	0.003	0.520	0.110	0.014	0.280	0.060	0.019
Copper	0.080	0.010	0.008	0.150	0.020	0.004	0.100	0.020	0.016	0.090	0.020	0.004
Zinc	0.230	0.040	0.110	0.820	0.130	0.040	0.350	0.040	0.220	0.630	0.070	0.247
Cadmium	0.0020	0.0003	0.0000	0.0040	0.0006	0.0000	0.0020	0.0002	0.0007	0.0020	0.0002	0.0003

* TVA values developed from "The Relationship of Urban Runoff to Land Use and Groundwater Resources" TVA 1984.
KNOX values developed from Knoxville NPDES Part 2 Representative Monitoring Program (from USGS).

estimates which were developed from a statistical analysis of the TVA data. The USGS EMC values were evaluated as a potential source for determining nonpoint pollutant loadings with the WMM model. While these data represent the latest analysis of water quality in the City of Knoxville, the values are based on only three storms per site, which is not considered a statistically representative sample set. Continued monitoring at the representative outfall sites as part of the on-going monitoring program will produce more statistically valid EMCs which can then be used in the WMM model to revise annual and/or seasonal loadings from the City of Knoxville to the waters of the United States.

Nonpoint Pollution Loading Factors

The WMM converts the EMCs described above into nonpoint loading factors based on the runoff volume for each land use within a watershed. The pollution loading factors (expressed as lb/ac/yr) vary by land use and the percent imperviousness associated with each land use. The pollution loading factor M_L is computed for each land use L using the following equation:

$$M_L = EMC_L * R_L * K \qquad \text{(Equation 2)}$$

Where: M_L = loading factor for land use L (lb/yr)

EMC_L = event mean concentration of runoff from land use L (mg/l); EMC varies by land use and pollutant

R_L = total average annual surface runoff from land use L (in/yr)

K = 0.2266, a unit conversion constant.

By multiplying the pollutant loading factor by the acreage in each land use and summing for all land uses, the total annual surface runoff pollution load from a watershed can be computed.

Baseflow Estimation

The Watershed Management Model has the capability to include baseflow loading based upon annual baseflow volumes and average baseflow concentrations of the selected parameters. The USEPA STORET database and the USGS NWIS database did not contain water quality data for the Knoxville tributaries which were considered "current". That is, there were no ambient water quality data for the Knoxville creeks since before 1977. Therefore baseflow loadings were not estimated for this analysis. Loadings were based only on pollution from storm water runoff.

Uncertainty Analysis

Because of the need to develop estimates of high and low extremes of pollutant loadings, and particularly to assess whether such estimates would result in different management decisions, it is desirable to perform an uncertainty analysis on the loading factors.

The EMCs shown in Table 4-4 are derived from medium loading factors and thus represent the "medium" or "most probable" estimate of the nonpoint pollution loading factor for each specific land use. To estimate "high" and "low" loading factors for each pollutant, a statistical approach is used. A coefficient of variation (CV) is applied to EMCs specific to each pollutant and land use. The CV is an indication of the relative degree of uncertainty associated with the EMC estimates. The CVs assigned to each pollutant and to each land use category in the model are summarized in Table 4-6.

"High" and "low" EMCs are then calculated from the mean EMC, and a CV is estimated for each pollutant and land use category based on its specific probability of exceedence. The WMM used "high" and "low" EMCs based on the 90th and 10th percentile shown on Tables 4-7a and 4-7b, respectively. An EMC in the 90th percentile will be exceeded during only 10% of the storm events, whereas an EMC in the 10th percentile will be exceeded during 90% of the storm events. The following relationship is used to calculate "high" and "low" EMCs:

TABLE 4-5

COEFFICIENTS OF VARIATION

Land Use	% Impervious	Oxygen Demand & Sediment				Nutrients				Heavy Metals			
		BOD CV	COD CV	TSS CV	TDS CV	TP CV	SP CV	TKN CV	NO23 CV	Pb CV	Cu CV	Zn CV	Cd CV
Forest/Open	5.0%	0.5	0.5	0.5	0.5	0.7	0.7	0.5	0.5	0.0	0.0	0.0	0.0
Agriculture/Pasture	5.0%	0.5	0.5	0.5	0.5	0.7	0.7	0.5	0.5	0.0	0.0	0.0	0.0
Cropland	5.0%	0.5	0.5	0.5	0.5	0.7	0.7	0.5	0.5	0.0	0.0	0.0	0.0
LDSF	10.0%	0.4	0.6	1.0	1.0	0.7	0.5	0.7	0.8	0.8	1.0	0.8	0.8
MDSF/Institutional	25.0%	0.4	0.6	1.0	1.0	0.7	0.5	0.7	0.8	0.8	1.0	0.8	0.8
HDR	45.0%	0.4	0.6	1.0	1.0	0.7	0.5	0.7	0.8	0.8	1.0	0.8	0.8
Commercial	90.0%	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Office/Light Industrial	65.0%	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Heavy Industrial	80.0%	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Water	100.0%	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Wetlands	100.0%	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Major Highway	90.0%	0.7	0.7	1.2	1.2	1.1	1.1	0.7	0.8	2.0	0.9	1.4	1.4
Optional Land Use #1	35.0%	0.4	0.6	1.0	1.0	0.7	0.5	0.7	0.8	0.8	1.0	0.8	0.8
Optional Land Use #2	35.0%	0.4	0.6	1.0	1.0	0.7	0.5	0.7	0.8	0.8	1.0	0.8	0.8
Optional Land Use #3	0.0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 4-6a
HIGH EMCS FOR LOADING ESTIMATES

	%	mg/L											
		Oxygen Demand & Sediment				Nutrients				Heavy Metals			
Land Use	Impervious	BOD	COD	TSS	TDS	TP	SP	TKN	NO23	Pb	Cu	Zn	Cd
Forest/Open	5.0%	13.1	83	354	164	0.43	0.11	2.24	1.20	0.00	0.00	0.00	0.000
Agriculture/Pasture	5.0%	13.1	83	354	164	0.43	0.11	2.24	1.20	0.00	0.00	0.00	0.000
Cropland	5.0%	13.1	83	354	164	0.43	0.11	2.24	1.20	0.00	0.00	0.00	0.000
LDSF	10.0%	13.0	91	270	126	0.51	0.20	1.06	0.79	0.31	0.08	0.23	0.002
MDSF/Institutional	25.0%	26.7	251	1248	218	1.43	0.23	2.74	0.95	0.87	0.15	0.82	0.004
HDR	45.0%	26.7	251	1248	218	1.43	0.23	2.74	0.95	0.87	0.15	0.82	0.004
Commercial	90.0%	19.0	112	196	133	0.82	0.35	1.29	0.81	0.52	0.10	0.35	0.002
Office/Light Industrial	65.0%	17.7	106	227	176	0.38	0.09	0.98	0.97	0.28	0.09	0.63	0.002
Heavy Industrial	80.0%	17.7	106	227	176	0.38	0.09	0.98	0.97	0.28	0.09	0.63	0.002
Water	100.0%	13.7	92	178	196	0.44	0.18	2.00	1.03	0.23	0.07	0.69	0.004
Wetlands	100.0%	13.7	92	178	196	0.44	0.18	2.00	1.03	0.23	0.07	0.69	0.004
Major Highway	90.0%	17.9	174	222	64	0.70	0.36	2.99	1.41	0.59	0.08	0.53	0.004
Optional Land Use #1	35.0%	26.7	251	1248	218	1.43	0.23	2.74	0.95	0.87	0.15	0.82	0.004
Optional Land Use #2	35.0%	26.7	251	1248	218	1.43	0.23	2.74	0.95	0.87	0.15	0.82	0.004

TABLE 4-6b
LOW EMCS FOR LOADING ESTIMATES

	%	mg/L											
		Oxygen Demand & Sediment				Nutrients				Heavy Metals			
Land Use	Impervious	BOD	COD	TSS	TDS	TP	SP	TKN	NO23	Pb	Cu	Zn	Cd
Forest/Open	5.0%	3.9	25	105	49	0.09	0.02	0.67	0.36	0.00	0.00	0.00	0.0000
Agriculture/Pasture	5.0%	3.9	25	105	49	0.09	0.02	0.67	0.36	0.00	0.00	0.00	0.0000
Cropland	5.0%	3.9	25	105	49	0.09	0.02	0.67	0.36	0.00	0.00	0.00	0.0000
LDSF	10.0%	4.7	24	34	16	0.10	0.07	0.20	0.12	0.06	0.01	0.04	0.0003
MDSF/Institutional	25.0%	9.7	67	157	27	0.29	0.08	0.51	0.15	0.16	0.02	0.13	0.0006
HDR	45.0%	9.7	67	157	27	0.29	0.08	0.51	0.15	0.16	0.02	0.13	0.0006
Commercial	90.0%	8.7	43	30	20	0.17	0.07	0.45	0.25	0.11	0.02	0.04	0.0002
Office/Light Industrial	65.0%	8.2	40	34	27	0.08	0.02	0.34	0.30	0.06	0.02	0.07	0.0002
Heavy Industrial	80.0%	8.2	40	34	27	0.08	0.02	0.34	0.30	0.06	0.02	0.07	0.0002
Water	100.0%	6.3	35	27	30	0.09	0.04	0.70	0.32	0.05	0.01	0.07	0.0004
Wetlands	100.0%	6.3	35	27	30	0.09	0.04	0.70	0.32	0.05	0.01	0.07	0.0004
Major Highway	90.0%	3.5	34	21	6	0.07	0.04	0.63	0.24	0.02	0.01	0.04	0.0003
Optional Land Use #1	35.0%	9.7	67	157	27	0.29	0.08	0.51	0.15	0.16	0.02	0.13	0.0006
Optional Land Use #2	35.0%	9.7	67	157	27	0.29	0.08	0.51	0.15	0.16	0.02	0.13	0.0006

$$EMC_{(HIGH, LOW)} = e^{(U+J+W)} \qquad \text{Equation 3}$$

Where: EMC = "high" or "low" EMC

U = log mean = LN (M*SQRT(1+CV^2))

J = standardized normal deviate = 1.282 for 90th percentile, -1.282 for 10th percentile

W = log standard deviation = SQRT(LN(1+CV^2)

Evaluation Of Best Management Practices (BMPs)

The pollutant removal effectiveness of major structural controls can be evaluated using the watershed management model. There are three major regional detention basins located in the City of Knoxville. Currently, these basins are only designed to manage storm water quantity (i.e flood control). Although some water quality benefits are probably achieved by these basins, a retrofit would be necessary to designate the ponds as BMPs. If a retrofit is accomplished, the WMM can be used to evaluate the reduction in pollutant loading from a watershed.

4.3.2 ANNUAL LOADING AND EMC ESTIMATES

Average annual storm water pollution loading projections and event mean concentrations for each watershed in the City of Knoxville are presented in Table 4-8. The drainage area and corresponding percent imperviousness in addition to total runoff (ac-ft/yr) for each watershed are also presented. Estimates shown are the medium loads with the high and low estimates presented for uncertainty analysis. Estimates of annual loadings and EMCs are also presented in graphical format in Appendix C.

TABLE 4-7
WMM Model Output Summary
Annual Loadings and EMCs

Drainage Basin: First Creek and White Creek

	Annual Loading			EMCs		
Constituent	Low (lbs/yr)	Medium (lbs/yr)	High (lbs/yr)	Low (mg/l)	Medium (mg/l)	High (mg/l)
BOD	526,425	934,685	1,428,778	8.4	14.9	22.8
COD	3,426,561	7,389,624	12,405,323	55	118	198
TSS	6,963,485	26,546,121	53,679,123	111	424	858
TDS	1,580,227	5,788,863	11,598,191	25	93	185
Total-P	13,584	37,278	68,648	0.22	0.60	1.10
Dissolved-P	3,902	8,496	14,361	0.06	0.14	0.23
TKN	30,281	79,318	143,912	0.48	1.27	2.30
NO2&NO3	11,902	32,853	60,761	0.19	0.52	0.97
Lead	7,341	22,239	42,208	0.117	0.355	0.674
Copper	968	3,723	7,544	0.015	0.059	0.121
Zinc	5,845	20,835	41,430	0.093	0.333	0.662
Cadmium	28	103	205	0.000	0.002	0.003
Drainage Area:	13,852					
% Impervious:	35.3%					
Runoff (ac-ft/yr):	23,011					

Drainage Basin: Second Creek

	Annual Loading			EMCs		
Constituent	Low (lbs/yr)	Medium (lbs/yr)	High (lbs/yr)	Low (mg/l)	Medium (mg/l)	High (mg/l)
BOD	180,942	322,030	493,534	7.9	14.0	21.5
COD	1,149,521	2,458,477	4,115,160	50	107	179
TSS	2,059,109	7,743,489	15,610,484	90	338	681
TDS	539,845	1,924,775	3,831,319	24	84	167
Total-P	4,337	12,140	22,511	0.19	0.53	0.98
Dissolved-P	1,325	3,221	5,700	0.06	0.14	0.25
TKN	11,351	28,287	50,423	0.49	1.23	2.20
NO2&NO3	4,881	12,692	22,999	0.21	0.55	1.00
Lead	2,339	7,381	14,156	0.102	0.322	0.617
Copper	339	1,257	2,524	0.015	0.055	0.110
Zinc	1,793	6,784	13,684	0.078	0.296	0.597
Cadmium	9	35	72	0.000	0.002	0.003
Drainage Area:	4,597					
% Impervious:	41.0%					
Runoff (ac-ft/yr):	8,434					

TABLE 4-7 (continued)
WMM Model Output Summary
Annual Loadings and EMCs

Drainage Basin: Third Creek

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	384,774	698,381	1,081,867	7.3	13.3	20.5
COD	2,474,204	5,373,720	9,055,808	47	102	172
TSS	4,435,895	16,524,241	33,242,840	84	314	631
TDS	1,209,238	4,250,242	8,431,981	23	81	160
Total-P	9,084	25,810	48,100	0.17	0.49	0.91
Dissolved-P	2,874	7,078	12,596	0.05	0.13	0.24
TKN	25,591	64,211	114,726	0.49	1.22	2.18
NO2&NO3	11,207	29,538	53,778	0.21	0.56	1.02
Lead	4,778	15,659	30,318	0.091	0.297	0.576
Copper	726	2,701	5,430	0.014	0.051	0.103
Zinc	3,824	14,686	29,725	0.073	0.279	0.564
Cadmium	20	79	160	0.000	0.001	0.003
Drainage Area:	11,266					
% Impervious:	37.2%					
Runoff (ac-ft/yr):	19,368					

Drainage Basin: Fourth Creek

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	216,087	384,890	589,640	7.7	13.7	20.9
COD	1,380,514	2,958,635	4,954,555	49	105	176
TSS	2,726,080	10,066,158	20,209,396	97	357	718
TDS	698,586	2,420,539	4,785,254	25	86	170
Total-P	5,404	14,916	27,525	0.19	0.53	0.98
Dissolved-P	1,641	3,749	6,471	0.06	0.13	0.23
TKN	13,442	33,894	60,676	0.48	1.20	2.15
NO2&NO3	5,642	14,867	27,069	0.20	0.53	0.96
Lead	2,855	8,752	16,659	0.101	0.311	0.592
Copper	390	1,476	2,980	0.014	0.052	0.106
Zinc	2,183	7,943	15,875	0.078	0.282	0.564
Cadmium	11	41	82	0.000	0.001	0.003
Drainage Area:	6,515					
% Impervious:	33.0%					
Runoff (ac-ft/yr):	10,355					

TABLE 4-7 (continued)
WMM Model Output Summary
Annual Loadings and EMCs

Drainage Basin: Baker Creek

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	50,051	89,091	136,230	8.6	15.4	23.5
COD	331,413	716,049	1,202,356	57	123	207
TSS	765,045	2,832,884	5,691,254	132	489	981
TDS	169,344	586,610	1,159,813	29	101	200
Total-P	1,380	3,728	6,827	0.24	0.64	1.18
Dissolved-P	379	769	1,256	0.07	0.13	0.22
TKN	2,943	7,766	14,125	0.51	1.34	2.44
NO2&NO3	1,088	3,021	5,600	0.19	0.52	0.97
Lead	721	2,109	3,964	0.124	0.364	0.684
Copper	86	342	697	0.015	0.059	0.120
Zinc	569	1,933	3,797	0.098	0.333	0.655
Cadmium	3	9	18	0.000	0.002	0.003
Drainage Area:	1,568					
% Impervious:	25.5%					
Runoff (ac-ft/yr):	2,132					

Drainage Basin: Ft. Loudoun Lake

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	193,524	344,483	526,823	8.9	15.9	24.3
COD	1,291,615	2,804,035	4,718,438	60	129	218
TSS	2,906,653	11,021,028	22,259,658	134	508	1026
TDS	603,678	2,190,699	4,380,120	28	101	202
Total-P	5,363	14,539	26,658	0.25	0.67	1.23
Dissolved-P	1,460	2,968	4,856	0.07	0.14	0.22
TKN	10,948	29,473	53,969	0.50	1.36	2.49
NO2&NO3	3,877	11,150	20,895	0.18	0.51	0.96
Lead	2,859	8,437	15,901	0.132	0.389	0.733
Copper	345	1,365	2,782	0.016	0.063	0.128
Zinc	2,281	7,800	15,345	0.105	0.360	0.708
Cadmium	11	37	73	0.001	0.002	0.003
Drainage Area:	4,977					
% Impervious:	33.4%					
Runoff (ac-ft/yr):	7,974					

TABLE 4-7 (continued)
WMM Model Output Summary
Annual Loadings and EMCs

Drainage Basin: Goose Creek

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	62,864	110,288	167,415	8.0	14.0	21.3
COD	395,834	831,264	1,378,946	50	106	175
TSS	871,276	3,068,464	6,091,678	111	390	774
TDS	237,754	764,652	1,482,599	30	97	188
Total-P	1,556	4,195	7,677	0.20	0.53	0.97
Dissolved-P	439	935	1,562	0.06	0.12	0.20
TKN	3,899	9,592	17,017	0.50	1.22	2.16
NO2&NO3	1,731	4,317	7,707	0.22	0.55	0.98
Lead	798	2,309	4,327	0.101	0.293	0.549
Copper	104	398	805	0.013	0.051	0.102
Zinc	626	2,207	4,376	0.080	0.280	0.556
Cadmium	3	10	20	0.000	0.001	0.003
Drainage Area:	2,245					
% Impervious:	23.2%					
Runoff (ac-ft/yr):	2,896					

Drainage Basin: Holston River

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	48,678	88,039	135,736	7.2	13.1	20.2
COD	329,024	719,311	1,213,703	49	107	181
TSS	806,322	2,936,102	5,876,096	120	437	874
TDS	178,474	597,840	1,172,186	27	89	174
Total-P	1,393	3,768	6,904	0.21	0.56	1.03
Dissolved-P	382	764	1,239	0.06	0.11	0.18
TKN	3,052	8,094	14,744	0.45	1.20	2.19
NO2&NO3	1,095	3,081	5,734	0.16	0.46	0.85
Lead	705	2,071	3,900	0.105	0.308	0.580
Copper	81	329	673	0.012	0.049	0.100
Zinc	559	1,869	3,654	0.083	0.278	0.544
Cadmium	3	9	18	0.000	0.001	0.003
Drainage Area:	2,036					
% Impervious:	20.8%					
Runoff (ac-ft/yr):	2,471					

TABLE 4-7 (continued)
WMM Model Output Summary
Annual Loadings and EMCs

Drainage Basin: Knob Creek

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	73,631	133,902	207,149	6.6	12.0	18.6
COD	465,353	1,000,586	1,676,651	42	90	151
TSS	1,119,678	3,722,123	7,283,475	101	334	654
TDS	335,219	1,004,460	1,909,281	30	90	172
Total-P	1,902	5,161	9,465	0.17	0.46	0.85
Dissolved-P	628	1,324	2,204	0.06	0.12	0.20
TKN	5,288	12,992	23,030	0.48	1.17	2.07
NO2&NO3	2,363	6,045	10,890	0.21	0.54	0.98
Lead	891	2,621	4,937	0.080	0.235	0.443
Copper	113	447	911	0.010	0.040	0.082
Zinc	658	2,243	4,410	0.059	0.202	0.396
Cadmium	4	12	24	0.000	0.001	0.002
Drainage Area:	3,935					
% Impervious:	15.1%					
Runoff (ac-ft/yr):	4,093					

Drainage Basin: Knob Fork

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	96,208	175,247	271,641	7.3	13.3	20.7
COD	627,294	1,360,057	2,288,601	48	104	174
TSS	1,363,418	4,794,564	9,516,077	104	365	725
TDS	365,497	1,169,016	2,263,750	28	89	172
Total-P	2,490	6,898	12,745	0.19	0.53	0.97
Dissolved-P	756	1,734	2,997	0.06	0.13	0.23
TKN	6,786	16,916	30,149	0.52	1.29	2.30
NO2&NO3	2,831	7,359	13,333	0.22	0.56	1.02
Lead	1,232	3,822	7,301	0.094	0.291	0.556
Copper	163	628	1,273	0.012	0.048	0.097
Zinc	938	3,372	6,719	0.071	0.257	0.512
Cadmium	5	18	36	0.000	0.001	0.003
Drainage Area:	3,762					
% Impervious:	23.0%					
Runoff (ac-ft/yr):	4,829					

TABLE 4-7 (continued)
WMM Model Output Summary
Annual Loadings and EMCs

Drainage Basin: Love Creek

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	135,593	245,162	378,705	7.3	13.2	20.3
COD	869,284	1,873,608	3,145,626	47	101	169
TSS	1,748,149	6,229,726	12,403,986	94	335	666
TDS	477,603	1,565,624	3,051,714	26	84	164
Total-P	3,433	9,551	17,673	0.18	0.51	0.95
Dissolved-P	1,086	2,574	4,510	0.06	0.14	0.24
TKN	9,355	23,124	41,088	0.50	1.24	2.21
NO2&NO3	3,945	10,222	18,500	0.21	0.55	0.99
Lead	1,742	5,445	10,418	0.094	0.292	0.560
Copper	238	899	1,815	0.013	0.048	0.097
Zinc	1,271	4,666	9,345	0.068	0.251	0.502
Cadmium	7	25	51	0.000	0.001	0.003
Drainage Area:	4,897					
% Impervious:	26.7%					
Runoff (ac-ft/yr):	6,845					

Drainage Basin: Sinking Creek

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	117,784	208,791	318,788	8.5	15.1	23.0
COD	767,147	1,642,850	2,749,087	55	118	198
TSS	1,658,532	6,113,616	12,269,198	120	441	885
TDS	389,906	1,339,858	2,643,497	28	97	191
Total-P	3,109	8,465	15,543	0.22	0.61	1.12
Dissolved-P	867	1,880	3,170	0.06	0.14	0.23
TKN	7,146	18,288	32,912	0.52	1.32	2.37
NO2&NO3	2,803	7,448	13,601	0.20	0.54	0.98
Lead	1,635	4,856	9,166	0.118	0.350	0.661
Copper	206	795	1,612	0.015	0.057	0.116
Zinc	1,264	4,433	8,780	0.091	0.320	0.633
Cadmium	6	22	43	0.000	0.002	0.003
Drainage Area:	3,562					
% Impervious:	27.9%					
Runoff (ac-ft/yr):	5,099					

TABLE 4-7 (continued)
WMM Model Output Summary
Annual Loadings and EMCs

Drainage Basin: Ten Mile Creek

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	308,190	550,106	843,000	8.5	15.1	23.1
COD	2,029,459	4,375,808	7,343,560	56	120	202
TSS	4,470,847	16,474,283	33,059,725	123	452	908
TDS	1,023,825	3,511,600	6,925,554	28	96	190
Total-P	8,369	22,816	41,918	0.23	0.63	1.15
Dissolved-P	2,352	5,103	8,610	0.06	0.14	0.24
TKN	19,103	49,223	88,794	0.52	1.35	2.44
NO2&NO3	7,214	19,490	35,790	0.20	0.54	0.98
Lead	4,364	13,019	24,606	0.120	0.358	0.676
Copper	538	2,090	4,245	0.015	0.057	0.117
Zinc	3,324	11,566	22,857	0.091	0.318	0.628
Cadmium	16	57	113	0.000	0.002	0.003
Drainage Area:	9,540					
% Impervious:	26.9%					
Runoff (ac-ft/yr):	13,390					

Drainage Basin: Toll Creek

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	29,060	51,160	77,821	7.6	13.3	20.3
COD	180,986	378,152	625,916	47	98	163
TSS	401,917	1,369,009	2,695,402	105	356	701
TDS	118,978	367,093	703,544	31	96	183
Total-P	698	1,885	3,452	0.18	0.49	0.90
Dissolved-P	201	435	734	0.05	0.11	0.19
TKN	1,910	4,589	8,068	0.50	1.19	2.10
NO2&NO3	889	2,159	3,814	0.23	0.56	0.99
Lead	347	1,008	1,889	0.090	0.262	0.492
Copper	47	177	357	0.012	0.046	0.093
Zinc	273	972	1,933	0.071	0.253	0.503
Cadmium	1	5	9	0.000	0.001	0.002
Drainage Area:	1,171					
% Impervious:	20.5%					
Runoff (ac-ft/yr):	1,413					

TABLE 4-7 (continued)
WMM Model Output Summary
Annual Loadings and EMCs

Drainage Basin: Turkey Creek

Constituent	Annual Loading			EMCs		
	Low (lbs/yr)	Medium (lbs/yr)	High (lbs/yr)	Low (mg/l)	Medium (mg/l)	High (mg/l)
BOD	189,377	339,078	520,852	7.6	13.5	20.8
COD	1,209,752	2,565,913	4,276,878	48	102	171
TSS	2,638,678	9,043,191	17,833,464	105	361	711
TDS	751,618	2,319,569	4,446,207	30	92	177
Total-P	4,716	12,950	23,852	0.19	0.52	0.95
Dissolved-P	1,357	3,149	5,467	0.05	0.13	0.22
TKN	13,365	32,245	56,776	0.53	1.29	2.26
NO2&NO3	5,870	14,430	25,616	0.23	0.58	1.02
Lead	2,324	7,030	13,334	0.093	0.280	0.532
Copper	311	1,172	2,365	0.012	0.047	0.094
Zinc	1,764	6,396	12,772	0.070	0.255	0.509
Cadmium	9	32	64	0.000	0.001	0.003
Drainage Area:	7,442					
% Impervious:	21.6%					
Runoff (ac-ft/yr):	9,223					

Drainage Basin: Williams Creek

Constituent	Annual Loading			EMCs		
	Low (lbs/yr)	Medium (lbs/yr)	High (lbs/yr)	Low (mg/l)	Medium (mg/l)	High (mg/l)
BOD	53,168	94,556	144,751	7:8	13.9	21.3
COD	337,668	718,023	1,198,349	50	106	177
TSS	676,670	2,428,458	4,843,197	100	358	714
TDS	180,253	595,832	1,163,842	27	88	172
Total-P	1,352	3,722	6,862	0.20	0.55	1.01
Dissolved-P	412	970	1,694	0.06	0.14	0.25
TKN	3,506	8,600	15,241	0.52	1.27	2.25
NO2&NO3	1,464	3,730	6,711	0.22	0.55	0.99
Lead	700	2,130	4,046	0.103	0.314	0.596
Copper	93	349	704	0.014	0.051	0.104
Zinc	500	1,817	3,631	0.074	0.268	0.535
Cadmium	3	10	19	0.000	0.001	0.003
Drainage Area:	1,692					
% Impervious:	29.2%					
Runoff (ac-ft/yr):	2,494					

TABLE 4-7 (continued)
WMM Model Output Summary
Annual Loadings and EMCs

Drainage Basin: Woods Creek

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	47,706	86,783	134,375	6.5	11.8	18.2
COD	298,671	634,627	1,058,335	41	86	144
TSS	704,880	2,251,150	4,357,903	96	305	591
TDS	230,892	663,491	1,244,946	31	90	169
Total-P	1,153	3,156	5,806	0.16	0.43	0.79
Dissolved-P	367	821	1,403	0.05	0.11	0.19
TKN	3,685	8,726	15,250	0.50	1.18	2.07
NO2&NO3	1,750	4,246	7,498	0.24	0.58	1.02
Lead	520	1,563	2,960	0.071	0.212	0.402
Copper	71	274	554	0.010	0.037	0.075
Zinc	397	1,419	2,824	0.054	0.192	0.383
Cadmium	2	7	15	0.000	0.001	0.002
Drainage Area:	2,620					
% Impervious:	14.9%					
Runoff (ac-ft/yr):	2,711					

Drainage Basin: Total for City

Constituent	Annual Loading Low (lbs/yr)	Annual Loading Medium (lbs/yr)	Annual Loading High (lbs/yr)	EMCs Low (mg/l)	EMCs Medium (mg/l)	EMCs High (mg/l)
BOD	2,714,061	4,856,673	7,457,105	7.87	14.09	21.64
COD	17,564,300	37,800,739	63,407,293	51.0	109.7	184.0
TSS	36,316,633	133,164,608	266,922,956	105.4	386.4	774.4
TDS	9,090,938	31,060,763	61,193,796	26.4	90.1	177.5
Total-P	69,322	190,977	352,165	0.20	0.55	1.02
Dissolved-P	20,427	45,970	78,830	0.06	0.13	0.23
TKN	171,650	435,339	780,902	0.50	1.26	2.27
NO2&NO3	70,551	186,649	340,297	0.20	0.54	0.99
Lead	36,151	110,451	210,090	0.105	0.320	0.610
Copper	4,818	18,422	37,268	0.014	0.053	0.108
Zinc	28,069	100,940	201,157	0.081	0.293	0.584
Cadmium	139	511	1,022	0.000	0.001	0.003
Drainage Area:	85,677					
% Impervious:	29.4%					
Runoff (ac-ft/yr):	126,740					

4.4 SCHEDULE FOR ESTIMATES OF SEASONAL POLLUTANT LOADS

One of the primary objectives of this ongoing monitoring program described in Section 4-6 is to collect a statistically significant number of data to determine local event mean concentrations and annual loadings. The City is proposing to continue sampling at three to five sites over the five year permit term. Sampling frequency will be approximately 12 to 15 storm events per site annually. This frequency should provide the City with water quality data for approximately three to four storm events per season for each year of the five year permit term. The City will collect this data, analyze the seasonal fluctuations of water quality data and determine seasonal pollutant loads and event mean concentrations in the final year of the permit.

4.5 PROPOSED ONGOING MONITORING PROGRAM

The representative monitoring program conducted by the USGS and the analysis of the results from the program provide the foundation for the development of the proposed ongoing monitoring program. The sampling requirements for the representative monitoring program included the analysis for a wide range of pollutants. This analysis provided the City with the information to target more specific pollutants when developing ongoing monitoring program.

Long-term goals of the ongoing monitoring program include:

- Identification of pollutants of concern in stormwater discharges from individual urban land use categories and assessment of potential pollutant sources.

- Estimation of pollutant loads from individual land use categories based on a statistically significant number of storm event s over a range of hydro-meteorologic conditions.

- Assessment of the performance of specific stormwater pollution controls and the overall stormwater management program.

- Identification of receiving water quality impacts resulting from stormwater pollution discharges.

A standard operating procedures manual (SOP) for the ongoing monitoring plan have been developed to meet these long term goals. These procedures describe the location of field screening points, why the location is representative, the frequency of sampling, parameters to be sampled, and a description of sampling equipment as required by the regulations. In addition, the SOP provides Quality Assurance/Quality Control procedures for field and laboratory work, equipment installation procedures, sampling and storm event analysis procedures, inspection and maintenance procedures, and health and safety procedures. The SOP is presented in Appendix D.

4.5.1 IMPLEMENTATION SCHEDULE

The proposed monitoring program will be coordinated with the proposed stormwater quality management programs presented in Section 5 of this document. At this time, one sampling station has been established and two more stations are projected to be in place and operational during the first year of the permit term. During the five-year permit term, the City will evaluate the need for additional stations or station relocation. Up to five monitoring stations will be established during the permit term.

4.5.2 STAFFING REQUIREMENTS

The staffing requirements to implement the City's ongoing monitoring program are presented in Table 4-9. A new staff position within the Engineering Department Planning and Technical Services Division will include a Stormwater Engineer who will spend approximately 25% of his/her time on the monitoring program. An existing Engineering Technician III (Tech III) will spend approximately 40% of his time on managing the sampling program, coordinating with the laboratory, and analyzing storm events. A new Engineering Technician II will spend approximately 30% of his/her time assisting the Tech III with the program, performing site inspections, collecting samples, and maintaining the sampling equipment.

Table 4-9 provides annual salary costs for the monitoring program. A more detailed fiscal analysis of the program is presented in Section 7 of this document.

Table 4-9

SUMMARY OF
PROPOSED WATER QUALITY MONITORING PROGRAM

Element	Description	Schedule Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
(1) Pilot Station	Monitoring of 12-15 storms/year at Acker Place monitoring station.					
(2) Additional Equipment/Stations	Acquire additional equipment for 3 to 4 monitoring stations. Identify monitoring station locations.					
(3) Install Additonal Stations	Install/operate additional monitoring stations for analysis of representative land uses or BMP performance.					
(4) Sample Analysis	Collect samples for 12 to 15 storms/year/station for analysis of selected parameters by KUB. Analyze storm events.					
(5) Relocate Stations	Relocate monitoring stations for BMP analysis or for representative land use analysis.					
(6) Comprehensive Pollutant Analysis	Collect automatic and manual grab samples for analysis of full suite of pollutant parameters by KUB one sample/station/permit term.					
(7) Annual Report	Prepare annual summary of monitoring results and storm event analyses.					

Partial Implementation

Full Implementation

Staffing Requirements	Position	Percent of Workload Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
	Chief Engineer	1%	1%	1%	1%	1%
	Stormwater Engineer	27%	27%	27%	27%	27%
	Technician III	38%	38%	38%	38%	38%
	Technician II	31%	31%	31%	31%	31%
	Service Deptartment Field Crew	7%	7%	7%	0%	0%

Responsible City Department		
	Primary Responsibility:	Engineering Department/Planning and Technical Services Division
	Supporting Departments:	Public Service Department
	Other Agencies:	KUB

Estimated Cost ($1,000 per year)	Program Element	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
	(1) Pilot Station	$3.7	$3.9	$4.0	$4.1	$4.2	$19.9
	(2) Equipment Procurement & Maintenance	$60.3	$24.5	$18.5	$18.9	$19.1	$141.3
	(3) Monitoring Site Installation	$1.4	$1.4	$1.5	$1.5	$1.5	$7.3
	(4) Sample Analysis	$28.7	$29.1	$29.5	$30.0	$30.4	$147.7
	(5) Station Relocation	$4.0	$4.1	$4.2	$4.3	$4.5	$21.1
	(6) Comprehensive Pollutant Analysis	$1.3	$1.3	$1.3	$1.4	$1.4	$6.6
	(7) Annual Report	$4.8	$5.0	$5.1	$5.3	$5.4	$25.5
	Total	$104.1	$69.2	$64.1	$65.5	$66.6	$369.4

5.0 PROPOSED COMPREHENSIVE MANAGEMENT PROGRAM

5.1 INTRODUCTION AND OVERVIEW

The Part 2 NPDES stormwater regulations require a description of a comprehensive stormwater management program which covers the duration of the five-year permit. This description shall include [40 CFR 122.26 (d)(2)(iv)]:

> *"a comprehensive planning process which involves public participation and where necessary intergovernmental coordination, to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques, and system, design and engineering methods, and such other provisions which are appropriate. The program shall also include a description of staff and equipment available to implement the program. Separate proposed programs may be submitted by each coapplicant. Proposed programs may impose controls on a systemwide basis, a watershed basis, a jurisdictional basis or on individual outfalls. Proposed programs will be considered by the Director when developing permit conditions to reduce pollutants in discharges to the maximum extent practicable. Proposed management programs shall describe priorities for implementing controls."*

A comprehensive management program has been developed for the City of Knoxville as required by the regulations. The proposed plan identifies structural and nonstructural control measures the City deems appropriate for the first five years of the permit, to control the discharge of pollutants to the maximum extent practicable. The focus of the development and implementation of a comprehensive stormwater plan is to build on the foundation of existing stormwater management programs including citywide stormwater plans, ordinances, maintenance programs, and public education programs. The continuation of existing programs, with the development of new programs where required, is proposed as the most cost-effective approach to stormwater management.

There are five major program components, as stipulated in the regulations, that are proposed in this application. They include:

- Program for Residential and Commercial Areas
- Program for Illicit Connections and Improper Disposal
- Program for Industrial Areas
- Program for Construction Sites
- Program for Ongoing Water Quality Monitoring

The first four of these programs are described in this Section. The program for ongoing water quality monitoring was described in Section 4. Each description presents the details of the proposed program and describes the associated public participation programs, schedules, and staffing/equipment required to implement the program.

The new stormwater management programs will require the addition of one Stormwater Management (SWM) Engineer, three Engineering Technicians II, and a five-person field crew, in addition to a rededication to the programs by existing personnel and City departments. Detailed analyses of each program are presented in this Section.

5.2 MANAGEMENT PROGRAM FOR RESIDENTIAL AND COMMERCIAL AREAS

The City of Knoxville's policy on stormwater runoff from residential and commercial areas to the municipal storm sewer system has traditionally focused on the control and management of stormwater quantity. The proposed management program will also incorporate water quality and will include a plan to reduce the pollutants from urban areas through the use of structural and source controls. The City proposes to evaluate new development on a regional level and to assume responsibility for the maintenance of regional Best Management Practice (BMP) facilities. Under the proposed program, property owners will be required to take a more active role in the maintenance of smaller on-site BMPs. The City also proposes to increase the level of stream and channel maintenance. The City's proposed plan will require the addition of a new five person field crew and will require part-time dedication of the Chief Engineer, the new Stormwater Engineer, and a new

Engineering Technician II. Table 5-1 presents an overall summary of the proposed program for residential and commercial areas, implementation schedule, estimated costs, staffing requirements, and City departments.

5.2.1 REGULATORY REQUIREMENTS

The Part 2 NPDES stormwater regulations require inclusion of the following six (6) program elements in the permit application [40 CFR 122.26 (d)(2)(iv)(A)]:

> *" A description of structural and source control measures to reduce pollutants from runoff from commercial and residential areas that are discharged from the municipal storm sewer system that are to be implemented during the life of the permit, accompanied with an estimate of the expected reduction of pollutant loads and a proposed schedule for implementing such controls. At a minimum, the description shall include:*
>
> *(1) A description of maintenance activities and a maintenance schedule for structural controls to reduce pollutants (including floatables) in discharges from municipal separate storm sewers;*
>
> *(2) A description of planning procedures including a comprehensive master plan to develop, implement and enforce controls to reduce the discharge of pollutants from municipal separate storm sewers which receive discharges from areas of new development and significant redevelopment. Such plan shall address controls to reduce pollutants in discharges from municipal separate storm sewers after construction is completed. (Controls to reduce pollutants in discharges from municipal separate storm sewers containing construction site runoff are addressed in paragraph (d)(2)(iv)(D) of this section;*
>
> *(3) A description of practices for operating and maintaining public streets, roads, and highways and procedures for reducing the impact on receiving waters of discharges from municipal storm sewer systems, including pollutants discharged as a result of deicing activities.*

Table 5-1

SUMMARY OF PROPOSED RESIDENTIAL AND COMMERCIAL AREAS MANAGEMENT PROGRAM

Element	Component	Schedule Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
(1) Maintenance Activities	Develop and implement stream restoration and channel maintenance program.	Partial	Partial	Full	Full	Full
	Require Standard Maintenance Agreement for onsite facilities	Partial	Partial	Full	Full	Full
	Routine/major maintenance of BMP facilties.		Partial	Full	Full	
	Sediment disposal for BMP Maintenance		Partial	Partial	Full	Full
(2) Planning for new development	Revise Stormwater Detention Ordinance to require Water Quality BMPs for new dev.	Partial	Partial	Full	Full	Full
	Develop guidance crtieria for BMPs	Partial	Partial	Partial	Full	Full
	Plan and site location for regional BMP facilities for areas of new development	Partial	Partial	Partial	Partial	Partial
(3) Maintenance for public streets, roads, and highways	No proposed changes					
(4) Evaluation of flood management projects	Evaluate regional BMP facilties for water quality retrofit		Partial	Partial	Full	Full
	Plan and implement inspection program to inventory on-site BMP facilities and identify maintenance needs	Partial	Partial	Partial	Partial	Partial
(5) Monitoring of solid waste facilties	Program described in City's new management program for industrial areas					
(6) Management of pesticides, herbicides, and fertilizer	Evaluate effect of fertilizers as part of the City's ongoing monitoring program.	Partial	Full	Full	Full	Full
	Develop public education program as part of illicit connection and improper disposal program.		Full	Full	Full	Full

Partial Implementation

Full Implementation

Staffing Requirements	Position	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
	Chief Engineer	10%	10%	10%	10%	10%
	Stormwater Engineer	17%	17%	17%	17%	17%
	Technician II	30%	30%	30%	30%	30%
	Field Crew (5)	0%	493%	493%	493%	493%

Responsible City Department	Primary Responsibility:	Engineering Department/Planning and Technical Services Division; Public Service Department
	Supporting Departments:	Public Information

Estimated Cost ($1,000 per year)	Program Element	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
	(1) Maintenance activities	$1.5	$111.4	$114.8	$118.2	$121.8	$467.6
	(2) Planning for new development	$6.3	$6.4	$6.6	$6.8	$7.0	$33.2
	(3) Maintenance of streets, roads, highways	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
	(4) Evaluation of flood control projects	$11.7	$12.1	$12.4	$12.8	$13.2	$62.1
	(5) Monitoring of solid waste facilities	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
	(6) Program for pesticides, herbicides, fertilizer	$1.5	$1.5	$1.6	$1.6	$1.7	$7.9
	Total	$20.9	$131.4	$135.4	$139.4	$143.6	$570.8

(4) A description of procedures to assure that flood management projects assess the impacts on the water quality of receiving water bodies and that existing structural flood control devices have been evaluated to determine if retrofitting the device to provide additional pollutant removal from storm water is feasible;

(5) A description of a program to monitor pollutants in runoff from operating or closed municipal landfills or other treatment, storage or disposal facilities for municipal waste, which shall identify priorities and procedures for inspections and establishing and implementing control measures for such discharges (this program can be coordinated with the program developed under paragraph (d)(2)(iv)(C) of this section); and

(6) A description of a program to reduce to the maximum extent practicable, pollutants in discharges from municipal separate storm sewers associated with the application of pesticides, herbicides, and fertilizer which will include, as appropriate, controls such as educational activities, permits, certifications and other measures for commercial applicators and distributors, and controls for application in public right-of-ways and at municipal facilities."

5.2.2 MAINTENANCE ACTIVITIES FOR STRUCTURAL CONTROLS

The program for maintenance of structural controls will require no changes to the current maintenance procedures. Additional maintenance activities will be proposed under the NPDES stormwater permit.

Existing Maintenance Activities

Maintenance of the municipal stormwater system is handled by the Construction Division of the City's Service Department. The Service Department has developed and maintains an extensive database to track work tasks performed during the year. The database not only tracks labor category (e.g., Equipment Operator) and labor hours devoted to each task, but also includes equipment type and costs. The Service Department database produces summary reports for monthly and annual work production and costs. The database includes more than 70 task activities of which 12 were identified as relating directly or indirectly to stormwater management. Table 5-2 presents a summary of the fiscal year 1991-1992 Service Department expenditures related to maintenance activities that may impact stormwater management. During fiscal year 1991-1992 the Service Department devoted 30,588 hours or almost 15 full-time equivalent positions to these maintenance activities. The total cost to the City was $1,345,185. The City also provides brush and leaf pickup services which are <u>not</u> included in this total.

Stormwater maintenance in the City places some of the maintenance responsibilities on individual property owners. The City holds easements and rights-of-way on only a small portion of the stormwater conveyance system and generally assumes no responsibility for maintenance or improvements on private property.

Maintenance by the City within rights-of-way and easements is normally performed on an as-needed basis by the Service Department. Approximately 75 percent of the storm drainage system maintenance work performed by the Service Department is in response to direct calls from property owners and requests from the Engineering Department. The remainder of the storm drainage system maintenance work is in response to maintenance needs detected by the Service Department, such as repairing collapsed pipes. Under normal conditions, the Service Department can respond to all complaints which are the responsibility of the City as defined by the City's stormwater policy.

Under the current system, the Service Department has divided the City into six zones, known as model maintenance zones. Each zone is assigned a two-man crew for routine facility maintenance for localized problems. These crews perform such duties as hand ditching, unclogging drains, street sweeping, cleaning of curb inlets, and the flushing of storm sewers. In addition to the zone crews, central crews are used to perform stormwater maintenance activities. These crews are dedicated as follows:

TABLE 5-2

KNOXVILLE SERVICE DEPARTMENT

SUMMARY OF STORMWATER DRAINAGE SYSTEM MAINTENANCE

FISCAL YEAR 1991-1992

Task	Hours	Labor	Equipment	Production	
Street Sweeping	7,864	$141,869	$61,111	20,165	miles
Street Flushing	2,645	$47,653	$20,522	6,719	miles
Grate Replacement	115	$3,956	$306	275	jobs
Curb & Gutter Repair	177	$18,072	$3,940	1,315	feet
Catch Basin Cleaning	3,136	$158,077	$73,801	9,114	jobs
Ditching (Tractor/Gradall)	146	$4,905	$2,816	5,222	feet
Ditching (Auger Truck)	681	$32,112	$114,331	134,450	feet
Ditching (Hand)	431	$19,195	$2,125	11,375	feet
Storm Sewer Installation	2,178	$231,176	$48,407	2,155	jobs
Storm Sewer Repair	1,288	$136,720	$28,645	370	jobs
Catch Basin Repair	458	$48,570	$10,182	150	jobs
Hand Clearing	11,469	$136,694	$0	594	jobs
Total	30,588	$978,999	$366,186		

- A central four-man crew which is dedicated to work on maintenance of stormwater sewers, emergency flooding, and complaint response. This crew is also available to assist the zone crews with their local stormwater maintenance activities.

- A three-man crew which is responsible for roadside ditching, catch basin cleaning and inspection, and special projects.

- Additional personnel are dedicated to a special projects team. This team is pulled from other projects for emergencies. In the winter, a portion of this team's time is spent cleaning creeks and removing flow impediments.

Each zone crew and the central crew are equipped with:

- two Vac-Alls (the central crew has only one), used to clean curb inlets, sweep streets, and flush storm sewers,

- a redyeing machine,

- two small pumps,

- one industrial pump (100 gpm),

- a variety of hand tools, and

- access to a self-loading auger.

Catch basins are inspected annually. Cleaning and maintenance of catch basins are performed "as-needed". Most drainage facility maintenance is performed in response to complaints or known problems. The Service Department logs all complaints by address and by category into a computerized database. Routine work (planned according to policy) is tracked through work orders issued for geographical service areas.

Street cleaning is performed daily for downtown streets, and bi-weekly for all other streets. Streets with curbing are swept, while streets without curbing are flushed. Mowing occurs between the months of April and September and is performed on a four-week schedule.

Proposed Maintenance Activities for Residential/Commercial Areas

Under the City's proposed program for residential and commercial areas, maintenance activities will be expanded to include the following:

- Comprehensive stream restoration and channel maintenance program,
- Standard maintenance requirements by property owners as part of permitting on-site detention ponds
- Routine and major maintenance of selected regional detention pond (BMP) facilities by City crews
- Sediment disposal for maintenance activities

Stream Restoration/Channel Maintenance. The stream restoration and channel maintenance program will require the Service Department to dedicate one field crew nearly full-time to maintenance and restoration of urban stream channels and portions of the major creeks.

During the first and second year of the program, the Engineering Department will begin inspections of the channel system and develop channel maintenance guidance procedures and a schedule. Channel inspections will be performed by the Stormwater Engineer and the City Arborist. The Engineering Department will work closely with TDEC and the Tennessee Wildlife Resources Agency to identify maintenance activities that will provide habitat and water quality improvements but also maintain the channel flood conveyance capacity. The stream restoration guidance materials will address:

- Access for equipment and crews
- Equipment requirements to minimize damage to banks and erosion problems,

- Disposal of material removed from the streams,
- Minimizing bank clearing/channel realignments.

Shading by large trees along stream reaches will be maintained or improved if possible. Natural snags and other obstructions causing pool areas within the channel will not be removed if they do not impact channel conveyance. The initial focus of the program will be stream restoration and channel maintenance along areas designated as Floodways under the Metropolitan Planning Commission (MPC) zoning maps. The stream restoration/channel maintenance program may target additional upstream areas later in the permit term. The stream restoration program is intended to become an ongoing program within the City. After streams are initially restored, a maintenance schedule will be developed to reinspect the streams and perform limited hand clearing on a regular schedule.

The Service Department crew will also be responsible for the removal of trash and debris from the creeks and streams. The City currently is considering an "Adopt-a-Stream" program which would rely on volunteers to periodically pickup trash and debris along stream reaches within the City. The Service Department crews would assist volunteers by providing receptacles for collecting trash and debris and removal of these receptacles. The City could also provide Adopt-a-Stream volunteers with safety information, trash bags, pickup sticks, and assistance with coordination. It is unlikely that the Adopt-a-Stream volunteers would be able to handle larger items. These items would be removed by the Service Department crews using appropriate equipment as necessary. The Adopt-a-Stream program would be coordinated by the Policy Development Department.

The Service Department field crews will be instructed to report incidences of illicit discharges and/or improper disposal along major channels system to the Stormwater Management Engineer in the Planning and Technical Services Department (see management program for illicit discharges and improper disposal).

Maintenance Agreements. The City also proposes to include a standard maintenance agreement as a permit requirement for developments that will require on-site water quality facilities. Minimum maintenance requirements of the water quality facility will be developed to ensure that the facility is kept functional. The maintenance agreement will specify minimum maintenance requirements and intervals to be performed by the property owner. Minimum maintenance requirements will include annual cutting by bushhog or mower. The maintenance agreement will also grant permission to the City to enter the subject property and to inspect the stormwater detention facilities as deemed necessary. If the facility is not being maintained the City will notify the property owner to repair/maintain the facility within a reasonable time period. If the property owner fails to repair/maintain the facility, the City will perform the required maintenance at the property owner's expense.

Regional BMP Maintenance. The City proposes to study the feasibility of assuming direct maintenance responsibility for large regional structural detention ponds that serve multiple upstream developments. Examples of these BMPs located within Knoxville are described in Sections 4.0 and 6.0. Routine maintenance will be conducted annually and includes a general inspection of the facility, the cleaning of accumulated trash and debris, and mowing. Outlet structures will be inspected for flow impediments or other factors which could reduce the flow capacity and/or reduce the pollutant removal efficiency of the BMP. Restoration of outlet structures will be conducted if necessary. Major maintenance of regional BMPs includes the removal of accumulated sediment and excess vegetation, as well as repair of erosion or structural damage. Major maintenance will occur "as needed".

Sediment Disposal for Maintenance Activities. Disposal of spoil from maintenance of detention ponds, stream restoration activities and other ditches and waterways will be addressed during the 5-year term of the NPDES permit. There is increasing regulatory attention on the potential toxicity of sediment from BMPs. Currently sediments classified as nontoxic (e.g., passing the EPA toxicity test) can be disposed of in municipal landfills.

Tradeoffs between on-site disposal and hauling to landfills sites will be evaluated. Sediments classified as "nontoxic" for landfill disposal may not be suitable for "on-site" disposal. Requirements for minimum depth to groundwater, setback distance from surface waters, and guidelines similar to land application of sludge, and erosion and sediment control should be investigated. The City will also investigate changes to property easement requirements to facilitate sediment removal and facility maintenance.

Implementation Schedule for Proposed Maintenance Activities

The City will develop the stream restoration and channel maintenance program during the first and second years of the permit term. The City does not have drainage easements or rights-of-way along many of the channels within the City. Therefore implementation of the stream restoration and channel maintenance program will begin after the City adopts the new stormwater ordinances. BMP maintenance will not begin until the City has begun implementing new BMP requirements. Partial implementation of proposed maintenance activities is projected to begin during the second year of the permit term, and full implementation is projected to occur in the third year.

5.2.3 PLANNING PROCEDURES FOR NEW OR REDEVELOPED AREAS

Existing Planning Procedures

Under the City's existing Stormwater Detention Ordinance, developers are required to minimize increases in peak flows from urban development and establish procedures to ensure that appropriate measures are implemented which adequately control these increases. In most cases, this requirement is met by developers by implementing on-site detention structures. While these structures probably provide some limited water quality benefits, their primary function is flood control.

Proposed Planning Procedures

Under the proposed program for residential and commercial areas, the City will investigate revising the Stormwater Detention Ordinance to require new developments or significant redevelopment to provide controls to reduce the discharge of pollutants to the municipal storm sewer system after construction (the management program for construction sites provides controls during construction). The revised Stormwater Detention Ordinance will expand the requirements for submission of stormwater drainage and detention plans for City review. The stormwater plans for new developments or redeveloping areas will be required to meet water quality performance standards in addition to flow quantity control. Performance standards for water quality might specify the protection or restoration of the quality of ground and surface waters and protection of the beneficial functioning of existing stream channels or wetlands for natural storage of surface waters and reduction and assimilation of pollutants.

Design criteria to be used in the development of stormwater plans for areas of new development or redevelopment should consider the following:

- Runoff routed through detention systems to allow suspended solids to settle and remove pollutants.
- Runoff should be detained or retained before entering any natural watercourse to preserve natural hydrodynamics and to prevent siltation or other pollution. Detention and retention ponds should be designed to manage the increased and accelerated runoff from impervious developed areas.
- Runoff from large parking lots, particularly parking lots serving industrial areas with heavy bus or truck traffic, should be treated to remove oil, grease and sediment before entering receiving waters
- Vegetated filter strips should be created or retained in their natural state along the banks of all watercourses, stream channels, or wetland areas, to trap sediment and other pollutants in overland runoff.
- Offsite drainage facilities may be acceptable if discharges from the site can be treated at a downstream site and on-site treatment options are not available.

- Stormwater treatment facilities should be sited to avoid Waters of the State or wetlands areas.

During the permit term, the City will prepare a guidance criteria document or adopt an existing document applicable to the physiographic and hydrometeorologic conditions in the region. The guidance criteria will describe acceptable types of BMPs, design standards, and maintenance requirements for BMPs to be used throughout the City to meet the requirements of the revised Stormwater Detention Ordinance. The guidance criteria should be kept on file in the Engineering Department and distributed to developers as the official reference to ensure proper selection, design and maintenance criteria for BMPs. Because maintenance of BMPs is critical to their long-term effectiveness in reducing pollutant loading from stormwater, the guidance criteria should also incorporate maintenance considerations with the design criteria to ensure that effective and maintainable BMPs are constructed in the City. The guidance criteria should address the goals of the NPDES stormwater program by allowing only BMPs which are effective in reducing pollutants targeted in the NPDES stormwater regulations.

Whereas the current policy results in numerous on-site, owner-maintained detention facilities, during the five year permit term the City will also consider implementation of regional water quality impacts of development. During the term of the permit, the City will target large development projects or strategically located smaller developments that are suitable for siting regional BMPs. Regional BMPs would serve multiple upstream developments and typically have drainage areas ranging from 50 acres to several hundred acres. The City may consider offering incentives to developers to site regional BMP facilities. Incentives might include: 1) cost share arrangements whereby the City contributes a share of the construction costs and recoups these costs from other upstream developments; 2) city maintenance of regional BMPs; 3) city provides assistance with design, or other in-kind contributions. Since most development activity within the City is primarily "infill" that occurs on the limited number of remaining vacant parcels, there are only very limited opportunities for siting regional BMPs without impacting existing developments.

Under the City's ongoing monitoring program (see program for water quality monitoring), the City will consider siting water quality monitoring stations to evaluate pollutant removal efficiencies of BMP facilities during the 5-year permit term. Typically a BMP monitoring program will require collection of stormwater samples at stations located immediately upstream and downstream of a BMP facility. Long-term monitoring, utilizing automatic sampling equipment, is usually required to assess pollutant removal efficiencies over a wide range of storm events. The City will use the results from this program, as available, to modify BMP planning procedures.

Schedule for Implementation of Proposed Planning Procedures

The City will begin investigating revisions to the Stormwater Detention Ordinance during the first year of the permit term. The Ordinance revisions will be completed and implemented by the third year of the permit term. Implementation of the BMP monitoring program will be dependent on identifying a suitable site.

5.2.4 MAINTENANCE ACTIVITIES FOR PUBLIC STREETS, ROADS, AND HIGHWAYS

The street sweeping activities for public streets, roads, and highways are described under the maintenance activities program in this report (Section 5.2.1).

Deicing of roadways is performed by the Service Department and is an essential program to ensure public safety. Sodium chloride, stored undercover at the Loraine Street facility, is applied to highways and streets by spreaders as necessary. Application of deicing salt targets highways and major arteries first, and residential streets secondarily. Because of the importance of maintaining public safety and because of the relatively small amount of annual snowfall in the Knoxville area, the City does not propose any changes to the current deicing program.

5.2.5 EVALUATION OF FLOOD MANAGEMENT PROJECTS

In order to assure that future flood management projects assess the impacts of water quality receiving water, the City will investigate revising the Stormwater Detention Ordinance as described in Section 5.2.3. The proposed program for the evaluation of existing flood control projects is described below.

Existing Flood Control Facilities

Currently, there are three regional detention facilities that have been constructed for flood control currently within the City. These are:

- The detention pond on East Tennessee Natural Gas property near Downtown West Shopping Center,
- The detention pond adjacent to Middlebrook Pike and Weisgarber Road at the Acker Place development, and
- The detention pond located at East Towne Mall.

Proposed Program for Evaluation of Flood Control Projects

Although the three regional detention basins identified above were designed for flood control, it may be possible to retrofit these facilities to achieve additional water quality benefits. The City will inspect each site and evaluate the feasibility of retrofitting these facilities for water quality benefits during the first year of the five-year permit term. The City has already initiated evaluation of the detention pond at the Acker Place development.

Under the proposed program, the City will also initiate investigations of existing on-site BMP facilities. Currently, the City does not have a complete inventory of these structures. The City will begin the process of inventorying these structures and identifying maintenance requirements. Since there is a very large number of on-site facilities located throughout the City, inspections and inventory activities will primarily be in response to complaints or known problem areas. Retrofitting on-site facilities to provide water quality control will be on a strictly voluntary basis during the first five year permit term, unless the City can demonstrate that the facility is the cause of known flooding or water quality problems. If a property owner finds it necessary to reconfigure an existing on-site detention pond, investigation of the feasibility of water quality features will be mandatory.

Schedule for Evaluation of Flood Control Projects

The City has already initiated evaluation of the detention basin at the Acker Place development and will evaluate the feasibility of retrofitting water quality controls at the other two facilities in the second and third year of the permit term. Development of an on-site detention pond inventory and maintenance requirements will also begin in the first year of the permit although completion of this inventory is not likely during the first five year permit term. Inspections and maintenance compliance will begin pending the adoption of the new Stormwater Detention Ordinance.

5.2.6 MONITORING OF SOLID WASTE FACILITIES

Paragraph (d)(2)(iv)(C) of 40 CFR 122.26 presents regulations to provide stormwater quality improvements to selected industrial facilities and to landfills and hazardous waste facilities. The City's program to address those requirements is presented in the management program for industrial facilities.

5.2.7 MANAGEMENT PROGRAM FOR PESTICIDES, HERBICIDES, AND FERTILIZER

Existing Pesticide/Herbicide/Fertilizer Program

Pesticides, herbicides, and fertilizer are stored in a building at the Loraine Street facility. This building is in compliance with all regulations regarding the storage of hazardous materials. The Service Department's Division of Horticulture and Grounds Maintenance is responsible for the application of pesticides, herbicides, and fertilizer. The herbicide "Round-Up" is applied annually to City parks and rights-of-way to control unwanted weed growth. The herbicide is sprayed by Service Department personnel who have been certified and licensed by the University of Tennessee. Fertilizer is only used for minor landscaping projects and stormwater runoff from these projects is not considered a threat to receiving water quality.

The City does not currently require registration by commercial applicators, however commercial applicators must be licensed under State and Federal Regulations. There are no regulations restricting the use of these substances by individual land owners, however, household hazardous waste collection programs have been utilized to collect all types of hazardous wastes including pesticides, herbicides, and fertilizer.

Proposed Pesticide/Herbicide/Fertilizer Program

For pesticide, herbicide, and fertilizer pollutants, the control program is difficult to define since the presence of pesticides, herbicides, and fertilizers in urban runoff is not always evident. Current problems with pesticide, herbicide, and fertilizer pollutants are not believed to be significant. As part of the water quality monitoring program, the City will try to better establish whether problems with these pollutants are significant.

The City will establish a public educational program for the storage, use, and disposal of herbicides, pesticides, and fertilizers. This program will be developed in conjunction with the public education program developed under the City's management program for illicit connections and improper disposal. These programs could include activities such as the following:

- Educational mailings inserted into utility bills,
- Public Service Announcements (PSAs) in the local media,
- Household hazardous waste collection sites.

Schedule for Proposed Pesticide/Herbicide/Fertilizer Program

Public education programs for pesticides, herbicides, and fertilizer have already been implemented in conjunction with City public education programs for collection and recycling of household hazardous waste. These programs will continue throughout the five-year permit term. Construction of a household hazardous waste (HHW) collection facility is contingent on State grant funds. It is anticipated that construction of an HHW collection facility will be complete within a year after these funds are granted. The HHW collection program, which will include collection of pesticide, herbicide, and fertilizer waste material, will be implemented thereafter.

5.2.8 STORMWATER MANAGEMENT PROGRAM STAFFING REQUIREMENTS

The staffing requirements to implement the City's stormwater management program for residential and commercial areas are presented in Table 5-1. The Service Department will add one new five-person field crew. This crew's primary responsibility will be to conduct the stream cleaning and channel maintenance as defined in Section 3. In addition, a small portion of their time will be dedicated to the routine and major maintenance of regional BMP facilities as defined in Section 6. The new field crew will also assist in the construction and installation of automatic sampling stations as defined in the City's management program for water quality monitoring.

In addition to the new field crew, the management program will also require the Chief Engineer and the new Stormwater Engineer to dedicate a portion of their time to revising and implementing the Stormwater Detention Ordinance to include water quality requirements and evaluating plans for new development. The Stormwater Engineer will also dedicate a portion of his/her time to the evaluation of water quality controls for existing flood control projects (water quality retrofit) as defined in Section 6.

A new Engineering Technician II will be responsible for the site inspection and property owner notification of on-site BMPs described in Section 6. This program will require approximately 30 percent of the technician's time, with the remaining time dedicated to other projects proposed under the NPDES stormwater permit.

5.3 MANAGEMENT PROGRAM FOR ILLICIT CONNECTIONS AND IMPROPER DISPOSAL

5.3.1 INTRODUCTION

The objective of the proposed management program for the detection and correction of illicit connections within the storm sewer system is to protect water quality by effectively prohibiting non-stormwater discharges from entering the City's stormwater system and to define methods to identify and remove existing illicit connections to the local storm sewer system. The proposed program also includes a public education program to encourage public participation and support in reducing illicit discharges.

The proposed program contains seven major elements addressing the Federal NPDES requirements:

1. Implementation and enforcement of a new City Storm Sewer System Discharge Ordinance which prohibits illicit discharges to the storm sewer system.

2. Field screening activities to monitor and evaluate dry weather flows in the storm sewer system.

3. Investigation of the storm sewer system for sources of non-stormwaters where field screening data and other information indicate a reasonable potential for illicit discharges and improper disposal.

4. Prevention, containment, and response to spills that may discharge into the storm sewer system.

5. Public reporting of the presence of illicit discharges.

6. Public information activities to facilitate the proper management and disposal of used oil and toxic materials.

7. Controls to limit infiltration of seepage from the sanitary sewers to the storm sewer system.

Table 5-3 presents an overall summary of the City's proposed management program for illicit connections and improper disposal, implementation schedule, estimated costs, staffing requirements, and impacted City departments.

5.3.2 REGULATORY REQUIREMENTS

The Part 2 NPDES stormwater regulations require inclusion of the following elements in the program to eliminate illicit connections and improper disposal [40 CFR 122.26 (d)(2)(iv)(B)]:

> *"A description of a program, including a schedule, to detect and remove (or require the discharger to the municipal separate storm sewer to obtain a separate NPDES permit for) illicit discharges and improper disposal into the storm sewer. The proposed program shall include:*
>
> > *(1) A description of a program, including inspections, to implement and enforce an ordinance, orders or similar means to prevent illicit discharges to the municipal separate storm sewer system; this program description shall address all types of illicit discharges, however the following category of non-storm water discharges or flows shall be addressed where such discharges are identified by the*

Table 5-3

SUMMARY OF PROPOSED ILLICIT CONNECTION AND IMPROPER DISPOSAL MANAGEMENT PROGRAM

Element	Component	Schedule Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
(1) Ordinance	Develop new City Ordinance prohibiting non-stormwater discharges	Partial	Full			
	Implement new Stormwater Ordinance	Partial	Full	Full	Full	Full
(2) Ongoing Field Screening	Perform follow up analysis at the 65 Part 1 Field Screening Sites	Full				
	Investigate 30-40 new field sites per year	Partial	Full	Full	Full	Full
(3) Investigation of Storm Sewer System	Implement procedures for mapping , field surveys, and upstream source identification	Partial	Full	Full	Full	Full
	Implement enforcement procedures and follow up monitoring/inspections	Partial	Partial	Full	Full	Full
	Coordinate with KUB sanitary sewer inspections	Partial	Full	Full	Full	Full
(4)Spill Response Program	Coordinate with KERT & TDEC	Full	Full	Full	Full	Full
(5) Reporting of Illicit Discharges	Establish and monitor "Hot-Line" phone number for public reporting	Partial	Full	Full	Full	Full
	Publicize "Hot-Line"		Partial	Full	Full	Full
(6) Used Oil & Toxic Materials Program	Implementation and coordination of recycling program.		Full	Full	Full	Full
	Construct household hazardous waste facility	When funds allocated by State				
(7) Control Infiltration	Assess rehabilitation study from outside consultant. Recommend capital improvements		Partial	Full	Full	Full

Partial Implementation

Full Implementation

Staffing Requirements	Position	Percent of Workload Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
	Chief Engineer	10%	10%	10%	10%	10%
	Stormwater Engineer	21%	21%	21%	21%	21%
	Technician III	50%	50%	50%	50%	50%
	(2) Technician II	35%	35%	35%	35%	35%

Responsible City Department	Primary Responsibility:	Engineering Department/Planning and Technical Services Division
	Supporting Departments:	Law Dept., Public Information KERT, Solid Waste
	Other Agencies:	TDEC, KUB

Estimated Cost ($1,000 per year)	Program Element	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
	(1) Ongoing Field Screening	$14.0	$14.4	$14.9	$15.3	$15.8	$74
	(2) Investigation of Storm Sewer	$21.0	$21.6	$22.3	$22.9	$23.6	$111
	(3) Spill Response	$1.5	$1.5	$1.6	$1.6	$1.7	$8
	(4) Public Reporting	$1.2	$1.2	$1.3	$1.3	$1.4	$6
	(5) Used Oil and Toxic Materials	$0.7	$0.7	$0.7	$0.8	$0.8	$4
	(5) Control Infiltration from Sanitary Sewer	$1.5	$1.5	$1.6	$1.6	$1.7	$8
	Total	$39.9	$41.1	$42.3	$43.6	$44.9	$211.8

municipality as sources of pollutants to waters of the United States: water line flushing, landscape irrigation, diverted stream flows, rising ground waters, uncontaminated ground water infiltration (as defined at 40 CFR 35.2005(20)) to separate storm sewers, uncontaminated pumped ground water, discharges from potable water sources, foundation drains, air conditioning condensation, irrigation water, springs, water from crawl space pumps, footing drains, lawn watering, individual residential car washing, flows from riparian habitats and wetlands, dechlorinated swimming pool discharges, and street wash water (program descriptions shall address discharges or flows from fire fighting only where such discharges or flows are identified as significant sources of pollutants to waters of the United States);

(2) A description of procedures to conduct on-going field screening activities during the life of the permit, including areas or locations that will be evaluated by such field screens;

(3) A description of procedures to be followed to investigate portions of the separate storm sewer system that, based on the results of the field screen, or other appropriate information, indicate a reasonable potential of containing illicit discharges or other sources of non-storm water (such procedures may include: sampling procedures for constituents such as fecal coliform, fecal streptococcus, surfactants (MBAS), residual chlorine, fluorides and potassium; testing with fluorometric dyes; or conducting in storm sewer inspections where safety and other considerations allow. Such description shall include the location of storm sewers that have been identified for such evaluation);

(4) A description of procedures to prevent, contain, and respond to spills that may discharge into the municipal separate storm sewer;

(5) A description of a program to promote, publicize, and facilitate public reporting of the presence of illicit discharges or water quality impacts associated with discharges from municipal separate storm sewers;

(6) A description of educational activities, public information activities, and other appropriate activities to facilitate the proper management and disposal of used oil and toxic materials; and

(7) A description of controls to limit infiltration of seepage from municipal sanitary sewers to municipal separate storm sewer systems where necessary;"

As noted in (1), EPA specifically exempts three limited classes of non-stormwater discharges. These classes include:

- Discharges that are authorized by an NPDES permit to discharge to the storm sewer system,
- Discharges or flows from fire fighting,
- Discharges from water line flushing, landscape irrigations, diverted stream flows, rising groundwater, uncontaminated groundwater infiltration, uncontaminated pumped groundwater, potable water sources, foundation drains, air conditioning condensation, irrigation water, springs, crawl space pumps, footing drains, lawn watering, individual residential car washing, riparian habitats and wetlands, dechlorinated swimming pool water, street washing.

The exemption applies only where these discharges are identified by the municipality as not being significant sources of pollutants to waters of the State. The City of Knoxville's proposed program for illicit connections/improper disposal assumes that these sources will be detected and corrected under the ongoing field screening and storm sewer investigations. These sources typically do not represent significant pollutant sources. EPA has provided no guidance for determining when these discharges represent significant pollutant sources.

5.3.3 ORDINANCE IMPLEMENTATION AND ENFORCEMENT

Existing Illicit Discharge Ordinance

Through the City Charter and the enabling authority provided in the State Code, the City possesses the power to enact ordinances necessary for the health, convenience, safety, and general welfare of its inhabitants, including the provisions for fines, forfeitures, and penalties for the violation of any such ordinances. Currently, there are no city ordinances that specifically address prevention of illicit discharges and improper disposal into the storm sewer system. Enforcement of Article V, Section 19-156, which forbids vandalism to city owned property, has been used to prohibit improper disposal; and Article V, The Plumbing Code has been cited to prevent illicit connections.

While Knoxville's Charter empowers the City to enact ordinances, the penalties for violations of these ordinances are not severe. The maximum fine for a violation of an ordinance is $50 a day plus court costs. A new ordinance is needed to address the requirements of the NPDES regulations and to specifically prohibit illicit connections and improper disposal. The State of Tennessee Stormwater Bill (Senate Bill No. 68, House Bill No. 56) provides the City with sufficient authority to develop and enforce the required ordinance. The State legislation would increase maximum civil penalties to $5,000 per day and provide the City with powers to exercise general regulation over stormwater facilities whether owned and operated by the City or not.

Proposed Illicit Discharge Ordinance

The City of Knoxville proposes to develop a new ordinance that prohibits the discharge or dumping of any waste, wastewaters, or other polluted waters to any natural outlets, or storm sewers which drain to natural outlets, which are part of the City's storm drainage system. The proposed ordinance will authorize the City to carry out all inspection, surveillance and monitoring procedures necessary to determine compliance and noncompliance with the ordinance. The proposed ordinance will allow for enforcement of the ordinance with penalties granted by the State of Tennessee Code. A model ordinance is presented in Appendix A. The responsibility for enforcement of the proposed ordinance will be with the Engineering Department Planning and Technical Services Division. The Engineering Department will coordinate with the Public Information Department to issue public notices (through newspaper/media announcements) regarding the new ordinance. The notices will be directed toward residential, commercial, and industrial facilities and will list specific prohibited activities such as disposal of commercial boiler overflows to parking lots and ultimately to the storm sewer system.

The proposed ordinance will grant inspection and monitoring authority to the Engineering Department as necessary to administer and enforce the ordinance. There are two major enforcement activities related to inspections and monitoring that will be included in the ordinance: 1) a proposed dry weather field screening program described below, and 2) existing industrial/commercial facility pretreatment inspections performed by KUB. The Engineering Department will also notify other City Departments that perform various types of inspections to report violations. Special attention should be directed to facilities that have outdoor washing or vehicle fueling/repair equipment to prevent illicit discharges to the storm sewer system.

Schedule for Illicit Discharge Ordinance Implementation

Recent State passage of the State Stormwater Bill (Senate Bill No. 68, House Bill No. 56), provides the City with sufficient enabling authority for development and implementation of the proposed new City ordinance addressing illicit discharges and improper disposal. Based upon internal City meetings with the Law Department, it is believed that the proposed ordinance can be developed and approved within the first year of the permit term. Implementation and enforcement of the proposed ordinance will be carried out throughout the remainder of the permit term.

5.3.4 ON-GOING FIELD SCREENING PROGRAM

An ongoing field screening program will be conducted during the term of the permit to monitor field screening points during dry weather conditions, for the presence of illicit discharges and improper disposal. The proposed program will include two major categories of field screening points: 1) field screening points identified in the Part 1 permit application monitoring program as potential sites for illicit discharges and improper disposal, and 2) new field screening points throughout the City. These two programs are presented below.

Continuation of Part 1 Field Screening Sites Evaluation

For the Part 1 NPDES permit application, 251 field screening points were screened for illicit connections and improper disposal during the winter of 1991-1992. Descriptions of dry weather flow, color, odor, turbidity and the presence of oil sheen and surface scum were recorded. For the parameters pH, total chlorine, total copper, total phenol and detergents, analyses were performed in the field using calorimetric test kits. Samples were collected and taken to the Knoxville Utility Board (KUB) laboratory for analysis of fecal coliform. Simple flow measurement methods were used to estimate dry weather flow rates at the field screening points under the Part 1 application field screening program. Results from the Part 1 field screening program were recorded, stored in the stormwater database, and presented in Knoxville Tennessee NPDES Part 1 Stormwater Application (May 1992).

Dry weather flow was observed at 65 of the field screening points, or about 26% of the 251 total sites observed. Detailed results of the sampling analysis are presented in Appendix M of the Part 1 permit application. The vast majority of the quantitative field screening results were at or just above the detection limit for the field test kit, therefore data on all parameters monitored at each site were considered in making a determination whether dry weather flows were potentially impacted by illicit connections or improper disposal. In many cases, the descriptive data regarding the presence of an oil sheen, surface scum, or odor were the sole indicators of a potential problem because field test kits were negative. The results of the Part 1 dry weather field screening program indicate that illicit connections or improper disposal to the City of Knoxville storm sewer system, which would cause spike concentrations of the selected parameters, are relatively uncommon.

The results of the field screening were evaluated and of the 65 sites that exhibited dry weather flow, 51 merit further investigation of potential illicit connections or other dry weather sources. Table 5-4 summarizes the screening results made at each of these 51 sites. In addition to the sites which exhibited dry weather flow, 16 sites which were dry during the

TABLE 5-4
SUMMARY OF OBSERVATIONS FOR FIELD SCREENING SITES
WHICH MAY MERIT FURTHER INVESTIGATION
FOR POTENTIAL ILLICIT DISCHARGE

CELL COUNT	SAMPLE POINT	SAMPLE ID.	GRID CELL	SAMPLE TYPE	SAMPLE DATE	CHLOR. (ppm)	COLOR (PCU)	COLIF. MPN PER 100 ml	COPPER (ppm)	DETRG. (ppm)	FLOW (cfs)	pH (su)	PHENOL (ppm)	TURBID. (NTU)	ODOR	SCUM	OIL SHEEN	PROB.
1	00-300-0385	00-300-0385-1	BF75	GRAB	02/03/1992	0.00	40	NR	0.00	0.40	0.01<	7.8	0.25	50<	CHEM/SEWAGE	NONE	NONE	IC
	00-300-0385	00-300-0385-2	BF75	GRAB	02/04/1992	0.00	25	60000	0.00	0.25	0.01<	7.8	0.15	50<	CHEMICALS	NONE	NONE	IC
2	01-100-0560	01-100-0560-1	AS68	GRAB	11/14/1991	0.00	40	NR	0.00	0.25<	0.01<	8.2	0.00	0	DIESEL	SLIGHT	SLIGHT	IC
	01-100-0560	01-100-0560-2	AS68	GRAB	11/15/1991	0.15	30	10	0.00	0.25<	0.01<	8.4	0.00	50<	DIESEL	SLIGHT	SLIGHT	IC
3	01-100-0660	01-100-0660-1	AO71	GRAB	11/14/1991	0.05	20	NR	0.00	0.00	0.01<	8.2	0.00	0	NONE	SLIGHT	SLIGHT	FI
	01-100-0660	01-100-0660-2	AO71	GRAB	11/15/1991	0.00	20	60	0.00	0.00	0.01<	8.2	0.00	0	NONE	SLIGHT	SLIGHT	FI
4	01-100-0920	01-100-0920-1	AK70	GRAB	11/18/1991	0.10	20	NR	0.05	3.0>	0.01<	7.3	0.15	75	NONE	NONE	NONE	ID
	01-100-0920	(DRY @ 2 VISIT)	AK70	NONE	11/19/1991	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	
5	01-300-0060	01-300-0060-1	BD73	GRAB	11/13/1991	0.00	10	590	0.00	0.40	0.01<	8.5	0.00	0	NONE	SLIGHT FOAM	NONE	IC
	01-300-0060	01-300-0060-2	BD73	GRAB	11/13/1991	0.00	25	NR	0.05	0.25<	0.01<	8.1	0.00	0	NONE	BROWN FOAM	NONE	IC
6	01-300-0095	01-300-0095-1	BC74	GRAB	03/03/1992	0.00	500	110	0.00	1.00	0.01<	7.0	3.50	200	CHEM/SEWAGE	NONE	NONE	IC
	01-300-0095	01-300-0095-2	BC74	GRAB	03/04/1992	0.00	500	NR	0.00	0.75	0.01<	7.4	0.15	75	CHEM/SEWAGE	NONE	NONE	IC
7	01-300-0150	01-300-0150-1	BA74	GRAB	11/13/1991	0.10	0	NR	0.00	3.0>	>0.01	8.1	0.00	0	YES	FOAM	SLIGHT	IC
	01-300-0150	01-300-0150-2	BA74	GRAB	11/14/1991	0.10	10	1900	0.00	1.00	>0.01	8.4	0.00	0	YES	FOAM	SLIGHT	IC
8	01-300-0200	01-300-0200-1	AY74	GRAB	11/13/1991	1.80	15	NR	0.00	0.25<	>0.01	7.7	0.00	0	NONE	GREY FOAM	NONE	IC
	01-300-0200	01-300-0200-2	AY74	GRAB	11/14/1991	1.80	5	0	0.00	0.25<	>0.01	7.8	0.00	0	NONE	GREY FOAM	NONE	IC
9	01-300-0350	01-300-0350-1	AT70	GRAB	11/14/1991	0.00	130	0	0.00	0.40	<0.01	12.1	0.00	1000>	CONC/DIESEL	WHITE CHALK	NONE	ID
	01-300-0350	(DRY @ 2 VISIT)	AT70	NONE	11/14/1991	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	

IC - POTENTIAL ILLICIT CONNECTION
ID - POTENTIAL ILLEGAL DUMP
FI - FUTHER INVESTIGATION REQUIRED TO DETERMINE SOURCE
SHADING INDICATES SIGNS FOR POTENTIAL ILLICIT DISCHARGE

TABLE 5-4 (continued)
SUMMARY OF OBSERVATIONS FOR FIELD SCREENING SITES
WHICH MAY MERIT FURTHER INVESTIGATION
FOR POTENTIAL ILLICIT DISCHARGE

CELL COUNT	SAMPLE POINT	SAMPLE ID.	GRID CELL	SAMPLE TYPE	SAMPLE DATE	CHLOR. (ppm)	COLOR (PCU)	COLIF. MPN PER 100 ml	COPPER (ppm)	DETRG. (ppm)	FLOW (cfs)	pH (su)	PHENOL (ppm)	TURBID. (NTU)	ODOR	SCUM	OIL SHEEN	PROB.
10	FSP-BF73	02-100-0090-1	BF73	GRAB	11/06/1991	1.50	0	0	0.00	0.00	0.01	8.5	0.00	0	CHLORINE	NONE	NONE	IC
	FSP-BF73	02-100-0090-2	BF73	GRAB	11/07/1991	2.00	0	NR	0.00	0.00	0.01	9.0	0.00	0	NONE	NONE	NONE	IC
11	02-100-0105	02-100-0105-1	BE71	GRAB	11/06/1991	0.25	0	0	0.00	0.00	0.01	8.0	0.00	0	NONE	SUDS	NONE	IC
	02-100-0105	02-100-0105-2	BE71	GRAB	11/07/1991	0.30	0	NR	0.00	0.25<	0.01	7.9	0.00	0	NONE	SUDS	NONE	IC
12	FSP-AT65	02-100-0385-1	AT65	GRAB	11/07/1991	0.10<	10	1700	0.1<	1.50	0.01<	8.0	0.00	25	SEWAGE	NONE	SLIGHT	IC
	FSP-AT65	02-100-0385-2	AT65	GRAB	11/07/1991	0.00	35	NR	0.00	5.0>	0.01<	8.0	0.00	75	SEWAGE	NONE	SLIGHT	IC
13	02-100-0515	02-100-0515-1	AS60	GRAB	11/06/1991	0.10	10	NR	0.1<	0.25<	0.01<	9.0	0.10	25<	NONE	SLIGHT	NONE	ID
	02-100-0515	(DRY @ 2 VISIT)	AS60	NONE	11/07/1991	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	
14	02-200-0530	02-200-0530-1	AR61	GRAB	11/06/1991	0.60	10	NR	0.15	0.25<	0.01<	8.4	0.00	0	NONE	NONE	SLIGHT	IC
	02-200-0530	02-200-0530-2	AR61	GRAB	11/07/1991	0.35	10	NR	0.10	0.25<	0.01<	8.4	0.00	25	NONE	NONE	SLIGHT	IC
15	02-300-0165	02-300-0165-1	BC71	GRAB	11/06/1991	0.00	70	NR	0.00	1.50	0.09	9.0	0.00	75	SEWAGE	GREY/TAN	NONE	IC
	02-300-0165	02-300-0165-2	BC71	GRAB	11/07/1991	0.10	15	600000	0.00	0.50	0.09	7.8	0.00	0	SEWAGE	GREY/TAN	NONE	IC
16	02-300-0180	02-300-0180-1	BA70	GRAB	03/03/1992	1.50	0	10	0.00	0.00	0.01<	8.9	0.00	0	METALIC	NONE	NONE	IC
	02-300-0180	02-300-0180-2	BA70	GRAB	03/04/1992	1.50	0	NR	0.00	0.00	0.01<	8.8	0.00	0	NONE	NONE	NONE	IC
17	02-300-0190	02-300-0190-1	BA70	GRAB	11/06/1991	0.00	25	NR	0.00	0.75	0.21	7.7	0.00	25	SEWAGE	PAPER FIBER	NONE	IC
	02-300-0190	02-300-0190-2	BA70	GRAB	11/07/1991	0.20	20	600000	0.00	0.25	0.35	7.8	0.00	25	SEWAGE	BROWN/GREY	NONE	IC
18	02-300-0230	02-300-0230-1	AZ68	GRAB	11/07/1991	0.05	5	NR	0.00	0.00	1.00	8.2	0.00	0	NONE	NONE	NONE	IC
	02-300-0230	02-300-0230-2	AZ68	GRAB	11/08/1991	0.00	70	290	0.00	0.65	1.00	7.4	0.00	175	NONE	NONE	NONE	IC

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FI - FUTHER INVESTIGATION REQUIRED TO DETERMINE SOURCE
SHADING INDICATES SIGNS FOR POTENTIAL ILLICIT DISCHARGE

TABLE 5-4 (continued)
SUMMARY OF OBSERVATIONS FOR FIELD SCREENING SITES
WHICH MAY MERIT FURTHER INVESTIGATION
FOR POTENTIAL ILLICIT DISCHARGE

CELL COUNT	SAMPLE POINT	SAMPLE ID.	GRID CELL	SAMPLE TYPE	SAMPLE DATE	CHLOR. (ppm)	COLOR (PCU)	COLIF. MPN PER 100 ml	COPPER (ppm)	DETRG. (ppm)	FLOW (cfs)	pH (su)	PHENOL (ppm)	TURBID. (NTU)	ODOR	SCUM	OIL SHEEN	PROB.
19	02-300-0270	02-300-0270-1	AX66	GRAB	11/07/1991	0.05	5	NR	0.00	0.25<	0.01<	8.4	0.00	50<	IRON	SLIGHT	NONE	IC
	02-300-0270	02-300-0270-2	AX66	GRAB	11/08/1991	0.00	75	230	0.00	0.65	0.01<	7.5	0.00	25	NONE	NONE	NONE	IC
20	FSP-BI69	03-100-0045-1	BI69	GRAB	11/12/1991	0.50	0	NR	0.00	0.75	>0.1	8.4	0.00	0	NONE	NONE	NONE	IC
	FSP-BI69	03-100-0045-2	BI69	GRAB	11/13/1991	0.60	5	23	0.00	0.25	>0.1	8.3	0.00	0	NONE	NONE	NONE	IC
21	03-100-0090	03-100-0090-1	BI68	GRAB	11/12/1991	0.15	0	6000	0.00	0.75	0.01<	8.4	0.00	0	NONE	NONE	NONE	IC
	03-100-0090	03-100-0090-2	BI68	GRAB	11/13/1991	0.00	0	NR	0.00	0.75	0.01<	8.4	0.00	0	NONE	NONE	NONE	IC
22	03-100-0380	03-100-0380-1	BI64	GRAB	11/12/1991	0.05	5	NR	0.00	3.70	<0.01	8.2	0.00	25	CHEM/SEWAGE	MEDIUM	NONE	IC
	03-100-0380	03-100-0380-2	BI64	GRAB	11/13/1991	0.15	5	300	0.00	0.15	<0.01	8.1	0.00	25	NONE	MEDIUM	NONE	IC
23	FSP-BG62	03-100-0455-1	BG62	GRAB	11/11/1991	0.00	0	NR	0.05	1.00	0.03	8.2	0.00	0	NONE	NONE	NONE	IC
	FSP-BG62	03-100-0455-2	BG62	GRAB	11/12/1991	0.05	0	40	0.00	0.37	0.03	8.0	0.00	0	NONE	NONE	NONE	IC
24	03-200-0870	03-200-0870-1	BB47	GRAB	11/11/1991	0.00	40	130	0.00	0.00	0.01<	8.0	0.00	75	HUMIC	NONE	SLIGHT	FI
	03-200-0870	03-200-0870-2	BB47	GRAB	11/11/1991	0.00	90	NR	0.10	0.00	0.01<	7.5	0.00	75	HUMIC	NONE	SLIGHT	FI
25	03-200-0990	03-200-0990-1	AV57	GRAB	11/12/1991	0.05	10	150	0.00	0.00	0.01<	7.9	0.00	0	NONE	SLIGHT	NONE	FI
	03-200-0990	03-200-0990-2	AV57	GRAB	11/12/1991	0.00	10	NR	0.00	0.00	0.01<	7.9	0.00	0	NONE	NONE	NONE	FI
26	03-300-0075	03-300-0075-1	BI68	GRAB	03/03/1992	0.00	20	10	0.10	0.00	0.01<	7.7	0.00	0	CHEMICAL	NONE	NONE	FI
	03-300-0075	03-300-0075-2	BI68	GRAB	03/04/1992	0.00	0	NR	0.00	0.00	0.01<	7.7	0.00	0	NONE	NONE	NONE	FI
27	03-300-0115	03-300-0115-1	BH68	GRAB	03/03/1992	0.15	35	140	0.20	0.15	<0.01	6.9	0.00	25	LAUNDRY	NONE	NONE	FI
	03-300-0115	03-300-0115-2	BH68	GRAB	03/04/1992	0.00	0	NR	0.00	0.00	<0.01	7.9	0.00	0	NONE	NONE	NONE	FI

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FI - FUTHER INVESTIGATION REQUIRED TO DETERMINE SOURCE
SHADING INDICATES SIGNS FOR POTENTIAL ILLICIT DISCHARGE

TABLE 5-4 (continued)
SUMMARY OF OBSERVATIONS FOR FIELD SCREENING SITES
WHICH MAY MERIT FURTHER INVESTIGATION
FOR POTENTIAL ILLICIT DISCHARGE

CELL COUNT	SAMPLE POINT	SAMPLE ID.	GRID CELL	SAMPLE TYPE	SAMPLE DATE	CHLOR. (ppm)	COLOR (PCU)	COLIF. MPN PER 100 ml	COPPER (ppm)	DETRG. (ppm)	FLOW (cfs)	pH (su)	PHENOL (ppm)	TURBID. (NTU)	ODOR	SCUM	OIL SHEEN	PROB.
28	03-300-0655	03-300-0655-1	BG58	GRAB	03/04/1992	0.00	35	NR	0.00	0.00	0.01<	8.1	0.10	0	NONE	YELLOW	HEAVY	IC
	03-300-0655	03-300-0655-2	BG58	GRAB	03/04/1992	NR	NR	NR	NR	NR	<0.01	NR	NR	NR	GASOLINE	YELLOW	HEAVY	IC
29	FSP-BG55A	03-300-0660-1A	BG55	GRAB	11/11/1991	0.05	100>	NR	0.05	3.0>	0.30	7.5	0.05	1000	NONE	NONE	SLIGHT	IC
	FSP-BG55A	03-300-0660-2A	BG55	GRAB	11/12/1991	0.00	0	460	0.00	0.15	0.30	7.5	0.00	0	NONE	NONE	SLIGHT	IC
30	03-300-0670	03-300-0670-1	BG57	GRAB	03/04/1992	0.00	55	NR	0.00	0.00	0.01<	7.4	0.10	25	CHEMICALS	ORANGE	HEAVY	IC
	03-300-0670	03-300-0670-2	BG57	GRAB	03/04/1992	0.15	20	NR	0.00	0.00	0.01<	7.5	0.00	0	CHEMICALS	ORANGE	HEAVY	IC
31	04-100-0250	04-100-0250-1	BO55	GRAB	11/14/1991	0.00	0	NR	0.00	0.25<	0.01<	8.2	0.00	0	OIL/GAS	NONE	MEDIUM	IC
	04-100-0250	04-100-0250-2	BO55	GRAB	11/15/1991	0.05	100	NR	0.00	3.0>	0.01<	7.9	0.00	50	PETROLEUM	NONE	MEDIUM	IC
32	04-200-0270	04-200-0270-1	BM54	GRAB	11/13/1991	0.10	10	NR	0.00	0.05	0.77	8.1	0.00	0	NONE	NONE	NONE	IC
	04-200-0270	04-200-0270-2	BM54	GRAB	11/14/1991	0.00	0	200	0.00	0.10	0.77	8.1	0.00	0	NONE	NONE	NONE	IC
33	06-100-0200	06-100-0200-1	BL79	GRAB	11/19/1991	0.05	35	6000	0.20	3.0>	0.01<	5.6	0.30	250	SOURMILK	NONE	NONE	IC
	06-100-0200	06-100-0200-2	BL79	GRAB	11/20/1991	0.30	35	NR	0.20	3.0>	0.01<	4.4	0.20	250	SOURMILK	NONE	NONE	IC
34	06-500-0110	06-500-0110-1	BH79	GRAB	11/19/1991	0.05	0	10	0.00	0.00	0.09	7.9	0.00	0	NONE	NONE	SLIGHT	FI
	06-500-0110	06-500-0110-2	BH79	GRAB	11/20/1991	0.00	0	NR	0.00	0.25<	0.09	7.7	0.00	0	NONE	NONE	NONE	FI
35	FSP-AY79	07-100-0055-1	AY79	GRAB	11/20/1991	0.15	0	6000	0.00	0.25	0.06	7.5	0.00	0	FISH	NONE	NONE	IC
	FSP-AY79	07-100-0055-2	AY79	GRAB	11/20/1991	0.15	0	NR	0.00	0.75	0.06	7.6	0.00	0	FISH	NONE	NONE	IC
36	FSP-AX79	07-100-0090-1	AX79	GRAB	11/20/1991	NR	100	6000	FSL	3.0>	<0.01	8.5	0.00	2000>	ORGANIC	MEDIUM	HEAVY	IC
	FSP-AX79	07-100-0090-2	AX79	GRAB	11/20/1991	NR	100	NR	0.25	3.0>	<0.01	7.9	0.00	2000>	ORGANIC	MEDIUM	HEAVY	IC

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FI - FUTHER INVESTIGATION REQUIRED TO DETERMINE SOURCE
SHADING INDICATES SIGNS FOR POTENTIAL ILLICIT DISCHARGE

TABLE 5-4 (continued)
SUMMARY OF OBSERVATIONS FOR FIELD SCREENING SITES
WHICH MAY MERIT FURTHER INVESTIGATION
FOR POTENTIAL ILLICIT DISCHARGE

CELL COUNT	SAMPLE POINT	SAMPLE ID.	GRID CELL	SAMPLE TYPE	SAMPLE DATE	CHLOR. (ppm)	COLOR (PCU)	COLIF. MPN PER 100 ml	COPPER (ppm)	DETRG. (ppm)	FLOW (cfs)	pH (su)	PHENOL (ppm)	TURBID. (NTU)	ODOR	SCUM	OIL SHEEN	PROB.
37	FSP-BA80	07-200-0015-1	BA80	GRAB	11/20/1991	0.05	10	6000	0.00	2.50	<0.01	7.5	0.05	0	GARBAGE	NONE	SLIGHT	IC
	FSP-BA80	07-200-0015-2	BA80	GRAB	11/20/1991	0.00	10	NR	0.00	2.00	<0.01	7.7	0.05	0	GARBAGE	NONE	SLIGHT	IC
38	FSP-BN43	10-200-0080-1	BN43	GRAB	11/14/1991	1.50	10	NR	0.00	.25<	<0.01	7.6	0.00	0	NONE	NONE	NONE	IC
	FSP-BN43	10-200-0080-2	BN43	GRAB	11/15/1991	2.00	5	NR	0.00	0.00	<0.01	7.7	0.00	0	NONE	NONE	NONE	IC
39	12-200-0055	12-200-0055-1	BX22	GRAB	11/14/1991	0.05	0	20	0.00	0.00	0.19	8.5	0.00	0	NONE	BROWN/GREY	NONE	IC
	12-200-0055	12-200-0055-2	BX22	GRAB	11/15/1991	0.00	0	NR	0.00	0.00	0.19	8.3	0.00	0	NONE	BROWN/GREY	NONE	IC
40	13-100-0240	13-100-0240-1	AZ65	GRAB	11/12/1991	0.00	450	NR	0.00	0.00	.01<	8.0	0.00	200	NONE	NONE	NONE	IC
	13-100-0240	13-100-0240-2	AZ65	GRAB	11/13/1991	0.00	5<	330	0.00	0.35	.01<	7.8	0.00	0	NONE	NONE	NONE	IC
41	13-300-0135	13-300-0135-1	BH67	GRAB	11/12/1991	0.10	25	90	0.00	0.75	.01<	8.4	0.00	50	NONE	NONE	SLIGHT	IC
	13-300-0135	13-300-0135-2	BH67	GRAB	11/13/1991	0.10	10	NR	0.00	0.65	.01<	8.4	0.05	25	NONE	NONE	NONE	IC
42	13-300-0150	13-300-0150-1	BG66	GRAB	11/12/1991	0.05	0	50	0.00	0.35	.01<	8.4	0.00	0	NONE	NONE	SLIGHT	IC
	13-300-0150	13-300-0150-2	BG66	GRAB	11/13/1991	0.30	5	NR	0.00	0.35	.01<	8.2	0.00	0	NONE	NONE	NONE	IC
43	13-300-0185	13-300-0185-1	BE65	GRAB	11/12/1991	0.35	0	0	0.00	0.15	0.10	7.6	0.00	0	NONE	NONE	NONE	IC
	13-300-0185	13-300-0185-2	BE65	GRAB	11/13/1991	0.30	0	NR	0.00	0.00	0.10	7.6	0.00	0	NONE	NONE	NONE	IC
44	13-300-0305	13-300-0305-1	BA63	GRAB	11/12/1991	0.00	0	NR	0.00	0.00	<0.01	7.8	0.00	0	NONE	SLIGHT	SLIGHT	FI
	13-300-0305	13-300-0305-2	BA63	GRAB	11/13/1991	0.00	5	40	0.00	0.00	<0.01	7.9	0.00	0	NONE	SLIGHT	NONE	FI
45	53-100-0045	53-100-0045-1	AR91	GRAB	11/20/1991	0.15	0	130	0.00	0.00	.01<	8.0	0.00	0	NONE	NONE	NONE	FI
	53-100-0045	53-100-0045-2	AR91	GRAB	11/20/1991	0.05	10	NR	0.00	0.00	.01<	7.9	0.00	0	NONE	NONE	NONE	FI

IC - POTENTIAL ILLICIT CONNECTION
ID - POTENTIAL ILLEGAL DUMP
FI - FUTHER INVESTIGATION REQUIRED TO DETERMINE SOURCE
SHADING INDICATES SIGNS FOR POTENTIAL ILLICIT DISCHARGE

TABLE 5-4 (continued)
SUMMARY OF OBSERVATIONS FOR FIELD SCREENING SITES
WHICH MAY MERIT FURTHER INVESTIGATION
FOR POTENTIAL ILLICIT DISCHARGE

CELL COUNT	SAMPLE POINT	SAMPLE ID.	GRID CELL	SAMPLE TYPE	SAMPLE DATE	CHLOR. (ppm)	COLOR (PCU)	COLIF. MPN PER 100 ml	COPPER (ppm)	DETRG. (ppm)	FLOW (cfs)	pH (su)	PHENOL (ppm)	TURBID. (NTU)	ODOR	SCUM	OIL SHEEN	PROB.
46	53-100-0065	53-100-0065-1	AR88	GRAB	11/20/1991	0.25	0	0	0.00	0.00	.01<	7.8	0.00	0	CHLORINE	NONE	NONE	IC
	53-100-0065	53-100-0065-2	AR88	GRAB	11/20/1991	1.00	0	NR	0.00	0.00	.01<	7.7	0.00	0	CHLORINE	NONE	NONE	IC
47	53-100-0075	53-100-0075-1	AS88	GRAB	11/20/1991	0.05	0	530	0.00	0.00	.01<	8.3	0.00	0	DECAY	NONE	NONE	IC
	53-100-0075	53-100-0075-2	AS88	GRAB	11/20/1991	0.00	0	NR	0.00	0.00	.01<	8.4	0.00	0	NONE	NONE	NONE	IC
48	53-100-0085	53-100-0085-1	AT87	GRAB	11/20/1991	0.00	0	NR	0.00	0.00	.01<	8.0	0.00	0	NONE	GREY/BROWN	NONE	FI
	53-100-0085	53-100-0085-2	AT87	GRAB	11/20/1991	0.00	10	NR	0.00	0.00	.01<	8.0	0.00	0	NONE	GREY/BROWN	NONE	FI
49	53-100-0090	53-100-0090-1	AT86	GRAB	11/20/1991	0.00	20	NR	0.00	0.00	.01<	8.3	0.00	0	NONE	GREY/BROWN	NONE	FI
	53-100-0090	53-100-0090-2	AT86	GRAB	11/20/1991	0.00	15	NR	0.00	0.00	.01<	8.4	0.00	0	NONE	GREY/BROWN	NONE	FI
50	FSP-AT62	FSP-AT62-1	AT62	GRAB	11/07/1991	0.30	0	NR	0.05	0.25<	0.04	7.8	0.00	0	NONE	NONE	NONE	ID
	FSP-AT62	FSP-AT62-2 (SECOND CREEK)	AT62	GRAB	11/08/1991	0.05	0	NR	0.00	0.00	0.04	7.5	0.00	0	NONE	NONE	NONE	ID
51	FSP-BC62	FSP-BC62-1	BC62	GRAB	11/06/1991	0.00	15	NR	0.00	0.25<	0.01	8.4	0.00	50<	NONE	NONE	SLIGHT	IC
	FSP-BC62	FSP-BC62-2 (THIRD CREEK)	BC62	GRAB	11/07/1991	0.15	10	170	0.00	0.25	0.01	9.2	0.00	0	NONE	NONE	HEAVY	IC

IC - POTENTIAL ILLICIT CONNECTION
ID - POTENTIAL ILLEGAL DUMP
FI - FUTHER INVESTIGATION REQUIRED TO DETERMINE SOURCE
SHADING INDICATES SIGNS FOR POTENTIAL ILLICIT DISCHARGE

TABLE 5-5
FIELD SCREENING SITES WHICH MAY
MERIT FURTHER INVESTIGATION FOR POTENIAL ILLEGAL DUMPING

SAMPLE POINT	SAMPLE ID.	GRID CELL	SAMPLE TYPE	SAMPLE DATE	CITY TOPO MAP ID.	POTENTIAL FOR ILLEGAL DUMPING/POINTS OF INTEREST
01-100-0155	01-100-0155-1	BA75	NONE	11/13/1991	G8	TRASH AND DEBRIS IN VICINITY, APRON UNDERCUT BY 3 FT, BOX IS CLEAN
01-100-0210	01-100-0210-1	AX74	NONE	11/14/1991	F7	SEDIMENT AND DEBRIS BLOCK 1/3 OF 36 IN RCP. SHOPPING CARTS, TRASH
FSP-AY72	01-100-0225-1	AY72	NONE	11/14/1991	F7	FILL AREA ALONG BANK OF FIRST CREEK, NOT STABILIZED, EROSION POTENTIAL
01-100-0230	01-100-0230-1	AX72	NONE	11/14/1991	F7	EROSION PROBLEM ALONG EDGE OF PARKING LOT, PIPE DRIPPING
01-100-0775	01-100-0775-1	AN70	NONE	11/18/1991	C7	SEVERAL TIRES AND SHOPPING CARTS HAVE BEEN DUMPED IN CREEK
01-100-0907	01-100-0907-1	AK70	NONE	11/18/1991	B7	OUTFALL NOT SHOWN ON STORM SEWER INVENTORY MAPS
01-100-0940	01-100-0940-1	AI70	NONE	11/18/1991	B7	OUTFALL IS 50% FILLED WITH BACKFILL AND TRASH. D/S IS OVERGROWN
01-300-0145	01-300-0145-1	BA73	NONE	11/13/1991	G7	APPROXIMATELY 15 IN OF SEDIMENT AND DEBRIS AT CHANNEL BOTTOM
02-100-0100	02-100-0100-1	BE72	NONE	11/06/1991	H7	DEBRIS AND DARK STAINS AROUND AND IN OUTFALL
02-100-0135	02-100-0135-1	BD71	NONE	11/06/1991	G7	PIPE IS APPROXIMATELY 25% FULL OF SEDIMENT
02-100-0375	02-100-0375-1	AU65	NONE	11/06/1991	E6	OIL DEPOSITS OVER ROAD EMBANKMENT, POTENTIAL ILLEGAL DUMPING
02-100-0380	02-100-0380-1	AT65	NONE	11/07/1991	E6	OIL SHEEN IN POOLS OF WATER D/S OF OUTFALL
FSP-AU66	02-100-0390-1	AU66	NONE	11/06/1991	E6	CATCH BASIN FILLED WITH LEAVES AND DEBRIS
FSP-AV63	02-100-0405-1	AV63	NONE	11/07/1991	E6	POOLS OF ANTIFREEZE & OIL ARE BELOW OUTFALL, CUNNINGHAM FORD IS U/S
FSP-AS63	02-100-0480-1	AS63	NONE	11/06/1991	D5	APPROXIMATELY 2 INCHES OF SILT IN OUTFALL
FSP-AW66	02-300-0295-1	AW66	NONE	11/07/1991	F6	ANTIFREEZE & USED OIL NOTED ALONG PARKING AREA, RED AND BLACK STAINS
03-100-0435	03-100-0435-1	BH62	NONE	11/11/1991	559655	FOAM IN MAINSTEM OF THIRD CREEK
03-100-0450	03-100-0450-1	BH61	NONE	11/11/1991	559655	STANDING WATER IN PIPE (PUDDLE)
FSP-BG61	03-100-0465-1	BG61	NONE	11/11/1991	559655	STANDING WATER IN CATCH BASIN, ORIGINAL OUTFALL ACCESS WAS PAVED
03-100-0830	03-100-0830-1	BC49	NONE	11/11/1991	G3	8 IN TO 12 IN OF SILT AND GRAVEL IN TWIN 30 IN PIPES
03-100-0845	03-100-0845-1	BC48	NONE	11/11/1991	G3	EROSION, 18 IN UNDERCUT OF CONCRETE APRON
03-200-0580	03-200-0580-1	BA60	NONE	11/12/1991	F5	ERODED AREA AT END OF CONCRETE CHANNEL
03-200-0595	03-200-0595-1	AY59	NONE	11/12/1991	F5	EROSION IN AREA
03-200-0900	03-200-0900-1	BA54	NONE	11/11/1991	G4	OPEN CHANNEL DITCH MOVED 200 FT NORTH, FILL AREA HAS REMOVED PORTION
FSP-AZ53	03-200-0920-1	AZ53	NONE	11/11/1991	F4	80% - 90% OF 30 x 48 IN CMPA IS BLOCKED
03-200-0930	03-200-0930-1	AX54	NONE	11/11/1991	F4	HEAVY VEGETATION AND TREES IN DITCH
03-300-0035	03-300-0035-1	BT69	NONE	11/12/1991	559705	HEAVY DEBRIS AND SCUM IN THIRD CREEK, ODOR FROM SANITARY INTERCEPTOR

SHADED LINES INDICATE POTENTIAL ILLEGAL DUMPING

TABLE 5-5 (continued)
FIELD SCREENING SITES WHICH MAY
MERIT FURTHER INVESTIGATION FOR POTENIAL ILLEGAL DUMPING

SAMPLE POINT	SAMPLE ID.	GRID CELL	SAMPLE TYPE	SAMPLE DATE	CITY TOPO MAP ID.	POTENTIAL FOR ILLEGAL DUMPING/POINTS OF INTEREST
FSP-BG62A	03-300-0460-1	BG62	NONE	11/11/1991	559655	OUTFALL 03-100-0460 HAS BEEN COVERED BY ROAD WIDENING
03-300-0615	03-300-0615-1	BF57	NONE	11/11/1991	559650	PONDED WATER AROUND OUTFALL HAS OIL SHEEN AND RUST COLORED SCUM
FSP-BG54	03-300-0660-1	BG54	NONE	11/11/1991	559555	DIRT AND DEBRIS IN CURB INLETS
03-300-0675	03-300-0675-1	BG55	NONE	11/11/1991	559650	OIL SHEEN AND ALGAL GROWTH IN PONDED WATER AROUND OUTFALL
04-100-0326	04-100-0326-1	BJ52	NONE	11/13/1991	559505	OUTFALL WAS 50% BURIED, RECENT ATTEMPT WAS MADE TO CLEAN OUT.
04-300-0337	04-300-0337-1	BJ51	NONE	11/13/1991	559505	HEADWALL AND PIPE WAS 95% COVERED BY SEDIMENT (ABBANDONED ?)
04-300-0345	04-300-0345-1	BI52	NONE	11/13/1991	559505	EROSION AT HEADWALL
04-300-0375	04-300-0375-1	BH49	NONE	11/13/1991	559555	EXPOSED 12 IN LINE IN CREEK BED
05-100-0100	05-100-0100-1	BN77	NONE	12/11/1991	558855	OUTFALL DRY, LARGE PIPE CONVEYING WATERS OF U.S. WAS WET
05-100-0165	05-100-0165-1	BP75	NONE	11/19/1991	558855	36 IN OUTFALL PIPE IS UNDER ROAD
FSP-BM73	05-100-0200-1	BM73	NONE	11/19/1991	558850	COULDNT FIND ENDWALL, TENN. ASPHALT CO. STRADLES CREEK, LEAKING DRUM
05-200-0130	05-200-0130-1	BN75	NONE	11/19/1991	558855	STANDING WATER IN CHANNEL OUTFALL, YARDS FLOOD DURING HEAVY RAINS
05-300-0035	05-300-0035-1	BM74	NONE	11/19/1991	559805	6 IN PARKING LOT DRAIN PIPE WITH FLOW, HOSING DOWN EQUIPMENT IN LOT
05-300-0240	05-300-0240-1	BP72	NONE	11/19/1991	558850	BRUSH AND TREES DUMPED IN CHANNEL
05-500-0145	05-500-0145-1	BO75	NONE	11/19/1991	558855	OIL SHEEN AT CONFLUENCE OF OPEN CHANNEL W/ GOOSE CREEK
06-200-0135	06-200-0135-1	BJ78	NONE	11/19/1991	559900	CONSTRUCTION PROJECT HAS FILLED IN D/S PORTION OF OUTFALL CHANNEL
06-200-0190	06-200-0190-1	BL80	NONE	11/19/1991	559900	CHRONIC YARD FLOODING, INCOMPLETE DAM SITE DEVELOPED FOR BNKRPT G.C.
FSP-AZ80	07-100-0130-1	AZ80	NONE	11/20/1991	F9	OIL AND SCUM IN MAINSTEM OF CREEK
07-200-0005	07-200-0005-1	BC81	NONE	11/20/1991	G9	LOTS OF TRASH IN STREAM
08-200-0010	08-200-0010-1	BT79	NONE	11/19/1991	558900	SLIGHT OIL SHEEN & OIL FILTER IN KNOB CREEK
11-200-0600	11-200-0600-1	AL76	NONE	11/18/1991	C8	OIL SHEEN IN PONDED WATER
11-300-0613	11-300-0613-1	AL76	NONE	03/04/1992	B8	DIRTY STANDING WATER AT OUTFALL
13-100-0255	13-200-0255-1	AZ64	NONE	11/12/1991	F5	HEAVY VEGITATION IN THIRD CREEK
13-300-0190	13-300-0190-1	BD66	NONE	11/11/1991	G6	TRASH AND DEBRIS AROUND OUTFALL
53-200-0190	53-200-0190-1	AL85	NONE	11/26/1991	INTERGR.	STANDING WATER, NO FLOW

SHADED LINES INDICATE POTENTIAL ILLEGAL DUMPING

Table 5-4 field screening were identified as sites which might be impacted by illegal dumping. Table 5-5 lists the 16 sites and gives a description of the conditions at the screening point which would suggest that the site might be impacted by illegal dumping. During the first year of the permit, a proposed continuation of the dry weather monitoring program will be conducted at each of the 67 sites identified above. The proposed field screening program will require four additional site visits conducted by a two person field crew at each site employing the following protocols:

- Two samples will be collected within a 48 hour period with a minimum of four hours between samples.
- Two more samples will be collected during dry weather approximately one month after the first set of samples is collected.

If dry weather flows are observed, descriptive data will be recorded for color, odor, turbidity, oil sheen, and surface scum. Field analysis will also be performed using test kits for pH, chlorine, copper, phenol, detergents, ammonia and flow rate. For samples which exhibit an ammonia level which is higher than the detection limit, a sample will also be collected and taken to the KUB lab for fecal coliform analysis. Based on the recommendation of TVA water quality staff, the City is also evaluating the use of test kits procedures that will provide Presence/Absence for E-coli, since this microorganism is much more indicative of contamination by human waste. Figure 5-1 presents an example of the form which will be utilized by the field crew to record the sampling results from the on-going dry weather screening.

The proposed dry weather screening program is virtually identical to the one conducted for the Part 1 permit application with the following exceptions:

1) To assist field crews in the logistics of field sampling, the two samples at each site can be collected within a 48-hour period as opposed to the 24-hour period defined in Part 1.

FIGURE 5-1

NPDES STORMWATER PERMIT APPLICATION
FIELD SCREENING DATA FORM

DATE ________ DAY ________ TIME ________

CREW ________ WEATHER ________ PRECIP ________

TEST KIT # ________ GRID CELL # ________ TOPO MAP # ________

PHOTO ID ________ OUTFALL ID ________

SAMPLING LOCATION ________________________________

OUTFALL LOCATION ________________________________

REMARKS/
PHOTO DESCRIPTION ________________________________

DRY WEATHER FLOW OBSERVED (YES/NO) ________________

NOTE: COMPLETE BOTTOM OF DATA SHEET ONLY IF FLOW IS OBSERVED

	FIRST SAMPLE		SECOND SAMPLE	
	TIME	DATE	TIME	DATE
DESCRIPTIVE DATA	DESCRIBE	YES/NO	DESCRIBE	YES/NO
FLOW				
COLOR				
ODOR				
TURBIDITY				
OIL SHEEN				
SURFACE SCUM				
FIELD ANALYSIS	RESULT	UNITS	RESULT	UNITS
pH				
TOTAL CHLORINE				
TOTAL COPPER				
TOTAL PHENOL				
DETERGENTS				
AMONNIA				

NOTE: SIGN AND DATE ALL COMPLETED FORMS

FIELD INVESTGATOR ________________ DATE ________

REMARKS ________________________________

CDM

FIGURE 5-1 (continued)

DRY WEATHER FLOW ESTIMATE

PLAN VIEW SKETCH

SECTION VIEW SKETCH

FLOW MEASUREMENTS AND CALCULATIONS

OPEN CHANNEL

SHAPE ______
TOP WIDTH ______ ft
BOTTOM WIDTH ______ ft
FLOW DEPTH ______ ft
CROSS SECTION AREA ______ sq-ft
SPECIAL CONDITIONS ______
______
______

PIPE

SHAPE ______ (Cir,Elip)
PIPE DIMENSIONS ______ ft
MATERIAL ______ (RCP,CMP)
MANNING N ______
SLOPE ______ ft/ft
HYDRAULIC RADIUS ______ ft
FLOW DEPTH ______ ft
CROS SECTION AREA ______ sq-ft

VELOCITY MEASUREMENTS

DISTANCE ______ ft
TIME
TRIAL #1 ______ sec
TRIAL #2 ______ sec
TRIAL #3 ______ sec
AVERAGE ______ sec

FLOW VELOCITY ______ ft/sec

FLOW RATE ESTIMATE ______ cfs
ENTER ON FRONT OF FORM

OTHER NOTES/METHOD DESCRIPTION

______
______
______
______
______
______
______
______
______

CDM

2) Ammonia has been added as a sampling parameter because it is present in raw sewage and because the field test analysis can be conducted inexpensively and easily. Nessler test kits can be easily used to detect ammonia and are readily available. Since the presence of ammonia in the sample will provide an indication of the possibility of sanitary waste, a sample will be collected and taken to the KUB laboratory for fecal coliform analysis if the field test detects that ammonia is present in the dry weather discharge.

3) If the first re-inspection indicates a potential contaminant, the field crews will collect a water sample for laboratory analysis. The field test kits will be used only to confirm the absence of a pollutant. A true positive reading, (e.g., much greater than the visual detection limits) will require collection of water samples for submittal to the KUB laboratory.

This monitoring program for the sites identified in the Part 1 program will confirm or reject conclusions in the Part 1 program. Results from the proposed ongoing field screening will be recorded in the City's stormwater database. Changes in the status of an outfall should also be updated in the City's GIS database. Monitoring of these field screening points will be performed periodically after enforcement procedures until the identified problem is corrected.

<u>Investigation of New Field Screening Sites</u>

The Part 1 application identified 269 major stormwater outfalls and 704 minor stormwater outfalls within the City of Knoxville. 251 of these outfalls, virtually all major outfalls, were screened for dry weather flow. Dry weather field screening of sites which were not identified and evaluated under part 1 will continue during the term of the permit.

The existing grid system developed and utilized for the Part 1 application will be used to locate and keep track of cells for the on-going field screening program during the life of the permit. An effort was made during the Part 1 screening to locate each field screening point in a unique grid cell. New sites selected as field screening points should also be located in a unique grid cell when possible. Additionally, selection of new sites should be concentrated in commercial, industrial, and older residential areas. 36 of the 51 sites that exhibited potential for illicit connections were located in First/Whites Creek, Second Creek, and Third/East Fork Creek. New field screening sites should also be concentrated along these tributaries.

The storm event water quality data for three storm events collected by the USGS at the five monitoring stations will be analyzed for the presence of pollutants not usually associated with the land use which the monitoring station is representing. High concentrations of certain
unexpected pollutants could indicate illicit connections or improper disposal. If the evaluation of the USGS data indicates this potential, outfalls upstream of the monitoring stations will be targeted as new sites for dry weather screening.

Final selection of field screening points will be based on field inspection. Where possible, the field screening analysis will be performed at the point selected based on available map information. If the selected outfall is inaccessible, the field crews will trace back upstream along selected portions of the storm sewer system in order to locate an appropriate field screening point. If a field screening location in the selected storm sewer system cannot be found, a new storm sewer system within the same cell will be identified and the procedure re-started.

During the term of the permit, 50 to 100 field screening points will be screened and evaluated for potential illicit discharges and improper disposal each year. Each site will be inspected by a two person crew. Information about these sites will be recorded in field screening forms (see Figure 5-1) and input into the City's database. If dry weather flow is observed, only two samples will be collected during a 48-hour period with a minimum period of four hours between samples. Descriptive data will include: color, odor, turbidity, oil sheen, and surface scum; and analyses using test kits will include: pH, total chlorine, total copper, total phenol, detergents/surfactants and ammonia. If ammonia is detected in a sample, a sample will be collected for fecal coliform analysis at the KUB laboratory.

If a "new" outfall has been investigated, the City's GIS database will be updated to reflect the screening status of the new site. City maps will indicate that a site has been screened for the presence of dry weather flow and will indicate the results of that screening.

Where the results of the analyses of a new outfall indicate a potential for illicit discharges and/or improper disposal, a follow-up monitoring program will be conducted in the same manner as the dry weather monitoring program described in Section 4.1 for sites identified in Part 1. That is, two sets of two samples taken one month apart. Subsequent follow-up monitoring will be performed until the problem is corrected.

Schedule for Ongoing Field Screening Program

Re-inspection of the 67 sites identified in the Part 1 application will be performed during the first year of the permit term. Field screening activities will be performed at new sites during year two through five of the permit term. The follow-up monitoring for sites that demonstrate a potential for illicit connections and improper disposal will also be conducted concurrently during the five-year permit term.

5.3.5 INVESTIGATION OF STORM SEWER SYSTEM

Detailed investigations of the storm sewer system may be required upstream of the field screening program described in Section 4.0 to pinpoint sources of illicit discharges or improper disposal. The detailed investigation will be based on evaluation of the data from the ongoing field screening program and other information (e.g., public reporting) that the City may acquire during the term of the permit which would identify areas of the storm sewer system that would be suspected of illicit discharges or improper disposal. This element of the proposed program will serve to detect and remove these other pollution sources. Areas that have "clean" dry weather flows will not be further investigated. The program to investigate and remove illicit connections will involve targeting the sites for detailed investigation, then performing intensive field investigation upstream of the field screening point to identify the source. Details of the proposed program are presented below.

Description and Location of Targeted Outfalls

Investigations will be conducted for three categories of field screening points that have shown or may show reasonable potential of containing illicit discharges and improper disposal. They include:

Category 1	Field screening points which were identified in the Part 1 field screening program, and which exhibited dry weather discharge when reinvestigated during the on-going field screening program;
Category 2	New field screening points that exhibit dry weather flow when investigated under the field screening program described in Section 4.2; and
Category 3	New outfalls identified by public reporting of illicit discharges or water quality impacts associated with discharges from the storm sewer system.

The category 1 outfalls identified in the Part 1 field screening program (Table 5-4) are located throughout the City. Locations of outfalls from category 2 and category 3 will be determined as the program is implemented.

Procedures for Detailed Investigation of Storm Sewers

The program for the investigation of the storm sewer system has three major components, including mapping and evaluation, field surveys, and source identification. These components are described below.

Mapping and Evaluation. For each area to be investigated above a targeted outfall, a large-scale working map will be generated from the City GIS that includes the entire upstream storm sewer network highlighted, drainage area delineated, and parcel boundaries indicated. Land use information will be evaluated to determine the types of residential, commercial, and industrial areas which might contribute the type of pollution identified at the outfall.

Field screening observations and analyses will be evaluated with consideration given to the types of land uses that discharge stormwater into the sewer system above the field screening point. Commercial and industrial land uses will be targeted for these investigations. Chemical and physical properties tables published in the Assessment of Non-Storm Water Discharges into Separate Storm Drainage (EPA, 1990) and other similar sources can be used to evaluate the upstream land uses. Special attention will be given to sanitary, industrial, commercial, septic tanks, and vehicle maintenance activities as potential pollution sources.

1) Field Surveys. After performing the mapping evaluation, a manhole-by-manhole inspection will be conducted to try to pinpoint the location in the storm sewer system which is the source of the illicit discharge. This inspection requires a two person crew to go to the outfall where the polluted dry weather discharge was detected, and should be performed immediately after the dry weather field screening. The field crew will be equipped with the same testing and safety equipment used during initial dry weather screening. After confirming that dry weather flow is present at the outfall, the field crew will move to the next upstream manhole or access point. If flow is present at the next manhole, a sample will be collected and descriptive data will be recorded. Descriptive data will include: color, odor, turbidity, oil sheen, surface scum, and any other descriptive information that could help identify the type of discharge in the sample. A description and location of the manhole will be recorded as well. The field crew should evaluate any commercial/industrial facilities, residences, and other land uses in the proximity of the manhole to try to identify potential sources of illicit discharges or improper disposal. Figure 5-2 presents the field screening form to be utilized by the field crew during manhole inspections for potential illicit connections.

Once dry weather flow at the upstream manhole has been identified as containing the potential illicit discharge, the field crew will move to the next upstream manhole and repeat the procedures. In cases where there is more than one source of dry weather discharge entering a manhole, the field crew will record this information on the screening form, and then track each source separately. All sources should be tracked upstream manhole-by-manhole until the dry weather discharge is no longer detected. The field crew should identify the last manhole where dry weather flow is present and assess the potential sources in the proximity of that manhole. This data will be important for source identification.

The field crew should also determine whether there has been a change in the flow rate between one manhole and the next upstream manhole. If the flow rate appears to have decreased, an illicit connection might exist between the two manholes. If this is the case, quantitative samples will be taken at each manhole to try to determine if there has been a change in the pollutant parameters as well as the change in the flow rate. Changes in the concentration of the pollutant parameters could help confirm the presence of an illicit connection between the two manholes. The field crew should record quantitative field measurements on the field screening form presented in Figure 5-2.

2) Source Identification. Once the manhole inspection has identified the outfall area (i.e. between two manholes) and the probable type of industrial or commercial activity, sanitary, or other source has been identified, source testing will be necessary. If there is only one possible source in the area (i.e., a pipe discharging gasoline from a tank farm), source identification and follow-up for corrective action should be straightforward. Multiple sources, or non-definitive sources may require additional evaluation and testing.

For a single source, five steps will be taken to remove the illicit discharge or prevent improper disposal in to the storm sewer. These steps include: 1) sending a letter with questionnaire, 2) a site visit and interview, 3) dye tests or smoke tests if required, 4) notification of noncompliance, and 5) follow-up inspections.

Figure 5-2

NPDES STORMWATER PERMIT APPLICATION
POTENTIAL ILLICIT CONNECTION INSPECTION

GRID CELL: ____________ CREW: ____________ DATE: ____________

OUTFALL ID: ____________ WEATHER: ____________

#	DESCRIPTION	LOCATION/ ADDRESS	POSSIBLE SOURCES	COMMENTS	TIME	FLOW (Y/N)	COLOR	ODOR	TURBIDITY	OIL SHEEN	SURFACE SCUM	OTHER

Step 1 Send a notification letter to the owner/operator of the property/site suspected of discharging a source of pollution. Request that the owner/operator fill out a questionnaire that describes the activities on the site and the possible sources of non-stormwater discharge. The questionnaire will require identification of items such as: a list of hazardous substances, chemical storage practices, materials handling and disposal practices, storage tanks, types of permits and pollution prevention plans.

Step 2 Setup a meeting at the site between City inspectors and the owner/operator of the property where the pollution source is suspected. Most illicit discharges and improper disposal can probably be detected during this step. Site owners/operators will be made aware of the problem and will be encouraged to take voluntary corrective measures.

Step 3 Perform additional tests as necessary if the initial site inspection was not successful in identifying the source of the problem. Fluorometric dye tests of the plumbing fixtures and floor drains, and/or smoke tests could be used to pinpoint the source. If this step becomes necessary, the City can request the Knoxville Utility Board to assist with these tests.

Step 4 Issue of a notice of noncompliance if the owner/operator does not voluntarily initiate corrective action. This step is dependent on the enactment of a new storm sewer discharge ordinance described in Section 2. Upon notification of noncompliance, the owner will be subject to the penalties stipulated in the ordinance.

Step 5 Perform follow-up inspections to determine if corrective actions have been implemented to remove the illicit discharge or eliminate the improper disposal. This inspection will be conducted after the owner/operator has had reasonable time to assess the problem and take corrective action. Flagrant violation or disregard of the ordinance can result in daily penalties. Other measures, such as notification of TDEC and/or the news media, will also be considered.

The City's responsibility for each of these steps will vary depending on the nature of the source. If an illicit discharge or improper disposal is traced to an industrial facility who may be unaware of the problem, the City will send a letter to the facility notifying the owner or operator. Industrial facilities are responsible for obtaining either individual or group NPDES stormwater discharge permits, and responsibility for investigation and compliance belongs with the State. If the non-stormwater discharge is determined to be an illicit sanitary sewer connection to the storm sewer system, the City will notify the Knoxville Utility Board which should take action according to its current policies to correct such problems.

Under the program for residential and commercial areas, the City Service Department will have one field crew assigned full time to the maintenance and cleaning of the city's creeks and tributaries. The field crews will also be instructed on how to identify cases of improper disposal and to report these problems to the Engineering Department. If the location of illicit discharge/improper disposal is on private property, and the owner of the property is suspected of the dumping, the field crew will report this to the Engineering Department. The City will then follow the steps listed above to make the owner aware of the violation and ensure that the problem will not reoccur.

Schedule for Detailed Storm Sewer Investigations

The detailed storm sewer investigations include three major activities: mapping and evaluation, field surveys, and source identification. The schedule and level of effort required to conduct the proposed program is difficult to determine until the extent of the illicit connection/improper disposal is better defined. Furthermore, each investigation may involve a very different allocation of manpower and resources. Therefore, no formal schedule can be developed for this portion of the management plan. The detailed investigations of the potential problem areas identified under Part 1 will be initially targeted during years one and two of the permit term.

5.3.6 SPILLS RESPONSE PROGRAM

The components of the City's Spill Response program include 1) inspection and prevention and 2) spill response and cleanup. These programs are adequately handled by existing City/State programs and the City's proposed program will be limited to increasing levels of interagency coordination.

Existing Spills Response Program

The Knoxville Emergency Response Team (KERT) is a coordinated function of the Knoxville Fire Department (KFD), the Knoxville Police Department (KPD), and the Knoxville-Knox County Emergency Management Agency (KKEMA). KERT operates under the administration of the Chief of the Knoxville Fire Department and the Chief of the Knoxville Police Department.

KERT has a detailed Standard Operating Procedures Manual (SOP) which defines all protocols for emergency response. The KERT "action plan" provides for the following procedures:

1. Safety of citizens
2. Safety of emergency personnel
3. Evacuation of endangered area if necessary
4. Control of situation
5. Stabilization of material involved and/or
6. Disposal or removal of materials

All KERT personnel are trained to follow the above procedures and to meet at least the minimum State and Federal Guidelines.

KERT is equipped with adsorbents and flame retardant foams. Reserve supplies are offered by private industrial facilities. KERT is also equipped with a quick response vehicle called Emergency Response One (ER-1). This vehicle, manned by a minimum of two fully trained KFD personnel, offers swift mitigation of hazardous materials spills and rescues of victims of hazardous materials incidents. KERT is equipped with all safety equipment necessary to ensure the safety of its personnel.

Once safety has been established at a spill, KERT uses adsorbents and diversions to contain spills. Booms are used if a spill enters a stream. Once a spill is contained, the company responsible for the spill contacts one of several approved companies that dispose of hazardous materials. The company responsible for the spill negotiates a contract with the company specializing in hazardous material disposal.

The company responsible for the clean-up of the spill must send a summary report to KERT identifying actions taken to re-establish pre-spill conditions. In many instances, KUB and the State perform the required water quality sampling and testing. Samples are collected when a spill occurs, during points of spill stabilization, and after the spill has been cleaned-up. This information is used to determine the impact of the spill on the surrounding water quality environment.

Inspections Program

The federal government requires a spill prevention and control and countermeasures (SPCC) program which regulates non-transportation related facilities that may reasonably be expected to discharge oil into waters of the State. An SPCC plan must include an inspections schedule. In addition there are other programs that address facilities which may be involved with a spill. For example, OSHA regulates equipment specifications at oil storage facilities and requires periodic inspections (by OSHA) to ensure compliance of storage tanks. The U.S. Coast Guard regulates facilities capable of transferring oil in bulk from any vessel with a capacity of more than 250 barrels (approximately 10,500 gallons). Inspections of these facilities are performed annually. The EPA Office of Underground Storage Tanks requires inspections of underground storage tanks.

Due to resource limitations, the City of Knoxville is not proposing any enhancements to the existing spill prevention and inspection program beyond increased levels of coordination and communication between City departments and with state and federal agencies. KERT shall provide the City Engineering Department with information on any spills that have occurred that could affect the city's storm sewer system. The Engineering Department will assess this information and assess what impact the spill will have on the other programs defined under the NPDES stormwater permit (i.e. stream flow monitoring, source identification, etc.).

5.3.7 REPORTING OF ILLICIT DISCHARGES AND WATER QUALITY IMPACTS

Public Education Programs

The City of Knoxville has sponsored or co-sponsored a number of excellent programs to educate the public on environmental issues that relate to water quality and ways to protect it. The Knoxville Department of Policy Development and Human Resources developed a brochure entitled "Knoxville's Waterfront: Environmental Initiatives". This brochure was distributed to businesses and residential households that own property along the lakes and rivers within the city and includes descriptions of programs that address water quality. Among these programs is the Water Quality Forum, the River Rescue Coalition, the Knoxville Area High School Environmental Conference, and the Knoxville Greenways and Community Trails Commission.

> Water Quality Forum: A cooperative network of representatives from organizations and agencies charged with monitoring and regulating regional water quality. Includes City staff (Policy Development, Engineering, Law), Knox County Health Department, TVA, University of Tennessee, East Tennessee Development District, TDEC, Knoxville-Knox County Metropolitan Planning Commission, U.S. Coast Guard, Tennessee Emergency Management Agency, Knoxville-Knox County Emergency Management Agency, US SCS, Tennessee Wildlife Resources Agency, and USGS.
>
> River Rescue Coalition: Community volunteers organized by the "Festival on the River" to clean up the banks of the Lake Loudoun reservoir and it's tributaries. The objective is to educate and stimulate community awareness of pollution sources and prevention.

Regional High School Environmental Conference: Involves high school students in the design and implementation of projects that enhance the environment and foster environmental responsibility. Informs students of various opportunities available to respond to environmental problems.

Knoxville Greenways and Community Trails Commission: Reviews existing plans related to greenways, is creating a plan for an overall greenway system, especially along selected stream corridors including, Third Creek, First Creek, North River, Ten Mile Creek, and Love's Creek.

Public education is a major element of all of these programs which promote awareness and responsiveness to the environmental needs of the city, particularly recognition of the importance of City's waterways. These programs will increase the level of community action, public and private support, and will facilitate progress towards cleaning the City's creeks and rivers.

The City also co-sponsors Clean Water Week during which representatives meet with school children to show them how pollution affects the streams around them. This usually involves a boat trip or stream walk to show children the effects of pollution on water quality. Field trips of this type help children develop an awareness and understanding of the importance of controlling pollution. The City is also developing an "Adopt-A-Creek" program to involve citizens in cleanup and restoration of the City's creeks.

Existing Reporting Programs

Drainage complaints and reporting of spill incidents and other polluting activities are referred to the Engineering Department. An inspector in the Engineering Department Civil Engineering Division currently handles all drainage (flooding) complaints. Polluting activities (water quality) are referred to an Inspector in the Engineering Department Planning and Technical Services Division. There is currently no systematic method for reporting the presence of illicit discharges and other related water quality problems and there is only limited interaction between the flooding and water quality complaint response.

The Knoxville office of the Federal Bureau of Investigation (FBI) and the Eastern (Tennessee) District of the United States Attorney's Office have established an environmental hotline, which is designed for the reporting of environmental crimes. Tips from the hotline, a toll-free "800" number, are immediately followed up, and the FBI fully investigates the situation if there is evidence of environmental crimes. The intent of this program is for the FBI to take a more active role in the enforcement of environmental laws and to encourage public participation in the reduction of environmental crimes.

Proposed Public Information Program

During the term of the permit, the City of Knoxville proposes to establish and publicize a separate "Hot-Line" telephone number that citizens can call to report instances of illicit discharges and improper disposal. A member of the Engineering Department will be responsible for monitoring the hotline and coordinating with other proposed programs (i.e. source identification, long-term water quality monitoring). Calls will be recorded with an answering machine 24-hours a day. The recording will identify a City contact person.

The City will continue to be a co-sponsor with organizers of various water quality programs, such as the River Rescue, to ensure that public reporting is encouraged in each of the programs. The City will ensure that the hotline phone number is included in brochures and leaflets produced by the water quality programs. Educational literature and the hotline phone number will also be inserted into utility bills mailed by KUB. Public service announcements (PSAs) which identify practices that are considered illicit and/or improper (i.e. dumping used oil) should be produced for the local media. These PSAs will also identify the hotline phone number. The goal of all these educational programs should be to make each citizen aware of his/her own responsibility to assure clean water in the city.

5.3.8 MANAGEMENT AND DISPOSAL OF USED OIL AND TOXIC MATERIALS

Existing Used Oil Toxic Materials Program

The City of Knoxville does not currently operate a used oil/household hazardous waste disposal program. Used oil, antifreeze, and used batteries are accepted from the public at several local gas stations and WalMart stores. There are also several private firms located in the City that collect and recycle larger quantities of used oil from industrial facilities. The City uses one of these companies for oil disposal for City-owned vehicles and equipment. The City also operates a tire shredder which accepts used tires from the public. Shredded tires are currently disposed of in a municipal landfill. A one-day collection program for household and commercial hazardous waste materials was held in 1991 by TVA and a private industry (Rohm & Haas).

Proposed Used Oil and Toxic Materials Program

During the term of the permit, the City Office of Solid Waste will be developing a program which encourages the proper disposal of used oils and toxic materials by the public. Elements of this program will include drop-off recycling centers located in convenient locations throughout the City, educational brochures to be mailed with utility bills, public service announcements promoted through the local media, and telephone numbers of agencies to contact for further information.

The Office of Solid Waste is responsible for implementation and coordination of the recycling program. The City Engineering Department will periodically meet with the Office of Solid Waste to keep apprized of development of the program and any changes to the program during the term of the permit.

The City has applied for a State grant which would provide funds for construction of a facility to collect household hazardous waste. The State Solid Waste Act provides $1 million to be allocated between each of the four major cities in Tennessee. Grant funds for only one facility will be available per budget cycle, therefore it will require four years to construct HHW facilities in all four cities.

Schedule for Used Oil and Toxic Material Program

The City is co-sponsoring a Household Toxics Roundup on May 8, 1993. Other sponsors of the Roundup include the Knoxville News-Sentinel and TVA. Various other private industries and organizations are providing services or financial support. The Roundup will provide the public with an opportunity to safely dispose of unwanted items that otherwise might be disposed of in trash, sanitary sewers, or by improper disposal (dumping). The Roundup will accept the following materials:

- Automobile Products — antifreeze, auto batteries, transmission /brake fluid, used motor oil,
- Household Products — Ammonia based cleaners, cleaners containing bleach, disinfectants, drain cleaners, floor and furniture polishes, household batteries, mothballs, oven cleaners, photographic chemicals, poll chemicals, rug and upholstery cleaners, scouring powders, and toilet cleaners,
- Paint Products — Furniture stripper, paint (latex or oil-based), paint thinner, wood preservative or stains,
- Pesticides — Insecticides, fungicides, herbicides, pet flea collars/soaps/sprays, roach or ant killers.

Construction of a permanent facility for Household Hazardous Waste Collection is contingent on State Grant Funds. It is anticipated that construction of an HHW collection site will be complete within one year after these funds are granted and that the HHW collection program will be implemented thereafter.

5.3.9 CONTROL PROGRAM TO LIMIT INFILTRATION FROM SANITARY SEWERS

Existing Sanitary Sewer Program

The Knoxville Utility Board (KUB) has operated the sanitary sewer system within the City of Knoxville since 1987. KUB has taken a two-pronged approach to limit exfiltration from sanitary sewers by 1) a monitoring program along the major streams to identify existing problem areas, and 2) ensuring that all new construction meets design criteria. KUB requires quality assurance tests on all sanitary sewer mains, laterals, and manholes. All new sewer line and manhole construction is air tested by the contractor. A KUB inspector witnesses the air test and furnishes required meters and gauges. The contractor is required to provide material and equipment to set up the air test (e.g., air compressors, blowers). KUB provides specific guidance on allowable pressure drops in accordance with ASTM C-828. If the sanitary sewer does not pass the air test, the leak must be located, corrected and the line re-tested. KUB also requires vacuum testing of manholes immediately after installation. Manholes that do not pass the vacuum test must be repaired by digging around the outside as well as sealing the leaks from the inside. KUB also requires a final visual inspection of sanitary sewer lines and manholes to identify and correct any broken or cracked pipe.

Proposed Sanitary Sewer Program

KUB is currently having a sanitary sewer system rehabilitation study performed by an outside engineering consultant. The study recommendations will be completed by July 1993. The sewer system study will identify system deficiencies and will recommend and prioritize capital improvements to the sanitary sewer system.

5.3.10 STAFFING REQUIREMENTS

The staffing requirements to implement the City's management program for illicit connections and improper disposal are presented in Table 5-3. The Engineering Department Planning and Technical Services Division will add one new Engineering Technician II to assist the existing Field Inspector (Engineering Technician III). The existing Field Inspector will spend approximately 50% of his time on this program. The Field Inspector has been deputized and has authority to issue notices of violation and other actions as required to enforce City ordinances. The new Engineering Technician II will spend approximately one third of his/her time on the illicit connection program. A new staff position within the Engineering Department Planning and Technical Services Division will include a Stormwater Engineer who will spend approximately 20% of his/her time supervising the field operations and reviewing and reporting on field screening results.

5.4 MANAGEMENT PROGRAM FOR INDUSTRIAL FACILITIES

5.4.1 INTRODUCTION

The stormwater regulations target certain industrial facilities as potentially discharging significant pollutant loads into the storm sewer system of the City of Knoxville. Although many industries are already covered by monitoring, reporting and inspection requirements of their own individual or general NPDES stormwater permits, the City recognizes the importance of identifying potential impacts from industries discharging stormwater to the City's municipal separate storm sewer system. The City proposes to increase coordination with the Tennessee Department of Environmental Conservation (TDEC), the Knoxville Utilities Board (KUB), and industries which have applied for NPDES storm water permits. The City proposes to review the inspection and monitoring programs implemented by individual industries or as part of KUB's pretreatment program and to identify discharges associated with industrial activities through other programs proposed under the City's Part 2 NPDES stormwater permit application. The City will maintain a database of information relating to discharges of stormwater from industrial facilities. The City's proposed program will not require full time dedication of existing or additional staff members, but a portion of their time will be required for the program described herein. Responsibility for this program will belong with the Knoxville Engineering Department Planning and Technical Services Division. Table 5-6 presents an overall summary of the proposed management program for industrial facilities, including an implementation schedule, estimated costs, staffing requirements and City departments involved.

5.4.2 REGULATORY REQUIREMENTS

The Part 2 NPDES stormwater regulations require inclusion of the following programs in the permit application [40 CFR 122.26 (d)(2)(iv)(D)]:

> *"A description of a program to monitor and control pollutants in storm water discharges to municipal systems from municipal landfills, hazardous waste treatment, disposal and recovery facilities, industrial facilities that are subject to section 313 of title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), and industrial facilities that the municipal permit applicant determines are contributing a substantial pollutant loading to the municipal storm sewer system. The program shall:*
>
> *(1) Identify priorities and procedures for inspections and establishing and implementing control measures for such discharges;*
>
> *(2) Describe a monitoring program for storm water discharges associated with the industrial facilities identified in paragraph (d)(2)(iv)(C) of this section, to be implemented during the term of the permit, including the submission of quantitative data on the following constituents: any pollutants limited in effluent guidelines subcategories, where applicable; any pollutant listed in an existing NPDES permit for a facility; oil and grease; COD, pH, BOD_5, TOSS, total phosphorus, total Kjeldahl nitrogen, nitrate plus nitrite nitrogen, and any information on discharges required under 40 CFR 122.21 (g)(7)(iii) and (iv)."*

Table 5-6

SUMMARY OF PROPOSED INDUSTRIAL FACILITIES MANAGEMENT PROGRAM

Element	Component	Schedule Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
(1) Ordinance	Develop new City Ordinance prohibiting non-stormwater discharges.	Partial	Full			
	Implement new Stormwater Ordinance.	Partial	Full	Full	Full	Full
(2) Inspection Element	Collect and analyze NOIs from Industrial Permit applicants.	Full				
	Collect and analyze KUB inspection reports. Assess impact to storm sewer system.	Partial	Full	Full	Full	Full
	Identify potential industrial discharges through Illicit Connection and Improper Disposal Program.	Partial	Full	Full	Full	Full
	Develop inspection program as part of PPPs for municipal industrial facilities (KTRANS, others).	Partial	Full	Full	Full	Full
(3) Monitoring Element	Collect monitoring data from industrial storm water dischargers. Assess impacts to storm sewer system.		Partial	Full	Full	Full
	Analyze results from ongoing monitoring program. Identify industrial pollutants and cross-reference land use information to identify industrial sources.	Partial	Full	Full	Full	Full
	Manage and conduct monitoring program at municipal industrial facilities (KTRANS, others)	Partial	Full	Full	Full	Full

Partial Implementation

Full Implementation

Staffing Requirements	Position	Percent of Workload Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
	Chief Engineer	2%	2%	2%	2%	2%
	Stormwater Engineer	21%	21%	21%	21%	21%
	Technician III	10%	10%	10%	10%	10%
	Technician II	4%	4%	4%	4%	4%

Responsible City Department		
	Primary Responsibility:	Engineering Department/Planning and Technical Services Division
	Supporting Departments:	Law Dept.
	Other Agencies:	TDEC, KUB

Estimated Cost ($1,000 per year)	Program Element	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
	(1) Inspection Element	$7.4	$7.6	$7.9	$8.1	$8.3	$39.3
	(2) Monitoring Element	$6.7	$6.9	$7.1	$7.3	$7.5	$35.6
	Total	$14.1	$14.5	$15.0	$15.4	$15.9	$74.9

The City of Knoxville does not own any operating or closed landfills, or any facilities subject to SARA regulations. The objective of this section is to describe the City's existing efforts and proposed enhancements to the program that address the two elements specified by the NPDES regulations.

5.4.3 INSPECTION PRIORITIES AND PROCEDURES

Inspection protocols under the City's industrial facilities management program will include increased coordination with industries, TDEC, and the Knoxville Utilities Board (KUB) as well as coordination with other management programs proposed under the City's NPDES stormwater permit application as described below.

Existing Inspection Procedures

Inspections of industrial facilities are currently performed by KUB inspectors as part of the pretreatment program. KUB inspectors currently inspect approximately 2,000 commercial and industrial facilities per year for backflow preventor operation, approximately 1,700 facilities per year for fire protection, 35 large clients which have industrial discharge permits, and about 100 customers whose discharge to the wastewater sewer system contains high levels of BOD_5.

Industrial permit holders are subject to complete facility inspections annually. KUB personnel visit the industrial facility equipped with an industrial compliance inspection checklist. This checklist is presented in Figure 5-3. Some items on the checklist address impacts of potential contamination of storm sewer runoff from the industrial sites. These items include a description of facility spill control plans/procedures (item 19), identification of priority pollutants used at the facility (item 24), and location of plumbing fixtures (floor drains, etc.) in the facility (item 26).

Figure 5-3

INDUSTRIAL COMPLIANCE INSPECTION

1.) Date:__________ Time__________

2.) Company Name:______________________________

3.) Address:______________________________

4.) Contact Official:______________________________

5.) Authority Interviewed:______________________________

6.) Telephone No.:______________________________

7.) Type of Industry:______________________________

8.) SIC Code:______________________________

9.) Water Source:
KUB: __________GPD Acc. No.__________
Well: __________GPD
Other: __________GPD

10.) Sewage Volume:__________GPD

11.) Hours of Operation:______________________________

12.) Are the pretreatment facilities being properly operated and maintained?

13.) Are there any flows diluting the process flow?

14.) To what degree is Q.C. maintained with respect to conformance to established procedures in obtaining:
a.) samples

b.) flows

c.) analysis

d.) instrument calibration

e.) records, pH charts, etc.

15.) Does this plant split samples with WWCS?

16.) Who hauls the process generated solid waste?

Figure 5-3

17.) Where does this solid waste go?

18.) Scavengers for grease, etc?

19.) Describe spill control plans/procedure.

20.) Surface area of production (sq-m, sq-yds, sq-ft)______ or amount produced (kkg, 1000 lbs, cu-m, cu-yds,cu-ft)________ __________.

21.) If metal plating, how often is cleaning solution, bath, etc. changed?

22.) Are the facility's process wastewaters segregated such that only process wastes are sampled?

23.) If metal plating does the company own the products it plates?

24.) Chemicals Used

a.) In Process:

b.) In Maintenance:

c.) Priority Pollutants:

25.) Follow-up compliance activities:

Figure 5-3

26.) DESCRIPTION OF PROCESS DIAGRAM:
Please include the location of:

a.) water meter(s)
b.) sampling point(s)
c.) sewer tap(s)
d.) pretreatment system
e.) plumbing fixtures (floor drains, etc.)

27.) DESCRIPTION OF PROCESS NARRATIVE:

28.) ______________________________
INSPECTOR'S SIGNATURE

As part of the inspections, KUB inspectors also try to identify obvious cases where runoff from industrial facilities could impact the stormwater quality, such as floor drains on loading docks which drain to creeks, or outdoor storage of chemicals or hazardous materials. KUB performs dye tests at facilities which are suspected of having improper connections to the storm sewer system.

Proposed Inspection Procedures

The City's proposed inspection program for industrial facilities will focus on increasing the level of coordination between industries, TDEC, KUB, and the City to target facilities that are suspected of discharging pollutants to the municipal separate storm sewer system. The City is not proposing to perform on-site facility inspections because of resource limitations and because this would duplicate much of the facility inspection currently being performed by TDEC and KUB. Storm sewer inspections described in the proposed illicit connections and improper disposal management program in the City's Part 2 NPDES stormwater permit application will be the primary tool for assisting the City to identify discharges from industrial facilities. The City will also be responsible for preparation and monitoring requirements of the NPDES stormwater discharge permits for municipal industrial facilities (i.e. KTRANS).

Under the stormwater regulations, industrial facilities, as defined in 40 CFR 122.26(b)(14), must obtain NPDES permits directly from the TDEC. These regulations require that facilities discharging to Knoxville's municipal storm sewer system must also notify the operator (Chief Engineer) of Knoxville's system. The City proposes to coordinate with TDEC and the industrial facilities to ensure that all Notices of Intent (NOIs) have been submitted to the City. The City will review these notices and evaluate the potential impact of stormwater runoff to the municipal storm sewer system. As part of the permit requirements, an industrial facility may be required to develop a Pollution Prevention Plan (PPP) to ensure that pollutants are not entering the storm sewer system. Upon review of an NOI, if the City determines that additional information is needed, the City may require that the industry also submit a copy of the PPP to the Chief Engineer. The City will maintain these data in the industrial database.

Part of KUB's inspectors current pretreatment program includes inspecting a large number of facilities which may not be included in the state industrial stormwater requirements. Under the City's proposed program, KUB has agreed to include a stormwater checklist as part of the pretreatment checklist. This stormwater checklist will include items addressing potential pollutant contamination of runoff to the storm sewer system. The proposed stormwater checklist is presented in Figure 5-4. The first question on this checklist asks if the facility is currently operating under or applying for an NPDES stormwater discharge permit. If the answer is affirmative, the inspector will note the NPDES permit number, and no other information will be required. If the answer is negative, the inspector will continue to address the items on the checklist.

Items on the Industrial Stormwater Facility Checklist include descriptions of materials stored with potential exposure to stormwater runoff; descriptions of stormwater control measures; descriptions of the locations and the nature of activities which could cause exposure of pollutants to stormwater; and a description of the spill history at the facility. Most of these questions can be completed by an authorized facility employee (i.e. plant manager). KUB may require that this checklist be completed by an authorized facility employee at the time of the inspection with instructions to transmit the completed checklist directly to the Knoxville Engineering Department.

The KUB will transmit inspection schedules and provide the City with copies of the completed inspection checklists. The City will review and evaluate these forms to assess the potential impact of stormwater runoff from the facilities. If the City determines that a certain facility is a potential source, the illicit connection/improper disposal field monitoring activities will target outfalls receiving these discharges. The City will maintain the inspection results in the industrial database.

Figure 5-4

INDUSTRIAL STORMWATER FACILITY INSPECTION CHECKLIST

1.) Is this facility currently covered under an NPDES Storm Water Discharge Permit?
Y? __ N?

2.) If Yes, what is the permit number? ____________ Sign and submit form.
If No, Continue with questionnaire.

3.) Where does the stormwater runoff discharge from this facility?
Draw schematic on back.

4.) Describe any significant materials (fuel, chemicals, fertilizers, etc.) stored outside exposed to rainfall.

5.) Describe any control measures established to contain stormwater exposed to these materials, such as flow diversions, detention ponds, sediment traps, etc.

6.) Describe locations and activities that could cause exposure of pollutants to stormwater runoff (loading docks, fueling stations, maintenance areas, dumps, etc.)

Location	Activity

7.) Describe any spills or leaks in the last three years.

8.) ________________________________ ______________

Signed Date Title

The proposed illicit connection and improper disposal program defined under the City's Part 2 NPDES stormwater permit application will also address runoff from industrial facilities. Illicit connections or improper disposal from industrial facilities which are discovered while inspecting the storm sewer system under this program will be recorded in the facilities' file in the database. This City will contact the TDEC, KUB and/or industrial facility directly to identify the problem. Enforcement of corrective action may vary depending on the nature of the discharge. For example, the KUB is responsible for industrial facilities with illicit sanitary sewer connections, and the TDEC is responsible for facilities with NPDES storm water permits.

The City will develop the Pollution Prevention Plan (PPP) for the City's municipal industrial facilities (i.e. KTRANS, others). The PPP will be developed in conjunction with KTRANS staff as part of the responsibilities of the new Stormwater Engineer and will be completed in accordance to the rules promulgated in the Tennessee Baseline General Permit for Storm Water Discharges Associated with Industrial Activity (Dept. Rule 1200-4-10-.04). The TDEC will be responsible for the approval of the Pollution Prevention Plans of the City's municipal industrial facilities.

Schedule for Inspection Program

Collection, review, and evaluation of all NOIs will be completed in the first year of the permit term. Evaluation of stormwater inspection checklists compiled by KUB and any PPPs will begin in the second year of the permit, and continue for the duration of the permit term. Development and management of the municipal industrial facilities PPPs will begin in the first year of the permit and will continue for the duration of the permit term. Staff required to implement this plan will be hired during FY93 and FY94. (Staff will also work on other programs defined in the NPDES permit application.)

5.4.4 DESCRIPTION OF MONITORING PROGRAM

The City's monitoring program for industrial facilities will rely primarily on data collected by TDEC, KUB, and on self-monitoring by industrial facilities. The City is not proposing to monitor stormwater discharges from individual facilities. Areas of industrial land use (e.g. industrial parks) will be included in the sites selected for the Ongoing Monitoring Program defined in the City's Part 2 NPDES stormwater permit application. In addition, the City will manage and perform the annual monitoring requirements for the City's municipal industrial facilities (KTRANS, others,).

Existing Monitoring Program

There are no existing programs established by the City of Knoxville for monitoring storm water runoff from industrial facilities located within the City.

Proposed Monitoring Program

As part of the NPDES Permit for stormwater discharges associated with industrial activity, applicants are required to monitor, at least annually, all stormwater outfalls identified on the facilities' Pollution Prevention Plans. Applicants must monitor in accordance with TDEC Rule 1200-4-10-.04. The City will obtain the results of the industrial outfall self-monitoring either from TDEC or directly from the industrial discharger. The City will maintain this information in the City's industrial database, and will assess the impact of the monitored discharges on the water quality of the storm sewer system on an annual basis. If the City determines that additional data needs to be provided in the monitoring program (reports on additional parameters, etc.), requirements for an expanded program for subsequent monitoring events will be coordinated with TDEC and the industrial discharger. The City is not proposing to perform storm event monitoring for individual industrial facilities.

The City's Ongoing Monitoring Program defined in the Part 2 NPDES stormwater permit application will include the monitoring of stormwater runoff from areas of industrial facilities (e.g. industrial parks). Stormwater samples will be collected and analyzed for 12 to 15 storms at three to five sites under this program. These sites typically will drain large areas that will include more than one industrial facility. Data from these samples will be evaluated, along with land use information for the individual drainage areas. The presence of pollutants typically associated with industrial activities could indicate contamination of stormwater runoff from industrial facilities. The City will evaluate this information and will target additional dry weather field screening to identify potential sources of the pollutants. This data will be compared to data collected from the industrial facilities to assist in the identification of the pollutant source.

The City will also monitor stormwater runoff from the municipal industrial facilities (KTRA-NS, others) from outfalls defined in their Pollution Prevention Plans and as described in the Tennessee Baseline Rule. The monitoring program will be subject to approval by the TDEC and results will be sent to the TDEC and kept in the City's industrial database. Monitoring at these facilities will be conducted by Engineering Technicians from the Knoxville Engineering Department Planning and Technical Services Division.

Schedule for Monitoring Program

The City will collect and analyze the monitoring data from the industrial facilities as it becomes available. This will likely begin in the second year of the permit, and will continue for the duration of the permit term. Analysis for industrial impacts on the monitoring data from the City's ongoing monitoring program will begin during the first year of the permit term and will continue for the duration of the permit. The monitoring program for the municipal industrial facilities (KTRANS, others) will be developed during the first year of the permit. Monitoring will be conducted during the second year of the permit and will be conducted annually for the duration of the permit term.

5.5 MANAGEMENT PROGRAM FOR CONSTRUCTION SITES

5.5.1 INTRODUCTION

The control of runoff from construction sites is an important component of the City's NPDES stormwater management program. The City of Knoxville recognizes that effective erosion and sediment (E&S) control can significantly reduce the amount of pollution runoff from construction sites. The City proposes to significantly enhance their existing E&S control program by incorporating the requirements of the Tennessee Erosion and Sediment Control Manual, and the Tennessee General Permit for Stormwater Discharges Associated with Construction Activity. The City also proposes to increase staffing for plan review and site inspections. Table 5-7 presents an overall summary of the proposed management program for construction sites, implementation schedule, estimated costs, staffing requirements and City departments.

5.5.2 REGULATORY REQUIREMENTS

The Part 2 NPDES stormwater regulations require inclusion of the following programs in the permit application [40 CFR 122.26 (d)(2)(iv)(D)]:

> *"A description of a program to implement and maintain structural and non-structural best management practices to reduce pollutants in storm water runoff from construction sites to the municipal storm sewer system which shall include:*
>
> *(1) A description of a procedures for site planning which incorporate consideration of potential water quality impacts;*
>
> *(2) A description of requirements for nonstructural and structural best management practices;*

Table 5-7

SUMMARY OF
PROPOSED CONSTRUCTION SITE MANAGEMENT PROGRAM

Element	Component	Schedule Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
(1) Site Planning	Revise City Ordinance to require construction sites >10,000 ft^2 to submit E&S Control Plans	Partial	Full			
	Require site plans submittals per Tennessee E&S Control Handbook		Partial	Full	Full	Full
	Develop minimum criteria for plan review and checklists		Partial	Full		
	Provide training for City plan review staff	Partial	Full	Full	Full	Full
(2) BMP Requirements	Require Construction BMPs from Tennessee E&S Control Handbook	Partial	Full	Full	Full	Full
	Evaluate additional BMP requirements and design modifications	Partial	Partial	Partial	Full	Full
	Construction site "good housekeeping" Practices	Partial	Partial	Full	Full	Full
(3) Inspection/ Enforcement	Expand inspections to include smaller construction sites (single family)	Partial	Partial	Full	Full	Full
	Implement scheduled site inspections : rough grading, E&S control installation, final grading, final stabilization	Partial	Full	Full	Full	Full
	Increase penalties for violations to: $5,000 or 30 days	Partial	Partial	Full	Full	Full
(4) Training Programs	Cosponsor E&S Control Practice Seminars for City staff, developers, contractors		Full	Full	Full	Full
	Evaluate training materials from other jurisdictions	Partial	Partial	Full	Full	Full

Partial Implementation
Full Implementation

Staffing Requirements	Position	Percent of Workload Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
	Chief Engineer	9%	9%	9%	9%	9%
	Stormwater Engineer	14%	14%	14%	14%	14%
	Technician III	100%	100%	100%	100%	100%
	(2) Technician II	100%	100%	100%	100%	100%

Responsible City Department		
	Primary Responsibility:	Engineering Department/Planning and Technical Services Division
	Supporting Departments:	Law Dept., Public Information
	Other Agencies:	TDEC, TDOT, TVA

Estimated Cost ($1,000 per year)	Program Element	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
	(1) Site Planning	$10.1	$10.4	$10.7	$11.0	$11.4	$53.6
	(2) BMP Requirements	$4.7	$4.8	$4.9	$5.1	$5.2	$24.7
	(3) Inspection/Enforcement	$77.9	$80.2	$82.6	$85.1	$87.7	$413.6
	(4) Education and Training	$2.7	$2.8	$2.9	$3.0	$3.1	$14.4
	Total	$95.4	$98.2	$101.2	$104.2	$107.4	$506.4

(3) *A description of procedures for identifying priorities for inspecting sites and enforcing control measures which consider the nature of the construction activity, topography, and the characteristics of soils and receiving water quality; and*

(4) *A description of appropriate educational and training measures for construction site operators.*

The City of Knoxville currently requires that plans be submitted by developers which describe pollution prevention procedures for certain categories of construction sites. The objective of this section is to describe the City's current Erosion and Sediment Control program and proposed enhancements to the current program that address the four elements specified by the NPDES regulations.

5.5.3 PROCEDURES FOR SITE PLANNING

The City's proposed erosion and sediment control program will require changes in the plan submittal requirements and plan review procedures to provide for additional erosion and sediment controls from new development or major redevelopment areas as described below.

Existing Site Planning Procedures

A program to control erosion and sediment from construction sites is established in the Code of the City of Knoxville, City Code Section 19-162 entitled "Alteration of Existing or Natural Drainage; Grading Permit Required." In order to obtain a grading permit to perform construction activities within the City of Knoxville, plans must be submitted for review and approval by the Knoxville Engineering Department Planning and Technical Services Division. These plans must specify measures to control soil erosion during and after site grading on the site as well as other adjacent or affected properties. The City of Knoxville Engineering Department Planning and Technical Services Division currently requires a Sediment and Drainage Control Plan for large construction projects.

Design of erosion controls for public works projects and public road construction is performed by the Civil Engineering Division of the Engineering Department. Site planning and design for most medium sized and small public works projects is performed by the Civil Engineering Division. Site planning and design of large public works projects is typically performed by engineering consultants.

Prior to plan submittal, the Inspector from the Planning and Technical Services Division typically meets with developers and contractors to determine what will be required to complete a project according to City standards. The inspector considers the nature of the site and the topography and advises the applicant on what control measures would be necessary to minimize the impact of erosion and siltation from construction stormwater runoff. An erosion and sedimentation control plan is then submitted for approval by the Engineering Department Planning and Technical Services Division. Currently the City does <u>not</u> require submittal of an erosion and sediment control plan for the following:

1. Sites less than one acre for road, commercial, industrial, educational, institutional, and recreational projects;
2. Sites less than two acres for multi-family residential developments;
3. Sites less than five acres and/or five lots for single family residential developments.

Plans must be submitted and approved before construction can begin and plans must be stamped with the following notice:

> "Adequate erosion and sediment control measures must be maintained by contractor during and after construction.
>
> REFERENCE: Erosion and Sediment Control Handbook, Knox County Soil Conservation District"

Currently performance bonds are only required for large construction sites or where the Planning and Technical Services Department deems that there is a significant risk for erosion and sedimentation problems.

Proposed Site Planning Procedures

Under the City's proposed construction site planning program the major requirements of the revised City ordinance addressing erosion and sediment control will be expanded to include:

1) All developments involving a land disturbance of 10,000 sq-ft or more will be required to submit an Erosion and Sediment Control Plan for review and approval by the City;

2) All new developments not specifically exempted will be required to meet erosion control requirements (even if E&S Control Plan submittal is not required);

3) Certification that all land clearing, grading, and construction will be performed as required by approved E&S Control Plans;

Residential construction on single lots has generated complaints resulting from poor erosion and sediment control practices in the past. This primarily results from "infill" residential development on single lots within existing neighborhoods. To address these problems, the City proposes to apply E&S control requirements for all construction sites greater then 10,000 sq ft. Erosion and sediment control plans would also be required for steeply sloping sites (greater than seven percent grade), and sites in close proximity to, or crossing, perennial streams (Waters of the State).

The City's proposed erosion and sediment control plan requirements will be initially based on the State of Tennessee Erosion and Sediment Control Handbook (1990). The State handbook establishes minimum requirements for submittal of narrative information as well as E&S

control plans. The specific requirements for an Erosion and Sediment Control Plan as described in the State Handbook are as follows:

I. Narrative erosion and sediment control plans shall include:

1. Project description
2. Name of adjacent waterbody
3 Soil type, topographic, vegetative, and drainage pattern
4. Construction and maintenance schedules
5. Erosion and sediment control structure
6. Calculations for runoff estimation and sizes of sediment basins and traps

II Site plan for erosion and sedimentation control shall include:

1. Vicinity map showing the boundaries of the project
2. Existing contour and final contour
3. Existing vegetation and vegetation after clearing
4. Marked areas of critical erosion
5. Marked locations of erosion and sediment control structures
6. Detailed drawing of all control measures
7. Detailed construction notes and maintenance schedule for all erosion and sediment controls.

The State Handbook also provides a checklist for review of Erosion and Sediment Control Plans. The State Handbook does not appear to provide sufficient guidance regarding many aspects of site planning for erosion and sediment control for City plan reviewers to decide what is required in an approved Erosion and Sediment Control Plan. The City will develop a list of minimum criteria to be applied to the State checklist for various categories of sites (residential, commercial, etc.). These criteria will used by City staff involved in the plan review process and would ensure consistency in the plan review process.

The City will also provide opportunities for training staff involved with construction site plan review and inspections. Training may include short courses, videos, and outside seminars and will be coordinated with the education element of the proposed program described below. Tennessee has no certification program for Erosion and Sediment Control technicians. Therefore, City staff performing site plan review and field inspections will be required to achieve a minimum level of technical expertise through a combination of experience and training. During construction, actual field conditions may develop where revisions to an approved plan are required. In these cases field inspector(s) with sufficient technical expertise shall have the authority to approve necessary on-site revisions and a copy of these changes will be documented in the project file. Construction site plan reviewers will also provide technical assistance with applications for waivers, appeals, and variances.

Schedule for Revisions to Site Planning Requirements

City Ordinances will be revised to include the expanded site plan submittal requirements and minimum criteria during the first and second year of the permit term. The requirements for E&S controls as part of site planning will be fully implemented during years three to five of the permit term. Revisions and refinements to the site planning process will be an ongoing process. Staff required to implement the construction site planning requirements will be hired during FY93 and FY94.

5.5.4 DESCRIPTION OF BEST MANAGEMENT PRACTICES

Existing BMP Requirements

The Knoxville Engineering Department currently stamps grading plans with a reference to the Knox County Soil Conservation District "Erosion and Sediment Control Handbook" (1981). This handbook currently provides the City standards and specifications for twenty (20) erosion and sediment control BMPs:

1) Permanent Cover - Ky 31 Fescue Seeding
2) Permanent Cover - Crownvetch and Ky 31 Fescue Seeding
3) Permanent Cover - Sericea Lespedeza and Ky 31 Fescue Seeding
4) Permanent Cover - Bermuda Grass and Annual Lespedeza Seeding
5) Permanent Cover - Ky 31 Fescue, Bermudagrass, and Bluegrass Sodding
6) Permanent Cover - Tree Planting
7) Permanent Cover - Ky 31 Fescue Seeding

8) Temporary Cover - Browntopmillet
9) Temporary Cover - Annual Ryegrass
10) Temporary Cover - Mulch Only
11) Grade Stabilization Structure - Urban Areas
12) Diversions - Urban Areas
13) Grassed Waterways or Outlet - Urban Areas
14) Use of Fibrous Netting Material for Erosion Control - Urban Areas
15) Land Grading - Urban Areas
16) Drain - Urban Areas
17) Debris Basin - Urban Areas
18) Sediment Control Measure - Dike
19) Urban Stream Bank Protection
20) Urban Gutter Drain - Sediment Barrier

For each BMP Standard, the Knox County Handbook provides the following information to assist with applications:

- Definition of the practice
- Scope and Purpose
- Sites Where Applicable
- Design Criteria
- Construction Specifications.

About half of these BMPs relate to permanent or temporary vegetative covers which are not appropriate for areas undergoing active construction. In addition, many of these BMP specifications are applicable to general erosion problems in urbanizing areas (e.g., channel erosion, and landscaped areas) and are not specifically oriented to construction activities.

City of Knoxville City Code Section 19-162 entitled "Alteration of Existing or Natural Drainage; Grading Permit Required" enables the Engineering Department to require a performance bond equal in amount to the work to be performed to enforce compliance with the E&S controls submitted on approved plans.

Proposed BMP Requirements

The City proposes to include additional BMP requirements as described in the Tennessee Erosion and Sediment Control Handbook and to evaluate other BMP requirements as described below.

Tennessee Erosion and Sediment Control Handbook. The City proposes to require E&S control plans to follow the Tennessee Erosion and Sediment Control Handbook (TDHE, 1990). The State Handbooks presents specifications for the following structural BMP controls.

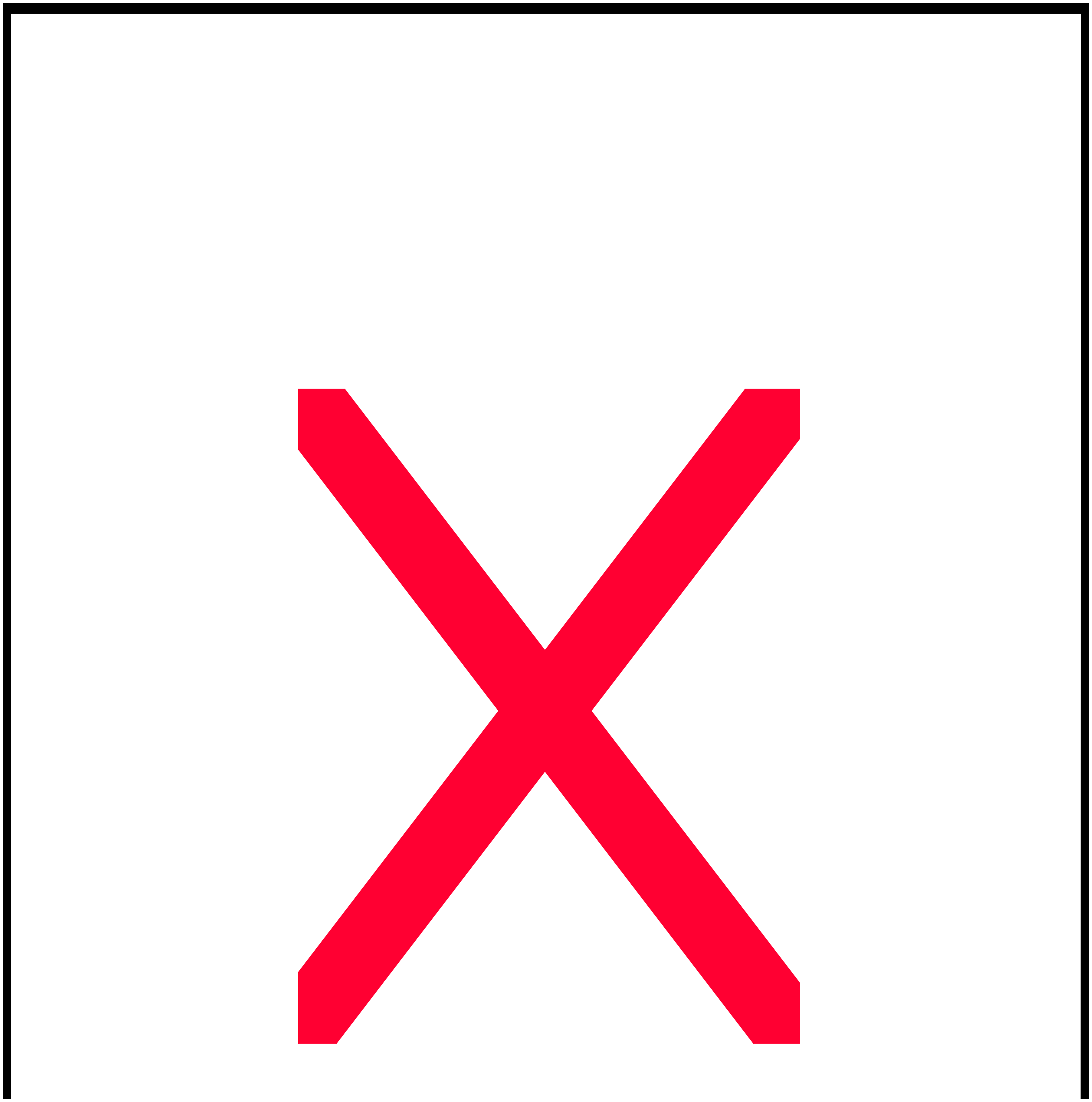
	Structure	Maximum Drainage Area (acres)	Duration (months)
1.	Straw bale barrier	2 (or 1/4 ac. per 100 feet)	3
2.	Silt fence	2 (or 1/4 ac. per 100 feet)	3
3.	Temporary diversion dike	5	18
4.	Diversion	NA	NA
5.	Temporary sediment trap	5	18
6.	Temporary sediment basin	5	18
7.	Check dams	10	NA
8.	Riprap	NA	Permanent
9.	Construction road stabilization	NA	NA

The maximum drainage area indicates the maximum area that can be served by each type of control and the duration indicates the length of time that temporary controls typically are effective. The State handbook also presents erosion and sediment control practices for stream crossing activities and vegetative controls. The State handbook provides general design guidelines in the form of design criteria and detail drawings. However, specific design requirements cannot be defined for every situation and are left to the designer of specific site controls. The choice of various types of approved structural controls for erosion and sedimentation control depends on the individual design requirements and preferences, functional effectiveness, aesthetics, cost, and maintenance. As mentioned in Section 3.2, the City will develop minimum criteria and/or a checklist to provide guidance for plan review staff and to ensure consistency in the plan review process.

Additional BMP Requirements. Table 5-8 lists E&S controls that are included under the minimum state requirements for Virginia and North Carolina. The E&S Controls required by the Tennessee and Knox County handbooks are presented for comparison. During the first year of the permit term the City will review these handbooks and consider inclusion of additional BMP requirements outlined therein. It should be noted that the Tennessee Handbook contains numerous references to the 1980 Virginia Handbook as a source of detailed information and design criteria. A revised version of the Virginia Handbook was issued in 1992 which included many changes resulting from additional field experience over the past 12 years. Some of the major changes include:

- Sedimentation Traps - The required storage volume was increased from 67 cubic yards per acre to 134 cubic yards per acre. One half of the storage is permanent pool (wet storage) and the other half is drawdown (dry pool). The maximum drainage area that can be served by sediment traps was reduced from five acres to three acres.

- Sedimentation Basins - The required storage volume is the same as sedimentation traps. The drainage area ranges from three to 100 acres.



The Virginia and North Carolina Handbooks reference use of a uniform coding system for map symbols and keys for submittal of E&S control plans which could facilitate review of E&S control plans submitted to the City.

Construction Site "Good Housekeeping" Practices. The City will evaluate additional ordinance revisions to ensure that construction sites are kept clean and orderly, and to minimize pollutants in stormwater runoff as a result of other construction activities. This may involve requiring that site plans address the following considerations:

1) Designated areas for construction equipment maintenance and repair and prohibiting discharges of oil and grease into the storm sewer system or receiving waters.

2) Designated areas for construction equipment washing provided with a gravel or rockbase and ensuring the wash waters are discharged to a regularly maintained temporary holding basin or sediment control device.

3) Provision of storage areas for construction materials and receptacles for liquids (solvents, paints, acids) and solids in accordance with manufacturers recommendations.

4) Provision of adequate waste storage areas and ensuring that the locations for collection of waste materials do not receive concentrated runoff.

5) Provision of adequate sanitary facilities on construction sites in accordance with Health Department Regulations.

Schedule for Construction Site BMP Requirements

City Ordinances will be revised to incorporate by reference the Tennessee Erosion and Sediment Control Handbook during the first year of the permit term. Additional requirements for E&S controls will be reviewed during year one through three of the permit term.

Revisions to the BMP design requirements will be made on an ongoing basis and as new technology refinements allow. Staff required to revise and implement the new BMP requirements will be hired during FY93 and FY94.

5.5.5 INSPECTION AND ENFORCEMENT OF CONTROLS

The City of Knoxville has identified inspection of construction sites as an area of the stormwater management program that has been inadequately addressed in the past due to resource limitations.

Existing Inspection and Enforcement Program

The City's current and proposed inspections and enforcement programs are described below.

Description of Existing Inspections Program. The Knoxville Engineering Department Planning and Technical Services Division has one inspector responsible for site inspections of erosion and sediment control on private development projects, throughout the city. This inspector covers all site work except for public works projects which are inspected by the Civil Engineering Division of the Engineering Department. Site work inspected includes grading, installation and maintenance of erosion and sedimentation controls, and construction of utilities and other infrastructure. The inspector is responsible for all commercial sites, sites with grading permits, sites with right-of-way construction permits, about 15 to 20 subdivisions per year, and some smaller single family residential sites.

Currently there is no formal prioritization plan for the inspection of construction sites. The inspector visits a site when the construction manager indicates that an inspection needs to take place. Inspections are often required before another phase of a project can begin.

Unannounced and unplanned inspections are done randomly when the inspector is "in the neighborhood". Inspections after rainfalls are performed on sites with grading permits or on sites where a problem is known or suspected.

When the inspector arrives at a site, the following procedures are followed:

1. Inspect road access for any dirt or runoff into the street and/or municipal storm sewer system.

2. Inspect perimeter of site to ensure there are no adverse effects on adjacent properties.

3. Inspect off-site of the construction area to ensure no impacts from erosion and siltation downstream of the construction activity.

4. Inspect on-site to ensure that all control measures on the drainage plan are being employed and to identify areas where additional controls might be required.

5. Meet with construction personnel to advise on any remedial action that might be necessary.

These inspection procedures meet the NPDES requirement that inspections "consider the nature of the construction activity, topography, and the characteristics of soils and receiving water quality".

Existing City Enforcement Program. The Alteration of Existing or Natural Drainage; Grading Permit Required (Section 19-162 of the City Code), enables the City Engineer to halt all land disturbing activities if a grading permit has not been issued or if the terms of the permit have been violated. Additionally, the City Engineer can require a performance bond equal to the amount to the work being performed to ensure that the drainage plans are adequately employed. The City Engineer issues a Notice of Violation (NOV) if it is determined that a violation has occurred. This NOV must include a description of the property on which the violation occurred, and must list the requirements of the plan which were violated. Violations are considered misdemeanors and are punishable with a $50 fine plus court costs for each day that the violation occurs.

Although the City Code empowers the City Engineer to enforce the terms of the drainage plan as described above, only very rarely do such enforcement measures occur. Current penalties are not severe enough to discourage noncompliance. Current operating policy is more a "working relationship" between the developer and the city. NOVs are not often written, but rather if the site inspector notices a violation, he informs the construction manager of the problem and gives advice on what procedures are necessary to correct the problem. Often, the site inspector will stay on-site while the violation is being remedied to offer advice and to ensure that the problem is corrected.

Performance bonds are generally not required unless the City Engineer determines that the site is large enough, or if the City Engineer has reason to believe that a problem might occur (problem site, poor contractor history, etc.).

Proposed Inspection and Enforcement Program

The existing procedures for inspections and enforcement are inadequate, primarily due to insufficient staffing and penalties that are inadequate to ensure compliance. The City's proposed E&S program will increase the number of inspectors from one to three, which will help the City better enforce management practices which reduce pollutants in stormwater discharges from construction sites.

Proposed Inspections Procedures. Inspections will be expanded to include a number of sites which are not currently regulated, such as single family residences, to better address the erosion and sedimentation problem in the City of Knoxville. The following guidelines will be followed for scheduling inspections of construction sites:

- Initial inspection - (when the site is staked for grading but prior to grading) large construction projects only

- Rough grading inspection - after stripping, compaction, and installation of subsurface drains

- Erosion and Sediment Control compliance inspection - immediately after installation of sediment basins, dikes, and other control measures

- Final grading inspection - after completion of all grading, paving, and permanent stormwater drainage structures

- Final Stabilization inspection - after planting and landscaping is completed.

In addition to the inspections listed above, large construction sites or known problem sites should be inspected after major storm events to assess E&S control performance and identify maintenance needs.

The Tennessee Erosion and Sediment Control Handbook includes a construction site monitoring report. The monitoring report can be completed by City inspectors or for smaller sites "self-monitoring" by the developer or contractor may be sufficient. This would be consistent with Tennessee General NPDES Permit for Storm Water Discharges Associated with Construction Activity, which requires that the permittee perform routine self-inspections and maintenance on control measures. These self-inspections must be done weekly during dry periods and after rainfalls of 0.5 inches or more. Records of inspection and maintenance must be maintained and made available to a State inspector upon request. The City will consider imposing similar requirements for small construction sites because even with additional City staff for construction site inspections, it may not be possible to inspect many of the smaller construction sites on a routine basis. Shifting some of the responsibility of site inspections to the contractor would reduce the City's inspection burden, while ensuring the requirement that all construction sites employ management practices that address pollution from stormwater runoff. The self-monitoring reports would be signed by a construction site supervisor, and would either be sent to the Engineering Department, or made available to site inspectors upon request.

Proposed Enforcement Procedures. The City anticipates that increased inspections and contractor awareness of E&S control requirements will be the primary enforcement tool. Inspectors have authority to issue "Notice of Violations" and "Stop Work Orders". The City proposes to revise existing ordinances to increase the penalties for violations to $5,000 or 30 days in prison. Revision of ordinances has been facilitated by the State Stormwater Bill approved in April 1993. Requirements for performance bonds will be expanded to include smaller construction sites at the discretion of the Engineering Department.

Schedule for Inspection and Enforcement Program

Increased inspections and plan review will be implemented during year one and two of the permit term. The City will attempt to educate developers and contractors regarding the revised E&S control requirements as part of the increased attention to site inspections. Rigorous enforcement of revised City Ordinances will be coordinated following contractor training programs and will be phased in to educate the developers about new Erosion & Sediment Control requirements. Initially, enforcement of the ordinances will focus on known problem areas and individuals. Staff required to revise and implement the new BMP requirements will be hired during FY93 and FY94.

5.5.6 EDUCATION AND TRAINING OF CONSTRUCTION SITE OPERATORS

Seminars and Workshops

The City will sponsor or co-sponsor periodic Erosion and Sediment Control seminars or workshops to provide educational materials to plan reviewers, inspectors, developers, contractors, and others who may be impacted by the new requirements established by the NPDES stormwater discharge permit described herein. The Engineering Department will review materials prepared for a recent seminar for highway inspectors sponsored by TVA and TDOT and consider co-sponsoring annual or biannual workshops. Potential cosponsors of the seminars would include: TDEC, TDOT, TVA, University of Tennessee, and local Chamber of Commerce.

Training Materials

During years one and two of the permit term, the Engineering Department will assemble training materials from other jurisdictions. These training materials will include E&S control manuals, slide presentations, training videos, and information brochures. In addition to the Tennessee E&S Control Handbook, training materials already compiled by the City include:

- Nashville Storm Water Management Manual
- Virginia Erosion and Sediment Control Handbook (Third Edition, 1992)
- North Carolina Sediment Control Planning and Design Manual (1988)
- Fairfax County, Virginia E&S Control Inspector Training Video
- USEPA Developing Pollution Prevention Plans and Best Management Practices for Storm Water Management for Construction Activities (1992)

During years three to five of the permit term the Engineering Department will assess the need to develop training materials specific to the City of Knoxville and will coordinate distribution of these materials to developers and construction site operators.

Schedule for Training Programs

Training materials will be compiled and reviewed by City staff during years one and two. Annual or semiannual training workshops will be cosponsored by the City during years two to five.

5.5.7 STAFFING REQUIREMENTS

The staffing requirements to implement the City's management program for construction sites are presented in Table 5-7. The Engineering Department Planning and Technical Services Division will add two new Engineering Technicians II as full time site inspectors to implement the program described in this report. The new inspectors will share the responsibilities of all site inspections with the existing inspector.

In addition to the new inspectors, the management program will require additional staffing for plan reviews and approvals. A new staff position within the Engineering Department Planning and Technical Services Division will be for a Stormwater Engineer who will spend approximately 25% of his/her time on the program for construction sites. The engineer's responsibilities under the Erosion and Sediment Control Program will include final review/approval of erosion and drainage control plans, supervision of site inspections, coordination of training programs, and technical assistance with revisions to City ordinances addressing erosion and sedimentation control. The existing City Inspector (Engineering Technician III) will continue to be dedicated full time to the Erosion and Sediment Control Program. This Inspector (Engineering Technician III) spends about 20% of his time performing reviews of erosion and drainage control plans and the remainder meeting with contractors and performing field inspections.

6.0 ASSESSMENT OF CONTROLS

The Part 2 NPDES stormwater regulations [CFR 122.26 (d)(2)(v)] require the applicant to assess the impact of the stormwater controls proposed in the management programs describe in Section 5. Specifically, the regulations require:

> *"Estimated reductions in loadings of pollutants from discharges of municipal storm sewer constituents from municipal storm sewer systems expected as the result of the municipal storm water quality management program. The assessment shall also identify known impacts of storm water controls on ground water."*

6.1 ESTIMATED POLLUTANT LOAD REDUCTIONS

6.1.1 NONSTRUCTURAL CONTROLS

Many of the Best Management Practices proposed for implementation under the City of Knoxville stormwater management program are nonstructural controls. However, there is currently very little data available to assess the pollutant removal effectiveness of nonstructural stormwater quality controls. These controls reduce pollutant loads by controlling the source of pollution, and no specific load reduction for designated pollutants (e.g., zinc, phosphorous) have been determined. Indirect measurements of nonstructural controls will be used to assess the true effectiveness of these programs once the stormwater programs are implemented. For example, the program to remove illicit connections and improper disposal may be assessed based on the number of incidences reported or corrected during each year of the permit term.

6.1.2 STRUCTURAL CONTROLS

The structural controls that may be required through the revised Stormwater Detention Ordinance will primarily be located in areas of new development. Ranges of average annual pollutant removal efficiencies that can be achieved by retention, extended dry detention, and wet detention ponds are presented in Table 6-1.

Table 6-1

AVERAGE ANNUAL POLLUTANT REMOVAL RATES FOR RETENTION AND DETENTION BASIN BMPs

POLLUTANT	RANGE OF POLLUTANT REMOVAL RATES (%)		
	RETENTION	EXTENDED DRY DETENTION	WET DETENTION
BOD5	80%-99%	20%-30%	20%-40%
COD	80%-99%	20%-30%	20%-40%
TSS	80%-99%	80%-90%	80%-90%
TDS	80%-99%	0%	20%-40%*
Total-P	80%-99%	20%-30%	40%-50%
Dissolved-P	80%-99%	0%	60%-70%
NO_2+NO_3	80%-99%	0%	30%-40%
TKN	80%-99%	10%-20%	20%-30%
Cadmium	80%-99%	70%-80%	70%-80%
Copper	80%-99%	50%-60%	60%-70%
Lead	80%-99%	70%-80%	70%-80%
Zinc	80%-99%	40%-50%	40%-50%

NOTES:

1. Extended dry detention basin efficiencies assume that the storage capacity of the extended detention pool is adequately sized to achieve the design detention time for at least 80% of the annual runoff volume. For most areas of the U.S. extended dry detention basin efficiencies assume a storage volume of at least 0.5 inches per impervious acre.

2. Wet detention basin efficiencies assume a permanent pool storage volume which achieves average hydraulic residence time of at least two weeks.

3. Retention removal rates assume that the retention BMP is adequately sized to capture at least 80% of the annual runoff volume from the BMP drainage area. For most areas of the U.S., the required minimum storage capacity of the retention BMP will be in the range of 0.50 to 1.0 inch of runoff from the BMP drainage area, but the required minimum storage capacity should be determined for each location.

* No data is available for TDS removal in wet ponds.

Since removal efficiency data do exist for structural controls such as dry and wet detention systems, the City can make estimates for pollutant reductions which could result if these structural controls were required for future development of undeveloped areas located within the City of Knoxville boundaries. As noted in Section 5.2, the City is considering implementing these controls on new development if they are adopted and implemented on a regional basis. The City will estimate pollutant removal efficiencies of regional detention facilities when these controls are planned and located.

6.2 CONTROLS FOR O&M PRACTICES FOR STREETS

Stormwater pollution loadings attributable to the operation and maintenance of the City's roadways will continue to be reduced with ongoing practices such as erosion and sediment controls, inspection, catch basin and roadway ditch cleaning, highway litter cleanup, and training of staff responsible for deicing operations. Erosion and sediment control will prevent solids, and metal or other pollutants adsorbed on the solids, from entering the storm sewer system. Catch basin cleaning will reduce contamination caused by pollutants that have settled in the basins. With sediment and erosion controls and catch basin cleaning, the total suspended solids removal is estimated to be in the 70-90 percent range. Dissolved pollutants are estimated to have a much lower removal rate, somewhere in the 10-30 percent range.

6.3 CONTROLS FOR FLOOD MANAGEMENT PROJECTS

Under the revised Stormwater Detention Ordinance, the feasibility of including water quality control in the design of detention ponds will be evaluated. The reduction in loadings of pollutants will be a function of the final design. For example, if an extended dry detention pond is incorporated in the design, then pollutant removal efficiencies will be determined by the average hydraulic residence time in the pond. Ranges of average annual removal rates for wet and extended detention dry facilities are shown in Table 6-1.

There are a limited number of existing onsite ponds, which were previously designed for flood control, that provide removal efficiencies equal to that of wet detention basins. There are, however, seven specific systems that do not, at present, provide maximum removal efficiencies. These structures will be evaluated and, if feasible, design changes will be considered to retrofit the structures to provide for a larger hydraulic residence time, so that the structures will provide the maximum removal efficiency.

Three regional flood control detention ponds will be evaluated during the term of the permit to determine if retrofitting the systems would provide additional pollutant removal from stormwater. If retrofitting is shown to be feasible, pollutant reduction loads will be determined as part of the evaluation.

6.4 PROGRAM FOR PESTICIDE, HERBICIDE AND FERTILIZER

The City plans to address this element of the Stormwater Management Program through management of municipal users and public education. The City's ongoing monitoring will provide additional data regarding the presence of these pollutants in stormwater runoff. The City will report on the type of and number of educational mailings sent out each year of the permit term. Available information on the volume of these materials collected as part of the City's household hazardous waste collection program will be reported during the permit term.

6.5 PROGRAM FOR ILLICIT DISCHARGES AND IMPROPER DISPOSAL

The City proposes to develop an illicit discharge ordinance that will prohibit non-stormwater discharges to the storm sewer system. The implementation and enforcement of this ordinance will reduce pollutant loadings to the storm sewer system system by prohibiting the discharge of sanitary, industrial, and other wastes (e.g., used oil and household chemicals). In order to detect and remove illicit discharges and improper disposal into the storm sewer under the new ordinance, the proposed program includes: ongoing field screening activities to monitor and evaluate dry weather flows in the storm sewer system, and storm sewer investigations which include system mapping, field surveys, and upstream source identification. Once the sources of illicit discharge or improper disposal have been identified, the owner will be required to operate in compliance with the ordinance. This action will remove the discharge to the storm sewer system and should result in a 100% reduction in pollutant load from that source.

The spill response program operated by the Knoxville Emergency Response Team (KERT) and coordinated with other local, state and federal agencies will continue to respond to hazardous material spills during the term of the NPDES permit. The initial containment of the spill by KERT and subsequent cleanup by the responsible party will prevent pollutants from entering the storm sewer system and receiving waters. The reduction in pollutant load to the system will be a function of the nature of the spill and the response time. For example, if the response time allows for complete containment of the spilled material and if total removal of the material is possible, then the operation should achieve 100 percent removal of the pollutant load that, otherwise, may have been discharged to the storm sewer system.

Programs for reporting of illicit discharges, and proper management and disposal of used oil and toxic material, will also reduce the pollutant loads from the discharges of the storm sewer system. As the public becomes aware of the pollution associated with stormwater and the impacts on the receiving waters, reporting should provide the City with another mechanism to detect illicit discharges and improper disposal, in addition to the City's field screening and storm sewer investigation programs. The City can then respond to have the discharges removed and thus reduce the pollutant load to the system. Educational programs for proper management and disposal of used oil and toxic materials will reduce the pollution load by informing the public of the pollution impacts caused by improper procedures and by providing them with alternative disposal procedures, such used oil collection at service stations, recycling programs at local drop-off centers, and collection sites for household hazardous wastes.

For the various programs to detect and remove illicit discharges and improper disposal, the reduction in pollution loads will be a function of several responses to the program, including: the level of enforcement of the new illicit discharge ordinance, the number of calls and mail-ins to the City reporting illicit discharges, the amount of used oil and household chemicals that are delivered to drop-off sites, and the amount of material collected for recycling.

6.6 PROGRAM FOR INDUSTRIAL FACILITIES

The City's program for industrial facilities will rely primarily on data collected under the ongoing field screening program to detect spills or discharges downstream from industrial facilities. Detection and removal of these spills or discharges will be documented and the pollutants removed from the City's stormwater system will be assessed on a case-by-case basis.

As part of KUB's existing pretreatment inspection program, KUB inspectors will fill out a new stormwater checklist as part of their annual inspection of industrial permit holders. The checklist will identify materials within each facility which may be exposed to stormwater runoff. The effectiveness of this program will be assessed in terms of the number of inspections performed during each year of the permit term and number of corrective actions taken. The checklist will also inventory any previous known spills or leaks.

6.7 PROGRAM FOR CONSTRUCTION SITES

Construction site pollution will be reduced by requiring additional erosion and sediment control devices under a revised City ordinance. The use of structural controls such as sediment basins and traps, perimeter dikes, and sediment barriers (straw, burlap and synthetic materials) can reduce solid pollutant loads by 70 to 80 percent, and dissolved pollutant loads to a much lesser extent. The number of site inspections and enforcement activities of the construction site program will be documented during each year of the permit term.

6.8 KNOWN IMPACTS OF STORMWATER CONTROLS ON GROUNDWATER

The City of Knoxville was one of the sites of the Nationwide Urban Runoff Project (NURP) performed by TVA during 1981-1983. One of the unique aspects of the Knoxville NURP study was the investigation of the impact of urban runoff on groundwater resources. Much of Knoxville is underlain by soluble carbonate rock which is known to cause the following impacts on local hydrology:

- Reduction or elimination of stream baseflow in carbonate areas
- Reduction in storm peak discharge
- Increases in the impacts of urbanization on flooding
- Reduction in the transport of pollutants from a watershed

Groundwater tracer studies conducted under the TVA NURP study within the City concluded that stormwater drainage into sinkholes can be a probable source of groundwater contamination to water wells drilled in karst formations. The TVA NURP study also concluded that although carbonate-rock influences local hydrology in many areas of the City, particularly in the Second Creek area, many pollutants are trapped in the overlaying soils. Under the TVA NURP study, no direct measurement of groundwater quality was performed. The indirect evidence suggested that urban runoff hydrology and pollutants may impact areas underlain by soluble carbonate rock. Other NURP studies in Fresno, CA and Long Island, NY which did investigate groundwater impacts resulting from deliberate recharge of urban runoff into aquifers. In these cases, recharge of runoff did not appear to threaten groundwater quality. The NURP study showed that in most areas soil processes are efficient in retaining pollutants in stormwater runoff close to the land surface. Pollutant breakthrough of the upper soil layers of stormwater BMPs that had been recharging for more than 20 years was not evident in either the Fresno, CA or the Long Island, NY NURP studies. Harper (1988) compared groundwater quality beneath stormwater management systems with surface water quality and also groundwater quality for control areas. Stormwater characteristics, with the exception of a few parameters, were shown to have very little effect on groundwater quality beneath stormwater BMPs. Since large portions of the City of Knoxville are underlain by soluble carbonate rock, special studies assessing groundwater quality impacts of stormwater discharges and BMPs will be considered during the permit term.

7.0 FISCAL ANALYSIS

7.1 REGULATORY REQUIREMENTS

The Part 2 NPDES stormwater regulations require inclusion of the following programs in the permit application [CFR 122.26 (d)(2)(vi)]:

> *"For each fiscal year to be covered by the permit, a fiscal analysis of the necessary capital and operation and maintenance expenditures necessary to accomplish the activities of the programs under paragraphs (d)(2)(iii) and (iv) of this section. Such analysis shall include a description of the source of funds that are proposed to meet the necessary expenditures, including legal restrictions on the use of such funds."*

The objective of this section is to describe the budget requirements of the City's current and proposed stormwater programs and to describe the financing mechanisms necessary to support these programs. Section 7.2 addresses the estimated capital, operation, and maintenance costs for current City programs as well as for new programs proposed under the NPDES stormwater permit. Section 7.3 describes financing options needed to fund the management programs.

7.2 FISCAL ANALYSIS

A comprehensive cost analysis for the stormwater permit program is presented in Table 7-1. This table presents estimated costs for existing stormwater management programs as well as for costs which are proposed under the new NPDES management program. The analysis includes estimated costs for:

- Salaries,
- Vehicles and equipment,

Table 7-1

City of Knoxville NPDES Stormwater Management Program
Preliminary Estimate 5-Year Program Summary

	Existing 1992-1993	Fiscal Year 1993-1994	Fiscal Year 1994-1995	Fiscal Year 1995-1996	Fiscal Year 1996-1997	Fiscal Year 1997-998
Salaries (1)						
Engineering Department						
Civil Engineering	$175,000	$180,250	$185,658	$191,227	$196,964	$202,873
Planning and Technical Services	$105,000	$108,150	$111,395	$114,736	$118,178	$121,724
NPDES Stormwater Management	$0	$120,000	$123,600	$127,308	$131,127	$135,061
Service Department						
Existing Drainage Maintenance	$979,000	$1,008,370	$1,038,621	$1,069,780	$1,101,873	$1,134,929
Water Quality Maintenance	$0	$0	$111,240	$114,577	$118,015	$121,555
Subtotal	$1,259,000	$1,416,770	$1,570,513	$1,617,628	$1,666,157	$1,716,142
Equipment						
Engineering Department						
Samplers/Flowmeters	$12,000	$54,000	$18,000	$12,000	$12,000	$12,000
Accessories/Computer/Software	$4,000	$15,000	$15,000	$15,000	$15,000	$15,000
Service Department						
Drainage Maintenance	$366,000	$366,000	$366,000	$366,000	$366,000	$366,000
Water Quality	$0	$0	$50,000	$50,000	$50,000	$50,000
Subtotal	$382,000	$435,000	$449,000	$443,000	$443,000	$443,000
Contract Services (2)						
NPDES Permit Assistance	$232,000	$25,000	$25,000	$25,000	$25,000	$25,000
Stormwater Utility Rate Study	$0	$300,000	$0	$0	$0	$0
Laboratory Services	$0	$15,000	$15,000	$15,000	$15,000	$15,000
USGS Services	$52,000	$12,860	$13,503	$14,178	$14,887	$15,631
Subtotal	$284,000	$352,860	$53,503	$54,178	$54,887	$55,631
Capital Improvements Budget(3)						
Drainage CIP for FY91-92						
Tiffany Lane/Aubrey Lane	$215,000	$0	$0	$0	$0	$0
Drainage CIP Assumed for FY 94-95	$0	$0	$500,000	$0	$0	$0
Drainage CIP Assumed for FY 95-98	$0	$0	$0	$1,000,000	$1,000,000	$1,000,000
Water Quality Improvements (4)	$0	$0	$250,000	$500,000	$500,000	$500,000
Subtotal	$215,000	$0	$750,000	$1,500,000	$1,500,000	$1,500,000
Total	$2,140,000	$2,204,630	$2,823,016	$3,614,807	$3,664,044	$3,714,773
NPDES Mandatory	$300,000	$541,860	$621,343	$873,063	$881,029	$889,247
% NPDES Requirement of Total	14%	25%	22%	24%	24%	24%

Notes:

(1) Assumes a 3.0% annual increase

(2) Previous year contract services for preparation of NPDES Permit application prior to FY 92-93 = $325.000 (CDM) + $105,000 (USGS) = $430,000

(3) CIP Budgets may be more or less in any given year and may be prorated over the permit term

(4) Assumes water quality contol features can be piggybacked on Drainage/Flooding CIP projects and that a Stormwater Utility has been created with a fee structure adequate to fund the projects

- Contract services, and
- Capital improvements.

7.2.1 SALARIES

Detailed summaries of the staffing requirements and estimated salary costs of each new management program proposed under the City's NPDES Part 2 permit application are presented in the report describing the specific program. These estimated costs are based on current employee base salary rates plus fringe benefits. Annual salary projections assume phased implementation of the stormwater management program and a 3% annual increase over the 5-year permit term. The new positions include a Stormwater Management Engineer, three level II Engineering Technicians, and a five-person Service Department field crew.

7.2.2 EQUIPMENT

The proposed Stormwater Management Program will involve expenditures for purchasing new equipment required as part of certain program elements. Major equipment expenditures include: stream restoration heavy equipment and truck(s); two vehicles for site inspections; samplers and flowmeters for water quality monitoring; and computer hardware, software, and accessories.

Based on detailed data compiled by the Service Department for FY91-92, equipment costs related to existing drainage maintenance programs are $366,000 per year. These equipment costs are projected to remain constant during the 5-year permit term. Specific additional heavy equipment that will be required for the proposed stream restoration field crew has not been identified. Discussions with the Service Department indicate that these equipment costs are likely to be on the order of $50,000 per year. This cost would include operation and maintenance (O&M) and assumes capital costs for one-time purchase of heavy equipment is allocated over the 5-year permit term. The types of equipment required and costs will be further defined during the first year of the permit term.

The cost for vehicles for site inspections is estimated to be approximately $5,000 annually over the permit term. The cost for water quality monitoring equipment is estimated to be $54,000 during FY93-94, $18,000 during FY94-95, and $12,000 annually for the remaining three years of the permit. Annual costs for computer hardware, software, and accessories are estimated to be $15,000 over the 5-year permit term.

7.2.3 CONTRACT SERVICES

For some aspects of the proposed management programs, it may be more efficient for the City to engage contract services. These services have been categorized as follows:

- Laboratory services for analysis of samples collected as part of the ongoing monitoring program and the illicit connection and improper disposal program;
- NPDES permit assistance for assistance with database management, establishing monitoring stations, conducting BMP pilot studies, etc.;
- USGS services for assistance with water quality monitoring; and
- A stormwater utility rate study.

The estimated cost for laboratory services is projected to be approximately $15,000 annually. NPDES permit assistance is projected to be approximately $25,000 per year. Continued flow monitoring by the USGS is projected to be $12,000 per year. The State Stormwater Legislation provides sufficient authority for the City to implement a stormwater utility. The cost for preparing a stormwater utility rate study is projected to be $300,000 during FY93-94.

7.2.4 CAPITAL IMPROVEMENTS

Estimated costs for capital improvements were determined from budget projections of projects targeted by the Knoxville Engineering Department. Additional costs for NPDES water quality improvements assume that water quality control features can be "piggybacked" on the targeted drainage/flooding CIP projects. Capital improvements for water quality improvements include construction of regional BMP facilities as described in the management plan for residential and commercial areas. The City will consider committing funds for capital improvements once a stormwater utility is approved and implemented.

7.3 FUNDING SOURCES

Sources of funding within the City of Knoxville include the General and Sales Tax funds which are tax-based and Enterprise funds which are revenue-based. Enterprise funds are established by City ordinance and the General Fund must pay for all items not paid for under Enterprise funds. Enterprise funds must be used only for functions and activities specified by ordinance and this generally applies to activities falling with the jurisdiction of the individual utilities/department associated with the fund. Under the proposed FY92-93 budget, all new stormwater activities within the City will be paid for by Enterprise funds.

The Tennessee State Legislature recently passed Stormwater Management Legislation (Senate Bill No. 68 and House Bill No. 56) which provides the City of Knoxville with sufficient enabling authority to implement the required NPDES stormwater management programs. This legislation also provides the City with the option to finance the stormwater management program with a stormwater utility. The City is currently considering a stormwater utility study which would determine billing rates for property owners who discharge stormwater to the municipal storm sewer system. Typically, stormwater utility rates are based on the percentage of impervious area on a property. The City has considered applying the Stormwater Utility Fee through the Knoxville Utility Board (KUB) existing billing system. If the City chooses to implement a Stormwater Utility, the fee system would be devised to provide sufficient funding for all of the proposed NPDES stormwater management programs.

APPENDIX A

CITY OF KNOXVILLE

MODEL STORMWATER ORDINANCE

MODEL ORDINANCE PROVISIONS
40 CFR 122.26(d)(1)(ii) - PREAMBLE AND DEFINITIONS

ORDINANCE NO. ______
AN ORDINANCE OF THE CITY COUNCIL OF THE
CITY OF [___________] ADOPTING PROVISIONS RELATING TO
USE OF THE STORMWATER SYSTEM

WHEREAS, the federal Clean Water Act (33 U.S.C. 1251 et seq.), as implemented by regulations of the U.S. Environmental Protection Agency adopted November 16, 1990 (40 CFR Part 122), make necessary the adoption of local ordinance provisions relating to the Stormwater System; and

WHEREAS, the [city] is seeking to comply with all provisions of federal and state law; and

WHEREAS, the [city council] has conducted legally noticed public hearings and has provided all interested parties an opportunity to be heard on these ordinance provisions;

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF [_____________} DOES ORDAIN AS FOLLOWS:

Article 1.0 Title, Purpose and Definitions

This ordinance shall be known as the "City of [_____________] Initial Stormwater Control Ordinance", and may be so cited.

Section 1.1 Purpose and Intent

The purpose of this ordinance is to promote the health, safety and general welfare of the inhabitants of the City of [__________]. This ordinance is intended to comply with federal and state law and regulations regarding water quality.

Section 1.2 Definitions

(a) Authorized Official: any employee or agent of the city authorized in writing by the Director to administer or enforce the provisions of this ordinance

(b) Director: the Director of Engineering

(c) Discharge: any direct or indirect entry of any solid, liquid or gaseous matter

(d) Person: any natural individual, corporation, partnership, institution, or other entity

(e) Site of Industrial Activity: any area or facility used for manufacturing, processing or raw materials storage, as defined under 40 CFR Section 122.26(a)(14) of regulations of the U.S. Environmental Protection Agency, as amended

(f) Stormwater: any stormwater runoff, and surface runoff and drainage

(g) Stormwater System: the system of conveyances used for collecting, storing, and transporting Stormwater owned by the city but not including any facilities intended to be used in accordance with applicable law for collecting and transporting sanitary or other wastewater

MODEL ORDINANCE PROVISIONS
40 CFR 122.26(d)(1)(ii)(A) - INDUSTRIAL ACTIVITY

Article 2.0 Industrial Activity

Section 2.1 General Prohibitions

Any Discharge into the Stormwater System in violation of any federal, state, county, municipal or other law, rule, regulation or permit is prohibited.

Section 2.2 Specific Prohibitions

By adoption of industrial activity stormwater regulations or by issuance of industrial activity stormwater permits, or both, the Director may impose reasonable limitations as to the quality of Stormwater (including without limitation the designation of maximum levels of pollutants) Discharged into the Stormwater System from Sites of Industrial Activity. Any promulgation of such regulations and issuance of permits by the Director shall be in accordance with applicable law.

Section 2.3 Administrative Orders

The Director may issue an order to any Person to immediately cease any Discharge determined by the Director to be in violation of any provision of this ordinance, or in violation of any regulation or permit issued hereunder.

Section 2.4 NPDES Permits

Any Person who holds a National Pollutant Discharge Elimination System (NPDES) permit shall provide a copy of such permit to the Director no later than the later of: sixty (60) calendar days after the effective date of this ordinance or sixty (60) calendar days after issuance.

MODEL ORDINANCE PROVISIONS
40 CFR Section 122.26(d)(1)(i)(B) - ILLICIT DISCHARGES

Article 3.0 Illicit Discharges

Section 3.1 General Prohibitions

Except as set forth under Section 3.3 of this ordinance or as in accordance with a valid NPDES permit, any Discharge to the Stormwater System that is not composed entirely of Stormwater is prohibited.

Section 3.2 Specific Prohibitions

Any Discharge to the Stormwater System containing any sewage, industrial waste or other waste materials, or containing any materials in violation of federal, state, county, municipal, or other laws, rules, regulations, orders or permits, is prohibited.

Section 3.3 Authorized Exceptions

Unless the Director determines that it is not properly managed or otherwise is not acceptable, the following Discharges are exempt from the general prohibition set forth under Section 3.1 of this ordinance: flows from fire fighting, water line flushing and other contributions from potable water sources, landscape irrigation and lawn watering, irrigation water, diverted stream flows, rising groundwaters, direct infiltration to the Stormwater System, uncontaminated pumped groundwater, foundation and footing drains, water from crawl space pumps, air conditioning condensation, springs, individual residential car washings, flows from riparian habitats and wetlands, and dechlorinated swimming pool contributions.

Section 3.4 Illicit Connections

No Person may maintain, use or establish any direct or indirect connection to the Stormwater System that results in any Discharge in violation of this ordinance. This prohibition is retroactive and applies to connections made in the past, regardless of whether made under a permit, or other authorization, or whether permissible under laws or practices applicable or prevailing at the time the connection was made.

Section 3.5 Administrative Order

The Director may issue an order to any Person to immediately cease any Discharge, or any connection to the Stormwater System, determined by the Director to be in violation of any provision of this ordinance, or in violation of any regulation or permit issued hereunder.

MODEL ORDINANCE PROVISIONS
40 CFR Section 122.26(d)(1)(i)(C) - SPILLS AND DUMPING

Article 4.0 Spills and Dumping

Section 4.1 General Prohibitions

Except as set forth under Section 3.3 of this ordinance or as in accordance with a valid NPDES permit, any Discharge to the Stormwater System that is not composed entirely of Stormwater is prohibited.

Section 4.2 Specific Prohibitions

Any Discharge to the Stormwater System containing any sewage, industrial waste or other waste materials, or containing any materials in violation of federal, state, county, municipal, or other laws, rules, regulations, orders or permits, is prohibited.

Section 4.3 Notification of Spills

As soon as any Person has knowledge of any Discharge to the Stormwater System in violation of this ordinance, such Person shall immediately notify the Director by telephoning [____________________], and if such Person is directly or indirectly responsible for such Discharge, then such Person shall also take immediate action to ensure the containment and clean up of such Discharge and shall confirm such telephone notification in writing to the Director at [____] within three calendar days.

Section 4.4 Administrative Order

The Director may issue an order to any Person to immediately cease any Discharge, or connection to the Stormwater System, determined by the Director to be in violation of any provision of this ordinance, or in violation of any regulation or permit issued hereunder.

MODEL ORDINANCE PROVISIONS
40 CFR 122.26(d)(1)(ii)(E) - REQUIRE COMPLIANCE

Article 5.0 Enforcement

Section 5.1 Civil Penalties

Any violation of any provision of this ordinance, or of any regulation or order issued hereunder, shall be subject to a civil penalty up to a maximum of $________ per day for each violation.

Section 5.2 Criminal Penalties

Any intentional or willful violation of any provision of this ordinance, or of any regulation or order issued hereunder, shall be subject to a criminal penalty up to a maximum of $_________ per day, or imprisonment of up to one year, or both, for each violation.

Section 5.3 Injunctive Relief

Any violation of any provision of this ordinance, or of any regulation or order issued hereunder, shall be subject to injunctive relief if necessary to protect the public health, safety or general welfare.

Section 5.4 Continuing Violation

A Person shall be deemed guilty of a separate violation for each and every day during any continuing violation of any provision of this ordinance, or of any regulation or permit issued hereunder.

Section 5.5 Enforcement Actions

The Director may take all actions necessary, including the issuance of notices of violation and the filing of court actions, to require and enforce compliance with the provisions of this ordinance and with any regulation or permit issued hereunder.

MODEL ORDINANCE PROVISIONS
40 CFR 122.26(d)(1)(ii)(F) - INSPECTION AND MONITORING

Article 6.0 Inspections and Monitoring

Section 6.1 Authority For Inspections

Whenever necessary to make an inspection to enforce any of the provisions of this ordinance, or regulation or permit issued hereunder, or whenever an Authorized Official has reasonable cause to believe there exists any condition constituting a violation of any of the provisions of this ordinance, or regulation or permit issued hereunder, any Authorized Official may enter any property, building or facility at any reasonable time to inspect the same or to perform any duty related to enforcement of the provisions of this ordinance or any regulations or permits issued hereunder; provided that (a) if such property, building or facility is occupied, such Authorized Official shall first present proper credentials and request permission to enter, and (b) if such property, building or facility is unoccupied, such Authorized Official shall make a reasonable effort to locate the owner or other person having charge or control of the property, building or facility, and shall request permission to enter. Any request for permission to enter made hereunder shall state that the owner or person in control has the right to refuse entry, and that in such event that entry is refused, the Authorized Official may enter to make inspection only upon issuance of a search warrant by a duly authorized magistrate. If the owner or person in control refuses permission to enter after such request has been made, the Authorized Official is hereby authorized to seek assistance from any court of competent jurisdiction in obtaining entry. Routine or area-wide inspections shall be based upon such reasonable selection processes as may be necessary to carry out the purposes of this ordinance, including but not limited to random sampling and sampling in areas with evidence of stormwater contamination, non-stormwater discharges, or similar factors.

Section 6.2 Authority For Monitoring and Sampling

Any Authorized Official may establish on any property such devices as are necessary to conduct sampling or metering of Discharges to the Stormwater System. During any inspections made to enforce the provisions of this ordinance, or regulations or permits issued hereunder, any Authorized Official may take any samples deemed necessary.

Section 6.3 Requirements For Monitoring

The Director may require any Person engaging in any activity or owning any property, building or facility (including but not limited to a Site of Industrial Activity) to undertake such reasonable monitoring of any Discharge(s) to the Stormwater System and to furnish periodic reports.

APPENDIX B

USGS REPRESENTATIVE

MONITORING DATA

STORMWATER DATA FOR KNOXVILLE, TENNESSEE, 1991-92

By George S. Outlaw and Robert A. Aycock

U.S. GEOLOGICAL SURVEY

Open-File Data Report 93-xxx

Prepared in cooperation with the

CITY OF KNOXVILLE, TENNESSEE

Nashville, Tennessee

1993

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

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Nashville, Tennessee 37203

Copies of this report can be purchased from:

U.S. Geological Survey
Books and Open-File Reports
Federal Center,
Box 25425
Denver, Colorado 80225

CONTENTS

ILLUSTRATION

TABLES

CONVERSION FACTORS

Mulitply	By	To obtain
Inch (in.)	25.4	millimeter
Square mile (mi^2)	259.0	hectare
Square mile (mi^2)	259.0	square kilometer
Cubic foot (ft^3)	0.02832	cubic meter
Cubic foot (ft^3)	28.32	liter
Cubic foot (ft^3)	28,320	cubic centimeter
Cubic foot per second (cfs)	0.02832	cubic meter per Second
Pound, avoirdupois (lb)	0.4536	kilogram
Microsiemens per centimeter at 25° Celsius (µS/cm)	1.0	microhms per centimeter at 25° Celsius

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = 1.8 * °C + 32$$

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STORMWATER DATA FOR KNOXVILLE, TENNESSEE, 1991-92

By George s. Outlaw and Robert A. Aycock

ABSTRACT

The Knoxville stormwater monitoring network consists of five urban watersheds in Knoxville, Tennessee, that were monitored with rain gages and streamflow gages. Each watershed was monitored during three storms to develop information about the seasonal relation between land use, rainfall, and stormwater quality. Information was collected for 15 storms occurring from March 1991 through August 1992. This informatiom will assist the City of Knoxville in meeting U.S. Environmental Protection Agency regulations aimed at reducing the amount of pollution carried by Knoxville stormwater to the Tennessee River.

Stormwater-quality characteristics presented in this report include storm-runoff mean concentrations of selected volatile organic compounds, acidic organic compounds, base/neutral organic compounds, organic pesticides, toxic metals, and conventional pollutants. Also, several physical properties of the stormwater were analyzed.

Laboratory analyses of Knoxville stormwater found several constituents in each catagory at concentrations above minimum reported values. Storm loads were computed for these constituents by multiplying the concentration by the volume of storm runoff and a conversion factor.

INTRODUCTION

Pollution is a problem which greatly affects the water resources of the United States. Many activities of society contribute to this problem by producing pollutants that are mobilized by the energy of rainfall and transported in stormwater to streams, rivers, lakes, and ground water. Generally, the pollution carried by storm runoff does not come from a single identifiable source. This type of pollution is referred to as nonpoint source. In recent years, government regulations have been implemented to reduce the severity of nonpoint-source water pollution caused by urban stormwater.

Currently, Federal stormwater regulations apply to cities having more than 100,000 residents (U.S. Environmental Protection Agency, 1992). These regulations require large cities to perform studies to identify the type, concentration, and amount of pollutants present in stormwater. Such an analysis is accomplished by monitoring the quantity of precipitation and the quantity and quality of storm runoff from watersheds with different land-use characteristics.

To assist with characterizing stormwater quantity and quality at Knoxville, Tennessee, the u.s. Geological Survey (USGS), in cooperation with the City of Knoxville, established the Knoxville stormwater monitoring network. The monitoring network (fig. 1) consists of five urban watersheds that have been instrumented with a rain gage and a streamflow gage. Each watershed was selected to represent a different type of land use in the Knoxville area.

Samples of stormwater were manually collected at the gages and sent to the USGS National Water Quality Laboratory in Arvada, Colorado, for analysis of all constituents presented in this report except suspended sediment, biological oxygen demand, and fecal bacteria. Suspended sediment concentrations were measured at the USGS Alabama District sediment laboratory; biological oxygen demand was determined at the Knoxville Utilities Board Kewauhee Wastewater Treatment Plant Laboratory; and fecal bacteria counts were determined by the USGS Tennessee District. For constituents with concentrations above minimum reported values, storm loads, in pounds, were computed by multiplying the concentration by the volume of stormwater and a conversion factor. This report presents results of these analyses for 15 storms.

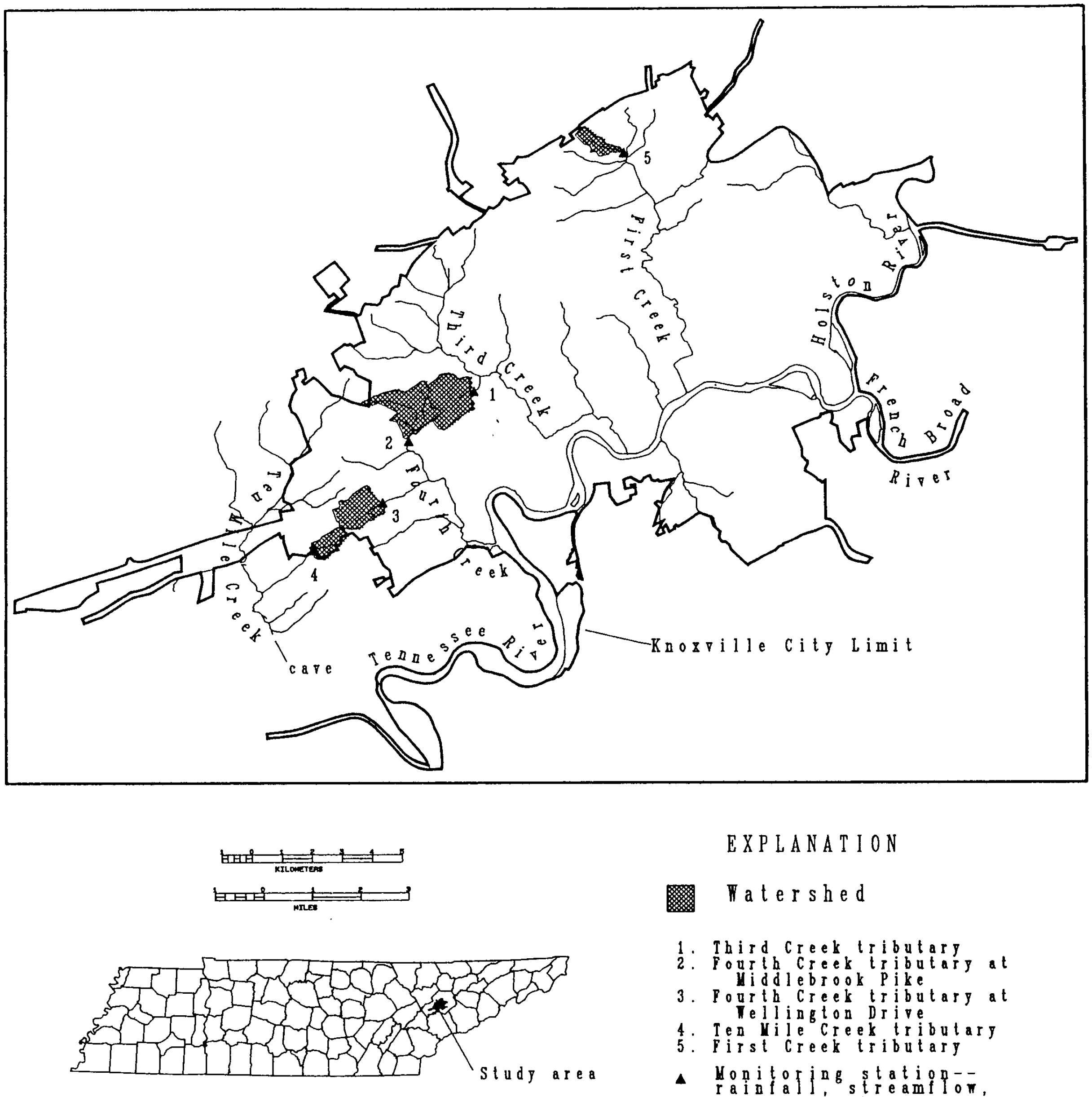

Figure 1.--Location of watersheds and monitoring stations in the Knoxville stormwater monitoring network.

DESCRIPTION OF MONITORED WATERSHEDS

Land use in Knoxville is composed of approximately 70-percent developed land and 30-percent undeveloped land. The developed land is approximately 50-percent residential, 10-percent commercial, 2-percent industrial, and 8-percent other urban land uses, including parks and golf courses. Watersheds in the Knoxville stormwater monitoring network (table 1) allow for characterization of storm runoff from areas of residential, commercial, and industrial land use.

Storm runoff from an area of light commercial and industrial development with bulk-fuel storage and shipping terminals was monitored at Third Creek tribuary at Third Creek Road (watershed 1). The monitoring station was located at the downstream side of the culvert at Third Creek Road about 300 feet from the intersection of Third Creek Road and Middlebrook Pike. The 0.64-square-mile watershed is composed of approximately 10-percent commercial development, 10-percent industrial development, 14-percent residential development, and 9-percent streets and roads. The remaining 57 percent of the watershed is undeveloped.

Table 1.--Watersheds in the Knoxville stormwater monitoring network

[Drainage area is given in square miles]

Watershed number on map	Station number	Station name	Drainage area	Primary land use
1	03497041	Third Creek tributary at Third Creek Road	0.64	Light commercial and industrial with bulk-fuel storage
2	03497103	Fourth Creek tributary at Middlebrook Pike	0.84	Moderate commercial and industrial
3	034971055	Fourth Creek tributary at Wellington Drive	0.58	Concentrated commercial
4	03499193	Ten Mile Creek tributary at Chisholm Trail	0.27	High-density residential
5	03495905	First Creek tributary at Midlake Drive	0.23	Low-density residential

Storm runoff from an area of moderate commercial and industrial development was monitored at Fourth Creek tributary at Middlebrook Pike (watershed 2). The monitoring station was located at the downstream side of the culvert at Middlebrook Pike about 900 feet west of the intersection of Middlebrook Pike and Weisgarber Road. This 0.84-square-mile watershed is composed of approximately 25-percent industrial development, 15-percent commercial development, 12-percent residential development, and 12-percent streets and roads. The remaining 36 percent of the watershed is undeveloped.

Storm runoff from an area of concentrated commercial development was monitored at Fourth Creek tributary at Wellington Drive (watershed 3). The monitoring station was located about 50 feet upstream from the culvert at Wellington Drive about 300 feet from the intersection of Wellington Drive and Kingston Pike. This 0.58-square-mile watershed is composed of approximately 38-percent commercial development, 18-percent residential development, and 17-percent streets and roads. The remaining 27 percent of the watershed is undeveloped.

Storm runoff from an area of high-density residential development was monitored at Ten Mile Creek tributary at Chisholm Trail (watershed 4). The monitoring station was located 30 feet from the end of Chisholm Trail. This 0.27-square-mile watershed is composed of 52-percent high-density residential development, 6-percent commercial development, and 8-percent streets and roads. The remaining 34 percent of the watershed is undeveloped.

Storm runoff from an area of low-density residential development was monitored at First Creek tributary at Midlake Drive (watershed 5). The monitoring station was located about 30 feet downstream from the culvert at Midlake Drive about 400 feet from the intersection of Midlake Drive and Fountain Road. This 0.23-square-mile watershed is occupied by about 62-percent low-density residential development, 1-percent commercial development, and 16-percent streets and roads. The remaining 21 percent of the watershed is undeveloped.

DESCRIPTION OF SAMPLED STORMS

Rainfall hyetographs and discharge hydrographs were recorded with automatic instruments at each of the monitored watersheds (fig. 1; table 1). The instruments record rainfall amounts and streamflow discharge every 5 minutes. Rainfall data is used to characterize storm duration, storm intensity, and antecedent moisture conditions. Streamflow data is used with water-quality data to determine storm-runoff mean concentrations and storm loads.

During this study, water-quality samples were collected and analyzed for 15 storms. The location; date and time of storm and sampling; rainfall amounts before, during, and after sampling for storm; volume of storm runoff; and the volume of storm runoff sampled have been provided for each storm (table 2). Daily rainfall amounts for 4 days preceding the day of sample collection (table 3) provide information about antecedent moisture conditions.

The Supplemental Data section in this report provides incremental rainfall and discharge values for the monitored storms. Information about rainfall amount, duration, and intensity, and volume of storm runoff is provided by these incremental values.

Table 2.--Date and time of storm and sampling; rainfall amounts before, during, and after sampling for storm; volume of storm runoff; and volume of storm runoff sampled

[Time is given in hours and minutes; rainfall amounts are given in inches; volume is given in cubic feet; e, estimated; TC, Third Creek tributary; FM, Fourth Creek tributary at Middlebrook Pike; FW, Fourth Creek tributary at Wellington Drive; TM, Ten Mile Creek tributary; FC, First Creek tributary; see Supplemental Data for incremental rainfall and discharge values]

Watershed number on map	Storm number	Date of storm	Time of runoff		Time of sampling		Rainfall amounts			Volume of storm runoff	Volume of storm runoff sampled
			Start	End	Start	End	Before sampling	During sampling	After sampling		
1	TC1	03-12,13-91	1840	0555	1855	2155	0.07	0.18	0.13	108,000	35,800
	TC2	04-27-91	1530	1950	1535	1835	.01	.23	.00	51,700	48,600
	TC3	02-13-92	1135	1505	1155	1455	.03	.07	.00	4,060	3,990
2	FM1	03-27,28-91	2300	0340	2305	0205	.24	.10	.00	113,000	109,000
	FM2	11-20-91	1540	1955	1555	1855	.10	.09	.01	40,700	38,600
	FM3	08-21-92	1650	2115	1655	1955	.40	.78	.01	730,000	712,000
3	FW1	04-08-91	1740	2150	1755	2055	.06	.12	.00	108,000	105,000
	FW2	11-01-91	1050	1705	1055	1340	.03	.13	.00	34,000	24,800
	FW3	03-18-92	0700	1350	0715	1015	.06	.16	.14	105,000	27,200
4	TM1	08-14-91	0855	1315	0915	1215	.17	.07	.00	4,870	4,430
	TM2	07-31-92	1915	2120	1920	2120	.19	.00	.00	1,170	1,170
	TM3	09-18-92	1110	1520	1130	1430	.26	.41	.01	62,900	61,800
5	FC1	04-19-91	1120	1250	1140	1240	.24	.62	.00	5,810	2,990
	FC2	03-06-92	1535	1750	1545	1745	.82	.31e	.00	6,490	5,920
	FC3	04-15-92	1550	1625	1555	1625	.37	.00	.00	129	129

Table 3.--Daily rainfall amounts for 4 days preceding the 41 day of sample collection

[Rainfall amounts are given in inches; TC, Third Creek tributary; FM, Fourth Creek tributary at Middlebrook Pike; FW, Fourth Creek tributary at Wellington Drive; TM, Ten Mile Creek tributary; FC, First Creek tributary]

		Daily rainfall amounts for preceding days			
Watershed number on map	Storm number	1	2	3	4
1	TC1	0.00	0.00	0.00	0.00
	TC2	.00	.00	.00	.00
	TC3	.00	.00	.05	.10
2	FM1	.00	.00	.00	.50
	FM2	.00	.00	.00	.00
	FM3	.00	.00	.00	.65
3	FW1	.00	.00	.25	.00
	FW2	.00	.00	.00	.00
	FW3	.00	.00	.00	.00
4	TM1	.00	.00	.00	1.00
	TM2	.00	.00	.00	.40
	TM3	.00	.00	.00	.00
5	FC1	.00	.00	.00	.00
	FC2	.10	.00	.00	.00
	FC3	.00	.00	.00	.20

QUALITY ASSURANCE AND QUALITY CONTROL

Throughout this study, a program of quality control and quality assurance of the field and laboratory methods used to collect and analyze all water samples was in force. A procedures manual was developed to provide field personnel with a standard operating procedure for collecting, handling, processing, and shipping water samples. Standard forms were developed and used for field data collection, requesting analytical services, and to provide a chain of custody when shipping water samples. The purpose of the quality assurance and control program was to ensure the accuracy of the data presented in this report.

Quality-control samples collected during the course of this study included equipment blanks, trip blanks, and replicate samples. These samples were collected, handled, processed, and shipped to the laboratory following guidelines set forth in the procedures manual.

Analysis of equipment and trip blanks found no contamination of water samples during collection, handling, shipment, storage, or laboratory analysis. Analysis of replicant samples found no significant difference between regular storm samples and replicant samples. Furthermore, the U.S. Geological Survey National Water Quality Laboratory performs continuous quality assurance and quality control of the laboratory equipment and techniques used to determine the values presented in this report.

STORM-RUNOFF MEAN CONCENTRATIONS AND STORM LOADS AT MONITORED WATERSHEDS

Stormwater samples were collected for 15 storms at the monitored watersheds during the period March 1991 through August 1992. Laboratory analyses of stormwater samples were conducted for a wide range of constituents (table 4). The general categories of these constituents are volatile organic compounds; acidic organic compounds; base/neutral organic compounds; organic pesticides; toxic metals, cyanide, and phenols; conventional pollutants, pH, and water temperature; and additional constituents and physical properties.

Discrete water samples were collected at approximately 15-minute intervals for a period up to 3 hours for the storms. A flow-weighted composite sample was generated for each storm by combining the discrete samples in equivalent proportion to the volume of storm runoff represented by the discrete sample. The flow-weighted composite sample was analyzed for all constituents except volatile organic compounds, cyanide, phenols, fecal bacteria, field pH, water temperature, oil and grease, field specific conductance, and suspended sediment. Values for the latter constituents were determined from one or more of the discrete samples. Results of these laboratory analyses were assumed to be representative of the mean value for the total amount of runoff produced by the storm.

Table 4.--Minimum reported values for analyzed constituents

[Laboratory code refers to analytical procedure described by Fishman and Friedman, 1989; µg/L, micrograms per liter; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter; col/100 mL, colonies per 100 milliliters; --, no data]

Constituent	Laboratory code	Minimum reported value
Volatile organic compounds		
Acrolein, total, in µg/L	1650	20
Acrylonitrile, total, in µg/L	1651	20
Benzene, total, in µg/L	1287	.2
Bromoform, total, in µg/L	1288	.2
Carbontetrachloride, total, in µg/L	1289	.2
Chlorobenzene, total, in µg/L	1290	.2
Chlorodibromomethane, total, in µg/L	1291	.2
Chloroethane, total, in µg/L	1292	.2
[a] 2-Chloroethylvinylether, total, in µg/L	1293	.2
	1658	1
Chloroform, total, in µg/L	1294	.2
Dichlorobromomethane, total, in µg/L	1295	.2
1,1-Dichloroethane, total, in µg/L	1297	.2
1,2-Dichloroethane, total, in µg/L	1298	.2
1,1-Dichloroethylene, total, in µg/L	1299	.2
1,2-Dichloropropane, total, in µg/L	1301	.2
1,3-Dichloropropene, total, in µg/L	1302	.2
Ethylbenzene, total, in µg/L	1303	.2
Methylbromide, total, in µg/L	1304	.2
Methylchloride, total, in µg/L	1318	.2
Methylenechloride, total, in µg/L	1305	.2
1,1,2,2-Tetrachloroethane, total, in µg/L	1306	.2
Tetrachloroethylene, total, in µg/L	1307	.2
Toluene, total, in µg/L	1308	.2
1,2-Transdichloroethene, total, in µg/L	1300	.2
1, 1, 1-Trichloroethane, total, in µg/L	1309	.2
1,1,2-Trichloroethane, total, in µg/L	1310	.2
Trichloroethylene, total, in µg/L	1311	.2
Vinylchloride, total, in µg/L	1313	.2
Acidic organic compounds		
2-Chlorophenol, total, in µg/L	1056	5
2,4-Dichlorophenol, total, in µg/L	1057	5
2,4-Dimethylphenol, total, in µg/L	1059	5

Table 4.--Minimum reported values for analyzed constituents--Continued

Constituent	Laboratory code	Minimum reported value
Acidic organic compounds--Continued		
4,6-Dinitroorthocresol, total, in µg/L	1060	30
2,4-Dinitrophenol, total, in µg/L	1061	20
2-Nitrophenol, total, in µg/L	1062	5
4-Nitrophenol, total, in µg/L	1063	30
Parachlorometacresol, total, in µg/L	1055	30
Pentachlorophenol, total, in µg/L	1064	30
Phenol, total, in µg/L	1065	5
2,4,6-Trichlorophenol, total, in µg/L	1058	20
Base/neutral organic compounds		
Acenaphthylene, total, in µg/L	1067	5
Acenaphthene, total, in µg/L	1066	5
Anthracene, total, in µg/L	1068	5
Benzidine, total, in µg/L	1069	40
Benzo (A) anthracene, total, in µg/L	1070	10
Benzo (A) pyrene, total, 1n µg/L	1073	10
Benzo (B) fluoranthene, total, in µg/L	1071	10
Benzo (GHI) perylene, total, in µg/L	1074	10
Benzo (K) fluoranthene, total, in µg/L	1072	10
BIS (2-Chloroethoxy) methane, total, in µg/L	1076	5
BIS (2-Chloroethyl) ether, total, in µg/L	1077	5
BIS (2-Chloroisopropyl) ether, total, in µg/L	1078	5
BIS (2-Ethylhexyl) phthalate, total, in µg/L	1094	5
4-Bromophenyl phenyl ether, total, in µg/L	1079	5
N-Butyl benzyl phthalate, total, in µg/L	1075	5
2-Chloronaphthalene, total, in µg/L	1080	5
4-Chlorophenyl phenyl ether, total, in µg/L	1081	5
Chrysene, total, in µg/L	1082	10
1,2,5,6-Dibenzanthracene, total, in µg/L	1083	10
[a]l,2-Dichlorobenzene, total, in µg/L	1085	5
	1314	.2
[a]l,3-Dichlorobenzene, total, in µg/L	1086	5
	1315	.2
[a]l,4-Dichlorobenzene, total, in µg/L	1087	5
	1316	.2
3,3-Dichlorobenzidine, total, in µg/L	1088	20
Diethyl phthalate, total, in µg/L	1089	5
Dimethyl phthalate, total, in µg/L	1090	5

Table 4.--Minimum reported values for analyzed constituents--Continued

Constituent	Laboratory code	Minimum reported value
Base/neutral organic compounds--Continued		
Di-N-butyl phthalate, total, in µg/L	1084	5
2,4-Dinitro toluene, total, in µg/L	1091	5
2,6-Dinitro toluene, total, in µg/L	1092	5
Di-N-octyl phthalate, total, in µg/L	1093	10
Fluoranthene, total, in µg/L	1096	5
Fluorene, total, in µg/L	1095	5
Hexachlorobenzene, total, in µg/L	1097	5
[a] Hexachlorobutadiene, total, in µg/L	1098	5
	1675	.2
Hexachlorocyclopentadiene, total, in µg/L	1099	5
Hexachloroethane, total, in µg/L	1100	5
Indeno (1,2,3) pyrene, total, in µg/L	1101	10
Isophorone, total, in µg/L	1102	5
[a] Naphthalene, total, in µg/L	1103	5
	1677	.2
Nitrobenzene, total, in µg/L	1104	5
N-Nitrosodimethylamine, total, in µg/L	1105	5
N-Nitrosodi-N-propylamine, total, in µg/L	1107	5
N-Nitrosodiphenylamine, total, in µg/L	1106	5
Phenanthrene, total, in µg/L	1108	5
Pyrene, total, in µg/L	1109	5
[a] 1,2,4-Trichlorobenzene, total, in µg/L	1111	5
	1673	.2
Organic pesticides		
[a] Aldrin, total, in µg/L	0350	0.01
	1624	.04
[a] Alpha benzene hexachloride, total, in µg/L	0806	.01
	1619	.03
[a] Beta benzene hexachloride, total, in µg/L	0807	.01
	1620	.03
[a] Lindane, total, in µg/L	0359	.01
	1621	.03
[a] Delta benzene hexachloride, total, in µg/L	0808	.01
	1622	.09
Chlordane, cis isomer, total, in µg/L	1628	.1
Chlordane, trans isomer, total, in µg/L	1626	.1

Table 4.--Minimum reported values for analyzed constituents--Continued

Constituent	Laboratory code	Minimum reported value
Organic pesticides--Continued		
[a]Chlordane, total, in µg/L	0351	.1
	1637	.1
P,P' DDT, total, in µg/L	1636	.1
P,P' DDE, total, in µg/L	1630	.04
P,P' DDD, total, in µg/L	1633	.1
[a]Dieldrin, total, in µg/L	0355	.01
	1629	.02
Endosulfan I alpha, total, in µg/L	1627	.1
Endosulfan II beta, total, in µg/L	1632	.04
Endosulfan sulfate, total, in µg/L	1635	.6
[a]Endrin, total, in µg/L	0356	.01
	1631	.06
Endrin aldehyde, total, in µg/L	1634	.2
[a]Heptachlor, total, in µg/L	0357	.01
	1623	.03
[a]Heptachlor epoxide, total, in µg/L	0358	.01
	1625	.8
[a]Arochlor 1016 PCB, total, in µg/L	0809	.1
	1641	.1
[a]Arochlor 1221 PCB, total, in µg/L	0810	.1
	1639	1.
[a]Arochlor 1232 PCB, total, in µg/L	0811	.1
	1640	.1
[a]Arochlor 1242 PCB, total, in µg/L	0812	.1
	1642	.1
[a]Arochlor 1248 PCB, total, in µg/L	0813	.1
	1643	.1
[a]Arochlor 1254 PCB, total, in µg/L	0814	.1
	1644	.1
[a]Arochlor 1260 PCB, total, in µg/L	0815	.1
	1645	.1
[a]Toxaphene, total, in µg/L	0360	1
	1638	2
Toxic metals, cyanide, and phenols		
[a]Antimony, total, in µg/L as Sb	0080	1
	1646	10

Table 4.--Minimum reported values for analyzed constituents--Continued

Constituent	Laboratory code	Minimum reported value
Toxic metals, cyanide, and phenols--Continued		
[a] Arsenic, total, in µg/L as As	0118	1
	1584	1
Beryllium, total, in µg/L as Be	0236	10
Cadmium, total, in µg/L as Cd	1555	1
Chromium, total, in µg/L as Cr	0762	1
Copper, total, in µg/L as Cu	1559	1
[a] Cyanide, total, in mg/L as Cn	0023	.01
	1648	.01
Lead, total, in µg/L as Pb	1561	1
Mercury, total, in µg/L as Hg	0227	.1
Nickel, total, in µg/L as Ni	1563	1
Phenols, total, in µg/L	0052	1
[a] Selenium, total, in µg/L as Se	0286	1
	1585	1
[a] Silver, total, in µg/L as Ag	1553	1
	1647	.5
Thallium, total, in µg/L as TI	1569	5
Zinc, total, in µg/L as Zn	0296	10
Conventional pollutants, pH, and water temperature		
Biological oxygen demand, in mg/L	--	--
Chemical oxygen demand, in mg/L	0076	10
Coliform, fecal, col/100 mL	--	--
Streptococci, fecal, col/100 mL	--	--
Roe at 180° Celsius, dissolved, in mg/L	0027	1
Roe at 105° Celsius, suspended, in mg/L	0169	1
pH, field, standard units	--	--
pH, laboratory, standard units	0068	.1
Water temperature, field, degrees Celsius	--	--
Nitrogen, NO2 + NO3, total, in mg/L as N	0304	.05
[a] Nitrogen, NH4 + organic, total, in mg/L as N	0084	.2
	1688	.2
[a] Phosphorus, dissolved, in mg/L as P	0128	.01
	1685	.01
[a] Phosphorus, total, in mg/L as P	0129	.01
	1686	.01
Oil and grease, total, in mg/L	0127	1

Table 4.--Minimum reported values for analyzed constituents--Continued

Constituent	Laboratory code	Minimum reported value
Additional constituents and physical properties		
Specific conductance, field, in µs/cm	--	--
Specific conductance, laboratory, in µs/cm	0069	1
Alkalinity, laboratory, in mg/L as $CaCO_3$	0070	1
Calcium, dissolved, in mg/L as Ca	0659	.02
Chloride, dissolved, in mg/L as Cl	1571	.1
Magnesium, dissolved, in mg/L as Mg	0663	.01
Potassium, dissolved, in mg/L as K	0054	.1
Sodium, dissolved, in mg/L as Na	0675	.2
Sulfate, dissolved, in mg/L as SO_4	1572	.1
Carbon, organic, total, in mg/L as C	0114	.1
Sediment, suspended, in mg/L	--	--

[a] Two laboratory methods were used to analyze this constituent.

Laboratory codes and minimum reported values (table 4) are provided to document methods used to determine constituent values presented in this report (Fishman and Friedman, 1989). During this study, several constituents were analyzed using two methods. The change in laboratory methods was the result of a revision of laboratory analytical schedules, that was implemented in late 1991 to provide a more thorough and economical water-quality testing program. In most instances where a constituent was analyzed by two methods, the first laboratory code applies to storms sampled from March 1991 through August 1991 and the second laboratory code applies to storms sampled from September 1991 through the end of the study.

Constituent concentrations and physical property values are reported for 28 volatile organic compounds (table 5), 11 acidic organic compounds (table 6), 45 base/neutral organic compounds (table 7), 27 organic pesticides (table 8), 13 toxic metals, cyanide, and phenols (table 9), 11 conventional pollutants, pH, and water temperature (table 10), and 11 additional constituents and physical properties (table 11).

Storm loads (table 12) are provided for constituents with storm-runoff mean concentrations above minimum reported values. These loads, reported in pounds, were computed by multiplying the constituent concentration by the volume of storm runoff and a conversion factor.

Table 5.--Storm-runoff mean concentrations of volatile organic compounds for sampled storms

[All concentrations were determined from discrete samples and are reported as micrograms per liter; <, below minimum reported value; a, sample diluted for analysis; --, no data; TC, Third Creek tributary; FM, Fourth Creek tributary at Middlebrook Pike; FW, Fourth Creek tributary at Wellington Drive; TM, Ten Mile Creek tributary at Wellington Drive; FC, First Creek tributary]

Storm number	Acro-lein, total	Acrylo-nitrile, total	Benzene, total	Bromo-form, total	Carbon-tetra-chlor-ide, total	Chloro-benzene, total	Chloro-di-bromo-methane, total
TC1	--	--	2	<0.3a	<0.3a	<0.3a	<0.3a
TC2	--	--	92	<.2	<.2	<.2	<.2
TC3	<20	<20	160	<.2	<.2	<.2	<.2
FM1	--	--	<.2	<.2	<.2	<.2	<.2
FM2	<20	<20	<.2	<.2	<.2	<.2	<.2
FM3	<20	<20	<.2	<.2	<.2	<.2	<.2
FW1	--	--	<.2	<.2	<.2	<.2	<.2
FW2	<20	<20	<.2	<.2	<.2	<.2	<.2
FW3	<20	<20	<.2	<.2	<.2	<.2	<.2
TM1	--	--	<.2	<.2	<.2	<.2	<.2
TM2	<20	<20	<.2	<.2	<.2	<.2	<.2
TM3	<20	<20	<.2	<.2	<.2	<.2	<.2
FC1	--	--	<.2	<.2	<.2	<.2	<.2
FC2	<20	<20	<.2	<.2	<.2	<.2	<.2
FC3	<20	<20	<.2	<.2	<.2	<.2	<.2

Storm number	Chloro-ethane, total	2-Chloro-ethyl-vinyl-ether, total	Chloro form, total	Di-chloro-bromo-methane, total	1,1-Di-chloro-ethane, total	1,2-Di-chloro-ethane, total	1,1-Di-chloro-ethyl-ene, total
TC1	<0.3a	<0.3a	<0.3a	<0.3a	<0.3a	<0.3a	<0.3a
TC2	<.2	<.2	<.3a	<.2	<.2	<.2	<.2
TC3	<.2	<1	<.2	<.2	<.2	<.2	<.2
FM1	<.2	<.2	<.2	<.2	<.2	<.2	<.2
FM2	<.2	<1	<.2	<.2	<.2	<.2	<.2
FM3	<.2	<1	<.2	<.2	<.2	<.2	<.2
FW1	<.2	<.2	<.2	<.2	<.2	<.2	<.2
FW2	<.2	<1	.2	<.2	<.2	<.2	<.2
FW3	<.2	<1	<.2	<.2	<.2	<.2	<.2
TM1	<.2	<.2	<.2	<.2	<.2	<.2	<.2
TM2	<.2	<1	.4	<.2	<.2	<.2	<.2
TM3	<.2	<1	<.2	<.2	<.2	<.2	<.2
FC1	<.2	<.2	<.2	<.2	<.2	<.2	<.2
FC2	<.2	<1	<.2	<.2	<.2	<.2	<.2
FC3	<.2	<1	<.2	<.2	<.2	<.2	<.2

Table 5.--Storm-runoff mean concentrations of volatile organic compounds for sampled storms--Continued

Storm number	1,2-Dichloropropane, total	1,3-Dichloropropene, total	Ethylbenzene, total	Methylbromide, total	Methylchloride, total	Methylene-chloride, total	1,1,2,2-Tetrachloroethane, total
TC1	<0.3a	<0.3a	1.8	<0.3a	<0.3a	<0.3a	<0.3a
TC2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
TC3	<.2	--	.7	<.2	<.2	<.2	<.2
FM1	<.2	<.2	<.2	<.2	<.2	<.2	<.2
FM2	<.2	--	<.2	<.2	<.2	.2	<.2
FM3	<.2	--	<.2	<.2	<.2	<.2	<.2
FW1	<.2	<.2	<.2	<.2	<.2	<.2	<.2
FW2	<.2	--	.2	<.2	<.2	<.2	<.2
FW3	<.2	--	<.2	<.2	<.2	<.2	<.2
TM1	<.2	<.2	<.2	<.2	<.2	<.2	<.2
TM2	<.2	--	<.2	<.2	<.2	.3	<.2
TM3	<.2	--	<.2	<.2	<.2	<.4	<.2
FC1	<.2	<.2	.4	<.2	<.2	<.2	<.2
FC2	<.2	--	<.2	<.2	<.2	<.2	<.2
FC3	<.2	--	<.2	<.2	<.2	<.2	<.2

Storm number	Tetrachloroethylene, total	Toluene, total	1,2-Transdichloroethene, total	1,1,1-Trichloroethane, total	1,1,2-Trichloroethane, total	Trichloroethylene, total	Vinylchloride, total
TC1	<0.3a	8	<0.3a	<0.3a	<0.3a	<0.3a	<0.3a
TC2	<.2	100	<.2	<.2	<.2	<.2	<.2
TC3	<.2	190	<.2	<.2	<.2	<.2	<.2
FM1	<.2	<.2	<.2	<.2	<.2	<.2	<.2
FM2	.5	<.2	<.2	1	<.2	<.2	<.2
FM3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
FW1	<.2	<.2	<.2	<.2	<.2	<.2	<.2
FW2	1.7	2.3	<.2	<.2	<.2	<.2	<.2
FW3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
TM1	<.2	<.2	<.2	<.2	<.2	<.2	<.2
TM2	<.2	.3	<.2	<.2	<.2	<.2	<.2
TM3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
FC1	<.2	1.2	<.2	<.2	<.2	<.2	<.2
FC2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
FC3	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 6.--Storm-runoff mean concentrations of acidic organic compounds for sampled storms

[All concentrations were determined from flow-weighted composite samples and are reported as micrograms per liter; <, below minimum reported value; --, no data; a, sample diluted for analysis; b, sample destroyed during shipment; TC, Third Creek tributary; FM, Fourth Creek tributary at Middlebrook Pike; FW, Fourth Creek tributary at Wellington Drive; TM, Ten Mile Creek tributary; FC, First Creek tributary]

Storm number	2-Chloro-phenol, total	2,4-Di-chloro-phenol, total	2,4-Di-methyl-phenol, total	4,6-Di-nitro-ortho-cresol, total	2,4-Di-nitro-phenol, total	2-Nitro-phenol, total	4-Nitro-phenol, total
TC1	<5	<5	5	<30	<20	<5	<30
TC2	<5	<5	<5	<30	<20	<5	<30
TC3	<5	<5	<5	<30	<20	<5	<30
FM1	<5	<5	<5	<30	<20	<5	<30
FM2	<5	<5	<5	<30	<20	<5	<30
FM3	<5	<5	<5	<30	<20	<5	<30
FW1	<5	<5	<5	<30	<20	<5	<30
FW2	b	b	b	b	b	b	b
FW3	<5	<5	<5	<30	<20	<5	<30
TM1	<5	<5	<5	<30	<30a	<5	<30
TM2	<5	<5	<5	<30	<20	<5	<30
TM3	<5	<5	<5	<30	<20	<5	<30
FC1	<5	<5	<5	<30	<20	<5	<30
FC2	<5	<5	<5	<30	<20	<5	<30
FC3	<5	<5	<5	<30	<20	<5	<30

Storm number	Parachloro-metacresol, total	Penta-chloro-phenol, total	Phenol, total	2,4,6-Trichloro-phenol, total
TC1	<30	<30	<5	<20
TC2	<30	<30	5	<20
TC3	<30	<30	10	<20
FM1	<30	<30	<5	<20
FM2	<30	<30	<5	<20
FM3	<30	<30	<5	<20
FW1	<30	<30	<5	<20
FW2	b	b	--	b
FW3	<30	<30	<5	<20
TM1	<30	<30	<5	<20
TM2	<30	<30	<5	<20
TM3	<30	<30	<5	<20
FC1	<30	<30	<5	<20
FC2	<30	<30	<5	<20
FC3	<30	<30	<5	<20

Table 7.--Storm-runoff mean concentrations of base/neutral organic compounds for sampled storms

[All concentrations were determined from flow-weighted composite samples and are reported as micrograms per liter; <, below minimum reported value; --, no data; b, sample destroyed during shipment; TC, Third Creek tributary; FM, Fourth Creek tributary at Middlebrook Pike; FW, Fourth Creek tributary at Wellington Drive; TM, Ten Mile Creek tributary; FC, First Creek tributary]

Storm number	Ace-naphth-ylene, total	Ace-naphth-ene, total	Anthra-cene, total	Benzi-dine, total	Benzo (A) anthra-cene, total	Benzo (A) pyrene, total	Benzo (B) fluo-ran-thene, total	Benzo (GHI) peryl-ene, total
TC1	<5	<5	<5	--	<10	<10	<10	<10
TC2	<5	<5	<5	--	<10	<10	<10	<10
TC3	<5	<5	<5	<40	<10	<10	<10	<10
FM1	<5	<5	<5	--	<10	<10	<10	<10
FM2	<5	<5	<5	<40	<10	<10	<10	<10
FM3	<5	<5	<5	<40	<10	<10	<10	<10
FW1	<5	<5	<5	--	<10	<10	<10	<10
FW2	b	b	b	b	b	b	b	b
FW3	<5	<5	<5	<40	<10	<10	<10	16
TM1	<5	<5	<5	<40	<10	<10	<10	<10
TM2	<5	<5	<5	<40	<10	<10	<10	<10
TM3	<5	<5	<5	<40	<10	<10	<10	<10
FC1	<5	<5	<5	--	<10	<10	<10	<10
FC2	<5	<5	<5	<40	<10	<10	<10	<10
FC3	<5	<5	<5	<40	<10	<10	<10	<10

Storm number	Benzo (K) fluo-ran-thene, total	BIS (2-Chloro-ethoxy) methane, total	BIS (2-Chloro-ethyl) ether, total	BIS (2-Chloro-iso-propyl) ether, total	BIS (2-Ethyl-hexyl) phthal-ate, total	4-Bromo-phenyl phenyl ether, total	N-Butyl benzyl phtha-late, total	2-Chloro-naphth-alene, total
TC1	<10	<5	<5	<5	5	<5	<5	<5
TC2	<10	<5	<5	<5	<5	<5	<5	<5
TC3	<10	<5	<5	<5	17	<5	<5	<5
FM1	<10	<5	<5	<5	<5	<5	<5	<5
FM2	<10	<5	<5	<5	<5	<5	<5	<5
FM3	<10	<5	<5	<5	<5	<5	<5	<5
FW1	<10	<5	<5	<5	5	<5	<5	<5
FW2	b	b	b	b	b	b	b	b
FW3	<10	<5	<5	<5	<5	<5	<5	<5
TM1	<10	<5	<5	<5	<5	<5	<5	<5
TM2	<10	<5	<5	<5	<5	<5	<5	<5
TM3	<10	<5	<5	<5	<5	<5	<5	<5
FC1	<10	<5	<5	<5	<5	<5	<5	<5
FC2	<10	<5	<5	<5	<5	<5	<5	<5
FC3	<10	<5	<5	<5	<5	<5	<5	<5

Table 7.--Storm-runoff mean concentrations of base/neutral organic compounds for sampled storms--Continued

Storm number	4-Chloro-phenyl phenyl ether, total	Chry-sene, total	1,2,5,6-Dibenz-anthra-cene, total	1,2-Di-chloro-benzene, total	1,3-Di-chloro-benzene, total	1,4-Di-chloro-benzene, total	3,3-Di-chloro-benzi-dine, total	Diethyl phthal-ate, total
TC1	<5	<10	<10	<5	<5	<5	--	<5
TC2	<5	<10	<10	<5	<5	<5	--	<5
TC3	<5	<10	<10	<5	<5	<5	<20	<5
FM1	<5	<10	<10	<5	<5	<5	--	<5
FM2	<5	<10	<10	<5	<5	<5	<20	<5
FM3	<5	<10	<10	<5	<5	<5	<20	<5
FW1	<5	<10	<10	<5	<5	<5	--	<5
FW2	b	b	b	<.2	<.2	<.2	b	b
FW3	<5	<10	<10	<5	<5	<5	<20	<5
TM1	<5	<10	<10	<5	<5	<5	<20	<5
TM2	<5	<10	<10	<5	<5	<5	<20	<5
TM3	<5	<10	<10	<5	<5	<5	<20	<5
FC1	<5	<10	<10	<5	<5	<5	--	<5
FC2	<5	<10	<10	<5	<5	<5	<20	<5
FC3	<5	<10	<10	<5	<5	<5	<20	<5

Storm number	Di-methyl phthal-ate, total	Di-N-butyl phthal-ate, total	2,4-Di-nitro-toluene, total	2,6-Di-nitro-toluene, total	Di-N-octyl phthal-ate, total	Fluor-anthene, total	Fluor-ene, total
TC1	<5	<5	<5	<5	<10	<5	<5
TC2	<5	<5	<5	<5	<10	<5	<5
TC3	<5	<5	<5	<5	<10	<5	<5
FM1	<5	<5	<5	<5	<10	<5	<5
FM2	<5	<5	<5	<5	<10	<5	<5
FM3	<5	<5	<5	<5	<10	<5	<5
FW1	<5	<5	<5	<5	<10	9	<5
FW2	b	b	b	b	b	b	b
FW3	<5	<5	<5	<5	<10	8	<5
TM1	<5	<5	<5	<5	<10	<5	<5
TM2	<5	<5	<5	<5	<10	<5	<5
TM3	<5	<5	<5	<5	<10	<5	<5
FC1	<5	<5	<5	<5	<10	<5	<5
FC2	<5	<5	<5	<5	<10	<5	<5
FC3	<5	<5	<5	<5	<10	<5	<5

Table 7.--Storm-runoff mean concentrations of base/neutral organic compounds for sampled storms--Continued

Storm number	Hexa-chloro-ben-zene, total	Hexa-chloro-buta-diene, total	Hexa-chloro-cyclo-penta-diene, total	Hexa-chloro-ethane, total	Indeno (1,2,3) pyrene, total	Iso-pho-rone, total	Naphth-alene, total	Nitro-benzene, total
TC1	<5	<5	<5	<5	<10	<5	<5	<5
TC2	<5	<5	<5	<5	<10	<5	<5	<5
TC3	<5	<5	<5	<5	<10	<5	<5	<5
FM1	<5	<5	<5	<5	<10	<5	<5	<5
FM2	<5	<5	<5	<5	<10	<5	<5	<5
FM3	<5	<5	<5	<5	<10	<5	<5	<5
FW1	<5	<5	<5	<5	<10	<5	<5	<5
FW2	b	<.2	b	b	b	b	.6	b
FW3	<5	<5	<5	<5	19	<5	<5	<5
TM1	<5	<5	<5	<5	<10	<5	<5	<5
TM2	<5	<5	<5	<5	<10	<5	<5	<5
TM3	<5	<5	<5	<5	<10	<5	<5	<5
FC1	<5	<5	<5	<5	<10	<5	<5	<5
FC2	<5	<5	<5	<5	<10	<5	<5	<5
FC3	<5	<5	<5	<5	<10	<5	<5	<5

Storm number	N-N-Nitro sodi-methyl-amine, total	N-nitro-sodi-N-propyl-amine, total	Nitro-sodi-phenyl-amine, total	Phen-anthrene, total	Pyrene, total	1,2,4-Tri-chloro-benzene, total
TC1	<5	<5	<5	<5	<5	<5
TC2	<5	<5	<5	<5	<5	<5
TC3	<5	<5	<5	<5	<5	<5
FM1	<5	<5	<5	<5	<5	<5
FM2	<5	<5	<5	<5	<5	<5
FM3	<5	<5	<5	<5	<5	<5
FW1	<5	<5	<5	<5	6	<5
FW2	b	b	b	b	b	<.2
FW3	<5	<5	<5	<5	<5	<5
TM1	<5	<5	<5	<5	<5	<5
TM2	<5	<5	<5	<5	<5	<5
TM3	<5	<5	<5	<5	<5	<5
FC1	<5	<5	<5	<5	<5	<5
FC2	<5	<5	<5	<5	<5	<5
FC3	<5	<5	<5	<5	<5	<5

Table 8.--Storm-runoff mean concentrations of organic pesticides for sampled storms

[All concentrations were determined from flow-weighted composite samples and are reported as micrograms per liter; <, less than minimum reported value; a, sample diluted for analysis; --, no data; TC, Third Creek tributary; FM, Fourth Creek tributary at Middlebrook Pike; FW, Fourth Creek tributary at Wellington Drive; TM, Ten Mile Creek; FC, First Creek tributary]

Storm number	Aldrin, total	Alpha benzene hexa-chlor-ide, total	Beta benzene hexa-chlor-ide, total	Lindane, total	Delta benzene hexa-chlor-ide, total	Chlor-dane, cis isomer, total	Chlor-dane, trans isomer, total	Chlor-dane, total
TC1	<0.01	<0.01	<0.01	<0.01	<0.01	--	--	<0.1
TC2	<.01	<.01	<.01	<.01	<.01	--	--	<.1
TC3	<.04	<.03	<.03	<.03	<.09	<0.1	<0.1	<.1
FM1	<.01	.10	<.20a	<.01	<.01	--	--	<.1
FM2	<.04	<.03	<.03	<.03	<.09	<.1	<.1	<.1
FM3	<.04	<.03	<.03	<.03	<.09	<.1	<.1	<.1
FW1	<.01	<.01	<.01	<.01	<.01	--	--	<.1
FW2	<.04	<.03	<.03	<.03	<.09	<.1	<.1	<.1
FW3	<.04	<.03	<.03	<.03	<.09	<.1	<.1	<.1
TM1	<.40a	<.30a	<.30a	<.30a	<.90a	<1a	<1a	<1a
TM2	<.04	<.03	<.03	<.03	<.09	<.1	<.1	<.1
TM3	<.04	<.03	<.03	<.03	<.09	<.1	<.1	<.1
FC1	<.01	<.01	<.01	<.01	<.01	--	--	.1
FC2	<.04	<.03	<.03	<.03	<.09	<.1	<.1	<.1
FC3	<.04	<.03	<.03	<.03	<.09	<.1	<.1	<.1

Storm number	P,P' DDT, total	P,P' DDE, total	P,P' DDD, total	Di-eldrin, total	Endo-sul-fan I alpha, total	Endo-sul-fan II beta, total	Endo-sulfan sulfate, total	End-rin, total
TC1	--	--	--	<0.01	--	--	--	<0.01
TC2	--	--	--	<.01	--	--	--	<.01
TC3	<0.1	<0.04	<0.1	<.02	<0.1	<0.04	<.6	<.06
FM1	--	--	--	<.01	--	--	--	<.01
FM2	<.1	<.04	<.1	<.02	<.1	<.04	<.6	<.06
FM3	<.1	<.04	<.1	<.02	<.1	<.04	<.6	<.06
FW1	--	--	--	<.01	--	--	--	<.01
FW2	<.1	<.04	<.1	<.02	<.1	<.04	<.6	<.06
FW3	<.1	<.04	<.1	<.02	<.1	<.04	<.6	<.06
TM1	<1a	<.2a	<1a	<.2a	<1a	<.4a	<6a	<.6a
TM2	<.1	<.04	<.1	<.03a	<.1	<.04	<.6	<.06
TM3	<.1	<.04	<.1	<.02	<.1	<.04	<.6	<.06
FC1	--	--	--	.01	--	--	--	<.01
FC2	<.1	<.04	<.1	<.02	<.1	<.04	<.6	<.06
FC3	<.1	<.04	<.1	<.02	<.1	<.04	<.6	<.06

Table 8.--Storm-runoff mean concentrations of organic pesticides for sampled storms--Continued

Storm number	Endrin alde-hyde, total	Hepta-chlor, total	Hepta-chlor epoxide, total	Aroclor 1016 PCB, total	Aroclor 1221 PCB, total	Aroclor 1232 PCB, total	Aroclor 1242 PCB, total	Aroclor 1248 PCB, total
TC1	--	<0.01	<0.01	<0.1	<1a	<0.1	<0.1	<0.1
TC2	--	<.01	<.01	<.1	<.1	<.1	<.1	<.1
TC3	<.2	<.03	<.8	<.1	<1	<.1	<.1	<.1
FM1	--	<.01	<.01	<.1	<.1	<.1	<.1	<.1
FM2	<.2	<.03	<.8	<.1	<1	<.1	<.1	<.1
FM3	<.2	<.03	<.8	<.1	<1	<.1	<.1	<.1
FW1	--	<.01	<.01	<.1	<.1	<.1	<.1	<.1
FW2	<.2	<.03	<.8	<.1	<1	<.1	<.1	<.1
FW3	<.2	<.03	<.8	<.1	<1	<.1	<.1	<.1
TM1	<.2	<.3a	<8a	<1a	<1	<1a	<1a	<1a
TM2	<.2	<.03	<.8	<.1	<1	<.1	<.1	<.1
TM3	<.2	<.03	<.8	<.1	<1	<.1	<.1	<.1
FC1	--	<.01	<.01	<.1	<.1	<.1	<.1	<.1
FC2	<.2	<.03	<.8	<.1	<1	<.1	<.1	<.1
FC3	<.2	<.03	<.8	<.1	<1	<.1	<.1	<.1

Storm number	Aroclor 1254 PCB, total	Aroclor 1260 PCB, total	Toxa-phene, total
TC1	<0.1	<0.1	<1
TC2	<.1	<.1	<1
TC3	<.1	<.1	<2
FM1	<.1	<.1	<1
FM2	<.1	<.1	<2
FM3	<.1	<.1	<2
FW1	<.1	<.1	<1
FW2	<.1	.3	<2
FW3	<.1	<.1	<2
TM1	<1a	<1a	<20a
TM2	<.1	<.1	<2
TM3	<.1	<.1	<2
FC1	<.1	.1	<1
FC2	<.1	<.1	<2
FC3	<.1	<.1	<2

Table 9.--Storm-runoff mean concentrations of toxic metals, cyanide, and total phenols for sampled storms

[All concentrations were determined from flow-weighted composite samples, except cyanide and phenols which were determined from discrete samples; all concentrations are reported as micrograms per liter except for cyanide which is reported as milligrams per liter; a, sample diluted for analysis; <, less than minimum reported value; --, no data; TC, Third Creek tributary; FM, Fourth Creek tributary at Middlebrook Pike; FW, Fourth Creek tributary at Wellington Drive; TM, Ten Mile Creek tributary; FC, First Creek tributary]

Storm number	Antimony, total, as Sb	Arsenic, total, as As	Beryllium, total, as Be	Cadmium, total, as Cd	Chromium, total, as Cr	Copper, total, as Cu	Cyanide, total, as Cn	Lead, total, as Pb
TC1	1	14	<10	1	6	11	<0.01	15
TC2	1	2	<10	2	10	14	<.01	23
TC3	<10	14	<10	2	11	23	.01	29
FM1	1	3	<10	1	14	8	<.01	25
FM2	<10	2	<10	<1	6	--	<.01	18
FM3	<20a	2	<10	<1	6	5	<.01	14
FW1	3	<1	<10	<1	3	9	<.01	17
FW2	<10	<1	<10	2	28	28	.01	14
FW3	<20a	12	<10	<1	3	13	<.01	12
TM1	<1	<1	<10	<1	<1	3	<.01	--
TM2	<10	<1	<10	<1	7	6	<.01	5
TM3	<10	2	<10	<1	<1	3	<.01	5
FC1	1	2	<10	<1	8	6	<.01	54
FC2	<10	1	<10	<1	12	6	<.01	64
FC3	<10	2	<10	<1	6	12	<.01	40

Storm number	Mercury, total, as Hg	Nickel, total, as Ni	Phenols, total	Selenium, total, as Se	Silver, total, as Ag	Thallium, total, as Tl	Zinc, total, as Zn
TC1	0.2	2	120	<1	<1	<10a	150
TC2	<.1	11	33	<1	<1	<5	200
TC3	<.1	6	150	<2	<1	<10a	210
FM1	.1	8	<1	<1	<1	<5	350
FM2	<.1	9	8	<2	<1	<10a	240
FM3	<.1	4	3	<1	<1	<5	150
FW1	<.1	3	5	<1	<1	<5	170
FW2	.1	10	11	<1	<1	<5	340
FW3	<.1	4	14	<2	<1	<5	150
TM1	<.1	2	1	<1	<1	--	20
TM2	<.1	10	3	<1	<1	<5	50
TM3	<.1	1	4	<2	<1	<10a	50
FC1	<.1	6	--	<1	<1	<10a	110
FC2	<.1	6	3	<2	<1	<5	130
FC3	<.1	3	6	<2	<1	<10a	90

Table 10.--Storm-runoff mean concentrations of conventional pollutants, pH values, and water temperatures for sampled storms

[All concentrations were determined from flow-weighted composite samples, except fecal bacteria, and oil and grease, which were determined from discrete samples; all concentrations are reported as milligrams per liter, except fecal bacteria, which are reported as colonies per 100 milliliters; pH was determined from flow-weighted composite samples, unless otherwise noted, and is reported in standard units; water temperature is reported as degrees Celsius; <, below minimum reported value; K, results based on colony count outside the acceptable range; G, greater than; L, less than; --, no data; TC, Third Creek tributary; FM, Fourth Creek tributary at Middlebrook Pike; FW; Fourth Creek tributary at Wellington Drive; TM, Ten Mile Creek tributary; FC, First Creek tributary]

Storm number	Biological oxygen demand	Chemical oxygen demand	Coliform, fecal	Streptococci, fecal	Residue at 180° Celsius, dissolved	Residue at 105° Celsius, suspended	pH, field
TC1	72	220	220	720	129	87	7.5
TC2	10	98	2,500	7,400	100	143	7.9
TC3	270	250	K63	950	225	200	[a]8.4
FM1	72	89	K1,300	5,900	56	285	8.2
FM2	21	100	2,000	9,700	135	101	[a]7.4
FM3	52	71	20,000	56,000	54	281	--
FW1	20	130	3,900	45,000	48	43	7.0
FW2	370	650	K6,000	G1,000,000	157	75	[a]6.7
FW3	13	110	2,000	K190,000	110	23	[a]7.6
TM1	8	32	22,000	69,000	89	1	[a]7.7
TM2	26	84	690,000	17,000	117	23	[a]7.7
TM3	24	37	10,000	78,000	38	21	[a]8.0
FC1	8	77	24,000	22,000	38	100	--
FC2	36	92	K17,000	41,000	59	220	[a]8.7
FC3	27	130	56,000	48,000	85	186	[a]7.7

Table 10.--Storm-runoff mean concentrations of conventional pollutants, pH values, and water temperature for sampled storms--Continued

Storm number	pH, labor-atory	water temper-ature, field	Nitro-gen, NO2+NO3, total, as N	Nitrogen, NH4 and organic, total, as N	Phos-phorus, dis-solved, as P	Phos-phorus, total, as P	Oil and grease, total
TC1	7.1	10.0	0.61	2.2	0.91	1.5	<1
TC2	7.6	22.0	.46	1.3	.56	1.0	1
TC3	7.3	8.8	1.1	3.0	1.6	2.5	<1
FM1	7.9	18.0	.40	1.1	.04	.38	<1
FM2	7.1	16.0	.92	1.4	.38	.53	3
FM3	7.7	23.0	.50	.4	.04	.10	<1
FW1	7.0	21.0	.36	2.1	.11	.21	4
FW2	6.7	17.5	1.6	2.7	.52	.72	12
FW3	6.8	13.0	1.6	1.6	.12	.16	5
TM1	7.5	22.5	.99	.7	.05	.09	<1
TM2	7.2	25.0	1.4	1.8	.09	.14	1
TM3	7.7	23.0	.36	.5	.07	.14	<1
FC1	7.0	17.0	.32	1.2	.17	.32	<1
FC2	7.7	14.5	.32	1.1	.10	.30	<1
FC3	6.9	23.5	1.5	1.7	.24	.33	1

[a] Value from a discrete sample taken near the storm peak.

Table 11.--Storm-runoff mean concentrations of additional constituents and physical property values for sampled storms

[All concentrations were determined from flow-weighted composite samples except suspended sediment, which was determined from discrete samples; all concentrations are reported as milligrams per liter; specific conductance was determined from flow-weighted composite samples, unless otherwise noted, and is reported as microsiemens per centimeter at 25° Celsius; --, no data; TC, Third Creek tributary; FM, Fourth Creek tributary at Middlebrook Pike; FW, Fourth Creek tributary at Wellington Drive; TM, Ten Mile Creek tributary; FC, First Creek tributary]

Storm number	Specific conductance, field	Specific conductance, laboratory	Alkalinity, laboratory, as CaCO3	Calcium, dissolved, as Ca	Chloride, dissolved, as Cl	Magnesium, dissolved, as Mg	Potassium, dissolved, as K
TC1	230	201	81	28	4.8	2.5	2.0
TC2	240	173	54	22	4.6	1.8	1.6
TC3	[a]448	345	121	51	16	4.2	2.7
FM1	70	110	50	14	2.1	1.0	1.0
FM2	[a]296	223	73	28	5.9	2.5	2.8
FM3	[a]71	89	39	12	1.3	.90	1.9
FW1	170	84	33	12	1.1	1.1	1.0
FW2	[a]213	181	51	26	4.7	2.2	2.8
FW3	[a]201	162	34	20	7.4	1.7	1.3
TM1	[a]119	126	40	20	1.6	1.4	1.7
TM2	[a]165	165	48	23	8.0	1.7	2.8
TM3	[a]61	58	24	8.6	1.4	.72	1.8
FC1	60	73	34	9.1	.8	1.0	3.9
FC2	[a]41	75	35	11	.8	1.1	2.0
FC3	[a]99	106	42	14	.4	1.4	3.7

Table 11.--Storm-runoff mean concentrations of additional constituents and physical property values for sampled storms--Continued

Storm number	Sodium, dis- solved, as Na	Sulfate, dis- solved, as SO4	Carbon, organic, total, as C	Sediment, suspended
TC1	8.0	14	48	86.2
TC2	4.4	11	26	424
TC3	14	36	63	125
FM1	1.7	7.9	15	307
FM2	8.2	30	23	103
FM3	.7	7.9	17	374
FW1	1.2	8.2	27	88.2
FW2	6.0	37	190	70.0
FW3	4.8	24	26	43.2
TM1	.8	11	8.4	47.0
TM2	3.9	14	27	331
TM3	.6	3.6	11	54.9
FC1	.5	2.6	--	207
FC2	.3	2.3	25	307
FC3	.7	8.0	32	339

[a] Value from a discrete sample taken near the storm peak.

Table 12.--Storm loads for constituents with storm-runoff mean concentrations above minimum reported values

[All loads are given in pounds; L, less than; G, greater than; --, no data; TC, Third Creek tributary; FM, Fourth Creek tributary at Middlebrook Pike; FW, Fourth Creek tributary at Wellington Drive; TM, Ten Mile Creek tributary; FC, First Creek tributary]

Storm number	Benzene, total	Chloro-form, total	Ethyl-benzene, total	Methyl-ene chlo-ride, total	Tetra-chloro ethyl-ene, total	Toluene, total	1,1,1-Tri-chloro-ethane, total	2,4-Di-Methyl-phenol, total
TC1	0.013	--	0.012	--	--	0.054	--	0.034
TC2	.30	--	--	--	--	.32	--	--
TC3	.041	--	.00018	--	--	.048	--	--
FM1	--	--	--	--	--	--	--	--
FM2	--	--	--	0.00051	0.0013	--	0.0025	--
FM3	--	--	--	--	--	--	--	--
FW1	--	--	--	--	--	--	--	--
FW2	--	0.00042	.00042	--	0.0036	.0049	--	--
FW3	--	--	--	--	--	--	--	--
TM1	--	--	--	--	--	--	--	--
TM2	--	.000029	--	.000022	--	.000022	--	--
TM3	--	--	--	--	--	--	--	--
FC1	--	--	.00015	--	--	.00044	--	--
FC2	--	--	--	--	--	--	--	--
FC3	--	--	--	--	--	--	--	--

Storm number	Phenol, total	Benzo (GHI) peryl-ene, total	BIS (2-Ethyl-hexyl) phthal-ate, total	Fluor-anthene, total	Indeno (1,2,3) pyrene, total	Naphth-alene, total	Pyrene, total
TC1	--	--	0.034	--	--	--	--
TC2	.016	--	--	--	--	--	--
TC3	.0025	--	.0043	--	--	--	--
FM1	--	--	--	--	--	--	--
FM2	--	--	--	--	--	--	--
FM3	--	--	--	--	--	--	--
FW1	--	--	.034	0.061	--	--	0.040
FW2	--	--	--	--	--	0.0013	--
FW3	--	0.10	--	.052	0.12	--	--
TM1	--	--	--	--	--	--	--
TM2	--	--	--	--	--	--	--
TM3	--	--	--	--	--	--	--
FC1	--	--	--	--	--	--	--
FC2	--	--	--	--	--	--	--
FC3	--	--	--	--	--	--	--

Table 12.--Storm loads for constituents with storm-runoff mean concentrations above minimum reported values--Continued

Storm number	Alpha benzene hexa-chlor-ide, total	Chlor-dane, total	Di-eldrin, total	Aroclor 1260 PCB, total	Anti-mony, total, as Sb	Arsenic, total, as As	Cadmium, total, as Cd
TC1	--	--	--	--	0.0067	0.094	0.0067
TC2	--	--	--	--	.0032	.0065	.0065
TC3	--	--	--	--	--	.0035	.00051
FM1	0.00071	--	--	--	.0071	.021	.0071
FM2	--	--	--	--	--	.0051	--
FM3	--	--	--	--	--	.091	--
FW1	--	--	--	--	.020	--	--
FW2	--	--	--	0.00064	--	--	.0042
FW3	--	--	--	--	--	.079	--
TM1	--	--	--	--	--	--	--
TM2	--	--	--	--	--	--	--
TM3	--	--	--	--	--	.0078	--
FC1	--	0.000036	0.0000036	.000036	.00036	.00073	--
FC2	--	--	--	--	--	.00041	--
FC3	--	--	--	--	--	.000016	--

Storm number	Chrom-ium, total, as Cr	Copper, total, as Cu	Cyanide, total, as Cn	Lead, total, as Pb	Mercury, total, as Hg	Nickel, total, as Ni	Phenols, total
TC1	0.040	0.074	--	0.10	0.0013	0.013	0.81
TC2	.032	.045	--	.074	--	.035	.11
TC3	.0028	.0058	0.0025	.0073	--	.0015	.038
FM1	.099	.056	--	.18	.00071	.056	--
FM2	.015	--	--	.046	--	.023	.020
FM3	.27	.23	--	.64	--	.18	.14
FW1	.020	.061	--	.11	--	.020	.034
FW2	.059	.059	.021	.030	.00021	.021	.023
FW3	.020	.085	--	.079	--	.026	.092
TM1	--	.00091	--	--	--	.00061	.00030
TM2	.00051	.00044	--	.00037	--	.00073	.00022
TM3	--	.012	--	.020	--	.0039	.016
FC1	.0029	.0022	--	.020	--	.0022	--
FC2	.0049	.0024	--	.026	--	.0024	.0012
FC3	.000048	.000097	--	.00032	--	.000024	.000048

Table 12.--Storm loads for constituents with storm-runoff mean concentrations above minimum reported values--Continued

Storm number	Zinc, total, as Zn	Bio-logical oxygen demand	Chemical oxygen demand	Residue at 180° Celsius, dis-solved	Residue at 105° Celsius, sus-pended	Nitrogen, NO2+NO3, total, as N	Nitrogen, NH4 and organic, total, as N
TC1	1.0	490	1,500	870	590	4.1	15
TC2	.65	32	320	320	460	1.5	4.2
TC3	.053	68	63	57	51	.28	.76
FM1	2.5	510	630	390	2,000	2.8	7.8
FM2	.61	53	250	340	260	2.3	3.6
FM3	6.8	2,400	3,200	2,500	13,000	23	18
FW1	1.1	130	880	320	290	2.4	14
FW2	.72	780	1,400	330	160	3.4	5.7
FW3	.98	85	720	720	150	10	10
TM1	.0061	2.4	9.7	27	.30	.30	.21
TM2	.0037	1.9	6.1	8.5	1.7	.10	.13
TM3	.20	94	150	150	82	1.4	2.0
FC1	.040	2.9	28	14	36	.12	.44
FC2	.053	15	37	24	89	.13	.45
FC3	.00072	.22	1.0	.68	1.5	.012	.014

Storm number	Phos-phorus dis-solved as P	Phos-phorus, total, as P	Oil and grease, total	Alka-linity, labor-atory, as CaCO3	Calcium, dis-solved, as Ca	Chlor-ide, dis-solved, as Cl	Magnes-ium, dis-solved, as Mg
TC1	6.1	10	--	550	190	32	17
TC2	1.8	3.2	3.2	170	71	15	5.8
TC3	.41	.63	--	31	13	4.1	1.1
FM1	.28	2.7	--	350	99	15	7.1
FM2	.97	1.3	7.6	190	71	15	6.3
FM3	1.8	4.6	--	1,800	550	59	41
FW1	.74	1.4	27	220	81	7.4	7.4
FW2	1.1	1.5	25	110	55	10	4.7
FW3	.79	1.0	33	1,500	130	48	11
TM1	.015	.027	--	12	6.1	.49	.43
TM2	.0066	.010	.073	3.5	1.7	.58	.12
TM3	.27	.55	--	94	34	5.5	2.8
FC1	.062	.12	--	12	3.3	.29	.36
FC2	.040	.12	--	14	4.5	.32	.45
FC3	.0019	.0027	.0080	.34	.11	.0032	.011

Table 12.--Storm loads for constituents with storm-runoff mean concentrations above minimum reported values--Continued

Storm number	Potassium, dissolved, as K	Sodium, dissolved, as Na	Sulfate, dissolved, as SO4	Carbon, organic, total, as C	Sediment, suspended
TC1	13	54	94	320	580
TC2	5.2	14	35	84	1,400
TC3	.68	3.5	9.1	16	32
FM1	7.1	12	56	110	2,200
FM2	7.1	21	76	58	260
FM3	87	32	360	770	17,000
FW1	6.7	8.1	55	180	590
FW2	5.9	13	78	400	150
FW3	8.5	31	160	170	280
TM1	.52	.24	3.3	2.6	14
TM2	.20	.28	1.0	2.0	24
TM3	7.1	2.4	14	43	220
FC1	1.4	.18	.94	--	75
FC2	.81	.12	.93	10	124
FC3	.030	.0056	.064	.26	2.7

REFERENCES

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U.S. Environmental Protection Agency, 1992, Guidance manual for the preparation of part 2 of the NPDES permit applications for discharges from municipal separate storm sewer systems: Washington, D.C., 158 p.

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SUPPLEMENTAL DATA

Incremental rainfall and discharge values for sampled storms

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Storm TC1 -- March 12 & 13, 1991

Watershed 1 03497041 Third Creek tributary at Third Creek Road

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 1825 was 0.04 inch]

Baseflow--0.40 cubic foot per second

Time	Incremental rainfall amount	Discharge	Time	Incremental rainfall amount	Discharge	Time	Incremental rainfall amount	Discharge
1830	0.01	0.40	2220	0.00	2.8	0210	0.00	3.2
1835	.00	.40	2225	.00	3.0	0215	.00	3.3
1840	.00	.57	2230	.00	3.6	0220	.00	3.5
1845	.01	.57	2235	.01	3.7	0225	.01	3.5
1850	.01	.57	2240	.01	3.7	0230	.00	3.2
[a] 1855	.01	.57	2245	.01	3.7	0235	.00	3.0
1900	.00	.80	2250	.00	4.0	0240	.01	3.0
1905	.01	1.0	2255	.00	4.0	0245	.00	3.0
1910	.00	1.1	2300	.00	4.0	0250	.01	3.0
1915	.01	1.1	2305	.00	4.0	0255	.00	3.0
1920	.01	1.2	2310	.01	4.0	0300	.00	3.0
1925	.01	1.8	2315	.00	4.2	0305	.00	3.0
1930	.01	2.2	2320	.00	4.5	0310	.00	3.0
1935	.02	3.3	2325	.00	4.5	0315	.00	3.0
1940	.01	4.4	2330	.00	4.4	0320	.00	3.0
1945	.01	4.8	2335	.00	4.1	0325	.00	3.0
1950	.00	5.5	2340	.00	4.1	0330	.00	3.0
1955	.01	6.1	2345	.01	4.0	0335	.00	3.0
2000	.01	6.3	2350	.00	4.0	0340	.00	3.0
2005	.00	6.9	2355	.00	3.8	0345	.00	3.0
2010	.00	6.7	2400	.01	3.8	0350	.00	2.9
2015	.01	6.5	0005	.00	3.7	0355	.00	2.8
2020	.00	6.2	0010	.00	3.7	0400	.00	2.8
2025	.00	5.8	0015	.00	3.6	0405	.00	2.8
2030	.00	5.5	0020	.00	3.6	0410	.00	2.8
2035	.00	5.2	0025	.00	3.3	0415	.00	2.7
2040	.01	4.8	0030	.00	3.3	0420	.00	2.7
2045	.00	4.7	0035	.00	3.5	0425	.00	2.5
2050	.00	4.2	0040	.01	3.5	0430	.00	2.4
2055	.00	4.0	0045	.00	3.5	0435	.00	2.3
2100	.00	3.8	0050	.00	3.5	0440	.00	2.2
2105	.00	3.7	0055	.00	3.5	0445	.00	2.2
2110	.00	3.2	0100	.00	3.5	0450	.00	2.2
2115	.00	2.9	0105	.00	3.5	0455	.00	2.1
2120	.00	2.8	0110	.00	3.5	0500	.00	2.1
2125	.00	2.7	0115	.00	3.5	0505	.00	2.1
2130	.00	2.5	0120	.00	3.5	0510	.00	1.9
2135	.01	2.5	0125	.01	3.5	0515	.00	1.9
2140	.00	2.4	0130	.00	3.5	0520	.00	1.9
2145	.01	2.3	0135	.00	3.5	0525	.00	1.9
2150	.01	2.3	0140	.00	3.5	0530	.00	1.9
[b] 2155	.01	2.3	0145	.01	3.5	0535	.00	1.8
2200	.00	2.5	0150	.00	3.3	0540	.00	1.8
2205	.00	2.9	0155	.00	3.3	0545	.01	1.8
2210	.00	2.9	0200	.00	3.2	0550	.00	1.8
2215	.00	2.8	0205	.00	3.2	0555	.00	1.7

[a] Start of sampling.
[b] End of sampling.

Storm TC2 -- April 27, 1991

Watershed 1 03497041 Third Creek tributary at Third Creek Road

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 1500 was 0.00 inch]

Baseflow--0.20 cubic foot per second

Time	Incremental rainfall amount	Dis-charge	Time	Incremental rainfall amount	Dis-charge
1505	0.00	0.20	1735	0.00	2.5
1510	.00	.20	1740	.00	2.5
1515	.00	.20	1745	.00	2.5
1520	.00	.20	1750	.00	2.4
1525	.00	.20	1755	.00	2.2
1530	.01	.20	1800	.00	2.1
[a] 1535	.02	.91	1805	.00	1.9
1540	.02	2.2	1810	.00	1.8
1545	.02	3.6	1815	.00	1.7
1550	.03	6.5	1820	.00	1.6
1555	.09	9.0	1825	.00	1.4
1600	.03	15.0	1825	.00	1.4
1605	.00	16.0	[b] 1835	.00	1.3
1610	.00	12.0	1840	.00	1.1
1615	.01	10.0	1845	.00	1.1
1620	.00	8.4	1850	.00	1.1
1625	.00	7.3	1855	.00	1.1
1630	.00	6.6	1900	.00	1.0
1635	.00	5.6	1905	.00	1.0
1640	.01	5.3	1910	.00	.91
1645	.00	4.9	1915	.00	.91
1650	.00	4.5	1920	.00	.80
1655	.00	4.1	1925	.00	.80
1700	.00	4.0	1925	.00	.80
1705	.00	3.7	1935	.00	.80
1710	.00	3.3	1940	.00	.67
1715	.00	3.0	1945	.00	.67
1720	.00	2.9	1950	.00	.57
1725	.00	2.7	1955	.00	.57
1730	.00	2.5	2000	.00	.57

[a] Start of sampling.
[b] End of sampling.

Storm TC3 -- February 13, 1992

Watershed 1 03497041 Third Creek tributary at Third Creek Road

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 1115 was 0.00 inch]

Baseflow--0.08 cubic foot per second

Time	Incremental rainfall amount	Dis-charge	Time	Incremental rainfall amount	Dis-charge
1120	0.00	0.08	1325	0.00	0.80
1125	.01	.08	1330	.00	.67
1130	.01	.08	1335	.00	.57
1135	.00	.08	1340	.00	.47
1140	.00	.16	1345	.00	.40
1145	.00	.16	1350	.00	.40
1150	.01	.13	1355	.00	.40
[a] 1155	.00	.13	1400	.00	.40
1200	.00	.13	1405	.00	.40
1205	.00	.16	1410	.00	.33
1210	.01	.16	1415	.00	.20
1215	.01	.16	1420	.00	.20
1220	.02	.20	1425	.00	.20
1225	.00	.33	1430	.00	.16
1230	.00	.40	1435	.00	.16
1235	.01	.40	1440	.00	.16
1240	.00	.33	1445	.00	.16
1245	.01	.33	1450	.00	.16
1250	.00	.91	[b] 1455	.00	.16
1255	.01	1.0	1500	.00	.16
1300	.00	1.1	1505	.00	.13
1305	.00	1.1	1510	.00	.13
1310	.00	1.0	1515	.00	.13
1315	.00	1.0	1520	.01	.13
1320	.00	.91	1525	.00	.13

[a] Start of sampling.
[b] End of sampling.

Storm FM1 -- March 27 & 28, 1991

Watershed 2 03497103 Fourth Creek tributary at Middlebrook Pike

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 2210 was 0.00 inch]

Baseflow--0.05 cubic foot per second

Time	Incremental rainfall amount	Discharge	Time	Incremental rainfall amount	Discharge
2215	0.01	0.05	0100	0.00	4.0
2220	.00	.05	0105	.00	3.1
2225	.01	.05	0110	.00	2.6
2230	.00	.05	0115	.00	2.6
2235	.01	.05	0120	.00	2.4
2240	.00	.05	0125	.00	2.4
2245	.01	.05	0130	.00	1.9
2250	.01	.05	0135	.00	1.9
2255	.03	.05	0140	.00	1.6
2300	.16	.05	0145	.00	1.6
[a] 2305	.03	.14	0150	.00	1.4
2310	.02	4.0	0155	.00	1.3
2315	.02	24	0200	.00	1.3
2320	.01	36	[b] 0205	.00	1.1
2325	.00	36	0210	.00	.91
2330	.01	31	0215	.00	.91
2335	.00	26	0220	.00	.91
2340	.01	23	0225	.00	.91
2345	.00	21	0230	.00	.91
2350	.00	19	0235	.00	.91
2355	.00	17	0240	.00	.91
2400	.00	15	0245	.00	.91
0005	.00	13	0250	.00	.91
0010	.00	11	0255	.00	.76
0015	.00	9.9	0300	.00	.76
0020	.00	8.8	0305	.00	.63
0025	.00	7.3	0310	.00	.63
0030	.00	6.7	0315	.00	.63
0035	.00	5.7	0320	.00	.53
0040	.00	5.4	0325	.00	.53
0045	.00	4.9	0330	.00	.53
0050	.00	4.2	0335	.00	.53
0055	.00	4.2	0340	.00	.44

[a] Start of sampling.
[b] End of sampling.

Storm FM2 -- November 20, 1991

Watershed 2 03497103 Fourth Creek tributary at Middlebrook Pike

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 1445 was 0.00 inch]

Baseflow--0.04 cubic foot per second

Time	Incremental rainfall amount	Discharge	Time	Incremental rainfall amount	Discharge
1450	0.01	0.04	1725	0.01	4.0
1455	.01	.04	1730	.00	3.7
1500	.01	.04	1735	.00	3.7
1505	.00	.04	1740	.00	2.9
1510	.01	.04	1745	.00	2.9
1515	.01	.04	1750	.00	2.6
1520	.00	.04	1755	.00	2.4
1525	.01	.04	1800	.01	2.0
1530	.00	.04	1805	.00	2.0
1535	.01	.04	1810	.00	1.7
1540	.01	.04	1815	.00	1.7
1545	.01	.07	1820	.00	1.7
1550	.01	.17	1825	.00	1.7
[a] 1555	.01	.91	1830	.00	1.4
1600	.02	1.9	1835	.00	1.1
1605	.01	2.4	1840	.00	1.1
1610	.01	2.9	1845	.00	1.1
1615	.00	4.9	1850	.00	1.1
1620	.01	5.4	[b] 1855	.00	1.1
1625	.00	5.4	1900	.00	.76
1630	.00	6.0	1905	.00	.76
1635	.00	6.3	1910	.00	.76
1640	.00	8.2	1920	.00	.76
1645	.01	7.6	1925	.00	.76
1650	.00	7.3	1930	.00	.76
1655	.00	5.7	1935	.00	.76
1700	.00	5.4	1940	.00	.76
1705	.00	4.9	1945	.00	.76
1710	.00	4.9	1950	.00	.76
1715	.00	4.4	1955	.01	.63
1720	.00	4.2	2000	.00	.63

[a] Start of sampling.
[b] End of sampling.

Storm FM3 -- August 21, 1992

Watershed 2 03497103 Fourth Creek tributary at Middlebrook Pike

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 1635 was 0.00 inch]

Baseflow--0.00 cubic foot per second

Time	Incremental rainfall amount	Dis-charge	Time	Incremental rainfall amount	Dis-charge
1640	0.04	0.00	1900	0.00	12
1645	.17	.00	1905	.00	11
1650	.19	.00	1910	.00	10
[a] 1655	.04	.30	1915	.01	9.2
1700	.14	62	1920	.00	8.8
1705	.19	103	1925	.00	8.2
1710	.07	158	1930	.00	7.9
1715	.10	248	1935	.00	7.3
1720	.01	248	1940	.00	7.0
1725	.17	214	1945	.01	6.7
1730	.02	183	1950	.00	6.7
1735	.00	165	[b] 1955	.00	6.0
1740	.00	158	2000	.00	4.7
1745	.00	144	2005	.00	4.4
1750	.00	125	2010	.00	4.4
1755	.01	102	2015	.00	4.4
1800	.00	76	2020	.00	4.4
1805	.00	54	2025	.00	4.4
1810	.00	43	2030	.00	4.2
1815	.01	35	2035	.00	4.2
1820	.00	29	2040	.00	4.0
1825	.00	24	2045	.01	3.7
1830	.00	21	2050	.00	3.4
1835	.00	19	2055	.00	3.1
1840	.00	18	2100	.00	2.9
1845	.00	16	2105	.00	2.9
1850	.00	15	2110	.00	2.6
1855	.00	13	2115	.00	2.4

[a] Start of sampling.
[b] End of sampling.

Storm FW1 -- April 8, 1991

Watershed 3 034971055 Fourth Creek tributary at Wellington Drive

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 1720 was 0.00 inch]

Baseflow--0.0` cubic foot per second

Time	Incremental rainfall amount	Dis-charge	Time	Incremental rainfall amount	Dis-charge
1725	0.00	0.01	1940	0.00	2.6
1730	.00	.01	1945	.00	2.1
1735	.00	.01	1950	.00	1.6
1740	.01	.01	1955	.00	1.4
1745	.04	.03	2000	.00	1.2
1750	.01	4.2	2005	.00	1.1
[a] 1755	.03	3.9	2010	.00	.98
1800	.01	7.4	2015	.00	.84
1805	.00	5.3	2020	.00	.77
1810	.00	3.6	2025	.00	.72
1815	.00	2.9	2030	.00	.66
1820	.05	2.6	2035	.00	.61
1825	.02	13	2040	.00	.56
1830	.01	29	2045	.00	.52
1835	.00	39	2050	.00	.48
1840	.00	46	[b] 2055	.00	.44
1845	.00	46	2100	.00	.41
1850	.00	33	2105	.00	.38
1855	.00	28	2110	.00	.38
1900	.00	21	2115	.00	.35
1905	.00	15	2120	.00	.32
1910	.00	11	2125	.00	.32
1915	.00	8.9	2130	.00	.30
1920	.00	6.7	2135	.00	.30
1925	.00	5.3	2140	.00	.27
1930	.00	4.2	2145	.00	.27
1935	.00	3.3	2150	.00	.25

[a] Start of sampling.
[b] End of sampling.

Storm FW2 -- November 1, 1991

Watershed 3 034971055 Fourth Creek tributary at Wellington Drive

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 1020 was 0.00 inch]

Baseflow--0.00 cubic foot per second

Time	Incremental rainfall amount	Dis-charge	Time	Incremental rainfall amount	Dis-charge
1040	0.00	0.00	1400	0.00	2.9
1045	.01	.00	1405	.00	2.3
1050	.02	.00	1410	.00	1.8
[a] 1055	.02	.02	1415	.00	1.4
1100	.01	1.5	1420	.00	1.2
1105	.00	11	1425	.00	1.1
1110	.00	9.2	1430	.00	.84
1115	.00	7.0	1435	.00	.72
1120	.00	5.3	1440	.00	.66
1125	.00	3.9	1445	.00	.56
1130	.00	2.6	1450	.00	.48
1135	.00	1.9	1455	.00	.44
1140	.00	1.4	1500	.00	.38
1145	.00	1.1	1505	.00	.35
1150	.01	.98	1510	.00	.30
1155	.01	.84	1515	.00	.27
1200	.01	.77	1520	.00	.25
1205	.01	.84	1525	.00	.25
1210	.01	1.8	1530	.00	.20
1215	.00	2.1	1535	.00	.18
1220	.00	2.4	1540	.00	.17
1225	.00	4.2	1545	.00	.15
1230	.00	3.9	1550	.00	.15
1235	.00	3.3	1555	.00	.13
1240	.00	2.6	1600	.00	.12
1245	.00	1.9	1605	.00	.10
1250	.00	1.6	1610	.00	.10
1255	.00	1.2	1615	.00	.09
1300	.00	1.1	1620	.00	.09
1305	.00	.90	1625	.00	.08
1310	.00	.77	1630	.00	.08
i315	.00	.72	1635	.00	.08
1320	.01	.61	1640	.00	.07
1325	.01	.66	1645	.00	.07
1330	.02	.77	1650	.00	.06
1335	.01	.98	1655	.00	.06
[b] 1340	.00	2.9	1700	.00	.06
1345	.00	4.7	1705	.00	.05
1350	.00	4.5	1710	.00	.05
1355	.00	3.3	1715	.00	.05

[a] Start of sampling.
[b] End of sampling.

Storm FW3 -- March 18, 1992

Watershed 3 034971055 Fourth Creek tributary at Wellington Drive

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 0645 was 0.00 inch]

Baseflow--0.00 cubic foot per second

Time	Incremental rainfall amount	Dis-charge	Time	Incremental rainfall amount	Dis-charge
0650	0.01	0.00	1025	0.01	15
0655	.02	.00	1030	.01	16
0700	.02	.00	1035	.01	17
0705	.01	3.1	1040	.01	17
0710	.00	3.6	1045	.01	16
[a] 0715	.00	3.6	1050	.01	16
0720	.00	3.1	1055	.01	14
0725	.00	2.4	1100	.00	13
0730	.01	2.3	1105	.00	12
0735	.00	1.8	1110	.01	11
0740	.00	1.4	1115	.00	9.6
0745	.01	1.1	1120	.00	8.5
0750	.00	.98	1125	.00	7.4
0755	.00	.90	1130	.01	6.3
0800	.02	.84	1135	.00	6.0
0805	.00	.77	1140	.00	5.3
0810	.00	1.5	1145	.00	5.0
0815	.01	2.9	1150	.01	4.7
0820	.00	3.9	1155	.00	4.2
0825	.00	4.2	1200	.00	3.6
0830	.01	4.2	1205	.00	3.1
0835	.00	4.2	1210	.01	2.6
0840	.00	3.6	1215	.00	2.3
0845	.01	2.9	1220	.00	2.3
0850	.00	2.6	1225	.00	2.3
0855	.00	2.4	1230	.00	2.6
0900	.01	2.3	1235	.00	2.9
0905	.00	2.4	1240	.00	2.9
0910	.00	2.4	1245	.01	2.4
0915	.01	2.4	1250	.00	2.1
0920	.00	2.6	1255	.00	1.9
0925	.00	2.6	1300	.00	1.6
0930	.00	2.6	1305	.00	1.5
0935	.00	2.4	1310	.00	1.3
0940	.00	2.1	1315	.00	1.2
0945	.01	2.1	1320	.00	1.1
0950	.00	1.9	1325	.00	.98
0955	.00	1.9	1330	.00	.90
1000	.01	1.9	1335	.00	.77
1005	.01	2.4	1340	.00	.72
1010	.02	3.1	1345	.00	.66
[b] 1015	.02	3.9	1350	.00	.61
1020	.02	7.4	1355	.00	.61

[a] Start of sampling.
[b] End of sampling.

Storm TM1 -- August 14, 1991

Watershed 4 03499193 Ten Mile Creek tributary at Chisholm Trail

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 0825 was 0.02 inch]

Baseflow--0.00 cubic foot per second

Time	Incremental rainfall amount	Dis-charge	Time	Incremental rainfall amount	Dis-charge
0830	0.00	0.00	1055	0.00	0.29
0835	.00	.00	1100	.00	.29
0840	.00	.00	1105	.00	.29
0845	.01	.00	1110	.00	.26
0850	.02	.00	1115	.01	.23
0855	.02	.00	1120	.00	.23
0900	.03	.05	1125	.00	.23
0905	.04	.05	1130	.00	.20
0910	.03	.60	1135	.00	.18
[a] 0915	.01	1.1	1140	.00	.18
0920	.00	1.1	1145	.00	.15
0925	.01	1.0	1150	.00	.15
0930	.01	.83	1155	.00	.15
0935	.01	.78	1200	.00	.13
0940	.00	.74	1205	.00	.13
0945	.00	.74	1210	.00	.11
0950	.01	.64	[b] 1215	.01	.11
0955	.00	.60	1220	.00	.09
1000	.00	.52	1225	.00	.09
1005	.00	.48	1230	.00	.07
1010	.00	.44	1235	.00	.07
1015	.00	.38	1240	.00	.05
1020	.00	.38	1245	.00	.05
1025	.00	.32	1250	.00	.05
1030	.00	.29	1255	.00	.04
1035	.00	.29	1300	.00	.04
1040	.00	.26	1305	.00	.04
1045	.00	.26	1310	.00	.04
1050	.00	.29	1315	.00	.03

[a] Start of sampling.
[b] End of sampling.

Storm TM2 -- July 31, 1992

Watershed 4 03499193 Ten Mile Creek tributary at Chisholm Trail

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 1810 was 0.00 inch]

Baseflow--0.00 cubic foot per second

Time	Incremental rainfall amount	Dis-charge	Time	Incremental rainfall amount	Dis-charge
1815	0.01	0.01	2000	0.00	0.26
1820	.02	.01	2005	.00	.19
1825	.06	.01	2010	.00	.19
1830	.04	.01	2015	.00	.19
1835	.02	.01	2020	.00	.16
1840	.01	.01	2025	.00	.13
1845	.01	.01	2030	.00	.11
1850	.01	.01	2035	.00	.08
1855	.01	.01	2040	.00	.08
1900	.00	.01	2045	.00	.06
1905	.00	.01	2050	.00	.04
1910	.00	.01	2055	.00	.04
1915	.00	.01	2100	.00	.03
[a] 1920	.00	.22	2105	.00	.03
1925	.00	.33	2110	.00	.03
1930	.00	.41	2115	.00	.03
1935	.00	.37	[b] 2120	.00	.02
1940	.00	.33	2125	.00	.02
1945	.00	.26	2130	.00	.02
1950	.00	.29	2135	.00	.02
1955	.00	.26	2140	.00	.02

[a] Start of sampling.
[b] End of sampling.

Storm TM3 -- September 18, 1992

Watershed 4   03499193   Ten Mile Creek tributary at Chisholm Trail

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 1015 was 0.00 inch]

Baseflow--0.00 cubic foot per second

Time	Incremental rainfall amount	Dis-charge	Time	Incremental rainfall amount	Dis-charge
1020	0.00	0.00	1255	0.00	12
1025	.01	.00	1300	.00	8
1030	.01	.00	1305	.00	5.6
1035	.00	.00	1310	.00	4.1
1040	.02	.00	1315	.00	3.2
1045	.01	.00	1320	.00	2.6
1050	.00	.00	1325	.00	2.1
1055	.01	.00	1330	.00	1.7
1100	.02	.00	1335	.00	1.4
1105	.03	.00	1340	.00	1.2
1110	.04	.00	1345	.00	1.0
1115	.05	.08	1350	.00	.89
1120	.03	.19	1355	.00	.78
1125	.03	.26	1400	.00	.69
[a] 1130	.02	2.7	1405	.00	.63
1135	.02	2.8	1410	.00	.58
1140	.01	2.9	1415	.00	.53
1145	.02	2.8	1420	.00	.49
1150	.02	2.6	1425	.00	.45
1155	.03	2.2	[b] 1430	.00	.45
1200	.05	5.2	1435	.00	.41
1205	.04	7.3	1440	.00	.37
1210	.03	13	1445	.00	.37
1215	.02	14	1450	.00	.37
1220	.03	11	1455	.00	.37
1225	.04	13	1500	.01	.33
1230	.05	15	1505	.00	.33
1235	.01	18	1510	.00	.29
1240	.01	17	1515	.00	.29
1245	.00	14	1520	.00	.26
1250	.01	14	1525	.00	.26

[a] Start of sampling.
[b] End of sampling.

Storm FC1 -- April 19, 1991

Watershed 5 03495905 First Creek tributary at Midlake Drive

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 0945 was 0.24 inch]

Baseflow--0.00 cubic foot per second

Time	Incremental rainfall amount	Dis-charge	Time	Incremental rainfall amount	Dis-charge
0950	0.00	0.00	1135	0.01	4.1
0955	.01	.00	[a] 1140	.00	2.7
1000	.03	.00	1145	.00	2.1
1005	.00	.00	1150	.00	1.4
1010	.00	.00	1155	.00	.96
1015	.00	.00	1200	.00	.63
1020	.00	.00	1205	.00	.56
1025	.01	.00	1210	.00	.42
1030	.02	.00	1215	.00	.42
1035	.03	.00	1220	.00	.31
1040	.04	.00	1225	.00	.22
1045	.01	.00	1230	.00	.11
1050	.00	.00	1235	.00	.08
1055	.03	.00	[b] 1240	.00	.06
1100	.04	.00	1245	.00	.01
1105	.02	.00	1250	.00	.00
1110	.04	.00	1255	.00	.00
1115	.08	.00	1300	.00	.00
1120	.17	.00	1305	.00	.00
1125	.08	.08	1310	.00	.00
1130	.00	5.2	1315	.00	.00

[a] Start of sampling.
[b] End of sampling.

Storm FC2 -- March 6, 1992

Watershed 5 03495905 First Creek tributary at Midlake Drive

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 1455 was 0.82 inch]

Baseflow--0.00 cubic foot per second

Time	Incremental rainfall amount	Dis-charge
1500	0.00	0.00
1505	.00	.00
1510	.00	.00
1515	.00	.00
1520	.03e	.00
1525	.10e	.00
1530	.03e	.00
1535	.03e	.00
1540	.04e	2.0
[a] 1545	.02e	2.0
1550	.02e	1.6
1555	.04e	1.4
1600	.04e	1.3
1605	.04e	1.1
1610	.03e	.96
1615	.04e	1.5
1620	.02e	1.7
1625	.0le	1.7
1630	.0le	1.4
1635	0.0le	1.2
1640	.0le	.96
1645	.00	.70
1650	.0le	.56
1655	.0le	.42
1700	.00	.37
1705	.00	.26
1710	.00	.18
1715	.00	.14
1720	.00	.11
1725	.00	.08
1730	.00	.03
1735	.00	.03
1740	.00	.01
[b] 1745	.00	.01
1750	.00	.00
1755	.00	.00
1800	.00	.00
1805	.00	.00

[a] Start of sampling.
[b] End of sampling.

Storm FC3 -- April 15, 1992

Watershed 5 03495905 First Creek tributary at Midlake Drive

[Time is given in hours and minutes; rainfall amount is given in inches; discharge is given in cubic feet per second; rainfall amount occurring from 0001 through 1455 was 0.00 inch]

Baseflow--0.00 cubic foot per second

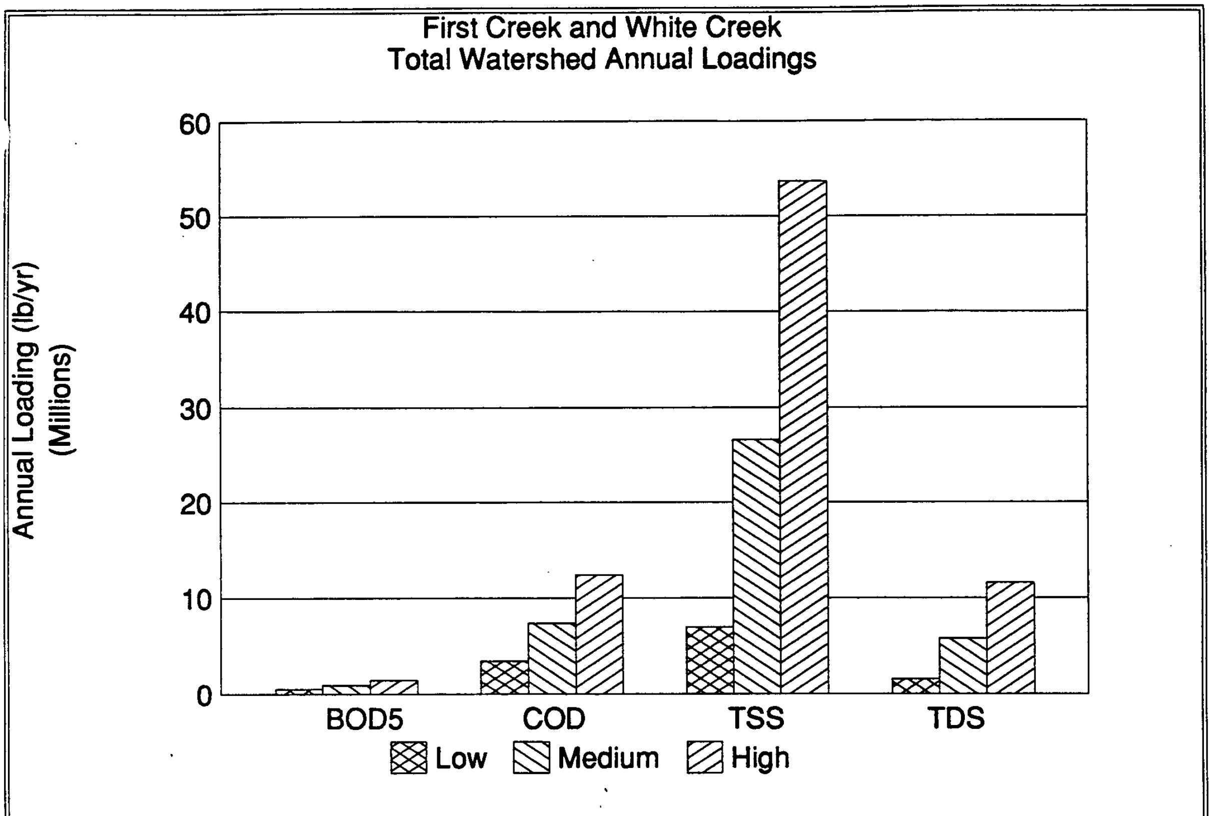
Time	Incremental rainfall amount	Discharge	Time	Incremental rainfall amount	Discharge
1500	0.00	0.00	[a] 1555	0.00	0.11
1505	.00	.00	1600	.00	.14
1510	.00	.00	1605	.00	.08
1515	.07	.00	1610	.00	.06
1520	.23	.00	1615	.00	.03
1525	.06	.00	1620	.00	.01
1530	.00	.00	[b] 1625	.00	.00
1535	.01	.00	1630	.00	.00
1540	.00	.00	1635	.00	.00
1545	.00	.00	1640	.00	.00
1550	.00	.00	1645	.00	.00

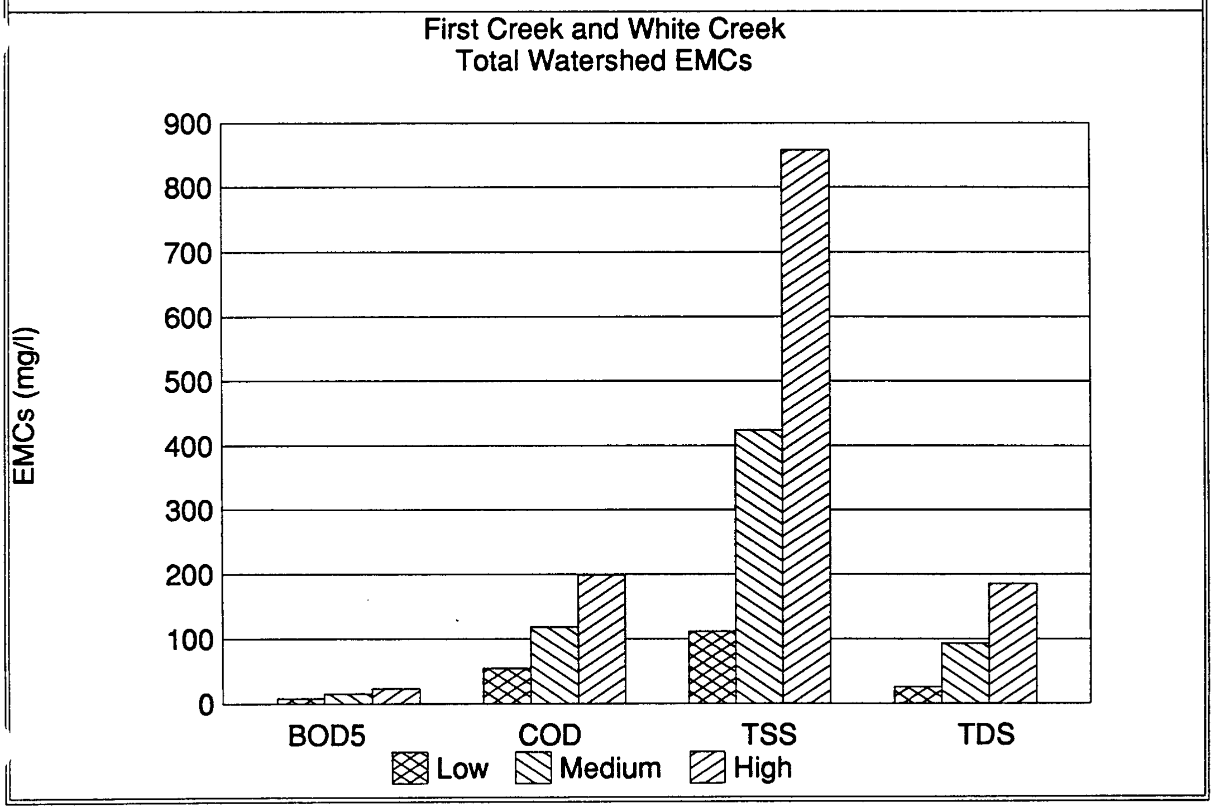
[a] Start of sampling.
[b] End of sampling.

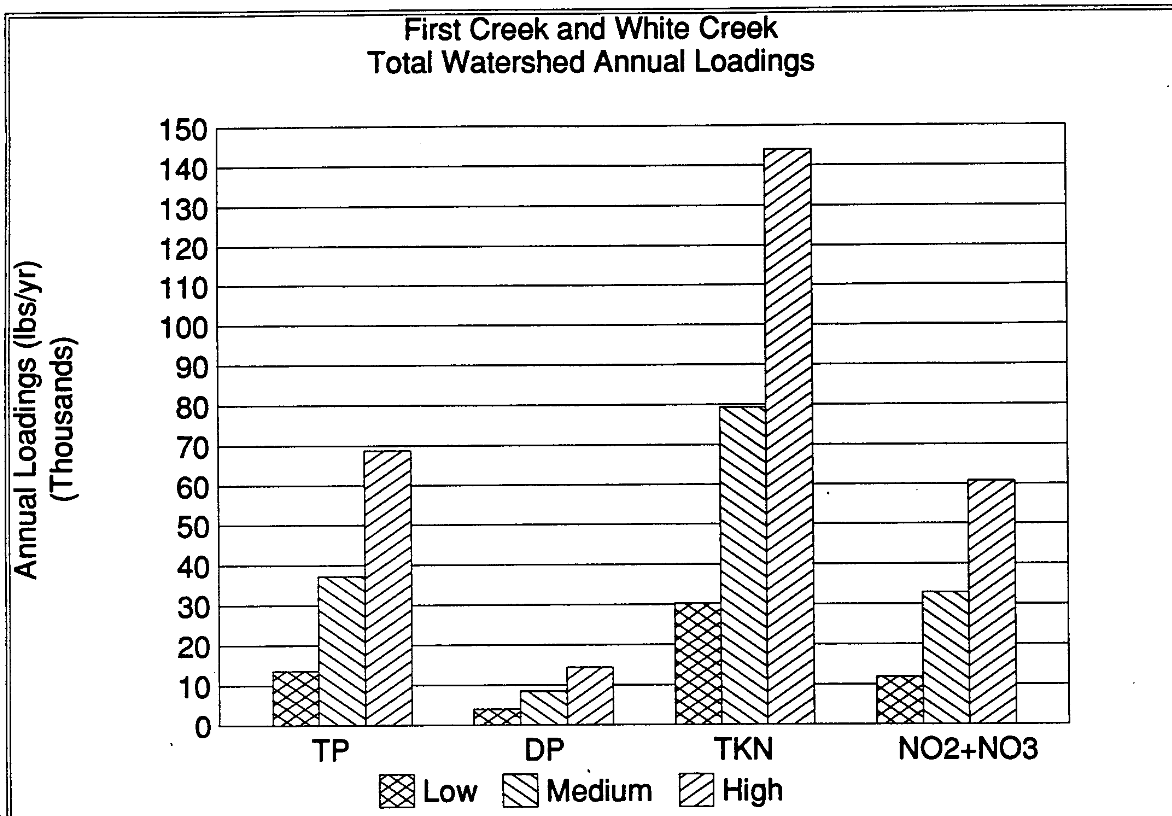
APPENDIX C

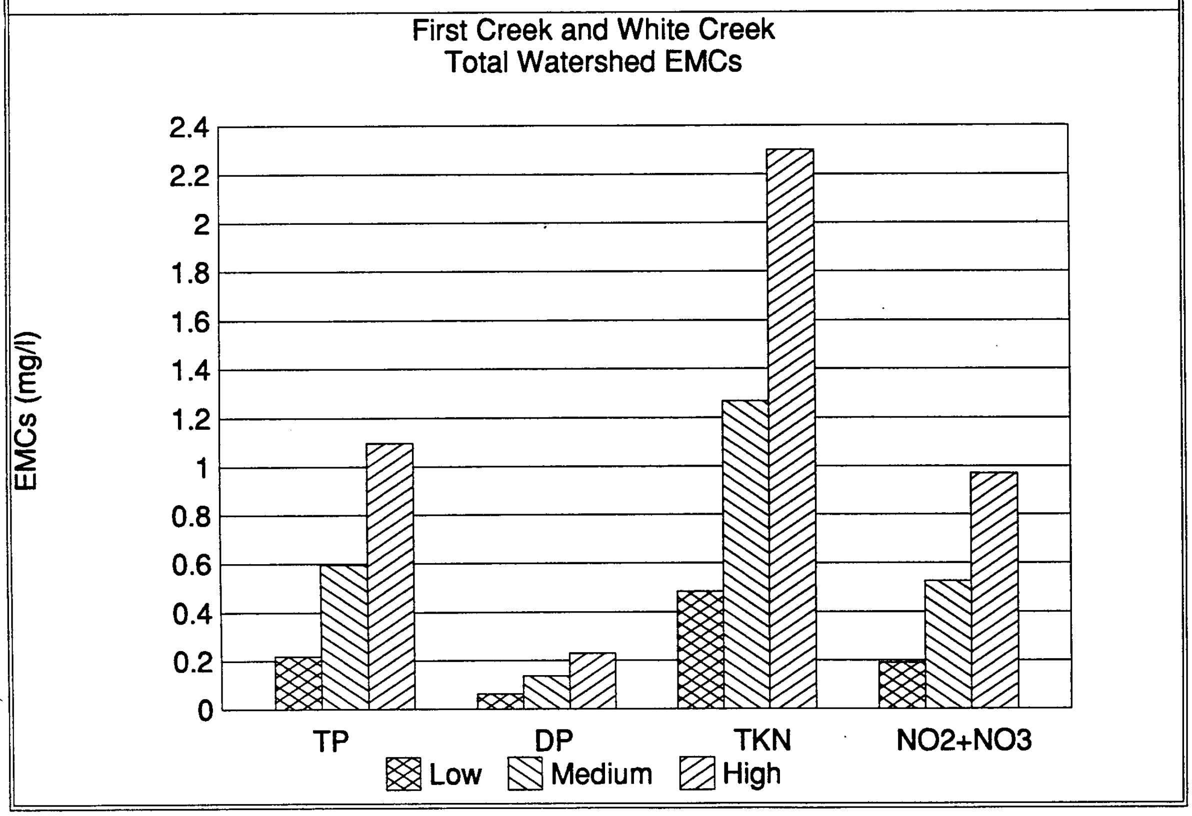
ANNUAL LOADING AND EMC ESTIMATE

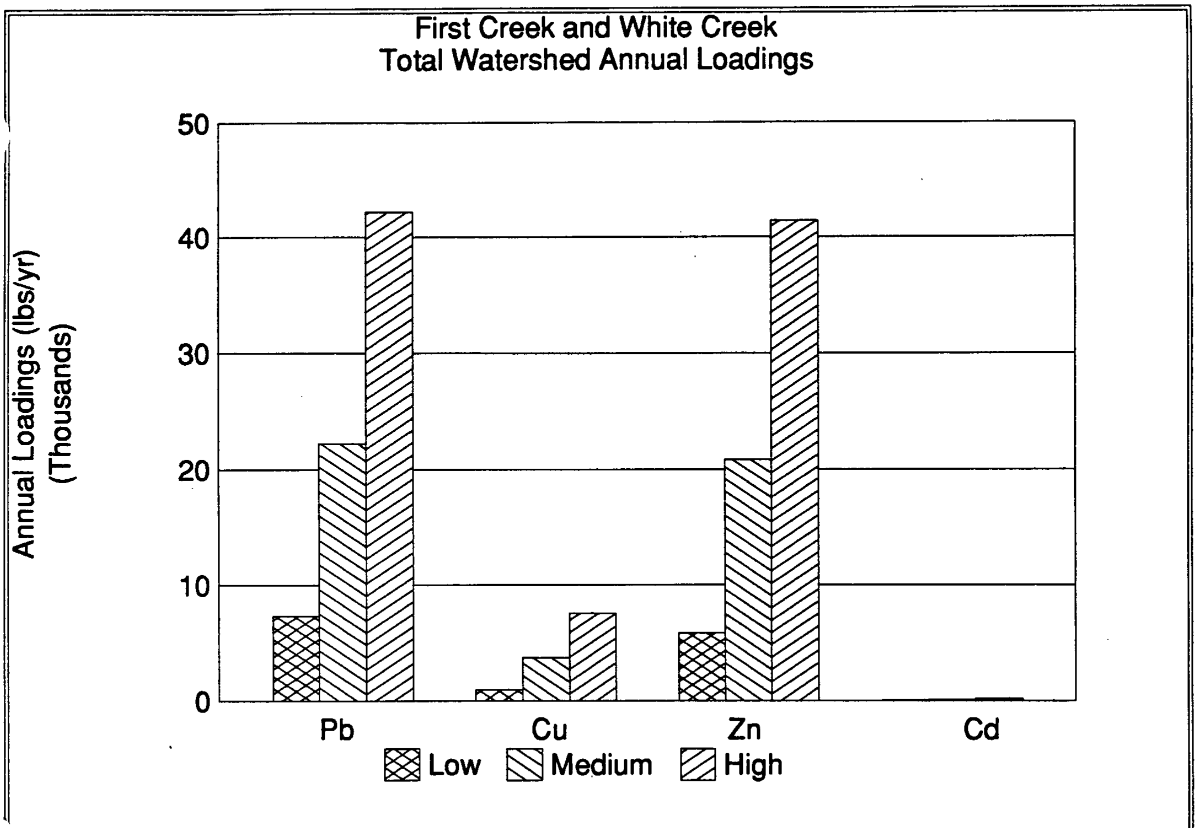
FIGURES

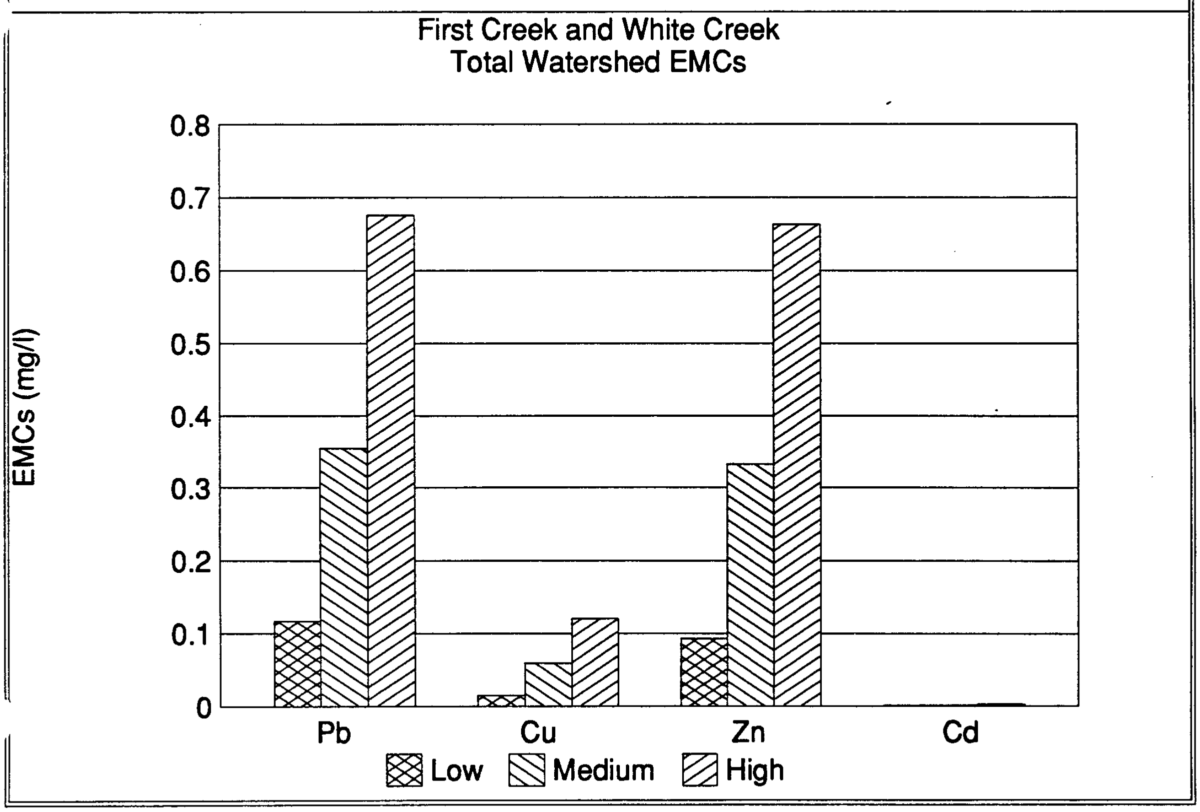

First Creek and White Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
60
50
40
30
20
10
0
BOD5
COD
TSS
TDS
Low
Medium
High

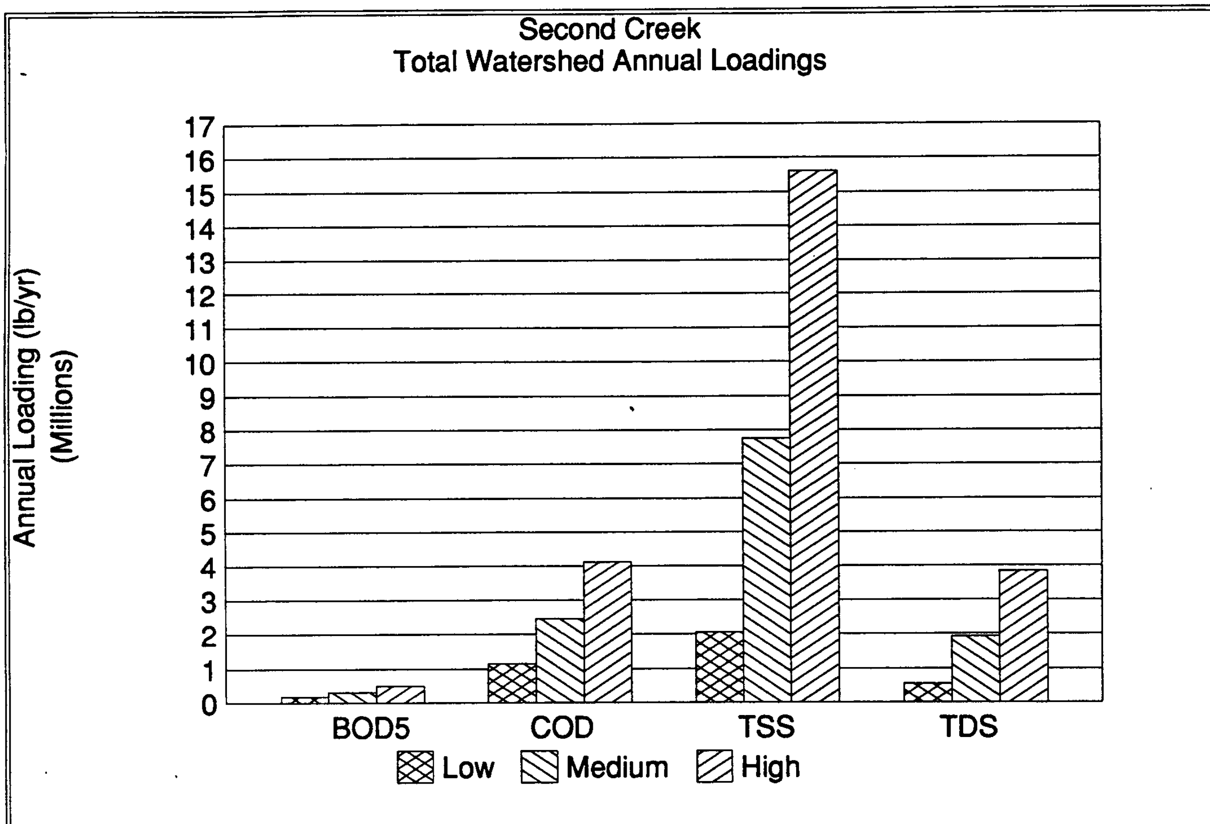

First Creek and White Creek
Total Watershed EMCs
EMCs (mg/l)
900
800
700
600
500
400
300
200
100
0
BOD5
COD
TSS
TDS
Low
Medium
High

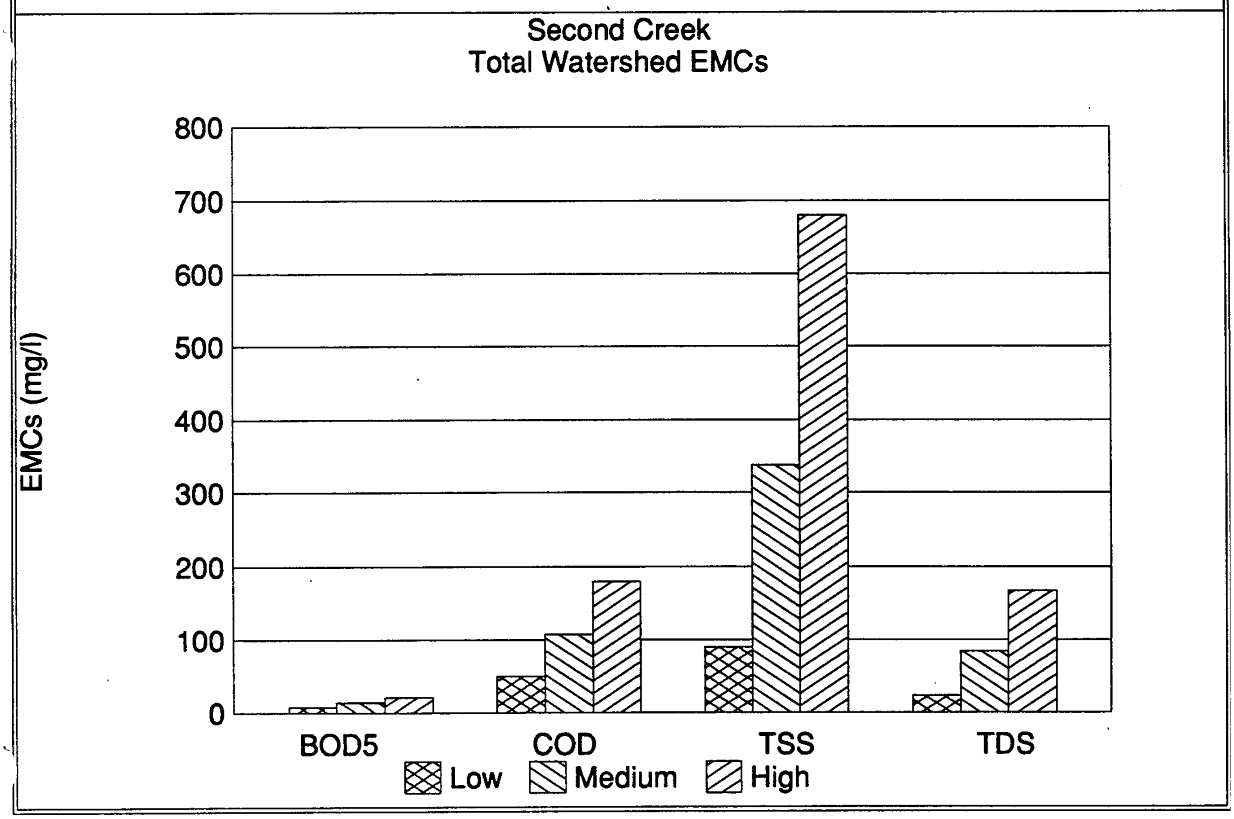

First Creek and White Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

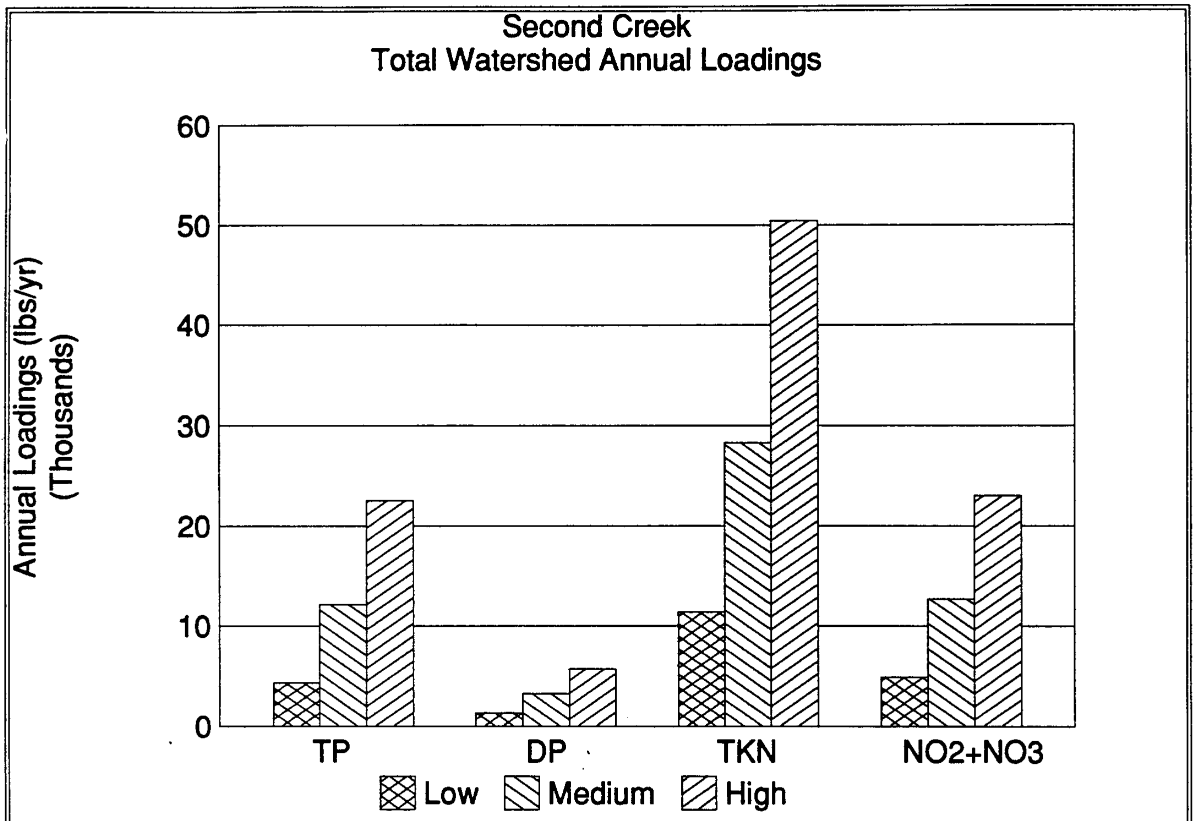

First Creek and White Creek
Total Watershed EMCs
EMCs (mg/l)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

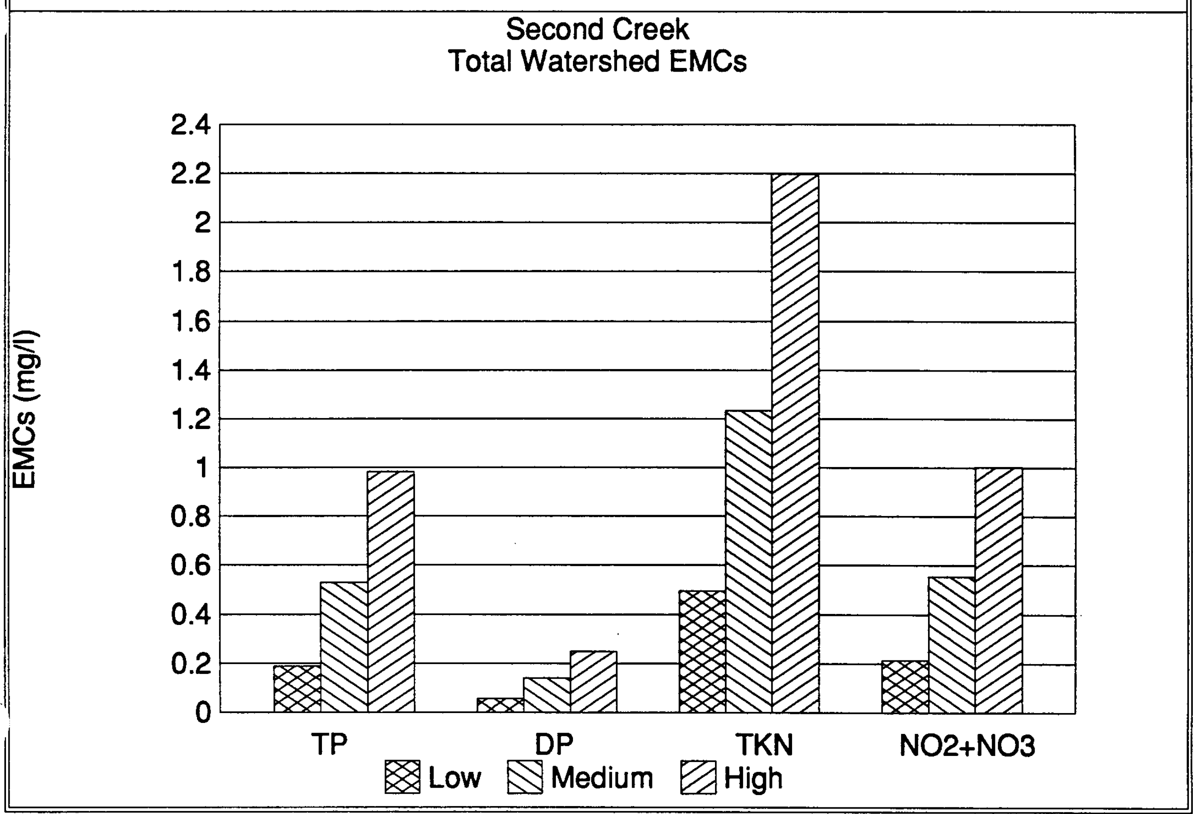

First Creek and White Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
50
40
30
20
10
0
Pb
Cu
Zn
Cd
Low
Medium
High

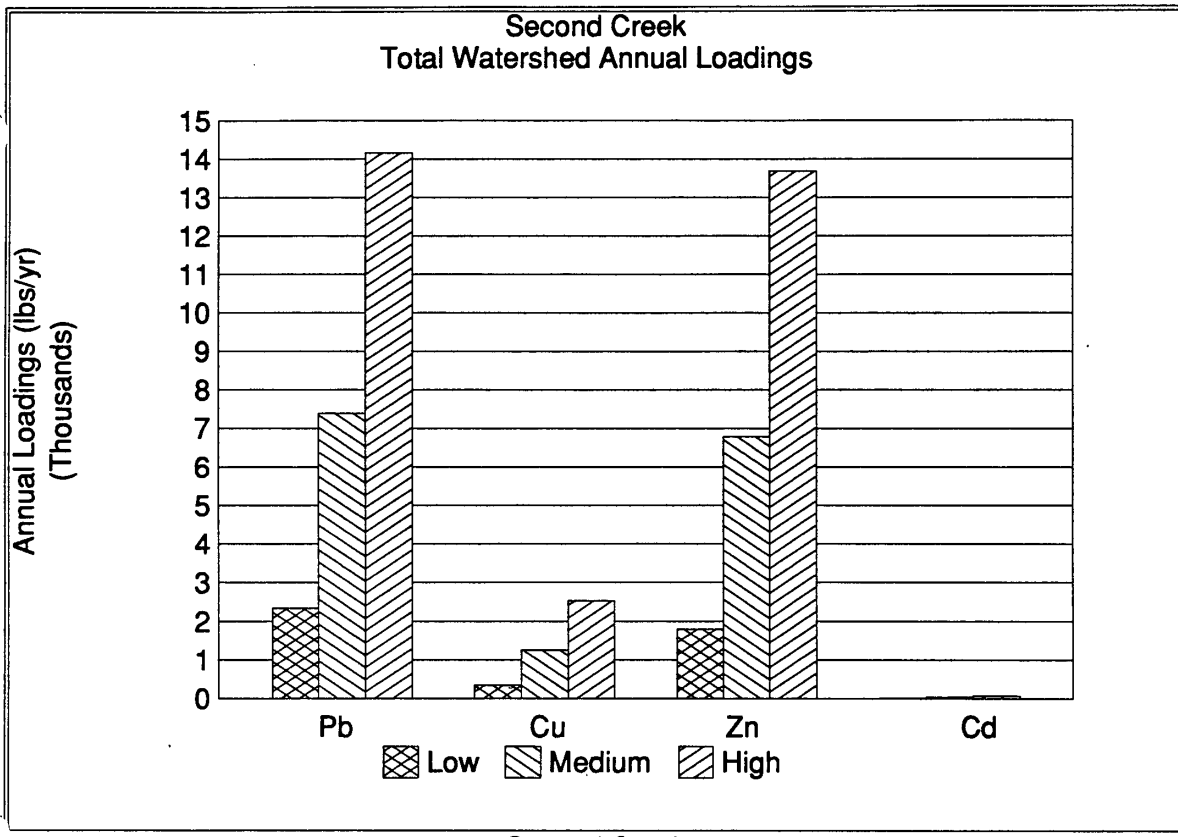

First Creek and White Creek
Total Watershed EMCs
EMCs (mg/l)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High

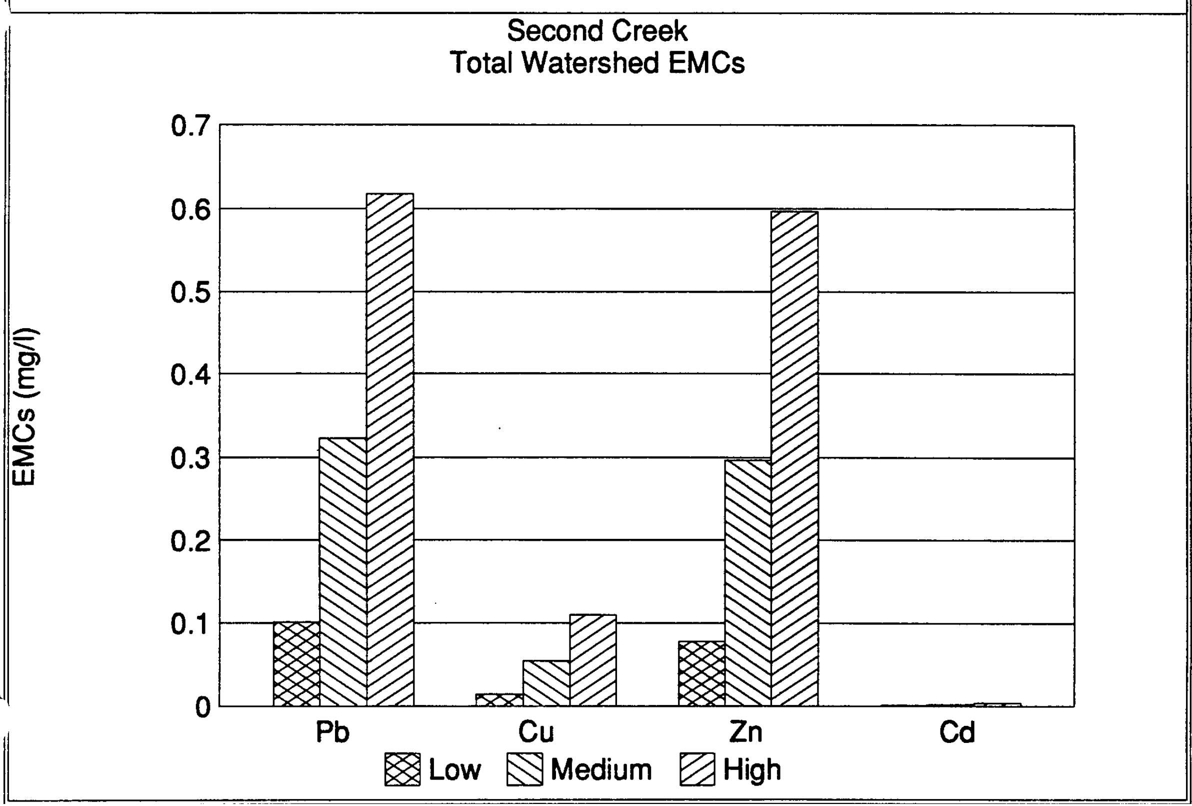

Second Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
BOD5
COD
TSS
TDS
Low
Medium
High

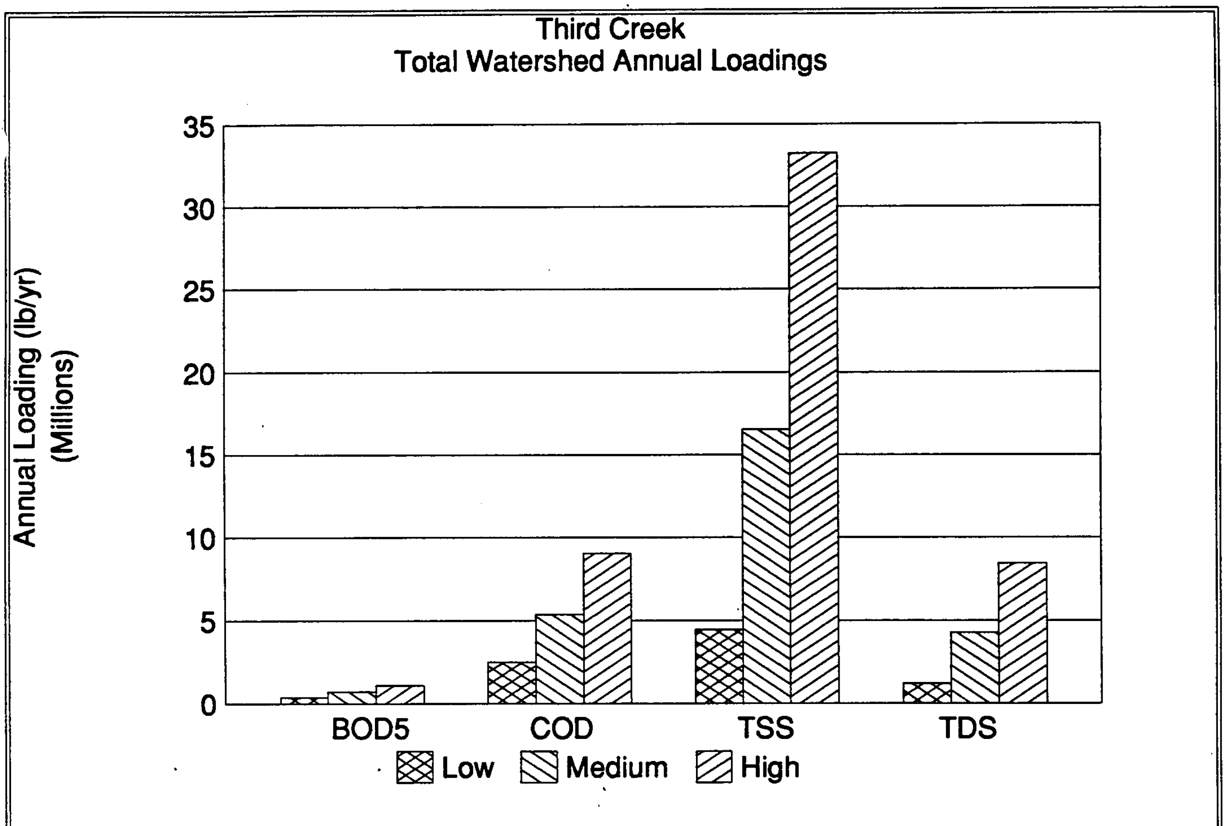

Second Creek
Total Watershed EMCs
EMCs (mg/l)
800
700
600
500
400
300
200
100
0
BOD5
COD
TSS
TDS
Low
Medium
High

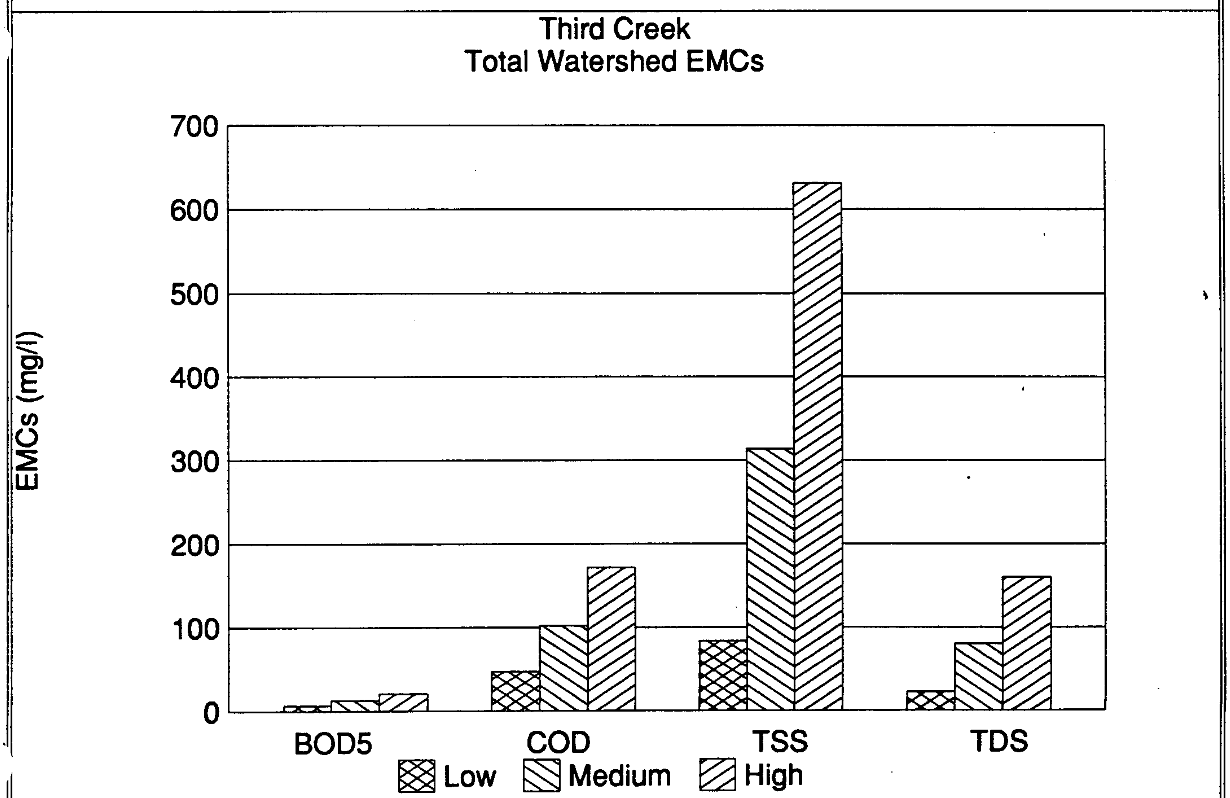

Second Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
60
50
40
30
20
10
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

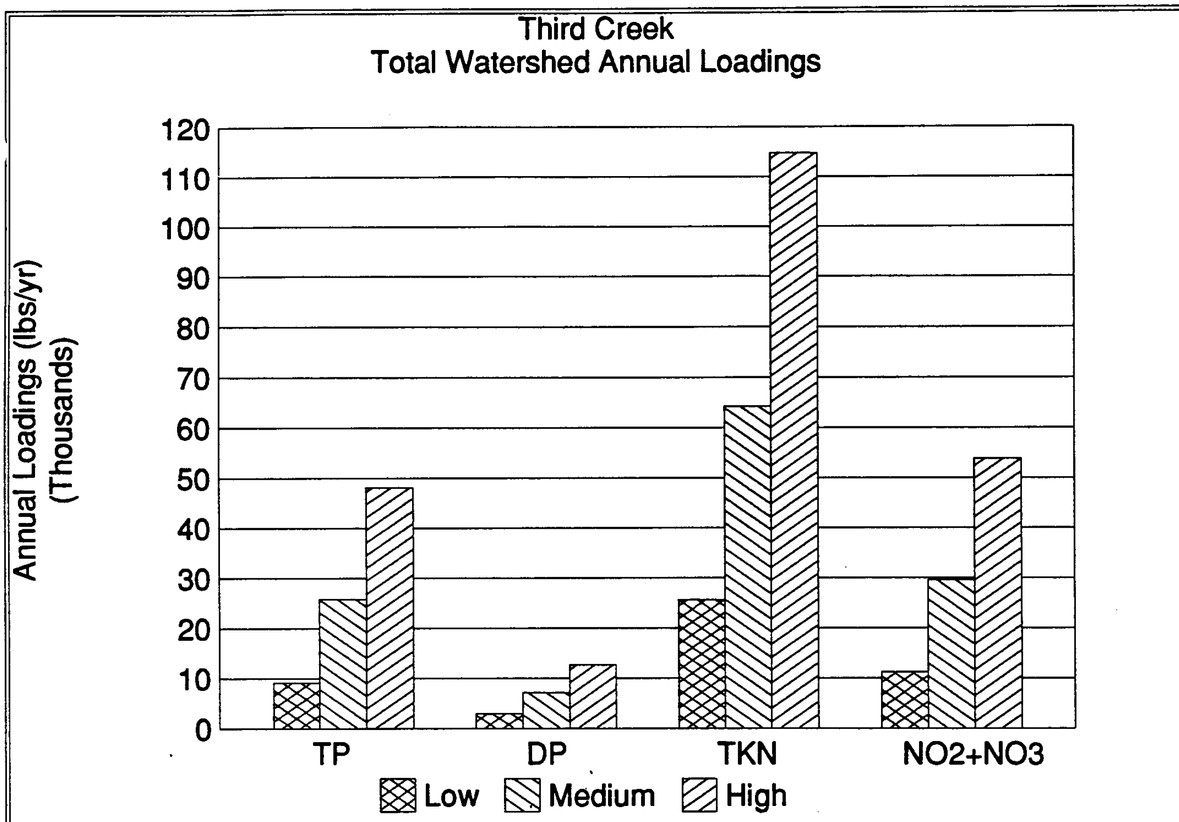

Second Creek
Total Watershed EMCs
EMCs (mg/l)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

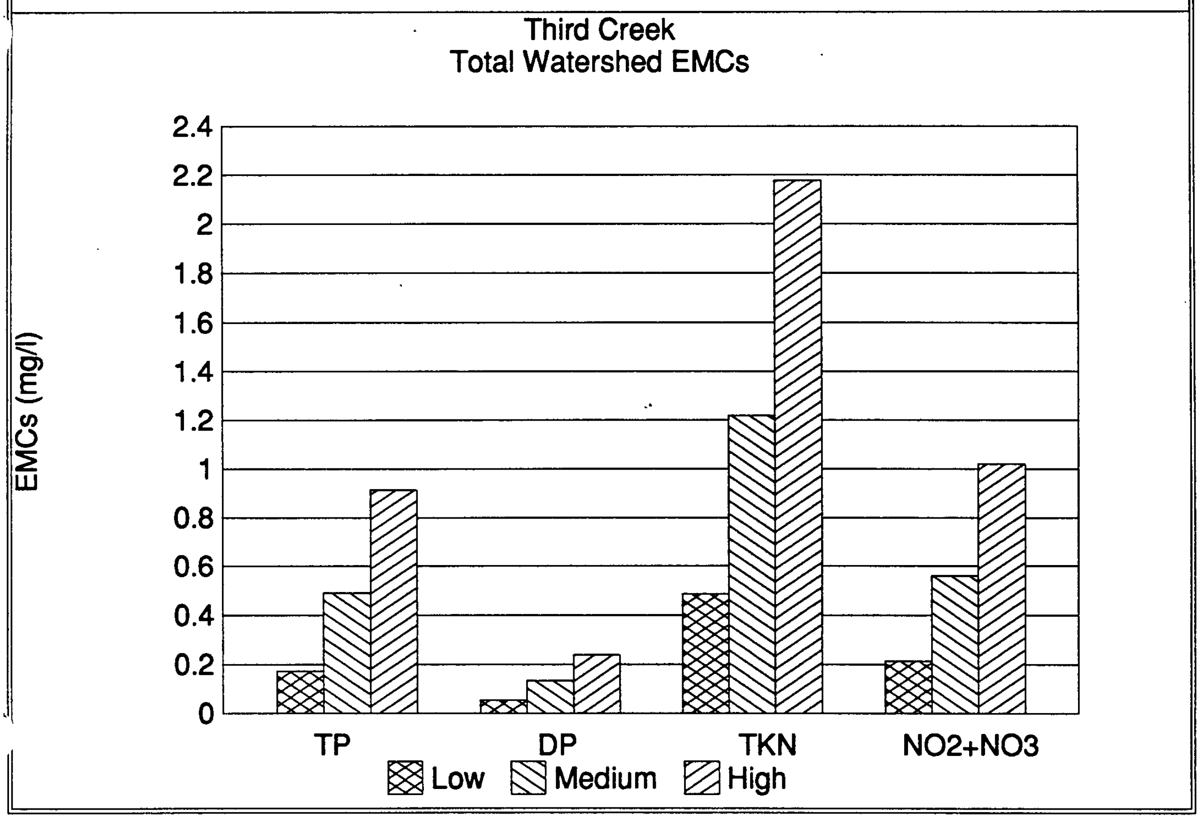

Second Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Pb
Cu
Zn
Cd
Low
Medium
High

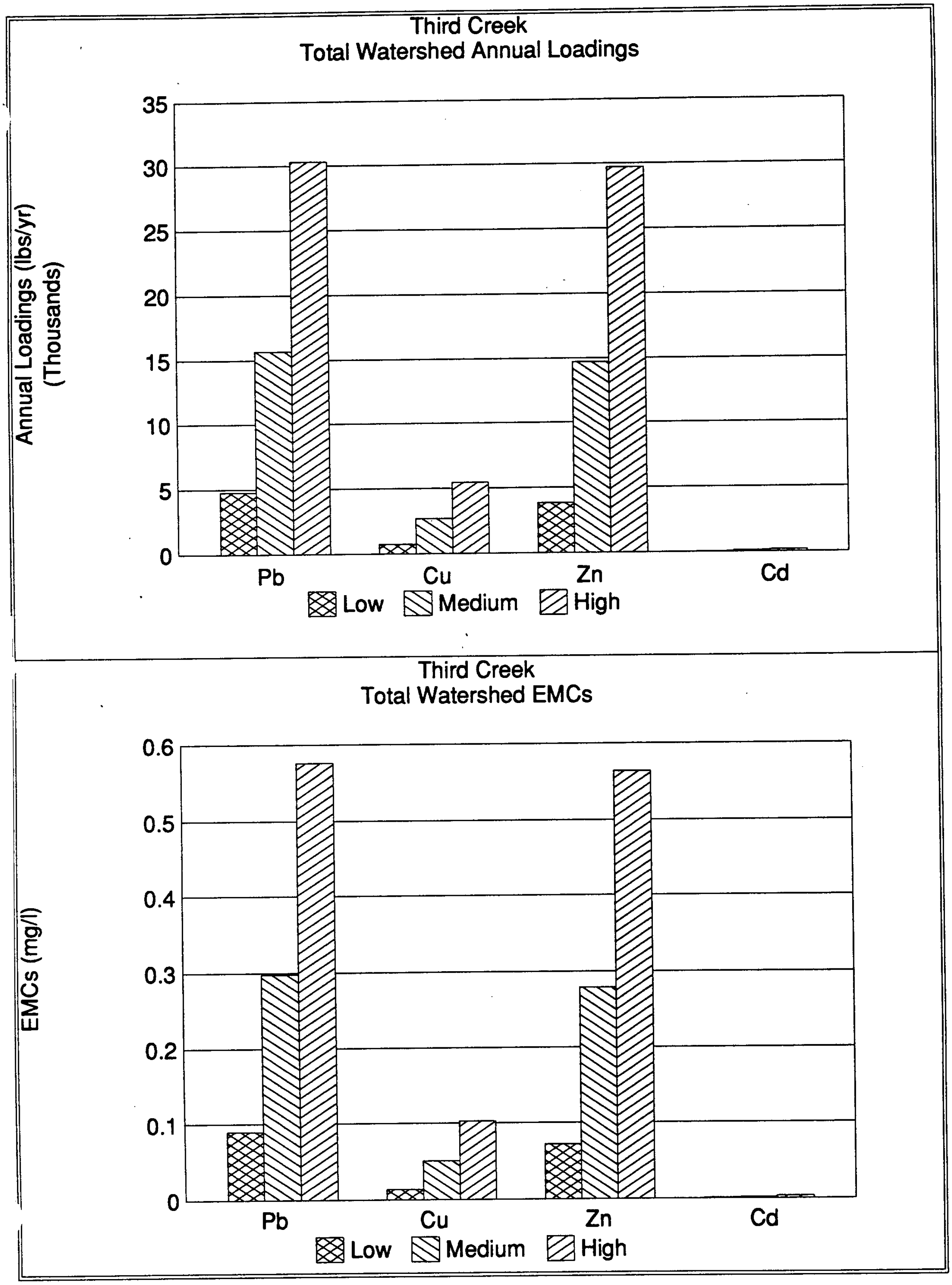

Second Creek
Total Watershed EMCs
EMCs (mg/l)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High


Third Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr) (Millions)
35
30
25
20
15
10
5
0
BOD5
COD
TSS
TDS
Low
Medium
High

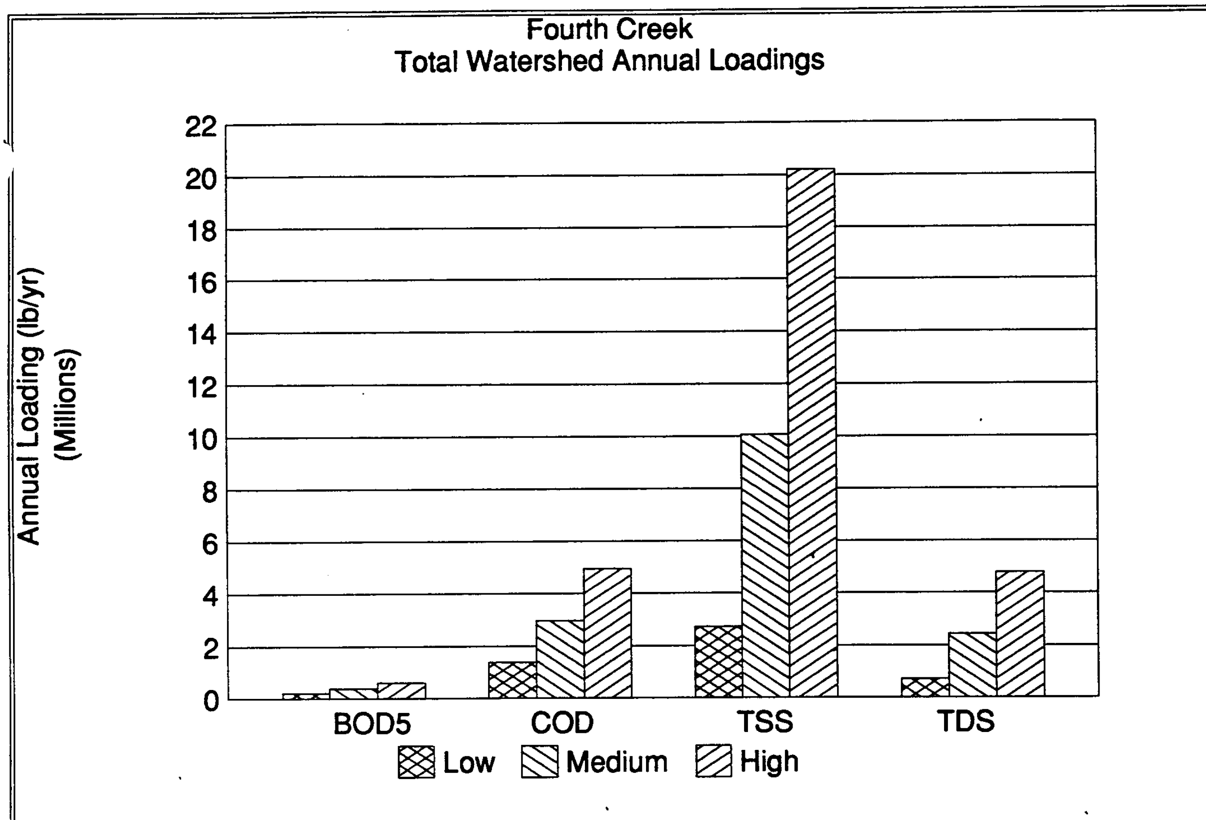

Third Creek
Total Watershed EMCs
EMCs (mg/l)
700
600
500
400
300
200
100
0
BOD5
COD
TSS
TDS
Low
Medium
High


Third Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr) (Thousands)
120
110
100
90
80
70
60
50
40
30
20
10
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

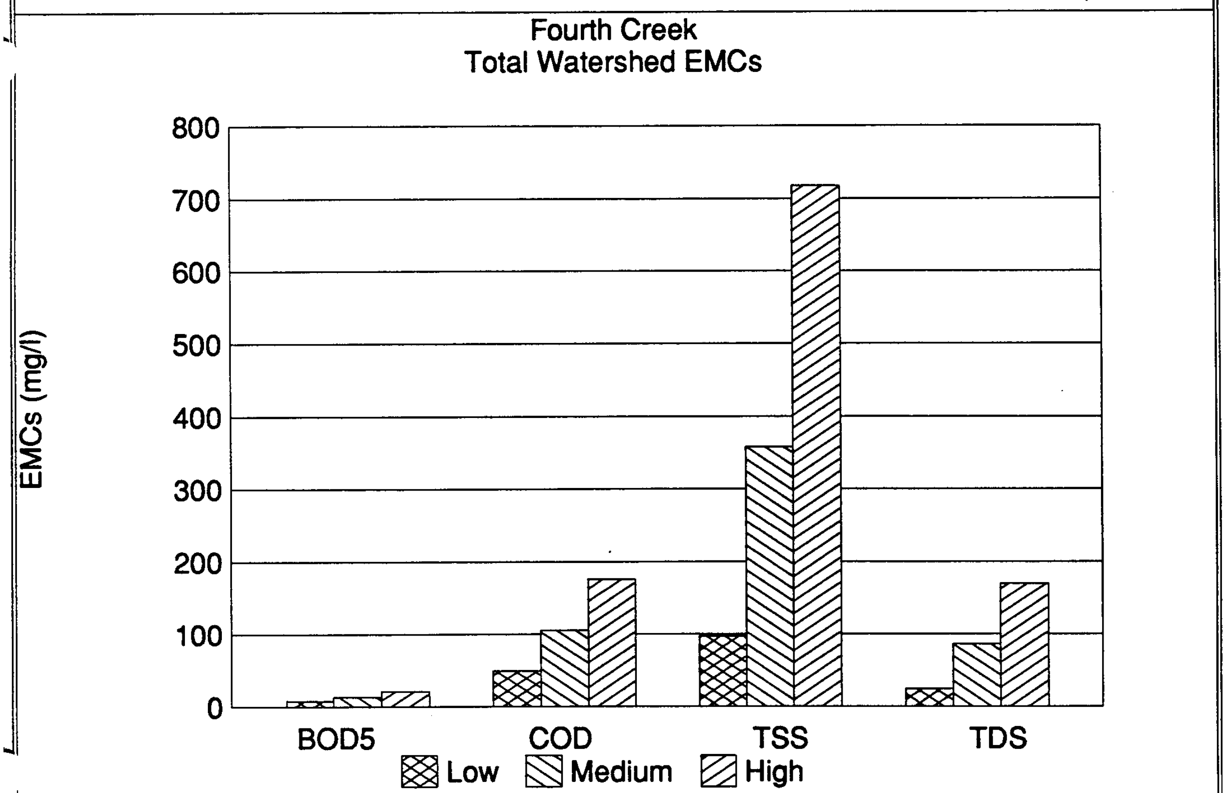

Third Creek
Total Watershed EMCs
EMCs (mg/l)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High



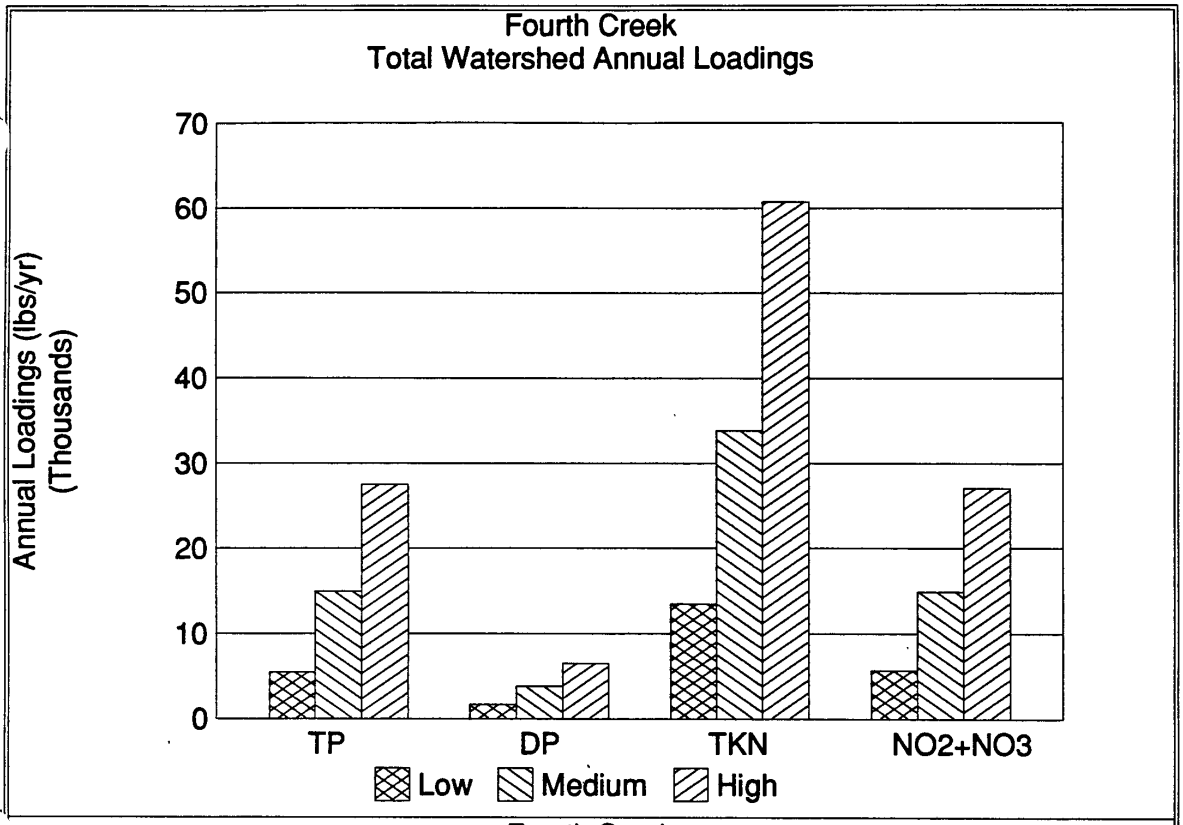
Third Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
35
30
25
20
15
10
5
0
Pb
Cu
Zn
Cd
Low
Medium
High
Third Creek
Total Watershed EMCs
EMCs (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High



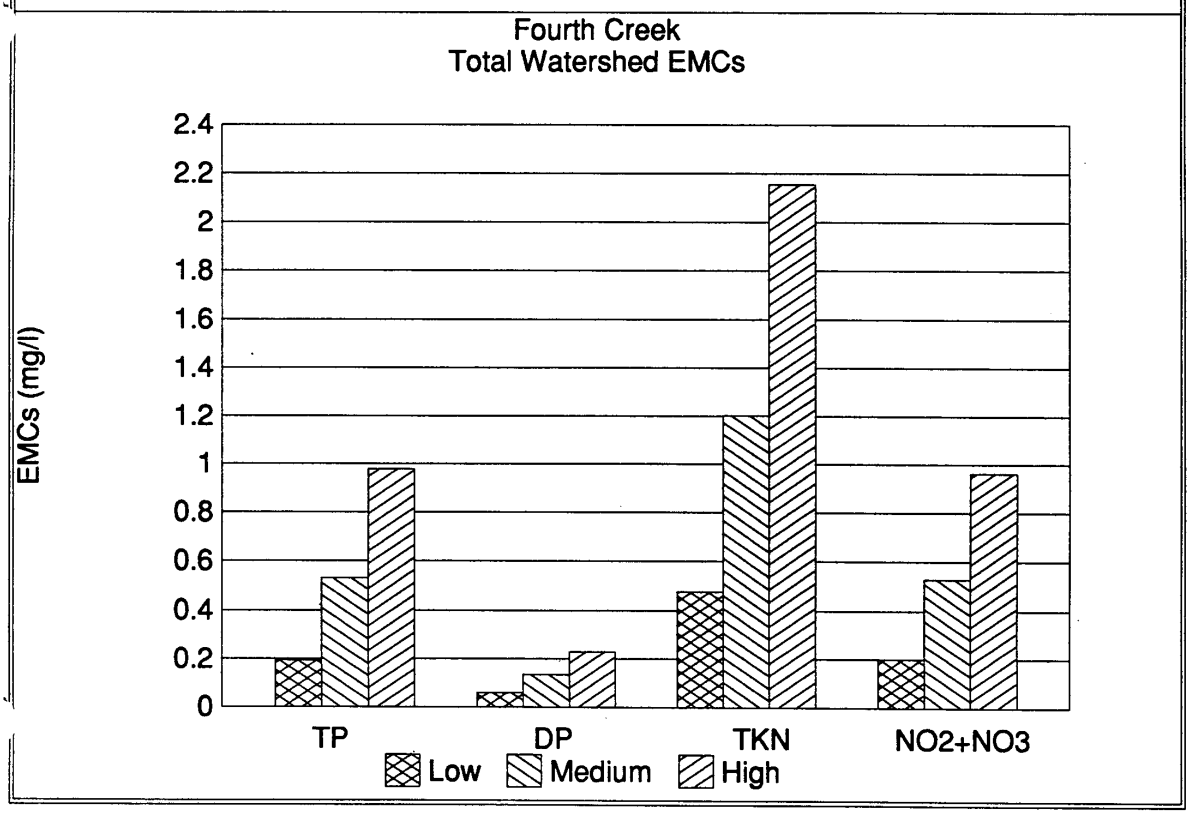
Fourth Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
22
20
18
16
14
12
10
8
6
4
2
0
BOD5
COD
TSS
TDS
Low
Medium
High



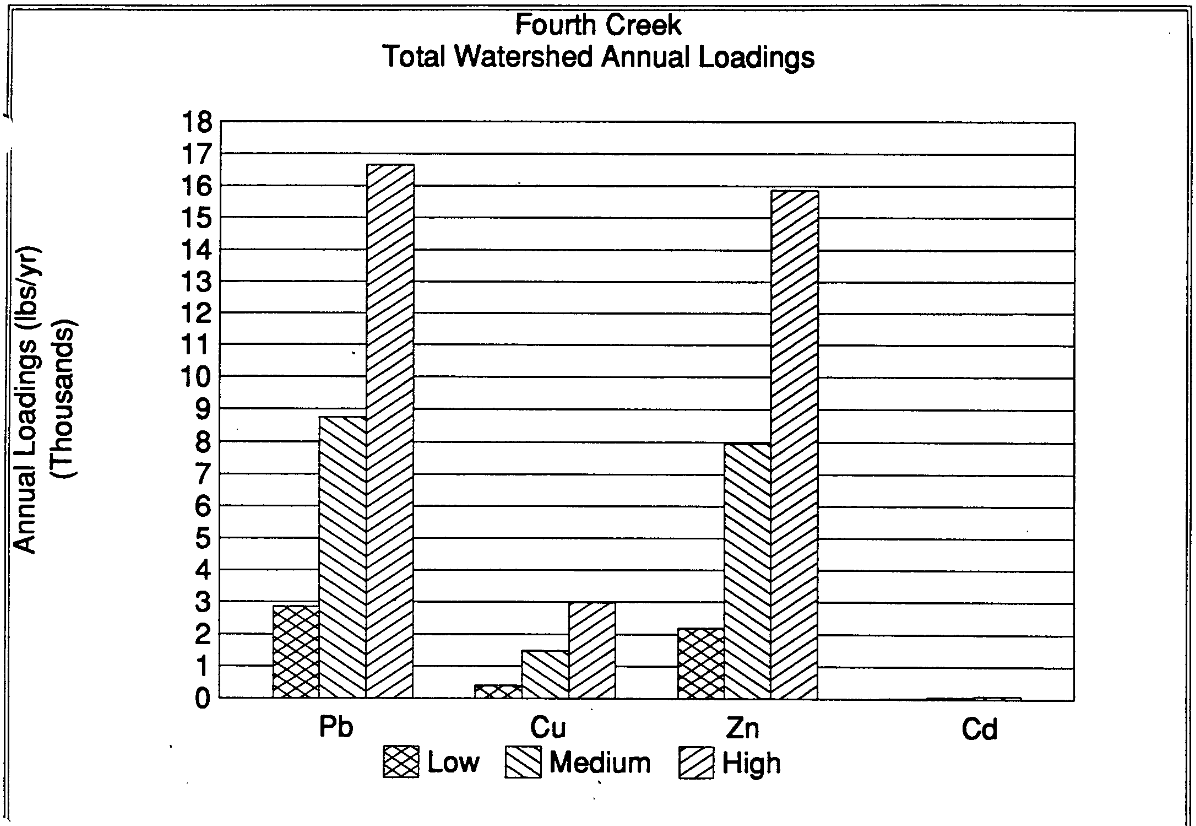
Fourth Creek
Total Watershed EMCs
EMCs (mg/l)
800
700
600
500
400
300
200
100
0
BOD5
COD
TSS
TDS
Low
Medium
High

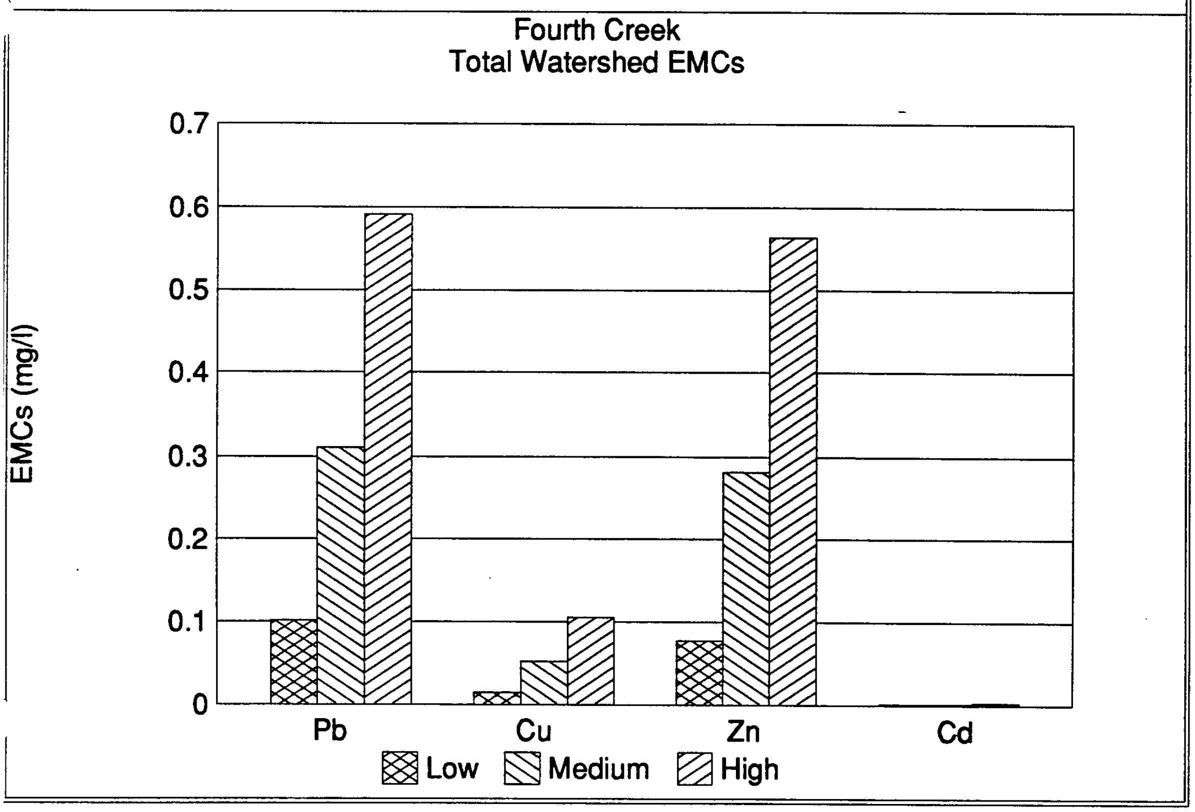


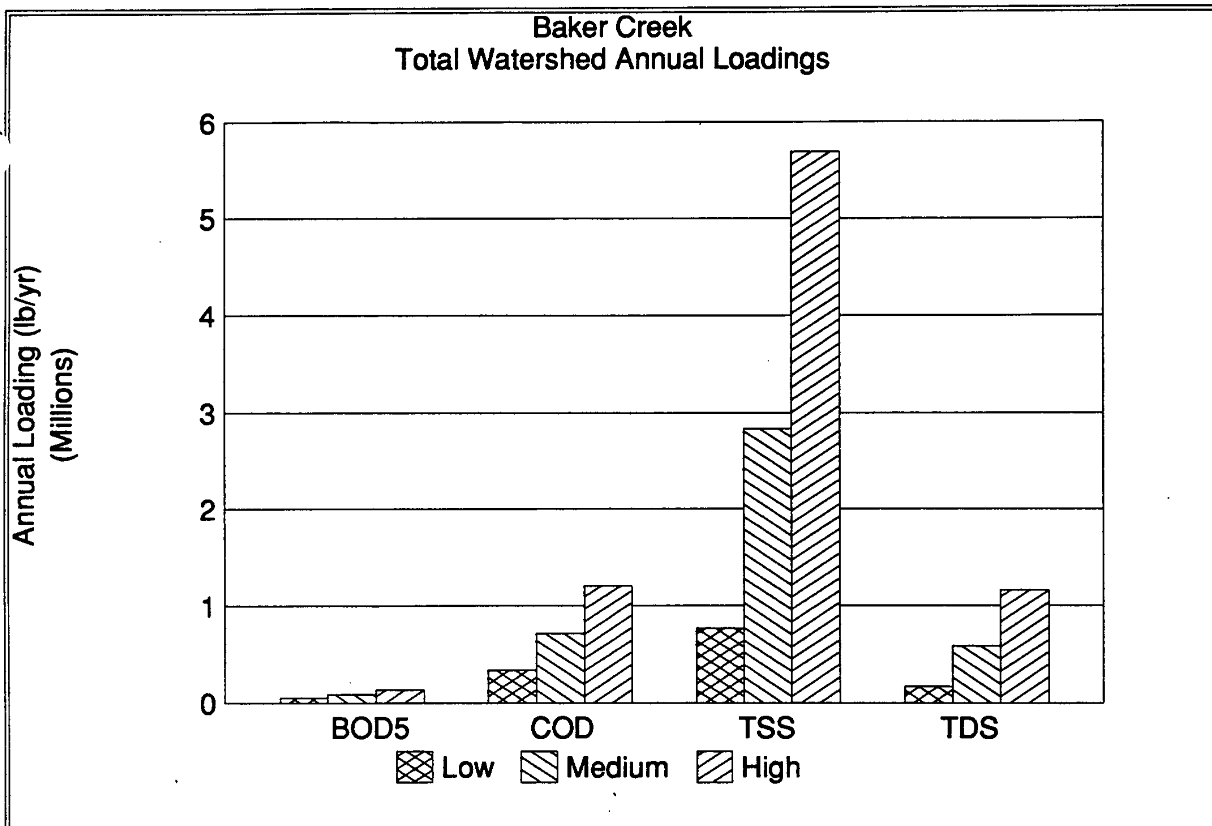
Fourth Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
70
60
50
40
30
20
10
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

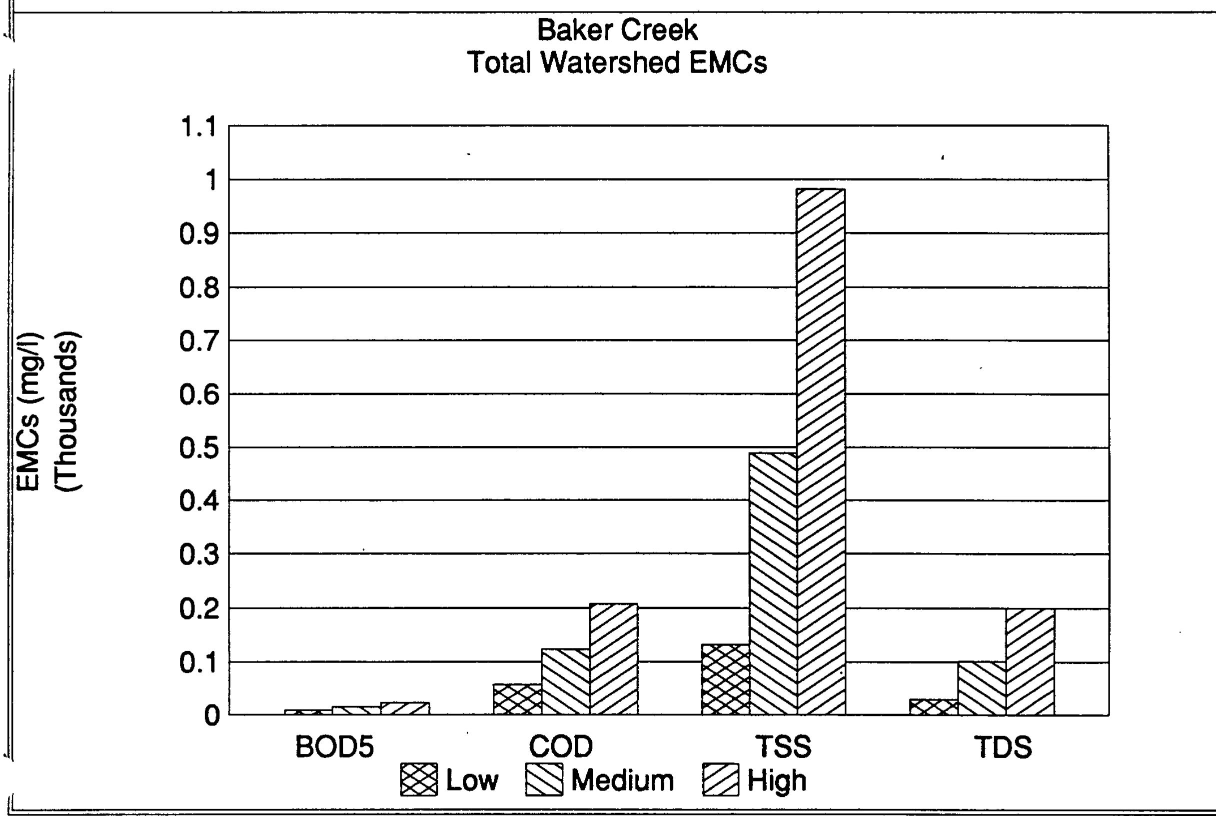


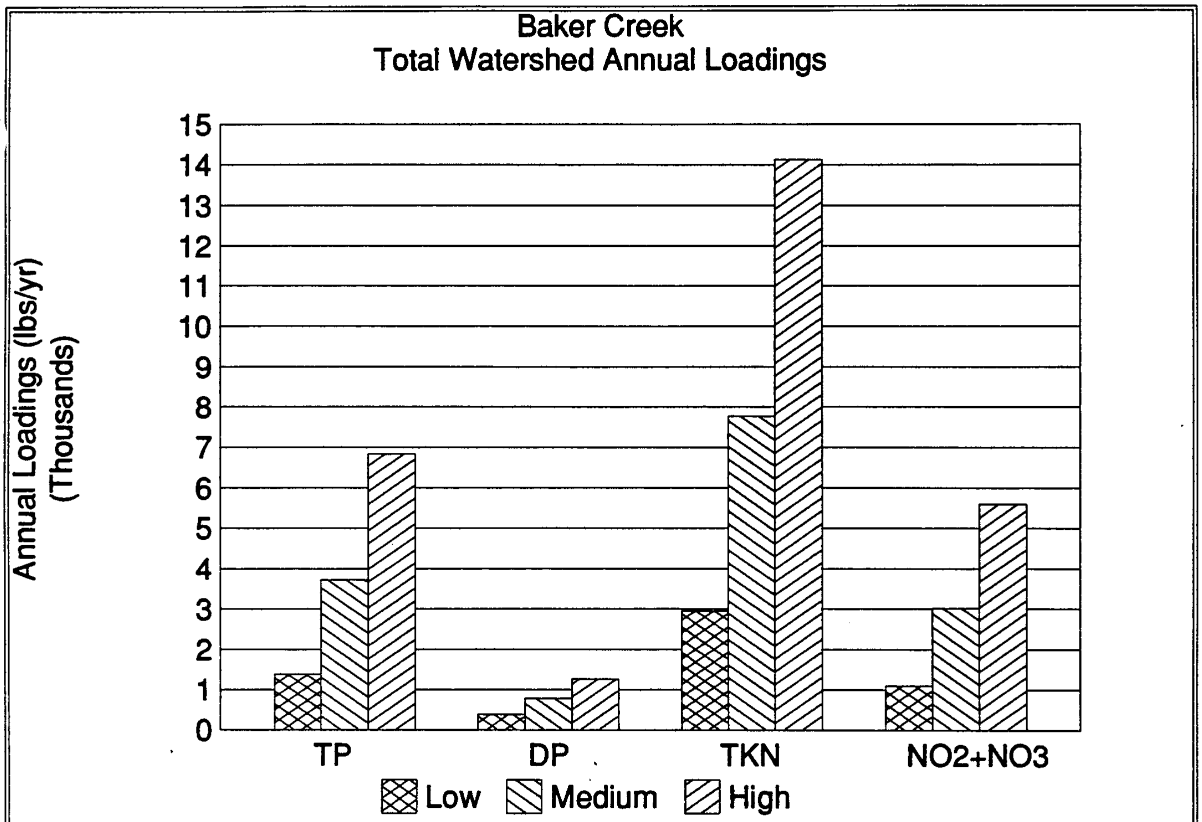
Fourth Creek
Total Watershed EMCs
EMCs (mg/l)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

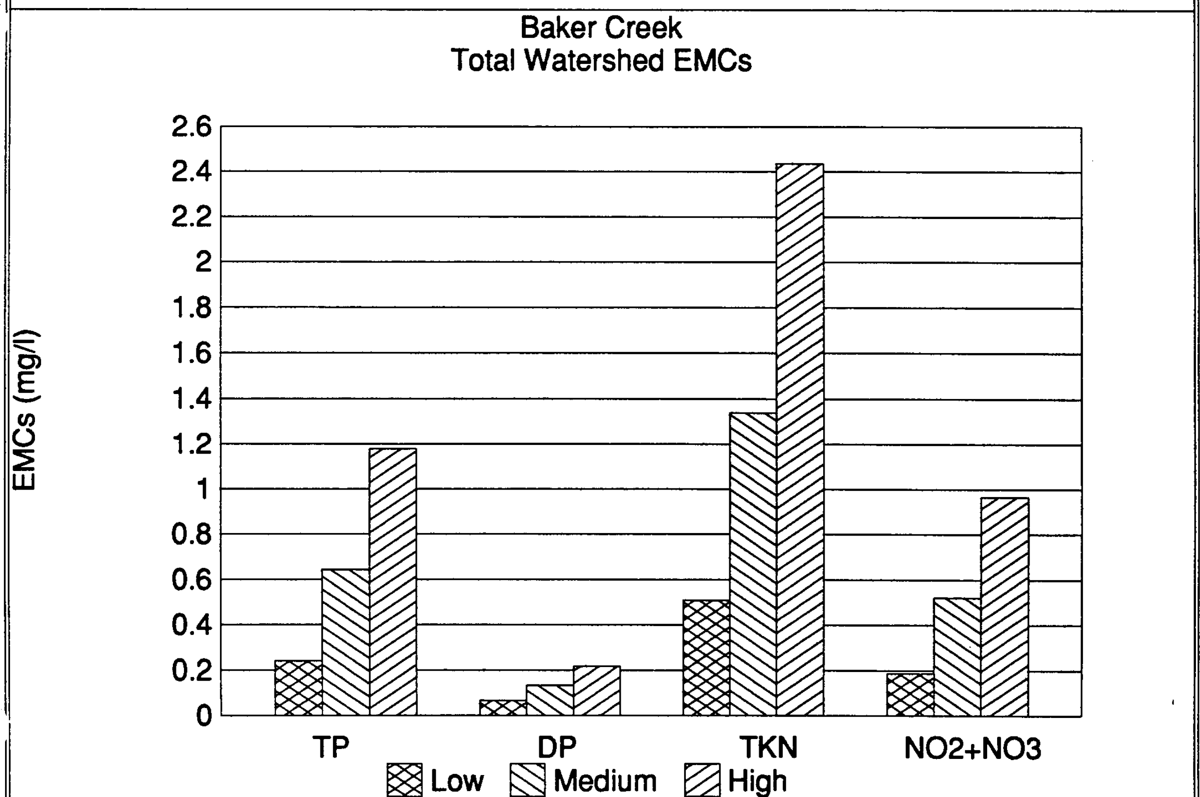

Fourth Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Pb
Cu
Zn
Cd
Low
Medium
High

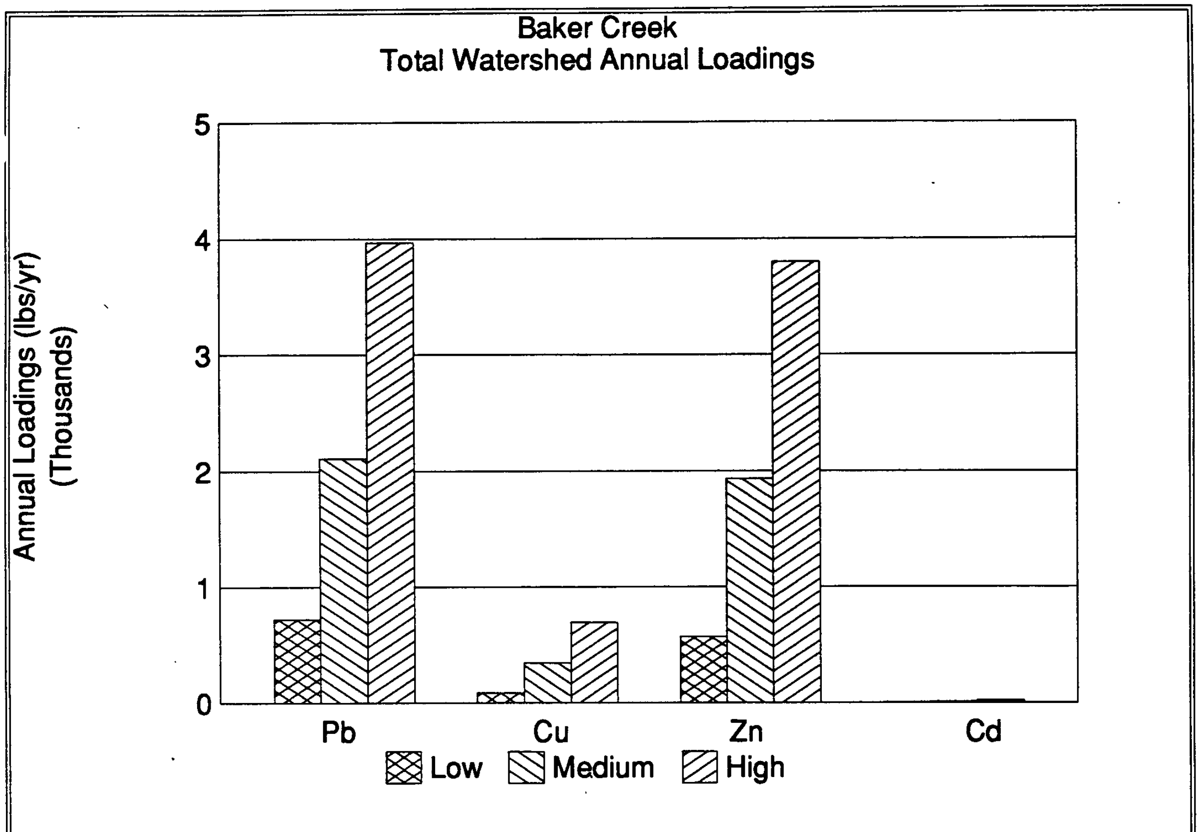

Fourth Creek
Total Watershed EMCs
EMCs (mg/l)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High

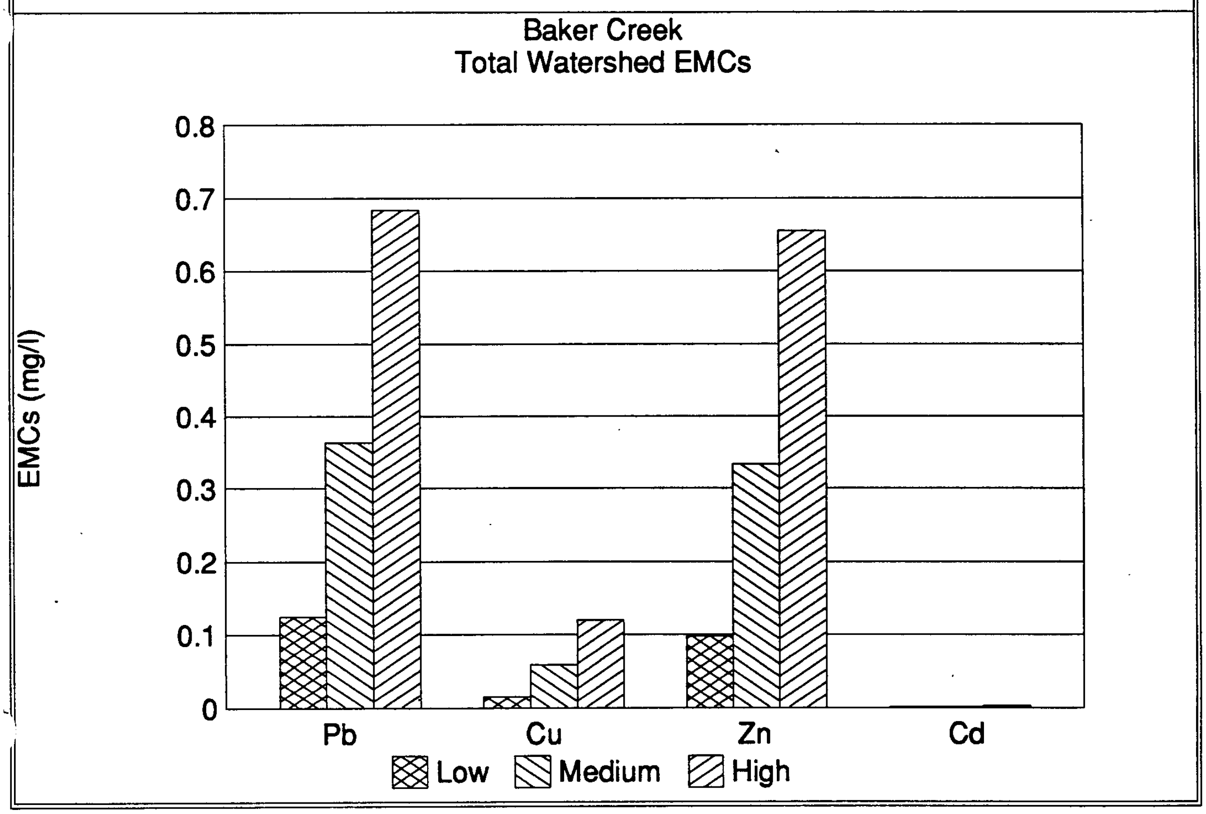

Baker Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
6
5
4
3
2
1
0
BOD5
COD
TSS
TDS
Low
Medium
High

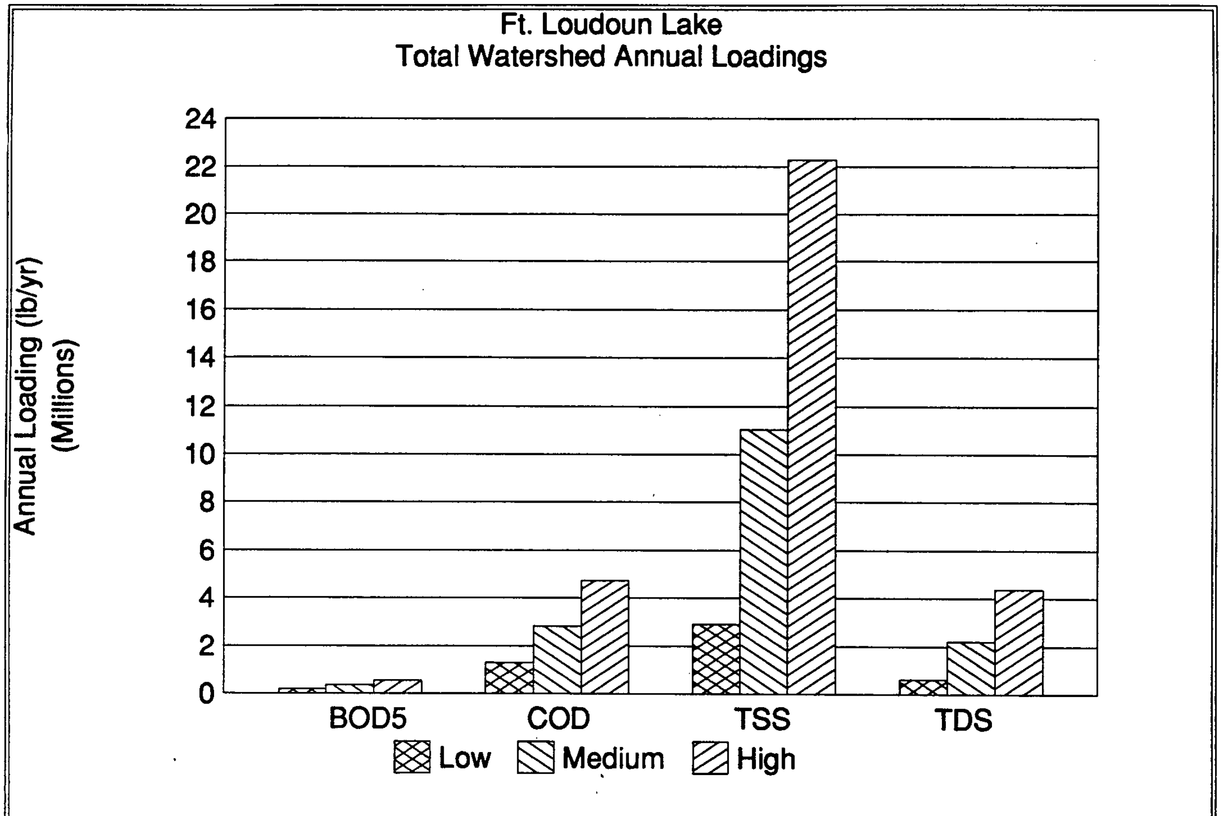

Baker Creek
Total Watershed EMCs
EMCs (mg/l)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
BOD5
COD
TSS
TDS
Low
Medium
High

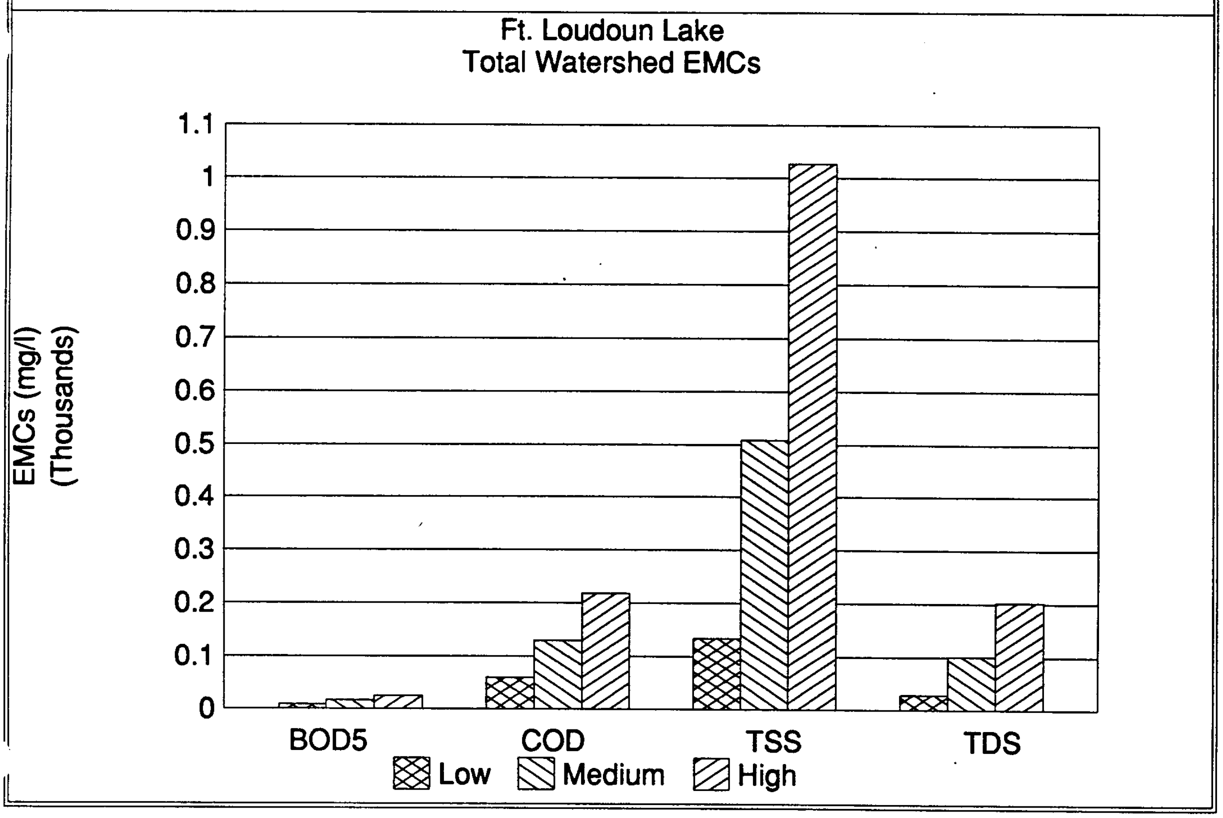

Baker Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

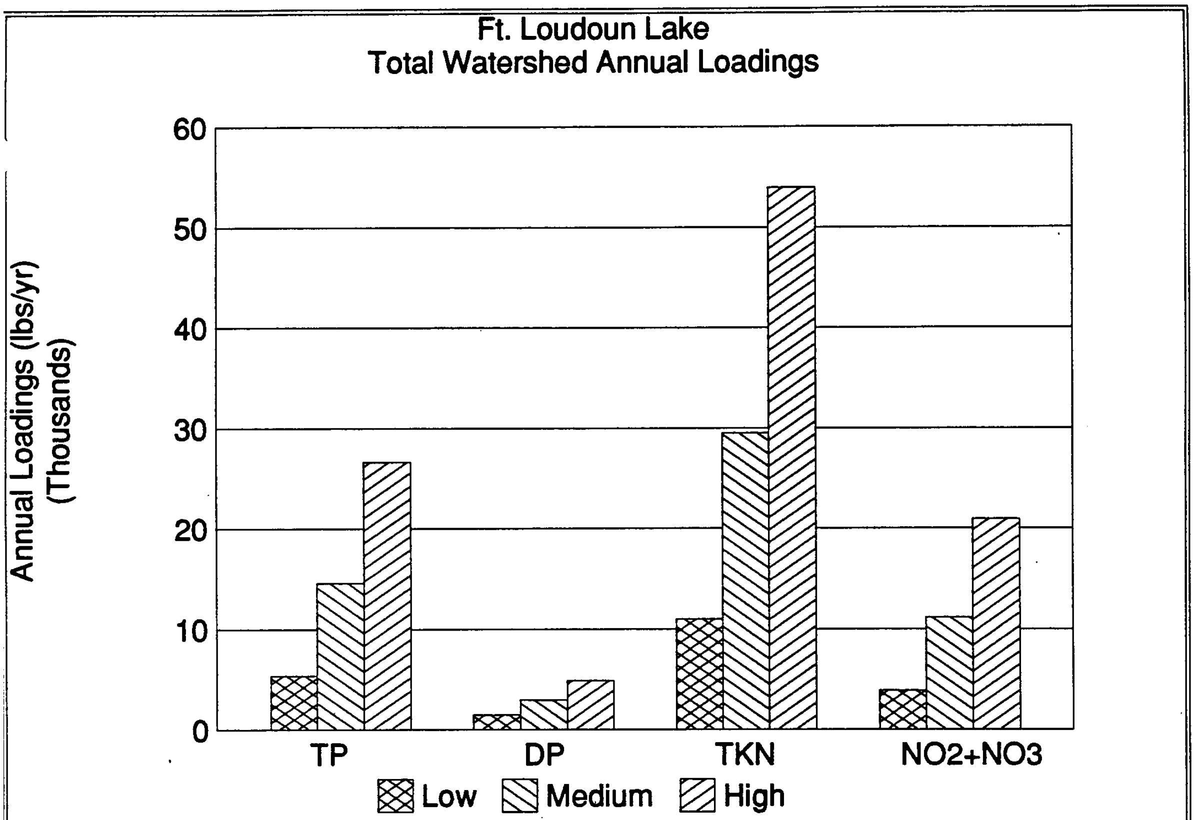

Baker Creek
Total Watershed EMCs
EMCs (mg/l)
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

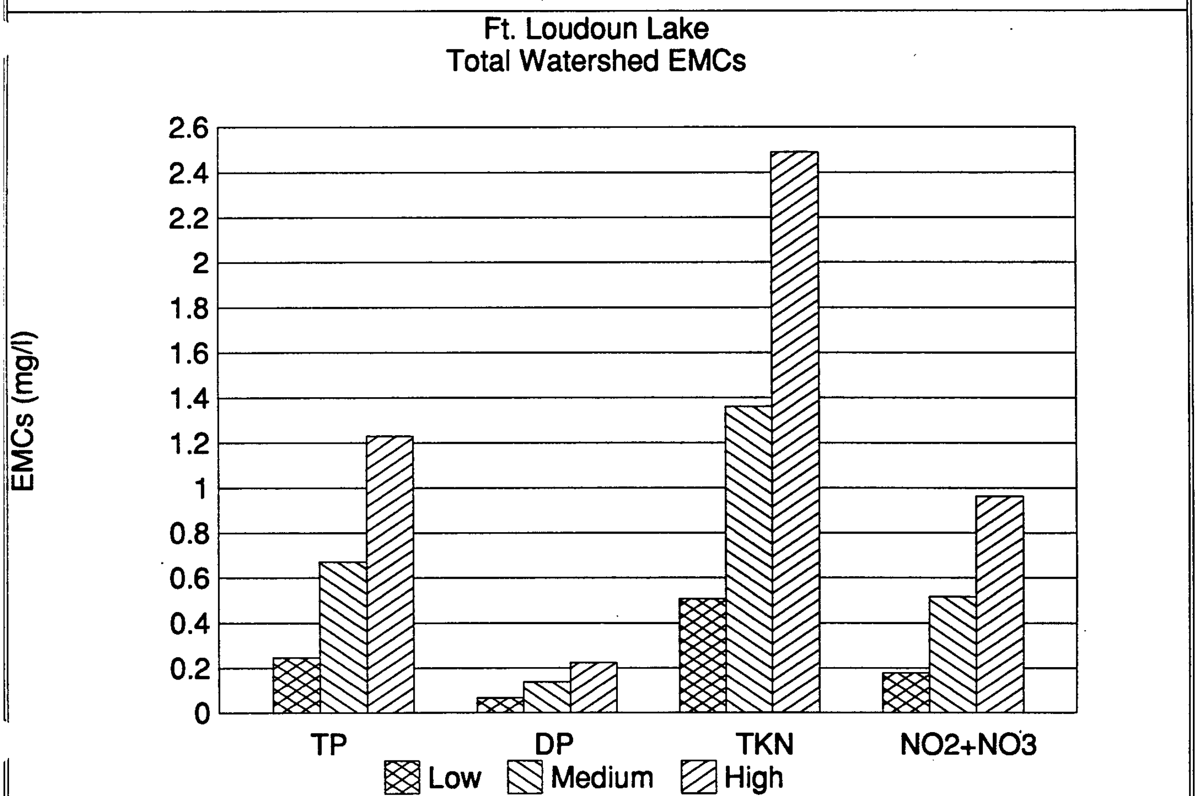

Baker Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
5
4
3
2
1
0
Pb
Cu
Zn
Cd
Low
Medium
High

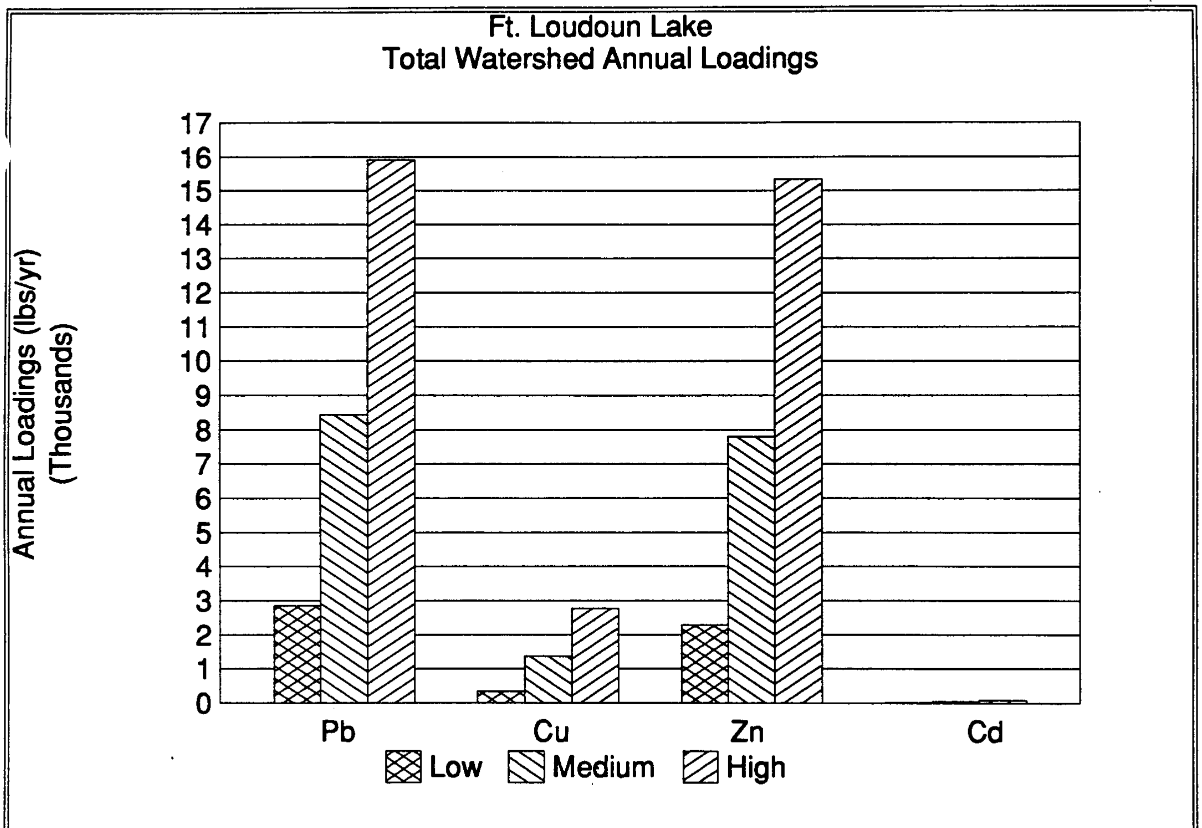

Baker Creek
Total Watershed EMCs
EMCs (mg/l)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High

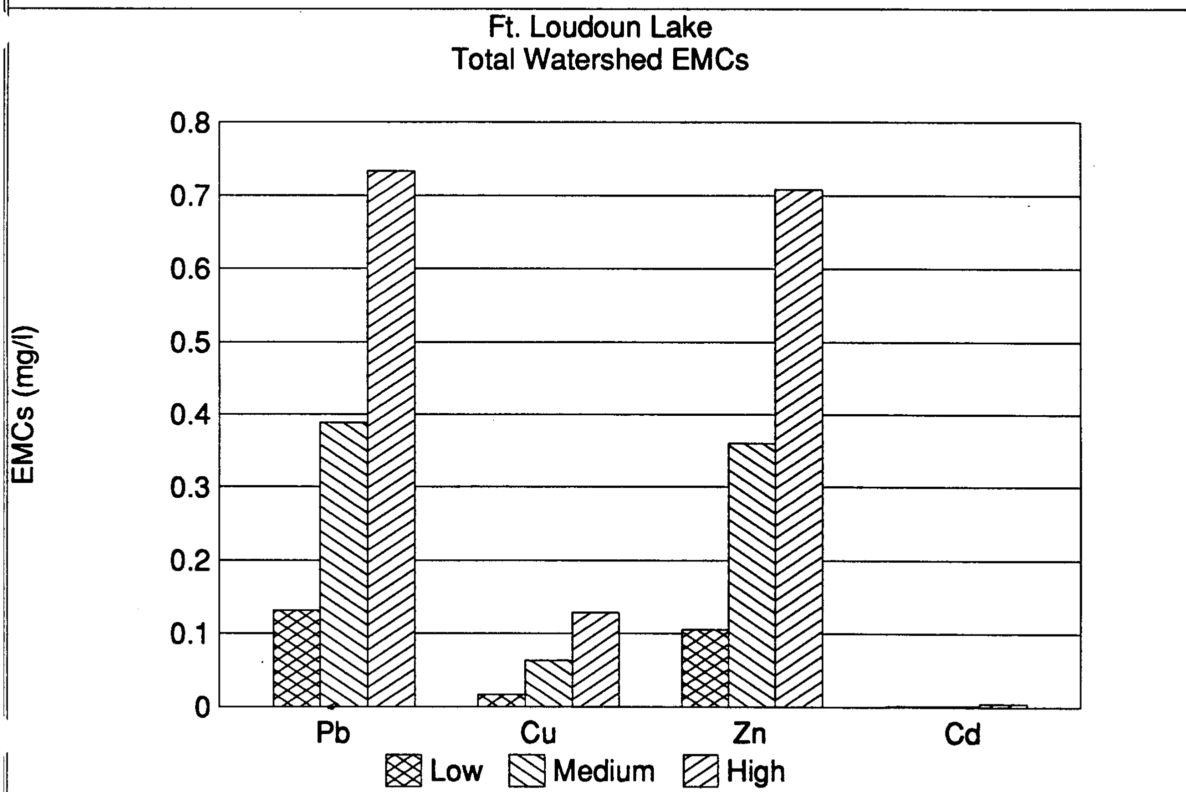

Ft. Loudoun Lake
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
24
22
20
18
16
14
12
10
8
6
4
2
0
BOD5
COD
TSS
TDS
Low
Medium
High

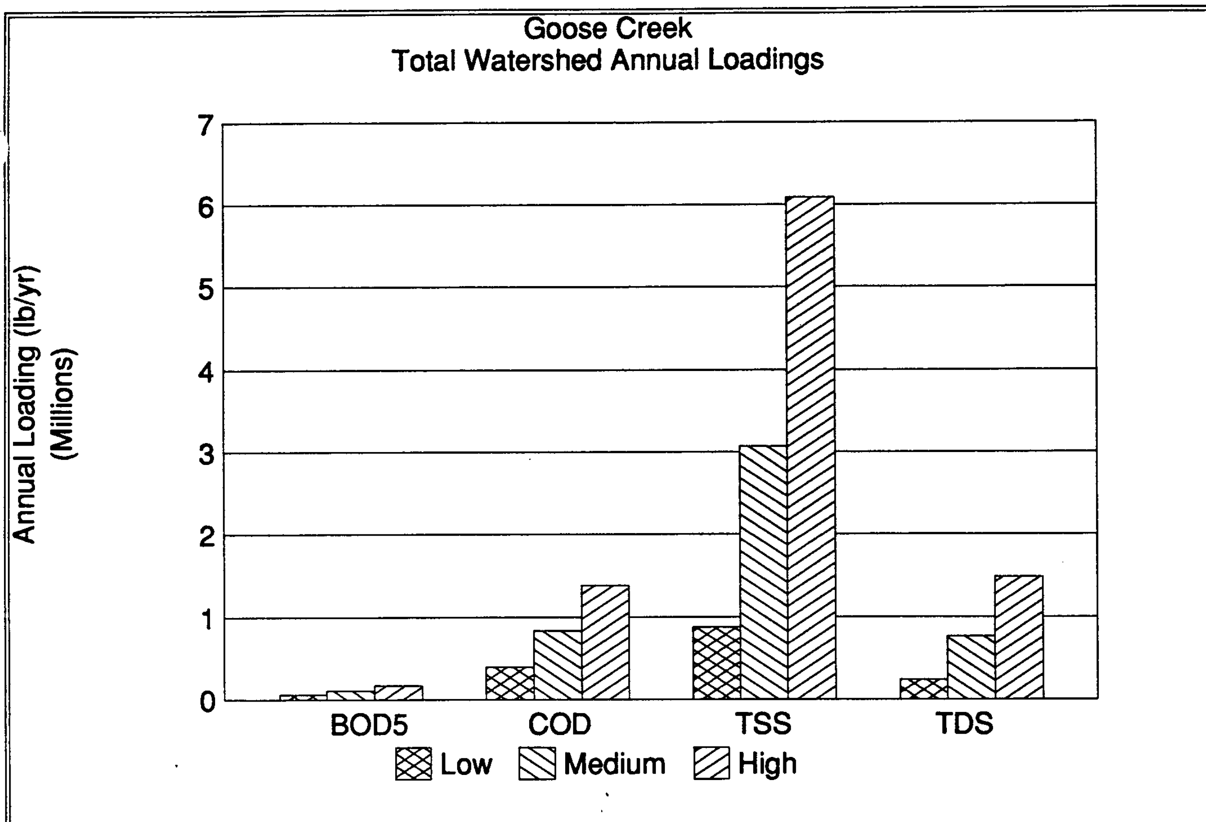

Ft. Loudoun Lake
Total Watershed EMCs
EMCs (mg/l)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
BOD5
COD
TSS
TDS
Low
Medium
High

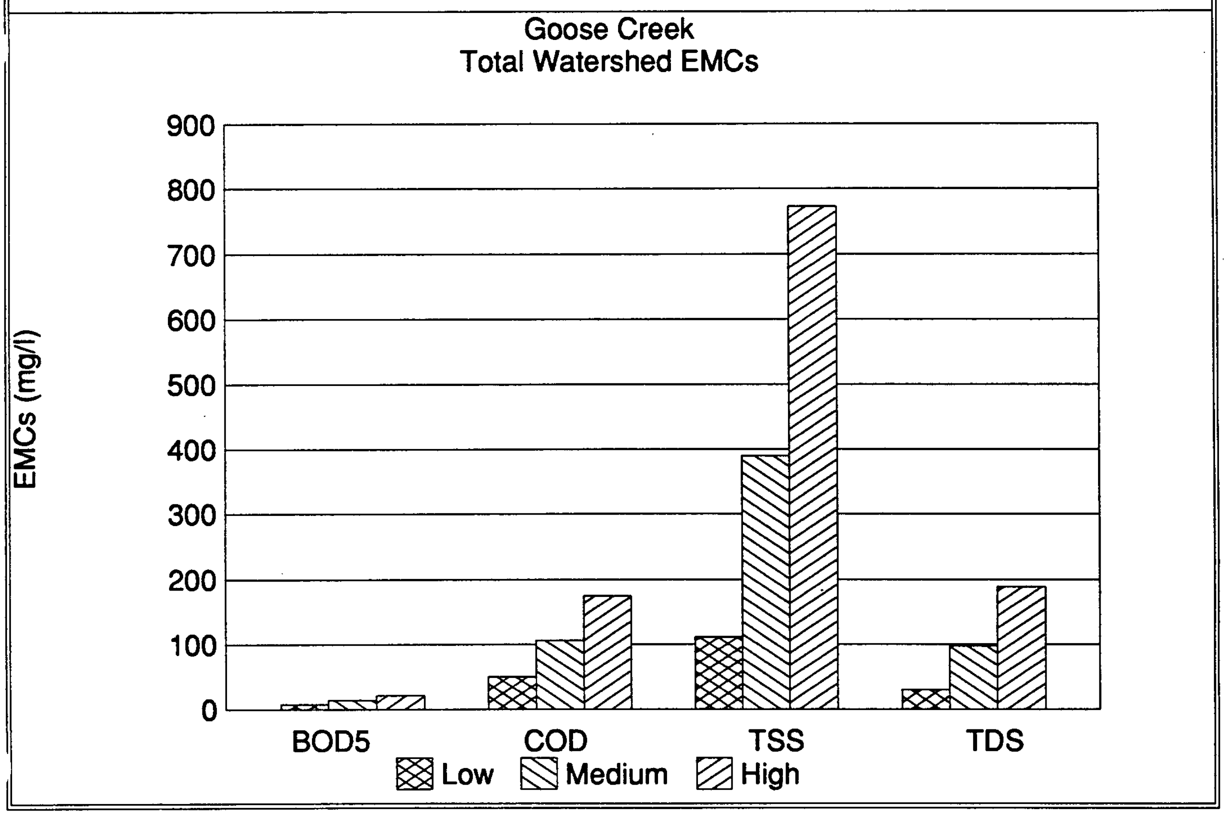

Ft. Loudoun Lake
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
60
50
40
30
20
10
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

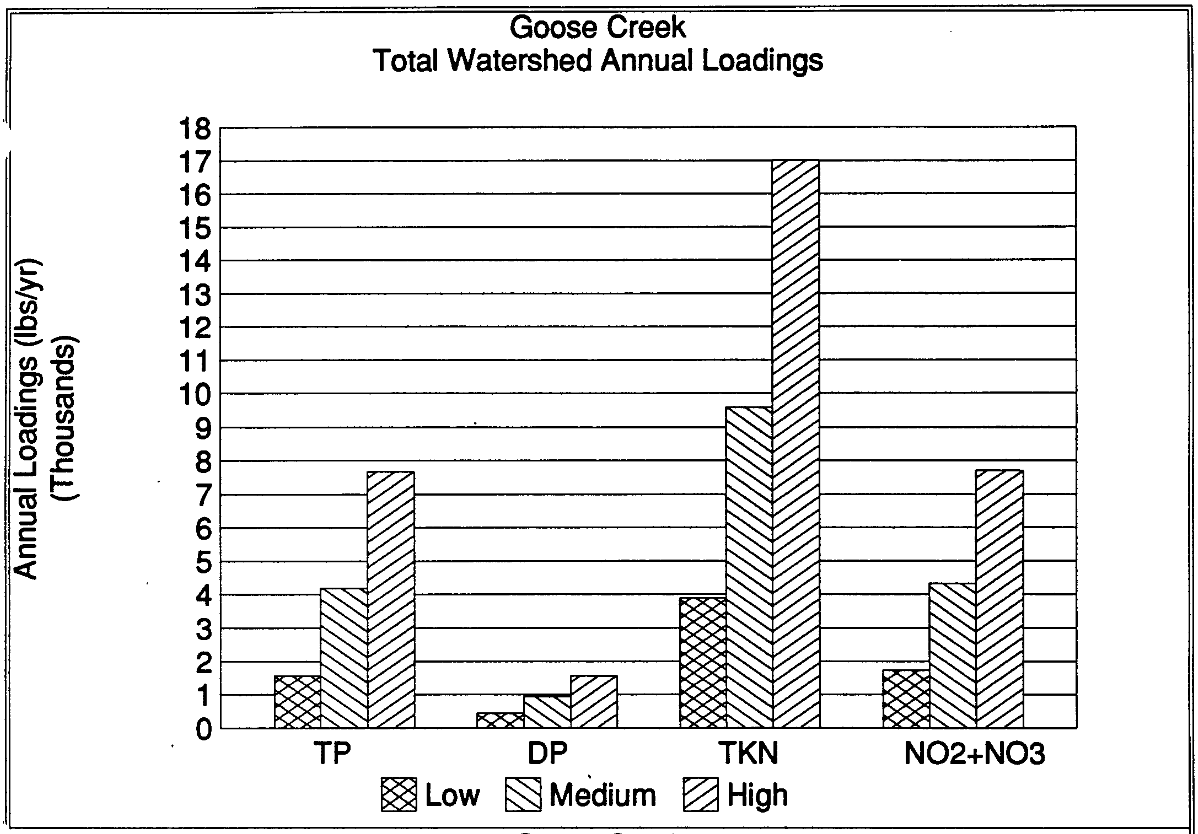

Ft. Loudoun Lake
Total Watershed EMCs
EMCs (mg/l)
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

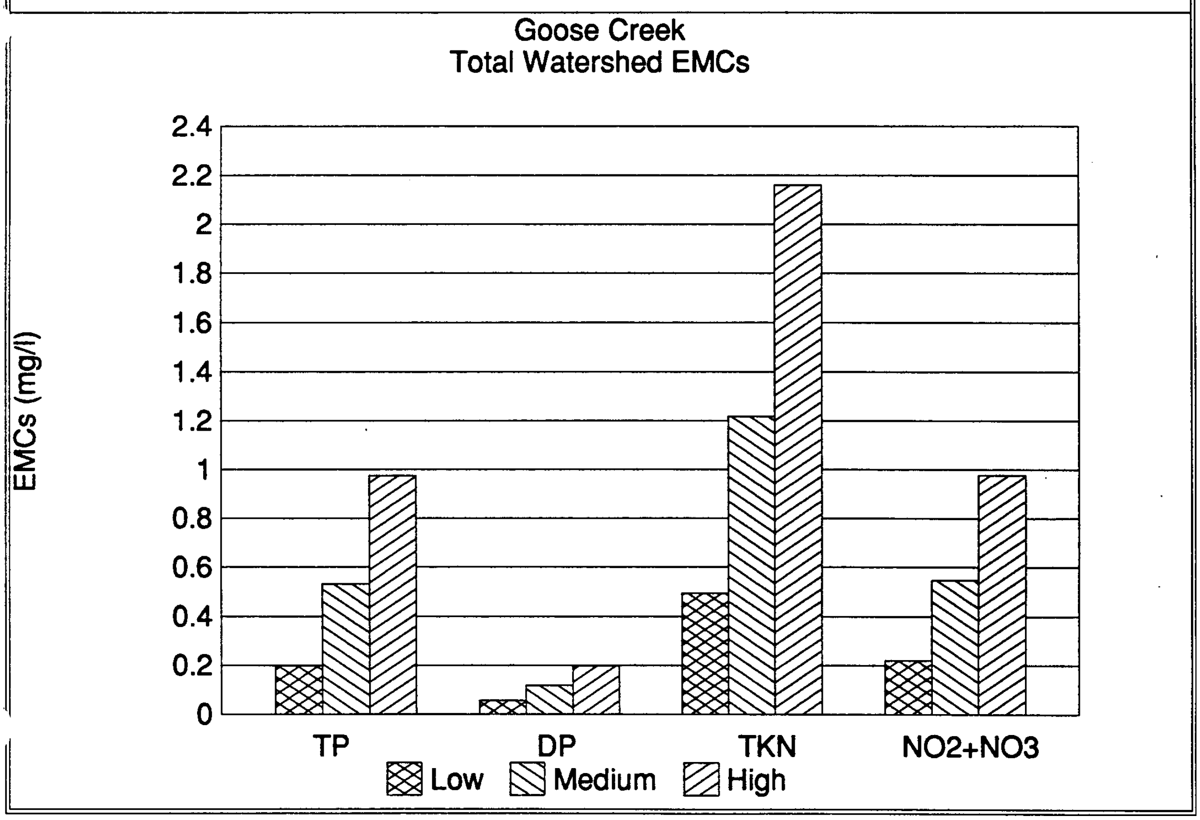

Ft. Loudoun Lake
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Pb
Cu
Zn
Cd
Low
Medium
High

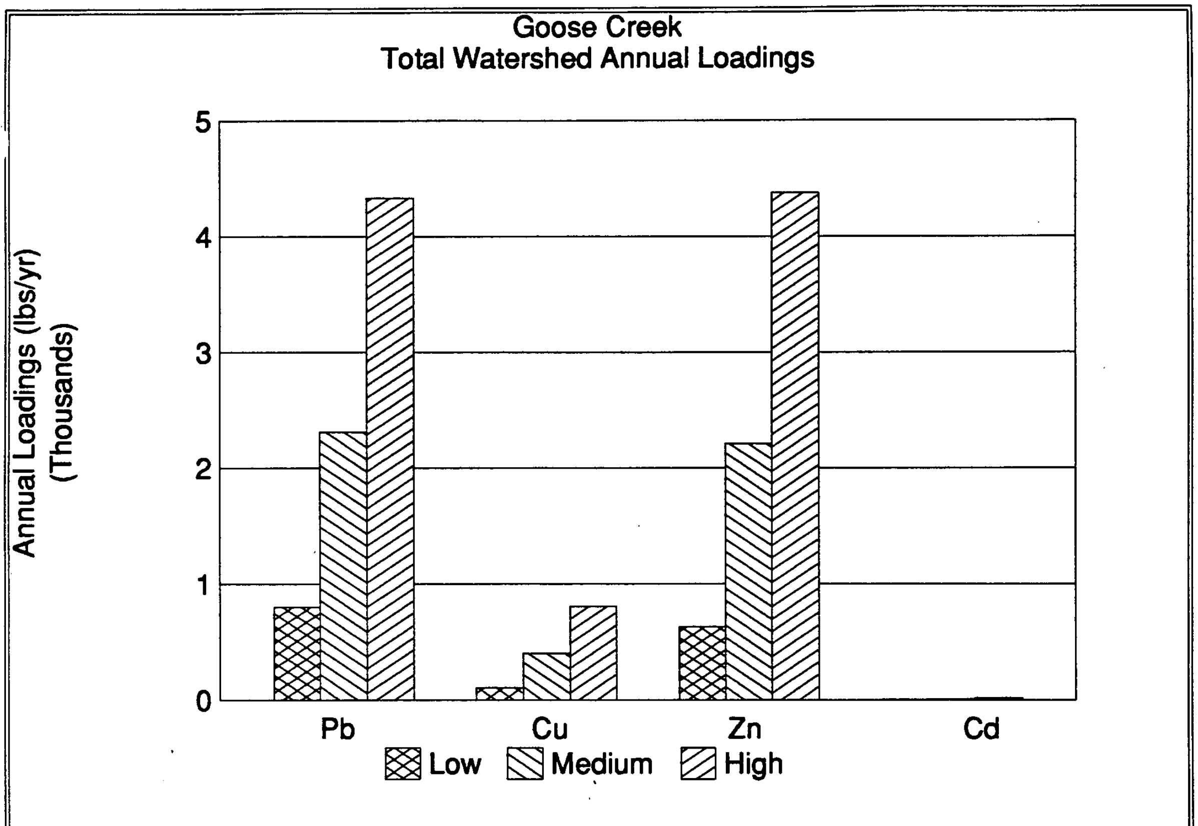

Ft. Loudoun Lake
Total Watershed EMCs
EMCs (mg/l)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High

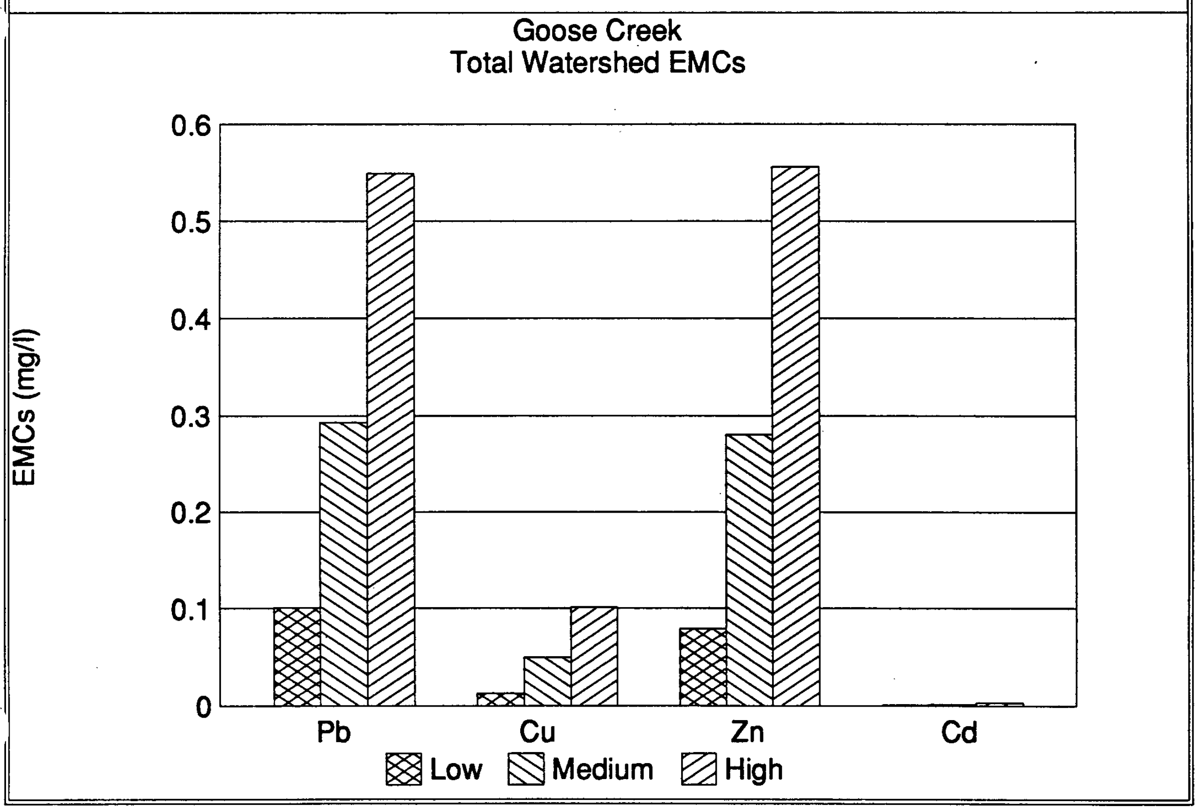

Goose Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
7
6
5
4
3
2
1
0
BOD5
COD
TSS
TDS
Low
Medium
High

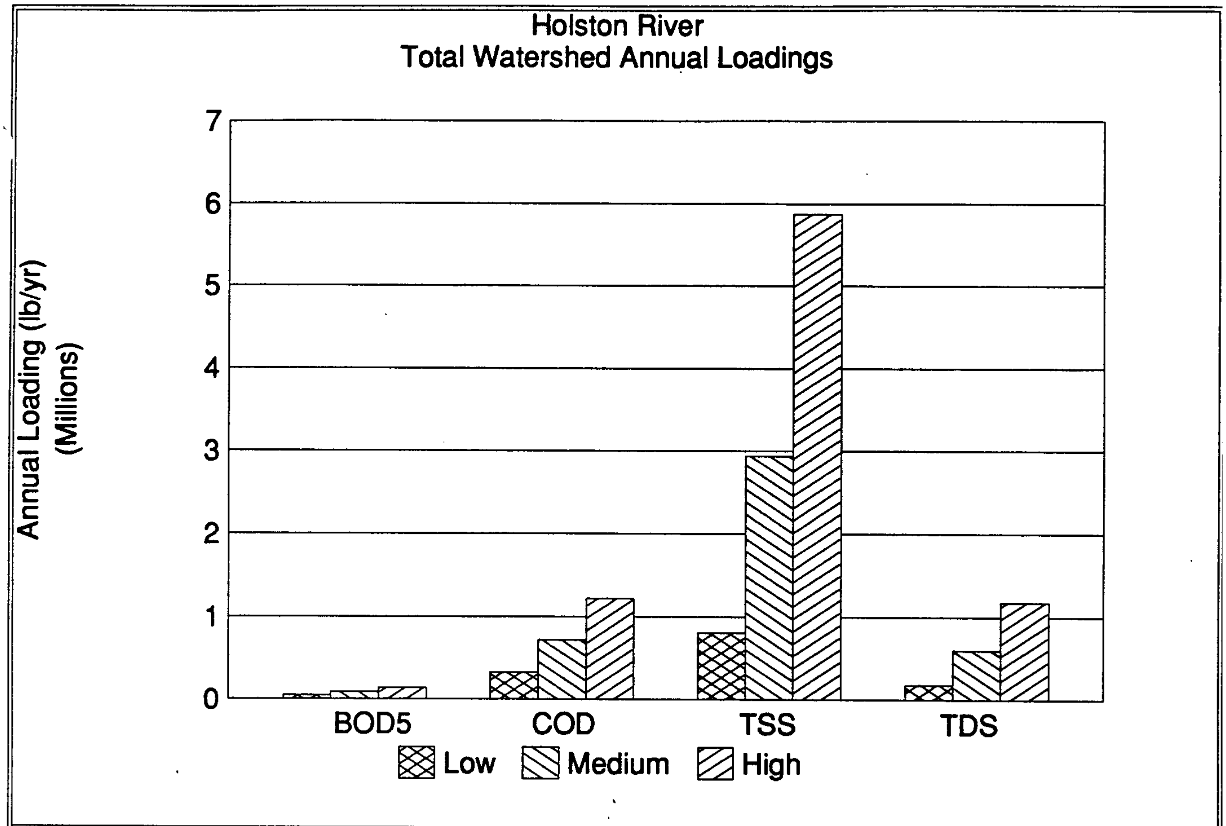

Goose Creek
Total Watershed EMCs
EMCs (mg/l)
900
800
700
600
500
400
300
200
100
0
BOD5
COD
TSS
TDS
Low
Medium
High

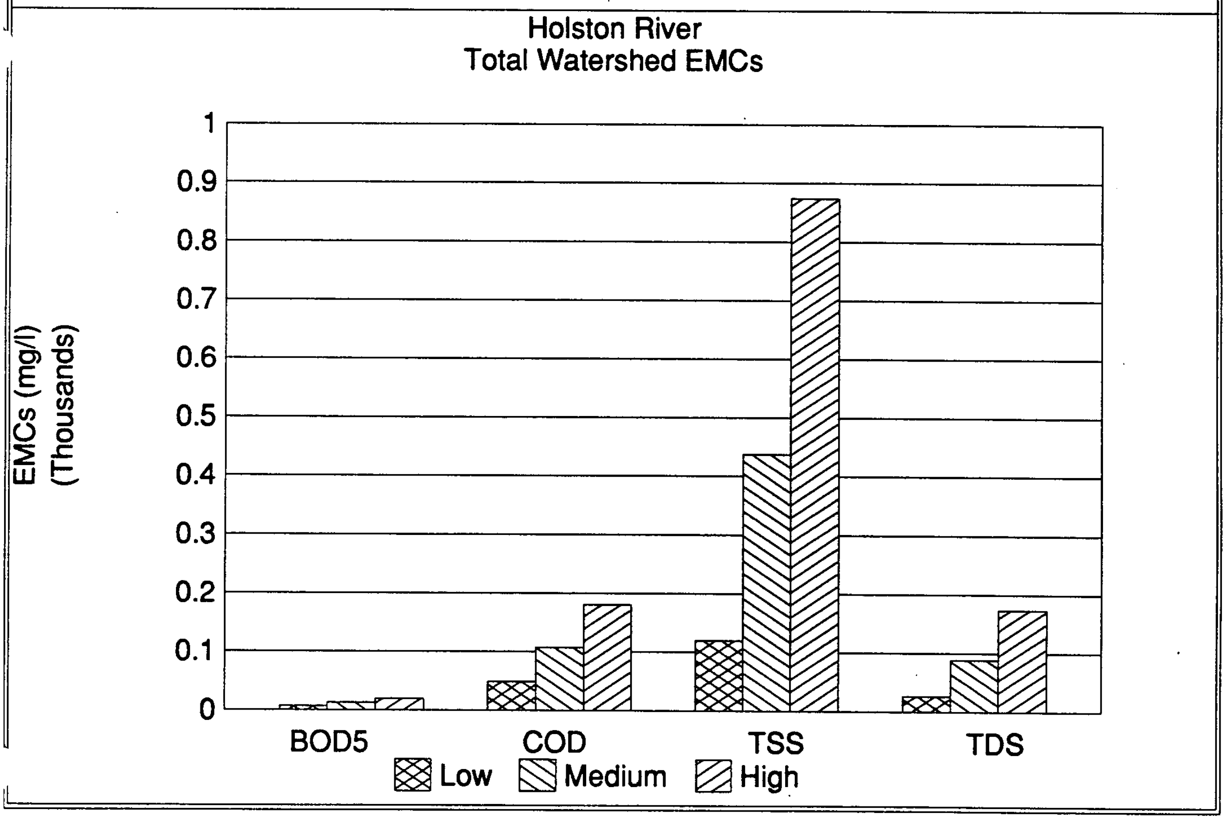

Goose Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

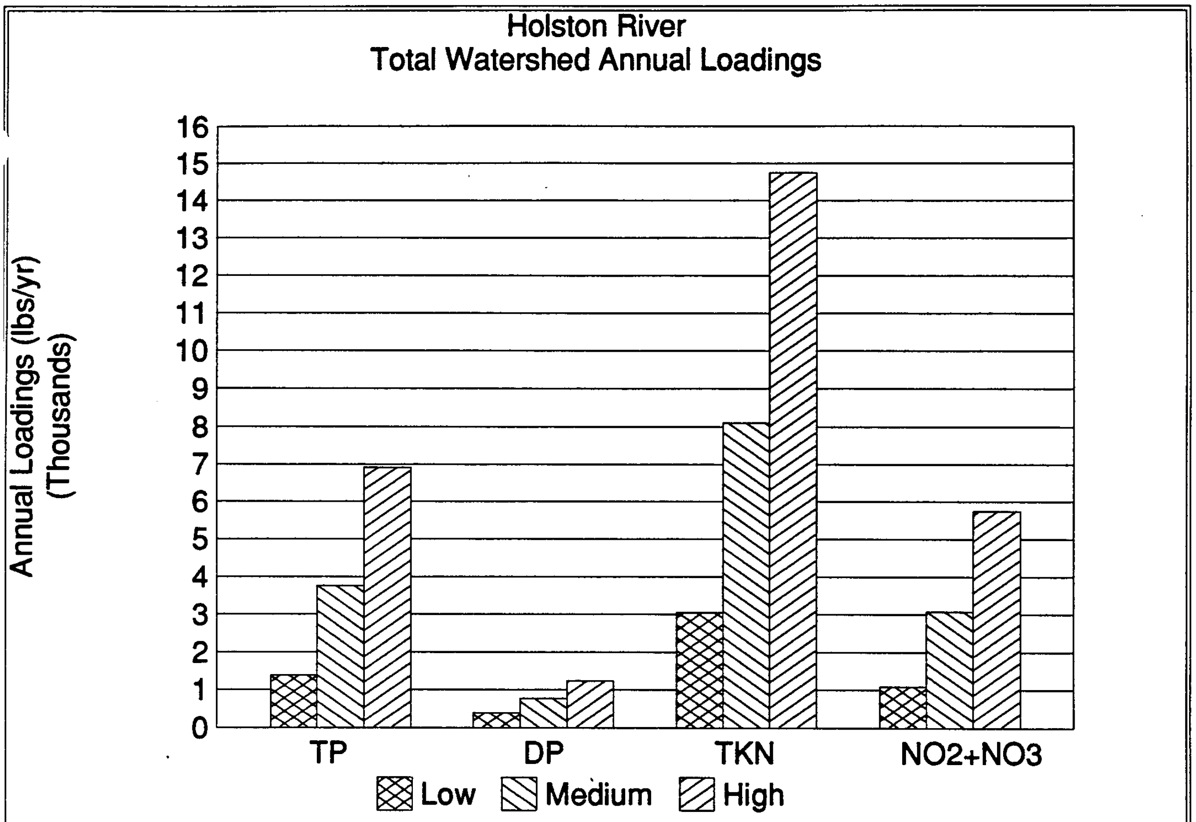

Goose Creek
Total Watershed EMCs
EMCs (mg/l)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

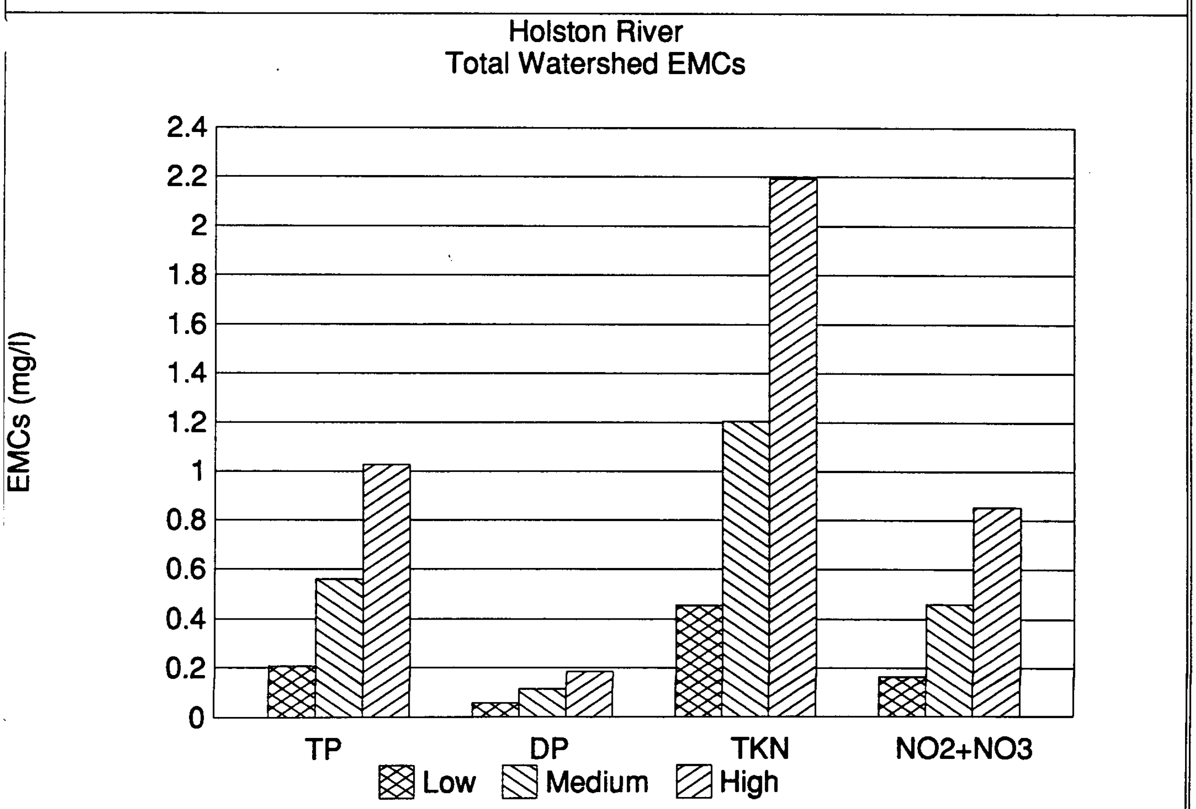

Goose Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
5
4
3
2
1
0
Pb
Cu
Zn
Cd
Low
Medium
High

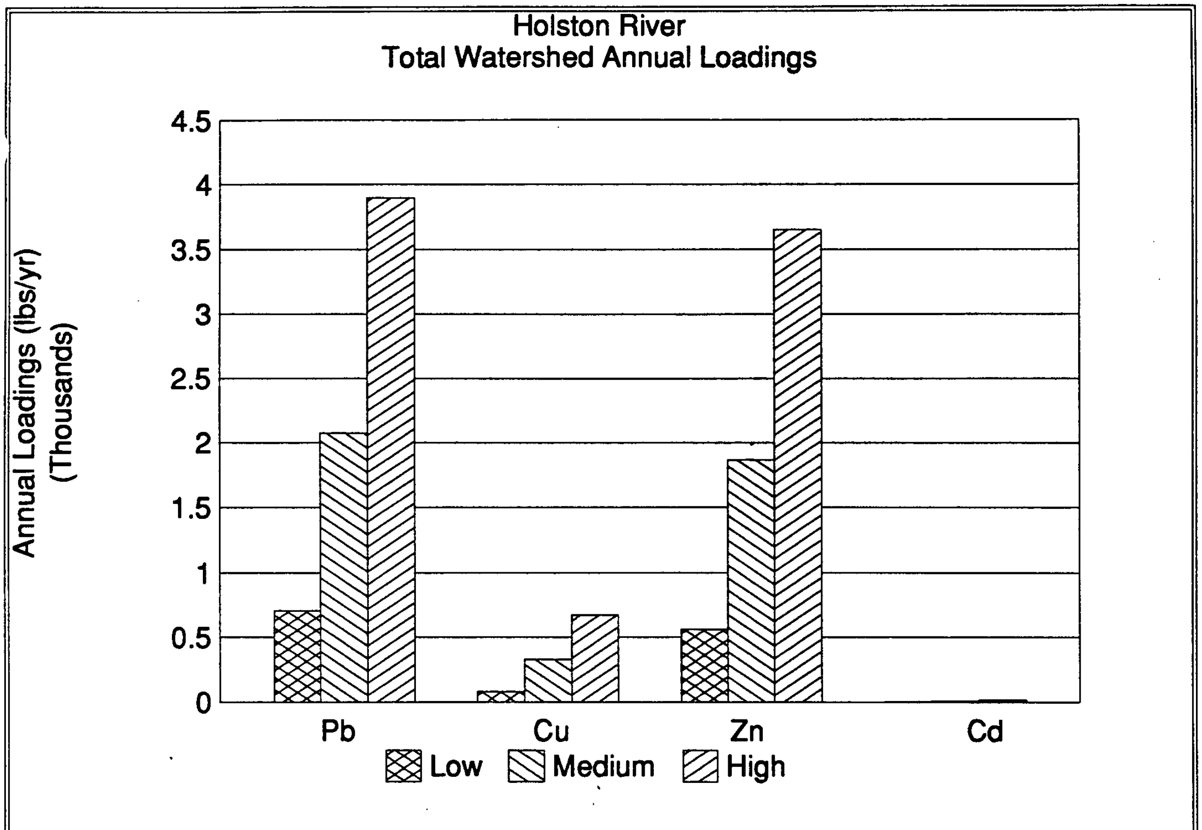

Goose Creek
Total Watershed EMCs
EMCs (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High

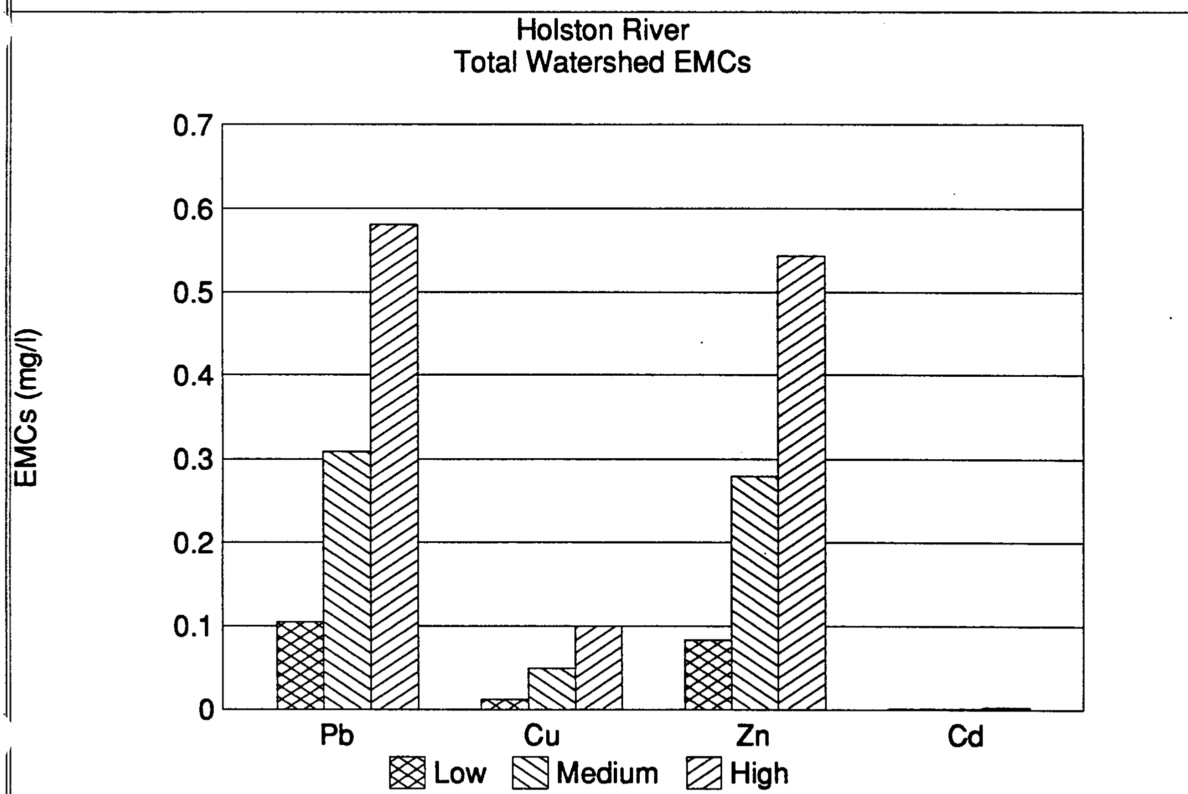

Holston River
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
7
6
5
4
3
2
1
0
BOD5
COD
TSS
TDS
Low
Medium
High

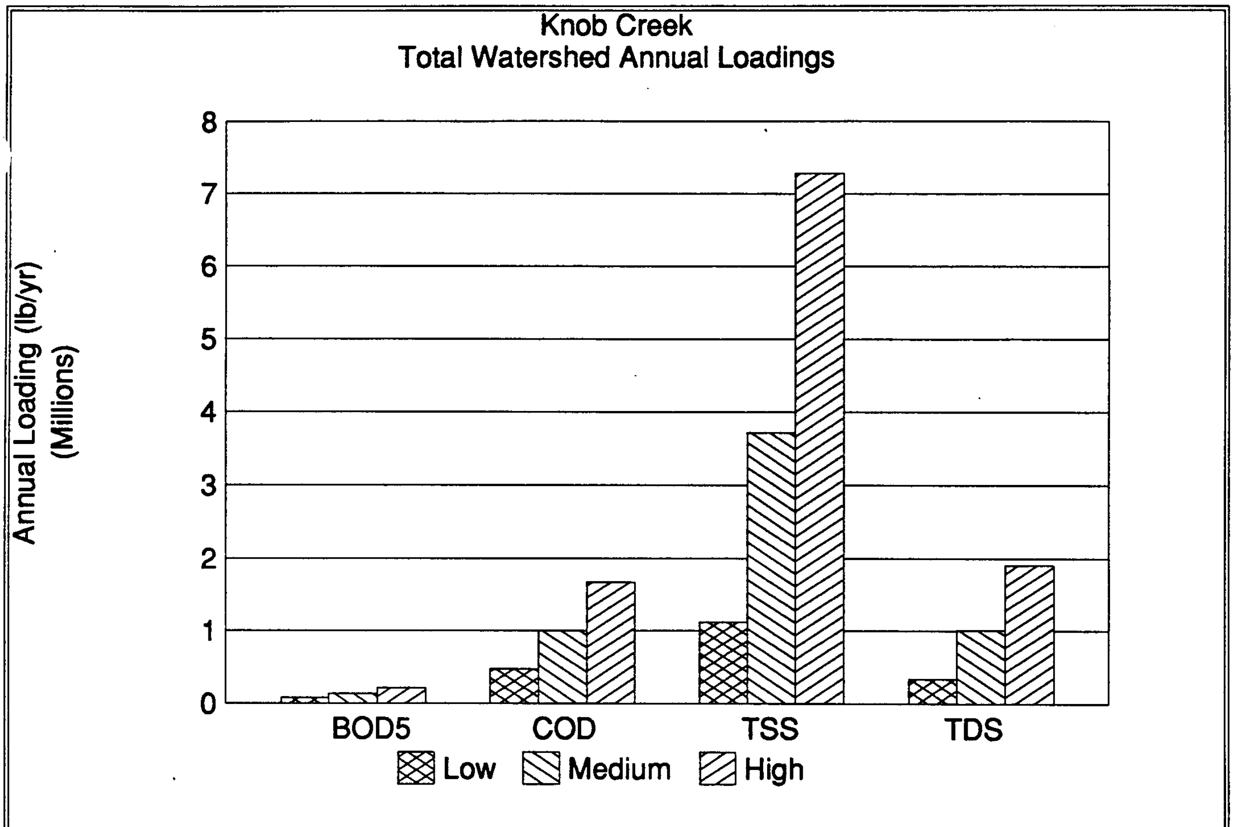

Holston River
Total Watershed EMCs
EMCs (mg/l)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
BOD5
COD
TSS
TDS
Low
Medium
High

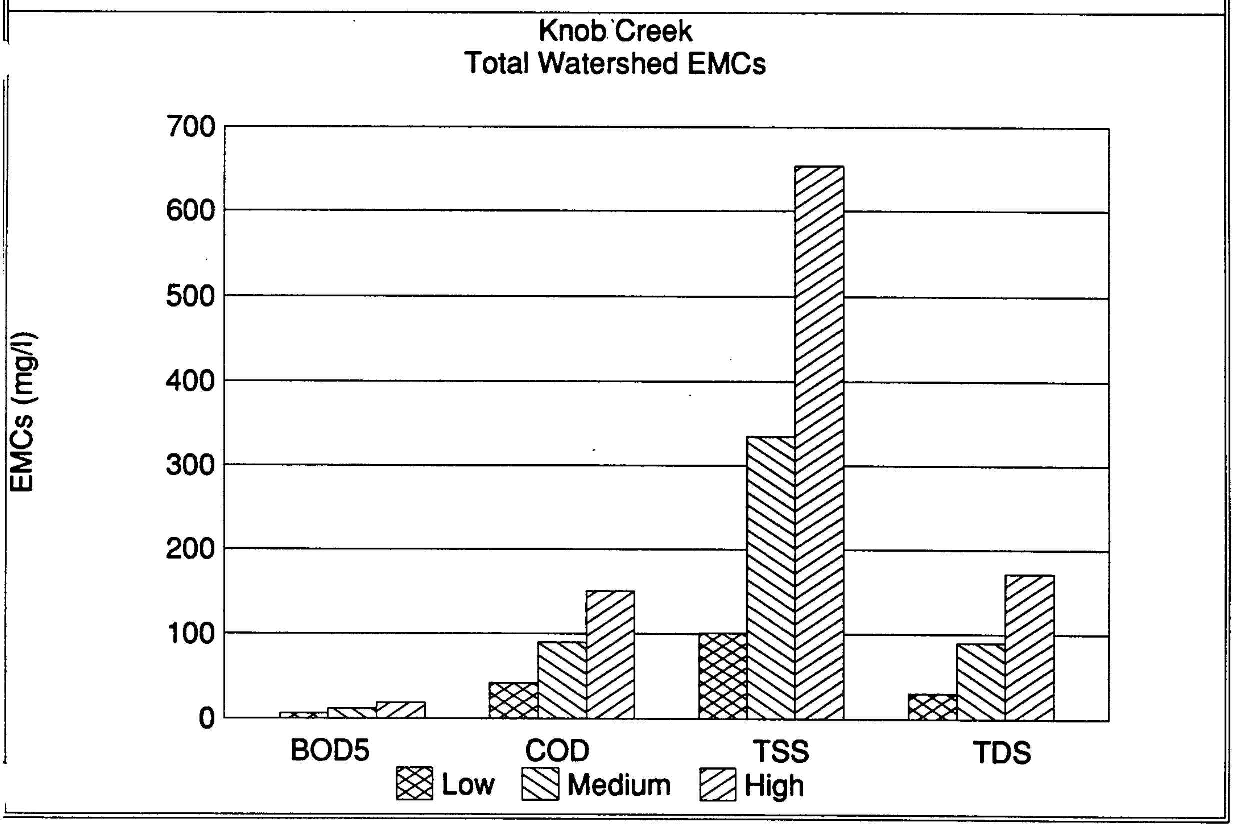

Holston River
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TP
DP
TKN
NO2+NO3
Low
Medium
High


Holston River
Total Watershed EMCs
EMCs (mg/l)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

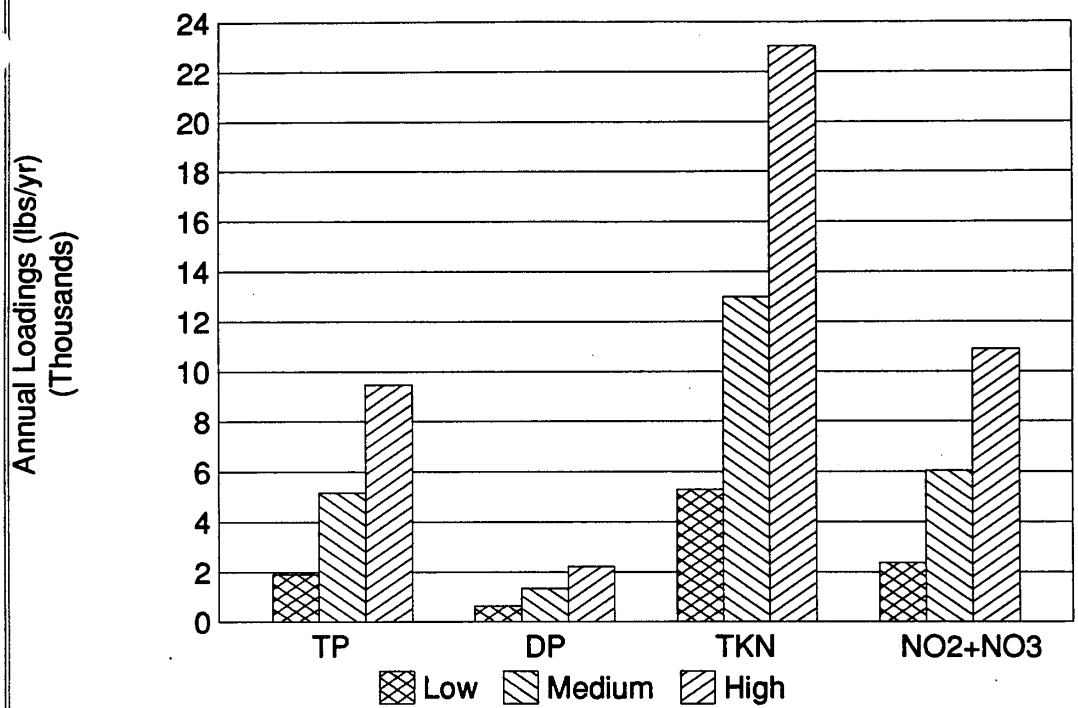

Holston River
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Pb
Cu
Zn
Cd
Low
Medium
High


Holston River
Total Watershed EMCs
EMCs (mg/l)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High

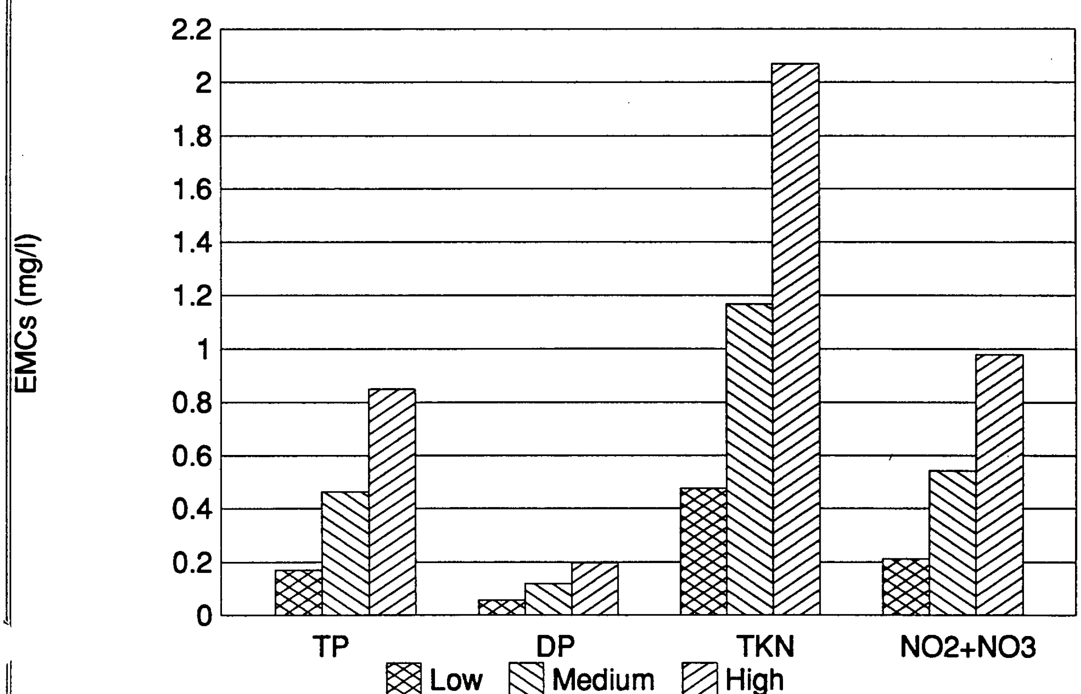

Knob Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
8
7
6
5
4
3
2
1
0
BOD5
COD
TSS
TDS
Low
Medium
High

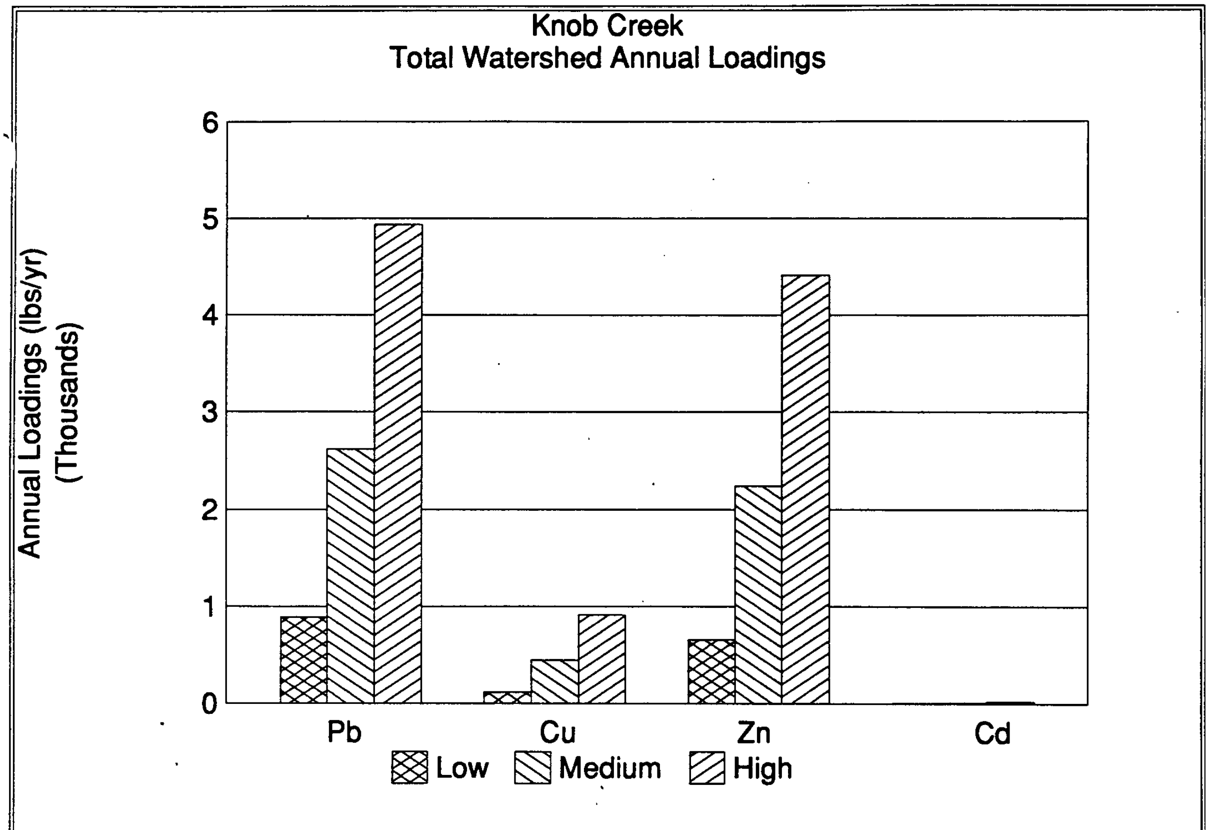

Knob Creek
Total Watershed EMCs
EMCs (mg/l)
700
600
500
400
300
200
100
0
BOD5
COD
TSS
TDS
Low
Medium
High

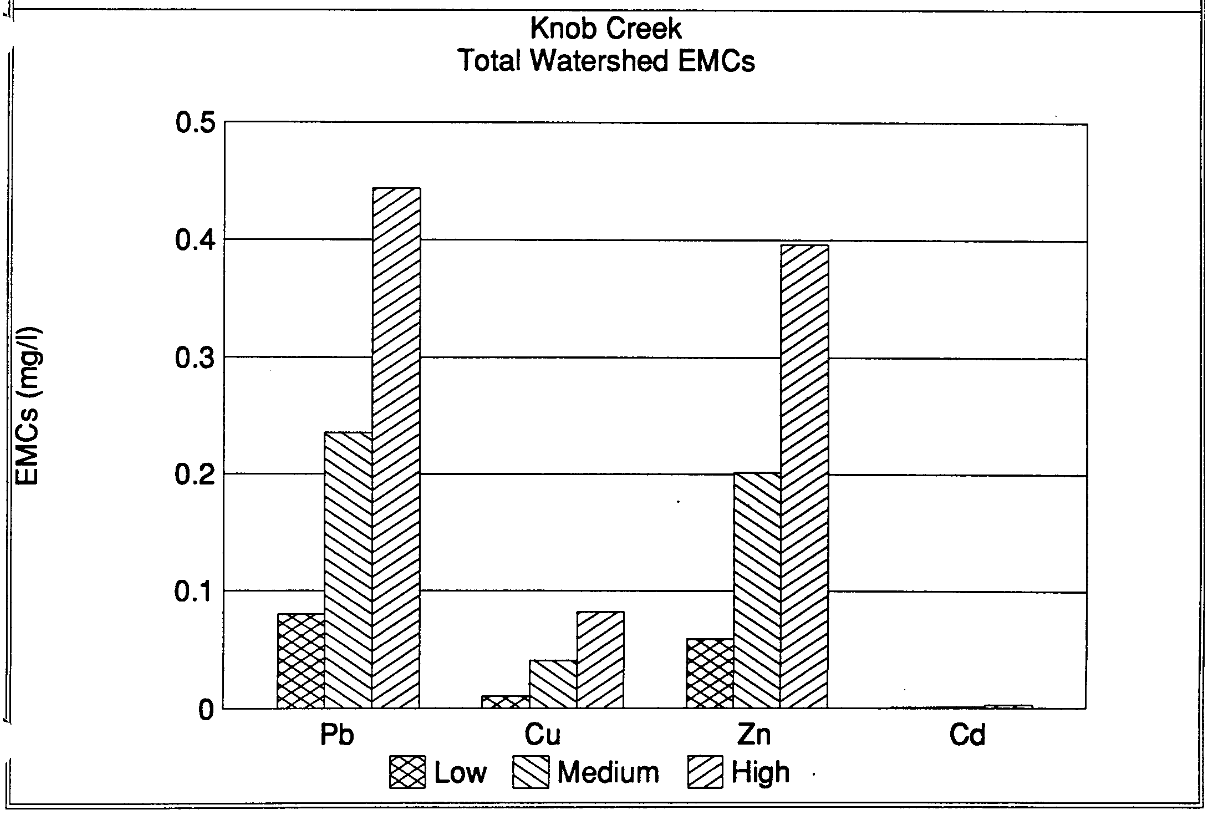
Knob Creek
Total Watershed Annual Loadings

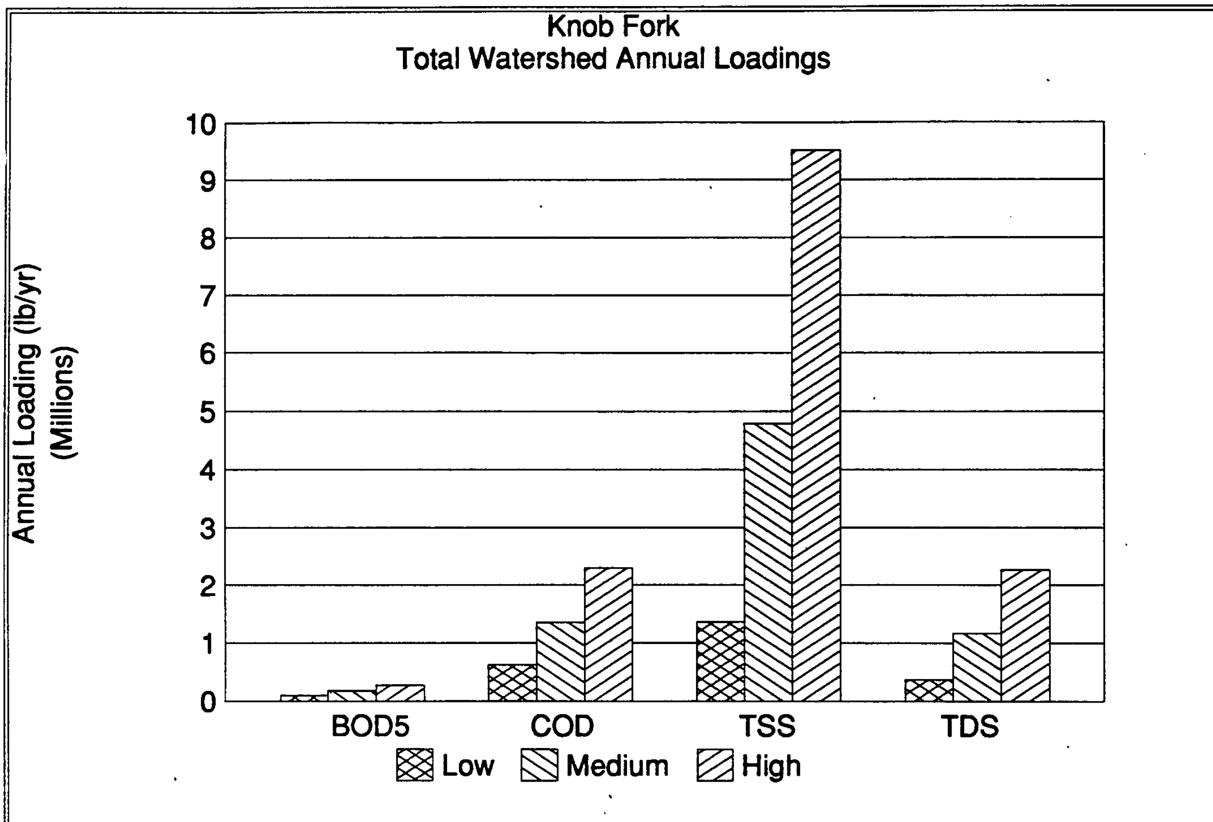


Knob Creek
Total Watershed EMCs

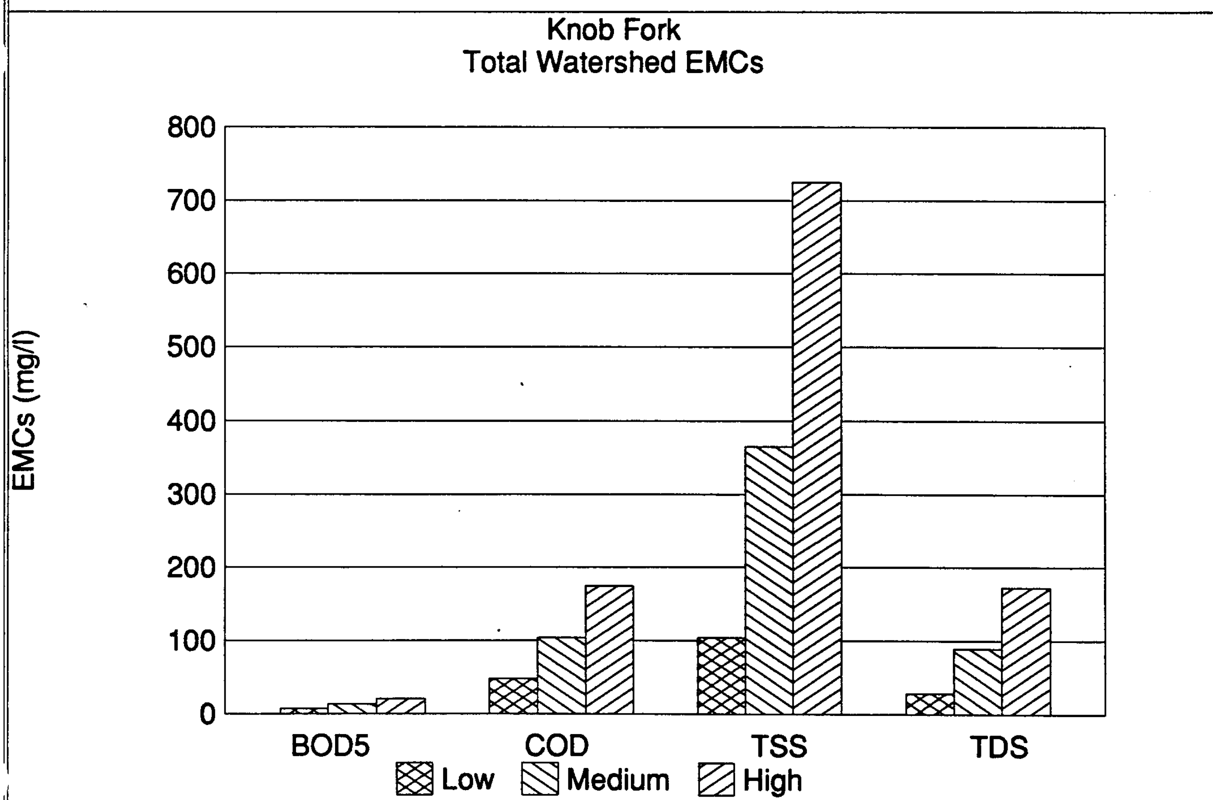



Knob Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
6
5
4
3
2
1
0
Pb
Cu
Zn
Cd
Low
Medium
High

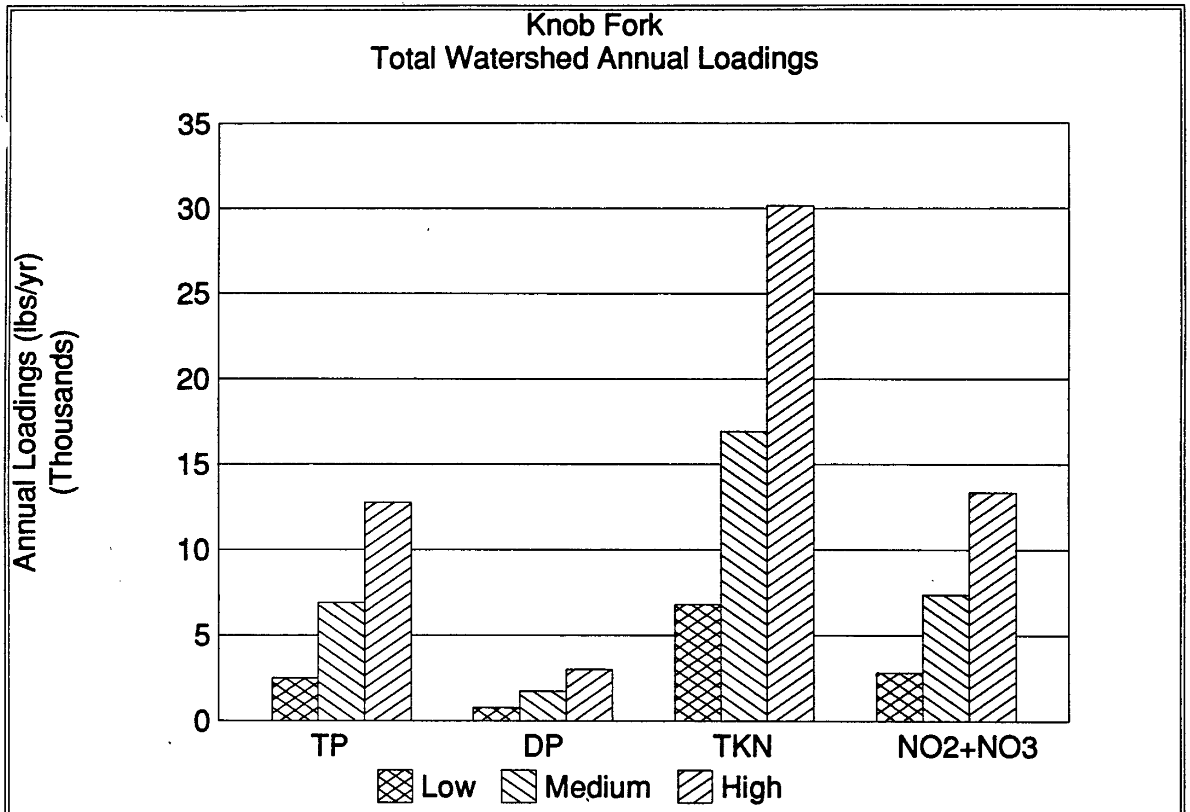

Knob Creek
Total Watershed EMCs
EMCs (mg/l)
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High

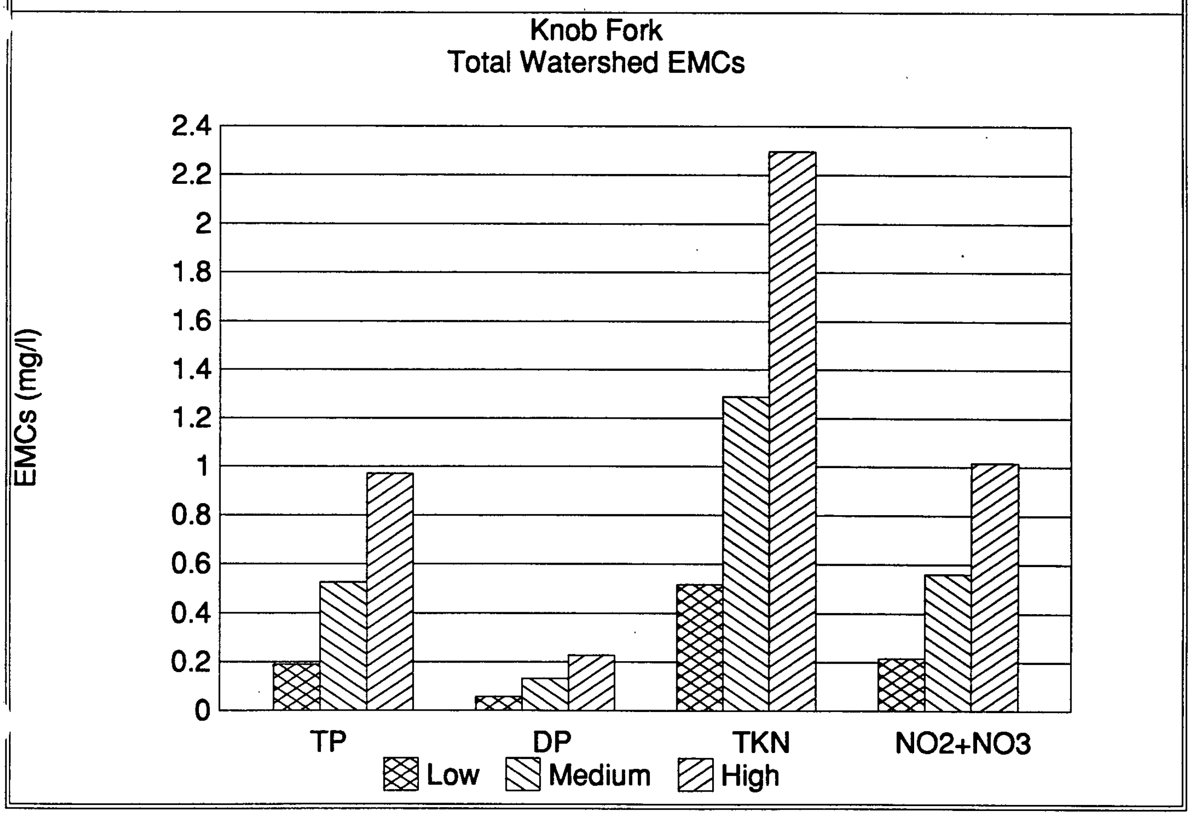


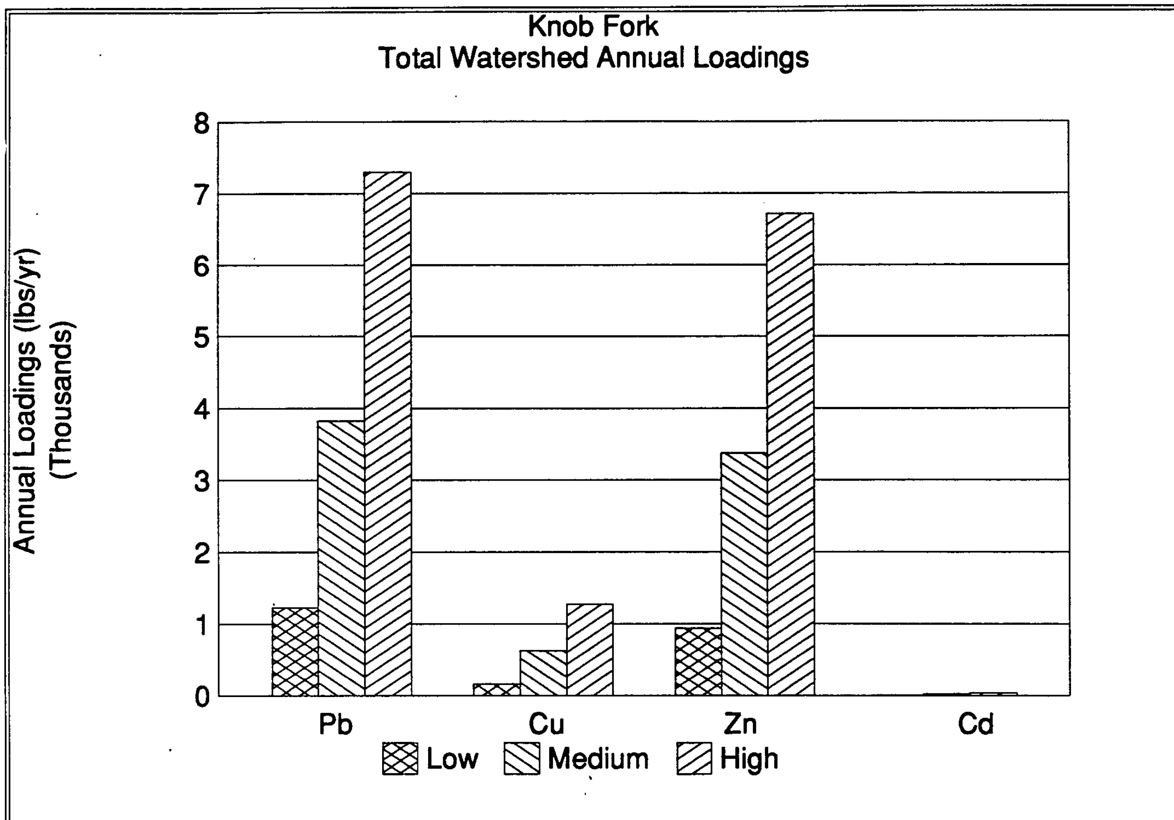
Knob Fork
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
10
9
8
7
6
5
4
3
2
1
0
BOD5
COD
TSS
TDS
Low
Medium
High

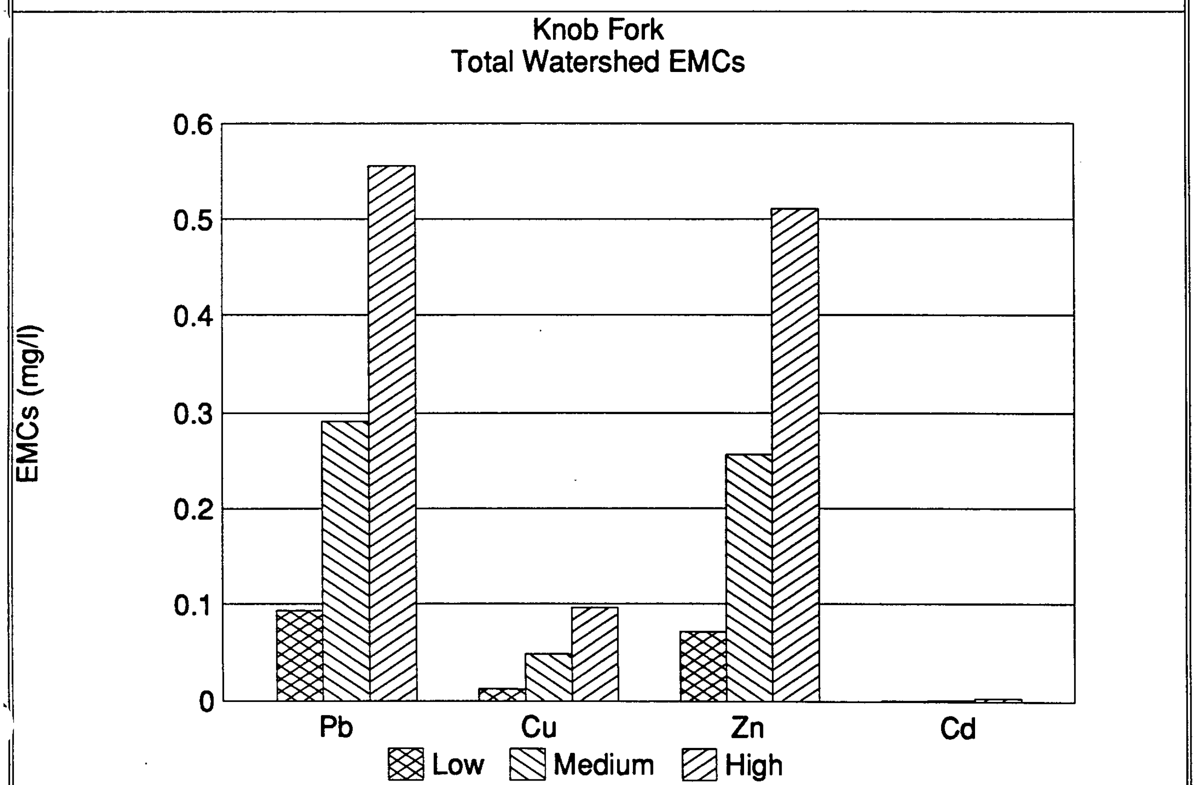


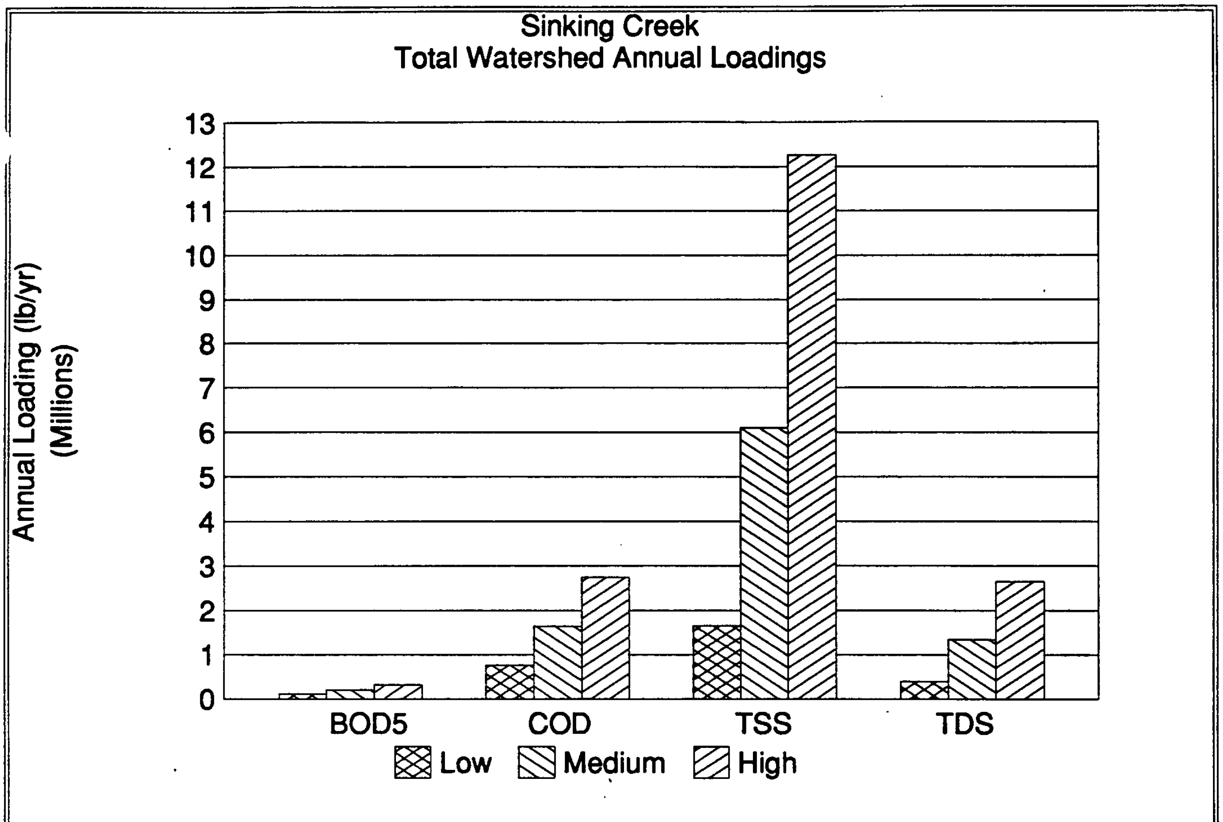
Knob Fork
Total Watershed EMCs
EMCs (mg/l)
800
700
600
500
400
300
200
100
0
BOD5
COD
TSS
TDS
Low
Medium
High

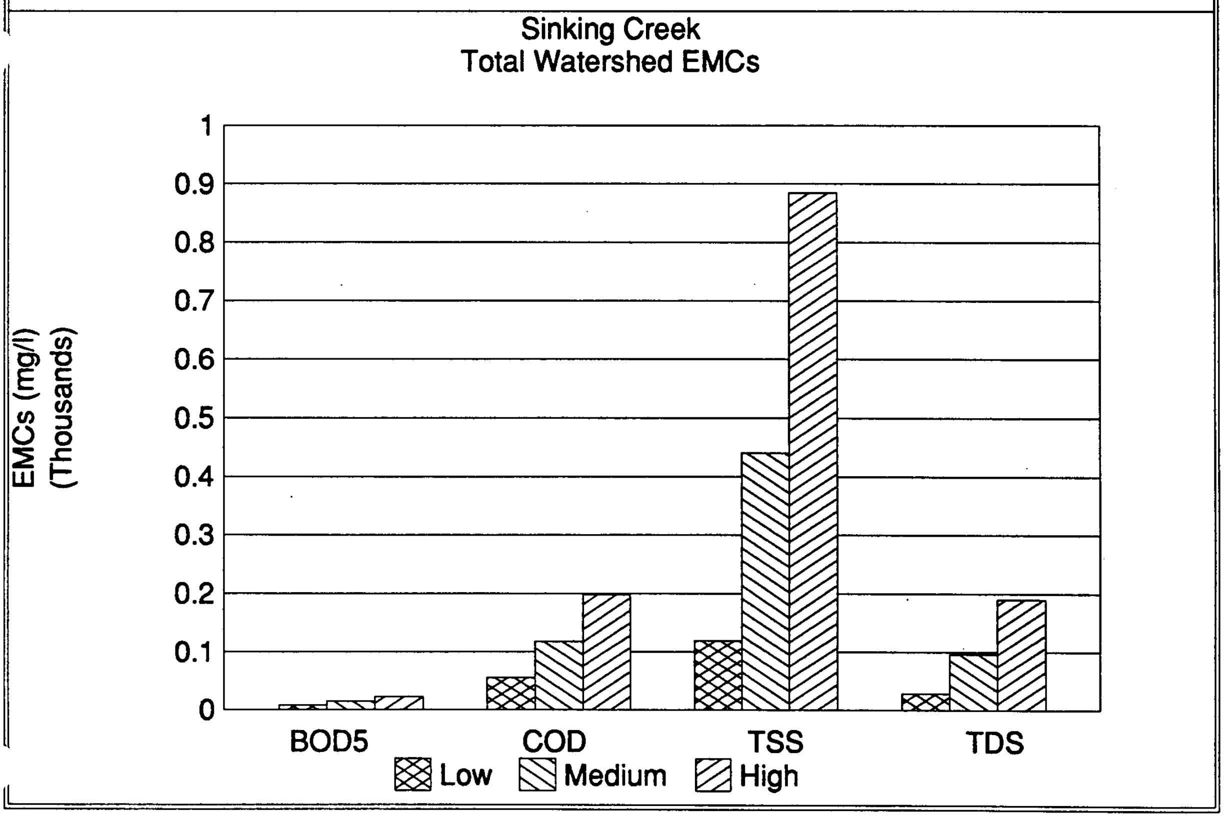

Knob Fork
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
35
30
25
20
15
10
5
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

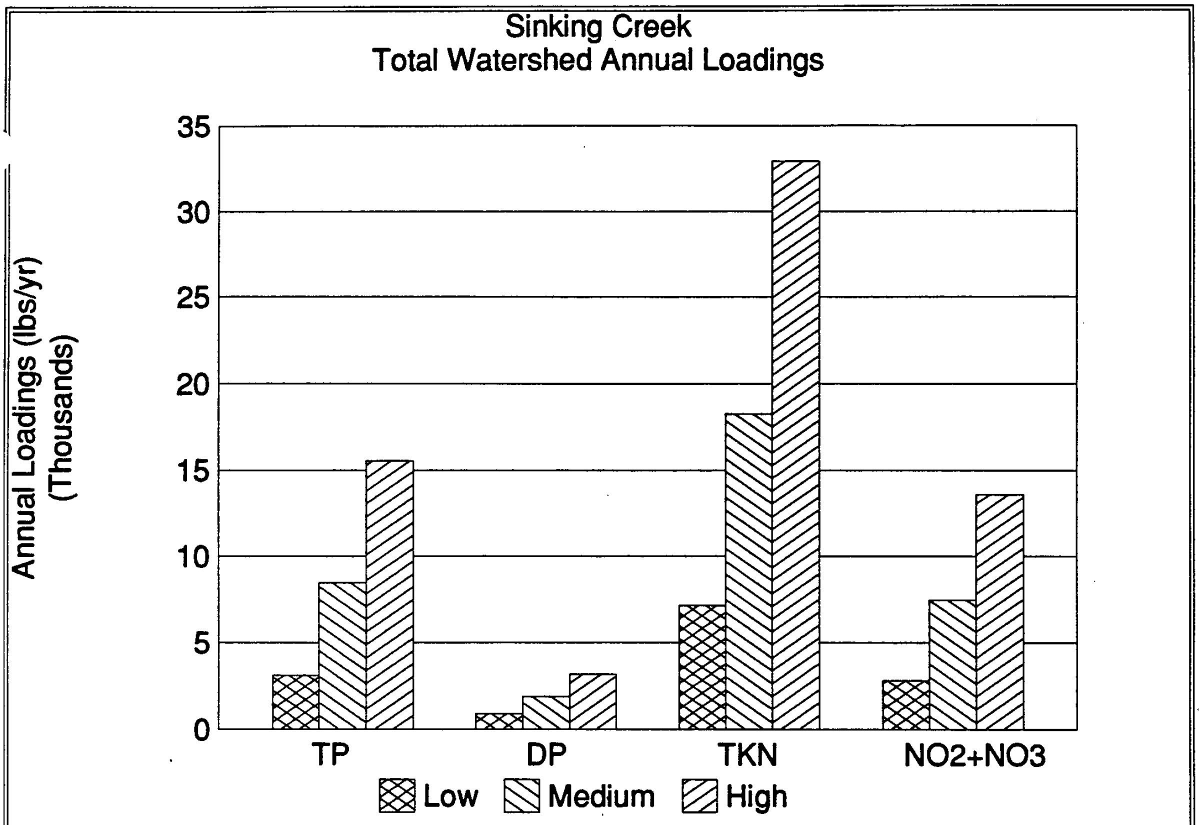

Knob Fork
Total Watershed EMCs
EMCs (mg/l)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High


Knob Fork
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
8
7
6
5
4
3
2
1
0
Pb
Cu
Zn
Cd
Low
Medium
High

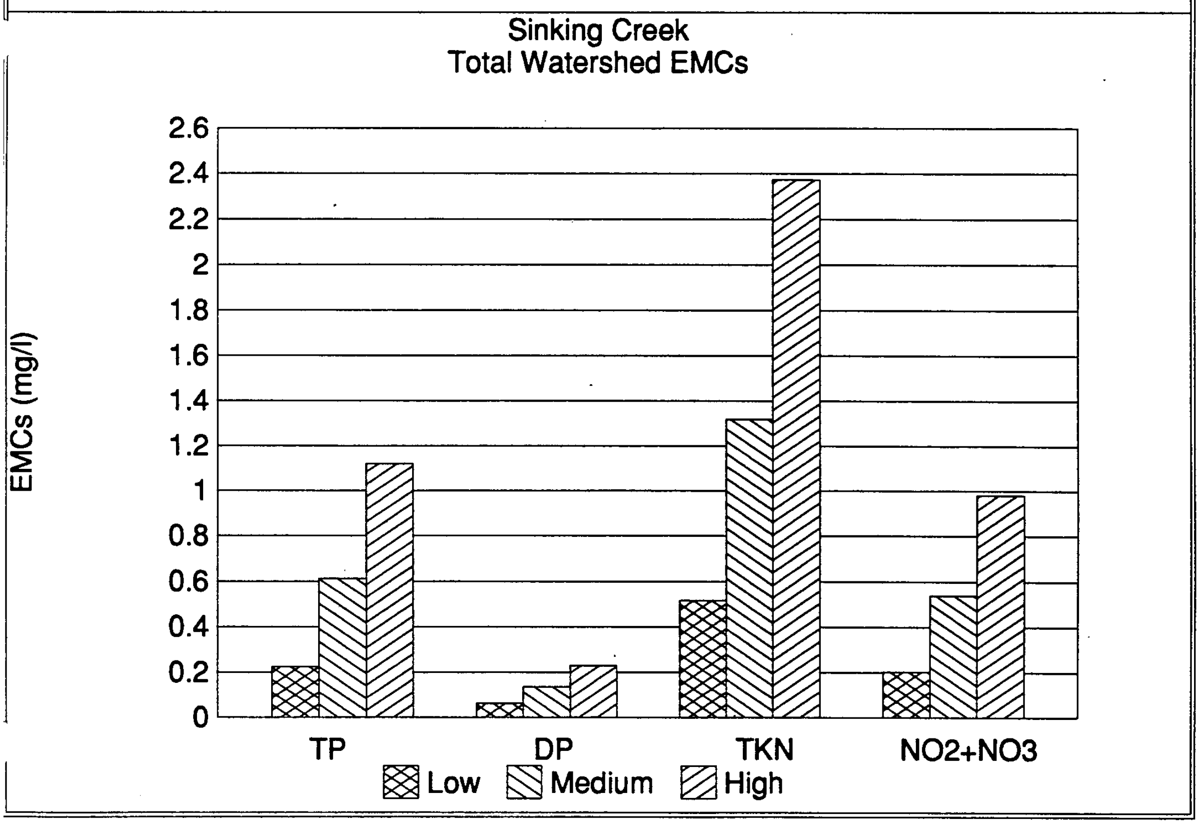

Knob Fork
Total Watershed EMCs
EMCs (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High


Sinking Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
BOD5
COD
TSS
TDS
Low
Medium
High

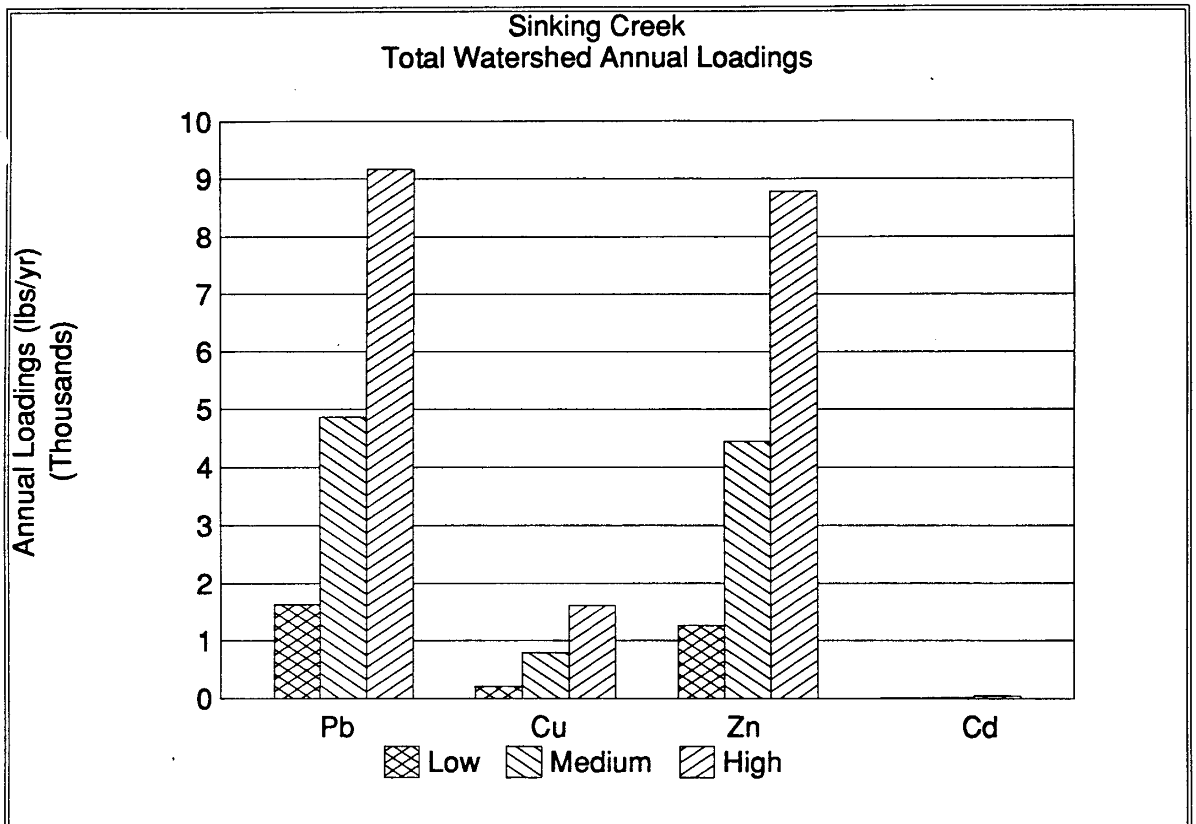

Sinking Creek
Total Watershed EMCs
EMCs (mg/l)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
BOD5
COD
TSS
TDS
Low
Medium
High

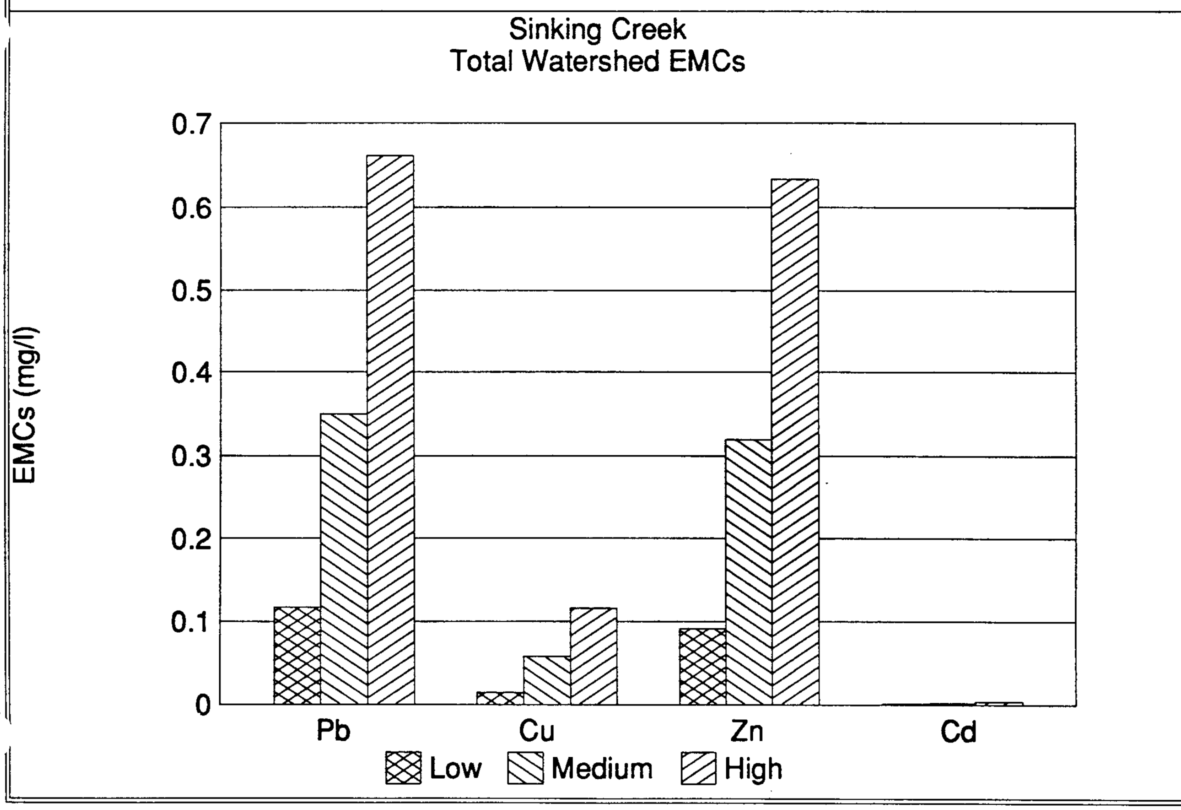


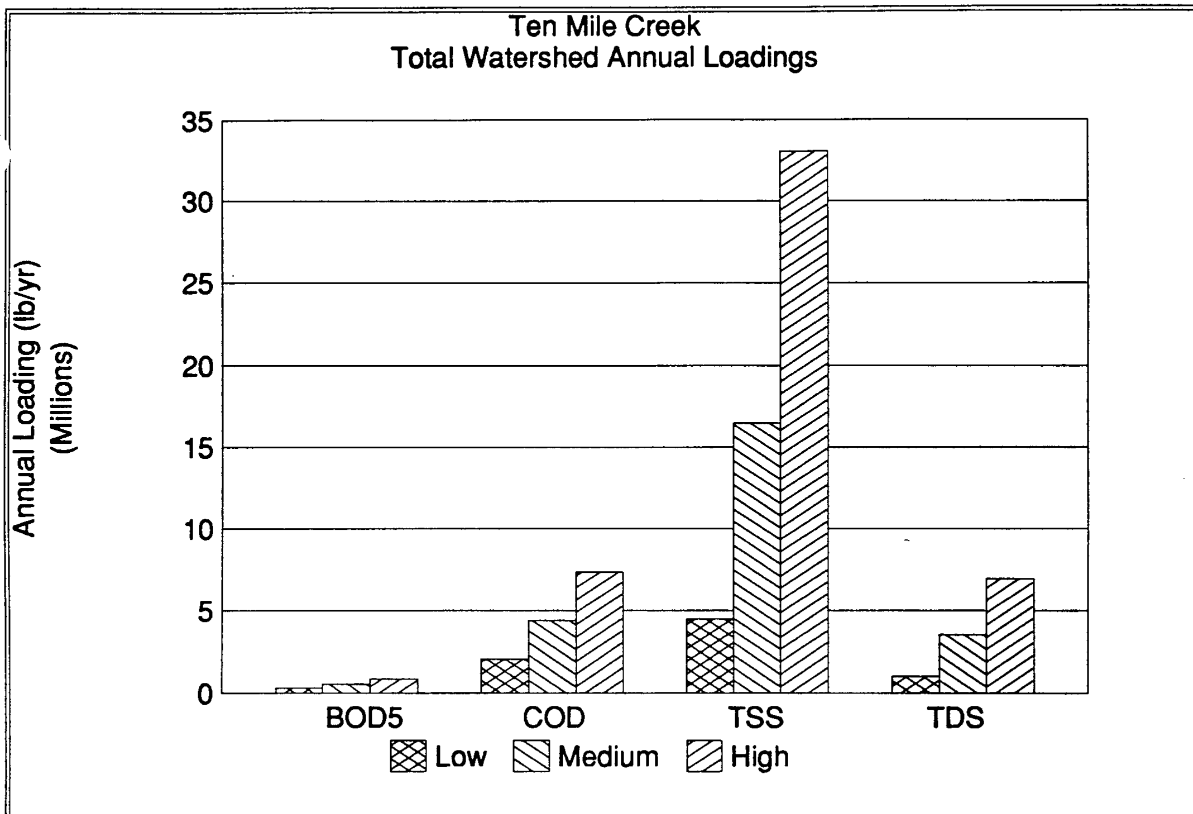
Sinking Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
35
30
25
20
15
10
5
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

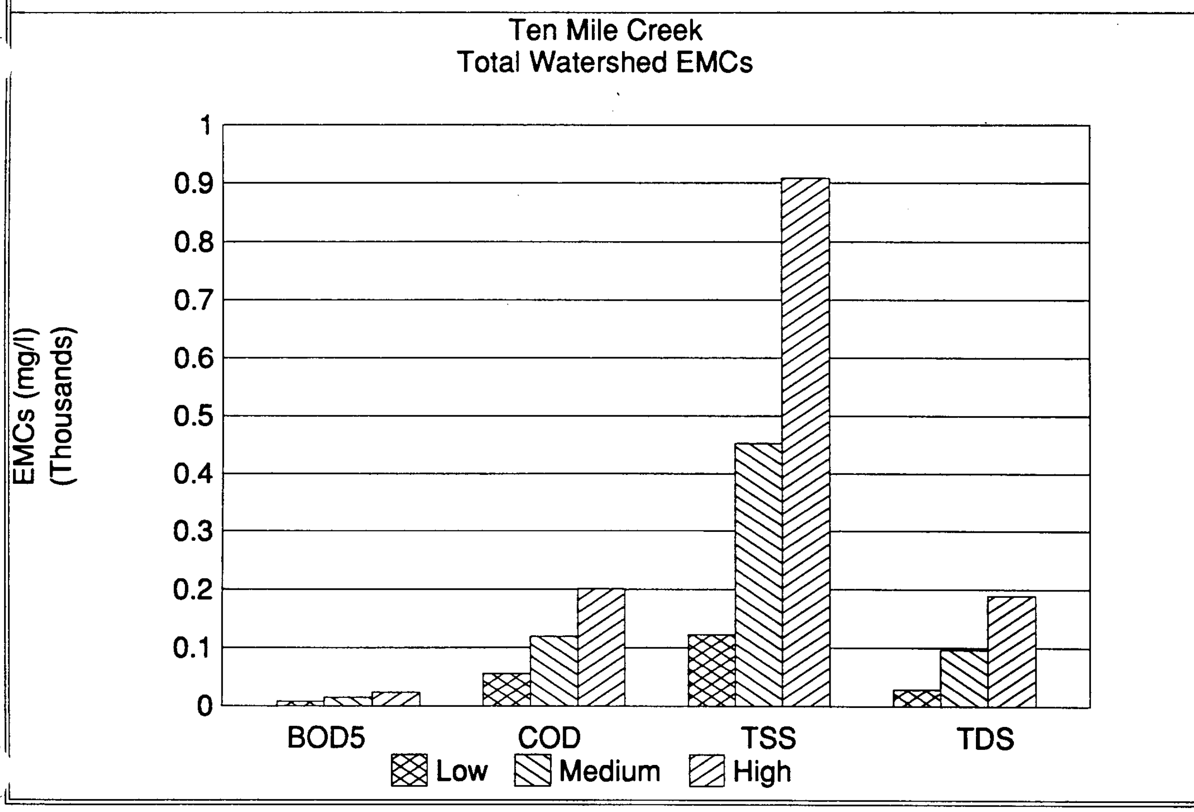


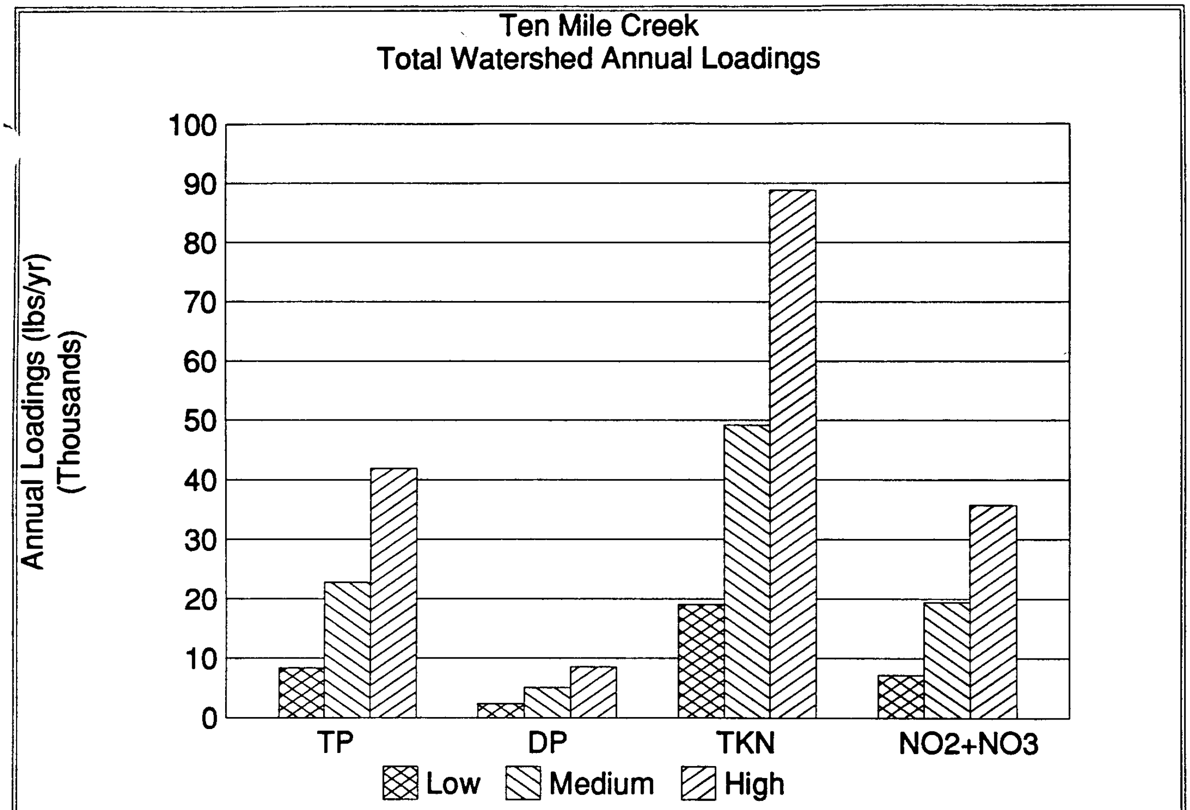
Sinking Creek
Total Watershed EMCs
EMCs (mg/l)
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

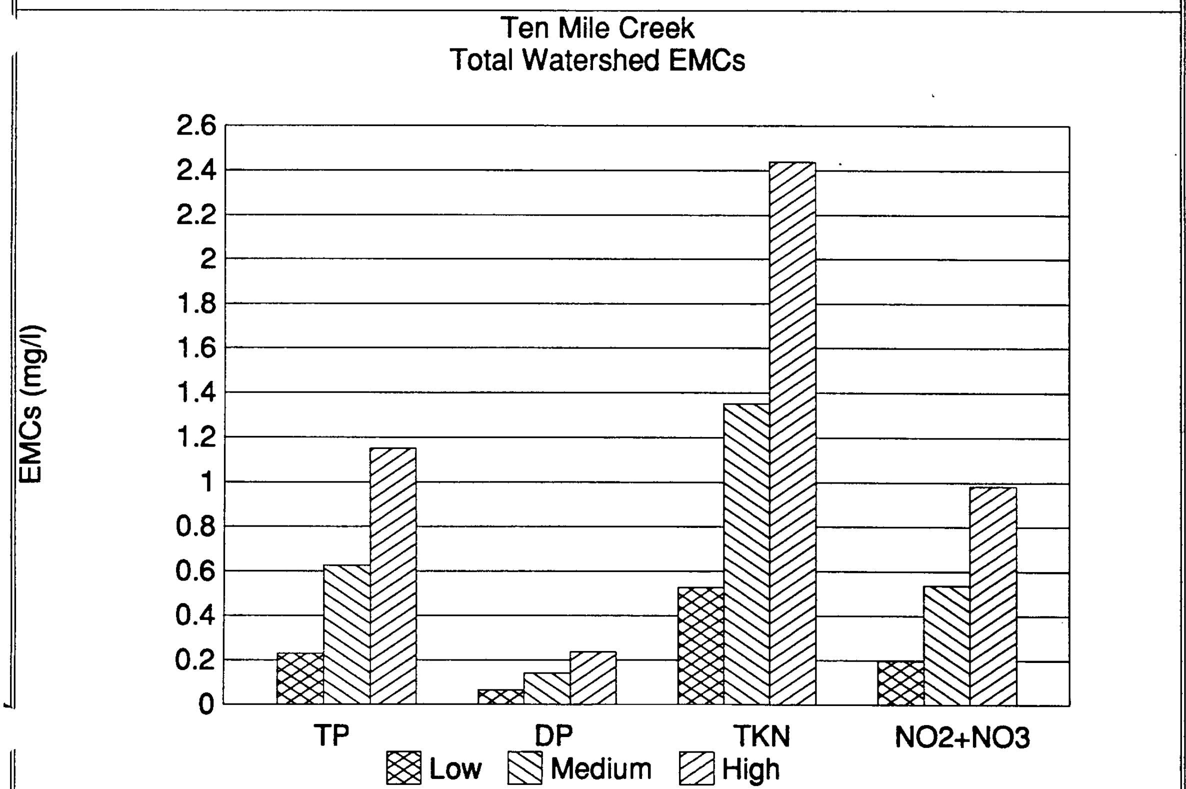

Sinking Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
10
9
8
7
6
5
4
3
2
1
0
Pb
Cu
Zn
Cd
Low
Medium
High

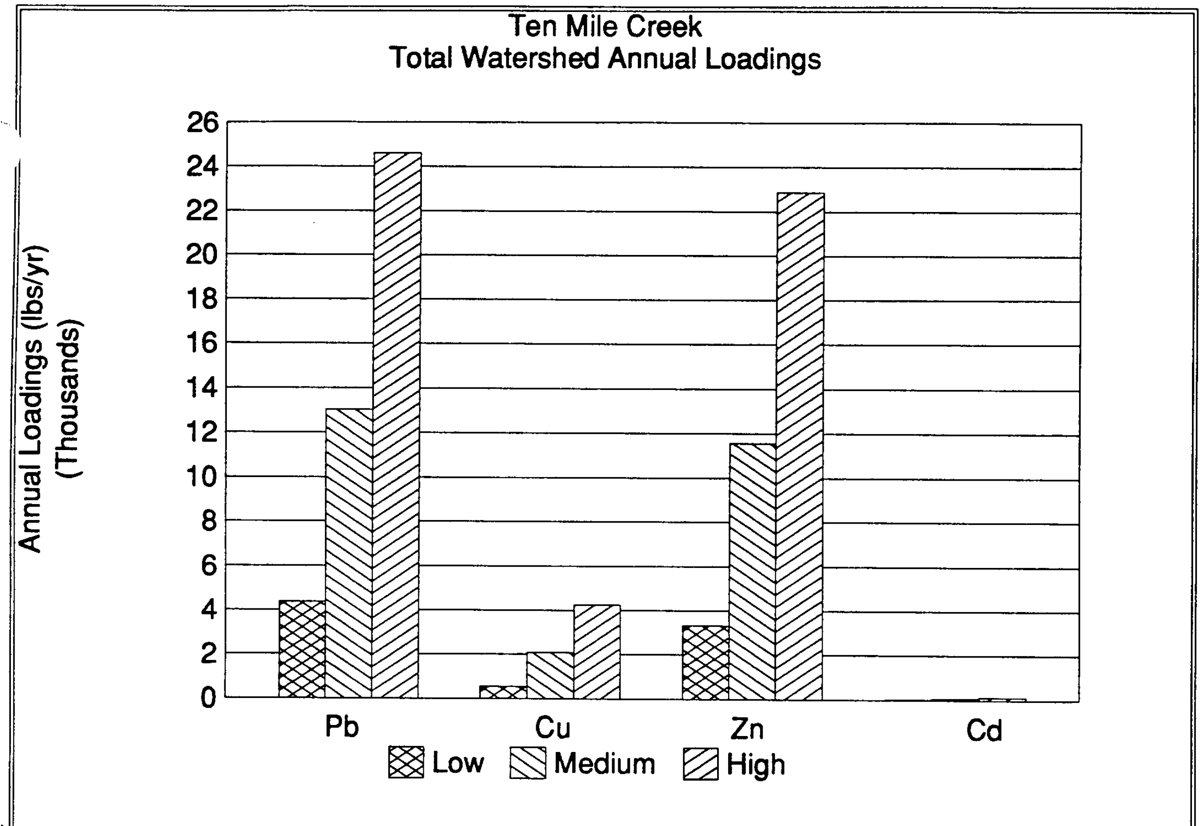

Sinking Creek
Total Watershed EMCs
EMCs (mg/l)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High


Ten Mile Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
35
30
25
20
15
10
5
0
BOD5
COD
TSS
TDS
Low
Medium
High

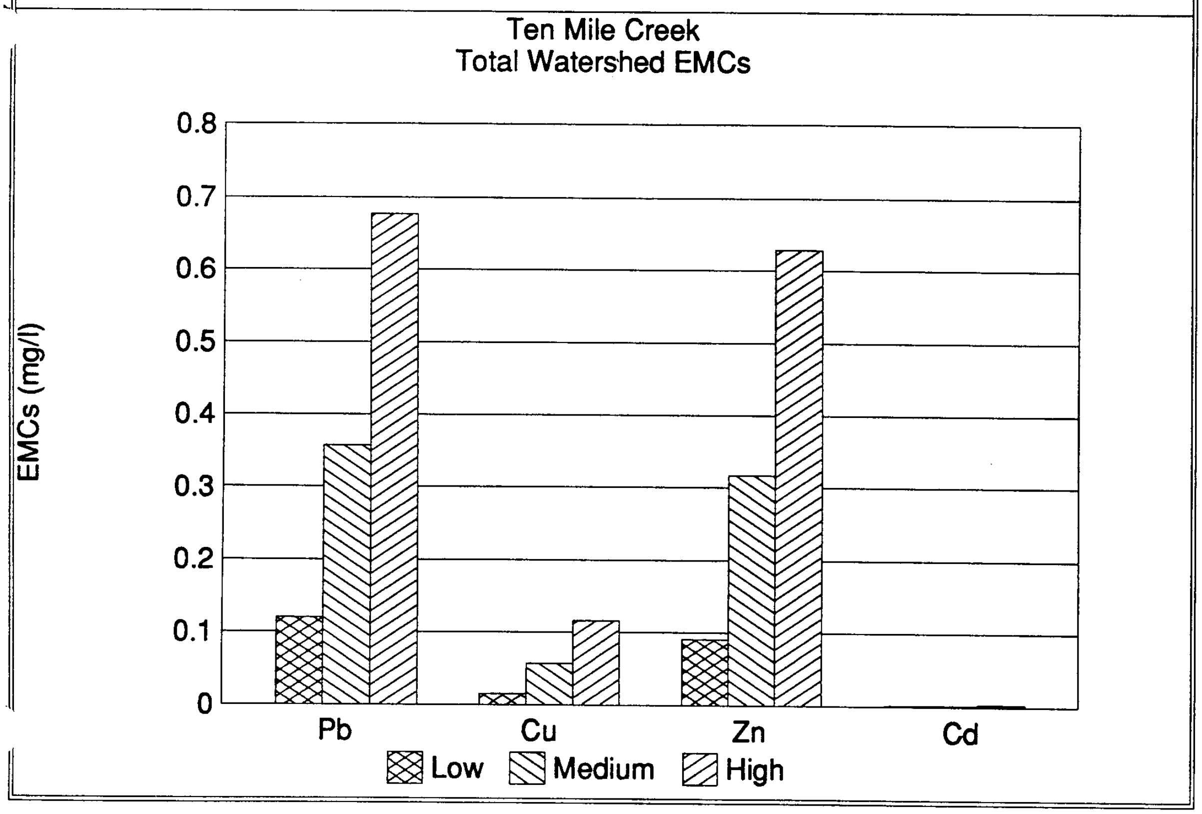

Ten Mile Creek
Total Watershed EMCs
EMCs (mg/l)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
BOD5
COD
TSS
TDS
Low
Medium
High


Ten Mile Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
100
90
80
70
60
50
40
30
20
10
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

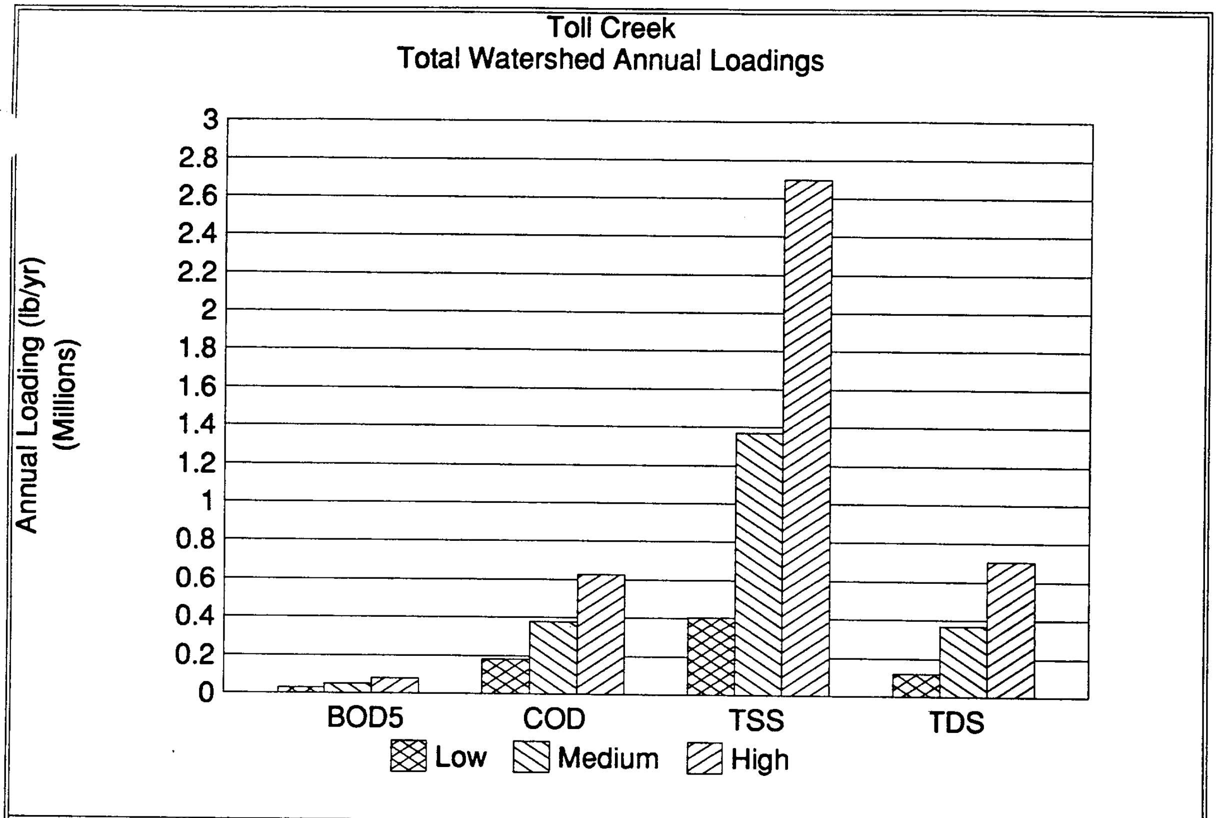

Ten Mile Creek
Total Watershed EMCs
EMCs (mg/l)
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

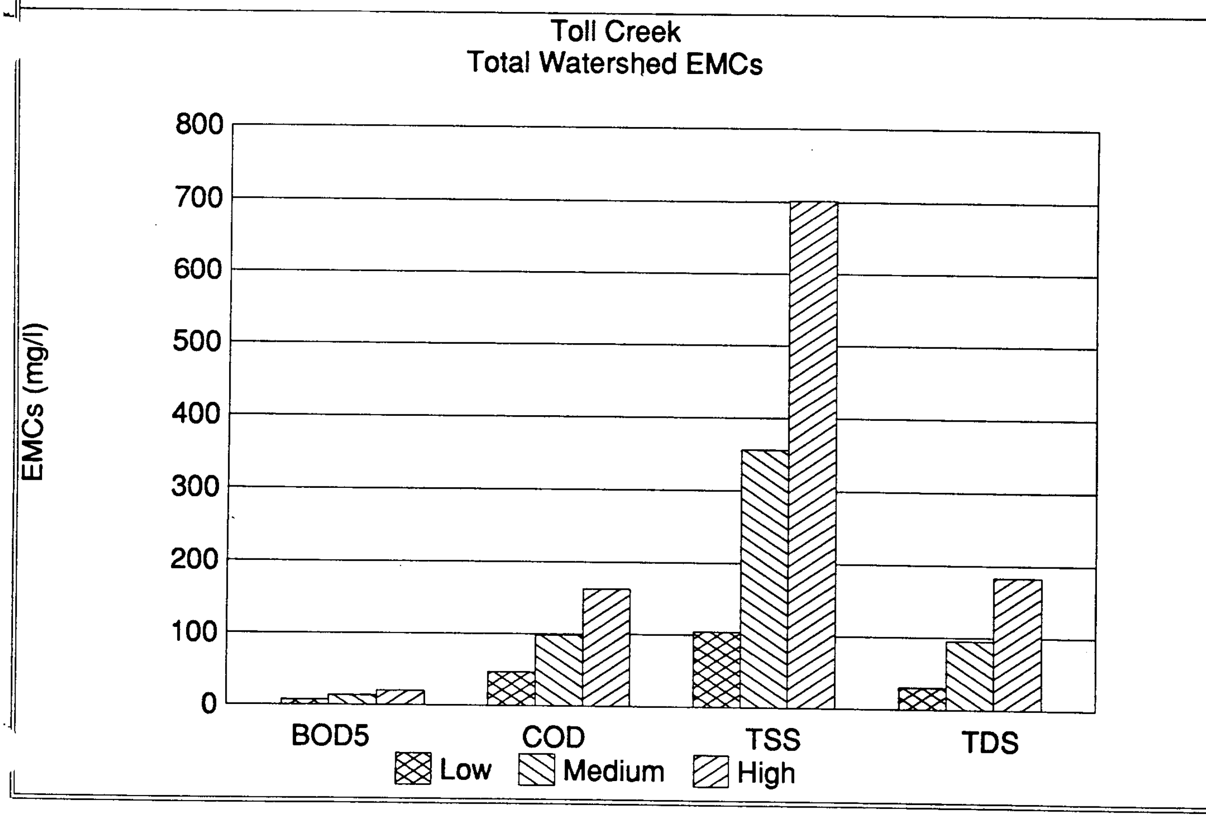


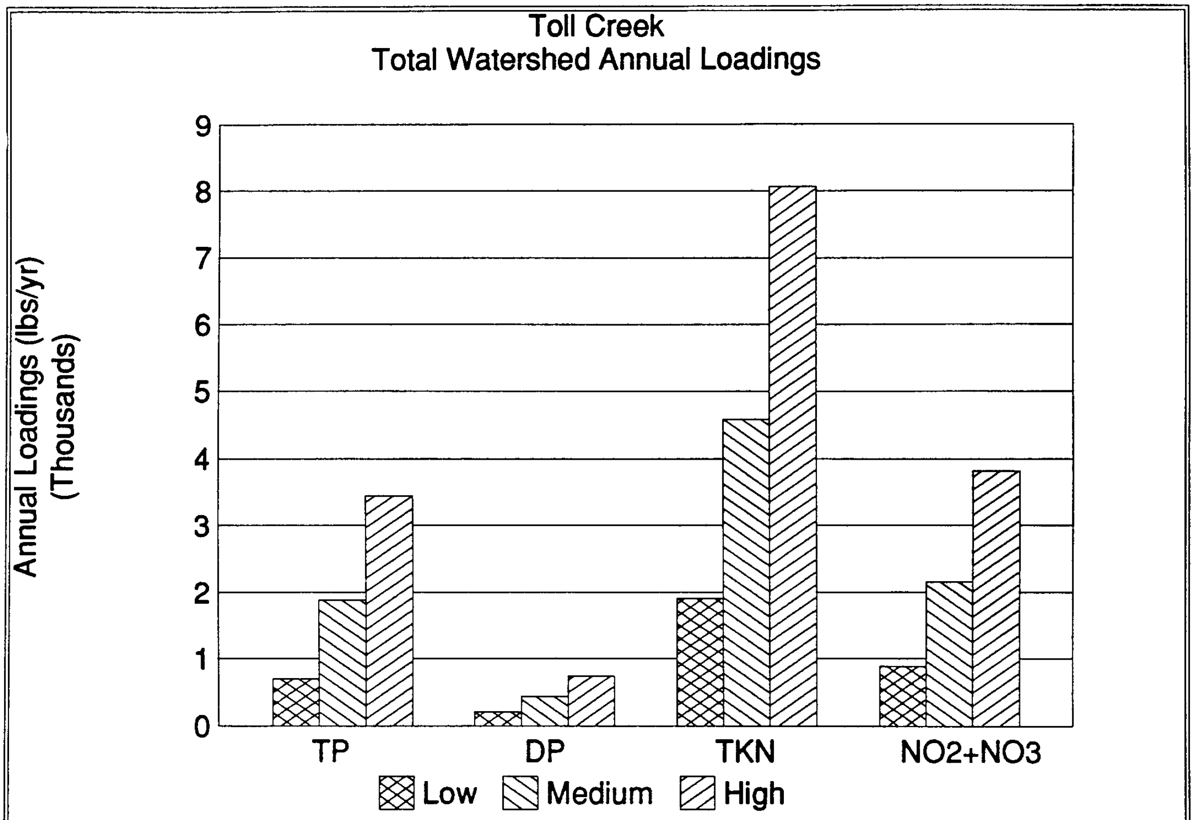
Ten Mile Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr) (Thousands)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Pb
Cu
Zn
Cd
Low
Medium
High



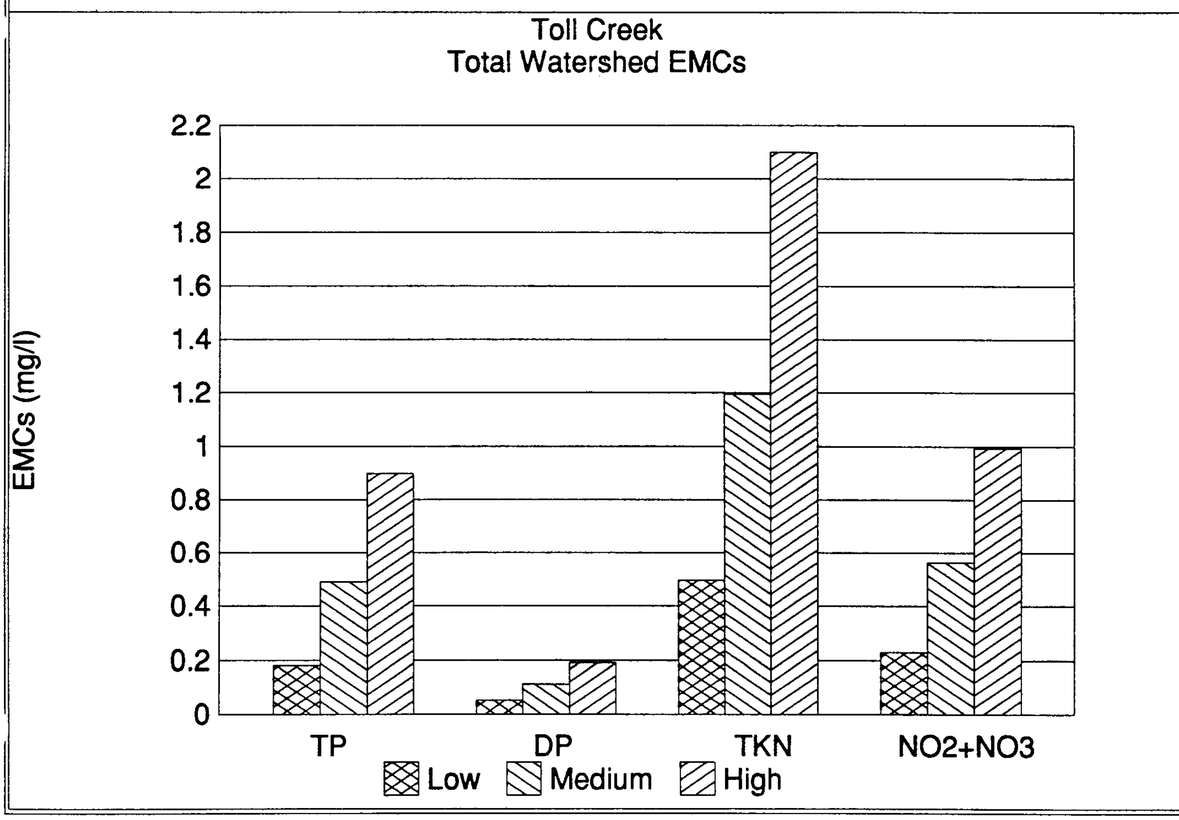
Ten Mile Creek
Total Watershed EMCs
EMCs (mg/l)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High


Toll Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
BOD5
COD
TSS
TDS
Low
Medium
High

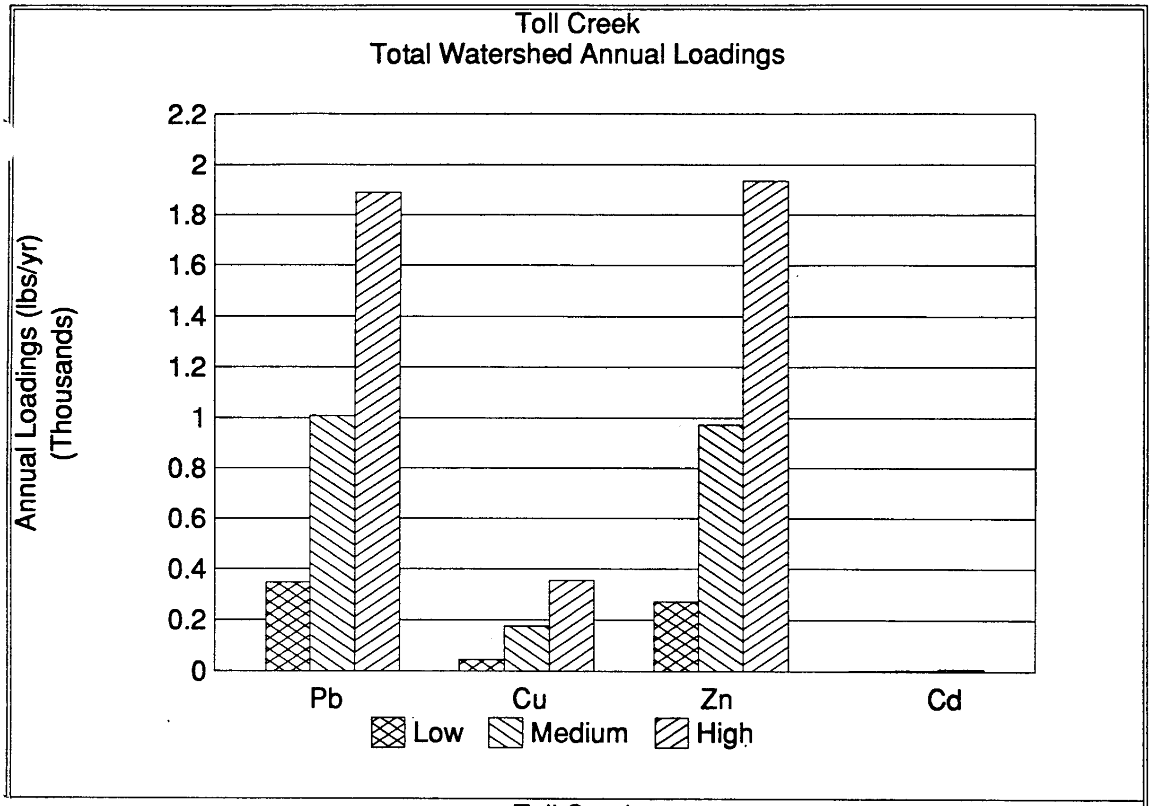

Toll Creek
Total Watershed EMCs
EMCs (mg/l)
800
700
600
500
400
300
200
100
0
BOD5
COD
TSS
TDS
Low
Medium
High

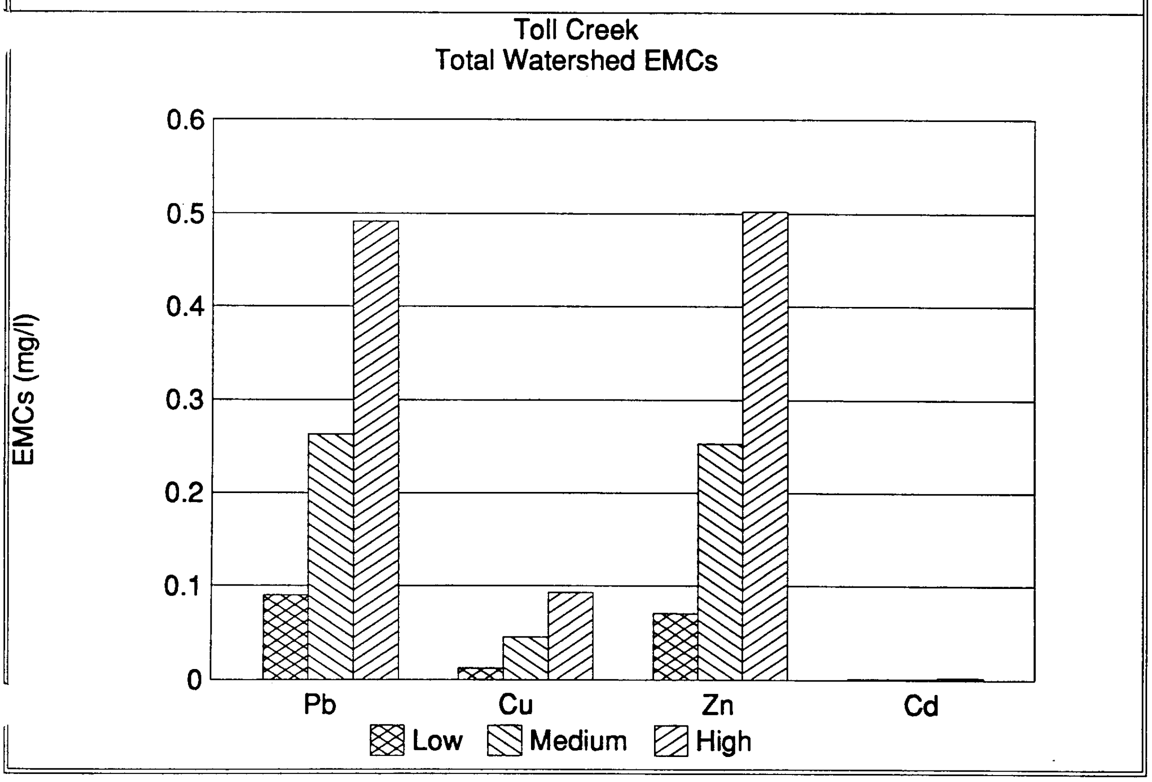


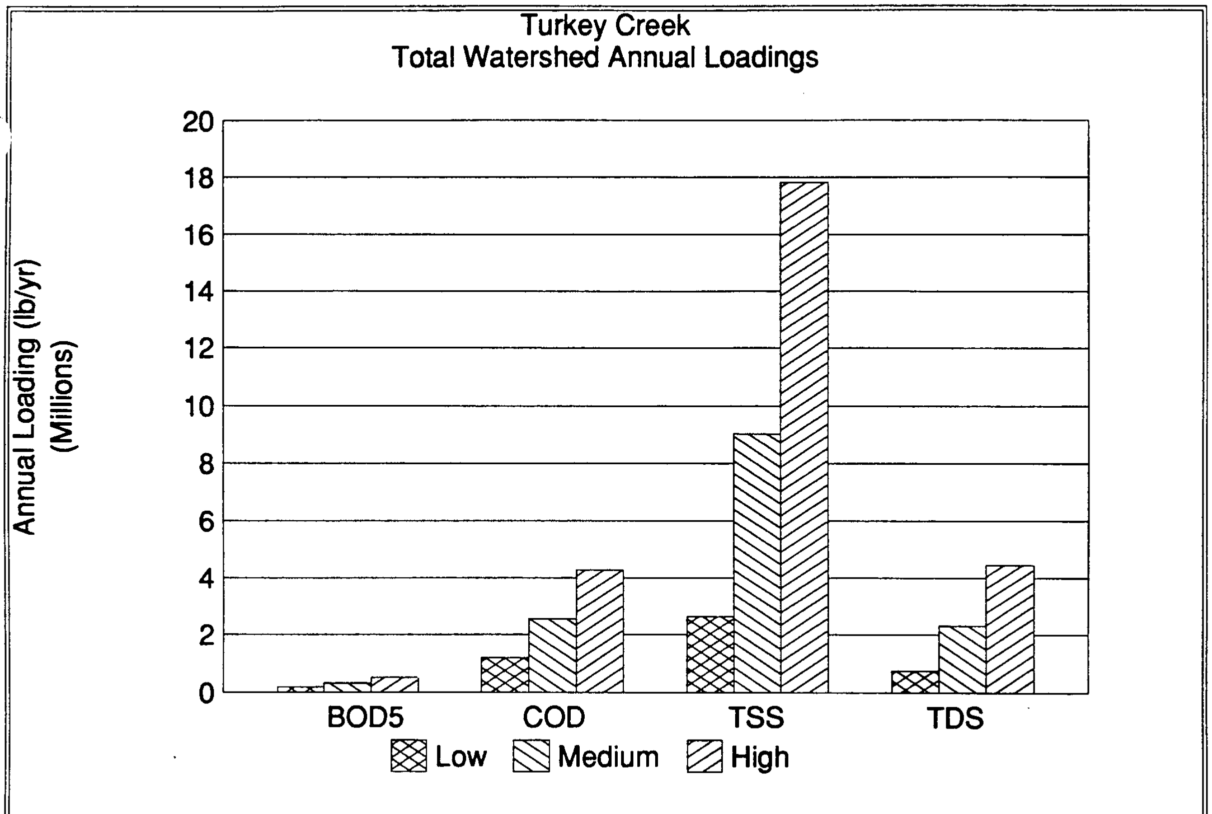
Toll Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
9
8
7
6
5
4
3
2
1
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

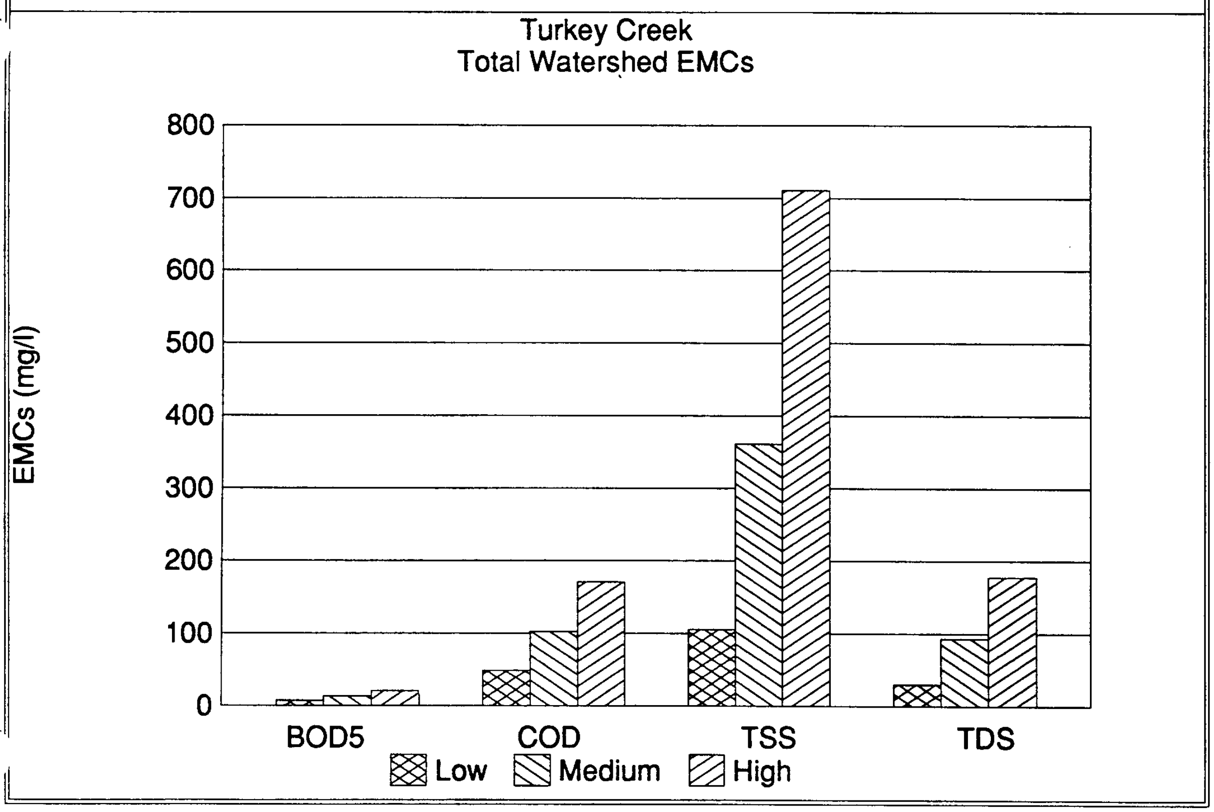


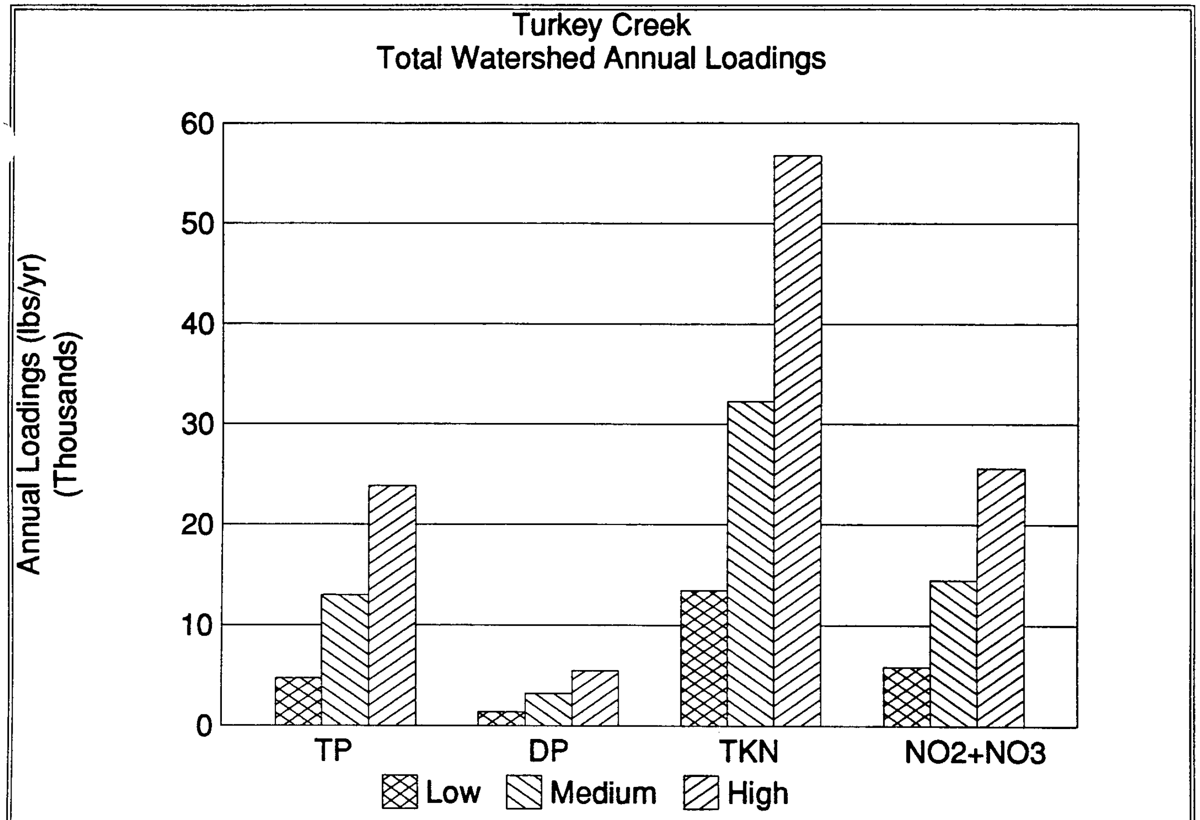
Toll Creek
Total Watershed EMCs
EMCs (mg/l)
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

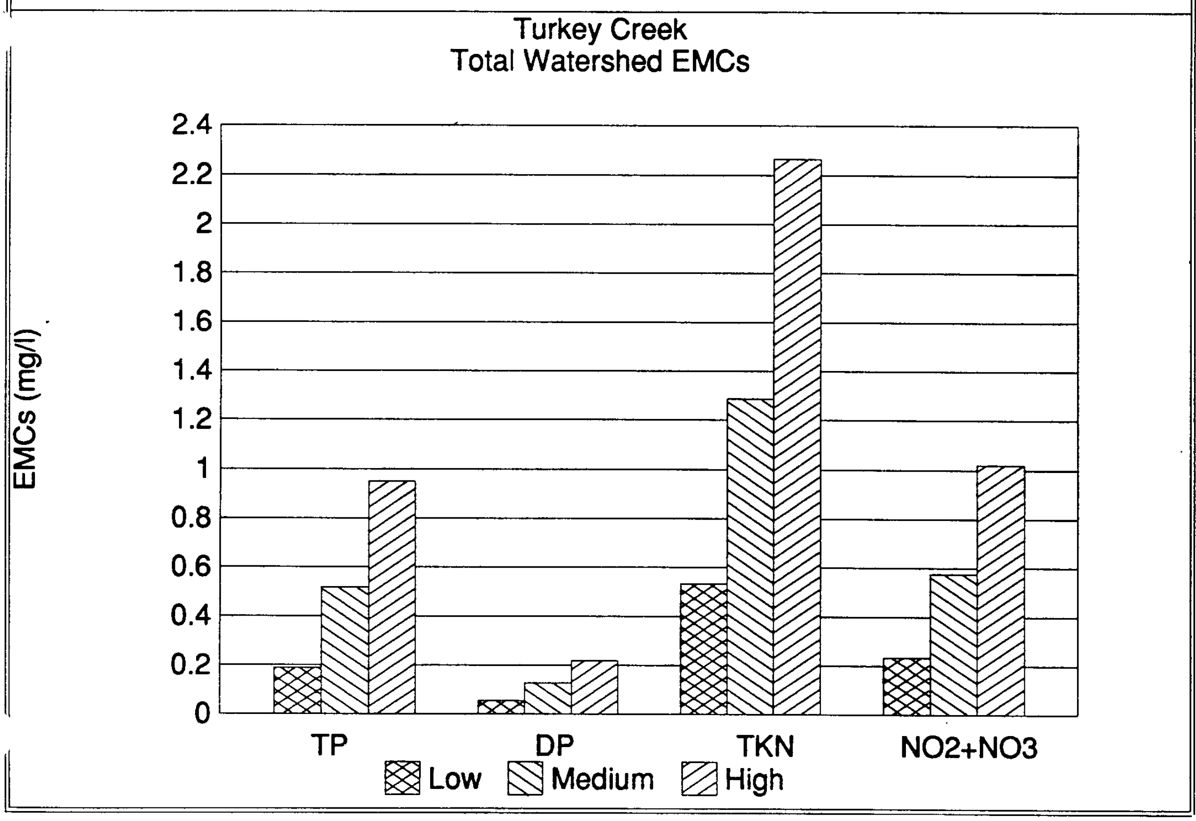

Toll Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr) (Thousands)
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Pb
Cu
Zn
Cd
Low
Medium
High

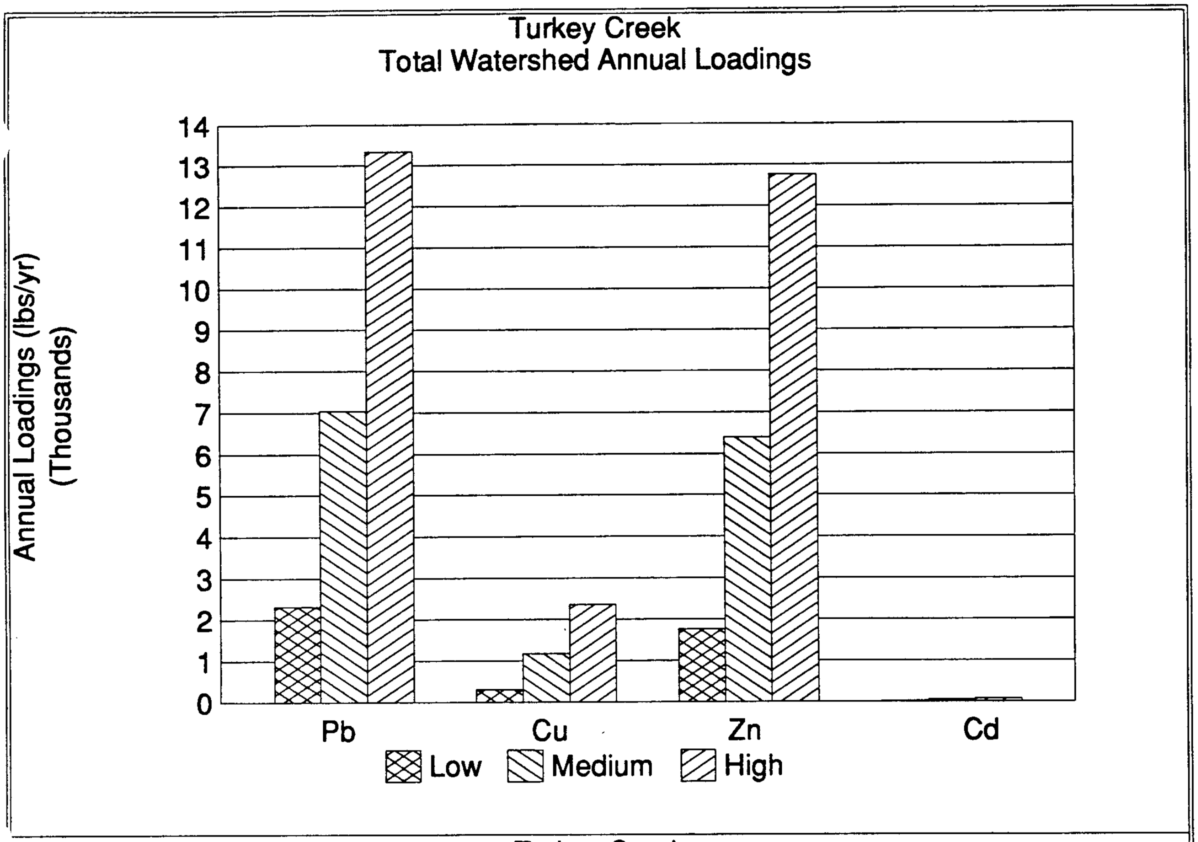

Toll Creek
Total Watershed EMCs
EMCs (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High

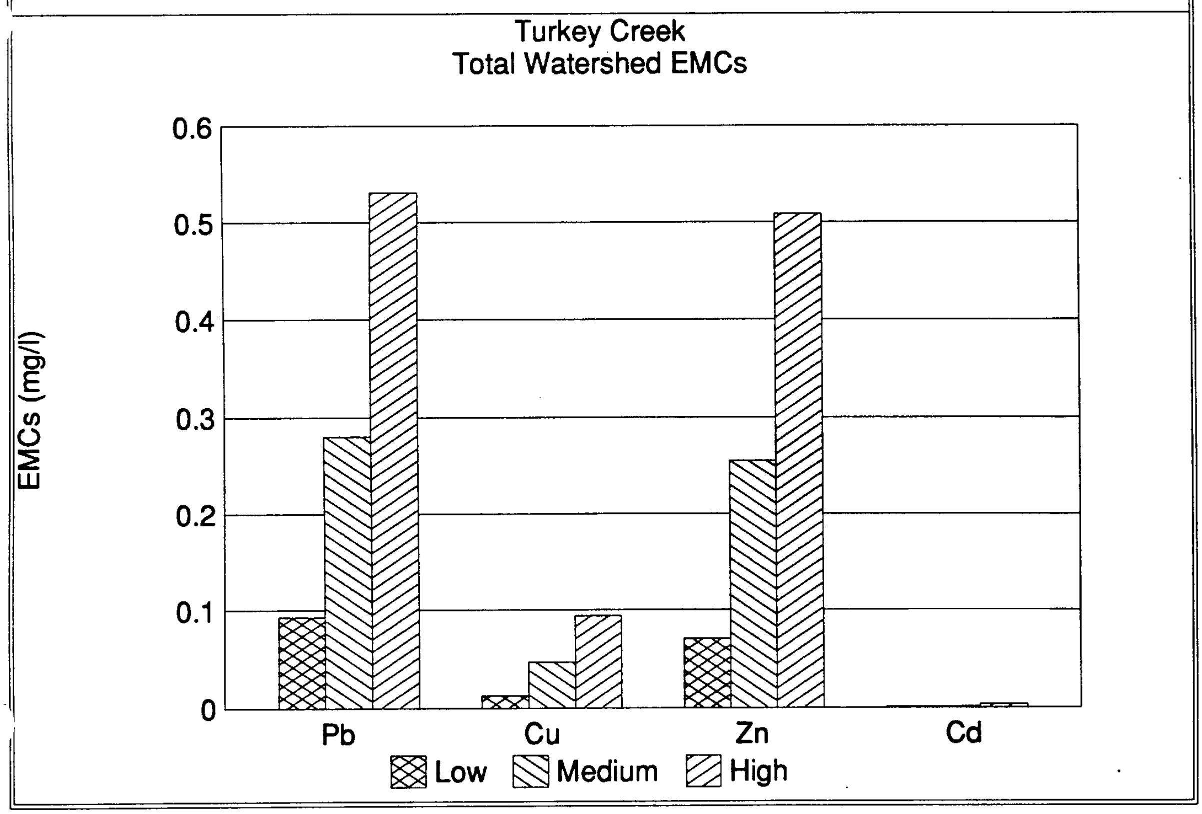

Turkey Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
20
18
16
14
12
10
8
6
4
2
0
BOD5
COD
TSS
TDS
Low
Medium
High

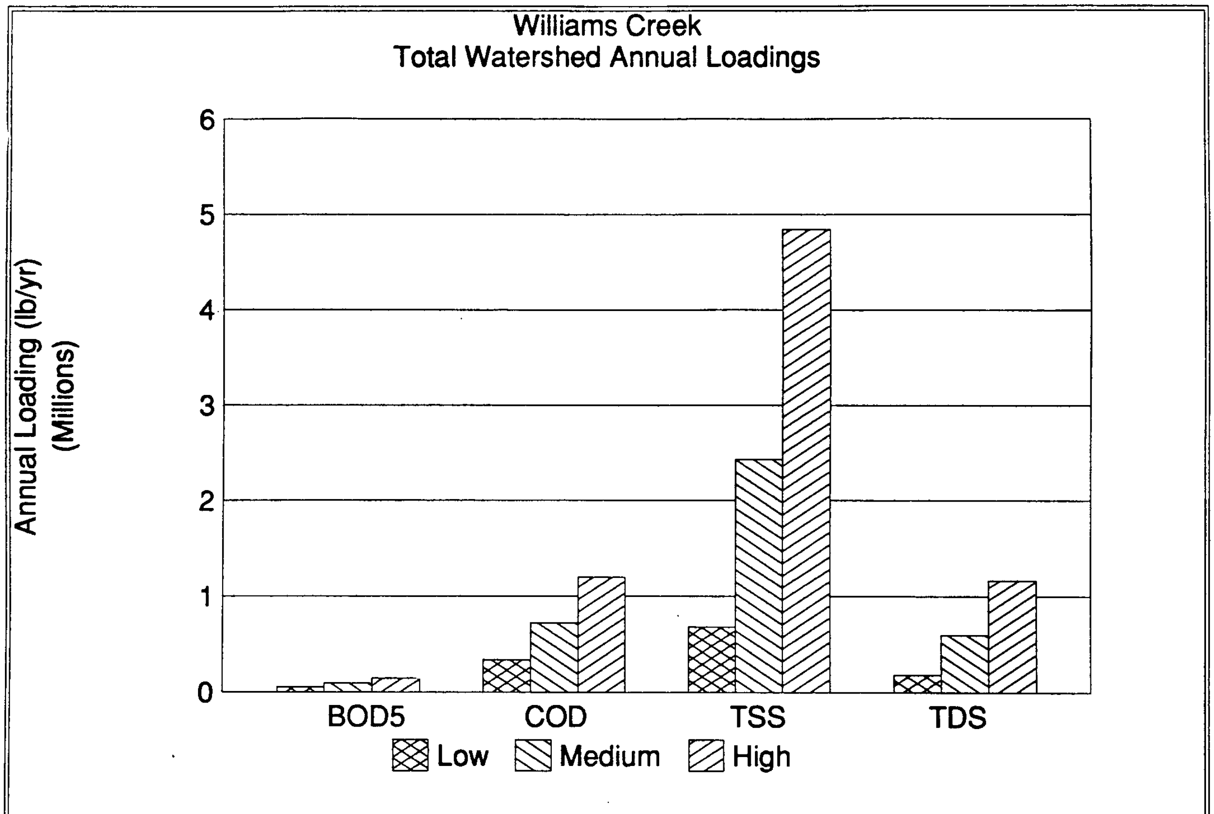

Turkey Creek
Total Watershed EMCs
EMCs (mg/l)
800
700
600
500
400
300
200
100
0
BOD5
COD
TSS
TDS
Low
Medium
High

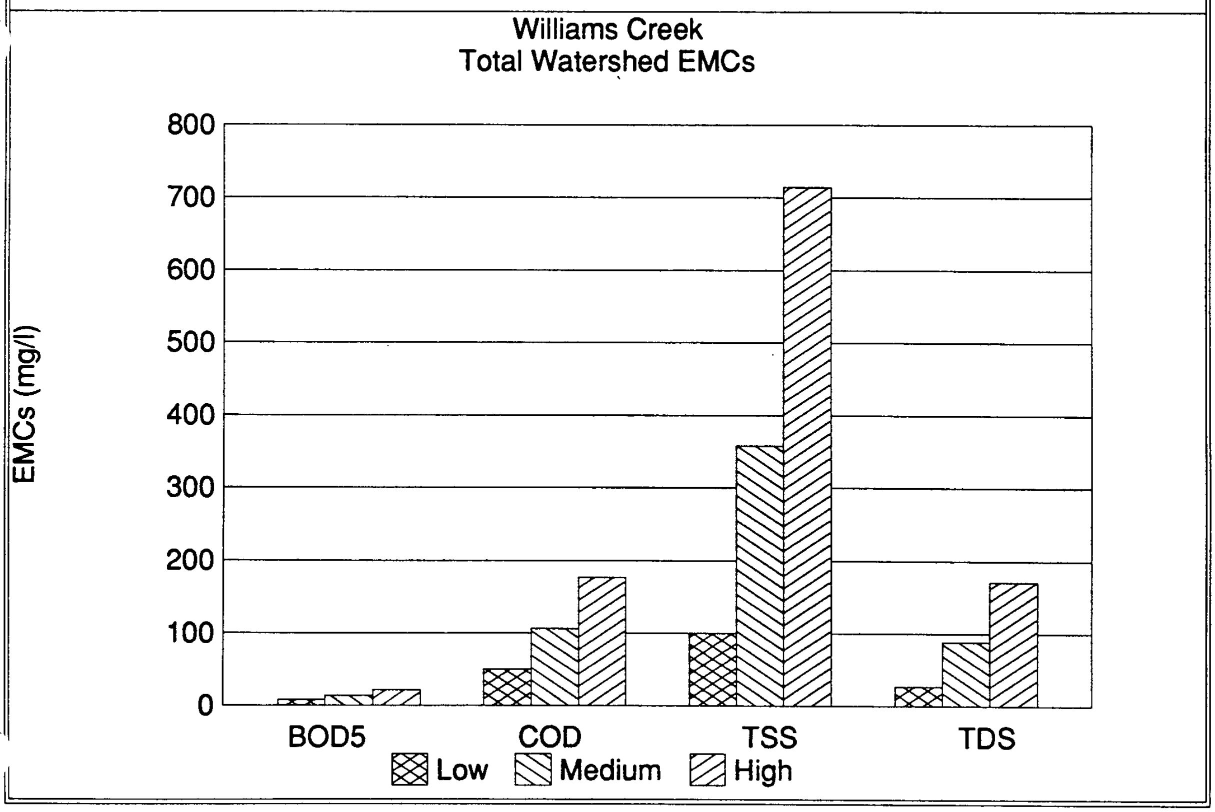

Turkey Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
60
50
40
30
20
10
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

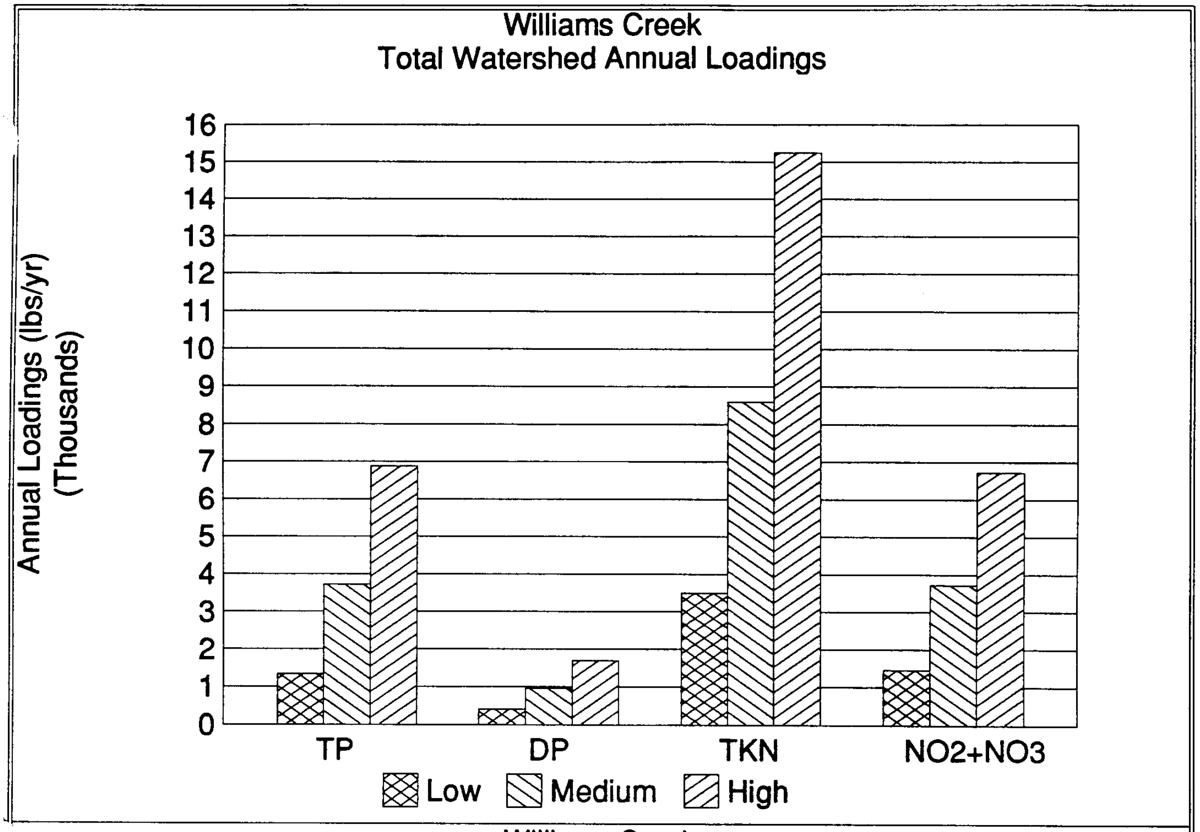

Turkey Creek
Total Watershed EMCs
EMCs (mg/l)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

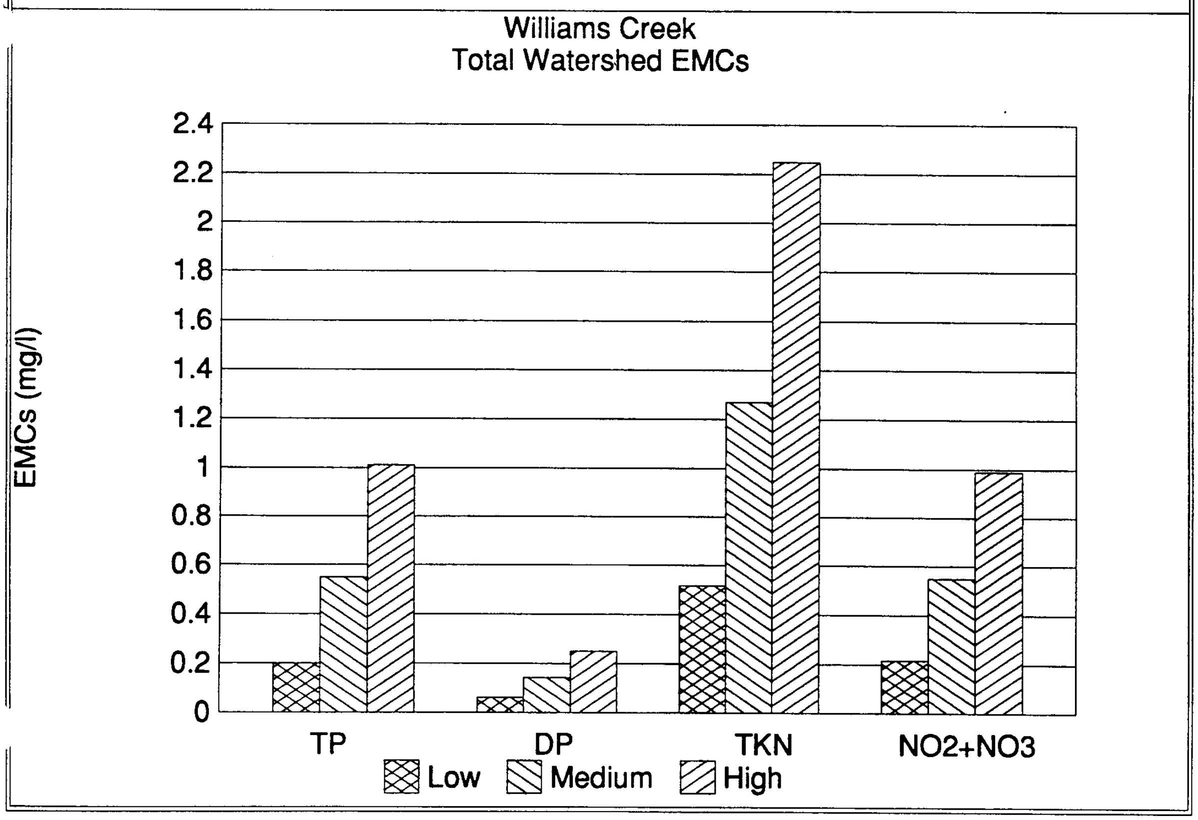

Turkey Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Pb
Cu
Zn
Cd
Low
Medium
High

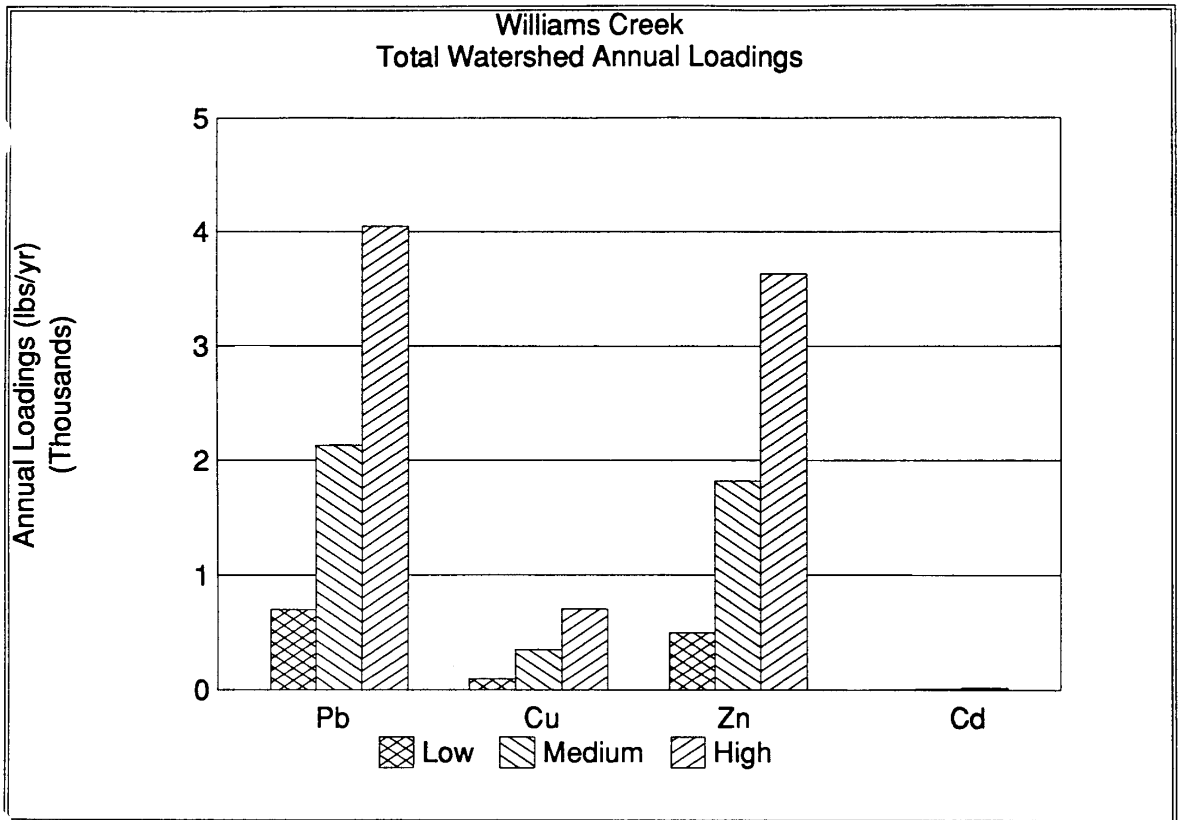

Turkey Creek
Total Watershed EMCs
EMCs (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High

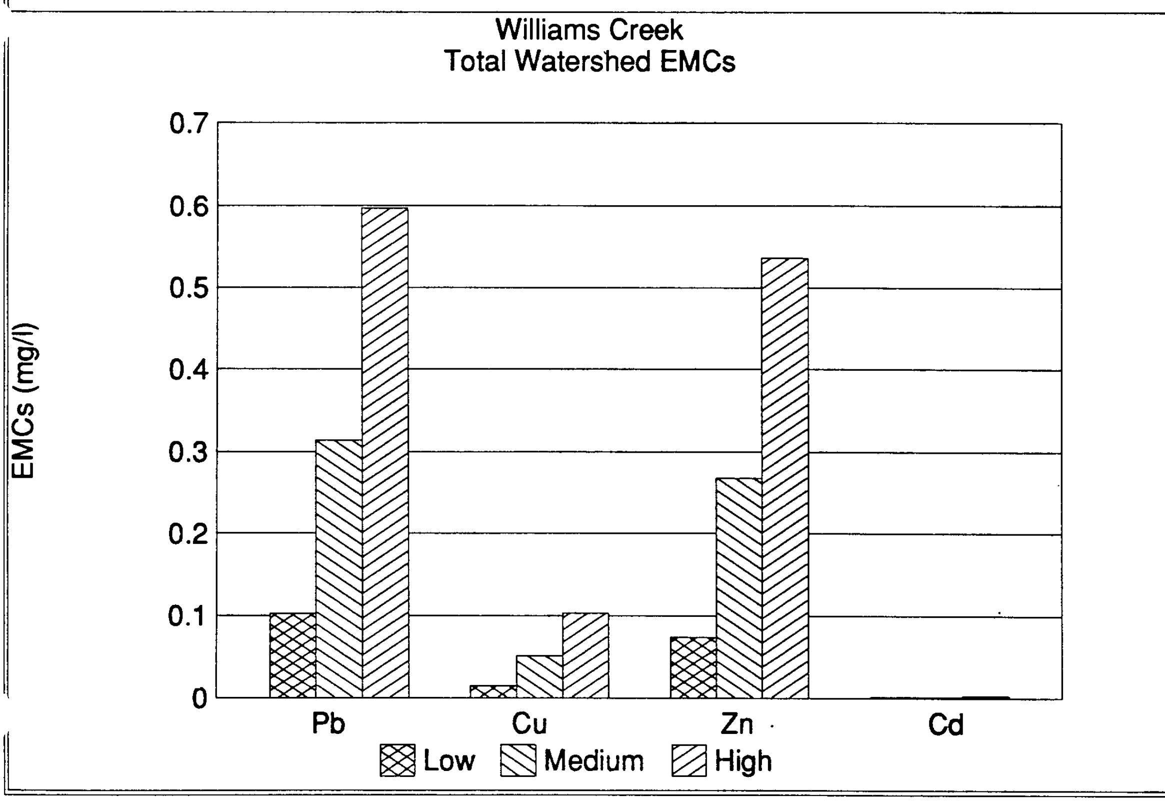

Williams Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
6
5
4
3
2
1
0
BOD5
COD
TSS
TDS
Low
Medium
High

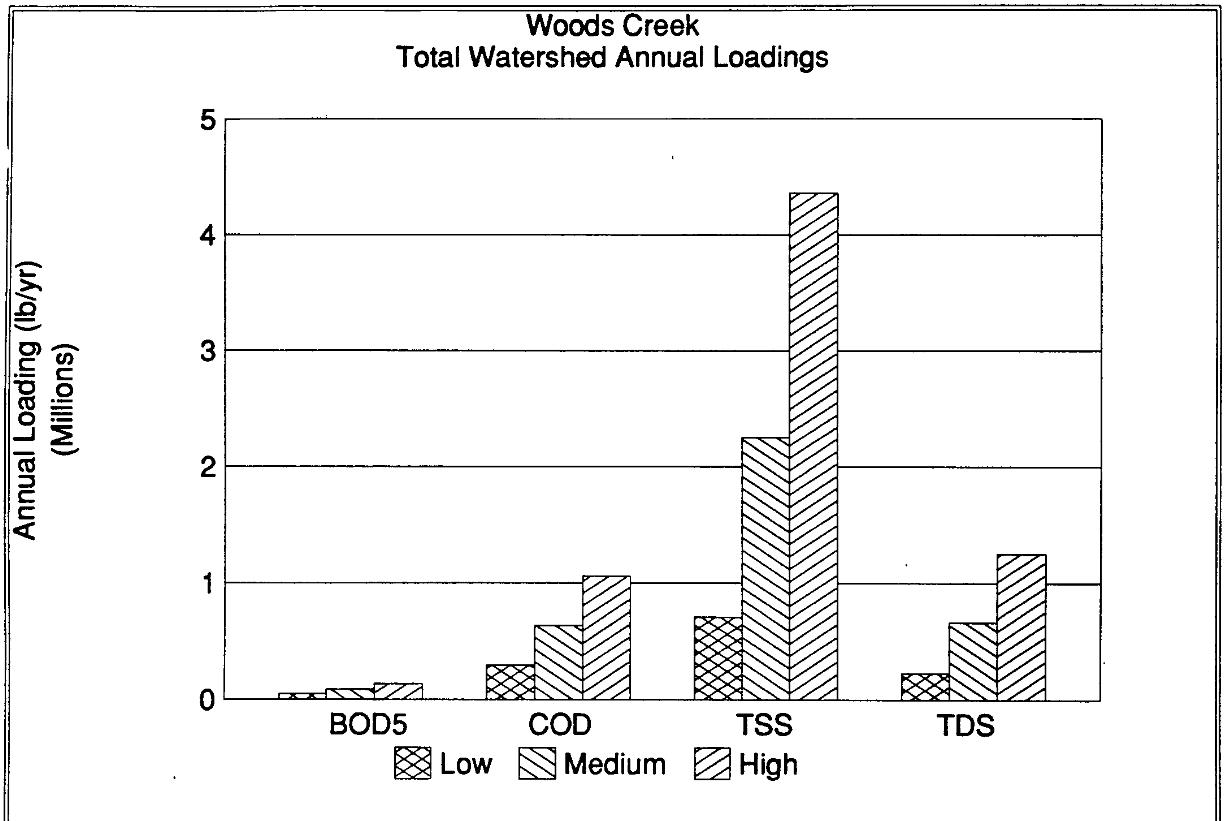

Williams Creek
Total Watershed EMCs
EMCs (mg/l)
800
700
600
500
400
300
200
100
0
BOD5
COD
TSS
TDS
Low
Medium
High

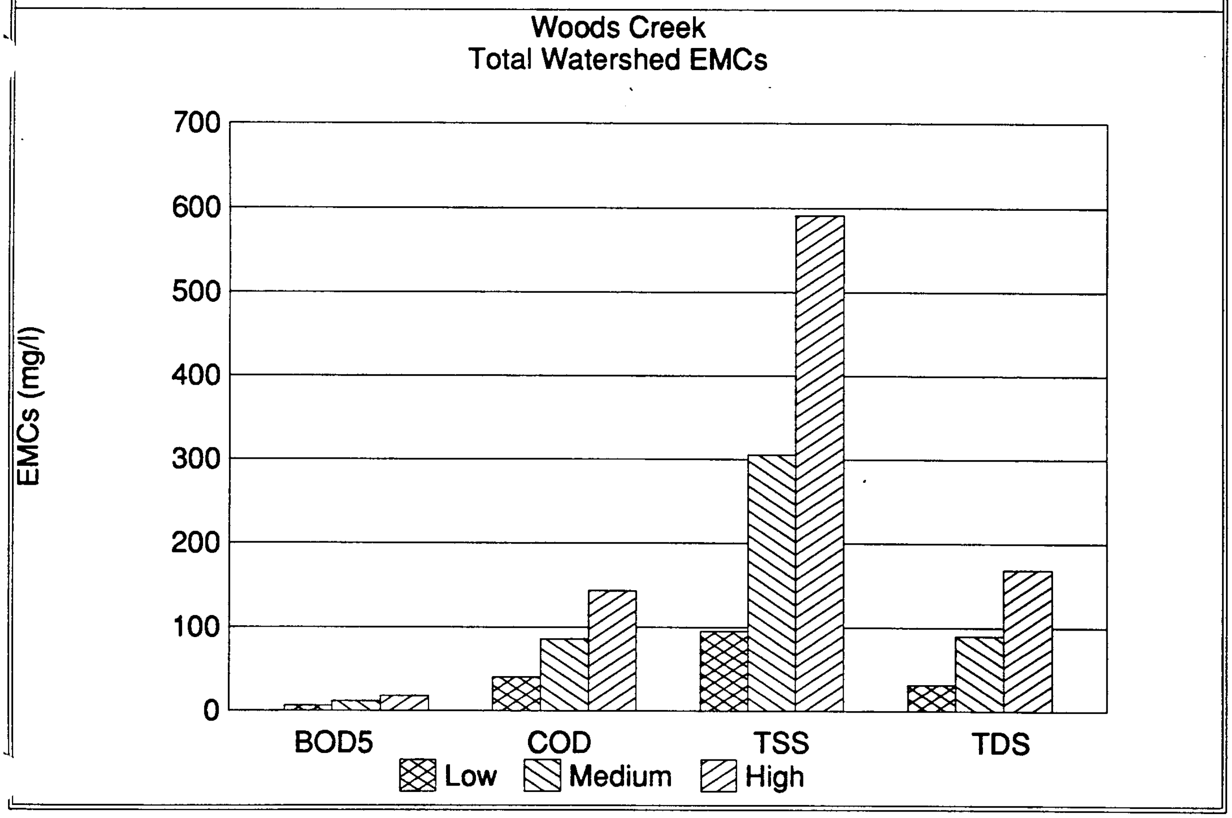

Williams Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

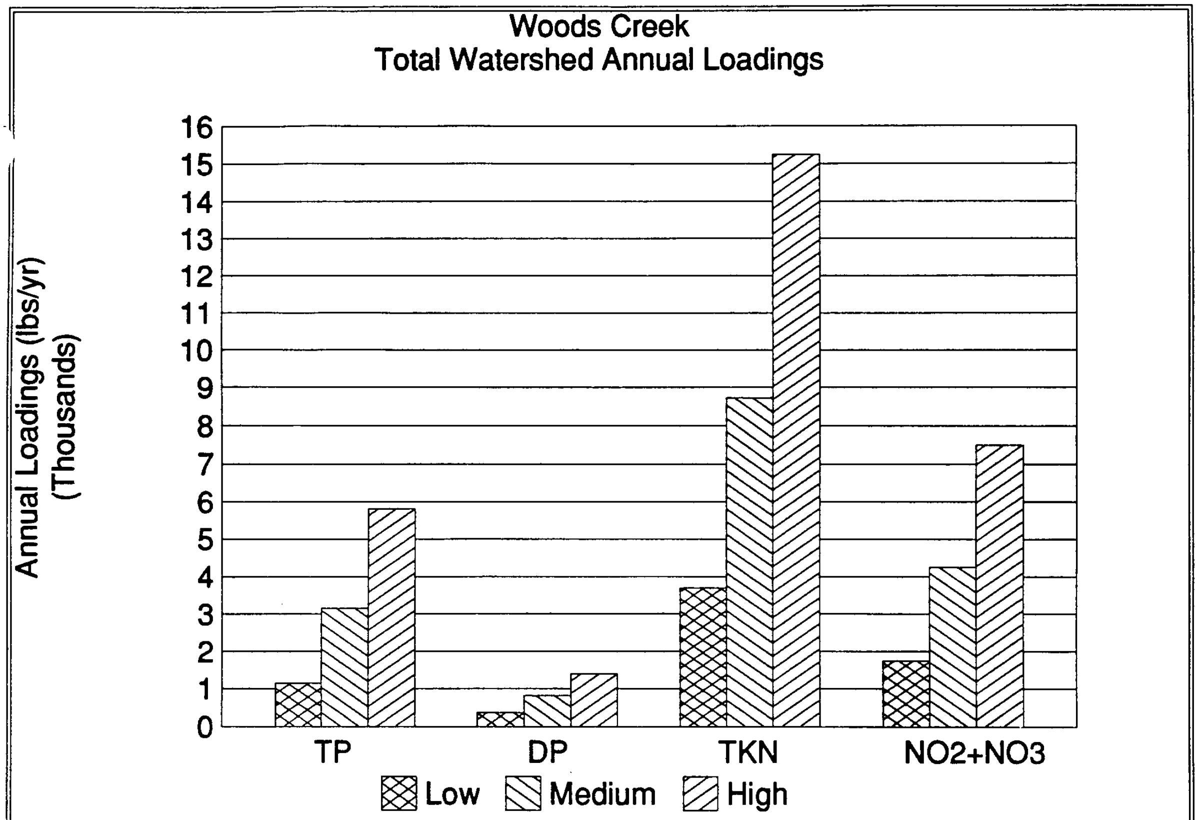

Williams Creek
Total Watershed EMCs
EMCs (mg/l)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High

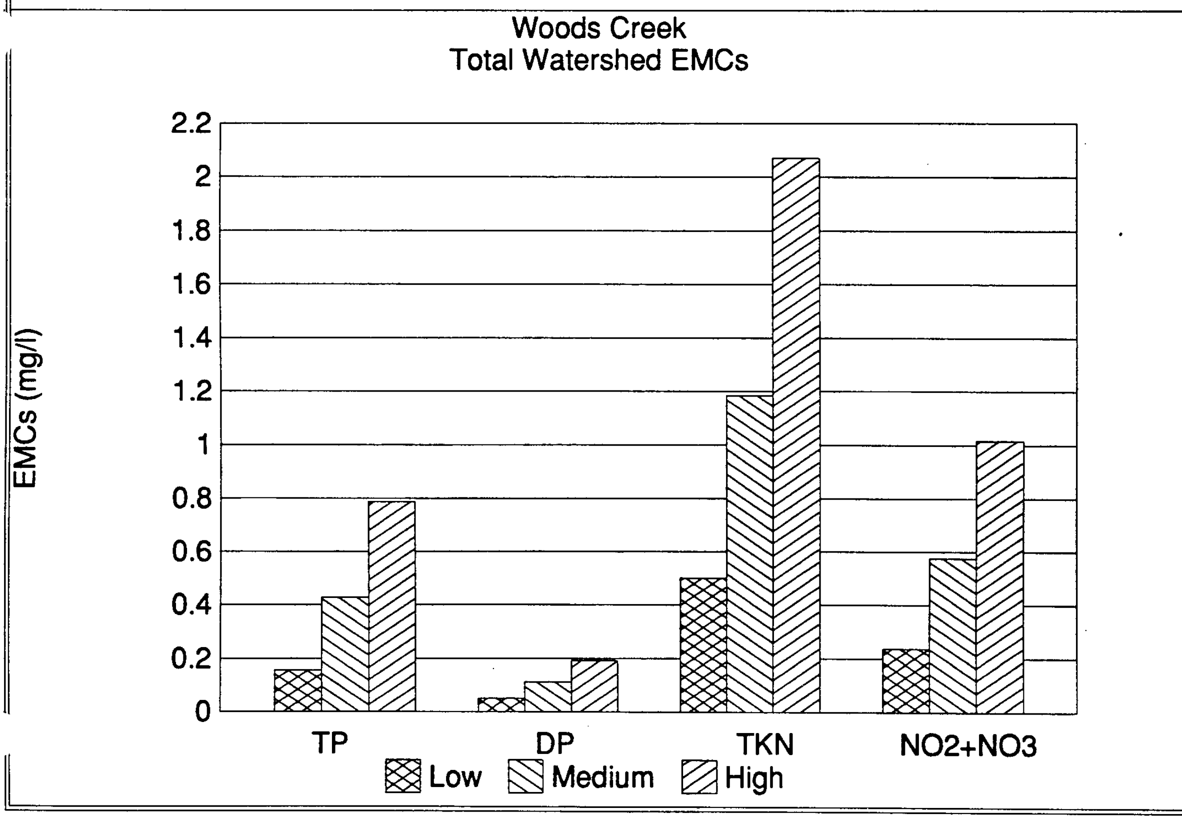

Williams Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
5
4
3
2
1
0
Pb
Cu
Zn
Cd
Low
Medium
High

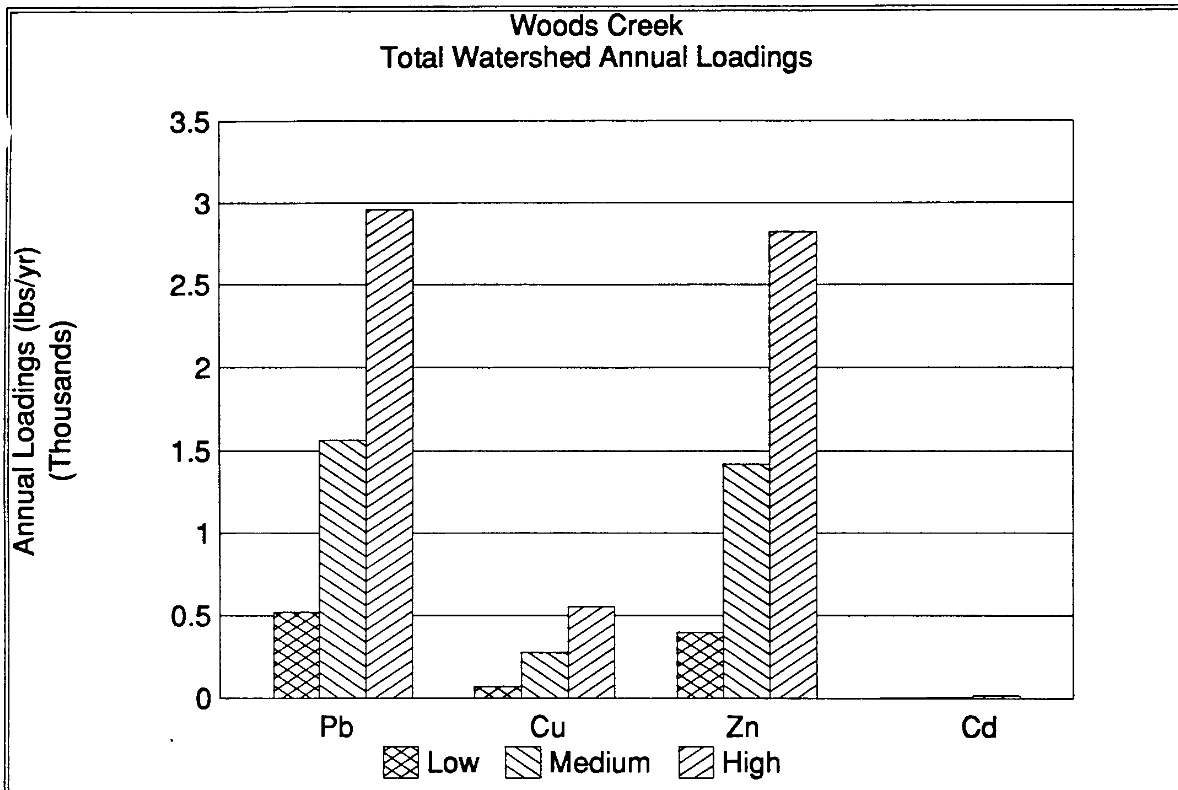

Williams Creek
Total Watershed EMCs
EMCs (mg/l)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High

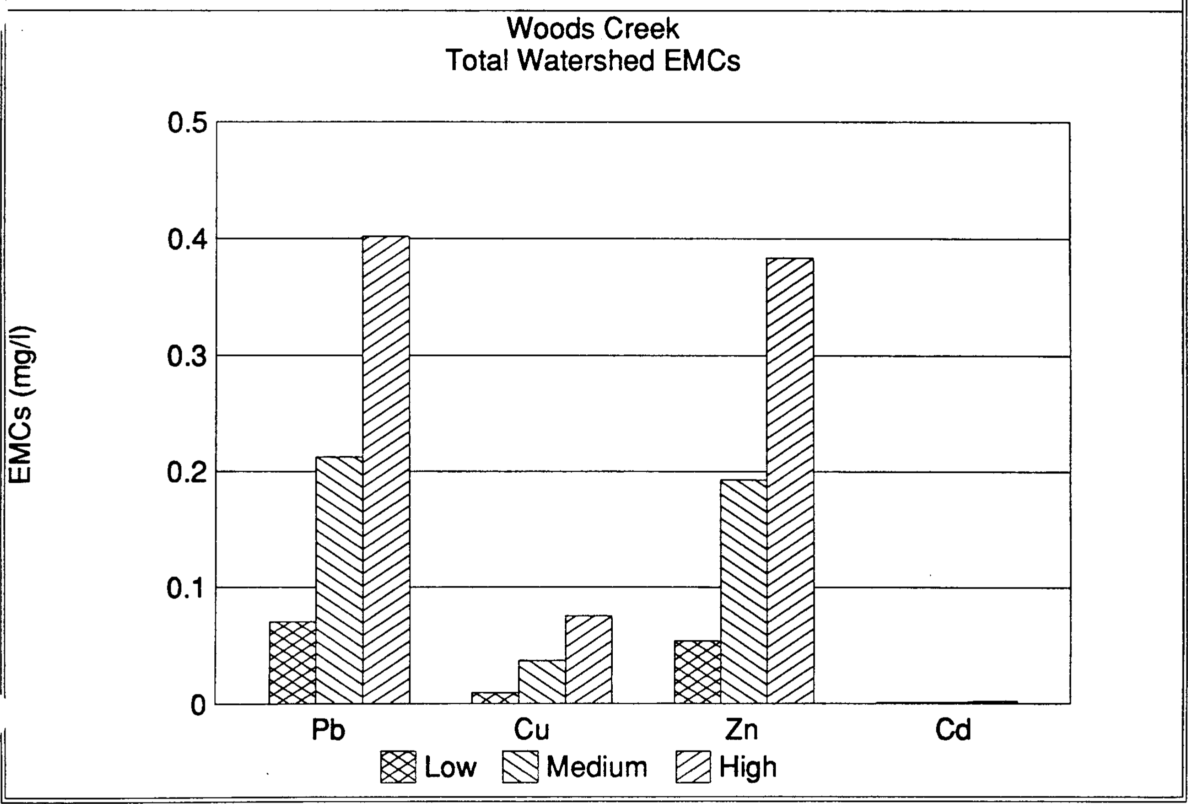

Woods Creek
Total Watershed Annual Loadings
Annual Loading (lb/yr)
(Millions)
5
4
3
2
1
0
BOD5
COD
TSS
TDS
Low
Medium
High


Woods Creek
Total Watershed EMCs
EMCs (mg/l)
700
600
500
400
300
200
100
0
BOD5
COD
TSS
TDS
Low
Medium
High


Woods Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr)
(Thousands)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TP
DP
TKN
NO2+NO3
Low
Medium
High


Woods Creek
Total Watershed EMCs
EMCs (mg/l)
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
TP
DP
TKN
NO2+NO3
Low
Medium
High


Woods Creek
Total Watershed Annual Loadings
Annual Loadings (lbs/yr) (Thousands)
3.5
3
2.5
2
1.5
1
0.5
0
Pb
Cu
Zn
Cd
Low
Medium
High


Woods Creek
Total Watershed EMCs
EMCs (mg/l)
0.5
0.4
0.3
0.2
0.1
0
Pb
Cu
Zn
Cd
Low
Medium
High

APPENDIX D

CITY OF KNOXVILLE

STANDARD OPERATING PROCEDURES

FOR THE

ONGOING MONITORING PROGRAM

STANDARD OPERATING PROCEDURES

ONGOING WATER QUALITY MONITORING PROGRAM

KNOXVILLE, TENNESSEE NPDES STORM WATER PERMIT APPLICATION

APRIL 1993

CAMP DRESSER & MCKEE INC.

CDM

environmental engineers, scientists, planners & management consultants

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

** PARTS (originally called appendices)

** Appendix D originally had four appendices called A, B, C and D. These have been renamed as four parts called A, B, C and D. Any references within Appendix D to one of its original appendices has been changed instead to refer to Part A, B, C or D.

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

This manual presents standard operating procedures (SOPs) for performing ongoing storm event monitoring as required under the Part 2 National Pollutant Discharge Elimination System (NPDES) storm water permit application for the City of Knoxville. The manual presents SOPs designed to fulfill the stormwater sampling requirements for the long-term sampling program required under 40 CFR 122.26(d)(2)(iii). All samples must be collected according to the procedures described herein or by using equivalent procedures to document the integrity of samples from the time of collection through transport to the laboratory.

1.1 BACKGROUND AND PURPOSE

Storm water monitoring studies such as the EPA Nationwide Urban Runoff Program (NURP) have concluded that pollutant concentrations are highly variable both within a particular storm event and from one event to another. Because of this variable nature of storm water discharges, EPA has established an overall monitoring scheme where the collection of water quality data will, primarily, be accomplished through monitoring programs during the term of the NPDES storm water permit. Under Part 2 of the permit application regulations, the City was required to collect samples of storm discharge from three storm events at 5 representative sampling locations (e.g., 15 stations-storms). Stations were selected to monitor areas of representative or typical land uses within the City under Part 1 of the storm water permit application. The representative sampling program was conducted by the United States Geological Survey (USGS).

The purpose of the Part 2 Representative Monitoring Program was to ensure that the discharges from the City's storm sewer system could be appropriately represented by the various existing water quality databases, and could provide a basis for developing the ongoing monitoring program to be implemented during the term of the permit. The sampling requirements for the Part 2 permit applications included the analysis for a wide range of pollutants. This analysis provided the City with the information to target more specific pollutants when developing the requirements for the ongoing monitoring programs to be conducted during the term of the permit.

The proposed ongoing monitoring program is a required element of the Part 2 permit application which will be submitted in May 1993. The standard operating procedures of the ongoing monitoring program, which are documented herein, define the background and the methods for conducting the ongoing monitoring program during the term of the permit.

The long-term goals of the monitoring program include:

- Identification of pollutants of concern in storm water discharges from individual urban land use categories and assessment of potential pollutant sources.
- Estimation of pollutant loads from individual land use categories based on a statistically significant number of storm events over a range of hydrometeorologic conditions.
- Assessment of the performance of specific storm water pollution controls and the overall storm water management program.
- Identification of receiving water quality impacts resulting from storm water pollution discharges.

1.2 SCOPE OF THE MANUAL

The overall ongoing monitoring program requirements including water quality parameters, sampling frequency, and sampling protocols are presented in Section 2.0. Section 3.0 provides detailed descriptions of the procedures for siting and installing storm water monitoring stations. Operation and programming of automatic samplers and flow meters are also presented in Section 3.0. Sample collection and equipment inspection procedures during storm events are presented in Section 4.0.

Quality Assurance/Quality Control procedures are also addressed in Section 4.0. Data collection from the monitoring sites and database management after storm events are presented in Section 5.0. Routine inspection and maintenance of flow monitoring and sampling equipment during dry weather periods are described in Section 6.0. Safety procedures which should be considered in addition to applicable local, state, and federal industrial safety regulations are presented in Section 7.0.

2.0 MONITORING REQUIREMENTS AND OVERALL APPROACH

A characterization plan for a storm event monitoring program (wet weather conditions) for five monitoring sites representative of commercial, industrial and residential land use activities was submitted under the Part I NPDES municipal storm water permit application. Quantitative storm event monitoring data from this representative monitoring program at these sites was required to complete Part 2 of the NPDES permit application for municipal storm water discharges. Monitoring of three representative storm events at the selected five sites and laboratory analyses of designated pollutant parameters was completed to satisfy this requirement. The Part 2 NPDES permit application also required a schedule for an estimate of the seasonal pollutant loadings to local receiving waters based upon results of the representative monitoring program. Flow monitoring was conducted during the storms in order to collect flow proportional samples and to calculate pollutant loads. The United States Geological Survey (USGS) conducted the representative monitoring program which fulfilled the Part 2 permit requirements. The representative monitoring program and the analysis of the results from the program provide the foundation for the development of the ongoing monitoring program described herein.

Three to five sites will be selected for the ongoing monitoring program during the 5-year permit term. At this time, one site has been chosen to be the initial station installed for the program. The site is on a tributary to Fourth Creek adjacent to the Post Office on Middlebrook Pike. This site is immediately downstream of a new commercial/industrial development called Acker Place, and for the remainder of this text, this monitoring site will be referred to as the "Acker Place Site". This section describes the required pollutants and sampling protocols for the initial site selected under the ongoing monitoring program. This section will also serve as the basis for determining the required pollutants and sampling protocols for the remaining sites to be established during the term of the permit.

2.1 WATER QUALITY CONSTITUENTS

Under the Part 2 NPDES municipal storm water permit application requirements, the city was required to analyze samples collected during the representative outfall monitoring program for all priority pollutants as well as for additional conventional pollutants. The primary purpose of this sampling strategy was to screen a wide array of water quality constituents to target pollutants of concern. For the city's ongoing monitoring program, the proposed list of water quality parameters is limited to pollutants that were detected in storm water runoff by the USGS under the representative outfall sampling program. Storm water samples collected for the representative outfall monitoring program had to be analyzed for all toxic pollutants listed in Table II and Table III of Appendix D of 40 CFR Part 122. In addition the samples had to be analyzed for the conventional pollutants listed in 40 CFR Part 122.26(d)(2)(iii)(B).

The results of the representative monitoring program were analyzed and parameters which were considered pollutants of concern at a site were targeted for analysis during the ongoing monitoring program. These parameters were chosen based upon the frequency of detection and the event mean concentration. If the parameter was found repeatedly at concentrations considered significant, it was selected for routine analysis during the 5-year permit term. For the Acker Place site, the pollutant parameters which have been selected are shown in Table 2-1. Table 2-1 additionally summarizes analytical protocols and sampling collection requirements that are addressed in Section 2.3.

2.2 SAMPLING FREQUENCY

Current stormwater NPDES regulations provide no recommendations for sampling frequency during the permit term. Since the primary objective of the ongoing monitoring program is to develop representative storm water quality data to support analysis of management program alternatives, it is necessary to establish a statistically significant database containing storm water quality parameters. The regulations do require an

Table 2-1

Summary of Sampling and Analytical Procedures for the Ongoing Monitoring Program for the City of Knoxville Storm Water Management Program

Group / Parameter	Method	Volume (mL) (Note 1)		Type of Container	Preservative / Handling	Holding Time
		Optimum	Minimum (Note 2)			
Arsenic, Chromium, Copper Lead, Nickel, Zinc	various EPA	1,000	350	Poly	HNO_3 to pH < 2	6 months
Total Suspended Solids	EPA 160.2	2,000	500	Poly	Cool to 4 deg C	7 days
Chemical Oxygen Demand Total Organic Carbon	EPA 410.4 EPA 415.1	500	250	Poly	H_2SO_4 to pH < 2	28 days
PH		NA	NA	NA	None	None
Nutrients:		500	300	Poly	Cool to 4 deg C, H_2SO_4 to pH < 2	28 days
Total Phosphorus	EPA 365.4	--	--	--		
NO2 + NO3	EPA 353.2	--	--	--		
TKN	EPA 351.2	--	--	--		
Ammonia (total)	EPA 350.3	--	--	--		
Dissolved Phosphorus	EPA 365.4	100	50	Poly	Cool to 4 deg C, H_2SO_4 to pH < 2, filtered	28 days

Total Sample Volume Required: 4,100 1,450

Note 1: Volumes shown are typical values. Individual laboratory volumes may vary.

Note 2: Minimum volumes do not allow for repeat analysis, replicates, or other QC samples.

estimation of pollutant loading on a seasonal basis, so the database must include data from enough storms to represent any variances in pollutant loading resulting from seasonal changes. In order to establish such a database, the proposed program will require sampling of ten (10) to fifteen (15) storms per year at each site established during the ongoing monitoring program. The water quality parameters to be analyzed under the routine monitoring are listed in Table 2-1.

In order to assess the impact of storm water quality management programs on the pollutants which were not targeted for routine monitoring and to continue to evaluate overall ambient water quality at the selected outfalls, monitoring for the full suite of pollutant parameters should be conducted once during the 5-year permit term. The full suite of pollutants are listed in Table 2-2 and 2-3 which are, respectively, the same pollutants listed in Table II and Table III of Appendix D of 40 CFR Part 122. In addition to the toxic pollutants listed in these tables, the following individual conventional pollutants are part of the full suite of parameters:

- Total Suspended Solids (TSS)
- Total Dissolved Solids (TDS)
- 5-day Biochemical Oxygen Demand (BODs)
- Chemical Oxygen Demand (COD)
- pH (grab sample required)
- Oil and Grease (grab sample required)
- Fecal Streptococcus (grab sample required)
- Fecal m (grab sample required)
- Total Dissolved Phosphorus
- Total Nitrogen
- Total Phosphorus
- Total Ammonia plus Organic Nitrogen (Total Kjeldahl Nitrogen).
- Nitrate and Nitrite

TABLE 2-2

Organic Toxic Pollutants
Listed in Table II of Appendix D of 40 CFR Part 122

VOLATILES	PESTICIDES
Acrolein	Aldrin
Acrylonitrile	Alpha-BHC
Benzene	Beta-BHC
Bromoform	Gamma-BHC
Carbon Tetrachloride	Delta-BHC
Chlorobenzene	Chlordane
Chlorobromomethane	4,4 '- DDT
Chloroethane	4,4 '- DDE
2 - Chloroethylvinyl Ether	4,4' - DDD
Chloroform	Dieldrin
Dichlorobromomethane	Alpha-Endosulfan
1, l - Dichloroethane	Beta-Endosulfan
1,2 - Dichloroethane	Endosulfan Sulfate
1,1 - Dichloroethylene	Endrin
1,2 - Dichloropropane	Endrin Aldehyde
1,3 - Dichloropropylene	Heptachlor
Ethylbenzene	Heptachlor Epoxide
Methyl Bromide	PCB-1242
Methyl Chloride	PCB-1254
Methylene Chloride	PCB-1221
1,1,2,2 - Tetrachloroethane	PCB-1232
Tetrachloroethylene	PCB-1248
Toluene	PCB-1260
1,2 - Trans-Dichloroethylene	PCB-1016
1,1,1 - Trichloroethane	Toxaphene
1,1,2 - Trichloroethane	
Trichloroethylene	
Vinyl Chloride	

TABLE 2-2
(continued)

Organic Toxic Pollutants
Listed in Table II of Appendix D of 40 CFR Part 122

ACID COMPOUNDS

2 - Chlorophenol
2,4 - Dichlorophenol
2,4 - Dimethylphenol
2,6 - Dinitro-O-Cresol
2 - Nitrophenol
4 - Nitrophenol
P-Chloro-M-Cresol
Pentachlorophenol
Phenol
2,4,6 - Trichlorophenol
2,4 - Dinitrophenol

TABLE 2-2
(continued)

Organic Toxic Pollutants
Listed in Table II of Appendix D of 40 CFR Part 122

BASE / NEUTRAL

Acenaphthene	Di-n-butyl phthalate
Acenaphthylene	2,4-Dinitrotoluene
Anthracene	2,6-Dinitrotoluene
Benzidine	Di-n-octyl phthalate
Benzo(a)anthracene	1,2-Diphenylhydrazine (as azabenzene)
Benzo(a)pyrene	Fluroranthene
3,4 - Benzocluomthene	Fluorene
Benzo(ghi)perylene	Hexachlorobenzene
Benzo(k)fluoranthene	Hexachlorobutadiene
Bis (2-chloroethoxy) methane	Hexachlorocyclopentadiene
Bis (2-chloroethyl) ether	Hexachloroethane
Bis (2-chloroisopropyl) ether	Indeno (1,2,3-cd) pyrene
B is(2-ethylhexyl)phthalate	Isophorone
4 - Bromophenyl phenyl ether	Napthalene
Butylbenzyl phthalate	Nitrobenzene
2 - chloronaphthalene	N-nitrosodimethylamine
4 - chlorophenyl phenyl ether	N-nitrosodi-n-propylamine
Chrysene	N-nitrosodiphenylamine
Dibenzo(a,h)anthracene	Phenanthrene
1,2 - Dichlorobenzene	Pyrene
1,3 - Dichlorobenzene	1,2,4 - Trichlorobenzene
1,4 - Dichlorobenzene	
3,3 - Dichlorobenzidine	
Diethyl phthalate	
Dimethyl phthalate	

TABLE 2-3

Pollutants Listed in Table III
(Toxic Metals, Cyanide, and Total Phenol)
of Appendix D of 40 CFR Part 122

Antimony, total	Mercury, total
Arsenic, total	Nickel, total
Beryllium, total	Phenols, total [1]
Cadmium, total	Selenium, total
Chromium, total	Silver, total
Copper, total	Thallium, total
Cyanide, total [1]	Zinc, total
Lead, total	

1) EPA requires analyses of a grab sample for this pollutant.

The NPDES storm water regulations require that:

> "all samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 in and at least 72 hours from the previously measurable (greater than 0.1 in rainfall) storm event."

However, to ensure that 10 to 15 storms per year can be collected, a minimum of 24 hours between storm events will be used for the proposed program.

Under the city's ongoing monitoring program, the sampling frequencies and monitored storm characteristics will attempt to meet the following criteria:

Number of storm events monitored per year per station	10-15
Preceding dry weather period	24 hours
Minimum storm rainfall	0.1-inch (site threshold dependent)
Maximum storm rainfall threshold	None
Interval (days) between monitored storm events	Not fixed (approx. 3-4 samples/season).

Proposed sampling frequencies for each type of parameter are summarized in Table 2-4. The monitoring program will be re-evaluated during the third year of the permit and the City will decide whether to relocate any monitoring stations at that time. To evaluate long term trends, the city may wish to continue monitoring at several of the sampling locations for the entire five-year permit term. Alternatively, there may be future opportunities for the city to assess BMP performance by relocating monitoring stations upstream and downstream of BMP facilities.

Table 2-4

Summary of Constituent Sampling Frequency for the Ongoing Monitoring Program
For the City of Knoxville Storm Water Management Program

Category	Group / Parameter	Type of Sample	Frequency of Analysis (per station)
ROUTINE ANALYSIS			
Toxic Metals (1)	Arsenic, Chromium, Copper, Lead, Nickel, Zinc	Composite	10-15 storms per year
Sediment	Total Suspended Solids	Composite	10-15 storms per year
Organics / Oxygen Demand	Total Organic Carbon Chemical Oxygen Demand	Composite Composite	10-15 storms per year 10-15 storms per year
Nutrients	Total Phosphorus Dissolved Phosphorus NO2 + NO3 TKN Ammonia (total)	Composite Composite Composite Composite Composite	10-15 storms per year 10-15 storms per year 10-15 storms per year 10-15 storms per year 10-15 storms per year
General	pH	-----	10-15 storms per year
SPECIAL ANALYSIS IN ADDITION TO ROUTINE ANALYSIS			
Table II of Appendix D of 40 CFR Part 122	Volatile Organic Compounds Base / Neutral Extractables Acid Extractables Pesticides / PCBs	Grab Composite Composite Composite	1 storm/permit term (2) 1 storm/permit term (2) 1 storm/permit term (2) 1 storm/permit term (2)
Table III of Appendix D of 40 CFR Part 122	Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Silver, Thallium, Zinc	Composite	1 storm/permit term (2)
	Cyanide Total Phenols	Grab Grab	1 storm/permit term (2) 1 storm/permit term (2)
General	Oil & Grease Fecal Bacteria Hardness	Grab Grab Composite	1 storm/permit term (2) 1 storm/permit term (2) 1 storm/permit term (2)

(1) Routinely analyzed toxic metals are a subset of Table III of Appendix D of 40 CFR Part 122

(2) Frequency of sampling for full suite of parameters is a minimum of 1 storm per 5-year permit term.

Upon completion of the first five-year permit term, the City of Knoxville will assess its long-term monitoring program and develop recommendations during permit renewal for modifying the sampling frequency based on management program requirements and additional characterization needs.

2.3 SAMPLING PROTOCOLS

A flow-weighted composite sample collected over the entire storm event is required to characterize the discharge for a storm. The NPDES regulations allow an exemption which would allow collection of the sample to be limited to the first three (3) hours of the storm event. The flow-weighted composite may be collected with an automatic sampler or as a combination of a minimum of three discrete samples (called aliquots) collected per hour during the entire discharge or for the first three hours of the discharge. A minimum of 15 minutes between collection of sample aliquots is required. Only one laboratory analysis of the composite of sample aliquots is required.

There are three methods for collecting the required flow-weighted composite samples during storm events:

1. Manual Grab Sampling - Field personnel are present during storm events to manually collect numerous discrete samples. After the storm event, the individual samples are manually composited proportional to available flow data.

2. Sequential Time-Paced Sampling - Uses an automatic sampler/flow meter which is activated by an increase in flow level. The sampler sequentially collects discrete samples on a constant time interval (e.g., every 15 minutes) during the storm. Samples are deposited into separate containers during the course of a storm event and later manually composited.

3. Composite Flow-Paced Sampling - Uses an automatic sampler/flow meter which combines all samples into a single large container. The flow meter controls the sampler such that samples are collected on a flow proportional basis {e.g., every 5,000 gallons).

The occurrence of storm water runoff is difficult to predict. Therefore, development of a reliable database requires a more sophisticated sampling program design than ambient (dry weather) water quality assessments, for example. When storm events occur, especially in small urban basins with short times of concentration (e.g., the time for storm water to travel from the most hydraulically distant point in the basin to the outfall point), the peak loadings of pollutants in storm water may occur before personnel are able to arrive at a site to begin manual sampling. In addition, logistics make storm event sampling difficult on weekends or in the middle of the night. For these reasons, automatic samplers and flow meters that are configured to initiate sampling at the beginning of a storm event will be used for the ongoing monitoring program.

Several of the parameters listed under the NPDES Part 2 permit application regulations can only be collected by manual grab samples. For example, volatile organic compounds (VOCs) cannot be sampled with automatic equipment because automatic samplers impose a partial vacuum that may cause constituents to volatilize, which thereby invalidates the sample. To assure the integrity of a sample that will be analyzed for VOCs, the sample must also be contained in a specific type of bottle that assures zero headspace. Automatic samplers currently available cannot provide such a sample; therefore, the sample must be collected manually. There are several other parameters for which the standard sampling protocols specifically require the collection of grab samples. These parameters are:

- pH
- Cyanide
- Total phenols
- Oil and grease
- Fecal coliform
- Fecal Streptococcus

These parameters require special handling such as immediate analysis or preservation and must be collected manually. As shown in Table 2-4, however, these parameters are not targeted for routine analysis during the 5-year permit term. Rather, these samples are part of the full suite of pollutants which will only be analyzed once during the 5-year permit term and will be collected by manually grabbing samples by field personnel located at the sampling station during a storm event. Additional discussion of manual sampling is presented below.

2.3.1 MANUAL SAMPLING

Manual sampling will not be required for the ongoing monitoring program except for certain parameters that cannot be sampled by automated methods and must be collected by manual grab samples as noted in Section 2.3. The strategy for monitoring these parameters will be to have field personnel placed on alert to arrive at the sampling stations as soon as practicable after a storm event begins. These personnel will test for pH and manually collect discrete samples for the parameters for which grab samples are required for immediate preservation and delivery to the laboratory. .A single grab sample collected as soon as field personnel arrive at the station after a storm event begins will be analyzed for these parameters. Under the ongoing monitoring program, manually collected grab samples should be collected for one (1) storm per station during the 5-year permit term.

2.3.2 AUTOMATIC SAMPLING

Commercially available automatic samplers typically can be configured to collect either sequential discrete or flow composite samples. Conversion of the sampler typically involves replacing the sampler base which holds the bottles and minor changes to the sample distribution system. For the City of Knoxville ongoing monitoring program, samplers will initially be configured to collect sequential discrete samples in the field. These samples will be manually composited in the laboratory in reference to the storm hydrograph. The sampler will be interfaced with a flow meter that will record each sample event on the flow strip chart and electronic data logger.

For the ongoing monitoring program, the automatic samplers will be configured with 24 one-liter poly bottles. The sample program will be set to collect one 250 ml sample aliquot every fifteen minutes during the storm event. A single one-liter bottle will be filled every hour during the storm up to a maximum of 24 hours. A liquid level actuator will be used to initiate sampling when the stage (depth) of the channel or outfall reaches a preselected level. The program will terminate sampling when the actuator detects that the stage has fallen below the predetermined level. The preselected sampling level is determined by approximating the stage in the channel or outfa1l which will occur after 0.1 inches of rainfall. This sampling level is both dependent on the particular site as well as on the seasonal baseflow conditions. The level must be adjusted as necessary to reflect hydrologic and hydraulic conditions at each site. The storm water sample will be collected through the vinyl intake tubes and polypropelene strainers which will be standard equipment for the City of Knoxville's monitoring program.

After each monitored storm event, the sample bottles which best represent the storm hydrograph will be selected for compositing using the hydrograph generated by the flow meter as a reference. The procedures for manually compositing multiple samples into a single flow-weighted composite sample for each storm event are documented in the SOP manual in part B of Appendix D.

2.3.3 SAMPLE COMPOSTING

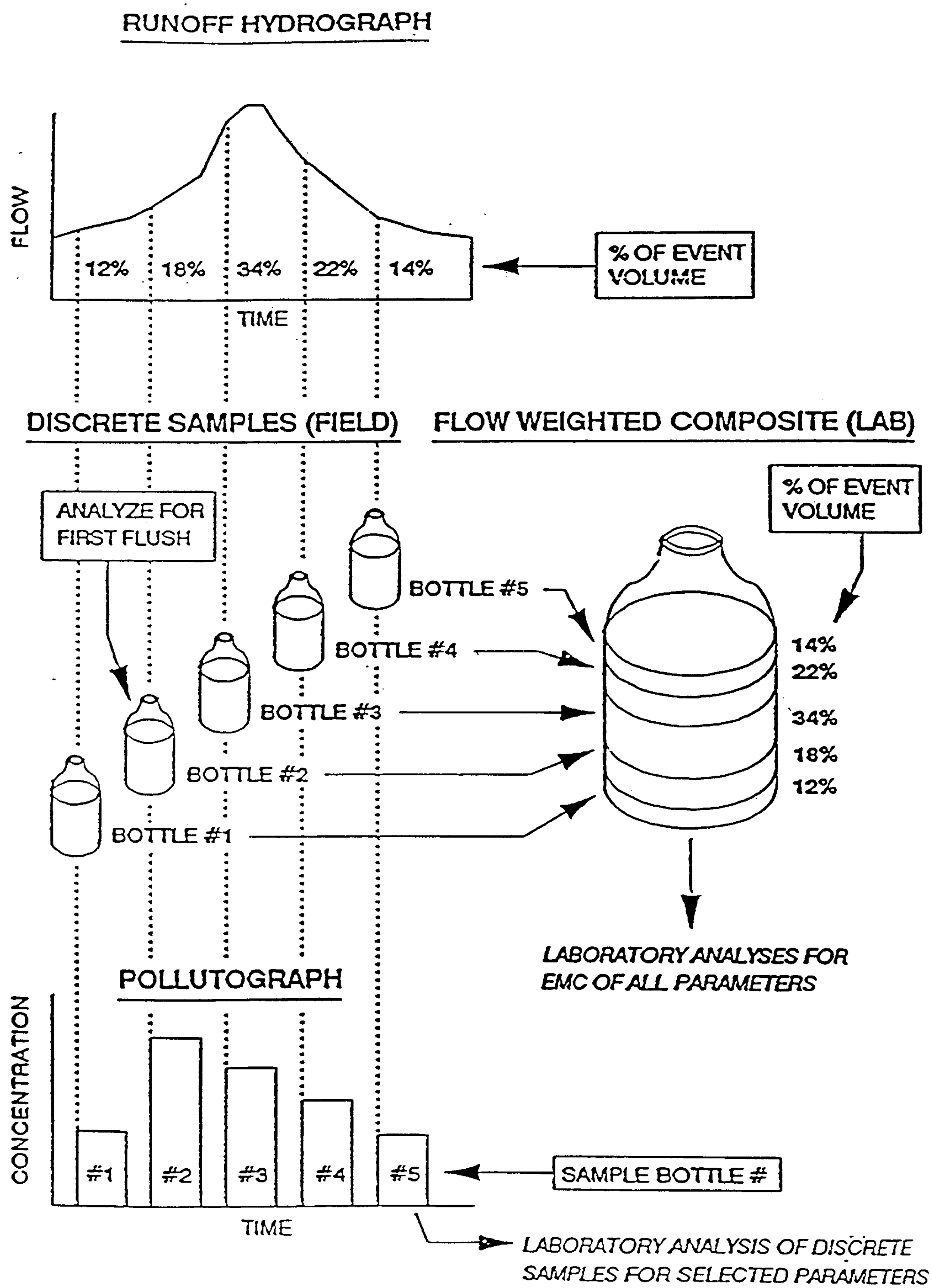
To produce a single, flow-weighted composite sample will require analysis of the storm event hydrograph to select those sample bottles that best represent the storm event. If the sampler is operating on a time-incremental basis (e.g., a sample aliquot is collected every 15 minutes), the flow hydrograph can be analyzed to determine the proportion of total storm event flow each sample bottle represents. A flow composite sample can be produced by proportionally combining individual samples. If the sampler is operated in a flow-proportional mode, each discrete sample will represent an equivalent flow volume and selected samples can be composited using equal volumes from each sample bottle to produce a flow-proportional storm event composite sample. Laboratory results from the composited sample will be representative of event mean concentrations (EMCs). The EMCs can be used to calculate pollutant loads to receiving waters. The EMC does not provide information about maximum pollutant concentration during the storm or intra-storm variability. The ongoing monitoring program for the City of Knoxville will initially employ time-incremental flow sampling.

Figure 2-1 schematically shows the basic procedures for determining event mean pollutant concentrations from field monitoring samples and data. The procedure shown in the figure is based on the compositing of time-incremental samples to obtain a flow-weighted sample. The composite proportions, determined from the hydrograph, will be reported to the laboratory. A flow-weighted composite sample will be prepared in the lab based on these proportions. Laboratory analyses will determine EMCs for each parameter tested.

2.3.4 FLOW MONITORING

Flow monitoring is essential because storm water pollutant loads cannot be estimated without accurate flow measurements. Flow monitoring equipment should be capable of recording sufficient data to generate storm hydrographs (e.g., flow rate vs. time) for monitored storm events. The hydrographs will be used to derive the required storm summary information: storm runoff volume, peak flow, and duration. Hydrographs should also indicate sample collection times to ensure that flow-weighted composite samples are collected. Runoff flows in municipal storm sewer systems are sporadic and typically vary over a wide range during storm events. Flow meters should be installed so that accurate flow measurements can be obtained over the range of expected storm flows.

FIGURE 2-1


RUNOFF HYDROGRAPH
FLOW
12%
18%
34%
22%
14%
TIME
% OF EVENT VOLUME
DISCRETE SAMPLES (FIELD)
FLOW WEIGHTED COMPOSITE (LAB)
ANALYZE FOR FIRST FLUSH
% OF EVENT VOLUME
BOTTLE #5
BOTTLE #4
BOTTLE #3
BOTTLE #2
BOTTLE #1
14%
22%
34%
18%
12%
LABORATORY ANALYSES FOR EMC OF ALL PARAMETERS
POLLUTOGRAPH
CONCENTRATION
#1
#2
#3
#4
#5
SAMPLE BOTTLE #
TIME
LABORATORY ANALYSIS OF DISCRETE SAMPLES FOR SELECTED PARAMETERS

Storm sewer systems are designed to convey storm runoff and are typically dry during periods between storm events. At larger sites, dry weather or base flows may be a result of ground water. Monitoring sites should be carefully screened to ensure that dry weather flows, if any, are not attributable to illicit connections or improper disposal. The dry weather field screening data collected under Part 1 of the permit application should be reviewed to determine whether improper disposal/illicit connections were detected at the monitoring site locations. Flow monitoring at sites characterized by dry weather flows will require extra care to ensure that sampling commences only during storm events.

2.3.5 PRECIPITATION MONITORING

The NPDES regulations require that precipitation data (duration, volume, antecedent dry period) be provided for monitored storm events. For sites which can not be covered by existing rain gages, a recording rain gage will be installed at selected sampling sites which are clear of surrounding rooftops and tree canopy. Monitoring sites in close proximity to one another can share rain gage information. Precipitation monitoring will be accomplished using a tipping-bucket rain gage and a data logger.

2.4 Quality Assurance/Quality Control Procedures

Quality assurance/quality control (QA/QC) measures include both field and laboratory procedures to ensure the precision accuracy of the data collected as part of the sampling program. The personnel responsible for setting up and maintaining the automatic sampling systems and for performing the grab sampling will have access to copies of this standard operating procedures manual and of equipment instructions to ensure that QA/QC procedures will be followed. In addition, all personnel will have hands-on training by qualified personnel in the field prior to initiation of the sampling program. Standard laboratory QA/QC procedures detailing the analysis of internal QA/QC samples and chain-of-custody protocols will also be followed. Associated field and laboratory QA/QC protocols are discussed herein.

2.4.1 FIELD PROCEDURES

Field QA/QC procedures include calibration of sampler pumps and flow meters as well as other field instruments (e.g., pH meters). The field team will document all of their activities, observations and measurements in either field logbooks or on pre-printed data collection forms. In addition, chain-of-custody records will be maintained for all samples collected for the ongoing monitoring program (see "Chain-of-Custody" section in this chapter).

QA/QC samples will be generated in the field. The laboratory will not be able to differentiate the field QA/QC samples from the original samples and, therefore, the QA/QC samples will be handled as if they were original samples by the laboratory. All samples will be transported from the field to the laboratory packed in ice. Samples may be put in a cooler, or ice can be put directly in the sample bottle carrousel and transported promptly to the lab.

The following QA/QC samples will be submitted for analysis:

- Travel blanks
- Field blanks
- Field duplicates
- Blind standards
- Automatic sampler blanks

<u>Travel Blanks</u>

Travel blanks will be employed to determine potential sample contamination occurring during: 1) shipment and storage of the samples; and 2) during laboratory handling and analysis of the samples. Travel blanks are created at the laboratory by filling a sampling bottle with reagent-grade deionized water. The travel blank is then transported to the sampling site in the field and then returned to the laboratory for analysis. Travel blanks should be prepared and analyzed for approximately 10% of monitored storm events.

Under the city's ongoing monitoring program, approximately 12 to 15 storms will be monitored at up to five stations each year. To maintain a QA/QC sample collection frequency of 10% of the monitored storms, a travel blank should be collected once per year per site.

Field Blanks

Field blanks will be employed to determine potential sample contamination occurring during: 1) sample collection; 2) handling; 3) shipment; 4) storage; and 5) laboratory handling and analysis of storm water samples. The field blanks for the grab samples will be created by transferring reagent-grade deionized water in the field from the collection container to the appropriate sample bottle and handling them with procedures identical to those used for the original samples. Since there is no practical method for obtaining a field blank with an automatic sampler without interrupting the sampler program, field blanks will not be analyzed for samples collected by automatic sampler. Under the city's ongoing monitoring program, grab samples will only be collected during one storm at up to five stations once during the 5-year permit term and at most once each year. To maintain a minimum QA/QC sample collection frequency of 10% of the monitored storms, a field blank should be collected at one station during one storm during which grab samples are collected.

Field Duplicates

Field duplicates will be used to assess natural sample variability or variability attributable to field collection, sample handling, shipment and storage methods, and to laboratory handling and analysis. For the grab samples, field duplicates are created by filling 2 sets of identical grab sample containers at the same location and at the same time from the same large grab sample. Duplicate samples will not be analyzed for samples collected from the automatic sampler. Duplicate samples will be analyzed for approximately 10% of the grab samples collected. Under the city's ongoing monitoring program, grab samples will only be collected during one storm at five stations once per 5-year permit term. To maintain a minimum QA/QC sample collection frequency of 10% of the monitored storms, a field duplicate should be collected at one station during one storm during which grab samples are collected.

Blind Standards

Blind standards can be used to assess the laboratory's ability to accurately prepare and analyze the samples for the parameters of concern. Blind standards are created either by spiking a sample container of reagent grade deionized water with known amounts of the target analyses or by purchasing prepared solutions of the target analyses and transferring them to the appropriate sample containers. There is no practical method to prepare a blind standard in the field since field teams will deliver bottles from the automatic samplers directly to the laboratory. Therefore, blind standards should be prepared only for the grab sample parameters. Blind standards will be submitted to the laboratory as original water samples at a frequency of once per year over the 5-year monitoring program. Submittal of blind standards early in the program will provide an evaluation of laboratory preparation and analysis procedures.

Autosampler Bottle Blank

To verify the effectiveness of the autosampler bottle cleaning, one set of bottle blanks should be analyzed for the full suite of autosampled parameters. The bottle blanks should be generated by filling a set of cleaned autos ampler bottles with reagent grade deionized water and submitting them blind to the laboratory for analysis. Contamination of the bottle blanks may indicate a need to revise the bottle cleaning procedure. Bottle blanks should be submitted to the laboratory as original water samples at a frequency of one per year.

QC Sample Labeling/Identification

All QC sample bottles should be pre-labeled on the bottles rather than the cap to identify the sample for laboratory analysis. The sample labels should include the type of sample (grab or composite), the type of QC sample (field duplicate, trip blank, etc.), and the field team names, date, time, and location. QC sample identification will use the following format:

<u>QC Sample Numbering Scheme:</u>

<u>QC Samples</u>

S- YYMMDD-T-NN

where:
S = Site Identification
TT = Year
MM = Month
DD = Day

T = Type of sample
- G = Grab sample
- C = Composite sample bottle

NN = Type of QC sample
- 01 = Field Duplicate
- 02 = Autosampler Bottle Blank
- 03 = Trip Blank
- 04 = Field Blank

Example: 01-920710-G-03

This sample is from monitoring site 01 (e.g. Acker Place site), collected on July 10, 1992. It is a trip blank grab sample.

Example: 01-920710-C-03

This sample is from monitoring site 01 (Acker Place), collected on July 10, 1992. It is an autosampler bottle blank.

<u>Blind Standards</u>

7-YYMMDD-G

where:
7 = Blind Standard
YY = Year
MM = Month
DD = Day
G = Grab sample

Example: 7-920715-G

This sample is a blind standard QC sample created on July 15, 1992 and submitted to the labs blind. The sample numbers for the blind standards samples will all begin with the number 7. The blind standard is a grab QC sample.

2.4.2 LABORATORY PROCEDURES

The laboratory is required to follow the requested analytical methodology (40 CFR Part 136 or other any suitable method if no analytical method is approved) for each parameter in order to produce reliable results. Laboratory analyses should be conducted under a QA/QC plan developed for this project. For the ongoing monitoring program, Table 2-3 presents a summary of the parameters, optimum and minimum sample volumes, sample types, containers, preservatives, and holding times.

Laboratory QA/QC measures will include:

- Initial and continuing calibration standards
- Performance check standards
- Method blanks
- Surrogate spikes
- Matrix spikes
- Duplicates.

Initial calibration standards are analyzed at the start of the project and establish the instrument's working linear range. Continuing calibration standards are generally analyzed on a daily basis and demonstrate that the instrument's response has not drifted out of control. The limits for the initial and continuing calibrations are either specified in the methods or will be specified in the analytical request submitted to the laboratory .

Performance check standards are prepared by the laboratory separately from the calibration standards. They are analyzed as a sample by the laboratory and are used to assess accuracy of the analytical procedures.

Method blanks are generally in the lab at the time of sample preparation. Method blanks are analytical controls consisting of all reagents, internal standards and surrogate standards that are carried through the entire analytical procedure. Method blanks are used to define the level of laboratory background contamination.

Surrogate spike compounds are added to every blank, sample, matrix spike, matrix spike duplicate, and standard and are used to evaluate analytical efficiency by measuring recovery.

A matrix spike is an aliquot of a storm water sample fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.

A duplicate sample is a second aliquot of an existing sample that is also analyzed in order to determine the precision of the method.

2.4.3 CHAIN OF CUSTODY

The ability to trace possession and sample handling from time of collection, through analysis and reporting of results and final disposition will be utilized to ensure the integrity of the sample results. This will be achieved through the chain-of-custody process. To establish the documentation necessary to trace sample possession from time of collection, a chain-of-custody record shall be completed and accompany every storm sample. The record shall contain the following information:

- Sample number/location

- Signature of collector
- Date and time of collection
- Sample tag number
- Signatures of people involved in the chain of possession
- Inclusive dates and times of possession

Blank chain-of-custody forms to be used for all grab and composite samples are presented in Part C of Appendix D.

A sample is considered to be in an individual 's custody if anyone or more of the following conditions exist:

1. The sample is in that individual's possession.
2. The sample is in view of the individual after possession has been taken.
3. The sample is secured by that individual so that the sample cannot be altered.

An individual who has taken custody of samples must comply with the chain-of-custody procedures. To maintain chain-of-custody, each individual in custody of the sample must sign the chain-of-custody forms at the time of accepting and relinquishing sample custody. Samples shall not be left unattended unless placed in a secured container with the chain-of-custody record.

In addition to the chain-of-custody procedures, the sampling team will document all field activities in field logbooks. Custody of samples prior to shipment to the laboratory should be traceable through both the chain-of-custody record and the field logbooks.

2.5 SAMPLE VOLUME REQUIREMENTS

Sample volume requirements for analysis of the full suite of parameters collected during the ongoing monitoring program are dependent on individual laboratory requirements. There should be no problem collecting sufficient sample volume for the manual grab sample since field crews must be present in the field to collect these samples. Since the ongoing monitoring problem only calls for, at most, one grab sample per station per year, obtaining the required volume for the full suite of parameters will not be a problem.

Since fewer pollutants will be analyzed during the routine sampling, optimum and minimum sample volumes are reduced. Table 2-3 provides the optimum and minimum sample volumes for each measured group/parameter. These volumes may vary depending on the laboratory used. It is likely that a storm which fill at least 3 to 4 bottles will contain sufficient volume for laboratory analysis.

SAMPLE ACKNOWLEDGEMENT / TRANSFER FORM

PROJECT:________________________________ **PROJECT MGR:** ____________________

SUBMITTED BY: ____

COMMENTS: ____

____

	COUNT	CONTAIN. TYPE	ID. NO.	SITE ID.	DATE	TIME	GRAB / COMP	VOL.
CYANIDE								
PHENOL								
VOA								
BACT.								
OIL & GREASE								
METALS								
Hg								
SOLIDS BOD5 DIS. P								
COD NUTS								
DETERG.								
Cu								

LABORATORY SAMPLE ACCEPTANCE CRITERIA SATISFIED:______________________________
(LAB PERSONNEL)

SAMPLES RELINQUISHED BY: ______________________________ **DATE:**________________

SAMPLES RECEIVED BY: ______________________________ **DATE:**________________

TRANSFER TIME: ________________________

FORM REVISION: 031092

CITY OF KNOXVILLE
NPDES STORM WATER PERMIT APPLICATION
ONGOING MONITORING PROGRAM

SAMPLE ACKNOWLEDGEMENT / TRANSFER FORM

STATION:_______________________________ **STORM EVENT DATE:** ____________________
SUBMITTED BY: ______________________________________ **DATE:** ____________________
SAMPLE TYPE: ____
COMMENTS: ____
____
____
____

SAMPLE ID	SAMPLE VOLUME	CONTAINER DESCRIPTION	PARAMETER	% CONTAINER VOLUME FOR COMPOSTING

LABORATORY SAMPLE ACCEPTANCE CRITERIA SATISFIED:_____________________________
(LAB PERSONNEL)
SAMPLES RELINQUISHED BY: _______________________________ **DATE:**________________
SAMPLES RECEIVED BY: ___________________________________ **DATE:**________________
TRANSFER TIME: ____
COMMENTS: ____
____
____
____

CDM

3.0 MONITORING STATION EQUIPMENT INSTALLATION, PROGRAMMING AND RELOCATION

The ongoing outfall monitoring program for Knoxville will employ automatic samplers, flow meters, and rain gages to collect the required flow composite samples. This section describes the automatic sampling equipment and typical configurations and installations for NPDES storm water monitoring sites.

3.1 SAMPLING SITE ANALYSIS

A preliminary analysis should be performed at each monitoring site to predict the hydrologic and hydraulic storm runoff characteristics from the range of storm events. An example of a "Storm Water Monitoring Site Analysis" form is presented in Figure 3-1. This form should be completed for each monitoring site. Sampling station data summarized on this form include drainage area and hydrologic information. Land use, impervious area, developable area, downstream receiving waters, and structural BMPs must be identified for each site. The hydrologic information includes the mean storm event characteristics as well as characteristics for the "low" (e.g., minus 50% below the mean) and "high" (e.g., 50% above the mean) storm events. Field data collected during site inspections can be summarized on this form. Field data includes channel geometry measurements, slope calculations and site sketches.

Runoff can be estimated using standard hydrologic methods. These methods could range from use of simple Rational Equation runoff coefficients to more sophisticated hydrologic models such as the Storm Water Management Model (SWMM). Runoff characteristics should be evaluated to determine: 1) whether sufficient depth of flow will occur over the storm hydrograph to collect sample through the sampler intake, 2) whether peak flows or velocities will be a concern during monitoring or grab sample collection by field crews, and 3) estimated total runoff volume.

Figure 3-1

CITY OF KNOXVILLE NPDES STORMWATER PERMIT APPLICATION
STORMWATER MONITORING SITE SELECTION

IDENTIFICATION

Site Identification #	SAMPLE 1
Database ID #	
Description	SAMPLE SITE 1

OUTFALL DRAINAGE AREA

Land Use	Acres	% Total	% Imperv.	Runoff Coeff.
Forest/Open/Agricultural	3.2	5%	5%	0.24
Single Family Residential	59.8	95%	25%	0.39
Multi-Family Residential	0.0	0%	55%	0.61
Office/Commercial	0.0	0%	65%	0.69
Industrial	0.0	0%	75%	0.76
Public	0.0	0%	50%	0.58
Total	63	100%	24%	0.38

% Built Out (Is open space developable?)	NO
Name of Receiving Water	

Structural BMPs	
Describe Type	NONE
% Coverage of Existing Dev.	NONE
% Coverage of Future Dev.	NONE

HYDROLOGY

Mean Storm Event	Low	Medium	High
Volume (inches)	0.21	0.42	0.63
Duration (hours)	3.5	7.0	10.5
Intensity (in/hr)	0.06	0.06	0.06
Runoff Volume			
Runoff Coefficient	0.38	0.38	0.38
Runoff Volume Estimate (gal)	137,404	274,808	412,212
Runoff Volume Estimate (ft^3)	18,370	36,739	55,109
Peak Flow			
Runoff Coefficient	0.38	0.38	0.38
Rainfall Intensity (in/hr)	0.03	0.06	0.12
Estimated Peak Flow (cfs)	0.73	1.46	2.91

Figure 3-1

CITY OF KNOXVILLE NPDES STORMWATER PERMIT APPLICATION
STORMWATER MONITORING SITE SELECTION

Depth of Flow

Estimated Peak Flow (cfs)	0.73	1.46	2.91	
Manning Coefficient	0.25	0.25	0.25	
Channel Slope (ft/ft)	0.02	0.02	0.02	
Side Slopes (ft/ft)	0.5	0.5	0.5	
Bottom Length (ft)	2.4	2.4	2.4	
Normal Depth (ft)	0.32	0.56	0.90	trial & error
	0.85384	1.70762	3.41593	computed
	0.85394	1.70789	3.41578	check

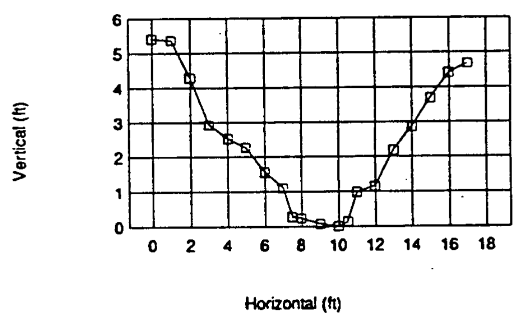
Measured Cross Section

X (ft)	Y (ft)
0	5.40
1	5.36
2	4.28
3	2.92
4	2.52
5	2.26
6	1.55
7	1.10
7.5	0.27
8	0.23
9	0.07
10	0.00
10.5	0.13
11	0.98
12	1.15
13	2.17
14	2.85
15	3.68
16	4.40
17	4.67

Slope Calculation

Length (ft)	Depth (ft)	Slope (ft/ft)
0	8.32	NA Upstream
10	8.41	0.01 @ X-section
20	8.73	0.03 Downstream
		0.02 Average

CROSS SECTION AT SAMPLE SITE
LOOKING D/S



The site analysis also should consider unusual hydraulic effects at each site. These effects might include potential backwater effects from downstream structures or waterbodies, and channel obstructions or configurations that may impact flow rating measurements.

For the Acker Place monitoring station, much of this background site analysis has been completed by the United States Geological Survey (USGS) as part of the Part 2 representative outfall program. Remaining sites chosen for the ongoing monitoring program may also include sites which were monitored as part of the USGS program. Available USGS or TVA reports should be reviewed when conducting site analysis.

3.2 ISCO 3700 AUTOMATIC SAMPLER

Only "off the shelf" equipment from well-established manufacturers will be used for the Knoxville NPDES permit term monitoring program. Custom equipment which may be difficult to operate and maintain over the 5-year permit term should be avoided. The ISCO 3700 sampler provides high lift capability , accurate delivery of sample volumes, high sample line velocity of 3 to 5 feet per second, and purge cycle(s) to minimize cross contamination of samples.

3.2.1 GENERAL CONFIGURATION

The ISCO 3700 automatic sampler consists of an intake line/strainer, a peristaltic pump, sample containers, and a controller. The sampler intake lines are vinyl (3/8 inch inside diameter) and the intake strainer is polypropylene. The intake strainer is attached at the end of the intake line and should be securely mounted in a well mixed section of flow. For the City's ongoing monitoring program, the City's automatic samplers will have a 24 one-liter poly bottles configuration. Until samples are transferred to laboratory containers, sample liquid will contact only vinyl, teflon, polypropylene, and silicon rubber. For priority pollutant applications, the sampler should be configured with Teflon-lined intake lines, a stainless steel strainer, and glass sample bottles with Teflon-lined caps. The samplers can be powered by a 12 volt direct current (VDC) deep cycle marine battery or by a direct AC power line to the site from an electric outlet. The City has established electrical power to the Acker Place site and will consider the same for future sites.

The flow meters available to the city are configured with a modem to allow connection to standard telephone lines which allows the station to be monitored from a remote office location during a storm event using a personal computer (PC). The City has provided a telephone connection to the Acker Place site and plans the same configuration for all future sites.

There are a variety of ways to configure ISCO 3700 automatic storm water samplers to collect representative samples from a flow stream. Samples can be collected with a fixed time interval between each sample or after a set volume of storm water has passed the monitoring point. Initially, the City's samplers will be configured to sample fixed volumes at fixed time intervals.

3.2.2 INSTALLATION CONSIDERATIONS

Installation of a sampler is highly site specific but general guidelines apply. The sampler should be located on a relatively flat surface at an elevation not exceeding 26 feet (the maximum suction lift) above the sampling point. The intake strainer is attached at the end of the intake line and must be securely mounted in a well-mixed portion of the flow stream. The intake strainer should be mounted so the channel bedload of solids or floating material is avoided. The intake line should be continuously sloped downhill from the sampler to the sampling point. The intake line will be protected within a PVC conduit or a flexible electrical conduit which will be anchored to avoid stress on the line. The protective conduit should not have sharp bends which could pinch the intake line during the sampling cycle. The line should be cut to the shortest length possible (even one foot increments). This will extend battery and/or pump tube life because a shorter pumping cycle will be needed to deliver the sample volume. Loops of coiled intake line or kinks in the intake line must be eliminated. This will facilitate drainage of the intake line between sample collection and ensure that purging and rinsing the intake lines before sampling will minimize cross contamination of samples.

3.2.3 PROGRAMMING THE ISCO 3700 SAMPLER

The programming mode in the ISCO 3700 sampler is self prompting. The control panel of the ISCO 3700 sampler is shown in Figure 3-2. Prompts displayed on the samplers's liquid crystal display (LCD) step through the programming process. If the unit is turned off or power is disconnected, the programming settings are retained in the sampler's memory. The sampler will accept only appropriate values for the program settings and will reject any unacceptable values. The sampler has three operating states: 1) standby, where the sampler is waiting for instructions, 2) run, where the sampler is executing a program or routine, and 3) the interactive state where the sampler is programmed. The interactive state contains two branches: the program sequence and the configuration sequence.

Configuration Sequence

The configuration sequence initially sets up the sampler specifications such as clock setting, bottle options, suction line data, purge/rinse cycles, etc. The configure sequence also enables various programming options. Figure 3-3 presents the recommended ongoing monitoring configuration sequence for the ISCO 3700 sampler. The prompt displayed on the sampler's LCD are presented. The default selection (if any) will be blinking. The appropriate selection is selected either by pressing the arrow to "move" the blinking selection to another option or by using the number keys to enter a numerical response. Configuring the sampler is usually necessary only during the initial setup at a given sampling site. Detailed step-by-step procedures for configuring the sampler are presented in Part B of Appendix D (Procedure B-l).

Figure 3-2

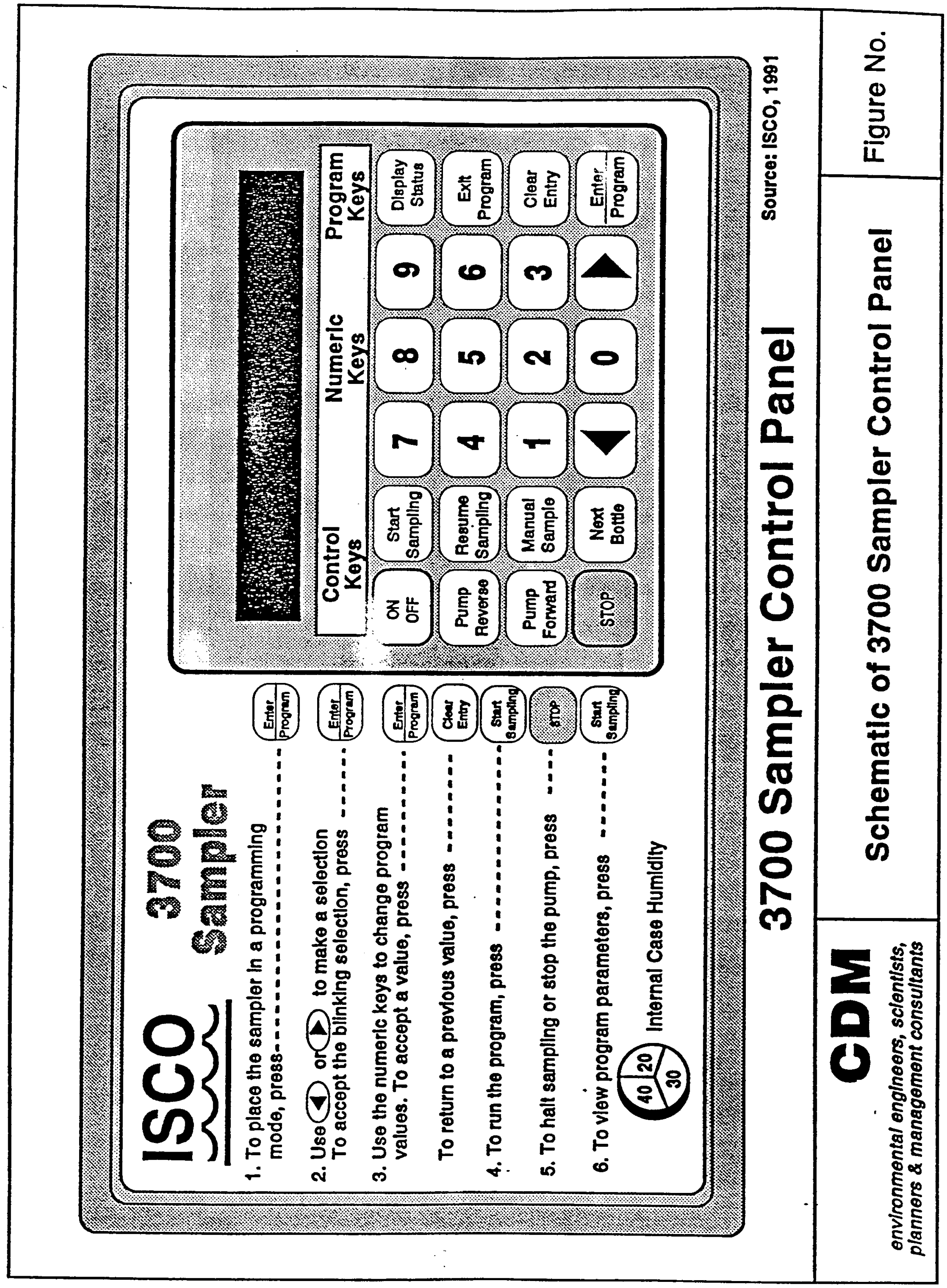

ISCO 3700 Sampler
1. To place the sampler in a programming mode, press
2. Use ◄ or ► to make a selection To accept the blinking selection, press
3. Use the numeric keys to change program values. To accept a value, press
To return to a previous value, press
4. To run the program, press
5. To halt sampling or stop the pump, press
6. To view program parameters, press
Enter Program
Clear Entry
Start Sampling
STOP
40 20 30
Internal Case Humidity
Control Keys
Numeric Keys
Program Keys
ON OFF
Pump Reverse
Pump Forward
STOP
Start Sampling
Resume Sampling
Manual Sample
Next Bottle
7 8 9
4 5 6
1 2 3
0
Display Status
Exit Program
Clear Entry
Enter Program
3700 Sampler Control Panel
Source: ISCO, 1991
CDM
environmental engineers, scientists, planners & management consultants
Schematic of 3700 Sampler Control Panel
Figure No.

Figure 3-3

ISCO SAMPLER MODEL 3700 CONFIGURING WORKSHEET

This example assumes a 24 bottle configuration where each bottle has a volume of 1000 ml.
It assumes a 3/8" ID TEFLON suction line with a length of 25 feet.
Selections shaded will be unique to each site.

ISCO Display #	Display	Selection	Comment
1.0	[PROGRAM, CONFIGURE] SAMPLER	CONFIGURE	Use arrow key and press ENTER/PROGRAM.
200.0	SELECT OPTION (<-- -->) SET CLOCK	ENTER/PROGRAM	Press the ENTER/PROGRAM key.
210.0	HH:MM MM/DD/YY *HH:MM MM/DD/YY*	11:40 4/16/92	This display requires five entries. Type the entry and press ENTER/PROGRAM.
200.0	SELECT OPTION (<-- -->) BOTTLES AND SIZES	ENTER/PROGRAM	Press the ENTER/PROGRAM key.
220.0	[PORTABLE, REFRIG] SAMPLER	PORTABLE	Use arrow keys, and press ENTER/PROGRAM.
222.0	[1, 4, 24] BOTTLES	24	Configures the sampler for 24 bottles.
223.0	BOTTLE VOLUME IS ---ML	1000	Enter the bottle size. This program uses 1000 ml bottles.
200.0	SELECT OPTION (<-- -->) SUCTION LINE	ENTER/PROGRAM	Press the ENTER/PROGRAM key.
230.0	SUCTION LINE ID IS [1/4, 3/8] INCH	3/8	Select the suciton line internal diameter.
231.0	SUCTION LINE IS [VINYL, TEFLON]	TEFLON	NPDES monitoring requires to use of TEFLON intake lines.
232.0	SUCTION LINE LENGTH IS -- FEET (3 - 99)	25	Example: 25 ft Be sure length is in even foot increments.
200.0	SELECT OPTION (<-- -->) LIQUID DETECTOR	ENTER/PROGRAM	Press the ENTER/PROGRAM key.
240.0	[ENABLE, DISABLE] LIQUID DETECTOR	ENABLE	This turns the liquid detector on.
241.0	- - RINSE CYCLES (0 - 3)	1	Example: 1.
242.0	ENTER HEAD MANUALLY? [YES, NO]	NO	This adds the suction head setting to the programming sequence.
243.0	RETRY UP TO - TIMES WHEN SAMPLING (0 - 3)	1	Example: 1.
200.0	SELECT OPTION (<-- -->) PROGRAMMING MODE	ENTER/PROGRAM	Press the ENTER/PROGRAM key.
250.0	[BASIC, EXTENDED] PROGRAMMING MODE	BASIC	Use arrow keys and press ENTER/PROGRAM.
200.0	SELECT OPTION (<-- -->) CALIBRATE SAMPLER	ENTER/PROGRAM	Press the ENTER/PROGRAM key.
290.0	[ENABLE, DISABLE] CALIBRATE SAMPLER	ENABLE	Use arrow keys and press ENTER/PROGRAM.
200.0	SELECT OPTION (<-- -->) START TIME DELAY	ENTER/PROGRAM	Press the ENTER/PROGRAM key.
310.0	---- MINUTES DELAY TO START (0 - 9999)	0	Example: 0 minutes delay of start time. Enter 0 and press the ENTER/PROGRAM key.

Figure 3-3

ISCO SAMPLER MODEL 3700 CONFIGURING WORKSHEET

This example assumes a 24 bottle configuration where each bottle has a volume of 1000 ml.
It assumes a 3/8" ID TEFLON suction line with a length of 25 feet.
Selections shaded will be unique to each site.

ISCO Display #	Display	Selection	Comment
200.0	SELECT OPTION (<-- -->) ENABLE PIN	**ENTER/PROGRAM**	Press the ENTER/PROGRAM key.
320.0	MASTER/SLAVE MODE? [YES, NO]	**NO**	Use arrow keys and press ENTER/PROGRAM.
321.0	SAMPLE UPON DISABLE? [YES, NO]	**NO**	Use arrow keys and press ENTER/PROGRAM.
322.0	SAMPLE UPON ENABLE? [YES, NO]	**NO**	Use arrow keys and press ENTER/PROGRAM.
323.0	RESET SAMPLE INTERVAL? [YES, NO]	**YES**	Use arrow keys and press ENTER/PROGRAM.
200.0	SELECT OPTION (<-- -->) EVENT MARK	**ENTER/PROGRAM**	Press the ENTER/PROGRAM key.
330.0	[CONTINUOUS SIGNAL, PULSE]	**PULSE**	Use arrow keys and press ENTER/PROGRAM.
332.0	AT THE BEGINNING OF [PURGE, FWD PUMPING]	**FWD PUMPING**	Use arrow keys and press ENTER/PROGRAM.
200.0	SELECT OPTION (<-- -->) PURGE COUNTS	**ENTER/PROGRAM**	Press the ENTER/PROGRAM key.
340.0	---- PRE-SAMPLE COUNTS (0 - 9999)	**150**	This sets the number of pre-sample pump counts needed to purge the intake line. The default is 150. Press the ENTER/PROGRAM key.
341.0	---- POST-SAMPLE COUNTS (0 - 9999)	**819**	This sets the number of post-sample pump counts needed to purge the intake line. Press the ENTER/PROGRAM key.
200.0	SELECT OPTION (<-- -->) TUBING LIFE	**ENTER/PROGRAM**	Press the ENTER/PROGRAM key.
350.0	---- PUMP COUNTS, WARNING AT ----		Informational display. Press the ENTER/PROGRAM key.
351.0	RESET PUMP COUNTER? [YES, NO]	**NO**	Use arrow keys and press ENTER/PROGRAM.
200.0	SELECT OPTION (<-- -->) PROGRAM LOCK	**ENTER/PROGRAM**	Press the ENTER/PROGRAM key.
360.0	[ENABLE, DISABLE] PROGRAM LOCK	**DISABLE**	Use arrow keys and press ENTER/PROGRAM.
200.0	SELECT OPTION (<-- -->) SAMPLER ID	**ENTER/PROGRAM**	Press the ENTER/PROGRAM key.
365.0	SAMPLER ID NUMBER IS ---------	**01**	Example: 01. Enter value and press ENTER/PROGRAM.
200.0	SELECT OPTION (<-- -->) RUN DIAGNOSTICS	**EXIT PROGRAM**	Press the EXIT PROGRAM key.
	-- STAND BY -- 11:59 4/16/92	**ENTER/PROGRAM**	Press ENTER/PROGRAM to begin the programming sequence.

NOTE: [shaded box] These entries will be unique for each site/time.

Program Sequence

The program sequence defines the sampling routine including sampler pacing, sample volumes, and sample distribution. Initial settings for each program parameter for the City of Knoxville ongoing monitoring program are presented in Figure 3-4.

Sample pacing options are either flow or time. Time pacing will be used initially under the Knoxville program. Sample distribution allows sequential or multiplexed sampling. Under a sequential mode, sample bottles are filled in order. Multiplexing allows programming for multiple "bottles per sample" or multiple "samples per bottle". The Knoxville ongoing monitoring program will initially employ the "samples per bottle" option because it is useful to collect a series of small aliquots within a single sample bottle. The sampler prompts for the required aliquot volume for each sample collected. The initial sample configuration for the Knoxville monitoring program will be four (4) sample aliquots per 1-liter sample bottle. Each sample aliquot should be 240 mL. The ISCO 3700 samplers provides a sample volume accuracy of ± 10% and repeatable to within ± 10 mL. Detailed step-by-step procedures for programming the sampler are presented in Part B of Appendix D (Procedure B-1).

Purge Cycles

The sampler should be programmed to purge the intake tube between collection of sample aliquots. The purge first fills the intake line until sample liquid reaches the peristaltic pump. Then the pump reverses, expelling the remaining liquid out of the intake line. The purge serves two purposes: 1) minimize cross contamination between samples, and 2) to clear blockage or accumulated solids around the intake strainer. If discrete samples are to be collected over the hydrograph, minimizing cross contamination between samples is critical. If only a single flow-composite sample will analyzed, cross contamination is less critical. Up to three purges can be programmed; however, the purges result in extra battery power consumption. For the Acker Place site, which has an AC power source, battery consumption is not a factor and three purges can be programmed. Only one (1),

Figure 3-4

ISCO SAMPLER MODEL 3700 PROGRAMMING WORKSHEET

This example assumes 250 ml aliquots to be taken every 15 minutes, with four aliquots filling a bottle.
Selections shaded will be unique to each site.

ISCO Display #	Display	Selection	Comment
1.0	[PROGRAM, CONFIGURE] SAMPLER	PROGRAM	Use arrow key and press ENTER/PROGRAM.
10.0	[TIME, FLOW] PACED SAMPLING	TIME	Use arrow key and press ENTER/PROGRAM.
21.0	SAMPLE EVERY --HOURS --MINUTES	0	Enter "0" to set the hours entry to 0.
21.0	SAMPLE EVERY --HOURS --MINUTES	15	Enter "15" to set the minutes entry to 15.
35.0	MULTIPLEX SAMPLES? [YES,NO]	YES	Sets the routine for bottles per sample or samples per bottle multiplexing.
36.0	[BOTTLES PER SAMPLE, SAMPLES PER BOTTLE]	SAMPLES PER BOTTLE	Use arrow key and press ENTER/PROGRAM.
31.0	-- SAMPLES PER BOTTLE (1 - 50)	4	Enter "4" to set the number of samples per bottle to 4.
50.0	SAMPLE VOLUMES OF --- ml EACH (10 - 990)	250	Enter sample volume of 250 ml.
90.0	ENTER START TIME? [YES,NO]	NO	Use arrow keys and press ENTER/PROGRAM.
310.0	--- MINUTES DELAY TO START (0 - 9999)	0	This sets the program to begin immediately.
	PROGRAMMING SEQUENCE COMPLETE...		This will automatically appear, and will be displayed briefly before returning to this standby state.
	--- STAND BY --- 11:02:00 4/16/92		Press START SAMPLING key to run the program.
141	START SAMPLING AT BOTTLE -- (1 - 4)	1	Starts the sampling routine with the first bottle. Press ENTER/PROGRAM to accept.
	--- SAMPLER INHIBITED --- 11:02:00 4/16/92		Display during normal operation. No entry is necessary.

NOTE: [shaded box] These entries will be unique for each site/time however, is recommended. For other sites in the program, which may not have an AC power source, one (1) purge cycle will be used. One purge cycle acts primarily to remove any accumulated solids from the intake tube, to clear the intake strainer of any settled sediment, and to rinse small droplets of the previous sample that adhere to the inside on the intake tube.

3.2.4 POTENTIAL SAMPLER PROBLEMS

The reliability and performance of automatic samplers can be improved if field personnel are aware of, and take steps to eliminate, the following potential problems. Most sampler problems are associated with the location and mounting of the intake strainer. The sampler intake strainer should be securely mounted to prevent damage from debris transported by fast moving storm flows. Cavitation around the intake strainer caused by high flow velocities can also be a problem in certain situations. The flexible intake tube connecting the intake strainer to the sampler is exposed to damage and potential vandalism. Therefore, the intake line should be encased in flexible electrical conduit which is either secured with clamps or trenched underground. The intake lines should be inspected regularly for holes, kinks, or loops which would cause low sample volume or cross-contamination of samples. All connections, especially the intake tube to the pump and the intake tube to the strainer, must be tight. The sampler programming should be routinely checked to verify that parameter selection and status is appropriate for a particular site. The caps of the sample bottles should be removed and placed in a plastic bag so as to minimize contamination. Detailed procedures for inspection of samplers and routine maintenance are presented in Section 6.0.

3.3 ISCO 3230 BUBBLER FLOW METER

The ISCO 3230 flow meters measure flow level and are configured with a dot matrix printer and internal memory which continuously records data measurements from several external probes including: 1) the flow level in the channel, 2) rainfall accumulations detected by a connected rain gage, and 3) sample collection times.

3.3.1 GENERAL CONFIGURATION

The ISCO 3230 flow meter uses a bubbler system to measure flow level. Air, supplied by an internal compressor, is bubbled out of a line in the stream at a constant rate. The differential pressure head required to discharge air into the water column corresponds to the depth of the water in the stream. The pressure is continuously measured and converted to an electric signal. The relationship between level or head and flow rate depth measurements (i.e., rating curve) is used to calculate the flow rate. The flow meter is interfaced with the sampler and is programmed to activate the automatic sampler when predefined criteria (e.g., flow and/or rainfall thresholds) for a storm event are met.

For the Knoxville program, the flow meter is programmed to initiate sampling based on user-selected conditions such as an increase in flow level or a specified rainfall volume over a time period. The conditions used to initiate storm event sampling are highly site specific. These conditions should be evaluated after each storm to determine whether adjustments are necessary. The flow meter can be powered by the same 12 volt direct current (VDC) deep cycle marine battery used to power the sampler or by a direct AC line provided to the site.

The flow meter's internal memory can be configured to record average flow level over a user selected time step. A 5-minute recording interval should be used when flows are changing rapidly (e.g., storm events). During baseflow periods, flows are relatively constant and longer recording intervals (e.g. 15-minute or 1-hour) should be used.

3.3.2 INSTALLATION CONSIDERATIONS

The flow meter measures open channel flow in a pipe or channel. Open channel flow is typically monitored at primary and secondary control sections. A primary control section is typically a structural flow control that produces a flow with a known relationship between level or head and flow rate. The primary flow control can either be a structure such as a weir or a flume located in the channel or a uniform and stable section of the channel or pipe. The secondary measuring device is an open channel flowmeter, such as the ISCO 3230, which continuously monitors the flow level or head in the channel. A properly installed weir or flume will produce a known head versus flow relationship without requiring field calibration; however weirs and flumes partially obstruct flow and require a certain amount of head loss to work properly. Weirs and flumes are accurate only over a limited range of flow rates.

Under the Knoxville NPDES storm water program, flow measurements will primarily rely on existing hydraulic structures (pipe, channels, weirs, etc.). Additional primary flow controls such as weirs or flumes will typically not be installed for this program. The selected monitoring sites will be characterized by sufficiently uniform and stable cross sections. The flow meter will record continuous stage or level measurements. Flow rate (cfs) is calculated from the continuous series of stage data after each storm event. The flow calculations should be based upon initial hydraulic calculations and subsequent limited field calibration (pipe or channel rating) measurements performed during high flows.

3.3.3 PROGRAMMING THE ISCO 3230 FLOW METER

Programming the ISCO 3230 flow meter involves configuring the memory of the flow meter as well as determining the control parameters of the flow meter's program. Most of the flow meter programming can be performed directly from the flow meter's keypad. Certain aspects of the programming must be performed through an IBM/compatible personal computer. The Knoxville program calls for the stations to be connected to standard telephone lines, and therefore flow meter programming and collection of monitoring data can be performed from a remote office location. If a site that is chosen cannot be accessed by a telephone line, a laptop computer would be needed to allow on-site programming of the flow meter.

FLOWLINK Software

ISCO FLOWLINK software and a computer are required to program and access the flow meter memory. FLOWLINK consists of several modules for memory management, data retrieval, database management and conversions, and report and graph generation. The module TELEFLOW is used to configure the flow meter's internal memory through a modem hook-up. The module LAPCOMM is used to configure the memory through a direct cable connection with a laptop computer. Detailed step-by-step procedures for configuring and programming the flow meter through TELEFLOW are included in Part B of Appendix D (Procedure B-l). Procedures for LAPCOMM vary only slightly and can be found in the FLOWLINK user's manual.

Memory Partitions

The flow meter is equipped with approximately 20K of non-volatile Random Access Memory (RAM). The flow meter's memory can be divided into three partitions. The size of each memory partition is user-selectable and should be determined considering the recording interval and the amount of data that will be collected between each flow meter interrogation. The memory partitions must be assigned to record data from the sampler and rain gage. A minimum of 64 readings can be allocated for the level, flow rate, or sampler partition and 28 readings for the rainfall partition. The maximum number of readings is the total capacity of the memory. The total capacity of the memory in readings varies according to the type of data stored.

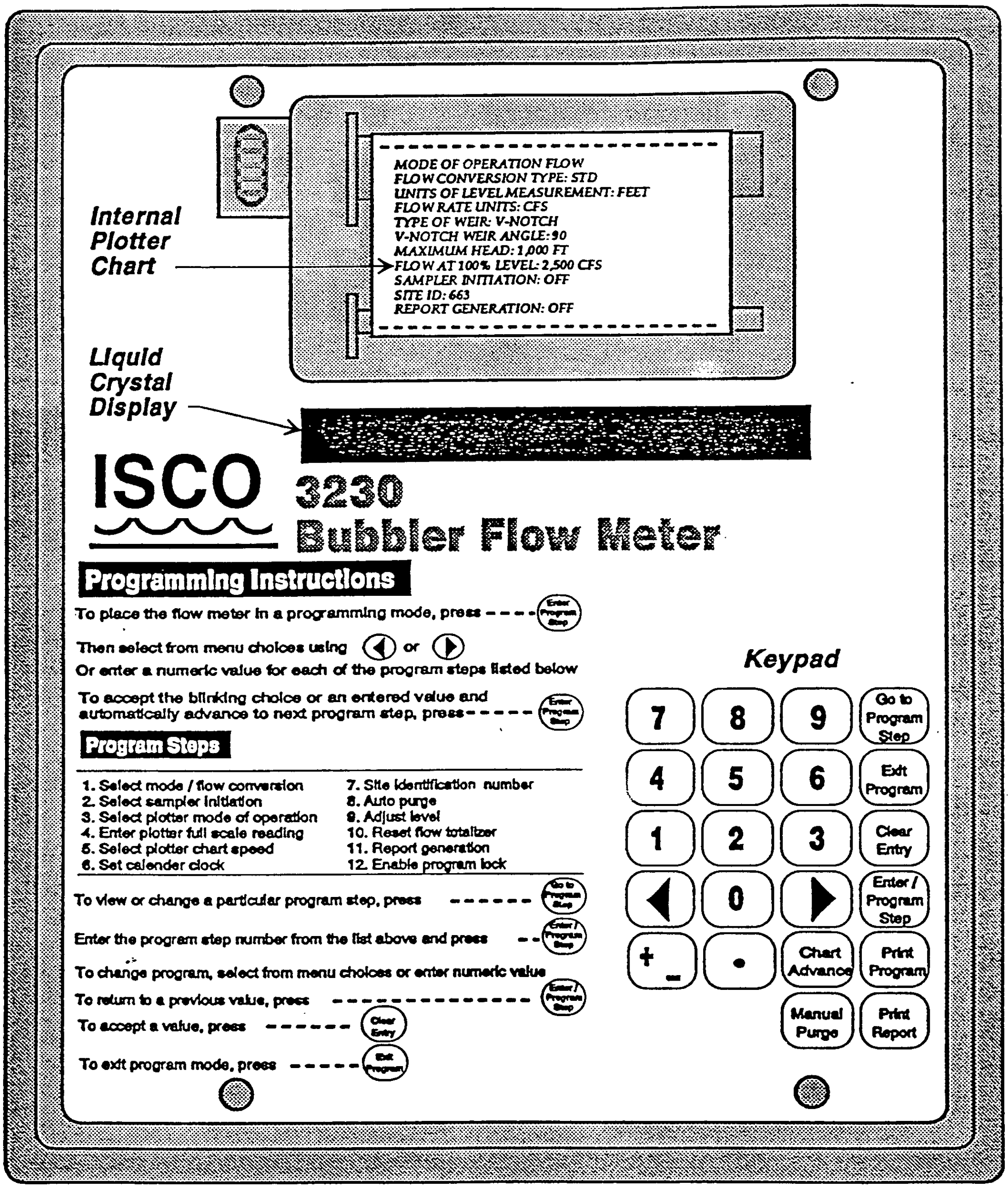
Four parameters must be specified when a new partition is created. These parameters are: type of data (level, flow, rainfall, or sampler); memory mode (rollover or slate) and any trigger conditions; size (in number of readings); and data interval (the amount of time between stored readings). Partitions which store sampler data do not require data intervals. A fifth specification, partition name, is optional. Creating a partition can be done only through the FLOWLINK software.

The flow meter's memory should be configured for three (3) partitions to store level data, rainfall data, and sampler data. The level and rainfall partitions should operate in triggered slate mode. This means that data will be stored in a continuous loop until a trigger condition (amount of rain, time, level reading, etc.) is satisfied. Once the trigger condition is satisfied, the flow meter stores data only until the partition memory is filled. This prevents storm data from being overwritten. The partition will receive new readings only after it has been restarted. The sampler partition should store data continuously. Part B of Appendix D (Procedure B-l) details the steps necessary to set up the ISCO 3230 flow meter.

Keypad Programming

A schematic of the front panel of the ISCO 3230 flow meter is presented in Figure 3-5. The flow meter is programmed with the aid of the LCD display. The keypad is used to enter program quantities and to control certain flow meter functions. The display is used to show both menu selections available and selections chosen (the entry selected will flash on the display). The display also indicates operational status and guides the user through the flow meter programming sequence by showing the step being programmed. Each time a key is pressed an audible signal is emitted. Channel or pipe rating measurements, if available, can be programmed into the flow meter. The flow meter can be preprogrammed for a number of primary devices (weirs, flumes, etc.). Initial program settings for the flow meter used for the Knoxville ongoing monitoring program are presented in Figure 3-6. These programming steps are also detailed in Part B of Appendix D (Procedure B-l). Advanced programming steps used in conjunction with standard weirs or flumes can be found in the manufacturer's user's manual for the flow meter.

Figure 3-5



Source: ISCO, 1991

3230 Bubbler Flow Meter

CDM environmental engineers, scientists, planners & management consultants	Model 3230 Front Panel, Showing Controls	

Figure 3-6

KNOXVILLE NPDES ONGOING STORMWATER MONITORING PROGRAM
ISCO MODEL FLOW METER 3230 PROGRAMMING WORKSHEET

This example assumes a 4 foot diameter pipe with current flow level of 0.15 feet.
Selections shaded will be unique to each site.

ISCO Display #	Display	Selection	Comment
1.0	SELECT MODE OF OPERATION 1. FLOW 2. LEVEL ONLY	LEVEL ONLY	Use Arrow Key and press ENTER
1.2	SELECT UNITS OF LEVEL MEASUREMENT 1. FEET 2. METERS	FEET	Selects feet as the unit of measurement
2.2	SELECT SAMPLER CONTROL 1. ENABLE 2. DISABLE 3. ENABLE BY LEVEL	ENABLE BY LEVEL	Programs the flowmeter to initiate sampling only when flow level increases
2.21	ENTER LEVEL AT WHICH TO ENABLE SAMPLER LEVEL: X.XXX FT	0.2	Enter the level which indicates the beginning of storm runoff, usually 0.2 to 0.3 ft above baseflow
2.22	ONCE ENABLED, SAMPLER WILL: 1. STAY ENABLED 2. DISABLE BELOW X.XX FT.	DISABLE BELOW X.XX FT.	This programs the flowmeter to stop the sampler if the flow falls below the storm threshold level
2.24	SELECT PLOTTER ON/OFF WITH SAMPLER ENAB: 1. NO 2. YES	NO	This will keep the plotter operational when the sampler is enabled
3.0	SELECT PLOTTER MODE OF OPERATION: 1. OFF 2. LEVEL	LEVEL	The plotter will record level information
4.0	ENTER PLOTTER FULL-SCALE READING: 100% LEVEL = __.__ FT	4.00	Enter the pipe diameter in feet. Note flowmeter will over-range once effectively doubling this entry
5.0	SELECT PLOTTER CHART SPEED: 1. .5"/HR 2. 1"/HR 3. 2"/HR 4. 4"/HR	1"/HR	This will generate 24" of chart per day and will provide a hard copy back up of storm data
6.0	SET: YEAR MONTH DAY HOUR MINUTE	1992 04 15 14 22	Example: April 15, 1992 at 2:22 PM Display will blink prompting input
7.0	ENTER SITE IDENTIFICATION NUMBER: SITE NUMBER = ____	001	Example: Site #001
8.0	SELECT AUTO-PURGE FREQUENCY 1. OFF 2. 5 3. 10 4. 15 5. 30 6. 60	60	Purges the bubbler line every 60 minutes. More frequent intervals recommended for high sediment
9.0	ADJUST LEVEL: UP/DOWN OR VALUE ENTER PRESENT LEVEL	0.15	Enter the current level at the bubbler Used for calibration of level readings
11.0	REPORT GENERATION 1. ON 2. OFF 3. PRINT	ON	Switches the internal plotter ON
11.1	CLEAR REPORT AFTER PRINT: 1. YES 2. NO	NO	Clears current report after printing
11.2	REPORT INTERVAL TO BE IN: 1. HOURS 2. DAYS 3. MONTHS	DAYS	Selects days for reporting interval
11.3	ENTER INTERVAL IN HOURS: ____ DAYS	1	Generates a printed report once per day
11.4	ENTER THE INTERVAL START TIME: YR:____ MONTH:____ DAY:__ HR:__ MIN:__	1992 04 15 14 22	Example: April 15, 1992 at 2:22 PM Display will blink prompting input
12.0	ENABLE PROGRAM LOCK? 1. YES 2. NO	NO	Disables password NOTE: password is "3230"
	LEVEL 14:22 15-APR-92 0.150 FT		Display during normal operation. No entry is necessary.

NOTE: [shaded box] These entries will be unique for each site/time

3.3.4 POTENTIAL CONSTRAINTS

Flow monitoring at sites which may be impacted by surcharge during storm events should be avoided because flow measurements will be inaccurate. The flow meter should be located within 50 feet of where the bubbler line is mounted in the stream. This is the maximum length of the standard bubbler line available. Generally, bubbler lines should be kept as short as possible. The water level above the bubbler line cannot exceed 10 ft.

Normal position of the bubbler line in the flow stream is at right angles to the flow. However, flow stream velocities of greater than five feet per second can result in lower measured liquid levels than the actual level in the flow stream. In this case, the end of the bubbler line should be positioned downstream parallel to the flow. The flow meter should be calibrated to the actual flow depth in the pipe or stream.

An advantage of the bubbler type flow meter is that all of the sensitive electronic components of the meter are protected in the instrument housing. The bubbler line is the only part exposed to storm flows and potential vandalism. This line can be easily and inexpensively replaced. The bubbler line does require special care to prevent conditions that may result in collection of inaccurate data. Holes and kinks can form in the bubbler line, causing inaccurate level readings. The flow meter must be periodically calibrated since the level calibration can drift after a period of time. Adjustments may be necessary to reset the level reading to match the actual flow stream depth. Improper programming can also cause errors. Detailed procedures for inspection and maintenance of the ISCO 3230 flow meter, presented in Section 6.0, should be carefully followed.

3.4 TIPPING BUCKET RAIN GAGE

3.4.1 GENERAL CONFIGURATION

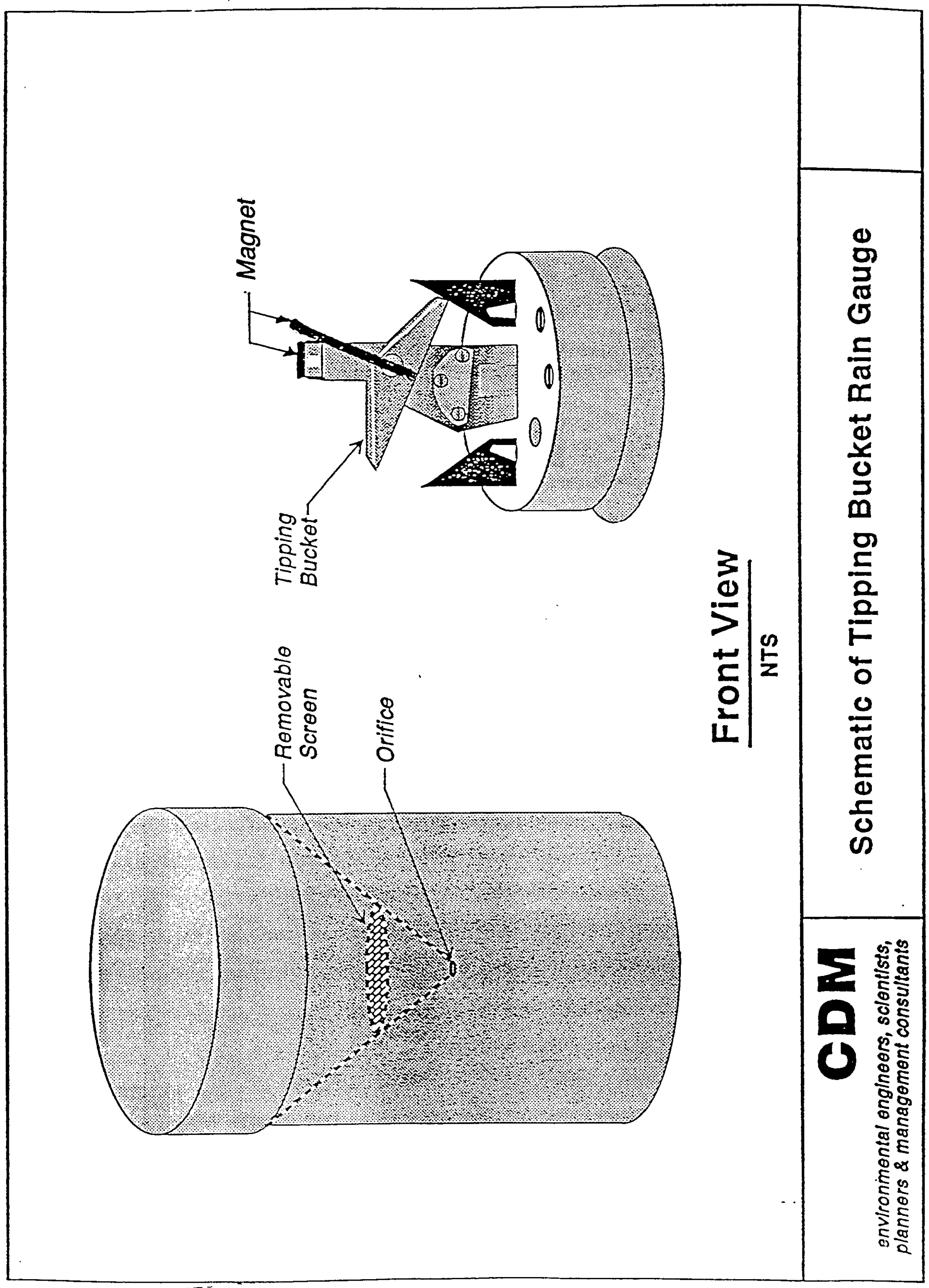
A schematic of a tipping bucket rain gage used to measure rainfall volume is presented in Figure 3-7. Rain is collected in a standard eight-inch National Weather Service (NWS) cylinder. Rainfall collected in the cylinder is funneled into the tipping bucket mechanism. The funnel is screened to keep out debris. The bucket tips when a volume equivalent to 0.01" of water over the cylinder orifice has accumulated. As the bucket tips, it causes a 0.1-second switch closure which is recorded by an external datalogger. The tip also brings a second bucket into position under the funnel, ready to fill and repeat the cycle. After the rain water is measured, it drains out through the base of the gage. The drain holes are covered by screens to prevent insect entry.

3.4.2 INSTALLATION CONSIDERATIONS

Careful consideration should be given to the location of the rain gage. The most accurate measurements are taken in sheltered areas which block wind and eddy currents in the vicinity of the gage. Fences or other objects can act together to serve as an effective windbreak. As a general rule, the heights and distances of the windbreak objects should be uniform. Their height above the rain gage should not exceed about twice their distance from the gage location. Since it is not always possible to select sites which provide adequate protection from adverse wind effects, an open site away from isolated objects may also be used.

The rain gage should be calibrated once installed according to Part B of Appendix D (Procedure B-7). Periodically, the rain gage' s calibration should be verified for possible mechanical problems. These problems are discussed in Section 6.0.

Figure 3.7


Magnet
Tipping Bucket
Removable Screen
Orifice
Front View
NTS
Schematic of Tipping Bucket Rain Gauge
CDM
environmental engineers, scientists,
planners & management consultants

3.5 EQUIPMENT INSTALLATION PROCEDURES

Storm water monitoring equipment should be installed only after conducting a final field investigation to document actual field conditions. The field inspection should provide sufficient information to fmalize equipment configurations and prepare installation schematics. Each installation will include a platform, shelter, and intake line protection. A fiberglass equipment shelter will be installed at each site to provide additional security and protection for the flow meter and sampler. To the extent possible, equipment installations should be standardized and prefabricated to ensure consistency between sites and to minimize installation time required.

3.5.1 FIELD INSPECTION

Prior to equipment installation, a field inspection should be performed by personnel who are familiar with the capabilities of the sampling equipment and have a practical knowledge of the hydrologic characteristics of the site. A final field inspection is required to evaluate site conditions and to develop site-specific plans which confirm feasibility of equipment installations and are used to finalize equipment configurations. The field investigation should assess each site for accessibility , hydraulic characteristics, safety hazards, and feasibility of equipment installation.

Accessibility

Each site should be assessed to determine whether it can be easily accessed by field crews for equipment installation, maintenance, and storm event inspections. The location of off-street parking, walking distance to the site, the location of fences, or private property should be noted during the field investigation.

Accessibility will be difficult at locations where monitoring equipment must be hung in a manhole. In order to perform the required manual grab sampling, equipment checks, and flow rating measurements, it will probably be necessary to first remove sampling equipment from the manhole. Manhole installation may also require installation by field personnel who are trained in OSHA confined space entry requirements. Manholes along roads with high traffic volumes or high speed limits should be avoided altogether.

Hydraulic Characteristics

The field investigation should eliminate potential sites where backwater effects caused by downstream conditions were observed. Field inspections should be conducted (when possible) during or soon after storm events to determine site conditions during high flow periods. The locations of upstream tributaries should be also be noted and the degree of mixing in the stream as indicated by the presence of plumes, turbulence, or flow velocity should be assessed.

The type of hydraulic control existing at the site or feasibility of installing a primary flow control device (weir, flume) should be assessed during the field investigation, although the Knoxville ongoing monitoring program will typically not require the installation of weirs or flumes. The development of a stage-discharge rating for open channels requires a uniform and stable channel for a distance equal to at least six channel widths upstream of the station. Access for performing rating measurements during storm events (bridge/culvert or wadable cross section) should be noted.

Safety Hazards

Potential hazards in the immediate vicinity of the monitoring site should be also assessed. The safety of the field crews as well as public safety aspects should be considered. Potential hazards include:

- Slips, trips, and falls related to steep slopes or poor footing
- Deep water/high flow velocities
- Proximity to roads with high traffic volume or high speed limit

Potential measures to minimize hazards at sites that were otherwise acceptable should also be identified. Additional safety equipment required to safely sample at a site (traffic controls, ropes, etc.) should be also noted.

Site Suitability

Site suitability factors should consider the installation of monitoring equipment and access by field crews during storm events. The following factors should be assessed during the field investigation:

- Property ownership: sites should be identified along public right-of-ways or on public property where possible.
- A relatively flat area (4 ft by 4 ft) for an equipment shelter is required for sampling equipment installation.
- The vertical distance from water surface to the station location should be considered. The sampler pumps provide a maximum vertical lift capability of about 25 ft. For manual sampling, the maximum practical length of a sample dipper is 10 ft to 15 ft.
- The availability of AC power should be assessed by noting the distance to the nearest power line pole. Provision of AC power to the monitoring station will greatly increase the reliability of a long-term automatic monitoring program.
- The feasibility of rain gage installation should be assessed by noting the amount of tree cover and the proximity of tall buildings in the area around the sampling station. The maximum practical separation between the sampling station and the rain gage is 50 ft to 100 ft. A single central rain gage location can be identified for sites in close proximity to one another.
- Public safety and security of equipment should also be considered based on qualitative judgement of the field investigator. The presence of small children, graffiti, and evidence of existing vandalism should be noted. The proximity of street lights, existing fencing, and police or fire stations, should also be noted.
- The potential for backwater conditions from downstream influences at the site during storm events should be also assessed.

Actual site conditions and potential hazards should be a primary consideration in determining whether storm event monitoring is feasible at each candidate monitoring site. The observations from the field investigation will facilitate proper equipment selection and installation and will potentially avoid delays and problems. The field investigation results will improve safety by either avoiding sites that cannot be safely sampled or noting special equipment needed for certain hazards.

3.5.2 EQUIPMENT PLATFORM

An equipment platform will be constructed at each monitoring location. The platform will provide a base for securing a fiberglass equipment shelter which will house the sampling equipment. The equipment platforms should be level and measure approximately 4 feet by 4 feet. Existing concrete pads at the monitoring sites should be considered if available and suitable. In most cases, the platform can be inexpensively fabricated from exterior grade plywood. To minimize potential vandalism problems, the plywood base should be securely mounted to the ground. If a relatively level space is available, the sampling equipment platform can be mounted on precast concrete beams to prevent tipping of the equipment shelters. The concrete beams can be anchored by small concrete footings. At sloping sites, a lightweight wooden deck should be constructed from pressure treated wood. Site work is difficult and time consuming at many monitoring locations since AC power typically is not available. Site work can be minimized by prefabricating the equipment platforms at a central location.

3.5.3 EQUIPMENT SHELTER

The flow meter, automatic sampler, and power source should be enclosed within an equipment shelter. The shelter can be constructed from wood or molded fiberglass. All shelters should be insulated, lockable, and ventilated. Provision of receptacles for AC power supply should be considered. The equipment shelter should include a flange around the base for bolting it to the equipment platform. Initially, the equipment shelters for the Knoxville program will be purchased from Plasti-Fab, a vendor which manufactures equipment shelters specifically for monitoring stations.

3.5.4 INTAKE LINES

Exposure of sampler intake tubing and flow meter bubbler line between the equipment platform and the sampling point in the storm water system should be avoided. This will minimize vandalism potential and ensure that these lines are not kinked or damaged by debris or high velocity storm flows.

The sampler intake tube and the flowmeter bubbler line should be routed through 3/4" PVC electrical conduit. Installation of the PVC conduit should avoid sharp right angle bends. Wide radius elbow fittings are available that will minimize the possibility of kinking the intake lines. The conduit should be secured with conduit clamps every 2 ft to 4 ft. Along earthen areas, the conduit can be secured by driving a 2x4 stake into the ground. Masonry anchors are required when the conduit must be secured to concrete surfaces. Sheet metal screws can be used for metal surfaces. If AC power in unavailable, a professional grade cordless drill will be required to install the masonry anchors and screws.

A standard electrical box can be installed in the equipment platform to secure the end of the conduit at the sampling equipment shelter. Portions of the intake lines which must be installed along the channel should be aligned to minimize flow obstruction. At sites where high flow velocities are anticipated, the lines should be anchored every 1 ft to 2 ft. The sampler intake should be installed midstream and parallel to flow. The sampler intake should be 3 ft to 6 ft downstream of the flow meter bubbler line to avoid causing turbulence that may interfere with flow measurements.

The flow meter bubbler line should be installed a sufficient distance upstream from the outfall to avoid hydraulic effects at the outfall discharge point. The length of the bubbler line should be kept as short as possible. The maximum length of bubbler line is 50 feet. For pipe installations, the bubbler line should be installed as close to the bottom as possible. The flow meter bubbler will terminate with a 4 ft long l/8-in ID stainless steel tube which should be securely fastened to the channel bottom using masonry anchors and small diameter cable clamps. The end of the bubbler line should be perpendicular to the flow. After installation, the intake lines should be hand checked to make sure they are secure.

3.5.5 RAIN GAGE MOUNTING POST

The tipping bucket rain gage requires a 12-in by 12-in plywood platform. A 25-ft connector cable is standard. In locations without any overhead obstructions, the rain gage can be installed on a 6 ft high 4x4 post mounted on the side of the equipment platform. The base of the post should be attached to a steel post anchor that is bolted to the equipment base. Steel braces should be used to secure the upper portion of the post to the equipment housing. The rain gage platform should be level. A cable connects the rain gage to the flow meter. Small cable staples should be used to fasten the cable to the rain gage post.

3.6 EQUIPMENT RELOCATION

3.6.1 PERMIT TERM YEAR 1 THROUGH YEAR 3

In the first two years of the permit term monitoring program, the City will install automatic sampling equipment at three to five sites. The ongoing monitoring program will initially extend monitoring at the five sampling stations monitored by the USGS to fulfill the Part 2 NPDES permit application requirements.

To increase the reliability and minimize the number of field personnel required to operate the monitoring program, the City is planning to install AC power and telephone lines to each of the long-term monitoring stations. The flow meters available to the city are configured with a modem to allow connection to standard telephone lines, which allows the stations to be monitored from a remote office location during a storm event using a personal computer (PC).

Based on the sampling protocols presented in Section 2, approximately 10 to 15 storm event samples per station per year will be collected over the first three years of the permit. All samples will be analyzed for those pollutants that were found to be present during the Part 2 monitoring program as presented in Table 2-1. In addition, the full suite of priority pollutants (toxic metals, volatiles, base/neutral acid extractables, and pesticides/PCBs) will be analyzed during one storm event per station during the 5-year permit term. Sampling for the full suite of pollutants will require a field crew to be on call to manually take grab samples during a storm event. Resource availability might restrict the frequency of sampling for the full suite of pollutants. Sampling at a frequency of 10 to 15 storms a year will provide a statistically significant number of sample points to refine pollutant loading factors, determine seasonal trends of pollutant loadings (if any), and assess the long-term effectiveness of management programs.

3.6.2 PERMIT TERM YEAR 4 THROUGH YEAR 5

The ongoing monitoring program will be re-evaluated during the fourth year of the permit and the City will decide whether to relocate monitoring stations at this time. To evaluate long-term trends, the City may wish to continue monitoring at the original sampling locations for the entire five-year permit term. This should provide sufficient storm event water quality data over a range of hydrometeorologic conditions to evaluate trends (e.g., improving vs. deteriorating water quality). Alternatively, there may be future opportunities for the City to assess BMP performance by relocating monitoring stations. For example a pair of monitoring stations located at the inflow and outflow to a structural BMP facility can be used to quantitatively measure pollutant removal efficiencies. Based on the third year evaluation of the program, the City will continue storm event monitoring during years 4 through 5 at up to five sites.

In addition, during the fourth year of the permit, the City will review the sampling protocols to determine whether other revisions are warranted. The re-evaluation of the City's storm water monitoring program will include the number of storms analyzed per station per year, water quality constituents submitted for laboratory analyses, and sample collection procedures and equipment. For example, certain constituents which are not detected in storm water discharges over a 2 to 3 year period will be dropped from the scheduled analyses. Under the City's proposed monitoring program, the full suite of priority pollutants (toxic metals, volatiles, base/neutral acid extractables, and pesticides/PCBs) will be analyzed during one (1) storm event per station per permit term. Pollutants consistently detected in these samples should added to the sampling program in the long term.

If the sampling stations will be relocated during years 4 through 5, the City will document the proposed new locations in an annual report. The proposed changes to sampling protocols, including the reasons for such changes, will be presented in the annual report.

4.0 STORM EVENT FIELD PROCEDURES

This section describes field procedures to be used immediately before and during storm events. Final equipment checks and adding ice to the samplers is required before each storm event. During storm events, field teams are sometimes required to visit each monitoring station to collect grab samples and check to make sure equipment is operating. If the rating curve for the site is incomplete, additional flow rating measurements should be performed during high flow conditions. Grab sampling will be performed either early in the storm or during periods of peak runoff if possible.

4.1 STORM EVENT PREPARATION

The field team should be mobilized immediately prior to and after the storm event to ensure proper collection of samples and to check that the sampling equipment is properly prepared and operational. If possible, the field team and the laboratory should be given a 24-hour notice of an approaching storm system. The final decision to mobilize field teams should be made 4 to 8 hours before the anticipated start of a storm to provide sufficient time to ice down sampler carrousels and perform final equipment calibration checks. For the storms which will be analyzed only for the selected pollutants described in Section 2, field teams should be prepared to inspect the stations immediately prior to and after storm events. It will not be necessary for field crews to be present at monitoring stations during storm events except when the full range of priority pollutants will be analyzed. This will occur at least once during the 5-year permit term.

4.1.1 STORM EVENT FORECASTS

The location of the nearest National Weather Service (NWS} station(s} and other local monitoring stations should be identified to aid in the forecasting of storm events. Television and radio weather forecasts should also be checked on a daily basis. Local cable "all weather" channels should also be considered if available. Rainfall recorded for the previous day at the nearest NWS station will also be noted in a rainfall database. The rainfall database will provide a continuous record of rainfall recorded at the NWS stations as well as at the NPDES monitoring stations equipped with rain gages. If localized rainfall patterns result in a discrepancy between gages, only the gage nearest to each monitoring site should be considered. Rainfall data collected by monitoring stations equipped with tipping bucket rain gages should be carefully scrutinized since many of these gages are easily accessible and can be impacted by birds, sprinklers, etc.

An effort should also be made to establish a local contact who lives/works in close proximity to each of the monitoring stations. This person should be contacted (during reasonable hours) at the beginning of a storm event to aid in determining conditions at each site. This information can be used in conjunction with observations made during site installation/calibration (e.g., short response time for highly impervious areas vs. longer response time for more pervious areas) to determine when to mobilize field teams.

4.1.2 FIELD TEAM SCHEDULING

For required grab sampling activities, the field crew has considerable flexibility in choosing the storm during which grab samples should be taken. The ongoing monitoring program calls for sampling for the full suite of pollutants at each site at a frequency of at least once during the 5-year permit term. The maximum number of stations for the ongoing monitoring program is five. Therefore, the field team should monitor the weather forecasts and choose a storm for grab sampling which is convenient to the field team (i.e. during normal working hours). If necessary, arrangements for field team "on call" availability during off-hours and weekends should be agreed upon in advance. Phone lists with home and work numbers should be distributed to all members of the field team.

All necessary sampling equipment should be prepared in advance and stored in a readily accessible area. A central contact person should be assigned who can make "go" or "no go" decisions as to whether to monitor a storm event. This person should contact "on call" field team members 4 to 8 hours before an anticipated storm event. "On call" field team members should remain attentive to weather forecasts and weather patterns. The central contact person should remain particularly alert to weather patterns and predictions when a storm is impending.

The laboratory personnel should be notified prior to storm events. Notification should include: 1) estimates of how many stations are operational, 2) the number of samples expected (e.g., grab samples only or both grab and composite samples), and 3) an approximate sample delivery time (if possible). In addition, laboratory personnel should be notified prior to storm events when no samples will be collected.

4.1.3 EQUIPMENT PREPARATION AND BOTTLE HANDLING

Routine station maintenance inspections (see Chapter 6) should be timed to precede forecasted storm events whenever possible. In addition, an effort should be made to ice down the carousel of empty bottles in the base of the samplers immediately before a storm event.

A checklist of equipment to be taken to the field during storm events for collection of storm water samples is presented in Part A of Appendix D. Preparation of sampling equipment should be completed at least 24 hours before a storm event. New, clean disposable gloves should be worn at all times during the cleaning and preparing of sample collection equipment.

Glass or stainless steel equipment must be used for manual collection of storm water samples that will be analyzed for the full suite of pollutant parameters. The sampler is configured with a polypropylene intake with vinyl tubing connecting the intake to the peristaltic pump. The peristaltic pump uses medical grade silicone rubber tubing. Samples are collected in polyethylene containers in the sampler base.

Automatic Sampler Equipment Preparation

All sampling equipment which contacts the source liquid must be cleaned with a phosphate-free laboratory-grade detergent (Liqui-Nox^{TM} or equivalent), hot water, and a scrub brush. The equipment must be rinsed well with hot tap water then rinsed 3 to 5 times with deionized water. Equipment used to collect samples to be analyzed for organics must also be rinsed twice (in a well-ventilated area) with pesticide-grade isopropanol, acetone, or hexane. Air dry the sample collection equipment for 24 hours then seal equipment in plastic bags using ties (do not use plastic tape).

Grab Sample Bottle Preparation

Containers for preservation of storm water samples required under the NPDES regulations must also be prepared in advance of a storm event. Required sample volumes for each sample parameter group will be specified by individual laboratories. Table 2-5 lists the sample volumes required for analysis by the laboratory for each required parameter group. Ideally sample bottles will be purchased from a reputable source and will not be re-used. If sample bottles are re-used, the following cleaning procedures should be followed.

Cyanide Sample Bottles: Containers for samples to be analyzed for cyanide must be cleaned with nutrient-free laboratory-grade detergent, rinsed with tap water, rinsed with 1:1 HCl, followed by three rinses with deionized water. The container for samples to be analyzed for cyanide will be precharged with NaOH such that the pH of the sample volume and preservative is greater than 12.

Phenol Sample Bottles: Containers for samples to be analyzed for phenols must be cleaned with nutrient-free laboratory-grade detergent, rinsed with tap water, rinsed with 1: 1 HCl, and rinsed three times with deionized water. The container for samples to be analyzed for phenol will be precharged with H_2SO_4 such that the pH of the sample volume and preservative is less than 2.

Bacteriological Sample Bottles: Containers for samples to be analyzed for fecal coliform and fecal streptococcus bacteria must be cleaned with nutrient-free laboratory-grade detergent, rinsed with tap water, and rinsed three times with deionized water. The bacteriological sample containers will also be sterilized prior to use.

Oil and Grease Sample Bottles: Containers for samples to be analyzed for oil and grease must be pre-rinsed with Freon, cleaned with nutrient-free laboratory-grade detergent, rinsed with tap water, and rinsed three times with deionized water. The container for samples to be analyzed for oil and grease will be precharged with H_2SO_4 such that the pH of the sample volume and preservative is less than 2.

VOA Sample Bottles (VOA Vials): Containers for samples to be analyzed for volatile organic compounds (VOC) will be rinsed with deionized water, hand washed with nutrient-free laboratory-grade detergent, and rinsed three times with deionized water. Glassware will then be placed in a chemsolv bath for 6 to 8 hours, rinsed with deionized water, 25% HNO_3, and rinsed three additional times with deionized water. Teflon-lined caps for VOA vials will be washed with nutrient-free laboratory grade detergent, rinsed with 25% HNO_3, and rinsed three times with deionized water. Containers will be rinsed with an organic solvent then allowed to air dry before being capped.

Other Constituent Sample Bottles: Containers for samples to be analyzed for all remaining parameters required under the NPDES regulations (i.e., composite samples listed in Table 2-5) must be rinsed with deionized water, hand washed with nutrient-free laboratory-grade detergent, and rinsed three times with deionized water.

For analysis of organic constituents glassware should be placed in a chemsolv bath for 6 to 8 hours, rinsed with deionized water, 25 % HNO_3, and rinsed three additional times with deionized water. Lids for glassware will be washed with nutrient-free laboratory-grade detergent, rinsed with 25% HNO_3, and rinsed three times with deionized water.

Containers will be rinsed with an organic solvent then allowed to air dry before being capped.

Grab Sample Bottle Handling

Containers for all grab samples must be iced down immediately after sample collection for transport to the laboratory for analysis (see Section 4.2.2). Therefore, a cooler large enough to contain all grab sample containers for a single storm event at a single monitoring station must be filled with ice prior to arriving at the monitoring site. Containers for composite samples from a storm event must also be iced down as soon as possible and covered from light.

Automatic Sampler Bottle Handling

For composite samples collected with automatic samplers, ice can be poured directly into the sampler base carousel for each monitoring station. If composite samples are obtained manually, a cooler with ice large enough to contain the composite sample containers must also be prepared.

STORM EVENT PROCEDURES

Prior to the start of a storm, the field team should inspect each monitoring station as quickly as possible. In the event of problems or delays, a central contact person should be notified as soon as possible to determine if other personnel or equipment can be diverted to assist with the collection of storm water samples.

4.2.1 INITIAL PROCEDURES

Equipment Checks

Upon arriving at a monitoring station during a storm event, the team should first check the status of all equipment. A visual inspection of the flow meter probe and the sampler intake should be attempted to ensure no debris has accumulated on the probes which may interfere with station operation. This inspection should not be attempted if the installation is in a manhole. The rain gage should be similarly inspected for debris. The status of the storm event as recorded by the monitoring station should then be checked. Detailed procedures for checking the operation and calibration of the samplers and flow meters are presented in Part B of Appendix D (Procedure B-l).

Equipment readings which should be checked and verified include:

1) instantaneous flow rate/stage,
2) total rainfall,
3) number of samples pumped
4) time to next sample.

In addition, the print out of the flow meter should be reviewed. The current flow rate/stage should be checked against a manual measurement.

<u>pH Measurement</u>

A hand-held digital pH meter will be used to field measure pH during the storm event. If possible, pH measurements should be made by dipping the probe into a well-mixed portion of the flow, such as the center of flow (both horizontally and vertically) at approximately the same location (just downstream) as the sampler strainer. Do not disturb bottom sediments when obtaining pH readings.

<u>Field Notes</u>

All observations made during the storm event site visit should be well-documented in the field notebook for the monitoring station. Minimum documentation should include:

1) team names,
2) date and time of arrival/sample collection,
3) current weather conditions,

4) problems encountered such as removal of debris from probes,
5) station maintenance (battery replacement),
6) equipment programming changes.

In addition, pertinent site visit information should also be recorded on the station maintenance log located inside the equipment housing.

4.2.2 GRAB SAMPLING PROCEDURES

Manually collected grab samples will be required during one (1) storm event over the 5-year permit term. Field personnel will be required to be present at the monitoring site during potentially dangerous storm event conditions. All grab samples should be obtained during the first three hours of runoff from a storm event. New, clean disposable gloves must be worn <u>at all times</u> during grab sample collection process.

<u>Grab Sample Collection</u>
Wading into the storm water flow should be avoided unless absolutely necessary or if depth of flow is greater than 2 feet. Use good judgement to ascertain whether wading can be safely accomplished. All wading should be performed downstream of the automatic sampler probes and the grab sample should be taken upstream of the wading area.

For manhole installations, the collection container should be lowered into the manhole using a rope. DO NOT ENTER A MANHOLE DURING A STORM EVENT.

For manual collection of grab samples, rinse the sample collection container and pouring beaker twice with source sample water. Obtain both the rinse water and the sample water from an area where flows are well-mixed. The samples should be collected from mid-depth if possible. Samples should be collected just downstream from the sampler intake strainer. Do not disturb bottom sediments when obtaining grab samples.

Sufficient sample for all grab samples should be collected at one time. Table 2-5 lists the grab sample volumes required for analyses by the laboratory. Approximately 4.3 mL (1.1 gal) is required (approximately 1/3 of 12.5 quart stainless steel bucket) to fill all of the parameter specific sample bottles.

Field Processing of Grab Sample

Immediately after collecting the grab sample, the sample should be processed into parameter specific bottles which are precharged with the appropriate preservatives as described in Section 4.1.3. These activities should be performed under cover as much as possible.

One member of the field team should take all notes, fill out labels, etc. while the other member does all of the sampling (if possible). However, two sets of hands may be required to hold a sample container steady and to pour sample into the container.

Because several of the grab sample containers have been precharged with preservatives (NaOH, H_2SO_4, $Na_2S_2O_3$), **safety goggles and new, clean disposable gloves** shall be worn by personnel while filling sample containers. All handling of opened grab sample containers shall be conducted in an open, well-ventilated area. Material safety data sheets (MSDS) for all preservatives used to precharge sample containers are given in Part D of Appendix D. Gently swirl sample in bucket and/or pouring beaker immediately prior to filling sample containers to ensure complete mixing.

VOC Samples: Volatile Organic Compounds (VOC) samples should be obtained immediately after collection of the initial storm water grab sample. The 40-mL VOA vials should be completely filled to prevent volatilization and caution should be exercised when filling a vial to avoid any turbulence which could also cause volatilization. Fill vials by pouring sample from collection container or pouring beaker into vial. Pour the last few drops of sample into the vial so that surface tension holds the water in a convex meniscus. Pour a few drops of sample into the cap and then apply cap to ensure that no air bubbles remain in the vial. After capping, turn the vial over and tap it to check for bubbles. If any bubbles are present, remove cap, add additional sample, recap, and recheck.

Other Parameters: Sample containers for cyanide, phenols, fecal bacteria, and oil and grease samples should be opened immediately before filling to prevent loss of preservative. After swirling sample in bucket, carefully fill appropriate container near brim and cap. Fill sample container by pouring sample into container. Do not fill container by immersing in sample collection container. Use care not to overfill and thus lose any preservative. Removal of all air bubbles before capping container is not necessary. All equipment used to obtain grab samples should be thoroughly rinsed with tap water in the field as soon as possible after use.

Sample Labeling/Identification: All grab sample bottles should be pre-labeled on bottle rather than the cap to identify parameter group for laboratory analysis. Sample labels should include sample identification, field team names, date, time, and location. Grab sample identification will use the following format:

S- YYMMDD-___

where:

S = Site Identification
YY = Year
MM = Month
DD = Day
___ = Type of sample
- G = Grab sample
- C# = Composite Sample Bottle, Number refers to Automatic Sampler Number

Example: I1-920710-C1

This sample is from monitoring site I1 (Acker Place), collected on July 10, 1992. It is a composite bottle from the automatic sampler having the ID number of 1.

Labels should be applied to each sample container using a waterproof pen immediately after filling. Be sure all container lids are on tight and will not leak. Filled and capped grab sample containers should be placed immediately on ice in a small cooler. Ice should completely surround all sample containers.

A chain of custody form (see example of form for grab samples in Part C of Appendix D) must be completed for all samples before leaving the site. The form should be completed using a waterproof pen and placed in a waterproof plastic bag. The completed chain of custody form should be placed inside the cooler on top of the ice; the cooler then should be taped shut (fiber tape). The cooler should also be labeled on the outside. All sampling activities must also be described in the field notebook for the monitoring station before leaving the site.

Laboratory Delivery: Delivery of the cooler containing the filled grab sample containers to the laboratory should occur as soon as possible and not longer than 6 hours after obtaining samples. The chain of custody form for the storm event grab samples will be completed by the laboratory as part of delivery of the samples. Completed chain of custody forms should be filed in the field notebook for that monitoring station.

Detailed, step-by-step procedures for obtaining manual grab samples are presented in Part B of Appendix D (Procedure B-2).

4.2.3 RATING MEASUREMENTS

Rating measurements are required to relate stage (depth) to a discharge rate in the flow control section (channel, pipe, weir). Rating measurements must be performed during storm events to calibrate/verify the stage discharge relationship during high flow conditions.

All rating measurements should be documented in the field notebooks for each site. Field crews should compare the flow level during previous rating measurements to the present flow level in the stream. If less than three or four rating measurements have been previously performed at a particular site, rating measurements should be performed. If more than four rating measurements have been performed previously and the present level is within the range of those measurements, additional rating measurements are optional. Additional rating measurements should be performed if the present flow depth is significantly higher than all previous rating measurements.

For the ongoing monitoring program, the city will continue to periodically collect stage-discharge information at the selected monitoring sites during storm flows. Approximately 2 to 3 rating measurements per year should be performed at each site. This information will be used to further refine the rating curves developed by USGS for each site under the Part 2 representative outfall monitoring program.

At sites where 1.) there is sufficient channel rating data, and 2) the channel rating remains consistent, the city may consider conversion of the time-paced sampling protocol to a flow paced protocol. This would require an analysis of monitored storm event runoff volumes to establish a flow interval that will cover a wide range of storms.

Rating measurements should be performed after the grab sample is collected during a storm event. The velocity-area method is used to estimate the instantaneous flow rate. The flow (Q) in a channel is equal to the average velocity (V) times the cross-sectional area (A) at the point where the average velocity was measured (Q = VxA).

Open channel rating measurements requires a channel cross-section (width and depth) and flow velocity at intervals across a cross-section of the channel. Closed-conduit measurements require, at a minimum, three observations across the width of the pipe: one at the centerline, and one each on either side of the centerline at the mid-point between the centerline and the pipe wall. Velocity measurements are made using a portable current meter (e.g., Marsh-McBimey Model 2000). Detailed procedures and equipment required for open channel and pipe flow measurements are included in Part B of Appendix D (Procedure B-3).

4.2.4 CONTINGENCY PLANS

This section describes contingency plans to address some of the problems that may be encountered in the field. In some cases, monitoring data can be obtained despite equipment failures or other unplanned factors. The field team should use good judgment to ascertain whether monitoring at a station can be safely accomplished for a given storm event.

Equipment Malfunction

If the automatic sampling equipment is malfunctioning, several options to salvage the storm event are available depending on type of equipment malfunction. Field crews should assess the current conditions at the site with respect to the following criteria:

1) The duration of storm before malfunction observed and forecasts for the remainder of the storm.

2) Whether the malfunction or problem can be corrected upon detection and thus enable the remainder of the storm to be salvaged.

3) Whether obtaining data from the present storm event is critical or will the schedule allow another storm event to be monitored at a later date.

Rain Gage Malfunction: Rainfall data available from the nearest NWS station is probably sufficient to characterize the storm event. Continue with automatic/grab sample collection.

Sampler Malfunction: If the malfunction is detected during the first part of storm and if the malfunction is correctable in situ (e.g., intake blocked), correct problem and continue with automatic/grab sample collection.

If the malfunction is detected during the first pan of storm and if the malfunction is not correctable in situ, consider manually collecting grab samples for compositing. A minimum of three discrete grab samples (aliquots) must be collected per hour for either the first three hours of the storm runoff or for the entire storm event. A minimum of 15 minutes between collection of sample aliquots is required.

Additional bottles should be included with field equipment taken to the site. Note that grab samples must also be collected as detailed in Section 4.2.2.

Flow Meter Malfunction: If the malfunction is detected during the first part of storm and if the malfunction is correctable in situ (e.g., debris on probe), correct problem and continue with automatic/grab sample collection. For other situations where the flow meter has malfunctioned, the field crew can consider continued monitoring of the storm event by manually activating the sampler to obtain a minimum of three discrete samples (aliquots) during either the first three hours of the storm runoff or for the entire storm event. A minimum of 15 minutes between collection of samples is required. The field crew should carefully note the depth of flow at each sample collection time to develop a flow weighted compositing scheme. Collection of required grab samples should also continue.

Inadequate SampIe Volume

As previously discussed, required sample volumes for each parameter group are specified in Table 2-1 for the laboratory. Optimal and minimum sample volumes requirements are presented for grab sample parameters and composite sample parameters. Field teams must be physically present to collect grab samples; it is unlikely that there will be insufficient sample volume for the grab sample.

The optimal sample volumes include additional sample volume necessary for the laboratory to perform QA/QC analyses for each parameter group. Therefore, it may be possible for the laboratory to analyze all required pollutants with somewhat less than the "optimal" sample volumes. In addition, if analysis of every storm event at the monitoring station is crucial to meet the permit application deadlines and most of the required sample volume has been obtained, it may be desirable to perform analyses for as many parameters as possible. If insufficient sample volume for all required QA/QC analyses is obtained for multiple storm events, the QA/QC analyses which are dropped should be different for each storm event so that QA/QC data for all parameter groups is available.

Safety/Risk

Safety of field crews should be paramount in the decision whether to monitor a particular storm event at a particular monitoring station. For example, if there is heavy lightning activity associated with the storm event, a decision to abort monitoring activities may be made. If the monitoring station is located in a high crime area, a decision not to monitor storm events which occur after 12:00 a.m. may be made. Additional safety information is presented in Section 7.0.

5.0 DATA COLLECTION AFTER STORM EVENTS

After each monitored storm event, the field team will be required to collect flow and rainfall data from each site, prepare a sample compositing scheme, and deliver samples to the laboratory for compositing. For the Knoxville program, the samplers will initially be time-paced and will collect one 250 mL sample every 15 minutes. For the ongoing monitoring program, samplers are configured with 24 one-liter polyethylene bottles which provides sampling coverage of a runoff event with a total duration of 24 hours. For the analysis of the storm water for the full suite of pollutants, samplers can be reconfigured with a different base that contains glass bottles. Bases can be configured with 4 four-liter glass bottles, and the sampler can be reprogrammed to take 1-liter aliquots every fifteen minutes for the first 4 hours of the storm event. This configuration would be required to sample for the organic pollutants listed in 40 CFR Part 122.

The field crew should schedule a visit to each site as soon as possible within 24 hours since the beginning of the storm event. Since the stations should be equipped with telephone modem connections, the conditions at each station can be monitored from the office to determine the status of the sampling program. If inspection of the sampling program reveals that the stage at a station has fallen below the trip level, the sampler will have stopped sampling and the field crew should visit the site as soon as possible afterwards. If a station does not have a telephone connection, the field crew can visit the site before the 24 hour period to check the status of the flow meter and sampler. If a rainfall event lasts for more than 24 hours, or if two events happen within 24 hours, it may be necessary to replace the sampler carousel during sampling; therefore it is important that the sampler is monitored closely either by field inspection or in the office by modem.

This section describes criteria for determining whether a storm should be considered for laboratory analyses and describes procedures for obtaining data from the monitoring equipment.

5.1 TERMINATION OF STORM MONITORING

In general, storm event monitoring should terminate when flows have subsided to levels reasonably close to those at which sampling was initiated. For smaller storm events, flows may subside below the minimum flow level used to trigger the sampler and sampling will terminate automatically. At larger sites with significant baseflow, it may be necessary to establish a cutoff point along the recession limb of the hydrograph. This cutoff can simply be expressed as a percentage of baseflow levels (e.g., 150% of baseflow).

Moriitoring Equipment Status

Upon arrival at each site immediately after a storm event, the current status of the sampler can be checked by pressing the DISPLAY key on the sampler. The sampler carousel should be visually inspected to confirm that all samples were successfully collected.

If all 24 bottles were filled, the sampler will automatically stop. If the stage is on the falling limb of the hydrograph, but still greater than the "trip" level, the field crew can reset the program so that the sampling level is greater than the current stage at the station. The sample carousel can then be replaced, and the program reset. The automatic sampler will not sample because the "trip" level is higher than the current stream level. As the stage in the channel recedes towards baseflow conditions, the sampling level can be lowered as well. This is most conveniently managed from the office via the modem, but can be accomplished by routine field visits. Detailed instructions on setting the sampling level are presented in Part B of Appendix D.

5.2 STORM DATA COLLECTION

The flow meter records rainfall, storm water flow levels, and the sample collection times. The data are printed on the internal dot matrix printer during the storm event, and are also stored in the internal memory of the flow meter where it can be retrieved by computer. ISCO FLOWLINK software must be used to access data stored in the flow meter's internal memory. Since the stations in the Knoxville program will be connected to standard telephone lines, monitoring data can be collected from an office location using the flow meter's internal modem. If a site is chosen for monitoring which can not be connected to a phone line, it will be necessary to access the sampler using a laptop or portable computer.

5.2.1 DATA COLLECTION

Data stored in the flowmeter's memory is collected either by a direct cable connection between an IBM compatible portable computer and the ISCO flowmeter, or through remote connection via modem and standard telephone lines. Transfer of data requires invoking the FLOWLINK software package, and downloading the data from the flowmeter to the portable computer.

For the Acker Place site and other Knoxville monitoring sites which are expected to be connected to telephone lines, field data collection can be accomplished from a central location (e.g., office or another connected monitoring site). Data will be collected from the flowmeter to a computer using a modem and ISCO FLOWLINK software.

Flow Meter Interrogation Using a Modem

The FLOWLINK module TELEFLOW allows interrogation of the memory partitions configured in the flowmeter using a 1200 baud modem and computer. TELEFLOW requires a 300 or 1200 baud modem connected to the COM1 or COM2 RS232 port of the computer and a standard telephone line connection between the modem and the flowmeter.

Once the modem is connected to the flowmeter, TELEFLOW software is used to interrogate the flow meter and transfer data from the flow meter's memory to a disk (hard or floppy) in the computer. A routine data collection schedule can be set up using the TELEFLOW software. Data collection should be performed as soon as possible after a storm event.

To collect the data using a modem, load the FLOWLINK software by typing FL and select TELEFLOW from the main menu. Once TELEFLOW is loaded select "Phonebook" from the menu near the top of the computer display. Using the up/down arrow keys on the computer keyboard, select a site to interrogate followed by the "Connect" menu command. The modem will dial the selected monitoring site telephone number and automatically connect the computer to the flow meter. Once connected, follow the steps for interrogation outlined in Part B of Appendix D (Procedure B-4).

Flow Meter Interrogation in the Field

Field interrogation using a laptop or portable computer is necessary for sites which can not be accessed by a telephone line. The FLOWLINK module LAPCOMM allows interrogation of the memory partitions configured in the flowmeter by a laptop computer. LAPCOMM requires a direct cable connection to communicate with the flow meter. Once the cable is connected to the flow meter, LAPCOMM software is used to interrogate the flow meter and transfer data from the flow meter's memory to a disk (hard or floppy) in the laptop computer. Data collection should be performed as soon as possible after a storm event.

To collect the data in the field, connect the laptop to the flowmeter via the interrogation cable which plugs into the laptop's communication ports (COM 1 or COM 2). Load the FLOWLINK software by typing FL and select LAPCOMM from the main menu. This will automatically connect the laptop to the flow meter. Once connected, follow the steps for interrogation outlined in Part B of Appendix D (Procedure B-4).

Resetting Flow Meter Memory

After interrogation, remember to restart partitions A (FLOWDEPTH) and B (PRECIP). These memory partitions are set up in a slate mode. When a slate partition becomes full, it is no longer able to store new readings. This option allows use of TELEFLOW or LAPCOMM to instruct the flow meter to begin recording new readings. Although the option is primarily intended to restart full slate partitions, it can be used on partially filled partitions. After Restart is selected for a particular partition operating in slate mode, it will return to rollover mode until the trigger conditions are again satisfied. When the Restart option is selected, TELEFLOW will present a menu listing the partitions. Select the slate partition where restart is desired. If a rollover partition is selected, TELEFLOW will not respond to the selection. When TELEFLOW is finished, it will return to the Partition Menu.

Data Conversion

The data is downloaded in a format only FLOWLINK can use. In order to make it compatible for other software (e.g., LOTUS-123), it must be converted to an ASCII file. This is done through the EXPORT module in FLOWLINK. Steps for this procedure are also detailed in Part B of Appendix D (Procedure B-4).

Data Analyses

The flow data can be analyzed using a spreadsheet template which generates a flow-weighted compositing scheme based on the available samples and the storm hydrographs showing the sample collection times. The spreadsheet template can also create rainfall hyetographs.

An example of the flow-weighted compositing scheme for a storm event is presented in Table 5-1. The compositing scheme identifies the aliquot volume required from each bottle to prepare a single flow-weighted composite sample. It also identifies where aliquot volumes exceed the available bottle volumes and corrects the volume accordingly. The flow compositing scheme includes chain of custody information and must accompany the discrete samples to the laboratory .

A LOTUS 123 v2.3 spreadsheet file, STORM.WK!, is utilized to convert the ASCII file into a spreadsheet file for computing flow-weighted sample compositing schemes. For each storm event at a monitoring site, the spreadsheet data is utilized to: 1) generate a hyetograph and hydrograph with superimposed sample collection times and grab sample time, 2) associate each bottle with a portion of the storm hydrograph, 3) compute the sample volume required from each bottle in order to generate a flow composite sample, and 4) generate a table for transmittal to the laboratory. The transmittal table contains the site name, date, bottle number, and bottle volume for compositing. Calculation of a flow-weighted compositing scheme for a sampled storm event is discussed below and outlined in Part B of Appendix D (Procedure B-5).

Software requirements for transferring sampler data from ASCII format to LOTUS spreadsheet format are LOTUS v2.3 and SQZ!, ASCII data files created by the FLOWLINK software (PRECIP.CSV, DEPTH.CSV, and SAMPLE.CSV), and LOTUS spreadsheet files XFER.WK! and STORM.WK!. The XFER.WK! spreadsheet converts the ASCII files created by the FLOWLINK software into a single spreadsheet file. The STORM.WK! spreadsheet calculates a flow-weighted compositing scheme for the storm event as well as a hydrograph, hyetograph, and statistics for the storm event.

TABLE 5-1

Example Calculation Of A Flow Weighted Composite Sample
From A Time-Paced Collection (15 minutes intervals).

24 Bottle Configuration (21 1/2 bottles filled)

START DATE: 01/01/93 NO. OF SAMPLE BOTTLES: 21 1/2

STORM NO: 1 STATION ID: I1 (Acker Place)

BOTTLE NUMBER	AVAILABLE SAMPE VOLUME (L)	% FLOW VOLUME	ALIQUOT %	COMPOSITE ALIQUOT VOLUME (L)	PERCENT REDUCE	CORRECTED ALIQUOT VOLUME (L)	% ALIQUOT OF TOTAL SAMPLE VOLUME
1	1.00	6.7 %	34 %	0.34	0 %	0.34	7 %
2	1.00	19.5%	100 %	1.00	0 %	1.00	20 %
3	1.00	13.5%	69 %	0.69	0 %	0.69	14 %
4	1.00	9.1 %	47 %	0.47	0 %	0.47	9 %
5	1.00	7.2 %	37 %	0.37	0 %	0.37	7 %
6	1.00	6.3 %	32 %	0.32	0 %	0.32	6 %
7	1.00	5.5 %	28 %	0.28	0 %	0.28	6 %
8	1.00	4.5 %	23 %	0.23	0 %	0.23	5 %
9	1.00	3.8 %	19 %	0.19	0 %	0.19	4 %
10	1.00	3.4 %	17 %	0.17	0 %	0.17	3 %
11	1.00	3.1 %	16 %	0.16	0 %	0.16	3 %
12	1.00	2.9 %	15 %	0.15	0 %	0.15	3 %
13	1.00	2.5 %	13 %	0.13	0 %	0.13	3 %
14	1.00	2.3 %	12 %	0.12	0 %	0.12	2 %
15	1.00	2.1 %	11 %	0.11	0 %	0.11	2 %
16	1.00	1.9 %	10 %	0.10	0 %	0.10	2 %
17	1.00	1.7 %	9 %	0.09	0 %	0.09	2 %
18	1.00	1.4 %	7 %	0.07	0 %	0.07	1 %
19	1.00	1.1 %	6 %	0.06	0 %	0.06	1 %
20	1.00	0.8 %	4 %	0.04	0 %	0.04	1 %
21	1.00	0.6 %	3 %	0.03	0 %	0.03	1 %
22	0.50	0.1 %	1 %	0.01	0 %	0.01	0 %
23	0.00	0.0 %	0 %	0.00	0 %	0.00	0 %
24	0.00	0.0 %	0 %	0.00	0 %	0.00	0 %
TOTAL	21.5	100.0 %		5.13		5.13	100 %

Begin the transfer process by loading LOTUS 123 v2.3 with SQZ! compression into the computer. Retrieve the file named XFER.WK! using the LOTUS commands "/FR A:\XFER.WK!". Make sure the compression add-in SQZ! is loaded before loading the compressed spreadsheet XFER.WK!.

Next change the default LOTUS worksheet directory to the subdirectory where a sites compositing data are stored. Import the ASCII data files into the XFER spreadsheet using the LOTUS macro routine. This routine will automatically import all the ASCII data files into the LOTUS XFER spreadsheet. Invoke this routine by holding the ALT key down while pressing the A key. The conversion takes approximately one minute on a 386 computer with a math co-processor.

Once the import/conversion process is complete, the current spreadsheet file will automatically be saved to the floppy disk as TEMP.WK!. At this point all the ASCII data files have been converted into the spreadsheet file. Next a spreadsheet file named STORM.WK! will automatically be loaded. This file is a spreadsheet template in which the date, time, depth of flow, precipitation, and samples-taken information from TEMP.WK! file are copied into.

The STORM.WK! spreadsheet file will automatically calculate a flow-weighted compositing scheme for a storm event with samples taken every 15 minutes. Sample times will be marked by an '*' in column J of the STORM.WK! spreadsheet and sample bottle numbers will be listed in column N. Adjust the bottle numbers in column N to reflect the sample times shown in column J. The bottle numbers in column N are representative of 4 samples taken every 15 minutes. Therefore, if sample number 2 was taken 30 minutes after sample 1, sample number 2 would be moved down to the correct sample time, thus adjusting all samples taken after sample number 2 as well. The percent flow volumes in the sample bottles in column O must be adjusted as well. The percent flow volume in a bottle is the volume in a bottle divided by the total sampled volume. The volume can be calculated in a number of ways depending on the sample collection interval. For sample bottles filled less than an hour apart, the volume in a bottle is calculated from the first sample in a bottle to the incremental volume just before the beginning of the following bottle. If sample bottles are filled over an hour apart, the volume in a bottle is calculated from the first sample in a bottle to the incremental volume mid-way between the following bottle. The procedure for adjusting the flow-weighted compositing scheme for a variable sample interval is outlined in Part B of Appendix D (Procedure B-5).

Once the compositing scheme has been calculated, it must be printed and taken to the laboratory as discussed previously. Next, produce and print the hydrograph and hyetograph associated with this storm event. Lastly, save the spreadsheet file for future retrieval and modification.

File Naming Convention

Each dataset from every storm event at every monitoring site should be stored on a separate floppy disk and backups should be made regularly. The STORM.WK! file created for every dataset should be saved on the appropriate disk and named using the DATESITE.WK! naming convention. The DATE should be the date of the last sample taken in the dataset and the SITE should be the two-digit site code for that monitoring site. For example, a dataset from the Acker Place monitoring station (site I1) containing samples taken on July 24, 1992 would have the file name 072492I1.WK!.

5.2.2 COMPOSITE SAMPLE PROCEDURES

After successful storm monitoring, the sampler will contain several bottles which were filled during the storm event. These bottles are used to prepare a flow-weighted composite sample representative of the monitored storm event. This section describes procedures which should be followed for processing the composite sample after each monitored storm event.

The sampler controller should be detached from the sampler base and the sample bottles should be kept in the sampler carousel if possible. The 24 one-liter poly bottles should be kept in the sampler carousel to avoid inadvertently reordering the bottle sequence. All filled or partially filled bottles should be immediately capped. Label each bottle by completing the date, time, team, location, bottle number, etc. on pre-printed forms. Composite sample identification will use the following format:

SSYYMMDDCNN

where:

SS is the Site ID (II, 12, R3 etc.)

YY is the year (93)

MM is the month (07 = July)

DD is the day (07 = seventh)

C indicates composite sample

NN is the bottle number in sequence of collection (1, 2, 3 etc.)

Be sure to label bottles and not only the bottle lids.

After labeling and capping sampler bottles, the bottles should be immediately iced down in the carousel or in a cooler. Ice should completely surround each bottle. A chain of custody form for composite samples (see example in Part C of Appendix D) must be completed for each sampling station using a waterproof pen and placed in a waterproof plastic bag. The completed chain of custody form shall be taped to the carousel or cooler. A plastic garbage bag or other opaque cover should be secured to the top of the carousel in order to minimize exposure of the filled sample bottles to light. Both the field log and the equipment maintenance log (located inside equipment housing) should be completed describing all sampling activities using a waterproof pen before leaving the site.

Clean, empty bottles should be installed in the sampler. Remember to remove and bag the bottle caps before installing the sampler controller.

A compositing scheme for the sample bottles filled during the storm event must be produced in the office before delivery of the sample bottles to the laboratory. Ensure that the filled bottles remain iced down and covered from light during the entire compositing scheme preparation time. Deliver the filled bottles and the compositing scheme for the storm event to the laboratory as soon as possible. The chain of custody form shall be completed by the laboratory as part of the delivery of samples. Completed chain of custody forms should be filed in the field notebook for that monitoring station. Detailed, step-by-step procedures for automatic sample handling are presented in Part B of Appendix D (Procedure B-6).

6.0 ROUTINE INSPECTlON AND MAINTENANCE

Routine site inspection and maintenance of the equipment are necessary components of a monitoring program. Each station must be kept on ready status to monitor storm events. During dry weather periods, each site should be inspected at least once a week. If possible, routine inspections should be timed to precede storm events. Maintenance logs will be completed for all pertinent equipment including pH meters, rain gages, flow meters, automatic samplers, and velocity meters.

6.1 SITE LOG

Up-to-date paperwork for each site will be incorporated into a maintenance log and field notebook for each station. The maintenance log will verify that each sampling site is prepared for the next storm event (e.g., charged battery, clean bottles, program reset, etc.) The maintenance log should also note if field equipment needs replacement. The field book will contain all recorded information for each site. Field book information should include daily rainfall totals, sampler status (# of bottles filled, etc.), outfall and stream physical conditions (presence of debris or excess silt, localized erosion, etc.), and any other pertinent information. All paperwork should be kept up-to-date.

6.2 INSPECTlON PROCEDURES

Site inspections should be conducted at least weekly and should include a thorough check of the following equipment:

- Power Source
- Sampler
- Flow Meter
- Rain Gage

6.2.1 POWER SOURCE

Direct AC power is proposed for all sites which will be monitored during this program. Power loss should rarely be a problem, but power sources should be checked after severe weather which could cause a power failure. Batteries are not expected to be utilized for the Knoxville program but, if used, they need to be charged every two weeks. Replacement batteries should be available and charged. Test batteries weekly and especially after a storm event (more power is used during storms). Check all connections to the equipment. Clean battery terminals on each site visit. A system of testing, charging, and labeling batteries should be set up in the office to ensure that fully-charged batteries are always available and properly labeled.

6.2.2 SAMPLER

This section covers routine inspection and maintenance of the sampler. Inspections should include the following items:

- Intake line
- Desiccant
- Pump tubing
- Cleaning

<u>Intake Line</u>
The intake line should be inspected on each site visit. Check the line for clogging, kinking, and other potential damage. If a visual inspection is not possible (cases where the line is in a protective conduit or buried), manually activate the sampler. If no sample or an amount of sample significantly less than what the sampler is programmed for is delivered, the intake line may be clogged or damaged. When manually sampling, be sure to use a spare bottle or other similar container to avoid contamination of the sample bottles in the sampler.

Replace the intake line when the line becomes worn, cut, contaminated, or otherwise damaged. In critical sampling, replace the intake line between sampling programs to avoid cross contamination. When site conditions change, it may be necessary to use an intake line with a different length.

To replace the intake line, pull the intake line out of the protective PVC conduit. If a new intake line (either with or without the optional stainless steel strainer) is to be used, install as described in Section 3. To install the strainer, carefully slip the strainer's tapered connector inside the intake line and tighten the hose clamp supplied with the strainer. If the intake line is in good condition and free of kinks and other signs of wear, the tube can be cleaned (see ISCO 3700 Sampler Instruction Manual) and reused.

Desiccant

The desiccant protects the electronic components inside the control box of the sampler from moisture damage. Periodically, this needs to be replaced and the old desiccant regenerated. A humidity indicator, labeled "INTERNAL CASE HUMIDITY," is located in the lower left corner of the control panel. It indicates the amount of moisture present inside the control box. The paper indicator is blue in a dry state.

The control box is a completely sealed unit. It is shipped from the factory with three fresh 4 ounce bags of desiccant installed inside. This desiccant should absorb any moisture which may accumulate in the control box. If moisture does accumulate, the numbered areas on the indicator will turn light pink or white, starting with the area numbered "20". This indicates that the relative humidity inside the control box exceeds 20%. As more moisture accumulates, the areas numbered "30" and "40" will turn light pink or white, indicating relative humidities of 30% and 40%. If the 30% area of the humidity indicator turns light pink or white, the control unit should be opened, inspected for leaks, and the desiccant renewed. This is done by unscrewing the ten screws around the outer rim of the control box bezel, and carefully lifting the bezel and cover off the control box.

If there is a leak, it should be repaired by referring to Sections 6.5 and 6.7 in the ISCO 3700 manual or returning the control box to the factory. The factory has specialized equipment to detect leaks and thoroughly test the units after repair. If no leak is detected, the desiccant is renewed by removing the three bags of desiccant from the control box, and placing them in an oven at 250°F for 4 hours. The desiccant bags will return to 90% of their original capacity. Replacement bags of desiccant are available from ISCO (refer to the Replacement Parts List in the back of the sampler manual). Before reinstalling the cover, coat the cover's gasket with a light fIlm of silicone grease to seal the control box. Tighten the ten screws which hold the control box cover and bezel in place using an even cross-torquing pattern.

Pump Tubing

The pump tube serves two functions: 1) a pump tubing in the peristaltic pump and 2) distributes the sample liquid from the pump outlet to the sample bottle. The pump tube consists of a single 42-inch (103.8 cm) piece of medical grade Silastic™ silicone rubber tubing. Medical grade tubing is used because of its superior mechanical properties and because it does not contain any organic materials.

The pump tubing is extremely durable. However, the constant mechanical strain placed on the tubing by the peristaltic action of the pump will eventually cause the tubing to fatigue and fail. Inspect the pump tubing in each site visit for wear inside the pump by removing the cover. Check the tubing for cracks where the pump roller compresses the tubing. Replace it with a spare pump tube, if necessary. The inspections should be fairly frequent when the liquid being sampled contains a high percentage of suspended solids. If the liquid is relatively free of solids, the inspections can be less frequent. The amount of tubing (13.5 inches) used in the pump is less than half of the total length of the pump tubing (42 inches). In some cases, when the tube has not been damaged to the point of leaking, the tube can be used twice by simply turning it around. Note that the black bands are used to correctly position the tubing in the pump and are placed on the one end only. If the tubing is turned around, the bands cannot be used for reference. Replace the pump tube every three months.

Cleaning

Sampler and the peripheral equipment such as the intake line, pump tube, and sample bottles should be cleaned periodically to prevent cross-contamination of samples. Sample bottles must be cleaned after each event (see Chapter 4). Refer to Chapter 6 of the ISCO 3700 Sampler Instruction Manual for recommended cleaning procedures.

6.2.3 FLOW METER

This section provides detailed instructions on the care and routine maintenance necessary to keep the flow meter in top operating condition. Included are sections on reactivating the desiccator, maintaining the bubbler line, servicing the internal plotter, and checking the level.

Desiccant

The Model 3230 is equipped with a reusable desiccant canister attached by two thumbscrews to the inside of the flow meter lid and two tubular desiccant cartridges mounted on the right side of the case next to the connectors. The canister contains silica gel which absorbs moisture trapped inside the flow meter's case when it is closed, keeping the inside of the case completely dry during shipment, storage and use. If the case is left open, the desiccant will absorb moisture from the surrounding air. Eventually, its absorption capacity will be reached, and it will no longer be able to protect the internal components of the flow meter.

The desiccant canister should be inspected each time the case is opened. The desiccant canister has a window on its side which look blue when the desiccant is in good condition. As the desiccant absorbs moisture, the window will turn pink. When the window is pink, the desiccant needs to be regenerated, or replaced with the spare canister provided in the flow meter accessory package. Refer to Chapter 4 of the flow meter manual for replacement and regeneration procedures.

The external cartridges should be inspected during each site visit. When the color is blue, the desiccant is fine; when jt is pink the desiccant should be replaced. Refer to Chapter 6 of the sampler manual for regeneration and replacement procedures.

Bubbler Line

The bubbler line on the ISCO Model 3230 flow meter should be inspected during each site visit to make sure that it is not kinked, frayed, cut, nicked, or otherwise damaged. If the bubbler line is found to be damaged, it should be replaced. A leaky or obstructed line may cause erroneous level readings and/or decreased battery life as a result of the pump having to run more frequently. If it becomes necessary to replace the bubbler line, a new line may be installed by following the instructions found in Section 3.0 of this SOP manual.

The outlet of the bubbler line should be inspected during each site visit to ensure that it has not become obstructed due to the accumulation of sedimentation, debris, or organic growth. If the line is found to be damaged, it should be cleaned, or the tip may simply be cut off. If clogging of the outlet of the bubbler line proves to be a continuing problem, it may be desirable to use a bubbler line with a larger inside diameter. However, it is usually preferable to increase the frequency of the automatic purge operation (see the following paragraph) rather than increasing the size of the bubbler line. Consult the factory for specific recommendations regarding the size of the line, special connectors required, etc.

The Model 3230 is equipped with an automatic purge feature used to clear the bubbler line with a discharge of air from the pump. This may be useful as an aid to keep the outlet of the bubbler line clean. The program step SELECT PURGE INTERVAL allows the user to establish the interval between purge cycles which ranges from five minutes to one hour. The manual purge button on the flow meter's front panel keypad also allows the user to purge the bubbler line at any time by pressing the button.

Internal Plotter

The internal plotter requires little maintenance beyond changing the paper roll and changing the ink ribbon. Periodic inspection for paper jams should be done. The end of a roll is near when a one-inch pink band appears on the left side of the take-up roll. The table below lists the approximate life of a plotter paper roll for the various chart speeds. Note that this is valid for cases where the report generator is off. If the generator is on, the times will be shorter .

ISCO Model 3230 Internal Plotter Paper Roll
Longevity at Various Chart Speeds
(NOTE: report generator is turned off)

Chart Speed Inches per Hour	Time Required to Fill Full Roll of Paper
4	195 Hours (8 1/8 Days)
2	16 1/4 Days
1	32 1/2 Days
0.5	65 Days

6.2.4 RAIN GAGE

This section discusses the operation and common equipment problems associated with the tipping bucket rain gage.

A schematic of the tipping bucket electronic rain gage is shown in Figure 3-7. The rain gage operates as a magnetic switch. The tipping buckets are attached to an L-shaped bracket with a magnet mounted on it. When the buckets are tipped to either side, the magnet is located far from the switch sensor and the circuit is open. When the buckets fill with rain and tip, the magnet passes over the sensor and momentarily closes the circuit and registers 0.01 inches of rainfall.

If a rain gage is moved from one site to another, the internal components may get jarred out of alignment (e.g. The magnet is shifted a distance too far from the sensor to be detected. Also, the magnet may be shifted too close to the sensor, causing the circuit to not open once the buckets are tilted). This will result in no rain being detected by the rain gage. The magnet can also be shifted to one side only. This will result in the flowmeter only recording half of the total rainfall being collected by the rain gage. The procedures for repairing and calibrating the tipping bucket electronic rain gage are detailed in Part B of Appendix D (Procedure B-7).

7.0 HEALTH & SAFETY PROCEDURES FOR STORM WATER SAMPLING

Stormwater sampling activities present a variety of potentially hazardous situations. These procedures and required equipment are to be implemented to minimize this potential. This section is intended to serve as a guide and may not include all applicable local, state, or federal regulations that may apply to the Knoxville NPDES monitoring program. This section is not intended to provide sufficient health and safety training for field crews. It is the responsibility of each individual worker to comply with all applicable regulations. All workers performing stormwater sampling must read and understand these procedures prior to commencing work.

7 .1 SAFETY EQUIPMENT

Advance planning should include determination of necessary safety equipment. This equipment along with properly trained personnel should be in place before work commences.

7.1.1 GENERAL SAFETY EQUIPMENT

The following equipment is required to be with personnel during all field activities:

- Fully equipped first aid kit
- Flashlight (waterproof) with extra batteries

7.1.2 TRAFFIC SAFETY EQUIPMENT

The following equipment is required during sampling activities on or near a public roadway:

- Warning Signs -Orange 36" x 36", diamond shaped, signs. They should have a weighted base and stand. Use either a "MEN AT WORK" or a "ROAD WORK AHEAD" sign.

- Traffic Cones
- Barricades
- Safety Vests - Orange with reflective tape.
- Warning Lights -All vehicles should be equipped with yellow, high intensity strobe lights. All signs and barricades should be equipped with a yellow flashing light that contains a photocell to turn the lights on at dusk.
- Manhole Barricade -A barricade which can be placed around an open manhole to prevent someone from accidentally walking into the hole.

7.1.3 CONFINED SPACE ENTRY EQUIPMENT

The following equipment is required for activities involving confined space entry:

- Multigas Meter -This meter should be able to test the air for four gases: Oxygen (O_2, Hydrogen Sulfide (H_2S). Carbon Monoxide (CO), and explosive gases.
- Body Harness
- Life Line - 2,000 pound test line
- Ventilation Blower - A blower provides air into the confined space through a large hose.
- Ground Fault Interrupter - All electrical devices must be plugged into one of these.
- Lanyards and Buckets - These are to be used for lifting tools and supplies in and out of a confined space.
- Self Contained Breathing Apparatus (SCBA) Units - At least two NIOSH approved pressure-demand SCBAs must be set up and readily accessible at the work site.

7.1.4 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The following PPE must be on hand when hazardous materials are suspected and/or within confined spaces:

- Safety glasses, goggles or shields
- Hard hat
- Latex and chemical resistent gloves
- Work boots
- Protective suits, i.e. coveralls, tyvek
- Hearing protection

7 .2 GENERAL SAFETY RULES AND GUIDELINES

Numerous hazards may be encountered in the course of storm water sampling Activities. Due care and common sense will alleviate most of these dangers. Some Hazards which may exist include:

- Trip hazards, slippery conditions and sharp objects
- Steep slopes
- Poor visibility
- Fast moving water
- Animals and insects

To minimize these potential hazards, adhere to the following rules and guidelines:

- Take care along the edges of fast moving water.
- If sampling is required at the edge of a fast moving body of water, use a lifeline and a personnel flotation device.
- Never work alone.
- Keep work area neat, pick up tools.

- Use adequate lighting when necessary. .

- Have a phone or other means of communication nearby.

- Always wear a hard hat in construction areas.

- Never leave open holes unattended.

- Clean up the work area before leaving.

7 .3 TRAFFIC SAFETY RULES AND GUIDELINES

Storm water sampling often involves work in and adjacent to traffic. In these cases all precautions must be taken to protect workers from moving vehicles. To minimize traffic hazards adhere to the following rules and guidelines:

- Set up work area so that it interferes as little as possible with traffic.

- Plan work when traffic is light.

- Warning signs to alert drivers must be placed at an adequate distance from the work area. These signs should be equipped with flashing lights for work at night or when visibility is poor. Usually a "Road Work Ahead" or a "Men Working Ahead" sign is sufficient for most sites. However, if a lane closure is necessary on a busy roadway, then another sign is required to inform drivers which lane is closed. This sign should be located at a distance of at least 1,000 feet ahead of the closure.

- If possible, place a vehicle equipped with a yellow flashing light, operational hazard lights, and/or a lighted arrow guide between the work area and oncoming traffic. Block tires.

- All personnel must wear an orange safety vest.

- Use cones and barricades to sufficiently divert traffic safely around the work area. Use flashing yellow lights at night and when visibility is poor.

- If traffic is diverted, assign someone to direct traffic.

- Place barricades or flagging around open manholes.

- Place all tools and equipment away from traffic and manhole.

- Stay visible and watch traffic.

7 .4 CONFINED SPACE ENTRY PROCEDURES

7.4.1 CONFINED SPACE

Confined spaces are considered dangerous because toxic gases and vapors accumulate to form oxygen deficient, toxic, or explosive atmospheres. Examples of confined spaces are tanks and vessels; manholes and pipelines; water transmission lines; tunnels; stilling wells; junction structures; valve and metering vaults; and pumping station wet wells.

A confined space is one in which the following conditions exist or may exist:

1. The ventilation is so poor that dangerous levels of air contamination and/or oxygen deficiency could possibly occur, and

2. Access in or out of the space is difficult because of the location or size of the opening to the outside.

7.4.2 CONFINED SPACE PRINCIPLES

No field personnel should enter a confined space unless they have received proper training and all safety precautions are taken. The most important principals to follow are:

1. Before work begins, evaluate the space to be entered.

   Ask essential questions. Is access a problem? What about the structural integrity of the space? Is the existing ventilation, if any, adequate to control any dangerous air contamination or oxygen deficiency that may develop?

2. Have the human and technical resources that you need on the site.

   A. Testing equipment - have the right tester for the space.

B. Ventilation equipment -is the blower big enough to clear the space if contamination develops?

C. Personal protective equipment particular to the hazards --- gloves, respirators, hard hats, coveralls, safety glasses or goggles, safety harness, safety line, and emergency rescue equipment

D. Workers must be trained in the hazards they may encounter in confined spaces and be prepared for emergencies. Have at least one standby person trained in CPR.

3. Do It by Numbers.

Have a set of written procedures (see below) to be used every time confined spaces are encountered. Document the steps that are taken. You must use the attached "Confined Space Entry Form". Workers may enter the confined space only after all parts of the entry permit are completed.

4. Maintain an Effective Means of Communication.

It is mandatory to maintain an effective means of communication between the worker in the confined space and the standby workers whenever respiratory protection is used, or when the worker in the confined space is out of sight.

5. Use Protective Clothing.

When there is contamination, or the possibility of contamination by hazardous substances, use protective clothing.

Only explosion safe equipment may be used in confined spaces. Temporary lighting, whether electrically or battery operated, shall be low voltage, double-insulated, and explosion-proof.

7.4.3 BUDDY SYSTEM

A minimum of two workers must remain outside the confined space when work is being performed within the confined space. One worker (rescue worker) stands by, ready to enter the space in the event of an emergency. The other (safety worker) remains in visual or audio contact with the persons inside.

7.4.4 MONITORING

Combined combustible gas indicators (CGI or "explosimeter") with hydrogen sulfide, carbon monoxide, and oxygen detectors must be used to test the atmosphere of the confined space for the presence of combustible or other dangerous gases and adequate oxygen levels before entering.

7.4.5 MONITORING PROCEDURES

Gases and vapors tend to stratify in confined spaces. The safety worker shall test the atmosphere within the confined space with the CGI/H_2S/O_2/CO detector, as described below. Follow the manufacturer's manual for instrument operation and calibration procedures.

- Start up, check voltage, and calibrate the combination CGI. Do not calibrate the detector with the probe in the confined space.
- Insert the probe about 12 inches into the space. Read the meter. Repeat every 12 vertical inches until the probe is lowered to the bottom of the space.
- To the extent possible, repeat with the probe in pockets, and comers, etc.
- Enter the highest reading for each gas on the Confined Space Entry Form under "Highest Gas Meter Readings Prior to Entry."

The action requirements for confined space are:

Compound	**Action Level**	**Action Required**
Oxygen	<19.5 percent	Wear SCBA.
LEL	> 10 percent	Exit area.
H_2S	>10 ppm	Wear SCBA.
CO	>50 ppm	Wear SCBA.

7.4.6 VENTILA TION

Ventilation equipment, such as fixed or portable blowers or fans, of sufficient size and capacity, shall be used to provide ventilation. All blowers used within confined spaces will be explosion-proof. Blowers should be coupled with a large diameter flexible hose that can direct air into the work area. The exhaust of all gasoline, diesel, or gas-operated equipment used near the confined space, must be oriented so that fumes cannot enter the confined work area.

7.4.7 ENTERING AND WORKING WITHIN CONFINED SPACES

Always inspect the condition of the entry steps of the confined space. If it appears that the steps will not support your weight, or if the confined space contains no steps, then some form of ready entry and exit must be provided, such as a ladder or approved hoist.

In spaces into which materials may flow:

- If valves are motor operated - disconnect and engage the lockouts.
- If the valves are manually operated - someone must be stationed at the valve operator or the operators must be chained and padlocked.

Climb into any confined space cautiously. Test each step with a gradual application of your weight as you descend. Do not carry tools or other objects in your hands while climbing in or out of the confmed space. Only one person at a time should descend or climb a ladder. Place a barricade around the open hole to prevent someone from inadvertently walking into the hole.

Never toss or lay objects on the ground near an open access hole where they can be accidentally knocked, pushed, or dragged into the confined space. Never drop tools or supplies to the worker below. Lower the object to the worker inside by a hand line, or a bucket attached to a hand line.

Topside workers should be careful of open access holes. Know where the holes are when moving about. When the job is finished and all objects have been removed from the confined space, replace the access cover immediately.

7.4.8 SAFETY HARNESS AND OTHER PROTECCI'IVE EQUIPMENT

A safety harness must be worn when entering, working in, and exiting a confined space. If the access hole is less than 18 inches, a wrist or shoulder/belt harness should be used. Otherwise, a standard waist harness with "D" rings may be used. A hard hat must also be worn at all times. Coveralls, boots, gloves, safety goggles, and other PPE should be worn as necessary, depending upon conditions.

The harness must be worn as designed. A co-worker must inspect the safety harness after it has been put on to determine if it is properly adjusted, and in the proper position.

The safety worker should tend the safety line at all times.

- Secure the safety line to a nearby well anchored object. Never tie off to movable equipment or a vehicle.
- The critical time in terms of safety harness usage is when the worker is climbing in and out of the confined space. If a mechanized recovery reel is not used, the safety worker should keep the safety line taut and pass it across the back of their hips and back and between their feet. Grasp both standards of the rope with a firm grip and keep your eyes on the person in the confined space.
- Never allow extra slack in the safety line.
- Always keep the safety line away from traffic and equipment with moving parts.

7.4.9 RESCUE PROCEDURES

Emergency situations within confined spaces may differ according to the type of confined space. All equipment for rescue or testing must be inspected, tested and repaired or replaced as necessary, prior to arriving at the work location. Be able to identify your work location with the nearest cross street in case emergency assistance is necessary.

A self-contained breathing apparatus (SCBA), in working order, should be ready for use. SCBAs must be tested before any employee enters the confined space. At least one person, in addition to the person entering the confined space, needs to know how to use the SCBA.

If you are within the Confined Space when an emergency occurs:

- Upon detection of a hazard, immediately notify the safety person outside the space, giving all known details as to the nature of the hazard.
- If possible, exit the area, proceeding to the nearest exit.

If you are outside the Confined Space when an emergency occurs:

- If a worker is incapacitated, the rescue worker should assist or help pull the incapacitated individual toward the exit.
- The backup person should immediately request assistance from emergency services.
- If appropriate, the rescue worker dons the SCBA and enters to offer assistance and correct the problem.
- No employee may enter the confined space without a SCBA until all causes of the incapacitation have been determined.
- The safety worker should remain outside the confined space to lower necessary rescue equipment into the space and render any other necessary assistance.

APPENDIX D -- PART A

WET WEATHER MONITORING PROGRAM EQUIPMENT CHECKLISTS

- Equipment Checklist for Grab Samples
- Equipment Checklist for Routine Monitoring Station Maintenance

NPDES STORM WATER PERMIT APPLICATION
ONGOING MONITORING PROGRAM
EQUIPMENT CHECKLIST FOR GRAB SAMPLES

SAMPLING		Grab Sample Bottle Kit (precharged with preservatives) (2 sets)
		Stainless Steel Sampling Bucket with Lid (cleaned and sealed)
		Line for Sampling Bucket
		pH Meter Kit (with spare battery)
		Glass Measuring Cup (cleaned and sealed)
		Cooler with Ice for Filled Grab Sample Bottles
		Ice for Sampler Carousel
		Replacement Sampler Carousel (bottles cleaned and sealed)
OTHER		Chain of Custody Forms
		Bottle Labels
		Fiber Tape
		Ziploc Bags (gallon)
		Clipboard / Waterproof Pens / Grease Pencil
		Field Notebook
		Resident Form Letters
		Automatic Camera (with extra film / batteries)
		Flashlight (2)
		Tape Measure
		Depth Measurement Rod (if none installed at station)
		Data Transfer Unit
		Charged Sampler Battery
		Strainer Brush
		5-gallon Carboy with Tap Water
		Garbage Bags with ties
		Paper Towels
		Keys to Equipment Housing
		Equipment Manuals
		Sampling Procedure Instructions
SAFETY / PERSONAL		Hard Hat
		Rubber Boots
		Safety Goggles
		Disposable Gloves (Latex)
		First Aid Kit
		ID Badge
		Safety Line / Rope
		Rain Gear

CDM

NPDES STORM WATER PERMIT APPLICATION EQUIPMENT CHECKLIST FOR ROUTINE MONITORING STATION MAINTENANCE

EQUIPMENT		Replacement Sampler Carousel (bottles cleaned and sealed)
		Ice for Sampler Carousel (if prior to storm event)
		Data Transfer Unit
		Charged Sampler Battery (if batteries used)
		Desiccant Replacement Bags (2)
		Pump Tubing (5 feet)
		Strainer Brush
		Keys to Equipment Housing
		Step Ladder
		Screwdrivers (flat head and phillips head)
		Sharp Knife
		5-gallon Carboy with Tap Water
		Tape Measure
		Depth Measurement Rod (if none installed at station)
		Clipboard / Waterproof Pens / Grease Pencil
		Field Notebook
		Resident Form Letters
		Automatic Camera (extra film and batteries)
		Flashlight
		Garbage Bags
		Paper Towels
		Equipment Manuals
SAFETY / PERSONAL		Hard Hat
		Work Gloves
		Rubber Boots
		Safety Goggles
		Disposable Gloves (Latex)
		First Aid Kit
		ID Badge
		Safety Line / Rope
		Rain Gear

CDM

APPENDIX D -- PART B

DETAILED PROCEDURES FOR MONITORING STATION OPERATION

- Procedure B-1: Configuring and Programming the ISCO Model 3700 Sampler and ISCO Model 3230 Flow Meter
- Procedure B-2: Procedures for Grab Sample Collection for NPDES Ongoing Monitoring Program (Full Suite of Pollutants)
- Procedure B-3: Standard Operating Procedures for Field Measurement of Stream Discharge in Open Channels and Closed Conduits
- Procedure B-4: Laptop Data Interrogation and ASCII File Creation Procedure
- Procedure B-5: Sample Compositing Scheme From FLOWLINK ASCII File
- Procedure B-6: Procedures for Composite Sample Collection for Ongoing Monitoring Program
- Procedure B-7: Maintenance Procedure for the NPDES Monitoring Station Rain Gage

Procedure B-1

CONFIGURING AND PROGRAMMING THE ISCO MODEL 3700 SAMPLER AND ISCO MODEL 3230 FLOW METER

Preparing the flow meter and sampler requires two steps:

1. Configuring the flow meter and sampler; and
2. Programming the flow meter and sampler.

While each requires a number of detailed steps, you should only need to conduct the procedure once for each unit. If changes are necessary during the course of the program, they can be made easily at any time once each unit has been prepared. Programming the flow meter and configuring and programming the sampler are done through the key pad on each unit. In order to utilize the flow meter's memory capabilities as well as take advantage of the variety of sampler enable/disable functions, the FLOWLINK program is used. This appendix will outline the steps necessary for both procedures. It is organized in the following manner:

PART I: Configuring/programming the Flow Meter and Sampler Through the Key Pad

PART II: Programming the Flow Meter and Sampler Through FLOWLINK

PART I: CONFIGURING/PROGRAMMING THE FLOW METER AND SAMPLER THROUGH THE KEY PAD

A. FLOW METER

These steps detail the programming necessary to operate the flow meter in LEVEL mode. For other programming options, see the user's manual. To enter a selection at a particular step press the corresponding number key, enter a value using the number keys, or use the left/right arrow keys. Press ENTER to accept the selection.

1. Turn flow meter on.

2. Press GO TO PROGRAM STEP key. The message "Enter Program Step Number 1-12" will appear.

3. Select a mode of operation. Selecting "LEVEL ONL Y will result in a request for the units of measure (feet or meters).

4. Select sampler control. Select ENABLE BY LEVEL.

5. Enter level at which to enable sampler.

6. Select DISABLE BELOW X.XX FT. This programs the sampler to stop sampling once the level falls below what was programmed in step 5.

7. Select plotter ON/OFF with sampler enable.

8. Select plotter mode of operation (OFF OR LEVEL).

9. Enter the plotter ful1-scale reading (100% LEVEL = XX/XXX FT).

10. Select plotter chart speed. The slower the chart speed, the less paper used and less power used.

11. Set the year, month, day, hour, and minute. This sets the correct time and date for the flow meter.

12. Enter the site identification number. .

13. Select the auto purge frequency.

14. Adjust the level. Set this value to the actual level in the stream/conduit.

15. Reset the flow totalizer (YES or NO).

16. All report generation (ON or OFF). If OFF is selected, skip to step 21.

17. Clear report data after print (YES or NO). If YES is chosen the minimum, maximum, and average levels and the volume for the period would be cleared.

18. Set the report interval (hourly, daily, or monthly).

19. Enter the report interval (print a report every XX hours, days, or months).

20. Enter interval start time. This sets the beginning time of the report.

21. Enable program lock (YES or NO). If the lock is enabled, that the user must supply a password before any changes to the program can be made. The password is "3230."

B. SAMPLER

These steps detail the programming necessary to configure and program the sampler operation. For other programming options, see the user's manual. To enter a selection at a particular step press the corresponding number key, enter a value using the number keys, or use the left/right arrow keys. Press ENTER/PROGRAM to accept the selection. To obtain more information about a particular step, press and hold the STOP key. The display will show the page number of the users manual which you can consult for detailed information.

CONFIGURE SAMPLER

NOTE: The Sampler only needs to be configured once at each location.

1. Turn on Sampler.

2. Access the configure sequence by selecting CONFIGURE. Select CONFIGURE by pressing the Right Arrow key once. When CONFIGURE blinks, accept the selection by pressing Enter/Program.

3. Press the Left Arrow or Right Arrow key to scroll through the Configure options.

4. The first option displayed when the Right Arrow key is pressed is the Set Clock configure option. If the time displayed on the LCD in the standby message is not current, reset the time with the Set Clock configure option. Access the Set Clock display by pressing Enter/Program.

   Pressing the Right Arrow or Enter/Program key on the last entry will store the values and advance to the next display.

5. To verify the Bottles and Sizes settings, press the Enter/Program key.

6. Because the Model 3700 is a portable sampler, select PORTABLE by using the Arrow keys. Accept the selection by pressing the Enter/Program key.

7. This sampler has 4 bottles, so select 4. Press the arrow keys until 4 blinks, then press the Enter/Program key.

8. Enter the bottle size here. press 3-8-0-0 (for the 1 gallon bottles). Press the Enter/Program key.

9. Press the Enter/Program key at this display to access the Intake Line input displays discussed in Steps 11 -13.

10. The tubing has a 3/8 inch inside diameter. Select 3/8. Press the Enter/Program key to accept the entry and advance to the next step.

11. Select teflon and press the Enter/Program key to accept the selection.

12. Enter the length of the intake line. The length should not include the tube coupling or the strainer. Press the numbers and the press the Enter/Program key to accept the entry and move to step 14. If this is a change from the suction line settings already in the sampler, the following message will appear for a short time.

13. Press the Enter/Program key at this display to access the Liquid Detector input displays discussed in Steps 14 -17.

14. Select ENABLE. Press Enter/Program to accept the selection.

15. Enter the number of rinse cycles and press Enter/Program. Rinse cycles condition the intake line to reduce cross contamination.

16. This setting determines whether the suction head will be entered manually during programming or computed by the sampler program. Select YES or NO, and press Enter/Program to accept the selection.

17. This setting determines the number of times the sampler will try to detect the presence of liquid for each sample event. Press Enter/Program to accept the entry.

18. This setting determines the programming mode of the sampler. Press Enter/Program. You must select EXTENDED to access the STORM program. Choose a mode, and press Enter/program to accept the choice.

19. Press Enter/Program to access sampler calibration options.

20. Select ENABLE. Press Enter/Program to accept the selection.

21. Press Enter/Program to access time delay options.

22. Enter a number of minutes to delay the sampler after it has been initially triggered. Typically, no delay is necessary, so a setting of 0 minutes should be entered. Press Enter/Program to accept the entry.

23. Press Enter/Program to access the ENABLE PIN options.

24. Select "NO" at the Master/Slave mode screen. Press Enter/Program to accept entry.

25. Select "NO" at the Sample Upon DISABLE screen. Press Enter/Program to accept entry.

26. Select "NO" at the Sample upon ENABLE screen. Press Enter/Program to accept entry.

27. Select "YES" at the RESET SAMPLER INTERVAL screen. Press Enter/Program to accept entry .

28. The next steps define the type event mark the sampler will use. Press Enter/Program to access options.

29. Select PULSE. Press Enter/Program to accept entry.

30. Select FWD PUMPING. Press Enter/Program to accept entry.

31. The next steps configure the pump counter (used for tracking the pump tubing life). Press Enter/Program to access options.

32. Enter the number of pre-sample counts. Press Enter/Program to accept entry.

33. Enter the number of post sample counts. Press Enter/Program to accept entry .

34. Press Enter/Program key to enter the tubing life options.

35. This screen will show the number of pump counts. Press Enter/Program to continue.

36. Select "NO" to when prompted to reset the pump counter. Press the Enter/Program key.

37. Set the number of pump counts at which a warning to change the pump tubing will be given. Press Enter/Program to accept entry.

38. Press Enter/Program to enter the program lock options.

39. Select Disable. Press Enter/Program to accept entry.

40. Press Enter/Program to enter the sampler identification options.

41. Enter the identification number of the sampler (site specific). Press Enter/Program to accept entry.

This screen completes the Configure section of the sampler. Leave the Configure sequence by pressing the Exit Program key. The sampler will return to the standby mode shown in the next display.

PROGRAM SAMPLER

The steps needed to program the sampler in the BASIC mode follow the procedure outlined below.

1. Turn the sampler on with the ON/OFF key. The "STANDBY" message will appear, or if the sampler were turned off while running a routine, the "PROGRAM HAL TED" message will be displayed.

2. Press the ENTER/PROGRAM key to access the interactive state. Select the program sequence. If you want to return to a previous display, press the EXIT PROGRAM key. The sampler will return to standby and you can repeat steps 1 and 2. Then press the ENTER/PROGRAM key to scroll through the settings until you locate the display in question.

3. Enter the Sample Pacing settings. The sampler will prompt you to select either time- or flow-pacing.

4. Enter the Sample Distribution settings. The settings in the Sample Distribution section allow you to perform sequential or multiplexed sampling.

   If you want to use bottles-per-sample or samples-per-bottle multiplexing, select "YES". The next display will prompt you to select either "BOTTLES PER SAMPLE" or "SAMPLES PER BOTTLE".

5. Enter the Sample Volume settings. The Sample Volume program section will always contain prompts for the sample volume. Depending on the selections made in the configure sequence, it may contain prompts for the intake head and for calibrating the sampler .

6. Enter the Key Times settings. In the basic programming mode, you will be asked if you want to enter a start time for the routine. If you select "YES", you will be prompted to enter a specific start time and date. If you select "NO", the sampler will use the start time delay.

7. The sampler will automatically return to standby.

8. From standby, start the routine by pressing the START SAMPLING key. This places the sampler into the run state.

Other programming features are discussed in Chapter 4 of the Sampler Manual.

PART II:

PROGRAMMING THE FLOW METER AND SAMPLER THROUGH FLOWLINK

A. FLOW METER

Preparing the flow meter for the first time requires a number of detailed steps that should only be conducted once for each unit. Changes to the flow meter can be made at any time once it has been prepared. The flow meter's I.D., Clock, and Name will change with each new sampling site. Refer to Step 6 for programming sequence. The flow meter's partition(s) will remain the same regardless of site location. Refer to Step 7 for programming procedures. The procedures below describe programming the flow meter from a remote location using a modem and the module TELEFLOW. On-site programming using a laptop computer and using the module LAPCOMM varies only slightly from these instructions. LAPCOMM procedures can be found in the FLOWLINK User's Manual.

1. Make sure that a phone line is connected to the computer's modem connection and the line is free.

2. Be sure the flow meter is on.

3. Turn on the computer and enter FLOWLINK by typing FL from the DOS prompt (C:\>).

4. Select TELEFLOW from the main menu. Select Phonebook from the Base Menu.

    a. If the phone number for the site has not been created, select NEW from the Phonebook Menu. Type the phone number for the site. If a "9" or similar number is needed to get to an outside line from an office, be sure to include it in the phone number. The new phone number will be added to the phonebook listing.

    b. If the site's phone number has been created, highlight the phone number using the arrow keys. Proceed to step 5.

5. Select Connect from the Base Menu. TELEFLOW will contact the flow meter and present the Connect Menu.

6. Select Adjust from the Connect menu. TELEFLOW will present the Adjust Menu. The Adjust Menu allows you to establish a site ID number; set the clock; enter a site name; calibrate the level for the 3230 flow meter, and set the unit password.

a. Select ID from the Adjust Menu. TELEFLOW will prompt you for a number; you can enter up to three digits.

b. Select Clock from the Adjust Menu to synchronize the flow meter's clock with the computer's clock. The computer's current time appears in the upper right corner of TELEFLOW's screens. The flow meter's time appears in the status display.

c. Select Name to enter text for the Site Name. You can enter up to 17 characters. The site name serves as a short description of the site; the flow meter's address is a typical entry.

d. To calibrate the flow meter's level readings, select Level. TELEFLOW will prompt you to enter a new level reading.

e. Select Quit or press Escape to return to the Connect Menu.

7. Select Partition from the Connect Menu. TELEFLOW will present the Partition Menu.

a. To create a new partition, select New from the partition Menu. TELEFLOW will display the Data Type Menu. The Data Type Menu allows to you specify the type of data stored in a partition. The menu will contain Level, Rainfall, and Sampler as options.

b. Select the menu option corresponding to the type of data you want to store in the partition. If you select Level, Flow or Rainfall, TELEFLOW will present the New Partition Menu and the specification box. The box contains the specification fields required to define a new partition: Memory Type/Recording Mode, Size (Readings), Data Interval, and Partition Name.

c. Creating a level, flow, or rainfall partition requires five steps: i) select rollover or slate memory mode; ii) determine the number of readings stored in the partition; iii) select the reading interval; iv) enter a name for the partition; and v) instruct TELEFLOW to create and initialize the partition in the flow meter. To create a level, flow, or rainfall partition, follow steps i through v, below.

Creating a sampler partition requires three steps: determine the partition size, name the partition, and instruct TELEFLOW to create and initialize and partition in the flow meter. To create a sampler partition, follow steps ii, iv, and v, below.

Note: Sampler partitions are available in rollover mode only; you cannot use slate mode memory for sampler partitions. The Mode Menu is therefore not available for sample partitions. Because sampler data is event driven rather than time driven, you cannot set a time interval for the data.

i. Select Mode from the Partition Menu. TELEFLOW will present the Mode Menu. The menu contains six options: No Slate, Slate, Level, Flow, Rainfall, and Time. Select the option which corresponds to the type of memory you need for the partition. After you select the memory type, TELEFLOW will prompt you for a set point. When you complete the set point entries, select Quit to return to the Partition Menu.

ii. Select Readings from the Partition Menu. TELEFLOW will prompt you for the number of readings. The minimum is 64; the maximum is the amount of memory not already committed to other partitions. TELEFLOW will round you entries up to the nearest multiple of 64 and recalculate the amount of time needed to fill the partition.

iii. Select Interval to set the reading interval for the partition.

iv. Select Name, and enter site name (optional).

v. Select Create to create and initialize the partition. If you leave the Partition Menu without first selecting Create, TELEFLOW will not create the partition in the flow meter.

d. Repeat step c for each additional partition. When you have created the partition you need, select Quit from the Partition Menu. TELEFLOW will return to the Connect Menu.

Note: Configure the flow meter's memory in the following way:

PARTITION A:

Data type = Level
Mode = LEVEL
Mode Set Point = ???? (site specific)
Size (Readings) = 4032 (14 days)
Data Interval = 5 minutes
Name = ????

PARTITION B:

Data type = Rainfall
Mode = Rainfall
Mode Set Point = # inches/tirne
Size (Readings) = 6220 (21.6 days)
Data Interval = 5 minutes
Name = ????

PARTITION C:

Data type = Sampler
Mode = NA
Mode Set Point = NA
Size (Readings) = 960 (10 "full carousel" events)
Data Interval = NA
Name = ????

Once the flow meter is configured, quit out of the Partition Menu back to the Connect menu by typing Q or ESC successively until the menu is reached.

B. SAMPLER

Skip to Step 6 if you have just configured the flow meter partitions. If you are only changing the sampler controls, begin at Step 1.

1. Be sure sampler and flow meter are on.

2. Make sure that a phone line is connected to the computer's modem connection and the line is free.

3. Turn the computer on and enter the FLOWLINK program by typing FL at the DOS prompt (C:\>).

4. Enter the TELEFLOW program by selecting TELEFLOW from the main menu. Select Phonebook from the main menu. Highlight the site's phone number using the arrow key and proceed to Step 5. (If the phone number has not been created, refer to Step A-4a above).

5. Select Connect from the top menu.

6. Select Sampler from the Connect menu. TELEFLOW will retrieve the Sampler Control Definition currently stored in the flow meter and the operating status data for any connected sampler.

   TELEFLOW will also present two display boxes in the lower section of the screen. The first box reports the following information: sampler enabled or disabled, sampler latched, and pacing enabled or disabled. The second box, labeled "Sampler Control Definition," contains four items: the control condition, the latch setting ("ENABLE SAMPLER CONTINUOUSLY..."), the plotter settings, and the front panel access setting.

   a. To enable or disable sampler pacing, select Pace from the Sample Menu. TELEFLOW will present the Sampler Pace Menu. This menu contains two options: Enable and Disable. Select Disable to disable flow pacing.

   b. To create a new SCD, select SCD from the Sampler Menu.

      i. Select New from the SCD Menu. TELEFLOW will prompt you for a file name. Press Enter to accept the default or replace the default with your own file name. (TELEFLOW will not allow you to enter a file name that already exists on the current data directory.)

      ii. Select the condition from the vertical menu; then select Set/Change from the Conditions Menu to accept the selection. TELEFLOW will present the SCD Change Menu, and will update the Conditions field of the Sampler Control Definition box with your selection.

         The SCD Change Menu varies according to the selected control condition. All menus will include the Conditions, Actions, and Save options as well as one or two of the following options; Level, Flow, Rainfall, and Time. To replace the current control condition with another, select the Conditions option to access the Conditions Menu again.

      iii. To enter the Actions settings, select Actions. When you select each option of the Actions Menu (Latch, Plot, or Block), TELEFLOW will present a prompt and a Yes/No menu. When you have completed the actions settings, TELEFLOW will return to the SCD Change Menu.

      iv. Select Level to enter a level set point.

v. Select Rainfall to enter a rainfall set points: an amount of rainfall measured in a time window. TELEFLOW will present the Rainfall Set Point Menu. This menu contains two options: Amount and Time. Select Amount to enter the amount of rain for the set point. Select Time to select a time window.

vi. After entering the set points, TELEFLOW will return to the SCD Change Menu. Select Save from the menu to save the file to the current data path. TELEFLOW will prompt you again for a file name. Rename the file, if desired. Press Enter to accept the default file name.

vii. TELEFLOW will save the file, return to the SCD Menu, and update the file name at the bottom of the display. It will also revise the "NOTE:" field in the Sampler Control Defmition box to inform you that the displayed SCD is not the flow meter's current SCD.

viii. To send the SCD to the flow meter, select Transmit from the SCD Menu. TELEFLOW will send the SCD to the flow meter and change the NOTE field in the Sampler Control Definition box to inform you that the displayed SCD is now the flow meter's current SCD.

Note: Samplers should be configured with the following settings:

ACTIONS: Enable sampler continuously once the conditions are satisfied? NO

Enable flow meter's print/plotter only while SAMPLE ENABLE is active? NO

Block access to SAMPLER ENABLE from flow meter's front panel? NO

CONDITIONS: Enable sampler on Level and Rainfall

LEVEL: ???? (X axis with sampling site)

RAINFALL: 0.1 inches / 30 minutes

Once the SCD is configured and transmitted to the sampler, quit out of FLOWLINK by typing Q or ESC successively until you reach the DOS prompt (C:\>).

Procedure B-2

PROCEDURES FOR MANUAL GRAB SAMPLE COLLECTION FOR NPDES ONGOING STORM WATER PERMIT APPLICATION (FULL SUITE OF POLLUTANTS)

1. New, clean disposable gloves should be worn at all times during grab sample collection process including when cleaning/preparing sample collection equipment and when obtaining samples in field.

2. Clean sample collection container, lid, and pouring beaker (glass or stainless steel) with phosphate-free laboratory-grade detergent (Liqui-Nox™ or equivalent), hot water, and a scrub brush. Rinse equipment well with hot tap water then rinse well with deionized water. Rinse equipment twice (in a well-ventilated area) with pesticide-grade isopropanol, acetone, or hexane. Air dry sample collection equipment for 24 hours; place container, lid, and pouring beaker in plastic bag; and seal bag (without plastic tape).

3. Ensure that pH meter is calibrated to pH buffer solutions.

4. All grab samples should be obtained during the first three (3) hours of runoff from a storm event after a three (3) day dry period. Note time of sample collection for correlation with storm hyetograph and hydrograph.

5. Notify lab personnel just prior to grab sample collection.

PROCEDURES

1. Visually inspect sampler and verify that it is working properly.

2. All grab samples should be obtained during the first three (3) hours of runoff from a storm event after a three (3) day dry period. Note time of sample collection for correlation with storm hyetograph and hydrograph. Review flow meter printout.

3. Obtain pH measurement of storm water discharge using hand-held pH meter (follow manufacturer's instructions) in well-mixed center of flow. If unable to access flow with pH meter, obtain a grab sample from the well-mixed center of flow using a clean container. Measure pH of grab sample.

4. Rinse sample collection container and pouring beaker twice with source sample water. Use well-mixed center of flow; do not disturb bottom sediments.

5. Obtain sample from the well-mixed center of flow at approximately the same location (just downstream) as the sampler strainer; do not disturb bottom sediments. For manhole sites, first connect a rope to the stainless steel bucket, then lower the bucket into the manhole. Do not enter the manhole during the storm event. Approximately 5,000 mL (1.1 gal) is required (approximately 1/3 of 12.5 quart stainless steel bucket) to fill all grab sample bottles; sufficient sample for all grab samples should be taken at one time.

6. After initial grab sample collection, remaining activities should be performed under cover as much as possible. One member of the field team should take all notes, fill out labels, etc. while the other member does all of the sampling (if possible). However, two sets of hands may be required to hold sample container steady and to pour sample into container.

7. Because several of the grab sample bottles have been precharged with preservatives (NaOH, H_2SO_4, $Na_2S_2O_3$), safety goggles and new, clean disposable gloves shall be worn by personnel while filling sample bottles. All handling of opened grab sample bottles shall be conducted in an open, well-ventilated area. Material safety data sheets (MSDS) for all preservatives are given in Part D of Appendix D.

8. Swirl sample in bucket and/or pouring beaker immediately prior to filling sample bottles to ensure complete mixing.

9. Volatile Organic Analysis (VOA) Samples: VOA samples should be obtained immediately after collection of the initial storm water grab sample. The 40-mL vials should be completely filled to prevent volatilization and caution should be exercised when filling a vial to avoid any turbulence which could also cause volatilization. Fill vials by pouring sample from collection container or pouring beaker into vial. Pour the last few drops of sample into the vial so that surface tension holds the water in a "convex meniscus". Pour a few drops of sample into cap and then apply cap to ensure that no air bubbles remain in vial. After capping, turn the bottle over and tap it to check for bubbles. If any bubbles are present, remove cap, add additional sample, recap, and recheck.

10. Cyanide, Phenols, Fecal Bacteria, and Oil and Grease Samples: Sample bottles shall be opened immediately before filling to prevent loss of preservative. After swirling sample in bucket, carefully fill appropriate container near brim and cap. Fill sample bottle by pouring sample into bottle; do not immerse bottle in sample collection container. Use care not to overfill and thus lose any preservative. Removal of all air bubbles before capping is not necessary.

11. All grab sample bottles should be pre-labeled on bottle (not cap) as to parameter group for laboratory analysis. Field completion of the sample identification including sample ID (see text for format), crew ID, date, time, and location should be completed for each sample using a waterproof pen immediately upon filling sample bottle. Be sure all bottle lids are on tight and will not leak.

12. Filled grab sample bottles shall be placed immediately on ice in a small cooler. Ice should completelv surround all sample bottles.

13. The chain of custody form shall be completed for the cooler contents using a waterproof pen and placed in a waterproof plastic bag. The completed chain of custody form shall be placed inside the cooler on top of the ice; the cooler then shall be taped shut (fiber tape). The cooler should also be labeled on the outside.

14. The field log describing all sampling activities must be completed before leaving the site.

15. All equipment used to obtain grab samples should be thoroughly rinsed with tap water in the field as soon as possible after use.

16. Notify lab that you are bringing grab samples in.

17. Delivery of the cooler containing the sample bottles to the laboratory must be made as soon as possible and not longer than 6 hours after obtaining samples. The chain of custody form for the storm event grab samples shall be completed by the laboratory as part of delivery of the samples. Completed chain of custody forms should be filed in the field notebook for that monitoring station.

Procedure B-3

STANDARD OPERATING PROCEDURES FOR FIELD FLOW MEASUREMENT

Stormwater monitoring projects will require use of proper field techniques for flow measurement. Flow measurements are required to develop stage-discharge relationships for monitoring stations equipped with automatic samplers and flow meters (stage recording). The velocity-area method is the established method of making instantaneous flow measurements in stream channels and closed-conduits (pipes). This method is particularly useful where the flow is too large to permit the installation of a primary flow device. It is also useful for checking the accuracy of an installed primary flow device or other flow measurement method.

The basic principle of this method is that the flow (Q) in a channel or pipe is equal to the average velocity (V) times the cross-sectional area (A) of the channel or pipe at the point where the average velocity was measured (i.e. $Q = A * V$). The velocity of stormwater is determined with a Marsh-McBirney (or compatible) velocity meter; the area of the channel or pipe is calculated using an approximation technique in conjunction with a series of velocity measurements.

While the velocity-area method is an instantaneous flow measurement method, it can be used to develop a continuous flow measurement system. This is accomplished by making a number of individual measurements at different flow rates and developing a curve or curves that relate water depth, or head, to discharge (generally referred to as a rating curve). This curve can then be utilized along with a stage recorder to provide a continuous flow record.

This appendix will outline the steps necessary for accurate flow measurement in channels and pipes. It is organized in the following manner:

PART I: Open Channel Flow Measurement

PART II: Closed Conduit Flow Measurement

PART I: OPEN CHANNEL FLOW MEASUREMENT

A. Equipment List

1. Depth
   - wading rod, graduated rod, or yard stick

2. Width
   - tag line, metallic tape or 50' measuring tape
   - survey stakes

3. Velocity
    - portable flow meter
    - probe mount (approx. 3/8 inches in diameter)

4. Miscellaneous
    - field data sheets (Figure B3-1 at end of this procedure) .
    - waders or boots
    - safety line
    - life jacket
    - gloves
    - hammer or mallet

B. Initial Site Investigation (conducted during dry weather)

1. Select a cross section and mark with survey stakes.
    - straight reach, parallel streamlines
    - velocity > 0.5 fps; depth > 0.5 ft
    - uniform streambed; relatively obstruction free
    - uniform flow; free from eddies, backwater, turbulence
    - close to control section or gage station (where applicable)

2. Record the width of the cross section using the measuring tape. The number of observation verticals (points across the cross section where velocity measurements will be taken) should be chosen such that no subsection contains more than 10 percent of the total discharge. Use the following convention in determining the amount of subsections:
    - each streambank is an observation vertical
    - maintain a minimum spacing of 6 inches between verticals across the section

    Record the distances from the stream bank along the selected cross section.

3. Install staff gage.
    - Be sure the zero level is aligned with the zero level of the flow control device (where applicable).
    - Install solidly and accurately to stream bank or flow control device.

C. Flow Measurement

1. Measure depth of flow at the centerline of the channel (this determines the velocity measurement method).
    - If depth > 2.5 ft, use the *two-point method* (0.2 and 0.8 of full depth)
    - If depth < 2.5 ft or stage is rapidly changing, use the 0.6-*depth method*.

- If velocities are distoned by overhanging vegetation, rocks, piers, etc., use the *three-point method* (0.2, 0.6, and 0.8 of full depth).

2. Record the following information on the field data sheet shown on Figure B3-1 at the end of this procedure:
   - Date and location of measurements
   - Depth of flow at centerline
   - Velocity measurement method
   - Distances from streambank where velocity measurements will be taken

3. First velocity measurement at the streambank. Record the following information:
   - Time
   - Staff gage height (if applicable)
   - Depth of flow
   - Velocity reading(s)

4. Velocity measurements in the channel. Record the following information:
   - Depth of flow at corresponding vertical
   - Velocity reading(s) at corresponding vertical

5. Final velocity measurement at the opposite streambank. Record the following information:
   - Time
   - Depth of flow
   - Velocity reading(s)
   - Staff gage height (if applicable)

6. Record any observations or unusual occurrences.

D. Data Analysis

1. Enter data into the rating curve spreadsheet developed for the site.

2. Calculate flows using the mid-section method (see Figure B3-2).
   - Compute the area of the sub-section suuounding the velocity venical
   - Average the velocity readings at that vertical
   - Multiply the area times the velocity to obtain the sub-section flow
   - Repeat for each sub-section in the channel cross-section
   - Sum the flows through each sub-section to obtain the total discharge through the cross-section

3. Develop/update rating curve.

4. QAQC
    - Outliers
    - Rating shifts
    - Human error (data entry, calculations, etc.)

PART II: CLOSED CONDUIT FLOW MEASUREMENT

NOTE: For these field measurements, use the Field Data Sheet shown in Figure B3-3 at the end of this procedure.

A. Equipment List

1. Depth
    - Wading rod, graduated rod, or yard stick

2. Width
    - 50' measuring tape

3. Velocity
    - Portable flow meter
    - Probe mount (approx. 3/8 inches in diameter)

4. Miscellaneous
    - Field data sheets (Figure B3-3 at end of this procedure)
    - Waders or boots
    - Safety line
    - Life jacket
    - Gloves

B. Flow Measurement

1. Record date, time, and location of measurement.

2. Record depth of flow at the centerline.

3. Take velocity reading(s) at centerline:
    - If depth >1.0', use the 2-point measurement method (0.2- and 0.8- depth).
    - If depth <1.0', or the flow is rapidly changing, use 0.6-depth method.

4. At minimum, record velocities at the centerline and at verticals one-half the distance between the centerline and the pipe wall on either side of the centerline. Typically up to 10 observation verticals will be sufficient. Use the convention described in Step 3 to determine the number of velocity readings in the verticals.

C. Data Analysis

1. Enter data into the rating curve spreadsheet developed for the site.

2. Compute the flows:
   - Calculate area using the centerline depth and the attached table.
   - Average the velocity at each vertical.
   - Multiply the area times the average velocity to obtain the flow.

3. Develop/update rating curve.

4. QAQC
   - Outliers
   - Rating shifts
   - Human error (data entry, calculations, etc.)

Figure B3-1

Meas. No. ________
Comp. by ________

Field Data Sheet for Open Channel Velocity Measurements

Date: ________
Location: ________
Flow Conditions: ________
Depth @ Centerline: ________
Gage Height (initial): ________ Gage Height (final): ________
Velocity Measurement Method: ________
(2-pt, 3-pt, 0.6*Depth)

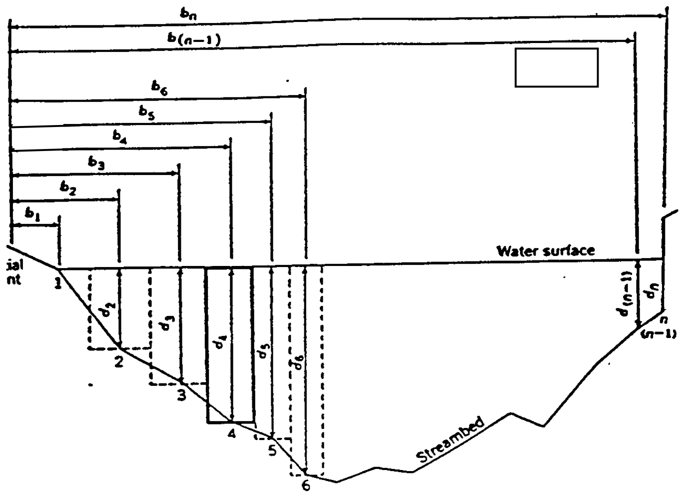
						Velocity at Observation Vertical				
	Time	*Distance of Section from Bank* b (ft)	*Width* w (ft)	*Depth* d (ft)	*Area* A (sq ft)	*0.2*d* v (fps)	*0.8*d* v (fps)	*0.6*d* v (fps)	*Mean Velocity* v (fps)	*Flow Rate* q (cfs)
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										

Total Flow ________

NOTES:
1. *Record time and gage height on initial and final readings only.*
2. *Refer to figure on the back of this page for calculating flows.*
3. *Record any additional comments/observations on the back.*
4. *When using the 3-point method, average the 0.2 and 0.8 readings first, then average the 0.6 reading.*

CDM

Figure B3-2



EXPLANATION

1, 2, 3 .... n	Observation verticals
$b_1, b_2, b_3, \ldots b_n$	Distance, in feet or meters, from the initial point to the observation vertical
$d_1, d_2, d_3, \ldots d_n$	Depth of water, in feet or meters, at the observation vertical
Dashed lines	Boundaries of subsections; one heavily outlined is discussed in text

$$q_x = v_x \left[\frac{(b_x - b_{(x-1)})}{2} + \frac{(b_{(x+1)} - b_x)}{2}\right] d_x$$

$$= v_x \left[\frac{b_{(x+1)} - b_{(x-1)}}{2}\right] d_x$$

where

q_x = discharge through subsection x,
v_x = mean velocity at vertical x,
b_x = distance from initial point to vertical x,
$b_{(x-1)}$ = distance from initial point to preceding vertical,
$b_{(x+1)}$ = distance from initial point to next vertical, and
d_x = depth of water at vertical x.

Thus, for example, the discharge through subsection 4 (heavily outlined in fig. 41) is

$$q_4 = v_4 \left[\frac{b_5 - b_3}{2}\right] d_4.$$

The procedure is similar when x is at an end section. The "preceding vertical" at the beginning of the cross section is considered coincident with vertical 1; the "next vertical" at the end of the cross section is considered coincident with vertical n. Thus,

$$q_1 = v_1 \left[\frac{b_2 - b_1}{2}\right] d_1$$

and

$$q_n = v_n \left[\frac{b_n - b_{(n-1)}}{2}\right] d_n.$$

ADDITIONAL COMMENTS/OBSERVATIONS:

Figure B3-3

Meas. No. ______

Comp. by ______

Field Data Sheet for Closed Conduit Velocity Measurements

Date: ______ Time: ______

Location: ______

Flow Conditions: ______

Comments/

Observations: ______

FIELD MEASUREMENTS:

Depth at Centerline, d: ______ *ft*

Diameter of Pipe, D: ______ *ft*

	Observation Vertical (CL,L,R)	*Velocity at Observation Vertical* 0.2*d v (fps)	0.8*d v (fps)	0.6*d v (fps)	*Mean Velocity in the Vertical* v (fps)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

FLOW CALCULATION:

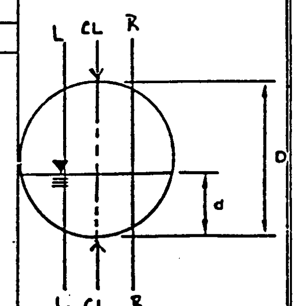
d/D: ______

Area/D^2: ______

Area, A: ______ *sq ft*

Mean Velocity, V: ______ *fps*

Total Flow, Q: ______ *cfs*



a. Calculate d/D and refer to table on back of this page to obtain Area/D^2.

b. Area, A = (D^2)(A/D^2)*

*c. Flow, Q = A*V.*

*NOTES: 1. If d >= 1.0 ft, use 2-point velocity measurement method. If d < 1.0 ft or if flow is rapidly changing, use 0.6*d velocity measurement method.*

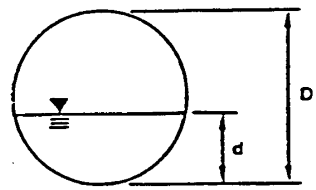
2. For Observation Vertical: CL = Centerline, L = Left of Centerline, R = Right of Centerline.

CDM

environmental engineers, scientists, planners, & management consultants

Figure B3-3

Area, Wetted Perimeter and Hydraulic Radius of Partially Filled Circular Pipes



d/D	area/D²	wet. per./D	hyd. rad./D	d/D	area/D²	wet. per./D	hyd. rad./D
0.01	0.0013	0.2003	0.0066	0.51	0.4027	1.5908	0.2531
0.02	0.0037	0.2838	0.0132	0.52	0.4127	1.6108	0.2561
0.03	0.0069	0.3482	0.0197	0.53	0.4227	1.6308	0.2591
0.04	0.0105	0.4027	0.0262	0.54	0.4327	1.6509	0.2620
0.05	0.0147	0.4510	0.0326	0.55	0.4426	1.6710	0.2649
0.06	0.0192	0.4949	0.0389	0.56	0.4526	1.6911	0.2676
0.07	0.0242	0.5355	0.0451	0.57	0.4625	1.7113	0.2703
0.08	0.0294	0.5735	0.0513	0.58	0.4723	1.7315	0.2728
0.09	0.0350	0.6094	0.0574	0.59	0.4822	1.7518	0.2753
0.10	0.0409	0.6435	0.0635	0.60	0.4920	1.7722	0.2776
0.11	0.0470	0.6761	0.0695	0.61	0.5018	1.7926	0.2797
0.12	0.0534	0.7075	0.0754	0.62	0.5115	1.8132	0.2818
0.13	0.0600	0.7377	0.0813	0.63	0.5212	1.8338	0.2839
0.14	0.0688	0.7670	0.0871	0.64	0.5308	1.8546	0.2860
0.15	0.0739	0.7954	0.0929	0.65	0.5404	1.8755	0.2881
0.16	0.0811	0.8230	0.0986	0.66	0.5499	1.8965	0.2899
0.17	0.0885	0.8500	0.1042	0.67	0.5594	1.9177	0.2917
0.18	0.0961	0.8763	0.1097	0.68	0.5687	1.9391	0.2935
0.19	0.1039	0.9020	0.1152	0.69	0.5780	1.9606	0.2950
0.20	0.1118	0.9273	0.1206	0.70	0.5872	1.9823	0.2962
0.21	0.1199	0.9521	0.1259	0.71	0.5964	2.0042	0.2973
0.22	0.1281	0.9764	0.1312	0.72	0.6054	2.0264	0.2984
0.23	0.1365	1.0003	0.1364	0.73	0.6143	2.0488	0.2995
0.24	0.1449	1.0239	0.1416	0.74	0.6231	2.0714	0.3006
0.25	0.1535	1.0472	0.1466	0.75	0.6318	2.0944	0.3017
0.26	0.1623	1.0701	0.1516	0.76	0.6404	2.1176	0.3025
0.27	0.1711	1.0928	0.1566	0.77	0.6489	2.1412	0.3032
0.28	0.1800	1.1152	0.1614	0.78	0.6573	2.1652	0.3037
0.29	0.1890	1.1373	0.1662	0.79	0.6655	2.1895	0.3040
0.30	0.1982	1.1593	0.1709	0.80	0.6736	2.2143	0.3042
0.31	0.2074	1.1810	0.1755	0.81	0.6815	2.2395	0.3044
0.32	0.2167	1.2025	0.1801	0.82	0.6893	2.2653	0.3043
0.33	0.2260	1.2239	0.1848	0.83	0.6969	2.2916	0.3041
0.34	0.2355	1.2451	0.1891	0.84	0.7043	2.3186	0.3038
0.35	0.2450	1.2661	0.1935	0.85	0.7115	2.3462	0.3033
0.36	0.2546	1.2870	0.1978	0.86	0.7186	2.3746	0.3026
0.37	0.2642	1.3078	0.2020	0.87	0.7254	2.4038	0.3017
0.38	0.2739	1.3284	0.2061	0.88	0.7320	2.4341	0.3008
0.39	0.2836	1.3490	0.2102	0.89	0.7384	2.4655	0.2996
0.40	0.2934	1.3694	0.2142	0.90	0.7445	2.4981	0.2980
0.41	0.3032	1.3898	0.2181	0.91	0.7504	2.5322	0.2963
0.42	0.3130	1.4101	0.2220	0.92	0.7560	2.5681	0.2944
0.43	0.3229	1.4303	0.2257	0.93	0.7612	2.6061	0.2922
0.44	0.3328	1.4505	0.2294	0.94	0.7662	2.6467	0.2896
0.45	0.3428	1.4706	0.2331	0.95	0.7707	2.6906	0.2864
0.46	0.3527	1.4907	0.2366	0.96	0.7749	2.7389	0.2830
0.47	0.3627	1.5108	0.2400	0.97	0.7785	2.7934	0.2787
0.48	0.3727	1.5308	0.2434	0.98	0.7816	2.8578	0.2735
0.49	0.3827	1.5508	0.2467	0.99	0.7841	2.9412	0.2665
0.50	0.3927	1.5706	0.2500	1.00	0.7854	3.1416	0.2500

eg. $D = 4'$

$d = 1'$

$\frac{d}{D} = \frac{1}{4} = 0.25$

$D^2 = 4 \times 4$

$= 16$ (S.F.)

FROM CHART

$\frac{area}{D^2} = 0.1535$

$Area = 0.1535 \times 16$

$= 2.456$ s.

$R = 0.1466 \times 4$

$= 0.5864$

Procedure B-4

DATA INTERROGATION AND ASCII FILE CREATION PROCEDURE

1. Connect the phone cord to the modem port on the computer. Make sure the phone line is free.

2. Turn the computer on.

3. From the DOS prompt (C:\>), type FL.

4. Select TELFLOW from the main menu. Choose Phonebook from the base menu and highlight the site using the arrow keys.

5. Select Connect from the top menu. The message "Dialing # ...Please stand by" will appear. When connected, the message "verifying flow/meter's status" will appear. The modem might not connect on the first attempt. After a few passes, if the modem does not connect, check for the following:

   a. Check the flow meter power: Flow meter must be ON if a connection is to be made. This step requires field inspection.

   b. Check the phone number. Is the phone number correct and does it have the necessary "code" to dial out of an office phone system (i.e. a "9" before the main number).

   c. Check the baud rate. The recommended rate is 1200. If TELEFLOW is not set for this rate, change it through the "Pgm-Config" menu.

   d. Bring a phone to the site and try to dial out from the phone jack. If you can not call from the site, the phone line is probably bad. Call the phone company for repair.

6. Select Graph from the Connect Menu. The flow meter has multiple partitions so TELEFLOW will display the Graph Menu. This menu allows you to specify the partitions you want to graph: A, B, or C. When the partition is graphed, it is automatically interrogated, and the data are downloaded to the computer.

   a. The Interrogate Menu will allow you interrogate the partitions but will not display a graph of the data. Interrogate allows you to specify which partitions you wish to interrogate: individually or singularly.

7. To retrieve data from all partitions, select ALL. If you want data from a single partition, select the appropriate letter from the menu. When TELEFLOW completes the interrogation, it will present the Restart Menu to allow you to restart the partition, if desired. This will occur only when partitions A (Flowdepth) and B (Rainfall) are interrogated.

8. To restart a partition's memory, select the corresponding letter from the Restart Menu. After TELEFLOW clears the partition, it will return to the Partition Menu.

9. Quit out of TELEFLOW and FLOWLINK. Type "Q" or ESC successively until the DOS prompt (C:\>) appears.

10. Turn computer off.

ASCII FILE CREATION PROCEDURE

These steps can be performed in the office.

1. Turn computer on and enter FLOWLINK (see Step 3 on previous page).

2. Select EXPORT from the main menu.

3. Select LEVEL from the menu.

   a. Select SOURCE.

   b. Select a data set from the vertical menu.

      - Select DESTINATION. This should be C:\FLOWLINK\FLOWDATA (or a customized site-specific directory).

   c. Select LEVEL. To export a segment of the file, select the FIRST and LAST options to change the first and last reading times.

      - Select a 24 Hour period to ensure 24 hour storm coverage.

      NOTE: Precipitation First and Last options must equal Levels.

   d. Select START to initiate translation from FLOWLINK to ASCII.
   EXPORT will prompt for an output filename for the translated file.
   Enter the filename DEPTH.CSV.
   (Only the last part of the filename will change.)

4. Press the ESC key twice, and select SAMPLER.

   a. Select SOURCE.

   b. Select a dataset from the vertical menu.

      - Make sure DESTINATION is correct.

   c. Select EXPORT. Enter the filename SAMPLE.CSV.

5. Hit the ESC key twice, and select RAINFALL.

   a. Select SOURCE.

   b. Select a dataset from the vertical menu.

      - Make sure DESTINATION is correct.

   c. Select EXPORT. This will present the Change Range menu. Use the First and Last options to change the first and last reading times. You must use the same interval used for DEPTH.CSV.

   d. Select START. Enter the filename PRECIP.CSV. .

6. Quit out of EXPORT and FLOWLINK. Type "Q" or ESC successively until the DOS prompt (C:\>) appears.

ASCII files have now been created with the file names: DEPTH.CSV, PRECIP.CSV, SAMPLE.CSV.

NOTE: For more detailed explanations of the interrogation and export steps, please refer to the FLOWLINK Instruction Manual, Chapters 7 and 9.

Be sure that the filenames shown in Steps 3d, 4c, and 5d are used. If these filenames are not used, the spreadsheet will not work properly.

Procedure B-5

SAMPLE COMPOSITING SCHEME FROM FLOWLINK ASCII FILE

The procedures below describe the steps necessary to convert storm data exported from FLOWLINK into a flow compositing spreadsheet. This spreadsheet, STORM, automatically imports the data and performs the compositing calculations. Summary tables, a storm hyetograph, a storm hydrograph, and a chain-of-custody form are automatically created by the program. The spreadsheet is self-automated and requires very little user input. The user needs only rudimentary experience with spreadsheets in order to follow these procedures. At any point during the execution of the compositing program, Ctrl-Break can be used to interrupt the calculations.

1. To load LOTUS 123 Version 2.3, type '123' from any hard drive directory prompt (i.e. C:\>).

2. Change the default spreadsheet directory to the correct sampling site directory (i.e. for the Acker Place Site the command could be '/FD C:\ACKER\'). Subdirectories must be created before this procedure, and downloaded site-specific sampler data (i.e. DEPTH.CSV, PRECIP .CSV , SAMPLE.CSV) must be stored in that site-specific subdirectory.

3. Load the spreadsheet file XFER.WKl from the selected sampling site directory. This spreadsheet will convert the ASCII file created by FLOWLINK into a LOTUS 123 spreadsheet file named TEMP.WK1. (/FR XFER.WK1)

4. The spreadsheet will automatically run the macro routine which converts the data. Look for command prompts which will appear at the top of the screen.

5. "lMPORT PRECIPITATION DATA? (1=YES / 0=NO):"
   Select "1" if rainfall data is available for this site.

6. "lMPORT SAMPLE DATA? (1=YES / 0=NO):"
   Select "1" if samples were taken during this time period. For compositing samples, this should always be "1".

7. After the macro has completed, the STORM.WKl spreadsheet will be loaded automatically. The spreadsheet file TEMP.WKl will contain all the converted ASCII data.

8. The macro routine to begin the sample compositing scheme in the STORM.WKl spreadsheet loads automatically. Look for command prompts which will appear at the top of the screen.

9. "lMPORT PRECIPITATION DATA? (1=YES / 0=NO):" (see Step 5)

10. "lMPORT SAMPLE DATA? (1=YES / 0=NO):" (see Step 6)

11. You must now write on paper the date, time, bottle number and sample number as shown on the computer screen starting at the cell location AG51.

12. Move the cell pointer to column "N". These columns show the date and time which define the X-axis of the storm hydrograph. Find the row in these columns which contains the date and time nearest to the time when the first sample was collected. (from Step 11)

13. Put an "*" in column "R" at the row which contains the time at which the first sample was collected.

14. Type ALT-D (hold the " Alt key and the "d" key at the same time) to continue with the sample compositing program.

15. Three different print ranges have been created, PRINTl, PRINT2, and PRINT3, which define a compositing summary table, a storm event summary table (with hyetograph and hydrograph) and a chain-of-custody form, respectively. These three pages can be printed separately by invoking the WYSYWYG Print command "Print". Choose Range,Set, and then choose a print range (PRINTl, PRINT2, or PRINT3). Select go. This will print the range selected.

16. Save file in the appropriate site directory using the file naming convention (date and site ID). For example, FEB11931.wkl represents a storm event on February 24, 199 at site 1 (Acker Place). It is very important to save the file under a new unique name. This will ensure that the template program and the individual storm data are preserved.

Procedure B-6

PROCEDURES FOR COMPOSITE SAMPLE COLLECTION FOR NPDES ONGOING MONITORING PROGRAM

1. New, clean disposable gloves should be worn at all times during handling of sample collection bottles in sampler carousel.

<u>Prior to Storm Event</u>

2. Perform routine maintenance of station immediately prior to storm event (if possible). Maintenance should include ensuring that the sampler strainer, the flow meter probe, and the rain gage cylinder are clean and free of debris.

3. Obtain sampler carousel containing clean, prepared, and capped bottles from laboratory and install in sampler. Remove lids from clean bottles before closing sampler. Ice down bottles in sampler carousel immediately prior to storm event (if possible).

4. Ensure that fully charged battery (if not connected to direct AC) is installed in sampler.

5. Check that sampler and flow meter are properly programmed and that program is running.

<u>After Storm Event</u>

6. After storm event is over and/or sample program is complete, download data from sampler, flow meter, and rain gage by modem (see Procedure B-5 for Data Interrogation and ASCII File Creation).

7. Go to site. Reset program; note equipment reset in equipment maintenance log located inside equipment housing.

8. Remove bottle carousel from sampler. Immediately cap all bottles. Label each bottle in carousel by filling in date, time, crew, location, etc. on pre-printed forms. Be sure to label bottles and not lids. Exposure of filled sample bottles to light should be minimized.

9. Immediately ice down filled bottles in sampler carousel. Ice should completely surround each bottle. Label outside of carousel as to contents including station location, storm event date and time, and crew ID.

10. The chain of custody form for composite samples shall be completed for the carousel contents using a waterproof pen and placed in a waterproof plastic bag. The completed chain of custody form shall be placed inside the carousel on top of the ice; the top of the carousel then should be sealed with a plastic bag (fiber tape). The carousel should also be labeled on the outside.

11. Install sampler carousel with empty cleaned bottles in sampler.

12. The field log describing all sampling activities must be completed using a waterproof pen before leaving the site.

13. At the office, transfer ASCII data into the LOTUS 1-2-3™ spreadsheet files created for that monitoring site to produce a compositing scheme for the storm event (see Procedure B-6 "Sample Compositing Scheme from FLOWLINK ASCII File".) Ensure that the filled bottles in the carousel remain iced down and covered from light during entire compositing scheme preparation time.

14. Deliver filled bottles in sampler carousel and compositing scheme for storm event to laboratory as soon as possible during working hours. The chain of custody form shall be completed by the laboratory as part of delivery of samples. Completed chain of custody forms should be filed in the field notebook for that monitoring station. Obtain another sampler carousel containing empty, capped, and prepared sample bottles from laboratory.

Procedure B-7

MAINTENANCE PROCEDURE FOR THE NPDES ONGOING MONITORING STATION RAIN GAGE

INTRODUCTION

The following "in-field" procedure corrects and calibrates an inoperable rain gage.

1. Remove the funnel from the rain gage.

2. Print a report to list the amount of rain recorded by the flow meter.

3. Flip the buckets back and forth a few times and count each time the magnet passes over the sensor.

4. Print another report to verify the correct amount of rainfall was detected.

5. If not correct, then gently bend the L-shaped bracket down towards the switch sensor (a small black box mounted on a green circuit board) as you move the magnet over the sensor. Again print a report. If the magnet had been jarred too far away from the sensor 0.01" of rain should be reported. If no rain was detected then the magnet was already too close to the sensor so go to step 7.

6. Repeat steps 3, 4 and 5 until you have successfully adjusted the magnet alignment.

7. Gently bend the bracket away from the sensor as you pass the magnet over the switch sensor. Again print a report. If the magnet had been jarred too close to the sensor 0.01" of rain should be reported.

8. Repeat steps 3, 4, and 7 until you have successfully adjusted the magnet alignment.

   Note: If the flow meter reports only half the amount, then only one side is out of alignment.

9. If you are not able to get the rain gage to record any rainfall after a few iterations of the above procedures you may want to bring the rain gage to the office or bring the ohmmeter to the site (see OHMMETER PROCEDURE).

PROCEDURE FOR SERVICING THE RAIN GAGE USING AN OHMMETER

1. Turn off power to the rain gage.

2. Set the ohmmeter to "resistance measurement" and connect a probe to each of the power terminals.

3. When the buckets are in the fully tilted position the circuit is open and the resistance should be very high. When the buckets are balanced the circuit is closed and the resistance should be very low. If both of these conditions are not satisfied, the rain gage will not record rainfall.

4. Adjust the bracket accordingly.

PROCEDURE FOR CALIBRATING THE RAIN GAGE

1. Connect the rain gage, with funnel, to a flow meter and power source. Make sure the rain gage is level.

2. Print a report to determine your starting rainfall amount. This value will be subtracted from the calibration value to determine the calibrated rainfall level. .

3. Carefully measure with a graduated cylinder 824 mL of water. Pour the water into the rain gage funnel.

4. It will take approximately three minutes for the water to drain out of the rain gage. Print a report to determine the new net amount of rainfall. Subtract the rainfall value determined in step 2 from this value to determine the calibrated rainfall level. The calibrated rainfall level should be one inch.

5. If the rain gage is not calibrated to one inch, adjust the tilt angle of the buckets by adjusting the screws beneath the buckets. For example, if more than one inch is reported, then you need to lower each side. Rotate each screw clockwise the same number of rotations. If less than an inch of rain is reported, then you must turn each screw counter-clockwise the same number of rotations.

6. Repeat steps 3, 4, and 5 until the rain gage reports one inch of rain for 824 mL of water.

APPENDIX D -- PART C

SAMPLE CHAIN OF CUSTODY FORMS

- Grab Sample Form
- Composite Sample Form

SAMPLE ACKNOWLEDGEMENT / TRANSFER FORM

PROJECT:______________________________________ **PROJECT MGR:** ____________________
SUBMITTED BY: ____
COMMENTS: ____

	COUNT	CONTAIN. TYPE	ID. NO.	SITE ID.	DATE	TIME	GRAB / COMP	VOL.
CYANIDE								
PHENOL								
VOA								
BACT.								
OIL & GREASE								
METALS								
Hg								
SOLIDS BOD5 DIS. P								
COD NUTS								
DETERG.								
Cu								

LABORATORY SAMPLE ACCEPTANCE CRITERIA SATISFIED:______________________________
(LAB PERSONNEL)
SAMPLES RELINQUISHED BY: __________________________________ **DATE:**_________________
SAMPLES RECEIVED BY: ______________________________________ **DATE:**_________________
TRANSFER TIME: __________________________

FORM REVISION: 031092

CITY OF KNOXVILLE
NPDES STORM WATER PERMIT APPLICATION
ONGOING MONITORING PROGRAM

SAMPLE ACKNOWLEDGEMENT / TRANSFER FORM

STATION:________________________________ **STORM EVENT DATE:** ____________________
SUBMITTED BY: ____ **DATE:** ____________________
SAMPLE TYPE: ____
COMMENTS: ____
____
____
____

SAMPLE ID	SAMPLE VOLUME	CONTAINER DESCRIPTION	PARAMETER	% CONTAINER VOLUME FOR COMPOSTING

LABORATORY SAMPLE ACCEPTANCE CRITERIA SATISFIED:_____________________________
(LAB PERSONNEL)
SAMPLES RELINQUISHED BY: ________________________________ **DATE:**________________
SAMPLES RECEIVED BY: ____________________________________ **DATE:**________________
TRANSFER TIME: ____
COMMENTS: ____
____
____
____

CDM

APPENDIX D -- PART D

MATERIAL SAFETY DATA SHEETS (MSDS)

- Sulfuric Acid (H_2SO_4)
- Sodium Hydroxide (NaOH)
- Sodium Thiosulfate ($Na_2S_2O_3$)

Mallinckrodt
Material Safety Data

Emergency Phone Number: 314-982-5000

Mallinckrodt, Inc., Science Products Division, P.O. Box M, Paris, KY 43061.

SULFURIC ACID 96%

PRODUCT IDENTIFICATION:

Synonyms: Oil of Vitriol

Formula CAS No.: 7664-93-9

Molecular Weight: 98.07

Chemical Formula: H_2SO_4

Hazardous Ingredients: Not applicable.

PRECAUTIONARY MEASURES

DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED. INHALATION MAY CAUSE LUNG DAMAGE.

Do not get in eyes, on skin, or on clothing.
Do not breathe mist.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.
This substance is classified as a POISON under the Federal Caustic Poison Act.

EMERGENCY/FIRST AID

In all cases call a physician. In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes. If swallowed, DO NOT INDUCE VOMITING! Give large quantities of water. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. SEE SECTION 5.

DOT Hazard Class: Corrosive Material

SECTION 1 Physical Data

Appearance: Colorless, oily liquid.

Odor: Odorless.

Solubility: Infinite @ 20°C.

Boiling Point: ca. 310°C (590°F)

Melting Point: ca. -14°C (6°F).

Specific Gravity: 1.84

Vapor Density (Air = 1): < 0.3 @ 25°C (77°F)

Vapor Pressure (mm Hg): 1 @ 146°C (250°F).

Evaporation Rate: No information found.

SECTION 2 Fire and Explosion Information

Fire:
Not combustible, but substance is a strong oxidizer and its heat of reaction with reducing agents or combustibles may cause ignition. Reacts with most metals releasing flammable, potentially explosive hydrogen gas.

Explosion:
Not combustible, but substance is a strong oxidizer and its heat of reaction with reducing agents or combustibles may cause ignition.

Fire Extinguishing Media:
Dry chemical, foam or carbon dioxide. Water spray may be used to keep fire exposed containers cool.

Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

SECTION 3 Reactivity Data

Stability:
Stable under ordinary conditions of use and storage.

Hazardous Decomposition Products:
Toxic fumes of oxides of sulfur. Will react with water or steam to produce toxic and corrosive fumes. Reacts with carbonates to generate carbon dioxide gas, and with cyanides and sulfides to form poisonous hydrogen cyanide and hydrogen sulfide respectively.

Hazardous Polymerization:
Will not occur.

Incompatibilities:
Water, bases, organic material, halogens, metal acetylides, oxides and hydrides, strong oxidizing and reducing agents and many other reactive substances.

SECTION 4 Leak/Spill Disposal Information

Dike and cover leaking or spilled liquid with dirt, vermiculite, kitty-litter or other inert absorbent. Cover spill with sodium bicarbonate or soda ash and mix. Clean-up personnel require protective clothing and respiratory protection from vapors and mists. Neutralized waste may be containerized and disposed in a RCRA approved waste disposal facility. Flush area of spill with dilute soda ash solution and discard to sewer.

Reportable Quantity (RQ)(CWA/CERCLA) : 1000 lbs.

Ensure compliance with local, state and federal regulations.

NFPA Ratings: Health: 3 Flammability: 0 Reactivity: 2 Other: Water reactive

Effective Date: 10-21-86 Supersedes 09-05-85

SULFURIC ACID 96%

SECTION 5 Health Hazard Information

A. EXPOSURE / HEALTH EFFECTS

Inhalation:
Inhalation produces damaging effects on the mucous membranes and upper respiratory tract. May cause lung edema. Symptoms may include irritation of the nose and throat, and labored breathing.

Ingestion:
Corrosive. Swallowing can cause severe burns of the mouth, throat, and stomach, leading to death. Can cause sore throat, vomiting, diarrhea.

Skin Contact:
Corrosive. Symptoms of redness, pain, and severe burn can occur.

Eye Contact:
Corrosive. Splashes can cause blurred vision, redness, pain and severe tissue burns.

Chronic Exposure:
Long-term exposure to mist or vapors may cause damage to teeth.

Aggrevation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

B. FIRST AID

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Ingestion:
If swallowed, DO NOT induce vomiting. Give large quantities of water or milk if available. Call a physician immediately. Never give anything by mouth to an unconscious person.

Skin Exposure:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician.

Eye Exposure:
Wash eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

C. TOXICITY DATA (RTECS, 1982)

Oral rat LD50: 2140 mg/kg. Inhalation Guinea Pig LC50: 18 mg/m^3.

SECTION 6 Occupational Control Measures

Airborne Exposure Limits:
-OSHA Permissible Explosure Limit (PEL):
1 mg/m^3 (TWA).
-ACGIH Threshold Limit Value (TLV):
1 mg/m^3 (TWA).

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, "Industrial Ventilation, A Manual of Recommended Practices", most recent edition, for details.

Personal Respirators: (NIOSH Approved)
If the TLV is exceeded a full facepiece chemical cartridge respirator may be worn, in general, up to 100 times the TLV or the maximum use concentration specified by the respirator supplier, whichever is less. Alternatively, a supplied air full facepiece respirator or airlined hood may be worn.

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Contact lenses should not be worn when working with this material. Maintain eye wash fountain and quick-drench facilities in work area.

SECTION 7 Storage and Special Information

Store in a cool, dry, ventilated storage area with acid resistant floors and good drainage. Protect from physical damage. Keep out of direct sunlight and away from heat, water, and incompatible materials. Do not wash out container and use it for other purposes. When diluting, always add the acid to water; never add water to the acid.

••

SUF96

DATE: 09/19/90 ACCT: 857366-03
INDEX: 15902601118 CAT NO: SS2544 PO NBR: 17831

DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS 49 CFR 172.101 AND SUBPART E:
CORROSIVE

DEPARTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49 CFR 173.249
EXCEPTIONS: 49 CFR 173.244

TOXICITY

SODIUM HYDROXIDE:
IRRITATION DATA: 500 MG/24 HOURS SKIN-RABBIT SEVERE; 1% EYE-RABBIT SEVERE; 50 UG/24 HOURS EYE-RABBIT SEVERE; 1 MG/24 HOURS EYE-RABBIT SEVERE; 400 UG EYE-RABBIT MILD; 1 MG/30 SECONDS RINSED EYE-RABBIT SEVERE; 1%/24 HOURS EYE-MONKEY SEVERE.
TOXICITY DATA: 140-340 MG/KG ORAL-RAT LD50 (VAN WATERS & ROGERS INC. MSDS); 500 MG/KG ORAL-RABBIT LDLO; 1350 MG/KG SKIN-RABBIT LD50 (VAN WATERS & ROGERS INC. MSDS); 40 MG/KG INTRAPERITONEAL-MOUSE LD50; MUTAGENIC DATA (RTECS).
CARCINOGEN STATUS: NONE.
LOCAL EFFECTS: CORROSIVE- EYE, SKIN, MUCOUS MEMBRANES.
ACUTE TOXICITY LEVEL: TOXIC BY INGESTION; MODERATELY TOXIC BY DERMAL ABSORPTION.
TARGET EFFECTS: NO DATA AVAILABLE.

HEALTH EFFECTS AND FIRST AID

INHALATION:
SODIUM HYDROXIDE:
CORROSIVE. 250 MG/M3 IMMEDIATELY DANGEROUS TO LIFE OR HEALTH.
ACUTE EXPOSURE- EFFECTS DUE TO INHALATION OF DUSTS OR MIST MAY VARY FROM MILD IRRITATION OF THE NOSE AT 2 MG/M3 TO SEVERE PNEUMONITIS DEPENDING ON THE SEVERITY OF EXPOSURE. LOW CONCENTRATIONS MAY CAUSE MUCOUS MEMBRANE IRRITATION WITH SORE THROAT, COUGHING, AND DYSPNEA. INTENSE EXPOSURES MAY RESULT IN DESTRUCTION OF MUCOUS MEMBRANES AND DELAYED PULMONARY EDEMA OR PNEUMONITIS. SHOCK MAY OCCUR.
CHRONIC EXPOSURE- REPEATED EXPOSURES OF 5000 MG/L WERE HARMLESS TO RATS, BUT 10,000 MG/L LED TO NERVOUSNESS, SORE EYES, DIARRHEA AND RETARDED GROWTH. PROLONGED EXPOSURE TO HIGH CONCENTRATIONS OF DUSTS OR MISTS MAY CAUSE DISCOMFORT AND ULCERATION OF NASAL PASSAGES. RATS EXPOSED 30 MINUTES/DAY TO UNMEASURED CONCENTRATIONS OF SODIUM HYDROXIDE AEROSOLS SUFFERED PULMONARY DAMAGE AFTER 2-3 MONTHS. DEATH OCCURRED IN 2 OF 10 RATS EXPOSED TO AN AEROSOL OF 40% AQUEOUS SODIUM HYDROXIDE FOR 30 MINUTES, TWICE A WEEK FOR 3 WEEKS. HISTOPATHOLOGICAL EXAMINATION SHOWED MOSTLY NORMAL LUNG TISSUE WITH FOCI OF ENLARGED ALVEOLAR SEPTAE, EMPHYSEMA, BRONCHIAL ULCERATION, AND ENLARGED LYMPH ADENOIDAL TISSUES. AN EPIDEMIOLOGIC STUDY OF 291 WORKERS CHRONICALLY EXPOSED TO CAUSTIC DUSTS FOR 30 YEARS OR MORE FOUND NO SIGNIFICANT INCREASE IN MORTALITY IN RELATION TO DURATION OR INTENSITY OF SUCH EXPOSURES.

FIRST AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, GIVE ARTIFICIAL RESPIRATION. MAINTAIN AIRWAY AND BLOOD PRESSURE AND ADMINISTER OXYGEN IF AVAILABLE. KEEP AFFECTED PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. ADMINISTRATION OF OXYGEN SHOULD BE PERFORMED BY QUALIFIED PERSONNEL. GET MEDICAL ATTENTION IMMEDIATELY.

SKIN CONTACT:
SODIUM HYDROXIDE:
CORROSIVE.
ACUTE EXPOSURE- UPON CONTACT WITH THE SKIN, DAMAGE INCLUDING REDNESS, CUTANEOUS BURNS, SKIN FISSURES AND WHITE ESCHARS MAY OCCUR WITHOUT IMMEDIATE PAIN. EXPOSURE TO SOLUTIONS AS WEAK AS 0.03 N (0.12%) FOR 1 HOUR HAS CAUSED INJURY TO HEALTHY SKIN. SOLUTIONS OF 25-50% CAUSED NO SENSATION OF IRRITATION WITHIN 3 MINUTES IN HUMAN SUBJECTS. WITH SOLUTIONS OF 0.4-4%, IRRITATION DOES NOT OCCUR UNTIL AFTER SEVERAL HOURS. SKIN BIOPSIES FROM HUMAN SUBJECTS HAVING 1 N SODIUM HYDROXIDE APPLIED TO THEIR ARMS FOR 15 TO 180 MINUTES SHOWED PROGRESSIVE CHANGES BEGINNING WITH DISSOLUTION OF THE CELLS IN THE HORNY LAYER AND PROGRESSING THROUGH EDEMA TO TOTAL DESTRUCTION OF THE EPIDERMIS IN 60 MINUTES. A 5% AQUEOUS SOLUTION CAUSED SEVERE NECROSIS TO THE SKIN OF RABBITS WHEN APPLIED FOR 4 HOURS. ALKALIES PENETRATE THE SKIN SLOWLY. THE EXTENT OF INJURY DEPENDS ON THE DURATION OF CONTACT. IF SODIUM HYDROXIDE IS NOT REMOVED FROM THE SKIN, SEVERE BURNS WITH DEEP ULCERATION MAY OCCUR. EXPOSURE TO THE DUST OR MIST MAY CAUSE MULTIPLE SMALL BURNS AND TEMPORARY LOSS OF HAIR. PATHOLOGIC FINDINGS DUE TO ALKALIES MAY INCLUDE GELATINOUS, NECROTIC AREAS AT THE SITE OF CONTACT.
CHRONIC EXPOSURE- EFFECTS ARE DEPENDENT UPON CONCENTRATION AND DURATION OF EXPOSURE. DERMATITIS OR EFFECTS SIMILAR TO THOSE FOR ACUTE EXPOSURE MAY OCCUR.

FIRST AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AT LEAST 15-20 MINUTES). IN CASE OF CHEMICAL BURNS, COVER AREA WITH STERILE, DRY DRESSING. BANDAGE SECURELY, BUT NOT TOO TIGHTLY. GET MEDICAL ATTENTION IMMEDIATELY.

EYE CONTACT:
SODIUM HYDROXIDE:

DATE: 09/19/90 ACCT: 857366-03
INDEX: 15902601118 CAT NO: SS254 PO NBR: 17831

SODIUM HYDROXIDE SOLUTIONS, 40% AND 50%
SODIUM HYDROXIDE SOLUTIONS, 40% AND 50%
SODIUM HYDROXIDE SOLUTIONS, 40% AND 50%

MATERIAL SAFETY DATA SHEET

FISHER SCIENTIFIC
CHEMICAL DIVISION
1 REAGENT LANE
FAIR LAWN NJ 07410
(201) 796-7100

EMERGENCY CONTACTS:
GASTON L. PILLORI: (201) 796-7100
AFTER BUSINESS HOURS; HOLIDAYS:
(201) 796-7523
CHEMTREC ASSISTANCE: (800) 424-9300

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SUBSTANCE IDENTIFICATION

CAS-NUMBER 1310-73-2

SUBSTANCE: **SODIUM HYDROXIDE SOLUTIONS, 40% AND 50%**

TRADE NAMES/SYNONYMS:
CAUSTIC SODA SOLUTION; LYE SOLUTION; SODA LYE; SODIUM HYDROXIDE SOLUTION; SODIUM HYDROXIDE LIQUID; WHITE CAUSTIC SOLUTION; SS-254; SS-410; SS-414; UN 1824; ACC40174

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=0 REACTIVITY=1 PERSISTENCE=0
NFPA RATINGS (SCALE 0-4): HEALTH=3 FIRE=0 REACTIVITY=1

COMPONENTS AND CONTAMINANTS

COMPONENT: SODIUM HYDROXIDE PERCENT: 40.0-50.0
CAS# 1310-73-2

COMPONENT: WATER PERCENT: 50.0-60.0

EXPOSURE LIMITS:
SODIUM HYDROXIDE:
2 MG/M3 OSHA CEILING
2 MG/M3 ACGIH CEILING
2 MG/M3 NIOSH RECOMMENDED 15 MINUTE CEILING

1000 POUNDS CERCLA SECTION 103 REPORTABLE QUANTITY

PHYSICAL DATA

DESCRIPTION: CLEAR LIQUID BOILING POINT: 289 F (143 C)

MELTING POINT: 59 F (12 C) SPECIFIC GRAVITY: 1.54

VAPOR PRESSURE: 13 MMHG @ 60 C PH: ALKALINE

SOLUBILITY IN WATER: COMPLETE

MSDS
FROM: North Shore Lab
DATE: 9-25-90
CHEMICAL IN USE: ✓
CHEMICAL NOT IN USE:

FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD:
NEGLIGIBLE FIRE HAZARD WHEN EXPOSED TO HEAT OR FLAME.

FIREFIGHTING MEDIA:
DRY CHEMICAL, CARBON DIOXIDE, HALON, WATER SPRAY OR STANDARD FOAM (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FOR LARGER FIRES, USE WATER SPRAY, FOG OR STANDARD FOAM (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FIREFIGHTING:
MOVE CONTAINERS FROM FIRE AREA IF POSSIBLE. COOL CONTAINERS EXPOSED TO FLAMES WITH WATER FROM SIDE UNTIL WELL AFTER FIRE IS OUT. STAY AWAY FROM STORAGE TANK ENDS (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4, GUIDE PAGE 60).

USE AGENT SUITABLE FOR TYPE OF FIRE; USE FLOODING QUANTITIES OF WATER AS FOG. APPLY FROM AS FAR A DISTANCE AS POSSIBLE. AVOID BREATHING CORROSIVE VAPORS. KEEP UPWIND.

TRANSPORTATION DATA

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49 CFR 172.101:
CORROSIVE MATERIAL

CORROSIVE.
ACUTE EXPOSURE- CONTACT MAY CAUSE DISINTEGRATION AND SLOUGHING OF CONJUNCTIVAL AND CORNEAL EPITHELIUM, CORNEAL OPACIFICATION, MARKED EDEMA AND ULCERATION. AFTER 7 TO 13 DAYS EITHER GRADUAL RECOVERY BEGINS OR THERE IS PROGRESSION OF ULCERATION AND CORNEAL OPACIFICATION. COMPLICATIONS OF SEVERE EYE BURNS ARE SYMBLEPHARON WITH OVERGROWTH OF THE CORNEA BY A VASCULARIZED MEMBRANE, PROGRESSIVE OR RECURRENT CORNEAL ULCERATION AND PERMANENT CORNEAL OPACIFICATION. BLINDNESS MAY OCCUR.
CHRONIC EXPOSURE- EFFECTS ARE DEPENDENT UPON CONCENTRATION AND DURATION OF EXPOSURE. CONJUNCTIVITIS OR EFFECTS SIMILAR TO THOSE FOR ACUTE EXPOSURE MAY OCCUR.

FIRST AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AT LEAST 15-20 MINUTES). CONTINUE IRRIGATING WITH NORMAL SALINE UNTIL THE PH HAS RETURNED TO NORMAL (30-60 MINUTES). COVER WITH STERILE BANDAGES. GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION:
SODIUM HYDROXIDE:
CORROSIVE/TOXIC.
ACUTE EXPOSURE- THE REPORTED LETHAL DOSE IN RATS IS 140-340 MG/KG. INGESTION MAY CAUSE A BURNING SENSATION IN THE MOUTH, CORROSION OF THE LIPS, MOUTH, TONGUE AND PHARYNX, AND SEVERE ESOPHAGEAL AND ABDOMINAL PAIN, VOMITING OF BLOOD AND LARGE PIECES OF MUCOSA, AND BLOODY DIARRHEA. ASPHYXIA CAN OCCUR FROM SWELLING OF THE THROAT. MEDIASTINITIS, ALKALEMIA, PALLOR, WEAK, SLOW PULSE, CARDIOVASCULAR COLLAPSE, SHOCK, COMA AND DEATH MAY OCCUR. PERFORATION OF THE ALIMENTARY TRACT AND CONSTRICTIVE SCARRING MAY RESULT. ESOPHAGEAL STRICTURE MAY OCCUR WEEKS, MONTHS, OR EVEN YEARS LATER TO MAKE SWALLOWING DIFFICULT. THE ESTIMATED FATAL DOSE IN MAN IS 5 GRAMS. CASES OF SQUAMOUS CELL CARCINOMA OF THE ESOPHAGUS HAVE OCCURRED WITH LATENT PERIODS OF 12 TO 42 YEARS AFTER INGESTION. THESE CANCERS WERE BELIEVED TO BE SEQUELA OF TISSUE DESTRUCTION AND POSSIBLY SCAR FORMATION RATHER THAN THE RESULT OF DIRECT CARCINOGENIC ACTION OF SODIUM HYDROXIDE.
CHRONIC EXPOSURE- DEPENDING ON THE CONCENTRATION, REPEATED INGESTION OF ALKALINE SUBSTANCES MAY RESULT IN INFLAMMATORY AND ULCERATIVE EFFECTS ON THE ORAL MUCOUS MEMBRANES AND OTHER EFFECTS AS WITH ACUTE INGESTION.

FIRST AID- DILUTE THE ALKALI BY GIVING WATER OR MILK IMMEDIATELY AND ALLOW VOMITING TO OCCUR. AVOID GASTRIC LAVAGE OR EMETICS. ESOPHAGOSCOPY IS THE ONLY WAY TO EXCLUDE THE POSSIBLITY OF CORROSION IN THE UPPER GASTROINTESTINAL TRACT, IF CORROSION IS SUSPECTED. ESOPHAGOSCOPY SHOULD USUALLY BE PERFORMED WITHIN 24 HOURS (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). MAINTAIN AIRWAY AND TREAT SHOCK. IF VOMITING OCCURS, KEEP HEAD BELOW HIPS TO HELP PREVENT ASPIRATION. GET MEDICAL ATTENTION IMMEDIATELY.

NTIDOTE:
O SPECIFIC ANTIDOTE. TREAT SYMPTOMATICALLY AND SUPPORTIVELY.

REACTIVITY

REACTIVITY:
REACTS EXOTHERMICALLY WITH WATER.

INCOMPATIBILITIES:
SODIUM HYDROXIDE:
ACETALDEHYDE: MAY RESULT IN VIOLENT POLYMERIZATION.
ACETIC ACID: MIXING IN CLOSED CONTAINER INCREASES TEMPERATURE AND PRESSURE.
ACETIC ANHYDRIDE: MIXING IN A CLOSED CONTAINER INCREASES TEMPERATURE AND PRESSURE.
ACIDS: MAY REACT VIOLENTLY.
ACROLEIN: MAY RESULT IN AN EXTREMELY VIOLENT POLYMERIZATION.
ACRYLONITRILE: MAY CAUSE VIOLENT POLYMERIZATION.
ALLYL ALCOHOL + BENZENE SULFONYL CHLORIDE: POSSIBLE EXPLOSION HAZARD.
ALLYL CHLORIDE: HYDROLYZES.
ALUMINUM: VIGOROUS REACTION.
ALUMINUM, ARSENIC TRIOXIDE, SODIUM ARSENATE: MAY GENERATE FLAMMABLE HYDROGEN GAS.
AMMONIA AND SILVER NITRATE: PRECIPITATION OF EXPLOSIVE SIVLER NITRIDE MAY OCCUR.
AMMONIUM SALTS: MAY REACT VIOLENTLY EVOLVING AMMONIA GAS.
BENZENE-1,4-DIOL: EXOTHERMIC REACTION.
N,N'-BIS(TRINITROETHYL)UREA: FORMATION OF EXPLOSIVE COMPOUND.
BROMINE: POSSIBLE EXPLOSION IF NOT STIRRED CONTINOUSLY.
CHLORINE TRIFLUORIDE: MAY CAUSE VIOLENT REACTION.
CHLOROFORM AND METHYL ALCOHOL: EXOTHERMIC REACTION.
CHLOROHYDRIN: MIXING IN A CLOSED CONTAINER CAUSES AN INCREASE IN TEMPERATURE AND PRESSURE.
4-CHLORO-2-METHYLPHENOL: POSSIBLE IGNITION.
CHLORONITROTOLUENES: POSSIBLE EXPLOSION.
CHLOROPICRIN: MAY CAUSE VIOLENT REACTION.
CHLOROSULFONIC ACID: MIXING IN A CLOSED CONTAINER CAUSES AN INCREASE IN TEMPERATURE AND PRESSURE.
CINNAMALDEHYDE: EXOTHERMIC REACTION.
COATINGS: MAY BE ATTACKED.
CYANOGEN AZIDE: MAY FORM SODIUM 5-AZIDOTETRAZOLIDE, WHICH IS EXPLOSIVE IF ISOLATED.
2,2-DICHLORO-3,3-DIMETHYLBUTANE: HAZARDOUS REACTION.

DATE: 09/19/90 ACCT: 857366-03
INDEX: 15902601118 CAT NO: SS2544 PO NBR: 17831

1,2-DICHLOROETHYLENE: MAY FORM SPONTANEOUSLY FLAMMABLE MONOCHLOROACETYLENE.
DIBORANE AND OCTANAL OXIME: EXOTHERMIC REACTION.
ETHYLENE CYANOHYDRIN: MIXING IN A CLOSED CONTAINER CAUSES AN INCREASE IN TEMPERATURE AND PRESSURE.
FLAMMABLE LIQUIDS: FIRE AND EXPLOSION HAZARD.
GLYCOLS: MAY CAUSE EXOTHERMIC DECOMPOSITION WITH EVOLUTION OF HYDROGEN GAS.
GLYOXAL: MIXING IN A CLOSED CONTAINER INCREASES TEMPERATURE AND PRESSURE.
HALOGENATED HYDROCARBONS: VIOLENT REACTION.
HYDROCHLORIC ACID: MIXING IN A CLOSED CONTAINER CAUSES AN INCREASE IN TEMPERATURE AND PRESSURE.
HYDROFLUORIC ACID: MIXING IN A CLOSED CONTAINER CAUSES AN INCREASE IN TEMPERATURE AND PRESSURE.
HYDROQUINONE: RAPID DECOMPOSITION OF HYDROQUINONE WITH EVOLUTION OF HEAT.
LEAD: MAY BE ATTACKED; FLAMMABLE HYDROGEN GAS MAY BE LIBERATED.
LEATHER: MAY BE ATTACKED.
MALEIC ANHYDRIDE: EXPLOSIVE DECOMPOSITION.
METALS: CORRODES METALS, REACTING TO FORM FLAMMABLE HYDROGEN GAS.
4-METHYL-2-NITROPHENOL: EXOTHERMIC REACTION.
NITRIC ACID: MIXING IN CLOSED CONTAINER INCREASES TEMPERATURE AND PRESSURE.
NITROBENZENE: POSSIBLY EXPLOSIVE REACTION UPON HEATING IN PRESENCE OF WATER.
NITROETHANE: FORMS AN EXPLOSIVE SALT.
NITROMETHANE: FORMS AN EXPLOSIVE SALT.
NITROPARAFFINS: THE NITROPARAFFINS, IN THE PRESENCE OF WATER, FORM DRY SALTS WITH ORGANIC BASES. THE DRY SALTS ARE EXPLOSIVE.
NITROPROPANE: FORMS AN EXPLOSIVE SALT.
O-NITROTOLUENE: POSSIBLE EXPLOSION.
OLEUM: MIXING IN A CLOSED CONTAINER CAUSES AN INCREASE IN TEMPERATURE AND PRESSURE.
ORGANIC PEROXIDES: INCOMPATIBLE.
PENTOL (3-METHYL-2-PENTENE-4-YN-1-OL): POSSIBLE EXPLOSION.
PHOSPHORUS: MAY FORM MIXED PHOSPHINES WHICH MAY IGNITE SPONTANEOUSLY IN AIR.
PHOSPHORUS PENTOXIDE: MAY REACT VIOLENTLY WHEN HEATED.
PLASTICS: MAY BE ATTACKED.
B-PROPIOLACTONE: MIXING IN A CLOSED CONTAINER CAUSES AN INCREASE IN TEMPERATURE AND PRESSURE.
PROPYLENE OXIDE: IGNITION OR EXPLOSION MAY OCCUR.
RUBBER: MAY BE ATTACKED.
SODIUM TETRAHYDROBORATE: DRY MIXTURES WITH SODIUM HYDROXIDE CONTAINING 15-40% OF TETRAHYDROBORATE LIBERATE HYDROGEN EXPLOSIVELY AT 230-270 C.
SULFURIC ACID: MIXING IN A CLOSED CONTAINER CAUSES AN INCREASE IN TEMPERAURE AND PRESSURE.
1,2,4,5-TETRACHLOROBENZENE: VIOLENT REACTION.
TETRACHLOROBENZENE + METHYL ALCOHOL: POSSIBLE EXPLOSION.
TETRACHLOROETHYLENE: POSSIBLE EXPLOSION.
TETRAHYDROFURAN: SERIOUS EXPLOSIONS CAN OCCUR.
TIN: EVOLUTION OF HYDROGEN GAS WHICH MAY FORM AN EXPLOSIVE MIXTURE.
1,1,1-TRICHLOROETHANOL: EXPLOSION MAY OCCUR.
TRICHLOROETHYLENE: FORMATION OF EXPLOSIVE MIXTURES OF DICHLOROACETYLENE.
TRICHLORONITROMETHANE + METHANOL: MAY CAUSE VIOLENT REACTION.
WOOL: MAY BE ATTACKED.
ZINC (DUST): FIRE AND EXPLOSION HAZARD.
ZIRCONIUM: MAY CAUSE EXPLOSIVE REACTION UPON HEATING.

DECOMPOSITION:
THERMAL DECOMPOSITION MAY RELEASE TOXIC FUMES OF SODIUM OXIDE.

POLYMERIZATION:
HAZARDOUS POLYMERIZATION HAS NOT BEEN REPORTED TO OCCUR UNDER NORMAL TEMPERATURES AND PRESSURES.

STORAGE AND DISPOSAL

OBSERVE ALL FEDERAL, STATE AND LOCAL REGULATIONS WHEN STORING OR DISPOSING OF THIS SUBSTANCE. FOR ASSISTANCE, CONTACT THE DISTRICT DIRECTOR OF THE ENVIRONMENTAL PROTECTION AGENCY.

STORAGE

STORE AWAY FROM INCOMPATIBLE SUBSTANCES.

DISPOSAL

DISPOSAL MUST BE IN ACCORDANCE WITH STANDARDS APPLICABLE TO GENERATORS OF HAZARDOUS WASTE, 40 CFR 262. EPA HAZARDOUS WASTE NUMBER D002.
100 POUND CERCLA SECTION 103 REPORTABLE QUANTITY.

CONDITIONS TO AVOID

AVOID CONTACT WITH OR STORAGE WITH WATER, ACIDS, AND OTHER INCOMPATIBILITIES. FLAMMABLE, POISONOUS GASES MAY ACCUMULATE IN TANKS AND HOPPER CARS.

SPILL AND LEAK PROCEDURES

SOIL SPILL:

DIG HOLDING AREA SUCH AS LAGOON, POND OR PIT FOR CONTAINMENT.

USE SOIL, SAND BAGS, FOAMED POLYURETHANE, OR FOAMED CONCRETE TO DIKE SURFACE FLOW.

USE FLY ASH OR CEMENT POWDER TO ABSORB BULK LIQUID.

USE VINEGAR OR OTHER DILUTE ACID TO NEUTRALIZE.

WATER SPILL:
ADD SUITABLE AGENT TO NEUTRALIZE SPILLED MATERIAL TO PH-7.

OCCUPATIONAL SPILL:
DO NOT TOUCH SPILLED MATERIAL. STOP LEAK IF YOU CAN DO IT WITHOUT RISK. FOR SMALL SPILLS, TAKE UP WITH SAND OR OTHER ABSORBENT MATERIAL AND PLACE INTO CONTAINERS FOR LATER DISPOSAL. FOR SMALL DRY SPILLS, WITH CLEAN SHOVEL PLACE MATERIAL INTO CLEAN, DRY CONTAINER AND COVER. MOVE CONTAINERS FROM SPILL AREA. FOR LARGER SPILLS, DIKE FAR AHEAD OF SPILL FOR LATER DISPOSAL. KEEP UNNECESSARY PEOPLE AWAY. ISOLATE HAZARD AREA AND DENY ENTRY.

REPORTABLE QUANTITY (RQ): 1000 POUNDS
THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) SECTION 304 REQUIRES THAT A RELEASE EQUAL TO OR GREATER THAN THE REPORTABLE QUANTITY FOR THIS SUBSTANCE BE IMMEDIATELY REPORTED TO THE LOCAL EMERGENCY PLANNING COMMITTEE AND THE STATE EMERGENCY RESPONSE COMMISSION (40 CFR 355.40). IF THE RELEASE OF THIS SUBSTANCE IS REPORTABLE UNDER CERCLA SECTION 103, THE NATIONAL RESPONSE CENTER MUST BE NOTIFIED IMMEDIATELY AT (800) 424-8802 OR (202) 426-2675 IN THE METROPOLITAN WASHINGTON, D.C. AREA (40 CFR 302.6).

PROTECTIVE EQUIPMENT

VENTILATION:
PROVIDE LOCAL EXHAUST OR PROCESS ENCLOSURE VENTILATION TO MEET PUBLISHED EXPOSURE LIMITS.

RESPIRATOR:
THE FOLLOWING RESPIRATORS AND MAXIMUM USE CONCENTRATIONS ARE RECOMMENDATIONS BY THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, NIOSH POCKET GUIDE TO CHEMICAL HAZARDS; NIOSH CRITERIA DOCUMENTS OR BY THE U.S. DEPARTMENT OF LABOR, 29 CFR 1910 SUBPART Z.
THE SPECIFIC RESPIRATOR SELECTED MUST BE BASED ON CONTAMINATION LEVELS FOUND IN THE WORK PLACE, MUST NOT EXCEED THE WORKING LIMITS OF THE RESPIRATOR AND BE JOINTLY APPROVED BY THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH AND THE MINE SAFETY AND HEALTH ADMINISTRATION (NIOSH-MSHA).

SODIUM HYDROXIDE:

50 MG/M3- ANY POWERED AIR-PURIFYING RESPIRATOR WITH A DUST AND MIST FILTER.
ANY SUPPLIED-AIR RESPIRATOR OPERATED IN A CONTINUOUS FLOW MODE.

100 MG/M3- ANY SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE.
ANY SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE.
ANY AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH EFFICIENCY PARTICULATE FILTER.

250 MG/M3- ANY SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE AND OPERATED IN A PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

ESCAPE- ANY AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH EFFICIENCY PARTICULATE FILTER.
ANY APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE AND OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE IN COMBINATION WITH AN AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

CLOTHING:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE (IMPERVIOUS) CLOTHING AND EQUIPMENT TO PREVENT ANY POSSIBILITY OF SKIN CONTACT WITH THIS SUBSTANCE.

GLOVES:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE GLOVES TO PREVENT CONTACT WITH THIS SUBSTANCE.

EYE PROTECTION:
EMPLOYEE MUST WEAR SPLASH-PROOF OR DUST-RESISTANT SAFETY GOGGLES AND A FACESHIELD TO PREVENT CONTACT WITH THIS SUBSTANCE.

EMERGENCY WASH FACILITIES:
WHERE THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES AND/OR SKIN MAY BE EXPOSED TO THIS SUBSTANCE, THE EMPLOYER SHOULD PROVIDE AN EYE WASH FOUNTAIN AND QUICK DRENCH SHOWER WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

DATE: 09/19/90 ACCT: 857366-03
INDEX: 15902601118 CAT NO: 6S2544 PO NBR: 17831

AUTHORIZED - FISHER SCIENTIFIC GROUP, INC.
CREATION DATE: 07/19/85 REVISION DATE: 05/09/90

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RECEIVED 7-23-90

PAGE: 1

DATE: 07/19/90 ACCT: 857366-01
INDEX: 15901970486 CAT NO: S446500 PO NBR: 16953

SODIUM THIOSULFATE
SODIUM THIOSULFATE
SODIUM THIOSULFATE

MATERIAL SAFETY DATA SHEET

FISHER SCIENTIFIC
CHEMICAL DIVISION
1 REAGENT LANE
FAIR LAWN NJ 07410
(201) 796-7100

EMERGENCY CONTACTS:
GASTON L. PILLORI: (201) 796-7100
AFTER BUSINESS HOURS; HOLIDAYS:
(201) 796-7523
CHEMTREC ASSISTANCE: (800) 424-9300

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FROM: Jessie
DATE: 7-26-90
CHEMICAL IN USE: ✓
CHEMICAL NOT IN USE:

SUBSTANCE IDENTIFICATION

CAS-NUMBER 7772-98-7

SUBSTANCE: **SODIUM THIOSULFATE**

TRADE NAMES/SYNONYMS:
THIOSULFURIC ACID (H2S2O3), DISODIUM SALT; THIOSULFURIC ACID, DISODIUM SALT; DISODIUM THIOSULFATE; SODIUM HYPOSULFITE; SODIUM THIOSULFATE ANHYDROUS; SODIUM THIOSULPHATE; DISODIUM THIOSULPHATE; SODIUM THIOSULFATE (NA2S2O3); SODIUM OXIDE SULFIDE; SODIUM OXIDE SULFIDE (NA2S2O3); HYPO; SODOTHIOL; CHLORINE CONTROL; S-HYDRIL; CHLORINE CURE; DECHLOR-IT; S-446; NA2S2O3; ACC21710

CHEMICAL FAMILY:
INORGANIC SALT

MOLECULAR FORMULA: NA2-S2-O3

MOLECULAR WEIGHT: 158.11

RATINGS (SCALE 0-3): HEALTH=1 FIRE=0 REACTIVITY=0 PERSISTENCE=0
RATINGS (SCALE 0-4): HEALTH=1 FIRE=0 REACTIVITY=0

COMPONENTS AND CONTAMINANTS

COMPONENT: SODIUM THIOSULFATE PERCENT: 100
CAS# 7772-98-7

OTHER CONTAMINANTS: NONE

EXPOSURE LIMITS:
NO OCCUPATIONAL EXPOSURE LIMITS ESTABLISHED BY OSHA, ACGIH, OR NIOSH.

PHYSICAL DATA

DESCRIPTION: ODORLESS, COLORLESS, MONOCLINIC CRYSTALS OR HYGROSCOPIC POWDER.

MELTING POINT: NOT AVAILABLE SPECIFIC GRAVITY: 1.667

PH: 6.5-8.0 IN SOLUTION SOLUBILITY IN WATER: 50%

SOLVENT SOLUBILITY: INSOLUBLE IN ALCOHOL.

FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD:
NEGLIGIBLE FIRE HAZARD WHEN EXPOSED TO HEAT OR FLAME.

FIREFIGHTING MEDIA:
DRY CHEMICAL, CARBON DIOXIDE, HALON, WATER SPRAY OR STANDARD FOAM
(1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FOR LARGER FIRES, USE WATER SPRAY, FOG OR STANDARD FOAM
(1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FIREFIGHTING:
NO ACUTE HAZARD. MOVE CONTAINER FROM FIRE AREA IF POSSIBLE. AVOID BREATHING [illegible] OR DUSTS; KEEP UPWIND.

TOXICITY

SODIUM THIOSULFATE:
ANHYDROUS: 4 GM/KG SUBCUTANEOUS-RABBIT LDLO; 6 GM/KG SUBCUTANEOUS-FROG LDLO.
PENTAHYDRATE: 300 MG/KG/7 DAYS ORAL-HUMAN TDLO; 5600 MG/KG

DATE: 07/19/90 ACCT: 857366-01
INDEX: 15901970486 CAT NO: 8446500 PO NBR: 16953

INTRAPERITONEAL-MOUSE LD50; 2350 MG/KG INTRAVENOUS-MOUSE LD50; 3000 MG/KG
INTRAVENOUS-DOG LDLO.
CARCINOGEN STATUS: NONE.
SODIUM THIOSULFATE MAY BE IRRITATING. THE TOXICITY HAS NOT BEEN FULLY CHARACTERIZED.

HEALTH EFFECTS AND FIRST AID

INHALATION:
SODIUM PENTAHYDRATE:
ACUTE EXPOSURE- NO DATA AVAILABLE.
CHRONIC EXPOSURE- NO DATA AVAILABLE.

FIRST AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

SKIN CONTACT:
SODIUM THIOSULFATE:
ACUTE EXPOSURE- MAY BE IRRITATING.
CHRONIC EXPOSURE- NO DATA AVAILABLE.

FIRST AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

EYE CONTACT:
SODIUM THIOSULFATE:
ACUTE EXPOSURE- MAY BE IRRITATING.
CHRONIC EXPOSURE- NO DATA AVAILABLE.

FIRST AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION:
SODIUM THIOSULFATE:
ACUTE EXPOSURE- SODIUM THIOSULFATE IS POORLY ABSORBED FROM THE BOWEL AND ACTS AS AN OSMOTIC CATHARTIC. INGESTION OF LARGE AMOUNTS MAY CAUSE DIARRHEA. THE PROBABLE LETHAL DOSE FOR HUMANS IS 0.5-5.0 GM/KG.
CHRONIC EXPOSURE- HUMAN EXPOSURE TO 300 MG/KG OF THE PENTAHYDRATE, FOR SEVEN DAYS, RESULTED IN CYANOSIS. SODIUM THIOSULFITE IS PERMITTED AS A FOOD ADDITIVE. POSSIBLE HUMAN EXPOSURE EXISTS, DUE TO MIGRATION TO FOOD FROM PACKAGING MATERIALS.

FIRST AID- TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY. IF VOMITING OCCURS, KEEP HEAD LOWER THAN HIPS TO PREVENT ASPIRATION.

ANTIDOTE:
NO SPECIFIC ANTIDOTE. TREAT SYMPTOMATICALLY AND SUPPORTIVELY.

REACTIVITY

REACTIVITY:
STABLE UNDER NORMAL TEMPERATURES AND PRESSURES.

INCOMPATIBILITIES:
SODIUM THIOSULFATE:
ACIDS: REACTS RELEASING SULFUR DIOXIDE.
CHLORINE (SOLUTIONS): FORMS SODIUM HYDROSULFATE.
HALOGENS: REACTS.
IODINE: INCOMPATIBLE.
LEAD SALTS: INCOMPATIBLE.
MERCURY SALTS: INCOMPATIBLE.
METAL NITRATES: MAY FORM EXPLOSIVE MIXTURES.
OXIDANTS: REACTS.
POTASSIUM NITRATE: MIXTURE IS EXPLOSIVE ON HEATING.
SILVER SALTS: INCOMPATIBLE.
SODIUM NITRATE: MIXTURE IS EXPLOSIVE ON HEATING.
SODIUM NITRITE: MAY EXPLODE VIOLENTLY ON HEAT DRYING.

DECOMPOSITION:
THERMAL DECOMPOSITION MAY RELEASE TOXIC OXIDES OF SULFUR AND TOXIC SODIUM OXIDE.

POLYMERIZATION:
HAZARDOUS POLYMERIZATION HAS NOT BEEN REPORTED TO OCCUR UNDER NORMAL TEMPERATURES AND PRESSURES.

STORAGE AND DISPOSAL

OBSERVE ALL FEDERAL, STATE AND LOCAL REGULATIONS WHEN STORING OR DISPOSING OF THIS SUBSTANCE. FOR ASSISTANCE, CONTACT THE DISTRICT DIRECTOR OF THE ENVIRONMENTAL PROTECTION AGENCY.

DATE: 07/19/90 ACCT: 857366-01
INDEX: 15901970486 CAT NO: S446500 PO NBR: 16953

STORAGE

STORE AWAY FROM INCOMPATIBLE SUBSTANCES.

CONDITIONS TO AVOID

NONE REPORTED.

SPILL AND LEAK PROCEDURES

OCCUPATIONAL SPILL:
SWEEP UP AND PLACE IN SUITABLE CLEAN, DRY CONTAINERS FOR RECLAMATION OR LATER DISPOSAL. DO NOT FLUSH WITH WATER. KEEP UNNECESSARY PEOPLE AWAY.

PROTECTIVE EQUIPMENT

VENTILATION:
PROVIDE GENERAL DILUTION VENTILATION.

RESPIRATOR:
THE FOLLOWING RESPIRATORS ARE RECOMMENDED BASED ON INFORMATION FOUND IN THE PHYSICAL DATA, TOXICITY AND HEALTH EFFECTS SECTIONS. THEY ARE RANKED IN ORDER FROM MINIMUM TO MAXIMUM RESPIRATORY PROTECTION.
THE SPECIFIC RESPIRATOR SELECTED MUST BE BASED ON CONTAMINATION LEVELS FOUND IN THE WORK PLACE, MUST NOT EXCEED THE WORKING LIMITS OF THE RESPIRATOR AND BE JOINTLY APPROVED BY THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH AND THE MINE SAFETY AND HEALTH ADMINISTRATION (NIOSH-MSHA).

DUST AND MIST RESPIRATOR WITH A FULL FACEPIECE.

AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER.

POWERED AIR-PURIFYING RESPIRATOR WITH A TIGHT-FITTING FACEPIECE AND HIGH-EFFICIENCY PARTICULATE FILTER.

TYPE "C" SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE OR WITH A FULL FACEPIECE, HELMET OR HOOD OPERATED IN CONTINUOUS-FLOW MODE.

SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE AND OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE IN COMBINATION WITH AN AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

CLOTHING:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE (IMPERVIOUS) CLOTHING AND EQUIPMENT TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE.

GLOVES:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE GLOVES TO PREVENT CONTACT WITH THIS SUBSTANCE.

EYE PROTECTION:
EMPLOYEE MUST WEAR SPLASH-PROOF OR DUST-RESISTANT SAFETY GOGGLES TO PREVENT EYE CONTACT WITH THIS SUBSTANCE.

EMERGENCY EYE WASH: WHERE THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES BE EXPOSED TO THIS SUBSTANCE, THE EMPLOYER SHOULD PROVIDE AN EYE WASH FOUNTAIN WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

AUTHORIZED - FISHER SCIENTIFIC GROUP, INC.
CREATION DATE: 04/18/86 REVISION DATE: 10/31/89

-ADDITIONAL INFORMATION-