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Assessment of Surface Runoff from Iron and Steel Mills

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February 1979

Assessment of Surface Runoff from Iron and Steel Mills

by

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1.0 INTRODUCTION

Since industries and municipalities are on the way to meeting the point source standards of the 1977 interim goal of PL 92-500 (Federal Water Pollution Control Act Amendments of 1972), the effect of non-point source pollution on water quality is gaining more attention. The National Commission on Water Quality reported in 1976 that "non-point pollutant sources are significant to the Commission's study because they may in some instances overwhelm and negate the reductions achieved through point source effluent limitations."[1] Based on these findings, the Commission recommended to Congress that "control or treatment measures shall be applied to agricultural and non-point discharges when these measures are cost-effective and will significantly help in achieving water quality standards."[2]

Non-point sources are diffuse in nature, usually intermittent, site specific, not easily monitored at their exact source, related to uncontrollable meteorological events (precipitation, snow melt, drought), and not usually repetitive in nature from event to event. The primary transport mechanism for non-point sources is water runoff from meteorological events. The three basic modes of runoff transport are overland (surface) flow, interflow (also called interstitial flow), i.e., flow through the ground between the surface and groundwater levels, and groundwater flow. Surface runoff will usually contain the highest quantity of contaminants and is the most rapid method of transport of non-point sources.

Because of the great quantities of water and raw material used in making iron and steel, mills are usually located near waterways. Contaminated stormwater runoff from these mills could rapidly reach these waterways; thus the potential of causing a detrimental environmental impact is present.

In April 1976 the Metallurgical Processes Branch of the Industrial Environmental Research Laboratory (IERL) of the Environmental Protection Agency (EPA) retained TRC - THE RESEARCH CORPORATION of New England to perform an assessment of surface runoff from iron and steel mills. The principal objective of this program was to provide EPA with an evaluation which it can use in determining if stormwater runoff from iron and steel mills is an environmental problem and should be included in the Agency's long-term planning as an area of concern.

The program had the following sub-objectives:

1. To identify sources of surface runoff unique to iron and steel mills and to characterize runoff streams in terms of quantity and composition.
2. To assess the specific problems of surface runoff at iron and steel mills and evaluate the contribution made by these individual sources to the overall problem.
3. To identify control systems used by the industry or by other industries which are or could be used to treat contaminated stormwater.

To meet these objectives, TRC performed a program including the following tasks:

Task I - Identification of Surface Runoff Sources

Task II - Field Program to Quantify and Qualify Surface Runoff

Task III - Review of Existing Control Technology

Task IV - Technical Evaluation

Task I included a review of existing data on stormwater runoff in the iron and steel industry and, through plant visits and conversations with plant personnel, an assessment of potential sources of contaminated runoff. This task is described in Section 4.0. Task II included a field survey at two steel mills. The field program and its results are presented in Section 5.0. Task III involved gathering information on stormwater control from plant visits and a literature search on industrial control in general. The information gathered is described in Section 6.0. Section 7.0 (Task IV) is a discussion of the program results as they apply to the iron and steel industry as a whole. A summary of the total program results is presented in Section 2.0, and major conclusions and recommendations are presented in Section 3.0.

Note - In some cases where information or data was received from outside sources, English units had been used rather than metric units and therefore were not converted.

2.0 SUMMARY

TRC - THE RESEARCH CORPORATION of New England was retained by the Metallurgical Processes Branch of the IERL/RTP EPA to perform an assessment of surface runoff from iron and steel mills. The assessment was performed utilizing a four task program which included:

- Task I - Identification of Surface Runoff Sources
- Task II - Field Program to Quantify and Qualify Surface Runoff
- Task III - Review of Existing Control Technology
- Task IV - Technical Evaluation

Before this program, little work had been performed on surveying stormwater and identifying potential sources of stormwater contamination in the steel industry. Previously, the most comprehensive studies had been undertaken by Armco Steel Corporation's Houston Works in Houston, Texas, and Kaiser Steel's Fontana, California plant (See Section 4.1.1).

At Armco, the mill was divided into drainage basins and characterized by size, activity, and land cover (i.e., buildings, paved area, railroad track, undeveloped land, stockpiles, and ponds). Each basin was sampled for several storms. Parameters measured included total suspended solids (TSS), oil and grease, biochemical oxygen demand (BOD_5), total organic carbon (TOC), and chemical oxygen demand (COD).

Armco found that stormwater quantity and quality varied appreciably with drainage basin characteristics and location. This limited the validity of any correlation of parameter concentrations between basins. Furthermore, the quality of stormwater runoff was found to vary directly with storm duration and intensity and also with the number of antecedent dry days prior to storms. As antecedent dry days increase, so does the potential particulate matter to be scoured.

Other significant results of the Armco study were the absence of a "first flush" effect, and the absence of significant quantities of organic matter. The "first flush" effect is a condition where the matter accumulated in a basin since the last runoff event is scoured from the area at the start of the next storm event. In almost all cases, the "flow dependent" effect was observed, i.e., peak parameter concentrations occurred at peak runoff flows.

The Kaiser program involved sampling during the rainy season (February and March) in 1975. Runoff from twelve storm events was sampled for chloride, conductivity, and oil and grease. The oil and grease results from the Kaiser program were much higher than those obtained at Armco.

Since the Armco and Kaiser studies were the only data existing on stormwater runoff from steel mills, several plants were toured as part of this program in an effort to combine a number of factors which affect site specific runoff, such as terrain, climate, mill locations and operations, into an overall industry wide assessment of the most probable sources of stormwater contamination. The following companies were contacted and/or visited:

United States Steel
National Steel
Armco Steel
Republic Steel
Youngstown Sheet and Tube
Inland Steel
Kaiser Steel
CF&I Steel
Alan Wood Steel

Runoff from the activities and operations of steel mills was segmented into the following groups:

- Runoff from storage and disposal piles (coal, coke, slag, iron).
- Runoff from adjacent urban areas into the mill.

- Runoff from slag handling and processing facilities.
- Runoff of accumulated materials from roof and ground areas from several mill operations (blast furnace, sinter plant, BOF shop, open hearth, coke and by-product plant, coal and coke handling, and finishing areas).

Because runoff is site specific, it was impossible to compare the contaminated stormwater potential of an area in one particular mill to the same area in another mill. Climate, terrain, operations, maintenance, and the location of processes relative to each other are unique to each mill. Therefore, a rating system was devised which ranked the relative potential of each activity or operation at an individual plant. Based on the assessments of TRC personnel, the ratings were entirely subjective, except where physical data were available (e.g. Armco's Houston Works). A field survey was designed to determine the quantity and quality of stormwater runoff from iron and steel mills with sampling concentrated on the following activities or operations which were rated as having the greatest potential for contaminating stormwater:

- Coal storage piles
- Coke storage piles
- Slag Dumps
- Iron ore and pellet storage piles
- Coal and coke handling

The survey program was performed at two different sites. Both sites were fully integrated mills on tidal rivers. However, neither location had a representative slag dump; therefore, no slag dump runoff data were obtained. In addition, because of tidal backflow problems, no iron ore pile runoff data were obtained at Site 1. The parameters measured in this program were:

Runoff Flow	Rainfall
Total Iron	Total Suspended Solids (TSS)
Dissolved Iron	Total Dissolved Solids (TDS)
Phenols	Cyanide
Ammonia	Sulfates

Oil and grease and organic parameters such as BOD_5, COD and TOC were not measured because previous work performed by TRC showed that these parameters would not be of sufficient magnitude to be of concern. Previous work by Armco revealed very high concentrations of COD and TOC which were concluded to be a result of inert coal and coke fines and not reactive organics.

Based on the data collected at the two sites, the coal and coke storage piles, and the coal and coke handling areas have the highest potential for contaminating stormwater. Table 2-1 is a summary of average concentrations of the various pollutants in these areas for the two mills sampled.

In order to determine the potential gross impact of stormwater runoff from the mills sampled, the stormwater runoff mass loadings were compared to the point source mass loadings which would exist under proposed BAT control.[3] Since BAT is EPA's next step in the control process (July, 1984), this comparison appears to be valid.

Table 2-2 compares selected annual and hourly runoff mass loadings to point source loadings based on proposed Best Available Technology (BAT) Effluent Guidelines for TSS. This table shows that TSS runoff loadings are generally higher than point source loadings. In addition to TSS, the field data indicate that runoff from coal piles could produce substantial mass loadings of ammonia, phenols and total iron.

In most cases at both sites, the parameter concentrations were rainfall intensity dependent (i.e., the concentration increased with increased rainfall intensity and vice versa). In some cases, the size and characteristics of the

TABLE 2-1

HIGHLIGHTS OF RESULTS
OF FIELD SAMPLING PROGRAMS

SITES 1 AND 2

MARCH-JUNE, 1977

Pollutant	Site No.	Potential Problem Areas	Average Wet Concentrations, mg/l
TSS	2	Coal Stor.	853
	1	Coke Stor.	505
	2		392[a]
	1	Coke & Coal Handling	184
TDS	2	Coal Stor.	471
	1	Coke Stor.	745
	2		959[a]
	1	Coke & Coal Handling	2158
TOTAL IRON	2	Coal Stor.	18
	1	Coke Stor.	32.3
	2		12.6[a]
	1	Coke & Coal Handling	2.4
DISSOLVED IRON	2	Coal Stor.	0.2
	1	Coke Stor.	0.09
	2		1.01[a]
	1	Coke & Coal Handling	0.12

Pollutant	Site No.	Potential Problem Areas	Average Wet Concentrations, mg/l
PHENOL	2	Coal Stor.	0.01
	1	Coke Stor.	0.06
	2		0.03[a]
	1	Coke & Coal Handling	0.37
AMMONIA	2	Coal Stor.	0.33
	1	Coke Stor.	2.1
	2		29.3[a]
	1	Coke & Coal Handling	43
CYANIDE	2	Coal Stor.	n.d.[b]
	1	Coke Stor.	0.01
	2		0.55[a]
	1	Coke & Coal Handling	n.d.[b]
SULFATE	2	Coal Stor.	132
	1	Coke Stor.	n.a.[c]
	2		129[a]
	1	Coke & Coal Handling	312

[a] There were two sampling points near the coke storage area at Site 2. The average concentration for only one (outfall 013) are shown.

[b] n.d. - none detected.

[c] n.a. - not analyzed.

TABLE 2-2

COMPARISON OF AVERAGE ANNUAL AND HOURLY POINT SOURCE LOADINGS WITH AVERAGE ANNUAL AND HOURLY RUNOFF LOADINGS OF TSS FOR SELECTED DRAINAGE BASINS

Sites 1 and 2

March-June, 1977

Site	Outfall	Average Annual Loadings Based on BAT Effluent Guidelines(3)(4) Kg/yr(lb/yr)	Average Annual Runoff Loadings Kg/yr(lb/yr)	Average Hourly Loadings Based on Maximum 1 Day BAT Effluent Guidelines(3) Kg/hr(lb/hr)	Rainfall Events Average Mass Loadings of Pollutants in Runoff Kg/hr(lb/hr)				
					3/24/77	3/27-3/28/77	4/16/77	6/9-6/10/77	6/20/77
1	009	—	TSS 3600 (8000)	—	—	—	—	—	—
	010	TSS 1850(4100)	TSS 80 (180)	TSS 0.6 (1.3)	TSS 0.06(0.13)	TSS 3.54 (7.8)		—	—
	011	TSS 1850(4100)	TSS 3315 (7290)	TSS 0.6 (1.3)	TSS 0.14(0.32)	TSS 10.3 (22.6)	TSS 1.74 (3.83)	—	—
	011 (Coal Pile)	—	TSS 4.1×10^5(9.0×10^5)	—	—	—	—	—	—
2	010	TSS 1.8×10^4(4.0×10^4)	TSS 1.5×10^4 (3.3×10^4)	TSS 6.0 (13)	—	—	—	TSS 219 (482)	TSS 136 (299)
	011 (Coal Pile)	—	TSS 7760 (1.7×10^4)	—	—	—	—	—	—
	012	—	TSS 310 (680)	—	—	—	—	—	—
	013	—	TSS 550 (1210)	—	—	—	—	—	—

drainage basin had an effect on the time lag between rain intensity and runoff flow, and the time lag between runoff flow and parameter concentrations. Finally, as in the Armco study and other industrial work performed,[5] the runoff data did not show a "first flush" effect.

Stormwater controls which presently exist within the steel industry are limited. The only system specifically designed for stormwater control exists at Armco's Houston Works, where coal piles have been diked as a control measure for both fugitive air emissions and stormwater runoff. Runoff collected within the diked area flows by gravity to an earth pond. In nearly two years of operation, losses from evaporation and percolation have prevented any observed overflow from this pond. On dry days, 190,000 liters (50,000 gallons) of water (equivalent to 6mm of rain) are sprayed on the coal piles to control fugitive dust emissions. This water is supplied from a separate concrete pump basin which receives water from the blowdown of a coke plant cooling tower.

Several mills contacted in this program collect stormwater runoff with process wastewater from certain mill areas and the water is subsequently treated at a terminal plant. This necessitates a system of combined sewers within the plant and in several cases a holding pond is needed prior to treatment to handle high flows from storms.

Many mills store their raw materials (predominantly iron ore) in concrete bunkers and bins. Some of these bunkers have concrete floors and stormwater has to be pumped out periodically. These bunkers were not installed for stormwater control but rather to guard against material loss; however, they can serve a control purpose by containing runoff which can then be pumped to a treatment system.

This program illustrates that certain areas within a steel mill may pose a problem. The problem, however, is site specific. Major conclusions and recommendations for the program are listed in the next section.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

Based on the industry evaluation it is apparent that, except for the Armco-Houston and Kaiser Surveys and this program, little quantification and qualification of stormwater runoff from iron and steel mills have been performed.

The following conclusions resulted from the field survey:

1. With the exception of runoff from coal and coke storage areas, the majority of the basins tested in the field survey had pollutant discharges which, on an annual basis, were less than the proposed BAT Effluent Guidelines for the point sources located within the basins. No data were obtained from iron ore and pellet storage piles and active slag dumps.

2. Runoff from the coal storage piles at Site 1 was found to have high pollutant loadings but it is controlled and not representative of the industry as a whole. Runoff from the coal storage piles at Site 2 has considerably lower mass loadings. TSS concentrations were typical of urban runoff while TDS values were approximately twice typical urban runoff concentrations.

3. At both plants, runoff from coal and coke handling areas and the coke plant area generated higher hourly mass loadings of total suspended solids than the average hourly loadings for point sources based on maximum 24-hour loadings in the proposed BAT Effluent Guidelines.

4. The coal storage areas sampled in this study had much lower runoff concentrations for TSS, TDS, total iron, and sulfate than those found in runoff from utility coal containing higher percentages of sulfur.

5. Since no "first flush" effect was observed for any pollutant at either of the field sites, it does not appear to be a problem with runoff from iron and steel mills.

6. In general, total suspended solids concentrations were typical of urban runoff.

7. Total dissolved solids concentrations were generally higher than those of typical urban runoff, particularly in the runoff from coal and coke storage piles and the coal and coke handling areas.

8. Many of the parameter concentrations, particularly phenols, displayed a consistent pattern at both sites. Phenol concentrations were "rainfall intensity dependent" (i.e., the concentration increased with increased rain intensity and vice versa).

9. In several cases, the size and characteristics of the drainage basin had an effect on the time lag between rain intensity and runoff flow and the time lag between runoff flow and parameter concentration. For example, in highly impervious drainage basins such as in finishing areas, there was essentially no time lag between rain intensity and flow and no time lag between flow and parameter concentration, while in more pervious drainage basins there was a time lag in which flow peaks occurred later than rainfall peaks and parameter concentration peaks occurred later than the flow peaks.

10. Total iron is a potential problem in both coal and coke storage areas and coal and coke handling areas. It exceeded proposed BAT Effluent Guidelines for point sources by 2 to 4 times. Dissolved iron, however, was only a small percentage of the total iron and was generally within BAT Effluent Guidelines.

11. Ammonia exceeded proposed BAT Effluent Guidelines for point sources by a factor of 2 during some storms in runoff from coal and coke handling at Site 1 and coke storage at Site 2.

12. Cyanide does not seem to be a problem except for two samples taken in the runoff from the coke storage area at Site 2. These samples averaged approximately twice the proposed BAT Effluent Guidelines for point sources.

13. Results from the two sites indicate that phenols are significantly less than proposed BAT Effluent Guidelines.

14. Sulfates were generally less than standards used for public water supplies.

15. At both sites, ammonia concentrations peaked at about the same time as the first rainfall intensity peak and then slowly decreased throughout the remainder of the storm event.

The following conclusions resulted from the evaluation of stormwater control:

1. Some iron and steel plants have made efforts to control stormwater, e.g., Armco-Houston diking its coal piles.

2. There are some methods of stormwater control available to the industry, e.g., rainfall detention ponding rings for flat roofs. However, there is little experience with the application of these control techniques in the steel-making industry.

3. The problem needs more definition on a plant by plant basis and, to be cost effective, treatment should be approached on a plant by plant basis. Areas of concern are the coal and coke storage areas and the coal and coke handling areas.

3.2 Recommendations

Based on the conclusions and observations of this program, the following recommendations are made:

1. Significant differences between plants make it desirable to develop a stormwater control strategy for the iron and steel industry on a plant by plant basis.

2. At some plants, it may be beneficial to treat stormwater from certain areas to bring runoff mass loadings down to the same order of magnitude as point sources based on the proposed BAT Effluent Guidelines. The most likely area is coal piles where it may be beneficial to treat runoff for total suspended solids, total dissolved solids, and total iron.

3. If stormwater runoff is found to be a problem at a specific site, more work should be performed to determine the feasibility of cost-effective controls for mill areas identified as having potential stormwater contamination problems.

4. Future studies should be directed to quantify and qualify stormwater runoff from the iron ore storage and slag disposal areas.

5. Because many steel plants are built on permeable soils next to waterways, groundwater contamination from storm events is possible. Future programs should investigate potential groundwater contamination from the industry.

6. In order to better quantify and qualify the stormwater runoff from coal and coke storage, coal and coke handling, iron ore storage, and slag disposal areas, sampling should be concentrated at the sources of the runoff from each of these areas to eliminate other interferences, such as process water and other runoff sources.

7. Continuous flow monitoring and sampling should be kept to a minimum number of sites located only in areas where stormwater runoff is a potential problem. Sampling equipment should be automated.

8. Continous monitoring of process water flows entering the storm sewer systems should be done in cases where interference with stormwater runoff cannot be avoided.

9. Samples should be collected prior to and as close to the beginning of a storm event as possible to better define the early reactions of the pollutants. This may involve collecting grab samples at the first sign of precipitation or continuous sampling on days when rainfall probability is high.

10. To make problem definition more cost effective, it may be feasible to reduce the quantity of sampling and substitute a mathematical model which will predict runoff quantity and concentrations. The Short Stormwater Management Model (SSWMM)(5) which has been adapted to coal-fired utility plants could be adapted to steel mills.

4.0 TASK I - IDENTIFICATION OF SURFACE RUNOFF SOURCES

To identify sources of surface runoff from the iron and steel industry, TRC used four major techniques to gather information:

- Literature Search
- Contacts with Regulatory Agencies
- Contacts with Industry Representatives
- Mill Visits

The literature search was used to locate any existing industry stormwater data and control technology. The search was of little use in providing existing data since most data obtained by the industry were too recent to have reached the literature bases searched. However, some useful information was obtained concerning control technology. It is discussed in Section 6.0.

Three EPA regional offices and three state agencies were contacted. They were able to provide some general background, but no agencies have yet focused on stormwater runoff from the iron and steel industry.

The majority of information was obtained through industry contacts and plant visits. While the industry has not yet generally concerned itself with stormwater, industry representatives have given TRC considerable time and effort in developing this assessment. The American Iron and Steel Institute (AISI) set up a task force to review program objectives. The task force included corporate environmental staff from United States Steel, Republic Steel and Armco Steel.

TRC contacted the eight largest steel companies which are:

- Armco Steel
- Bethlehem Steel
- Inland Steel
- Jones & Laughlin Steel
- National Steel
- Republic Steel
- United States Steel
- Youngstown Sheet & Tube

In addition, companies such as Kaiser Steel and Colorado Fuel and Iron, which are located in arid areas, were also contacted. Alan Wood Steel was added to the list because its mill is somewhat isolated from other industries and urban development. All of these companies were contacted either through personal plant tours or telephone conversations.

Table 4-1 shows the mills actually investigated and the basic mill processes. Plans made to tour the Aliquippa Works of Jones and Laughlin could not be met due to schedule limitations. Bethlehem Steel declined to actively participate in the program.

The identification of surface runoff sources is reported in two subsections of this report. Section 4.1 summarizes the available survey data gathered by the iron and steel industry. Section 4.2 identifies sources based on the plant tours performed by TRC personnel in this program.

4.1 Existing Data on Stormwater Runoff - Iron and Steel Industry

The literature search yielded no available data. Interviews with regulatory agencies and industry representatives provided two sets of existing data on stormwater. The first set of data is from a stormwater sampling program conducted at the Armco Steel Corporation's Houston Works, Houston, Texas, from May 1975-September 1976. The second set of data is a compilation of stormwater runoff data for 1975 from the Kaiser Steel Corporation, Fontana, California.

4.1.1 Armco Steel Corporation(6)

Armco Steel's Houston Works conducted a comprehensive survey of stormwater runoff from May 1975-September 1976. This study was the first attempt by a steel company to quantify and qualify stormwater from distinct process areas. In 1975,

TABLE 4-1

MILLS SURVEYED AND TOURED

COMPANY	NAME OF WORKS	LOCATION	PLANT OPERATIONS						
			COKE PLANT	SINTER PLANT	BLAST FURNACES	STEEL MAKING: BASIC OXYGEN FURNACES	STEEL MAKING: OPEN HEARTH FURNACES	STEEL MAKING: ELECTRIC FURNACES	FINISHING OPERATIONS
NATIONAL STEEL	Weirton Works	Weirton, WV	✓	✓	✓	✓	-	-	✓
U.S. STEEL	Edgar Thomson Works	Braddock, PA	-	✓ (a)	✓	✓	-	-	✓(b)
U.S. STEEL	Fairless Works	Fairless Hills, PA	✓	✓	✓	-	✓	✓	✓
U.S. STEEL	Geneva Works	Provo, UT	✓	✓	✓	-	✓	-	✓
REPUBLIC STEEL	Gulfsteel Works	Gadsden, AL	✓	✓	✓	✓	-	✓	✓
ARMCO STEEL	Houston Works	Houston, TX	✓	✓	✓	-	-	✓	✓
ARMCO STEEL	Middletown Works	Middletown, OH	✓	✓	✓	✓	✓	-	✓
ALAN WOOD STEEL	Alan Wood Steel Co.	Conshohocken, PA	✓	✓	✓	✓	-	-	✓
YOUNGSTOWN S & T	Campbell Works	Youngstown, OH	✓	✓ (c)	✓	-	✓	-	✓
CF & I STEEL	Pueblo Plant	Pueblo, CO	✓	✓	✓	✓	-	✓	✓
INLAND STEEL	Indiana Harbor Works	East Chicago, IN	✓	✓	✓	✓	✓	✓	✓
KAISER STEEL	Kaiser Steel Works	Fontana, CA	✓	✓	✓	✓	✓	-	✓

NOTES

✓ - means that plant has these facilities

(a) Discontinued operation in January 1975. No current plans for use.

(b) Majority of finishing done at Irvin Works.

(c) Will be shut down in 1977.

the Texas Water Quality Board wanted to set discharge limitations on seven of Armco's stormwater outfalls. After a literature search yielded no published data on industry stormwater, Armco successfully proposed to the state agency that Armco perform this comprehensive survey prior to the initiation of limitations on stormwater quality.

During a normal rainfall approximately 230 hectares of developed area at the Houston Works discharge stormwater runoff to seven stormwater outfalls and one combined wastewater-stormwater outfall which has treatment. Plant stormwater drainage is divided into nine fairly distinct basins which were determined by visual observations during storms. The total plant basin is divided as follows: 15.4% building area, 4.9% paved area, 8.2% railroad track, 70.4% either undeveloped land or stockpile areas, and 1.1% ponded area. The breakdown by basin is shown in Table 4-2. The stockpile area is segregated into a raw products area, composed of iron ore, limestone, coal and coke, and a finished steel products area.

The various activities and operations for each basin are summarized in Table 4-3.

In this survey, Armco found that stormwater quantity and quality varied appreciably by drainage basin which limited the validity of any correlation of parameter concentrations between outfalls. Furthermore, the quality of the stormwater runoff was found to vary directly with storm duration and intensity and also with the number of antecedent dry days between storms. As the antecedent dry days increased, so did the potential particulate matter to be scoured.

For this particular study, the "first flush" effect was only observed three times at a combined sewer discharge from the east ditch-west ditch drainage basins. This is a condition whereby the matter accumulated in a basin since the last runoff event is scoured from the area at the start of the next storm event. In almost every other case, the "flow dependent" effect was observed, i.e., peak parameter

TABLE 4-2

BASIN RUNOFF CHARACTERISTICS[6]
ARMCO STEEL CORPORATION STUDY

Sub-Basin	% Buildings	% Paved	% Track	% Ponded	% Undeveloped or Stockpiles	Basin Area Hectares
005	24.2	9.4	8.7	0.0	57.7	57.8
006	13.4	5.0	9.2	0.0	72.4	1.9
007	21.0	5.0	24.9	4.1	45.0	1.7
008	0.0	0.0	1.4	0.0	98.6	3.9
009	9.6	6.3	18.4	0.0	65.7	2.7
010	22.6	5.3	19.4	0.0	52.7	1.1
011	9.3	17.8	14.3	1.0	57.6	24.5
East Ditch	24.2	7.3	13.4	2.2	52.9	71.9
West Ditch	23.9	7.8	7.3	1.6	59.4	67
TOTAL	15.4%	4.9%	8.2%	1.1%	70.4%	232.5

TABLE 4-3

DESCRIPTION OF ACTIVITIES AND OPERATIONS IN BASIN[6]
ARMCO STEEL CORPORATION STUDY

Basin	Activities and Operation
005	Wide Flange Mill; Shipping Office; Roundhouse (car, truck, and railroad car repair facility); western halves of the No. 1 Electric Furnace Shop, No. 2 Plate Mill, Plate Shipping Building, Heavy Plate Shear Building, and Plate Heat Treat Building.
006	Direct Reduction Plant.
007	Sinter Plant.
008	Iron ore storage area located between the Stock House and docking facility.
009	West end of the Mold Foundry; area between the Coke Plant proper and the east end of the Stock House; Coke Transfer.
010	Coal transfer; main coal conveyor belt from the dock area to the coal storage area; Coal Shaker Building; numerous coal transfer points; located in immediate vicinity of the west end of the Coke Plant area.
011	Mold Preparation Shop; eastern part of the No. 2 Electric Furnace Shop; eastern half of the Coke Ovens; Coke Oven By-Products area; coal pile storage area; eastern half of the Mold Foundry; employee parking area.
West Ditch	Slag Storage Area; Slag Plant Area; West Pond; eastern halves of No. 1 Electric Furnace Shop, No. 2 Plate Mill, Plate Shipping Building, Heavy Plate Shear Building, and Plate Heat Treat Building; Truck Shipping area; Slab Yard Buildings; Structural Shape Storage Building; Bloom, Ingot and Slag Yard; western halves of structural Mill Building and Billet Yard; Roll Shop; Plate Torching and Shipping Building; 60" Mill Building; Soaking Pit Building; Material Storage Pile.
East Ditch	Covered Scrap; No. 1 Open Hearth Shop; eastern halves of Structural Mill Building and Billet Yard; Heat Treat Building; Rod Mill; Coil Storage Building; Wire Mill Building; Bar Storage Buildings; Mill Spares Building; Wire Mill Warehouse; East Pond; Blast Furnace; Power House; Western half of No. 2 Electric Furnace Shop.

concentrations occurred at peak runoff flows. The flow dependent concentrations occur because the vast majority of contaminated runoff at the Houston Works can be attributed directly to heavy particulate matter. This is mostly relatively heavy, insoluble iron oxides. This particulate matter is scoured in direct proportion to the flow of stormwater runoff.

Table 4-4 summarizes the flow, quality, and rainfall data for basins 005, 006, 009, 010, and 011. Armco found no discharge from basin 007 and 008 outfalls during the survey program. In addition, part of the stormwater from the east ditch and west ditch is combined with process water and sent to a treatment pond; therefore, these areas were not included in the survey.

The results in Table 4-4 show that basins 009 and 010 had the highest total suspended solids (TSS) concentrations. These results were expected since coal and coke handling occur in these areas. The major source of solids is fugitive dust fallout from material handling. Much of the ground area in these two basins is covered with dust fallout from coal and coke storage and handling. Basin 011 had one storm with a high TSS concentration (Storm #2 - 2378 mg/1), but overall the emissions are lower than 009 and 010. Generally, coal storage piles such as those located in basin 011 contribute high TSS concentrations, and therefore this area would normally be expected to have much higher TSS concentrations. However, Armco Houston has diked their coal piles, and runoff is contained in a holding pond (See Section 6.1).

The Armco data clearly show that oil and grease emissions are not of major concern in the stormwater. Armco has oil baffles on several stormwater discharges, but the baffles do not pick up significant quantities of oil.

Basin 007 discharges from a small pond via an overflow weir. During the survey, Armco did not detect any flow from the pond. All stormwater from 007 either percolated into the ground or evaporated. Armco constructed a weir in

TABLE 4-4

STORM DATA
ARMCO STEEL CORPORATION STUDY[6]

Basin	Storm #	Total Flow MG	Avg. TSS mg/1	Avg. Oil & Grease mg/1	Rainfall Inches
005	1	0.404	278.0	N/A	0.39
	2	0.690	355.0	2.0	0.32
	3	0.065	24.6	N/A	0.20
	4	0.546	119.5	<0.5	0.45
	5	0.501	115.1	<0.5	0.40
006	1	8.0×10^{-4}	505.0	N/A	0.20
	2	8.0×10^{-4}	426.0	N/A	0.02
	3	1.2×10^{-3}	584.0	N/A	0.40
009	1	6.3×10^{-3}	808.0	2.0	0.20
	2	6.3×10^{-3}	1471.8	0.5	0.15
	3	0.3816	2709.4	<0.6	2.30
	4	0.460	1117.0	<0.6	N/A
010	1	6.84×10^{-4}	10722.0	0.8	0.20
	2	6.3×10^{-4}	3186.0	0.6	0.15
	3	0.031	8561.9	<0.5	2.30
	4	1.2×10^{-3}	2481.8	<0.1	0.30
011	1	0.112	314.5	N/A	0.70
	2	0.470	2378.0	N/A	1.80
	3	0.266	854.1	0.5	1.20
	4	0.054	246.5	N/A	0.50
	5	0.016	4.0	N/A	0.20
	6	0.037	198.5	N/A	0.20

N/A = none analyzed

in a manhole of the 1.2m underground concrete channel which serves as basin 008's discharge. Since the weir was constructed, Armco personnel have not observed any flow. The majority of stormwater in the area infiltrates the lower soil strata.

4.1.2 Kaiser Steel Corporation[7]

Kaiser Steel Corporation, Fontana, California, is a fully integrated iron and steel plant. It is located in a region of little rainfall. Rain normally occurs only during February and March. Raw material piles are not located in bunkers or diked and are subject to stormwater runoff. During 1975, Kaiser monitored the mill runoff during the rainy season.

Most stormwater runoff flows to one drainage ditch. This ditch is a mountain creek and is dry most of the year. Flow is measured in this ditch with a Parshall flume, which has a maximum measurement of 11,400 lpm. Since this mill is in an arid climate, as much of the runoff as possible is retained for use as process water. The runoff which cannot be retained is discharged to the surrounding land as there is no receiving water body. Within a distance of less than two miles, all of the water either evaporates or percolates into the soil.

Table 4-5 is a summary of the monitoring data obtained during 1975. Samples from 12 different stormwater runoff events were reported. These data show much higher concentrations of oil in the runoff than were found at Armco Houston. The plant personnel could give no reasons why the oil concentrations were so high.

4.1.3 Source Information Industry-Wide

One area in which some work was performed on an industry-wide basis was an environmental assessment of steelmaking furnace dust disposal.[8] The report

TABLE 4-5

STORMWATER DATA - 1975
KAISER STEEL CORPORATION
FONTANA, CA[7]

Date of Sample	Estimated Total Flow MG	Chloride in mg/1	Electrical Conductivity in Micromhos/cm	Oil in mg/1	Visible Oil in Discharge	Color of Discharge
02/03/75	1.4988	17.6	200	23.0	No	Light Brown
02/04/75	.1831	98.6	1580	85.4	No	Gray
02/05/75	.8034	163.0	1360	28.0	No	Yellow Gray
02/09/75	1.4333	131.0	1060	12.8	No	Yellow
02/10/75	.786	85.2	1300	68.3	No	Gray Brown
03/05/75	.51	44.3	420	131.0	No	Gray Brown
03/08/75	3.1577	106.0	950	311.0	No	Gray Brown
03/10/75	1.5104	44.7	320	52.7	No	Gray Brown
03/14/75	.4135	72.6	550	494.0	Yes	Gray Brown
03/22/75	1.0378	54.0	470	56.1	No	Gray Brown
03/23/75	-	40.0	370	14.2	No	Gray
03/26/75	.7245	136.0	1040	81.7	No	Gray Brown
TOTAL	12.06					

concluded that runoff from disposal piles of steelmaking furnace dust collected by air pollution control equipment is a potential problem. This runoff can be contaminated with suspended and dissolved solids and heavy metals. The report stated that the magnitude of transport by surface runoff and its contamination depends largely upon the methods of disposal. Wastes buried in soil pits do not present a surface runoff problem, whereas waste piles exposed to precipitation are subject to particle dislodgement by runoff. The potential pollutants include antimony, mercury, cobalt, lead, zinc, chromium, selenium, and manganese.

4.2 TRC Assessment of Potential Sources of Contaminated Runoff

Since runoff is a site-specific problem, TRC toured several plants in an effort to obtain data to combine a number of factors which affect site-specific runoff (such as terrain, climate, mill locations and operations) into an overall assessment of most probable sources of stormwater contamination, industry-wide. The runoff from activities and operations of steel mills has been segmented into the following groups:

- Runoff from storage and disposal piles (coal, coke, slag, iron ore and and pellets).
- Runoff from slag handling and processing facilities.
- Runoff from adjacent urban areas into the mill.
- Runoff of accumulated materials from roof and ground areas from several mill operations (blast furnace, sinter plant, BOF shop, open hearth, coke and by-product plant, coal and coke handling, and finishing area).

The material piles are a potential source of contaminated stormwater because generally they are stored in open, flat terrain in undeveloped sections of the mill. They present large surface areas for contact with rainwater.

Slag handling and processing facilities are a potential source because of the quantity of materials and the continuous use of water as a coolant.

At some mills urban runoff from adjacent areas may contribute significantly to both the volume and mass loading of mill runoff.

A predominant source of accumulated materials within a mill is fallout from fugitive and uncontrolled air emissions. Only the finishing operations do not contribute fallout. The finishing area is included as a potential source of contaminated stormwater because it usually encompasses a large geographic area of the mill and contains a high percentage of impervious area, i.e., roof and pavement. Therefore, it is an area which can accumulate fallout and has essentially a 100% runoff rate.

Because runoff is site specific, it was impossible to compare the contaminated stormwater potential of an area of one particular mill to the same area in another mill. Climate, terrain, operations, maintenance, and the location of processes relative to each other are unique to each mill. Each plant was therefore rated according to a system designed to rank the relative potential for contaminated stormwater of each of its activities. A rating of 1 for a given mill indicated the area or areas with the highest potential for stormwater contamination. Ratings of 2 to 5 were assigned to areas in the order of lessening concern. Table 4-6 shows the rating for each activity or operation for the 11 plants toured or interviewed. These ratings are purely subjective based on TRC personnel assessments. The Armco Houston Works rating was compiled based on the Armco data presented in Section 4.1. At the botton of Table 4-6, the total and average ratings are reported. Because these numbers are subjective, it would be inappropriate to take a 1.6 rating as being of more concern than a 1.7. However, based on these ratings, the following activities and operations are most likely those of greatest potential for contaminating stormwater industry wide:

- Coal storage piles

TABLE 4-6

POTENTIAL SOURCES OF CONTAMINATED STORMWATER

MILLS	COAL PILES	COKE PILES	SLAG PILES	IRON ORE PILES	SLAG HANDLING/ PROCESSING	URBAN RUNOFF INTO MILL	BLAST FURNACE AREA	FUGITIVE FALLOUT TO ROOF & GROUND AREAS					
								SINTER PLANT	BOF SHOP	OPEN HEARTH SHOP	COKE BY-PRODUCT PLANT	COAL & COKE HANDLING	FINISHING AREAS
NATIONAL STEEL - Weirton (a)	1	2	1	Controlled at Source	1	2	3	3	3	-	2	1	3
U.S. STEEL - Edgar Thomson	-	2	3	2	1	1	1	-	1	-	-	2	-
U.S. STEEL - Fairless	1	1	1	1	2	5	2	2	-	2	2	3	4
U.S. STEEL - Geneva	1	1	2	2	4	3	4	3	-	4	3	2	4
REPUBLIC STEEL - Gadsden (b)	2	3	1	2	3	1	2	2	2	-	2	2	3
ARMCO STEEL - Houston	Controlled at Source	2	3	2	4	5	3	3	-	-	2	1	4
ARMCO STEEL - Middletown	3	3	1	3	2	2	2	2	2	2	3	3	4
ALAN WOOD STEEL - Conshohocken	2	2	1	Controlled at Source (c)	1	2	3	3	3	-	3	2	4
YOUNGSTOWN SHEET & TUBE - Campbell	3	3	3	Controlled at Source	3	1	2	2	-	1	1	2	2
COLORADO FUEL & IRON Pueblo	1	1	1	1	2	3	2	2	3	-	2	2	3
INLAND STEEL - Indiana Harbor	1	1	1	2	3	4	3	3	3	3	2	2	4
TOTAL RATING (d)	15	21	18	15	26	29	27	25	17	12	22	22	35
AVERAGE RATING	1.7	1.9	1.6	1.9	2.4	2.6	2.5	2.5	2.4	2.4	2.2	2.0	3.5

(a) Contaminated stormwater from all areas except storage piles and coal and coke handling go to terminal treatment systems.

(b) All contaminated stormwater goes to terminal treatment systems.

(c) Ore is stored in concrete diked area, rain seeps into ground and may infiltrate a creek which passes under storage piles. If this is true, the ore piles would be rated as a 1.

(d) Controlled at source activities are not included in either total or average rating.

- Coke storage piles
- Slag piles
- Iron ore and pellet storage piles
- Coal and coke handling

It was also concluded that, while finishing operations will contribute a large quantity of stormwater, they generally will be the lowest area of potential contamination. Since runoff is site specific, there will be many cases within the industry which will not fit the above criteria. This is evident in some of the mills listed in Table 4-6.

In addition to the rating of the 13 categories, there were special cases at some of the plants toured. These were not included in the table because they are not typical of the industry. At Armco's Middletown Works, there are two areas where sludge from pollution control is stored. One sludge pile is in the slag dump area which is rated as a number 1 area of concern. The Edgar Thomson Works of U.S. Steel stores tar as a fuel. The tar, if spilled, could contaminate stormwater, depending upon the adequacy of containment measures, and therefore it was given a rating of 3. The final "other" potential source was the disposal of chemical wastes at U. S. Steel's Fairless Works. It was given a rating of 2 among that mill's concerns.

4.2.1 Pollutants of Concern

Based on the observations made during tours and interviews, it was concluded that contaminated stormwater from iron and steel mills may contain the following pollutants in significant concentrations:

Total Suspended Solids	Total Dissolved Solids
Cyanide	Phenols
Ammonia	Total Iron
Dissolved Iron	Sulfates

Solids were of most concern since they are likely to be scoured from all areas of a mill. Phenols, cyanide, and ammonia were of most concern in coal and coke handling facilities and in the coke plant area. Dissolved iron was presumed to be only a small portion of the total concentration. The insoluble iron concentration, however, was thought to be significant contributor to the suspended solids concentration in many areas of a mill. Metals were assumed to be a major contaminant in the slag dump and disposal areas. Finally, sulfates were presumed to be a significant contaminant in the coal handling and coke plant areas.

In general, organics were not thought to be a problem when dealing with mill stormwater. Some plants will be exceptions, particularly those which have significant urban runoff combined with mill runoff. In these cases a filtered chemical oxygen demand (COD) would be of interest.

5.0 TASK II - FIELD PROGRAM

5.1 Description of Sites

Two steel mills were surveyed in the spring of 1977 for the stormwater runoff field program. Table 5-1 lists the general characteristics of each of these two sites.

The differences between the two sites are quite obvious. Site 1 is a much older plant and has one sixth of the acreage of Site 2. The drainage basins within Site 1 are clearly defined with permanent primary flow measurement devices previously constructed at the outfalls from each of the runoff basins. Site 1 was sampled first because it is a more consolidated mill, its drainage basins are clearly defined, and primary flow devices (weirs) were previously installed at the outfalls.

Site 2 is built on 5.5m of raised fill area above the floodplain of the tidal river. Due to the flat topography and the permeable nature of the soil, Site 2 has no well-defined natural runoff system. Unless directed by storm sewers or open channels, the runoff from Site 2 will percolate directly into the ground. The sampling program at Site 2, therefore, concentrated on the runoff entering the plant storm sewer network.

A more detailed description of each site follows. At both sites, identifying numbers were assigned to drainage basins. Each drainage basin had an outfall and a sampling location. Throughout this section of the report, the same number is used to identify either the basin or the outfall and sampling location for that basin.

TABLE 5-1

GENERAL SITE CHARACTERISTICS

	Site 1	Site 2
Age of Plant	37 Years	25 Years
Developed Area (Hectares)	230	1600
Terrain	Flat, Semi-Permeable	Flat, Permeable
Runoff Receiving Body	Tidal River	Tidal River
Plant Operations	Coke Plant, Sinter Plant, Blast Furnaces, Electric Furnaces, Finishing Operations	Coke Plant, Sinter Plant, Blast Furnaces, Open Hearth Furnaces, Electric Furnaces, Finishing Operations
Period of Sampling	3/77 to 4/77	5/77 to 6/77
Number of Sampling Points	5	13
Permanent Flow Devices	Yes	No

5.1.1 Description of Drainage Basins and Unit Operations - Site 1

Five drainage basins as listed in Table 5-2 were sampled.

Figure 5-1 shows the site plan with the five separate drainage basins and their associated outfalls. Basin 005 is the largest basin with 57.8 hectares. It contains various mills, shops, the shipping department, part of the No. 1 Electric Furnace Shop and the Roundhouse. Most of this basin, approximately 60%, is undeveloped or used for outside storage. The sampling location is a weir box on an open ditch at the southern corner of the basin.

Basin 006 is a small drainage area, approximately 1.9 hectares in size. It encompasses the Direct Reduction Plant. Seventy-two percent of this area is undeveloped or used for outside storage area.

Basin 009 is another relatively small drainage area. The major activity in this area is coke transfer. The west end of the Mold Foundry and the area between the Coke Plant proper and the east end of the Stock House comprise the 2.7 hectares of this basin.

Basin 010 is the smallest of the five drainage basins (1.1 hectares). Most of the activity in basin 010 is coal handling. Conveyor belts carrying coal from the dock area to the storage area, the Coal Shaker building and numerous other coal transfer points are located within this drainage basin.

Drainage basin 011, located in the southeastern section of the plant, is approximately 24.5 hectares. The list of activities within this basin is summarized in Table 5-2. The coal storage area is subject to stormwater runoff but, since a 0.46m earth dike surrounds the coal piles, the stormwater is contained. During large rainstorms this contained water is channeled into a holding pond.

TABLE 5-2

DESCRIPTION OF INDIVIDUAL DRAINAGE BASINS SAMPLED
SITE 1

Basin	Activities and Operations	Area (Hectares)
005	Wide Flange Mill; Shipping Office; Roundhouse (car, truck, and railroad car repair facility); western halves of the No. 1 Electric Furnace Shop, No. 2 Plate Mill, Plate Shipping Building, Heavy Plate Shear Building, and Plate Heat Treat Building.	57.8
006	Direct Reduction Plant.	1.9
009	West end of the Mold Foundry; area between the Coke Plant proper and the east end of the Stock House; Coke Transfer.	2.7
010	Coal transfer; main coal conveyor belt from the dock area to the coal storage area; Coal Shaker Building; numerous coal transfer points located in immediate vicinity of the west end of the Coke Plant area.	1.1
011	Mold Preparation Shop; eastern part of the No. 2 Electric Furnace Shop; eastern half of the Coke Ovens; Coke Oven By-products area; coal pile storage area; eastern half of the Mold Foundry; employee parking area.	24.5

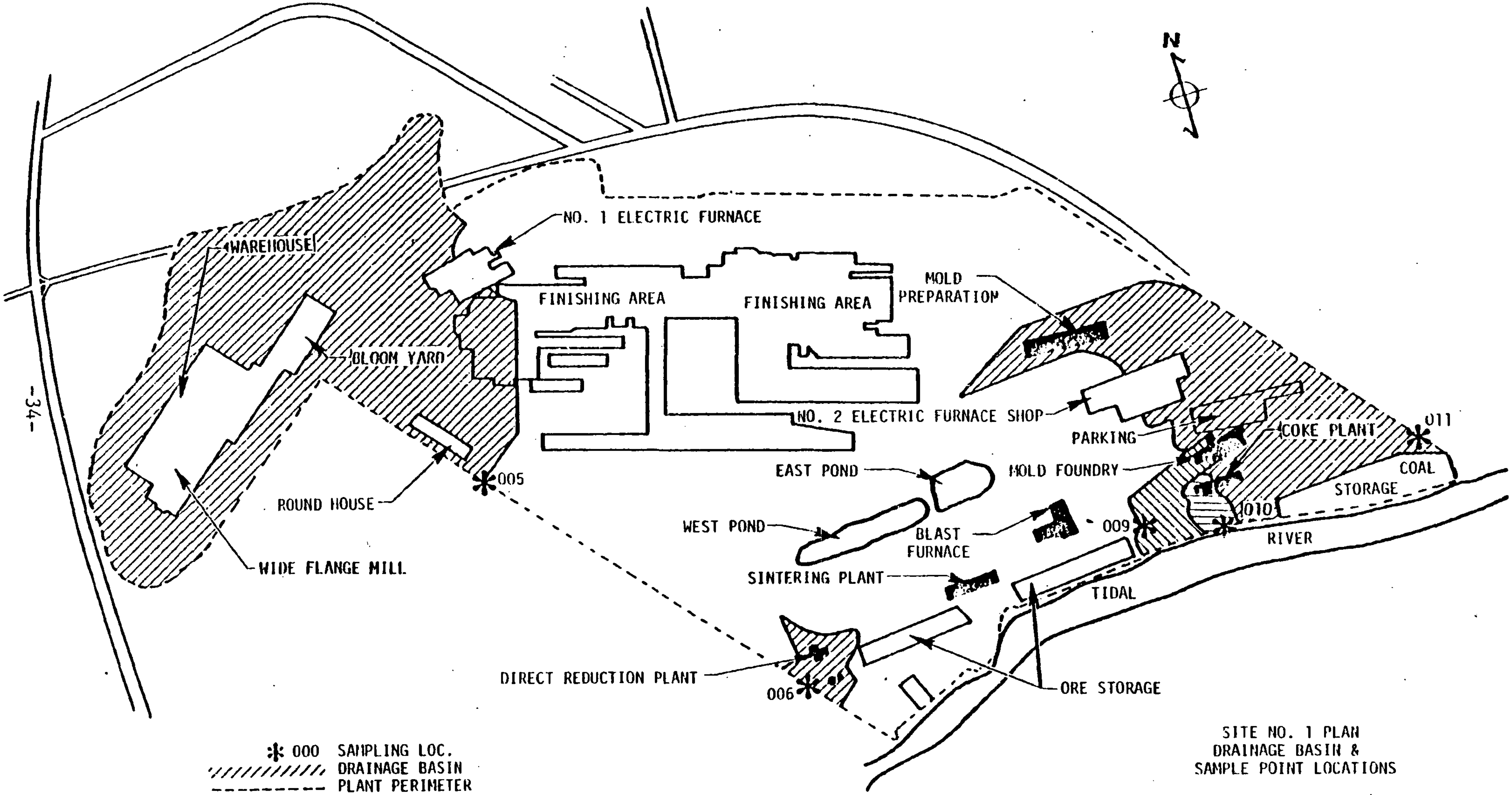


Figure 5-1: Plan - Site No. 1

The five drainage basins of Site 1 all empty into the tidal river running along the southern end of the plant. The outfalls themselves were located within either the discharge canal just before the canal empties into the river or within drainage pipes leading into the river.

5.1.2 Description of Drainage Basins and Unit Operations - Site 2

Because there are no well defined drainage basins within Site 2, the delineation of drainage areas was based upon the storm sewer plans for the plant. The storm sewer system for Site 2 originates at the roof drains from most of the plant operations, includes the road and railroad line runoffs, and terminates in either a canal leading into the tidal river or into the river directly. A general layout of Site 2 showing the drainage basins and the sampling locations is presented in Figure 5-2.

Basins 002, 003, 004, 005, 006 and 007 are all located on the central drainage canal. A description of the activities and operations within these separate basins is listed in Table 5-3. Outfalls 002, 006, and 007 receive the runoff from mill buildings and surrounding paved areas from which the storm sewers originate. Outfall 004 receives the runoff from the northeastern half of the Open Hearth Furnaces, the railroad lines, and the Mold Preparation Shop just to the south of the Open Hearths. The southwestern half of the Open Hearths drains into the 010 basin. Outfalls 003 and 005 receive the drainage from open exposed areas where slag was used to fill borrow pits. Some process water was continuously flowing from the Open Hearths (004), the Slab Cooling Process (006) and the Hot Strip Mills (007).

Drainage basins 008 and 009 contain buildings, ore conveyors and the surrounding paved areas of the Blast Furnace and Sinter Plants. Sampling point

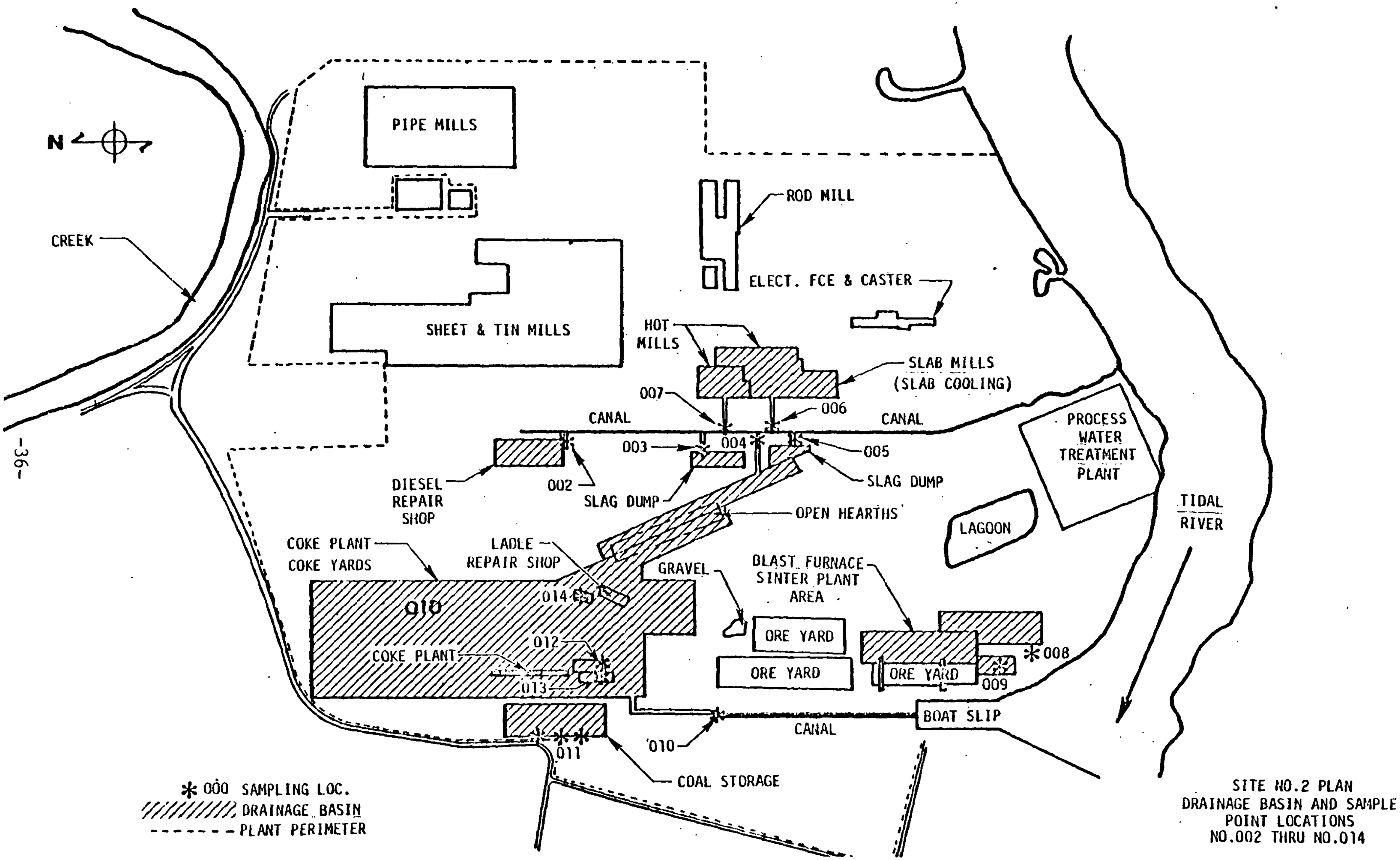


Figure 5-2: Plan - Site No. 2

TABLE 5-3

DESCRIPTION OF INDIVIDUAL DRAINAGE BASINS SAMPLED
SITE 2

Basin	Activities and Operations	Area (Hectares)
002	Diesel Repair Shop.	2.2
003	Slag Filled Borrow Area; Railroad tracks.	1.9
004	Mold Preparation Shop; northeast side of Open Hearth Furnaces; Railroad tracks.	7.5
005	South end of Open Hearth Shop; Railroad tracks; Slag Dump Area; Mold Preparation.	1.6
006	Hot mills; Slab cooling area; Slab mill; Billet mill.	4.9
007	Hot strip mills.	2.1
008	Blast furnace; Sinter Plant; Employee Parking; Ore Conveyors.	3.7
009	Sinter Plant; Ore Conveyors; Roadways.	4.6
010	One half of Open Hearth Plant; Coke Plant; Coke yards; Numerous Railroad lines; Coke By-Products Complex.	58.5
011	Coal storage.	4.0
012	Southern end of Coke Ovens - surface runoff.	0.53
013	Southern end of Coke Ovens - surface runoff.	0.61
014	Ladle Repair Shop; Railroad track area.	0.2

008 was a manhole on a line leading directly into the river. Sampling point 009 was another manhole on a line upstream of 008. Even though most of the ore storage areas were located adjacent to 008 and 009, little runoff from these piles entered the storm sewers because the ore piles were permeable and situated on flat permeable ground.

Runoff from the coal storage area either percolated into the ground immediately surrounding the coal piles or was collected in small ditches separating the coal piles from the bordering roadway. In no case was the coal pile runoff observed flowing off the plant property. Sample location 011 was one of the small ditches bordering the storage area.

Drainage basin 010 was the largest of the thirteen sampled. Even though drainage basins 012 and 013 are located within the bounds of basin 010, these two basins empty into a small settling pond to the south and do not flow into outfall 010. Outfall 014 runoff did lead into the storm sewer system terminating at outfall 010. Basin 010 included half of the Open Hearths plus the total storm sewer network surrounding the coke storage yards, the Coke Plant, the Ladle Repair Shop and the Coke By-Products Complex. All these storm sewers terminated in two 2.4 meter lines leading into the canal at the western end of the site.

Basins 012 and 013 were local surface runoff areas on the south end of the Coke Plant. The runoff was sampled at points just before it entered the settling pond. Basin 014 was a 0.2 hectares area just north of the Ladle Repair Shop. This basin was relatively flat and was made up of railroad lines leading into the shop and road surface.

5.2 Test Plan

A test plan was developed to attain the objective of quantifying the pollutants associated with stormwater runoff from iron and steel mills. No attempt was made to assess the effects of these pollutants on the receiving water. The test plan was designed to determine:

1. Background conditions at each sampling location prior to a storm event, i.e., dry weather flow conditions.
2. Volume of stormwater runoff and pollutant concentrations in the runoff as a function of time for the storm event.

The following additional data were gathered:

1. Rainfall accumulation as a function of time for the storm event.
2. Dustfall accumulation between storms.

The sampling sites were located in the following areas considered to have the highest potential for runoff problems:

1. Coal storage
2. Coke storage
3. Slag disposal
4. Iron ore and pellet storage
5. Coal and coke handling

Specific sampling sites were chosen which would be easily accessible and which would provide representative samples. The sites chosen precluded sampling of slag handling and disposal areas at both sites. Sample field data and calibration sheets are included in Appendix A.

5.2.1 Site 1 Test Plan

The selection of sampling locations at Site 1 proved to be a relatively easy task. The drainage basins were well-defined and weirs had been previously installed in several of the basins. Basins to be sampled were selected, based on the location of the areas/operations of concern to the program. Five basins (005, 006, 009, 010, and 011) each with a weir at its outfall were chosen. (See Figure 5-1 for location of basins and outfalls.) In addition, a drainage ditch in the coal storage area was chosen as a sampling location. A typical sampling equipment installation used in this program is shown in Figure 5-3. The equipment included an ISCO Sampling System and a Climatronics Electronic Weather Station (EWS). The ISCO Sampling System includes an ISCO Model 1680 Sequential Sampler, an ISCO Model 1700 Flow Meter and an ISCO Model 1710 Digital Printer. The ISCO Model 1680 Sequential Sampler collects samples automatically at a pre-set volume and frequency. Sampling can be triggered either by an internal clock or by an external flow meter. This piece of equipment facilitates sampling and allows workers to perform other tasks at the same time samples are being collected. Setting the controls for flow-based sampling results in frequent sampling at peak flow during a storm event. The ISCO Model 1700 Flow Meter indicates the water level in the weir with a submerged plastic tube which continuously emits bubbles just upstream of the weir. As the water level fluctuates, back-pressure changes in the tubing are accurately measured with a sensitive electronic transducer. An optically encoded function generator disc, specific for each size and type of weir, converts water level to flow rate.

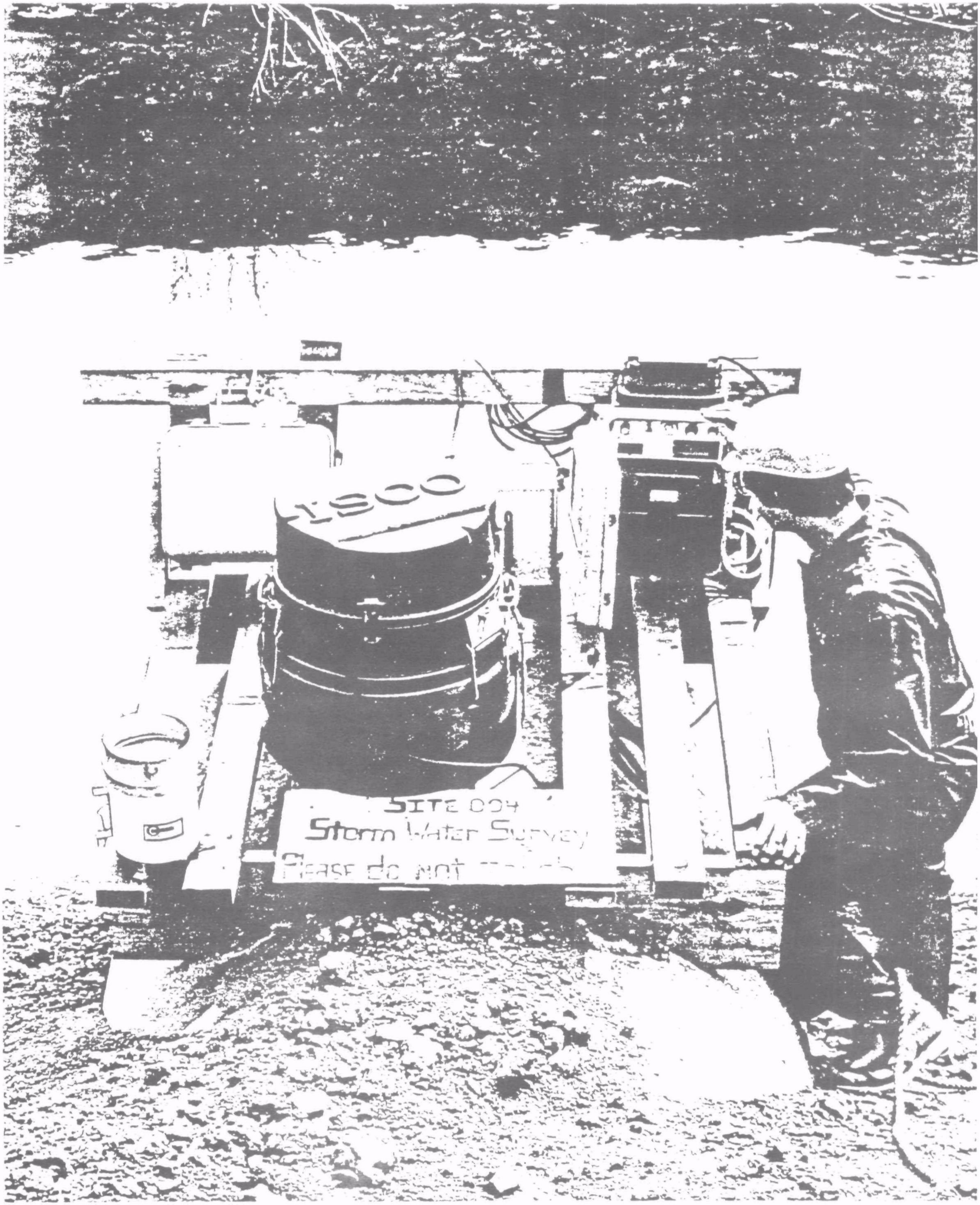


Figure 5-3: Typical ISCO Sampling System with Electronic Rain Gauge

5.2.1.1 Outfall 005

Outfall 005 discharges via a concrete weir box located in an open drainage ditch and equipped with a 90° V-notch weir (0.30m head height). Sampling equipment at this location included an ISCO Sampling System and a Climatronics Electronic Weather Station (EWS). For Outfall 005, a special combination disc (90° V-notch weir-0.30m head height/6.1m rectangular weir without end constrictions) was used to measure the highly variable storm flows.

Dry and wet weather samples were to be collected on a flow basis at Outfall 005. The flow meter was set to trigger the sampler to collect 500 ml of sample whenever 3780 liters of water had passed over the weir. It was estimated that this sample rate would provide ten-minute samples at peak flow during a storm event. The parameters to be analyzed at this outfall were total suspended solids (TSS) and total dissolved solids (TDS).

The ISCO Model 1710 Digital Printer provides a permanent typed record of totalized flow at pre-selected time intervals. The Climatronics Electronic Weather Station (EWS) was to be used only with the tipping bucket rain gage and a Rustrak recorder. The bucket tips whenever 0.25mm of rain accumulates, and the rainfall is recorded automatically.

5.2.1.2 Outfall 006

Outfall 006 is a 0.91m storm sewer discharging to an open ditch which follows the western boundary line of the plant. The outlet is equipped with a 90° V-notch weir (13cm head height). The ISCO Sampling System consisting of the Model 1680 Water Sampler, Model 1700 Flow Meter, and Model 1710 Digital Printer was mounted on a metal walkway beside the outfall pipe. A plastic rain wedge was strapped to one of the rail posts on the metal walkway. No dry weather flow was expected from Outfall 006 with the exception of water periodically flushed from the Direct Reduction Plant. This flow was to be sampled on a flow basis to be determined in the field. During storm events, the sampler was set to collect 500 ml of sample whenever 378 liters of water had passed over the weir, resulting in ten-minute samples at peak flow. The pollutants to be analyzed at this outfall were TSS and TDS.

The plastic rain wedge was to be read periodically during rainstorms and rainfall accumulation recorded.

5.2.1.3 Outfall 009

Outfall 009 discharges over a 90° V-notch weir (13cm head height) located in the inlet of a 1.2m closed pipe which leads to the tidal river. The ISCO Sampling System and a plastic rain wedge were mounted on the metal walkway above the pipe inlet. A combination disc (90° V-notch weir-13cm head height/ 1.2m rectangular weir without end constrictions) was used to measure the highly variable storm flows.

Dry and wet weather samples were to be collected on a flow basis at Outfall 009. The sampler was prepared to collect 2000 ml of sample whenever 378 liters of water had passed over the weir, resulting in ten-minute samples at peak flow during a storm event. The pollutants to be analyzed at this outfall were TSS, TDS, total iron, dissolved iron, phenols, cyanide, and ammonia. Total iron analyses were to be alternated with dissolved iron analyses, and phenols with cyanide. For example, one group of four sample bottles would be analyzed for total iron and phenols, and the next group would be analyzed for dissolved iron, and cyanide.

The plastic rain wedge was to be read periodically during a storm event and the rainfall accumulation recorded.

5.2.1.4 Outfall 010

Outfall 010 discharges from a concrete structure placed in a manhole of a 0.46m storm sewer line which drains to the tidal river. It was equipped with a 90° V-notch weir (13cm head height). The ISCO Sampling System was installed on a wooden platform constructed just above the weir. A plastic rain wedge was attached to a fence post in the vicinity of the manhole. A combination disc (90° V-notch weir-13cm head height/1.5m rectangular weir without end constrictions) was used to measure the highly variable storm flows.

Dry and wet weather samples were to be taken on a flow basis. The sampler was set to collect 2000 ml whenever 378 liters of water had passed over the weir. The pollutants to be analyzed at this outfall were the same as those at Outfall 009, with the addition of sulfates. Pollutants were alternated as they were at Outfall 009.

The plastic rain wedge was to be read periodically during a storm event and the rainfall accumulation recorded.

5.2.1.5 Outfall 011

Outfall 011 discharges via a concrete weir box placed in an open drainage ditch. A metal walkway and sampling platform provide for easy access to a 0.61m rectangular weir with end constrictions. The ISCO Sampling System was mounted on a metal walkway. A Belfort Rain Gage, a self-contained batter operated instrument, was mounted on a flat area of land in the vicinity of the concrete weir box.

Again, dry and wet weather samples were to be collected on a flow basis. The ISCO Sampling System was programmed to collect 2000 ml whenever 3780 liters of water had passed over the weir. The pollutants to be analyzed at this outfall were the same as those at Outfall 009, with the same procedure for alternating pollutants.

5.2.1.6 Coal Pile Ditch

Grab samples were to be obtained during rain storms from a drainage ditch which runs along the coal storage area in the vicinity of Outfall 011. No dry weather flow was expected in this drainage ditch.

5.2.1.7 Dustfall Sampling

Several flat locations were to be chosen for dustfall sampling which would be clear of obstructions and be near the test drainage basins. These locations would be marked off in 0.6 m by 0.6 m squares, one of which would be sampled daily from each site except during storm events, in which case a sample would not be collected.

5.2.2 Site 2 Test Plan

The selection of sampling locations and the installation of equipment proved to be a more difficult task at Site 2. Drainage basins had not been previously defined nor were there any permanent flow measuring devices. This necessitated the installation of weirs and platforms on which to mount equipment at several of the outfalls. The selection and subsequent maintenance of sampling locations was further complicated because of the vastness of the plant. A summary of the outfalls chosen is presented in Table 5-4.

See Figure 5-2 for outfall locations.

TABLE 5-4

SUMMARY OF SAMPLING SITES
SITE 2

Outfall	Sample Collection Method	Flow Method	Sampling Schedule for Storm Events	Parameters to be Analyzed
002	Grab	Bucket and stop-watch	Every storm event (when possible)	TSS, TDS
003	Grab	Bucket and stop-watch	Every storm event (when possible)--low priority	TSS, TDS
004	ISCO Sampler with weir	ISCO flow meter and printer	Sample 2 of sites 004,006,& 007 for each storm	TSS, TDS Total Fe Dissolved Fe
005	Grab	Bucket and stop-watch	Every storm event (when possible)--low priority.	TSS, TDS
006	ISCO Sampler with weir	ISCO flow meter and printer	Same as 004	TSS, TDS
007	ISCO Sampler with weir	ISCO flow meter and printer	Same as 004	TSS, TDS
008	Grab	None	Every storm event (when possible)	TSS, TDS Total Fe Dissolved Fe
009	Grab	None	Every storm event (when possible)	TSS, TDS Total Fe Dissolved Fe Metals
* 010A * 010B	ISCO Sampler	Gurley meter	Every storm event	TSS, TDS Total Fe Dissolved Fe Phenols, Ammonia, Cyanide
011	Grab	None	Every storm event	TSS, TDS, Sulfate, Phenols, Ammonia, Total Fe, Dissolved Fe, Metals
012	Grab	None	Sample 2 of sites 012,013, & 014 for each storm	TSS, TDS, Phenols, Sulfates, Ammonia, Total Fe, Dissolved Fe, Metals, Cyanide
013	Grab	None	Same as 012	TSS, TDS, Phenols, Sulfates, Ammonia, Total Fe, Dissolved Fe, Metals, Cyanide
014	Grab	None	Same as 012 & 013	TSS, TDS, Total Fe Dissolved Fe
015	Grab	None	Every storm event	TSS, TDS, Phenols, Sulfates, Ammonia, Total Fe, Dissolved Fe, Cyanide

*Two separate identical sampling locations.

5.2.2.1 Outfalls 002, 003 and 005

Outfalls 002, 003 and 005 are pipes which discharge to the central canal. Grab samples were to be taken at these locations. Flow data were to be determined by the free fall velocity (California Pipe) method.[14] Table 5-4 lists the parameters to be analyzed at each outfall.

5.2.2.2 Outfall 004

Outfall 004 is a 1.2m concrete pipe which also discharges to the central canal. In order to provide continuous flow measurements and facilitate sample collection, a portable 90° V-notch weir plate (25cm head height) was installed in the pipe. In addition, the ISCO Sampling System and the Climatronics EWS were mounted on a wooden platform bolted into the top of the pipe. Dry and wet weather samples were to be collected on a time basis. Dry weather sampling was to be performed at 30 minute intervals over an eight hour day. During a storm event, samples were to be taken at 15 minute intervals from the beginning of the storm through peak storm intensity to ensure that any possible "first flush" effects were measured. As the intensity of a storm event waned, the sampling interval was to be extended to 30 minutes. This sampling was to continue until the base flow returned to its pre-storm level.

5.2.2.3 Outfall 006

Outfall 006 is a 1.1m concrete pipe which also leads to the central canal. As with Outfall 004, a wooden platform was bolted into the top of the pipe upon which the ISCO Sampling System was mounted. A 25cm rectangular portable weir was installed in the pipe.

There is a large dry weather flow at this outfall which originates from the slab cooling area. The sampling frequency for both dry and wet weather sampling was the same as Outfall 004.

5.2.2.4 Outfall 007

Outfall 007 is a 0.77m pipe discharging to the central canal. As with Outfalls 004 and 006, a wooden platform was bolted onto the top of the pipe upon which was mounted the ISCO Sampling System. A portable 90° V-notch weir (13cm head height) was installed in the pipe. Dry and wet weather samples were to be collected at this outfall at the same intervals as Outfalls 004 and 006.

5.2.2.5 Outfalls 008 and 009

Outfalls 008 and 009 are located in manholes in the southwestern part of the mill (See Figure 5-2). Flow measurements were not taken at Outfall 008 because it is a junction manhole. A Gurley meter and a staff gage mounted in the manhole were to be used to determine flow at Outfall 009. The Gurley meter is a cable suspended current meter which is used to measure the velocity of the water in the pipe. Flow in the pipe can be calculated using this velocity, the diameter of the pipe, and the stage reading from the staff gage. Samples were to be collected at both outfalls with the ISCO Model 1680 Water Sampler. Sampling frequency called for 30 minute samples from the beginning of the storm event through peak storm intensity to ensure that the initial effects of the storm (including any possible "first flush" effects) were measured. As the storm waned, this interval would be extended to one hour and would be continued throughout post-rainfall sampling. Dry weather samples were to be collected hourly from each outfall. The schedule also called for sampling at Outfalls 008 and 009 to be alternated with each storm.

5.2.2.6 Outfall 010

This location includes two outfalls, 010A and 010B, which are two 2.4m pipes discharging to the west canal. A wooden platform was built on top of Outfall 010B. An ISCO Model 1680 Water Sampler and a Belfort Rain Gage were mounted on this platform. The flow in these pipes (approximately 80% full) was too high to install a weir and flow meter. A Gurley current meter and staff gages were used to measure flow.

Dry weather samples were to be collected at each outfall on an hourly basis. Wet weather samples were to be collected at 30 minute intervals from the beginning of a storm through peak storm intensity and lengthened to hourly at the end of the storm and throughout post-rainfall sampling.

5.2.2.7 Outfall 011

Outfall 011 is a small drainage ditch located in the coal storage area (See Figure 5-2) on the western side of the plant.

Wet weather samples were to be collected with sampler plugs which would be emptied every 15 minutes during a storm event. These plugs are inserted in the ground, flush with the surface. No dry weather flow was expected in this drainage ditch. A plastic rain wedge was mounted on a fence post in the vicinity of the drainage ditch.

5.2.2.8 Outfalls 012 and 013

Outfalls 012 and 013 are both located near the southern end of the coke ovens. Outfall 012 is a 0.30m pipe which discharges to a pond on the mill property. The pipe comes from a storm junction box. The box is below ground and only about 0.46m deep. A portable 90° V-notch weir (8cm head height) was installed in the pipe. Outfall 013 is an open drainage ditch leading from the coke battery to the same pond. A plywood weir was constructed and installed in the ditch. An instrument platform was built to house the ISCO Sampling System and a plastic rain wedge. The same platform was to be used for each outfall. Sampling was to be alternated between the outfalls with each storm.

Dry weather flow was not expected at either outfall. Wet weather samples were to be collected every 30 minutes from the beginning of the storm event through peak storm intensity and extended to one hour as the storm waned.

5.2.2.9 Outfall 014

Outfall 014 is a small, open gutter leading into the side of a manhole box through a 0.33m corrugated pipe. A portable 90° V-notch weir (8cm head height) was placed at the entrance to the pipe with the overflow going into the pipe. An instrument platform was constructed and placed on top of the manhole to house the ISCO Sampling System and a plastic rain wedge.

There was no dry weather flow expected at this outfall, and thus only wet weather samples were collected, with the same frequency as Outfalls 012 and 013.

5.2.2.10 Location 015

Location 015 is a small sampling pump used to sample the tidal river. Samples were to be taken periodically at this location whenever dry and wet weather sampling took place. The river water was sampled because it was used as process water and was a contributor to dry weather flow at several outfalls. Any difference in river quality would have to be accounted for in differences between dry and wet weather samples.

5.2.2.11 Dustfall Sampling

As at Site 1, several locations were to be chosen for dustfall sampling which would be clear of obstructions and be near the test drainage basins. These sites were to be sectioned off in the same manner as at Site 1 and a different section swept daily from each location except in the case of a storm event, when samples would not be collected.

5.2.3 Implementation of Test Plan at Site 1

A number of modifications to the test plan were required to obtain meaningful samples during the field survey. These were occasioned by the magnitude of the rainfall and some unforeseen physical conditions. With the exception of the changes noted in this section, the field survey followed the test plan described in Section 5.2.1.

Samples were collected on a time basis (hourly) during the first rainfall event (3/24/77) at Outfalls 005, 010, and 011 rather than on a flow basis because the steady all-day drizzle precluded a "first flush" effect. Sampling on a time basis provided more samples than would have been collected on a flow basis during this storm which caused only a slight increase in the water level over the weir at these three outfalls.

Outfall 006 showed no runoff on 3/24/77 and hence no samples were obtained. Runoff at this outfall was detected only during the storms of 3/27-3/28/77, and 4/16/77, but was of such low flow and short duration that automatic sampling was abandoned and a few grab samples were obtained.

Outfall 009 showed the effects of tidal backflow from the river and samples could not be obtained at the weir during any of the storms. Surface runoff did occur from the area and it drained to the small pond on the upstream side of the weir but samples could not be taken in the pond due to contamination from the tidal backflow. Grab samples were taken from a small stream of road runoff and a stormwater drain. Tidal backflow also occurred at Outfall 010 during the beginning of the 3/27-3/28/77 storm and delayed the start of sampling. Runoff was not detected during either of the small storms of 3/31/77 and 4/4/77 at Outfall 010 and hence no samples were obtained. With the exception of the above storms at Outfall 010, all of the storms at Outfall 005, 010, and 011 were sampled on a flow basis.

Due to the low number of samples taken during storm events at Outfall 005, the ISCO Sampling System was reset to collect samples whenever 1890 liters of water had passed over the weir instead of 3780 liters. This was employed during the storm of 4/16/77 and resulted in more samples being collected.

Dry weather sampling was conducted on a time basis (hourly) at Outfalls 005, 010, and 011 instead of a flow basis as planned. This resulted in the collection of a larger number of samples.

The test plan originally called for a dustfall sampling site to be set up in each of the drainage basins. Due to the scarcity of flat paved areas free from obstructions such as tall buildings and heavy traffic, only one area was found suitable for dustfall sampling. This was in the vicinity of the coal and coke handling operations (Basin 010). Three sampling sites were set up in this area.

5.2.4 Implementation of Test Plan at Site 2

As with Site 1, several modifications of the test plan were necessary once the field survey was underway. These dealt similarly with the method of sample collection and flow measurement at each outfall and are discussed below. The sample collection and flow measurement methods used are shown in Table 5-4.

The major difficulty encountered at this site was obtaining a rainfall of sufficient intensity and duration to create surface runoff. Most of the plant area was built on level, semi-permeable ground and, in order for surface runoff to occur, either an intense thunderstorm or a steady all-day rain resulting in substantial (greater than 2.54cm) rainfall was necessary. This occurred only twice during the entire field survey.

The planned sample collection method for several of the outfalls had to be modified for various reasons. The ISCO Model 1680 Water Samplers could not be used at Outfalls 008 and 009 because of possible damage due to heavy machinery traffic in the vicinity. Grab samples were collected periodically at these outfalls during both dry and wet weather sampling periods. Sampler plugs were not used at Outfall 011. The location of the drainage ditch and manpower constraints made grab sampling easier. The ISCO Water Samplers were not used at Outfalls 012, 013, and 014 because the short duration of surface runoff at each outfall favored grab sampling. Only a few samples were obtained from Outfalls 003 and 005 due to the low flows of very short duration at these sites.

In addition to these changes in sample collection methodology at several outfalls, changes were also made in flow measurement. Instead of using the free fall velocity (California pipe) method at Outfalls 002, 003, and 005, a bucket of known volume and a stopwatch were employed due to the short duration of runoff at each site and manpower constraints.

As at Site 1, dustfall sampling was limited due to a lack of suitable locations. Sampling sites (Basins 009 and 013) were set up in the vicinity of the slag disposal, coke storage, and iron ore storage areas, but it was impossible to set up sites which would provide representative samples in the coal storage and coal and coke handling areas.

5.3 Chemical Laboratory Procedures

No on-site chemical analyses were performed at either test site. All samples were composited and split into volumes required for the analysis of each parameter. All samples were preserved in accordance with the Manual of Methods for Chemical Analysis of Water and Wastes.[10] These preservation methods are shown in Table 5-5. Samples were shipped to the TRC corporate laboratory for analysis.

Prior to shipping the samples to the laboratory, the following information was recorded on each bottle label and on a sample log sheet (see Appendix A for sample log sheets):

- Sample number
- Sample location
- Date and time of collection
- Parameters to be analyzed
- Date and time of preservation

In addition, because of transit time, sample analyses for cyanide, phenols, and ammonia could not be accomplished within the time limitations of the standard presentation and analysis. The following procedure which was developed by the Analytical Quality Control Chief, EPA Region I was used for these samples. The samples were split and one-half of the sample was "spiked" with an appropriate standard (cyanide, phenols, and ammonia) while the other half was left "unspiked." Both samples were then sent to the laboratory for parallel analysis. A comparison of each "spiked" sample with its "unspiked" mate would show the degradation rate incurred during shipping for each of the three parameters.

TABLE 5-5

PRESERVATION AND ANALYTICAL METHODS

USED FOR SAMPLE ANALYSIS

Parameters	Preservative[a]	Concentration Technique	Analytical[b] Method
Total Suspended Solids (TSS)	Cool to 4°C	None	Filtration; Gravimetry
Total Dissolved Solids (TDS)	Cool to 4°C	None	Filtration; Evaporation; Gravimetry
Total Iron	HNO_3 to pH < 2	Evaporation	Atomic Absorption;[c] Air-Acetylene Flame
Dissolved Iron[d]	Filter (0.45 μ Filter); HNO_3 to pH < 2	Evaporation	Atomic Absorption;[c] Air-Acetylene Flame
Phenols	Collect in glass only; Cool to 4°C; H_3PO_4 to pH < 4; 1.0 g $CuSO_4$/l	Colored end product extracted with $CHCl_3$	Distillation; 4-Aminoantipyrine Method
Cyanide (Total)	Cool to 4°C; NaOH to pH 12	Reflux distillation into NaOH	Colorimetric Method (Chloramine-T)
Ammonia	Cool to 4°C; H_2SO_4 to pH < 2	None	Distillation at pH 9.5; Nesslerization
Sulfate	Cool to 4°C	None	Turbidimetry

(a) All samples preserved in accordance with the Manual of Methods for Chemical Analysis of Water and Wastes (EPA 1974).[10]

(b) Analyzed in accordance with procedures described in Standard Methods for the Examination of Water and Wastewater.[11]

(c) Strong acid digestion.

(d) Filtered on site.

Upon receiving the samples for analysis, the Supervisor of the Chemical Laboratory checked to insure agreement between the labeled shipping bottles and the accompanying sample log sheets. An analysis number was then assigned to the set of samples and the samples were scheduled for work-up by laboratory chemists and technicians.

All chemical analyses were performed according to procedures described in Standard Methods for the Examination of Water and Wastewater.(11) The procedures utilized are presented in Table 5-5.

Once analysis of the samples was completed, the final results and raw data were returned to the Supervisor who reviewed them for accuracy. The Supervisor then reported all final results to the project manager. A file was maintained by the Supervisor which contains all pertinent data for the specific project such as final results, calculations and project memoranda.

5.4 Field Survey Results

5.4.1 Site 1 Results

Table 5-6 summarizes the storm event data for Site 1.

Out of the five storm events sampled at Site 1, only the storm of March 31 approximated the high intensity, short duration rainfall typical of this semi-tropical area. From historical observations of previous storm events at Site 1, it was expected that the total rainfall at various locations around the plant would differ over the course of a storm. This uneven distribution of rainfall was never observed during the field program. During the sampling program, the rainfall was typically a steady drizzle with occasional heavy downpours uniformly distributed over the entire plant. In all five events, rain wedge totals closely corresponded to the recording rain gages.

TABLE 5-6

STORM EVENT DATA
SITE 1
MARCH - APRIL, 1977

Date	Storm Beginning	Storm Ending	Total Rainfall		Average Rainfall Intensity		Maximum Rainfall Intensity	
			cm	(inches)	cm/hr	(in/hr)	cm/hr	(in/hr)
3/24/77	0500	2130	0.84	(0.33)	0.05	(0.02)	0.13	(.05)
3/27- 3/28/77	2000 (3/27)	0200 (3/28)	1.42	(0.56)	0.23	(0.09)	0.61	(0.24)
3/31/77	1410	1430	0.20	(0.08)	0.61	(0.24)	1.07	(0.42)
4/4/77	0200	0500	0.36	(0.14)	0.13	(0.05)	0.41	(0.16)
4/16/77	0430	2000	0.71	(0.28)	0.05	(0.02)	0.56	(0.22)

Table 5-7 summarizes the flow data from Site 1. Time-weighted average flow data plus the range of flow for both dry and wet weather sampling are listed. The dry weather flows at Outfall 010 were not measurable; the water levels over the weir were essentially zero except for a small trickle which volumetrically was negligible. Wet flow data were limited at outfall 010 due to occasional tidal backflows. At outfalls 005 and 011 wet flows were significantly higher than dry flows.

Tables 5-8, 5-9, 5-10, 5-11, and 5-12 all refer to the pollutant data measured at Site 1. The range (Table 5-8), the mean (Table 5-9) and the average mass loadings (Table 5-10 through 5-12) of pollutants show the obvious differences between dry and wet weather conditions. Average mass loadings of pollutants for dry weather conditions were calculated by multiplying the mean concentrations value measured during each storm by the time-weighted average flows from Table 5-7. Average mass loadings for wet weather conditions were calculated by multiplying the time-weighted average concentrations by the time-weighted average flows, both determined from the concentration and flow curves for each rainfall event. The time-weighted average wet weather flows pertain to the time over which each parameter was sampled and may vary for the different parameters within each storm event. In some instances, due to lack of data, straight average concentrations, or in some cases, one data point, were used to calculate wet weather average mass loadings. When no flow data were measured, mass loadings were not calculated.

At all outfalls except the coal pile drainage ditch, the mean dissolved solids were higher than the suspended solids. At outfalls 005, 010, and 011, where automatic sampling was performed, the dissolved solids were consistently higher than the suspended solids, often by at least one order of magnitude. The reaction of dissolved solids varied with each outfall and each storm event. In

TABLE 5-7

DRY VS WET FLOWS[a][d]
SITE 1
MARCH - APRIL, 1977

OUTFALL	005				010		011			
DATE	DRY		WET		WET[b]		DRY		WET	
	Avg. Flow lpm(gpm)	Range lpm(gpm)	Avg. Flow lpm(gpm)	Range lpm(gpm)	Avg. Flow lpm(gpm)	Range lpm(gpm)	Avg. Flow lpm(gpm)	Range lpm(gpm)	Avg. Flow lpm(gpm)	Range lpm(gpm)
3/24			1056 (279)	227-2233 (60-590)	12.5 (3.3)	0 - 29.1 (0 - 7.7)			189 (50)	45 - 534 (12-141)
3/27 - 28			6083 (1607)	454-15026 (120-3970)	16.0 (4.2)	0 - 67.0 (0 - 17.7)			708 (187)	38 - 2203 (10 - 582)
3/29	473 (125)	435-568 (115-150)					38 (10)	27-53 (7-14)		
3/31			401 (106)	227-984 (60-260)	ND[c]	ND[c]			405 (107)	95-939 (25-248)
4/4			2112 (558)	568-4542 (150-1200)	ND[c]	ND[c]			170 (45)	15-367 (4-97)
4/5	227 (60)	227 (60)					3.4 (0.9)	0-13.2 (0-3.5)		
4/16			3456 (913)	228-15900 (60-4200)	13.3 (3.5)	0 - 49.02 (0 - 13.0)			583 (154)	83-1374 (22-363)
4/18	216 (57)	76-254 (20-67)					87 (23)	76-106 (20-28)		

(a) No flow data were taken at Outfalls 006 and 009, nor at the coal pile drainage ditch.
(b) There was no measurable dry flow at 010 during the program.
(c) ND - No flow data were obtained.
(d) Flow values are time weighted averages for the entire event.

TABLE 5-8

RANGE OF POLLUTANT CONCENTRATIONS AT THE
SAMPLING LOCATIONS AT SITE 1
MARCH - APRIL, 1977

Pollutant	Range of Pollutant Concentrations, mg/ℓ											
	Outfall 005		Outfall 006[b]		Outfall 009A[a],[b]		Outfall 010		Outfall 011		Coal Pile[b]	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Total Suspended Solids	4-31	11-113		11-676		156-951	4-649	10-1272	7-42	9-151		1116-9559
Total Dissolved Solids	327-463	238-964		200-1501		376-1316	2007-5438	661-4993	668-1049	427-1196		1419-2974
Total Iron						18-51	1.1-8.3	1.2-3.6	1.1-2.7	0.96-5.8		34-44
Dissolved Iron						0.10[c]	0.1-0.6	0.1-0.2	0.10[c]	0.10-0.30		0.50[c]
Phenols						0.04-0.09	16-34	0.02-1.1	0.02-0.68	0.01-0.52		0.13-0.85
Cyanide (Total)						n.d.-0.03[d]	n.d.-0.99[d]	n.d.[d]	n.d.[d]	n.d.-0.01[d]		n.d.-0.17[d]
Ammonia						0.23-3.5	54-96	3.6-73	0.57-26	0.65-28		27-84
Sulfate							400-1580	180-490				

[a] Road runoff at 009.
[b] No dry samples obtained.
[c] Only one value obtained.
[d] n.d. -not detectable - detectable limit = 0.001 mg/ℓ.

TABLE 5-9

MEAN POLLUTANT CONCENTRATIONS, IN mg/ℓ AT SITE 1
MARCH - APRIL, 1977

Outfall	005		006[a]		009[a]		010		011		Coal Pile Drainage Ditch[a]	
Pollutant	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
TSS	15	45		284		505	84	184	18	35		4188
TDS	396	541		762		745	3078	2158	868	919		2289
Total Iron						32.4	3.3	2.4	1.9	2.6		39.3
Dissolved Iron						0.1	0.4	0.1	0.1	0.2		_ (b)
Phenols						0.06	25	0.37	0.13	0.086		0.39
Cyanide (Total)						0.01	0.5	_(b)	_(b)	0.002		_(b)
Ammonia						2.1	73	43	9.1	3.4		56
Sulfate							718	312				

(a) No dry samples collected.

(b) Several non-detectable values were also obtained.

TABLE 5-10

AVERAGE MASS LOADINGS OF POLLUTANTS[(a),(b),(c)]
DRY VS. WET WEATHER
MARCH - APRIL, 1977
OUTFALL 005 - SITE 1

Date	3/24 (Wet)			3/27-28 (Wet)			3/29 (Dry)			3/31 (Wet)		
Parameter	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)
Total Suspended Solids	39	1200 (317)	2.82 (6.2)	48	3845 (1016)	11.1 (24.4)	16	473 (125)	0.45 (0.99)	38	401 (106)	0.91 (2.0)
Total Dissolved Solids	938	1200 (317)	67.5 (149)	332	3847 (1016)	76.6 (168.5)	353	473 (125)	10.0 (22.0)	581	401 (106)	14.0 (30.8)

Date	4/4 (Wet)			4/5 (Dry)			4/16 (Wet)			4/18 (Dry)		
Parameter	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)
Total Suspended Solids	37	2434 (643)	5.46 (12.0)	17	227 (60)	0.23 (0.51)	75	4205 (1111)	19.0 (41.8)	14	227 (60)	0.19 (0.42)
Total Dissolved Solids	669	2434 (643)	97.7 (214.9)	443	227 (60)	6.0 (13.2)	371	4205 (1111)	93.6 (206.0)	409	227 (60)	5.6 (12.3)

(a) Average Mass Loadings for wet weather calculated by multiplying the time weighted average concentration by the time weighted average flow, which were determined from the flow and concentration curves for each event.

(b) Average wet weather flows are time-weighted flows for the sampling period for each parameter. These may vary for the different parameters within each storm.

(c) Average Mass Loadings for dry weather calculated by multiplying the straight average concentration by the time-weighted average flow from Table 5-7.

TABLE 5-11

AVERAGE MASS LOADINGS OF POLLUTANTS[(a),(b),(c)]
DRY VS. WET WEATHER
MARCH - APRIL, 1977
OUTFALL 010 - SITE 1

Date	3/24 (Wet)			3/27-28 (Wet)		
Parameter	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)
Total Suspended Solids	76	12.7 (3.36)	0.06 (0.13)	1717	34.4 (9.1)	3.54 (7.80)
Total Dissolved Solids	2170	12.7 (3.36)	1.65 (3.64)	150	34.4 (9.1)	0.31 (0.68)
Total Iron	2.61	12.7 (3.36)	0.002 (0.004)			
Dissolved Iron				0.119	34.4 (9.1)	0.0002 (0.0005)
Phenol	0.46	12.7 (3.36)	0.0004 (0.0009)	0.559	34.4 (9.1)	0.001 (0.003)
Ammonia	50	4.43 (1.17)	0.013 (0.03)	41.0	34.4 (9.1)	0.08 (0.19)
Sulfate	285	14.7 (3.88)	0.25 (0.55)	224	34.4 (9.1)	0.46 (1.02)

(a) Average Mass Loadings for wet weather calculated by multiplying the time weighted average concentration by the time weighted average flow, which were determined from the flow and concentration curves for each event.

(b) Average wet weather flows are time-weighted average flows for the sampling period for each parameter. These may vary for the different parameters within each storm.

(c) Average Mass Loadings for dry weather calculated by multiplying the straight average concentration from Appendix B by the time-weighted average flow from Table 5-7.

TABLE 5-12

AVERAGE MASS LOADINGS OF POLLUTANTS(a),(b),(c)
DRY VS. WET WEATHER
MARCH - APRIL, 1977
OUTFALL 011 - SITE 1

Date	3/24 (Wet)			3/27-28 (Wet)			3/29 (Dry)			4/5 (Dry)			4/16 (Wet)			4/18 (Dry)		
Parameter	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)
Total Suspended Solids	11	217 (57.29)	0.14 0.32	97	1764 (466)	10.3 (22.6)	14	38 (10)	0.03 (0.07)	14	3.4 (0.9)	0.003 (0.007)	51	568 (150)	1.74 (3.83)	30	87 (23)	0.16 (0.34)
Total Dissolved Solids	1343	217 (57.29)	17.5 (38.5)	624	1764 (466)	66.0 (145.3)	683	38 (10)	1.56 (3.43)	1021	3.4 (0.9)	0.21 (0.46)	1062	568 (150)	36.2 (79.6)	785	87 (23)	4.1 (9.0)
Total Iron	0.98*	282 (74.4)	0.02 (0.04)	5.8**	742 (196)	0.26 (0.57)	1.3	38 (10)	0.003 (0.007)	2.6	3.4 (0.9)	0.001 (0.002)	3.63*	935 (247)	0.2 (0.45)	1.9	87 (23)	0.01 (0.02)
Dissolved Iron	0.1**	275 72.8	0.002 (0.004)	0.1**	696 (184)	0.004 (0.009)	0.1**	38 (10)	0.0002 (0.0005)	0.1	3.4 (0.9)	2.0×10^{-5} (4.4×10^{-5})	0.2*	935 (247)	0.01 (0.02)	0.1	87 (23)	0.001 (0.002)
Phenol	0.117	262 (69.22)	0.002 (0.004)	0.038	1669 (444)	0.004 (0.009)	0.055	38 (10)	0.0001 (0.0003)	0.26	3.4 (0.9)	5.3×10^{-5} (1.2×10^{-5})	0.08*	477 (126)	0.002 (0.004)	0.025	87 (23)	0.0001 (0.0003)
Ammonia	1.49	252 (66.63)	0.023 (0.05)	13.04	742 (196)	0.58 (1.28)	22	38 (10)	0.05 (0.11)	4.9	3.4 (0.9)	0.001 (0.002)	0.912	568 (150)	0.03 (0.07)	0.97	87 (23)	0.005 (0.011)

*straight average
**one value only

(a) Average Mass Loadings for wet weather calculated by multiplying the time weighted average concentration by the time weighted average flow, which were determined from the flow and concentration curves for each event.

(b) Average wet weather flows are time-weighted average flows for the sampling period for each parameter. These may vary for the different parameters within each storm.

(c) Average Mass Loadings for dry weather calculated by multiplying the straight average concentration from the time-weighted average flow from Table 5-7.

Figure 5-4 the dissolved solids at outfall 005 appear to correspond directly to both the flow and rainfall intensity curves but this was not always the case at the other outfalls. After plotting all the dissolved solids data and comparing these curves to the rainfall intensity and flow curves, no conclusive statement can be made concerning the reaction of dissolved solids to a storm event.

The reaction of total suspended solids to a storm event also varied with each outfall and event. In a few cases, suspended solids correspond directly to rainfall intensity and flow, but in most instances, as shown in Figure 5-4, there was a time lag between the rainfall intensity peaks and suspended solids concentration peaks.

The pollutant data from outfall 010 do show some interesting results. As indicated in Tables 5-8 and 5-9, the dry weather concentrations of total dissolved solids, total iron, dissolved iron, phenols, cyanide, ammonia and sulfates are greater than the wet weather concentrations. The mean measured values under dry conditions of 25 mg/l for phenols, 73 mg/l for ammonia and 718 mg/l for sulfates are quite high. These concentrations were brought to the attention of the mill personnel who are further investigating the results. During runoff conditions these levels were reduced significantly. The stormwater runoff at outfall 010, therefore, appeared to dilute these pollutants.

This same dilution effect was observed for phenols and ammonia concentrations at outfall 011, although the levels are much less than those measured at outfall 010. The mass loading data (Table 5-12) indicate that the dry weather loading is at least one order of magnitude less than the wet weather loading of phenols. In most cases the same is true for the ammonia loadings.

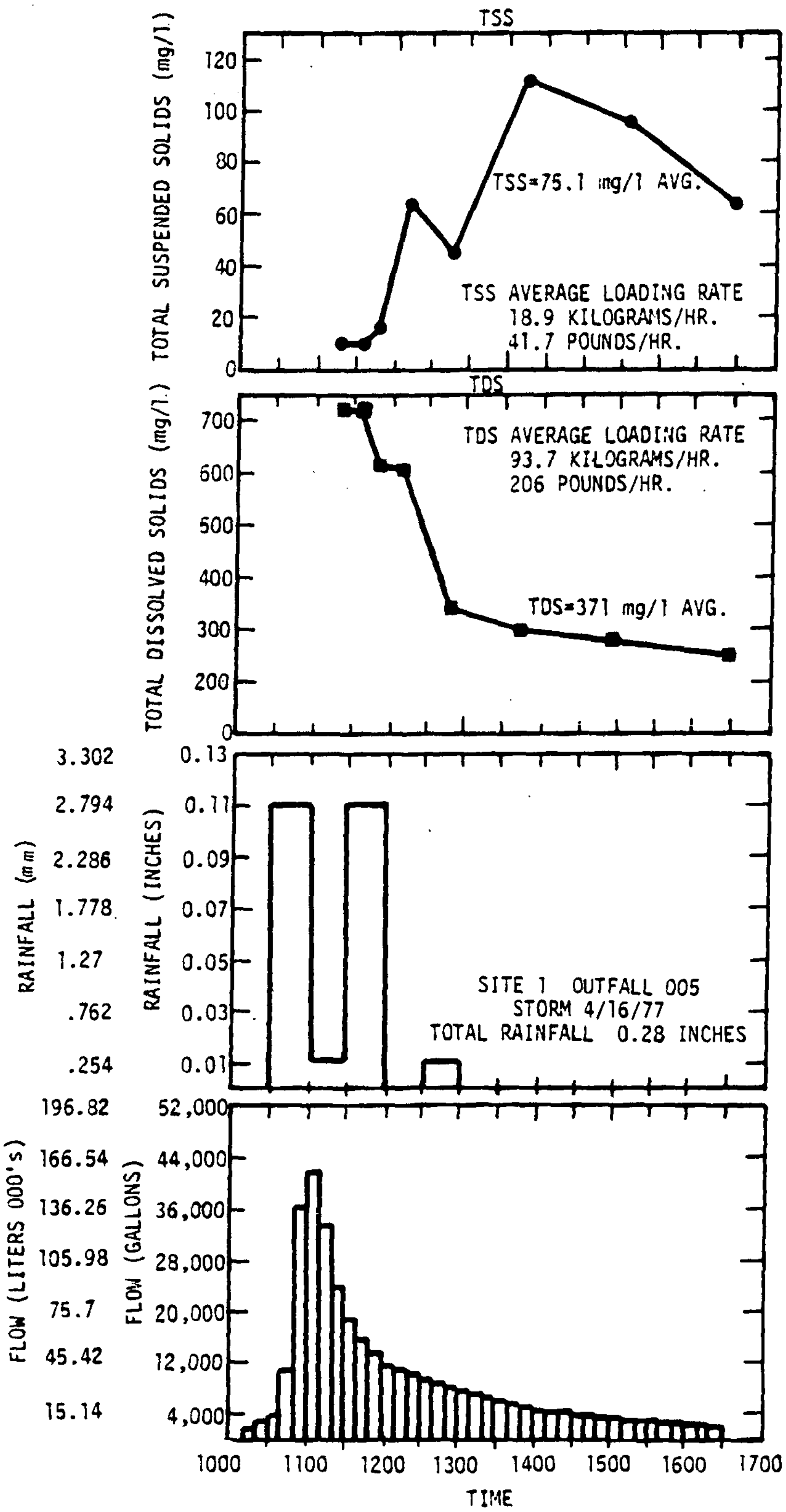


FIGURE 5-4: OUTFALL 005 - SITE 1 TSS & TDS CONCENTRATIONS VERSUS TIME COMPARED TO BASIN FLOW AND RAINFALL INTENSITY

From the limited data taken at outfalls 010 and 011, the concentrations of phenols exhibited a consistent pattern. It appears that increases and decreases in phenols loading in these drainage basins correspond directly to increases and decreases in rainfall intensity with very little time lag.

In three cases out of five, ammonia showed a general trend of decreasing concentration over the period of the storm. It appears that the stormwater acted to dilute the ammonia over the course of the storm rather than cause a "first flush" effect. In no case was a "first flush" effect observed.

Detailed sample results for all outfalls for Site 1 are presented in Appendix B.

Dustfall samples from drainage basin 010 were collected and analyzed for dry weight. Calculations performed on the results determined the average daily accumulation of dust in this basin where coal transfer was the major activity. The values ranged from 35.6 milligrams per day per square meter in a position directly under a coal conveyor to 1.1 milligrams per day per square meter in an area on the perimeter of the coal transfer area.

The next analytical step was to extrapolate the average dustfall accumulation over the entire basin and then to compare this total accumulation to the mass loading of solids during a rainfall event. The average total accumulation of dust in basin 010 was calculated at 0.19 kilograms per day. Comparing the hourly dustfall accumulation to the hourly mass loading of solids during a rainfall event, the dustfall percentage falls between 0.2% and 0.5%. Even comparing the total dustfall accumulations over the three dry days prior to the 3/27-28 storm, the dustfall percentage is still only 2.49% of the total solids loading.

A summary of the dustfall data is included in Appendix B. Sufficient dustfall samples were not collected at Site 1 so that a true quantitative analysis could be run over a series of storm events. From the limited data gathered, however, it is apparent that the amount of dustfall surrounding a raw materials handling area will have a minimal effect on the total solids pollutant loading from stormwater runoff.

5.4.2 Site 2 Results

Only two storm events occurred during the field program (May-June, 1977) which were of sufficient magnitude to produce surface runoff. Data from these events are summarized in Table 5-13.

The first storm event started as a steady downpour which then tapered off to a drizzle with occasional heavy showers. Surface runoff was evident at all of the sampling locations. The rainfall intensity curve for this storm event is shown in Figure 5-5.

The second storm event was short in comparison to the first, but again resulted in a considerable amount of surface runoff at all of the sampling sites. This storm was also a heavy downpour. Due to manpower constraints and equipment failure, very little data except total rainfall and storm duration was gathered.

There were also several other small storm events which resulted in 1.3cm of rain or less. Because most of the plant area is semi-permeable and level, surface runoff was not detected during any of these storms.

Table 5-14 shows the average flows and ranges of flow for several of the outfalls during dry and wet weather. Complete information exists only for outfalls 004, 006, and 007.

TABLE 5-13

STORM EVENT DATA
SITE 2
MAY - JUNE, 1977

Date	Storm Beginning	Storm Ending	Total Rainfall		Average Rainfall Intensity		Maximum Rainfall Intensity During Storm	
			cm	(inches)	cm/hr	(in/hr)	cm/hr	(in/hr)
6/9-6/10/77	0500 (6/9)	1500 (6/10)	4.45	(1.75)	0.13	(0.05)	1.42	(0.56)
6/20/77	0900	2030	2.59	(1.02)	0.23	(0.09)	-[a]	-[a]

[a] No rainfall intensity data were collected on June 20 due to equipment failure and manpower constraints.

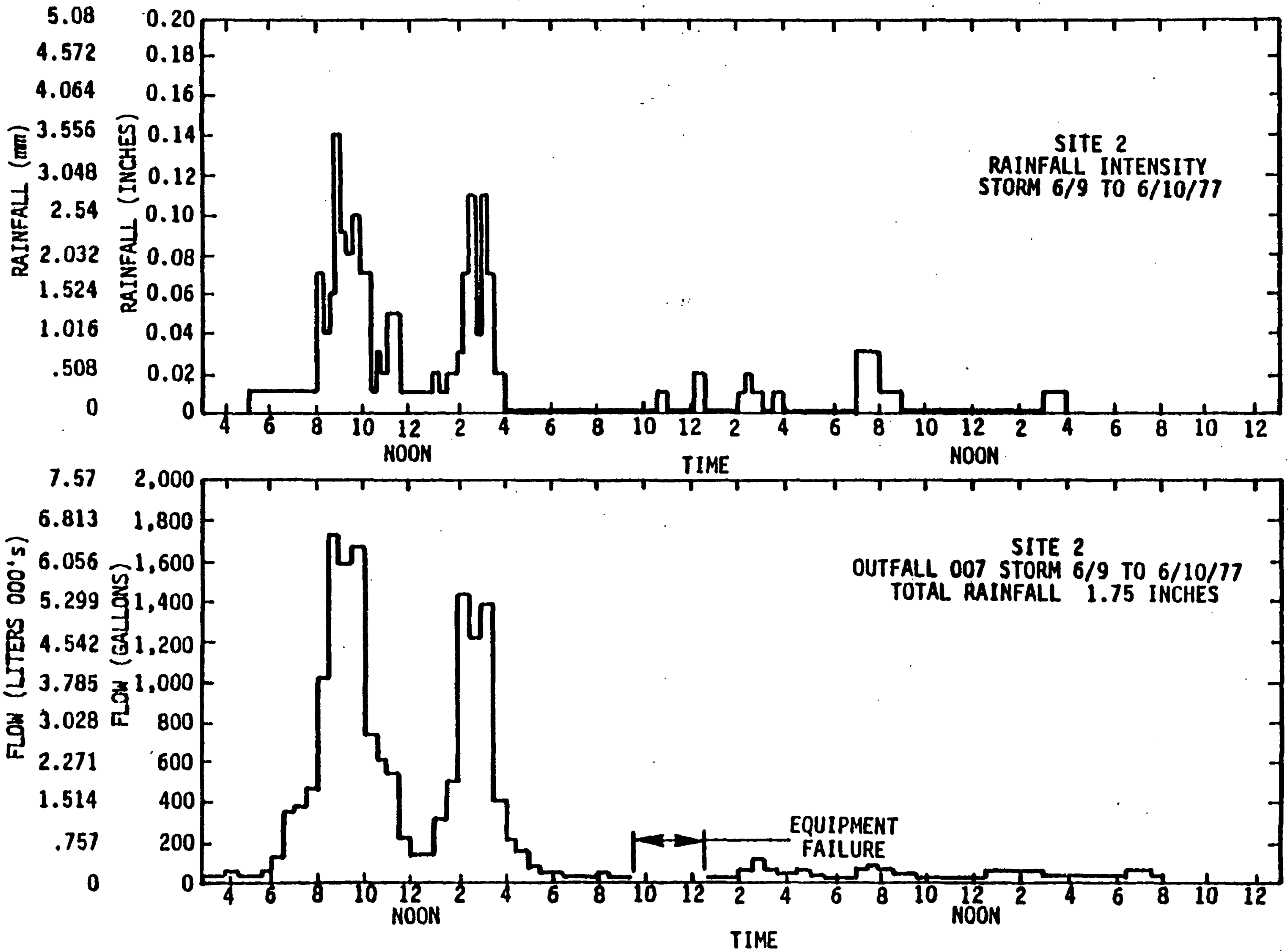


Figure 5-5: Rainfall and Flow in Basin 007 Versus Time,
Site 2, 6/9 to 6/10/77 Storm

TABLE 5-14

DRY VS. WET FLOWS[a]
SITE 2
MAY - JUNE, 1977

Outfall	Date	Sampling Condition	Average Flow lpm (gpm)	Range, lpm (gpm)
002[b]	5/10	Dry	-	-
	5/18	Dry	53 (14)	23-91 (6-24)
	6/9-10	Wet	-	-
	6/20	Wet	-	-
004[c]	5/10	Dry	163 (43)	132-310 (35-82)
	5/18	Dry	413 (109)	223-727 (59-192)
	6/9-10	Wet	549 (145)	163-988 (43-261)
	6/20	Wet	382 (101)	189-795 (50-210)
006[c]	5/10	Dry	1120 (296)	655-3410 (173-900)
	5/18	Dry	2150 (568)	1540-3293 (407-870)
	6/9-10	Wet	2498 (660)	730-4290 (193-1133)
	6/20	Wet	3066 (810)	1692-9463 (447-2500)
007[c]	5/10	Dry	4.5 (1.2)	4.0-4.9 (1.0-1.3)
	5/18	Dry	2.9 (0.8)	2.5-4.0 (0.7-1.0)
	6/9-10	Wet	45 (12)	1.1-216 (0.3-57)
	6/20	Wet	291 (77)	45-5776 (12-1526)
009[b]	5/10	Dry	-	-
	5/18	Dry	5344 (1412)	5223-5465 (1380-1444)
	6/9-10	Wet	-	-
	6/20	Wet	-	-
010A[b]	5/10	Dry	-	-
	5/18	Dry	1.08×10^5 (28570)	1.03×10^5-1.12×10^5 (27280-29580)
	6/9-10	Wet	-	-
	6/20	Wet	-	-
010B[b]	5/10	Dry	-	-
	5/18	Dry	5.14×10^4 (13590)	3.3×10^4-6.6×10^4 (8640-17480)
	6/9-10	Wet	-	-
	6/20	Wet	-	-

(a) Flow data were not collected at outfalls 003, 005, 008, 011, 012, 013, 014, and 015.

(b) Straight averages.

(c) Time-weighted averages.

In general, average wet weather flows were higher than dry weather flows. One notable exception is that the average dry weather flow on May 18 at outfall 004 was greater than the flow during the storm of June 20. This is probably due to an increase in process water flow on May 18, although the flow ranges for both days indicate that a higher peak flow occured on June 20.

The difference in average flow between dry and wet weather was not as evident at outfalls 004 and 006 as it was at outfall 007. While outfalls 004 and 006 showed average wet weather flows which ranged from one to three times the average dry weather flows, outfall 007 displayed average wet weather flows which ranged from ten to one hundred times the dry flow. This was visually evident during a storm event. The flow at outfall 007 increased from a steady trickle over the weir to a height above the weir, necessitating the conversion from a 90° V-notch weir to a rectangular weir.

The flow data for storm events at outfalls 004, 006, and 007 show some interesting trends. The flow peaks at outfalls 006 and 007 corresponded very closely to rainfall intensity peaks with almost no time lag. Figure 5-5 also shows the hydrograph of June 9-10 for outfall 007. At outfall 004 the time lag between rainfall intensity peaks and flow peaks ranged from 0.5 to 3.5 hours. The difference was probably due to the type of drainage basin associated with each outfall. Outfalls 006 and 007 receive stormwater either directly from roof drains or from paved areas. The basin which drains to outfall 004 is a mostly unpaved (permeable) area, causing the time lag between rainfall peaks and runoff peaks.

Tables 5-15, 5-16, and 5-17 through 5-23 show the range of concentrations, the mean concentrations, and the average mass loadings of the pollutants analyzed

TABLE 5-15

RANGE OF POLLUTANT CONCENTRATIONS AT THE SAMPLING LOCATIONS AT SITE 2 IN mg/l MAY - JUNE, 1977

POLLUTANT	Outfall 002 Dry	002 Wet	003 Dry	003 Wet	004 Dry	004 Wet	006 Dry	006 Wet	007 Dry	007 Wet	008 Dry	008 Wet	009 Dry	009 Wet
Total Suspended Solids	11-29	9-176		11-132	2-47	3-39	20-416	8-2537	1-60	3-119	22-56	19-89	4-58	55-109
Total Dissolved Solids	91-2019	112-284		93-148	113-205	160-359	102-159	145-490	54-245	107-418	112-172	224-265	116-138	151-251
Total Iron					0.20-1.2	0.18-2.2					1.0-2.2	2.8-7.5	0.78-1.4	3.0-5.2
Dissolved Iron[d]					n.d.-0.2	0.1-0.6					0.1-0.3	0.1-0.7	0.1-0.3	0.2-0.4

POLLUTANT	Outfall 010A Dry	010A Wet	010B Dry	010B Wet	011[a] Dry	011[a] Wet	012[a] Dry	012[a] Wet	013[a] Dry	013[a] Wet	014[a] Dry	014[a] Wet
Total Suspended Solids	5-37	3-48	13-28	12-702		56-2684		29-563		12-1380		24-121
Total Dissolved Solids	76-125	131-253	89-133	137-239		299-681		222-546		355-1690		232-524
Total Iron	0.57-1.3	0.93-5.9	1.5[b]	0.74-225		11-25		1.5-26		0.82-28		0.95-14
Dissolved Iron[d]	0.1	0.1-0.4	0.2[b]	n.d.-1.1		0.2		0.1-0.6		0.9-1.1		0.2-1.2
Phenol[e]	n.d.-0.01	n.d.-0.02	n.d.-0.01	n.d.-0.06		n.d.-0.02		0.01-0.19		0.01-0.04		
Cyanide(Total)[f]	0.01	0.01	n.d.-0.01	n.d.-0.02		(c) -		0.09-0.3		0.38-0.72		
Ammonia	3.8-8.6	0.1-0.7	7.1[b]	0.07-4.1		0.23-0.43		0.41-1.6		18-39		
Sulfate						195-270		52-128		36-190		

(a) No dry weather samples collected.

(b) Only one sample analyzed.

(c) Cyanide was not analyzed at this outfall.

(d) n.d.-not detectable. Detectable limit for dissolved iron is 0.02 mg/l.

(e) n.d.-not detectable. Detectable limit for phenol is 0.001 mg/l.

(f) n.d.-not detectable. Detectable limit for total cyanide is 0.001 mg/l.

TABLE 5-16

MEAN POLLUTANT CONCENTRATIONS IN mg/l AT SITE 2
MAY - JUNE, 1977

		Pollutant							
Outfall	Sampling Condition	TSS	TDS	Total Iron	Dissolved Iron	Phenol	Total Cyanide	Ammonia	Sulfate
002	Dry	20	749						
	Wet	47	178						
003[a]	Dry								
	Wet	21	110						
004	Dry	13	157	0.61	0.08				
	Wet	11	216	0.51	0.14				
006	Dry	96	130						
	Wet	298	223						
007	Dry	15	118						
	Wet	35	227						
008	Dry	44	149	1.6	0.21				
	Wet	45	241	5.2	0.2[illegible]				
009	Dry	32	124	1.1	0.2				
	Wet	73	201	4.0	0.2				
010A	Dry	18	104	0.85	0.1	0.01	0.01	18.45	
	Wet	23	183	1.75	0.2	0.004	0.01	0.26	
010B	Dry	19	102	-(b)	-(b)	0.005	0.005	-(b)	
	Wet	60	183	18	0.2	0.01	0.011	0.6	
011[a]	Dry								
	Wet	853	471	18	0.18	0.01		0.33	232
012[a]	Dry								
	Wet	257	360	11.4	0.2	0.04	0.2	1.0	78
013[a]	Dry								
	Wet	392	959	12.6	1.0	0.03	0.55	29.3	129
014[a]	Dry								
	Wet	64	416	5.8	0.5				

(a) No dry weather samples collected.

(b) Only one sample analyzed.

TABLE 5-17

AVERAGE MASS LOADINGS OF POLLUTANTS[(a),(b),(c),(f)]
DRY VS. WET WEATHER
MAY-JUNE, 1977
OUTFALL 002-SITE 2

Date	5/18 (Dry)			6/9-10 (Wet)			6/20 (Wet)[(d)]		
Parameter	Avg.[(e)] Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg.[(e)] Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg.[(e)] Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)
Total Suspended Solids	20	53 (14)	0.07 (0.14)	65	53 (14)	0.21 (0.45)	37	53 (14)	0.12 (0.26)
Total Dissolved Solids	114	53 (14)	0.36 (0.8)	212	53 (14)	0.67 (1.48)	133	53 (14)	0.42 (0.93)

(a) Average mass loadings for wet weather calculated by multiplying the time weighted average concentration by the time weighted average flow, which were determined from the flow and concentration curves for each event.

(b) Average wet weather flows are time weighted average flows for the sampling period for each parameter. These may vary for the different parameters within each storm.

(c) Average mass loadings for dry weather calculated by multiplying the straight average concentrations from the Appendices by the average flows from Table 5-14.

(d) Wet weather average mass loadings were estimated using dry weather flows because wet weather flow data were not obtained.

(e) Straight average used.

(f) No dry flow data collected on 5/10/77.

TABLE 5-18

AVERAGE MASS LOADINGS OF POLLUTANTS[(a),(b),(c)]
DRY VS. WET WEATHER
MAY-JUNE, 1977
OUTFALL 004 - SITE 2

Date	5/10 (Dry)			5/18 (Dry)			6/9-10 (Wet)			6/20 (Wet)		
Parameter	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)
Total Suspended Solids	9	163 (43)	0.09 (0.2)	15	413 (109)	0.37 (0.81)	10	662 (175)	0.4 (0.88)	9	401 (106)	0.22 (0.48)
Total Dissolved Solids	155	163 (43)	1.5 (3.3)	160	413 (109)	4.0 (8.8)	250	662 (175)	9.9 (21.8)	203	401 (106)	4.9 (10.8)
Total Iron	0.2[(d)]	163 (43)	0.002 (0.004)	0.68	413 (109)	0.02 (0.04)	0.49	662 (175)	0.02 (0.04)	0.36	401 (106)	0.01 (0.02)
Dissolved Iron	n.d.[(e)]	163 (43)	-	0.06	413 (109)	0.001 (0.002)	0.11 (0.002)	693 (183)	0.005 (0.011)	0.04	424 (112)	0.001 (0.002)

(a) Average mass loadings for wet weather calculated by multiplying the time weighted average concentration by the time weighted average flow, which were determined from the flow and concentration curves for each event.

(b) Average wet weather flows are time weighted average flows for the sampling period for each parameter. These may vary for the different parameters within each storm.

(c) Average mass loadings for dry weather calculated by multiplying the straight average concentrations from the Appendices by the average flows from Table 5-14.

(d) One value only.

(e) n.d.-not detectable. Detectable limit is 0.02 mg/l.

TABLE 5-19

AVERAGE MASS LOADINGS OF POLLUTANTS[a],[b],[c]
DRY VS. WET WEATHER
MAY-JUNE, 1977
OUTFALL 006 - SITE 2

Date	5/10 (Dry)			5/18 (Dry)			6/9-10 (Wet)			6/20 (Wet)		
Parameter	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)
Total Suspended Solids	41	1120 (296)	2.8 (6.2)	130	2150 (568)	16.8 (37)	495	1851 (489)	55 (121)	32	2824 (746)	5.4 (11.9)
Total Dissolved Solids	112	1120 (296)	7.5 (16.5)	148	2150 (568)	19.1 (42)	244	1851 (489)	27.1 (59.6)	186	2824 (746)	31.6 (69.3)

[a] Average mass loadings for wet weather calculated by multiplying the time weighted average concentration by the time weighted average flow, which were determined from the flow and concentration curves for each event.

[b] Average wet weather flows are time weighted average flows for the sampling period for each parameter. These may vary for the different parameters within each storm.

[c] Average mass loadings for dry weather calculated by multiplying the straight average concentrations from the Appendices by the average flows from Table 5-14.

TABLE 5-20

AVERAGE MASS LOADINGS OF POLLUTANTS[(a),(b),(c)]
DRY VS. WET WEATHER
MAY-JUNE, 1977
OUTFALL 007 - SITE 2

Date	5/10 (Dry)			5/18 (Dry)			6/9-10 (Wet)			6/20 (Wet)		
Parameter	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)
Total Suspended Solids	15	4.5 (1.2)	0.004 (0.009)	24	2.9 (0.8)	0.004 (0.009)	36	33.3 (8.8)	0.07 (0.15)	22	165.4 (43.7)	0.22 (0.48)
Total Dissolved Solids	149	4.5 (1.2)	0.04 (0.09)	84	2.9 (0.8)	0.01 (0.02)	222	33.3 (8.8)	0.44 (0.97)	244	165.4 (43.7)	2.42 (5.32)

(a) Average mass loadings for wet weather calculated by multiplying the time weighted average concentration by the time weighted average flow, which were determined from the flow and concentration curves for each event.

(b) Average wet weather flows are time weighted average flows for the sampling period for each parameter. These may vary for the different parameters within each storm.

(c) Average mass loadings for dry weather calculated by multiplying the straight average concentrations from the Appendices by the average flows from Table 5-14.

TABLE 5-21

AVERAGE MASS LOADINGS OF POLLUTANTS[a],[b],[c],[d]
DRY VS. WET WEATHER
MAY-JUNE, 1977
OUTFALL 009 - SITE 2

Date	5/18 (Dry)			6/9-10 (Wet)		
Parameter	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)
Total Suspended Solids	32	5344 (1412)	10.3 (22.7)	73	5344 (1412)	23.4 (51.5)
Total Dissolved Solids	124	5344 (1412)	39.8 (87.6)	201	5344 (1412)	64.4 (141.7)
Total Iron	1.1	5344 (1412)	0.35 (0.77)	4.0	5344 (1412)	1.28 (2.82)
Dissolved Iron	0.2	5344 (1412)	0.06 (0.13)	0.25	5344 (1412)	0.08 (0.18)

(a) Average mass loadings calculated by multiplying the straight average concentrations from the Appendices by the straight average flow.

(b) Wet weather average mass loadings were estimated using dry weather flow data because wet weather flow data were not obtained.

(c) No dry flow data collected on 5/10/77.

(d) No sample collected on 6/20/77.

TABLE 5-22

AVERAGE MASS LOADINGS OF POLLUTANTS[(a),(b),(c),(d)]
DRY VS. WET WEATHER
MAY-JUNE, 1977
OUTFALL 010A - SITE 2

Date	5/18 (Dry)			6/9-10 (Wet)		
Parameter	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/l	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)
Total Suspended Solids	23	1.08×10^5 (28570)	149 (328)	19	1.08×10^5 (28570)	123 (271)
Total Dissolved Solids	104	1.08×10^5 (28570)	674 (1483)	183	1.08×10^5 (28570)	1186 (2609)
Total Iron	1.06	1.08×10^5 (28570)	6.87 (15.11)	1.73	1.08×10^5 (28570)	11.21 (24.66)
Dissolved Iron	0.1	1.08×10^5 (28570)	0.65 (1.43)	0.2	1.08×10^5 (28570)	1.3 (2.86)
Phenol	0.005	1.08×10^5 (28570)	0.03 (0.07)	0.01	1.08×10^5 (28570)	0.06 (0.13)
Total Cyanide	0.01	1.08×10^5 (28570)	0.06 (0.13)	0.01	1.08×10^5 (28570)	0.06 (0.13)
Ammonia	4.9	1.08×10^5 (28570)	31.7 (69.7)	0.27	1.08×10^5 (28570)	1.75 (3.85)

[(a)] Average mass loadings calculated by multiplying the straight average concentrations from the Appendices by the straight average flow.

[(b)] Wet weather average mass loadings were estimated using dry weather flow data because wet weather flow data were not obtained.

[(c)] No dry flow data collected on 5/10/77.

[(d)] No sample collected on 6/20/77.

TABLE 5-23

AVERAGE MASS LOADINGS OF POLLUTANTS[a],[b],[c]
DRY VS. WET WEATHER
MAY-JUNE, 1977
OUTFALL 010B - SITE 2

Date	5/18 (Dry)			6/9-10 (Wet)			6/20 (Wet)		
Parameter	Avg. Conc., mg/1	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/1	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)	Avg. Conc., mg/1	Avg. Flow, lpm (gpm)	Avg. Mass Loading, kg/hr (lb/hr)
Total Suspended Solids	22	5.14×10^4 (13590)	67.8 (149.2)	71	5.14×10^4 (13590)	219 (482)	44	5.14×10^4 (13590)	136 (299)
Total Dissolved Solids	102	5.14×10^4 (13590)	314.6 (692.1)	185	5.14×10^4 (13590)	570.5 (1255.1)	181	5.14×10^4 (13590)	558.2 (1228)
Total Iron	1.5[d]	5.14×10^4 (13590)	4.63 (10.2)	20.3	5.14×10^4 (13590)	62.6 (137.7)	3.75	5.14×10^4 (13590)	11.57 (25.45)
Dissolved Iron	0.2[d]	5.14×10^4 (13590)	0.62 (1.36)	0.21	5.14×10^4 (13590)	0.65 (1.43)	0.1[d]	5.14×10^4 (13590)	0.31 (0.68)
Phenol	0.005	5.14×10^4 (13590)	0.02 (0.04)	0.014	5.14×10^4 (13590)	0.04 (0.09)	0.005	5.14×10^4 (13590)	0.02 (0.04)
Total Cyanide	0.005	5.14×10^4 (13590)	0.02 (0.04)	0.011	5.14×10^4 (13590)	0.03 (0.07)	0.01	5.14×10^4 (13590)	0.03 (0.07)
Ammonia	7.1[d]	5.14×10^4 (13590)	21.9 (48.2)	0.32	5.14×10^4 (13590)	0.99 (2.18)	0.98	5.14×10^4 (13590)	3.02 (6.64)

(a) Average mass loadings calculated by multiplying the straight average concentrations from the Appendices by the straight average flow.

(b) Wet weather average mass loadings were estimated using dry weather flow data because wet weather flow data were not obtained.

(c) No dry flow data collected on 5/10/77.

(d) One value only.

at each of the outfalls for both dry and wet weather. Mass loadings were calculated in the same manner as at Site 1. Wet weather mass loadings at outfalls 002, 009, 010A, and 010B were calculated using the mean dry weather flow at each of these outfalls to obtain a best estimate of storm loadings.

Table 5-24 shows the mean pollutant concentrations for both dry and wet weather conditions at location 015 (river water intake). These values were to serve as background data because all the water used by the plant comes from the river. The dry and wet weather data were not significantly different. Thus, any increase in pollutant concentrations at any of the sampling locations during wet weather could be due to stormwater runoff and not to the river water quality.

Table 5-15 through 5-23 show differences between dry and wet weather conditions. With few exceptions, the wet weather concentrations and mass loadings of pollutants were higher than those for dry weather. Dry and wet mean values for dissolved iron at outfalls 008 and 009 were identical as were the dry and wet values for total cyanide at outfall 010A. Total suspended solids and total iron were very similar at outfall 004 during both weather conditions. Dry weather values for total dissolved solids and ammonia for outfalls 002 and 010A respectively were considerably higher than during wet weather.

Total dissolved solids concentrations were much higher than total suspended solids concentrations at all of the outfalls during both dry and wet weather conditions with two exceptions, those being the wet weather concentrations at outfalls 006 and 011. A consistent pattern was established for total suspended solids. A direct relationship exists between TSS concentration and rainfall intensity. An increase in rainfall intensity corresponded directly to an increase in TSS concentration with no time lag. This is shown in Figures 5-6, 5-7, and

TABLE 5-24

MEAN POLLUTANT CONCENTRATIONS, mg/l
IN THE TIDAL RIVER AT SITE 2
MAY-JUNE, 1977
(SAMPLING LOCATION 015)

Pollutant	Mean Pollutant Concentrations, mg/l	
	Dry	Wet
TSS	19	35
TDS	120	182
Total Iron	0.43	0.83
Dissolved Iron	0.1	0.3
Phenols	0.005	0.010
Total Cyanide	0.004	-
Ammonia	-	0.34
Sulfates	20	-

5-8. These Figures show the rainfall intensity plot as previously indicated in Figure 5-5. Although Figure 5-7 shows a direct relationship between TDS and rainfall intensity, again as at Site 1, TDS concentrations were generally found to be erratic in relation to rainfall intensity and no consistent pattern was observed. No conclusive statements can be made concerning this relationship. This is most evident in Figures 5-6 and 5-8.

Several interesting trends occurred with total and dissolved iron. Six out of nine outfalls showed that an increase in rainfall intensity also corresponded directly to an increase in total iron concentration with no time lag. Figures 5-7 and 5-8 show this relationship. However, this was not true of dissolved iron, since five out of nine outfalls showed dissolved iron to vary inversely with total iron. As total iron concentration decreased, dissolved iron concentration would increase and vice versa.

Although there were only limited data for phenols, a pattern was observed similar to that at Site 1. Phenol concentration peaks were found to correspond with rainfall intensity peaks. This is most evident in Figure 5-7.

There appears to be no relationship of any kind between cyanide or sulfate concentration and rainfall intensity, although limited data prevent drawing any definite conclusions. No consistent pattern exists.

As at Site 1, three outfalls out of five showed that ammonia concentrations decreased over the period of the storm. Ammonia concentration appeared to peak around the time of the first rainfall intensity peak and then slowly decrease throughout the remainder of the storm event. Apparently, the stormwater dilutes the ammonia rather than causing a "first flush" effect. Figures 5-7 and 5-8 clearly depict this dilution effect. In no case was the "first flush" effect observed.

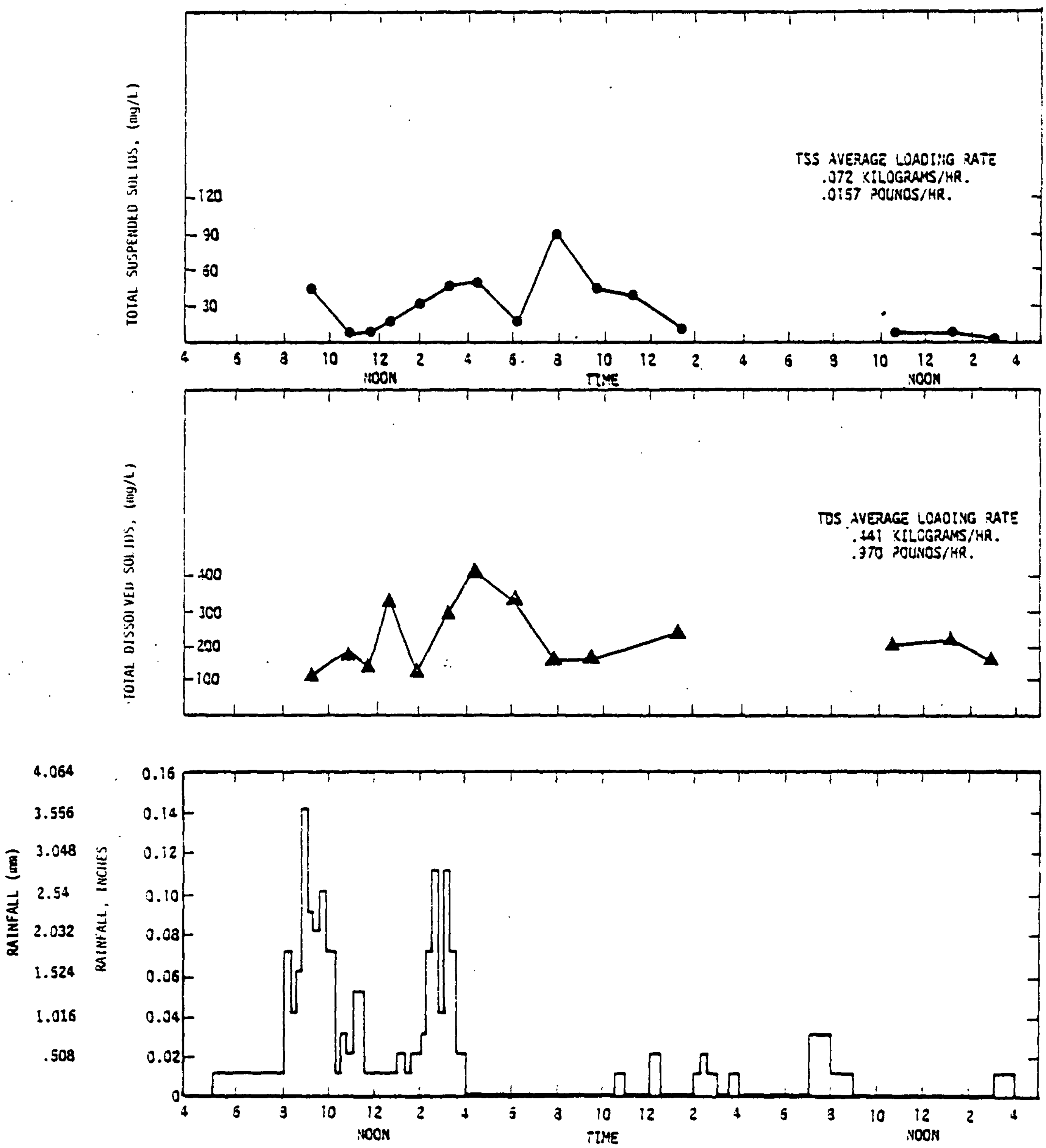


Figure 5-6: Outfall 007 - Site 2 TSS and TDS Concentrations Versus Time Compared to Rainfall Intensity

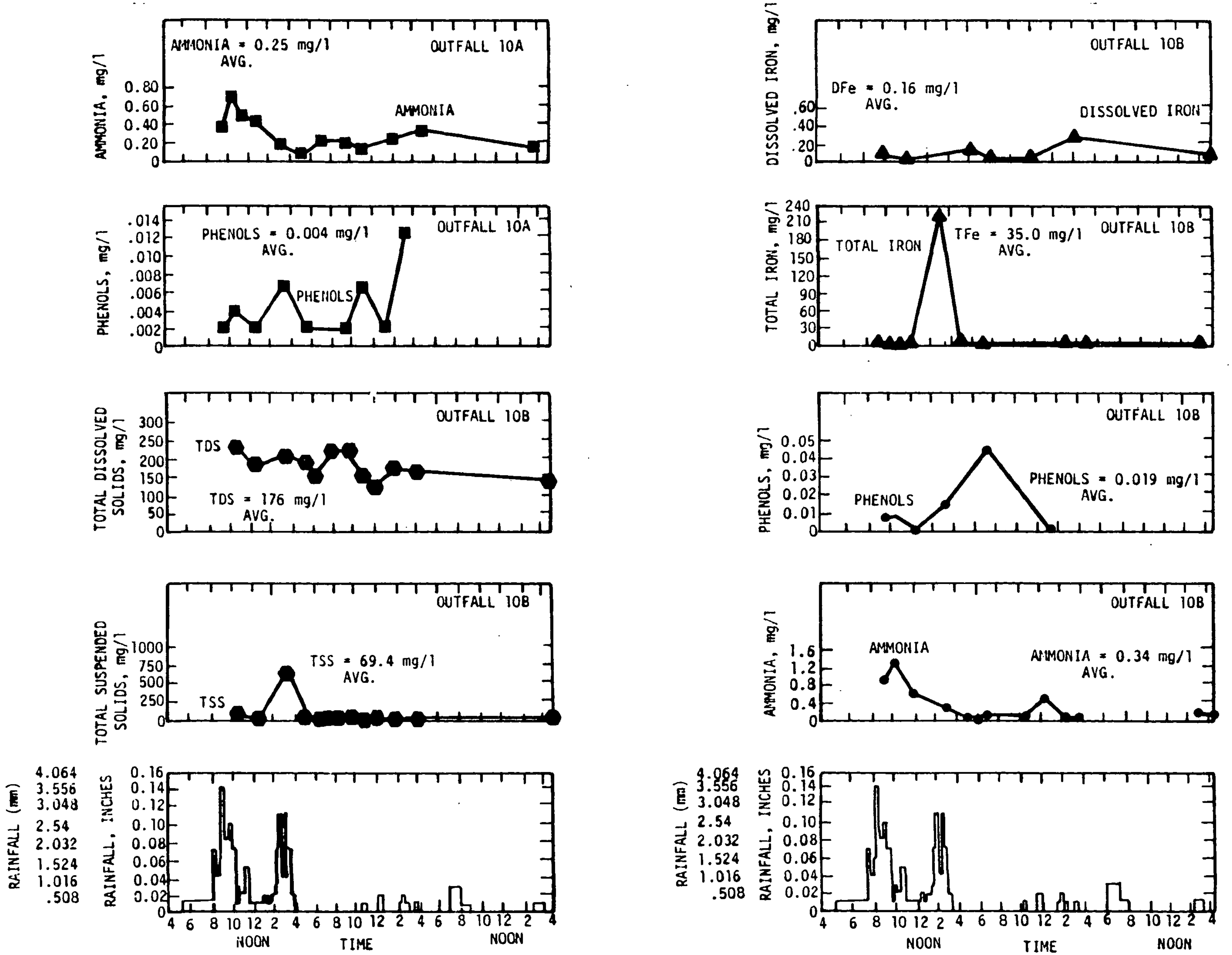


FIGURE 5-7: OUTFALLS 010A AND 010B - SITE 2, POLLUTANT CONCENTRATIONS VERSUS TIME COMPARED WITH RAINFALL INTENSITY

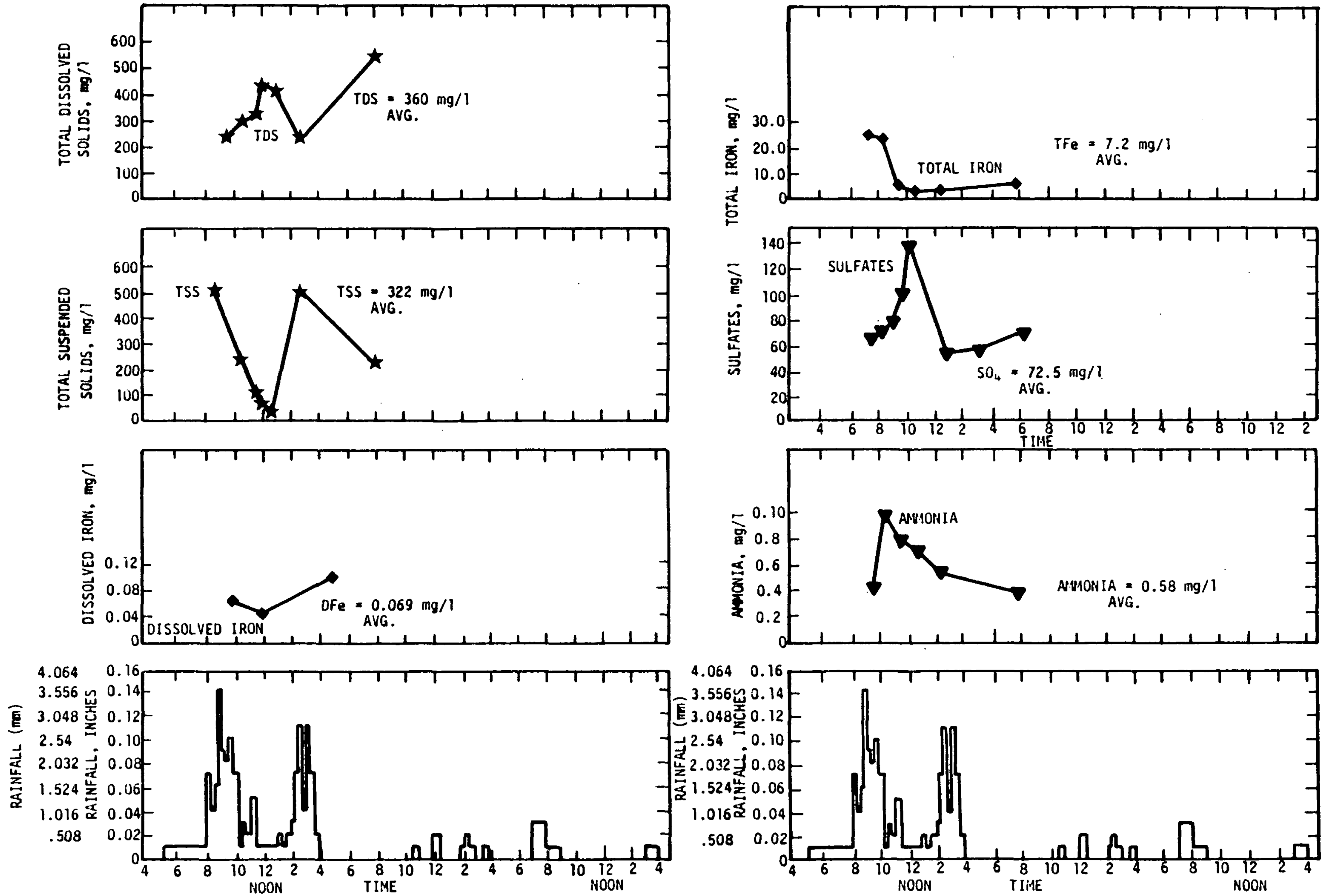


FIGURE 5-8: OUTFALL 012 - SITE 2, POLLUTANT CONCENTRATIONS VERSUS TIME COMPARED WITH RAINFALL INTENSITY

Detailed sample results of all outfalls for Site 2 are presented in Appendix B.

Dustfall samples were collected in two areas at Site 2, the Sinter Plant area and the coal and coke storage area. These samples were analyzed for dry weight only. Calculations were performed on the results to determine the average daily accumulations of dust in these two drainage basins. The data are presented in Appendix B. The daily accumulations of dust were greater in the Sinter Plant area than in the raw materials storage pile area. This was due to the low activity in these storage areas during the sampling program. The average accumulations were 2.6 milligrams per day per square meter compared to 3.6 milligrams per day per square meter for the Sinter Plant area.

The next analytical step was to extrapolate these average accumulations over the entire runoff basin and then to compare the total accumulation to the mass loading of solids during a rainfall event. At the Sinter Plant area, the average total accumulation was 0.17 kilograms per day. Comparing this to the average dry and wet weather loadings of total solids sampled at outfall 009, the dustfall accumulations are not significant. The total dry mass loadings were approximately 50 kilograms per hour. The dustfall data from the Sinter Plant have little significance when compared to the mass loading because the sampling point for runoff in this area was a storm drain in which most of the flow was process water and not runoff water. The dustfall data do indicate the quantity of dustfall to be expected in such an area and allow for comparision with other dustfall sites.

No comparisons to mass solids loading in the raw material area were performed because of the lack of significant runoff data in that area.

5.4.3 Comparison of Results from Sites 1 and 2

In general, a comparison of the data from the two sites while indicating similar pollutant trends, shows considerable differences attributable to the characteristics of the site. The data from both sites indicate that stormwater runoff from coal and coke storage and handling areas may be a potential problem if no control exists, when compared to Best Available Technology Economically Available (BATEA) Effluent Guidelines prepared for Iron and Steel Manufacturing[3] and with water quality criteria.[12][13] (See Section 2.0). However, there was a great difference between the two sites. Site 1 which had much higher loadings from the coal pile area, does not present a problem because the piles are diked and runoff is collected in a pond and recirculated as a fugitive air emission control system. The samples collected inside the diked area are probably unique and may not be representative of the iron and steel industry. At Site 2 the TSS values for the coal storage areas are well within the range of 26-2080 mg/l TSS for typical urban runoff. (See Section 7.0).[14][15][16] On the other hand, the range of TDS concentrations encountered in these areas at Site 2 exceeded the average concentration of 250 mg/l TDS for typical urban stormwater runoff.[14][15][16]

Average wet weather concentrations and mass loadings of pollutants were higher than dry weather average values at both sites. Similar trends were observed for pollutant concentrations. TDS concentrations were with few exceptions higher than TSS at all of the sampling locations during dry and wet weather conditions. In addition, TDS concentrations were found to be erratic in relation to rainfall intensity and no consistent pattern was observed. Such was not the case with TSS concentration. A direct relationship existed between TSS concentration and rainfall intensity at Site 2. An increase in rainfall intensity corresponded directly to an increase in TSS concentration and vice versa with little time lag. A similar pattern existed for total iron and phenols. Dissolved iron was found to vary inversely with total iron. As total iron concentration decreased, dissolved iron concentration would increase and vice versa. A "dilution" effect was observed with ammonia. Ammonia concentration generally peaked at a time corresponding to the first rainfall intensity peak and then decreased slowly throughout the remainder of the storm event. In no case was the "first flush" effect observed with any of the pollutants at either site.

5.5 Problem Areas

There were certain physical problems that were common to both sites in quantifying and qualifying the runoff. These problems can be extrapolated to pertain to the iron and steel industry as a whole when evaluating stormwater runoff.

The biggest problem encountered during the runoff program was the availability of manpower to ensure that flow data and samples were collected at every sampling point on a regular basis throughout the runoff period. Because a runoff field program is controlled by meteorological events, it is too costly to maintain an entire field crew on site at all times. Due to the unpredictability of the rainfall duration and the quantities of runoff, the on-site technicians may be faced with the enormous task of collecting samples, taking rain wedge readings, measuring flow where automated equipment is not used, and preserving samples during a lengthy storm while awaiting the arrival of backup personnel. This probem was not as apparent at Site 1 as it was at Site 2. The following factors decreased the efficiency of the on-site technicians at Site 2:

1. The physical size of the plant - Sampling points were spread out. With the 32 KPH speed limit it took, at the minimum, 1-1 1/2 hours to complete a circuit of all the sampling sites.

2. The number of sampling points - Twice as many points were sampled at Site 2 as at Site 1. Not all of these points could be treated the same way. Some samplers had to be turned on and flow adjusted only after a certain amount of runoff was encountered. Other points involved the lifting of manhole covers to gain access to the storm sewer lines.

3. Long term runoff period - When runoff lasted more than 12 hours, the ability of the technicians to keep up with the samples being collected, replace bottles, batteries, and recorder tape, and preserve the samples was hampered.

There are many ways of alleviating this manpower problem, but the most efficient would be to limit the number of sampling sites. Continuous flow monitoring and sampling should be kept to a minimum number of sites located only in areas where stormwater runoff is a potential problem. Sampling equipment should be automated at all locations.

Steel mills built on flat terrain present another physical problem, i.e., drainage basin definition. In such mills, the surface morphology is so complex that runoff from certain drainage areas can cross-contaminate adjacent basins. Diked areas, bermed areas, railroad crossings, and open ditches and construction areas all contribute to cross-contamination when the surface topography across the entire mill only varies a few feet. A pre-field study observation of a heavy rainfall can help in defining the runoff basins.

Obtaining good dry weather flow data at all sampling locations was another problem area. Where continuous flows existed, usually non-contact cooling water was being used and discharged at a sampling point. In other cases, such as at Outfall 006-Site 1, and Outfalls 012 and 013-Site 2, the dry weather flows were intermittent. There is no way of separating process water from runoff water during a sampling period. The only means of alleviating this problem is to have control of the process or non-contact cooling water or to maintain continuous records of the process or non-contact cooling water entering the storm sewer systems.

Pollutant data would be enhanced if dry weather samples were collected just prior to a rainfall event. In most cases when runoff flow levels have risen enough to trigger a sample, the pollutant to be measured has already been affected by the storm. An initial pre-event sample would better define the earlier reactions of the pollutants. In order to collect these pre-event samples, the field work plan should include grab samples at the first sign of precipitation, or sampling at least once a day when rainfall is imminent.

One problem common to both sites but not necessarily relevant to the whole industry was the tidal backflow at some of the outfalls. Two outfalls at Site 1 and one at Site 2 were subjected to periodic backflows due to abnormally high tides. These backflows produced erroneous flow data and also caused contamination of the waters upstream of the outfall weirs. At those times when tidal backflows were observed, sampling equipment was turned off and the samples discarded. Sampling locations near intertidal zones should be avoided.

One of the equipment problems encountered at both sites was with the weighing bucket rain gage. No matter where this rain gage was located, the always present ground vibration caused the pen linkage assembly to bounce and jam. For this reason, all the records from the weighing bucket gage were of poor quality. The records from the tipping bucket gage gave much better data because ground vibrations did not affect the sensing device.

The use of special measuring equipment such as the Gurley Current Meter to measure flows at outfalls 008, 009, 010A, and 010B at Site 2 posed a problem because too much time was spent setting up and taking these readings during a runoff. If special flow measuring or sampling equipment is to be used during a runoff program, extra field personnel should be employed to handle them. By keeping a runoff program as automated as possible, the on-site technicians can concentrate on maintaining the automated installation.

Finally, a minor equipment problem occurred with the bubbler line from the flow meter. The bubbler line emits air into the runoff stream. On occasion this influx of air caused enough biological growth around the outlet of the bubbler line to restrict the air flow. When bubbler type flow meters are used on a runoff program, care must be taken to periodically maintain the bubbler lines so they are free of any obstructions or fouling. This problem only occurred once at Site 1. A periodic check of the air flow was immediately incorporated into the maintenance procedures.

6.0 TASK III - CONTROL OF CONTAMINATED STORMWATER

In the course of touring several mills, a few methods of controlling stormwater were found within the industry. The only system installed primarily for stormwater control was at the Armco-Houston Plant. A literature search was conducted to survey methods of control used by other industries that might be applicable or adaptable to steel mills.

6.1 Iron and Steel Industry Control Systems

The Armco-Houston Works has diked its coal piles as a control measure for both fugitive air emissions and stormwater runoff. Blowdown from a cooling tower is discharged to a concrete holding basin. On dry days, 190,000 liters of this water (equivalent to 6mm of rain) are sprayed on the coal piles to control fugitive air emissions. To guard against runoff, dirt dikes were built around the coal piles. Runoff from the spray and stormwater is channeled to a holding pond. This water either evaporates or percolates into the soil. The potential exists for the stormwater and spray runoff to be recycled and used as a spray for the control of fugitive air emissions. This process controls a source which can contribute both to fugitive air emissions and contaminated stormwater. This control process is only practical at mills located in areas where the potential evapotranspiration is more than the mean annual precipitation. Unfortunately very few steel mills are located in such areas.

Six of the twelve plants contacted collect stormwater runoff with process wastewater for subsequent terminal treatment. This necessitates a system of combined sewers within the plant. In addition, a holding pond prior to treatment may be necessary to handle the high flows encountered. This control method can be costly to install (new sewer lines, etc.) and can be very costly to maintain. In addition, it is not an effective control measure for an urban mill which has space restrictions.

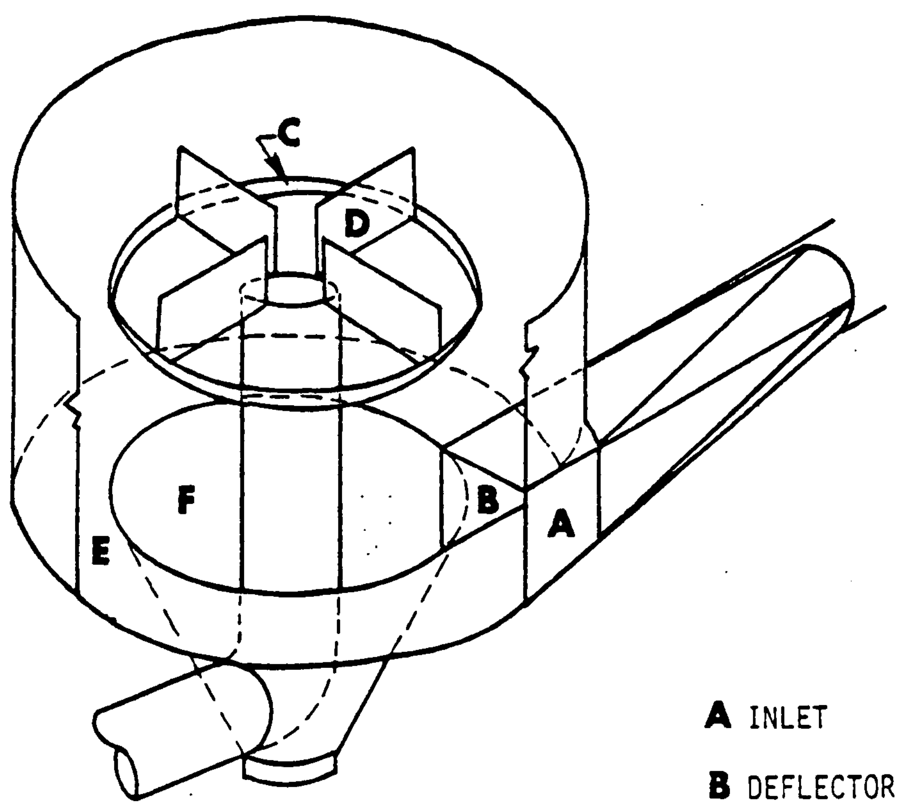
Several of the mills toured store their raw materials (predominantly iron ore) in concrete bunkers or bins. Some of these bunkers have concrete floors and stormwater has to be pumped out periodically. At other mills, the floors have drains and stormwater percolates into the ground. These bunkers were not installed for stormwater control but rather to guard against material loss; however, they do serve a purpose in controlling stormwater. For the bunkers with floors, stormwater collected in the bunkers could easily be pumped to lagoons. For bunkers with drains, the drains could be plugged to prevent the pile leachate from contaminating groundwater.

Some plants use concrete walls as barriers for storing iron ore. These barriers extend below grade permitting stormwater to percolate through the ore into the ground.

Some of the mills stored their raw materials in low graded areas where stormwater would pool and eventually infiltrate or evaporate.

6.2 Other Industries

Very little information is available on the control of stormwater runoff from industrial sites with the exception of the construction and mining industries. However, some of the technology developed for urban runoff control may be applicable to the iron and steel industry. The inception of the swirl degritter[17] shown in Figure 6-1 is an example of such technology.



A INLET

B DEFLECTOR

C WEIR AND WEIR PLATE

D SPOILER

E FLOOR

F CONICAL HOPPER

Figure 6-1: Isometric view swirl concentrator as a grit separator

This device, created originally to treat combined sewer overflows, requires no moving parts but utilizes a "swirl" action to effect separation and concentration of suspended solids from stormwater flows. The swirl degritter is being tested in Denver, Colorado for dual dry/wet weather flow treatment and has demonstrated potential as a control device.

Another urban runoff control technique with possible applications in the industrial sector is the use of flat roof buildings. These roofs are utilized for the detention of stormwater with subsequent settling and concentration of larger fugitive emission suspended solids. The rainfall detention ponding ring[18] pictured in Figure 6-2 was developed by Wright-McLaughlin Engineers for installation around a standard roof drain. It regulates the drainage rate of the roof leader causing some settling of downstream receiving bodies. At an iron and steel mill, this device could only be practically used on office buildings and warehouses.

Both devices shown require periodic maintenance to remove concentrated solids.

Several methods used by the mining and construction industries may be applicable to the iron and steel industry. One involves the use of sediment traps which are small, temporary structures used in various places to collect coarse sediment.[19],[20],[21],[22] Examples of such structures include small pits dug near areas of concentrated runoff, straw-bale barriers placed across small drainage ditches, and low gravel dikes placed across graded roadways or in drainage ditches. Detention basins or sediment ponds are used on larger drainageways and are designed to detain sediment-laden runoff and remove a significant amount of both coarse and fine sediments.[23] Several of the iron and steel plants that were contacted were already using basins as a form of wastewater treatment or as holding ponds prior to terminal treatment.

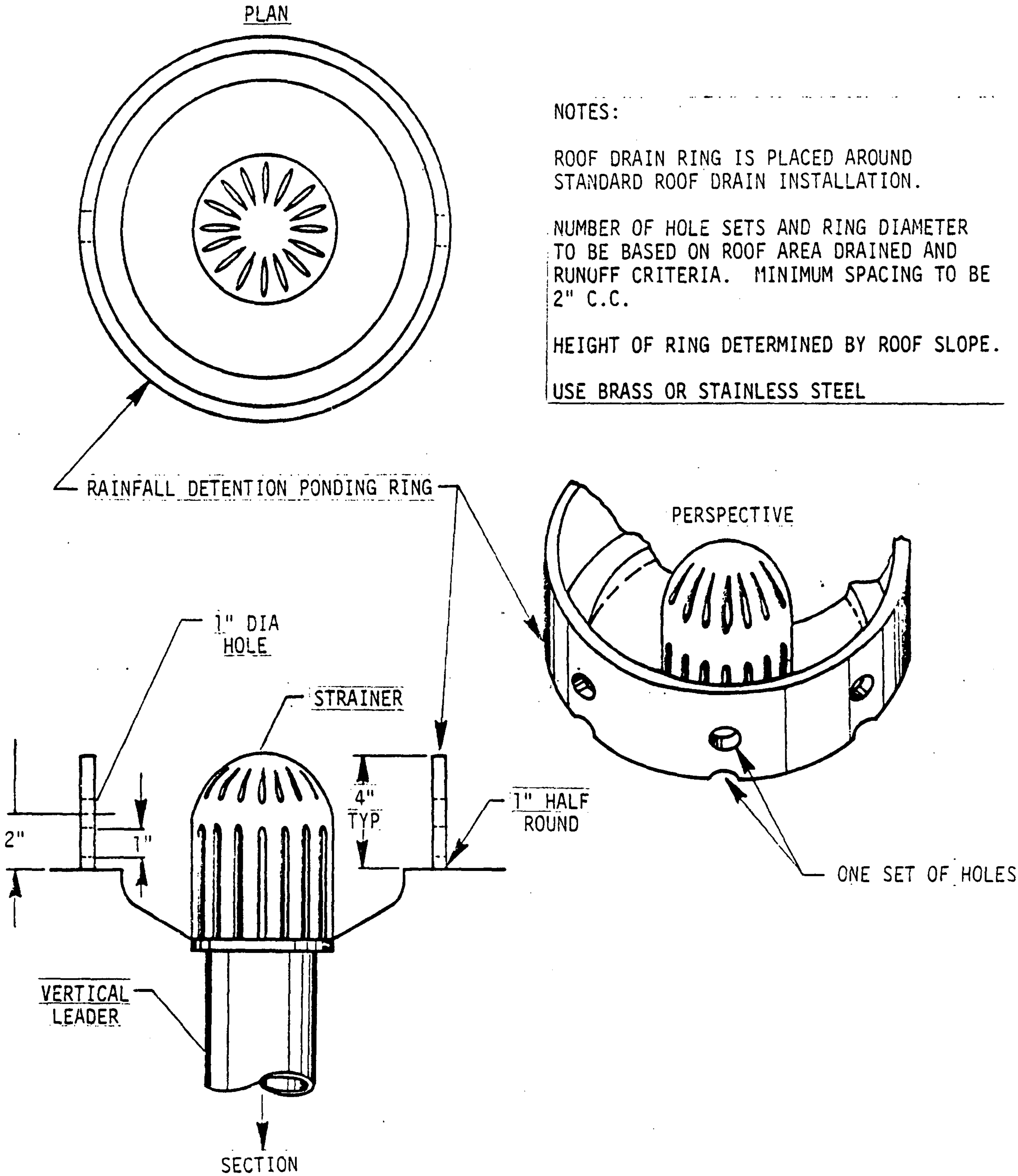


Figure 6-2: Rainfall detention ponding ring for flat roofs

7.0 TASK IV - TECHNICAL EVALUATION OF PROGRAM RESULTS

Table 7-1 shows a summary of the results for those areas at both sites which had the highest pollutant runoff concentrations. The TSS and TDS values are compared to typical urban runoff values. For the other parameters, water quality criteria values are shown for informational purposes. This data cannot be compared directly since receiving water sampling was beyond the scope of this program. Sampled runoff from coal storage, coke storage, and coal and coke handling were the areas which had the highest pollutant concentrations. The coal storage area at Site 1 showed much higher values for most pollutants than the same area at Site 2. However, this site is not typical of the rest of the industry because the piles are diked and recirculated stormwater and cooling water from a by-product plant cooling tower are sprayed on the pile for fugitive dust control. During dry days up to 190,000 liters of water is sprayed on the pile to prevent wind erosion of coal fines. The fines retained in the pile by this means could be expected to substantially increase the concentrations of TSS and total iron in the runoff compared to sites which do not have such a system. It is also probable that the high TDS, ammonia, and phenol concentrations resulted from the spray water system. Although this water originates from a noncontact cooling system, it is probable that the water contains high concentrations of TDS and also phenol and ammonia absorbed in the water from the coke plant air.

In order to determine the potential gross impact of stormwater runoff from the mills sampled, the stormwater runoff mass loadings were compared to the point source mass loadings which would exist under proposed BAT control.(3) Since BAT is EPA's next step in the control process (July, 1984), this comparison was assumed to be valid.

TABLE 7-1

SUMMARY OF RESULTS
Sites 1 and 2
POTENTIAL PROBLEM AREAS

MARCH-JUNE, 1977

Pollutant	Site No.	Potential Problem Areas	Average Wet Concentrations, mg/l	(14)(15)(16) Typical Values Urban Stormwater Runoff, mg/l	(12)(13) Water Quality Criteria, mg/l
TSS	1	Coal Stor.	4187	26-2080	-
	2		853		
	1	Coke Stor.	505		
	2		392 (d)		
	1	Coke & Coal Handling	184		
	2		n.s. (c)		
TDS	1	Coal Stor.	2289	250	-
	2		471		
	1	Coke Stor.	745		
	2		959 (d)		
	1	Coke & Coal Handling	2158		
	2		n.s. (c)		
TOTAL IRON	1	Coal Stor.	39.3	-	0.3(Public water supply) 0.1(Fresh water aquatic life)
	2		18		
	1	Coke Stor.	32.3		
	2		12.6 (d)		
	1	Coke & Coal Handling	2.4		
	2		n.s. (c)		
DISSOLVED IRON	1	Coal Stor.	n.d. (a)	-	-
	2		0.2		
	1	Coke Stor.	0.1		
	2		1.0(d)		
	1	Coke & Coal Handling	0.1		
	2		n.s. (c)		
PHENOLS	1	Coal Stor.	0.39	-	0.001 (Domestic water supply)
	2		0.01		
	1	Coke Stor.	0.06		
	2		0.03 (d)		
	1	Coke & Coal Handling	0.37		
	2		n.s. (c)		
CYANIDE (TOTAL)	1	Coal Stor.	n.d. (a)	-	5.0 (Fresh water & marine aquatic life & wildlife)
	2		n.d. (a)		
	1	Coke Stor.	0.01		
	2		0.55 (d)		
	1	Coke & Coal Handling	n.d. (a)		
	2		n.s. (c)		
AMMONIA	1	Coal Stor.	56	-	0.02(Fresh water aquatic life)
	2		0.33		
	1	Coke Stor.	2.1		
	2		29.3		
	1	Coke & Coal Handling	43		
	2		n.s. (c)		
SULFATE	1	Coal Stor.	n.a. (b)	-	250 (public water supply)
	2		232		
	1	Coke Stor.	n.a. (b)		
	2		129 (d)		
	1	Coke & Coal Handling	312		
	2		n.s. (c)		

(a) n.d. - none detected.

(b) n.a. - not analyzed.

(c) n.s. - no samples collected.

(d) There were two sampling points near the coke storage area at Site 2. The average concentrations for only one (outfall 013) are shown.

Tables 7-2 and 7-3 compare average yearly runoff loadings to average yearly effluent loadings from the activities and operations in several drainage basins. The effluent loadings are based on a summation of proposed BAT Effluent Guidelines[3] for daily average values over thirty consecutive days for all processes in a particular drainage basin. If only part of a process was located in a particular drainage basin, the loading was obtained by assigning a percentage of the operation to the basin and then using an estimate of the production rate.[4] The appropriate production rate and BAT Effluent Guidelines for each process in a basin were then multiplied to obtain an average annual effluent loading. All operations in a basin were then summed to obtain a total basin effluent loading. Average annual runoff loadings for each basin were calculated by multiplying estimated acreage by average annual precipitation (based on the years 1970-1976) by calculated runoff coefficients and by the mean pollutant concentrations from the sampling program. Examples of these calculations appear in Appendix C.

To obtain a worst case situation, it was assumed that rainwater which infiltrated the ground had the same mean pollutant concentration as the runoff. Therefore, Tables 7-2 and 7-3 contain a column labeled 100% runoff as a worst case. There are presently no BAT Guidelines for coal storage piles. However, the coal pile storage area at Site 1 yielded higher annual waste loadings than any of the summed point source loadings (based on BAT Guidelines) of the drainage basins tested.

Since runoff is an intermittent occurrence, another analysis was performed comparing average hourly mass loadings for each storm tested to average hourly loadings allowed based on the proposed maximum 24-hour BAT Effluent Guidelines. As in the previous analysis the allowable loadings from all point sources in a

TABLE 7-2

COMPARISON OF AVERAGE ANNUAL RUNOFF LOADINGS WITH
AVERAGE ANNUAL POINT SOURCE LOADINGS
FOR SELECTED DRAINAGE BASINS

SITE 1

MARCH-APRIL, 1977

Drainage Basin	Activities and Operations	Estimated Area, Hectares	Average Annual Rainfall[24] cm/yr(in/yr)	Average Annual Rainfall[24] l/yr(gal/yr)	Estimated Runoff Coefficient[25]	Average Annual Runoff, l/yr(gal/yr)	Total Average Annual Loadings Based on BAT Effluent Guidelines,[3],[4] Kg/yr(lb/yr)	Average Annual Runoff Loadings,[a],[c] Kg/yr(lb/yr) Outfall	Average Annual Runoff Loadings,[a],[c] Kg/yr(lb/yr) Coal Pile	Worst Case Average Annual Runoff Loadings(100% Runoff),[a],[c] Kg/yr(lb/yr) Outfall	Worst Case Average Annual Runoff Loadings(100% Runoff),[a],[c] Kg/yr(lb/yr) Coal Pile
009	Part of Mold Foundry; Coke Storage and Transfer	2.7	132(52)	$3.5x10^7$ $(9.3x10^6)$	0.2	$7.2x10^6(1.9x10^6)$	-	TSS 3600(8000) CN 0.1 (0.2) NH_3 14(30) ØOH 0.5 (1.0) TFe 209(460)	-	TSS $1.8x10^4(3.9x10^4)$ CN 0.4 (0.8) NH_3 90 (200) ØOH 2.0 (5.0) TFe 1020 (2250)	-
010	Coal Transfer; Coal Shaker Bldg; ½ of Coke Areas	1.1	132(52)	$1.4x10^7$ $(3.7x10^6)$	0.06	$8.3x10^5(2.2x10^5)$	TSS 1850(4100) CN 18(40)[b] NH_3 800(1700) ØOH 36(80)	TSS 80(180) CN 0.5 (1.0) NH_3 36 (80) ØOH 0.5 (1.0)	-	TSS 1400 (3100) CN 7.0 (15.0) NH_3 600 (1300) ØOH 7.0 (15.0)	-
011	Mold Preparation Shop; ½ of No. 2 Electric Furnace Shop; ½ of Coke Ovens; Coke By-Products Area; Coal Storage; ½ of Mold Foundry; Parking Areas	24.5	132(52)	$3.8x10^8$ $(1.0x10^8)$	0.25	$9.5x10^7(2.5x10^7)$	TSS 1850(4100) CN 18(40)[b] NH_3 800(1700) ØOH 36(80)	TSS 3315(7290) CN 0.2 (0.4) NH_3 300(700) ØOH 9(20) TFe --	$4.1x10^5(9.0x10^5)$ - $5.5x10^3(1.2x10^4)$ 36(80) 3750(8200)	TSS $1.3x10^4(2.9x10^4)$ CN 0.9 (2.0) NH_3 1300 (2800) ØOH 30 (70) TFe --	$1.6x10^6(3.5x10^6)$ - $2.1x10^4(4.7x10^4)$ 140(300) $1.5x10^4(3.3x10^4)$

[a] Coal pile drainage ditch was separate from the sampling station at Outfall 011.

[b] Cyanides amenable to chlorination.[3]

[c] Total cyanide.

TABLE 7-3

COMPARISON OF AVERAGE ANNUAL RUNOFF LOADINGS WITH AVERAGE ANNUAL POINT SOURCE LOADINGS FOR SELECTED DRAINAGE BASINS

SITE 2

MAY-JUNE, 1977

Drainage Basin	Activities and Operations	Estimated Area, Hectares	Average Annual Rainfall[24] cm/yr(in/yr)	l/yr(gal/yr)	Estimated Runoff Coefficient[25]	Average Annual Runoff, l/yr(gal/yr)	Total Average Annual Loadings Based on BAT Effluent Guidelines,[3][4] Kg/yr(lb/yr)	Average Annual Runoff Loadings, Kg/yr(lb/yr)[b]	Worst Case Average Annual Runoff Loadings (100% Runoff), Kg/yr(lb/yr)[b]
010[c]	1/2 of Open Hearth Furnaces; Coke Storage; Coke Ovens and By-Product Area; Railroad Tracks	58.5	112(44)	6.4×10^9 (1.7×10^8)	0.4	2.5×10^8 (6.6×10^7)	TSS 1.8×10^4 (4.0×10^4) CN[a] 90 (200) NH_3 3700 (8100) φOH 180 (400)	TSS 1.5×10^4 (3.3×10^4) CN 2.75 (6.1) NH_3 150 (330) φOH 2.75 (6.1)	TSS 3.8×10^4 (8.4×10^4) CN 7.0 (15.4) NH_3 384 (845) φOH 7.0 (15.4)
011	Coal Storage	4.0	112(44)	4.5×10^7 (1.2×10^7)	0.2	9.1×10^6 (2.4×10^6)	- -	TSS 7760 (1.7×10^4) NH_3 3.0 (6.6) φOH 0.09 (0.2) TFe 164 (361)	TSS 3.8×10^4 (8.4×10^4) NH_3 15 (33) φOH 0.45 (0.99) TFe 810 (1780)
012	Coke Storage; Coke Handling; Coke By-Product Area	0.53	112(44)	6.1×10^6 (1.6×10^6)	0.2	1.2×10^6 (3.2×10^6)	-	TSS 310 (680) CN 0.24 (0.53) NH_3 1.2 (2.64) φOH 0.05 (0.11) TFe 14 (30)	TSS 1570 (3455) CN 1.22 (2.7) NH_3 6.1 (13.4) φOH 0.24 (0.53) TFe 69 (152)
013	Coke Storage; Coke Handling; Coke By-Product Area	0.61	112(44)	6.8×10^5 (1.8×10^5)	0.2	1.4×10^5 (3.6×10^5)	-	TSS 550 (1210) CN 0.8 (1.7) NH_3 41 (90) φOH 0.04 (0.09) TFe 18 (40)	TSS 2670 (5875) CN 3.74 (8.23) NH_3 199 (438) φOH 0.2 (0.44) TFe 86 (189)

[a] Cyanides amenable to chlorination.[3]

[b] Total cyanide.

[c] Used 010B data.

given drainage basin were summed. Tables 7-4 and 7-5 present this evaluation for the two sites. These data show that TSS mass loadings were greater than the summed drainage basin point source loadings (based on BAT Effluent Guidelines) for moderate to heavy intensity storms. The other parameters are of the same magnitude or less than the drainage basin point source loadings. It can, therefore, be concluded that at some sites it may be beneficial to control TSS in runoff from certain activities and operations to bring them down to the same order of magnitude as point sources based on the proposed BAT Effluent Guidelines.

While the slag disposal areas at Site 2 did not contribute significantly to stormwater contamination, some of the mills visited in this program do have slag disposal piles which have a high potential for contaminating stormwater runoff. Slag disposal areas may also provide an opportunity for leachate contamination of groundwater, an aspect of nonpoint source contamination beyond the scope of this program. Both mills surveyed had highly permeable soils. If a worst case is assumed where the infiltrate has pollutant concentrations similar to the runoff, approximately three to four times as much material from these mills could infiltrate the soils and potentially reach the groundwater. A groundwater evaluation program may be warranted to verify this assumption.

Due to drainage patterns in the areas of iron ore and pellet storage, it was impossible to set up sampling sites to monitor stormwater runoff. At both sites, runoff from the iron piles ended up in ponds or depressions and never reached the receiving body. In addition, there was no distinct source from which to collect samples, such as the coal pile drainage ditches in the coal storage areas. Further studies should concentrate on the storage areas not covered in this program.

TABLE 7-4

COMPARISON OF AVERAGE HOURLY POINT SOURCE LOADINGS FOR DRAINAGE BASINS WITH AVERAGE RUNOFF MASS LOADINGS FOR SEVERAL STORMS

SITE 1

MARCH-APRIL, 1977

Drainage Basin	Average Hourly Production Rates, Kg/hr(lb/hr)(4)	Average Hourly Loadings Based on Maximum for 1 Day BAT Effluent Guidelines, Kg/hr(lb/hr)(3)			Average Mass Loadings of Pollutants in Runoff, Kg/hr(lb/hr): 3/24 Storm			3/27-28 Storm			4/16 Storm		
010	2.0×10^4 (4.5×10^4) Coke	TSS	0.6	(1.3)	TSS	0.06	(0.13)	TSS	3.54	(7.8)	TSS	n.d.(a)	
		ϕOH	0.01	(0.02)	ϕOH	0.004	(0.009)	ϕOH	0.001	(0.003)	ϕOH	n.d.(a)	
		NH_3	0.25	(0.55)	NH_3	0.013	(0.03)	NH_3	0.08	(0.19)	NH_3	n.d.(a)	
011	2.0×10^4 (4.5×10^4) Coke	TSS	0.6	(1.3)	TSS	0.14	(0.32)	TSS	10.3	(22.6)	TSS	1.74	(3.83)
		ϕOH	0.01	(0.02)	ϕOH	0.002	(0.004)	ϕOH	0.004	(0.009)	ϕOH	0.002	(0.004)
		NH_3	0.25	(0.55)	NH_3	0.023	(0.05)	NH_3	0.058	(1.28)	NH_3	0.03	(0.07)

(a) n.d. - no data obtained.

TABLE 7-5

COMPARISON OF AVERAGE HOURLY POINT SOURCE LOADINGS
FOR DRAINAGE BASINS WITH AVERAGE RUNOFF MASS LOADINGS
FOR SEVERAL STORMS

SITE 2

MAY-JUNE, 1977

Drainage Basin	Average Hourly Production Rates, Kg/hr(lb/hr)[4]	Average Hourly Loadings Based on Maximum for 1 Day BAT Effluent Guidelines, Kg/hr(lb/hr)[3]		Average Mass Loadings of Pollutants, Kg/hr(lb/hr)[b]			
				6/9-6/10 Storm		6/20 Storm	
010	$2.0x10^5$ $(4.4x10^5)$ Steel	TSS	6.0 (13)	TSS	219 (482)	TSS	136 (299)
		ØOH	0.06 (0.13)	ØOH	0.04 (0.09)	ØOH	0.02(0.04)
		CN[a]	0.03 (0.07)	CN	0.03 (0.07)	CN	0.03(0.07)
	$1.0x10^5$ $(2.2x10^5)$ Coke	NH_3	1.3 (2.9)	NH_3	0.09 (2.18)		3.02(6.64)

(a) Cyanides amenable to chlorination.[3]

(b) Total cyanide.

Both plants studied are representative of industry-wide operations. Therefore, while conclusions may be generally applied to the entire industry, each site should be addressed independently because many factors besides operations and climate affect the runoff loadings, including:

- Soil conditions
- Topography
- Size of drainage basins
- Location of activities and operations relative to one another
- Neighboring industries and urban areas
- Proximity of plant to receiving waters
- Plant size

The general results of the field program can also be applicable to the entire industry, but site specificity should be considered when evaluating surface runoff problems at individual plants.

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APPENDIX A

DATA SHEETS

SAMPLE LOG

Sample No. Wet or Dry	From Isco Bottle(s) No.	Sample Location	Date of Collection	By	Time of Sample From Flow Record	Time Preserved	Reserved for analysis of	Volume of Sample, mℓ	Date Shipped to Chem Lab.	Shipping Box No.	Date Received by Chem Lab.
1d	1,2	006	5/9/77	BCM/TEB	0000	0800	TDS/TSS	500	5/10/77	1	
2d	3,4				0030						
3d	5,6				0100						
4d	7,8				0130						
5d	9.10				0200						
6d	11,12				0230						
7d	13,14				0300						
8d	15,16				0330						
9d	17,18				0400						
10d	19,20				0430						
11d	21,22				0500						
12d	23,24				0530						
13d	25,26				0600						
14d	27,28				0630						
15d	1,2	007			0000						
16d	3,4				0030						
17d	5,6				0100						
18d	7,8				0130						
19d	9,10				0200						
20d	11,12				0230						
21d	13,14				0300						
22d	15,16				0330						
23d	17,18				0400						
24d	19,20				0430						
25d	21,22				0500						
26d	23,24				0530						
27d	25,26				0600						
28d	27,28				0630						

TRC - THE RESEARCH CORPORATION OF New England
125 Silas Deane Highway, Wethersfield, CT 06109

Project No. 32593-04

WATER SAMPLE DATA SHEET

Supervisor BCM

TRC THE RESEARCH CORPORATION of New England
125 SILAS DEANE HIGHWAY, WETHERSFIELD, CONNECTICUT 06109
Environmental Consultants To Management

FIELD SUPERVISOR'S DAILY ACTIVITY REPORT

Date 5/10/77 Field Supervisor BCM Project No. 32593-04

Job Location Site #2

FIELD PARTY

	Name	Work Hrs.		Name	Work Hrs.		Name	Work Hrs.
1.	BCM	11	4.			7.		
2.	TEB	11	5.			8.		
3.	DAK	11	6.			9.		

EQUIPMENT STATUS

	Item	S/N	Owner	Condition (maintenance, breakdowns, etc.)
1.	All equipment functioning normally.			
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

Summary of Day's Activity (1) Conducted equipment checks. (2) Preserved and packed samples for shipping. (3) Shipped samples to TRC laboratory. (4) Cleaned sample bottles and prepared for more dry weather sampling.

Tomorrow's Work Plan Continue dry weather sampling.

Weather: Partly cloudy, $60^{o}F$

Follow-up Work Orders (corrective action)

None

Provisional Form

Initials BCM

TRC THE RESEARCH CORPORATION of New England
125 SILAS DEANE HIGHWAY, WETHERSFIELD, CONNECTICUT 06109 203 563-1431
Environmental Consultants To Management

DAILY EQUIPMENT STATUS CHECK LIST Project No. 32593-04

Date 5/8/77 Checker(s) BCM, TEB

Site #2

Equipment	4	6	7	8	9	10	12	13	14
Time of Visit	1850	1840	1830			1800			1730
1680 Samplers									
1. All bottles clean and open	yes	yes	yes			yes	yes		yes
2. Sampler on bottle number	1	1	1			1	off		off
3. Nicad Battery changed	no	no	no			no	remov-ed		remov-ed
4. Purged sample line	no	no	no			no	no		no
5. Dessicant recharged	no	no	no			no	no		no
6. Pulses or min. before next sample	30	30	30			60	no		no
1700 Flow Meters									
1. Bubble rate bubbles/sec	1.3	1.4	1.3				no		no
2. Weir water level (feet)	0.48	0.30	0.102				no		no
3. Disk water level (feet)	0.455	0.31	0.095				no		no
4. Readjusted disk	no	no	no				no		no
5. Nicad battery changed	yes	yes	no				remov-ed		no
6. Dessicant recharged	yes	no	no				no		no
1710 Printer									
1. Paper tape replaced	yes	yes	no				no		no
2. Ink cartridge replaced	no	no	no				no		no
3. Dessicant recharged	no	no	no				no		no
4. Clock updated (yes or no)	no	no	no				no		no
5. Clock reading	1840	1827	1815				no		no

Climatronics Rain Gage-Time 1845

1. Chart paper replaced -
2. Batteries replaced -
3. General inspection OK

Belfort Rain Gage-Time 1815

1. Chart paper replaced -
2. Rainfall (inches) -
3. Ink reservoir filled -
4. Clock operating yes

1/4" = 0.021 feet

APPENDIX B

FIELD DATA

TABLE B-1

DUSTFALL DATA, SITE 1*

Outfall 010 Estimated Acreage 2.6 Coal Handling

Sample Area	Description
#1	Moderate Activity - Near Water Tower
#2	High Activity - Near Conveyor
#3	Low Activity - Outside Conveyor Area

	Dustfall Values (mg)/4 sq ft					
	#1		#2		#3	
Day No.	Cumulative Weights	Average Per Day	Cumulative Weights	Average Per Day	Cumulative Weights	Average Per Day
1	4.67	4.67	15.22	15.22	0.06	0.06
2	7.48	3.74	28.54	14.27	0.09	0.04
3	49.44	16.48	32.23	10.74	2.38	0.79
4	16.29	4.07	26.27	6.57	2.94	0.74
5	15.04	3.01	96.61	19.32	1.25	0.25

Total Daily Average/ft^2 = 1.67 mg/day/ft^2

Total Daily Average/Acre = 72.75 g/day/acre

Total Daily Average/Basin 010 = 0.19 kg/day (0.42 lb/day)

*Data is calculated in metric/English units from raw field data and is converted to metric units only in text of report.

TABLE B-2

DUSTFALL DATA SITE 2**

Sinter Plant — Estimated Acreage 11.4 — High Activity

Coke and Coal Piles — Estimated Acreage 1.5 — Moderate Activity

	Sinter Plant Dustfall Site — Dustfall Weights (mg)/4 sq ft									Coke and Coal Storage Site — Dustfall Weights (mg)/4 sq ft								
Sample Squares	#1	#2	#3	#4	#5	#6	#7	#8	#9	#1	#2	#3	#4	#5	#6	#7	#8	#9
	8.48	8.09	2.91	5.86	9.03	15.24	25.76	22.21	25.46	2.04	5.16	3.03	5.88	6.50	7.36	6.73	23.27	34.52
	11.38	16.90	8.72	13.16	6.98	7.86	14.09	4.05	4.71	8.92	11.73	*	5.66	5.39	13.55	6.05	0.82	1.59
	7.05	6.91	9.50	3.50	3.05	17.60	9.53	7.36		2.33	2.27	0.99	1.73	2.56	4.08	3.70	8.52	
Total Weight	26.91	31.9	21.1	22.52	19.06	40.7	49.38	33.62	29.63	13.29	19.16	4.02	13.27	14.45	24.99	16.48	32.61	36.11
No. Days	20	21	22	23	24	25	26	27	19	20	21	22	23	24	25	26	27	19
Avg. Wgh.	1.35	1.52	0.96	0.98	0.79	1.63	1.90	1.25	1.56	0.67	0.91	-	0.58	0.60	1.0	0.63	1.21	1.9

Average Daily Accumulation 1.33 mg/day/4 sq ft
0.33 mg/day/ft^2
14.48 gm/day/acre

Average Daily Accumulation for the Sinter Plant Area 0.17 kg/day
0.36 lb/day

Average Daily Accumulation 0.94 mg/day/4 sq ft
0.24 mg/day/ft^2
10.24 gm/day/acre

Average Daily Accumulation for the Coke and Coal Area 0.015 kg/day
0.034 lb/day

*The sample square was tampered with.

**Data is calculated in metric/English units from raw field data and is converted to metric units only in text of report.

TABLE B-3

TSS RESULTS, IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
	SITE #1				
4	011	3/24	1040	Storm #1	11
5			1100		10
13			1200		16
18			1300		12
21			1400		17
32	010		1000		122
38			1100		54
42			1200		44
47			1300		62
52			1400		59
59			1500		100
63			1600		163
64	005		1000		34
65			1100		45
66			1200		53
67			1300		64
68			1400		25
70			1600		17
78	009A	3/28	0115	Storm #2	527
85	009A	3/27	2100		761
91	Coal Pile	3/28	0012		2384
99	Coal Pile	3/28	0030		1116
100	006	3/27	2240		511
102	006	3/28	0305		180

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
112	011	3/28	0022	Storm #2	20
118		3/28	0225		151
125		3/28	1100		76
132	005	3/27	2230		69
134		3/28	0045		66
136		3/28	0140		78
138		3/28	0300		36
140		3/28	0830		22
144		3/28	1300		38
150	010	3/27	2100	Storm #2	22
154			2215		32
159			2225		293
163		3/28	0040		198
168		3/28	0145		238
172		3/28	0445		94
175		3/28	0645		10
181	011	3/29	0800	Dry Weather #1	15
188			1000		15
195			1200		15
201			1400		13
202	010		0800		14
209			0900		17
210			1000		5
216			1100		6
218			1200		7
224			1300		4
226			1400		11
231	005		0800		21
232			0900		15
233			1000		16
236			1300		19
240			1700		6
244			2100		17
245		3/31	1444	Storm #3	25
246		3/31	1740		44

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
247	005	3/31	2100	Storm #3	13
248		4/1	0315		65
249		4/1	0846		21
250		4/4	0450	Storm #4	50
251			0626		11
252			1031		67
253			1109		23
268	010	4/5	0900	Dry Weather #2	184
277			1100		81
282			1200		58
286			1300		29
291			1400		22
295			1500		27
297	005		0900		4
300			1200		23
303			1500		31
307			1900		8
310	011		0900		10
314			1000		11
318			1100		28
321			1200		20
325			1300		13
328			1400		7
332			1500		7
342	Coal Pile	4/16	1140	Storm #5	9559
347	Coal Pile		1155		3691
349	009A		1040		951
353			1125		474
358			1205		159
363			1415		156
365	006		1055		41
366	006		1120		676
367	005		1121		11

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
368	005	4/16	1133	Storm #5	11
369	↓	↓	1146	↓	18
370			1208		65
371			1245		47
372			1339		113
373			1504		96
374			1626		65
378	011		0842		20
381	↓		1138		84
387			1239		46
390			1423		34
400			1614		27
401			2223		18
409		4/17	0742		30
414	005	4/18	0945	Dry Weather #3	19
417	↓		1245	↓	12
420			1545		16
423			1845		14
426			2145		11
427			2245		10
431	011		0930		36
434	↓		1030		23
440			1130		42
444			1230		20
447	010		1137		649
450	↓		1237		171
457			1337		100
461			1437		52
465			1537		78
	SITE #2				
1	006	5/9	0000	Dry Weather	416
4	↓	↓	0130	↓	23
7			0300		20

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
10	006	5/9	0430	Dry Weather	25
14			0630		24
15	007		0000		10
18			0130		8
21			0300		1
24			0430		8
28			0630		5
39	015	5/10	1000		15
41	010A	5/9	0000		37
44			0100		17
50			0200		9
53			0300		15
59			0400		12
62			0500		19
68			0600		22
75	004		0000		18
78			0030		16
81			0100		7
84			0130		9
90			0230		6
97			0330		7
103			0430		11
109			0530		12
118	006	5/10	0000		38
122			0200		23
126			0630		63
127	007		0000		12
132			0230		30
136			0430		4
140			0630		13
141	004		0000		8
144			0030		8
150			0130		9
159			0300		7

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
168	004	5/10	0430	Dry Weather	7
177			0600		17
184	010A		0000		13
197			0300		16
205			0500		5
211			0600		9
219	015		1845		40
237	002		1340		29
238			1615		11
239	008		1125		55
242			1410		22
245			1550		56
248	009		1140		4
251			1400		33
254			1545		58
261	015		1050		2
268	006		1030		197
271			1200		46
274			1330	Dry Weather	188
277			1500		91
278	007		1030		10
281			1200		60
284			1330		1
287			1500		1
291			1700		50
292	004		1030		4
295			1100		2
298			1130		47
301			1200		13
304			1230		17
307			1300		10
310			1330		20
313			1400		8

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
316	004	5/18	1430	Dry Weather	12
319	↓	↓	1500	↓	12
322			1530		16
325			1600		17
328			1630		18
331			1700		18
335	010A		1030		21
338	↓		1130		27
344			1230		28
346			1330		19
351			1430		30
354			1530		11
363	010B		1030		19
366	↓		1130		13
371			1230		21
374			1330		26
379			1430		28
382			1530		24
387			1630		23
390	006	6/9	0930	Storm #1	2537
393	↓	↓	1015	↓	225
396			1100		812
400			1200		1720
403			1245		183
404	007		0930		45
412	↓		1130		6
416			1230		10
418	004		0930		11
430	↓		1030		8
442			1130		11
454			1230		6
460	007		1330		17
463	↓		1500		33
466			1630		48

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
469	007	6/9	1800	Storm #1	51
473	↓		2000		17
474	004		1345		6
483			1515		11
492			1645		8
501			1815		11
513	↓		2015		3
517	010A		0930		48
525			1030		20
533			1130		17
540	↓		1230		25
552	010B		1030		60
568	010B		1230		21
572	012		0930		513
582			1030		259
592			1130		109
596			1200		67
602			1230		29
607			1430		563
617	↓		1950		230
660	010A		1515		38
674			1915		15
682	↓		2115		31
685	010B		1515		702
693			1715		22
696			1815		12
701			1915		32
704			2015		27
709	↓		2115		29
712	006		1315		268
714			1415		331
716			1515		295
718			1615	↓	487
720	↓	↓	1715		85

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
722	006	6/9	1815	Storm #1	629
725	↓		1945		306
726	002		0950		176
727			1130		66
728			1630		11
729	↓		2005		9
730	003		0955		21
731			1125		14
732	↓		1630		11
733	005		1000		17
734	008		1030		41
736			1215		30
739			1605		19
742	↓		2315		89
745	009		1035		109
748			1230		69
751			1615		58
754	↓		2315		55
757	011		1045		448
760			1205		223
764			1520		2684
766	↓		2025		56
769	006		2215		354
772		↓	2345		218
776	↓	6/10	0145		151
783	007	6/9	2200		93
787		6/10	0000		45
791			0200		39
796	↓	↓	0430		10
842	013	6/9	1100		152
846			1150		72
850			1530		1380
854		↓	1650	↓	12
858	↓		1945		12

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
861	014	6/9	1115	Storm #1	76
868			1540		60
874			1935		24
877			2050		61
884	015	6/10	1145		49
887		6/9	2235		21
891	004		2225		7
894			2255		6
903		6/10	0025		39
912			0155		6
921			0325		9
933	010A		0000		21
941			0200		17
946			0300		13
953			0500		16
956			1516		7
960			1716		3
962			1816		7
966			2016		3
970	006		1500		232
972			1600		21
976			1800		54
980			2000		16
984	010B	6/9	2300		13
987		6/10	0000		20
994			0200		21
1001			0400		26
1011			1650		29
1018			1850		21
1029			2150		25
1032	010A		1550		23
1035			1650		20
1046			1950		27
1053			2150		18

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
1056	004	6/10	1440	Storm #1	10
1080			1840		3
1095	007	6/20	1545	Storm #2	32
1098			2110		29
1100			1615		119
1102			1645		100
1104			1715		8
1108			1815		62
1112			1915		77
1116			2015		71
1120			2115		21
1124			2215		6
1127	010B		1610		137
1135			1710		41
1138			1740		38
1143			1810		36
1151			1910		30
1154	006		1545		398
1156			1615		188
1158			1645		77
1160			1715		76
1164			1815		24
1168			1915		16
1172			2015		13
1176			2115		17
1180			2215		20
1182	004		1545		34
1185			1600		12
1188			1615		12
1191			1630		9
1194			1645		12
1197			1700		10
1200			1715		12
1206			1745		11
1212			1815		13

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
1219	004	6/20	1845	Storm #2	10
1222			1900		12
1226	007	6/21	0100		14
1230			0300		10
1234			0500		4
1238			0700		9
1242			0900		9
1246			1100		3
1252	006		0115		8
1256			0315		13
1260			0515		11
1268			0915		24
1272			1115		24
1276	012	6/20	1530		533
1279			1600		179
1284			1630		182
1286			1700		158
1303	004	6/21	0115		7
1315			0315		7
1327			0515		5
1339			0715		6
1343	010B	6/20	2345		24
1354		6/21	0245		29
1359			0345		27
1362			0445		31
1370	002	6/20	1540		79
1371			1555		17
1372			1650		15
1373	003		1535		132
1374			1550		97
1375			1635		34
1376			1645		23
1377	005		1535		78
1378			1550		36

TABLE B-3
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	TSS Concentration, mg/ℓ
1380	013	6/20	1525	Storm #2	727
1384	014		1530	↓	121
1387	↓		1600	↓	44

TABLE B-4

TDS RESULTS IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
	SITE #1				
4	011	3/24	1040	Storm #1	1196
5	↓	↓	1100	↓	1095
13			1200		1095
18			1300		1110
21			1400		1098
32	010		1000		2090
38	↓		1100		2222
42			1200		2269
47			1300		2088
52			1400		1964
59			1500		2310
63			1600		2262
64	005		1000		939
65	↓		1100		922
66			1200		964
67			1300		897
68			1400		947
70			1600		949
78	009A	3/28	0115	Storm #2	376
85	009A	3/27	2100	↓	617
91	Coal Pile	3/28	0012		2205
99	Coal Pile	3/28	0030		2557
100	006	3/27	2240		200
102	006	3/28	0305		373
112	011	3/28	0022		878
118	011	3/28	0225		506
125	011	3/28	1100		427
132	005	3/27	2230		319
134	↓	3/28	0045		300
136		3/28	0140		238

TABLE B-4

(Cont)

TDS RESULTS IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
138	005	3/28	0300	Storm #2	253
140	↓	3/28	0830	↓	357
144	↓	3/28	1300	↓	294
150	010	3/27	2100	↓	4993
154	↓	3/27	2215	↓	3791
159	↓	3/27	2225	↓	2376
163	↓	3/28	0040	↓	1059
168	↓	3/28	0145	↓	661
172	↓	3/28	0445	↓	1315
175	↓	3/28	0645		1684
181	011	3/29	0800	Dry Weather #1	676
188	↓		1000	↓	668
195	↓		1200	↓	689
201	↓		1400	↓	698
202	010		0800	↓	2007
209	↓		0900	↓	2110
210	↓		1000	↓	2172
216	↓		1100	↓	2044
218	↓		1200	↓	2048
224	↓		1300	↓	2066
226	↓		1400	↓	2108
231	005		0800	↓	327
232	↓		0900	↓	329
233	↓		1000	↓	347
236	↓		1300	↓	364
240	↓		1700	↓	385
244	↓		2100	↓	365
245	↓	3/31	1444	Storm #3	559
246	↓	3/31	1740	↓	556
247	↓	3/31	2100	↓	703
248		4/1	0315	↓	482

TABLE B-4
(Cont)
T[illegible] RESULTS IN mg/ℓ
[illegible]TES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
249	005	4/1	0846	Storm #3	623
250		4/4	0450	Storm #4	525
251			0626		642
252			1031		753
253			1109		641
268	010	4/5	0900	Dry Weather #2	4063
277			1100		4198
282			1200		3639
286			1300		3955
291			1400		4106
295			1500		4503
297	005		0900		445
300			1200		463
303			1500		433
307			1900		432
310	011		0900		1045
314			1000		1049
318			1100		998
321			1200		995
325			1300		1025
328			1400		1034
332			1500		998
342	Coal Pile	4/16	1140	Storm #5	1419
347	Coal Pile		1155		2974
349	009A		1040		1023
353			1125		1316
358			1205		609
363			1415		529
365	006		1055		1360
366	006		1120		376
367	005		1121		719

TABLE B-4
(Cont)

TDS RESULTS IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
368	005	4/16	1133	Storm #5	715
369	↓	↓	1146	↓	611
370			1208		603
371			1245		341
372			1339		305
373			1504		284
374			1626		259
378	011		0842		1155
381	↓		1138		1133
387			1239		892
390			1423		992
400			1614		915
401			2223		845
409		4/17	0742		753
414	005	4/18	0945	Dry Weather #3	395
417	↓	↓	1245	↓	424
420			1545		420
423			1845		400
426			2145		413
427			2245		399
431	011		0930		790
434	↓		1030		793
440			1130		790
444			1230		767
447	010		1137		2713
450	↓		1237		2757
457			1337		5438
461			1437		2741
465			1537		2728
	SITE # 2				
1	006	5/19	0000	Dry Weather	148

TABLE B-4
(Cont)

TDS RESULTS IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
4	006	5/9	0130	Dry Weather	140
7			0300		103
10			0430		131
14			0630		109
15	007		0000		126
18			0130		143
21			0300		124
24			0430		155
28			0630		87
39	015	5/10	1000		128
41	010A	5/9	0000		100
44			0100		122
50			0200		76
53			0300		106
59			0400		104
62			0500		116
68			0600		109
75	004		0000		144
78			0030		145
81			0100		153
84			0130		142
90			0230		164
97			0330		179
103			0430		151
109			0530		156
118	006	5/10	0000		109
122			0200		102
126			0630		126
127	007		0000		245
132			0230		140
136			0430		108

TABLE B-4

(Cont)

TDS RESULTS IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
140	007	5/10	0630	Dry Weather	102
141	004		0000		160
144			0030		140
150			0130		134
159			0300		205
168			0430		150
177			0600		144
184	010A		0000		93
197			0300		117
205			0500		98
211			0600		102
219	015		1845		130
237	002	5/18	1340		137
238			1615		91
239	008		1125		163
242			1410		172
245			1550		112
248	009		1140		138
251			1400		116
254			1545		119
261	015		1050		103
268	006		1030		138
271			1200		143
274			1330		152
277			1500		159
278	007		1030		66
281			1200		118
284			1330		54
287			1500		88
291			1700		92

TABLE B-4

(Cont)

TDS RESULTS IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
292	004	5/18	1030	Dry Weather	113
295	↓	↓	1100	↓	126
298			1130		114
301			1200		187
304			1230		187
307			1300		185
310			1330		193
313			1400		169
316			1430		132
319			1500		166
322			1530		189
325			1600		163
328	↓		1630		156
331			1700		162
335	010A		1030		108
338	↓		1130		125
344			1230		104
346			1330		99
351			1430		94
354	↓		1530		97
363	010B		1030		89
366	↓		1130		108
371			1230		133
374			1330		89
379			1430		108
382			1530		95
387	↓	↓	1630	↓	93
390	006	6/9	0930	Storm #1	301
393	↓	↓	1015	↓	228
396			1100		186
400	↓	↓	1200	↓	324

TABLE B-4
(Cont)

TDS RESULTS IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
403	006	6/9	1245	Storm #1	218
404	007	↓	0930		107
412	↓	↓	1130	↓	193
416	↓	↓	1230	↓	129
418	004	↓	0930	↓	171
430	↓	↓	1030	↓	184
442	↓	↓	1130	↓	202
454	↓	↓	1230	↓	201
460	007	↓	1330	↓	344
463	↓	↓	1500	↓	108
466	↓	↓	1630	↓	288
469	↓	↓	1800	↓	418
473	↓	↓	2000	↓	325
474	004	↓	1345	↓	305
483	↓	↓	1515	↓	326
492	↓	↓	1645	↓	359
501	↓	↓	1815	↓	254
513	↓	↓	2015	↓	276
517	010A	↓	0930	↓	173
525	↓	↓	1030	↓	211
533	↓	↓	1130	↓	253
540	↓	↓	1230	↓	212
552	010B	↓	1030	↓	239
568	010B	↓	1230	↓	185
572	012	↓	0930	↓	245
582	↓	↓	1030	↓	307
592	↓	↓	1130	↓	316
596	↓	↓	1200	↓	431
602	↓	↓	1230	↓	423
607	↓	↓	1430	↓	222
617	↓	↓	1950		546

TABLE B-4
(Cont)

TDS RESULTS IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
754	009	6/9	2315	Storm #1	172
757	011		1045		389
760			1205		516
764			1520		299
766			2025		681
769	006		2215		191
772			2345		190
783	007	6/9	2200		143
787		610	0000		155
791			0200		196
796			0430		240
842	013	6/9	1100		601
846			1150		873
850			1530		884
854			1650		1353
858			1945		1690
861	014		1115		430
868			1540		232
874			1935		496
877			2050		524
884	015	6/10	1145		150
887		6/9	2235		215
891	004		2225		233
894			2255		233
903		6/10	0025		213
912			0155		223
921			0325		222
933	010A		0000		186
941			0200		164
946			0300		158

TABLE B-4

(Cont)

TDS RESULTS IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
953	010A	6/10	0500	Storm #1	197
956	007		1516		207
960			1716		184
962			1816		232
966			2016		175
970	006		1500		285
972			1600		173
976			1800		171
980			2000		158
984	010B	6/9	2300		158
987		6/10	0000		138
994			0200		182
1001			0400		179
1011			1650		154
1018			1850		152
1029			2150		137
1032	010A		1550		165
1035			1650		175
1046			1950		158
1053			2150		138
1056	004		1440		231
1080			1840		190
1095			2110		253
1098	007	6/20	1545	Storm #2	172
1100			1615		157
1102			1645		196
1104			1715		352
1108			1815		192
1112			1915		186
1116			2015		144
1120			2115		361

TABLE B-4

(Cont)

TDS RESULTS IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
1124	007	6/20	2215	Storm #2	332
1127	010B		1610		146
1135			1710		158
1138			1740		161
1143			1810		191
1151			1910		185
1154	006		1545		490
1156			1615		199
1158			1645		231
1160			1715		251
1164			1815		226
1168			1915		213
1172			2015		190
1176			2115		190
1180			2215		253
1182	004		1545		188
1185			1600		164
1188			1615		174
1191			1630		164
1194			1645		176
1197			1700		170
1200			1715		160
1206			1745		167
1212			1815		188
1219			1845		195
1222			1900		180
1226	007	6/21	0100		270
1230			0300		205
1234			0500		225
1238			0700		201
1242			0900		271

TABLE B-4
(Cont)

TDS RESULTS IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	TDS Concentration, mg/ℓ
1246	007	6/21	1100	Storm #2	182
1252	006	↓	0115	↓	147
1256	↓	↓	0315	↓	153
1260	↓	↓	0515	↓	145
1268	↓	↓	0915	↓	149
1272	↓	↓	1115	↓	146
1276	012	6/20	1530	↓	372
1279	↓	↓	1600	↓	370
1284	↓	↓	1630	↓	378
1286	↓	↓	1700	↓	350
1303	004	6/21	0115	↓	203
1315	↓	↓	0315	↓	264
1327	↓	↓	0515	↓	218
1339	↓	↓	0715	↓	217
1343	010B	6/20	2345	↓	186
1354	↓	6/21	0245	↓	190
1359	↓	↓	0345	↓	216
1362	↓	↓	0445	↓	200
1370	002	6/20	1540	↓	112
1371	↓	↓	1555	↓	132
1372	↓	↓	1650	↓	156
1373	003	↓	1535	↓	106
1374	↓	↓	1550	↓	93
1375	↓	↓	1635	↓	98
1376	↓	↓	1645	↓	104
1377	005	↓	1535	↓	69
1378	↓	↓	1550	↓	59
1380	013	↓	1525	↓	355
1384	014	↓	1530	↓	398
1387	↓	↓	1600		416

TABLE B-5

TOTAL IRON RESULTS, IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	Total Iron Concentration, mg/ℓ
	SITE #1				
7	011	3/24	1100	Storm #1	0.96
20	011	↓	1400	↓	1.0
31	010	↓	1000	↓	3.6
40	↓	↓	1200	↓	2.6
61	↓	↓	1600	↓	2.3
79	009A	3/28	0115	Storm #2	51.0
90	Coal Pile	3/28	0012	↓	34.0
116	011	3/28	0131	↓	5.3
151	010	3/27	2215	↓	1.2
180	011	3/29	0800	Dry Weather # 1	1.5
200	011	↓	1400	↓	1.1
203	010	↓	0800	↓	1.5
220	↓	↓	1200		1.1
272	↓	4/5	1000	Dry Weather # 2	2.5
288	↓	↓	1400	↓	2.3
313	011	↓	1000	↓	2.7
327	011	↓	1400	↓	2.5
341	Coal Pile	4/16	1140	Storm #5	44.0
348	009A	↓	1040	↓	29.0
357	009A	↓	1205	↓	18.0
380	011	↓	1138	↓	3.7
386	↓	↓	1239	↓	3.5
391	↓	↓	1423	↓	3.7
402	↓	↓	2223		1.7
430	↓	4/18	0930	Dry Weather # 3	1.9
433	↓	↓	1030	↓	1.7
439	↓	↓	1130	↓	2.6
443		↓	1230		1.5

TABLE B-5
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Total Iron Concentration, mg/ℓ
448	010	4/18	1137	Dry Weather #3	8.3
451			1237		4.2
	SITE #2				
38	015	5/10	1000	Dry Weather	0.57
60	010A	5/9	0400		0.72
79	004		0030		0.57
110			0530		0.51
145		5/10	0030		0.20
200	010A		0300		0.57
240	008	5/18	1125		1.5
243			1410		2.2
246			1550		1.0
249	009		1140		0.78
255			1545		1.4
258	015		1050		0.26
266			1630		0.47
293	004		1030		1.2
302			1200		0.47
311			1330		0.26
320			1500		0.26
329			1630		1.2
337	010A		1030		1.3
361			1630		0.82
381	010B		1430		1.5
419	004	6/9	0930	Storm #1	2.2
431			1030		0.25
443			1130		0.28
455			1230		0.96
475			1345		0.35
484			1515		0.30
493			1645		0.29
502			1815		0.30
514			2015		0.18

TABLE B-5
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Total Iron Concentration, mg/ℓ
519	010A	6/9	0930	Storm #1	3.4
527	↓	↓	1030	↓	1.5
542	↓	↓	1230	↓	1.1
546	010B	↓	0930	↓	5.9
554	↓	↓	1030	↓	3.7
562	↓	↓	1130	↓	1.3
570	↓	↓	1230	↓	1.1
573	012	↓	0930	↓	26.0
583	↓	↓	1030	↓	25.0
593	↓	↓	1130	↓	6.0
603	↓	↓	1230	↓	1.5
608	↓	↓	1430	↓	3.4
618	↓	↓	1950	↓	6.5
662	010A	↓	1515	↓	5.9
669	↓	↓	1715	↓	1.5
676	↓	↓	1915	↓	1.1
684	↓	↓	2115	↓	1.6
687	010B	↓	1515	↓	225.0
695	↓	↓	1715	↓	1.1
703	↓	↓	1915	↓	1.2
735	008	↓	1030	↓	7.5
737	↓	↓	1215	↓	2.8
740	↓	↓	1605	↓	3.0
743	↓	↓	2315	↓	7.2
746	009	↓	1035	↓	4.2
749	↓	↓	1230	↓	5.2
752	↓	↓	1615	↓	3.0
755	↓	↓	2315	↓	3.6
759	011	↓	1045	↓	11.0
765	↓	↓	1520	↓	25.0
843	013	↓	1100	↓	5.7
852	↓	↓	1530	↓	27.0
859	↓	↓	1945	↓	0.82
862	014	↓	1115	↓	6.7
865	↓	↓	1145	↓	1.5

TABLE B-5
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Total Iron Concentration, mg/ℓ
869	014	6/9	1540	Storm #1	14.0
875	↓		1935	↓	0.95
878	↓		2050		3.2
881	015		1010		0.89
888	↓		2235		0.95
892	004		2225		0.68
895	↓	↓	2255		0.45
904		6/10	0025		0.68
913		↓	0155		0.40
922	↓		0325		0.38
940	010A		0100		1.1
948	↓		0300		1.3
955	↓		0500		0.93
1000	010B		0300		0.74
1007	↓		0500		0.80
1010			1550		0.93
1017			1750		0.90
1031	↓		2150		1.2
1034	010A		1550		0.98
1041	↓		1750		1.0
1048	↓		1950		1.1
1057	004		1440		0.29
1081	↓		1840	↓	0.22
1096	↓	↓	2110		1.2
1129	010B	6/20	1610	Storm #2	5.9
1183	004	↓	1545	↓	1.3
1186	↓		1600		0.18
1189			1615		0.35
1192			1630		0.41
1207			1745		0.22
1223	↓		1900		0.38
1277	012	↓	1530	↓	5.7
1285	↓		1630		18.0

TABLE B-5
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Total Iron Concentration, mg/ℓ
1316	004	6/21	0315	Storm #2	0.31
1340	↓	↓	0715		0.56
1345	010B	6/20	2345		1.6
1381	013		1525		16.0
1385	014		1530		11.0
1388	↓		1600	↓	3.2
1393	015	↓	1640		0.65

TABLE B-6

DISSOLVED IRON RESULTS, IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE 1977

Sample No.	Outfall	Date	Time	Sampling Event	Dissolved Iron Concentration, mg/ℓ
	SITE #1				
8	011	3/24	1100	Storm #1	0.1
89	009A	3/27	2100	Storm #2	0.1
120	011	3/28	0225	↓	0.1
147	010	3/27	2100	↓	0.2
167	010	3/28	0145	↓	0.1
183	011	3/29	0900	Dry Weather #1	0.1
207	010	↓	0900	↓	0.1
217	↓	↓	1100	↓	0.1
269	↓	4/5	0900	Dry Weather #2	0.6
287	↓	↓	1300	↓	0.6
311	011	↓	0900	↓	0.1
324	011	↓	1300	↓	0.1
344	Coal Pile	4/16	1155	Storm #5	0.5
352	009A	↓	1125	↓	0.1
361	009A	↓	1415	↓	0.1
379	011	↓	1138	↓	0.3
388	↓	↓	1423	↓	0.1
403	↓	↓	2223	↓	0.2
432	↓	4/18	1030	Dry Weather #3	0.1
441	↓	↓	1230	↓	0.1
449	010	↓	1237	↓	0.4
	SITE #2				
54	010A	5/9	0300	Dry Weather	0.1
80	004	↓	0030	↓	0.2
111	↓	↓	0530	↓	0.1
146	↓	5/10	0030	↓	n.d.(a)
190	010A		0100	↓	0.1
207	↓		0500		0.1

TABLE B-6
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Dissolved Iron Concentration, mg/ℓ
241	008	5/18	1125	Dry Weather	0.3
247	↓	↓	1550	↓	0.1
250	009	↓	1140	↓	0.3
256	↓	↓	1545	↓	0.1
260	015	↓	1050	↓	0.1
265	↓	↓	1630	↓	0.1
294	004	↓	1030	↓	n.d.(a)
303	↓	↓	1200	↓	0.1
312	↓	↓	1330	↓	0.1
321	↓	↓	1500	↓	n.d.(a)
330	↓	↓	1630	↓	0.1
339	010A	↓	1130	↓	0.1
347	↓	↓	1330	↓	0.1
385	010B	↓	1530	↓	0.2
420	004	6/9	0930	Storm #1	0.1
432	↓	↓	1030	↓	0.1
444	↓	↓	1130	↓	0.1
456	↓	↓	1230	↓	0.1
476	↓	↓	1345	↓	0.1
485	↓	↓	1515	↓	0.1
494	↓	↓	1645	↓	0.1
503	↓	↓	1815	↓	0.1
515	↓	↓	2015	↓	0.2
531	010A	↓	1100	↓	0.1
550	010B	↓	1000	↓	0.1
558	↓	↓	1100	↓	n.d.(a)
566	↓	↓	1200	↓	0.1
577	012	↓	1000	↓	0.1
587	↓	↓	1100	↓	0.6
597	↓	↓	1200	↓	0.1
612	↓	↓	1710	↓	0.1
666	010A	↓	1615	↓	0.2
673	↓	↓	1815	↓	0.3

TABLE B-6
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Dissolved Iron Concentration, mg/ℓ
681	010A	6/9	2015	Storm #1	0.3
692	010B		1615		n.d.(a)
700			1815		0.2
708			2015		0.1
736	008		1030		0.1
738			1215		0.7
741			1605		0.1
744			2315		0.1
747	009		1035		0.4
750			1230		0.2
753			1615		0.2
756			2315		0.2
763	011		1205		0.2
768			2025		0.2
849	013		1150		0.9
863	014		1115		0.9
867			1145		1.2
876			1935		0.3
879			2050		0.2
883	015		1010		0.3
890			2235		0.4
893	004		2225		0.1
905		6/10	0025		0.2
914			0155		0.6
937	010A		0000		0.1
952			0400		0.1
990	010B		0000		0.1
1004			0400		0.3
1014			1650		0.1
1024			1950		1.1
1038	010A		1650		0.1
1052			2050		0.4
1058	004		1440		0.1
1082			1840		0.1

TABLE B-6

(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Dissolved Iron Concentration, mg/ℓ
1097	004	6/10	2110	Storm #1	0.3
1133	010B	6/20	1640	Storm #2	0.1
1184	004	↓	1545	↓	0.1
1187	↓	↓	1600	↓	0.1
1190	↓	↓	1615	↓	0.1
1208	↓	↓	1745	↓	0.1
1224	↓	↓	1900	↓	0.1
1281	012	↓	1600	↓	0.1
1289	↓	↓	1700	↓	0.1
1317	004	6/21	0315	↓	0.1
1382	013	6/20	1525	↓	1.1
1386	014	↓	1530	↓	0.2
1389	↓	↓	1600	↓	0.3
1394	015	↓	1640	↓	0.1

a) n.d. - not detectable. Detectable limit is 0.02 mg/1.

TABLE B-7
PHENOL RESULTS, IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE, 1977

Sample No.	Outfall	Date	Time	Sampling Event	Phenol Concentration, mg/ℓ
	SITE #1				
1	011	3/24	1000	Storm #1	0.52
9			1200		0.01
19			1400		0.05
27		3/24	1600		0.01
30	010		1000		0.21
39			1200		0.03
48			1400		0.93
60			1600		0.44
77	009A	3/28	0115	Storm #2	0.04
96	Coal Pile	3/28	0030		0.85
109	011	3/27	2306		0.04
115		3/28	0131		0.06
122		3/28	0333		0.05
146	010	3/27	2100		0.05
155		3/27	2225		1.1
164		3/28	0145		0.02
178	011	3/30	1000		0.02
179		3/29	0800	Dry Weather #1	0.05
199			1400		0.06
265	010	4/5	0900	Dry Weather #2	31.0
283	010		1300		34.0
308	011		0900		0.68
315	011	4/5	1100		0.05
322	011		1300		0.05
334	Coal Pile	4/16	1140	Storm #5	0.13
335	Coal Pile		1155		0.18
340	009A	4/16	1205		0.09
360	009A		1415		0.06
375	011		0842		0.06
384			1239		0.10
406		4/17	0742		0.04
428		4/18	0930	Dry Weather #3	0.03
437			1130		0.02
445	010		1137		25.0
454			1337		16.0
462			1537		23.0

TABLE B-7
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Phenol Concentration, mg/ℓ
	SITE #2				
35	015	5/10	1000	Dry Weather	0.02
40	010A	5/9	0000		0.01
58			0400		n.d. (a)
183		5/10	0000		0.01
215	015		1845		n.d. (a)
262		5/18	1050		n.d. (a)
264			1630		n.d. (a)
334	010A		1030		0.01
350			1430		n.d. (a)
362	010B		1030		0.01
386			1630		n.d. (a)
516	010A	6/9	0930	Storm #1	0.01
524			1030		0.01
539			1230		0.01
543	010B		0930		0.01
551			1030		0.01
559			1130		0.06
567			1230		0.01
571	012		0930		0.01
581			1030		0.01
591			1130		0.01
601			1230		0.01
606			1430		0.03
616			1950		0.02
622	015		1010		0.01
624			2235		0.01
626		6/10	1145		0.01
627	011	6/9	1045		0.01
628			1205		0.02
629			1520		0.01
630			2025		n.d. (a)
631	013		1100		0.04
632			1150		0.04
633			1530		0.04

TABLE B-7
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Phenol Concentration, mg/ℓ
634	013	6/9	1650	Storm #1	0.02
635			1945		0.01
636	010A		1515		0.01
637			1715		0.01
639			2115		0.02
640	010B		1515		0.02
642			1915		0.01
645		6/10	0100		0.01
647			0500		n.d. (a)
648	010A	6/9	2300		0.01
649			0100		0.01
650			0300		0.01
651			0500		n.d. (a)
653			1750		0.01
656	010B		1550		n.d. (a)
658			1950		0.01
1126		6/20	1610	Storm #2	n.d. (a)
1142			1810		0.01
1150			1910		n.d. (a)
1275	012		1530		0.12
1283			1630		0.02
1290			1730		0.01
1297			1830		0.19
1342	010B		2345		0.02
1358		6/21	0345		n.d. (a)
1366			0545		n.d. (a)
1379	013	6/20	1525		0.04
1390	015		1640		0.03

(a) n.d. - not detectable. Detectable limit is 0.001 mg/ℓ.

TABLE B-8

CYANIDE RESULTS, IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE, 1977

Sample No.	Outfall	Date	Time	Sampling Event	Cyanide Concentration, mg/ℓ
	SITE #1				
6	011	3/24	1100	Storm #1	n.d. (a)
25	011		1500	↓	n.d
37	010		1100		n.d
51	↓		1400		n.d
54			1500		n.d.
82	009A	3/27	2225	Storm #2	n.d.
87	009A	3/27	2100	↓	n.d.
95	Coal Pile	3/28	0125		n.d.
113	011	3/28	0022		n.d.
121	↓	3/28	0225		n.d.
126		3/28	1100		n.d.
153	010	3/27	2215		n.d.
162	↓	3/28	0040		n.d.
171		3/28	0445		n.d.
184	011	3/29	0900	Dry Weather #1	n.d.
198	011		1300	↓	n.d.
205	010		0900		n.d.
222	↓		1300		n.d.
273		4/5	1000	Dry Weather #2	0.99
289			1400	↓	0.56
312	011		1000		n.d.
326	011		1400		n.d.
343	Coal Pile	4/16	1140	Storm #5	0.17
356	009A		1125	↓	0.03
362	009A		1415		0.01
383	011		1138		n.d.
389	011		1423		0.01
	SITE #2				
47	010A	5/9	0100	Dry Weather	0.01
55	↓		0300	↓	0.01

TABLE B-8
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Cyanide Concentration, mg/ℓ
189	010A	5/10	0100	Dry Weather	0.01
259	015	5/18	1050		0.01
267			1630		0.01
340	010A		1130		0.01
348			1330		0.01
367	010B		1130		0.01
383			1530		n.d.
521	010A	6/9	1000	Storm #1	0.01
529			1100		0.01
536			1200		0.01
548	010B		1000		0.02
556			1100		0.01
578	012		1000		0.22
588			1100		0.10
613			1710		0.3
664	010A		1615		0.01
671			1815		0.01
678			2015		0.01
690	010B		1615		0.02
698			1815		0.01
705			2015		0.01
848	013		1150		0.38
856			1650		0.72
935	010A	6/10	0000		0.01
942			0200		0.01
950			0400		0.01
988	010B		0000		0.01
995			0200		0.01
1002			0400		0.01
1012			1650		0.01
1019			1850		n.d.
1026			2050		0.01
1036	010A		1650		0.01
1050			2050		0.01

TABLE B-8
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Cyanide Concentration, mg/ℓ
1131	010B	6/20	1640	Storm #2	0.01
1139	↓		1740		0.01
1282	012		1600		0.29
1287			1700		0.09
1294	↓	↓	1800		0.17
1347	010B	6/21	0045		0.01
1355			0245		0.01
1363	↓	↓	0445		0.01
1392	015	6/20	1640	↓	0.01

(a) n.d. - not detectables. Detectable limit is 0.001 mg/ℓ.

TABLE B-9

AMMONIA RESULTS, IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE, 1977

Sample No.	Outfall	Date	Time	Sampling Event	Ammonia Concentration, mg/ℓ
	SITE #1				
2	011	3/24	1040	Storm #1	1.7
10			1200		1.5
14			1300		1.6
23			1500		1.1
34	010		1100		47.0
43	010		1300		52.0
84	009A	3/27	2225	Storm #2	3.5
88	009A	3/27	2100		0.23
92	Coal Pile	3/28	0012		84.0
111	011	3/27	2306		1.4
117		3/28	0131		2.0
131		3/28	1200		28.0
148	010	3/27	2100		73.0
157		3/27	2225		55.0
165		3/28	0145		3.6
182	011	3/29	0900	Dry Weather #1	20.0
190			1100		21.0
197			1300		26.0
206	010		0900		54.0
221			1300		56.0
266		4/5	0900	Dry Weather #2	96.0
284			1300		87.0
309	011		0900		4.9

TABLE B-9

AMMONIA RESULTS, IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE, 1977

Sample No.	Outfall	Date	Time	Sampling Event	Ammonia Concentration, mg/ℓ
	SITE #1				
2	011	3/24	1040	Storm #1	1.7
10			1200		1.5
14			1300		1.6
23			1500		1.1
34	010		1100		47.0
43	010		1300		52.0
84	009A	3/27	2225	Storm #2	3.5
88	009A	3/27	2100		0.23
92	Coal Pile	3/28	0012		84.0
111	011	3/27	2306		1.4
117		3/28	0131		2.0
131		3/28	1200		28.0
148	010	3/27	2100		73.0
157		3/27	2225		55.0
165		3/28	0145		3.6
182	011	3/29	0900	Dry Weather #1	20.0
190			1100		21.0
197			1300		26.0
206	010		0900		54.0
221			1300		56.0
266		4/5	0900	Dry Weather #2	96.0
284			1300		87.0
309	011		0900		4.9

TABLE B-9
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Ammonia Concentration, mg/ℓ
	SITE #1				
323	011	4/5	1300	Dry Weather #2	5.0
346	Coal Pile	4/16	1155	Storm #5	27.0
351	009A		1040		2.0
359	009A		1205		2.6
377	011		0842		1.3
385			1239		0.66
392			1423		0.77
405			2223		0.87
408		4/17	0742		0.65
429		4/18	0930	Dry Weather #3	0.57
436			1030		1.2
438			1130		1.1
442			1230		1.0
446	010		1137		66.0
453			1237		74.0
455			1337		56.0
460			1437		84.0
463			1537		82.0
	SITE #2				
32	015	5/9	1130	Dry Weather	6.0
42	010A		0000		5.2
56			0300		86.0
195		5/10	0200		4.8
336		5/18	1030		5.2

TABLE B-9
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Ammonia Concentration, mg/ℓ
	SITE #2				
349	010A	5/18	1330	Dry Weather	3.8
360			1630		5.7
380	010B		1430		7.1
518	010A	6/9	0930	Storm #1	0.36
526			1030		0.70
534			1130		0.49
541			1230		0.45
545	010B		0930		0.88
553			1030		1.3
569			1230		0.60
574	012		0930		0.41
584			1030		1.0
594			1130		0.79
604			1230		0.73
609			1430		0.56
661	010A		1515		0.17
668			1715		0.10
675			1915		0.22
683			2115		0.21
686	010B		1515		0.28
694			1715		0.10
702			1915		0.12
710			2115		0.10
762	011		1205		0.23
767			2025		0.43
845	013		1100		31.0
853			1530		39.0
882	015		1010		0.20
886			1145		0.39
889			2235		0.51
931	010A		2300		0.12

TABLE B-9
(Cont)

Sample No.	Outfall	Date	Time	Sampling Event	Ammonia Concentration, mg/ℓ
	SITE #2				
944	010A	6/10	0200	Storm #1	0.23
954			0500		0.33
985	010B	6/9	2300		0.11
992		6/10	0100		0.50
999			0300		0.10
1006			0500		0.10
1009			1550		0.15
1016			1750		0.15
1023			1950		0.10
1030			2150		0.15
1033	010A		1550		0.14
1040			1750		0.10
1051			2050		0.10
1128	010B	6/20	1610	Storm #2	4.1
1132			1640		1.2
1136			1710		0.50
1140			1740		1.6
1144			1810		0.39
1152			1910		0.40
1280	012		1600		1.3
1288			1700		1.6
1295			1800		1.6
1344	010B		2345		0.18
1356		6/21	0245		0.18
1364			0445		0.23
1383	013	6/20	1525		18.0
1395	015		1640		0.28

TABLE B-10

SULFATE RESULTS, IN mg/ℓ
SITES #1 AND #2
MARCH - JUNE, 1977

Sample No.	Outfall	Date	Time	Sampling Event	Sulfate Concentration, mg/ℓ
	SITE #1				
36	010	3/24	1100	Storm #1	270
41			1200		303
46			1300		260
55			1500		303
149		3/27	2100	Storm #2	490
152		3/27	2215		380
166		3/28	0145		180
204		3/29	0800	Dry Weather #1	560
211		3/29	1000		488
219			1200		1330
227		3/29	[illegible]		[illegible]
267		4/5	0900	Dry Weather #2	400
276		4/5	1100		450
285			1300		1580
294		4/5	1500		475
	SITE #2				
218	015	5/10	1845	Dry Weather	20
257		5/18	1050		20
263			1630		20
575	012	6/9	0930	Storm #1	68
580			1000		70
585			1030		79
595			1130		100
605			1230		128
610			1430		52
615			1710		54
620			1950		70
758	011		1045		195
761			1205		270
844	013		1100		160
851			1530		190
855			1650		36
1278	012	6/20	1530	Storm #2	85
1380	013		1525		128

APPENDIX C

CALCULATIONS FOR TABLES 7-2 THROUGH 7-5

CALCULATIONS FOR TABLES 7-2 THROUGH 7-5

Example: Site #1 Outfall 011

Operations: 1/2 of Coke Ovens and Coke By-Products Area

Production: $(1{,}079\ \frac{\text{ton}}{\text{day}}\ \text{coke})\ (\frac{365\ \text{days}}{1\ \text{year}})\ (0.5) = 2.0 \times 10^5\ \frac{\text{tons coke}}{\text{year}}$

This assumes that if one half of the operation is located in the basin, then one half of the production from this operation will take place in the basin.

REGULATIONS FOR BY-PRODUCT COKE SUBCATEGORY (BAT)

Effluent Characteristic	Maximum for Any One Day kg/kkg (lb/1000 lb) of Product	Average of Daily Values for Thirty Consecutive Days Shall Not Exceed
Cyanide A	0.0003	0.0001
Phenol	0.0006	0.0002
Ammonia	0.0126	0.0042
TSS	0.0312	0.0104

Thirty day average effluent limitations will be used.

Parameter		Average Annual Loadings from Operations
Cyanide A:	$(0.0001\ \text{lb}/1000\ \text{lb coke})\ (\frac{2000\ \text{lb}}{1\ \text{ton}})\ (2.0 \times 10^5\ \frac{\text{tons coke}}{\text{year}}) =$	40 lb/year (18 kg/year)
Phenol:	$(0.0002\ \text{lb}/1000\ \text{lb coke})\ (\frac{2000\ \text{lb}}{\text{ton}})\ (2.0 \times 10^5\ \frac{\text{tons coke}}{\text{year}}) =$	80 lb/year (36 kg/year)
Ammonia:	$(0.0042\ \text{lb}/1000\ \text{lb coke})\ (\frac{2000\ \text{lb}}{1\ \text{ton}})\ (2.0 \times 10^5\ \frac{\text{tons coke}}{\text{year}}) =$	1700 lb/year (800 kg/year)

Parameter	Average Annual Loadings from Operations
TSS: $(0.0104 \text{ lb}/1000 \text{ lb coke}) \left(\frac{2000 \text{ lb}}{1 \text{ ton}}\right) \left(2.0 \times 10^5 \frac{\text{tons coke}}{\text{year}}\right) =$	4100 lb/year 1850 kg/year

Acreage = 70.5

Average annual rainfall = 52 inches/year (132 cm/year)

Average runoff coefficient = 0.25

$$\left(52 \frac{\text{inches rain}}{\text{year}}\right) \left(\frac{1 \text{ ft}}{12 \text{ inches}}\right) (70.5 \text{ acres}) \left(\frac{3.259 \times 10^5 \text{ gal}}{1 \text{ acre-ft}}\right) =$$

$$1.0 \times 10^8 \frac{\text{gal rain}}{\text{year}} \quad \left(\frac{3.8 \times 10^8 \ \ell}{\text{year}}\right)$$

$$\frac{\text{Runoff}}{\text{Rainfall}} = \text{Runoff coefficient}$$

$$\frac{\text{Runoff}}{1.0 \times 10^8 \text{ gal/year}} = 0.25. \quad \text{Thus Runoff} = 2.5 \times 10^7 \frac{\text{gal}}{\text{year}} \quad \left(9.4 \times 10^7 \frac{\ell}{\text{year}}\right)$$

Parameter	Mean Runoff Concentration from Table 5-9, mg/ℓ
TSS	35.0
Ammonia	3.4
Phenol	0.086
Cyanide	0.002

Parameter	Average Annual Loadings from Runoff
TSS: $\left(2.5 \times 10^7 \frac{\text{gal}}{\text{year}}\right) \left(\frac{3.785 \ \ell}{1 \text{ gal}}\right) (35 \text{ mg}/\ell) \left(\frac{1 \text{ kg}}{10^6 \text{ mg}}\right) \left(\frac{2.2 \text{ lb}}{1 \text{ kg}}\right) =$	7290 lb/year (3315 kg/year)

Parameter		Average Annual Loading from Runoff
Ammonia:	$(2.5 \times 10^7 \frac{gal}{year}) (\frac{3.785\ \ell}{1\ gal}) (3.4\ mg/\ell)$	
	$(\frac{1\ kg}{10^6\ mg}) (\frac{2.2\ lb}{1\ kg}) =$	700 lb/year (300 kg/year)
Phenol:	$(2.5 \times 10^7 \frac{gal}{year}) (\frac{3.785\ \ell}{1\ gal}) (0.086\ mg/\ell)$	
	$(\frac{1\ kg}{10^6\ mg}) (\frac{2.2\ lbs}{1\ kg}) =$	20 lb/year (9.0 kg/year)
Cyanide:	$(2.5 \times 10^7 \frac{gal}{year}) (\frac{3.785\ \ell}{1\ gal}) (0.002\ mg/\ell)$	
	$(\frac{1\ kg}{10^6\ mg}) (\frac{2.2\ lbs}{1\ kg}) =$	0.4 lb/year (0.2 kg/year)

Parameter	Average Annual Loading from Operations Based on BAT Effluent Limitations, kg/yr (lb/yr)	Average Annual Loading from Runoff, kg/yr (lb/yr)
TSS	1850 (4100)	3315 (7290)
Cyanide*	18 (40)	0.2 (0.4)
Ammonia	800 (1700)	300 (700)
Phenol	36 (80)	9.0 (20)

*Cyanide A

Parameter	Average Annual Loading from Operations Based on 30 Day BAT Effluent Guidelines, kg/yr (lb/yr)	Average Hourly* Loadings for Operations Based on 30 Day BAT Effluent Guidelines, kg/hr (lb/hr)
TSS	1850 (4100)	0.2 (0.4)
Cyanide**	18 (40)	0.002 (0.004)
Ammonia	800 (1700)	0.08 (0.18)
Phenol	36 (80)	0.004 (0.008)

*All values calculated as follows: TSS: $(\frac{1850\ kg}{year}) (\frac{1\ year}{365\ days}) (\frac{1\ day}{24\ hours}) = 0.2\ \frac{kg}{hr}$

**Cyanide A.

Parameter	Average Hourly Loadings* Based on Maximum 1 Day BAT Effluent Guidelines, kg/hr (lb/hr)
TSS	0.6 (1.3)
Cyanide**	0.01 (0.02)
Ammonia	0.25 (0.55)
Phenol	0.01 (0.02)

*All values calculated as follows:

$$\text{TSS:}\quad \left(2.0 \times 10^{5}\ \frac{\text{tons coke}}{\text{year}}\right)\left(\frac{1\ \text{year}}{365\ \text{days}}\right)\left(\frac{1\ \text{day}}{24\ \text{hours}}\right)\left(\frac{2000\ \text{lbs}}{1\ \text{ton}}\right)\left(0.0312\ \frac{\text{lb}}{1000\ \text{lb coke}}\right)\left(\frac{1\ \text{kg}}{2.2\ \text{lb}}\right) = 0.6\ \frac{\text{kg}}{\text{hr}}$$

**Cyanide A

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-79-046	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Assessment of Surface Runoff from Iron and Steel Mills		5. REPORT DATE February 1979
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) G. T. Brookman, B. C. Middlesworth, and J. A. Ripp		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS TRC - The Research Corporation of New England, 125 Silas Deane Highway, Wethersfield, Connecticut 06109		10. PROGRAM ELEMENT NO. 1BB610
		11. CONTRACT/GRANT NO. 68-02-2133, Task 4
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15. SUPPLEMENTARY NOTES IERL-RTP project officer is Norman Plaks, MD-62, 919/541-2733.

16. ABSTRACT The report gives results of a program to determine if surface runoff from iron and steel mills is an environmental problem. It includes a compilation of data available before this program, information gathered from plant tours, and results of a field survey at two fully integrated mills on tidal rivers. Data collected at the two sites indicate that coal/coke storage piles and handling areas have the highest potential for contaminating stormwater. The data also indicate that total suspended solids (TSS) runoff concentrations are typical of urban runoff concentrations, while total dissolved solids (TDS) values are about 1 to 2 times the typical urban runoff concentrations. From plant tours it was found out that current stormwater controls in the steel industry are limited. The only system specifically designed for stormwater control is at Armco's Houston Works, where coal piles have been diked to control both fugitive air emissions and stormwater runoff. Some mills collect stormwater runoff with process wastewater for subsequent treatment at a terminal plant. Methods applicable to the industry include rainfall detention ponding rings for flat roofs, swirl degritters, and retention basins or sedimentation ponds. It was concluded that, except for runoff from coal/coke storage areas, stormwater runoff is not a problem when compared to point source control.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Runoff	Pollution Control	13B	08H
Iron and Steel Industry		Stationary Sources	11F, 05C	
Coal	Coal Storage	Non-Point Sources	08G, 21D	08I
Coke	Dust	Coke Handling		11G
Coal Handling		Coke Storage	15E	
Measurement		Particulate	14D	

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