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MONITORING THE EFFECTS OF A COMBINED SEWER OVERFLOW DISCHARGING TO A SMALL WATERCOURSE IN SOUTH WALES

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MONITORING EFFECTS OF A STORM SEWER OVERFLOW UPON THE NANT FFRWD, SOUTH WALES

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INTRODUCTION

The pollution of watercourses by storm sewage overflows has long been identified as a significant problem (MHLG 1970; SDD 1977). However, at present the mechanisms and processes by which storm sewage overflows impact upon water-courses are still not clearly understood. Furthermore, it has been generally recognised within the Water Industry that if future capital investment in sewerage systems and sewerage rehabilitation is to be both efficient and effective, this understanding needs to be extended. To this end, the Welsh Water Authority (WWA) and Water Research Centre (WRC) have established a detailed investigation into the effects of intermittent discharges from a storm sewage overflow (SSO) on a small river course in South Wales. The study forms part of the larger Water Industry River Basin Management Research Programme described elsewhere (Clifforde et al. 1986), and is designed to identify the conditions under which overflow occurs and the consequent effect upon the Nant Ffrwd, 1.2 km downstream to its confluence. The results are also to be used in the future development of sewer quality and river impact models designed to aid management decisions about the acceptability of such intermittent discharges.

THE STUDY

The Garndiffaith combined sewer overflow, described in Table 1, forms the only significant point-source effluent discharge into the Nant Ffrwd.

TABLE 1 Sewered catchment and chamber characteristics of the Garndiffaith SSO

Catchment Details		Chamber Details	
Population	3000	High sided weir	
Total Area	26.4 ha	Peak Inflow	250 $l\ s^{-1}$
Impermeable Area	9.2 ha	Carry on flow	60 $l\ s^{-1}$
Domestic only		Peak Overflow	190 $l\ s^{-1}$
		Dimensions	7x2.7x1.5 m
		Inlet	530 mm
		Outlet	230 mm

The system under investigation responds rapidly to rainfall, normally within 30 minutes, so that increases in river flow in response to the same rainfall input often lag significantly behind the SSO response (Figure 1).

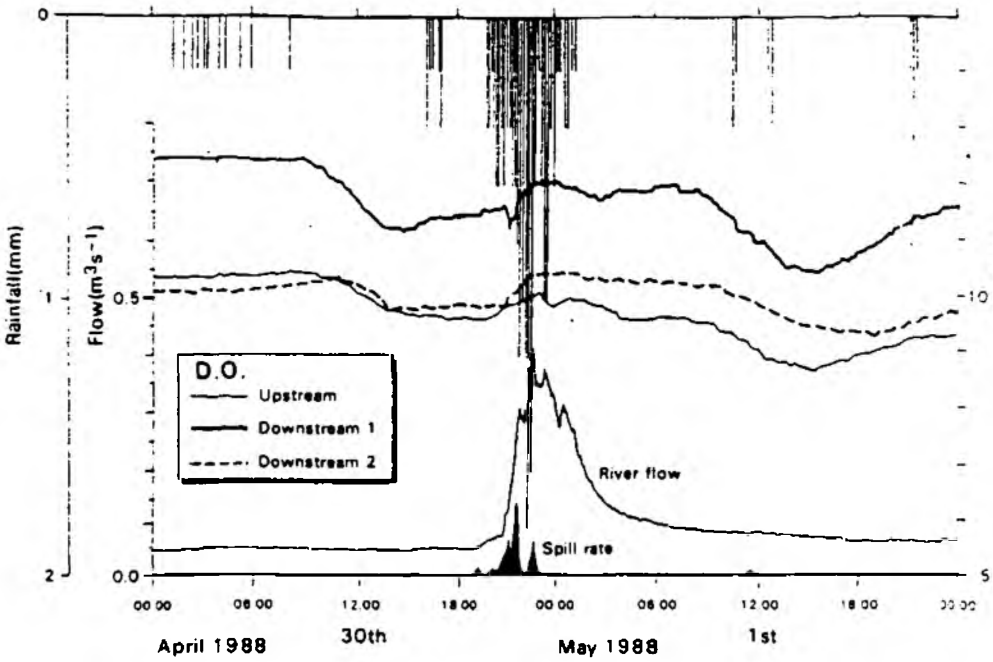

Fig. 1. Typical SSO response timing and D.O. impact

Sampling and Monitoring

At the commencement of a storm event, the rising water level in the overflow chamber activates an Authority designed pressure switch system, which is linked by a programmable controller, to a series of relays. The controller activates sampling at the overflow site, whilst simultaneously triggering via a radio link, samplers located at the upstream and three downstream river sites. Within-chamber quality sensors continuously record pH, temperature, ammonia and dissolved oxygen levels. The river monitoring sites are located: 50m upstream of the SSO, 80m downstream of the SSO, 500m downstream of the SSO and 1.2km downstream at its confluence with the Afon Llwyd. Quality sensors are located at each site. Continuous river flow and rainfall intensity data are gathered in order to provide a comprehensive picture of the consequences of each storm event of interest.

Monitoring work is also being undertaken to examine the impacts on stream biology. This includes the application of novel in-situ macroinvertebrate survival tests involving the exposure of known numbers and species. Fish-egg bioassay tests and fish survival and growth characteristics are also being undertaken.

RESULTS

Early results indicate a range of peak SSO pollutant concentrations of between 20 mg l^{-1} and 200mg l^{-1} BOD_5 depending on whether the spill occurs in the early hours of the morning, or at times of peak dry weather flow strength and/or volume. Correspondingly, ammoniacal nitrogen concentrations vary between 1.0 and 10.0mg l^{-1}. Even during relatively insignificant spills occurring in the early hours, first foul flush concentrations have accorded with observations elsewhere (Pearson et al. 1986). However, these only persist for periods of 10 minutes or less, typical spill durations being of the order of no more than 2 hours in total.

In-stream ammoniacal nitrogen concentrations are increased during every spill (Figure 2), with even minor events causing river concentrations to rise to 0.7mg l^{-1} or more in the first foul flush (insignificant levels being recorded above the SSO). BOD impacts vary more widely with events causing BOD peaks of up to 20mg l^{-1} (Figure 2), as opposed to levels of around 5.0mg l^{-1} or less recorded consistently above the SSO. Clearly other factors such as the antecedent weather conditions, the spill duration, magnitude and timing, all significantly affect the level of impact monitored.

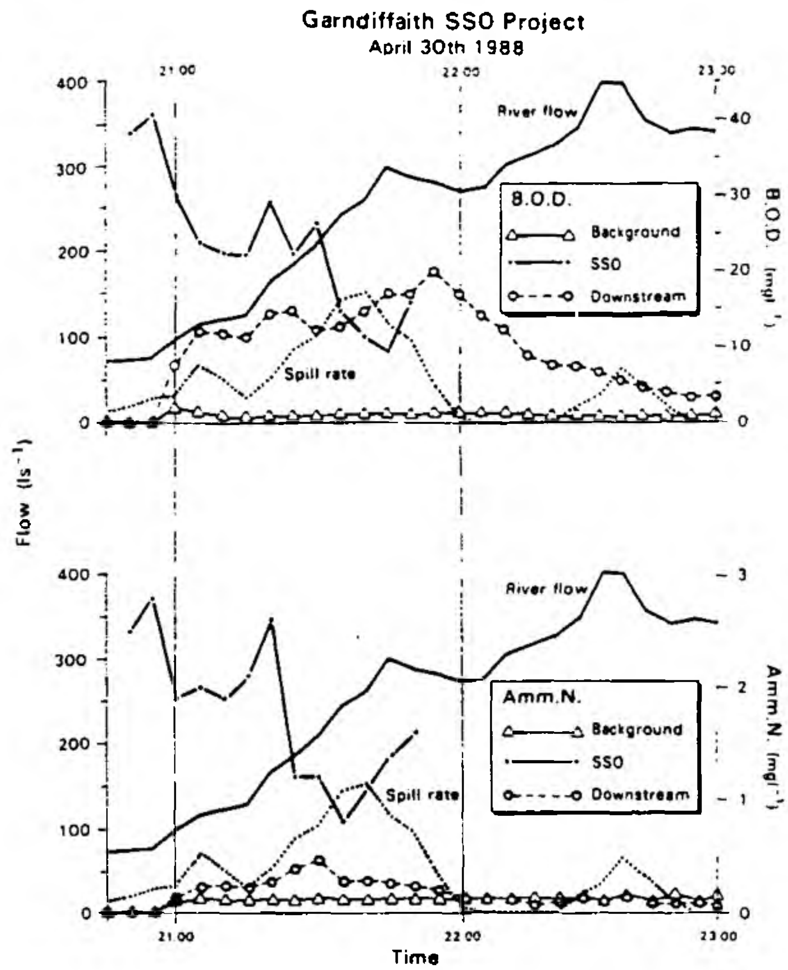

Fig. 2. Typical SSO spill impacts

Interestingly, typical impacts upon river dissolved oxygen levels are minimal and confined to the stretch immediately downstream of the overflow (Figure 1), probably due to the high reaeration and dispersion characteristics of the Nant Ffrwd.

Early survival experiments (July/August 1987) using caged macroinvertebrates, **Gammarus pulex** (freshwater shrimp) and **Ephemera danica** (mayfly), at the four river sites indicated significant mortalities at all downstream sites (of up to 40%), (Figure 3). In all, the indicator species have been studied over three periods to date and Ephemera was found to be the more sensitive species in all cases.

Fisheries investigations to date have included the monitoring of stocked swim-up Danish rainbow trout fry. Survival and growth rates are being determined by repetitive surveys. Fish stocked in April 1987 revealed higher trout densities downstream of the SSO during subsequent surveys. A repeat survey conducted in April 1988 revealed far higher densities ($34/100\ m^2$) immediately above the SSO, compared with below ($16/100\ m^2$). However, there was some suggestion of human interference, although by that time the stocked fish had also been exposed to more than 40 spill events since April 1987. Further stocking in July 1988 again revealed higher densities above than below the SSO, although both sites exhibited excellent populations. Native brown trout density surveys however, indicated poor populations both above and below.

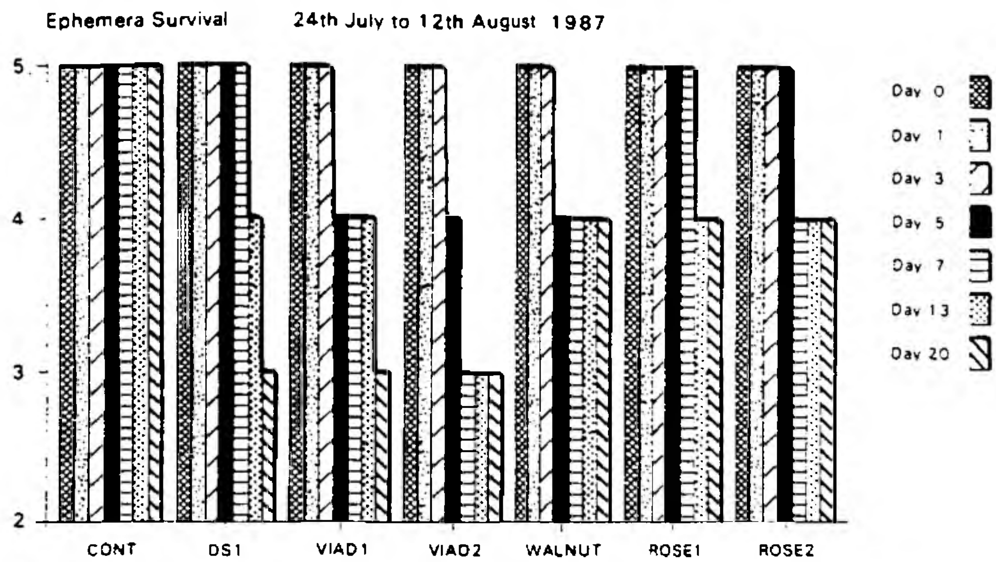

Fig. 3. Some Ephemera survival experiment results

Finally, rainbow trout egg bioassay experiments undertaken in July 1988 revealed no obvious impact specific to the overflow, cumulative mortalities averaging only 25% near the overflow and 46% further downstream. Hence, the impacts of such an SSO spill regime on the resident population remain inconclusive at present.

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MANAGEMENT SUMMARY

SUMMARY

This report summarises the results of a three year study examining the chemical and biological impacts of a combined sewer overflow on its receiving water in South Wales. The high side weir overflow serves a population of around 3,000 and is characterised only by domestic inputs. It discharges into a small highly reaerated stream of NWC Class 2 quality. The study began in 1987 under the control of the Welsh Water Authority, but was completed under the auspices of the National Rivers Authority (Welsh Region) research and development programme. In all 25 spill events were monitored and their impact assessed. The chemical quality of the overflow spill was highly variable with BOD levels averaging 77mgl^{-1}, ammonia 3.7mg^{-1} and suspended solids 462 mgl^{-1}. Broadly, spill quality appeared to reflect crude flow quality, with the most contaminated events occurring in the late afternoon and early evening. The presence of a first foul flush was observed in 36% of all cases. Most of those also exhibited a secondary flush at times of peak spill flow rates. Generally spill rates varied between 30 and 60 is^{-1}, not exceeding 420 ls^{-1}.

Receiving water chemical impacts could be discerned during each spill. However, due to the presence of significant volumes of remobilised coal solids suspended solids impacts were masked. With the benefit of hindsight such a situation that might have been avoided by the selection of an alternative study site given the extended time period required for the residual effects of the "Viponds" development to disappear. In addition, due to the small sewered population (ca.3000) and domestic only nature of the crude flow, ammonia impacts were insignificant, with stream levels rarely rising above 0.5mgl^{-1}. Meanwhile BOD levels exhibited significant increases reaching up to 54 mgl^{-1} in one case. On average BOD levels rose 6.2 mgl^{-1} below the overflow during each spill event. However, no correspondingly significant dissolved oxygen impacts were in evidence, presumably due to the high reaeration capacity of the receiving water. Indeed, complimentary biological and fisheries investigations revealed no significant impact attributable to the study overflow. Hence in this instance, a combination of the steeply sloping nature of the study sewer system and the high assimilative capacity of the receiving water, enable significant amounts of organic matter to be discharged into the receiving water without causing any significant environmental deterioration.

The study has proved the viability of two novel techniques for assessing the potential impacts of intermittent pollution, using fish egg survival and macroinvertebrate survival techniques. Moreover, the reliability of available water quality monitoring equipment has been rigorously assessed, indicating a ca.30% downtime. Thus, it has become clear that sewer flow and quality modelling together with river impact modelling offer the most cost-effective means of assessing the potential pollution risk from sewerage systems. Moreover, routine biological impact assessment techniques offer the most cost-effective means of assessing environmental impact and consent compliance.

MONITORING THE EFFECTS OF A COMBINED SEWER OVERFLOW DISCHARGING TO A SMALL WATERCOURSE IN SOUTH WALES

CONCLUSIONS

Clearly, monitoring and estimating the impact of CSOs on receiving waters is complex and necessitates careful consideration of a whole range of hydraulic, hydrological, chemical and biological processes and their interactions. The sewer system requires careful definition and both the crude flow and spill quality need to be closely monitored. This particular study has highlighted a number of factors to be considered in relation to the above and a number of important conclusions. These principally relate to several key aspects of the problem including: CSO monitoring strategies, chemical, biological and fisheries impacts. Each is addressed in turn:

1 Monitoring Implications

(1) The study overflow operates for less than 5% of the time in a typical year, necessitating the installation of a remotely triggered sampling system in order to accurately characterise chemical impacts. Routine chemical monitoring programmes will not pick up such affects.

(2) The existing technology is capable of providing the data required to characterise CSO impacts, but not without considerable periods of downtime (typically 30%).

(3) The installation of at least two downstream monitoring sites is essential in order to ensure that the impact event is fully monitored and dispersion/time of travel processes quantified.

(4) The first river samples taken in any monitoring run occassionally has a tendency toward elevated BOD levels, probably caused by the growth of organic matter in the inlet pipe. These should be discarded.

(5) Biological monitoring both above and below the overflow, offers a most cost effective means of assessing the environmental impact of CSO discharges.

2 Implications for water quality

2.1 Spill Characteristics

(1) The study CSO displayed the "typical" spill quantity and quality characteristics of a system serving 3000 people in a domestic-only situation. Spill rates varied between 5 and 10 DWF (30 - 60 ls^{-1}), whilst spill quality averaged 77 mgl^{-1} BOD, 4 $mg\ l^{-1}$ ammonia and 462 $mg\ l^{-1}$ suspended solids, generally lasting for 60 minutes or less.

(2) The most polluting spills occur at the time of peak crude sewage strength between the hours of 16:00 and 18:00 pm.

(3) The frequency of events and steepness of the severed catchment prevented the accumulation of significant quantities of sewer sediments and hence resulted in reduced first foul flush impacts when compared to less steep catchments.

(4) Antecedent weather conditions, spill duration and magnitude are all important factors affecting the overall level of spill impact.

(5) A first foul flush of low volume but high organic concentration (typical duration 10 minutes or less) was in evidence for 36% of all monitored spills. A further 12% of spills were characterised by multiple events, whilst 32% were characterised by a single peak pollutograph.

(6) Total event spill loads averaged 8.3kg BOD, 0.35 kg ammonia and 120 kg of suspended solids.

(7) Secondary pollutograph peaks tended to correspond to peak spill flows and were probably caused by erosion and wash off processes on the catchment surfaces.

(8) Multiple spill events tended to exhibit exhaustion effects (i.e. progressively reducing organic concentrations), except during periods of rapid flow fluctuations.

(9) Crude Bacterial loads and concentrations display a distinct diurnal pattern, with peaks at 12.00 - 14.00p.m. and 19.00p.m, in both Total Coliforms and E. Coli. Faecal Streptococci counts peak in early morning 06.00 - 09.00 am and early evening 15.00 - 18.00pm.

(10) Spill events are characterised by widely varying bacterial levels, but levels are generally higher during summer events.

2.2. River Quality Impacts

(1) The remobilisation of significant bed deposits of coal waste prevented any meaningful assessment of suspended solids impacts.

(2) River ammonical nitrogen impacts were relatively insignificant due to the low spill concentrations. Event levels never rose above 1.3 $mg\ l^{-1}$, more typically averaging $0.38mgl^{-1}$, increasing on average by just $0.27mgl^{-1}$. The study CSO represented the <u>only</u> significant source of ammonia in the catchment.

(3) River dissolved oxygen levels rarely fell below $10.0mgl^{-1}$, at most recording a $1.0mgl^{-1}$ reduction immediately below the CSO discharge. A combination of the steep stream gradient, high velocities, high diffusion and high reaeration rates all contribute to the above.

(4) River BOD levels rose in response to each significant event. On average, BOD levels were elevated by $6.2mgl^{-1}$. Worse-case impacts exhibited a $22mgl^{-1}$ increase in BOD immediately downstream of the CSO.

(5) In stream dilution levels were considered to be a key factor in determining the stream water quality impacts of the study CSO. Hence, where spill dilution levels were greater than 3:1 (River:Spill), no significant chemical impacts were noted. In all, 43% of monitored events exhibited a dilution of <3:1.

(6) Generally, spill impacts occurred early on the rising limb of the stream hydrograph, usually within 30 minutes of rainfall commencement.

(7) Occasionally, significant BOD inputs were monitored at the upstream control site. These could be attributed to limited illegal crude connections to storm water systems.

(8) Despite short duration periods of elevated river BOD levels of up to $34mgl^{-1}$, river D.O. levels remained at or near saturation.

3 Implications for Receiving Water Biota

3.1 Biological Impacts

(1) Benthic macroinvertebrate communities appear little affected by exposure to the study CSO and corresponding elevations in river BOD in particular. Indeed, overall BMWP scores have improved since the beginning of the study, probably in response to the improved situation in the upper catchment with regard to a reduction in diffuse coal solids inputs.

(2) The use of benthic macroinvertebrates as insitu bioassay organisms proved to be a successful and novel approach to assessing intermittent CSO impacts. Ephemera donica and gammarus pulex proved most sensitive to CSO exposure.

3.2 Fisheries Impact

(1) The fish stocking experiments and fish egg survival studies demonstrated that the CSO was having no detrimental impact on the fishery potential of the receiving water.

(2) The reappearance of naturally spawned brown trout during the study also showed that the stream was recovering, despite significantly elevated BOD levels.

(3) Fish egg survival assays have confirmed their potential application for assessing the toxicity of intermittent discharges.

4 Outstanding Issues

Whilst the chemical and corresponding biological impacts of the study CSO have been examined and reported, no examination of the overflows aesthetic impacts have been carried out. As a high side weir with scum boards, the study CSO represents albeit a less than perfectly designed example of a type recommended by WRC and CIRIA, not requiring a screening provision in less sensitive locations. Qualitatively, the experience of the study group would endorse such a recommendation in the case of such small (population 3000) domestic only sewer systems, discharging to small NWC Class 2 receiving waters of limited aesthetic value. Quantities of sewage derived debris appeared low in the study receiving waters. However, there is no substitute for a more quantiative study such as that undertaken on the Taff (Davies, 1989).

The study CSO has also been seen to act as a significant source of bacteriological inputs. Clearly only a qualitative examination of the problem has been undertaken in this study. A more quantitive examination is thus urgently recommended in the light of increasing public health concerns in relation to inland recreational water use.

Finally, in relation to the original objective (b) in Section 2, the development of the "NUT" water quality model to include the simulation of transient point source pollution from CSO's has since been overtaken by the NRA's adoption of a more sophisticated modelling tool.

5. Study Objectives

The original objectives of the study were agreed to be:-

(1) To develop a better appreciation of the qualitative and quantitative response of combined sewer overflows to rainfall events.

(2) To arrive at a better understanding of the nature and impact of storm overflow discharges on receiving waters.

(3) To assist in the development of more cost-effective design criteria for combined sewer overflows, based on the environmental impact on receiving waters.

(4) To test the effectiveness of sewerage upgrading measures carried out to overflows as a result of experimental works.

(5) To examine the effectiveness of current monitoring methods and programmes in detecting quality changes caused by transient discharges from storm overflows.

(6) To assist the development of the Newcastle-Upon-Tyne ("NUT") freshwater river quality model to include simulation of transient point source pollution from storm overflows.

RECOMMENDATIONS

1 Monitoring Implications

(1) Dry weather flow sampling above an overflow will provide a useful but crude basis for assessing potential chemical impacts, after consideration of the dilution provided before spillage occurs. Some visual assessment of sewer sediment presence/absence is also recommended.

(2) An analysis of the biological impacts and BMWP scores both above and below CSO's are recommended as the most cost effective means of rapidly assessing receiving water impacts and monitoring consent compliance.

(3) In cases warranting more detailed assessments, T.O.A.D. automated activated systems are strongly recommended. A minimum of 12 events should be assessed both upstream and downstream of the overflow, the latter preferably at two separate locations. Worse-case effects can probably be monitored between 16.00 and 19.00 pm on weekdays.

(4) Selective ion ammonia electrodes can be recommended for use in storm overflows, provided weekly maintenance visits are adopted.

(5) Macroinvertebrate bioassay tests using Gammarus pulex and Ephemera danica are recommended for an assessment of the extent of in-situ toxicity.

(6) Rainbow trout egg survival tests are recommended for an assessment of the extent of in-situ sensitive life stage fish population toxicity.

(7) The bacteriological impacts of CSO discharges requires further quantification.

(8) The aesthetic impacts of CSO discharges requires urgent and detailed investigation, perhaps using experimental design methods similar to that adopted for marine outfall studies (Thomas et al 1989).

2 Pollution Control Implications.

2.1 Implications for Consenting

(1) High side weir installations with well maintained scum boards appear to represent an acceptable design solution on sewer systems serving small domestic-only catchments discharging into fast flowing, well reaerated receiving waters. That is, provided overflow settings ensure a dilution of at least 3:1 in the receiving water at all times and comparable magnitude, frequency and duration event characteristics are in operation (i.e. spill duration typically 1 hour or less and < 50 events p.a.)

(2) Overflow settings should be designed to prevent spillage until a dilution in excess of 3:1 is available in highly reaerated receiving waters.

(3) An analysis of the biological impacts and BMWP scores both above and below CSO's are recommended as the most cost effective means of rapidly assessing receiving water impacts and monitoring consent compliance.

(4) First foul flush impacts should be restricted by the provision of adequately designed installations (as WRC recomendations) or the provision of on line storage.

(5) Sewer flow and quality modelling and river impact simulations offer the most cost effective means of assessing potential severage system impacts.

2.2 Implications for Impact Assessment

(1) Impact assessments should ideally not be restricted to considerations of potential river event BOD levels, some consideration of the corresponding dissolved oxygen conditions should also be undertaken. In the absence of available reaeration information, suitably relaxed event BOD levels should be adopted in fast flowing receiving waters.

(2) Sewer flow and quality modelling and river impact simulations offer the most cost effective means of assessing potential severage system impacts.

(3) Macroinvertebrate bioassay tests using Gammarus pulex and Ephemera danica are recommended for an assessment of the extent of in-situ toxicity.

(4) Rainbow trout egg survival tests are recommended for an assessment of the extent of in-situ sensitive life stage fish population toxicity.

ACKNOWLEDGEMENT

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MAIN REPORT

MONITORING THE EFFECTS OF A COMBINED SEWER OVERFLOW DISCHARGING TO A SMALL WATERCOURSE IN SOUTH WALES

1. INTRODUCTION

The pollution of water courses by combined sewer overflows has long been identified as a significant problem (MHLG 1970; SDD 1977; WRC/WWA 1984). However, whilst the Sewerage Rehabilation Manual (WRC/WWA 1984) and the Wallingford Procedure (NWC 1981) offer comprehensive guidelines for the renovation and hydraulic analysis of existing systems and for the hydraulic design of new systems, little consideration is currently given to the qualitative aspects of combined sewer design (Thomson and Saul 1986) and resulting receiving water impacts. Indeed the mechanisms and processes by which combined sewer overflows impact upon watercourses are still not fully understood. Clearly, if future capital investment in sewerage systems and sewerage rehabilitation is to be both effective and efficient, this understanding needs to be extended.

To this end, the UK Water Industry Research Programme on River Basin Management (Clifforde et al 1986; Clifforde and Price 1986) aims to provide the necessary tools and methodologies to allow the rational and objective upgrading of deficient sewer systems, taking into consideration the key problems identified by Tyson (1988) and listed below.

(1) Identification of the increase in pollutant concentrations and loads created by CSO discharges.

(2) Understanding the impacts of these measures on riverine communities and other uses.

(3) The development of standards to enable control of CSO discharges to acceptable levels of impact.

(4) Development of a river quality reporting system sensitive to the impact of episodic events.

The main products of the RBM programme are thus designed to provide:

a) Increased knowledge of the rainfall inputs to sewer flow simulation models (time series rainfall [Henderson 1986,1988]).

b) A sewerage sub-model to simulate quality for use with existing WASSP-SIM and WALLRUS procedures (MOSQITO, Modelling of Stormwater Quality including Tanks and Overflows [Moys, 1987].

c) A simple CSO river impact model (SPRAT, Spill Pollution Response Assessment Technique [Crockett et al, 1988]).

d) Improvement to the existing UK river classification system to take into account transient and short term changes in river quality due to storm events (Seager, 1988).

The National Rivers Authority (Welsh Region) and its predecessor organisation Welsh Water, have been represented on the RBM Steering Group since 1987 and are integrally involved in field data collection activities relating to the eventual development of the sewer flow quality and river impacts models. This report summarises the results of the involvement which entailed the detailed monitoring of a combined sewer overflow for the period April 1987 to March 1990.

During the above period, the Welsh Office W.E.P.D. contributed a total of £30k towards the total cost of the study, estimated to be £340k in all.

Complementary to the work undertaken elsewhere (Thornton and Saul 1986; Pearson et al 1986) and on very different sewer systems and receiving waters, the study was designed to identify the conditions under which overflow occurs and the consequent effect upon the receiving waters.

2. STUDY OBJECTIVES

The original objectives of the study were agreed to be:-

(1) To develop a better appreciation of the qualitative and quantitative response of combined sewer overflows to rainfall events.

(2) To arrive at a better understanding of the nature and impact of storm overflow discharges on receiving waters.

(3) To assist in the development of more cost-effective design criteria for combined sewer overflows, based on the environmental impact on receiving waters.

(4) To test the effectiveness of sewerage upgrading measures carried out to overflows as a result of experimental works.

(5) To examine the effectiveness of current monitoring methods and programmes in detecting quality changes caused by transient discharges from storm overflows.

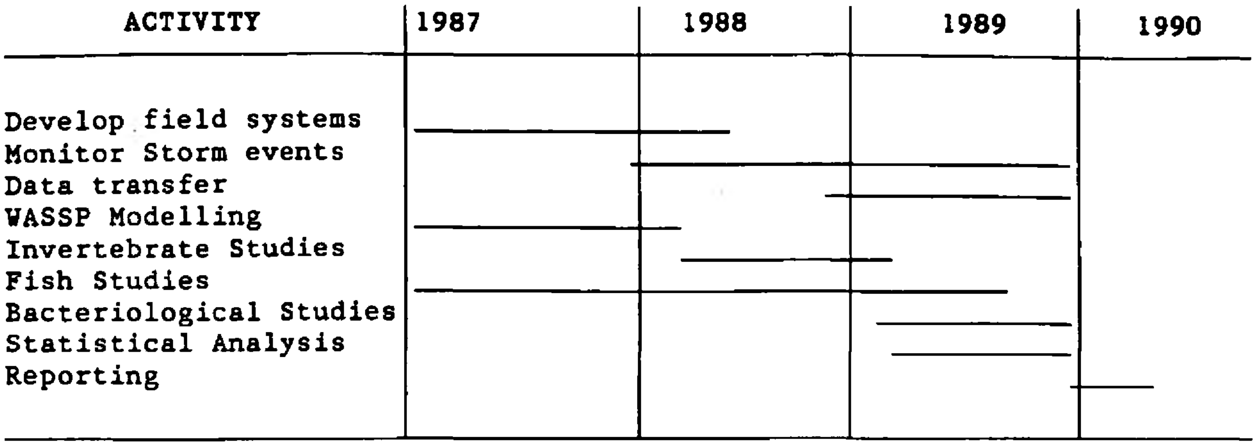
(6) To assist the development of the Newcastle-Upon-Tyne ("NUT") freshwater river quality model to include simulation of transient point source pollution from storm overflows.

3. PROJECT DESIGN AND TIMETABLE

Three aspects of CSO operation and impact have been investigated.

1. Overflow quantity and quality.
2. Receiving water quality and hydraulics.
3. Biological impact.

The Project timetable has been structured as follows:



4. STUDY DESCRIPTION

The need for more information and an understanding of the temporal behaviour of pollutants in combined sewers, and in particular the 'first foul flush' phenomenon has long been recognised. Indeed, there is much evidence to support the view that the first foul flush regularly occurs in many combined sewer systems (Lessard et al, 1982; Mance 1981; Pearson et al 1986; Thomson and Saul 1986). However, the concentration of pollutants associated with the first foul flush has also been shown to vary considerably in both magnitude and duration. Aspinall and Ellis (1986) have also described aspects of the impact of CSO's and urban runoff on river quality in terms of the pollutant load of such spillages. Impairment of Long Term River Quality Objectives (ie. chronic impacts) as well as more immediate shock effects (ie. acute impacts) were highlighted.

However, further data pertaining to the temporal patterns in pollutant concentration from CSO's are urgently required for use in the development of dynamic sewer quality and river impact models. The RBM study co-ordinates such monitoring at a number of locations in the UK including the North West, Midlands and Wales in particular.

4.1 Study Site

The Garndiffaith combined sewer overflow (CSO) forms the only significant point-source effluent discharge into the Nant Ffrwd, a small unclassified tributary of the Afon Llwyd (Figure 1) in Gwent. At the commencement of the study, the Ffrwd was tentatively classified as Class 2 (Table 1), on the basis of the current national NWC river classification system, but suffers from intermittently high suspended solids concentrations during wet weather caused by diffuse inputs of abandoned colliery tip waste. Biologically, the river is of much poorer quality with BMWP scores of only 51 (Class 3) above the overflow and 42 (Class 4) below it (Wade & Reynolds 1986). Chironomidae, Oligochaeta and Baetidae dominate the stream biology, whilst Ephemerellidae and Gammaridae are poorly represented.

4.2 Sewer System and Hydraulics

The sewered catchment and chamber characteristics are described in Table 2, along with the results of a dry weather flow survey. The system is steeply sloping and responds rapidly to rainfall, often well within 30 minutes, so that increases in river flow in response to the same rainfall input often lag significantly behind the CSO response. Typical overflow frequency is of the order of 50 significant events per year, maximum event volumes approaching 600 m^3 according to the validated WASSP-SIM model of the system (Figure 2). When subjected to a modified one year time series rainfall input, total overflow duration approximates to less than 5% of a typical year.

Crude flow quality is at its worst in the early morning and late evening (Table 2 and Figure 3) as is typical of a domestic-only situation. Crude quality is considerably improved between the hours of midnight and 06.00am. Ammoniacal nitrogen levels are far more stable than BOD_5 (ATU) and Total Solids levels. The rainfall inputs and steepness of the severed catchment results in only limited deposits of sewer sediments. The sewer network is shown in Figure 4, while the chamber design details are given in Figure 5. One key feature to note is the approach angle of the inflow pipe. Entering at a 90° angle,this causes unstable velocity fields to form in the chamber itself (Plate 1). Hence, the performance of this particular high sided weir cannot be considered optimal or indeed typical of such designs. Although not shown on the diagram, well- maintained scum boards are also in place along the length of the chamber (Plate 2).

4.3 Receiving Water Characteristics

The overflow discharges into a small watercourse, the Nant Ffrwd. The receiving water drains a 6.75 km^2 area and is characterised by the hydrological features identified in Table 3.

Table 3 Hydrological Characteristics of the Ffrwd Catchment

		Mean Velocity (ms^{-1})	Diffusion rate (m^2s^{-1})
95% ile flow	17 ls^{-1}		
90% ile flow	20		
75% ile flow	30		
50% ile flow	75		
20% ile flow	720	0.66	2.16
15% ile flow	800	0.81	3.54
10% ile flow	1000	1.0	-

The steep gradient of the receiving water is reflected in the relatively high velocities which characterise the stream. Stream reaeration capacity is particularly high in the vicinity of the CSO, where a series of rocky steps affords rapid mixing of CSO inputs and high reaeration levels (Plate 3). Indeed at the first sampling site below the CSO (Viaduct) the stream bed falls 2m in just 5m. In total, the stream falls some 60m between the overflow and its confluence with the Afon Llwyd (1.2km downstream).

Three monitoring sites were established on the receiving water. The upstream site W1 is some 50m upstream of the overflow (Plate 4). The first downstream site is located 80m downstream (W2, Viaduct), whilst a second downstream site (W3, Walnut) is located a further 400m below (Fig 1.). W1, W2 and W3 drain areas of 6.25km^2, 6.40km^2 and 6.55km^2 respectively.

5. METHODS

5.1 Water Quality Monitoring and Sampling Methods

5.1.1 Continuous Monitoring

i) Rainfall

Rainfall was measured using a Tipping Bucket Rainguage (with a 0.2mm tip), located centrally within the catchment. Readings were logged on a Tinylog event recorder at minute intervals.

ii) River Flow

Water levels on the Nant Ffrwd, at the Viaduct weir, were monitored using a Druck pressure transducer (0-175 mbars) and readings logged at 5 minutes intervals on a Tinylog data logger. Recorded levels were converted to river flows on the National Rivers Authority Data General Mv 100 mini computer using the Welsh Water developed program - LOGSYS. The software converts levels to flows applying a series of rating equations. The relationship between water level and flow was originally established by Welsh Water and NRA hydrologists, using current metering techniques.

iii) Water Quality

Dissolved oxygen, temperature and pH were continously monitored using a pHOX DPM multiparameter unit and the readings logged at 5 minute intervals on a Tinylog data logger at the upstream and two downstream river sites and within the sewer flow. During 1988, ammoniam was monitored using a DPM ammonia probe within the sewer, but this was discontinued in 1989 due to problems with probe fouling. Data were processed from millivolt readings to concentration units using the LOGSYS software.

5.1.2. Event Monitoring

i) Flow

Water level in the overflow spill chamber was monitored using an ultrasonic "Detectronic" flow monitor linked to a Tinylog data logger.

ii) Water Quality

When the overflow spill chamber started to fill, a pressure switch was activated which was linked to an NRA designed programmable control system based on a Scorpion Controller. This T.O.A.D. System (Trigger Operated Activation Device) recorded the timing of each event on a Tinylog event recorder and was programmed to control the activation of a Sirco Model PS-005 autosampler at the sewer overflow spill chamber. An activation signal was also transmitted to the three river sites (initially 4) via a licenced VHF radio transmitter. The SIRCO samplers therefore operated synchronously at the sewer and 3 river sites and were programmed to take 500ml samples at 5 minute intervals.

Notification of the spill event was made automatically to a control centre through a BT alarm system equipped with a status message, to prevent delay in sample collection. The samples were transported immediately on collection to the NRA Welsh Region laboratory at Llanelli where they were analysed for Conductivity (at 20°c); 5 day Biochemical Oxygen Demand (ATU method); Ammonia (as N); chloride; suspended solids at 105°c and mineral solids at 500°c using methods prescribed by the D.O.E. Standing Committee of Analysts published in "Methods for the Examination of Water and Associated Materials".

5.1.3 Bacteriological Quality

i) Dry Weather Flow

Samples were obtained at hourly intervals from the sewer using a SIRCO sampler by immersing the inlet tubing directly into the sewer flow. In order to prevent microbial growth in the samples during hot weather, freezer packs were used to cool the autosampler base and the samples during transportation to the Llanelli laboratory. Samples were analysed after dilution for <u>Faecal Streptococci</u> (per 100ml), Total Coliforms and <u>Eschericia Coli</u> (per ml).

On one occasion a series of 24 stream samples were collected from the upstream and viaduct sites at 3 minutes intervals using the SIRCO samplers, and analysed for the same determinands in order to obtain background river concentrations of bacteria.

ii) Event sampling

Microbiological samples were collected during discharge events by taking sub-samples from the autosampled water quality samples (See Section 5.1.2ii). Analysis was carried out at Llanelli laboratory as per the dry weather flow method described above.

5.2 Biological Impact Assessment

Benthic macroinvertebrate samples were taken using a standard three minute kick sampling technique from up to six sites, located on the Nant Ffrwd upstream and downstream of the combined sewer overflow (Fig 1) in July 1987 and October 1989. Samples were returned to the laboratory for analysis to family level; abundances were estimated on a logarithmic scale (1 = 1-9; 2=10-99, 3=100-999; 4> 1000). The quality of samples was assessed using the Biological Monitoring Working Party (BMWP) biotic index. (Appendix 3).

5.2.1 Macroinvertebrate Bioassay tests

An experimental in-situ bioassay test was developed which involved holding specimens of pollution sensitive macroinvertebrates (Gammarus pulex - freshwater shrimp and Ephemera danica - mayfly) in tubes secured within concrete blocks on the river bed. Percentage survival was measured over periods of up to 20 days. Bioassays were carried out at up to five sites (Fig. 1) during July/August 1987 and April - June 1988 during which CSO discharges were recorded.

5.3 Fishery Investigations

5.3.1 Population Estimates

Earlier fish stock assessments of the Nant Ffrwd (Jones, 1986) had shown it to be fishless due to an industrial discharge upstream of the CSO, (this discharge ceased before the CSO study began). Swim-up rainbow trout (Salmo gairdneri) fry were therefore stocked into the Nant Ffrwd during April 1987 at a density of approximately 2 per m^2 and again in July 1988 at sites immediately upstream and downstream of the CSO. Quantitative electrofishing surveys were carried out at various intervals during 1987 and 1988 to assess survival, distribution and growth rates of the stocked fish and the naturally recolonising brown trout (Salmo trutta L.) population. Population estimates were made using the Zippin (1958) method.

5.3.2 Egg Survival Studies

Rainbow trout eggs were planted out inside plastic Netlon containers secured within hollow breeze blocks at four sites (Fig. 1) during June and again in July 1988. Eight replicates of 100 eggs were placed at each site and examined twice per week throughout the hatching period and into the alevin stage. Mortalities were removed regularly and the tests were terminated when swim-up fry developed. A control batch of eggs was kept under ideal conditions at Cynrig hatchery during both experiments. Attempts to repeat these experiments over the winter of 1989-90 were thwarted by the exceptionally high water flows, however further experiments were carried out in 1988/89 to improve the inherent survival rate of eggs by incubation with a variety of artificial media; the results of which are to be reported elsewhere.

6. WATER QUALITY IMPACTS

Figure 6 gives an indication of the antecedent conditions prior to each event monitored.

6.1 CSO Spill Quality

6.1.1 CSO Chemical Quality

The overflow spill quality for all monitored events is summarised in Table 4 and Figure 7. BOD, Ammoniacal nitrogen and suspended solids concentrations averaged $77mgl^{-1}$, $3.7mgl^{-1}$ and $462mgl^{-1}$ respectively. Maximum concentrations of $204mgl^{-1}$ BOD, $7.0mgl^{-1}$ ammonical nitrogen and 2530 mgl^{-1} suspended solids were also recorded. Events 5 (28/5/88), 10 (2/8/88), 18 (24/5/89) and 22(20/10/89) were the most significant especially in terms of BOD and suspended solids (Figures 8 to 22).

Each of the above events exemplifies a number of key spill characteristics found at the overflow. First, Event 5 (Figure 8-13) exhibits a clear first foul flush of BOD and ammonia during the first 10 minutes of a 30 minute spill. Peak spill rates reached 250 ls^{-1} compared to the average peak rate monitored of 110 ls^{-1}. Peak spill loads reached $20gs^{-1}$ and 1.2 gs^{-1} for BOD and ammonia respectively (compared to average monitored peaks of 5.7 gs^{-1} and 0.27 gs^{-1}). Total spill loads reached 22.6 kg (BOD), 1.11kg (ammonia) and 84.0 kg (SS) (280%, 260% and 50% above the average monitored load).

Event 10 (Figures 14-16) exhibits an even more pronounced first foul flush recorded during a 40 minute event. The other key statistics are given in Table 4. Peak spill rates reached 420 ls^{-1} giving peak BOD spill rates 2 times larger than event 5 ($49.9gs^{-1}$). Total BOD spill loads were correspondingly larger at 49.9kg (125% greater than event 5). In both cases, ammonia concentrations and loads are seen to be quite low.

Event 18 (Figures 17-19) was of a similar duration, but exhibited a single spill peak. Again the key statistics are shown in Table 4. In contrast, Event 22 (Figures 20-22) was a long duration event of more than 2 hours, and was characterised by widely fluctuating BOD, ammonia and suspended solids concentrations.

Events 4 (30/4/88), 20 (16/9/88) and 24 (9/11/89) are further good examples of significant spill events (Figures 23 to 31). Event 20 is a particularly good example of a very short duration event of only 6 minutes, whilst, Event 24 is a further example of a long duration spill. Furthermore, Events 12 (18/10/88) and 25 (13/12/89) are good examples of multiple spill events which are quite common at the study site (Figures 32 to 49).

More generally, 25 spill events have been monitored in all. Spill duration averaged 74 minutes (range 11 to 298 minutes) and peak spill flows averaged 126 ls^{-1} (range 5 to 420 ls^{-1}). Peak spill concentrations averaged 77mgl^{-1} (BOD), 3.7mgl^{-1} (ammonical nitrogen) and 462 mgl^{-1} (SS), with ranges of 1 to 298 mg l^{-1} BOD, 1.1 to 7.0 mg l^{-1} ammonia and 112 to 2530 mg l^{-1} SS respectively. In 36% of cases a first foul flush was in evidence during the spill, most of which were followed by identifiable secondary peaks. A further 32% of events exhibited single spill peaks, whilst 12% were characterised by multiple spills.

Peak loads averaged 5.70 gs^{-1} BOD and 0.27 gs^{-1} ammonia, with a range of 0.13 to 48 gs^{-1} and 0.01 to 1.3 gs^{-1} for BOD and ammonia respectively. Finally, total spill loads averaged 8.3 kg of BOD, 0.35 kg of ammonia and 120kg of suspended solids. Corresponding ranges of 0.12 to 49.9kg BOD, 0.01 to 1.11 kg ammonia and 1.02 to 496kg SS were monitored. Appendix 1 contains plots of all of the monitored data.

6.1.2 Bacteriological Quality

Bacteriological concentrations were monitored in the dry weather flow on six occasions for Total Coliforms, E.coli and Faecal Streptococci (Figures 50 to 52). As can be seen winter results were significantly reduced (eg 6/12/89), whilst during summer, microbial populations are clearly highly variable. Average concentrations display a distinct diurnal pattern, with peaks at 12.00 - 14.00pm and 19.00pm in both Total coliforms and E. coli (Figure 53). Faecal streptococci counts exhibit a slightly different pattern, with peaks in the early morning 06.00 - 9.00am and early evening 15.00 to 18.00 pm.

Three spill events were also monitored for bacteriological concentrations and loads, Event 19 (14/8/89), Event 23 ((9/11/89) and Event 25 (13/12/89). As can be seen from Figures 54 to 61, microbial counts were significantly higher in the summer Event (19). During Event 23, counts were highly variable, whilst in Event 25 they were less so, but with a marked flush.

Mean background concentrations were slightly elevated in the Nant Ffrwd at the Viaduct site (Faecal Streptoccae 10 per 100ml, Total coliforms 9.0 per ml and Eschericia Coli 2 per ml) compared to upstream (Faecal Streptoccocae 9 per 100ml, Total Coliforms 7.5 per ml and Eschericia Coli 1.0 per ml) although samples were taken at Dry Weather Flow in the river.

6.2 Impact on River Quality

The chemical impact of the 25 monitored events is summarised in Figures 62 to 64, for the Upstream, Viaduct and Walnut monitoring stations. As can be seen, in all cases the CSO impact in relation to suspended solids is masked by the in-situ mobilisation of bed deposited coal solids despite the closure of the "Viponds" site in the upper catchment (previously described). Hence, no further investigation of such impacts is proposed.

With regard to the BOD and ammonical nitrogen impacts, it is clear that an unknown BOD source intermittently affects the upstream control site complicating impact interpretation. However, the immediate downstream site continues to exhibit the worst chemical quality in BOD and ammonia terms, with concentrations reaching up to 34 mg l^{-1} and 1.3 mg l^{-1} for BOD and ammonia respectively during Event 18 (24/5/89). Indeed, further downstream at Walnut, concentrations reached an even higher level of BOD (54 mg l^{-1}).

The spill event impacts are summarised in more detail in Table 5. Events 5 (28/5/88), 10 (2/8/88), 18 (24/5/89) and 22 (20/10/89) correspond with the four most significant spills described in Section 6.1.1. (Figures 65-90). These events resulted in a range of worse-case BOD impacts from +2.0 mg l^{-1} BOD (Event 10) to +22.0 mg l^{-1} (Event 5). In the case of Event 5, the above was matched by a +0.5 mg l^{-1} ammoniacal nitrogen peak impact. Thus, the BOD peak rose by 360%, whilst the ammonia peak rose by 250%. Peak loads were similarly affected. Figures 65 to 75 demonstrates the overiding influence of the CSO during the spill event. River flows are also seen to be immediately affected with the peak spill rate of 250 ls^{-1} dominating the flow during the 30 minutes of the event, giving less than a 1:1 dilution.

Event 10 (2/8/88) exhibited a reduced impact, immediately downstream despite high spill loads (Figures 76 to 84). However, at the lower downstream point, the impacts were highly significant, reaching a peak of 25 mgl^{-1} BOD and 1.1 mgl^{-1} ammoniacal nitrogen. This would seem to suggest that the peak spill impact was missed at the Viaduct site, but caught 20 minutes later at Walnut. Dilution levels again appeared to average around 1:1 during the spill event.

Event 18 exhibited a significant BOD and ammonia impact at both downstream sites (Figures 85 to 86), again with dilutions only averaging 1:1 during the spill. The lowermost monitoring site once more exhibited the most significant BOD impact, suggesting an incomplete coverage of the peak at the Viaduct site. The impact was almost instantaneous at Viaduct, whilst at Walnut peak concentrations were recorded 10 minutes later.

Event 22 (20/10/89) (Figures 87 to 90) is seen to occur during a prolonged rainfall event during rising river flows. Hence, a minimum dilution ratio of 7:1 was achieved throughout the event, with river impacts being correspondingly small.

Events 4 (30/4/88), 20 (16/9/88) and 24 (9/11/89) represent other significantly impacted events (Figures 91 to 100 and Table 5). During Event 4 maximum dilutions again averaged only 1:1, resulting in peak river BOD levels of 20 mg l^{-1} . The peak river impact lagged the peak spill impact by ca. 20 minutes. Again the CSO spill is seen to significantly increase river flows, responding well before the catchment.

Event 20, represents a short duration 'flashy' CSO Spill lasting just 5 minutes but impacting significantly on river quality (Figures 95 to 98). Peak downstream BOD levels reached 20 mg l^{-1} again at a time of limited dilution (ca. 1:1). Ammonia levels were similarly affected.

Event 24, represents a long duration spill (Figures 99 to 100). As can be seen, in the early part of the spill, river impacts are significant due to the limited dilution available. However, as the storm progresses, river levels rise and rapidly dilute the CSO spill loads, until a pollutant spike towards the end of the event.

Events 12 (18/10/88) and 25 (13/12/89) correspond to the multiple spill events described in section 6.1.1.(Figures 101 to 113). Both clearly mirror the effects of the individual spill peaks. In the case of Event 12, worse-case dilution ratios average 9:1, yielding limited impacts. Whilst in the case of event 25 dilution ratios are extremely high (in excess of 100:1).

The remainder of the monitored event impacts are provided in Appendix 2. Generally, river impacts ranged from a 0.5 mg l^{-1} increase in BOD up to a 22 mg l^{-1} increase. In many cases, dilution ratios were around 1:1 at the height of the spill event. Ammonia impacts ranged from zero to 1.1mgl^{-1} with the CSO being the only significant source. The lag time between spill commencement and peak impact immediately downstream averaged 13 minutes ranging between 1 to 55 minutes. Further downstream the lag averaged 27 minutes, ranging from 15 minutes to 55 minutes when monitored. Both of the above reflect the respective time of travel for the sites relative to the overflow. Throughout the study DO impacts were seen to be minimal river levels remaining around 10.0mg l^{-1}, irrespective of spill conditions. Clearly the high reaeration capacity of the stream prevents any major DO depletion.

6.3 Biological Impacts

A biological survey of the Nant Ffrwd in July 1987 showed that it was of poor (Class 4) to very poor (Class 5) quality in the upper reaches and attained moderate to good quality (Class 3) just upstream of the CSO (Table 6). The general paucity of the fauna at sites 1 and 2 and the absence of even organic pollution tolerant taxa suggests that some form of inert and/or toxic pollution (eg coal solids or acidic conditions) existed in the upper reaches. There was a moderate but not significant reduction in BMWP score immediately downstream of the CSO at site 5 (BMWP score fell from 85 to 67) but generally there was no measurable detrimental impact on the macroinvertebrate fauna due to the CSO. Other polluting influences in the upper reaches were apparently having a greater impact on biological quality (Figure 114).

In October 1989 the biological quality of the upper reaches in particular was much improved (Class 3) and equivalent to the lower reaches of the 1987 survey (Table 7). Pollution sensitive taxa, such as Heptageniidae, Leuctridae and Hydropsychidae were found throughout and there was no change in composition of the fauna downstream of the CSO. The overall biological quality of the Nant Ffrwd on this occasion was moderate to good (Figure 114).

6.4 Macroinvertebrate Bioassay Tests

Initial bioassays (July/August 1987) using G. Pulex and E. danica indicated significant mortalities (up to 40%) for E. danica at all sites downstream of the CSO (Fig. 115). No mortalities were recorded at upstream control sites throughout the 20 day study thus validating the assay techniques used (Wade 1987). First mortalities occurred after 5 days following the first significant storm event. In all during this assay the indicator species were subjected to three significant discharge events. *Ephemera* was the most sensitive species in all cases.

Further bioassays carried out in April 1989 gave similar results; 100% survival was recorded at control sites whilst up to 40% mortalities occurred at downstream sites (Fig. 115). However during later assays in May/June, results were less conclusive as significant mortalities occurred at both control and downstream sites. On one occasion this occurred following heavy rain which resulted in substantial silting in the test tubes and was probably responsible for the mortalities.

6.5 Fishery Investigations

6.5.1 Population Estimates

Repeated electrofishing surveys during July, August and September 1987, following the stocking with rainbow trout in the preceding April, revealed higher densities of trout downstream of the CSO on all three occasions (Table 8i). The densities at all sites were indicative of moderate to good populations and there was no apparent effect due to the CSO. No native brown trout were present, confirming that the brown trout fishery had not recovered from the historical coal solids pollution problem in the upper reaches. Growth rates of the stocked fish (as measured by mean fish length Table 8i) were significantly greater at the two lower most downstream sites than at both the immediate downstream site and the two upstream sites. Trout from the two upstream sites were of similar size. However throughout this survey period only 6 significant storm events were recorded, compared to 19 events in the following 3 month period.

A repeat survey in April 1988 revealed higher densities (34 100m-2) immediately above the CSO than at any of the three downstream sites (Table 8i) although all but the uppermost site still supported good to excellent populations. There was evidence of human interference at some sites, however, and by this time the stocked fish had been exposed to more than 40 spill events since April 1987. There were no significant differences between the mean lengths of stocked trout from any site on this occasion.

Following additional stocking of swim-up rainbow trout fry (at a density of 2 m^{-2}) into the Nant Ffrwd at sites immediately upstream and downstream of the CSO in July 1988, electrofishing in September 1988 revealed higher densities upstream, but significantly greater growth rates downstream of the CSO. Native brown trout were recorded, albeit at very low densities, for the first time during this survey, which indicated that the brown trout population had begun to recover from the historical coal solids pollution problem and that spawning had taken place. (Table 8ii).

6.5.2 Egg Survival Studies

The June 1988 experiment was abandoned as all eggs had died within 3 days of planting. This was thought to be due to heat shock during the handling/planting out stage as the Cynrig hatchery control batch demonstrated 90% survival to the swim-up stage.

A repeat of the experiment in July 1988 was more successful in that the eggs did not suffer from heat shock, however the results were inconclusive (Table 9). The lowest mean mortality rate (22%) was recorded immediately downstream of the CSO. However at the uppermost control site it was 27% and at the two most downstream sites 38% and 54% respectively. This data suggests that for the duration of the experiment there was no effect due to the CSO but that other influences may be affecting the hatching success of trout.

7. DISCUSSION OF RESULTS

7.1 CSO SPILL CHARACTERISTICS

Spill quality levels vary enormously, although the majority of the most polluting spills appear to correspond with periods of peak crude sewage strength between the hours of 16:00 and 18:00 pm in particular. Indeed the average peak concentrations of BOD (77mgl) ammonia (3.7mgl) and suspended solids (462mgl) are broadly in line with those typical levels identified by WRC (Crabtree et al, 1988), for domestic only sewage (Table 10). Correspondingly the least polluting spills were recorded during the early hours of the morning, typically 00:00 to 06:00am. The steepness of the sewered catchment would also appear to limit the amount of in-sewer sediments available for resuspension during spill events. Moreover, visual monitoring of the above by WRC personnel has confirmed the relative absence of in-situ sediments other than inert inorganic minerals.

Clearly other factors such as the antecedent weather conditions, spill duration and frequency are also important factors affecting the overall level of spill impact.

Even during relatively insignificant spills occurring in the early hours, first foul flush effects were in evidence as is the case elsewhere (Pearson et al 1986). More significant events exhibit both a clear first foul flush BOD and suspended solids peak, along with a secondary peak coinciding generally with the peak in spill flow. Typically first foul flush conditions pertain for a short period of 10 minutes or less during spill durations in excess of 30 minutes and at times of an early rise in sewer spill flows.

As mentioned above, secondary flushes tend to correspond to periods of rapidly increasing or peak flows in the system and hence are probably related to erosion and wash-off of pollutant from catchment surfaces and the scouring of any available sediment deposits, as is often the case in such systems (Thornton and Saul, 1986). Peak concentrations in the secondary flush are also generally lower than those observed in the first flush, but in terms of pollution load the second flush often accounts for a larger proportion of the total storm load.

Multiple spill events tended to be characterised by progressively reducing peak concentrations, unless an individual peak was characterised by very high flow rates. Hence, exhaustion effects appear to operate in most situations, except where excessive flushing effects are encountered.

The only other notable variation on the above spill patterns was the occurrence of a single spill peak, with no recognisable first foul flush. Typically these occurred either in response to small, short duration spills, or at times of low crude sewage strength, especially in the early hours of the morning.

In many cases, no such flushing effects were recorded in relation to ammoniacal nitrogen concentrations. The existence of single concentration and load peaks, thus support the suggestion that dilution of the crude flow quality was the key process of operation in this small, wholly domestic sewage system.

A correlation matrix of the spill characteristic summary data (Table 11) reveals few significant correlations. Most notable of those which are not simply a product of auto-correlation are the following:

Peak BOD v Peak Suspended Solids Concentration ($r = 0.644$)
Peak Flow v Peak Suspended Solids Concentration ($r = 0.692$)
Peak Flow v Peak BOD load ($r = 0.707$)
Peak BOD Load v Mean Event Rainfall ($r = 0.841$)
Peak Flow v Peak NH_3 load ($r = 0.713$)
Peak Flow v Spill SS load ($r = 0.678$)

Hence, it can be seen that the magnitude of the spill flow rate is a key factor in determining the extent of the polluting load of the spill in relation to suspended solids, BOD and ammonia. Furthermore, BOD and suspended solids concentrations appear closely linked, whilst this is not the case for ammonia, further supporting the observations mentioned above.

In relation to the spill flow characteristics, peak flow rates typically correspond to 20 x DWF although a range of 1 to 70 x DWF were monitored. More normally, mean spill event flow rates varied between ca. 5 to 10 x DWF, (DWF being $6.0ls^{-1}$ as indicated in table 2).

Bacterial concentrations and load characteristics appear typical for such a small, domestic only sewer system and are comparable with those reported elsewhere (Payne & Mays, 1989). Clearly, only a qualitative analysis of such problems was attempted in this study. The impact of such CSO's on the bacteriological quality of receiving waters may become increasingly important in view of the increased recreational use of waters and heightened public awareness of public health issues. Hence, the data reported in this study are merely designed to contribute to the debate on the subject (Dempsey et.al 1989), particularly in relation to the potential riverine contribution to bathing waters bacterial contamination.

Finally, one aspect of CSO spill characteristics not investigated in this study relates to their potential for aesthetic contamination of receiving waters. Clearly, the overflow under study appeared to fulfill the criteria recommended by WRC (Balmforth and Henderson, 1988) and CIRIA (CIRIA, 1988) in relation to less sensitive locations. Both of the above recommend the installation of well designed high side weirs with scum boards, without the necessity for a screening provision. As to whether the study CSO complies with suggested design criteria seems doubtful, since the approach to the overflow is clearly unorthodox (creating chaotic flow patterns) and there also appears to be an inadequate provision of a stilling length. However, explicit investigation of what is acknowledged as a widespread potential problem was not undertaken. Studies elsewhere, in Wales, suggest that an average 19% of receiving water litter is sewerage derived (reaching up to 42% in some locations on the Taff, [Davies, 1989]). Hence, it is important to recognise the need for further work and an investigation into optimal screening provisions in sensitive locations. In relation to the above the experimental design employed in the joint Welsh Water/WRC study of marine outfalls (Thomas et al, 1989) is strongly recommended. In sensitive locations both CIRIA and WRC recommend the provision of fine screens ($\leq$ 6mm), although in the case of the study site clearly such a provision would be likely to be unnecessary.

7.2 Receiving Water Impacts

7.2.1 Water Quality

Interestingly, the observed impact upon river dissolved oxygen levels remained minimal, typically resulting in a less than 1.0mgl drop in DO levels. Any impacts were also confined to the stretch immediately downstream of the overflow. Indeed, even in-sewer DO levels remained quite high at all times probably due to the steeply sloping nature of the sewer system and the low levels of organic sewer sediment. The insignificant DO impacts can probably be related to the high reaeration flow velocities, and dispersion characteristics of the receiving water, with its bouldery substrate and rocky steps and the relatively high DO levels of the spilled waters. Hence high BOD levels may not always be characterised by significant river DO reductions.

In-stream impacts varied considerably although increases in BOD and ammonia levels could be identified during every spill. Ammonia impacts were however, minimal due to the low concentrations in the crude sewage and diluted spills. In all cases, ammonia levels in the stream were directly related to CSO spill characteristics, being influenced principally by the process of dilution.

Indeed, in-stream dilution ratios were the key factor in determining river impacts during all events. Those events receiving a dilution in excess of around 3:1 (River : CSO) rarely exhibited significant increases in river BOD and ammonia. Of the events monitored, 9 exhibited dilutions of <3:1 most of which gave increases in river BOD levels of at least $4.0mgl^{-1}$. However, as mentioned above, no significant impacts on river DO levels were in evidence.

In relation to the spill BOD river impacts, on average the low dilution spill events appeared to result in a single class downgrading of the stream during an event typically from NWC Class 1B to Class 2B ($5mgl^{-1}$ BOD to 9 mgl^{-1} BOD). However, in exceptional circumstances, river BOD levels deteriorated to 20 mgl^{-1} BOD or worse (ie. worse than NWC Class 3). In-stream impacts tended to last for only slightly longer than the spill duration, typically 30 to 120 minutes.

Lag times were also small with river impacts being recorded almost immediately following each CSO spill. The time lag between the two downstream monitoring sites, merely reflected time of travel and dispersion effects between the two sites.

On several occasions however, during short duration events, the lowermost monitoring site recorded more significant impacts. This phenomenon can be explained by the fixed sampling regime employed at the site nearest to the overflow which sometimes causes the peak impact to be underestimated since stream dispersion effects are minimal before the first downstream site at times of high stream flow.

Lastly, on several occasions notable inputs of BOD in particular, were monitored at the upstream site. These were found to be attributable to apparent illegal connections to storm water overflows located above the study CSO. Corresponding ammonia effects were relatively low (when compared to the CSO impacts) supporting the suggestion of a probable storm water source (see Table 10).

7.3 Biological and Fisheries Impacts

The impact of the Garndiffaeth CSO on the benthic macroinvertebrate communities was not significant on either occasion that it was assessed. The biological quality of the river in 1987 was generally moderate to poor, especially upstream of the discharge and this was attributed to the effects of discharges from the recent coal reprocessing operation in the upper catchment. Significant improvements in the overall biological quality of the stream were evident in 1989 due to natural recovery from the earlier industrial pollution problems, but the impact of the CSO was still negligible. The use of benthic macroinvertebrates as bio-assay organisms was a novel approach to assessing CSO impact, and the technique proved to be successful, (Ephemera danica and Gammarus pulex were kept alive throughout the earlier assays at the control site). An apparent toxic impact (up to 40% morality) was demonstrated with E. danica after significant storm events during the 1987 trials. E. danica is a pollution sensitive species which was not recorded in the Nant Ffrwd, and is more susceptible to organic pollution than many of the invertebrates which were recorded. However significant mortalities at the control site during subsequent assays cast some doubt on the validity of the results and factors other than those due to the CSO discharge (e.g. inorganic solids concentrations) were suspected as influencing the results. Also, other minor upstream source(s) of NH_3 -N, which were demonstrated from the water quality data may have affected the assays. The technique was however validated and is worth considering in appropriate circumstances as a toxicity screening assay for intermittent discharges.

The fish stocking experiments and fish egg survival studies demonstrated that the CSO was having no detrimental impact on the fishery potential of the Nant Ffrwd. As with the macroinvertebrate fauna, the greatest impact on fish spawning and survival had been the industrial pollution in the upper reaches. The reappearance of naturally spawned brown trout in the Nant Ffrwd during the study and the survival and growth rates of stocked rainbow trout showed that the stream was recovering. There was no evidence that this recovery was being impaired by discharges from the CSO, on the contrary, growth rates of stocked fish were greatest downstream of the discharge.

The fish egg survival studies were inconclusive with regard to the CSO impact because unexplained mortalities occurred at the control sites. During independent trials, survival of ova was improved by the introduction of artificial media into the incubation chambers. However, due to high overwinter flows and the unavailability of suitable eggs, the in situ survival studies could not be repeated. As with the macroinvertebrate bioassays, fish egg survival assays have potential applications for assessing the toxicity of storm water and other intermittent discharges, but were unsuccessful in contributing towards our understanding of the impact of the Garndiffaeth CSO.

8. CONCLUSIONS

Clearly, monitoring and estimating the impacts of CSOs on receiving waters is complex and necessitates careful consideration of a whole range of hydraulic, hydrological, chemical and biological processes and their interactions. The sewer system requires careful definition and both the crude flow and spill quality need to be closely monitored. This particular study has highlighted a number of factors to be considered in relation to the above and a number of important conclusions. These principally relate to several key aspects of the problem including: CSO monitoring strategies, chemical, biological and fisheries impacts. Each is addressed in turn:

8.1 Monitoring Implications

(1) The study overflow operates for less than 5% of the time in a typical year, necessitating the installation of a remotely triggered automated sampling system in order to accurately characterise chemical impacts. Routine chemical monitoring programmes will not pick up such effects.

(2) The existing technology is capable of providing the data required to characterise CSO impacts, but not without considerable periods of down-time (typically 30%).

(3) The installation of at least two downstream monitoring sites is essential in order to ensure that the impact event is fully monitored and dispersion/time of travel processes quantified.

(4) The first river samples taken in any monitoring run occasionally has a tendency toward elevated BOD levels, probably caused by the growth of organic matter in the inlet pipe. These should be discarded.

(5) Biological monitoring both above and below the overflow, offers the most cost-effective means of assessing the environmental impact of CSO discharges.

8.2 Implications for Water Quality

8.2.1 Spill Characteristics

(1) The study CSO displayed the "typical" spill quantity and quality characteristics of a system serving 3000 people in a domestic-only situation. Spill rates varied between 5 and 10 DWF (30 - 60 ls^{-1}), whilst spill quality averaged 77 mgl^{-1} BOD, 4 mg l^{-1} ammonia and 462 mg l^{-1} suspended solids, generally lasting for 60 minutes or less.

(2) The most polluting spills occur at the time of peak crude sewage strength, between the hours of 16:00 and 18:00 pm in particular.

(3) The steepness of the severed catchment and rainfall characteristics prevented the formation of significant quantities of sewer sediments and hence resulted in reduced first foul flush impacts when compared to less steep catchments.

(4) Antecedent weather conditions, spill duration, frequency and magnitude are all important factors affecting the overall level of spill impact.

(5) A first foul flush (typical duration 10 minutes or less) was in evidence for 36% of all monitored spills. A further 12% of spills were characterised by multiple events, whilst 32% were characterised by a single peak pollutograph.

(6) Total event spill loads averaged 8.3kg BOD, 0.35 kg ammonia and 120 kg of suspended solids.

(7) Secondary pollutograph peaks tend to correspond to peak spill flows and are probably caused by erosion and wash off processes on the catchment surfaces.

(8) Multiple spill events tend to exhibit exhaustion effects, except during periods of rapid flow fluctuations.

(9) Crude Bacterial loads and concentrations display a distinct diurnal pattern, with peaks at 12.00 - 14.00p.m. and 19.00p.m in both Total Coliforms and E. Coli. Faecal Streptococci counts peak in early morning 06.00 - 09.00 am and early evening 15.00 - 18.00pm.

(10) Spill events are characterised by widely varying bacterial levels, but the levels are generally higher during summer events.

8.2.2. **River Quality Impacts**

(1) The remobilisation of significant bed deposits of coal waste prevented any meaningful assessment of suspended solids impacts.

(2) River ammonical nitrogen impacts were relatively insignificant due to the low spill concentrations. Event levels never rose above 1.3 mgl^{-1}, more typically averaging 0.38mgl^{-1}, increasing on average by just 0.27mgl^{-1}. The study CSO represented the <u>only</u> significant source of ammonia in the catchments.

(3) River dissolved oxygen levels rarely fell below 10.0mgl^{-1}, at most recording a 1.0mgl^{-1} reduction immediately below the CSO discharge. A combination of the steep stream gradient, high velocities, high diffusion and high reaeration rates all contribute to the above.

(4) River BOD levels rose in response to each significant event. On average, BOD levels were elevated by 7.4mgl^{-1}. Worse-case impacts exhibited a 22mgl^{-1} increase in BOD immediately downstream of the CSO.

(5) In-stream dilution levels were considered to be a key factor in determining in-stream water quality impacts at the study CSO. Hence, where spill dilution levels were greater than 3:1 (River:Spill), no significant chemical impacts were noted. In all, 43% of monitored events exhibited a dilution of <3:1.

(6) Generally, spill impacts occurred early on the rising limb of the stream hydrograph, usually within 30 minutes of rainfall commencement.

(7) Occasionally, significant BOD inputs were monitored at the upstream control site. These could be attributed to limited illegal crude connections to storm water systems.

(8) Despite short duration periods of elevated river BOD levels of up to $34mgl^{-1}$, river D.O. levels remained at or near saturation.

8.3 Implications for Receiving Water Biota

8.3.1 Biological Impacts

(1) Benthic macroinvertebrate communities appear little affected by exposure to the study CSO and corresponding elevations in river BOD in particular. Indeed, overall BMWP scores have improved since the beginning of the study, probably in response to the improved situation in the upper catchments with regard to a reduction in diffuse coal solids inputs.

(2) The use of benthic macroinvertebrates as bioassay organisms proved to be a successful and novel approach to assessing intermittent CSO impacts. **Ephemera danica** and **Gammarus pulex** proved most sensitive to CSO exposure.

8.3.2 Fisheries Impacts

(1) The fish stocking experiments and fish egg survival studies demonstrated that the CSO was having no detrimental impact on the fishery potential of the receiving water.

(2) The reappearance of naturally spawned brown trout during the study also showed that the stream was recovering, despite significantly elevated BOD levels.

(3) Fish egg survival assays have confirmed their potential applications for assessing the toxicity of intermittent discharges.

8.4 Outstanding Issues

Whilst the chemical and corresponding biological impacts of the study CSO have been examined and reported, no examination of the overflow's aesthetic impacts have been carried out. As a high-side-weir with scum boards, the study CSO represents albeit a less than perfectly designed example of a type recommended by WRC and CIRIA, not requiring a screening provision in less sensitive locations. Qualitatively, the experience of the study group would endorse such a recommendation in the case of such small (population 3000) domestic only sewer systems, discharging to small NWC Class 2 receiving waters of limited aesthetic value. Quantities of sewage derived debris appeared low in the study receiving waters. However, there is no substitute for a more quantitative study such as that undertaken on the Taff (Davies, 1989).

The study CSO has also been seen to act as a significant source of bacteriological inputs. Clearly only a qualitative examination of the problem has been undertaken in this study. A more quantitative examination is thus urgently recommended in the light of increasing public health concerns in relation to inland recreational water use.

Finally, in relation to the original objective (b) in Section 2, the development of the "NUT" water quality model to include the simulation of transient point source pollution from CSO's has since been overtaken by the NRA's adoption of a more sophisticated modelling tool ("MIKE 11").

9 RECOMMENDATIONS

9.1 Monitoring Implications

(1) Dry weather flow sampling above an overflow will provide a useful but crude basis for assessing potential chemical impacts, after consideration of the dilution provided before spillage occurs. Some visual assessment of sewer sediment presence/absence is also recommended.

(2) An analysis of the biological impacts and BMWP scores both above and below CSO's are recommended as the most cost effective means of rapidly assessing receiving water impacts and monitoring consent compliance.

(3) In cases warranting more detailed assessments, T.O.A.D. automated activated systems are strongly recommended. A minimum of 12 events should be assessed both upstream and downstream of the overflow, the latter preferably at two separate locations.
Worse case effects should be monitored between 16.00 and 19.00 pm on weekdays.

(4) Selective ion ammonium electrodes can be recommended for use in storm overflows, provided weekly maintenance visits are adopted.

(5) Macroinvertebrate bio-assay tests using **Gammarus pulex** and **Ephemera danica** are recommended for an assessment of the extent of in-situ toxicity.

(6) Rainbow trout egg survival tests are recommended for an assessment of the extent of in-situ sensitive life stage fish population toxicity.

(7) The bacteriological impacts of CSO discharges requires further quantification.

(8) The aesthetic impacts of CSO discharges requires urgent and detailed investigation, using the experimental design methods adopted for marine outfall studies (Thomas et al 1989).

9.2 Pollution Control Implications

(1) High side weir installations with well maintained scum-boards appear to represent an acceptable design solution on sewer systems serving small domestic-only catchments discharging into fast flowing, well reaerated receiving waters. That is, provided overflow settings ensure a dilution of at least 3:1 in the receiving water at all times and comparable magnitude, frequency and duration event characteristics are in operation (i.e. spill duration typically 1 hour or less and < 50 events p.a.).

(2) Overflow settings should be designed to prevent spillage until a dilution in excess of 3:1 is available in highly reaerated receiving waters.

(3) First foul flush impacts should be restricted by the provision of adequately designed installations (as WRC recommendations) or the provision of on line storage.

(4) Impact assessments should ideally not be restricted to consideration of potential river event BOD levels. Some consideration of the corresponding dissolved oxygen conditions should also be undertaken. In the absence of available

reaeration information, suitably relaxed event BOD levels should be adopted in fast flowing receiving waters.

(5) Sewer flow and quality modelling and river impact simulations offer the most cost effective means of assessing potential sewerage system impacts.

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TABLES

Table 1 **Nant Ffrwd River Water Quality (1985-87)**

	BOD_5(ATU)	Ammoniacal N.	Particulate Solids
N	10	12	14
Mean	2.115	0.083	99
Maximum	6.15	0.21	644
Minimum	0.70	<0.04	7
S.D.	1.60	0.056	177
95%ile (Lognormal)	5.11	0.19	346

Table 2 **Study C.S.O. Details**

Catchment Details

Population - 3000

Total Area - 26.4 ha

Impermeable Area - 9.2 ha

Domestic only

Chamber Details

High Sided Weir

Peak inflow (1yr ret. period) - 250 ls-1

Carry-on flow - 60 ls -1

Peak overflow (1yr ret. period) - 190 ls -1

Dimensions - 7 x 2.7 x 1.5m

Inlet - 530mm

Outlet - 230mm

Dry Weather Flow - 6.0 ls -1

Dry Weather Flow Details

	BOD_5(ATU)	Ammoniacal N.	Total Suspended Solids
N	17	18	16
Mean	177	16.8	204
Maximum	306	24.6	362
Minimum	15	6.2	16
S.D.	101	6.0	117
95%ile (Lognormal)	368	28	425

TABLE 4 CSO EVENT SUMMARY

NO	DATE	5-DAY ANTECEDENT RAINFALL (MM)	SPILL TIME START (HH:MM)	SPILL DURATION (MINS)	PEAK CONCENTRATION (mgl) BOD	AMM.N	SS	PEAK LOAD (g/s) BOD	AMM.N	PEAK FLOW (ls)	TOTAL SPILL LOAD (Kg) BOD	AMM.N	SS	RAINFALL TOTAL (MM)	MEAN INT (MMH-1)	POLLUTION FLUSH 1ST	2ND	MULTI
2	15.3.88	11	01:37	56	23	1.1	194	1.73	0.09	110	2.51	0.2	22.7	3.0	0.8	Y	N	N
3	16.4.88	9	04:55	25	34	1.6	127	0.13	0.01	7	0.21	0.02	1.02	5.4	1.4	N	N	N
4	30.4.88	9	21:00	64	40	2.9	252	4.0	0.26	155	6.49	0.46	22.0	N/A	N/A	N	N	N
5	28.5.88	19	17:07	30	204	5.8	614	20.25	1.21	250	22.61	1.11	84.0	7.15	0.6	Y	Y	N
6	8.6.88	4	20:36	55	32	4.0	115	0.42	0.08	15	2.62	0.42	8.02	6.0	0.75	Y	Y	N
7	26.6.88	3	04:00	56	60	6.1	170	N/A	N/A	30	N/A	N/A	N/A	7.75	1.38	N/A	N/A	N/A
8	2.7.88	14	04.00	264	95	1.5	486	N/A	N/A	50	N/A	N/A	N/A	3.06	0.57	N/A	N/A	N/A
9	10.7.88	30	06:00	30	130	5.9	177	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	2.8.88	14	16:04	30	110	2.5	1134	48.0	0.62	420	49.9	0.66	496.0	7.0	14.0	Y	Y	N
11	13.9.88	2	08.19	20	93	3.3	370	0.28	0.01	5	0.88	0.03	3.67	5.02	2.12	N	N	N
12	18.10.88	4	17:11	45+10	66	4.9	271	1.51	0.09	60	2.22	0.12	6.41	6.4	3.35	Y	Y	Y
13	21.1.89	14	22:30	298	80	5.8	418	N/A	N/A	50	N/A	N/A	N/A	16.6	3.05	N/A	N/A	N/A
14	23.2.89	64	20:12	70	71	4.4	196	1.75	0.14	90	8.59	0.42	27.4	21.0	1.9	Y	Y	N
15	6.3.89	45	16:23	40	62	1.8	866	7.68	0.09	170	7.62	0.12	79.7	7.4	2.11	Y	N	N
16	19.3.89	12	12:59	35	108	2:3	384	7.64	0.16	80	17.8	0.33	46.4	13.1	1.32	N	N	N
17	26.4.89	3	N/A	N/A	140	3.5	988	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 4 CSO EVENT SUMMARY

NO	DATE	5-DAY ANTECEDENT RAINFALL (MM)	SPILL TIME START (HH:MM)	SPILL DURATION (MINS)	PEAK CONCENTRATION (mgl) BOD	PEAK CONCENTRATION (mgl) AMM.N	PEAK CONCENTRATION (mgl) SS	PEAK LOAD (g/s) BOD	PEAK LOAD (g/s) AMM.N	PEAK FLOW (ls)	TOTAL SPILL LOAD (Kg) BOD	TOTAL SPILL LOAD (Kg) AMM.N	TOTAL SPILL LOAD (Kg) SS	RAINFALL TOTAL (MM)	RAINFALL MEAN INT (MMH-1)	POLLUTION FLUSH 1ST	POLLUTION FLUSH 2ND	POLLUTION FLUSH MULTI
18	24.5.89	8	16:05	30	180	5.0	2530	4.8	1.3	370	22.4	0.47	750	7.5	2.57	Y	N	N
19	14.8.89	28	18:59	189	42	3.1	478	9.09	0.26	370	7.3	0.24	102.3	13.66	2.77	N	N	N
20	16.9.89	17	08:55	6	51	7.0	436	0.39	0.06	50	0.12	0.01	204	7.12	1.42	N	N	N
21	20.10.89	32	12:05	11	65	3.0	272	0.74	N/A	14	0.18	N/A	N/A	7.92	1.49	N	N	N
22	20.10.89	32	16:35	116	150	2.5	574	2.5	0.1	110	3.95	0.19	120	7.92	1.49	N	N	N
23	8.11.89	28	06:11	115	27	6.4	141	0.98	0.2	160	2.17	0.35	22	N/A	N/A	N	N	N
24	9.11.89	38	17:15	120	25	1.5	128	1.5	0.12	120	2.93	0.15	14	N/A	N/A	N	N	N
25	13.12.89	28	06:23	25+25+20	25	3.9	120	0.58	0.15	60	3.36	0.84	249.6	26.23	2.91	Y	Y	Y
26	16.12.89	94	05:49	50	17	2.9	112	0.66	0.19	150	2.48	0.47	21.1	23.07	2.71	Y	Y	N
MEAN		23		74	77	3.7	462	5.7	0.27	126	8.3	0.35	120	10.1	2/44			
MAX		94		298	204	7.0	2530	48	1.3	420	49.9	1.11	496	26.23	14.0			
MIN		2		11	17	1.1	112	0.13	0.01	5	0.12	0.01	1.02	3.0	0.6			
TOTAL	25	25	24	24	25	25	25	20	19	23	20	19	19	20	20	10	7	2
WIN	13																	
SUM	12																	
AM			10															
PM			14															

TABLE 5 RIVER IMPACT SUMMARY

No	PEAK CONCENTRATION IMPACT (mg/1) B.O.D U.S	B.O.D D.S.1 (Diff)	B.O.D D.S.2 (Diff)	AMMONIACAL N. U.S	AMMONIACAL N. D.S.1 (Diff)	AMMONIACAL N. D.S.2 (Diff)	PEAK RIVER LOAD IMPACT (g/s) B.O.D. U.S	B.O.D. D.S.1	B.O.D. D.S.2	AMMONACAL N U.S	AMMONACAL N D.S.1	AMMONACAL N D.S.2	CSO TIME START TO PEAK IMPACT LAG (mins) D.S.1	CSO TIME START TO PEAK IMPACT LAG (mins) D.S.2	MINIMUM DILUTION (RIVER: SPILL)
2	3.0	4 +1.0)	-	0.04	0.2+0.16)	-	n/a	n/a	n/a	n/a	n/a	n/a	10	-	n/a
3	2.1	2.6+0.5)	1.0-1.1	0.06	0.06 (0)	0.06 (0)	0.2	0.4	0.2	0.1	0.1	0.02	15	25	27:1
4	2.0	20 (+18)	-	0.10	0.42+032)	-	0.5	5.6	-	0.01	0.1	-	55	-	1:1
5	6.0	28 (+22)	-	0.2	0.7(+0.5)	-	1.0	7.0	-	0.03	0.15	-	1	-	1:1
6	2.0	3.0(+1)	-	0.07	0.4(+.33)	-	0.5	0.6	-	0.015	1.10	-	5	-	14:1
10	3.0	5.0(+2)	25.0+22	0.2	0.55+0.35	1.2(+1.0)	1.0	1.5	7.5	0.04	0.17	0.36	5	20	<1:1
11	8.5	12.0+3.5	-	0.3	0.55+0.35	-	n/a	n/a	n/a	n/a	n/a	n/a	1	-	n/a
12	3.2	5.4(+2.2	-	0.4	0.26-0.14	-	0.6	1.1	-	0.08	0.06	-	15	-	3:1
14	2.0	5.8(+3.8	4.0+2.0	0.03	0.05+0.02	0.08+0.05	1.0	3.2	2.8	0.02	0.03	0.06	35	55	2:1
15	2.0	8.0(+6.0	9.0+7.0	0.04	0.16+0.12	0.14(+0.1	1.0	3.5	4.2	0.01	0.08	0.06	10	20	2:1
16	1.1	3.6(+2.5	3.7+2.6	0.05	0.05 (0)	-	0.6	1.7	3.0	0.01	0.01	-	15	35	3:1
18	21	34 (+13)	54(+33)	0.2	1.3(+1.1)	1.2(+1.0)	0.7	10.0	17.0	0.01	0.4	0.38	5	15	<1:1
20	3.0	21.0(+18	-	0.01	0.8(+0.79	-	.05	0.6	-	0.001	0.02	-	25	-	<1:1
21	1.5	4.0(+2.5	6.0+4.5	n/a	n/a	n/a	0.4	0.8	1.0	n/a	n/a	n/a	15	20	9:1
22	3.0	6.0(+3.0	4.0+1.0	n/a	n/a	n/a	1.0	3.0	2.9	n/a	n/a	n/a	15	20	6:1

TABLE 5 RIVER IMPACT SUMMARY

No.	PEAK CONCENTRATION IMPACT (mg/1) B.O.D U.S	B.O.D D.S.1 (Diff)	B.O.D D.S.2 (Diff)	AMMONIACAL N. U.S	AMMONIACAL N. D.S.1 (Diff)	AMMONIACAL N. D.S.2 (Diff)	PEAK RIVER LOAD IMPACT (g/s) B.O.D. U.S	B.O.D. D.S.1	B.O.D. D.S.2	AMMONACAL N U.S	AMMONACAL N D.S.1	AMMONACAL N D.S.2	CSO TIME START TO PEAK IMPACT LAG (mins) D.S.1	CSO TIME START TO PEAK IMPACT LAG (mins) D.S.2	MINIMUM DILUTION (RIVER: SPILL)
23	0.5	2.8(+2.3	-	0.08	0.15+0.07	-	0.3	1.1	-	0.03	0.07	-	20	-	>3:1
24	6.0	26.0(+20	-	n/a	n/a	n/a	2.0	13.0	-	n/a	n/a	n/a	1	-	.3:1
	4.0	20.0(+16	-	n/a	n/a	n/a	10.0	50.0	-	n/a	n/a	n/a	1	-	19:1
25	2.0	2.3(+0.3		n/a	n/a	n/a	1.8	2.0	-	n/a	n/a	n/a	5	-	15:1
	1.8	3.7(+1.9		n/a	n/a	n/a	1.8	4.0	-	n/a	n/a	n/a	5	-	17:1
	1.8	3.8(+2.0		n/a	n/a	n/a	2.0	5.4	-	n/a	n/a	n/a	5	-	22:1
26	1.1	1.8(+0.7	2.1(+1.0	0.08	0.08 (0)	0.08 (0)	2.7	4.7	6.0	0.25	0.25	0.25	25	45	2:1
	1.4	2.6(+1.2	1.9(+0.5	0.16	0.4 +0.24	0.14-0.02	4.4	8.5	6.2	0.5	1.5	0.4	15	17	3:1
MEAN	3.6	9.8(+6.2	11.1+7.4	0.13	0.38+0.27	0.41+0.31	1.6	6.1	5.1	0.08	0.22	0.22	13	27(+14)	7.5:1
MAX	21	34 (+22)	54 (+33)	0.4	0.7(+1.1)	1.2(+1.0)	10	50	17	0.5	1.5	0.4	55	55(0)	27:1
MIN	0.5	1.8(+0.5	1.0 (+0)	0.01	0.05 (0)	0.06 (0)	0.5	0.4	0.2	0.001	0.01	0.02	1	15(+14)	<1:1
N	23	23	10	16	16	7	21	21	10	14	4	7	23	10	21

Table 6 **CSO Impact Assessment**

SUMMARY OF B.M.W.P. SCORE DATA

RIVER:- NANT FFRWD
DATE 7/7/88

FAMILIES	SCORE FAMILY	SITE NUMBERS 1	2	3	4	5	6
Heptageniidae	10				1	1	2
Ephemerellidae	10		2		3	2	2
Leuctidae	10		2		2	2	2
Perlodidae	10						1
Chloroperlidae	10				1		
Nemouridae	7	1		1			1
Rhyacophilidae	7		1		1	1	2
Limnephilidae	7			1			
Gammaridae	6			3	1	1	2
Mesovelidae	5	1					
Dytiscidae	5	1		1	1		
Helodidae	5			1			
Elminthidae	5						1
Tipulidae	5			1		1	
Simuliidae	5	1	1	1	2	2	2
Planariidae	5			2	1		
Baetidae	4	1	3	1	3	2	2
Erpobdellidae	3			1			
Asellidae	3				1		
Chironomidae	2	1	1	1	3	2	1
Oligochaeta	1		1	1	3	2	1
TOTAL TAXA		6	7	13	14	11	12
BMWP SCORE		28	39	62	85	67	77
A.S.P.T.		4.7	5.6	4.8	6.1	6.1	6.4

Table 7 **CSO Impact Assessment**

SUMMARY OF B.M.W.P. SCORE DATA

RIVER:- NANT FFRWD
DATE 12/10/89

FAMILIES	SCORE FAMILY	SITE NUMBERS 1	2	4	5	6
Heptageniidae	10	2	2	2	1	2
Leptophlebiidae	10	1				
Ephemerellidae	10					1
Leuctridae	10	3	2	2	2	2
Perlodidae	10	1		1		
Perlidae	10				1	1
Caenidae	7		2		1	
Nemouridae	7	3	2	2	2	2
Rhyacophilidae	7	1	1	1	1	2
Polycentropodidae	7	1	1	1	1	1
Ancylidae	6	1				
Gammaridae	6			2		
Dytiscidae	5			1		
Hydrophilidae	5					1
Elminthidae	5	1	1	1	1	
Hydropsychidae	5	2	3	2	2	2
Tipulidae	5	1	1	1	1	1
Simuliidae	5	3	2	2	2	2
Baetidae	4		2	2	2	2
Erpobdellidae	3		1	1	1	1
Chironomidae	2		2	2	2	2
Oligochaeta	1	1	1	2	2	2
TOTAL TAXA		13	14	16	15	15
BMWP SCORE		88	84	92	94	97
A.S.P.T.		6.8	6.0	5.8	6.3	6.6

Table 8

Population estimates for (i) Rainbow and (ii) Brown trout in the Nant Ffrwd following stocking experiments.

(i) Rainbow trout (Salmon gairdneri)

Date	Perameter	Age	Site 1	2	3	4	5
July 87	Density/100m	0+	N.S.	87	119	68	134
	Mean length cm.		N.S.	6.5	6.6	7.3	7.4
August 87	D	0+	66	53	74	61	72
	ML		7.6	8	8	9.1	9.3
Sept. 87	D	0+	20	38	62	64	52
	ML		9.7	10.1	10.6	12	11.7
April 88	D	0+	5	34	16	25	25
	ML		14.3	13.8	13.5	12.9	13.7
Sept. 88	D	0+	N.S.	72	51	N.S.	N.S.
	ML		N.S.	5.9	6.3	N.S.	N.S.
Sept. 88	D	>0+	N.S.	1.5	1.1	N.S.	N.S.
	ML		N.S.	--	--	N.S.	N.S.
(ii) Brown trout (Salmo trutta)							
Sept. 88	D	0+	N.S.	8.5	6	N.S.	N.S.
	ML			7.9	8.5		
Sept. 88	D	>0+		0	0.6		
	ML			--	--		

Table 9 <u>**Results of fish egg survival studies**</u>

<u>**July 1988**</u>

Results are expressed as mean % cumulative mortality

Days from start.

Sites	3	7	10	14	17	20
1	1	9	13	24	25	27
3	3	12	17	20	22	22
4	2	25	32	36	37	38
5	6	38	47	52	54	54

N.S. not sampled

Table 10. <u>Typical Pollutant Concentrations in CSO's (Crabtree et al. 1988).</u>

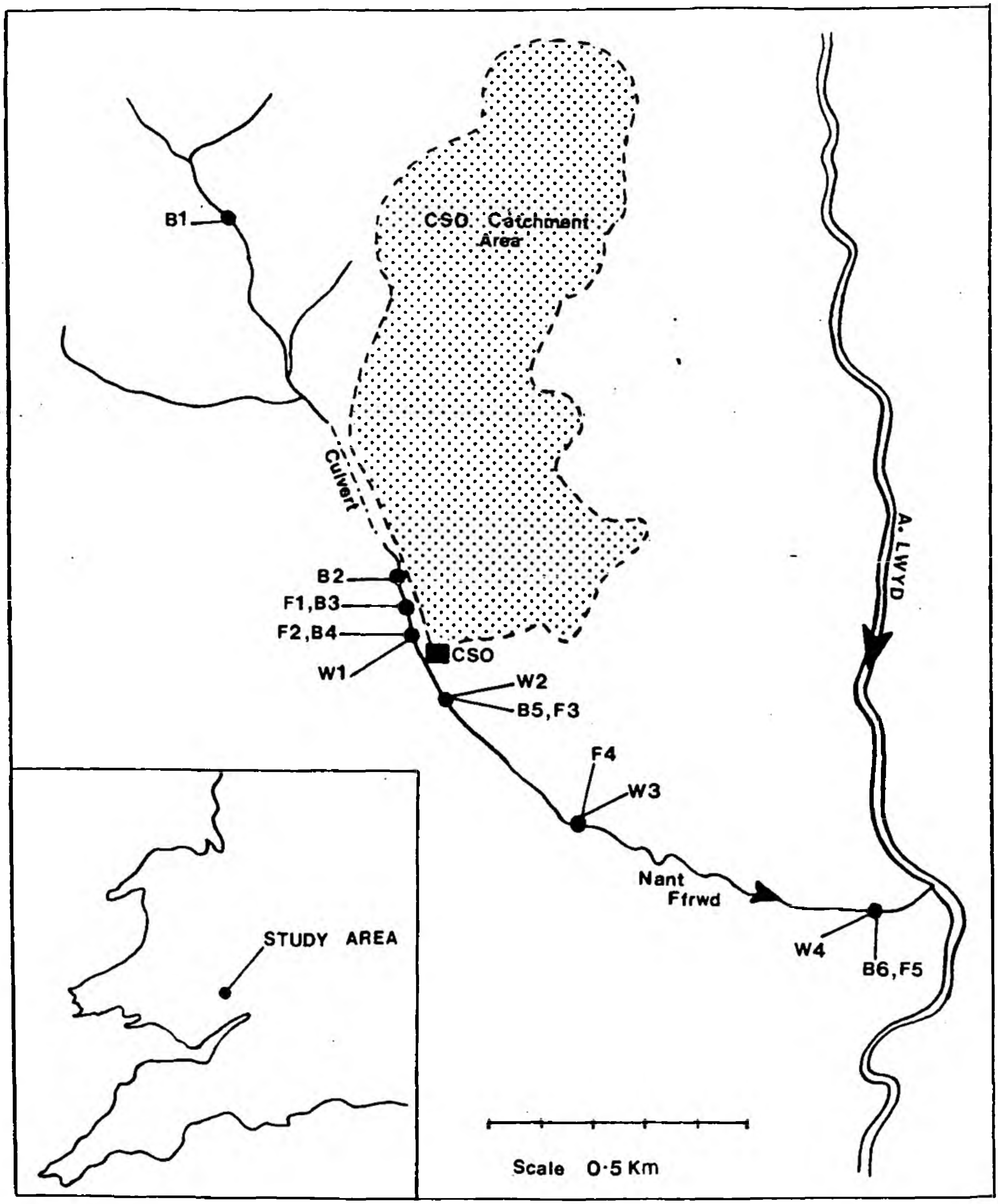
	BOD (mgl^{-1})	AMMONIA (mgl^{-1})	SUSPENDED SOLIDS (mgl^{-1})
Mean Concentration	100	8	400
Crude Sewage Multiplier Derived (For Study CSO)	54	5	300
Mean Concentration for Steep Systems	75	6	350
Monitored Mean Peak Concentrations (For Study CSO)	77	4	462
Mean Concentration in Storm Water Runoff	15	2	190

Table 11. CSO Spill Characteristics Correlation Matrix

	1 5 DAY RAIN (MM)	2 SPILLDUR (MINS)	3 BOD mgl^{-1}	4 NH3 mgl^{-1}	5 SS mgl^{-1}	6 BODLOAD g/s
2 SPILLDUR	0.218					
3 BOD	-0.243	-0.153				
4 NH3	-0.098	-0.208	0.309			
5 SS	-0.202	-0.151	0.644	0.181		
6 BODLOAD	-0.117	-0.087	0.396	-0.076	0.349	
7 NH3LOAD	-0.126	-0.154	0.768	0.382	0.755	0.476
8 PEAKFLOW	0.068	0.282	0.444	0.017	0.692	0.707
9 SPILLBOD	-0.134	-0.170	0.558	-0.002	0.573	0.929
10 SPILLNH3	0.151	-0.024	0.397	0.265	0.155	0.472
11 SPILLSS	-0.186	-0.146	0.465	0.246	0.884	0.441
12 TOTRAIN	0.704	0.288	-0.294	0.070	-0.260	-0.166
13 MEANRAIN (mml^{-1})	-0.037	-0.069	0.084	-0.138	0.299	0.841

7	8	9	10	11	12
NH3LOAD	PEAKFLOW	SPILLBOD	SPILLNH3	SPILLSS	TOTRAIN
g/s	l/s	kg	kg	kg	min
0.713					
0.656	0.757				
0.656	0.414	0.538			
0.687	0.678	0.636	0.313		
-0.108	-0.021	-0.104	0.398	-0.032	
0.197	0.572	0.770	0.228	0.504	-0.003

Fig.1 Map showing the study area and the location of the Combined Sewage Overflow (CSO), and Water quality (W), Biological (B) and Fisheries (F) sites.



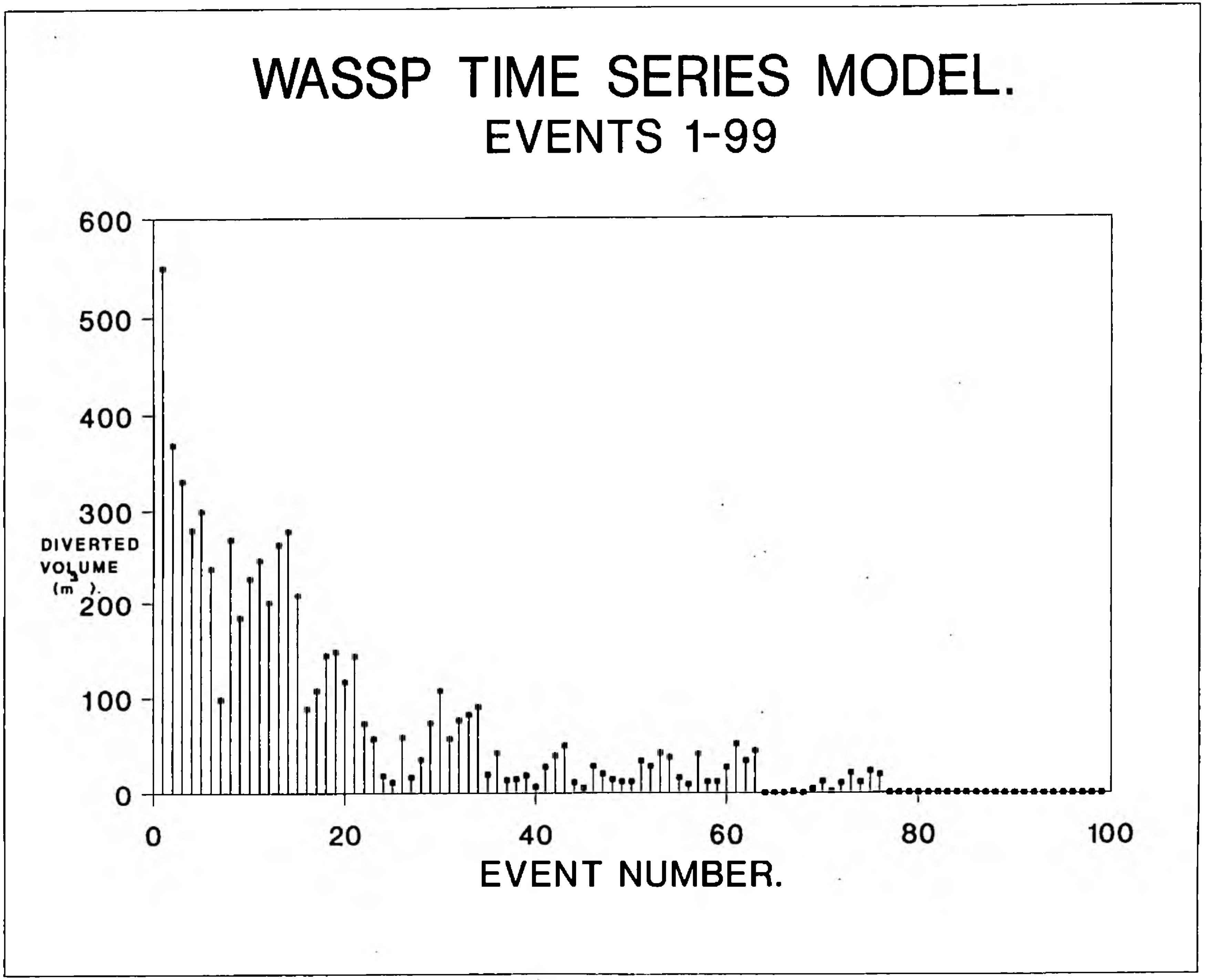
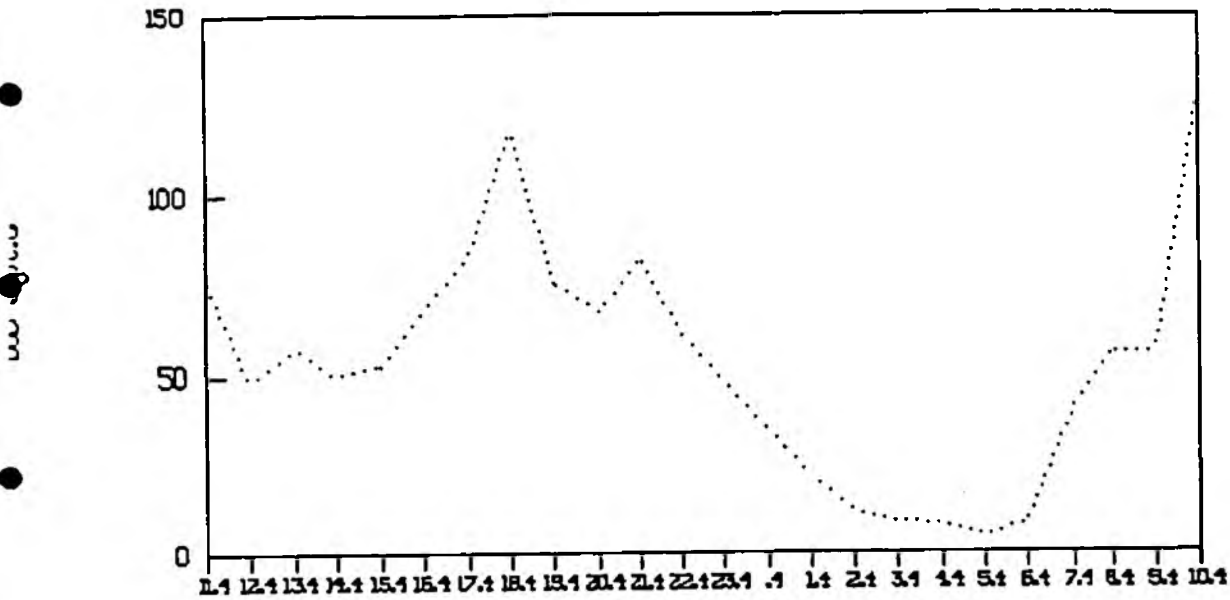

WASSP TIME SERIES MODEL.
EVENTS 1-99
DIVERTED VOLUME (m³).
600
500
400
300
200
100
0
0
20
40
60
80
100
EVENT NUMBER.

FIG.2

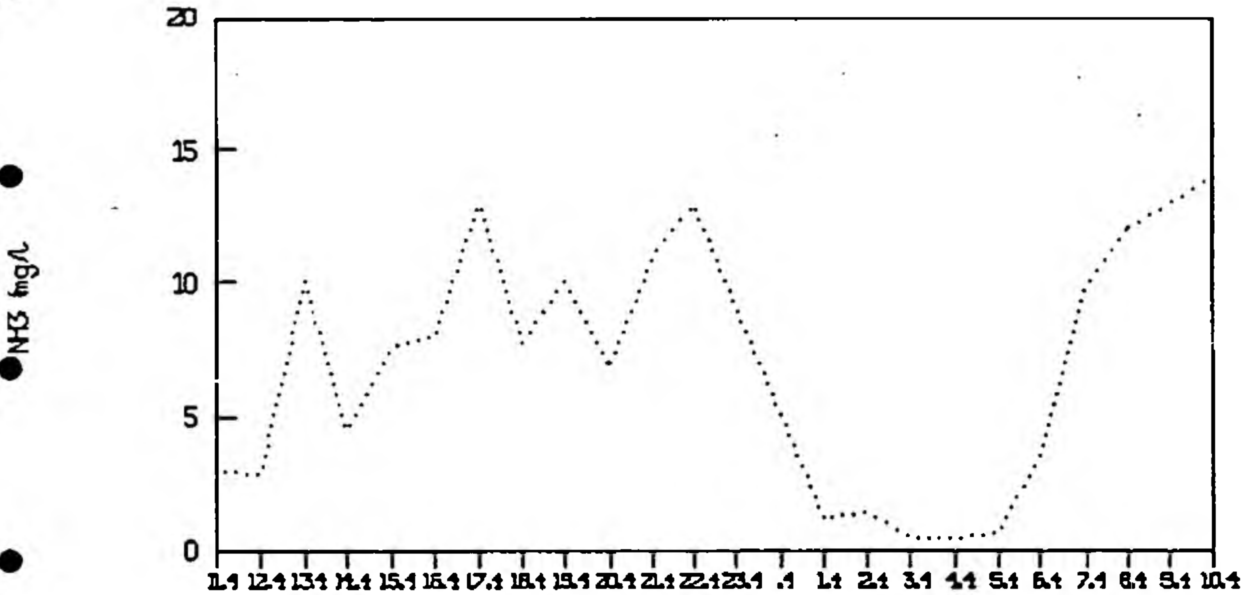
GARNDIFFAITH 550 DRY-FLOW SEWER QUALITY.

FIG.3

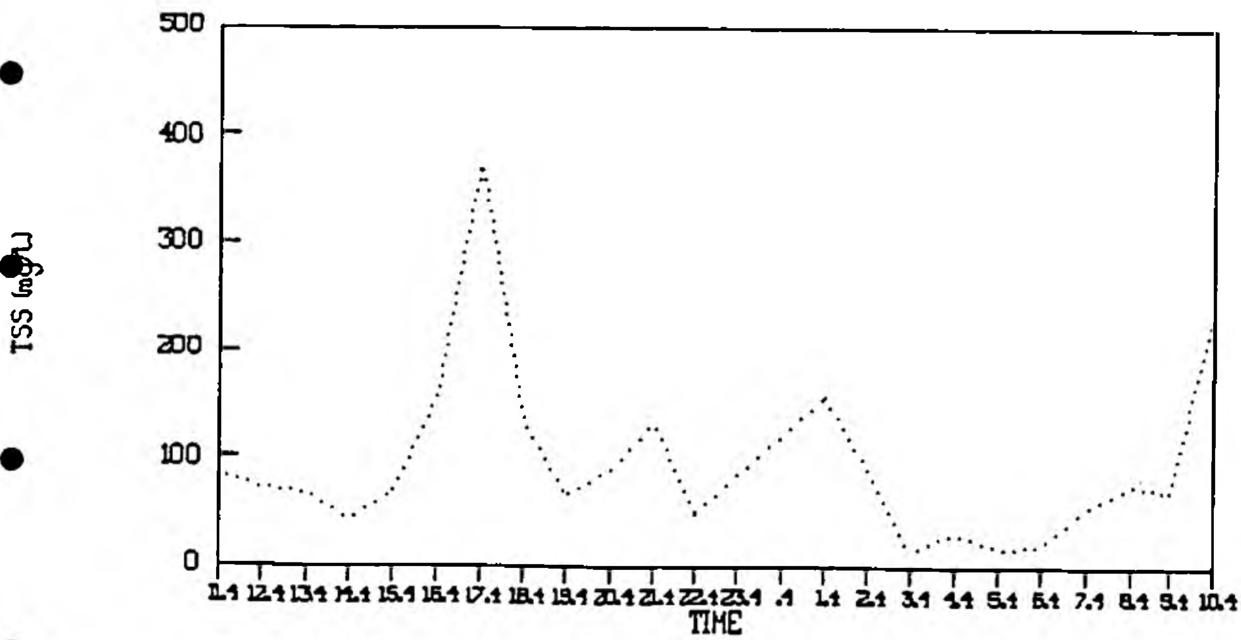
BOD VALUES



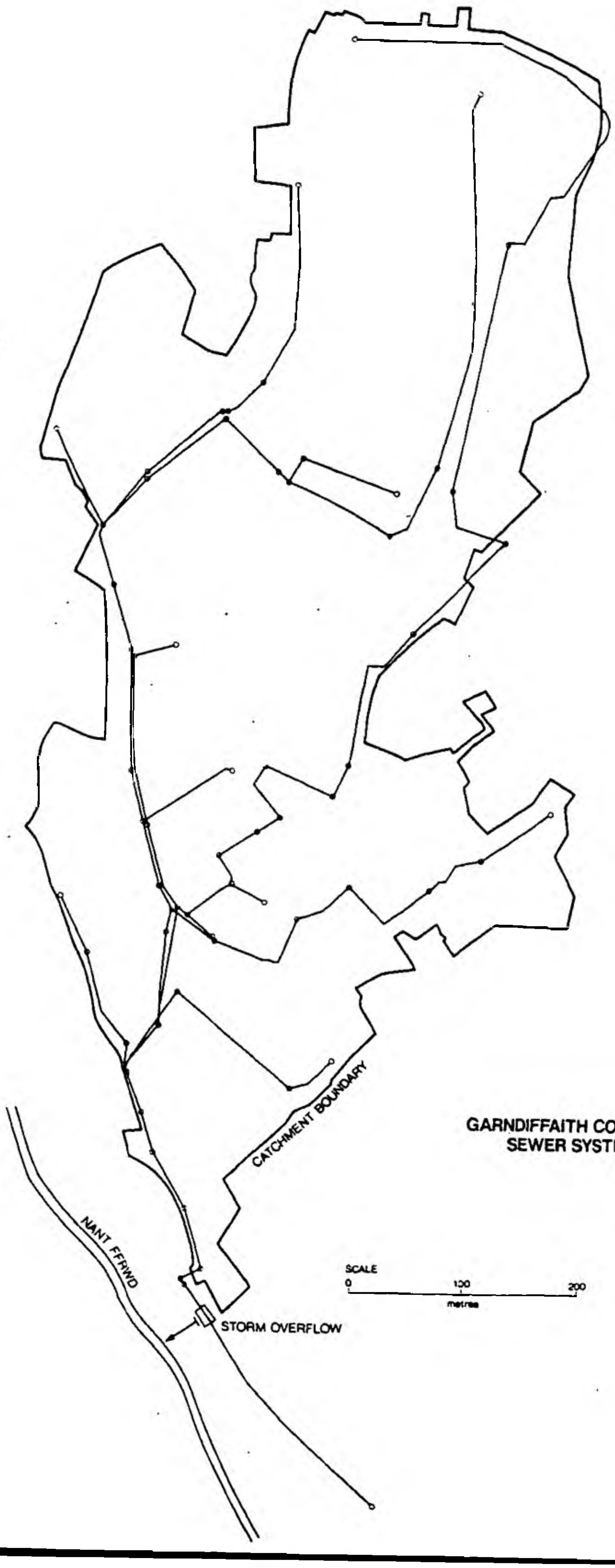
NH3 VALUES



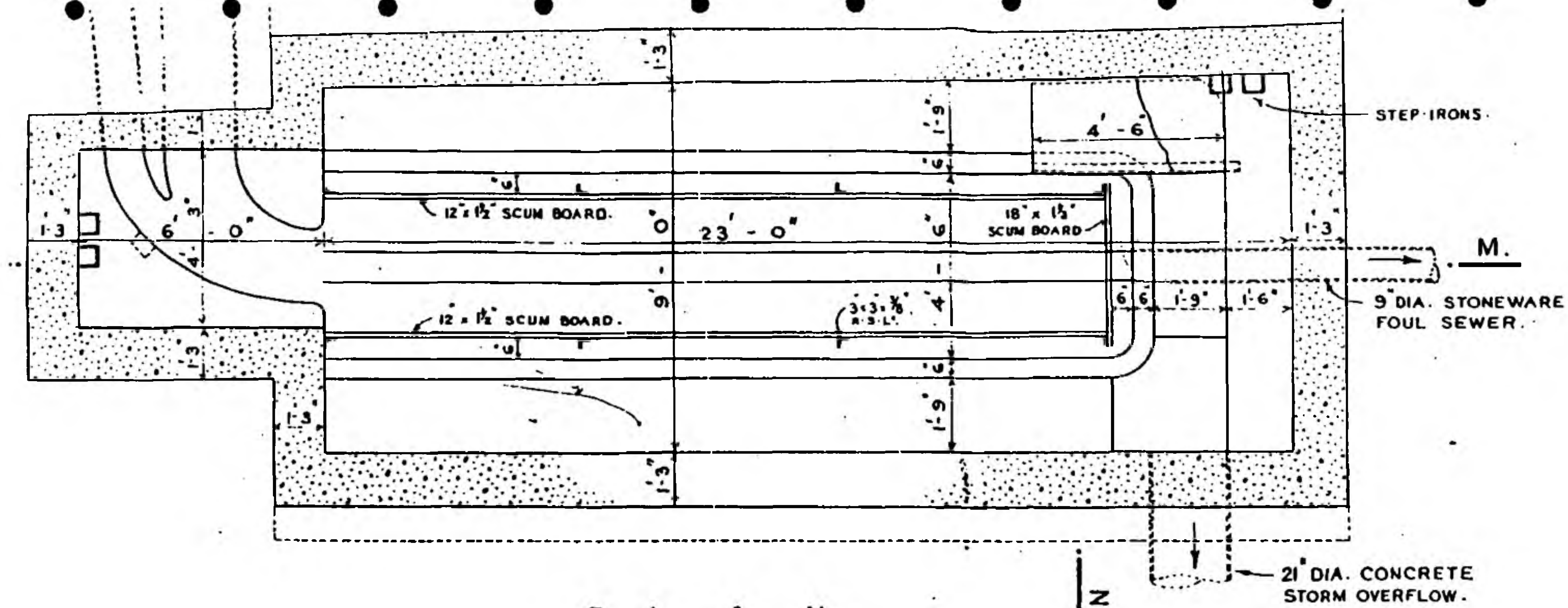
SOLIDS VALUES



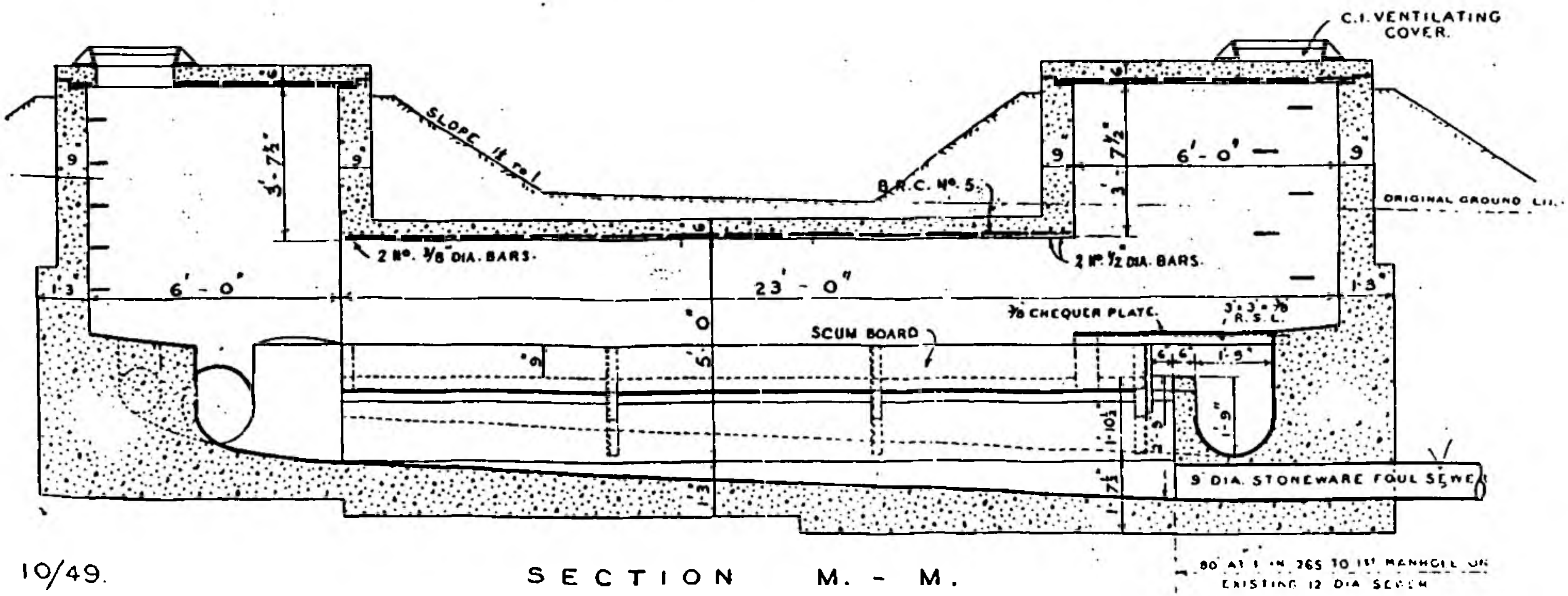
TAKEN 20/10/87



GARNDIFFAITH COMBINED
SEWER SYSTEM



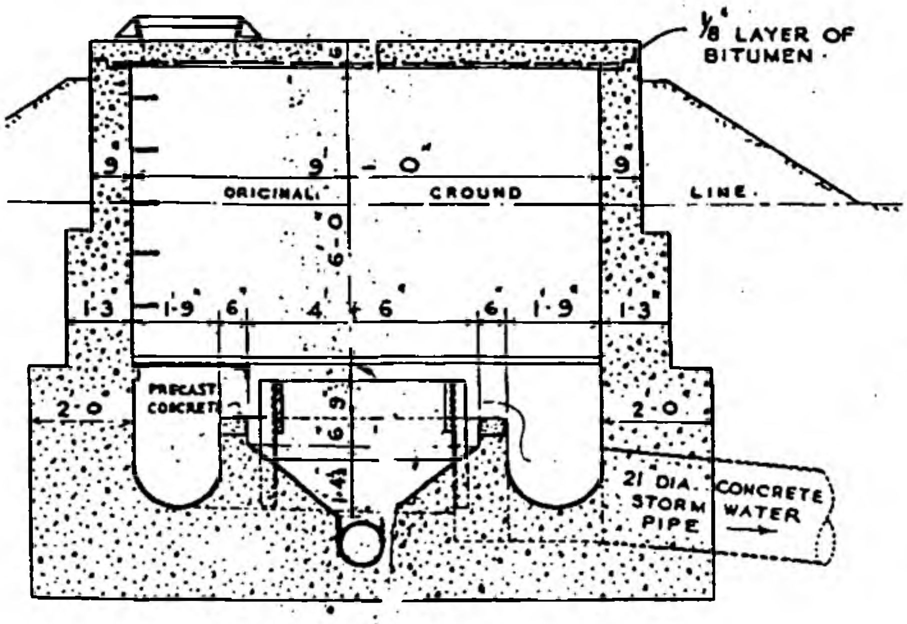
P L A N.



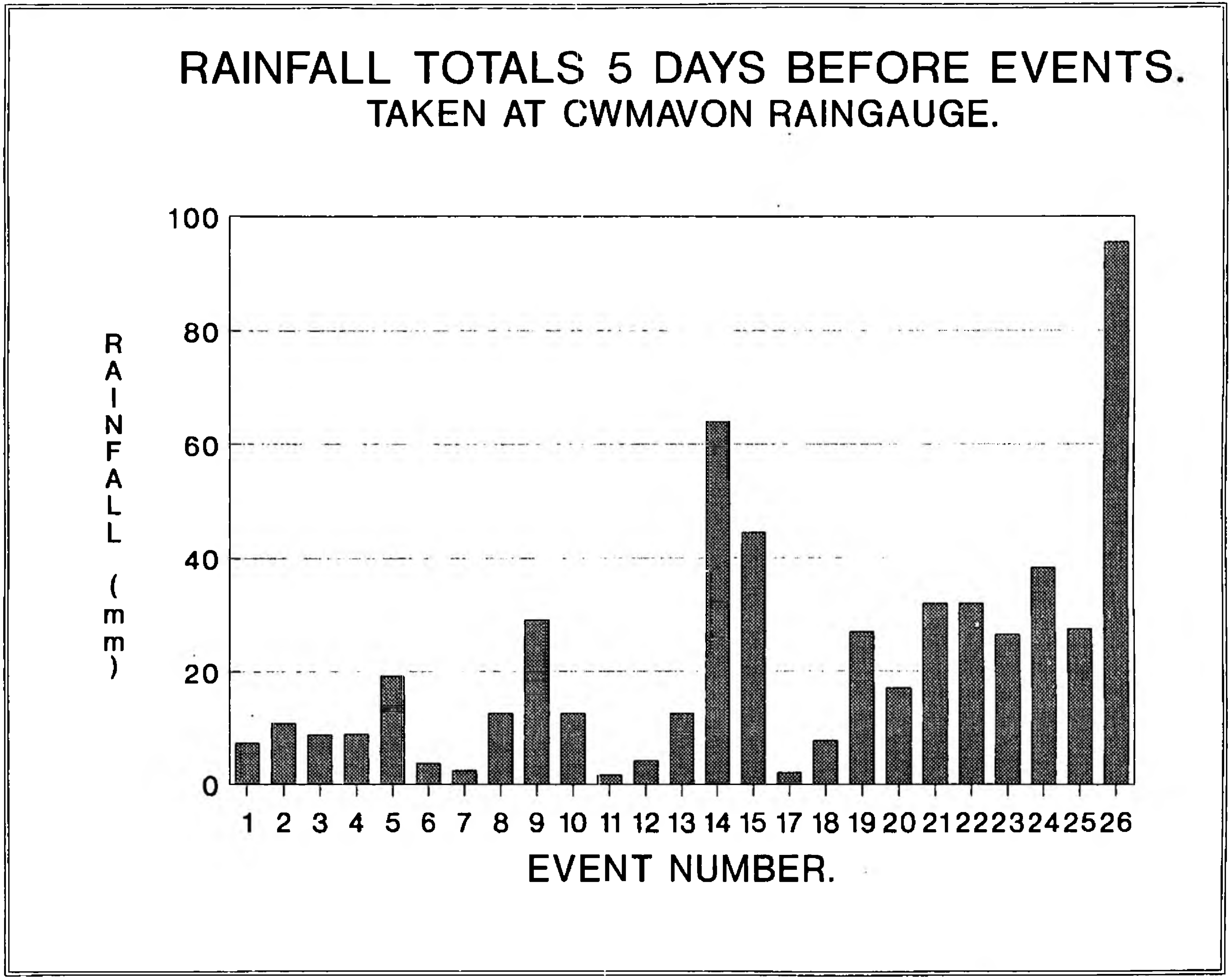
10/49.

SECTION M.-M.

FIG. 5


1/8" LAYER OF BITUMEN.
9'-0"
ORIGINAL GROUND LINE.
PRECAST CONCRETE
21" DIA. CONCRETE STORM WATER PIPE

SECTION. N.-N.



RAINFALL TOTALS 5 DAYS BEFORE EVENTS.
TAKEN AT CWMAVON RAINGAUGE.
RAINFALL (mm)
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 21 22 23 24 25 26
EVENT NUMBER.

FIG.6

SUMMARY GRAPHS FOR SEWER

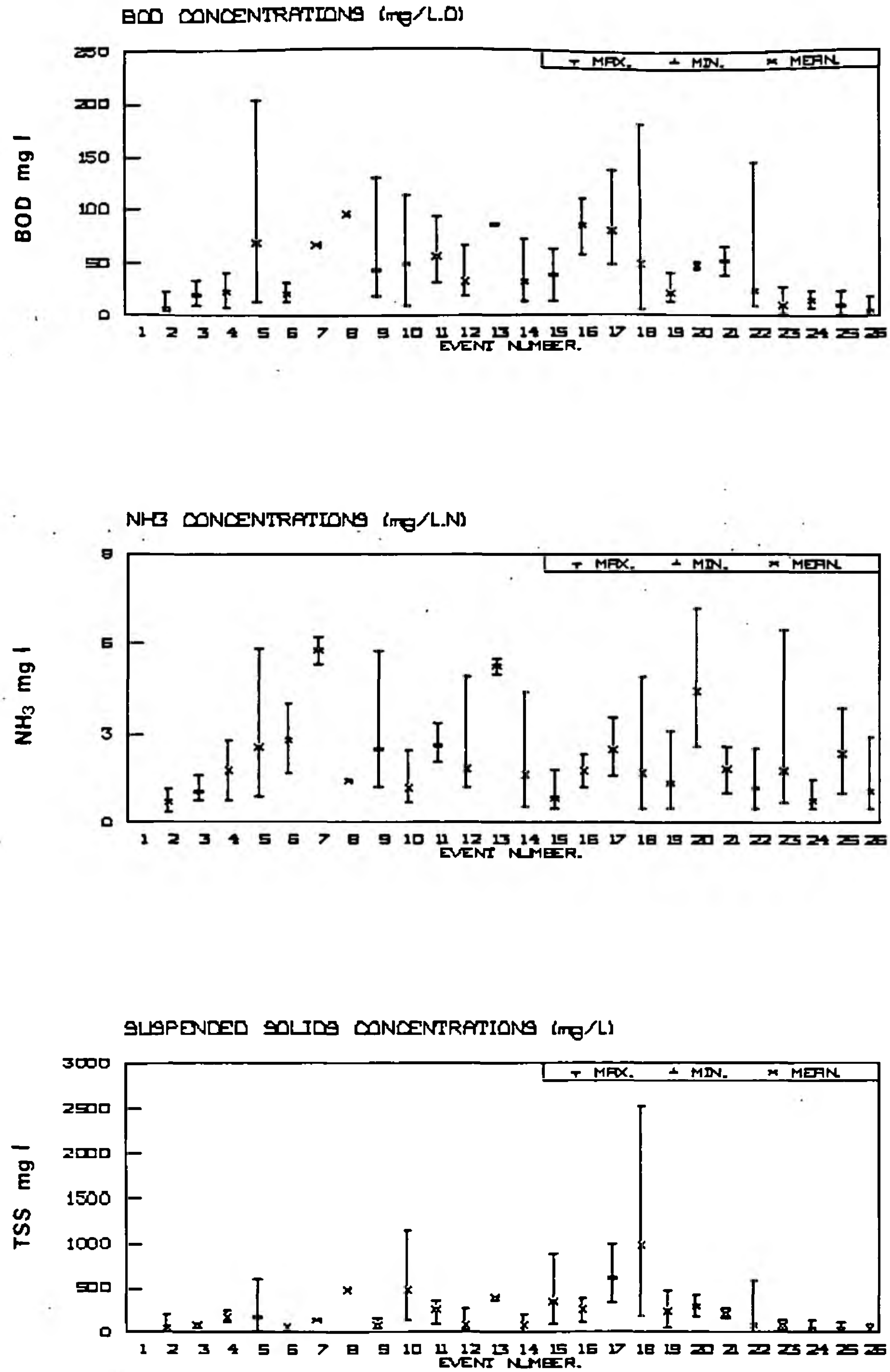
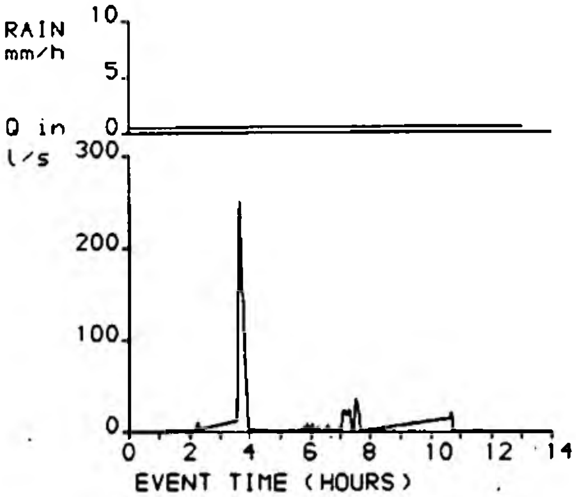


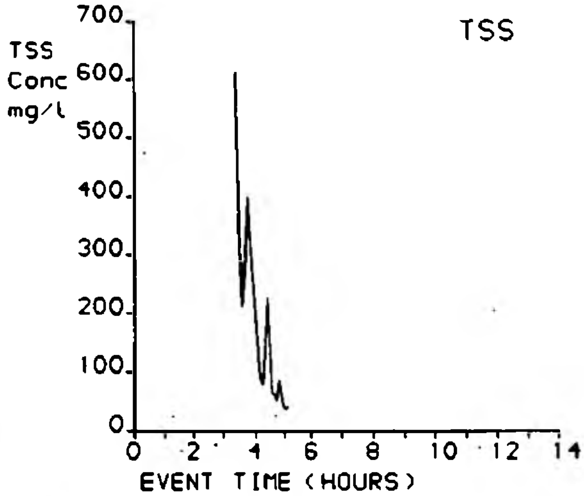
FIG. 8

Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880528SD.DAT EVENT 5

Grid Ref: 262044
Storm Date: 880528
Start Time (R/F): 1338
Rainfall Depth (mm): 30.8

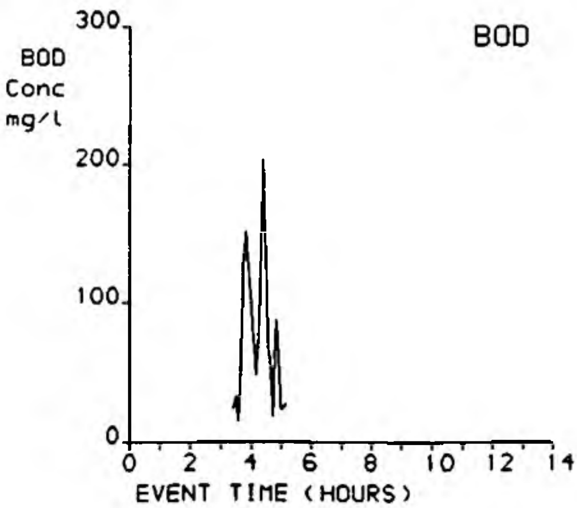
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 773.





NO DATA FOR COD

NO DATA FOR TDS



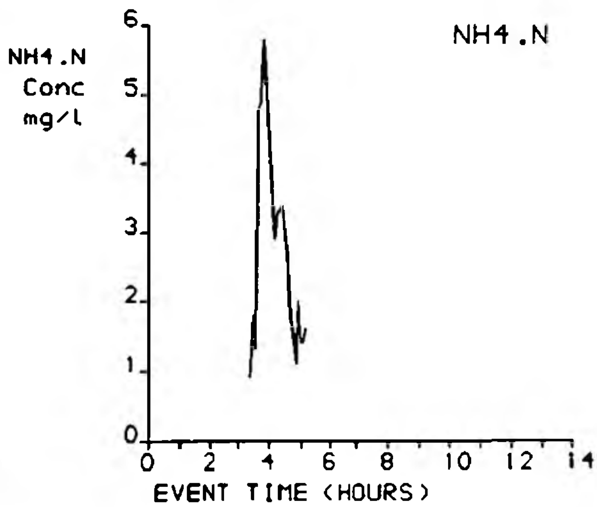


FIG. 9

Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880528SO.DAT

Grid Ref: 262044 Weather Conditions:
Storm Date: 880528 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1338 Antec. Dry Weather Period (hours): 0
RainFall Depth (mm): 30.8 RainFall Event Duration (mins): 773.

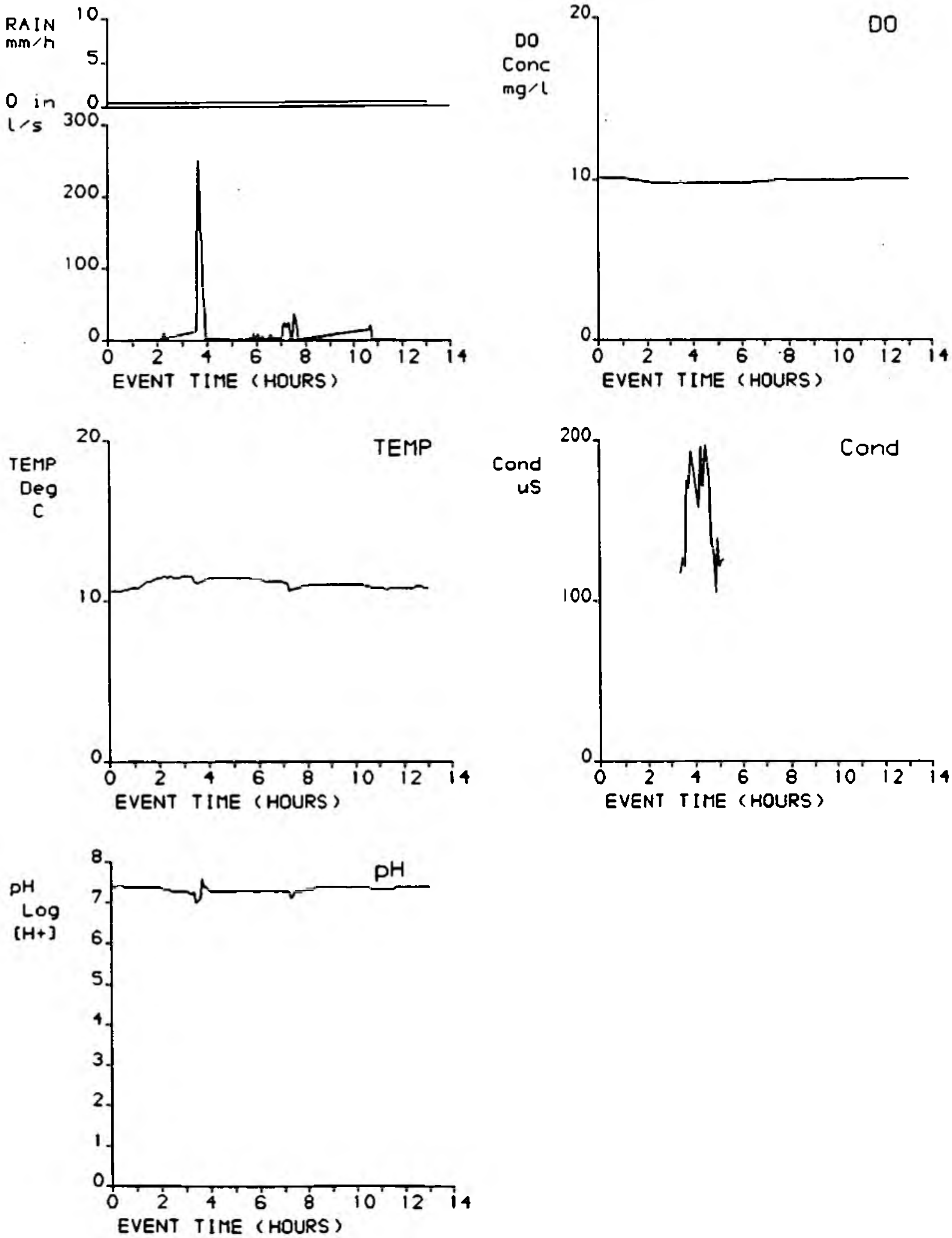
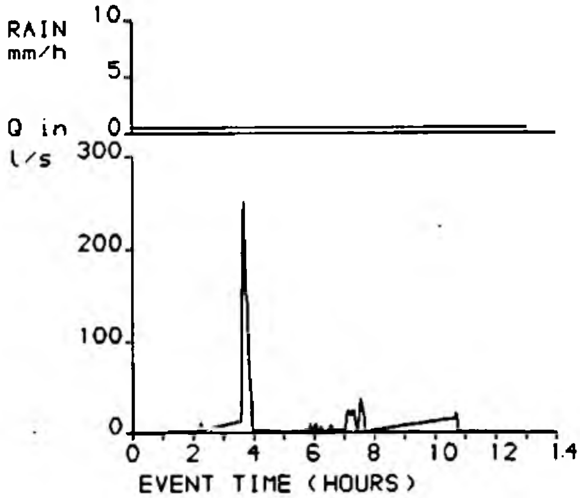


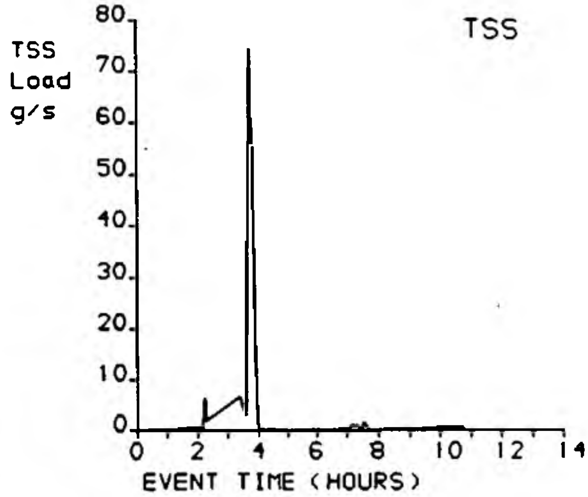
FIG.10

Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880528SO.DAT

Grid Ref: 262044
Storm Date: 880528
Start Time (R/F): 1338
Rainfall Depth (mm): 30.8

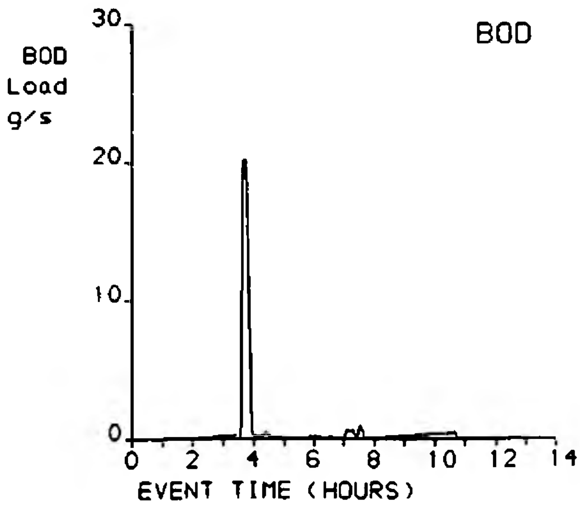
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 773.

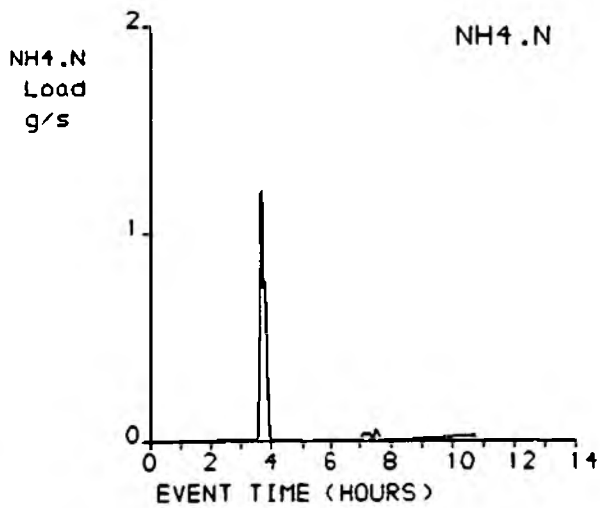




NO DATA FOR COD

NO DATA FOR TDS

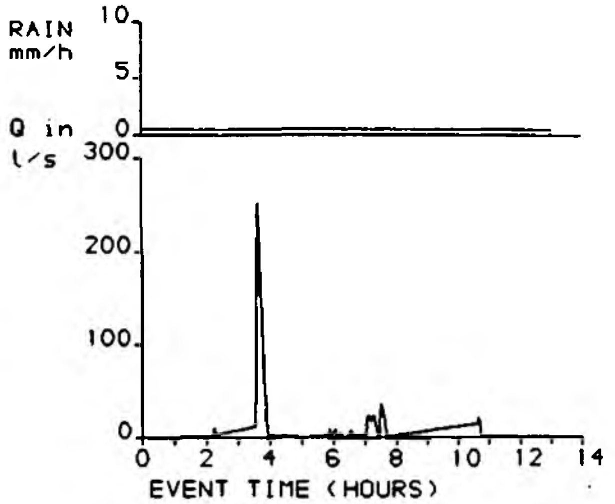


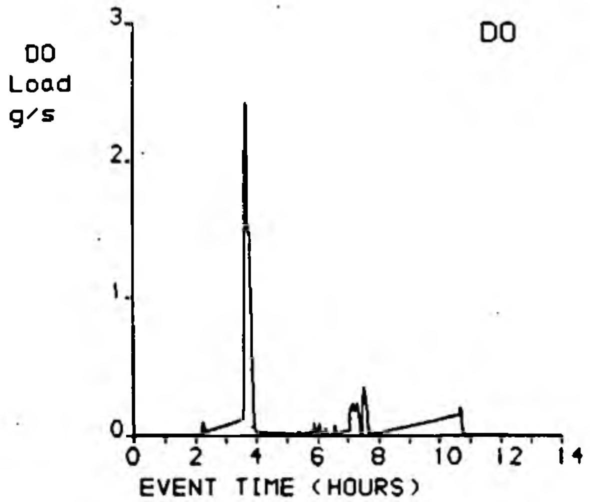


Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880528SO.DAT

Grid Ref: 262044
Storm Date: 880528
Start Time (R/F): 1338
RainFall Depth (mm): 30.8

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
RainFall Event Duration (mins): 773.





NO DATA FOR TEMP

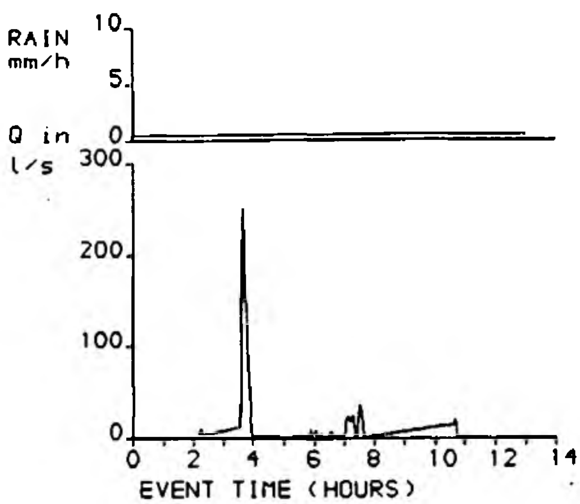
NO DATA FOR Cond

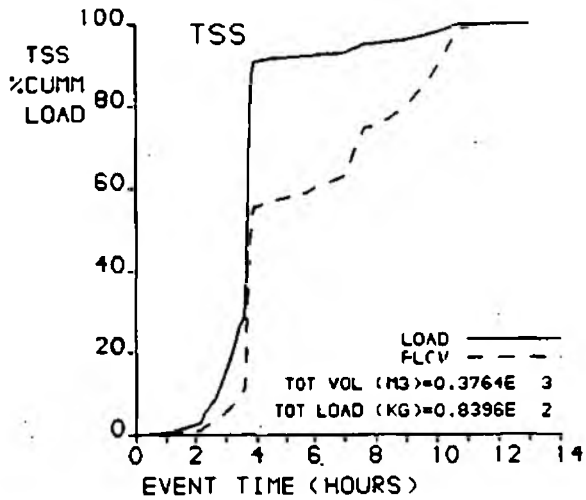
NO DATA FOR pH

FIG. 12

Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880528SO.DAT

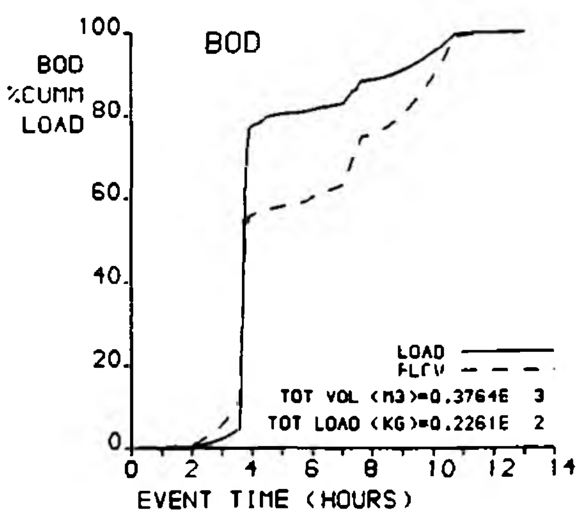
Grid Ref: 262044 Weather Conditions:
Storm Date: 880528 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1338 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 30.8 Rainfall Event Duration (mins): 773.





NO DATA FOR COD

NO DATA FOR TDS



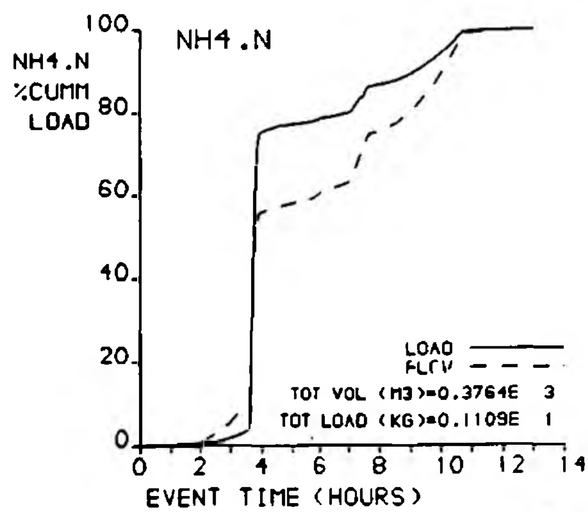
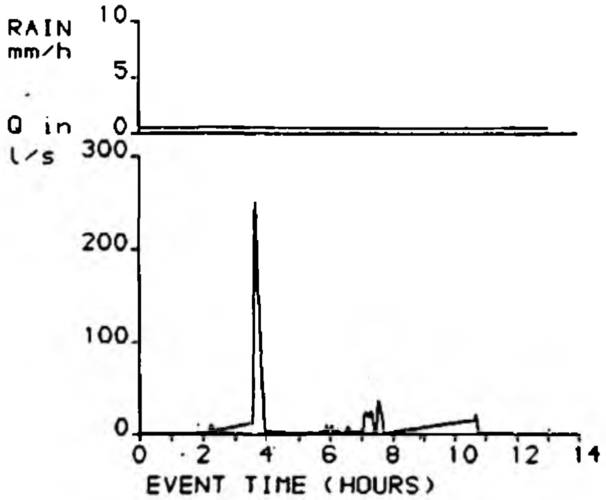


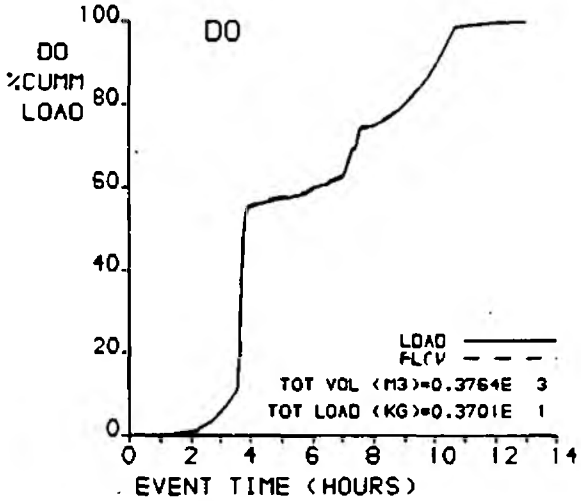
FIG. 13

Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880528SO.DAT

Grid Ref: 262044
Storm Date: 880528
Start Time (R/F): 1338
Rainfall Depth (mm): 30.8

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 773.





NO DATA FOR TEMP

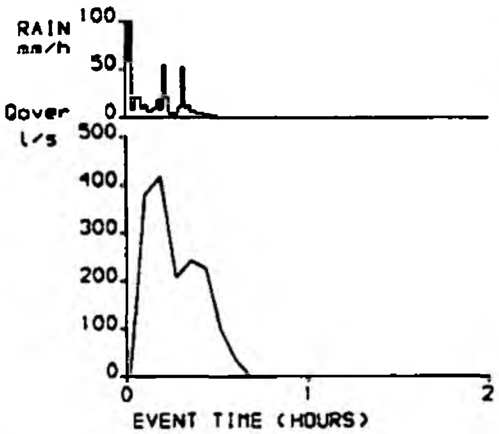
NO DATA FOR Cond

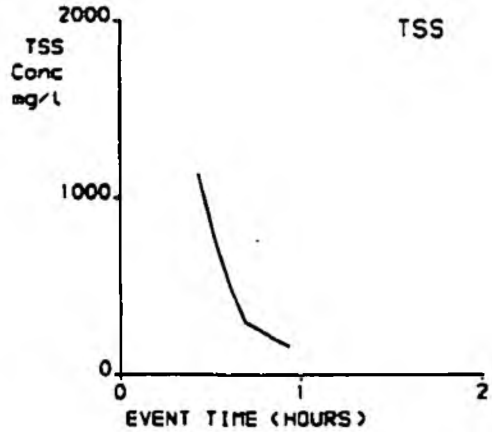
NO DATA FOP

FIG. 14

Site: GARNDIFFAITH SSO TO NANT FFRWD Overflow GN880802SO.DAT EVENT 10

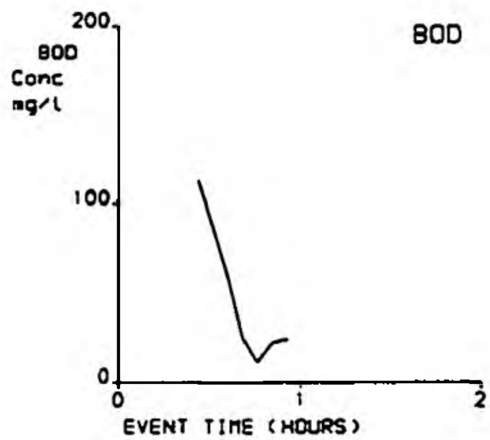
Grid Ref:
M/H Identification: /////
Storm Date: 880802
Date/Time of last monitored storm:
Start Time (R/F): 1604
Antec. Dry Weather Period (hours):
Rainfall Depth (mm): 7.2
Rainfall Event Duration (mins): 30.

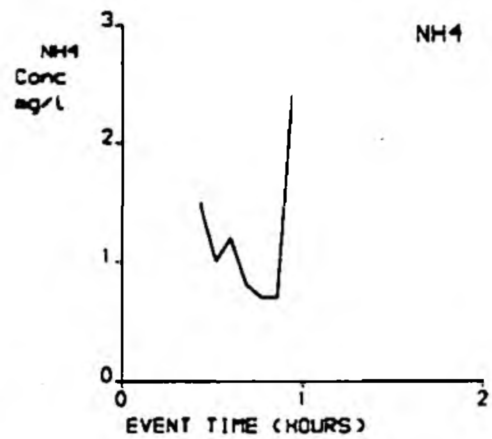




NO DATA FOR COD

NO DATA FOR TDS



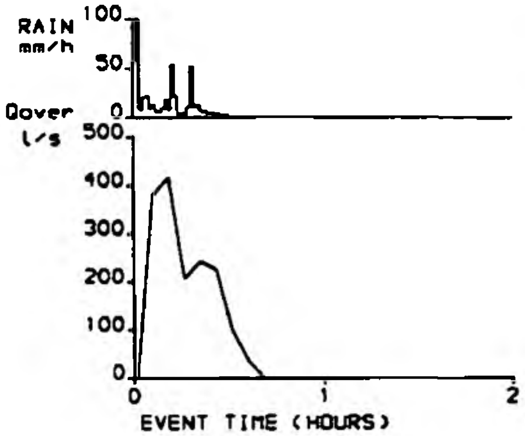


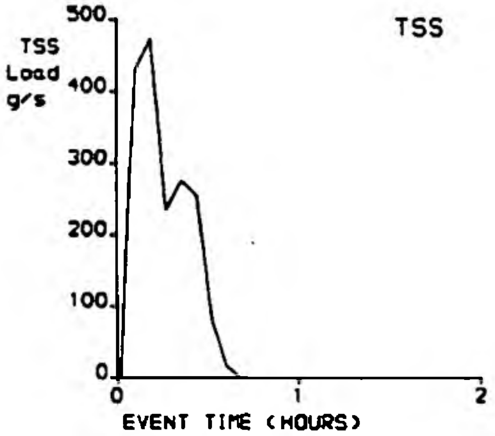
Site: GARNDIFFAITH SSO TO NANT FFRWD

Overflow
GN880802SO.DAT

Grid Ref:
Storm Date: 880802
Start Time (R/F): 1604
Rainfall Depth (mm): 7.2

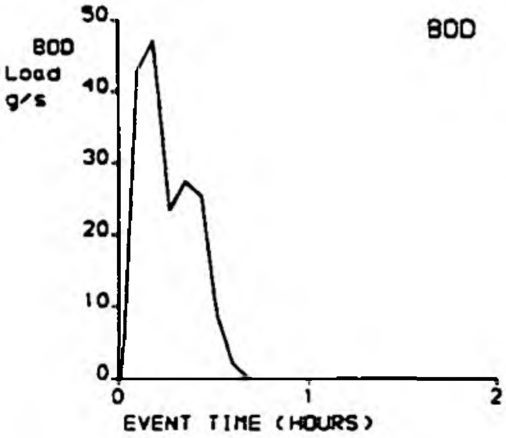
M/H Identification: /////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 30.

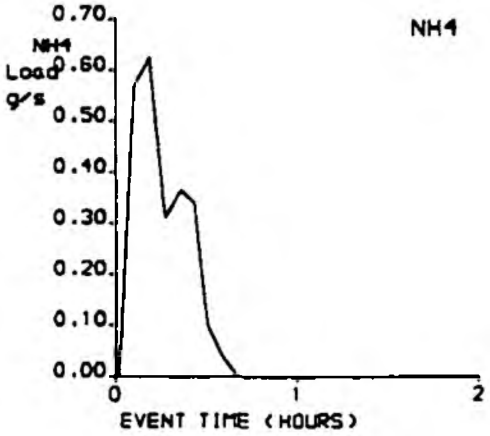




NO DATA FOR COD

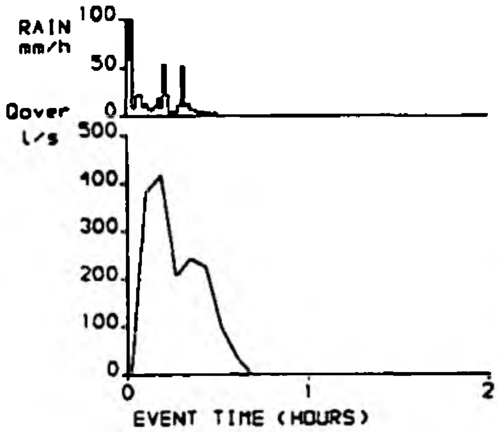
NO DATA FOR TDS

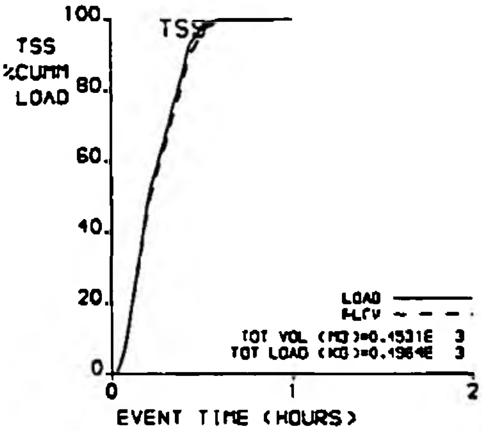




Site: GARNDIFFAITH SSO TO NANT FFRWD Overflow GN880802SO.DAT

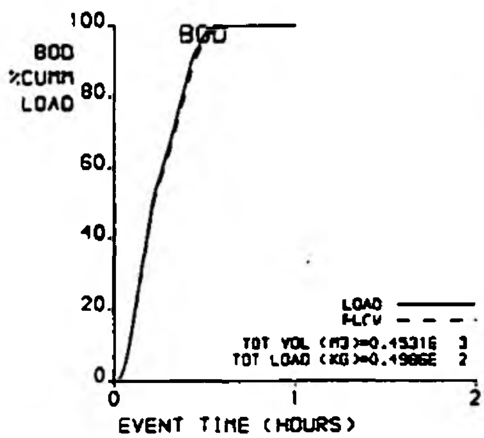
Grid Ref: M/H Identification: //////
Storm Date: 880802 Date/Time of last monitored storm:
Start Time (R/F): 1604 Antec. Dry Weather Period (hours):
Rainfall Depth (mm): 7.2 Rainfall Event Duration (mins): 30.

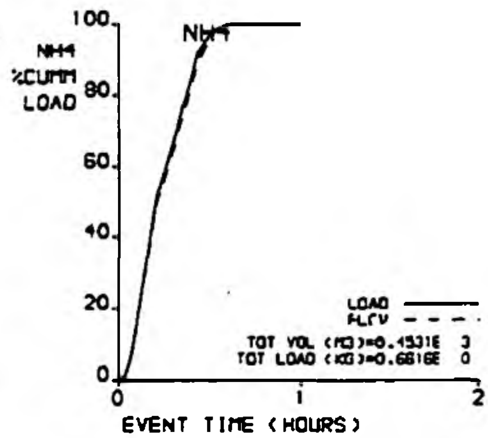




NO DATA FOR COD

NO DATA FOR TDS

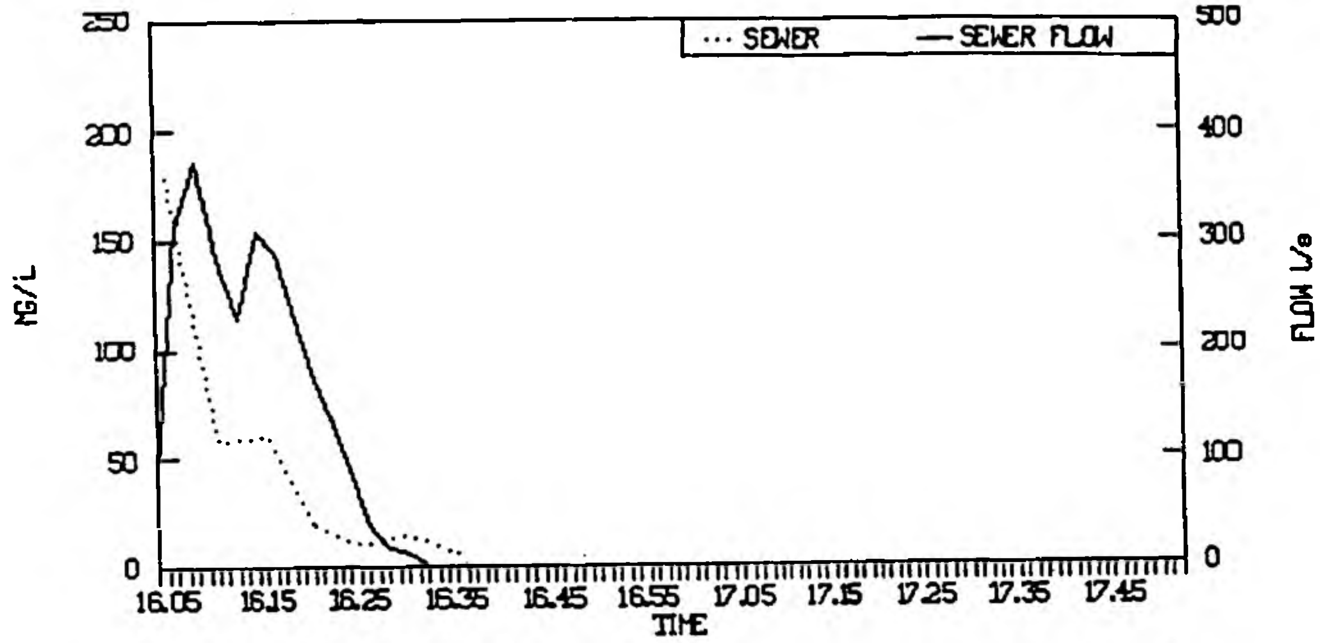




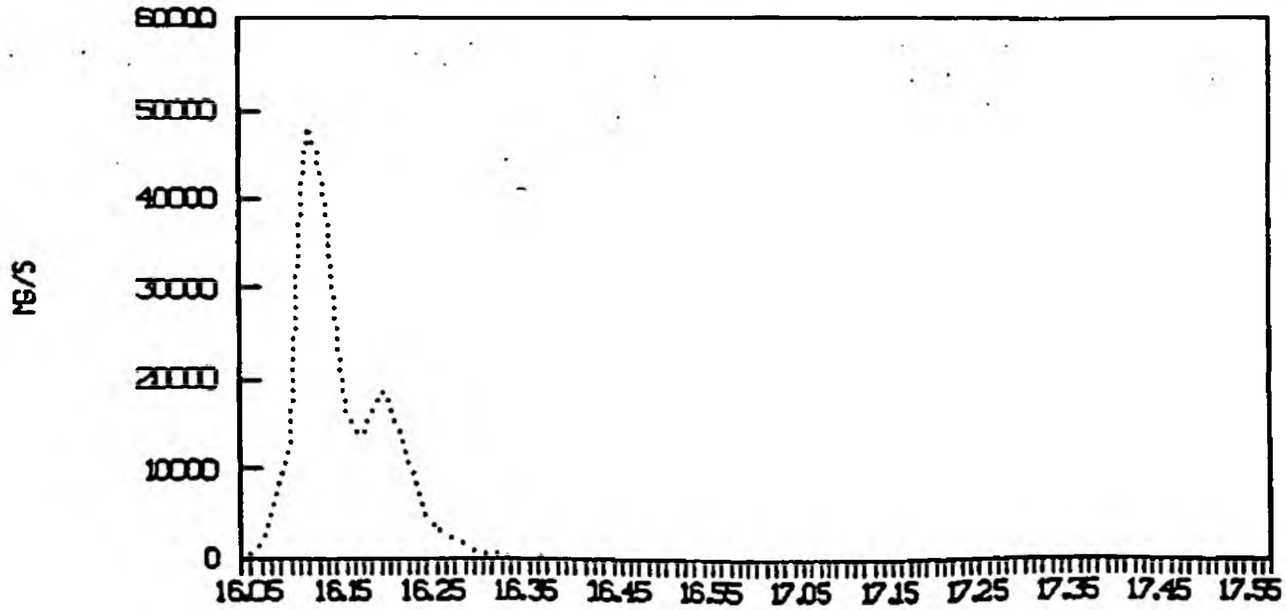
GARNDIFFAITH SSO EVENT 18 24-05-89

FIG.17

BOD CONCENTRATIONS AT SEWER.



BOD LOADS AT SEWER.



CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW.

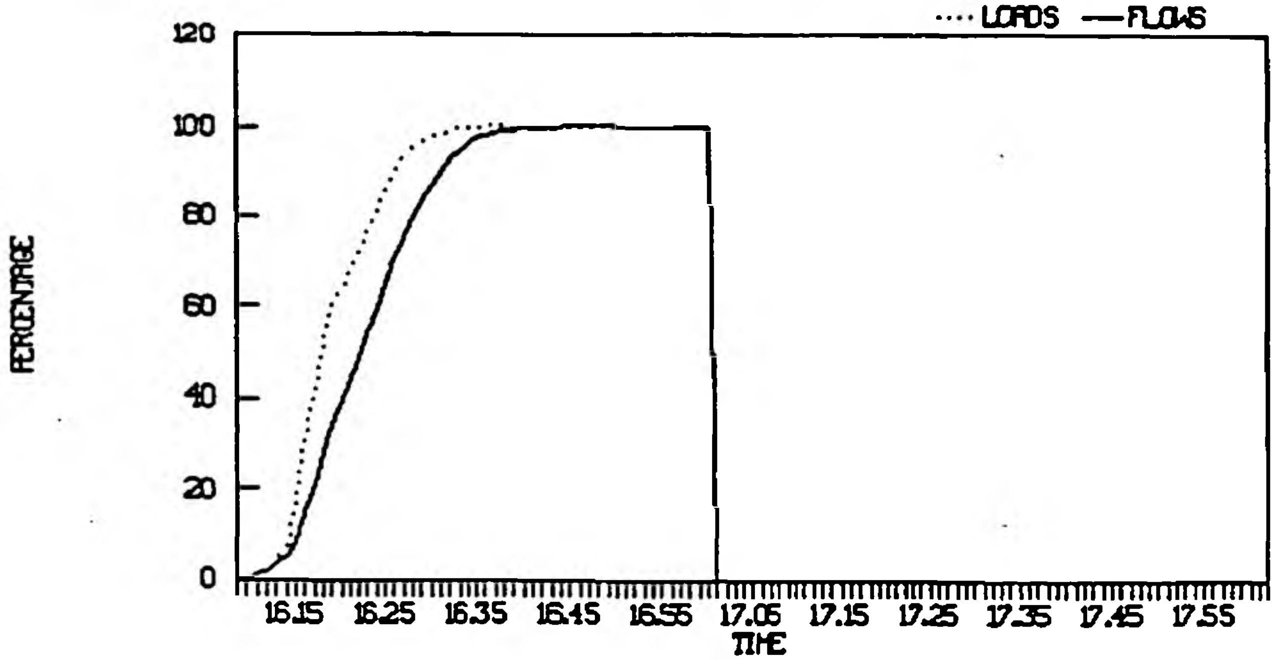
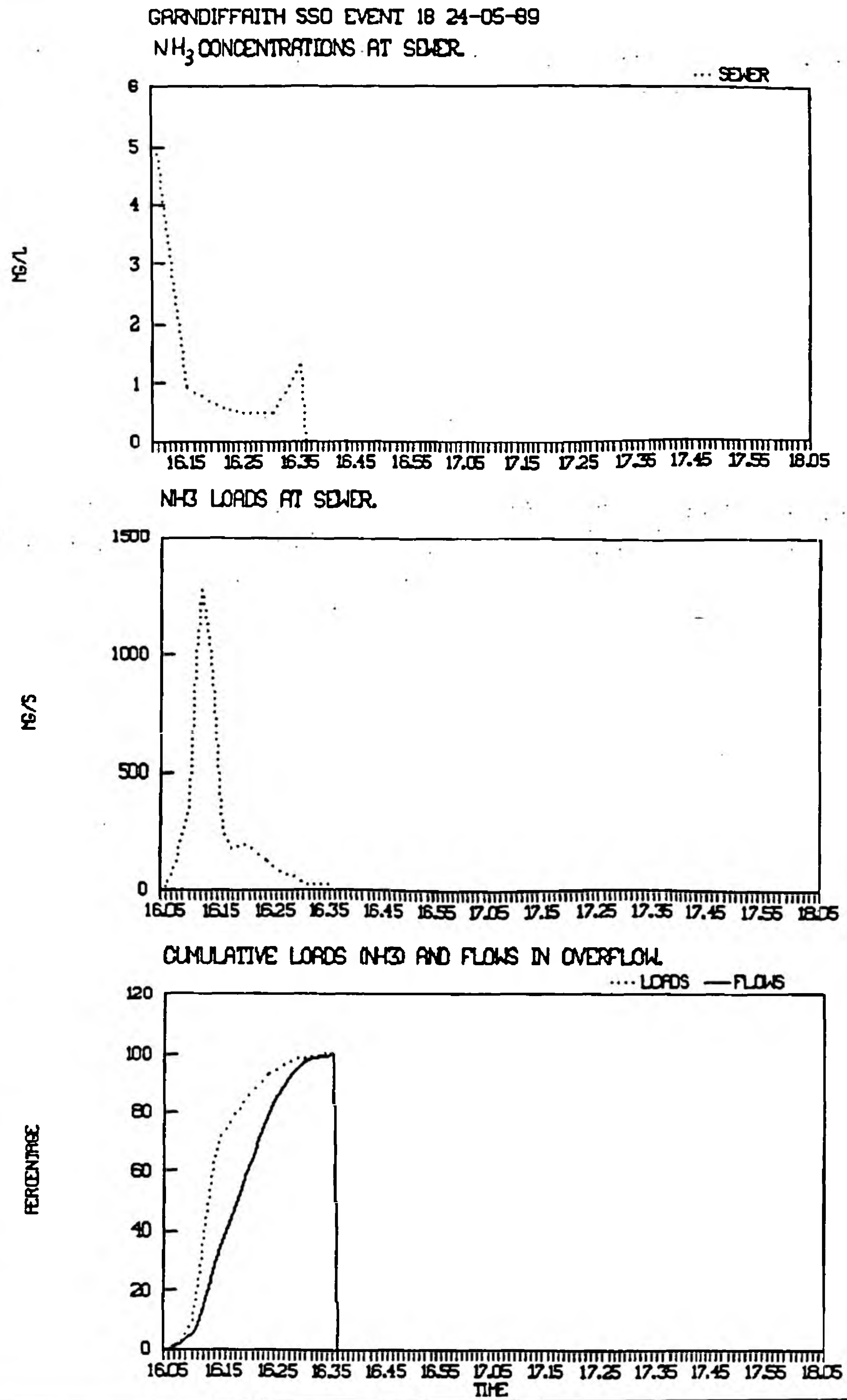


FIG. 18

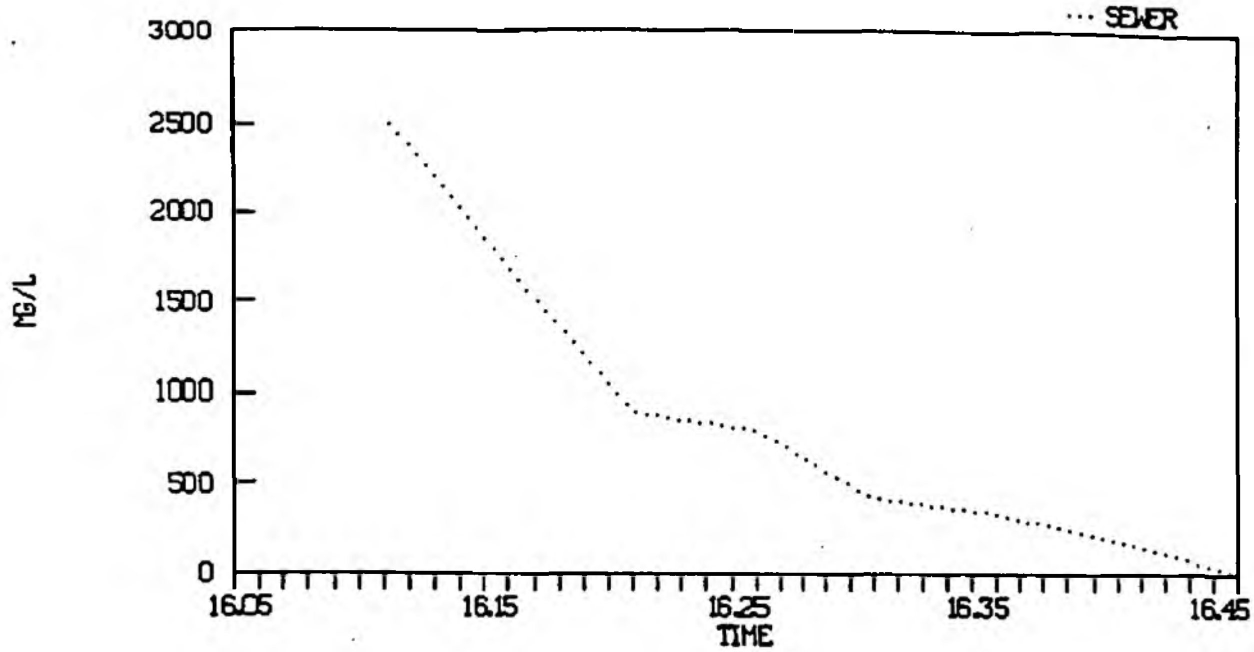


GARNDIFFAITH SSO EVENT 18 24-05-89
NH3 CONCENTRATIONS AT SEWER.
SEWER
MG/L
NH3 LOADS AT SEWER.
MG/S
CUMULATIVE LOADS (NH3) AND FLOWS IN OVERFLOW
LOADS
FLOWS
PERCENTAGE
TIME

FIG. 19

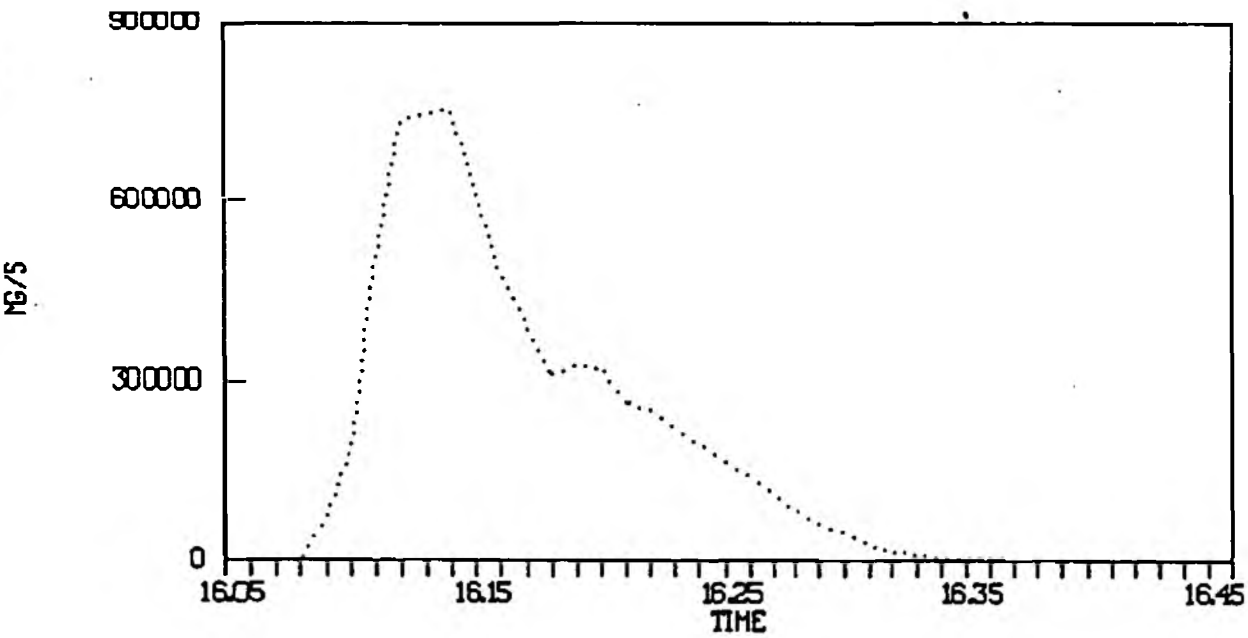
GARNDIFFAITH SSO EVENT 18 24-05-89

TSS CONCENTRATIONS IN OVERFLOW



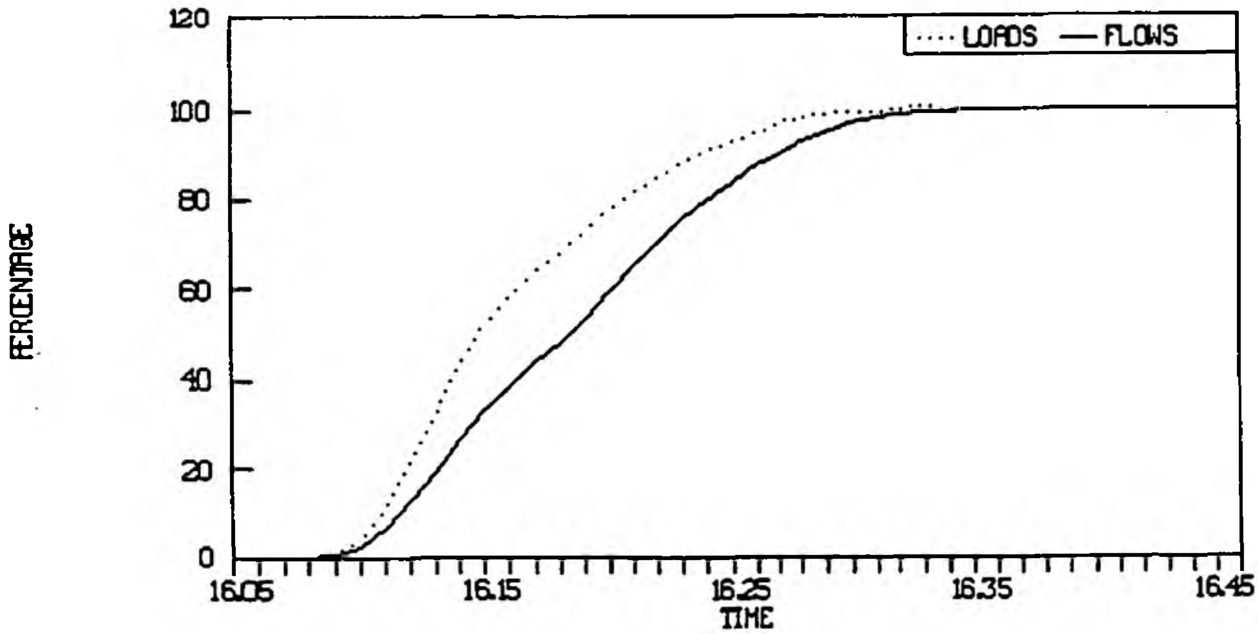
GARNDIFFAITH SSO EVENT 18 24-05-89

TSS LOADS IN OVERFLOW.



GARNDIFFAITH SSO EVENT 18 24-05-89

CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW.



GARNDIFFAITH SSO EVENT 22 20-10-1989

BOD CONCENTRATIONS AT SEWER

FIG. 20

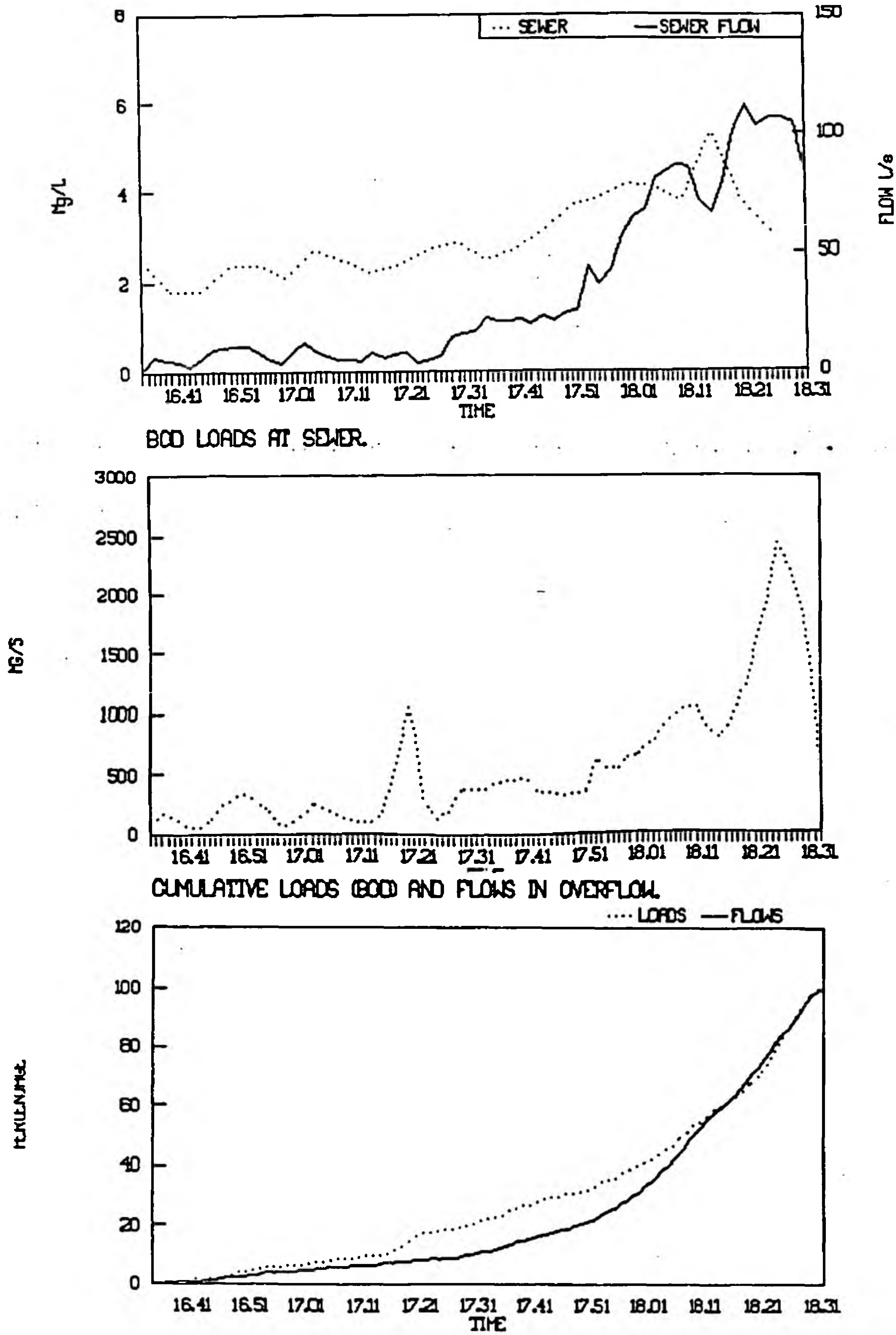


FIG. 21

GARNDIFFAITH SSO EVENT 22 20-10-89

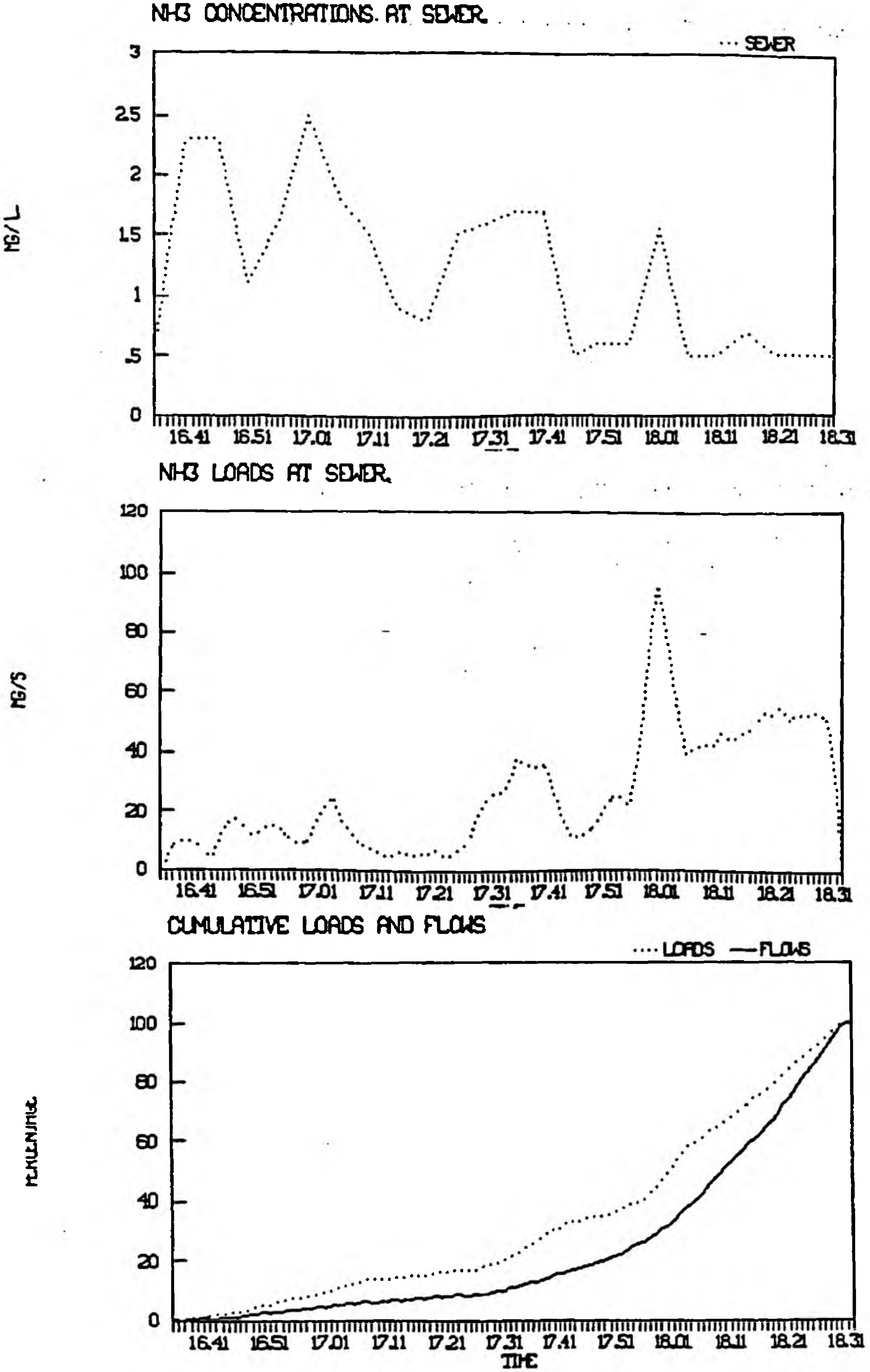
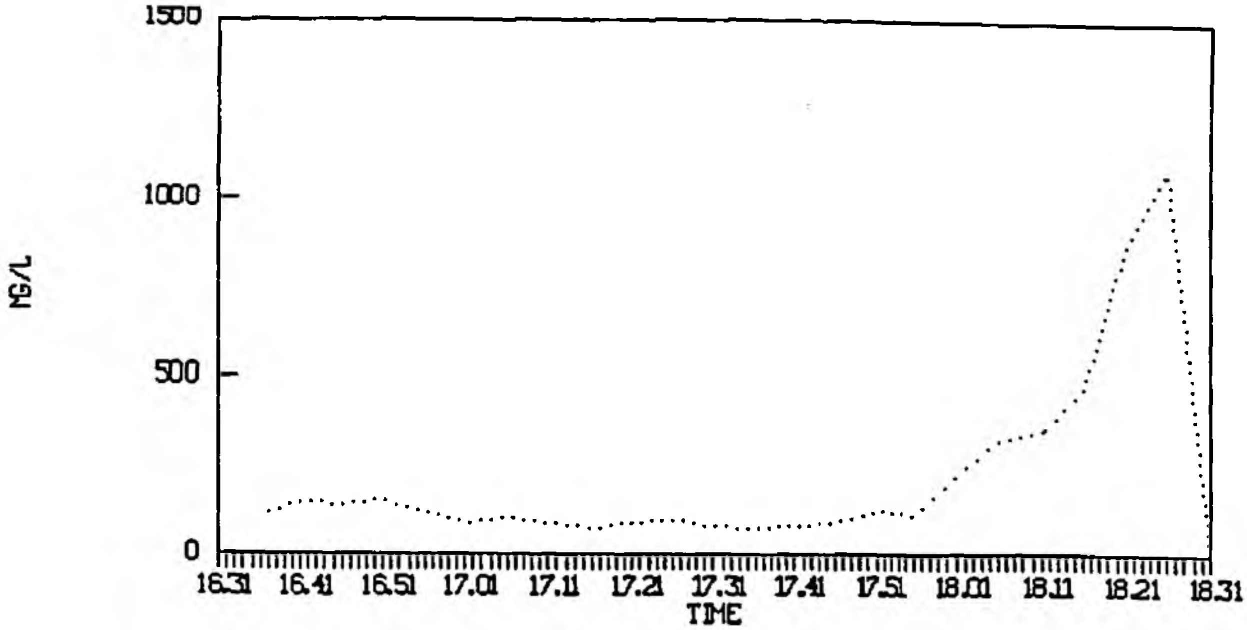
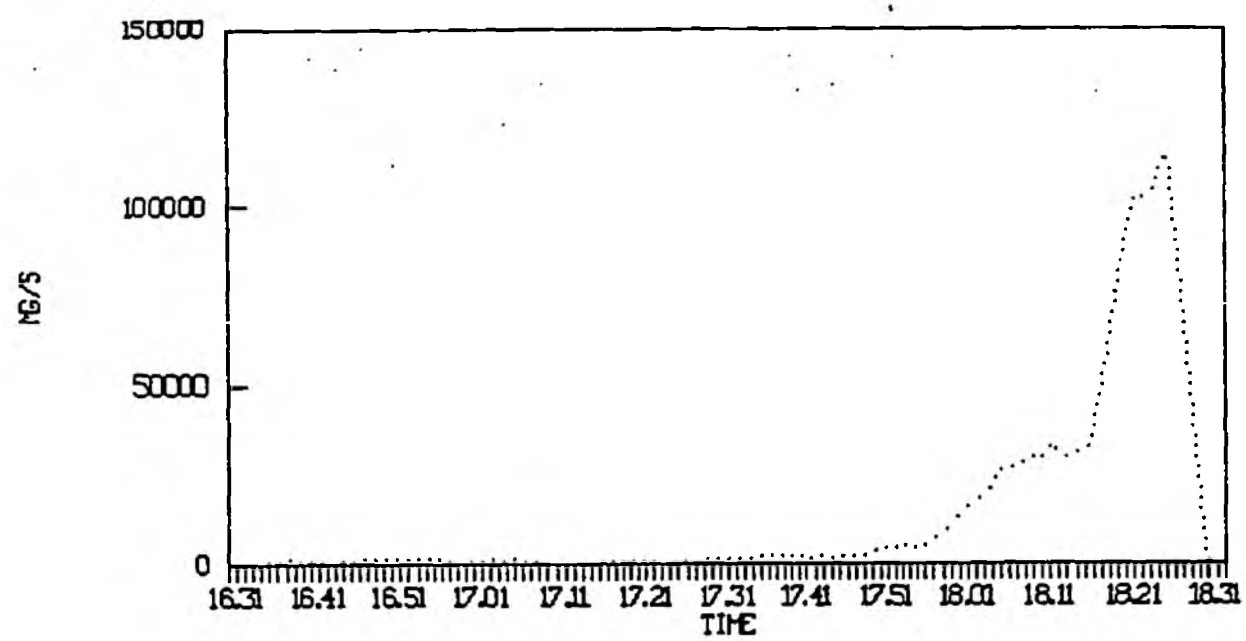


FIG. 22

GARNDIFFAITH SSO EVENT 22 20-10-89
TSS CONCENTRATIONS IN OVERFLOW



GARNDIFFAITH SSO EVENT 22 20-10-89
TSS LOADS IN OVERFLOW



GARNDIFFAITH SSO EVENT 22 20-10-89
CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW

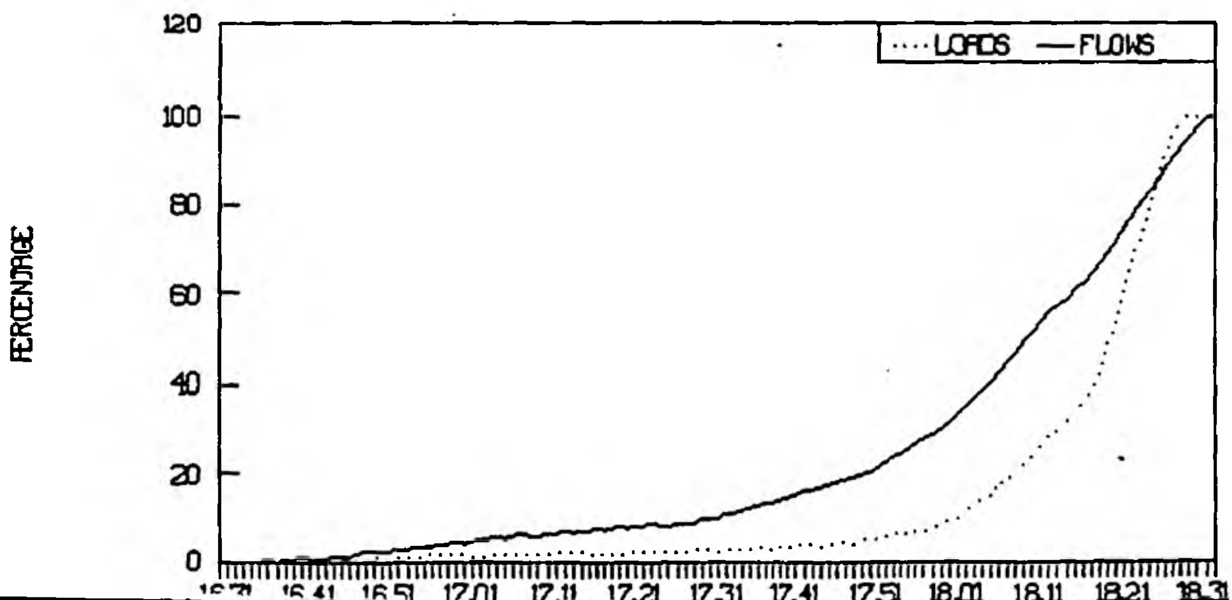
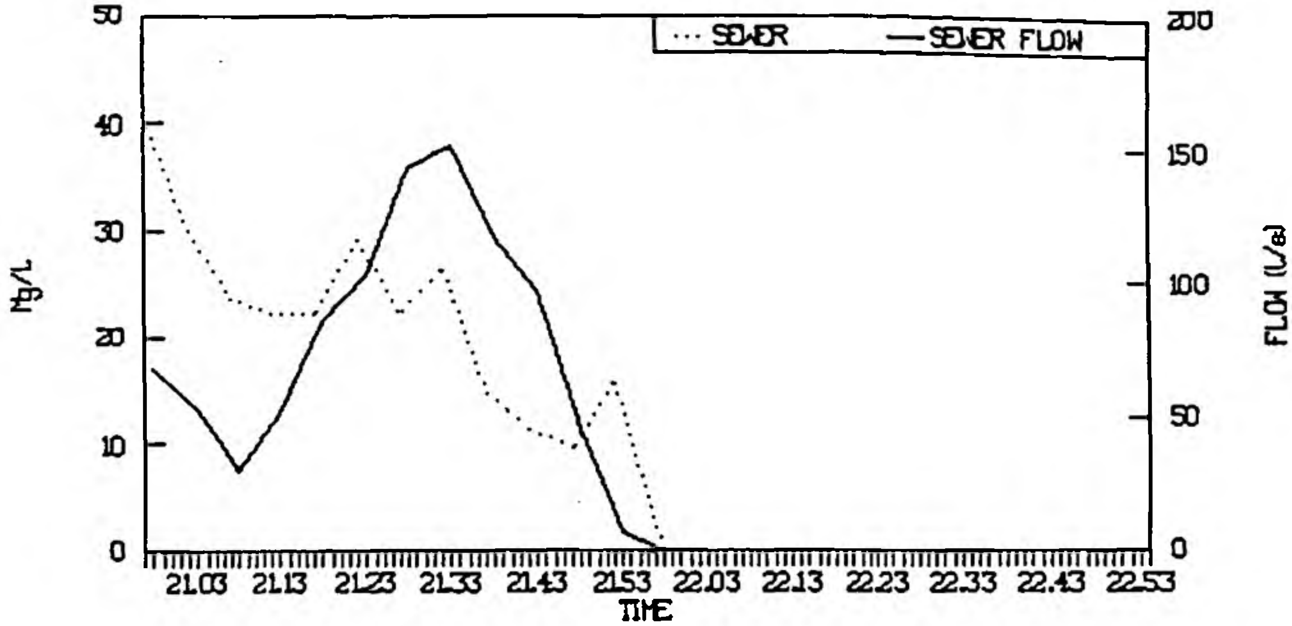
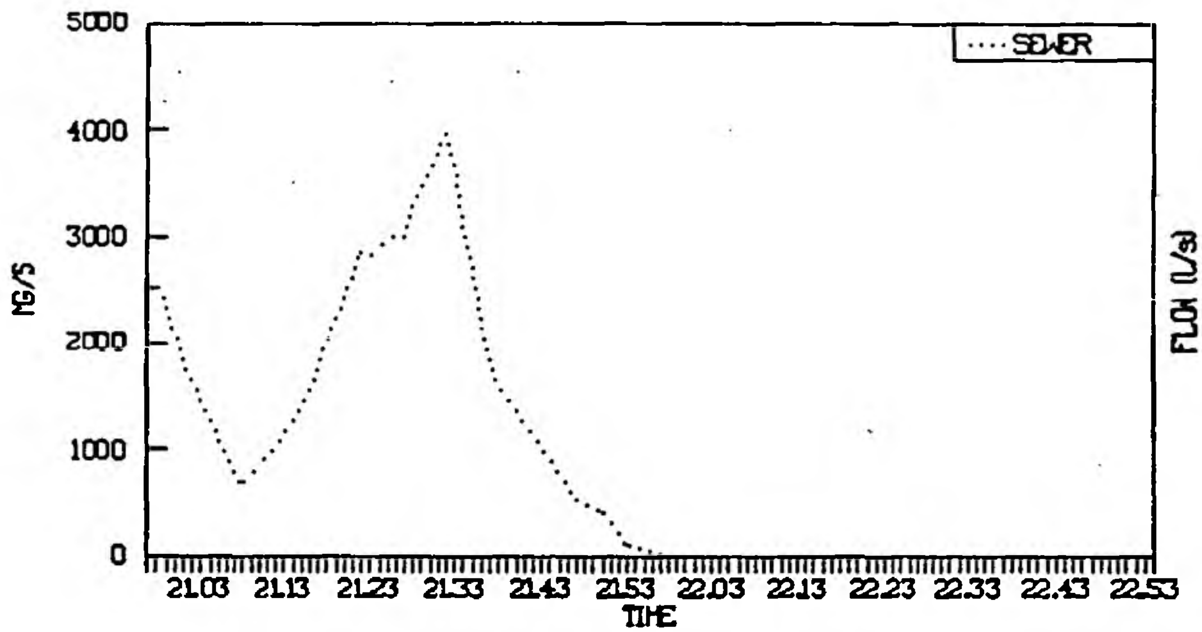


FIG 23

GARNDIFFAITH SSO EVENT 4 30-04-88
BOD CONCENTRATIONS AT SEWER.



GARNDIFFAITH SSO EVENT 4 30-04-88
BOD LOADS AT SEWER.



GARNDIFFAITH SSO EVENT 4 30-04-88

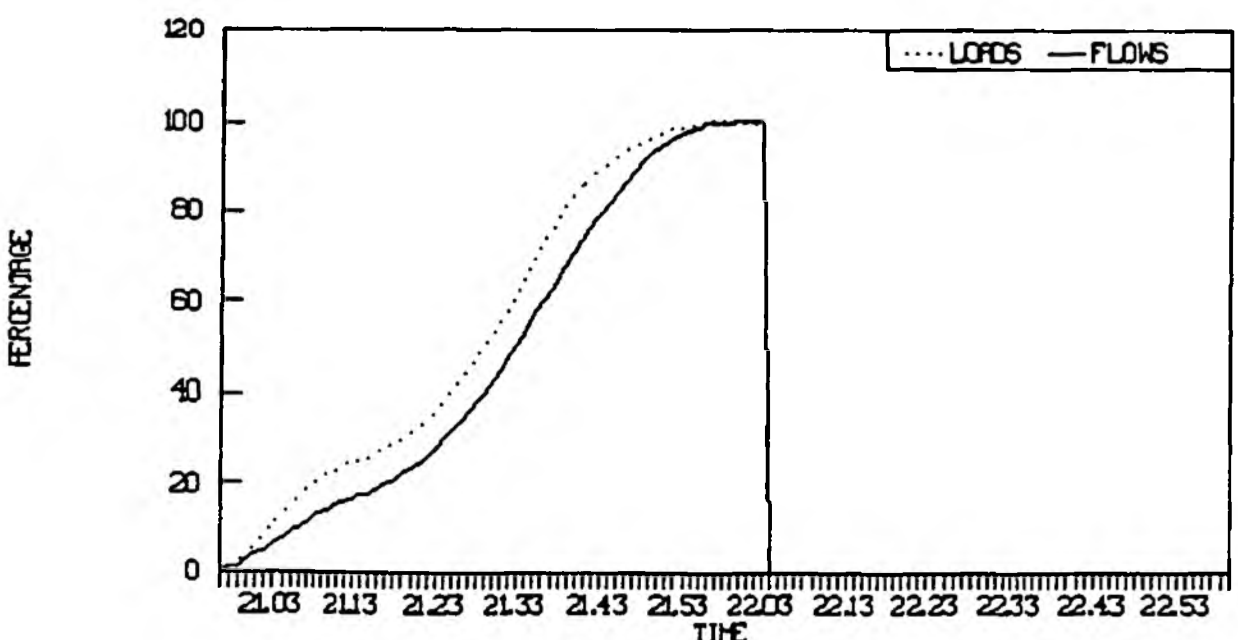
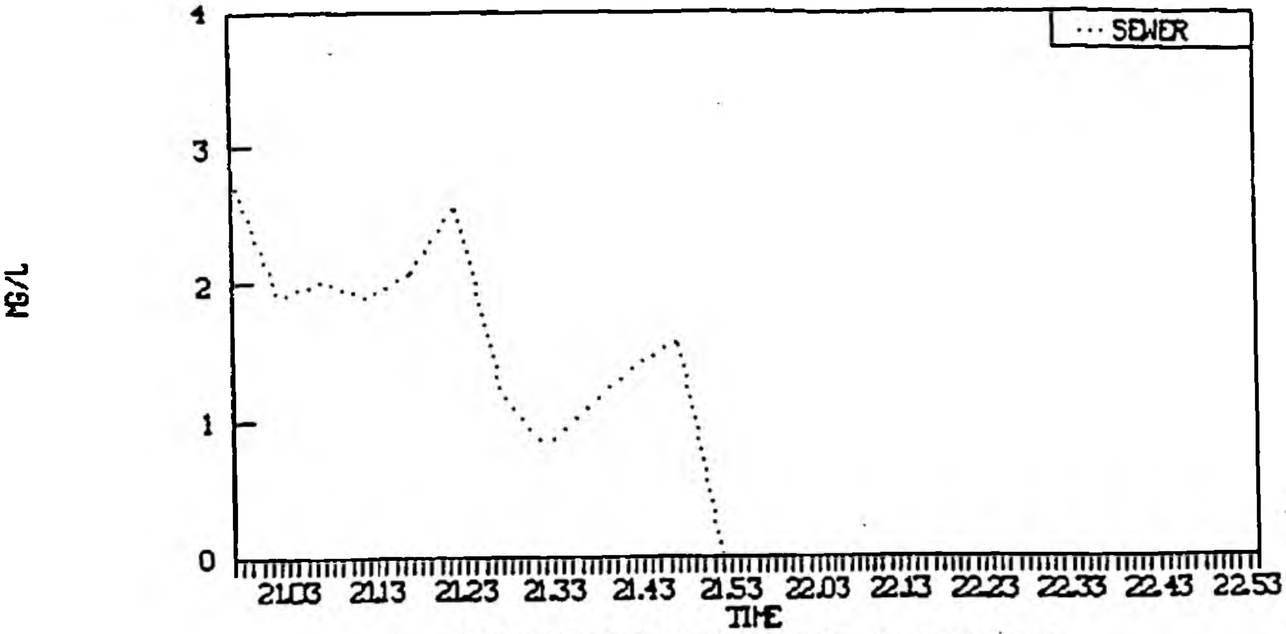
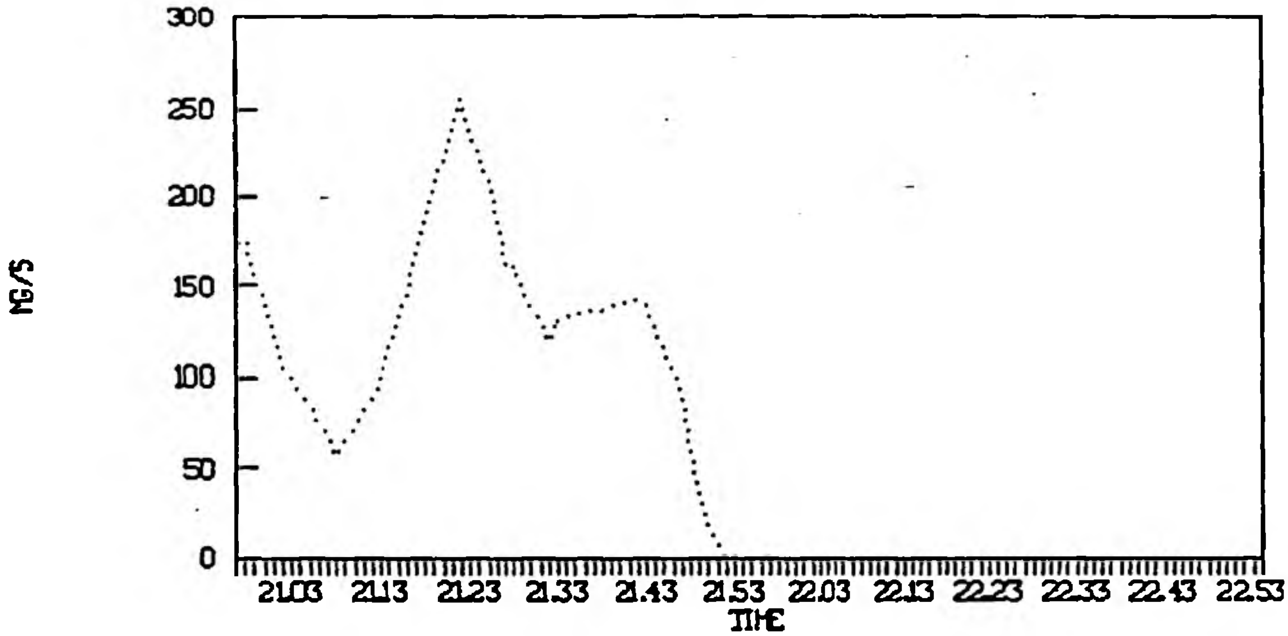


FIG. 24

GARNDIFFAITH SSO EVENT 4 30-04-88
NH3 CONCENTRATIONS AT SEWER.



GARNDIFFAITH SSO EVENT 4 30-04-88
NH3 LOADS AT SEWER.



GARNDIFFAITH SSO EVENT 4 30-04-88
CUMULATIVE LOADS AND FLOWS

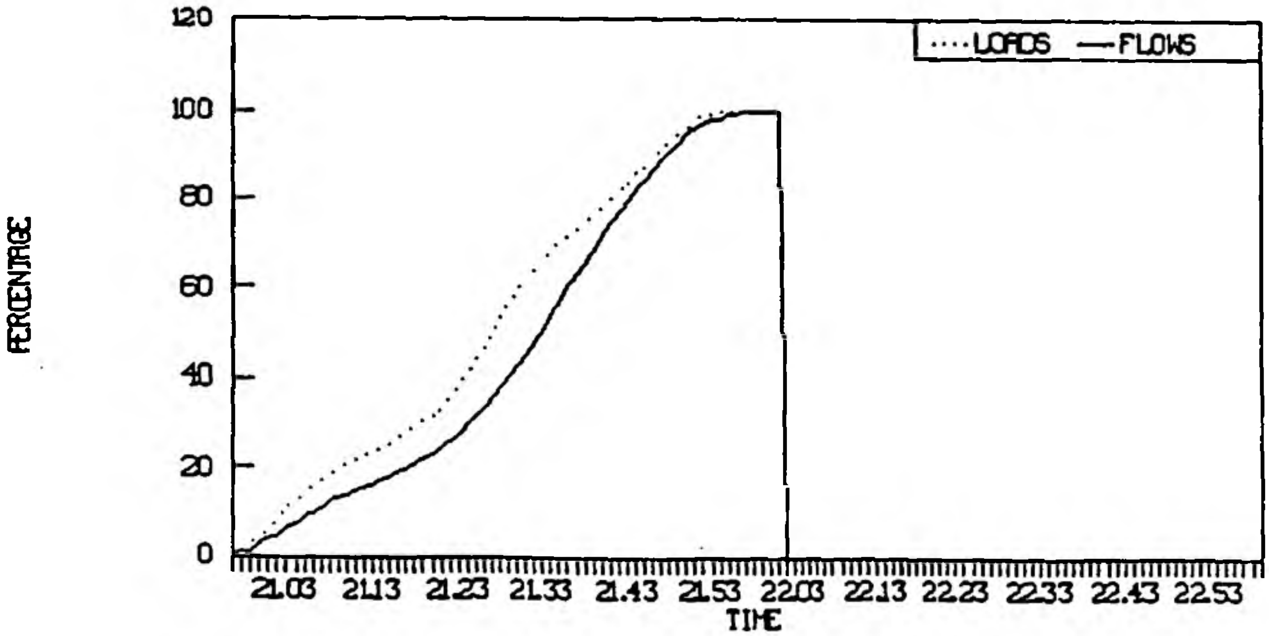
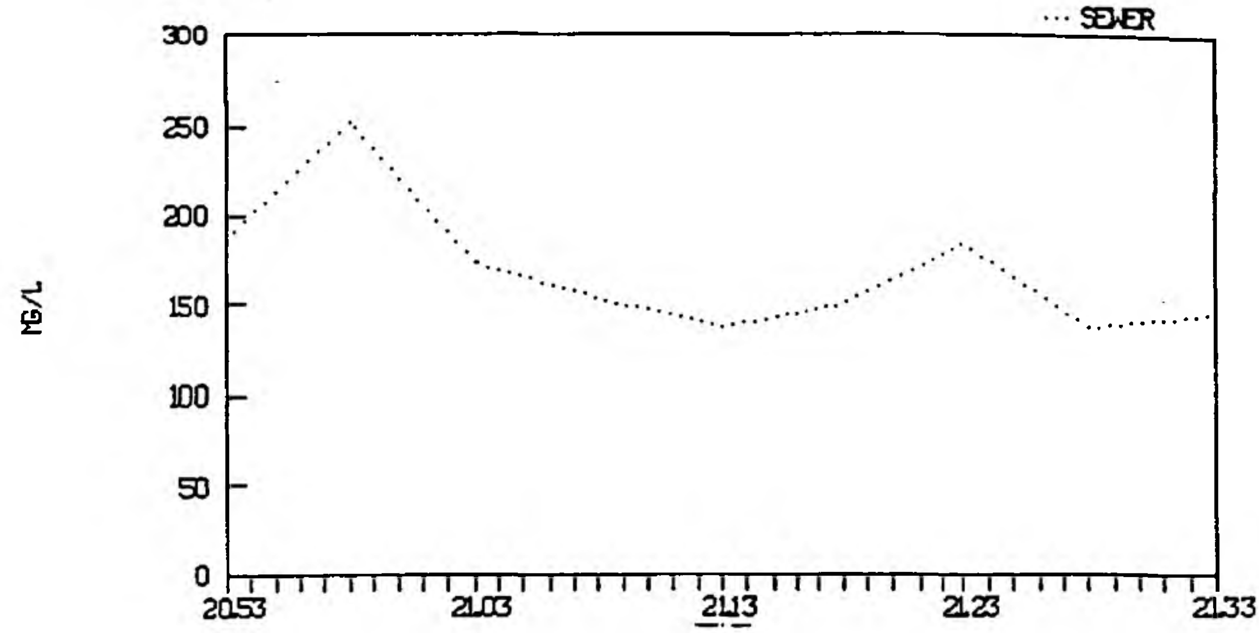
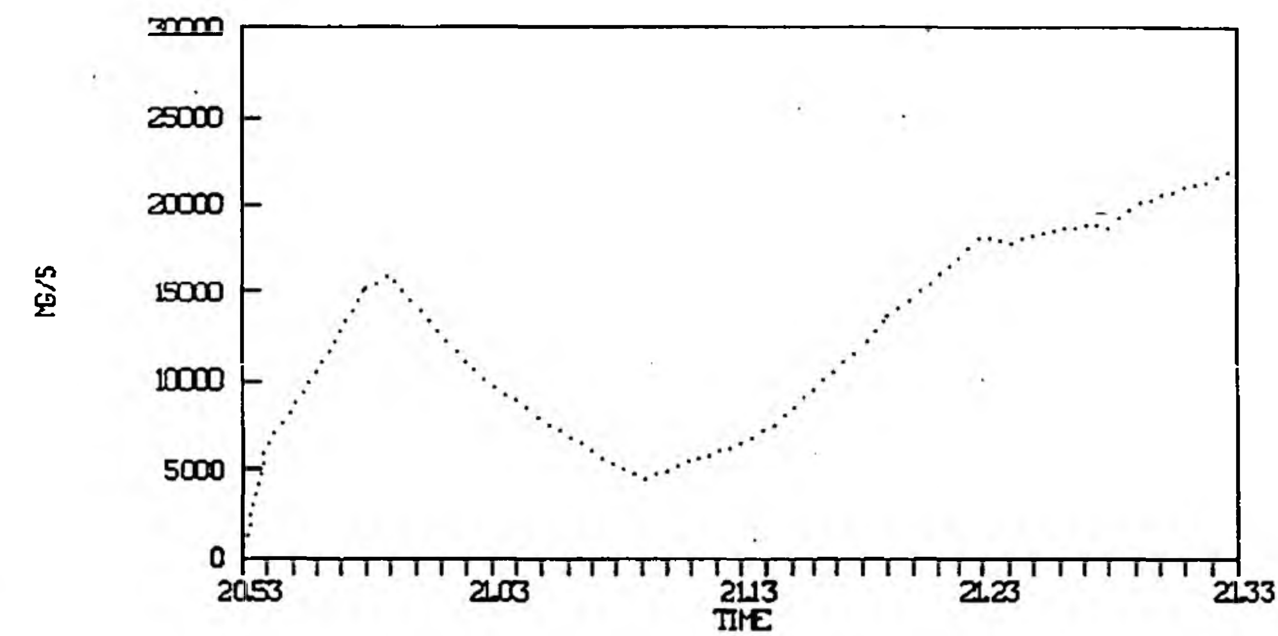


FIG. 25

GARNDIFFAITH SSO EVENT 4 30-04-88
TSS CONCENTRATIONS IN OVERFLOW



GARNDIFFAITH SSO EVENT 4 30-04-88
TSS LOADS IN OVERFLOW.



GARNDIFFAITH SSO EVENT 4 30-04-88
CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW.

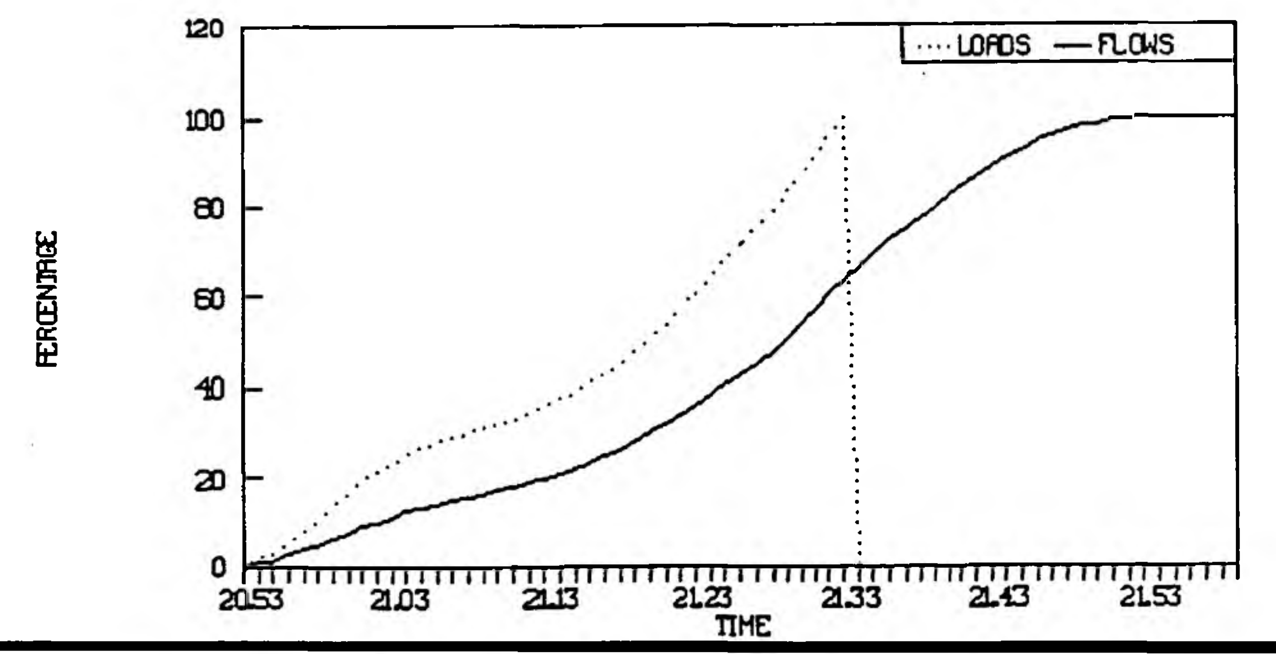
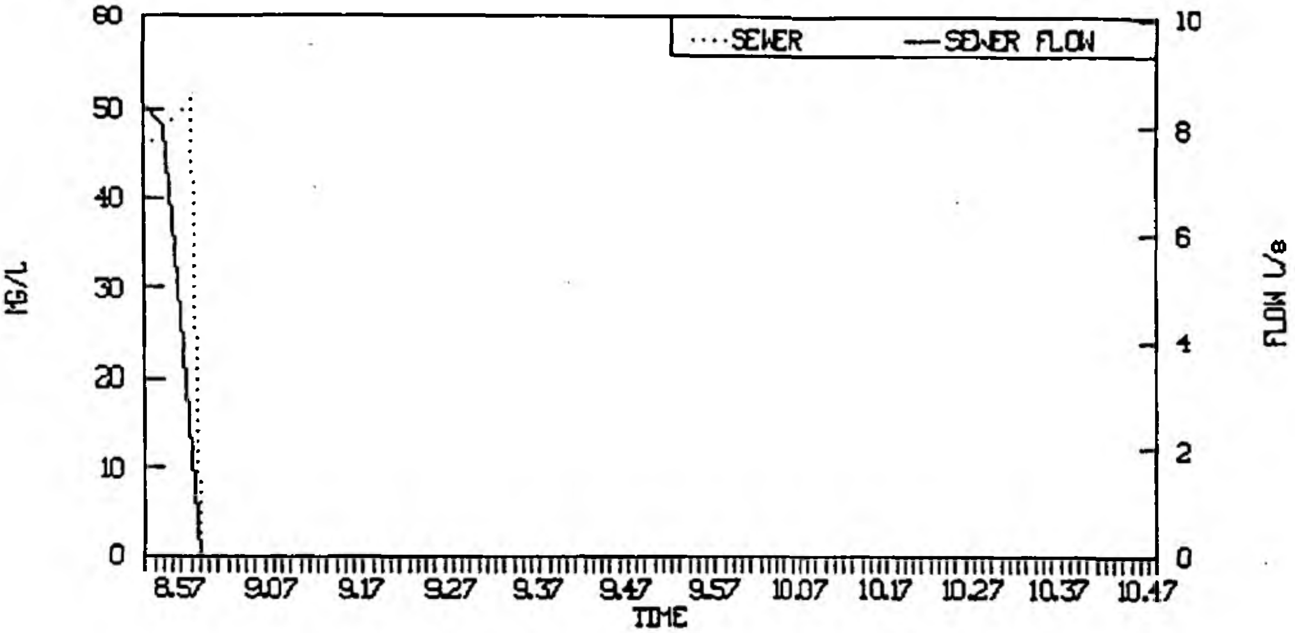


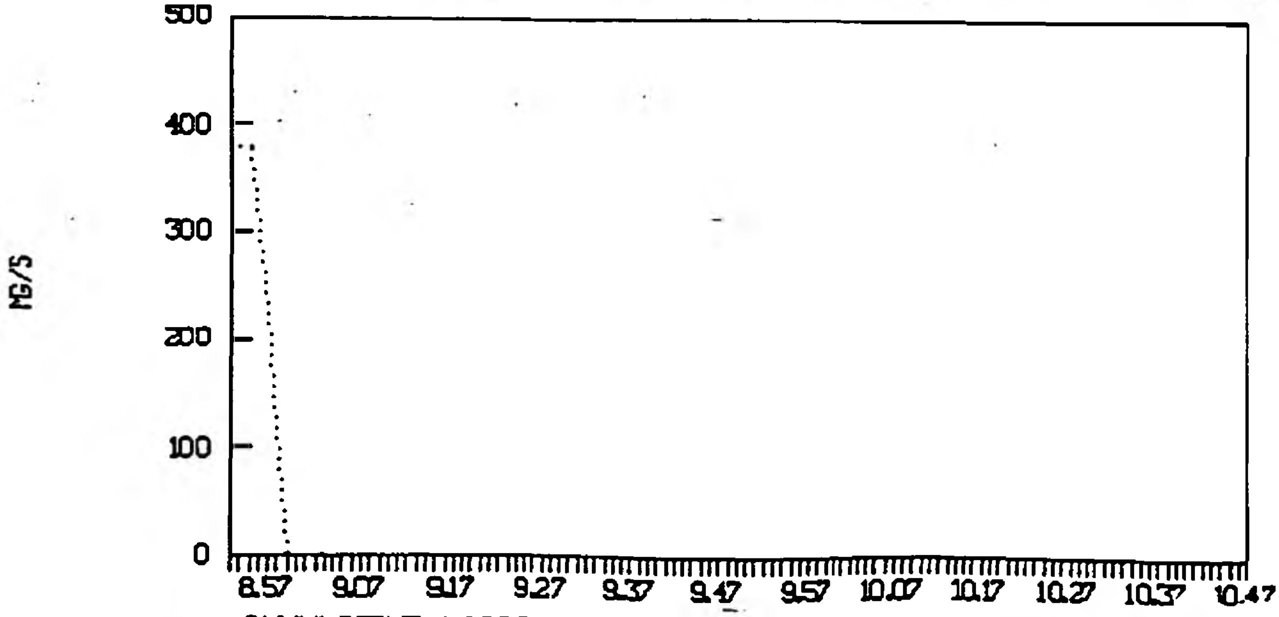
FIG.26

GARNDIFFAITH SSO EVENT 20 16-09-89

BOD CONCENTRATIONS AT SEWER



BOD LOADS AT SEWER



CUMULATIVE LOADS (BOD) IN OVERFLOW

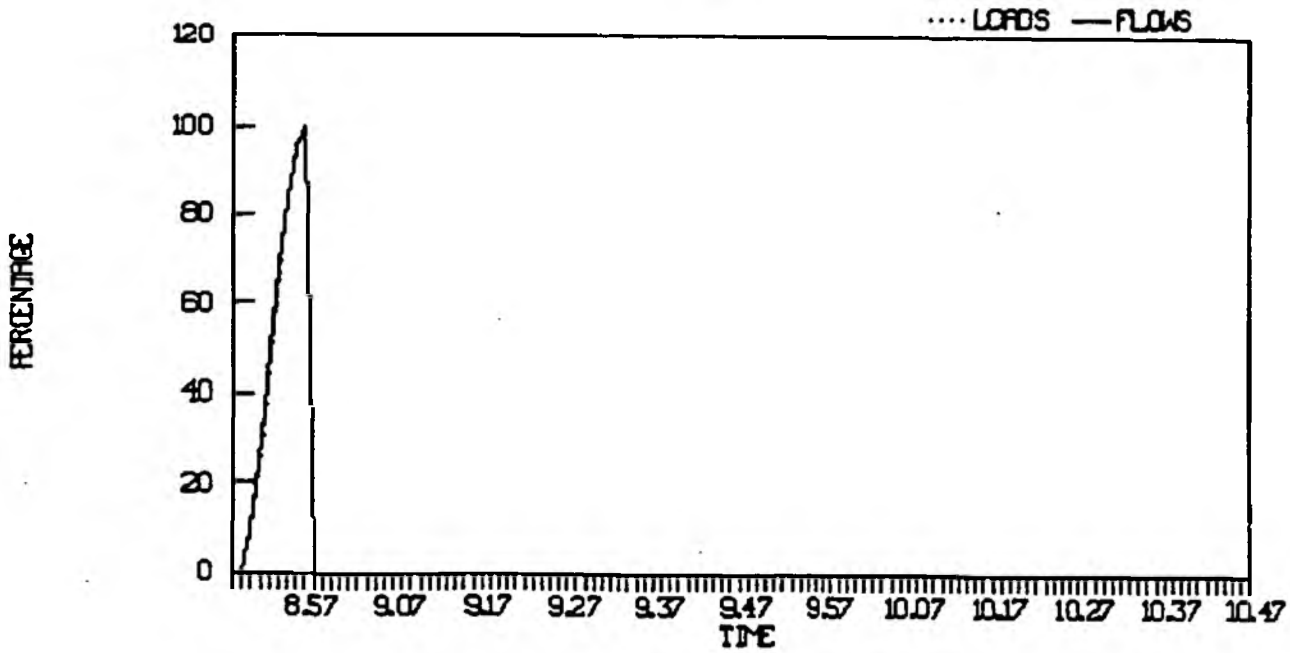
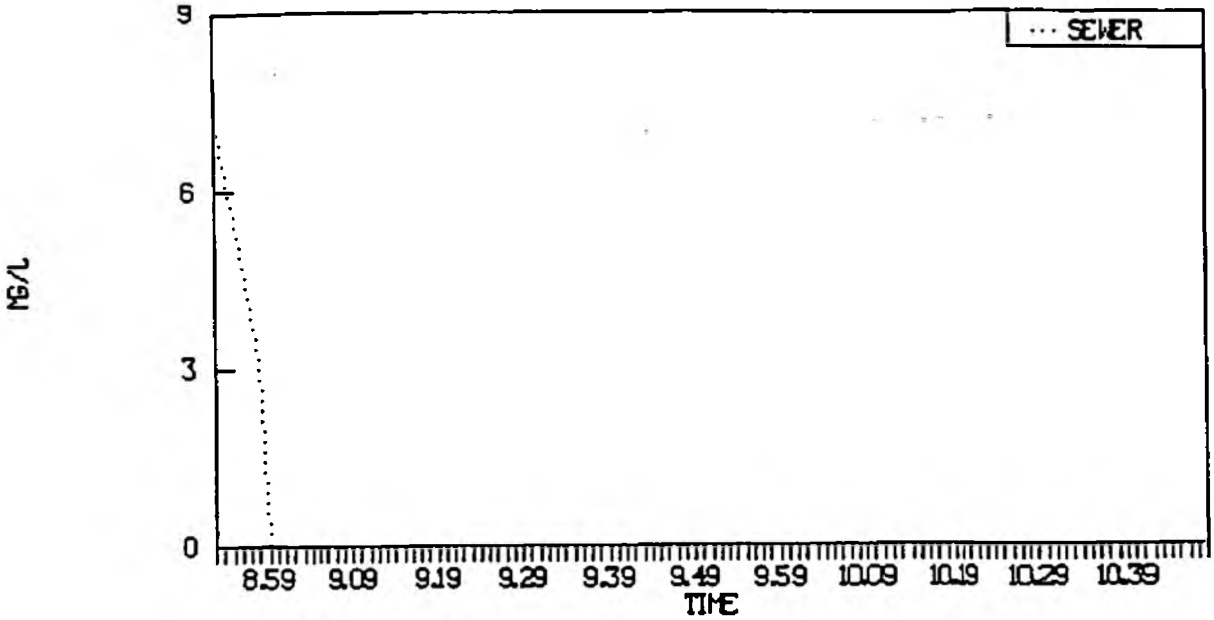
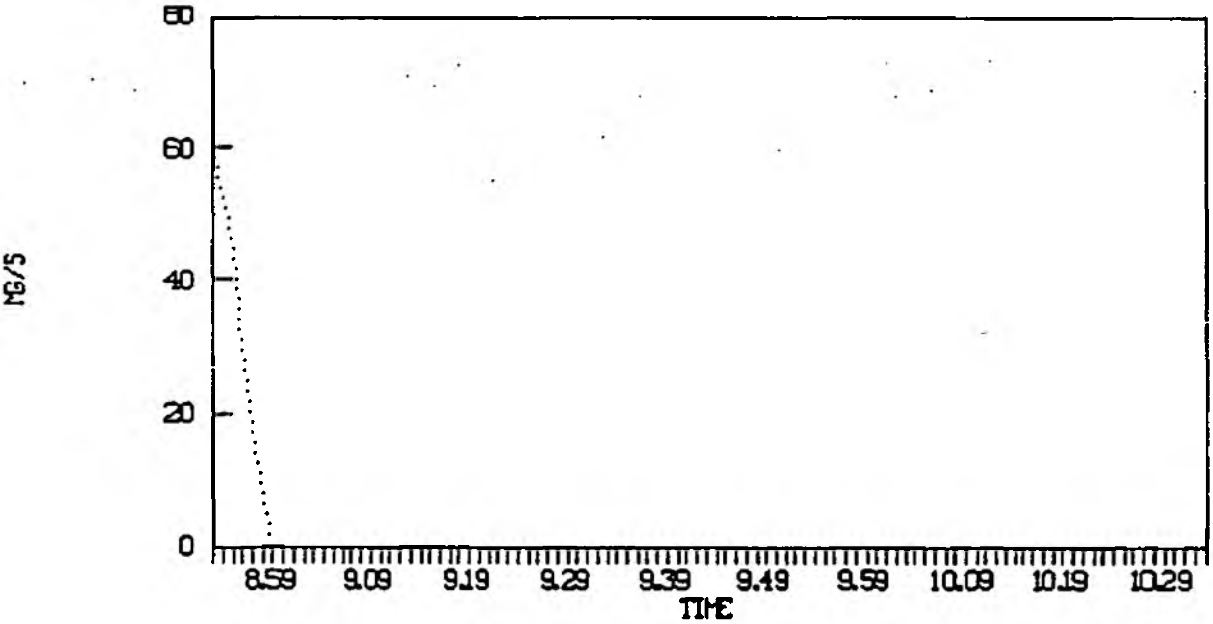


FIG.27

GARNDIFFAITH SSO EVENT 20 16-09-89
NH3 CONCENTRATIONS AT SEWER.



GARNDIFFAITH SSO EVENT 20 16-09-89
NH3 LOADS AT SEWER.



GARNDIFFAITH SSO EVENT 20 16-09-89
CUMULATIVE LOADS (NH3) AND FLOWS IN OVERFLOW

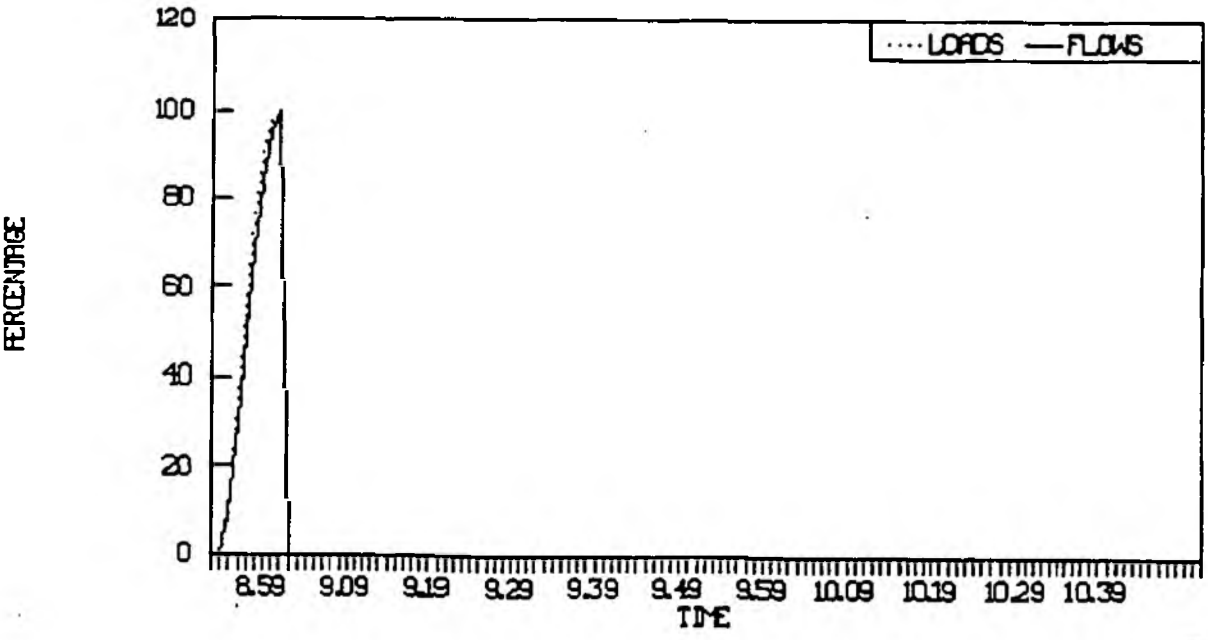
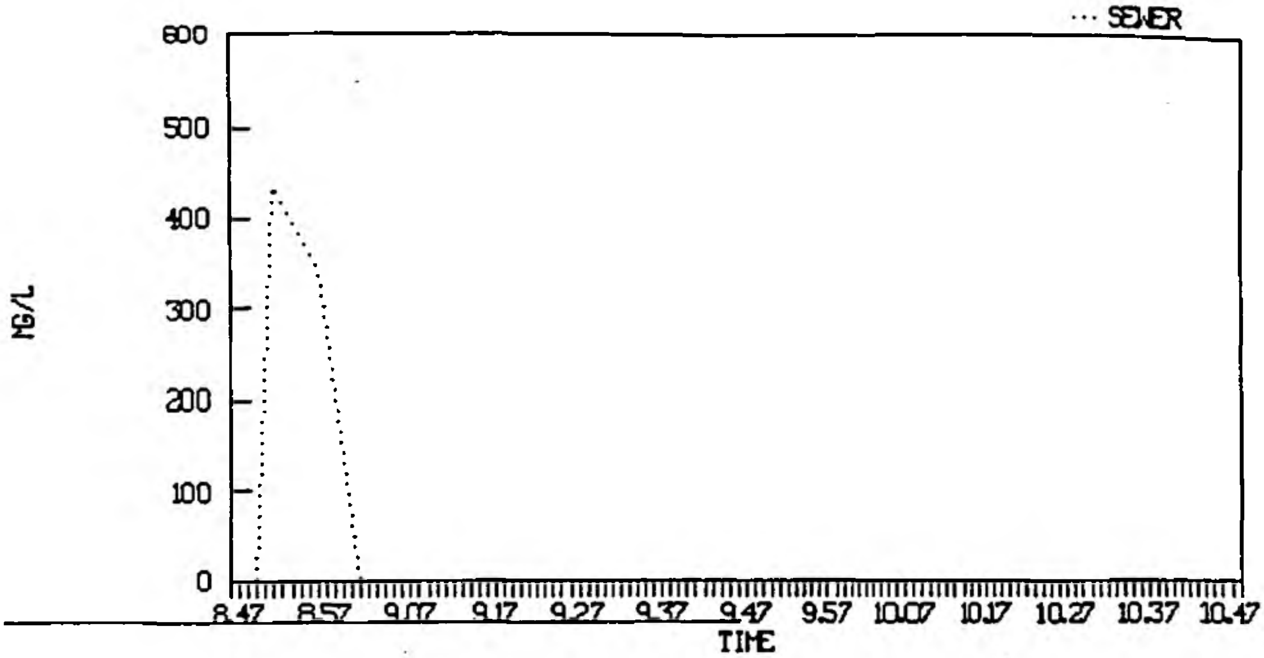


FIG. 28

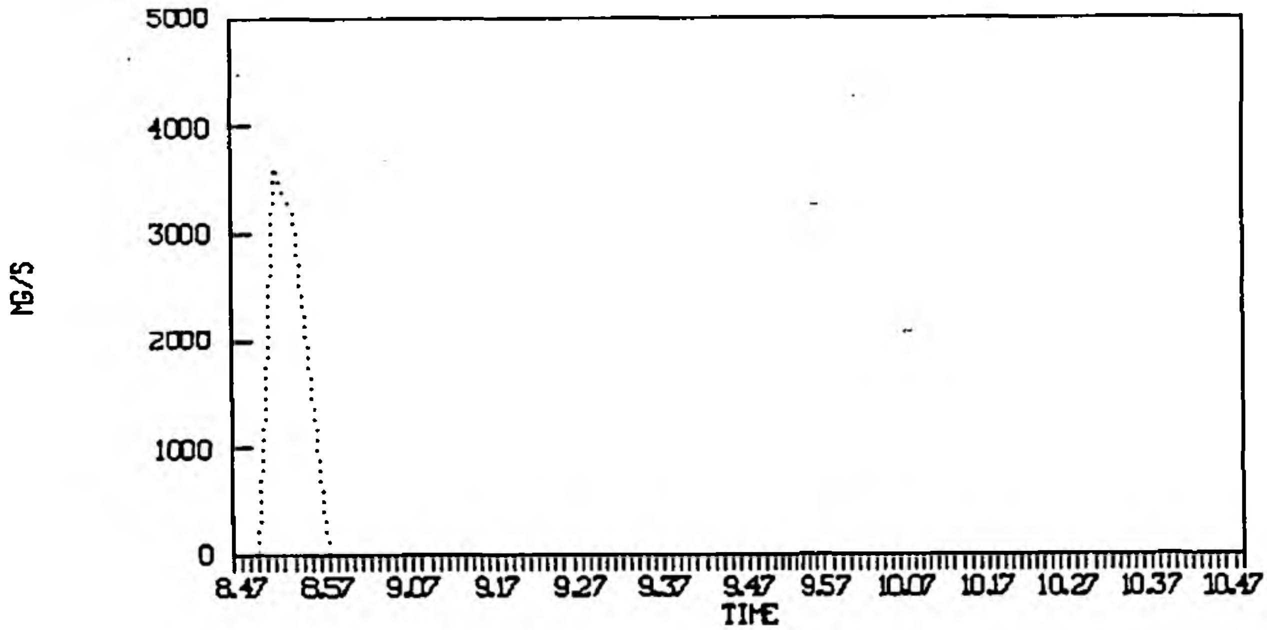
GARNDIFFAITH SSO EVENT 20 16-09-89

TSS CONCENTRATIONS IN OVERFLOW



GARNDIFFAITH SSO EVENT 20 16-09-89

TSS LOADS IN OVERFLOW



GARNDIFFAITH SSO EVENT 20 16-09-89

CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW

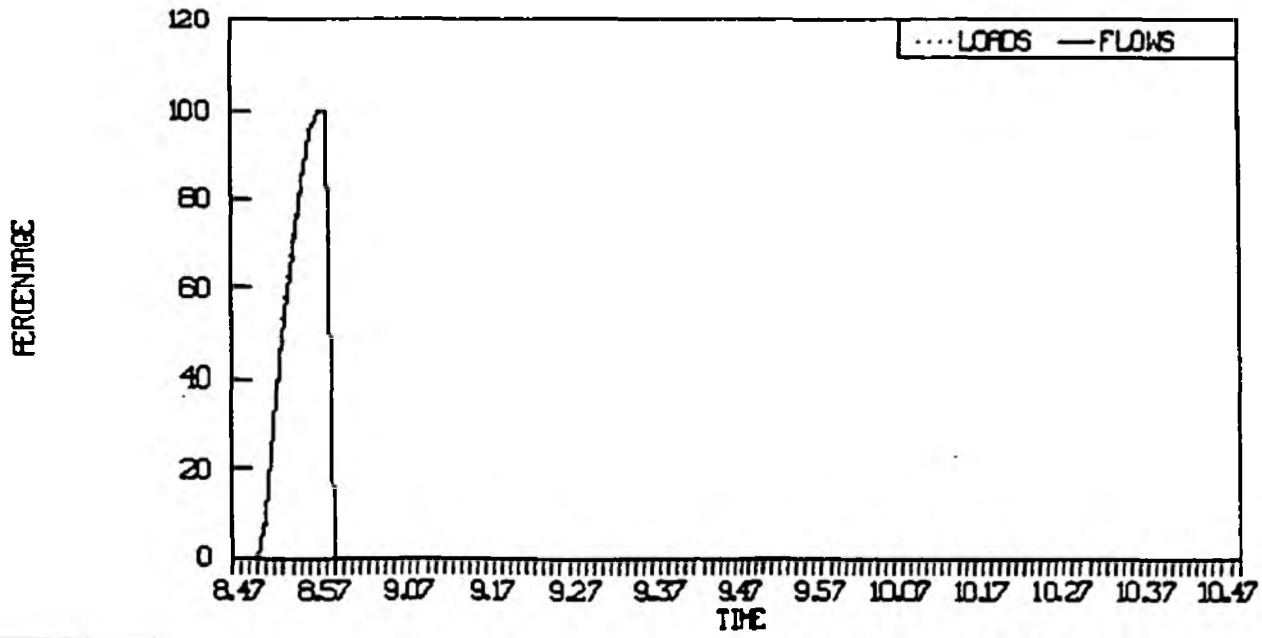
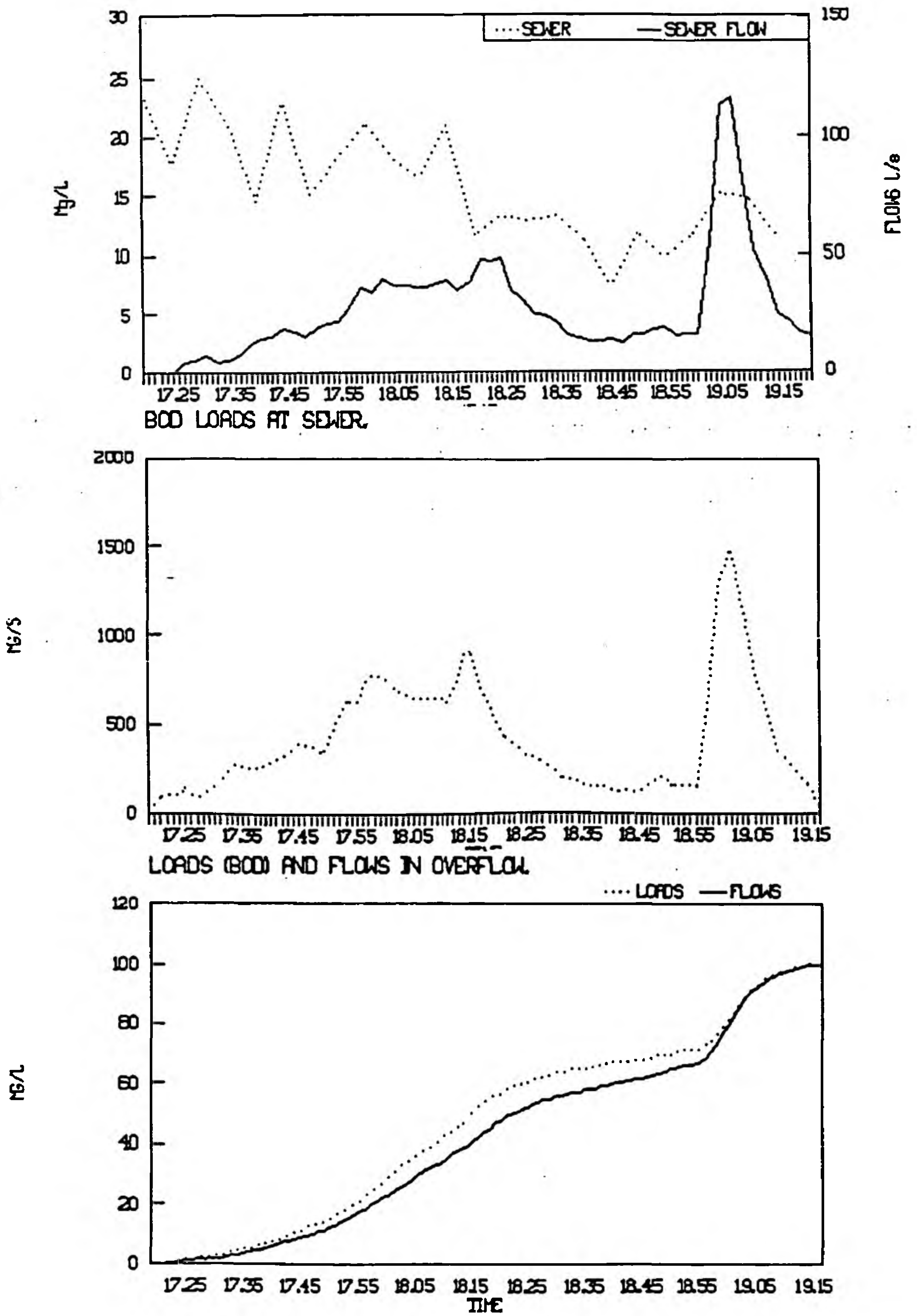


FIG. 29

GARNDIFFAITH SSD EVENT 24 09-11-1989

BOD CONCENTRATIONS AT SEWER



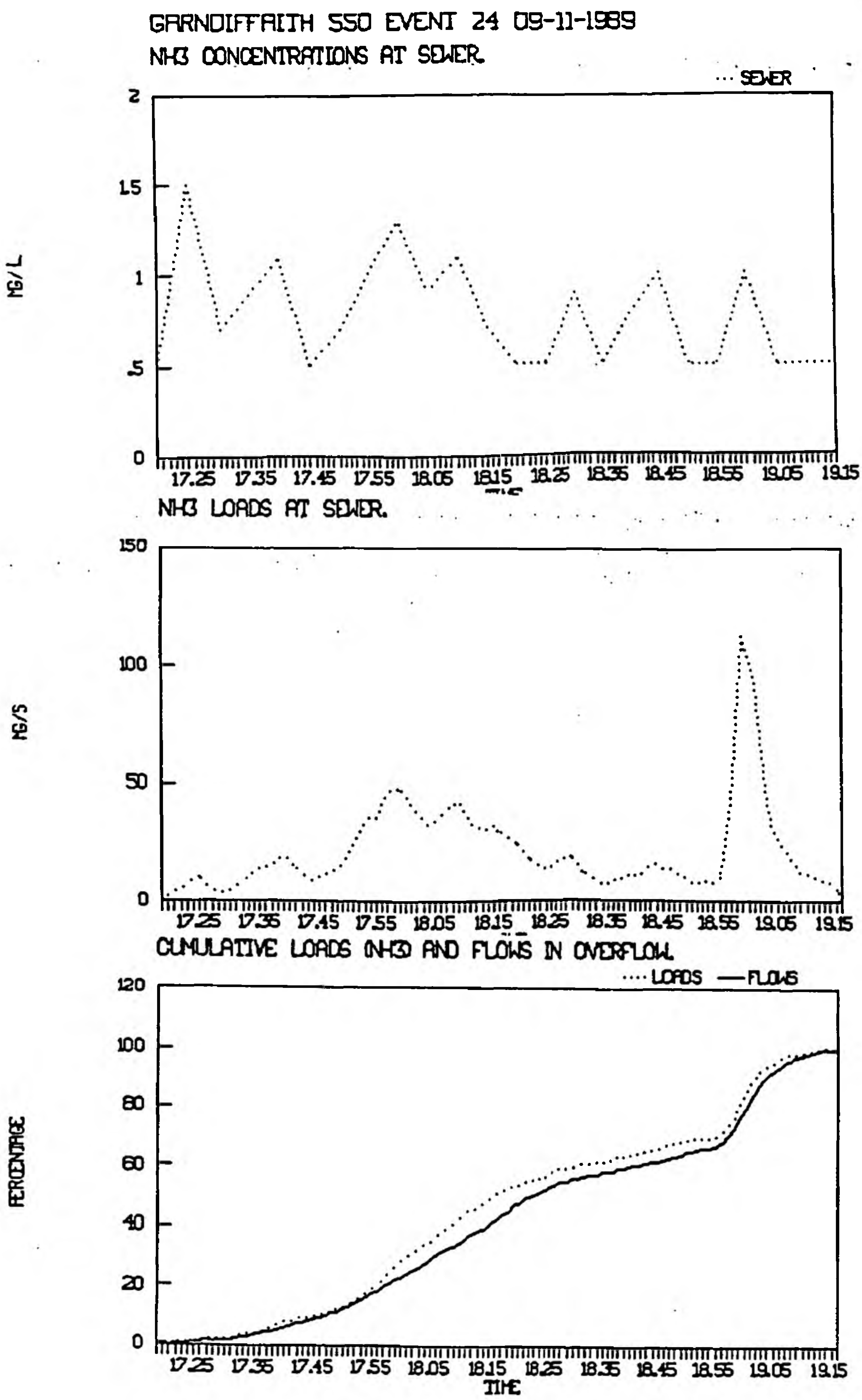
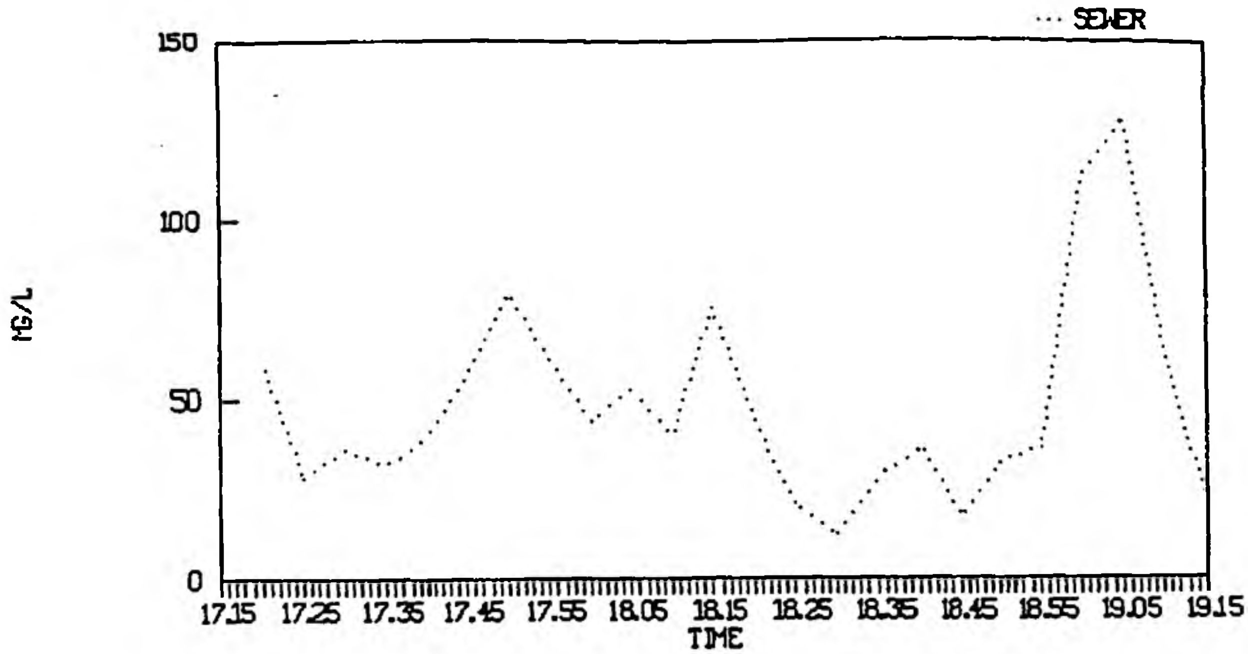

GARNDIFFAITH SSO EVENT 24 09-11-1989
NH3 CONCENTRATIONS AT SEWER
··· SEWER
MG/L
2
1.5
1
.5
0
17.25 17.35 17.45 17.55 18.05 18.15 18.25 18.35 18.45 18.55 19.05 19.15
NH3 LOADS AT SEWER.
MG/S
150
100
50
0
17.25 17.35 17.45 17.55 18.05 18.15 18.25 18.35 18.45 18.55 19.05 19.15
CUMULATIVE LOADS (NH3) AND FLOWS IN OVERFLOW
···· LOADS —— FLOWS
PERCENTAGE
120
100
80
60
40
20
0
17.25 17.35 17.45 17.55 18.05 18.15 18.25 18.35 18.45 18.55 19.05 19.15
TIME

FIG. 31

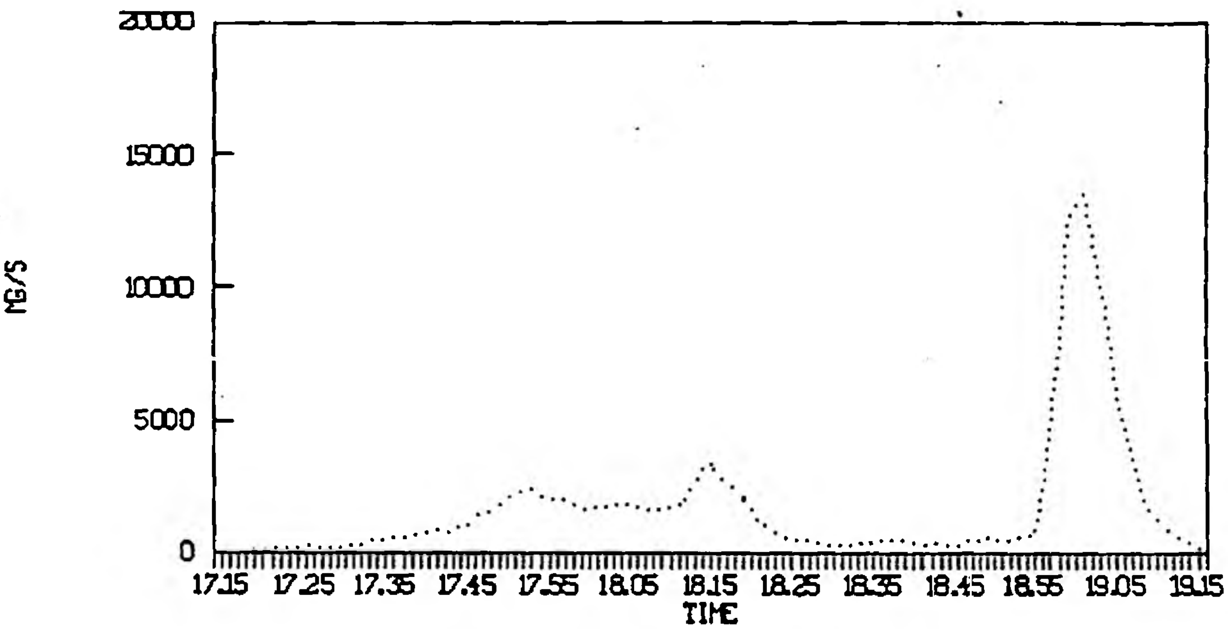
GARNDIFFAITH SSO EVENT 24 09-11-89

TSS CONCENTRATIONS IN OVERFLOW



GARNDIFFAITH SSO EVENT 24 09-11-89

TSS LOADS IN OVERFLOW



GARNDIFFAITH SSO EVENT 24 09-11-89

CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW

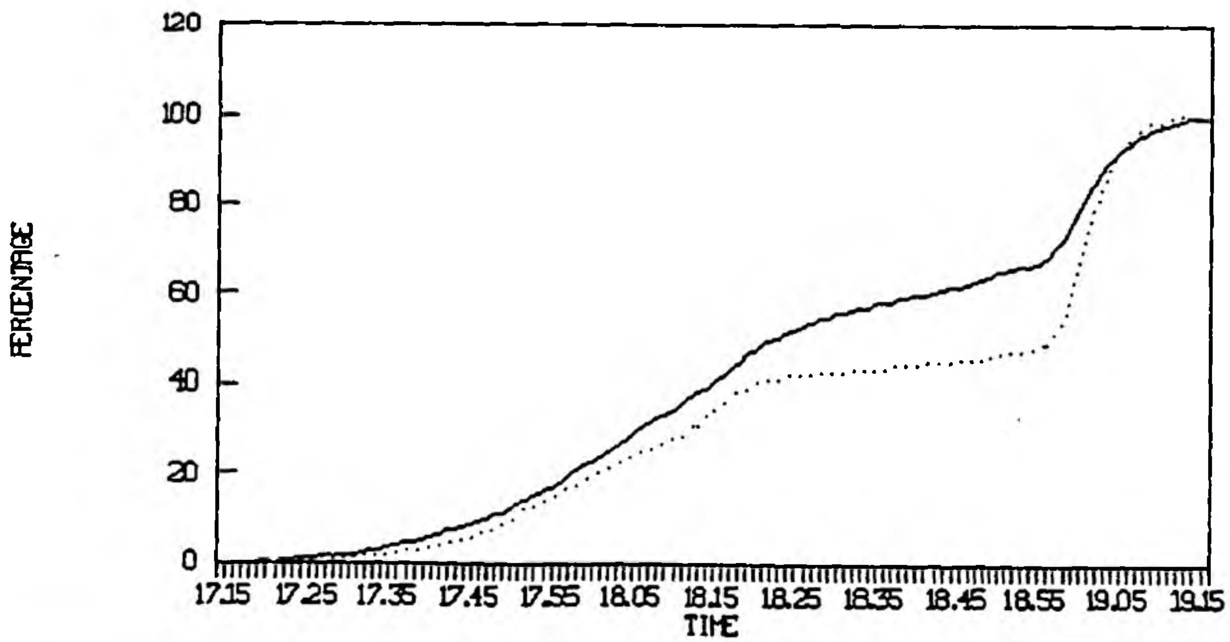
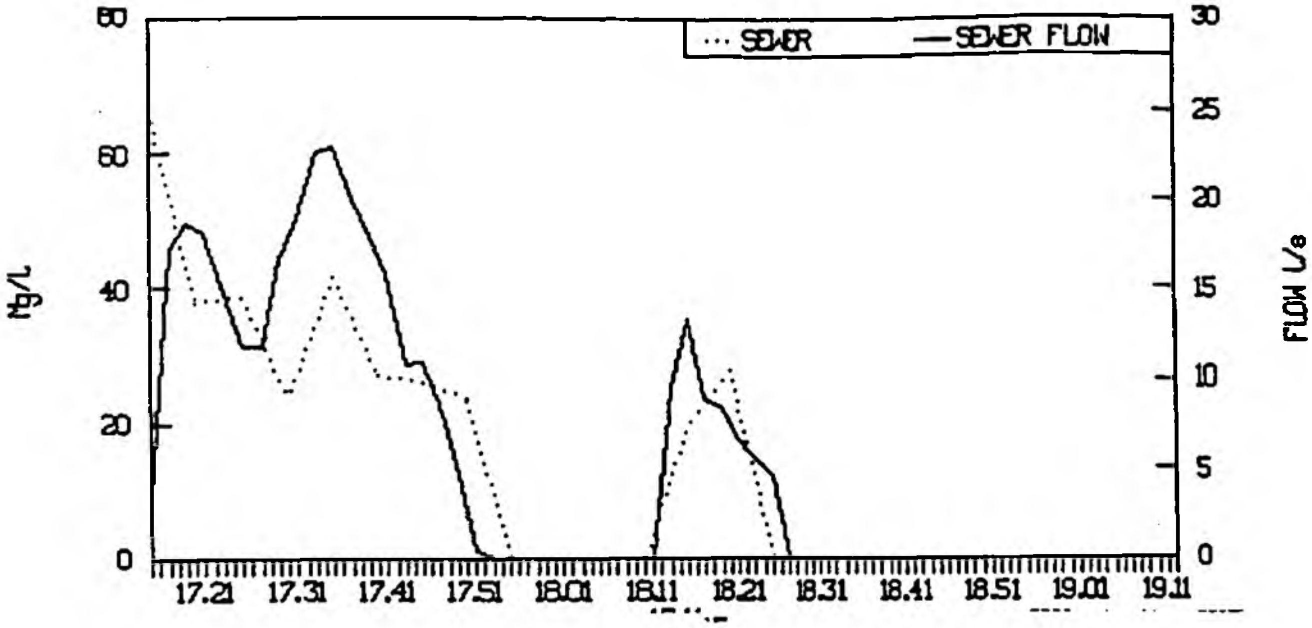


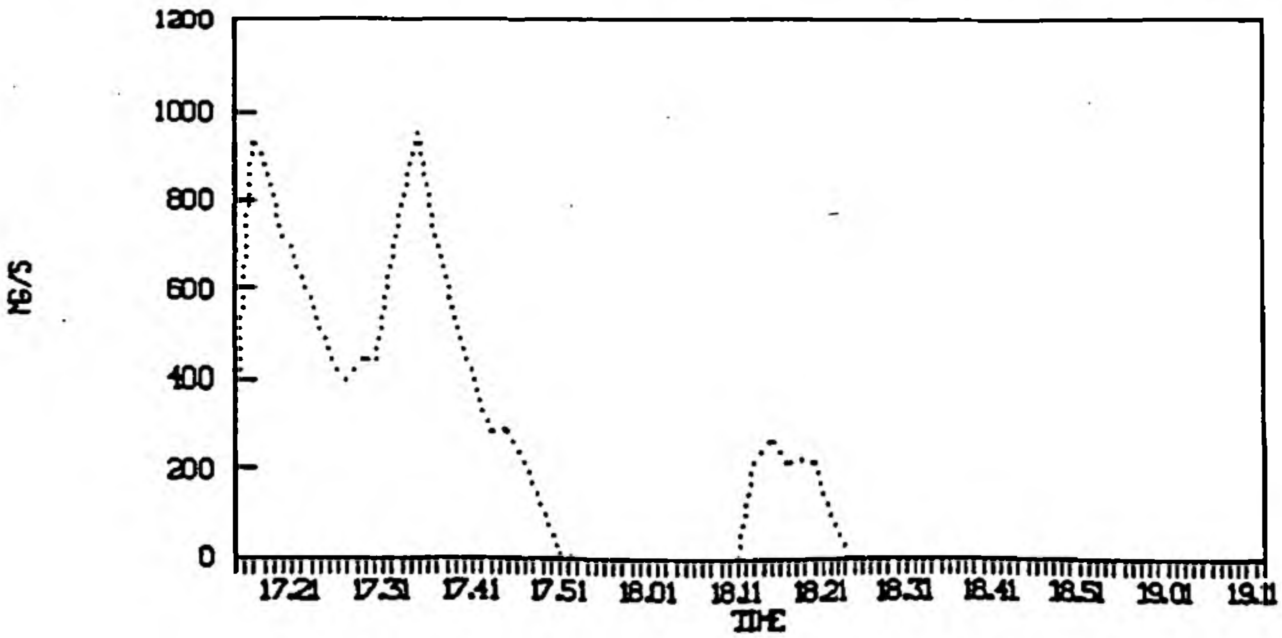
FIG. 32

GARNDIFFAITH SSO EVENT 12 18-10-88.

BOD CONCENTRATIONS AT SEWER.



BOD LOADS AT SEWER.



CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW.

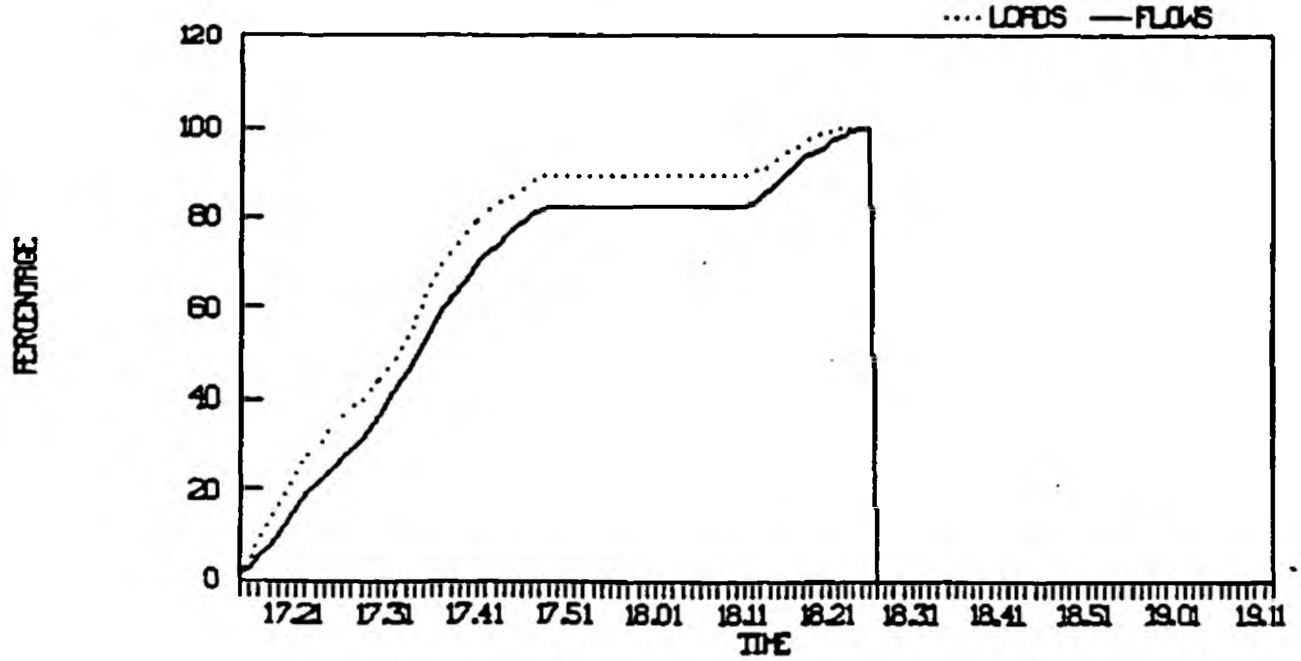
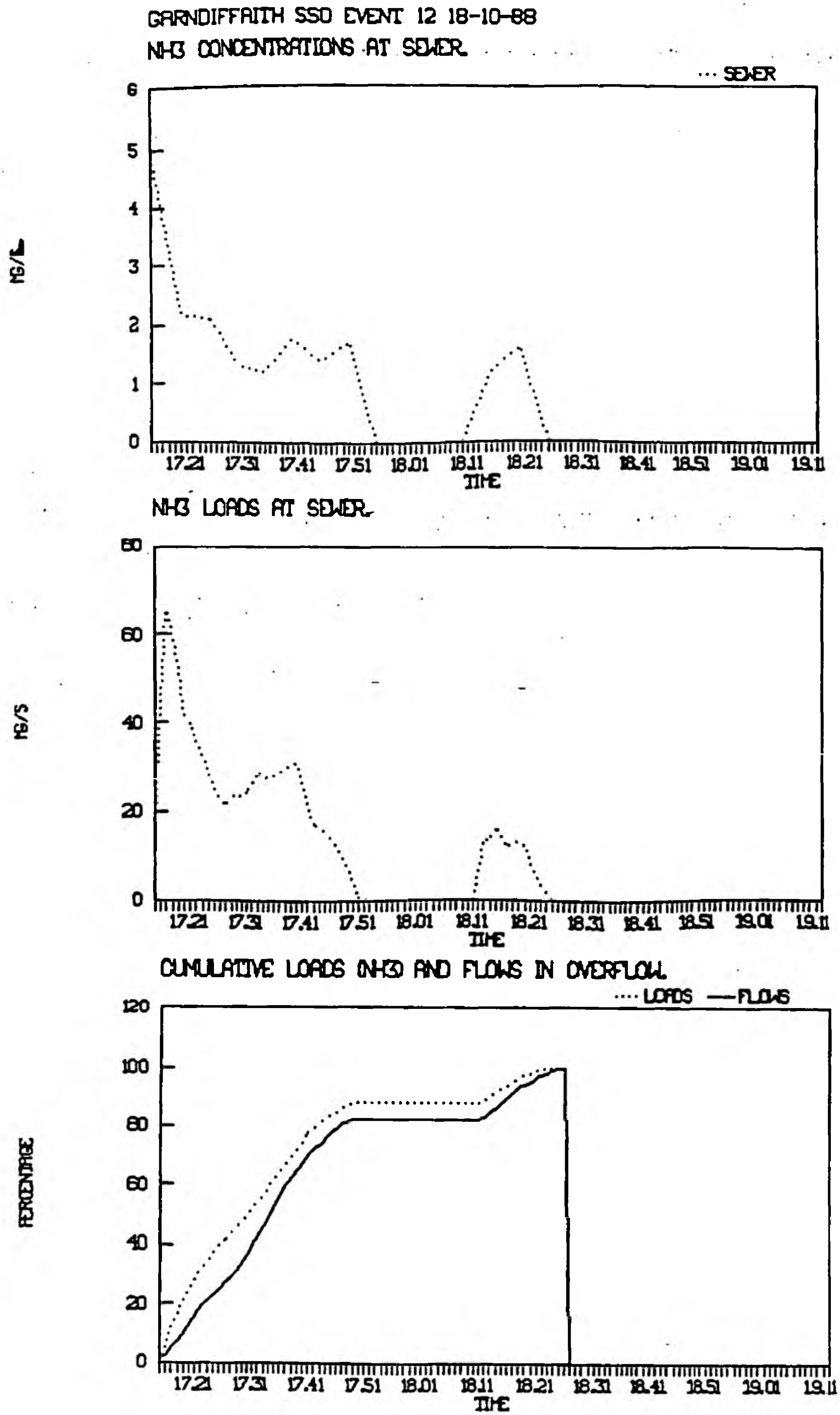


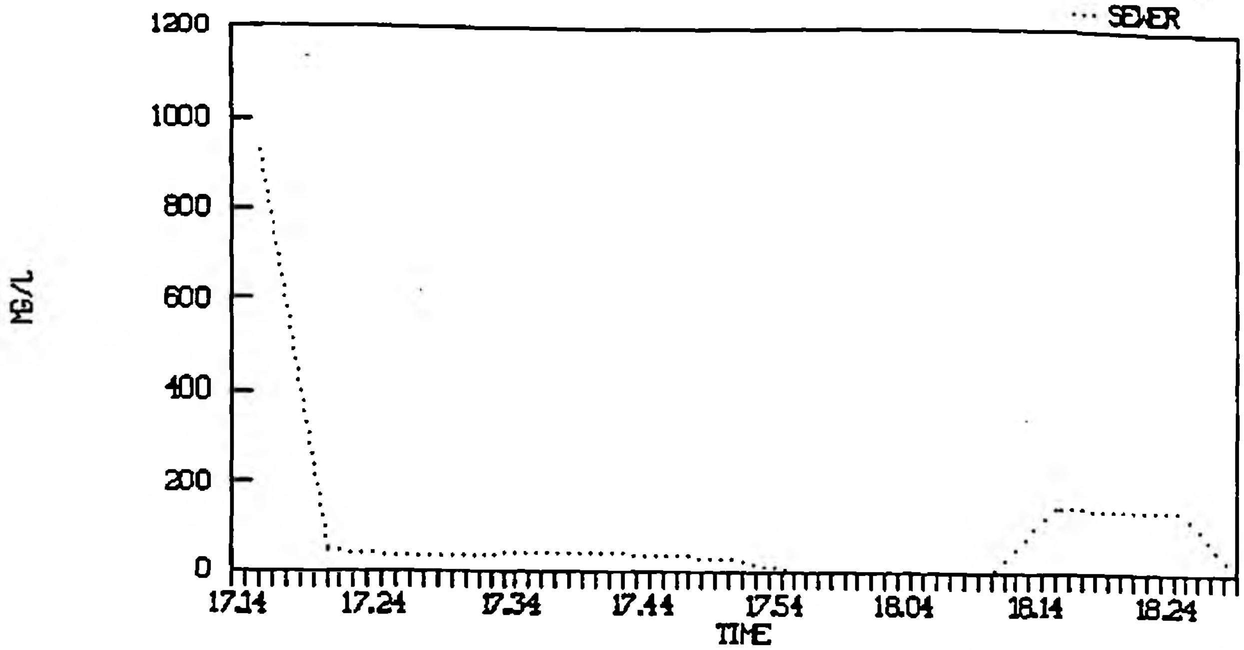
FIG. 33



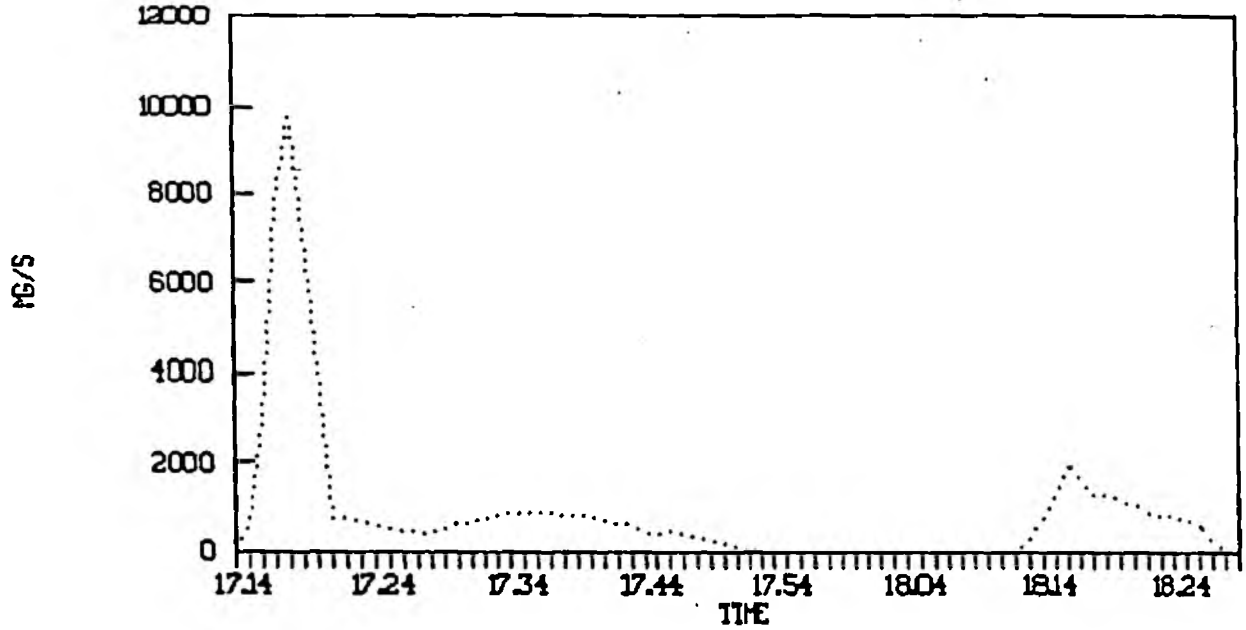
GARNDIFFAITH SSO EVENT 12 18-10-88
NH3 CONCENTRATIONS AT SEWER
··· SEWER
MG/L
6
5
4
3
2
1
0
17.21 17.31 17.41 17.51 18.01 18.11 18.21 18.31 18.41 18.51 19.01 19.11
TIME
NH3 LOADS AT SEWER
MG/S
80
60
40
20
0
17.21 17.31 17.41 17.51 18.01 18.11 18.21 18.31 18.41 18.51 19.01 19.11
TIME
CUMULATIVE LOADS (NH3) AND FLOWS IN OVERFLOW
···· LOADS —— FLOWS
PERCENTAGE
120
100
80
60
40
20
0
17.21 17.31 17.41 17.51 18.01 18.11 18.21 18.31 18.41 18.51 19.01 19.11
TIME

FIG. 34

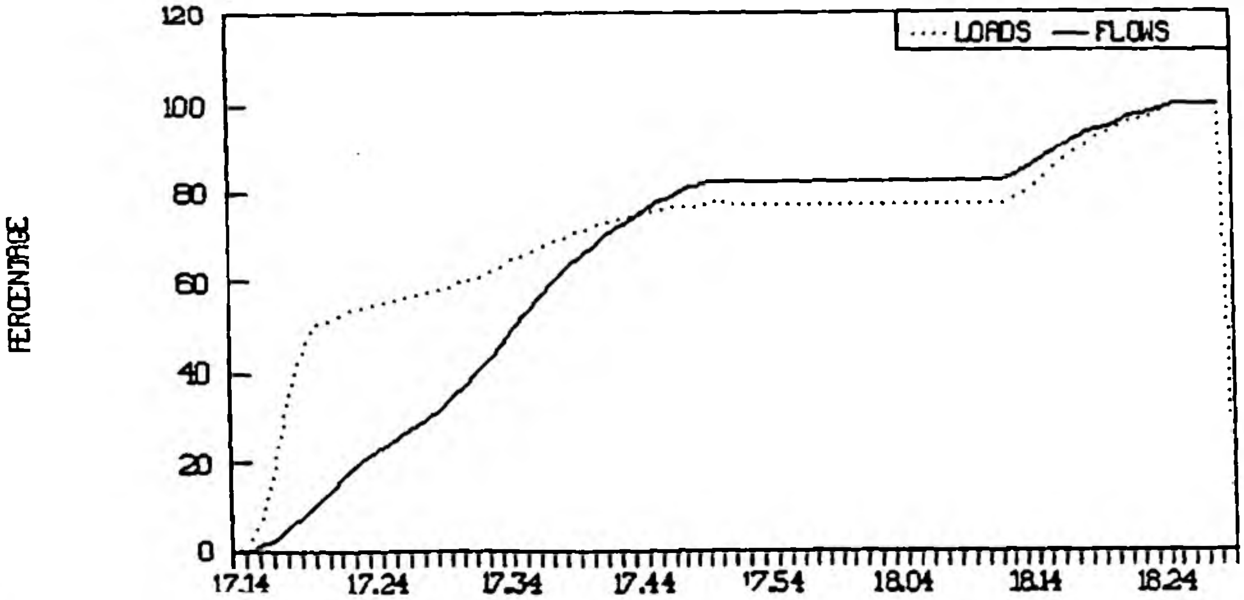
GARNDIFFAITH SSO EVENT 12 18-10-88
TSS CONCENTRATIONS IN OVERFLOW



GARNDIFFAITH SSO EVENT 12 18-10-88
TSS LOADS IN OVERFLOW

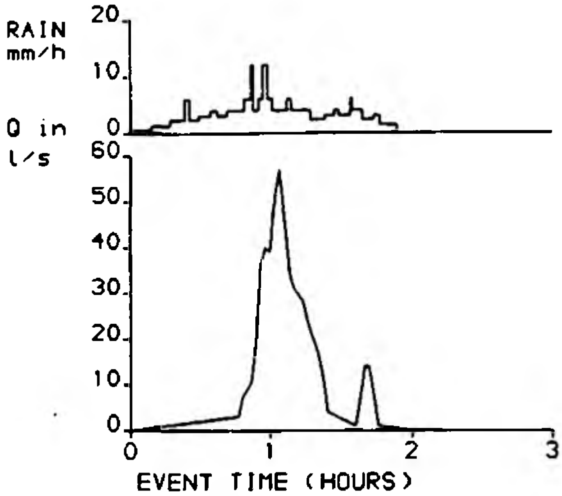


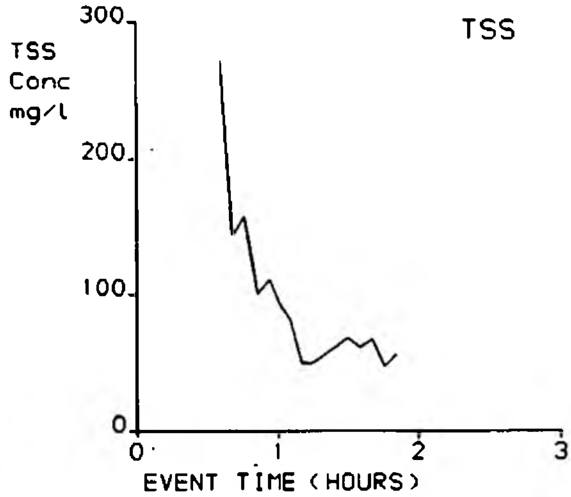
GARNDIFFAITH SSO EVENT 12 18-10-88
CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW.



Site: STORM SEWAGE OVERFLOW TO NANT FFR GN881018SO.DAT

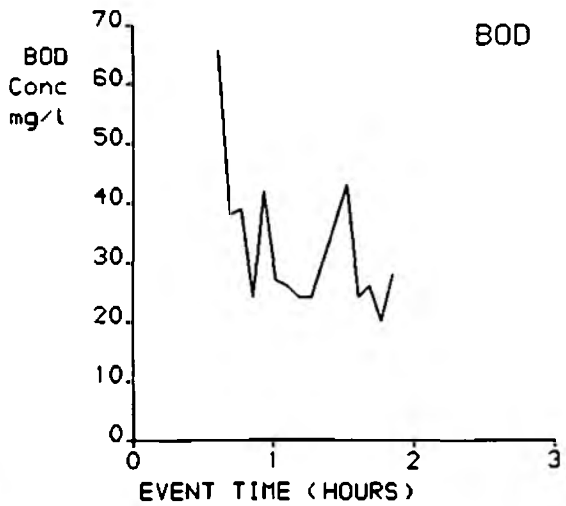
Grid Ref: 262044 Weather Conditions:
Storm Date: 881018 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1640 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 6.4 Rainfall Event Duration (mins): 107.

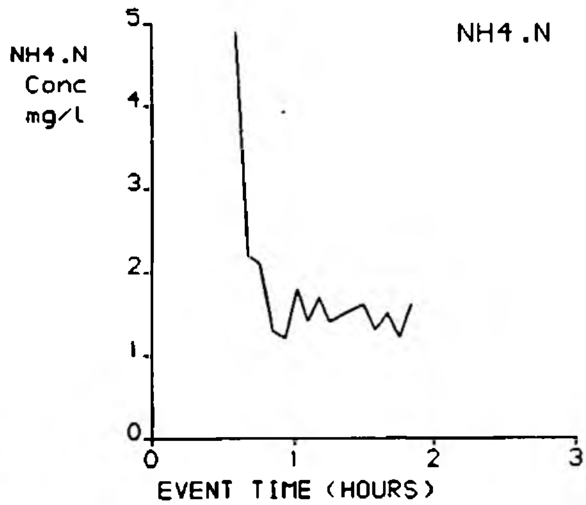




NO DATA FOR COD

NO DATA FOR TDS

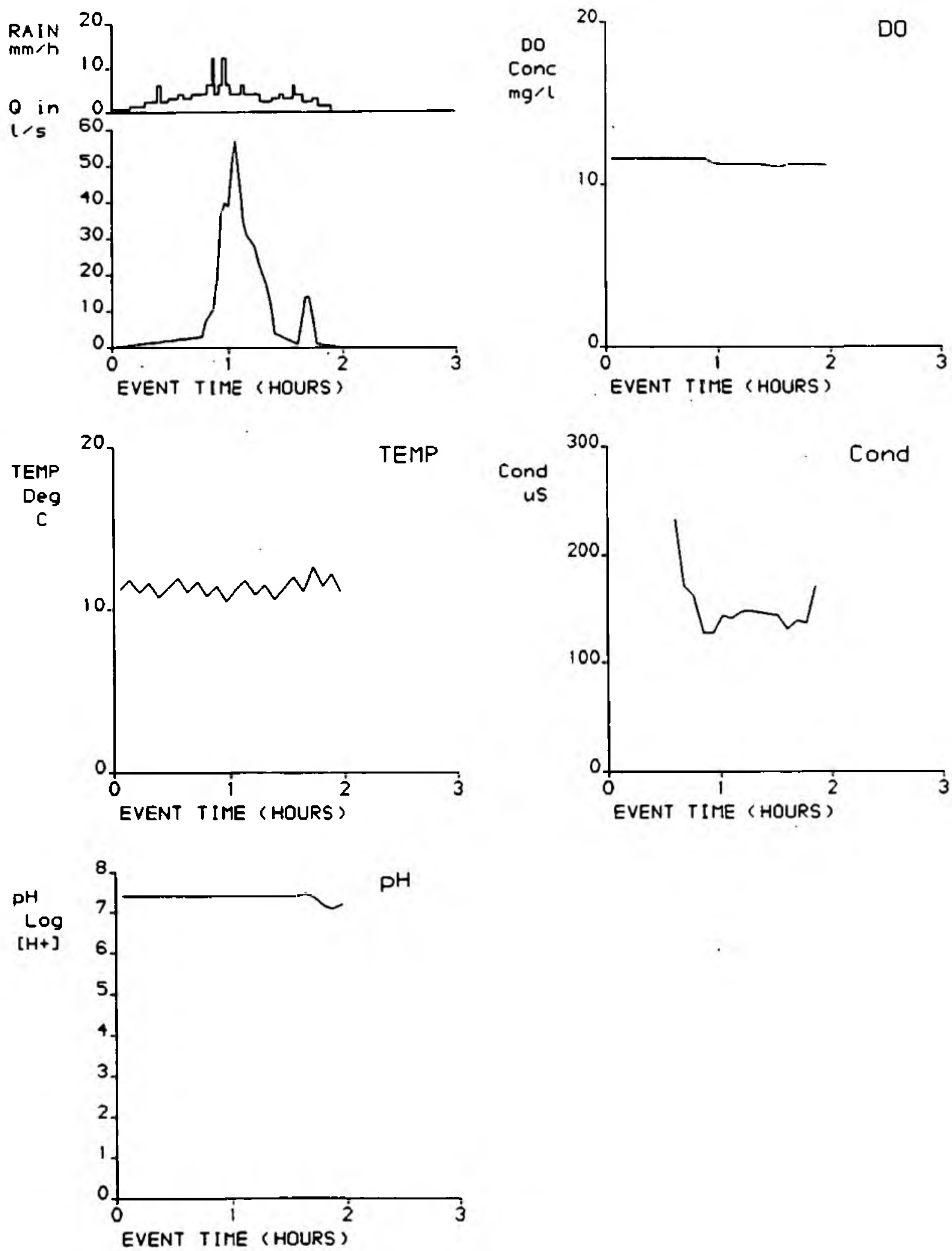




Site: STORM SEWAGE OVERFLOW TO NANT FFR GN881018S0.DAT

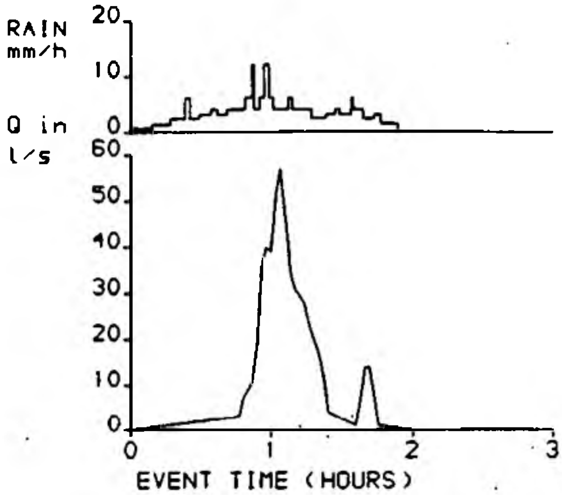
Grid Ref: 262044
Storm Date: 881018
Start Time (R/F): 1640
Rainfall Depth (mm): 6.4

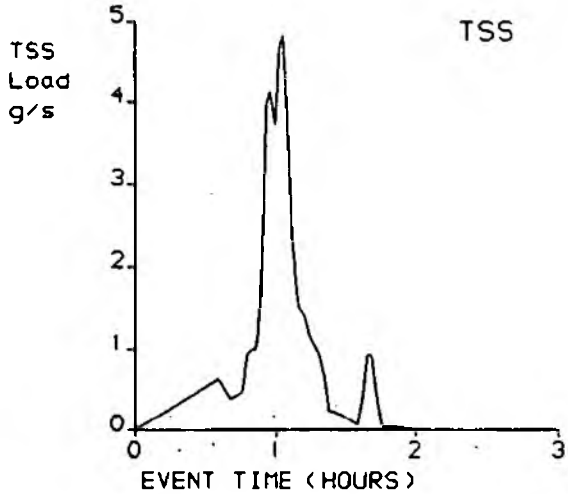
Weather Conditions:
Date/Time last recorded storm: 0/ . 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 107.



Site: STORM SEWAGE OVERFLOW TO NANT FFR GN881018SO.DAT

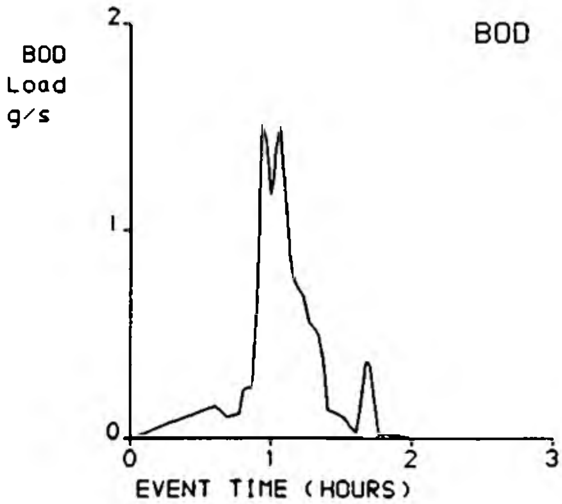
Grid Ref: 262044	Weather Conditions:
Storm Date: 881018	Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1640	Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 6.4	Rainfall Event Duration (mins): 107.

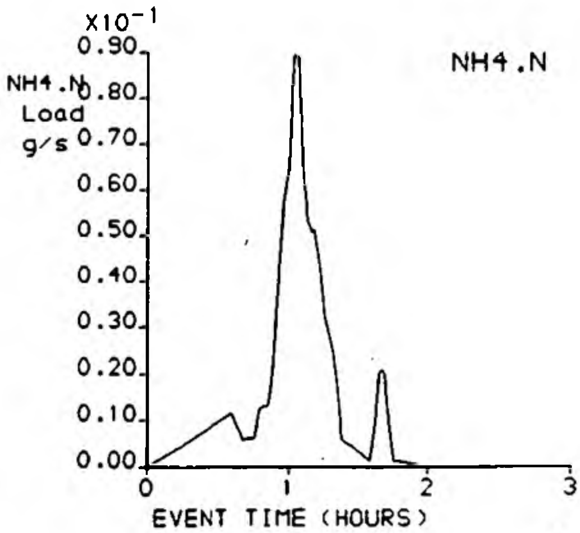




NO DATA FOR COD

NO DATA FOR TDS

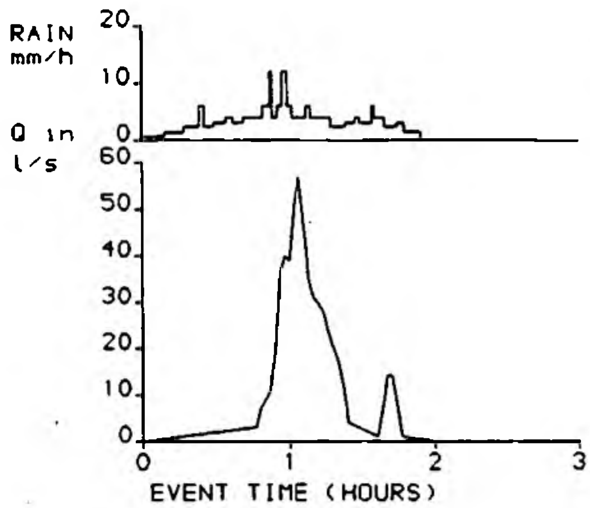


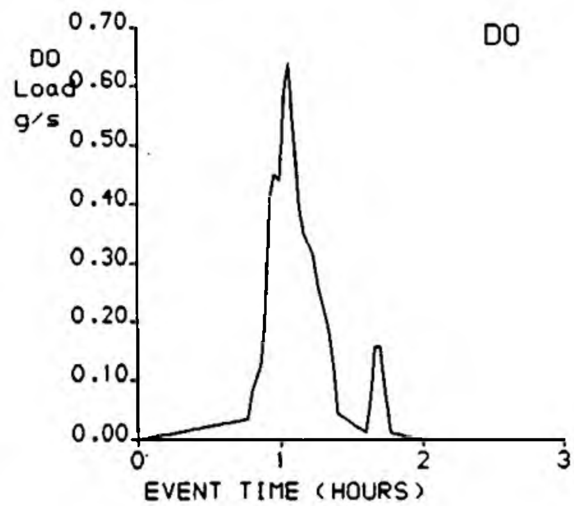


Site: STORM SEWAGE OVERFLOW TO NANT FFR GN881018SO.DAT

Grid Ref: 262044
Storm Date: 881018
Start Time (R/F): 1640
RainFall Depth (mm): 6.4

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
RainFall Event Duration (mins): 107.





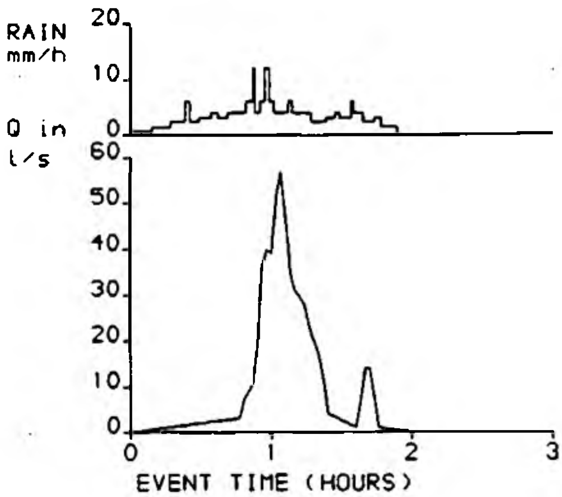
NO DATA FOR TEMP

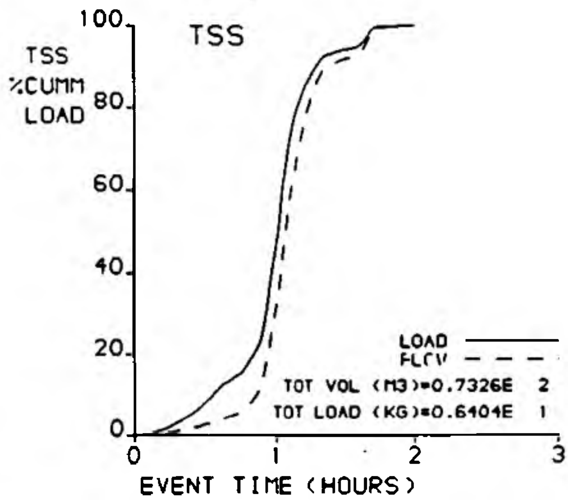
NO DATA FOR Cond

NO DATA FOR pH

Site: STORM SEWAGE OVERFLOW TO NANT FFR GN881018SO.DAT

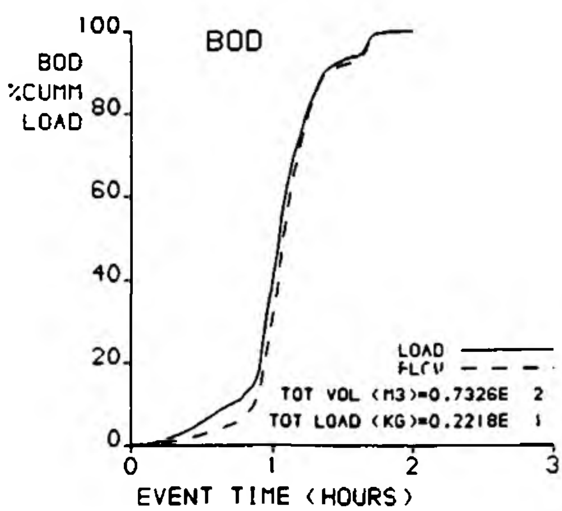
Grid Ref: 262044 Weather Conditions:
Storm Date: 881018 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1640 Antec. Dry Weather Period (hours): 0
RainFall Depth (mm): 6.4 RainFall Event Duration (mins): 107.

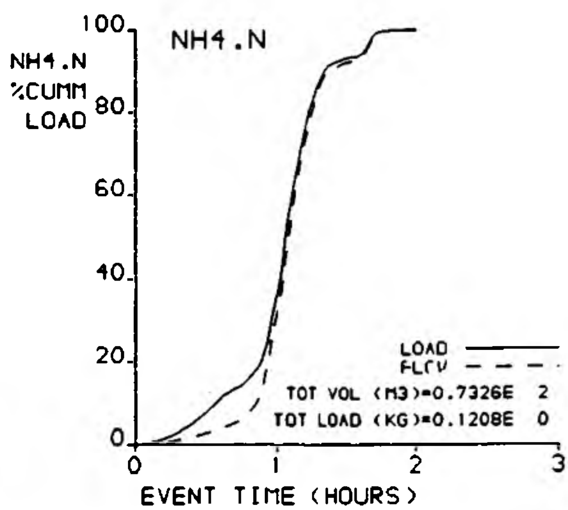




NO DATA FOR COD

NO DATA FOR TDS

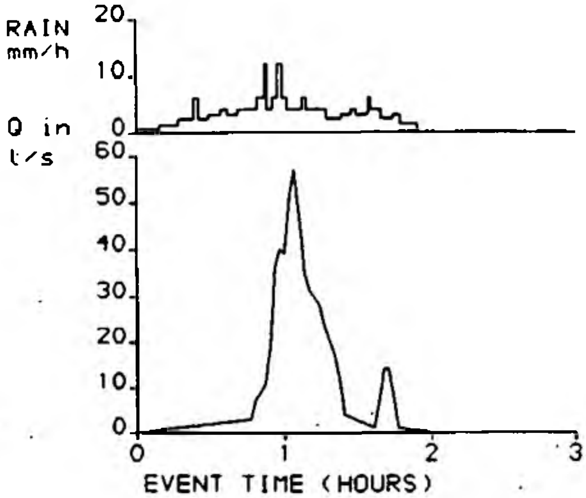


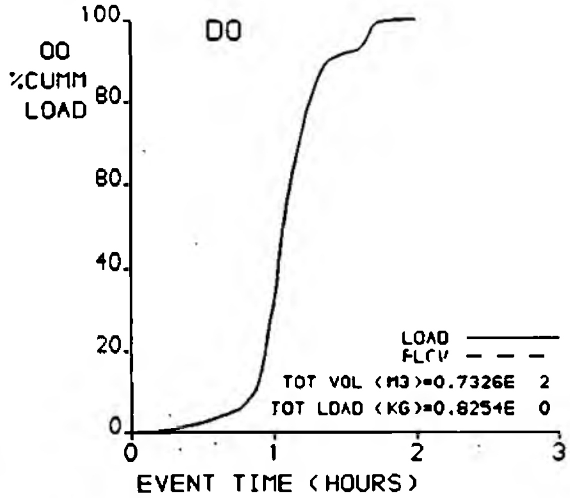


Site: STORM SEWAGE OVERFLOW TO NANT FFR GN881018SO.DAT

Grid Ref: 262044
Storm Date: 881018
Start Time (R/F): 1640
Rainfall Depth (mm): 6.4

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 107.





NO DATA FOR TEMP

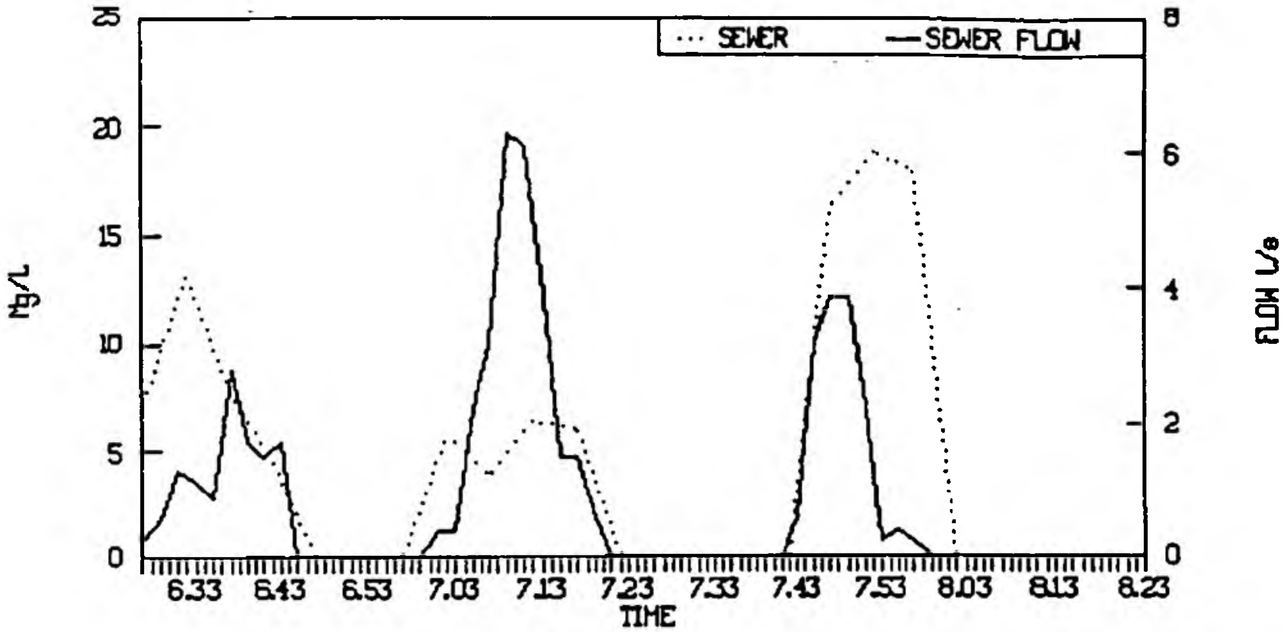
NO DATA FOR Cond

NO DATA FOR

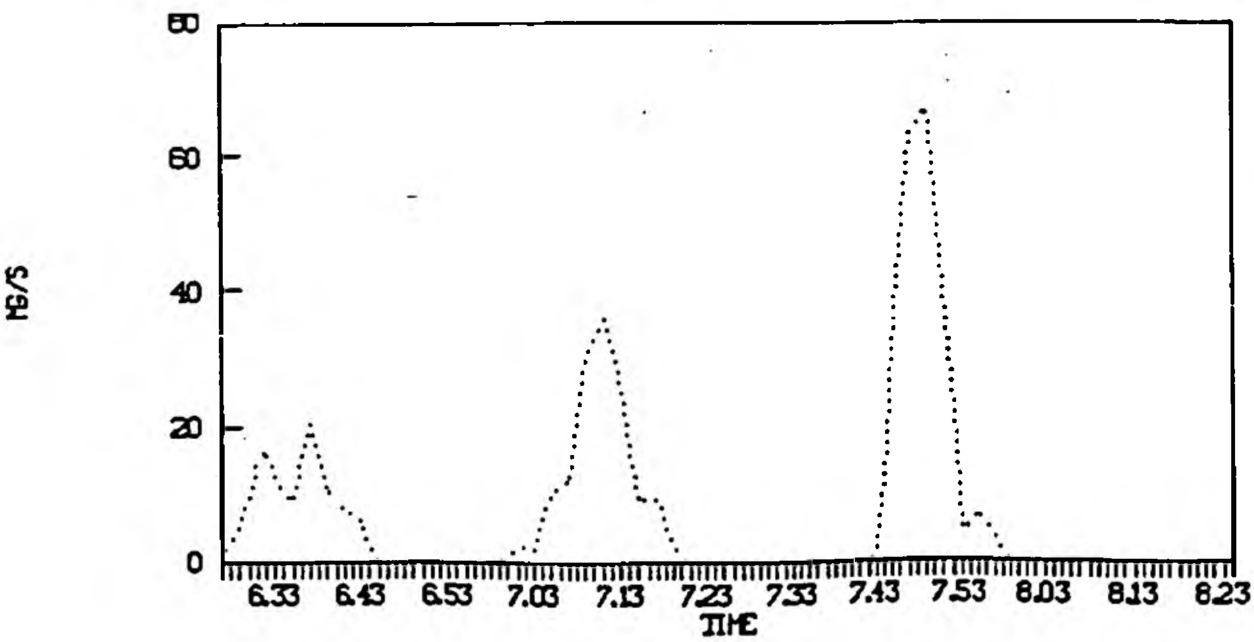
GARNDIFFAITH SSO EVENT 25 13-12-89

FIG.41

BOD CONCENTRATIONS AT SEWER



BOD LOADS AT SEWER



CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW

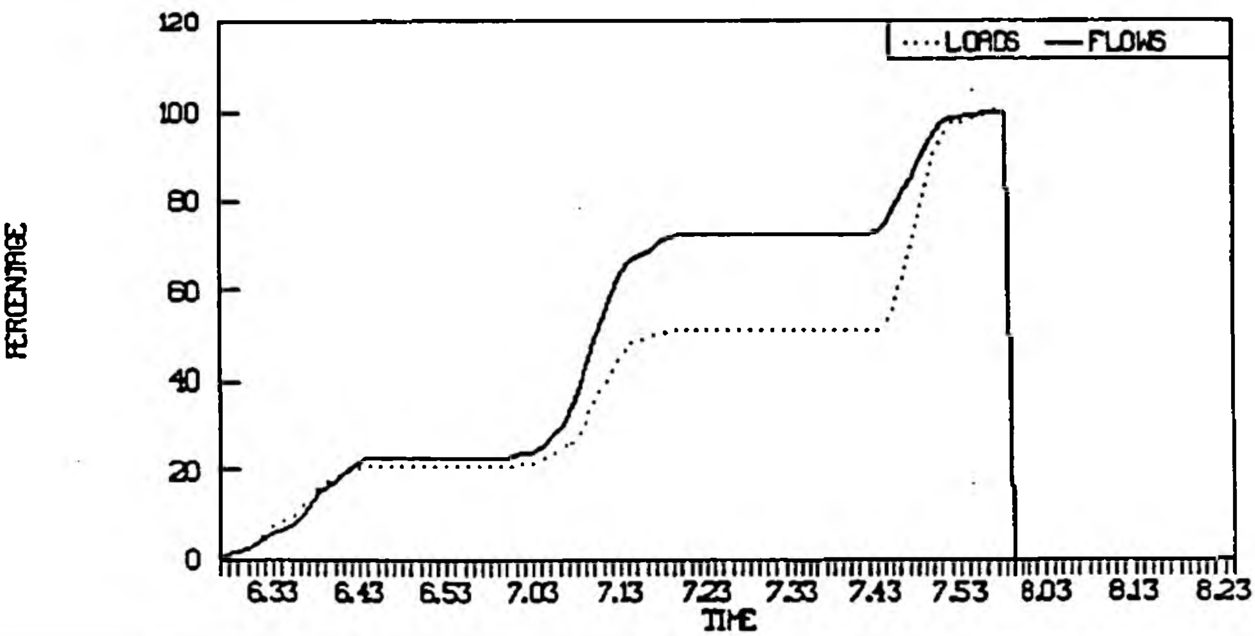
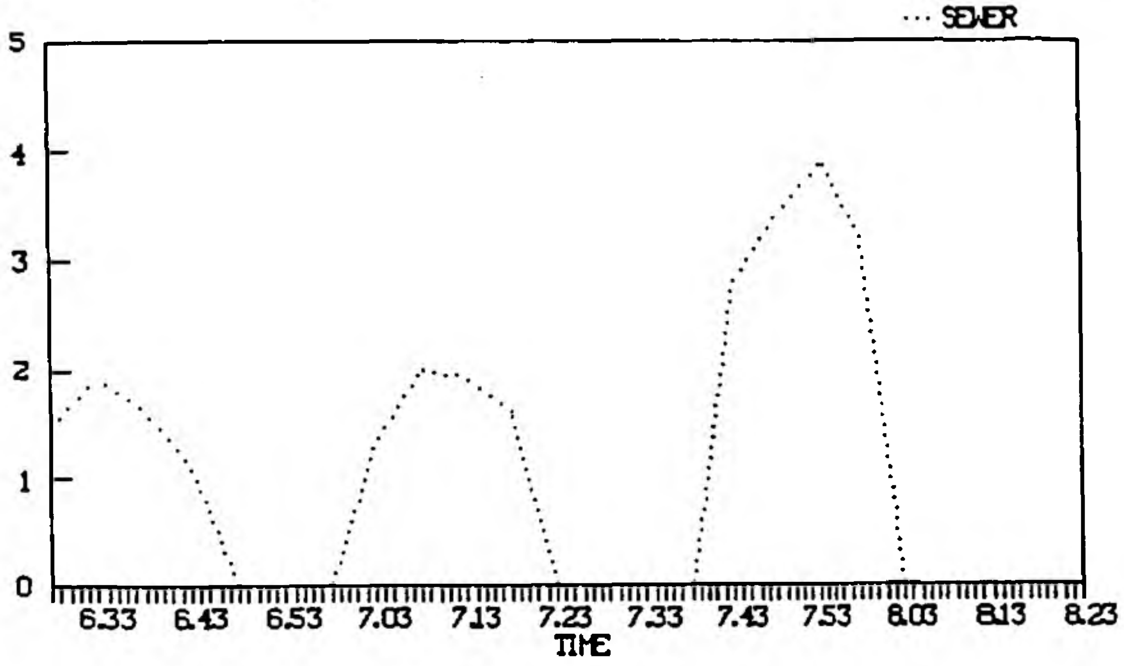


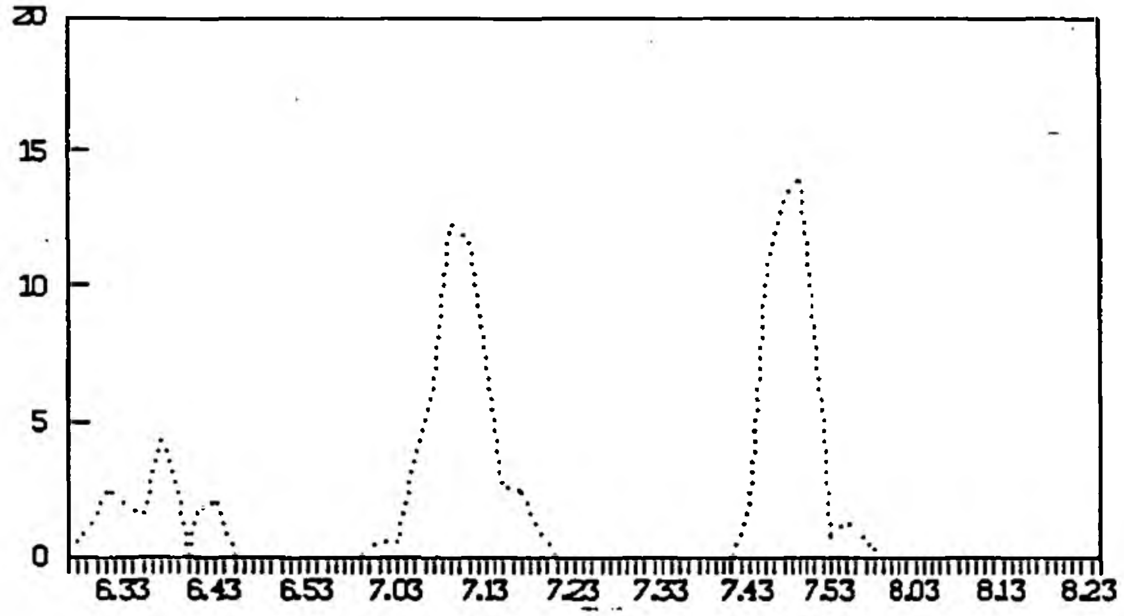
FIG.42

GARNDIFFAITH SSO EVENT 25 13-12-89

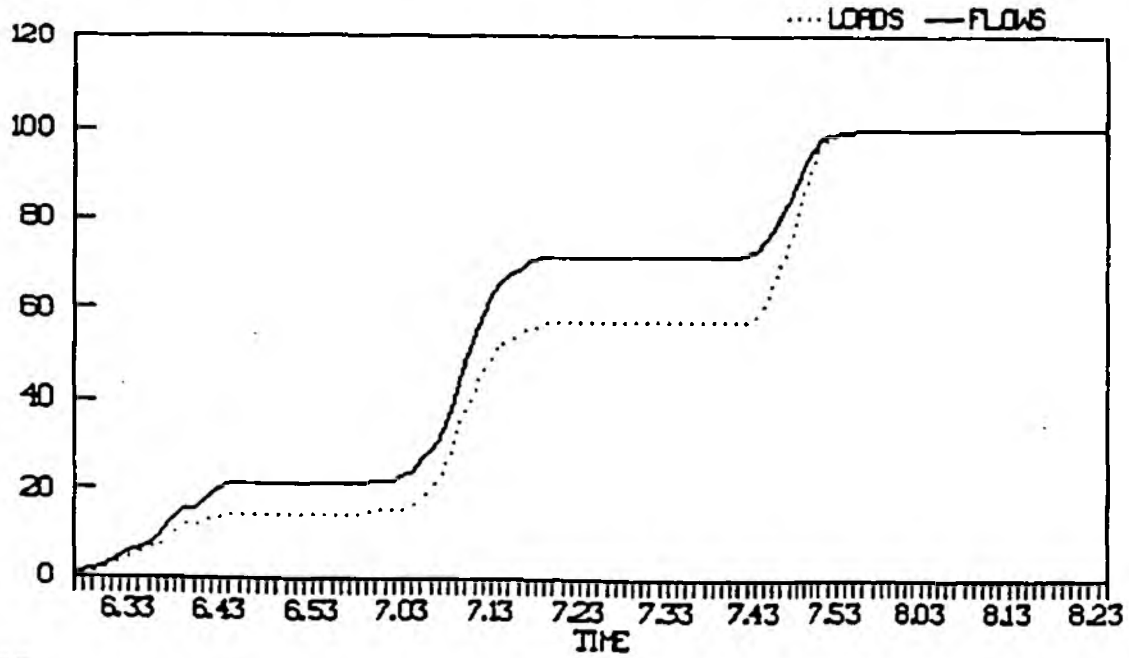
NH3 CONCENTRATIONS AT SEWER.



NH3 LOADS AT SEWER.



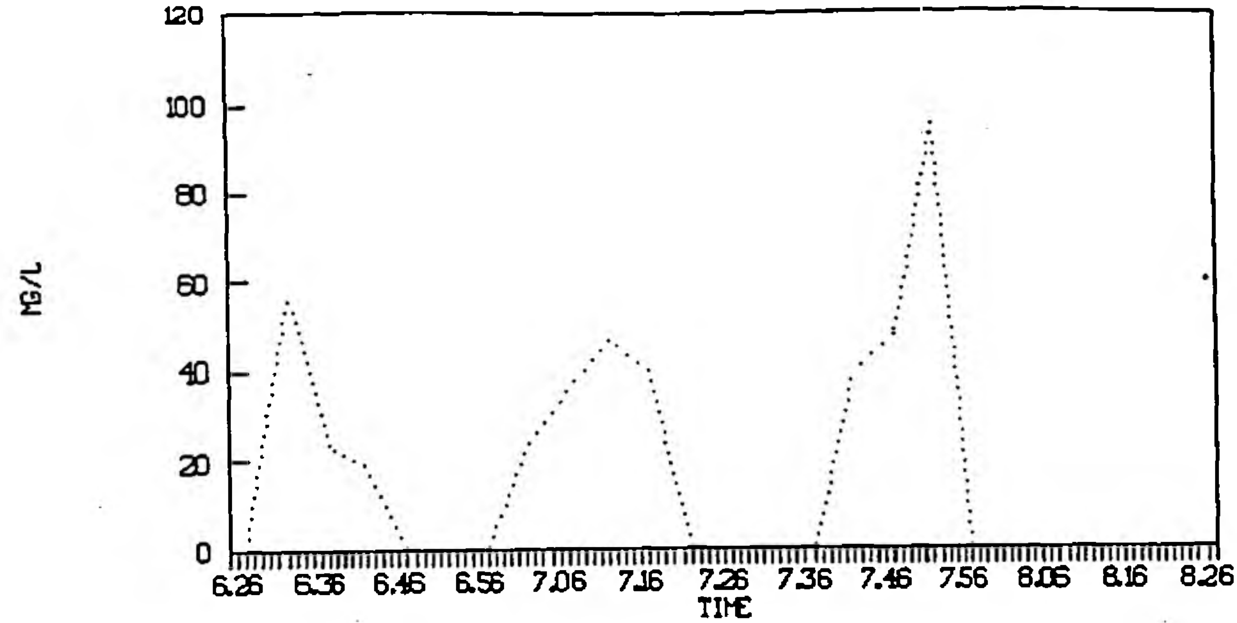
CUMULATIVE LOADS AND FLOWS



GARNDIFFAITH SSO EVENT 25 13-12-89

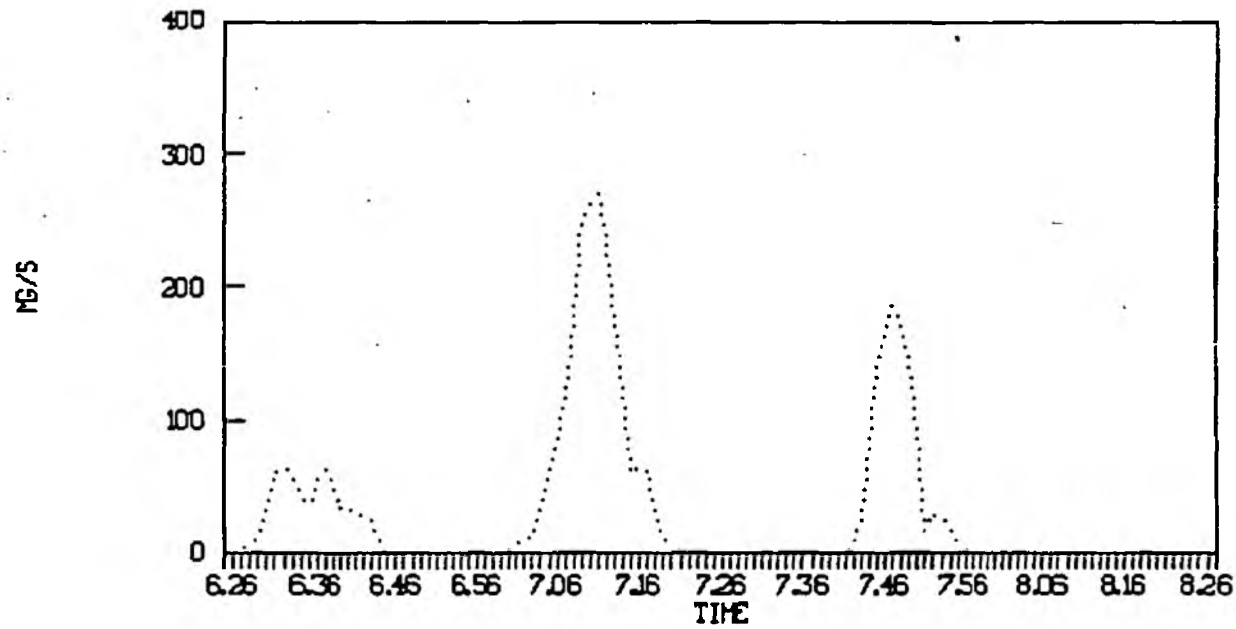
TSS CONCENTRATIONS IN OVERFLOW

FIG 43



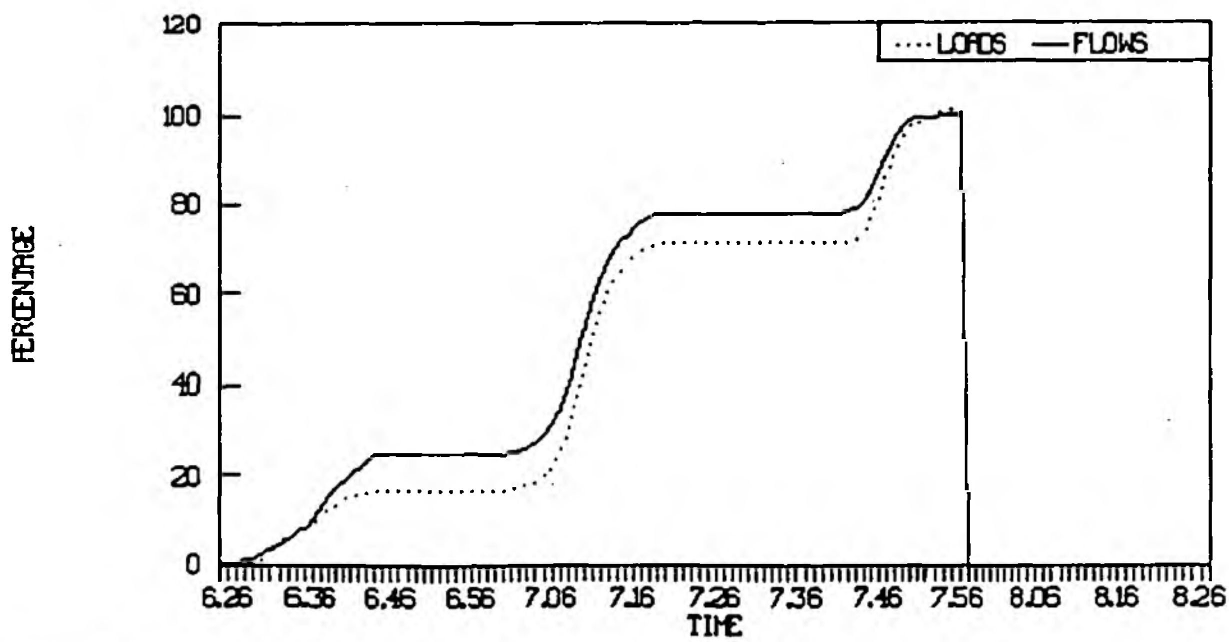
GARNDIFFAITH SSO EVENT 25 13-12-89

TSS LOADS IN OVERFLOW



GARNDIFFAITH SSO EVENT 25 13-12-89

CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW

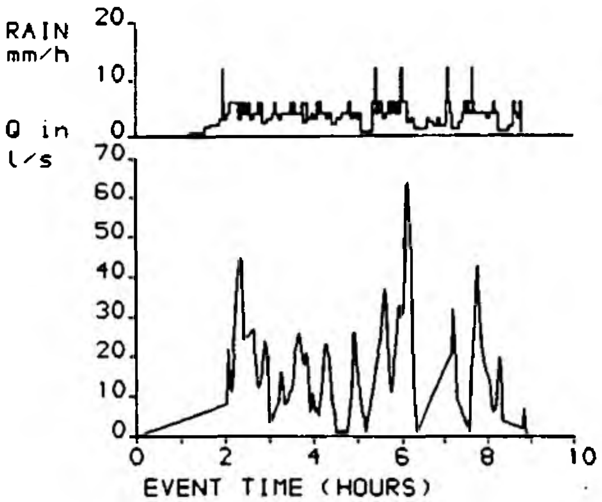


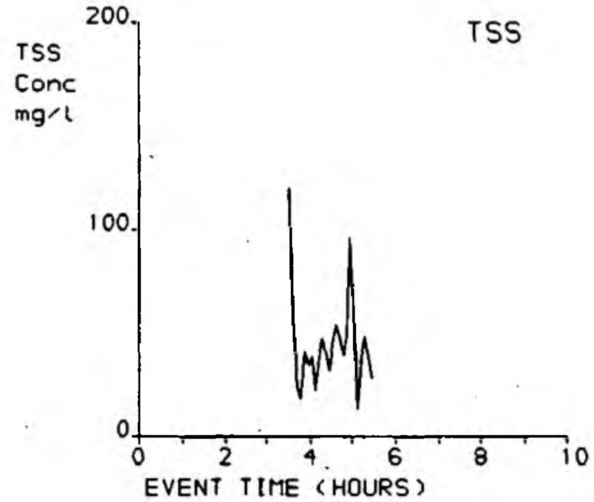
Site: SSO TO NANT FFRWD

GN891213SO.DAT

Grid Ref: 262044
Storm Date: 891213
Start Time (R/F): 300
Rainfall Depth (mm): 26.6

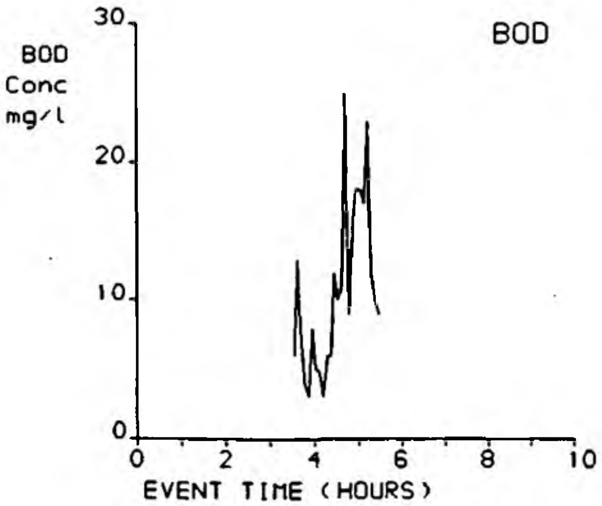
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 1235.





NO DATA FOR COD

NO DATA FOR TDS



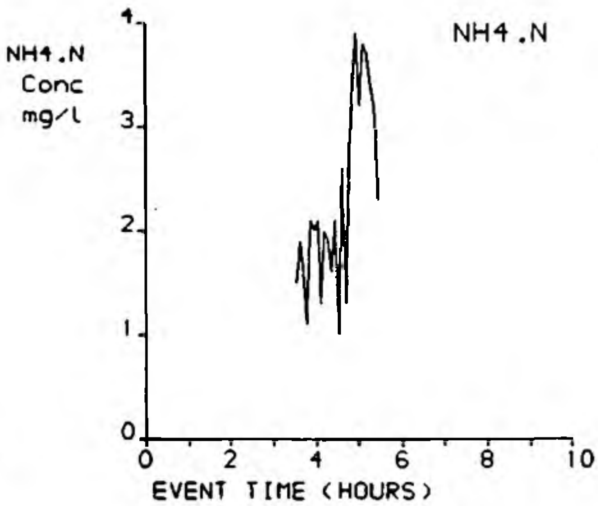


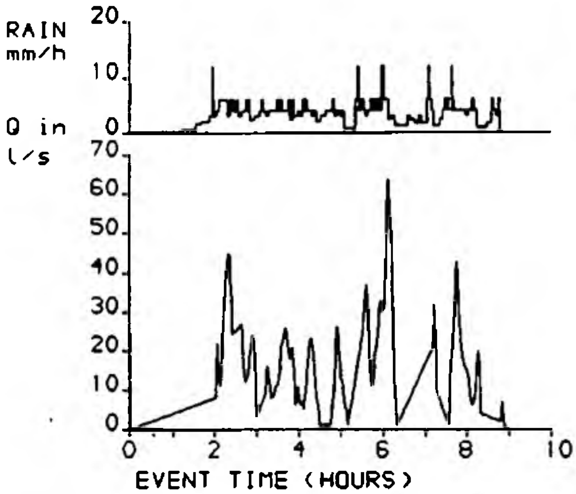
FIG.45

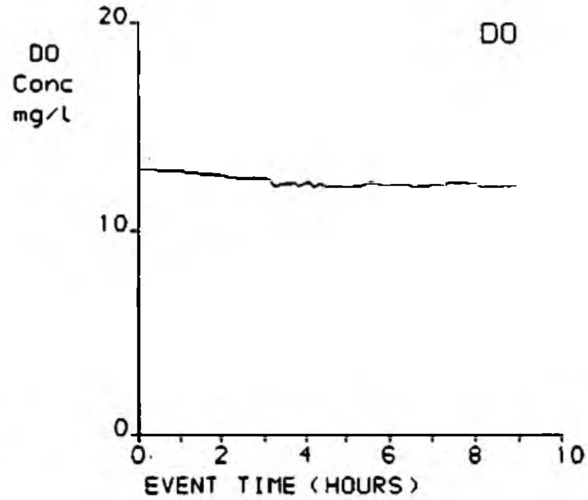
Site: SSO TO NANT FFRWD

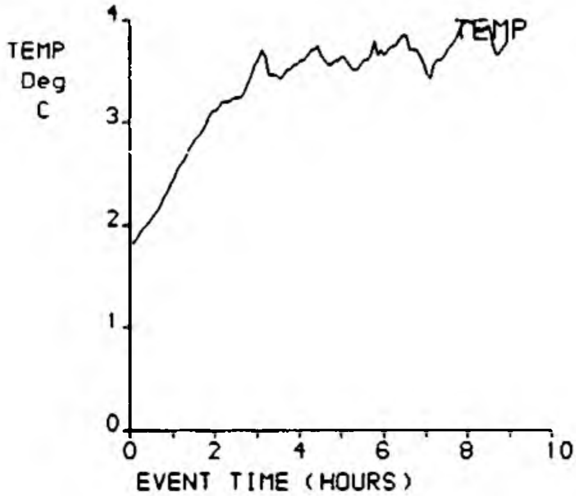
GN891213SO.DAT

Grid Ref: 262044
Storm Date: 891213
Start Time (R/F): 300
Rainfall Depth (mm): 26.6

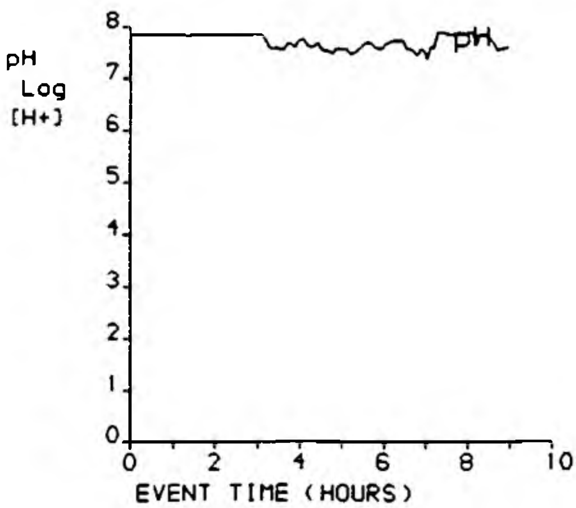
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 1235.







NO DATA FOR Cond

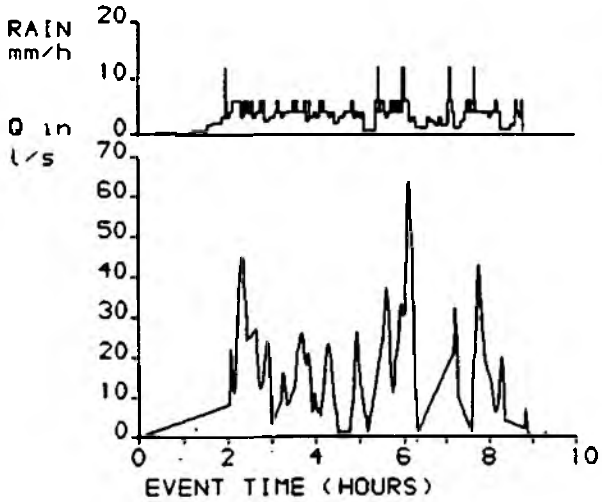


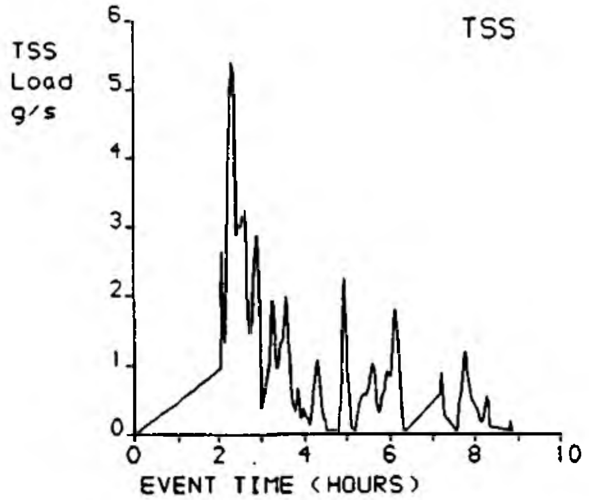
Site: SSO TO NANT FFRWD

GN891213SO.DAT

Grid Ref: 262044
Storm Date: 891213
Start Time (R/F): 300
Rainfall Depth (mm): 26.6

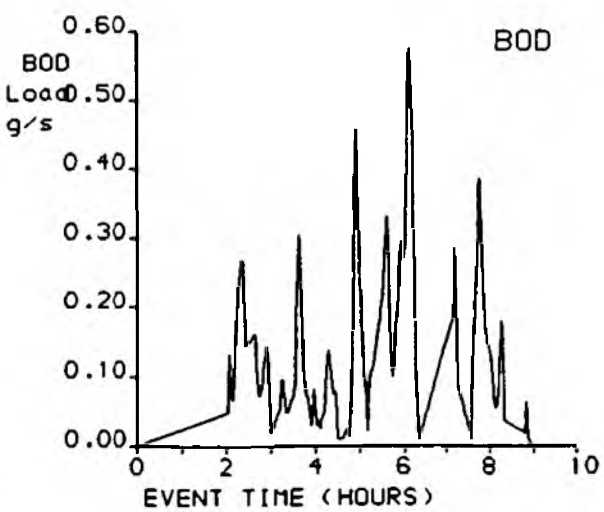
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 1235.





NO DATA FOR COD

NO DATA FOR TDS



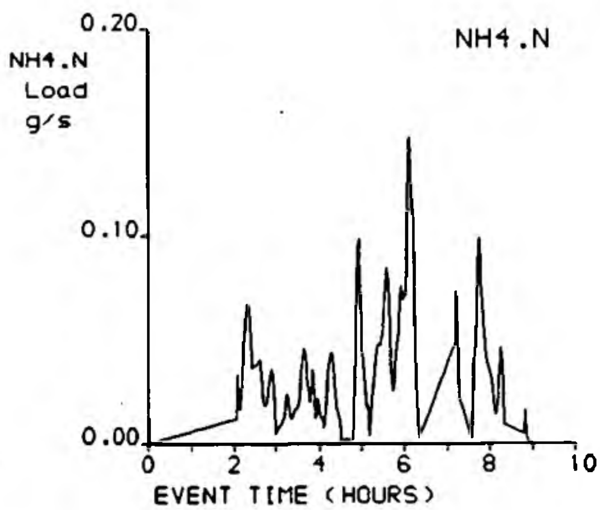


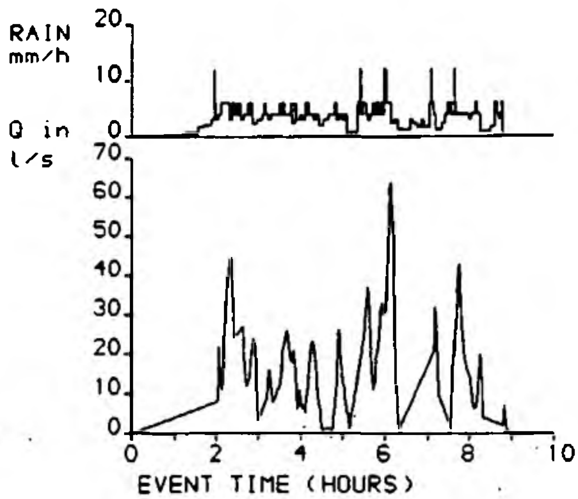
FIG. 47

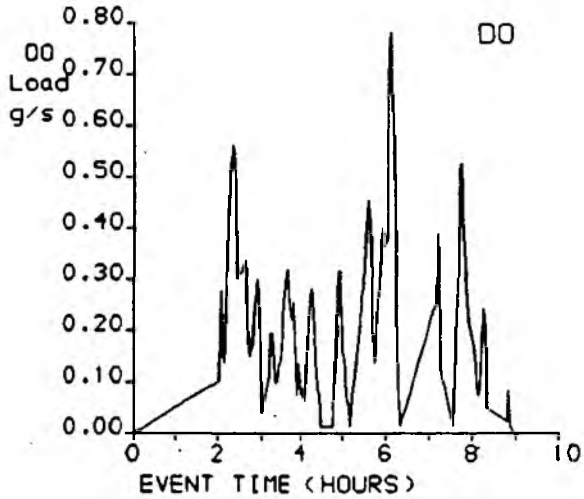
Site: SSO TO NANT FFRWD

GN891213SO.DAT

Grid Ref: 262044
Storm Date: 891213
Start Time (R/F): 300
Rainfall Depth (mm): 26.6

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 1235.





NO DATA FOR TEMP

NO DATA FOR Cond

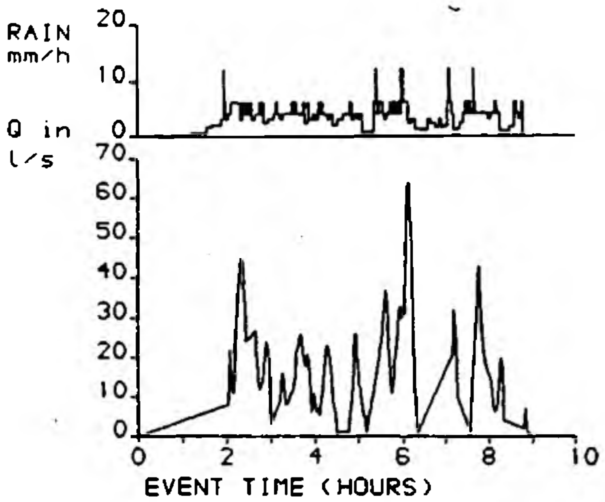
NO DATA FOR pH

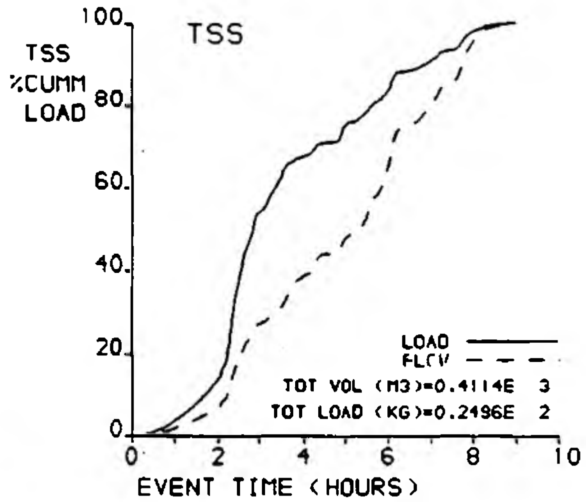
Site: SSO TO NANT FFRWD

GN891213SO.DAT

Grid Ref: 262044
Storm Date: 891213
Start Time (R/F): 300
Rainfall Depth (mm): 26.6

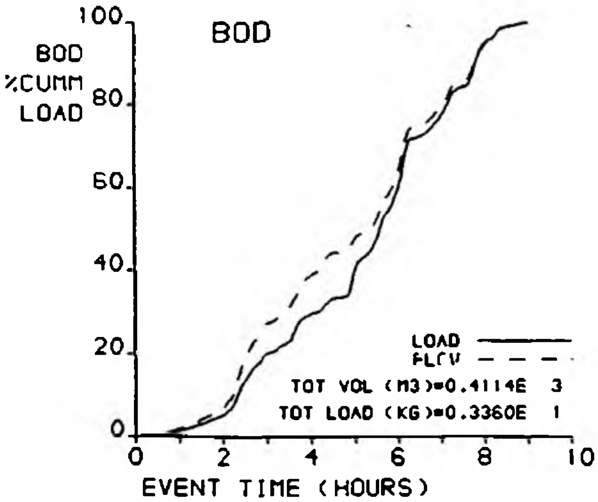
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 1235.

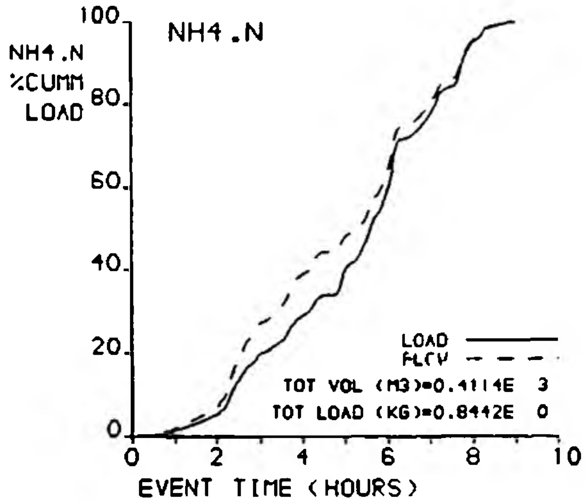




NO DATA FOR COD

NO DATA FOR TDS

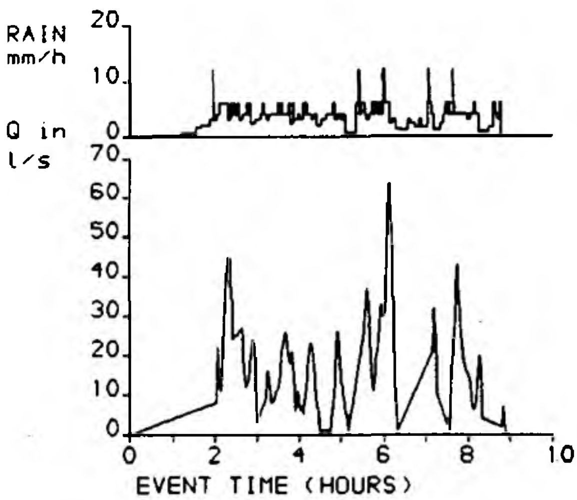


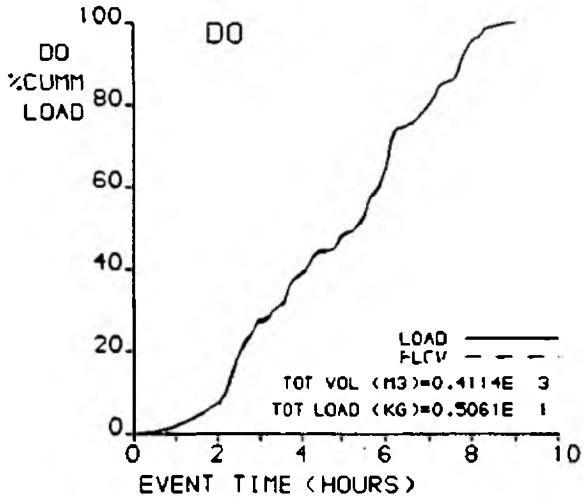


Site: SSO TO NANT FFRWD

GN891213SO.DAT

Grid Ref: 262044 Weather Conditions:
Storm Date: 891213 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 300 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 26.6 Rainfall Event Duration (mins): 1235.





NO DATA FOR TEMP

NO DATA FOR Cond

NO DATA FOR pl

DRY-WEATHER BACTERIAL CONCENTRATIONS.
TOTAL COLIFORMS.

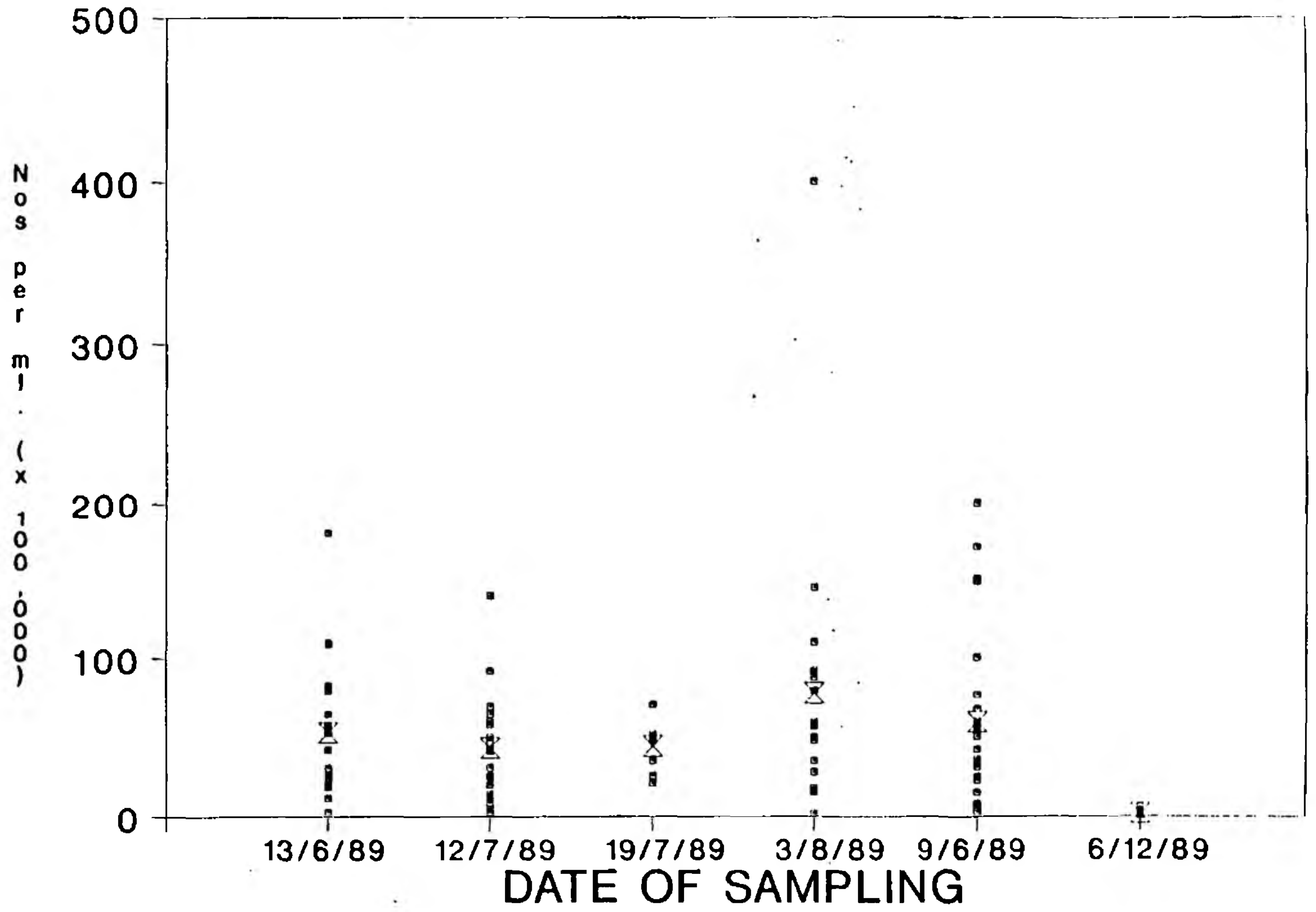


FIG.50

DRY-WEATHER BACTERIAL CONCENTRATIONS.
E.COLI.

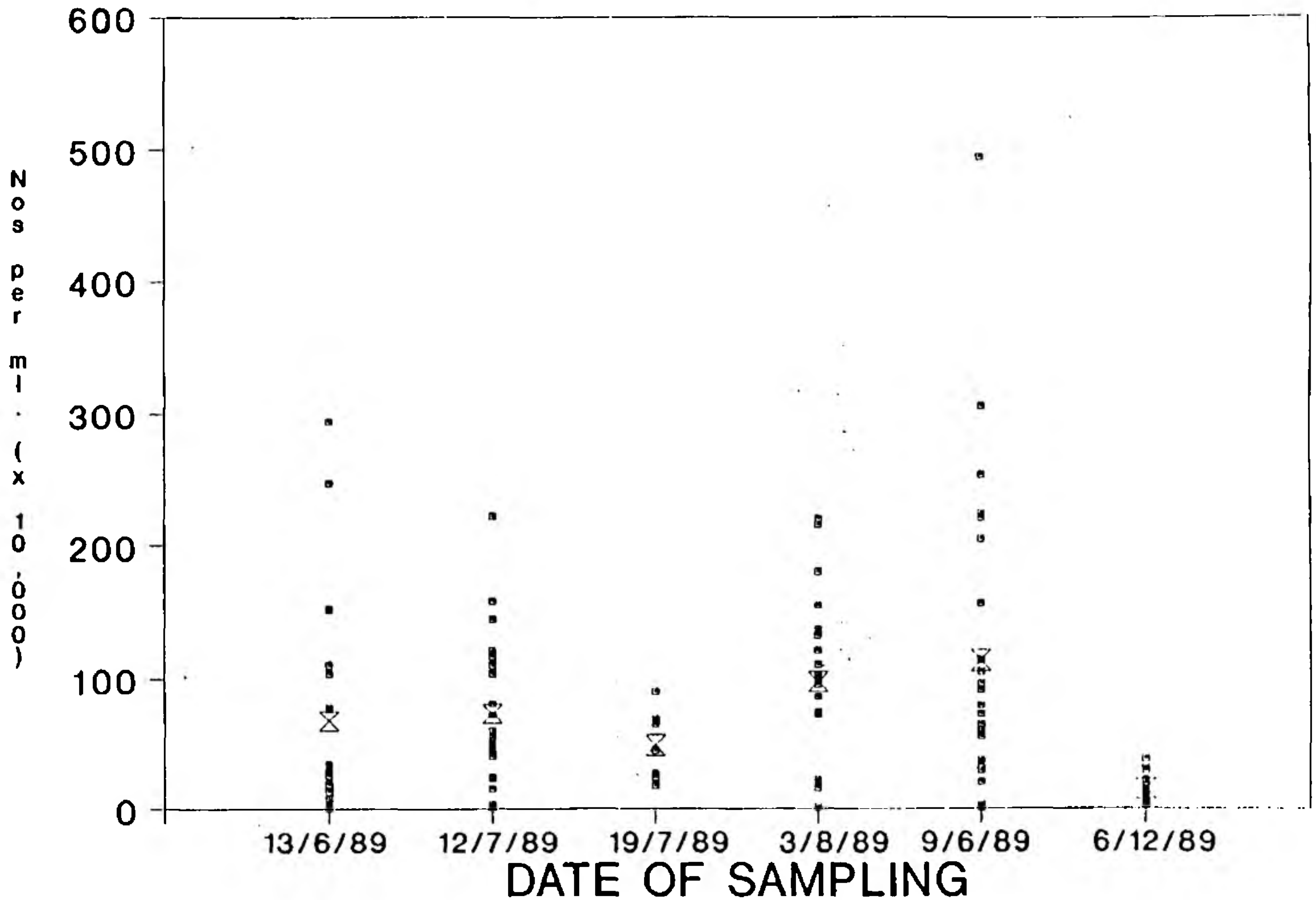


FIG.51

DRY-WEATHER BACTERIAL CONCENTRATIONS.
FAECAL STREPS.

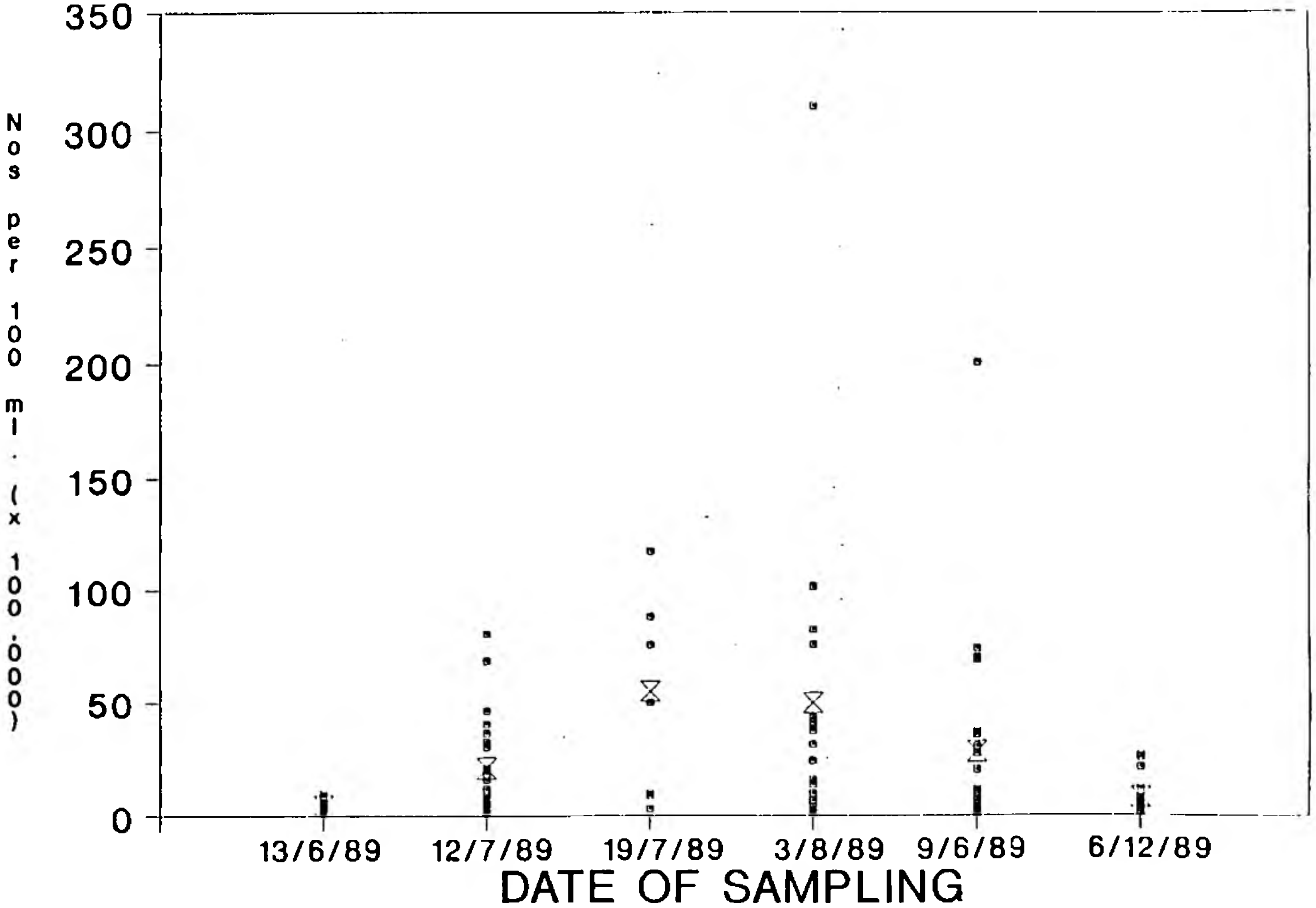
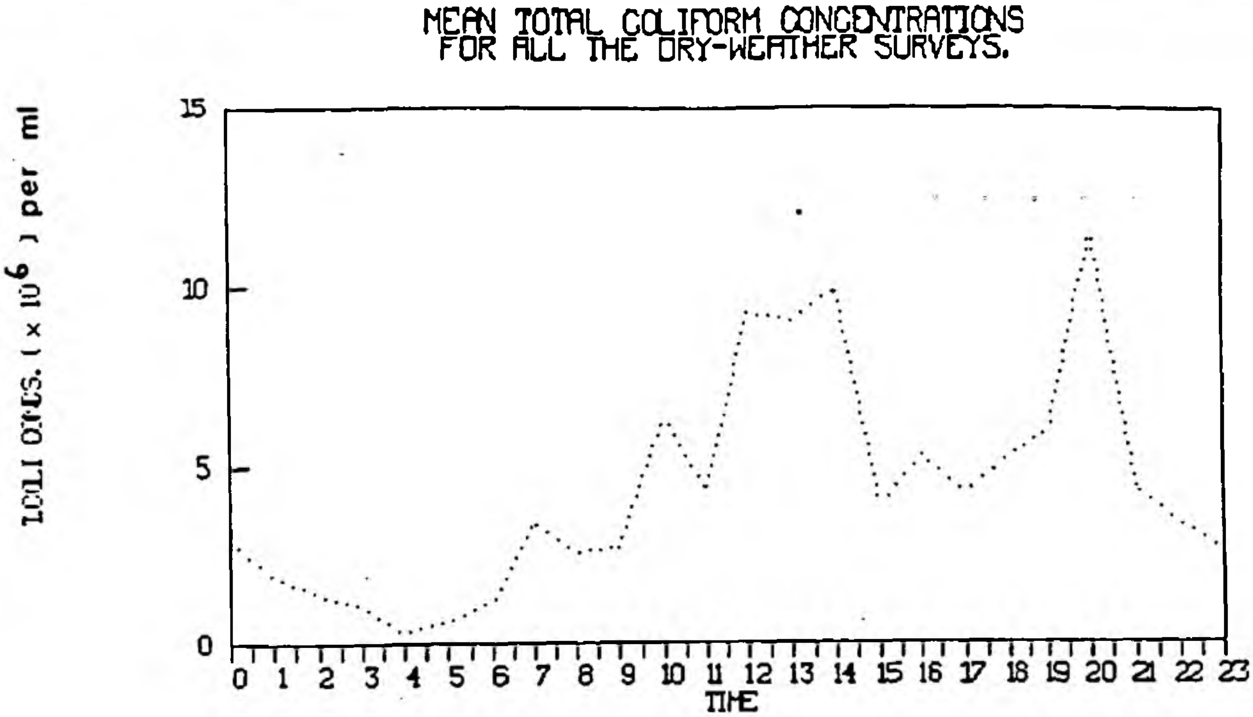
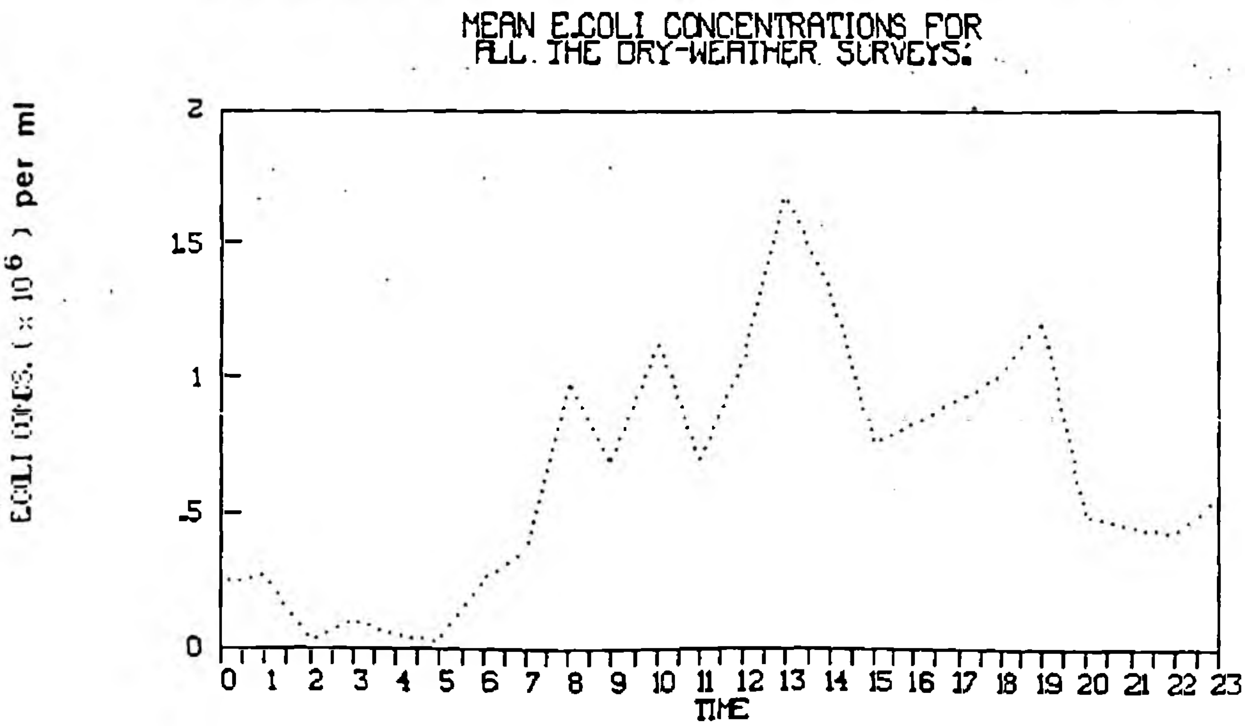


FIG.52

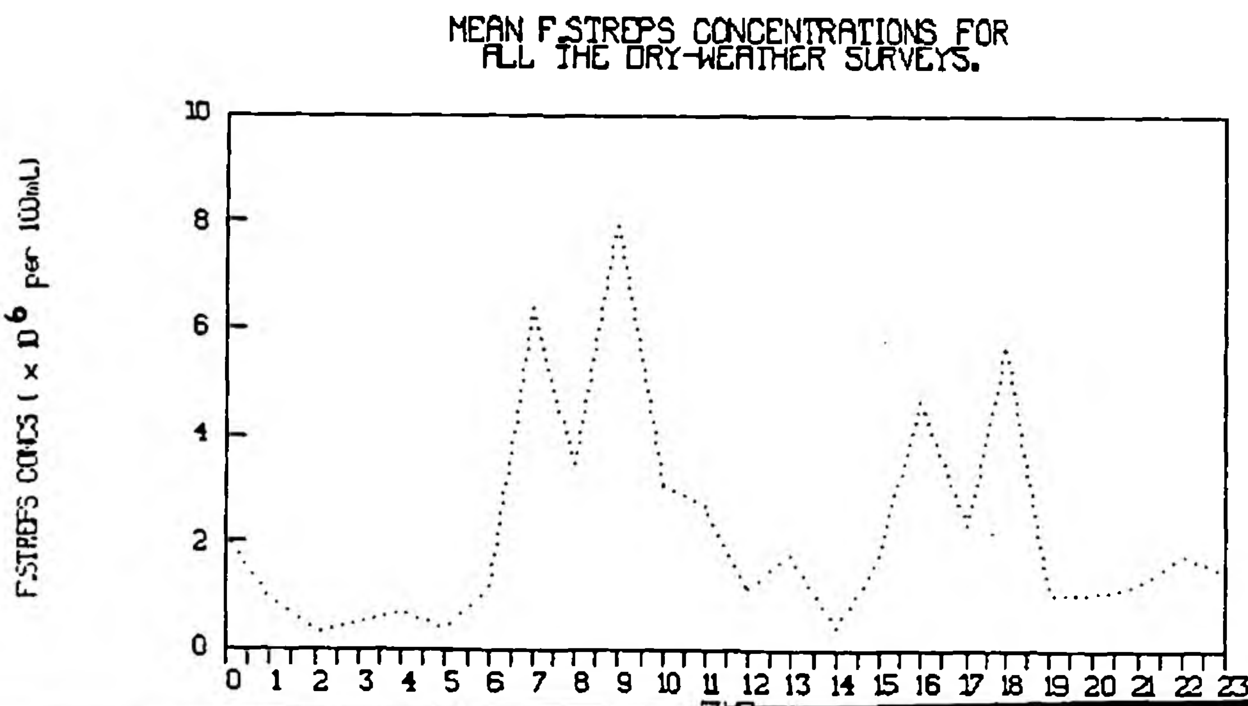
FIG. 53



MEAN TOTAL COLIFORM CONCENTRATIONS FOR ALL THE DRY-WEATHER SURVEYS.
TCOLI CONCS. (x 10^6) per ml
0
5
10
15
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
TIME

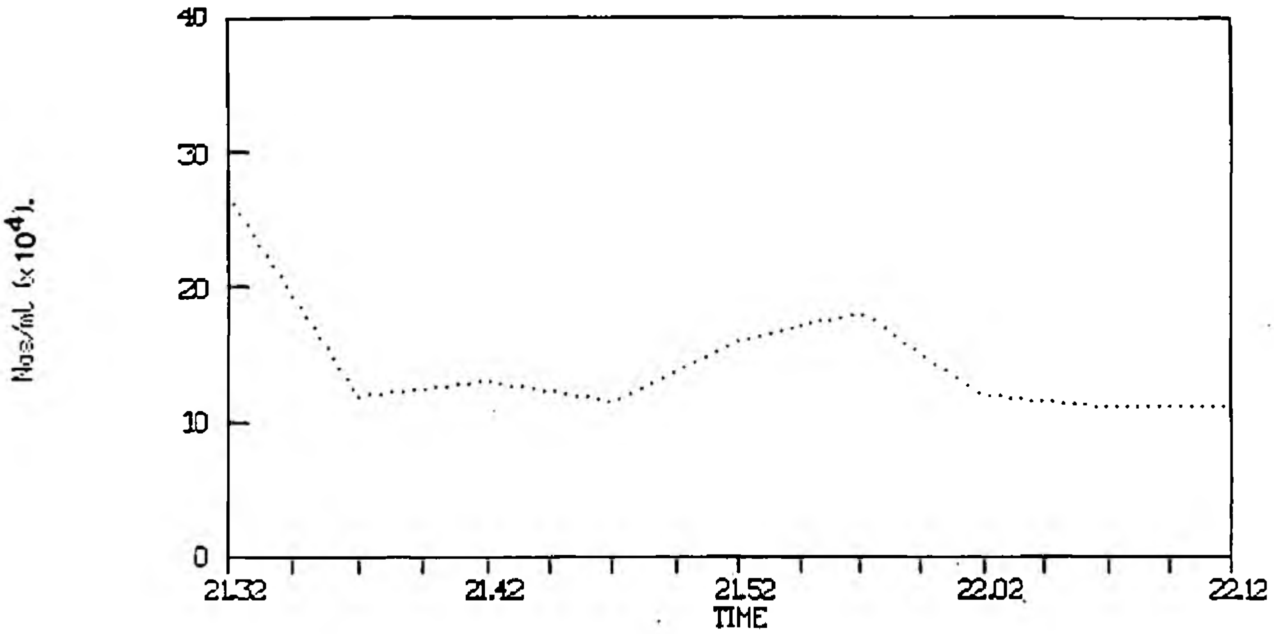


MEAN E.COLI CONCENTRATIONS FOR ALL THE DRY-WEATHER SURVEYS.
ECOLI CONCS. (x 10^6) per ml
0
.5
1
1.5
2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
TIME

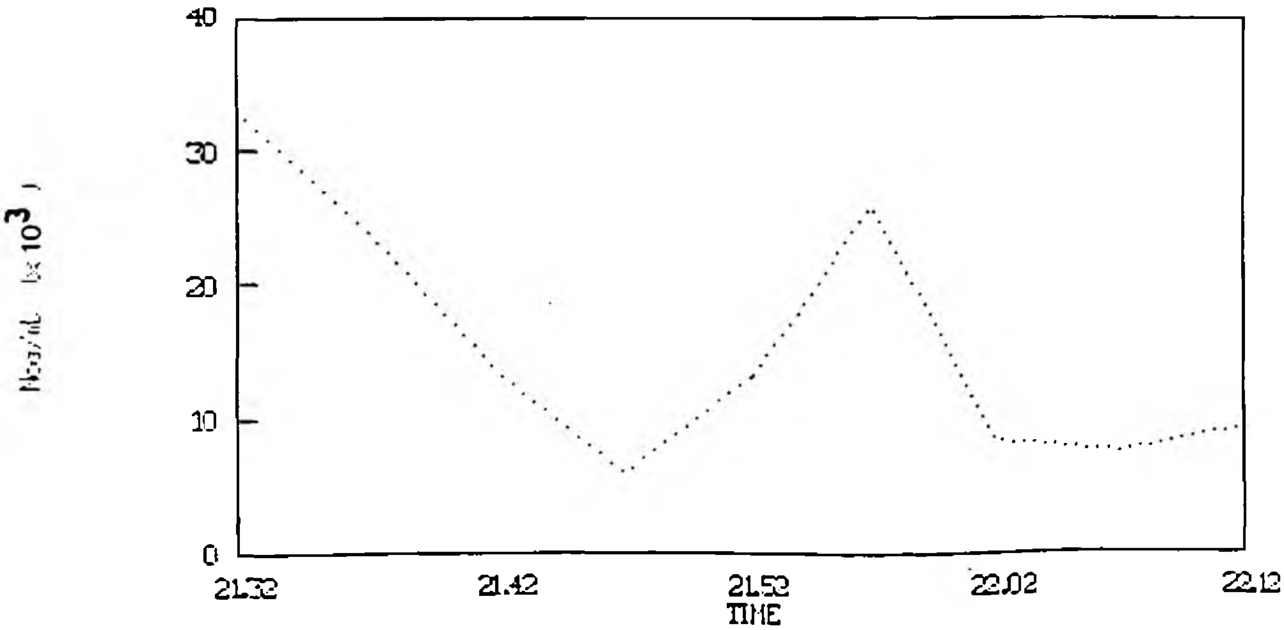


MEAN F.STREPS CONCENTRATIONS FOR ALL THE DRY-WEATHER SURVEYS.
F.STREPS CONCS (x 10^6 per 100mL)
0
2
4
6
8
10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

TOTAL COLIFORM CONCENTRATIONS IN THE SEWER
DURING EVENT 19, 14-08-89.



E.COLI CONCENTRATIONS IN THE SEWER
DURING EVENT 19, 14-08-89.



FAECAL STREPS. CONCENTRATIONS IN THE SEWER
DURING EVENT 19, 14-08-89.

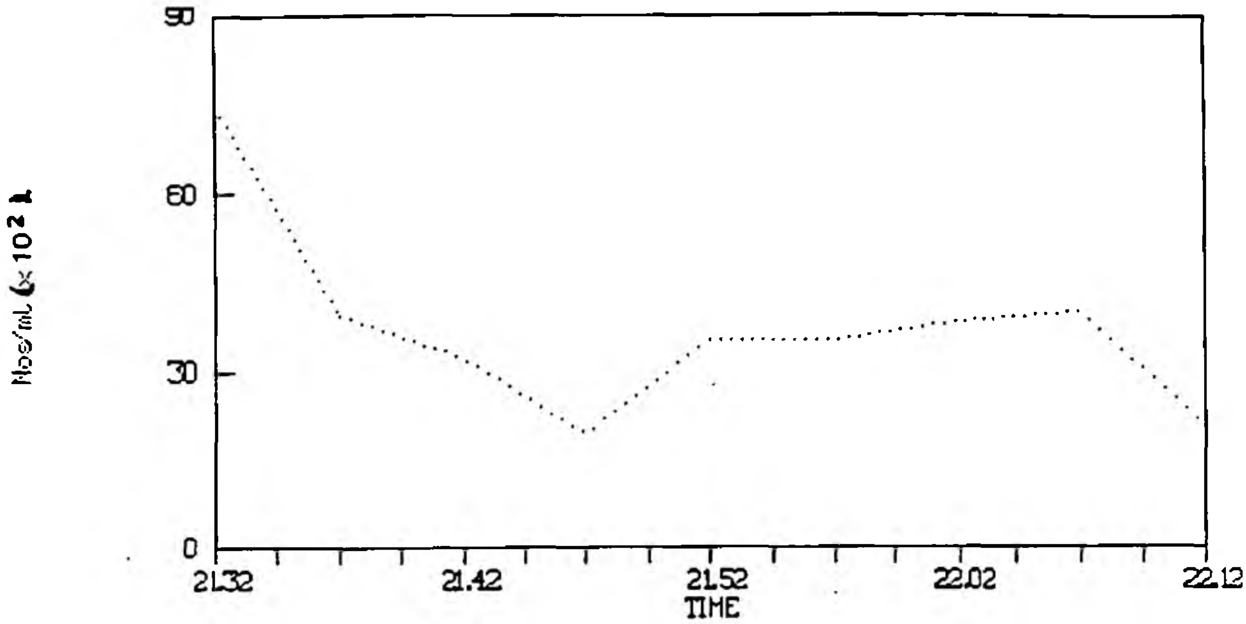
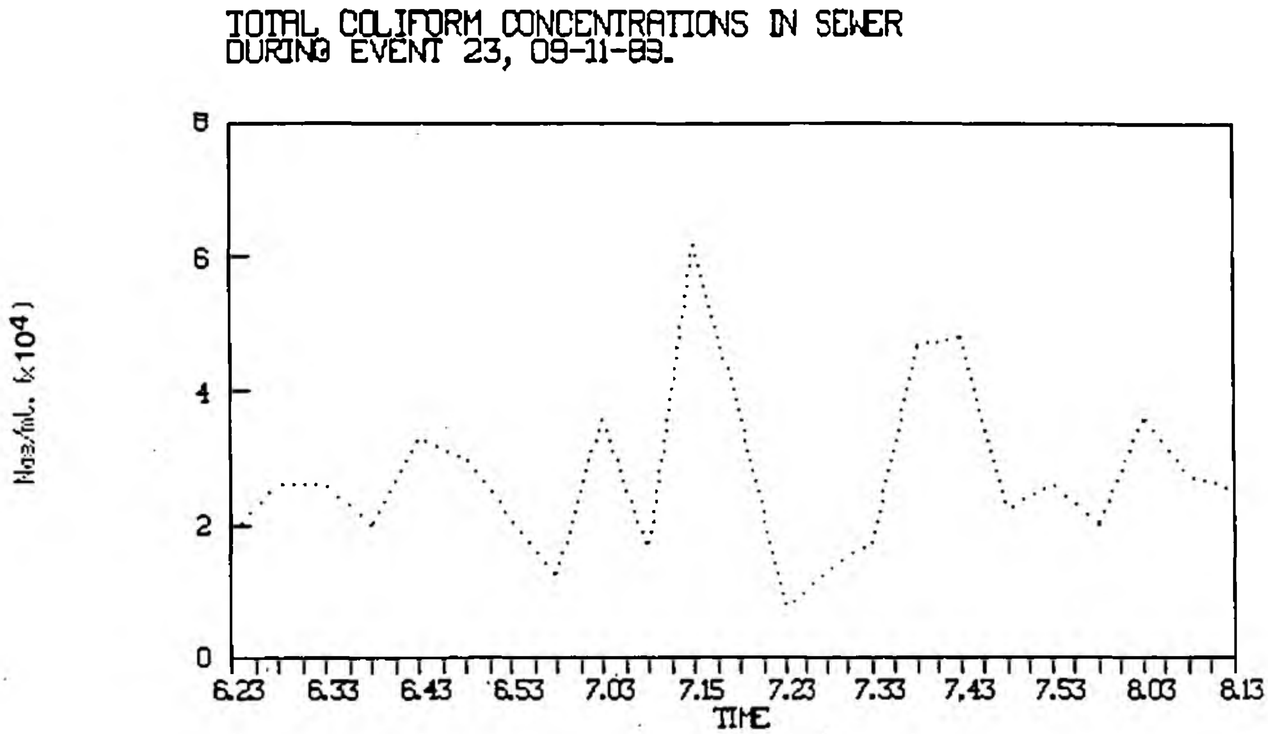
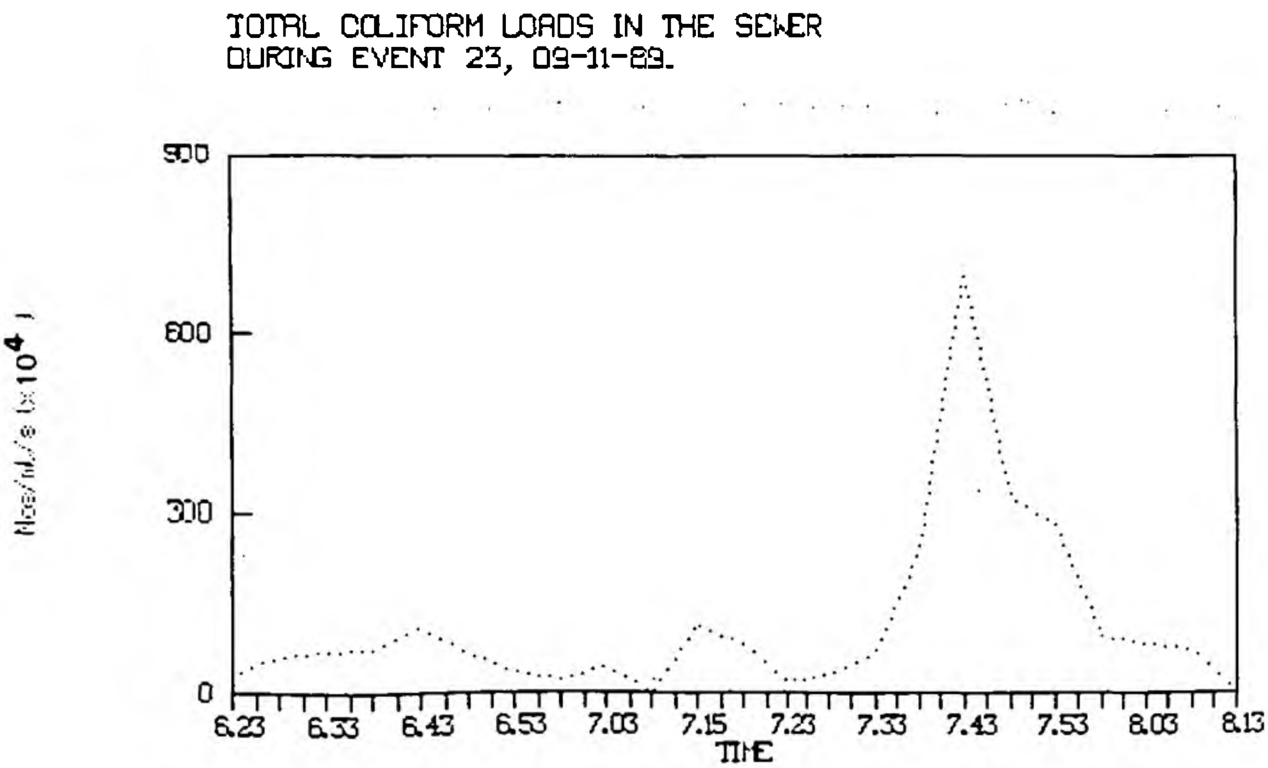
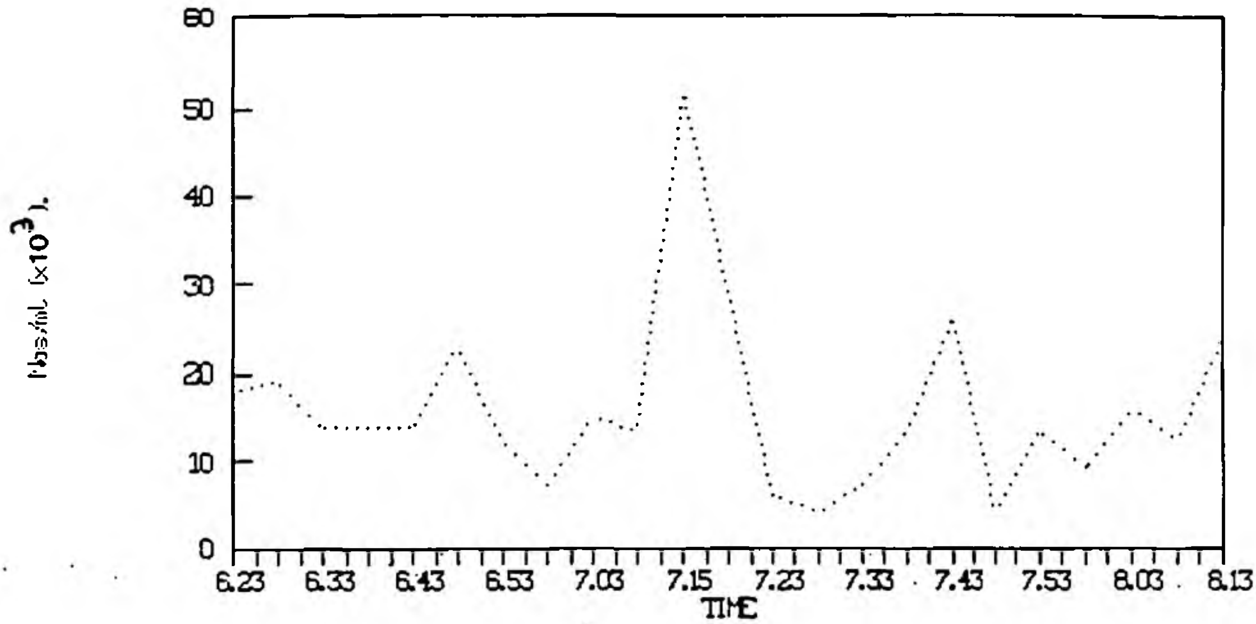


FIG. 56

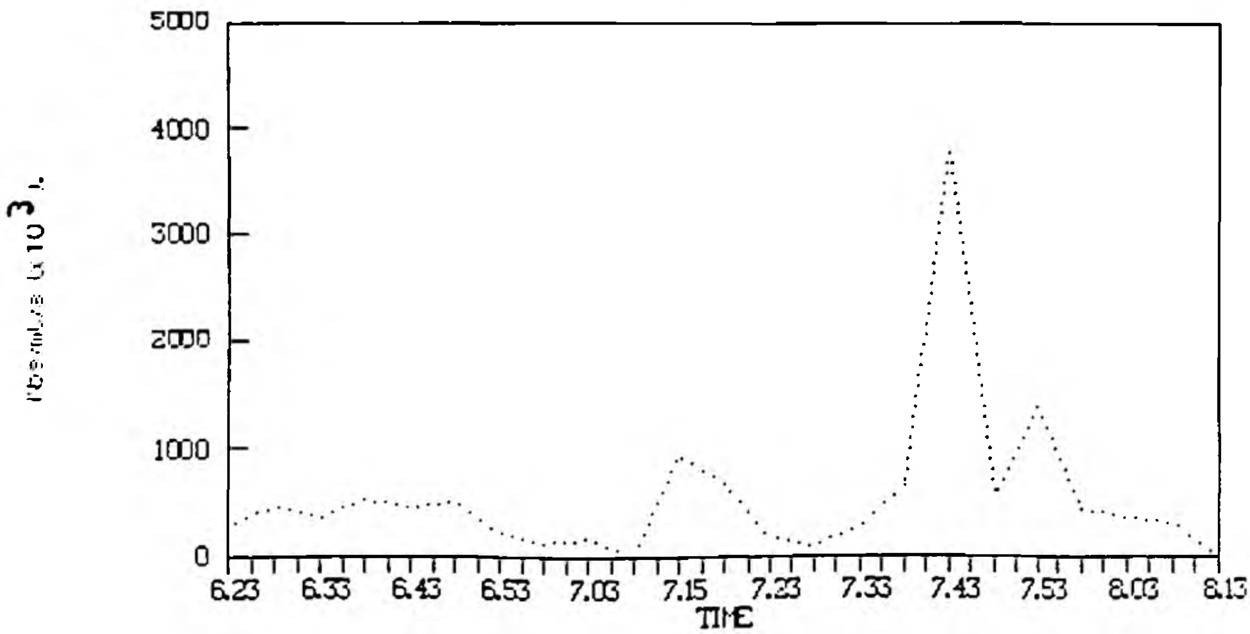

TOTAL COLIFORM CONCENTRATIONS IN SEWER
DURING EVENT 23, 09-11-89.
Nos/mL. (x10⁴)
8
6
4
2
0
6.23
6.33
6.43
6.53
7.03
7.15
7.23
7.33
7.43
7.53
8.03
8.13
TIME


TOTAL COLIFORM LOADS IN THE SEWER
DURING EVENT 23, 09-11-89.
Nos/mL/s (x10⁴)
900
600
300
0
6.23
6.33
6.43
6.53
7.03
7.15
7.23
7.33
7.43
7.53
8.03
8.13
TIME

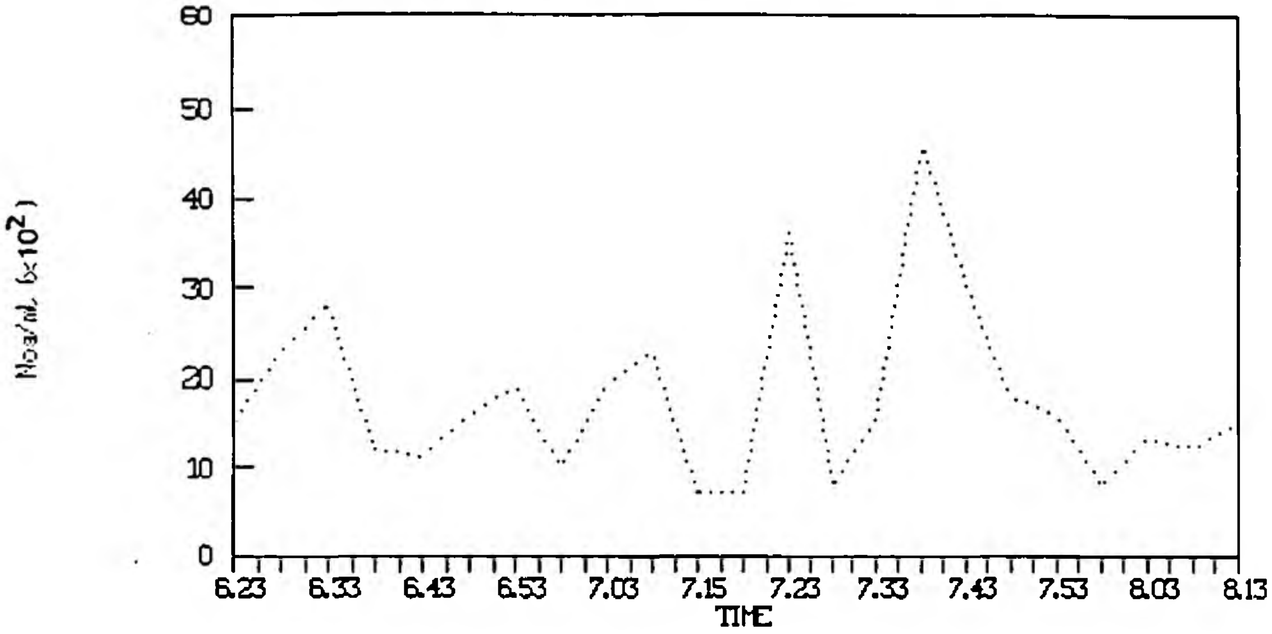
E.COLI CONCENTRATIONS IN THE SEWER DURING
EVENT 23 , 09-11-89.



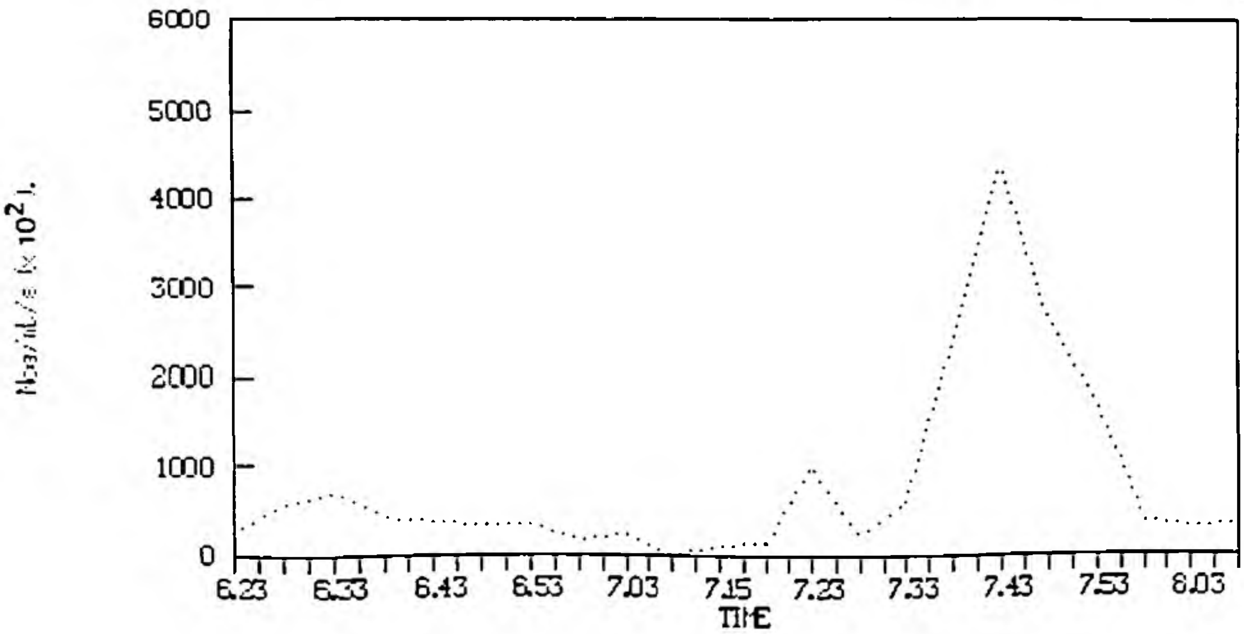
E.COLI LOADS IN THE SEWER DURING
EVENT 23, 09-11-89.



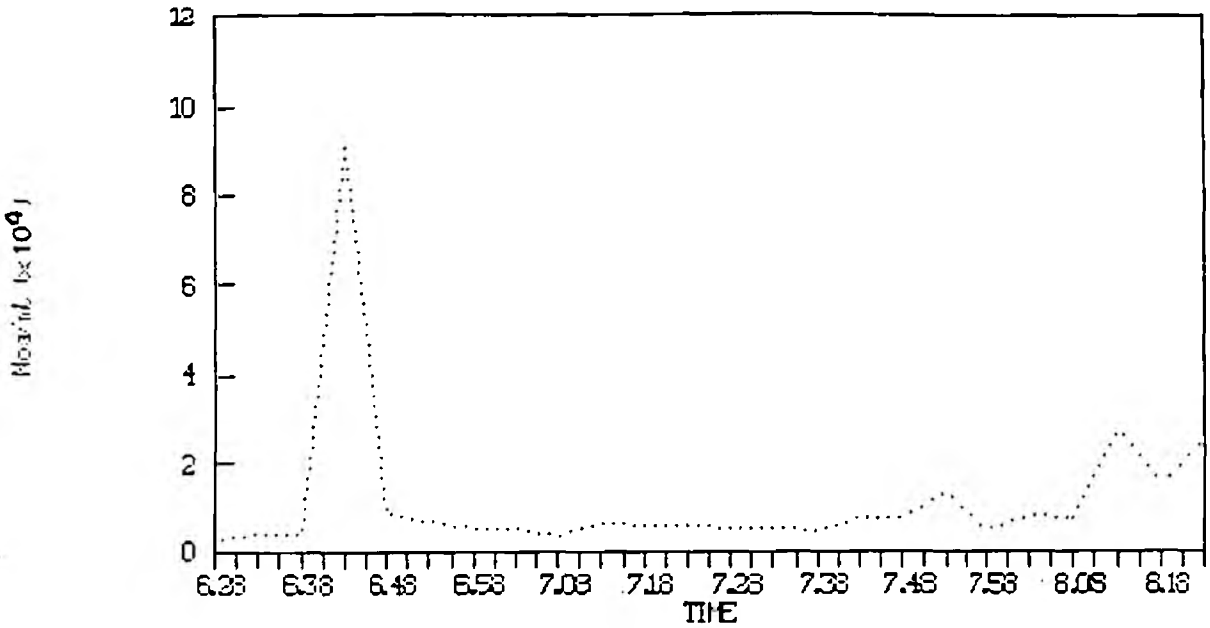
FAECAL STREPS. CONCENTRATIONS IN THE SEWER
DURING EVENT 23, 09-11-89.



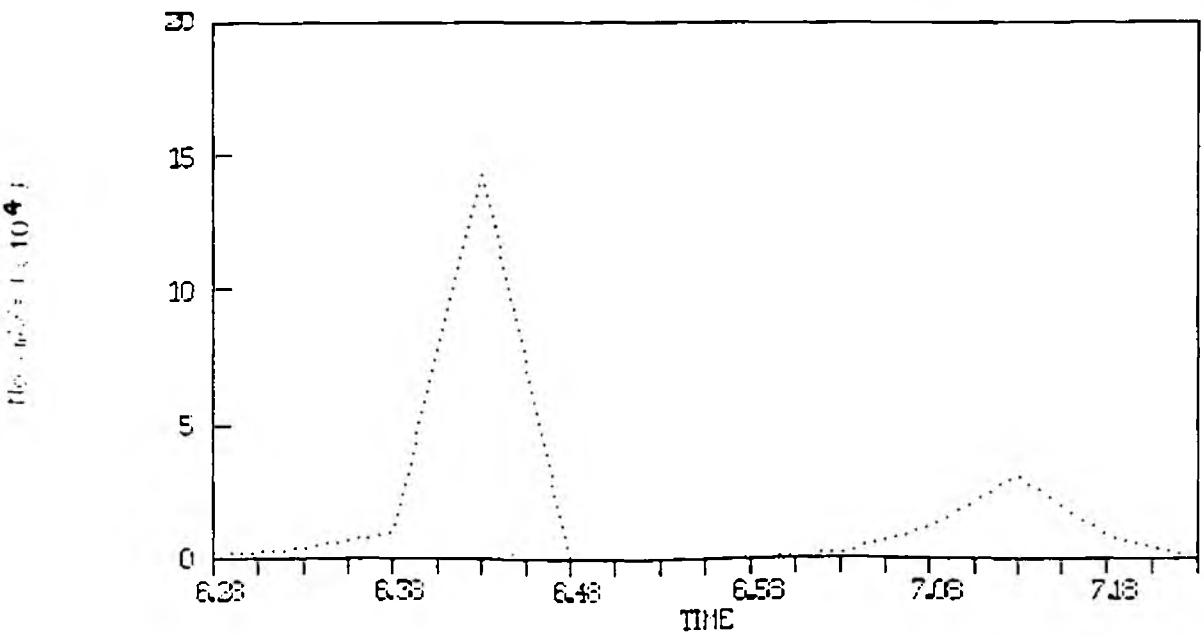
FAECAL STREPS. LOADS IN THE SEWER
DURING EVENT 23, 09-11-89.



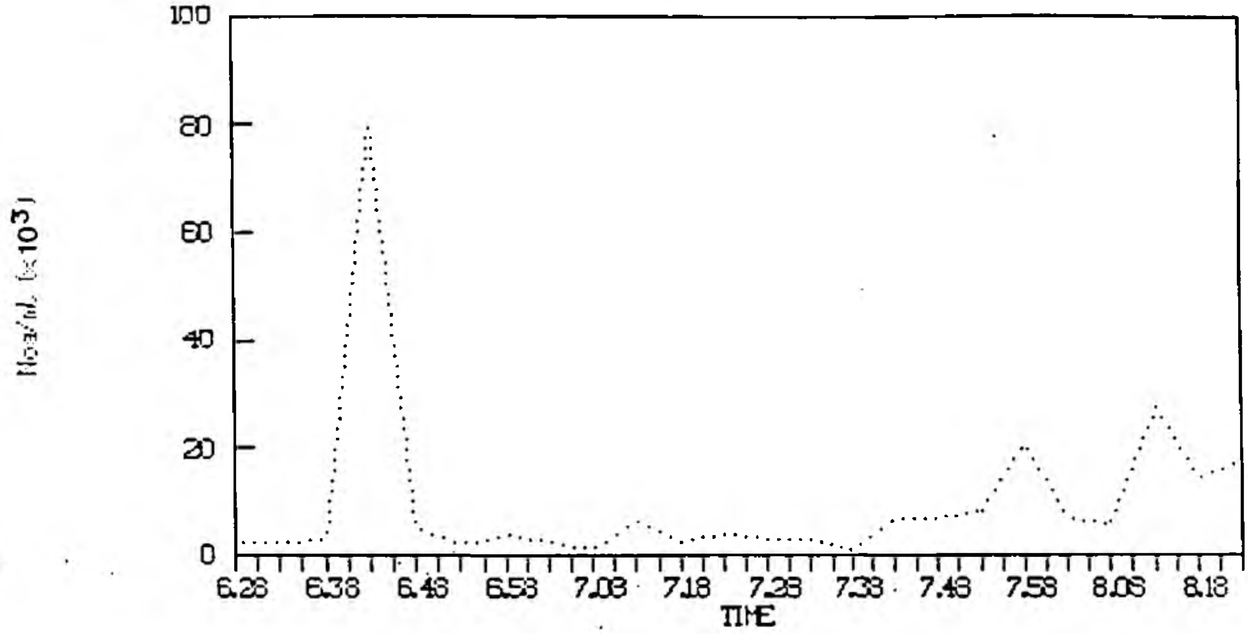
TOTAL COLIFORM CONCENTRATIONS IN THE SEWER DURING EVENT 25, 13-12-89.



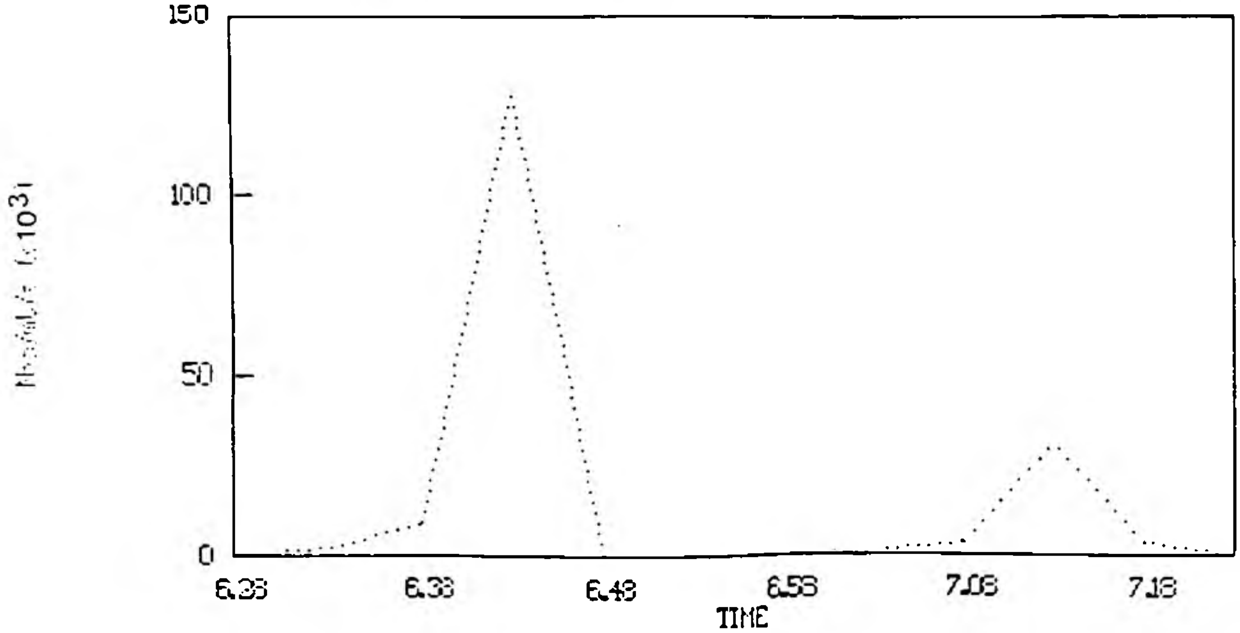
TOTAL COLIFORM LOADS IN THE SEWER DURING EVENT 25, 13-12-89..



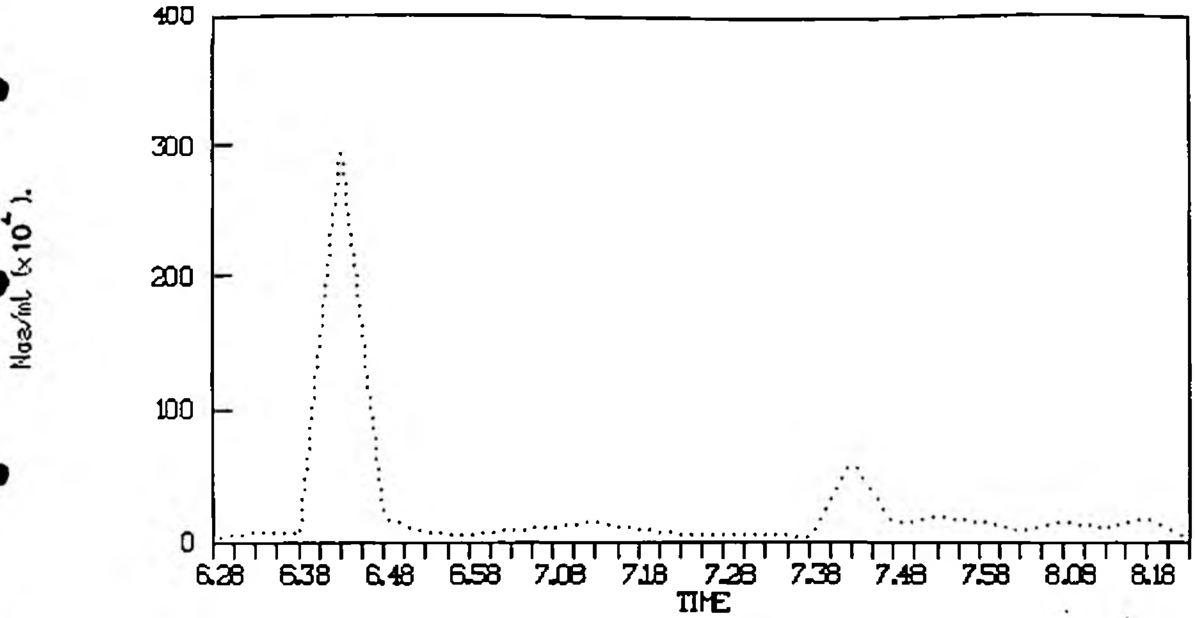
E.COLI CONCENTRATIONS IN THE SEWER
DURING EVENT 25, 13-12-88.



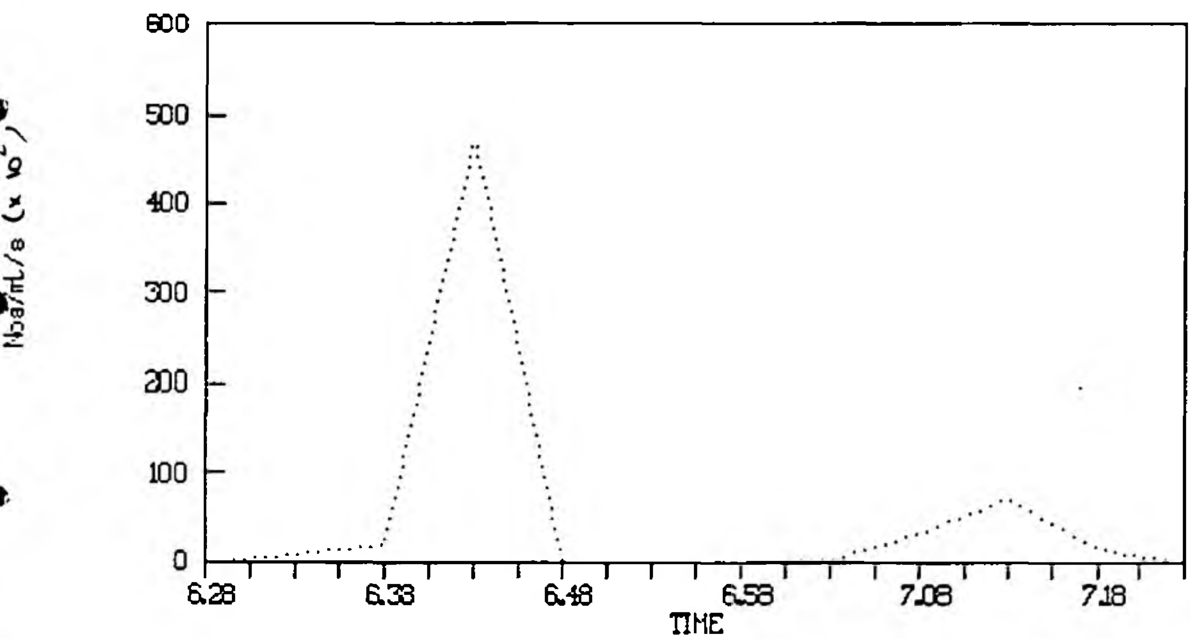
E.COLI LOADS IN THE SEWER DURING
EVENT 25, 13-12-88.



FAECAL STREPS. CONCENTRATIONS IN THE SEWER
DURING EVENT 25, 13-12-89

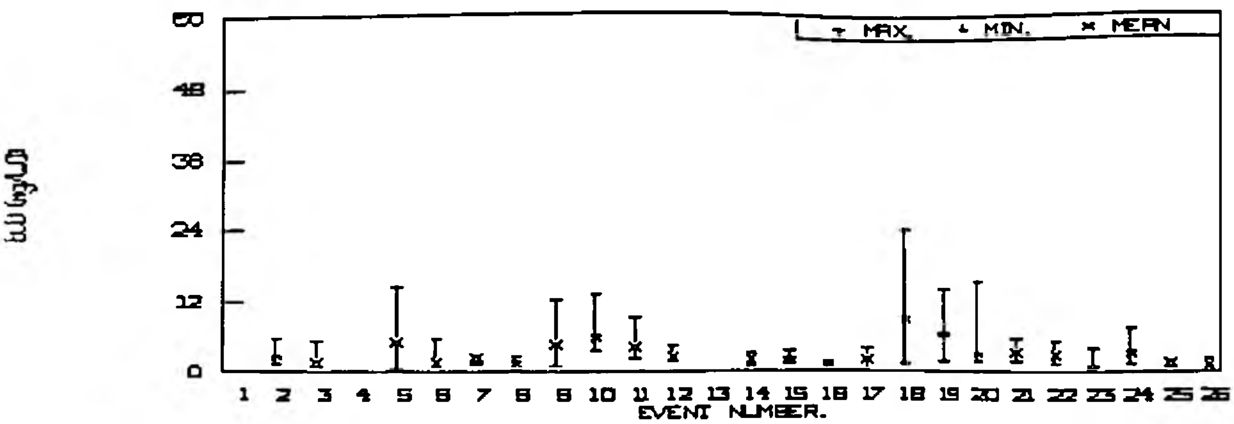


FAECAL STREPS. LOADS IN THE SEWER
DURING EVENT 25, 13-12-89.

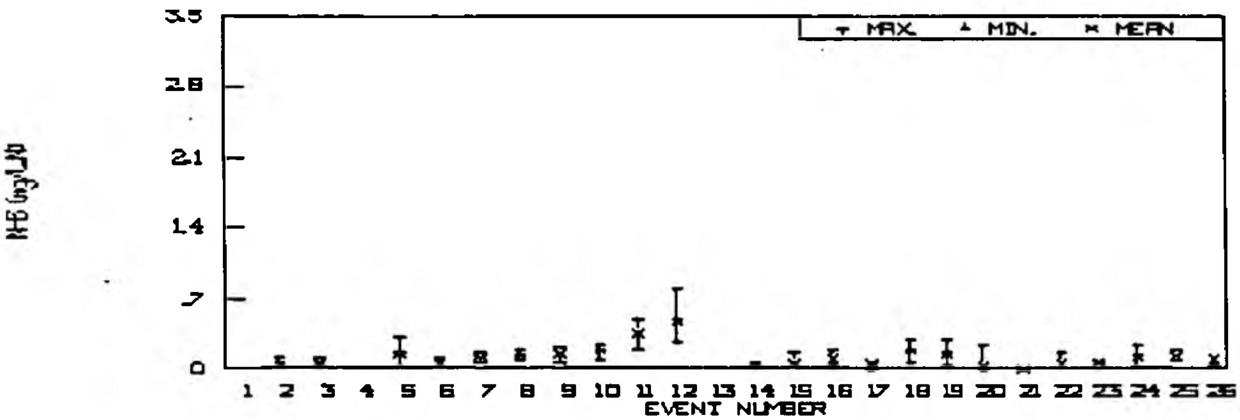


SUMMARY GRAPHS FOR UPSTREAM.

BOD CONCENTRATIONS (mg/L.O)



NH3 CONCENTRATIONS (mg/L).



SUSPENDED SOLIDS CONCENTRATIONS (mg/L)

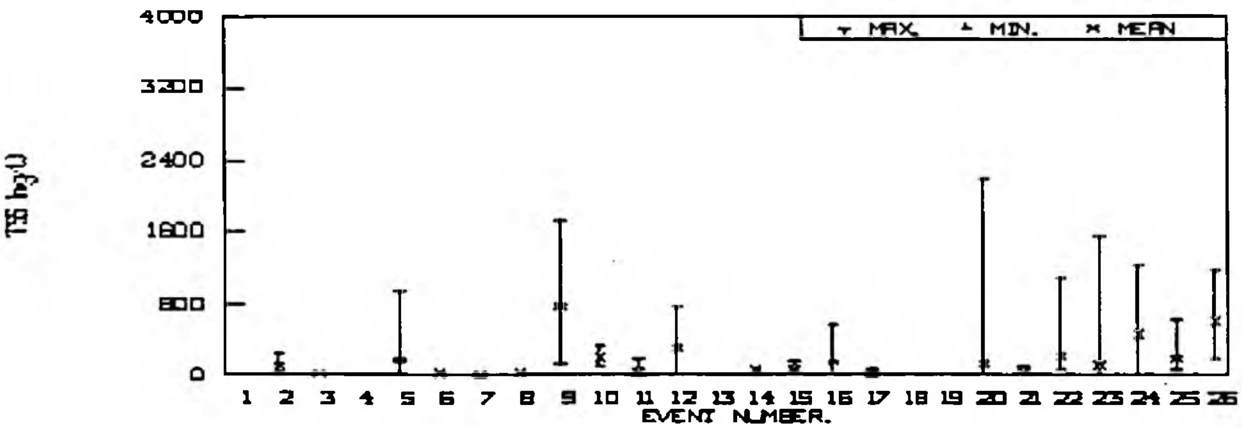
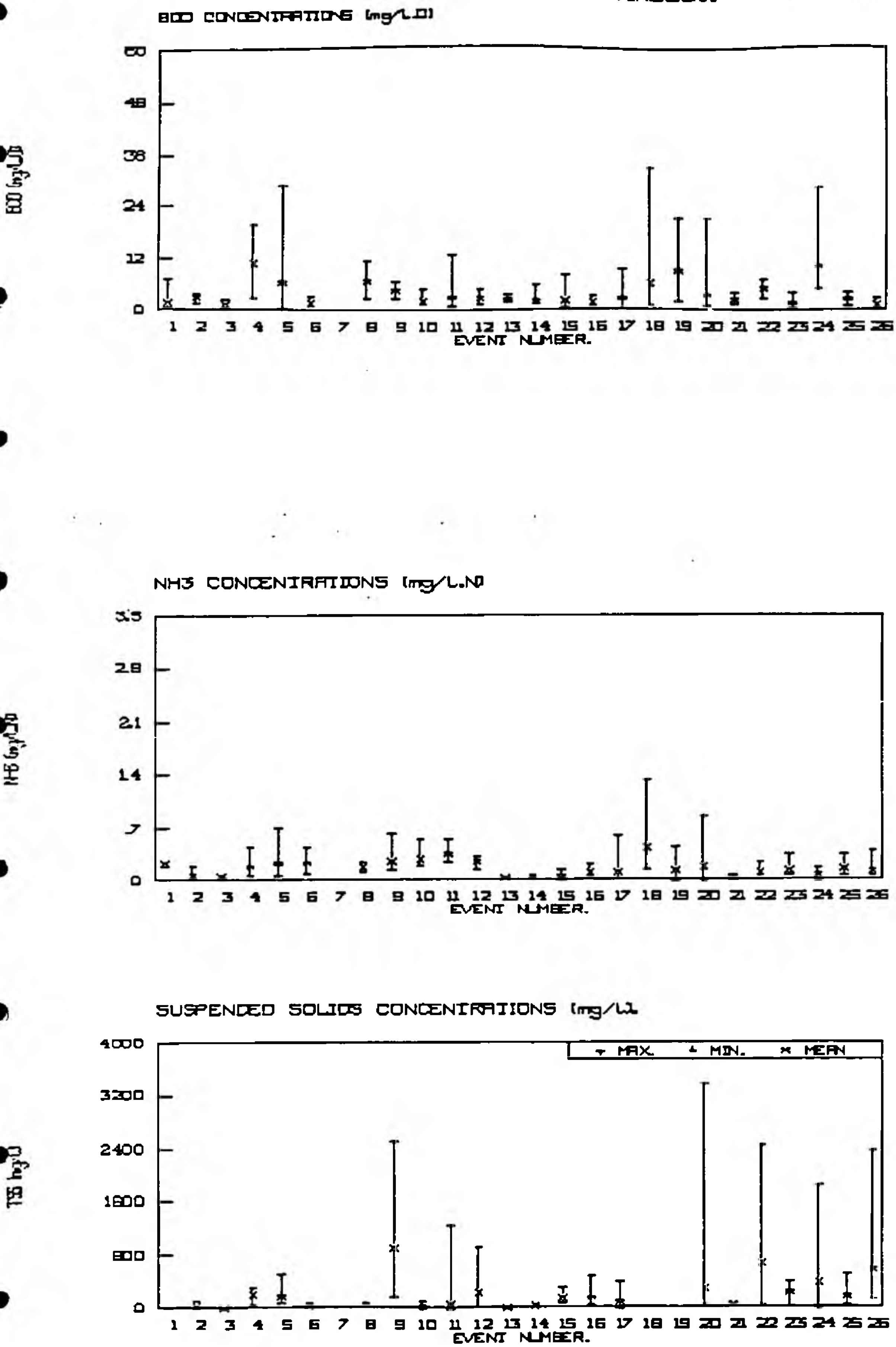
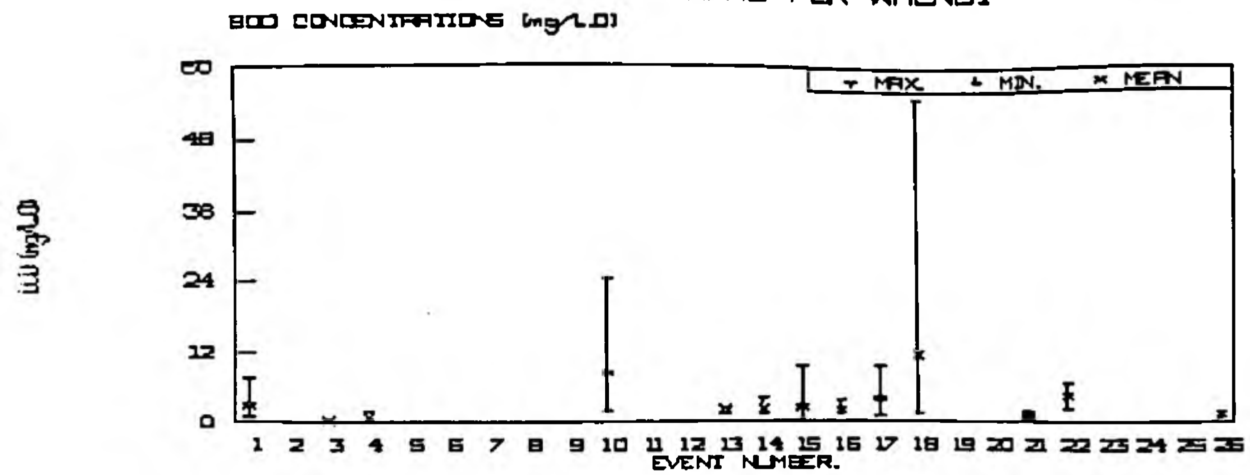


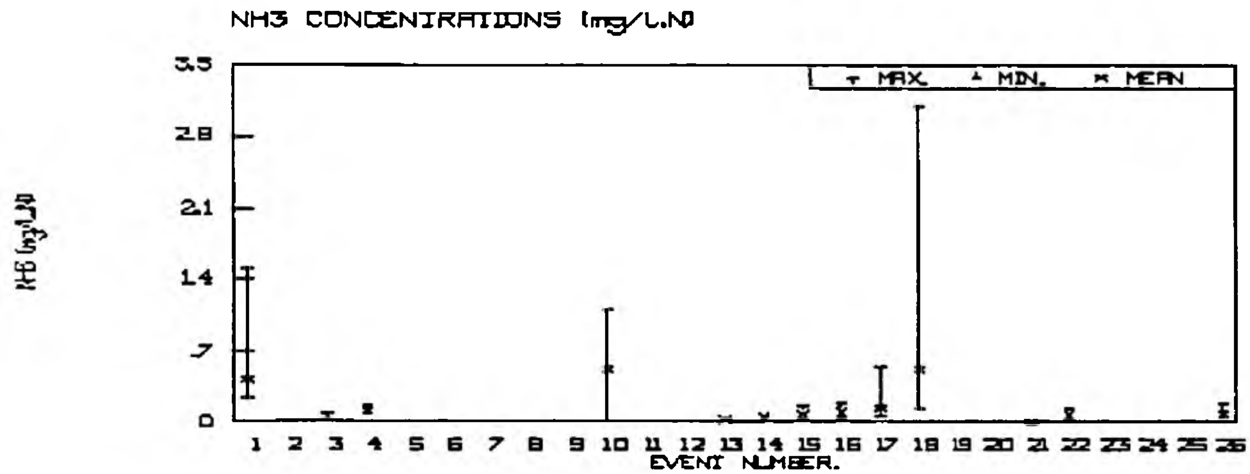
FIG. 63

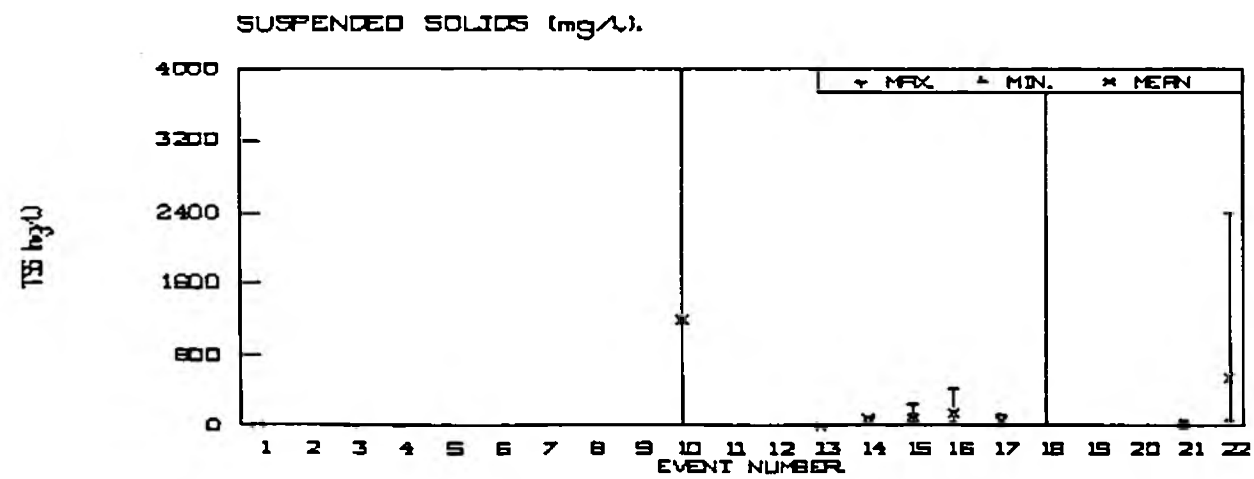
SUMMARY GRAPHS FOR VIADUCT.



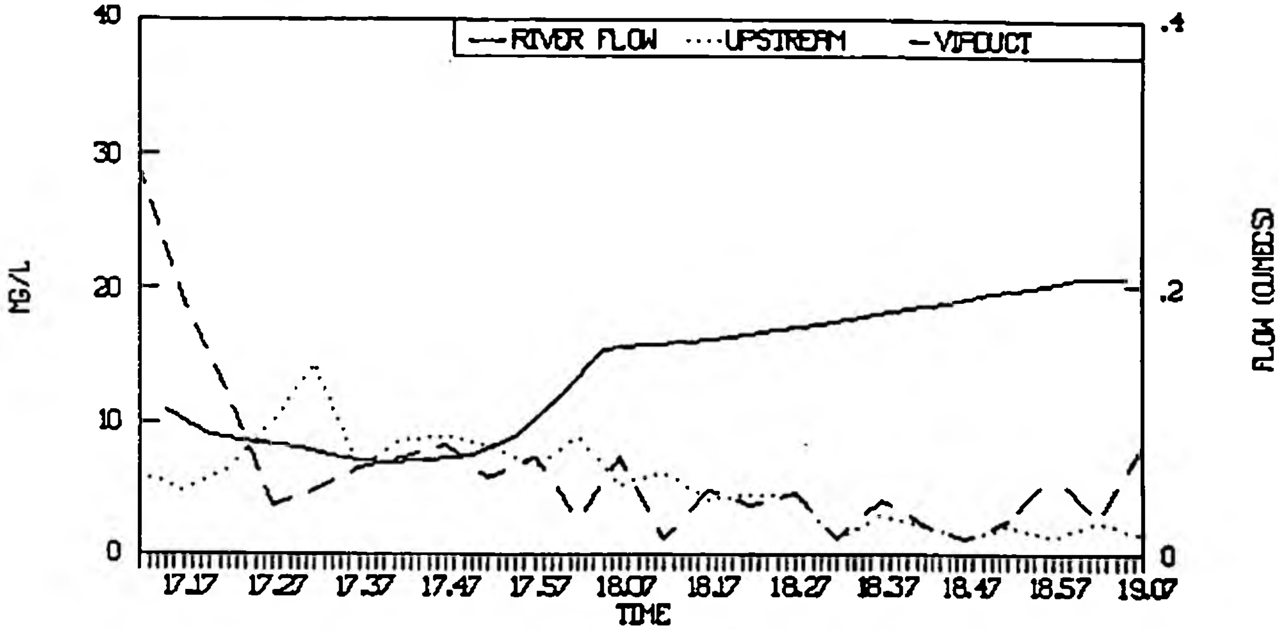
SUMMARY GRAPHS FOR WALNUT



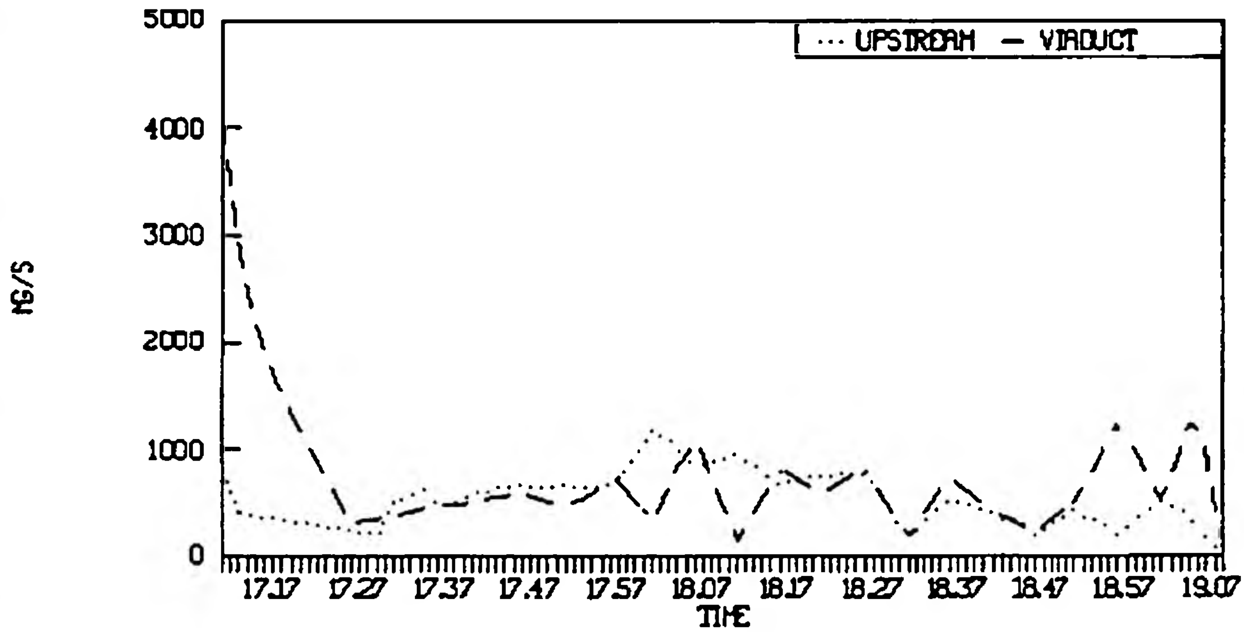




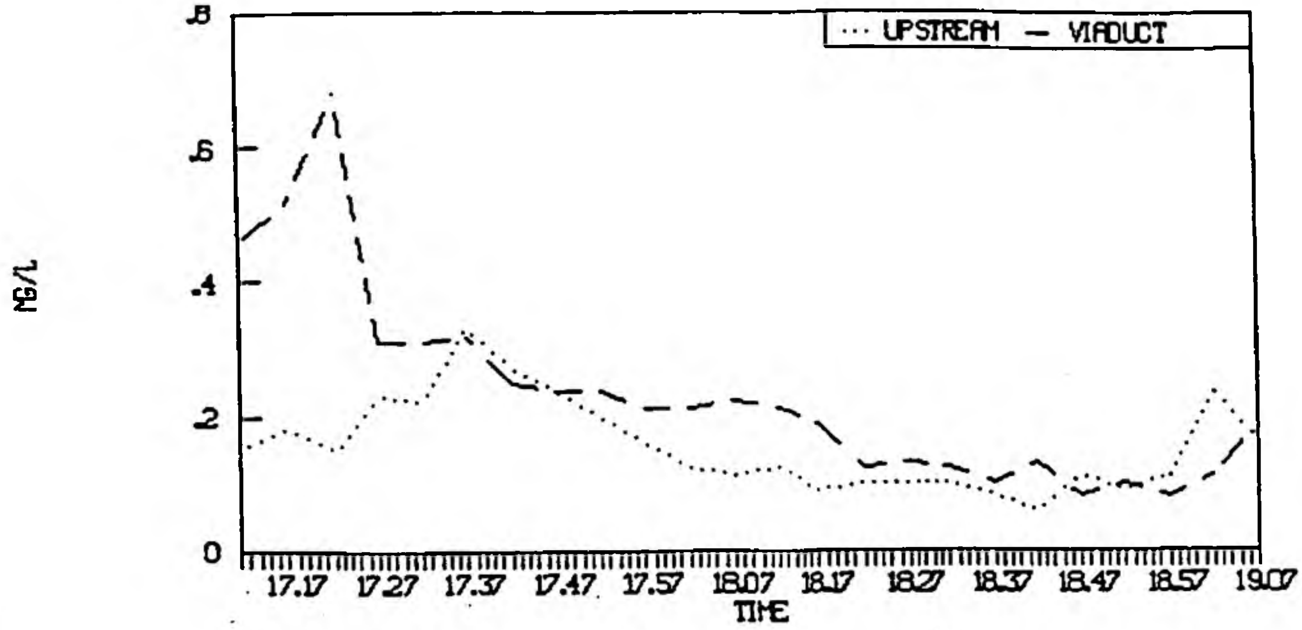
GARNDIFFAITH SSO EVENT 5 28-05-88
BOD CONCENTRATIONS



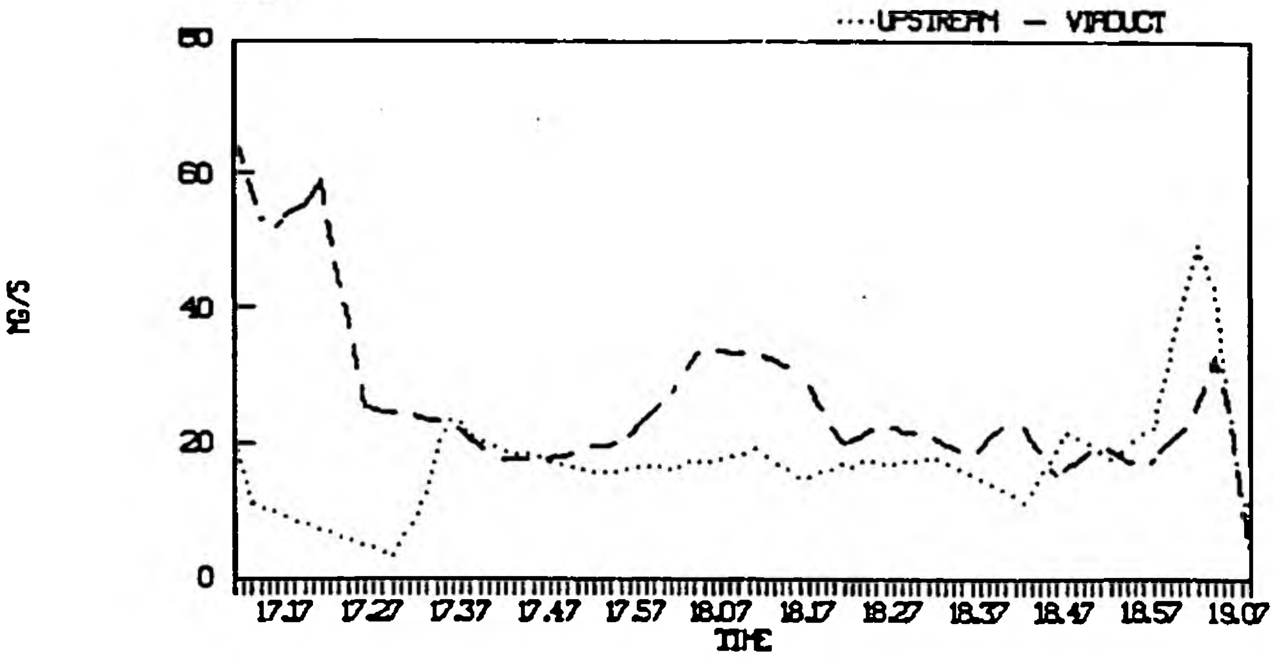
GARNDIFFAITH SSO EVENT 5 28-05-88
BOD LOADS



GARNDIFFAITH SSO EVENT 5 28-05-88
NH3 CONCENTRATIONS

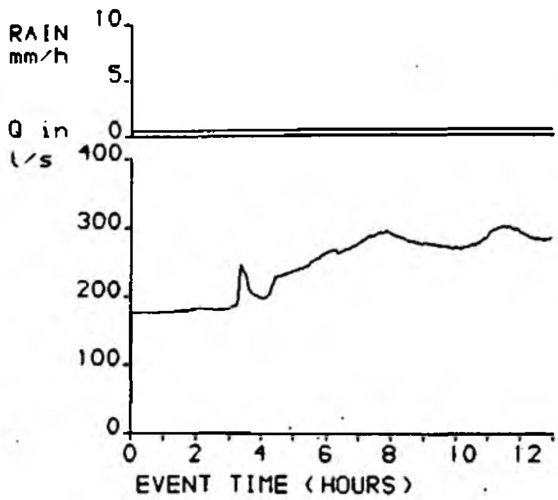


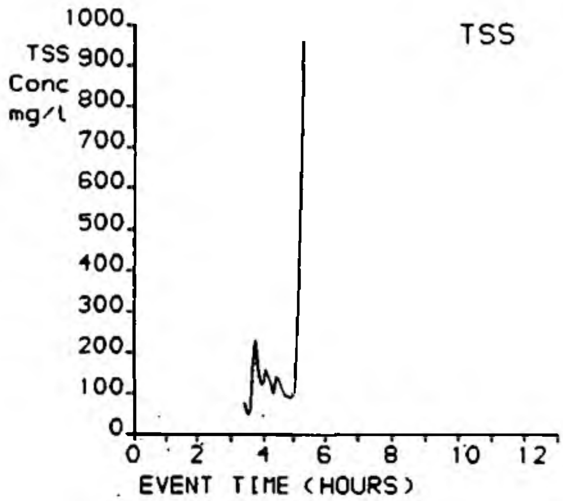
GARNDIFFAITH SSO EVENT 5 28-05-88
NH3 LOADS



Site: NANT FFRWD, U/S SSO GARNDIFFAITH GN880528U1.DAT

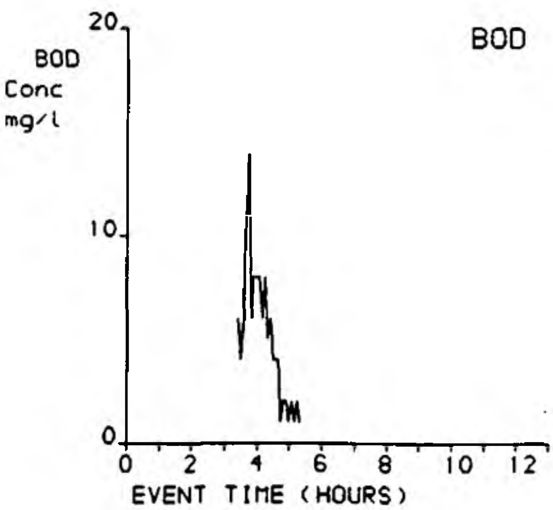
Grid Ref: 262045
Storm Date: 880528
Start Time (R/F): 1338
Rainfall Depth (mm): 30.8
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 773.

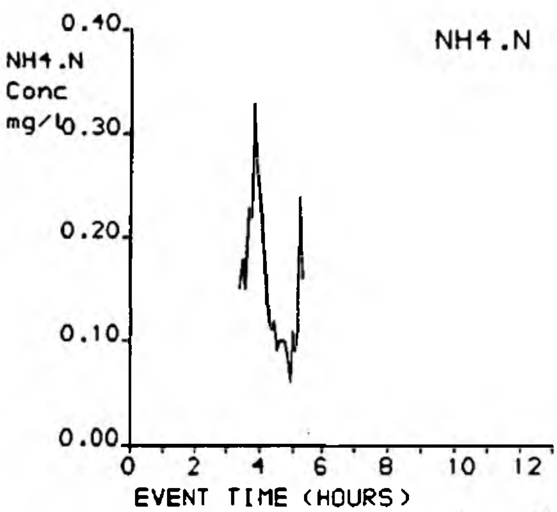




NO DATA FOR COD

NO DATA FOR TDS

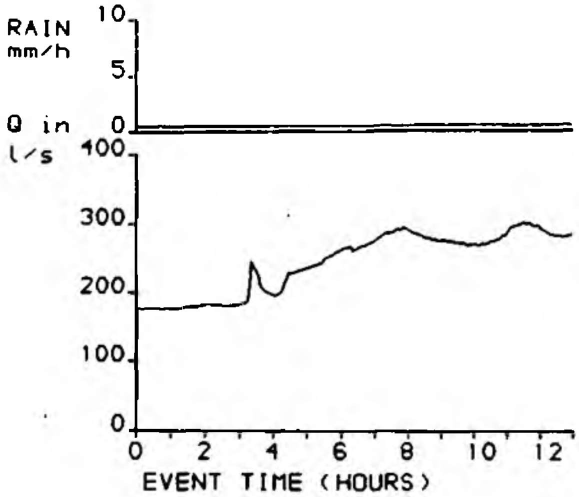




Site: NANT FFRWD,U/S SSO GARNDIFFAITH GN880528U1.DAT

Grid Ref: 262045
Storm Date: 880528
Start Time (R/F): 1338
Rainfall Depth (mm): 30.8

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 773.



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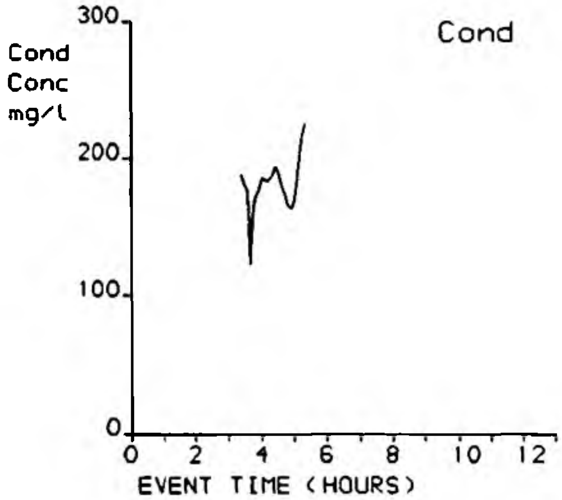


NO DATA FOR TEMP

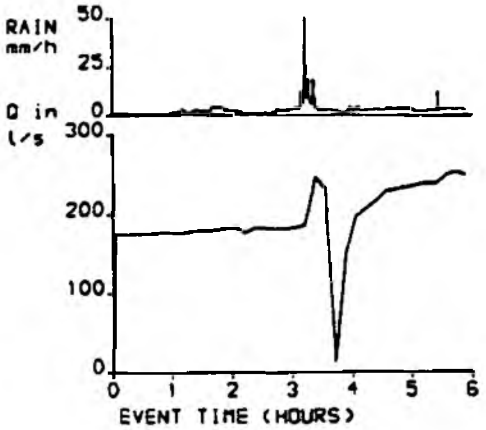
NO DATA FOR

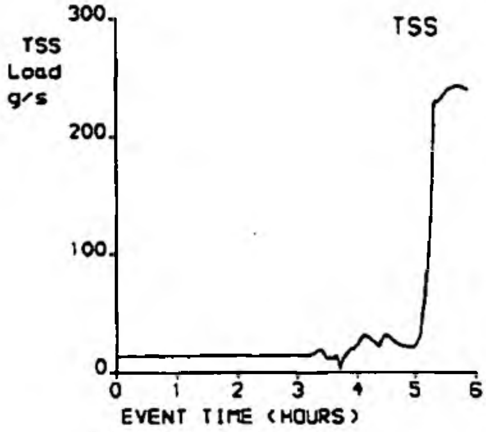
FIG. 69

Site: NANT FFRWD, U/S SSO, GARNDIFFAITH GN880528U1.DAT

Grid Ref:
Storm Date: 880528
Start Time (R/F): 1337
Rainfall Depth (mm): 31.2

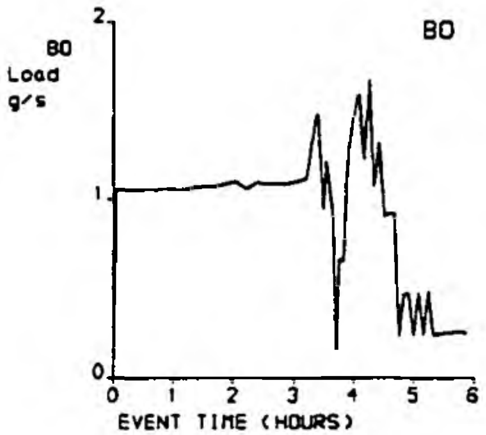
M/H Identification: //////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 3667.

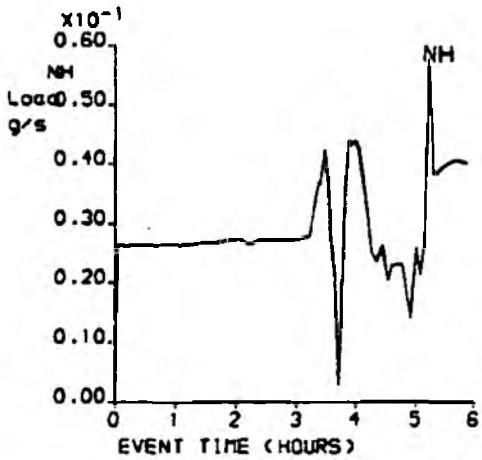




NO DATA FOR CO

NO DATA FOR TDS

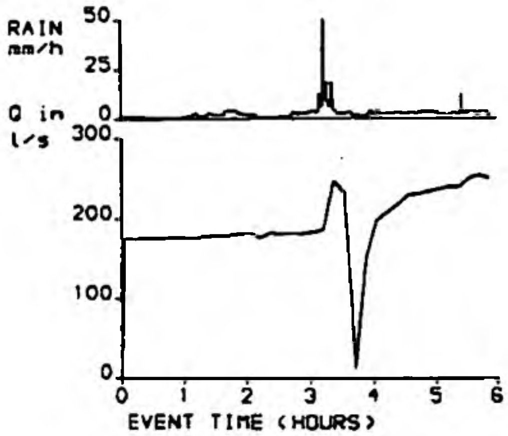


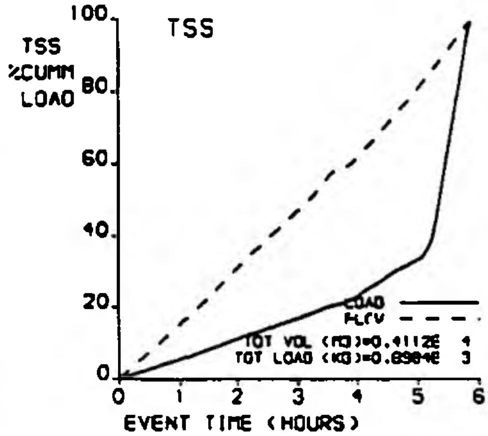


Site: NANT FFRWD, U/S SSO, GARNDIFFAITH GN880528U1.DAT

Grid Ref:
Storm Date: 880528
Start Time (R/F): 1337
Rainfall Depth (mm): 31.2

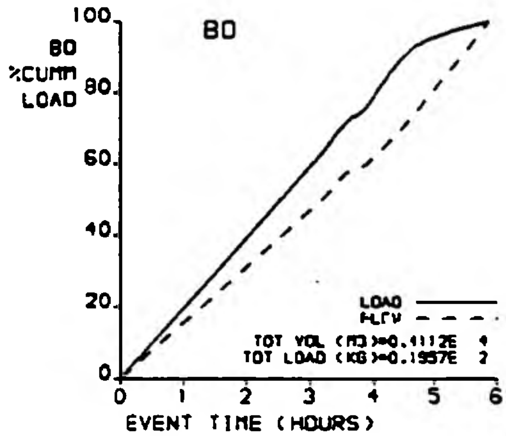
M/H Identification: /////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 3567.

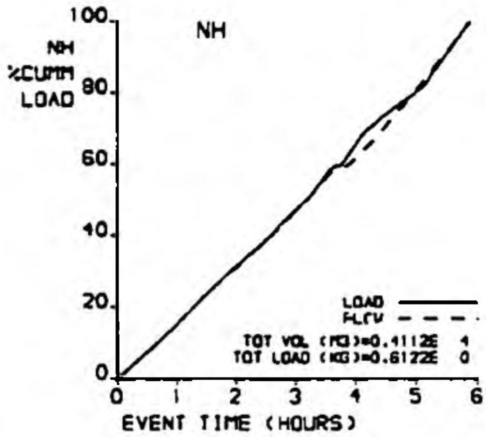




NO DATA FOR CO

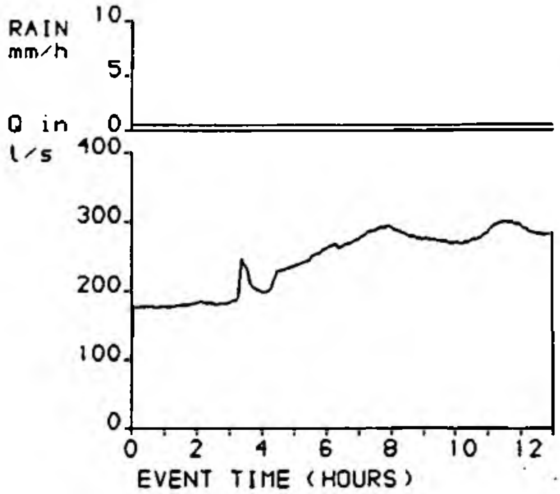
NO DATA FOR TDS

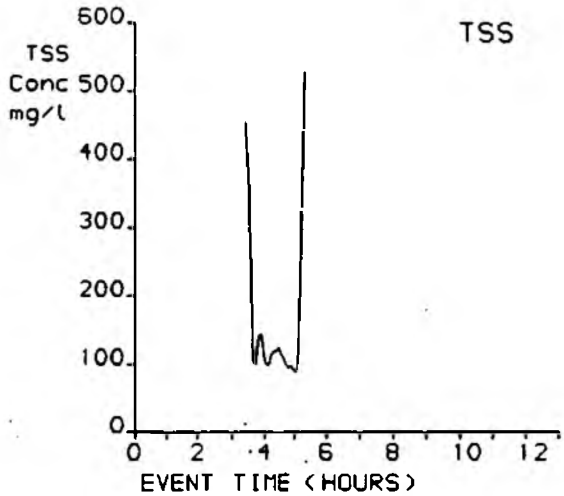




Site: NANT FFRWD, VIADUCT RD, UNDER VIADUCT GN880528D1.DAT

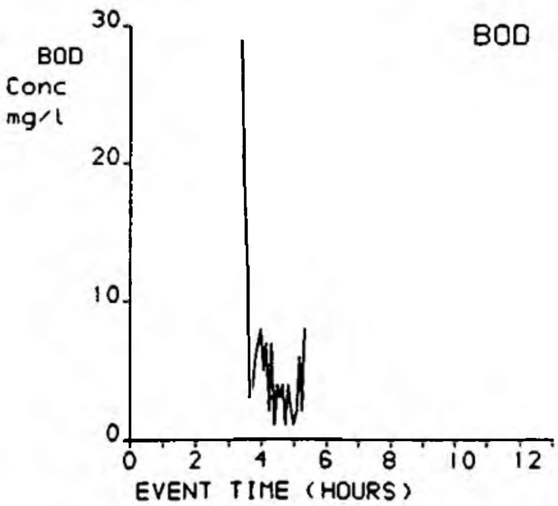
Grid Ref: 262043	Weather Conditions:
Storm Date: 880528	Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1338	Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 30.8	Rainfall Event Duration (mins): 773.

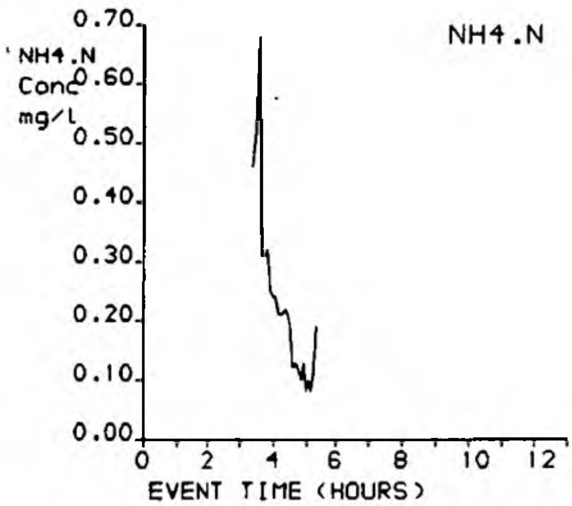




NO DATA FOR COD

NO DATA FOR TDS

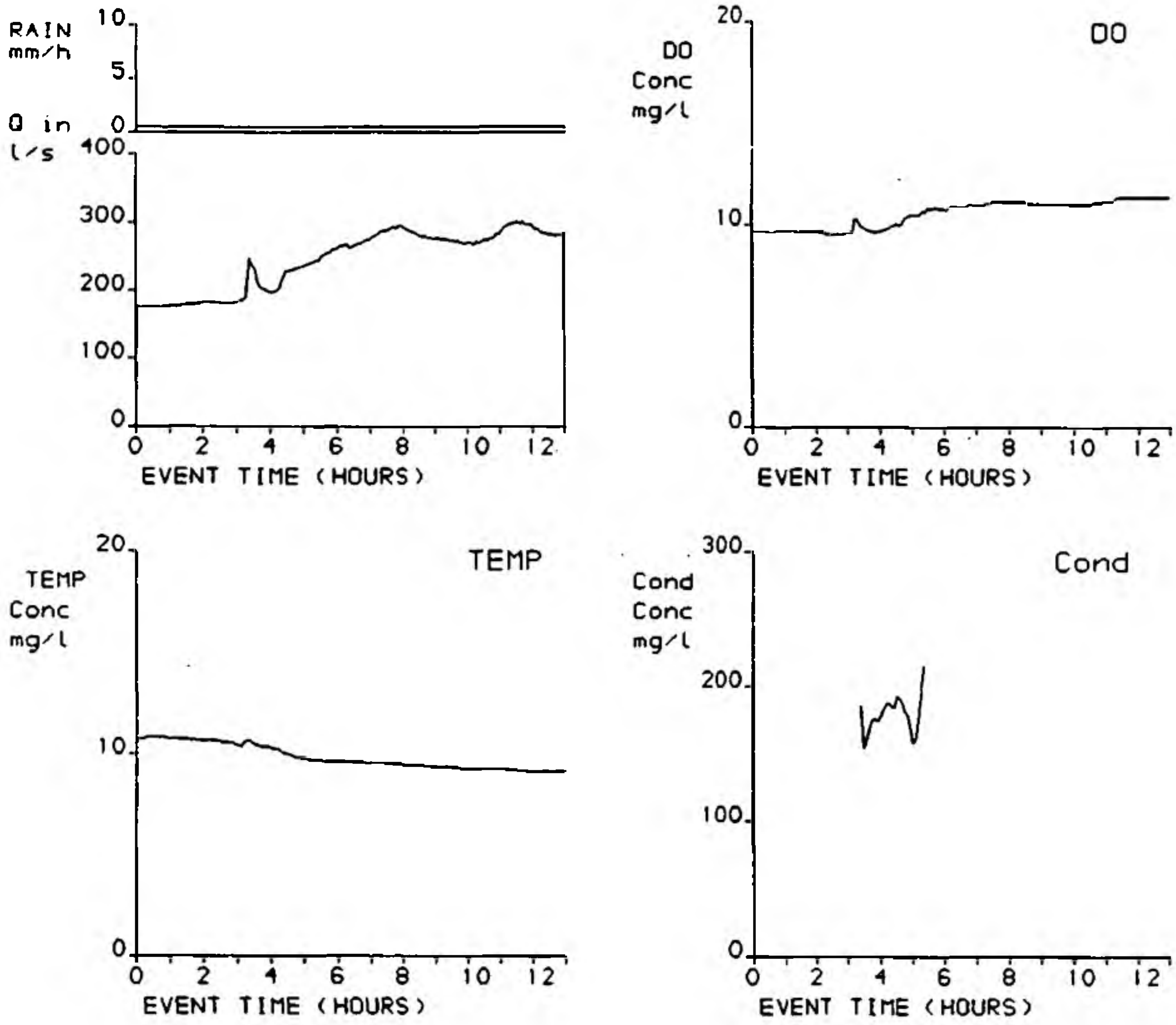




Site: NANT FFRWD,VIADUCT RD,UNDER VIADUCT GN880528D1.DAT

Grid Ref: 262043
Storm Date: 880528
Start Time (R/F): 1338
Rainfall Depth (mm): 30.8

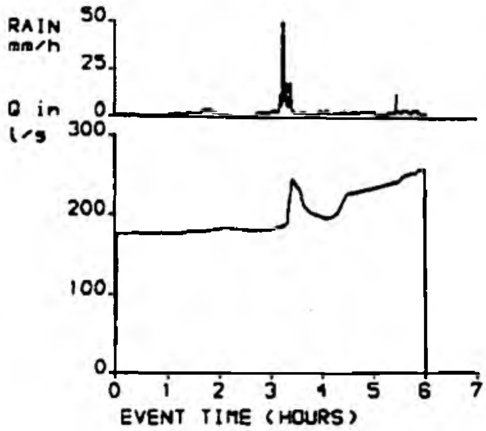
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 773.

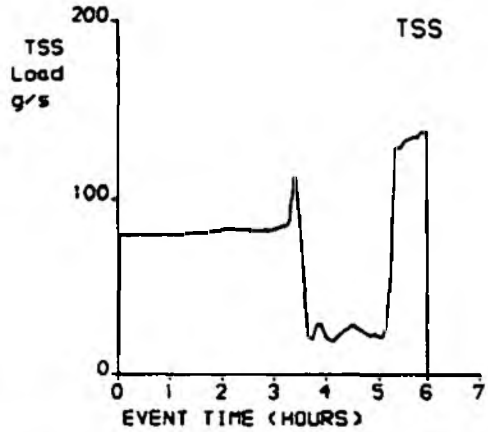


NO DATA FOR pH

Site: GARNDIFFAITH, NANT FFRWD, VIADUCT R GN8805280I.DAT

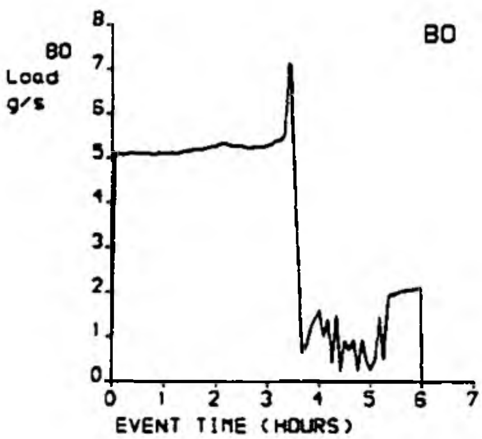
Grid Ref: M/H Identification: /////
Storm Date: 880528 Date/Time of last monitored storm:
Start Time (R/F): 1337 Antec. Dry Weather Period (hours):
Rainfall Depth (mm): 31.2 Rainfall Event Duration (mins): 3667.





NO DATA FOR CO

NO DATA FOR TDS



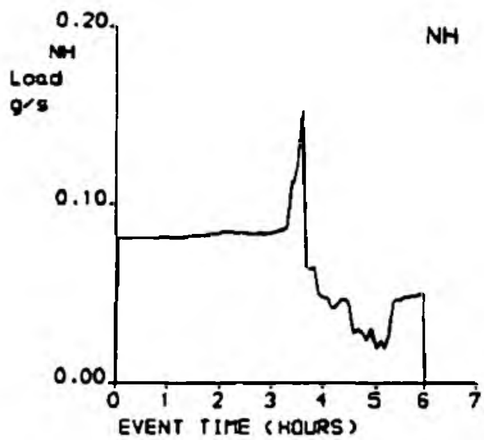
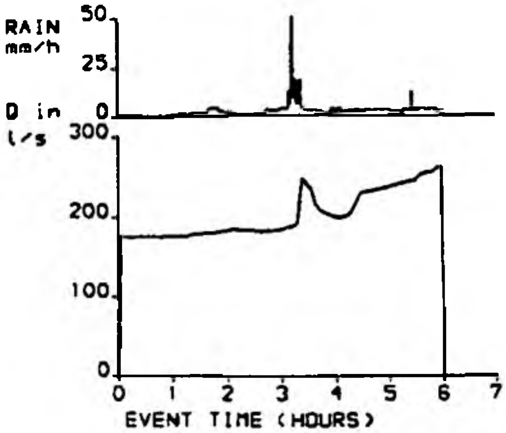


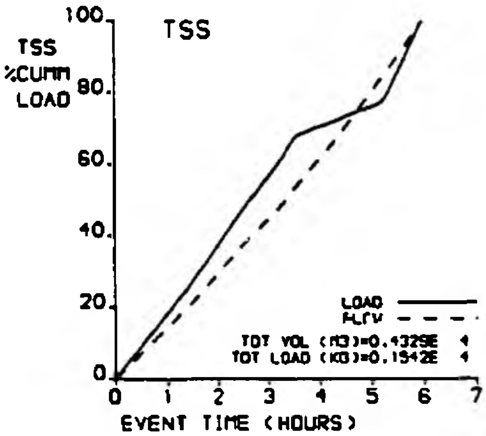
FIG.74

Site: GARNDIFFAITH,NANT FFRWD,VIADUCT R GN88052801.DAT

Grid Ref:
Storm Date: 880528
Start Time (R/F): 1337
Rainfall Depth (mm): 31.2

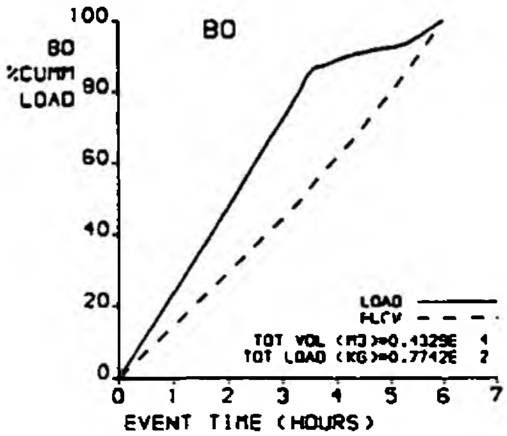
M/H Identification: //////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 3667.

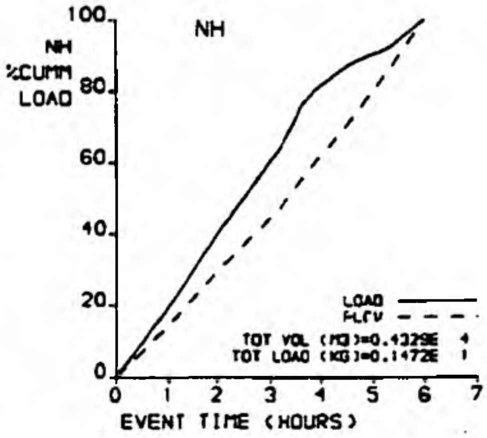




NO DATA FOR CO

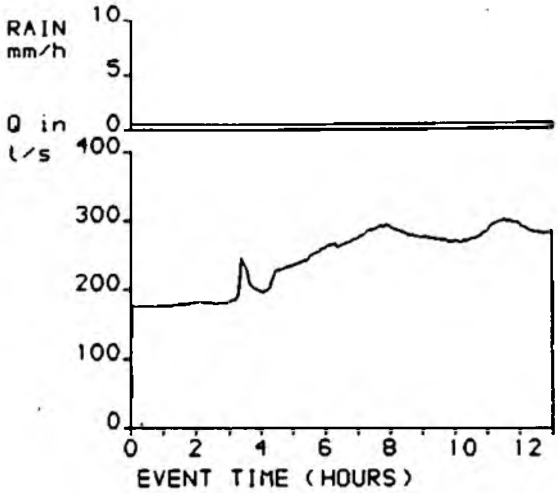
NO DATA FOR TDS

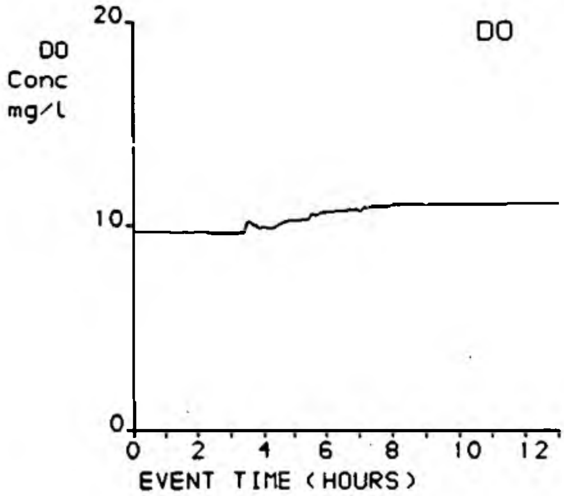


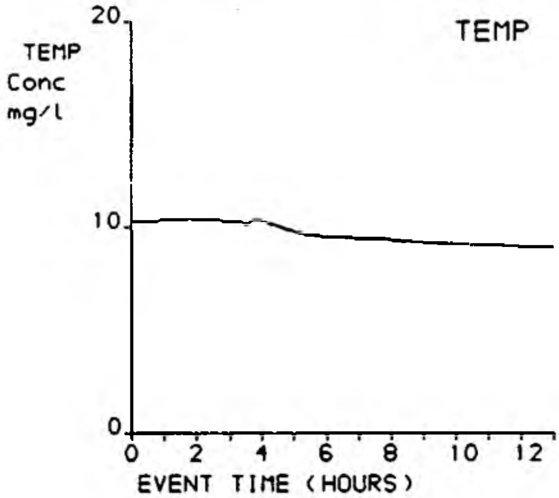


Site: NANT FFRWD,U/S VICTORIA RD BRIDGE GN88052802.DAT

Grid Ref: 264042	Weather Conditions:
Storm Date: 880528	Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1338	Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 30.8	Rainfall Event Duration (mins): 773.







NO DATA FOR Cond

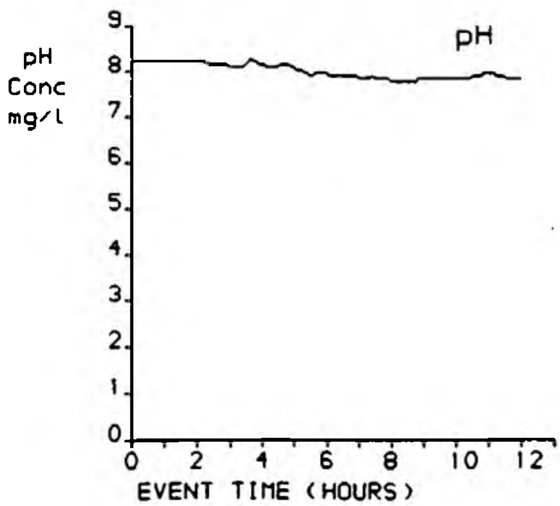
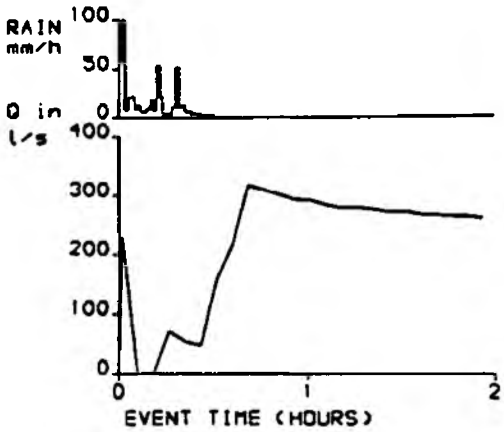


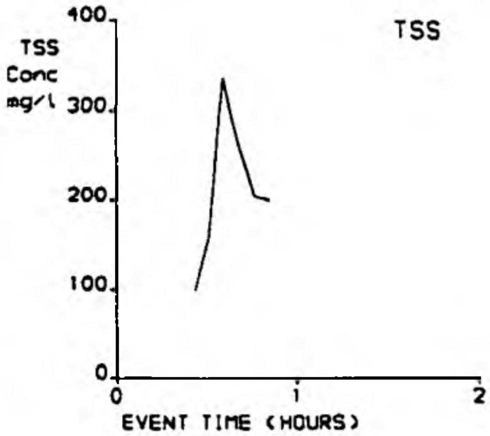
FIG.76

Site: NANT FFRWD, U/S SSO GARNDIFFAITH GN880802U1.DAT

EVENT 10

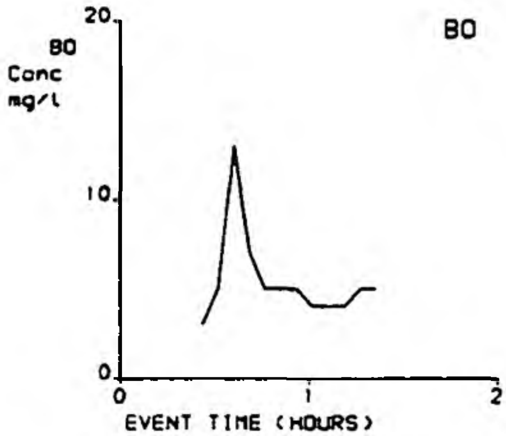
Grid Ref:	M/H Identification: /////
Storm Date: 880802	Date/Time of last monitored storm:
Start Time (R/F): 1604	Antec. Dry Weather Period (hours):
Rainfall Depth (mm): 7.2	Rainfall Event Duration (mins): 30.





NO DATA FOR CO

NO DATA FOR TDS



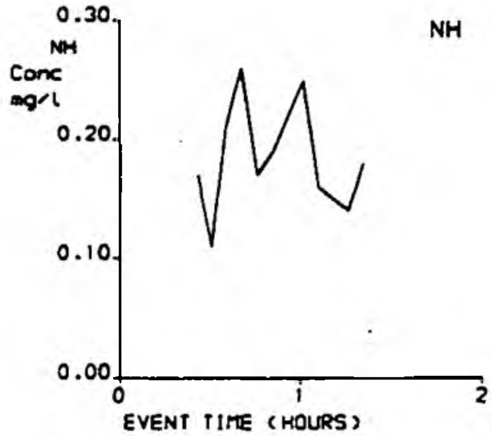
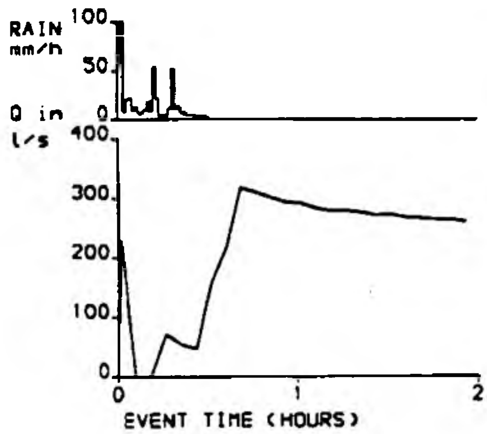
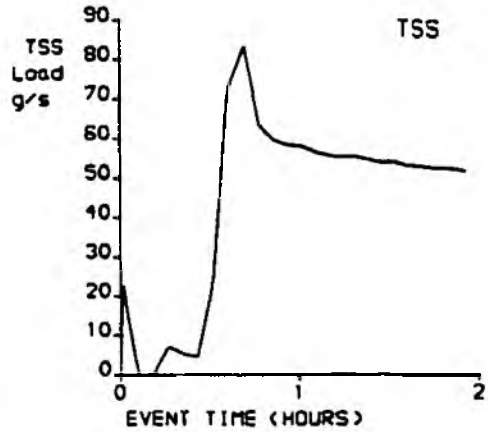


FIG. 77

Site: NANT FFRWD, U/S SSO GARNDIFFAITH GN880802U1.DAT

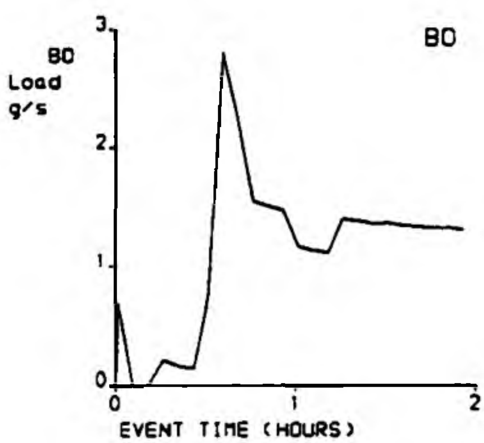
Grid Ref:
M/H Identification: /////
Storm Date: 880802
Date/Time of last monitored storm:
Start Time (R/F): 1604
Antec. Dry Weather Period (hours):
Rainfall Depth (mm): 7.2
Rainfall Event Duration (mins): 30.





NO DATA FOR CO

NO DATA FOR TDS



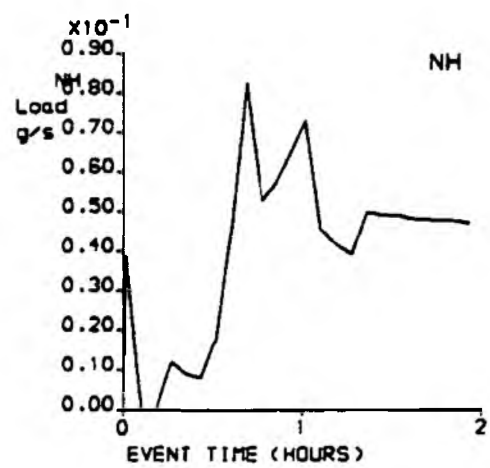
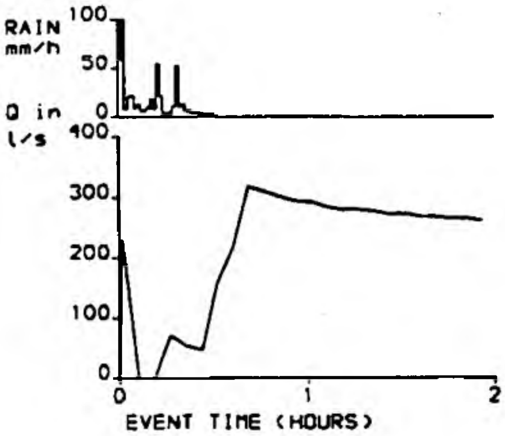


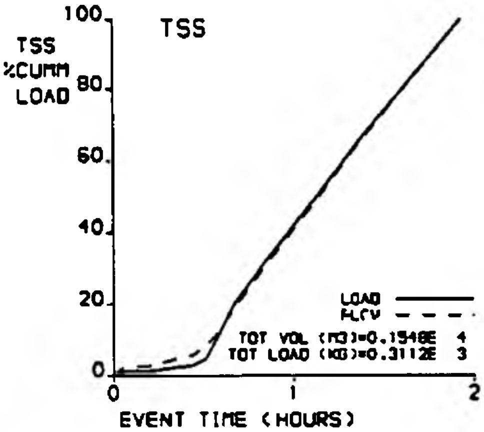
FIG. 78

Site: NANT FFRWD, U/S SSO GARNDIFFAITH GN880802U1.DAT

Grid Ref:
Storm Date: 880802
Start Time (R/F): 1604
Rainfall Depth (mm): 7.2

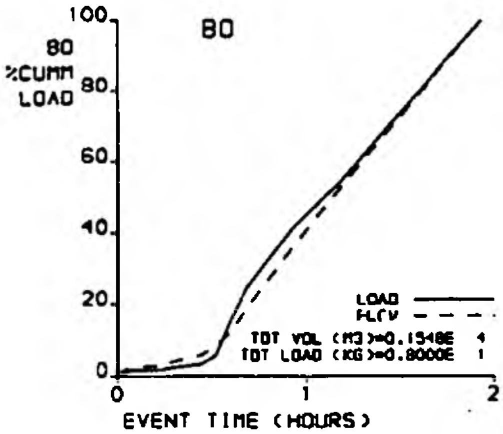
M/H Identification: /////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 30.

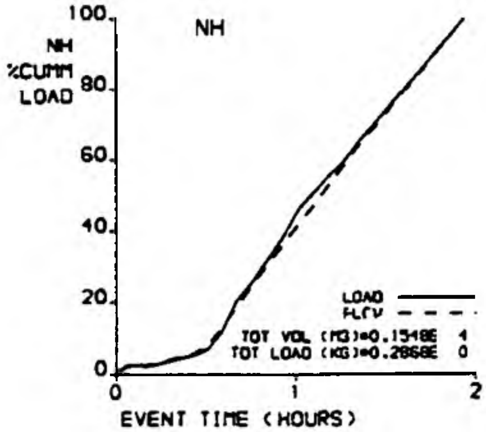




NO DATA FOR CO

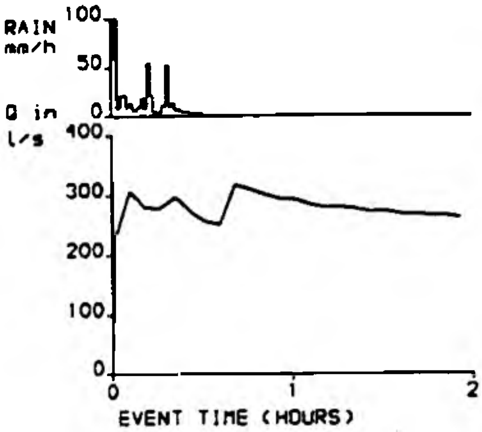
NO DATA FOR TOS

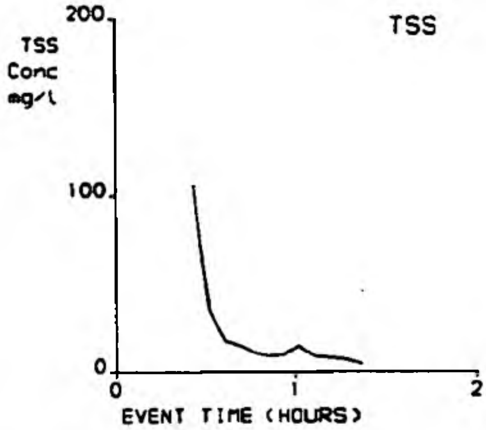




Site: NANT FFRWD, VIADUCT ROAD, UNDER V GN8808020I.DAT

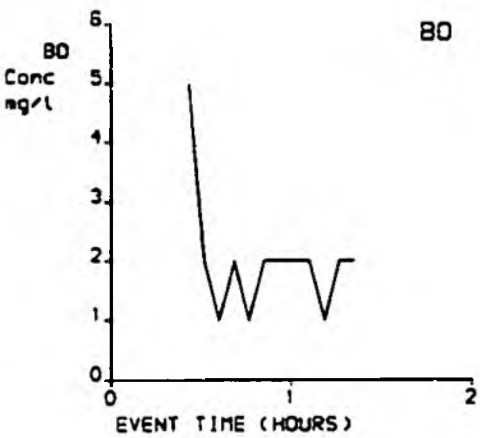
Grid Ref: M/H Identification: /////
Storm Date: 880802 Date/Time of last monitored storm:
Start Time (R/F): 1604 Antec. Dry Weather Period (hours):
Rainfall Depth (mm): 7.2 Rainfall Event Duration (mins): 30.

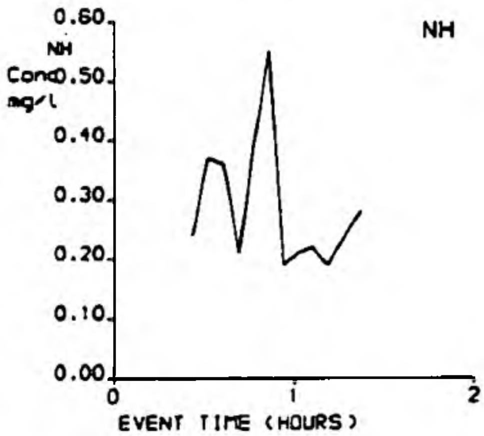




NO DATA FOR CO

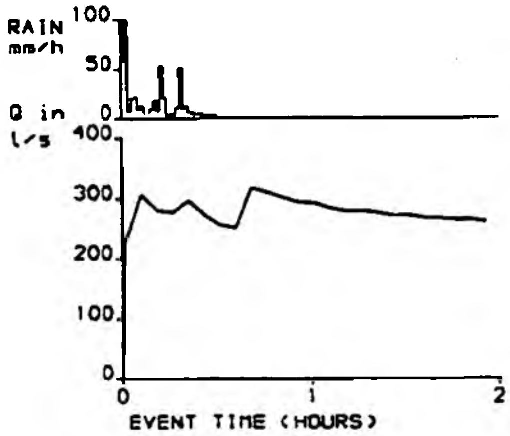
NO DATA FOR TDS

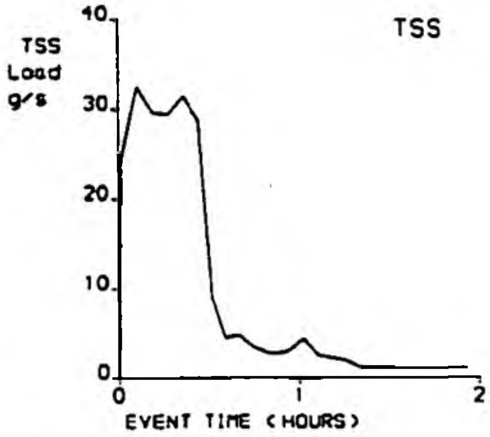




Site: NANT FFRWD, VIADUCT ROAD, UNDER V GN88080201.DAT

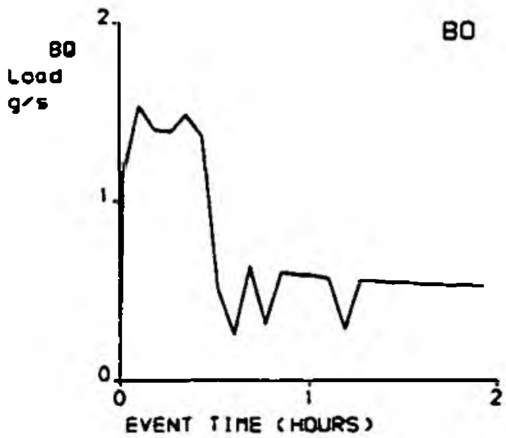
Grid Ref:
Storm Date: 880802
Start Time (R/F): 1604
Rainfall Depth (mm): 7.2
M/H Identification: /////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 30.





NO DATA FOR CO

NO DATA FOR TDS



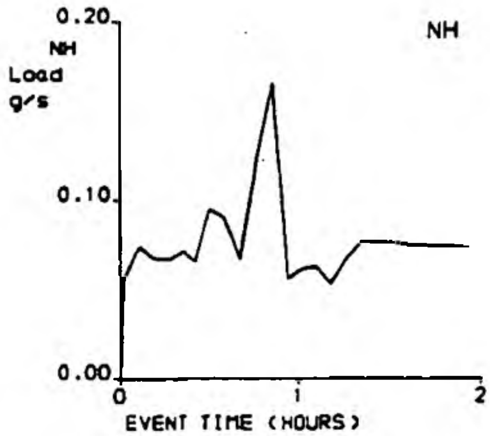
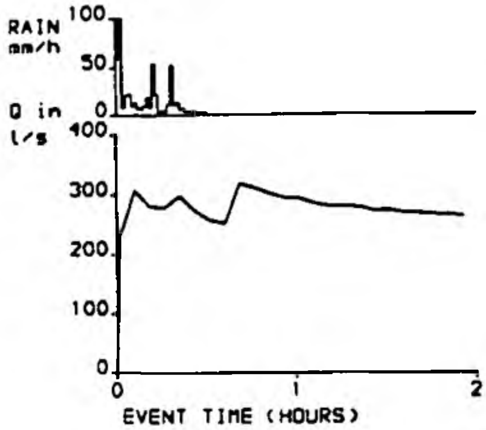
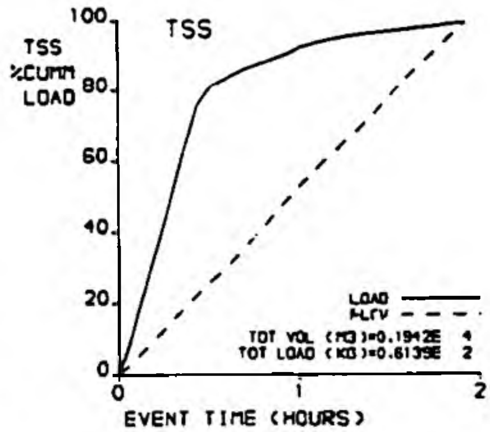


FIG.81

Site: NANT FFRWD, VIADUCT ROAD, UNDER V GN88080201.DAT

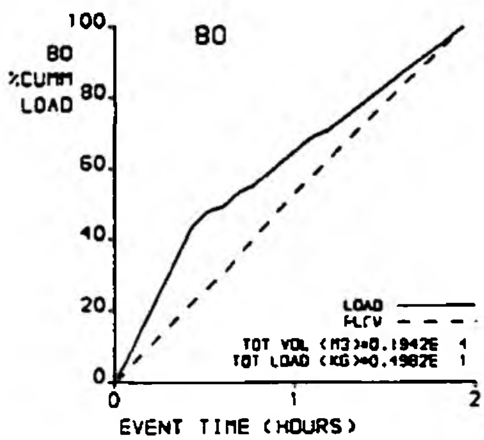
Grid Ref:
M/H Identification: //////
Storm Date: 880802
Date/Time of last monitored storm:
Start Time (R/F): 1604
Antec. Dry Weather Period (hours):
Rainfall Depth (mm): 7.2
Rainfall Event Duration (mins): 30.

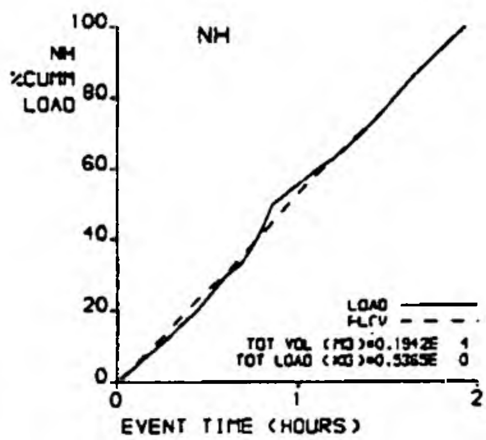




NO DATA FOR CO

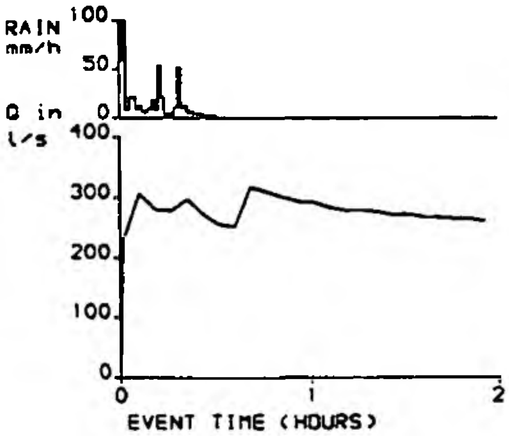
NO DATA FOR TDS

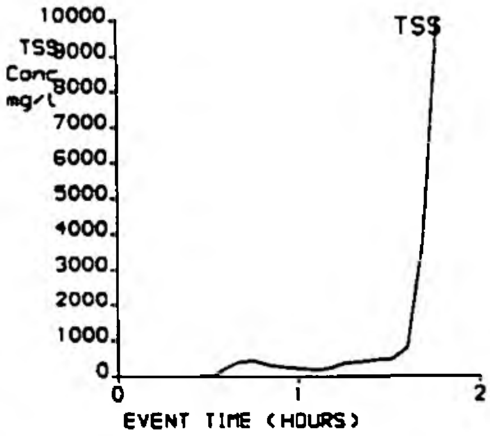




Site: NANT FFRWD, U/S VICTORIA ROAD BRI GN88080202.DAT

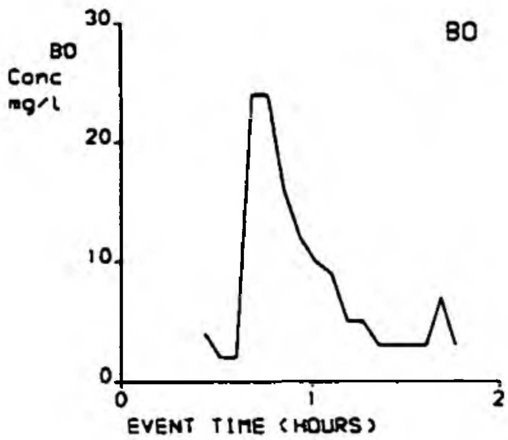
Grid Ref: M/H Identification: /////
Storm Date: 880802 Date/Time of last monitored storm:
Start Time (R/F): 1604 Antec. Dry Weather Period (hours):
Rainfall Depth (mm): 7.2 Rainfall Event Duration (mins): 30.





NO DATA FOR CO

NO DATA FOR TDS



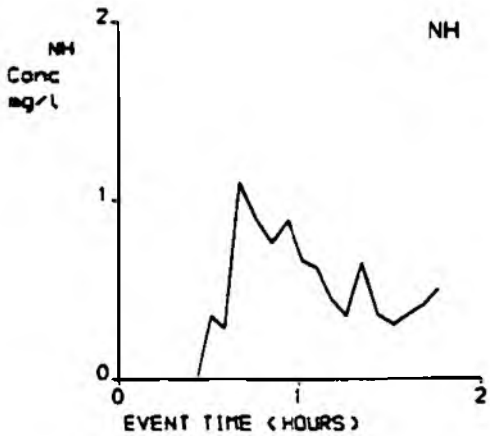
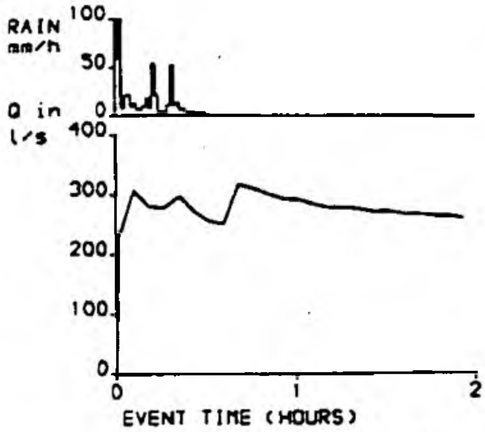


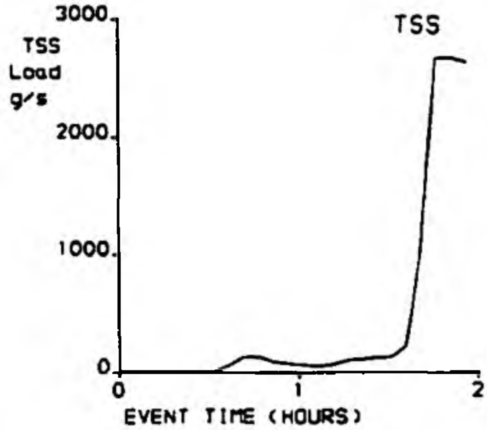
FIG.83

Site: NANT FFRWD, U/S VICTORIA ROAD BRI GN88080202.DAT

Grid Ref:
Storm Date: 880802
Start Time (R/F): 1604
Rainfall Depth (mm): 7.2

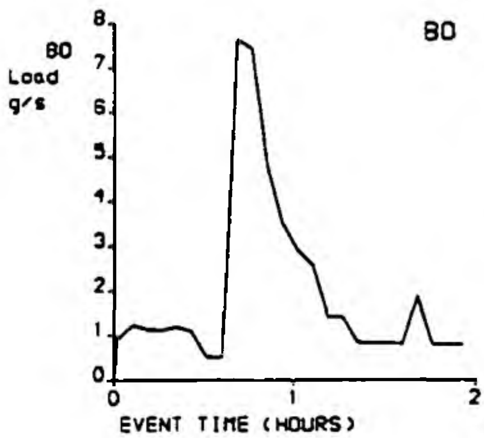
M/H Identification: //////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 30.

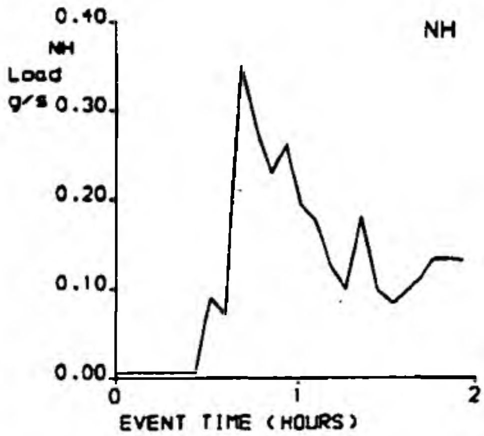




NO DATA FOR CO

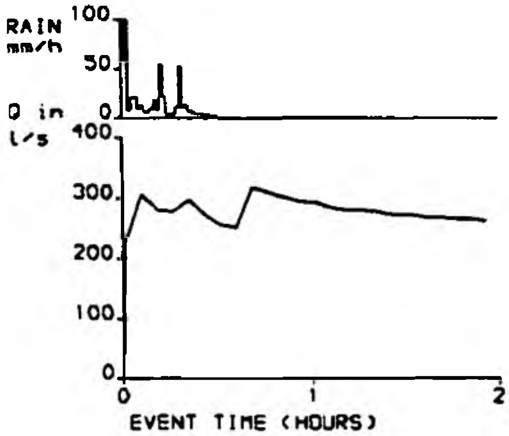
NO DATA FOR TDS

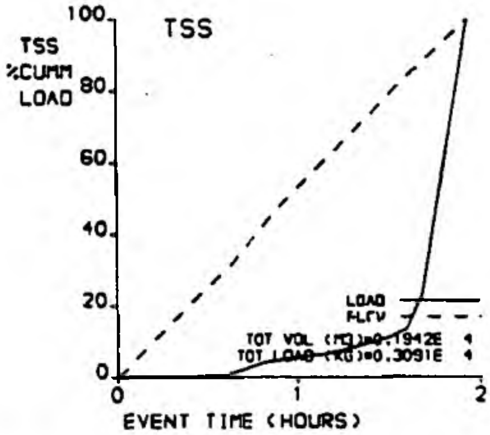




Site: NANT FFRWD, U/S VICTORIA ROAD BRI GN880802D2.DAT

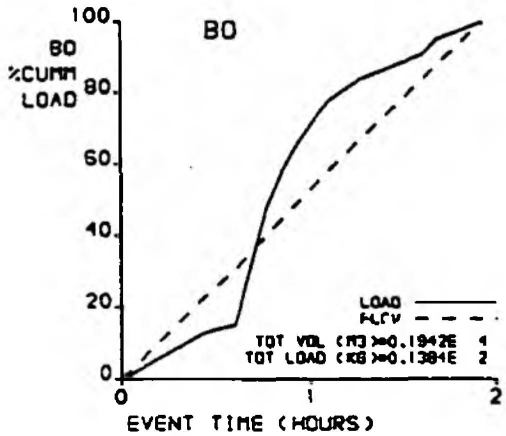
Grid Ref:
M/H Identification: /////
Storm Date: 880802
Date/Time of last monitored storm:
Start Time (R/F): 1604
Antec. Dry Weather Period (hours):
Rainfall Depth (mm): 7.2
Rainfall Event Duration (mins): 30.

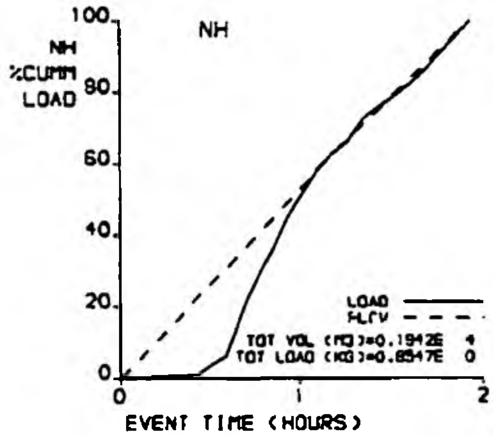




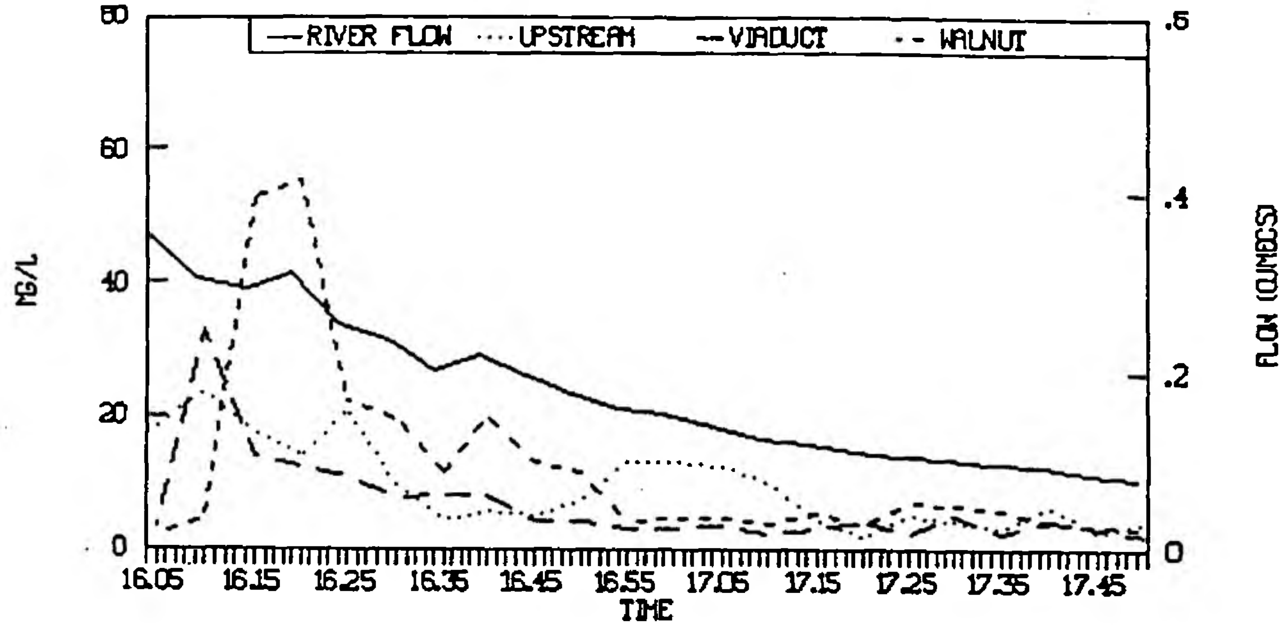
NO DATA FOR CO

NO DATA FOR TDS

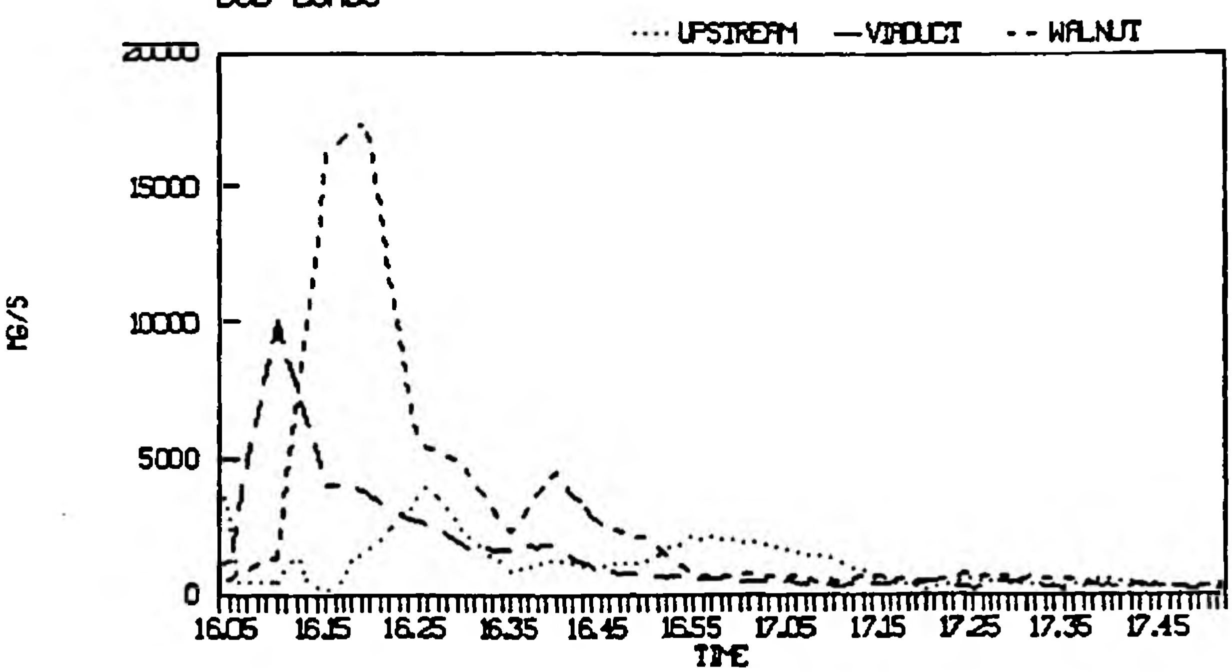


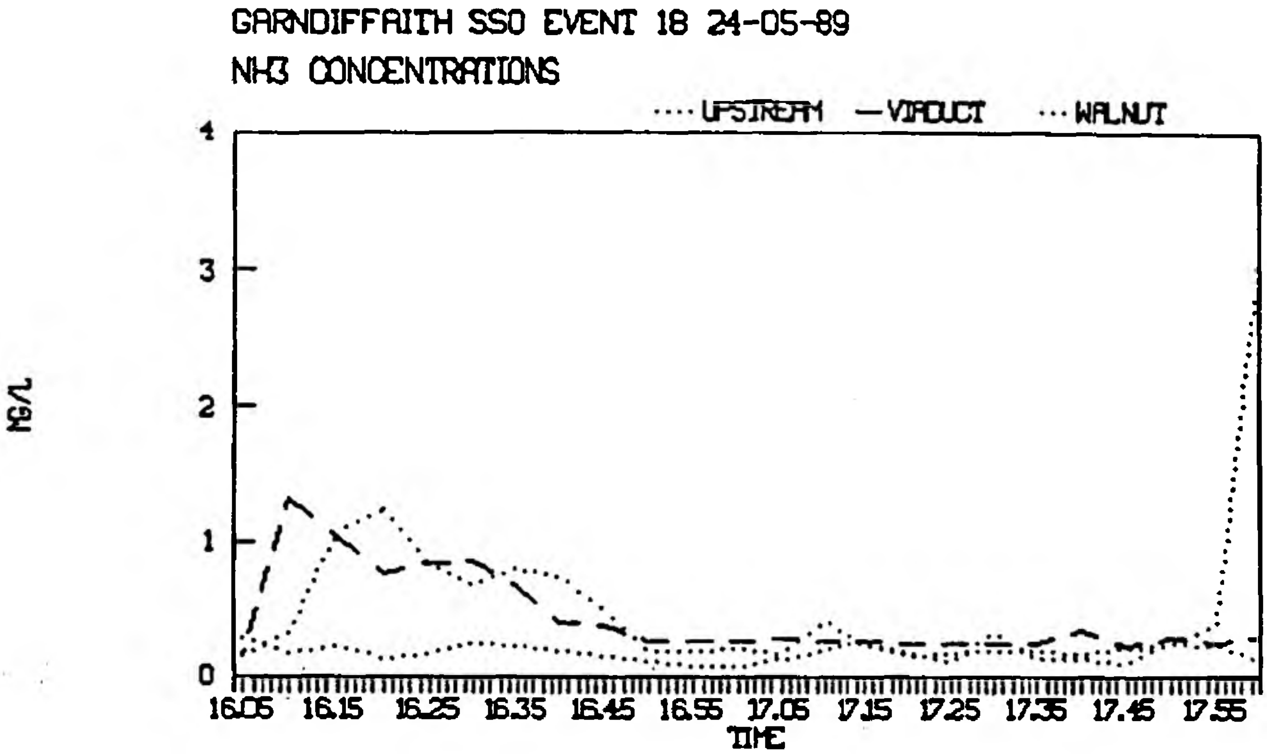


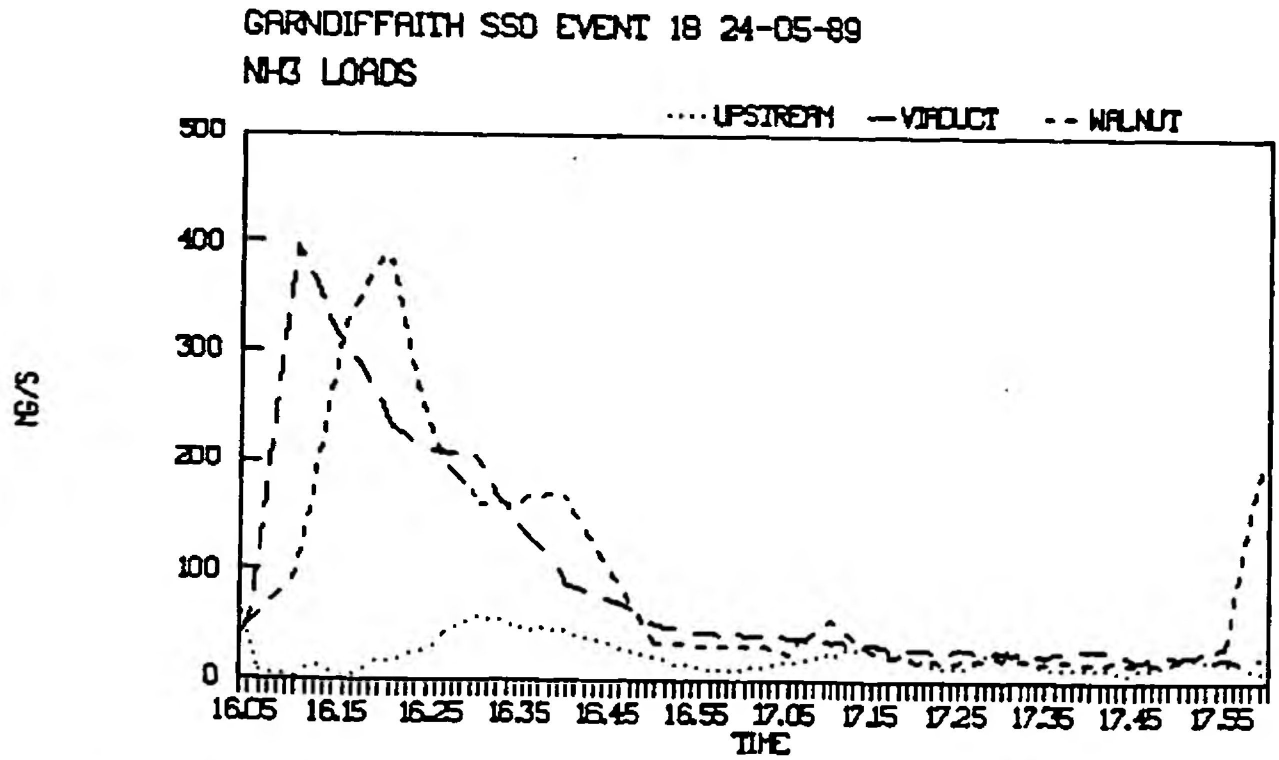
GARNDIFFAITH SSO EVENT 18 24-05-89
BOD CONCENTRATIONS

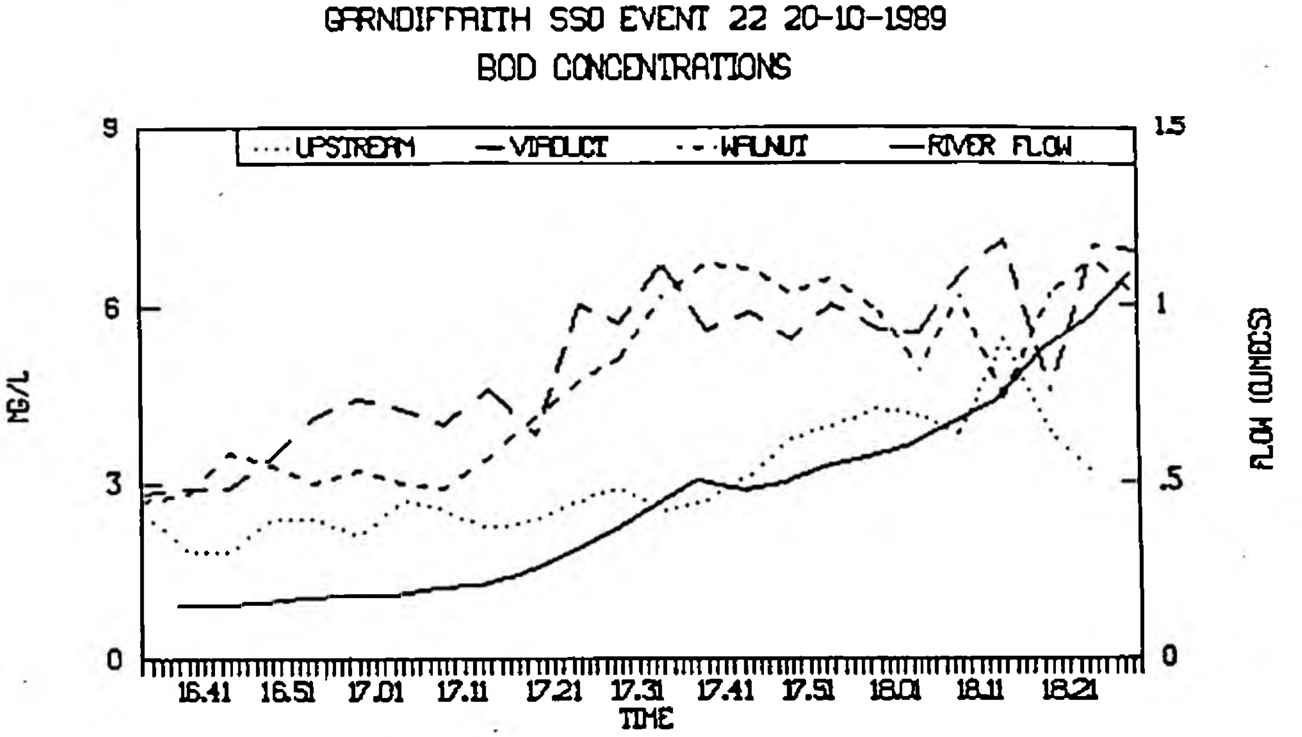


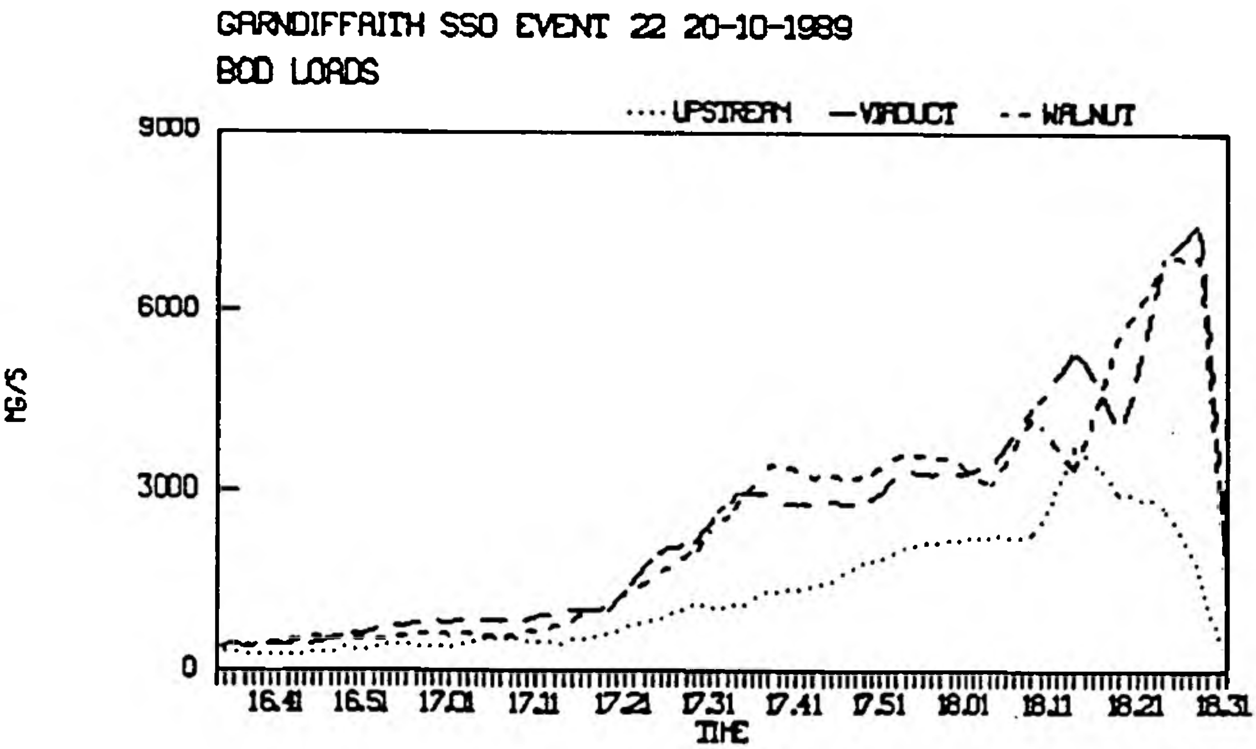
GARNDIFFAITH SSO EVENT 18 24-05-89
BOD LOADS



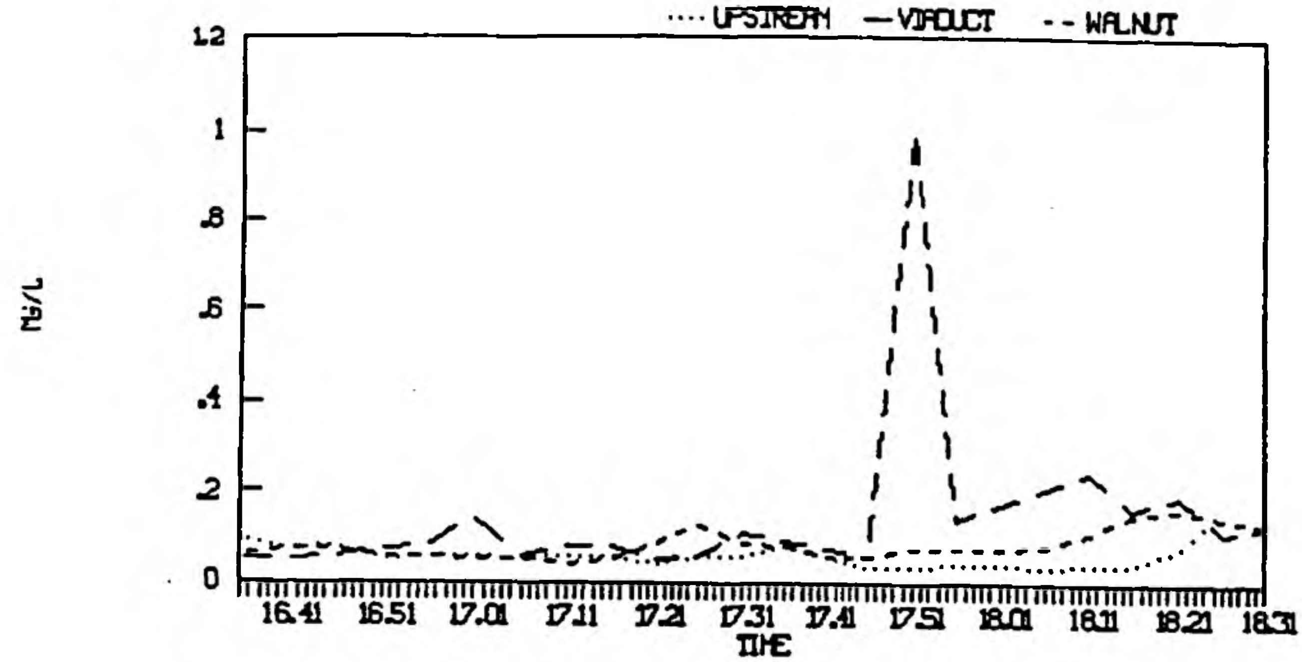

GARNDIFFAITH SSO EVENT 18 24-05-89
NH3 CONCENTRATIONS
UPSTREAM
VIADUCT
WALNUT
MG/L
4
3
2
1
0
16.05 16.15 16.25 16.35 16.45 16.55 17.05 17.15 17.25 17.35 17.45 17.55
TIME


GARNDIFFAITH SSO EVENT 18 24-05-89
NH3 LOADS
UPSTREAM
VIADUCT
WALNUT
MG/S
500
400
300
200
100
0
16.05 16.15 16.25 16.35 16.45 16.55 17.05 17.15 17.25 17.35 17.45 17.55
TIME


GARNDIFFAITH SSO EVENT 22 20-10-1989
BOD CONCENTRATIONS
UPSTREAM
VIADUCT
WALNUT
RIVER FLOW
MG/L
FLOW (CUMECS)
9
6
3
0
1.5
1
.5
0
16.41
16.51
17.01
17.11
17.21
17.31
17.41
17.51
18.01
18.11
18.21
TIME


GARNDIFFAITH SSO EVENT 22 20-10-1989
BOD LOADS
UPSTREAM
VIADUCT
WALNUT
MG/S
9000
6000
3000
0
16.41
16.51
17.01
17.11
17.21
17.31
17.41
17.51
18.01
18.11
18.21
18.31
TIME

GARNDIFFAITH SSO EVENT 22 20-10-89
NH3 CONCENTRATIONS



GARNDIFFAITH SSO EVENT 22 20-10-89
NH3 LOADS

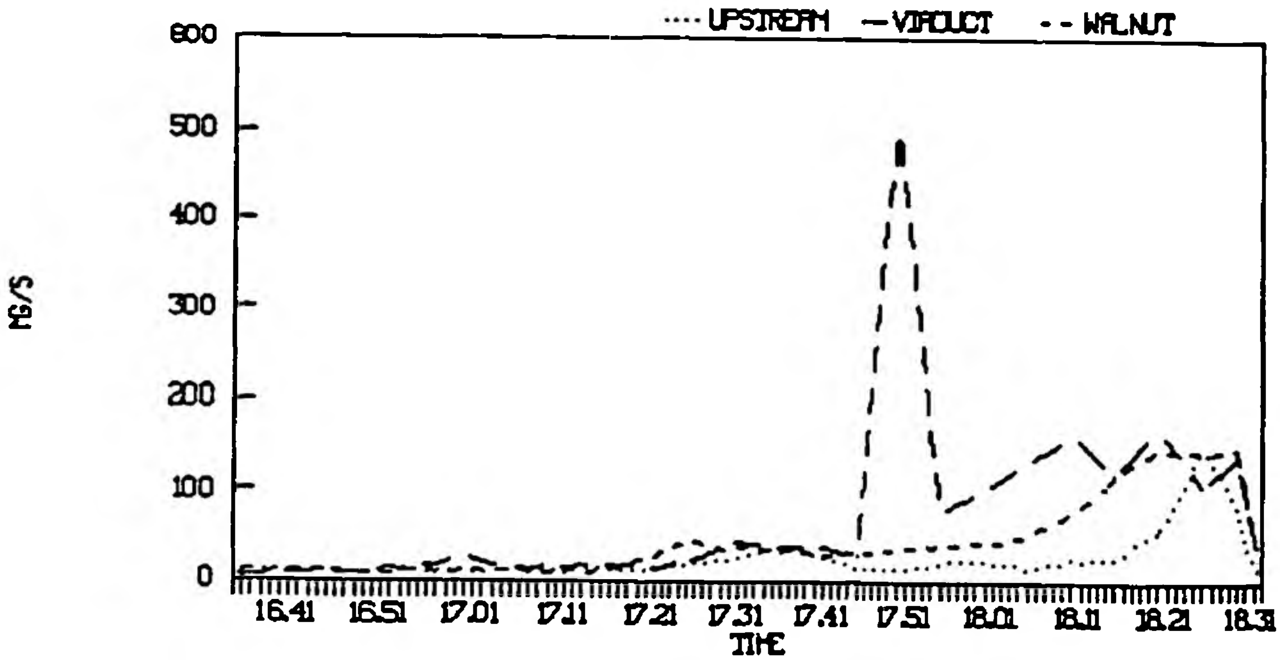
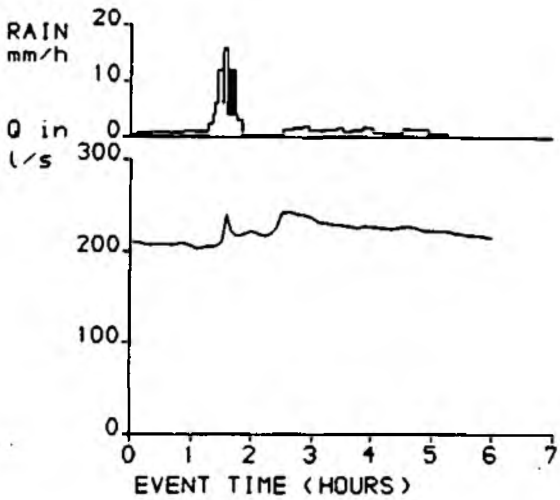
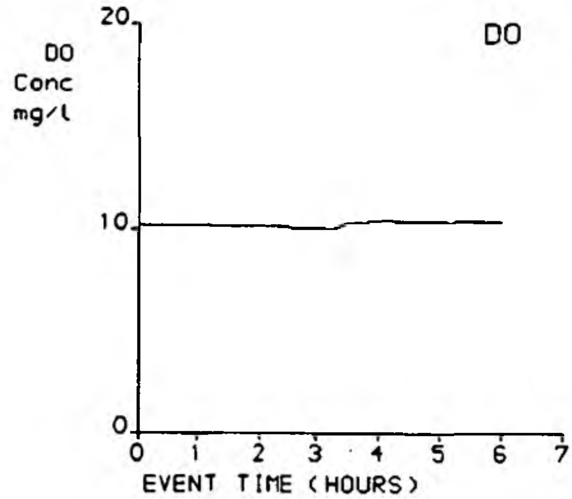


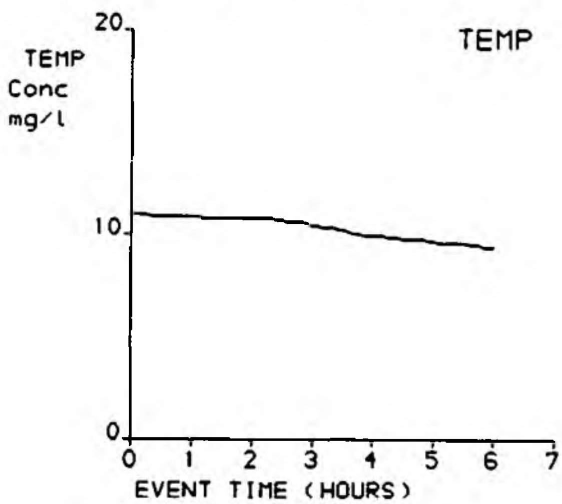
FIG.89

Site: NANT FFRWD,U/S SSO GARNDIFFAITH GN891020U1.DAT

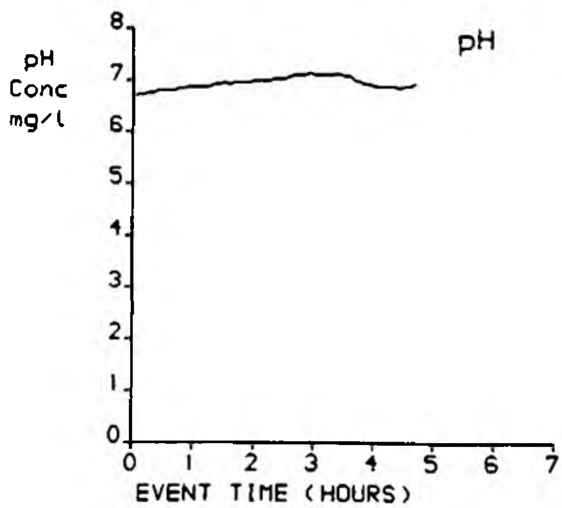
Grid Ref:	262045	Weather Conditions:	
Storm Date:	891020	Date/Time last recorded storm:	0/ 0
Start Time (R/F):	0	Antec. Dry Weather Period (hours):	0
Rainfall Depth (mm):	8.0	Rainfall Event Duration (mins):	313.







NO DATA FOR Cond

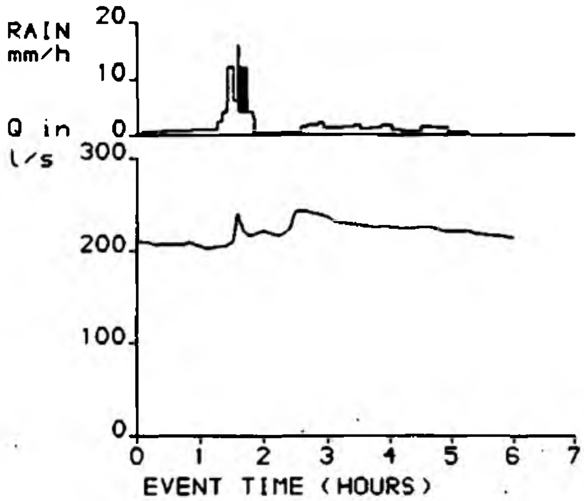


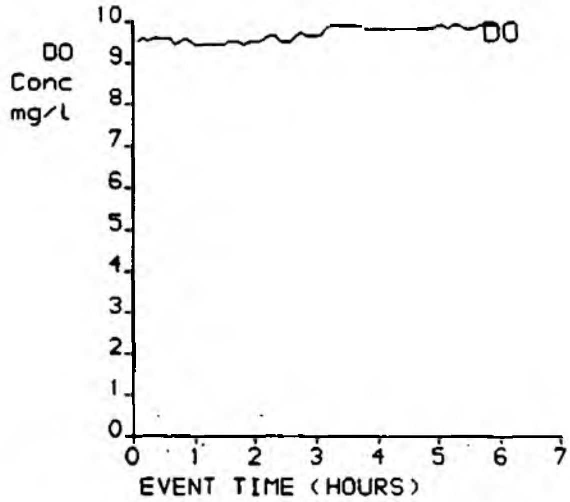
Site: NANT FFRWD, UNDER VIADUCT

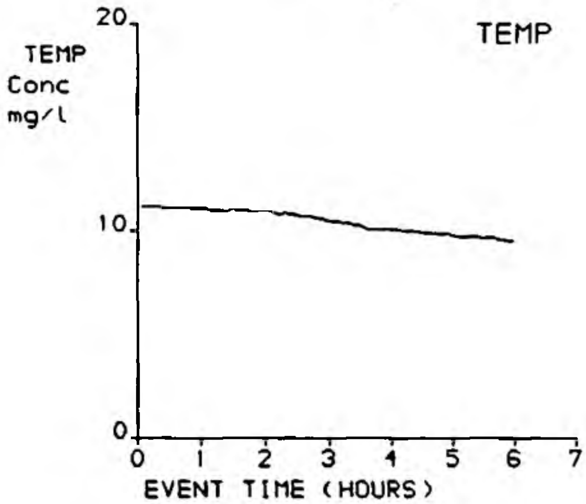
GN89102001.DAT

Grid Ref: 262043
Storm Date: 891020
Start Time (R/F): 0
Rainfall Depth (mm): 8.0

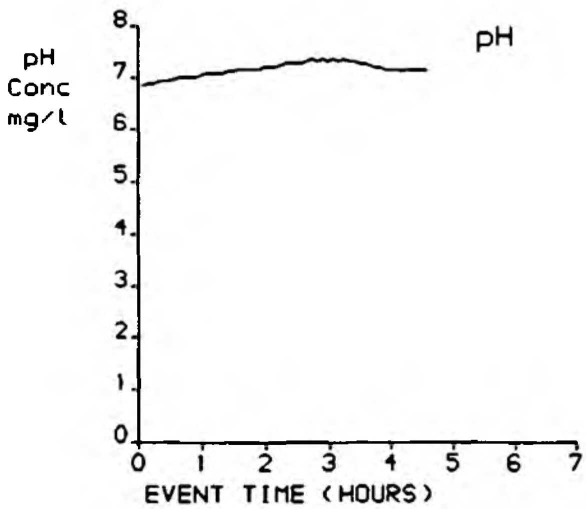
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 313.



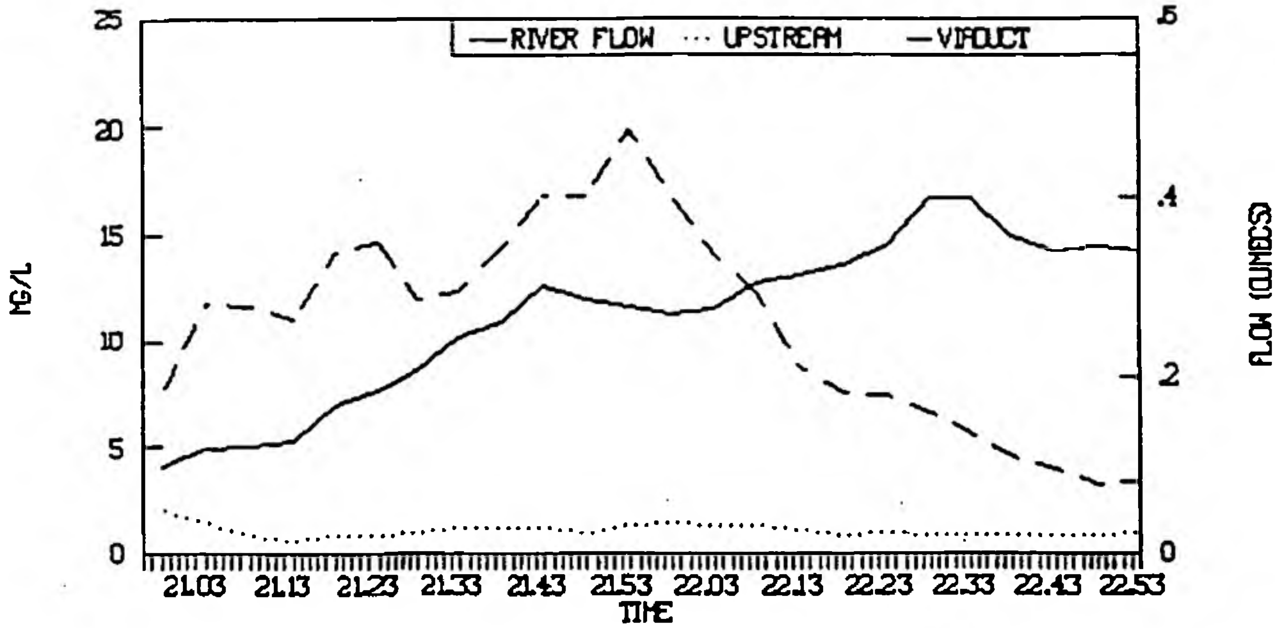




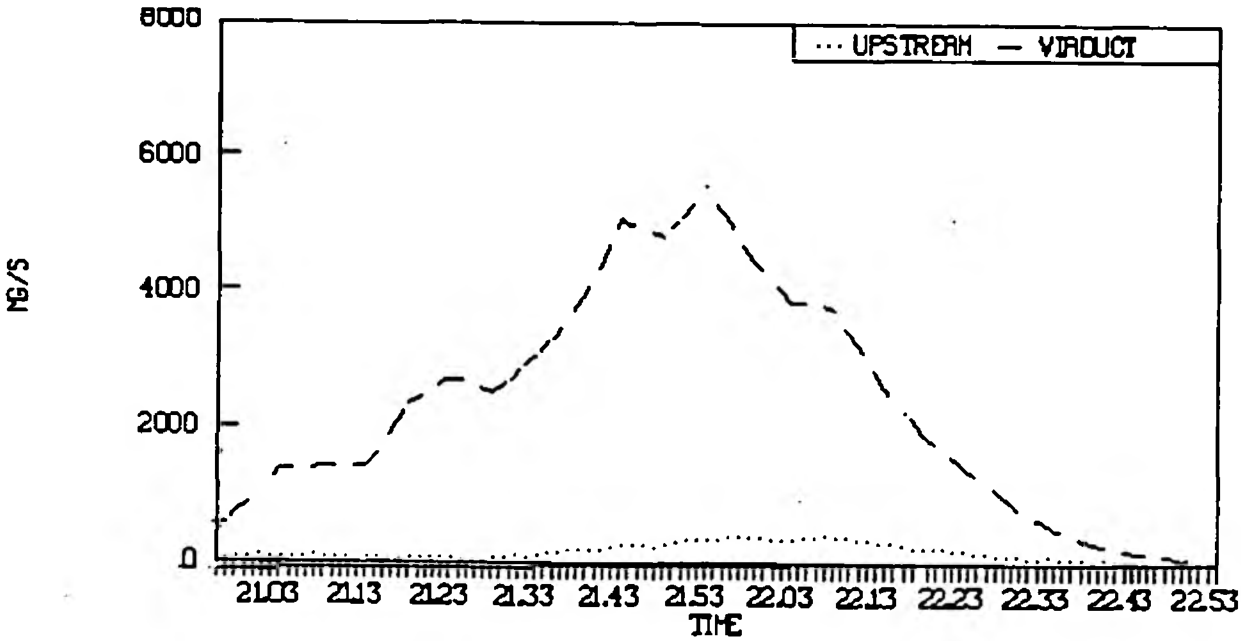
NO DATA FOR Cond



GARNDIFFAITH SSO EVENT 4 30-04-88
BOD CONCENTRATIONS

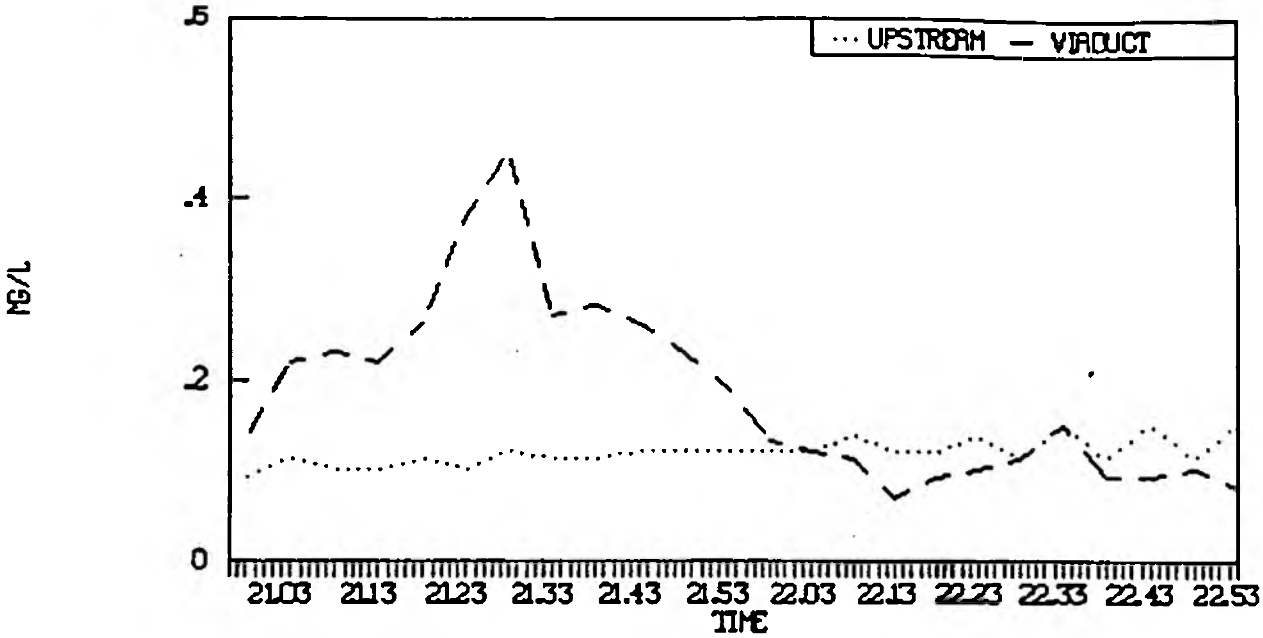


GARNDIFFAITH SSO EVENT 4 30-04-88
BOD LOADS



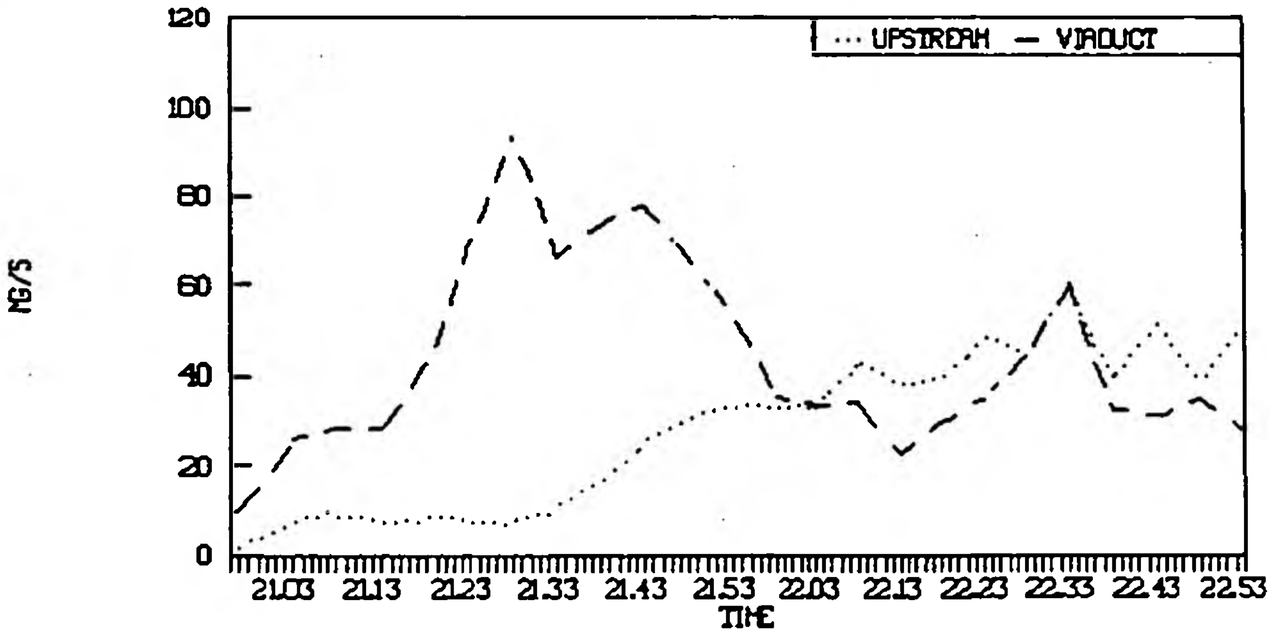
GARNDIFFAITH SSO EVENT 4 30-04-88

NH3 CONCENTRATIONS



GARNDIFFAITH SSO EVENT 4 30-04-88

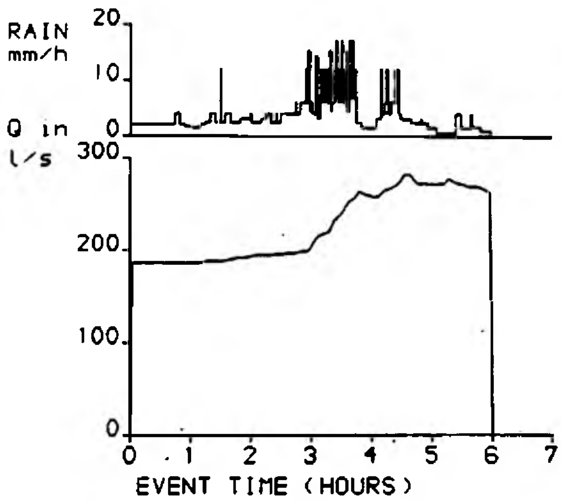
NH3 LOADS

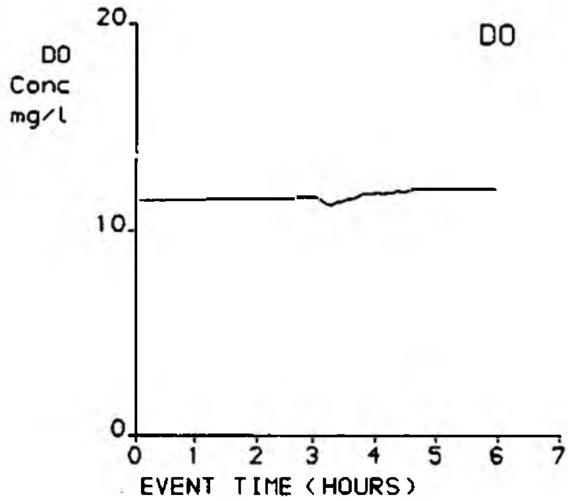


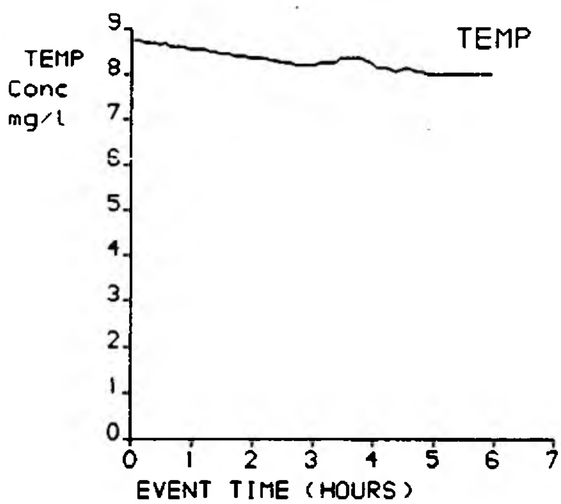
Site: NANT FFRWD, VIADUCT RD, UNDER VIADUCT GN880430D1.DAT

Grid Ref: 262043
Storm Date: 880430
Start Time (R/F): 1758
Rainfall Depth (mm): 19.2

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 314.





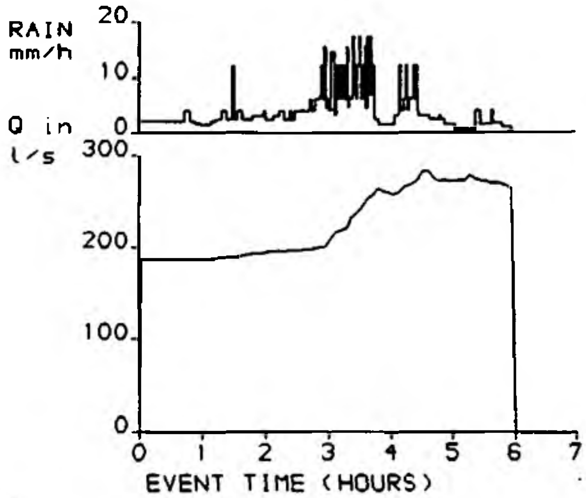


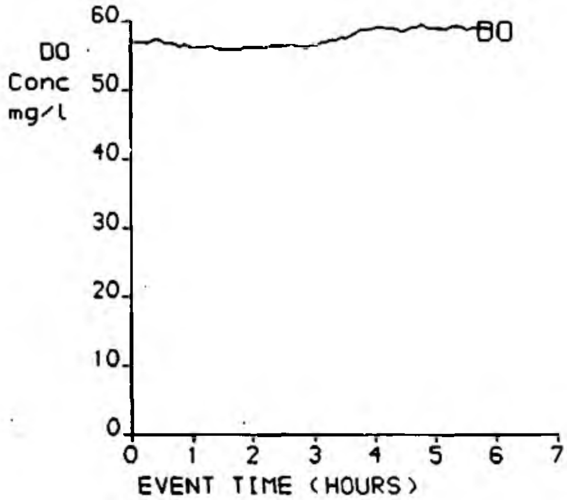
NO DATA FOR Cond

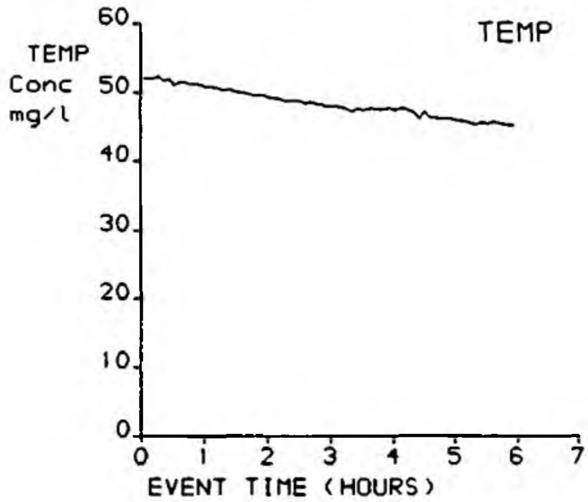
NO DATA FOR pl

Site: NANT FFRWD,U/S VICTORIA RD BRIDGE GN880430D2.DAT

Grid Ref: 264042	Weather Conditions:
Storm Date: 880430	Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1758	Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 19.2	Rainfall Event Duration (mins): 314.







NO DATA FOR Cond

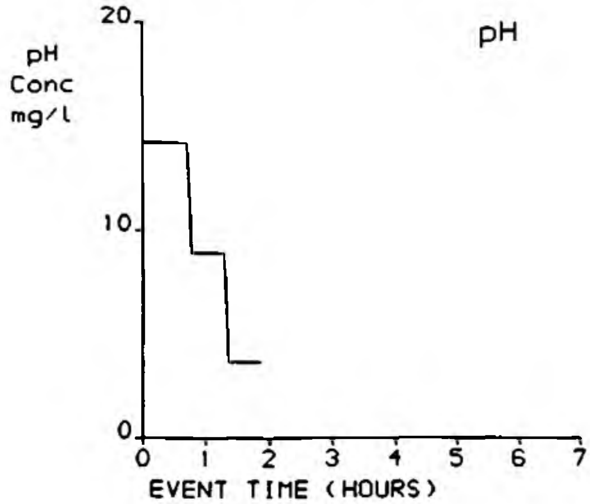
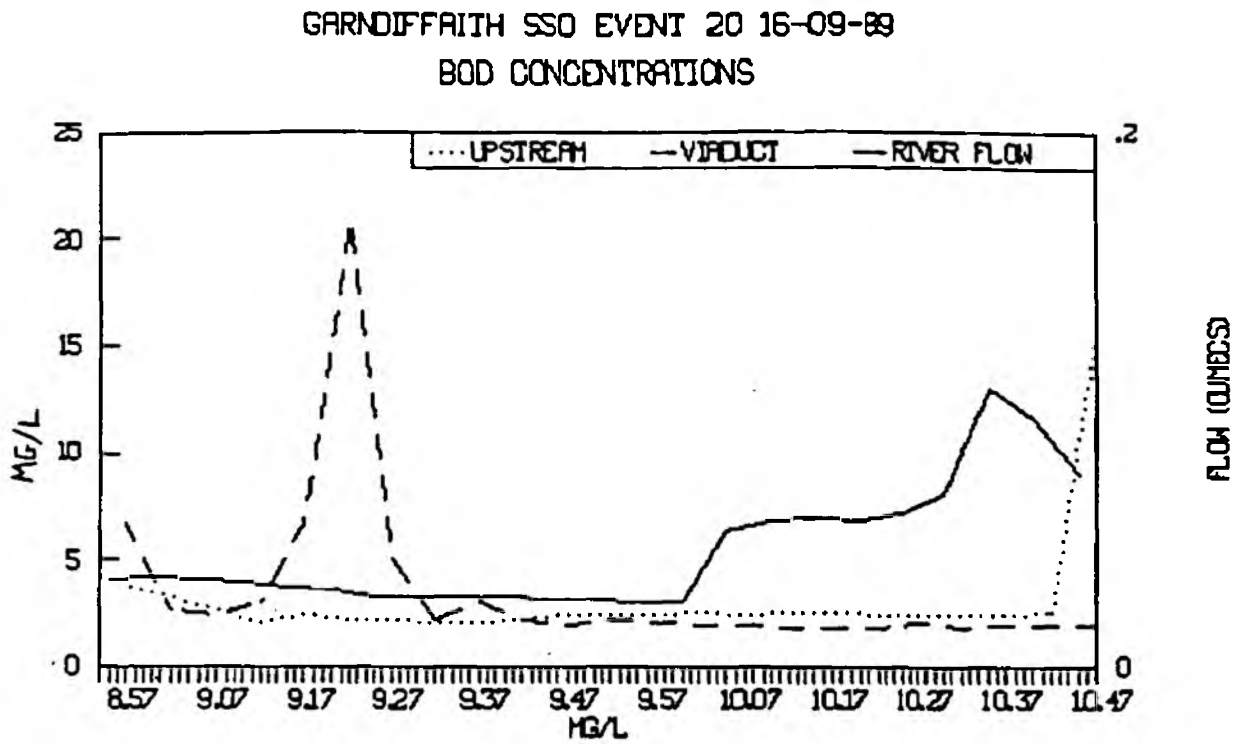
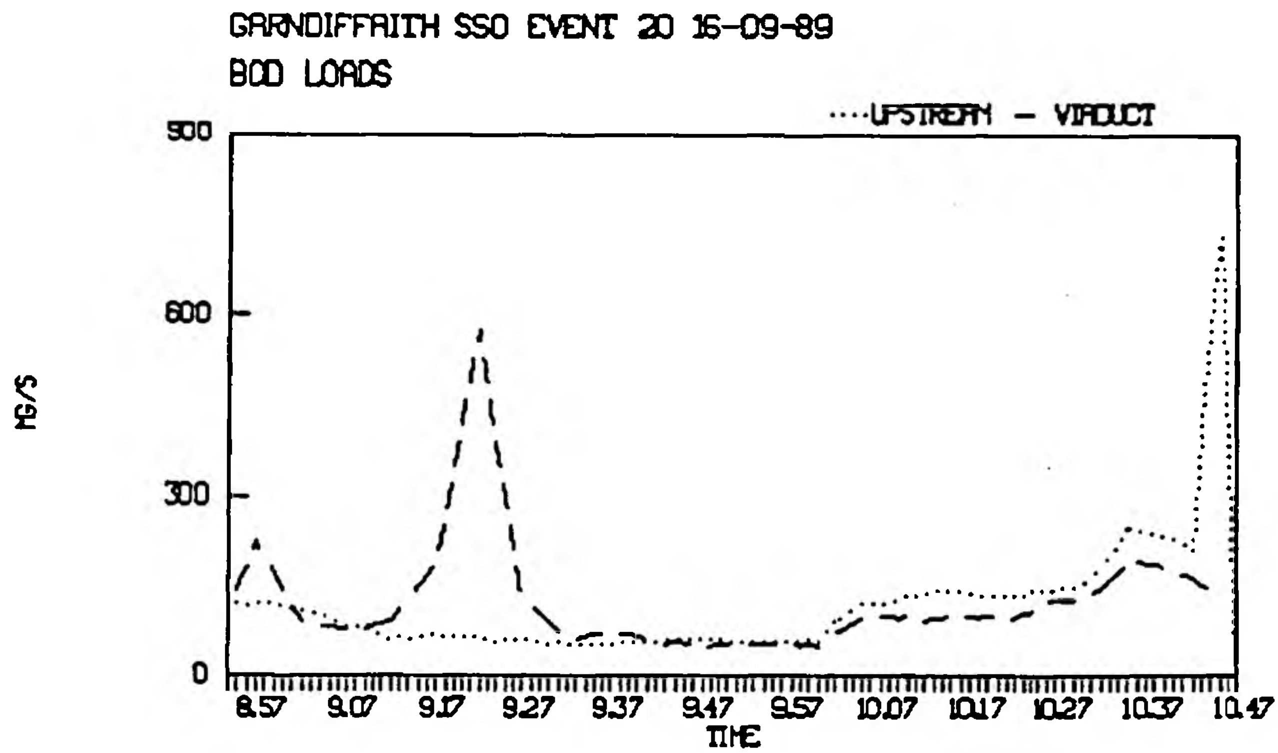
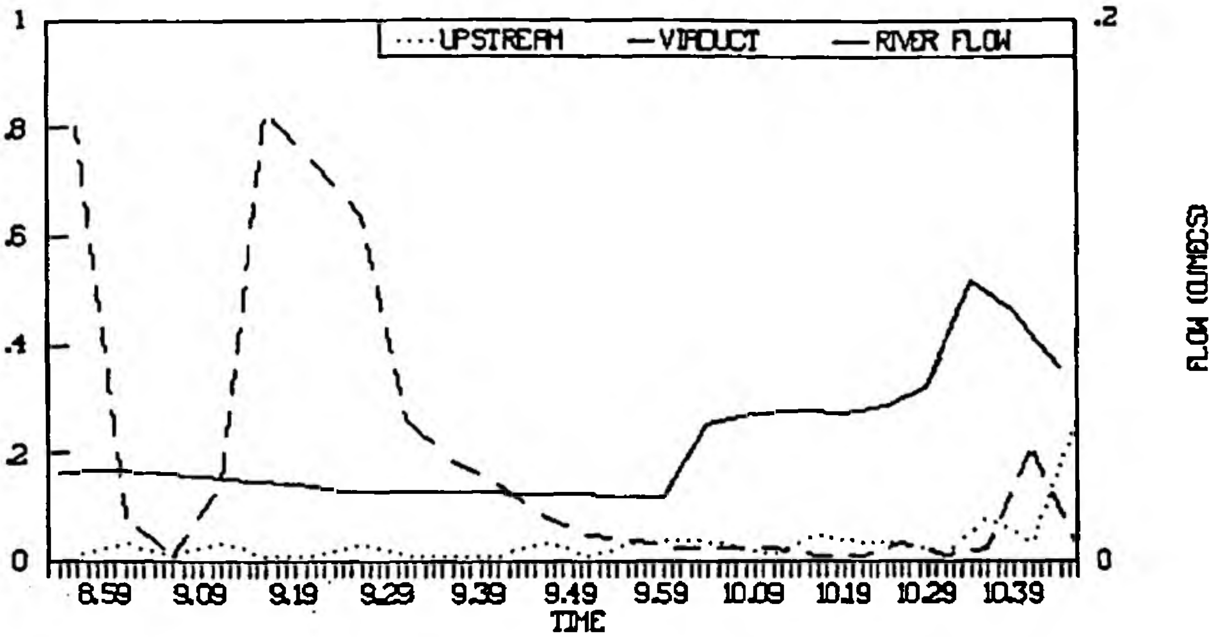


FIG. 95

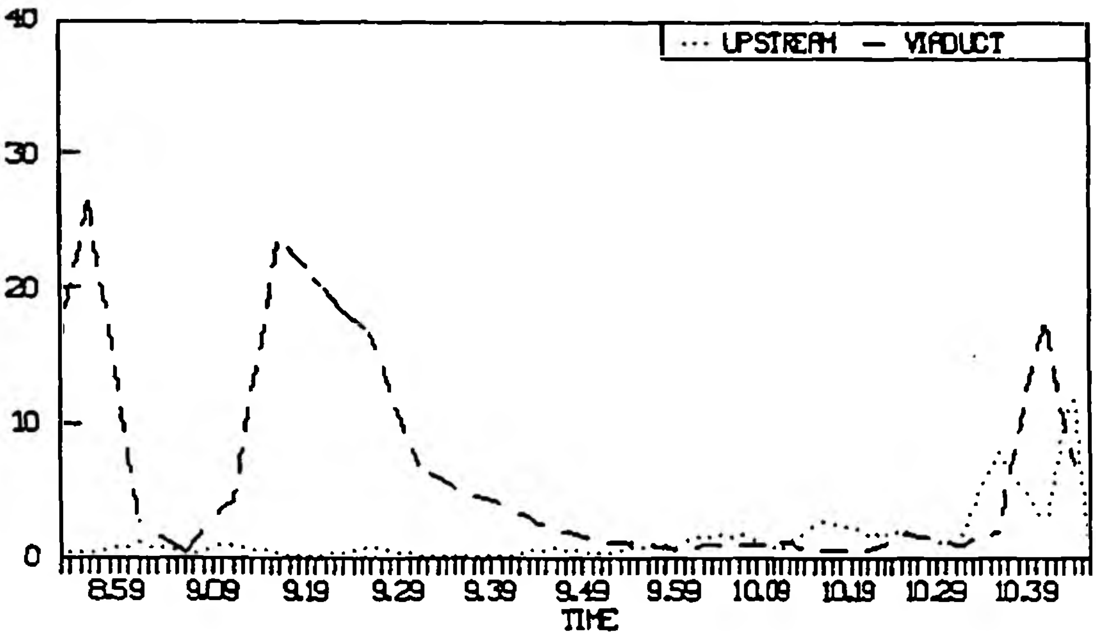

GARNDIFFAITH SSO EVENT 20 16-09-89
BOD CONCENTRATIONS
UPSTREAM
VIADUCT
RIVER FLOW
MG/L
FLOW (CUMECS)
25
20
15
10
5
0
.2
0
8.57
9.07
9.17
9.27
9.37
9.47
9.57
10.07
10.17
10.27
10.37
10.47
MG/L


GARNDIFFAITH SSO EVENT 20 16-09-89
BOD LOADS
UPSTREAM
VIADUCT
MG/S
900
600
300
0
8.57
9.07
9.17
9.27
9.37
9.47
9.57
10.07
10.17
10.27
10.37
10.47
TIME

GARNDIFFAITH SSO EVENT 20 16-09-89
NH3 CONCENTRATIONS

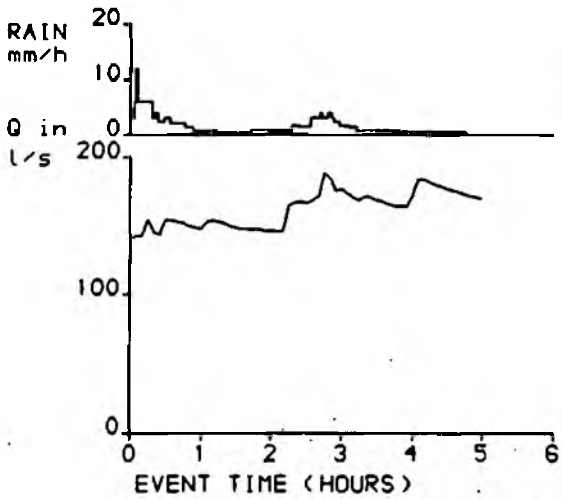


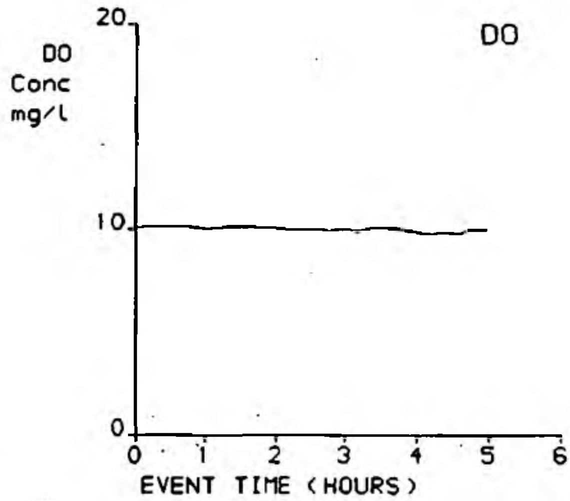
GARNDIFFAITH SSO EVENT 20 16-09-89
NH3 LOADS

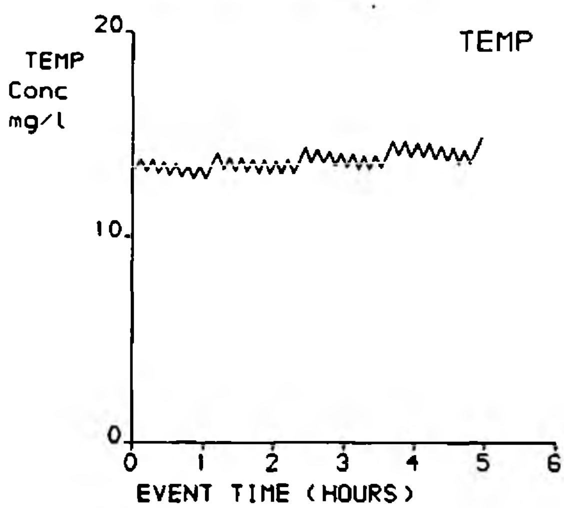


Site: NANT FFRWD,U/S SSO GARNDIFFAITH GN890916U1.DAT

Grid Ref: 262045
Storm Date: 890916
Start Time (R/F): 850
Rainfall Depth (mm): 7.4
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 907.







NO DATA FOR Cond

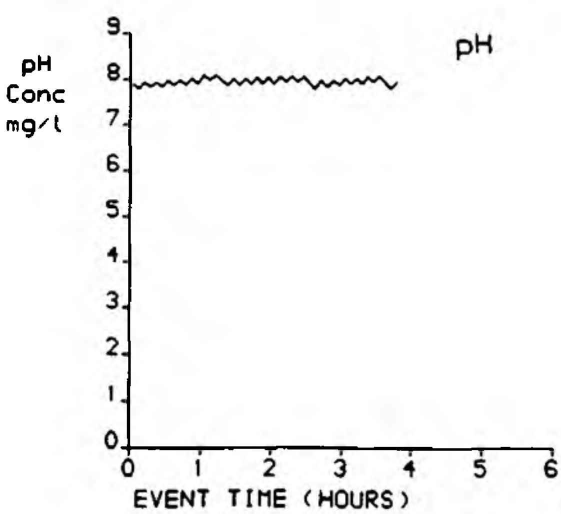


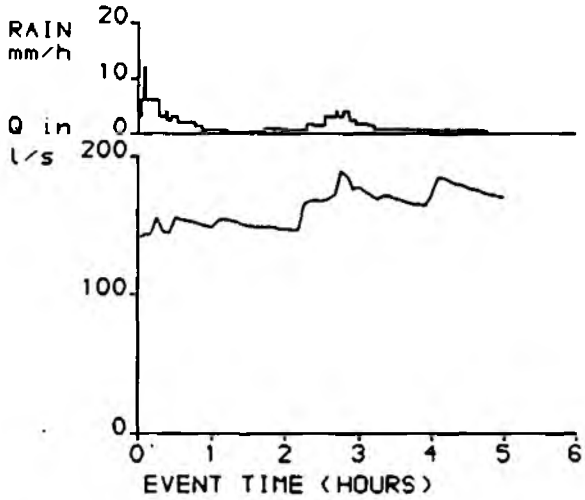
FIG 98

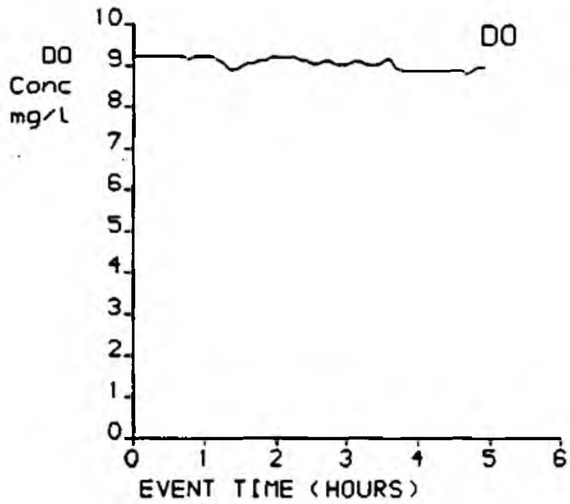
Site: NANT FFRWD, UNDER VIADUCT

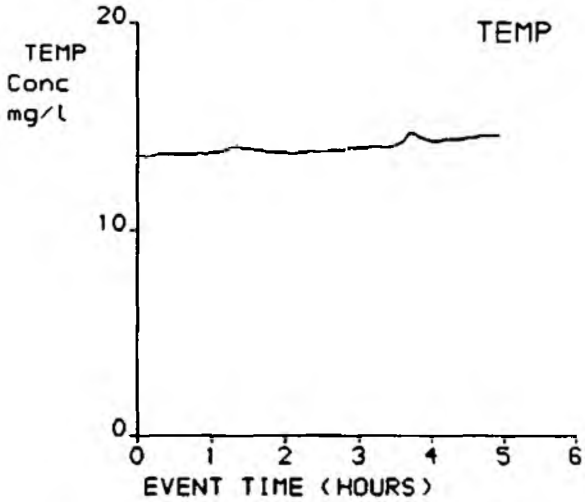
GN89091 6D1 .DAT

Grid Ref: 262043
Storm Date: 890916
Start Time (R/F): 850
Rainfall Depth (mm): 7.4

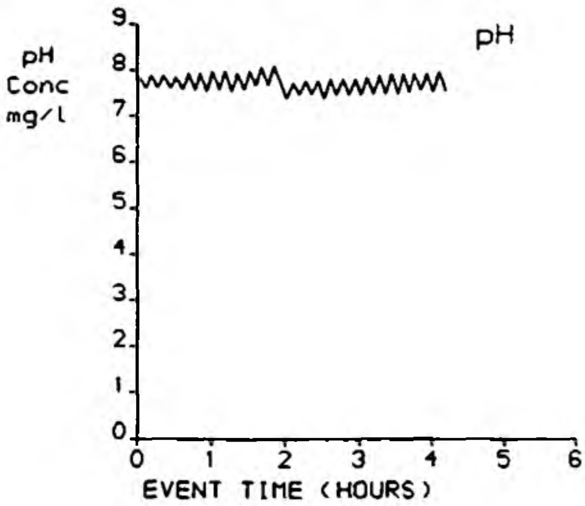
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 907.



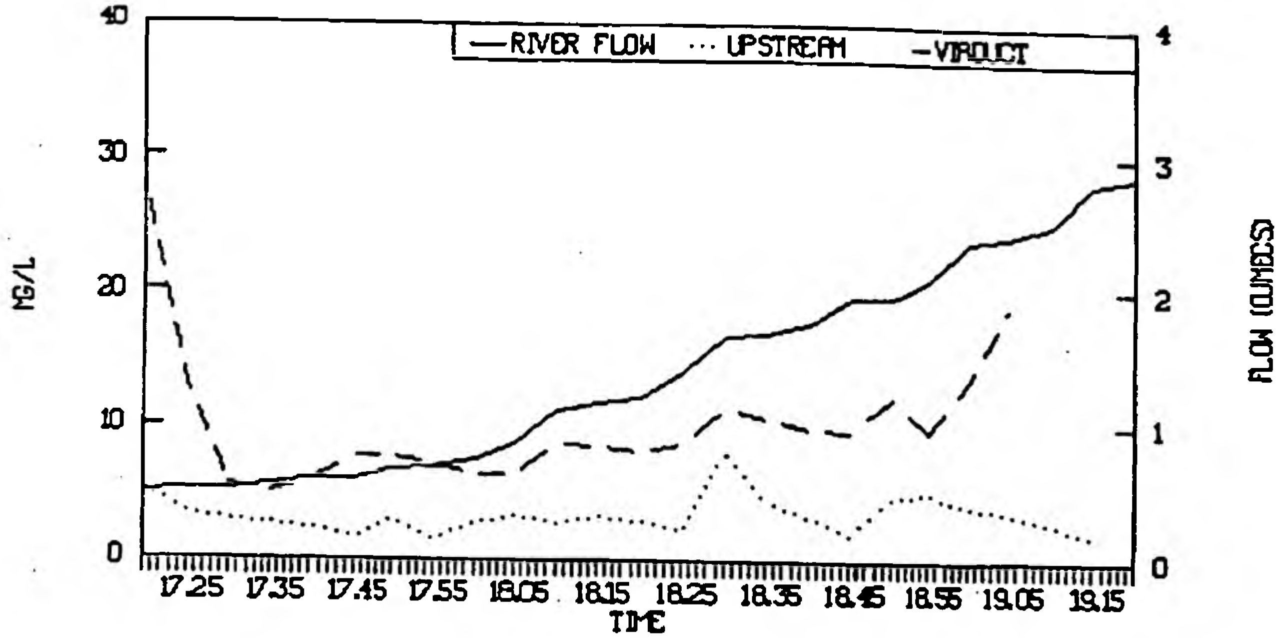




NO DATA FOR Cond



GARNDIFFAITH SSO EVENT 24 09-11-1989
BOD CONCENTRATIONS



GARNDIFFAITH SSO EVENT 24 09-11-1989
BOD LOADS

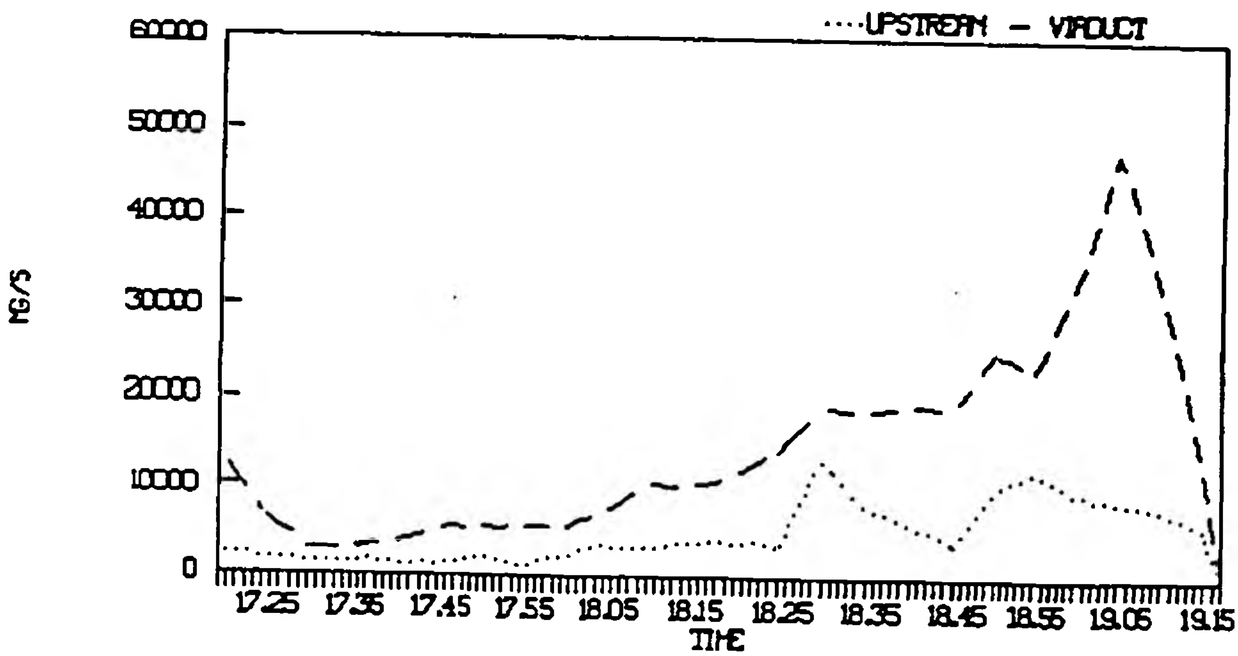
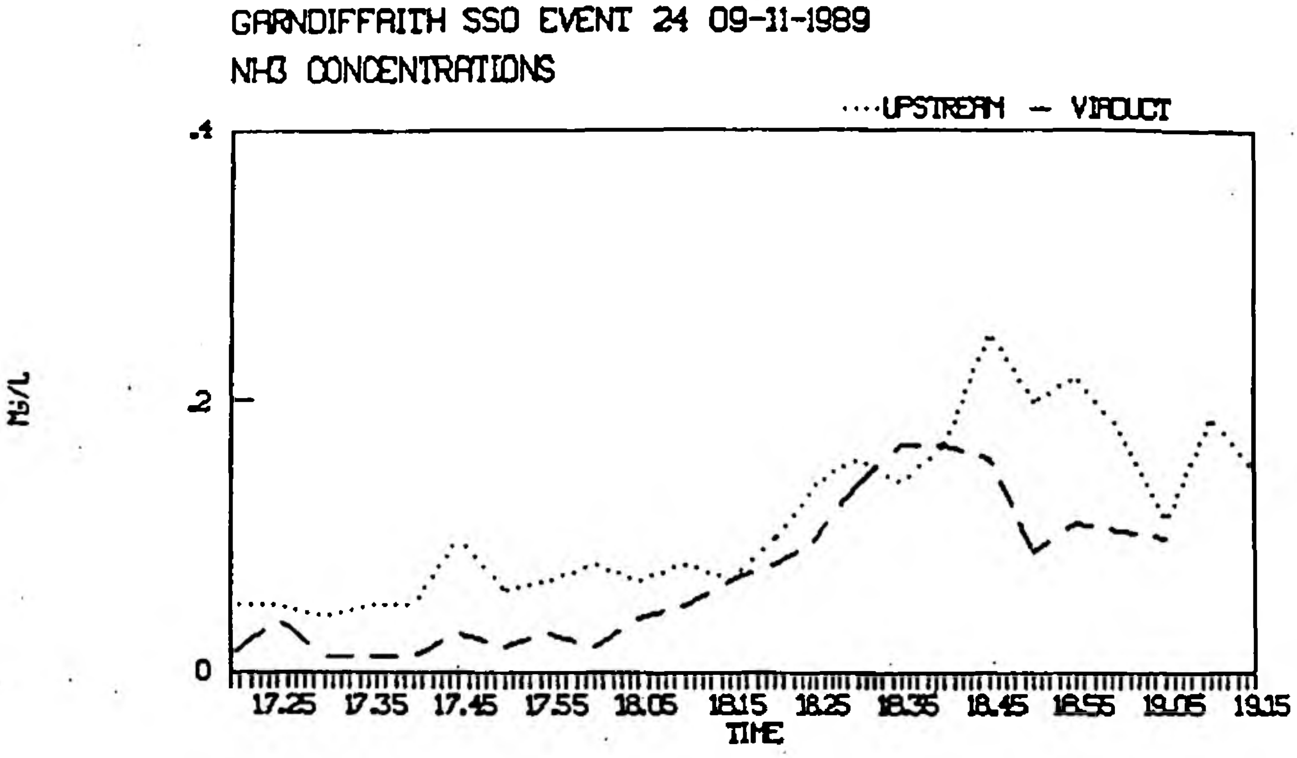
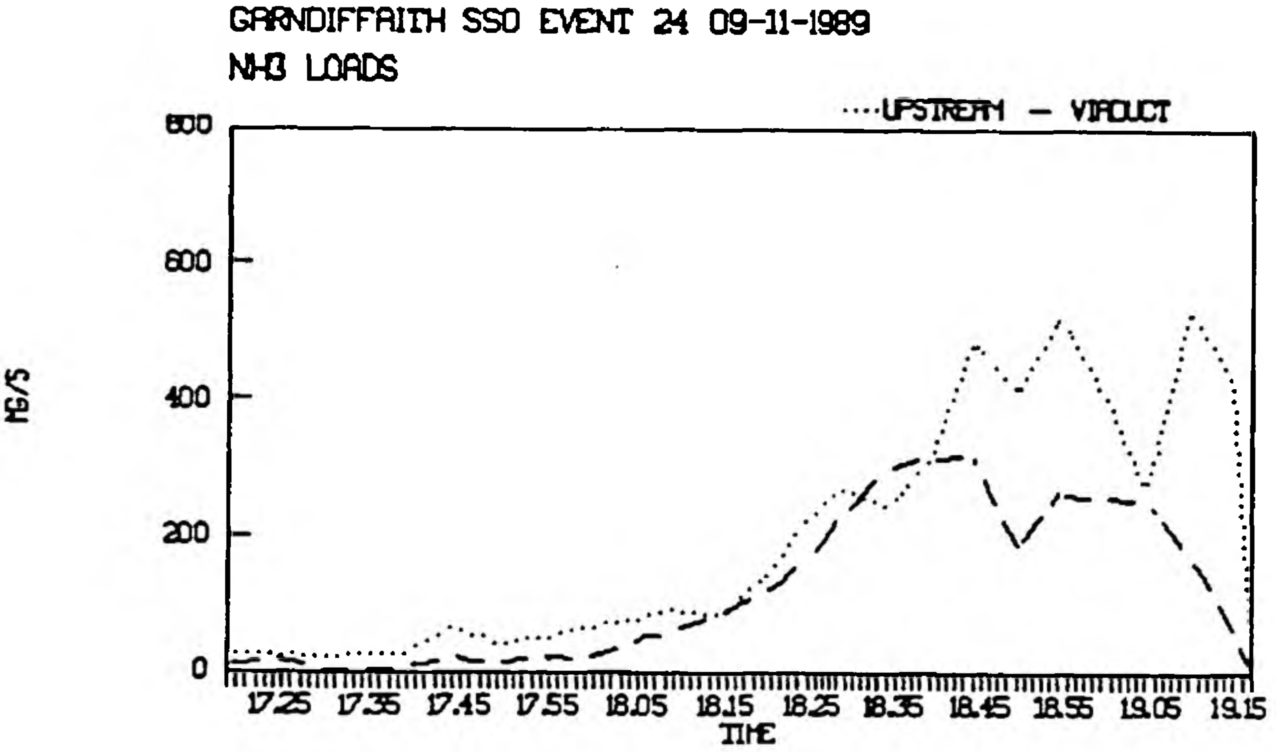
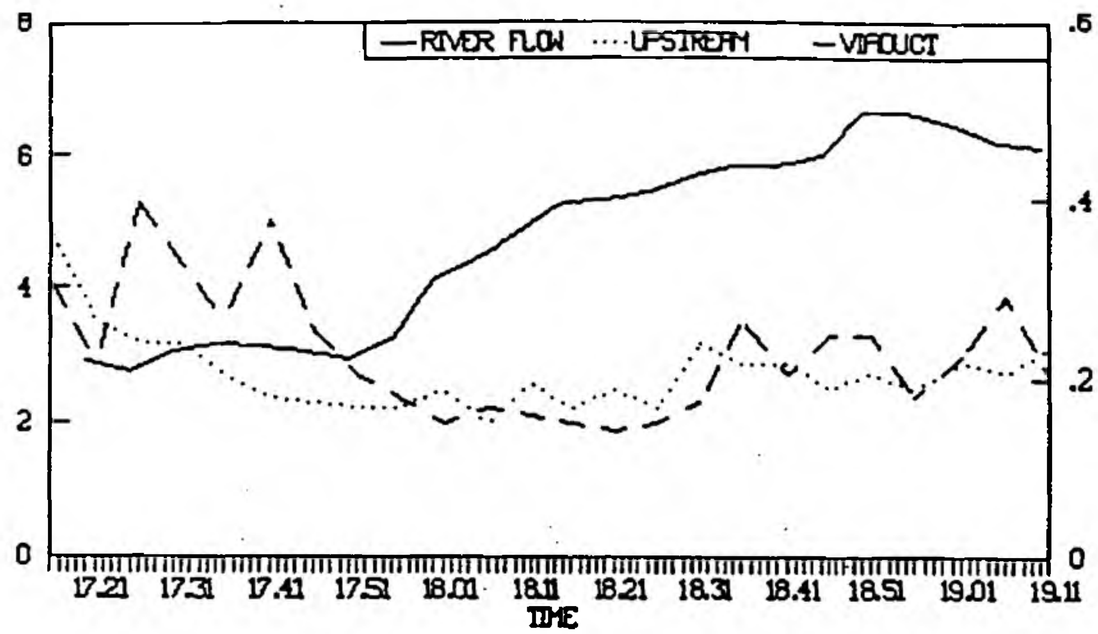


FIG.100

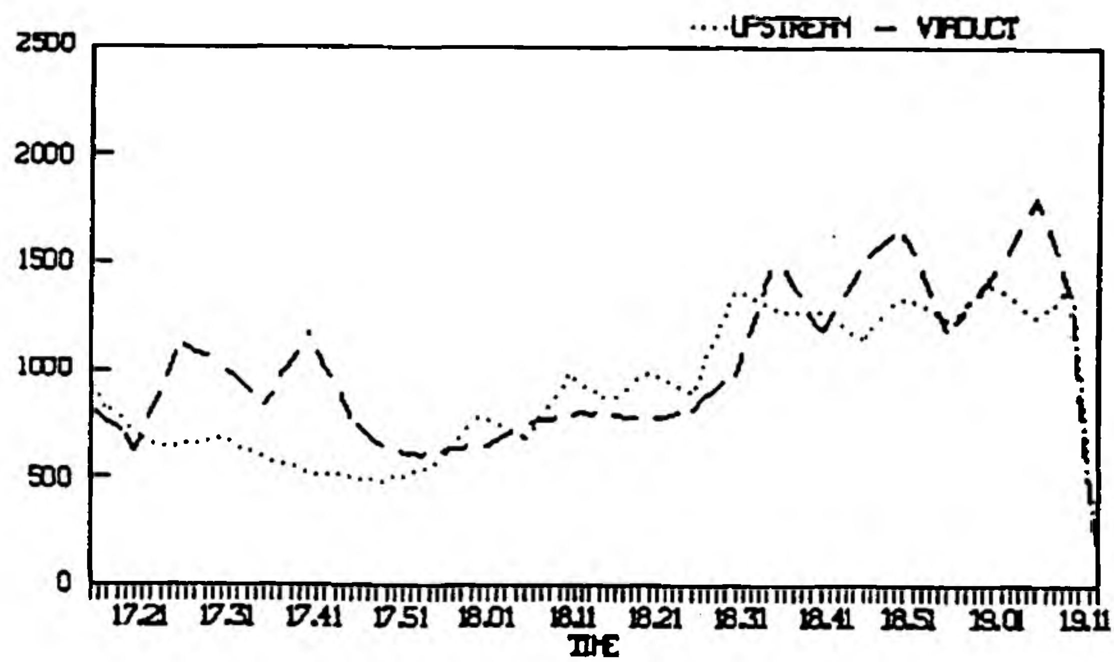

GARNDIFFAITH SSO EVENT 24 09-11-1989
NH3 CONCENTRATIONS
····UPSTREAM — VIADUCT
MG/L
.4
.2
0
17.25 17.35 17.45 17.55 18.05 18.15 18.25 18.35 18.45 18.55 19.05 19.15
TIME


GARNDIFFAITH SSO EVENT 24 09-11-1989
NH3 LOADS
····UPSTREAM — VIADUCT
MG/S
800
600
400
200
0
17.25 17.35 17.45 17.55 18.05 18.15 18.25 18.35 18.45 18.55 19.05 19.15
TIME

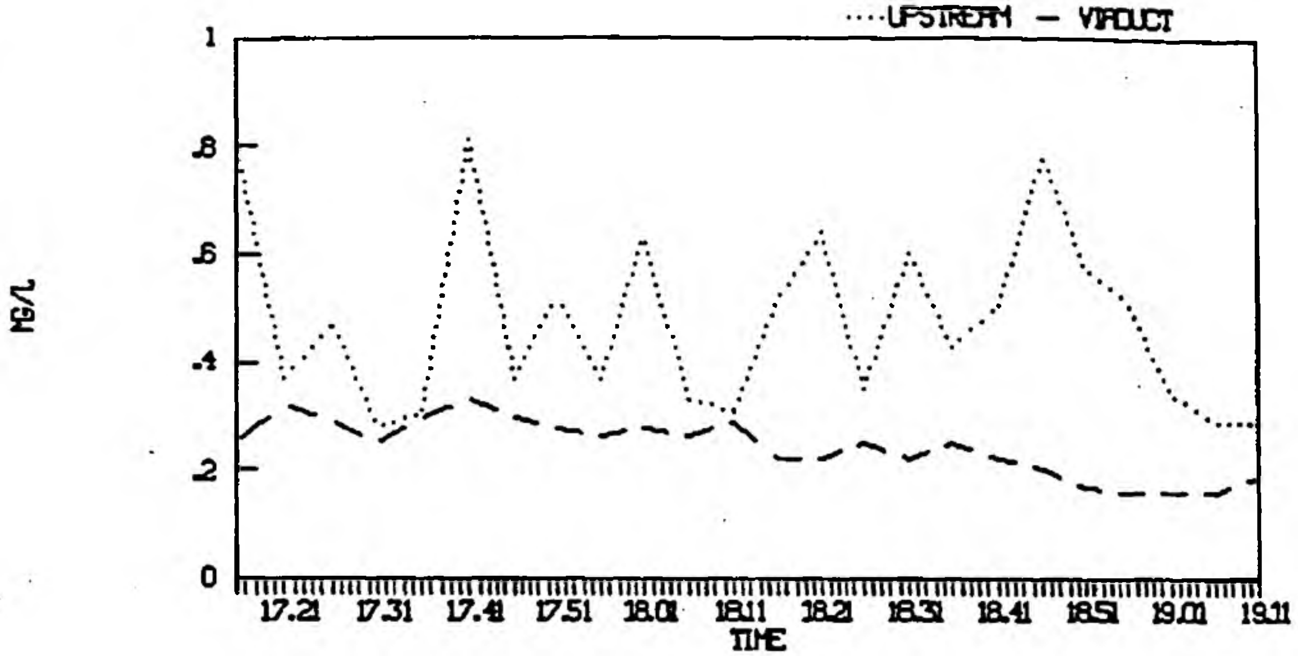
GARNDIFFAITH SSO EVENT 12 18-10-88.
BOD CONCENTRATIONS



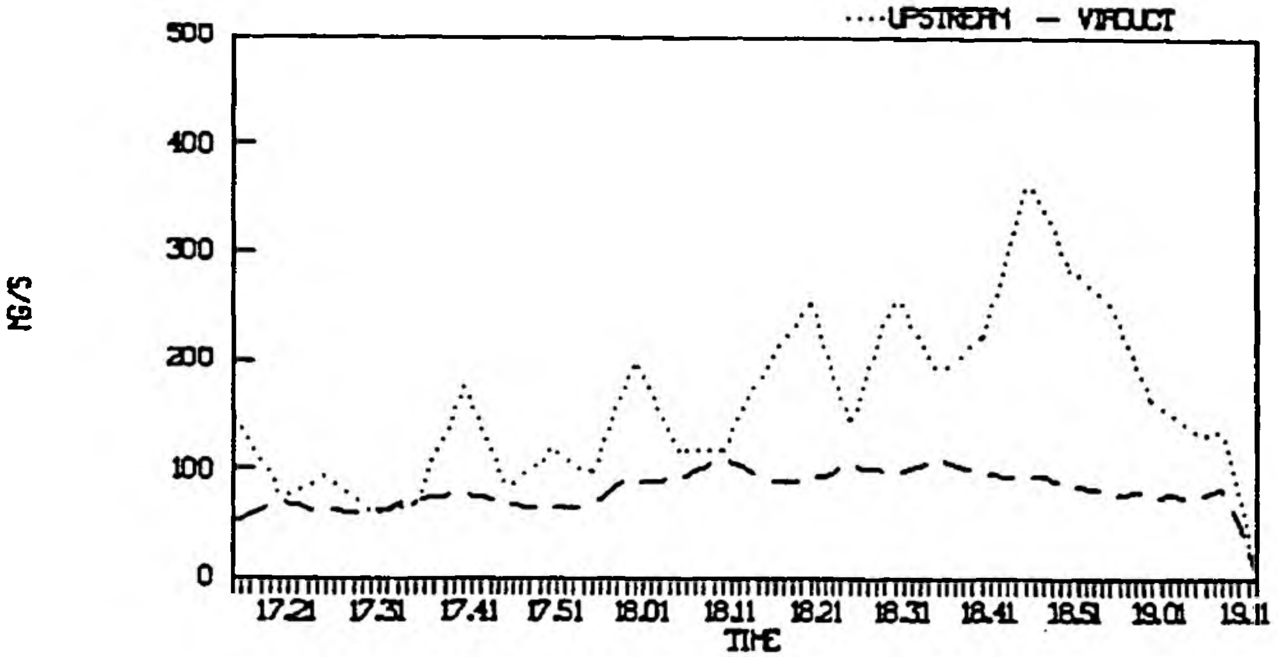
GARNDIFFAITH SSO EVENT 12 18-10-88.
BOD LOADS



GARNDIFFAITH SSO EVENT 12 18-10-88
NH3 CONCENTRATIONS

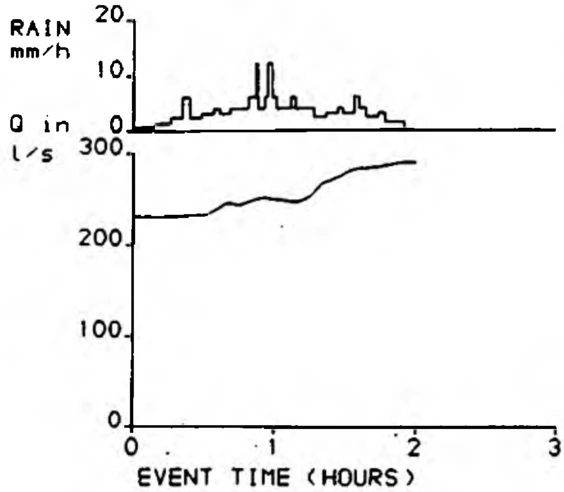


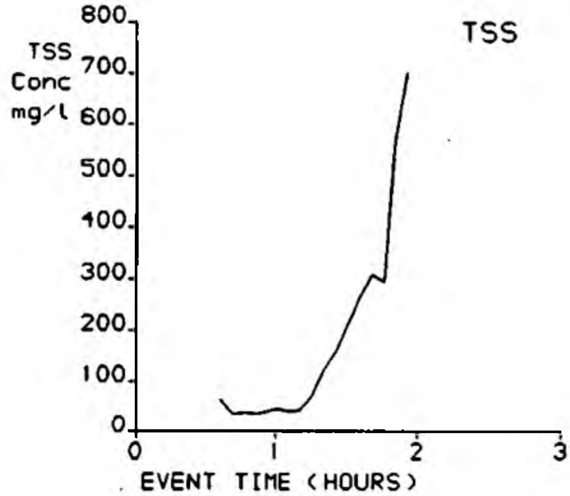
GARNDIFFAITH SSO EVENT 12 18-10-88
NH3 LOADS



Site: NANT FFRWD, U/S SSO GARNDIFFAITH GN881018U1.DAT

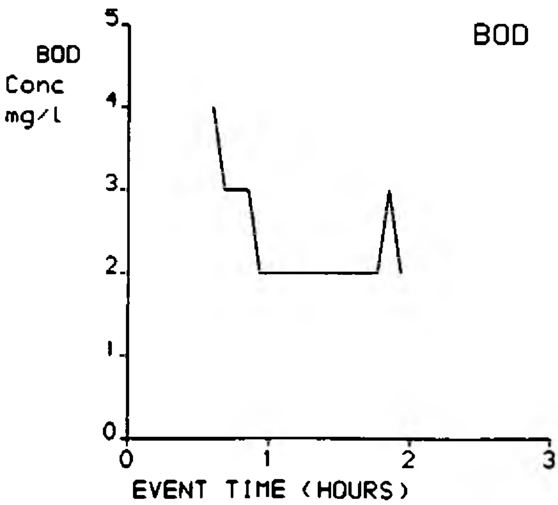
Grid Ref: 262045
Storm Date: 881018
Start Time (R/F): 1640
Rainfall Depth (mm): 6.4
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 107.

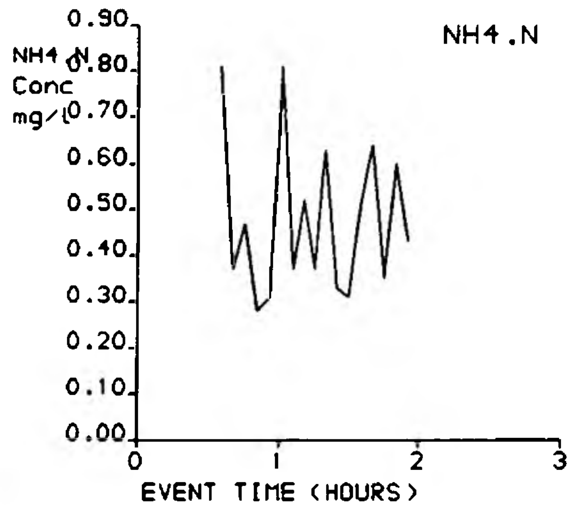




NO DATA FOR COD

NO DATA FOR TDS





Site: NANT FFRWD,U/S SSO GARNDIFFAITH GN881018U1.DAT

Grid Ref: 262045
Storm Date: 881018
Start Time (R/F): 1640
Rainfall Depth (mm): 6.4

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 107.

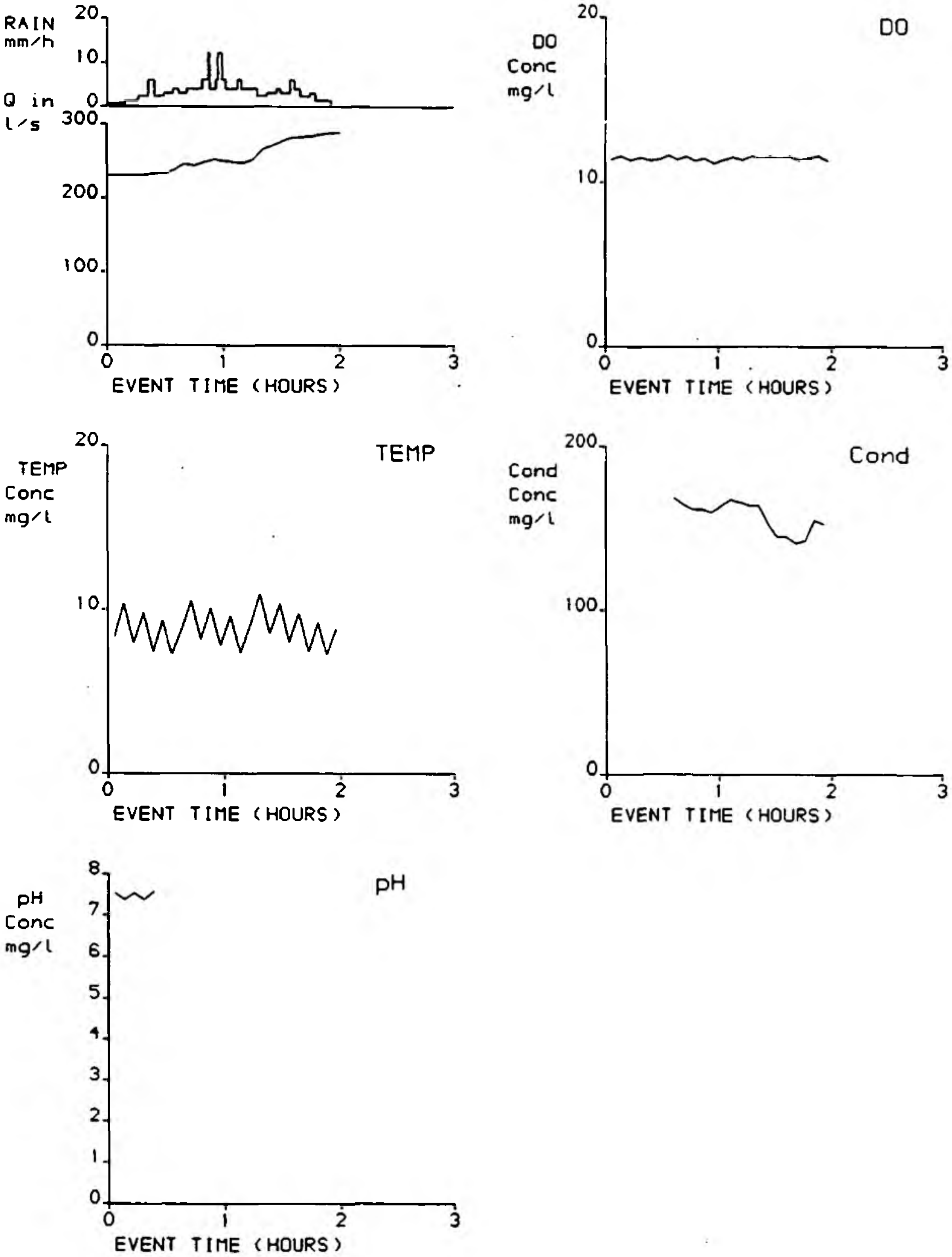
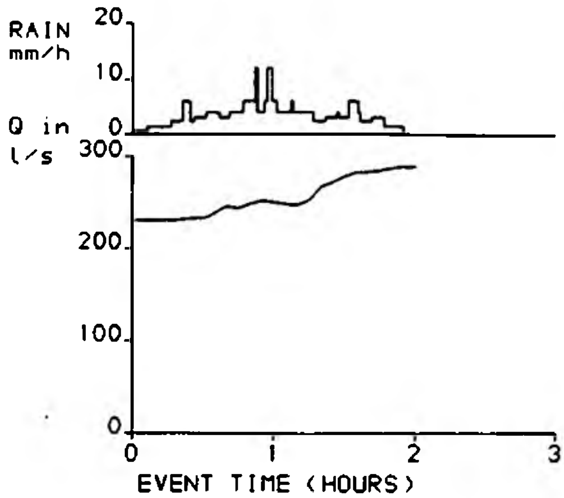


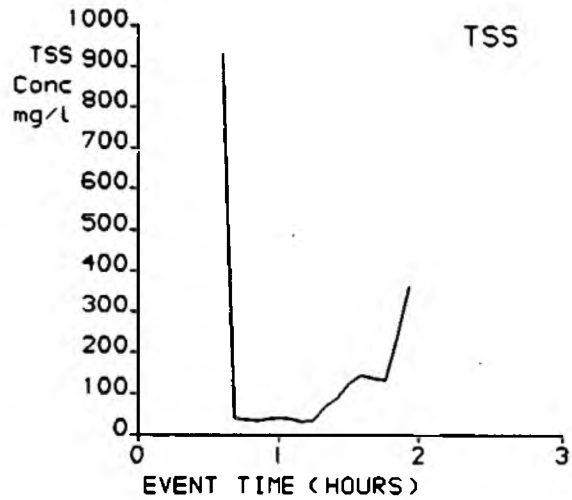
FIG.105

Site: NANT FFRWD, VIADUCT RD, UNDER VIADUCT GN881018D1.DAT

Grid Ref: 262043
Storm Date: 881018
Start Time (R/F): 1640
Rainfall Depth (mm): 6.4

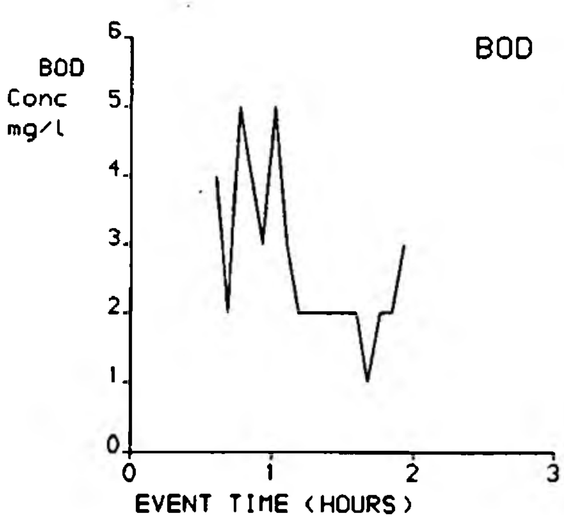
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 107.

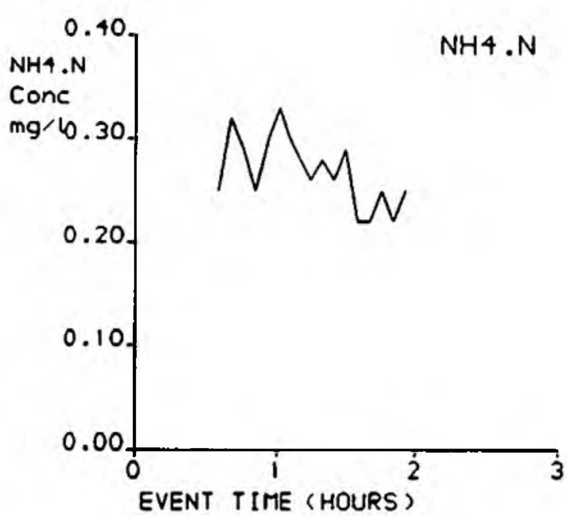




NO DATA FOR COD

NO DATA FOR TDS

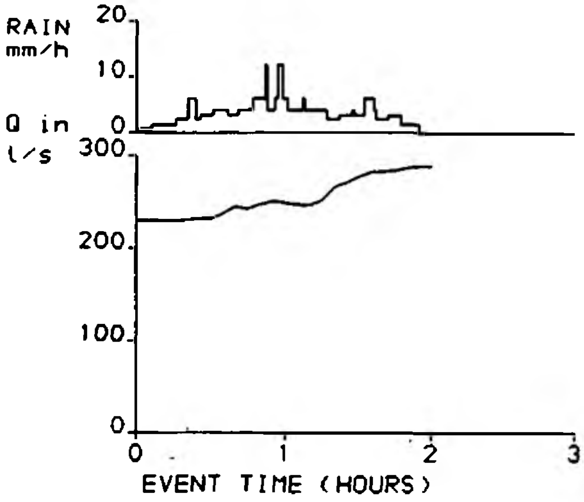




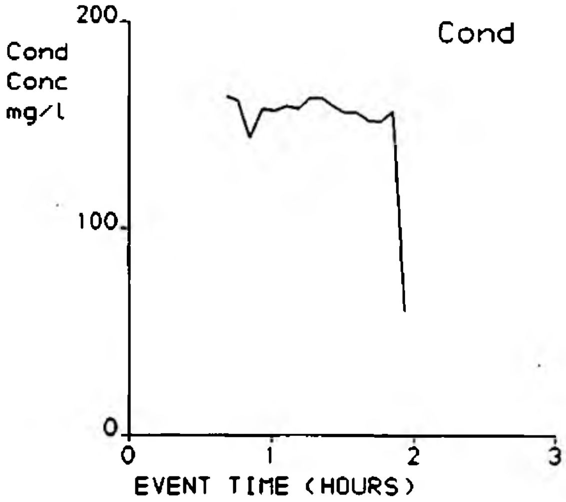
Site: NANT FFRWD, VIADUCT RD, UNDER VIADUCT GN881018D1.DAT

Grid Ref: 262043
Storm Date: 881018
Start Time (R/F): 1640
Rainfall Depth (mm): 6.4

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 107.



NO DATA FOR DO



NO DATA FOR TEMP

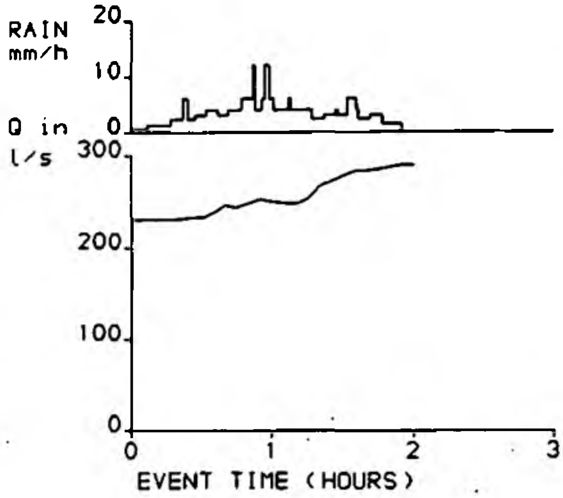
NO DATA FOR pH

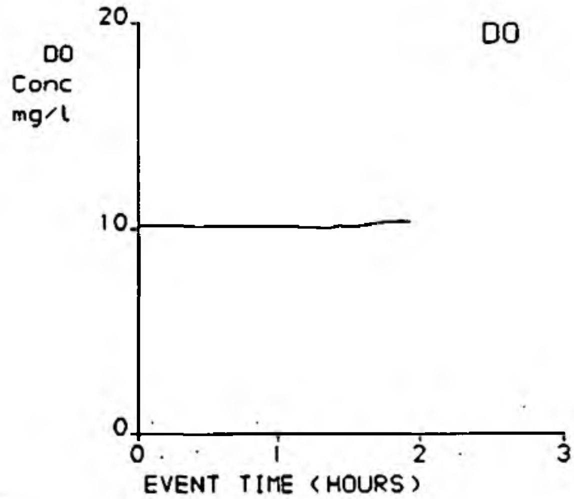
FIG. 107

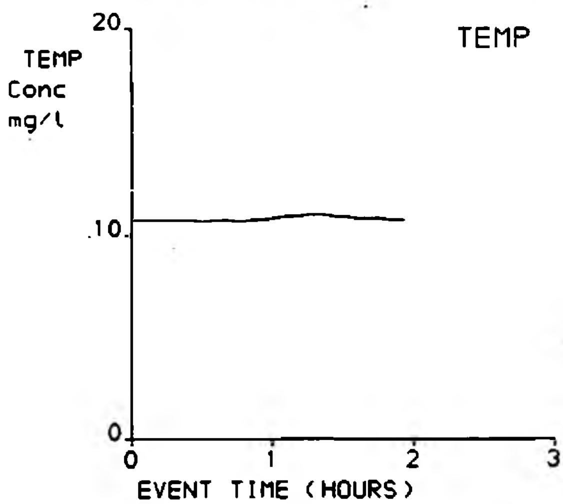
Site: NANT FFRWD, U/S VICTORIA RD BRIDGE GN881018D2.DAT

Grid Ref: 262042
Storm Date: 881018
Start Time (R/F): 1640
Rainfall Depth (mm): 6.4

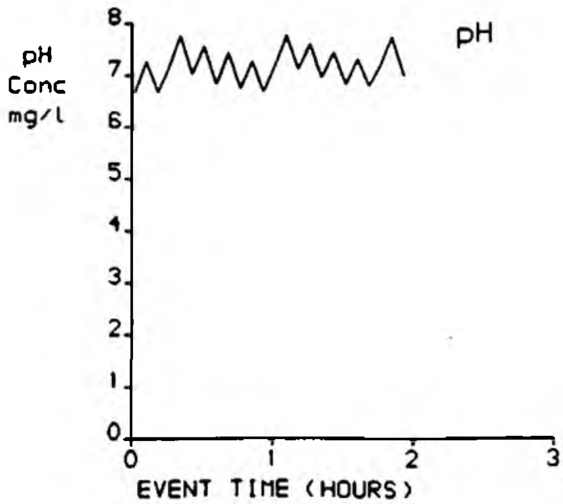
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 107.

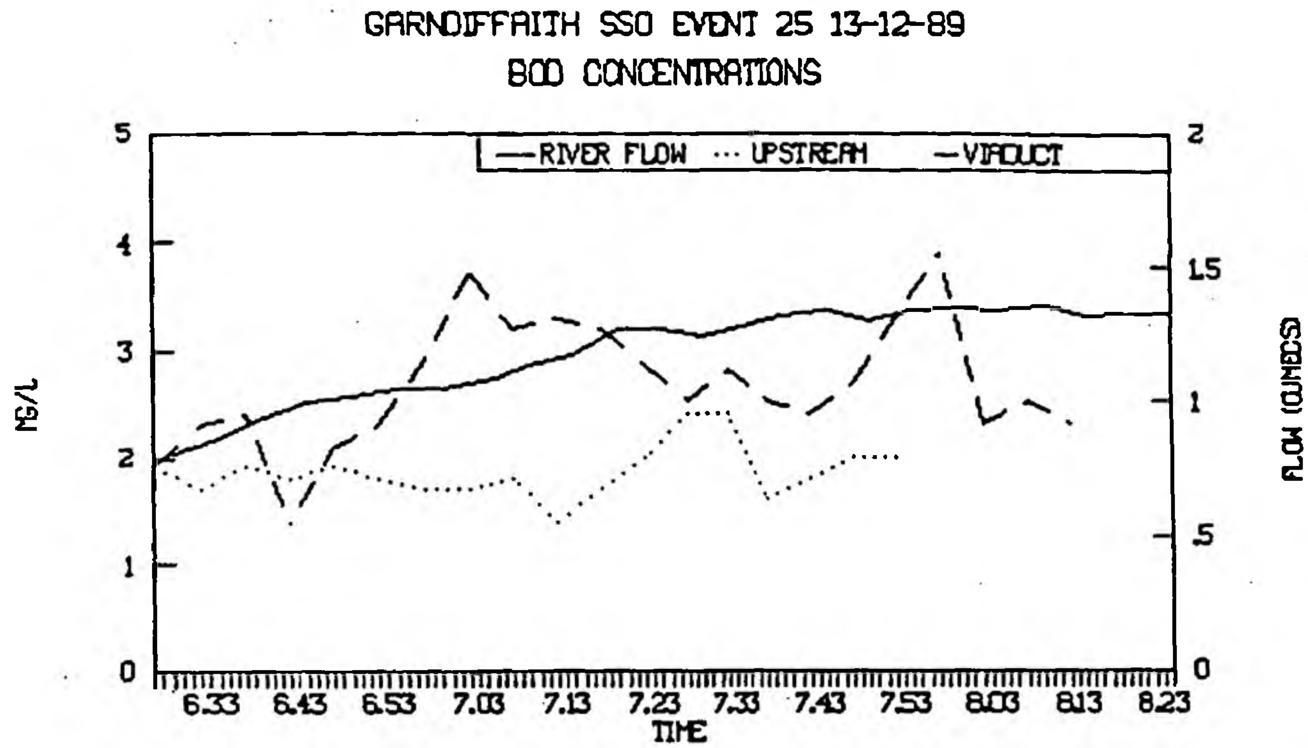


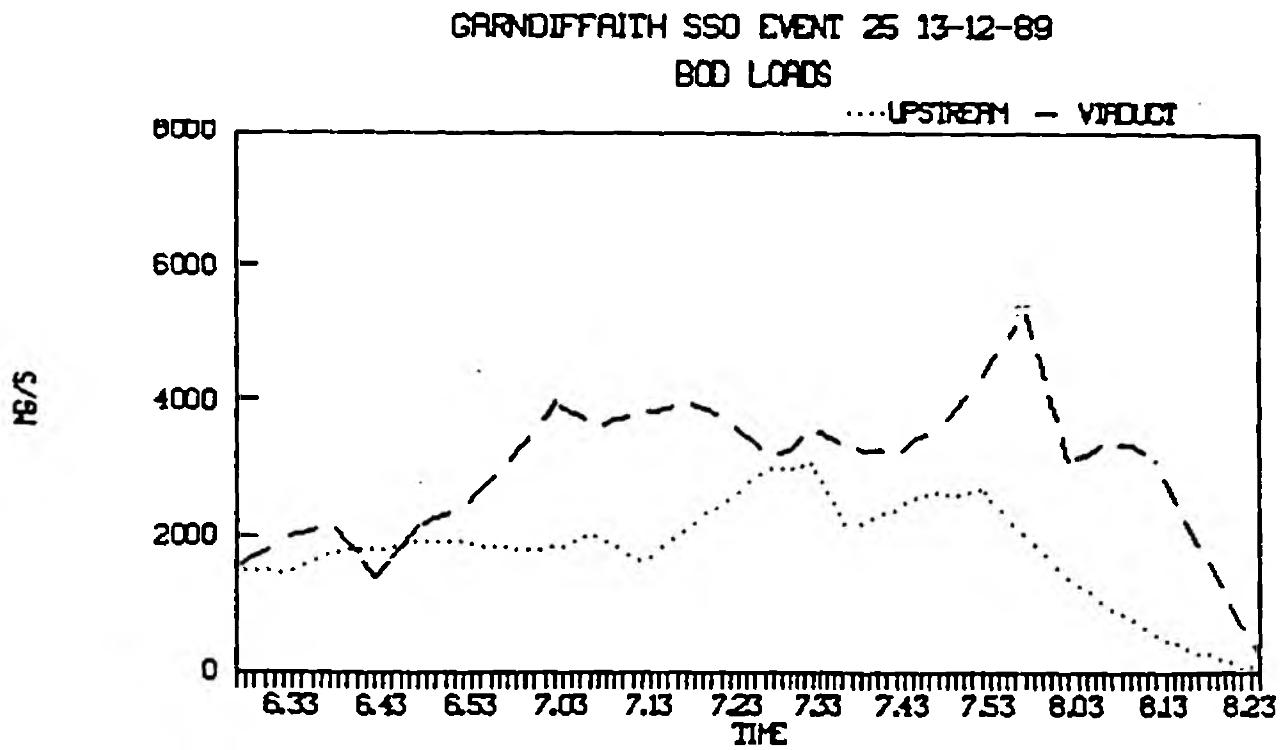


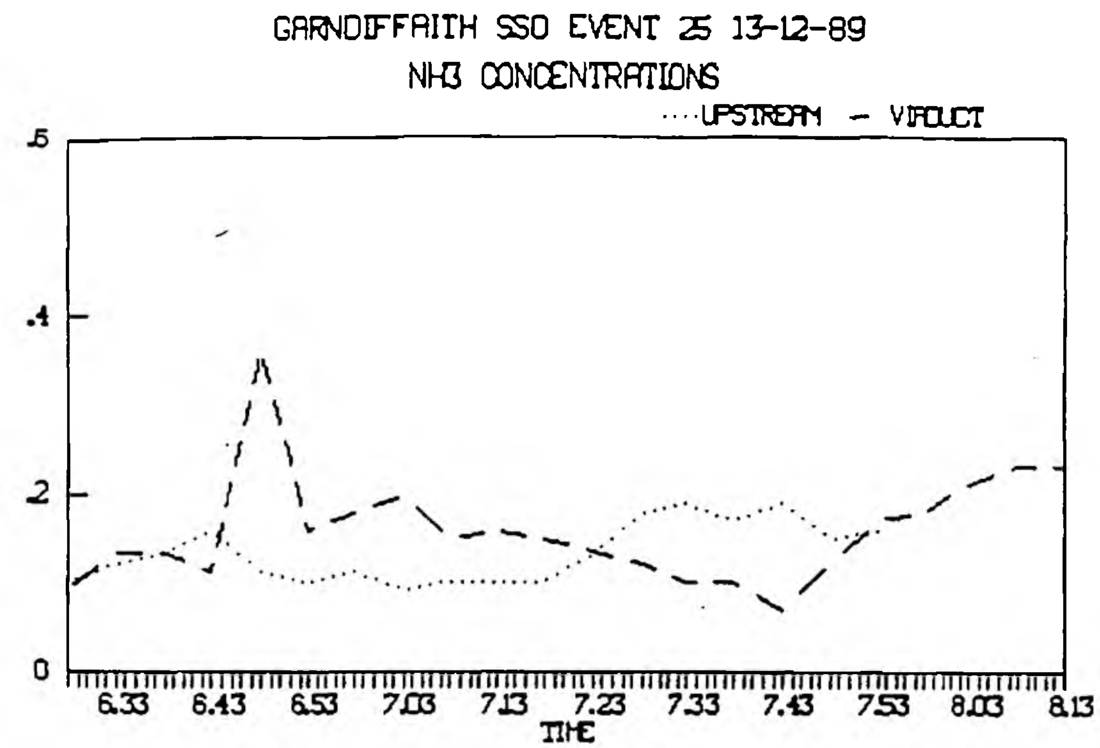


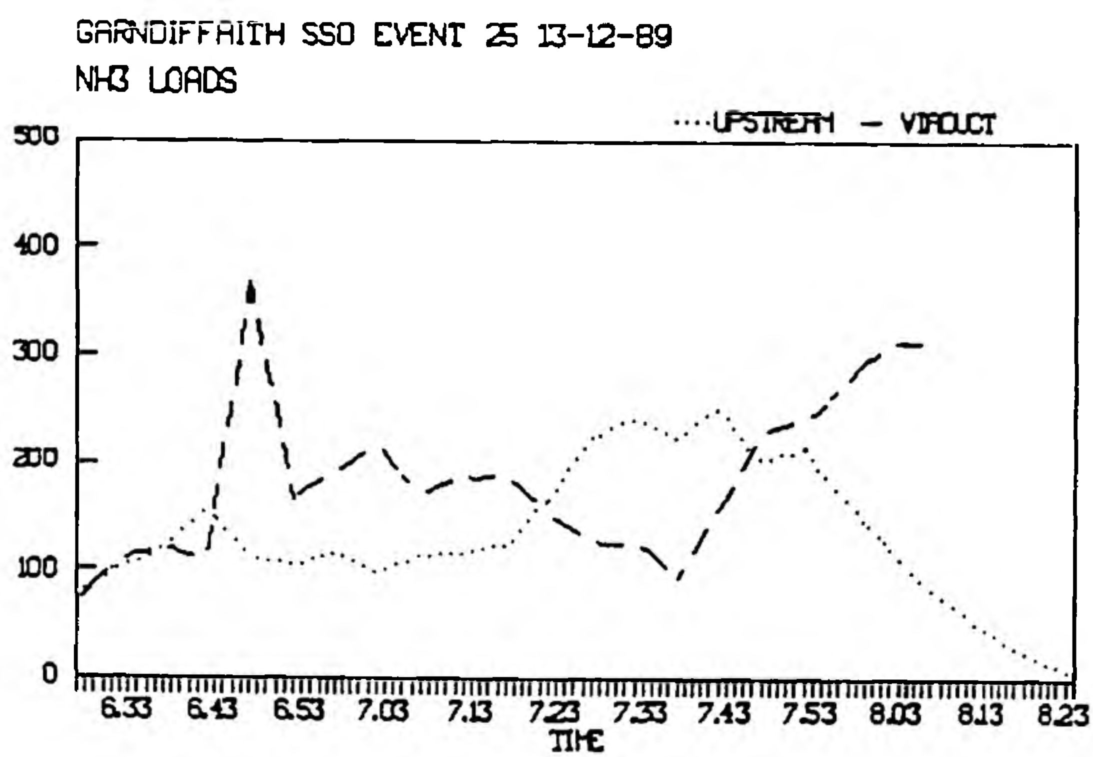
NO DATA FOR Cond




GARNDIFFAITH SSO EVENT 25 13-12-89
BOD CONCENTRATIONS
RIVER FLOW
UPSTREAM
VIADUCT
MG/L
FLOW (CUMECS)
TIME
6.33 6.43 6.53 7.03 7.13 7.23 7.33 7.43 7.53 8.03 8.13 8.23

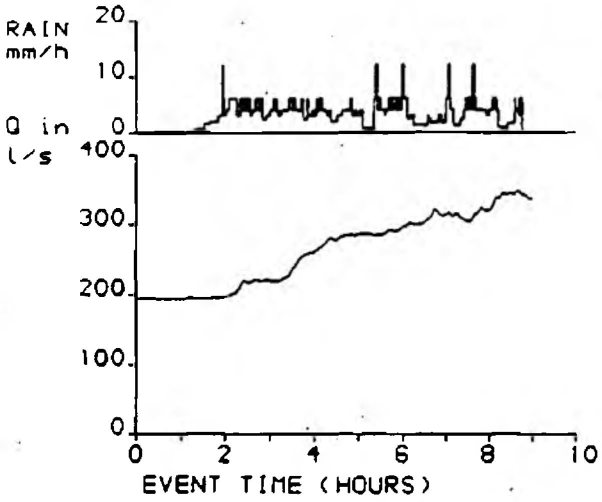

GARNDIFFAITH SSO EVENT 25 13-12-89
BOD LOADS
UPSTREAM
VIADUCT
MG/S
TIME
6.33 6.43 6.53 7.03 7.13 7.23 7.33 7.43 7.53 8.03 8.13 8.23

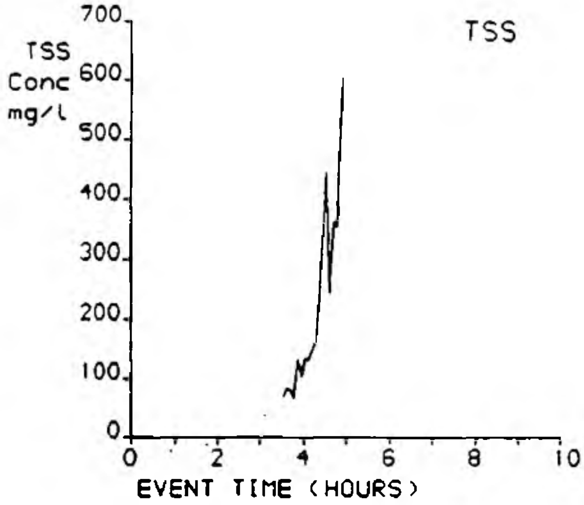

GARNDIFFAITH SSO EVENT 25 13-12-89
NH3 CONCENTRATIONS
····UPSTREAM — VIADUCT
.5
.4
.2
0
6.33 6.43 6.53 7.03 7.13 7.23 7.33 7.43 7.53 8.03 8.13
TIME


GARNDIFFAITH SSO EVENT 25 13-12-89
NH3 LOADS
····UPSTREAM — VIADUCT
500
400
300
200
100
0
6.33 6.43 6.53 7.03 7.13 7.23 7.33 7.43 7.53 8.03 8.13 8.23
TIME

Site: NANT FFRWD,U/S SSO GARNDIFFAITH GN891213U1.DAT

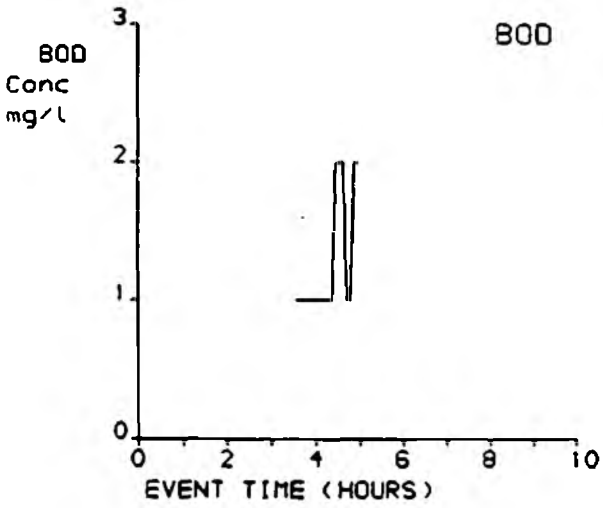
Grid Ref: 262045 Weather Conditions:
Storm Date: 891213 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 300 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 26.6 Rainfall Event Duration (mins): 1235.

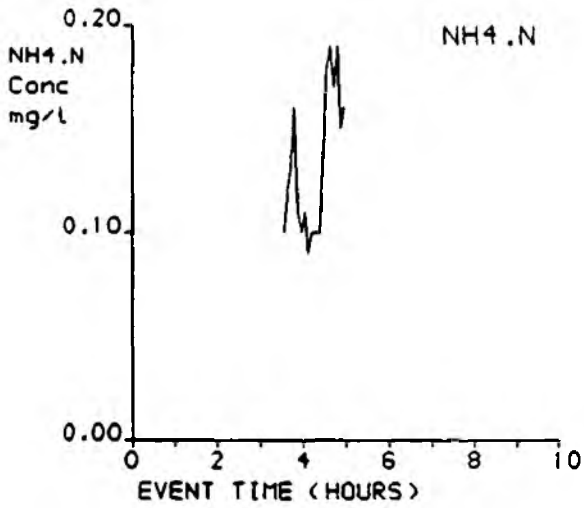




NO DATA FOR COD

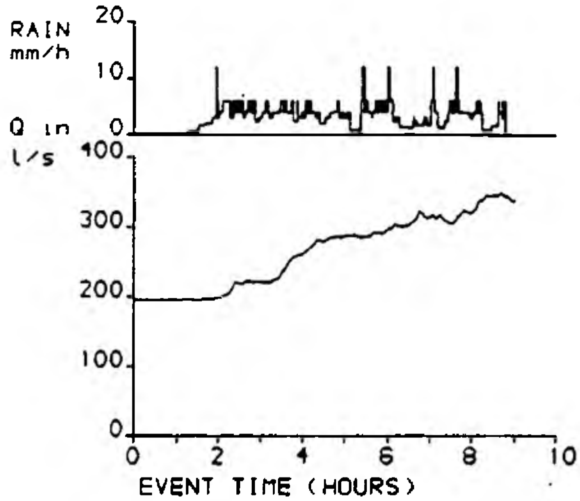
NO DATA FOR TDS

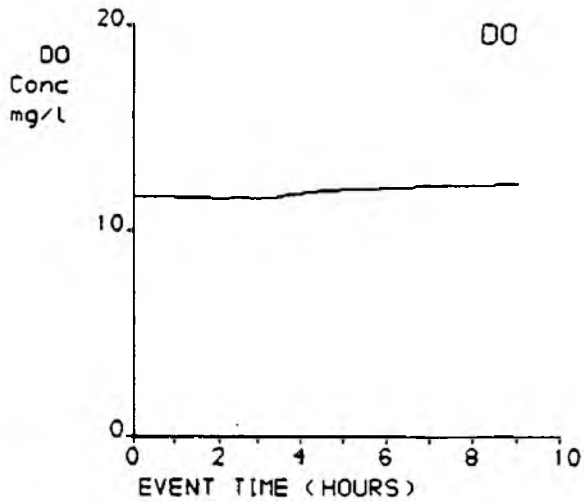


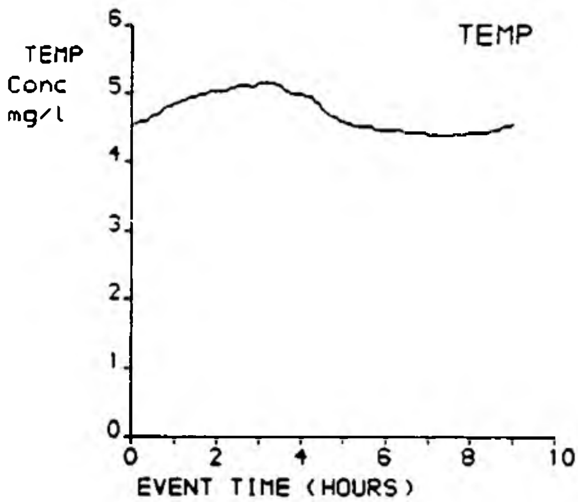


Site: NANT FFRWD,U/S SSO GARNDIFFAITH GN891213U1.DAT

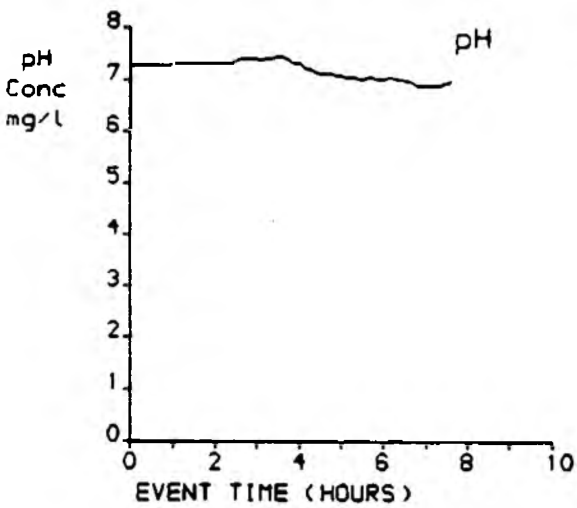
Grid Ref: 262045 Weather Conditions:
Storm Date: 891213 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 300 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 26.6 Rainfall Event Duration (mins): 1235.







NO DATA FOR Cond

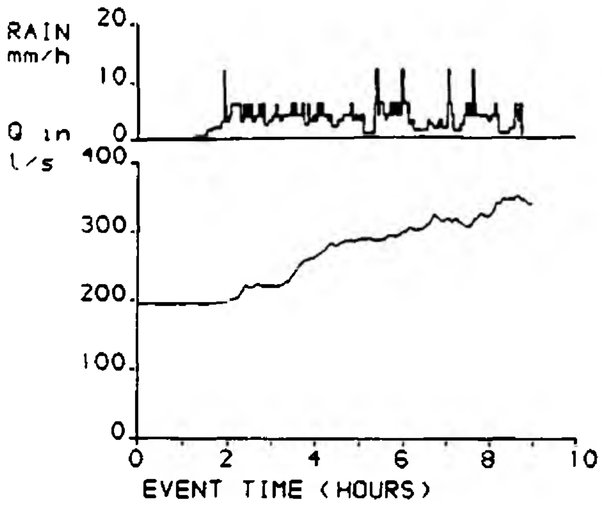


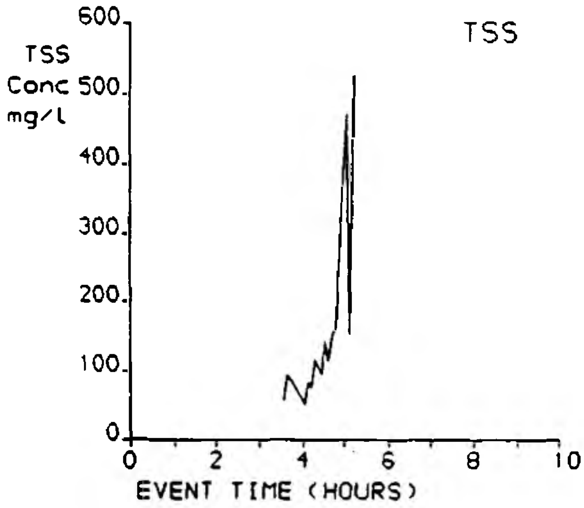
Site: NANT FFRWD, UNDER VIADUCT

GN891213D1.DAT

Grid Ref: 262043
Storm Date: 891213
Start Time (R/F): 300
Rainfall Depth (mm): 26.6

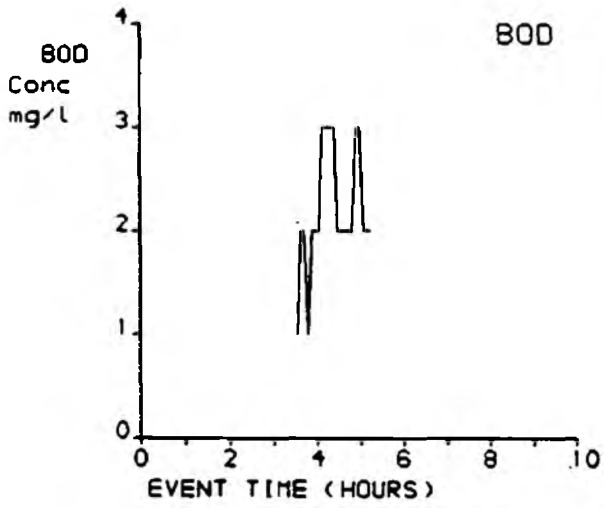
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 1235.

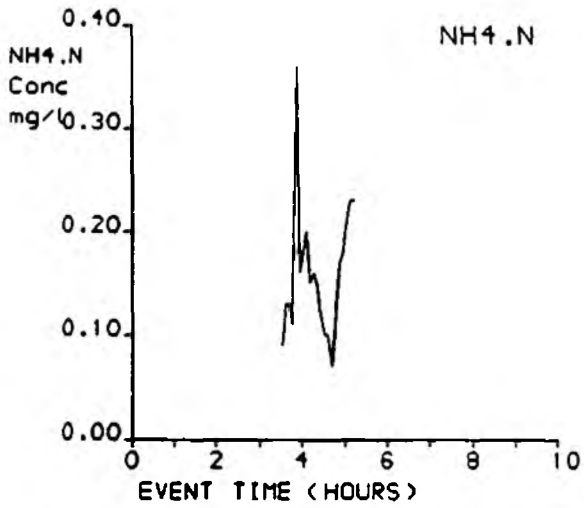




NO DATA FOR COD

NO DATA FOR TDS



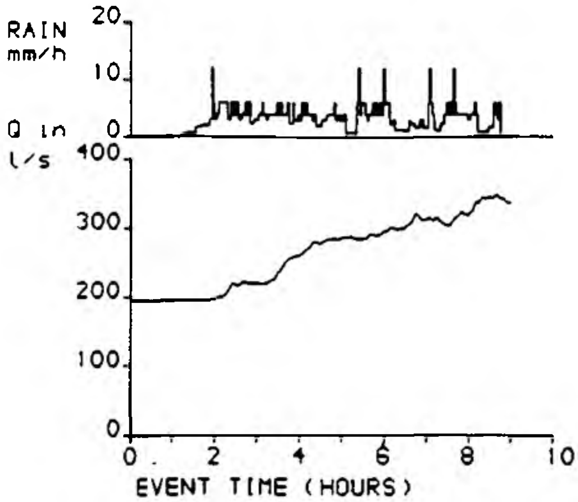


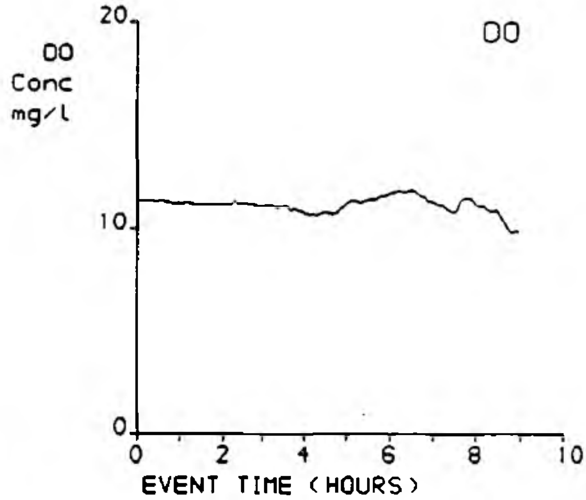
Site: NANT FFRWD,UNDER VIADUCT

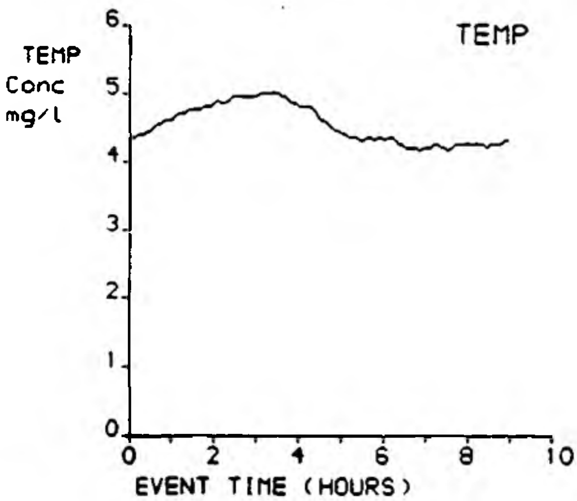
GN891213D1.DAT

Grid Ref: 262043
Storm Date: 891213
Start Time (R/F): 300
RainFall Depth (mm): 26.6

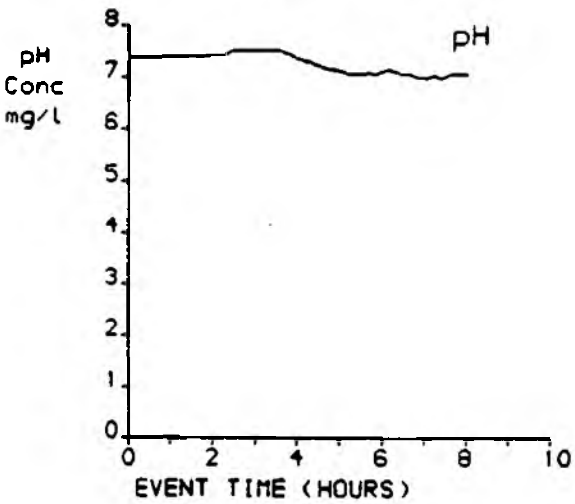
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
RainFall Event Duration (mins): 1235.







NO DATA FOR Cond



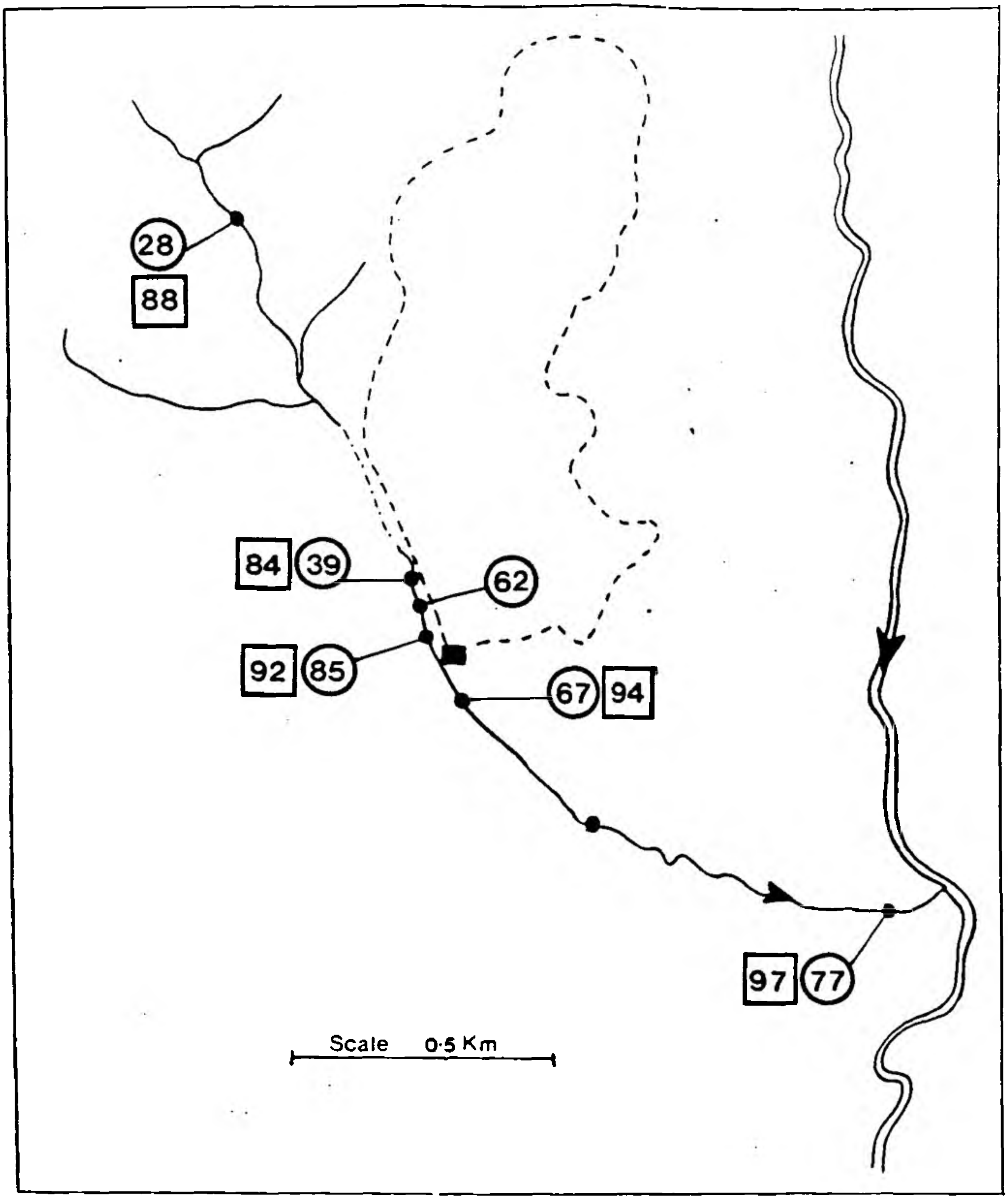
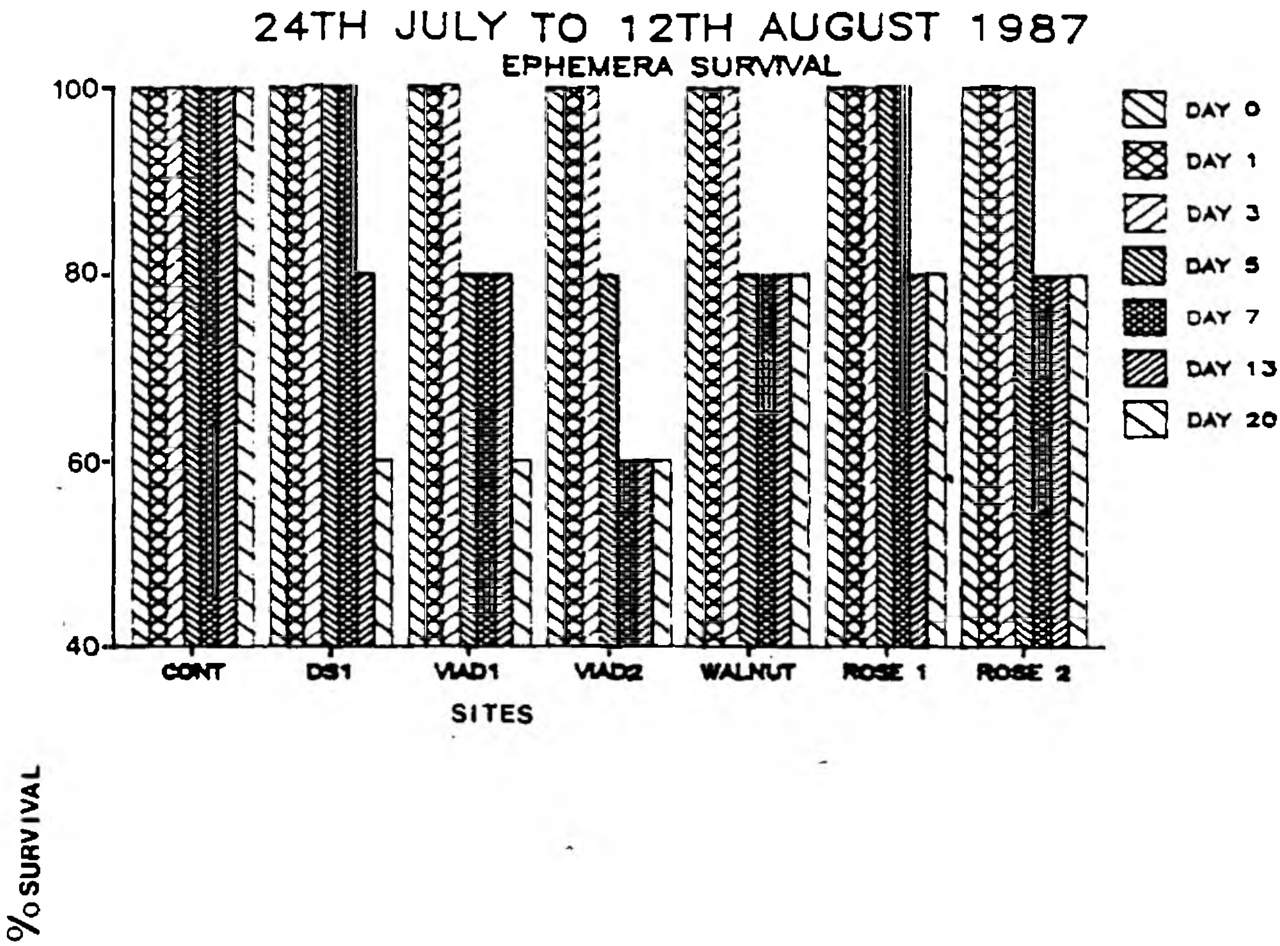


Fig.114 Biological Monitoring Working Party Scores (BMWP) for the Nant Ffrwd in July 1987 ◯ and October 1989 ☐

Fig. 115 Results of the macroinvertebrate bioassay tests.



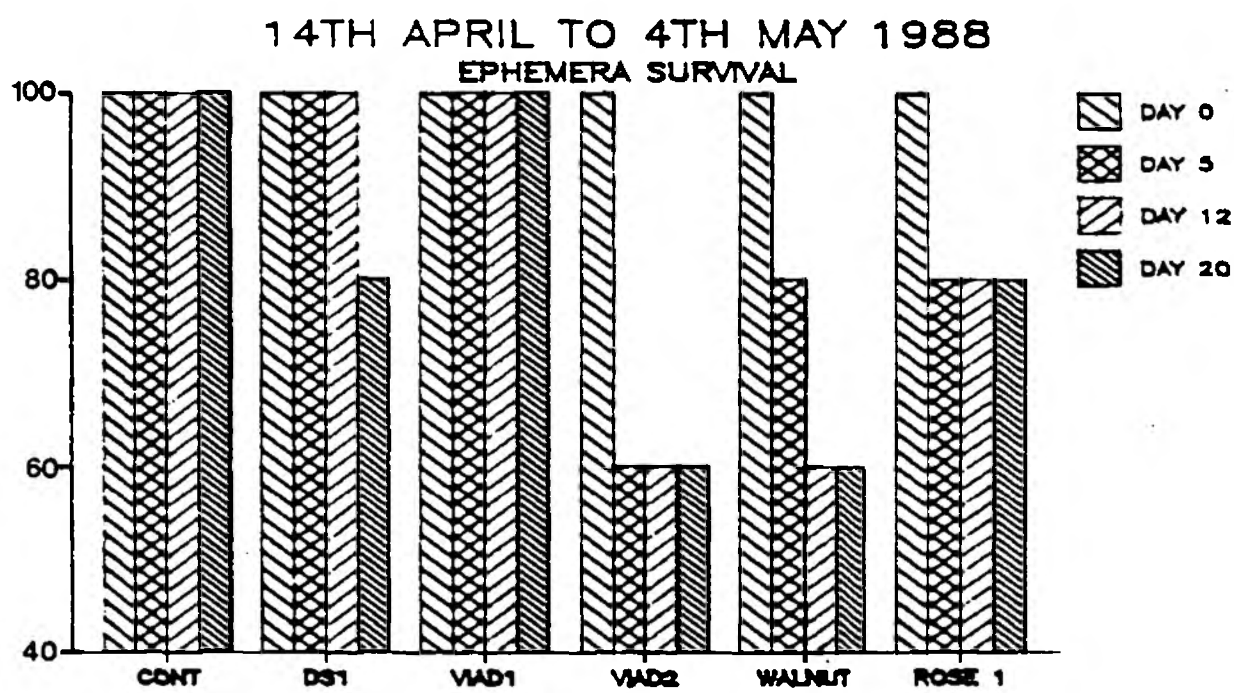


PLATE 1 CSO Chamber Entry.

PLATE 2 High Side Weir - with scum boards.

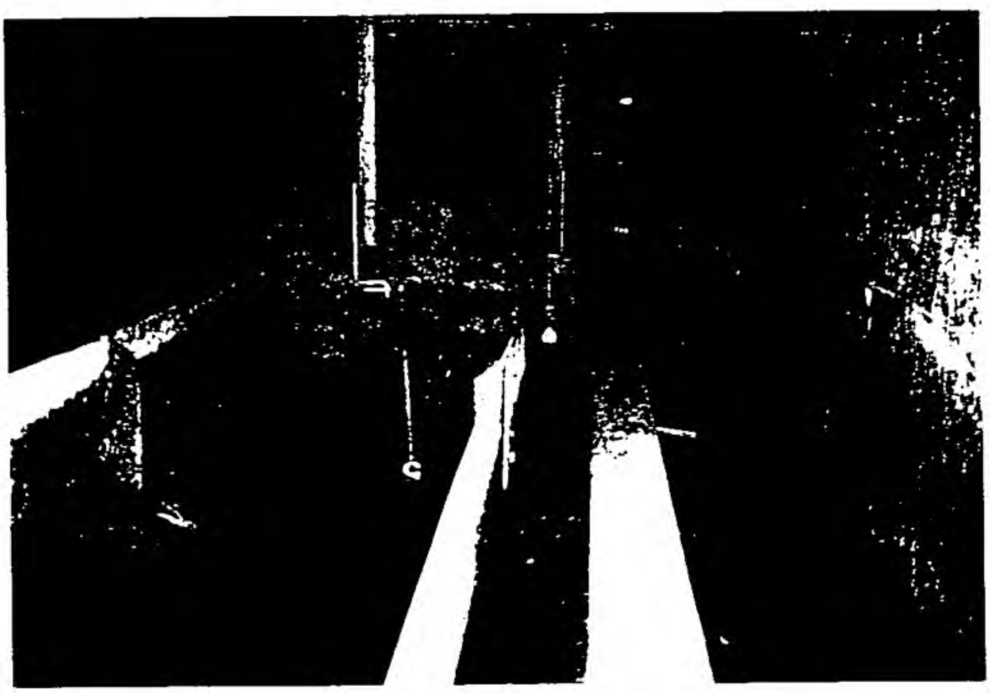


PLATE 3 Viaduct Sampling Site Approaches.

PLATE 4 View Upstream from Viaduct (CSO on the right).

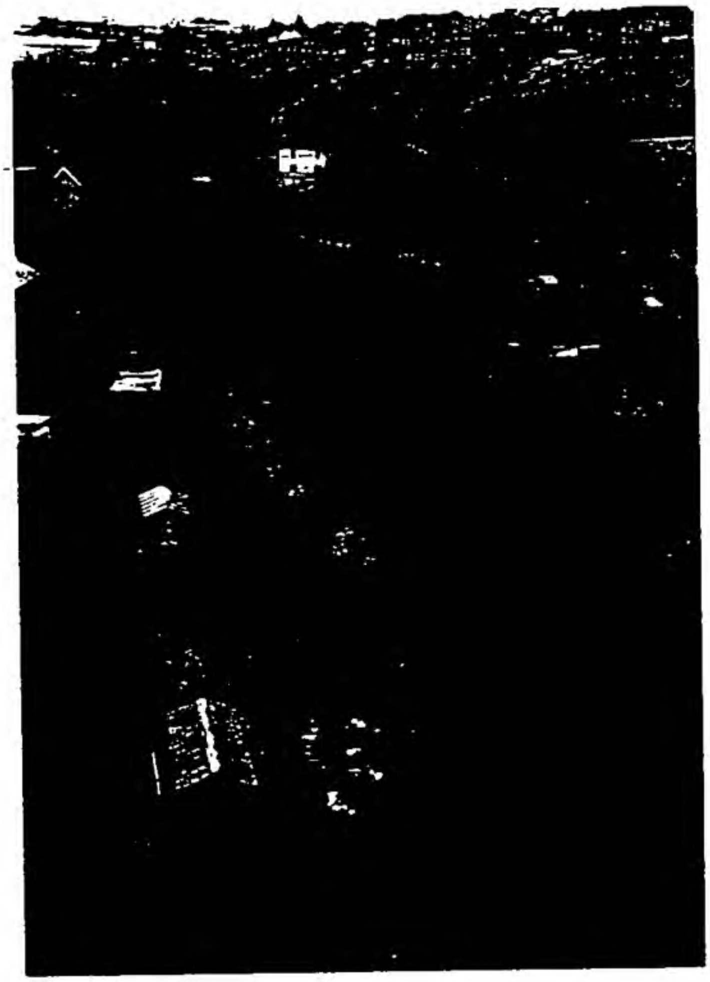
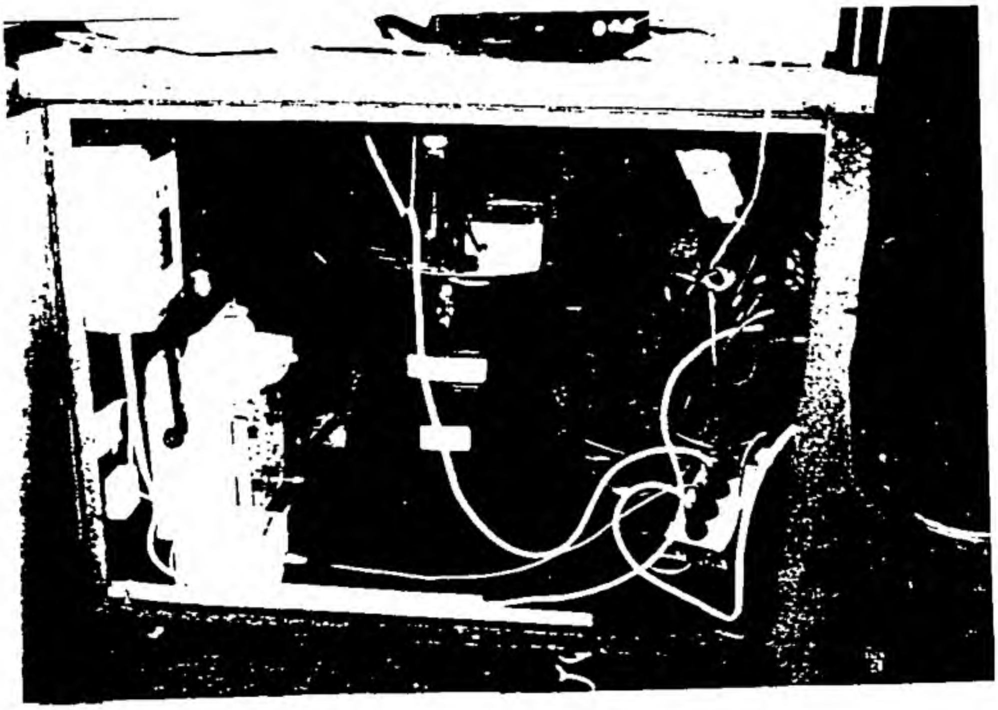


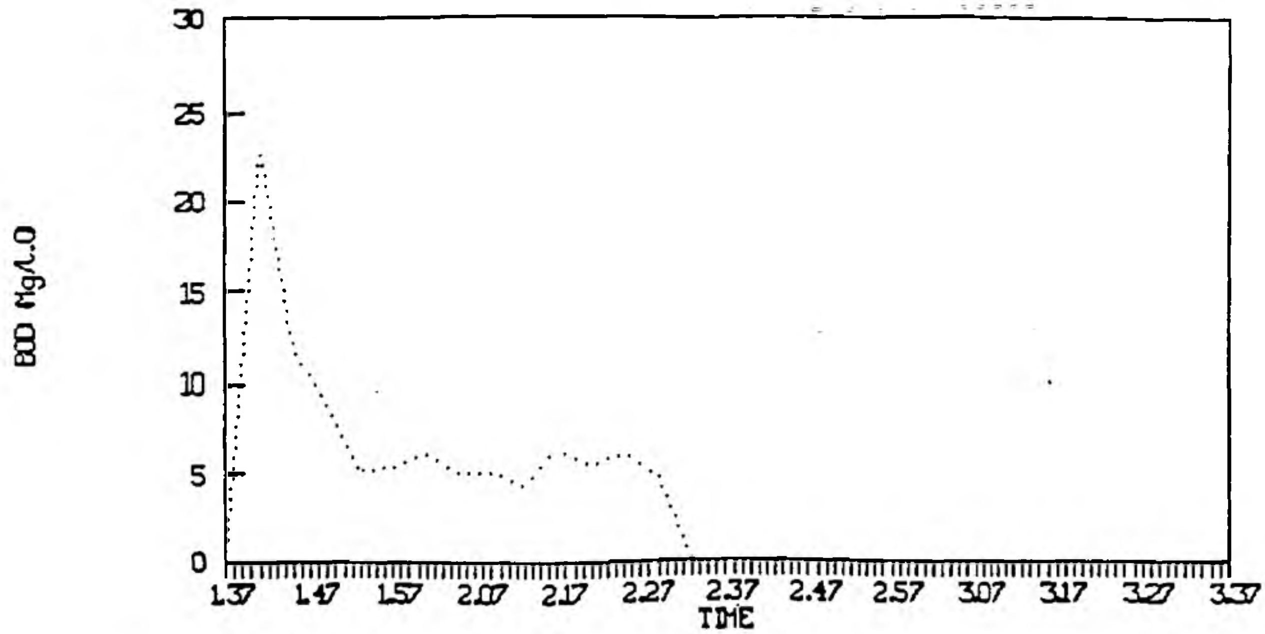
PLATE 5 Typical Instrumentation Set-up.



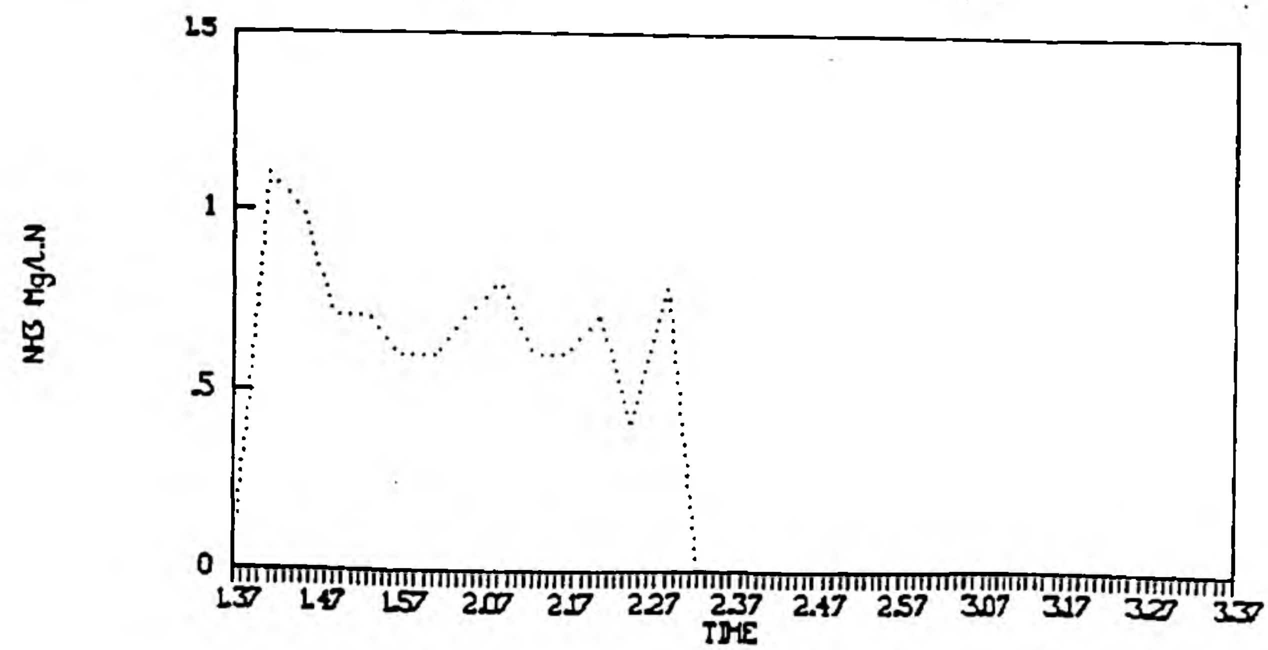
APPENDIX 1

COMBINED SEWER OVERFLOW QUALITY

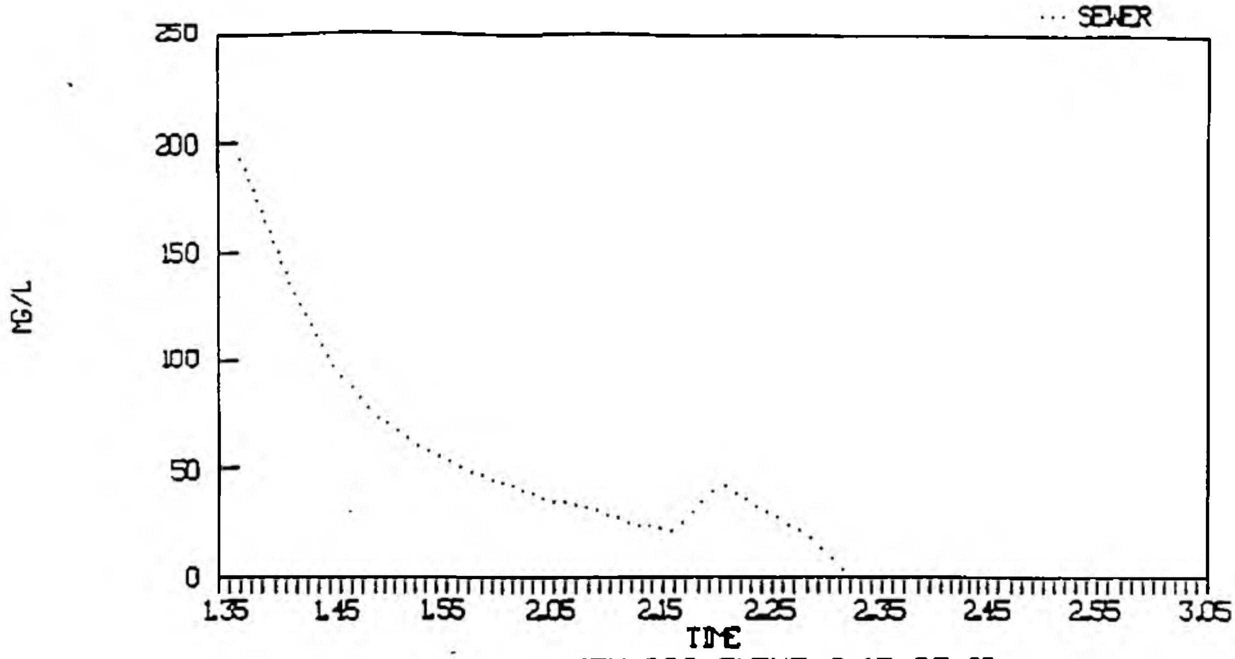
GARNDIFFAITH SSO EVENT 2 15-03-88.
BOD CONCENTRATIONS IN SEWER.



GARNDIFFAITH SSO EVENT 2 15-03-88.
NH3 CONCENTRATIONS IN SEWER.

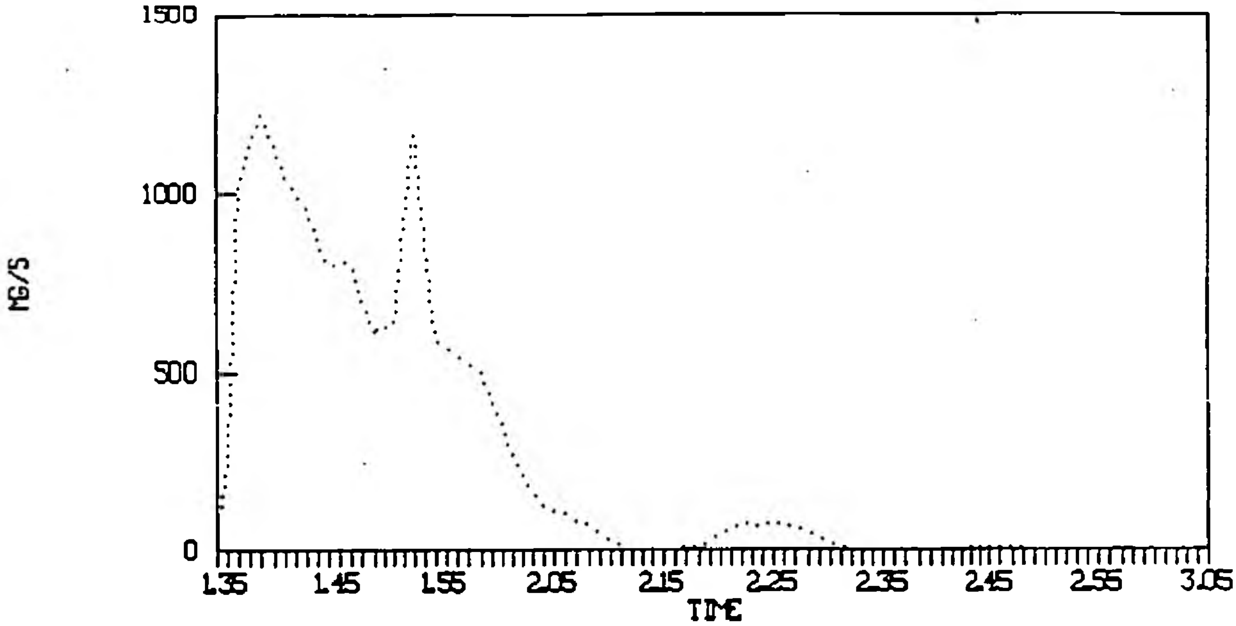


TSS CONCENTRATIONS IN OVERFLOW



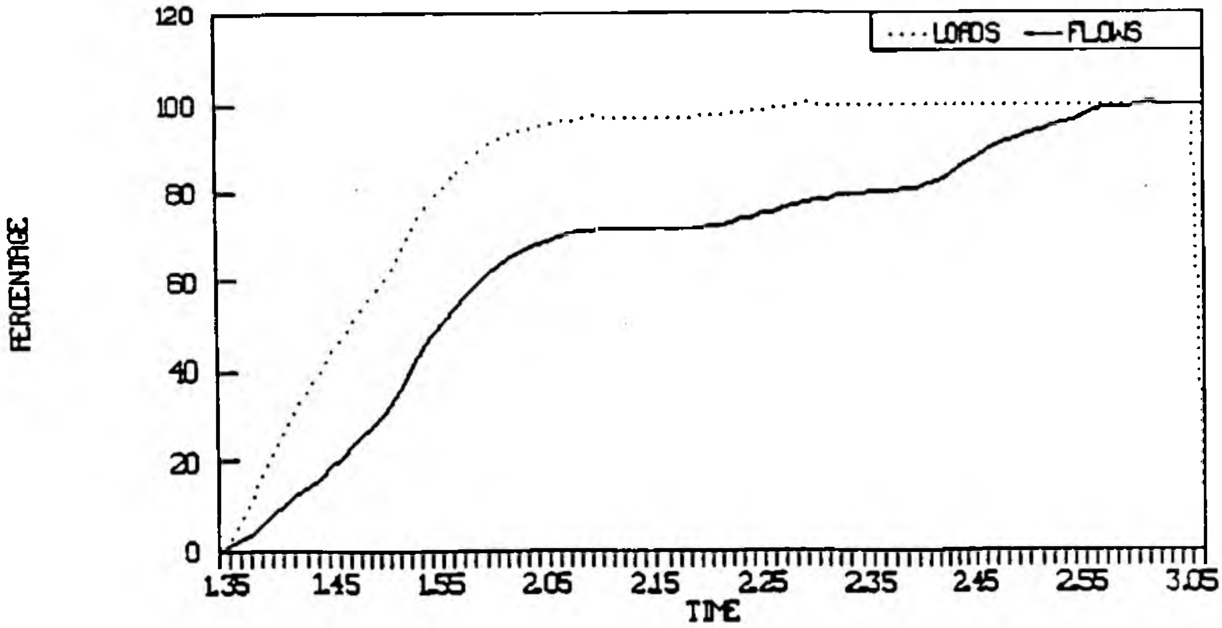
GARNDIFFAITH SSO EVENT 2 15-03-88

TSS LOADS IN OVERFLOW



GARNDIFFAITH SSO EVENT 2 15-03-88

CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW

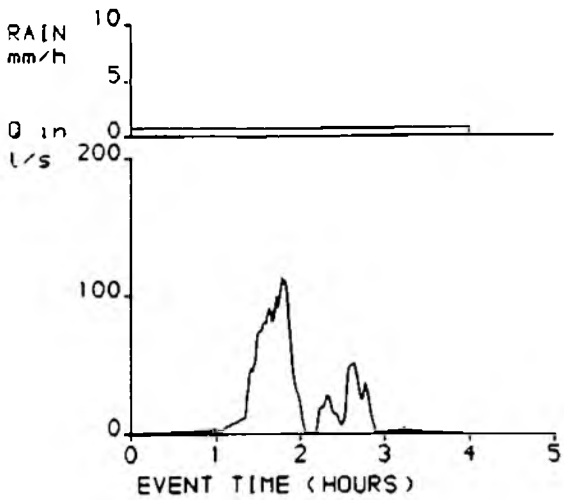


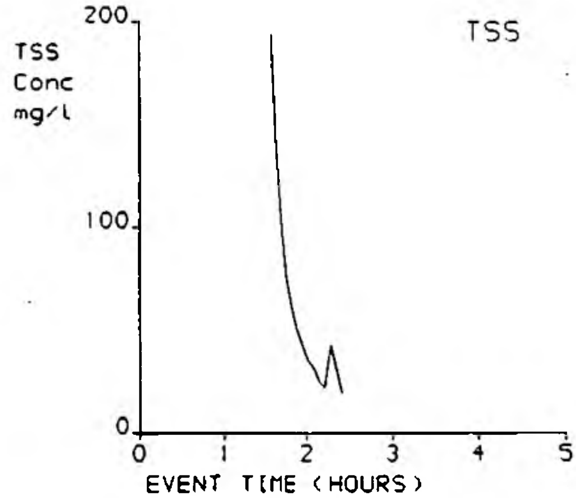
Site: GARNDIFFAITH SSO TO NANT FFRWD

GN880315SO.DAT

Grid Ref: 262044
Storm Date: 880315
Start Time (R/F):0.08
Rainfall Depth (mm): 13.2

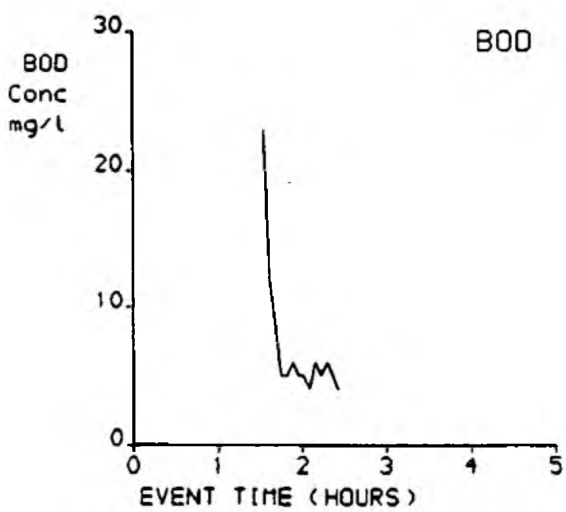
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 217.

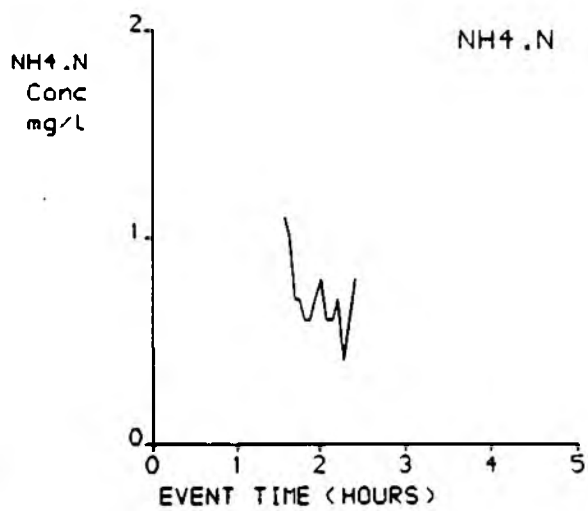




NO DATA FOR COD

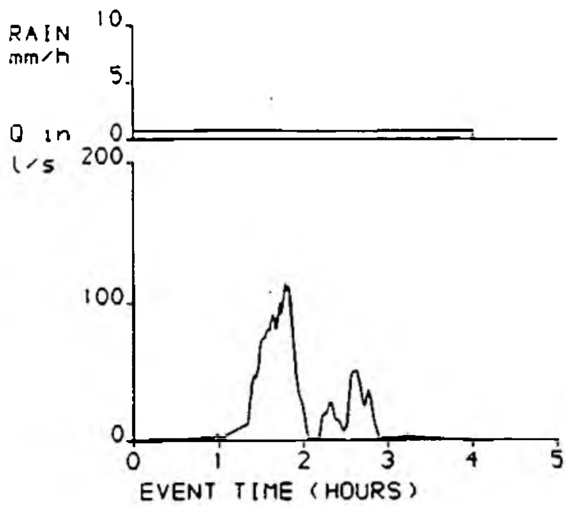
NO DATA FOR TDS

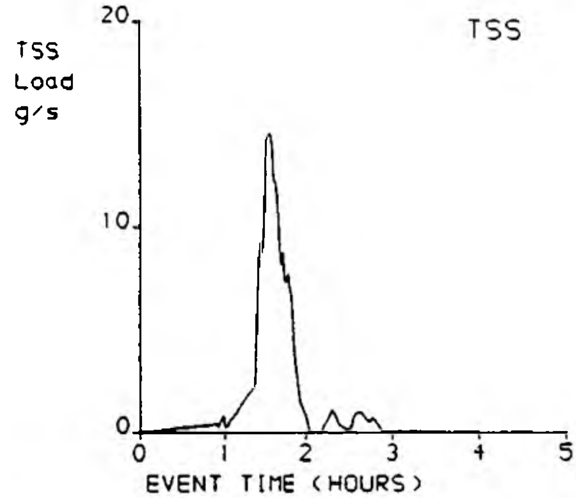




Site: GARNDIFFAITH SSO TO NANT FFRWD GN880315SO.DAT

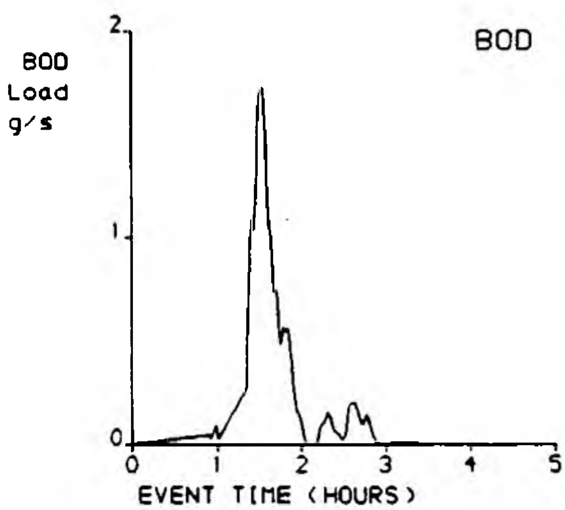
Grid Ref: 262044 Weather Conditions:
Storm Date: 880315 Date/Time last recorded storm: 0/ 0
Start Time (R/F):0.08 Antec. Dry Weather Period (hours): 0
RainFall Depth (mm): 13.2 RainFall Event Duration (mins): 217.

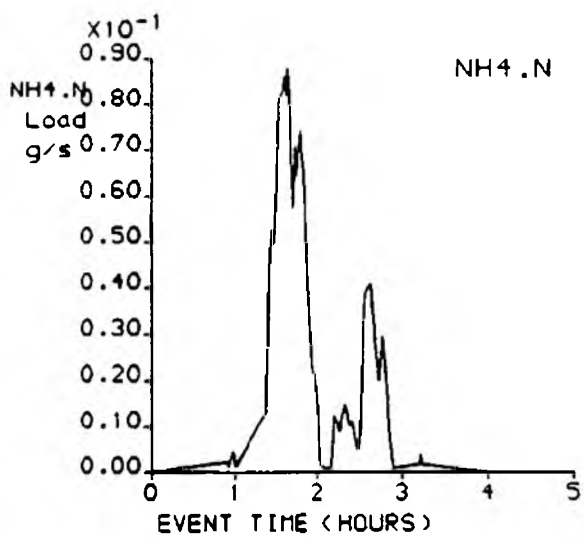




NO DATA FOR COD

NO DATA FOR TDS

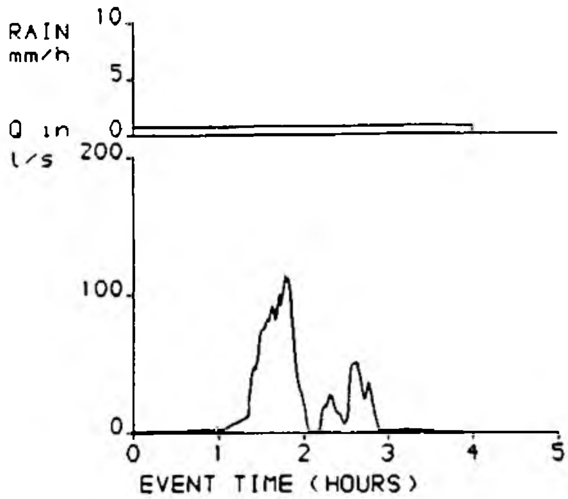


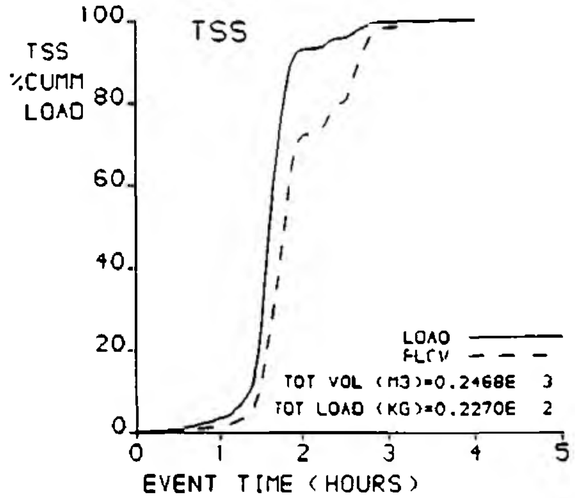


Site: GARNDIFFAITH SSO TO NANT FFRWD GN880315SO.DAT

Grid Ref: 262044
Storm Date: 880315
Start Time (R/F):0.08
Rainfall Depth (mm): 13.2

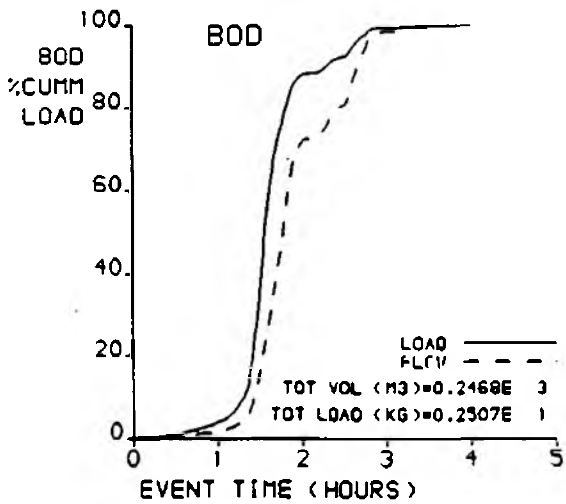
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 217.

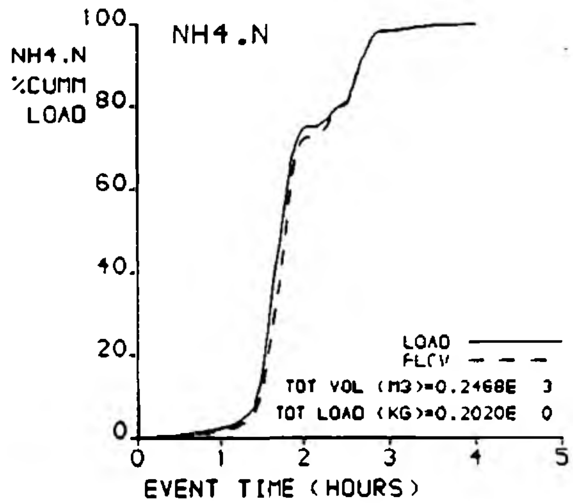




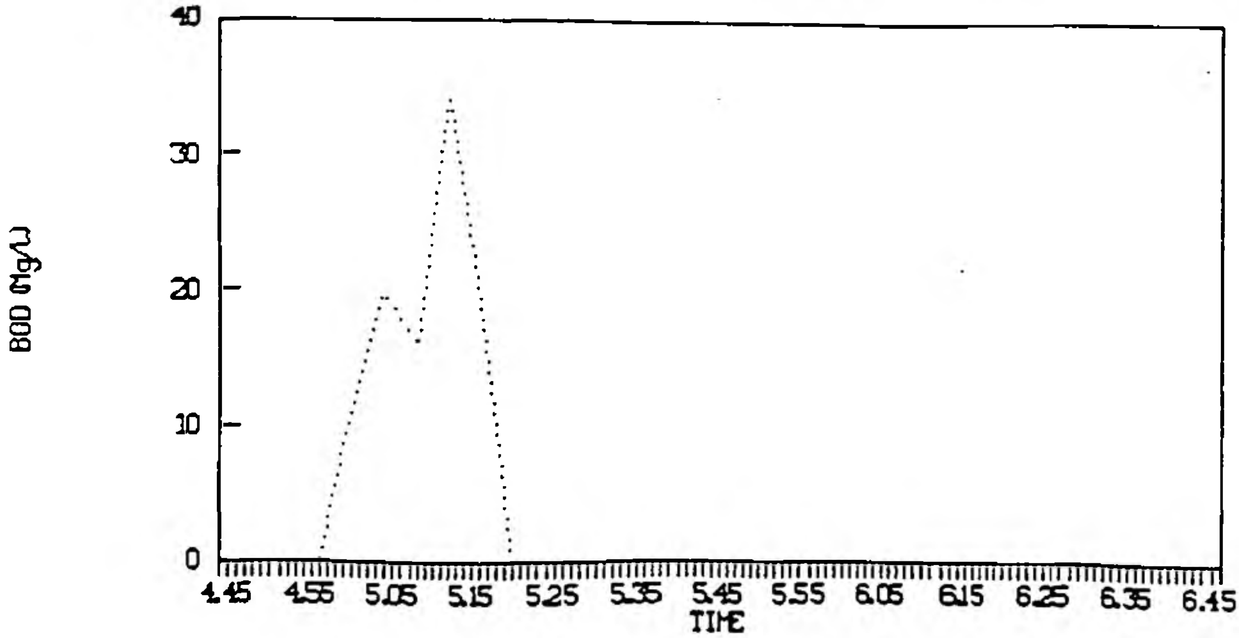
NO DATA FOR COD

NO DATA FOR TDS

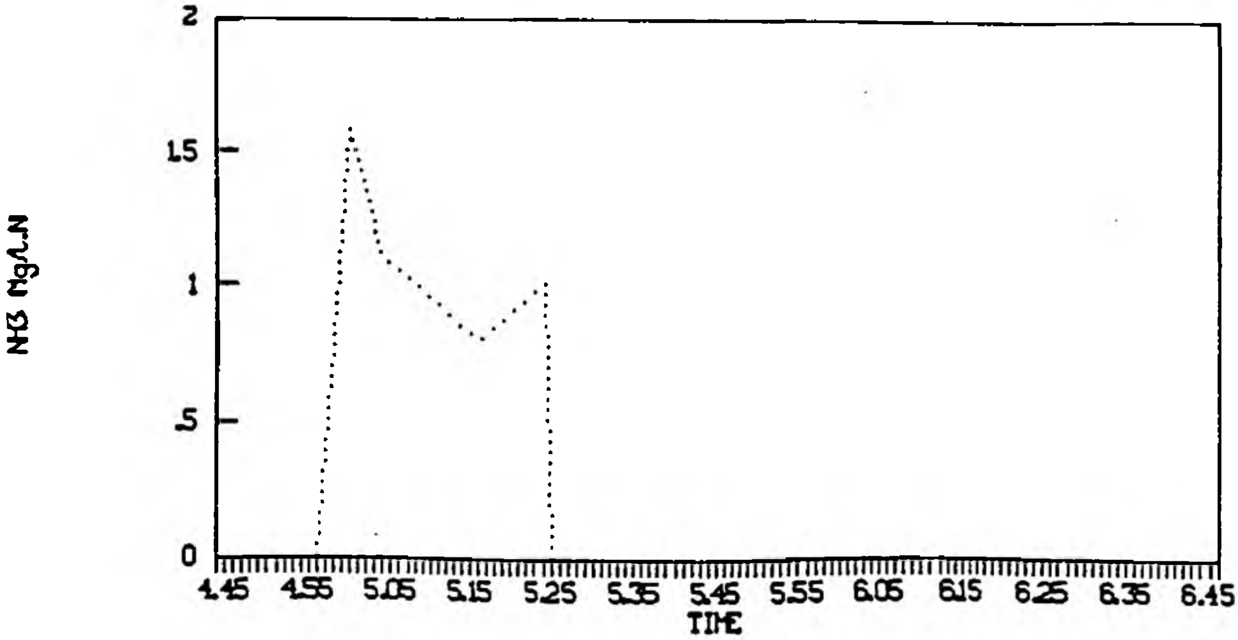




GARNDIFFAITH SSO EVENT 3 16-04-88.
BOD CONCENTRATIONS IN SEWER.



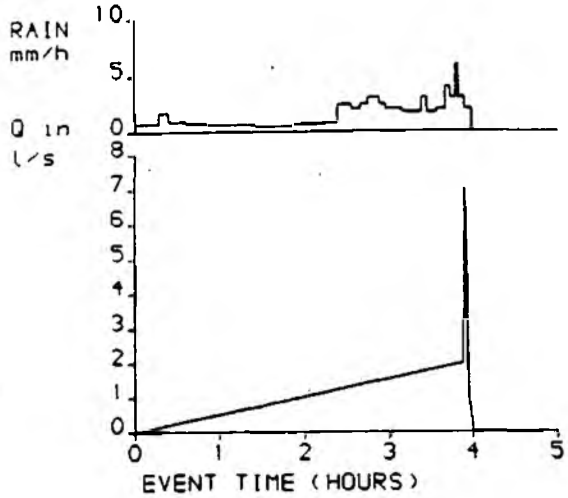
GARNDIFFAITH SSO EVENT 3 16-04-88.
NH3 CONCENTRATIONS IN SEWER.

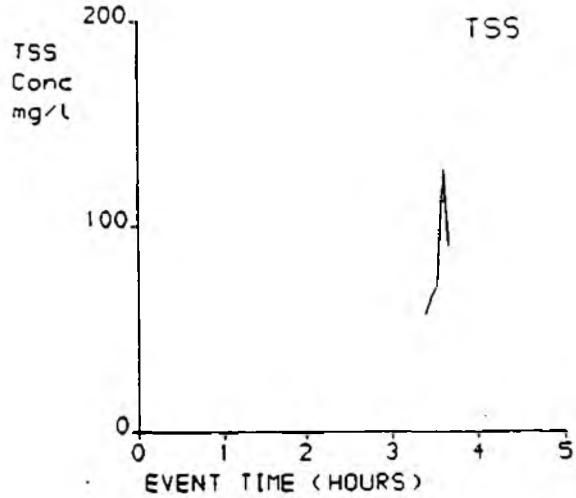


Site: GARNDIFFAITH SSO TO NANT FFRWD GN880416SO.DAT

Grid Ref: 262044
Storm Date: 880416
Start Time (R/F): 138
RainFall Depth (mm): 5.6

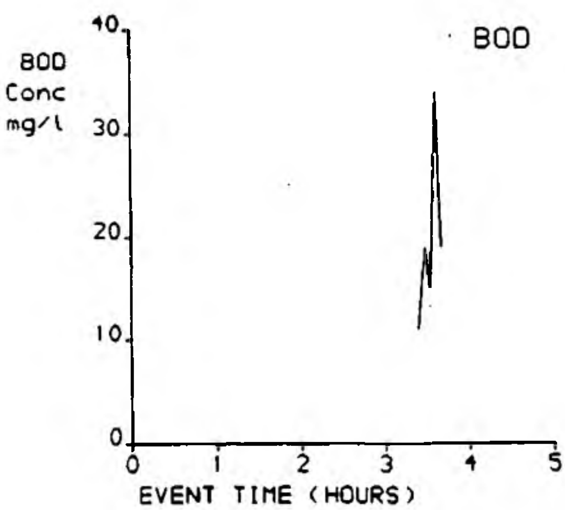
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
RainFall Event Duration (mins): 239.

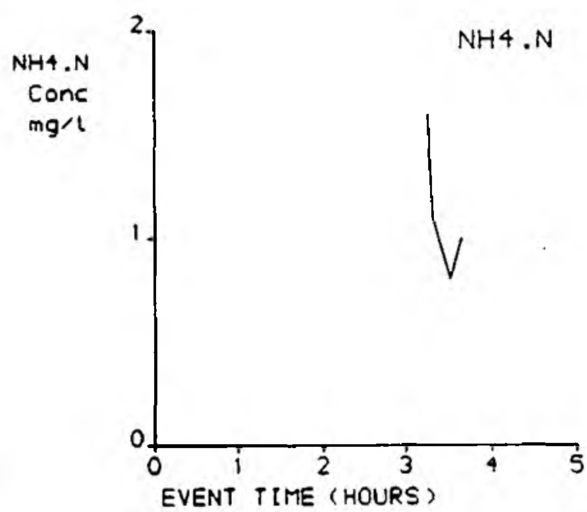




NO DATA FOR COD

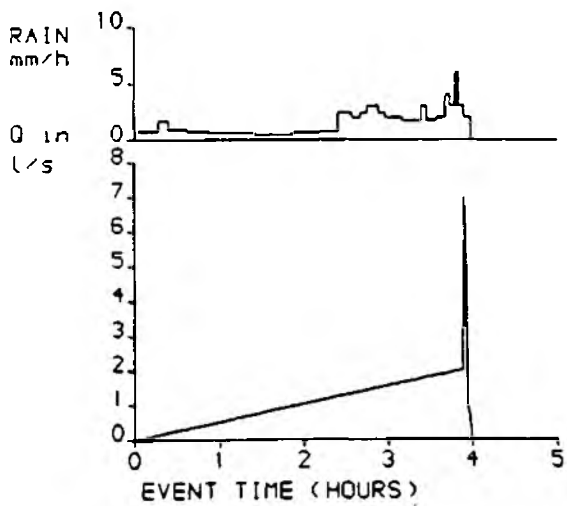
NO DATA FOR TDS

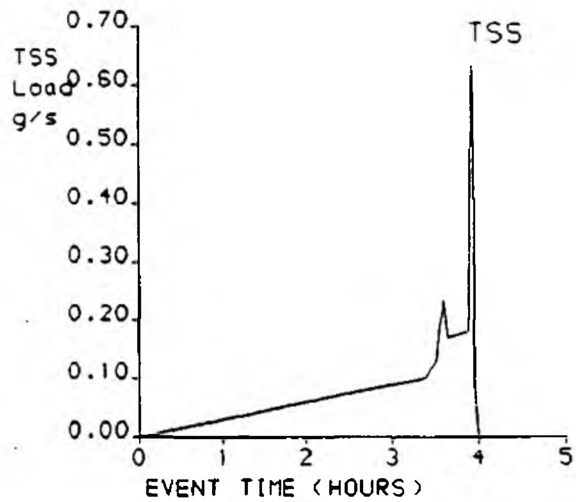




Site: GARNDIFFAITH SSO TO NANT FFRWD GN880416SO.DAT

Grid Ref: 262044 Weather Conditions:
Storm Date: 880416 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 138 Antec. Dry Weather Period (hours): 0
RainFall Depth (mm): 5.6 RainFall Event Duration (mins): 239.





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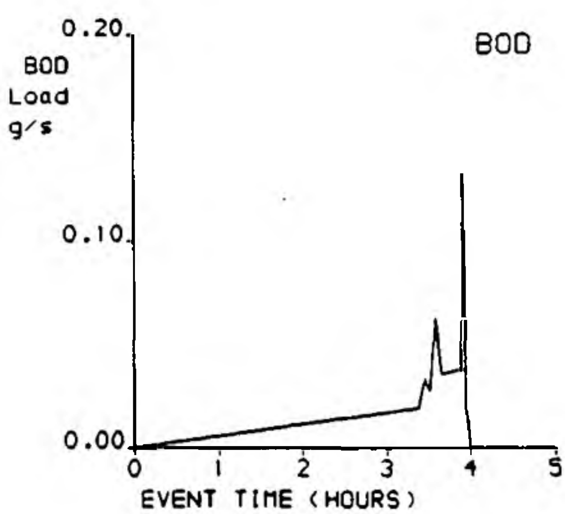
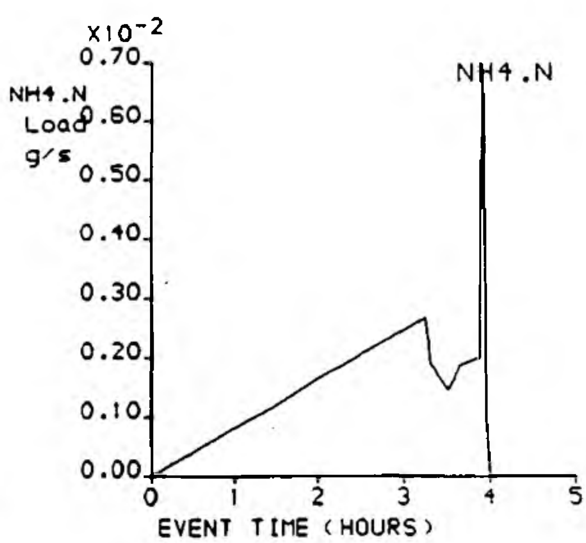
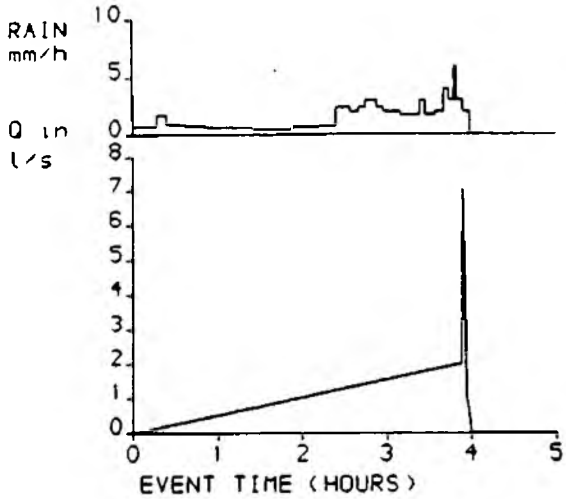


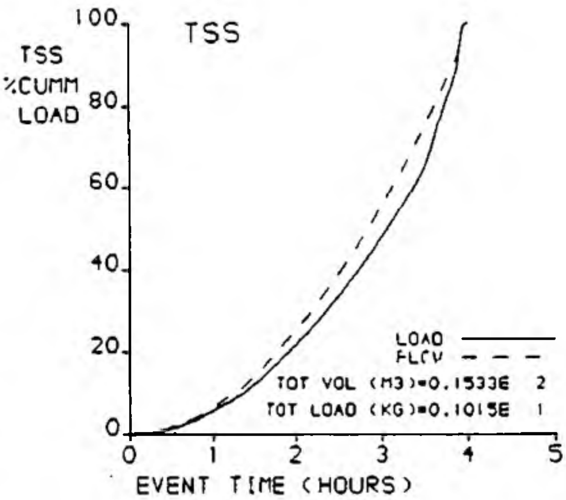


Site: GARNDIFFAITH SSO TO NANT FFRWD GN880416SO.DAT

Grid Ref: 262044
Storm Date: 880416
Start Time (R/F): 138
Rainfall Depth (mm): 5.6

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 239.





NO DATA FOR COD

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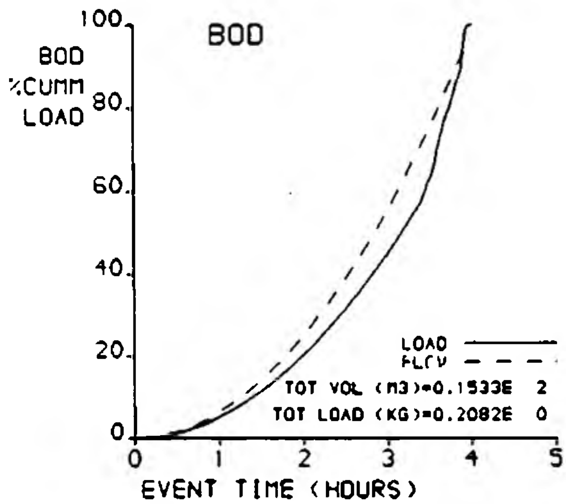
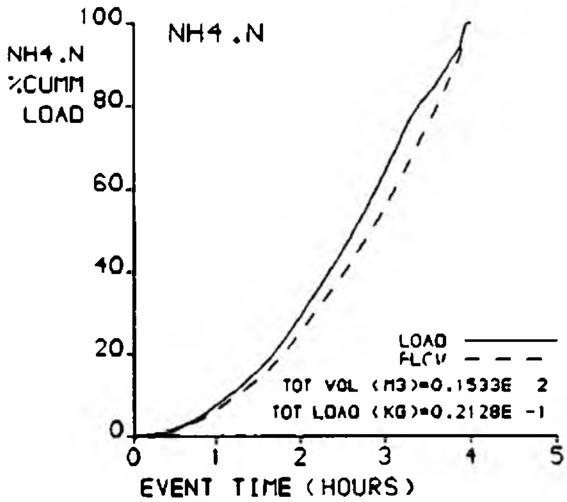
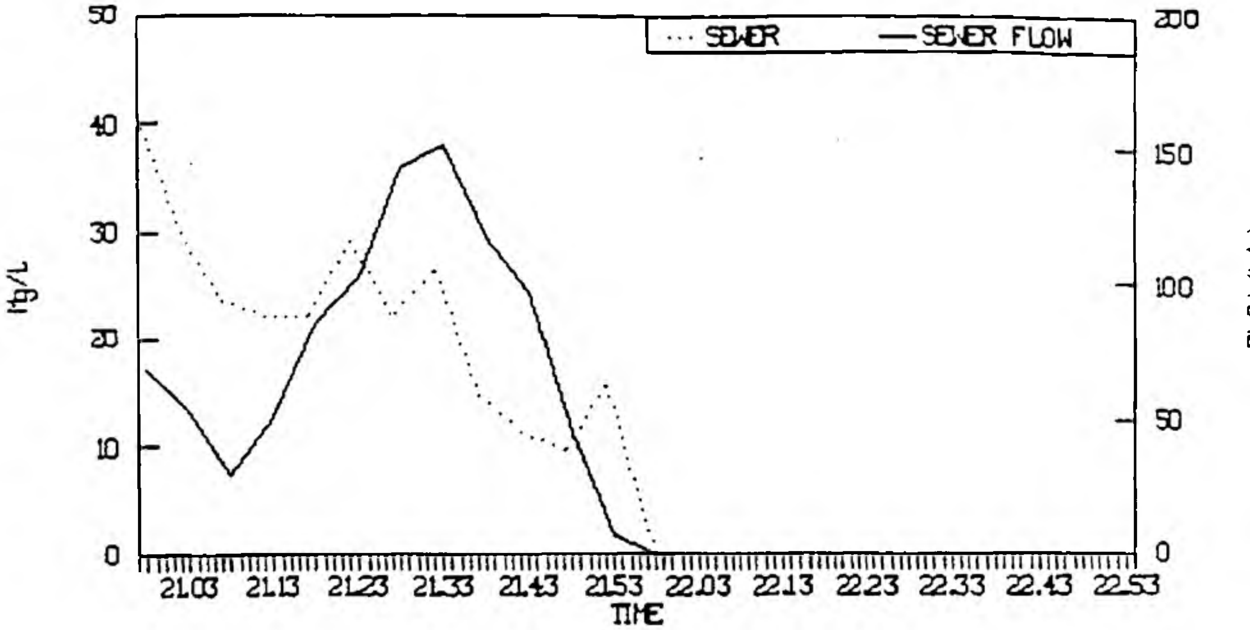


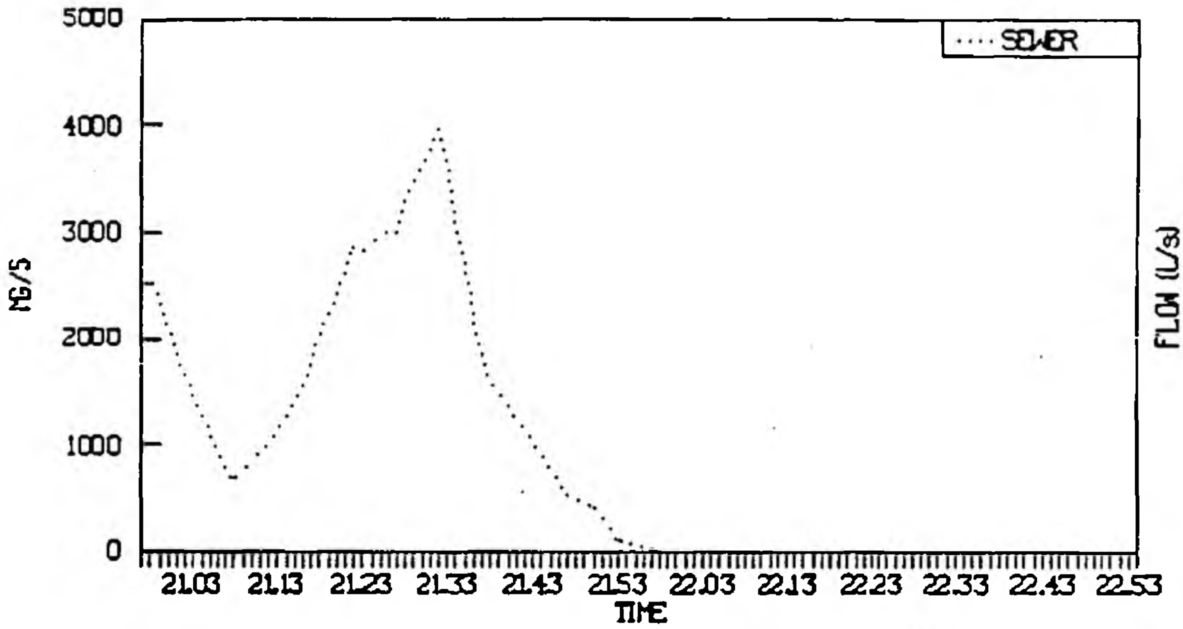


BOD CONCENTRATIONS AT SEWER.

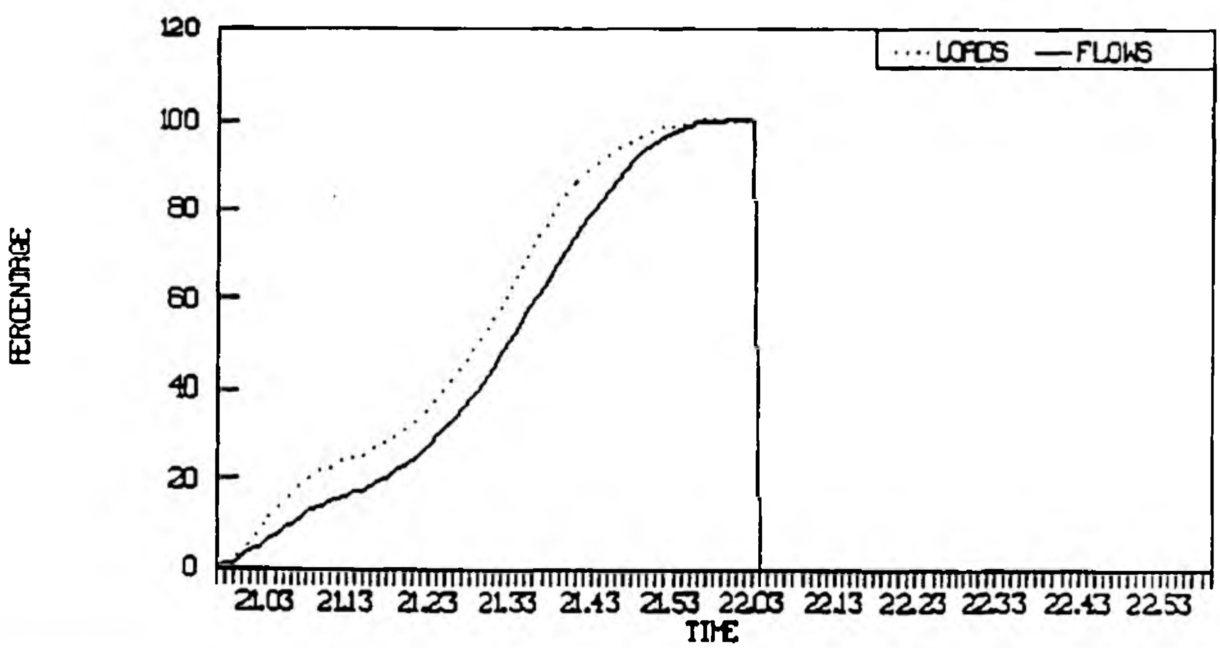


GARNDIFFAITH SSO EVENT 4 30-04-88

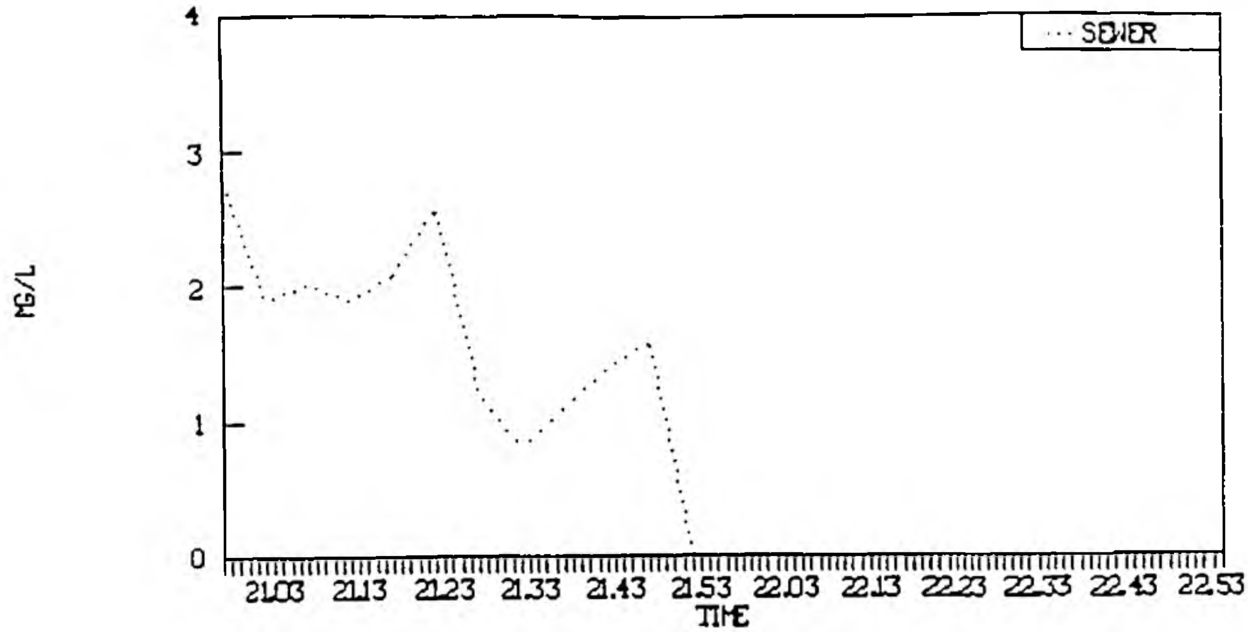
BOD LOADS AT SEWER.



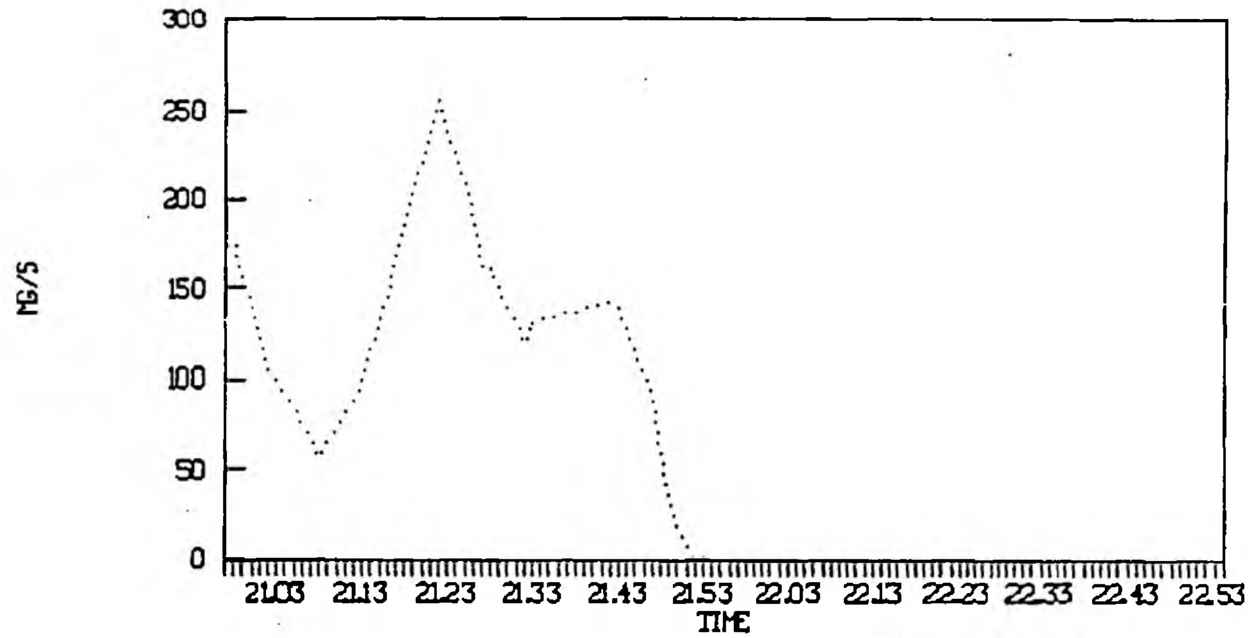
GARNDIFFAITH SSO EVENT 4 30-04-88



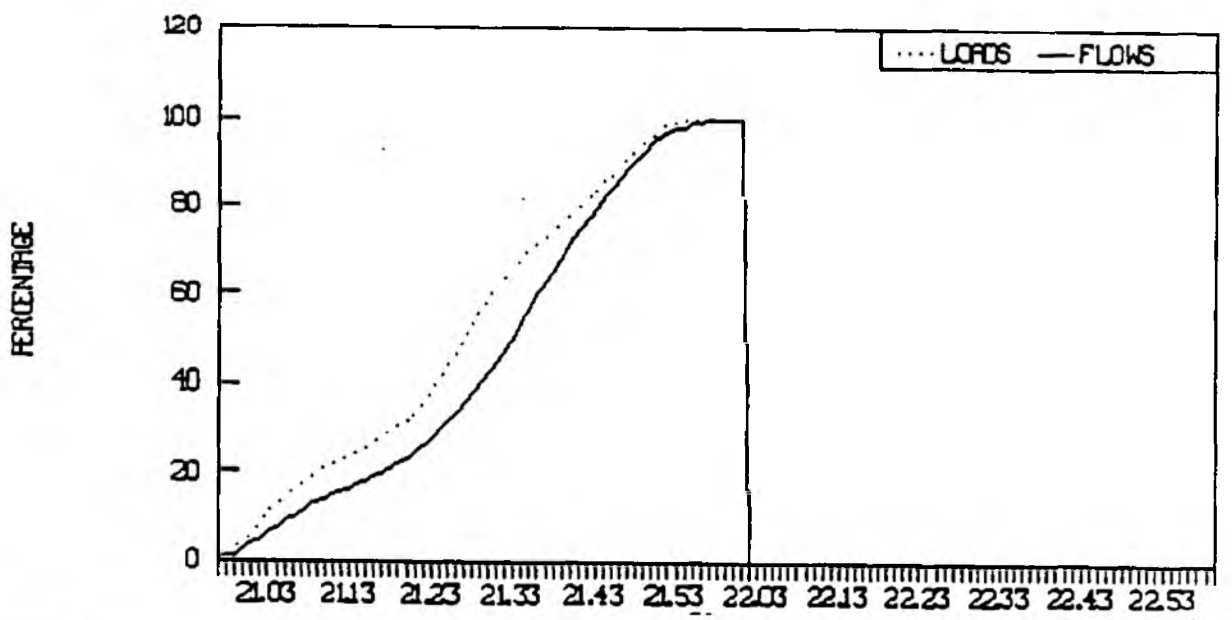
GARNDIFFAITH SSO EVENT 4 30-04-88
NH3 CONCENTRATIONS AT SEWER.



GARNDIFFAITH SSO EVENT 4 30-04-88
NH3 LOADS AT SEWER.

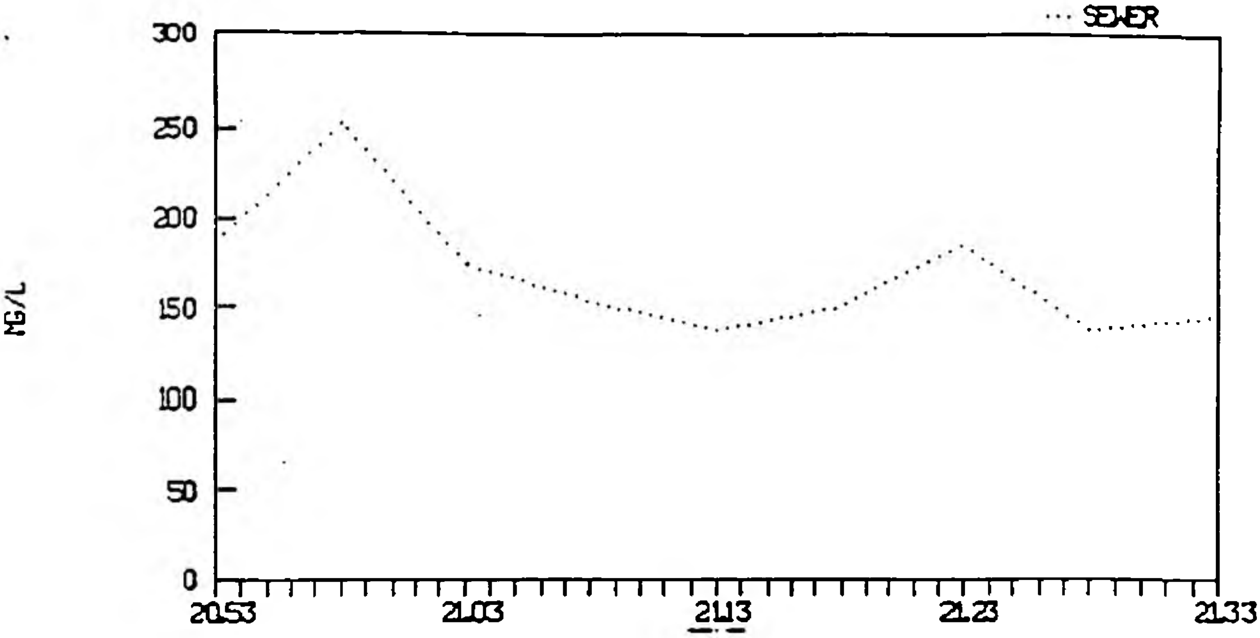


GARNDIFFAITH SSO EVENT 4 30-04-88
CUMULATIVE LOADS AND FLOWS



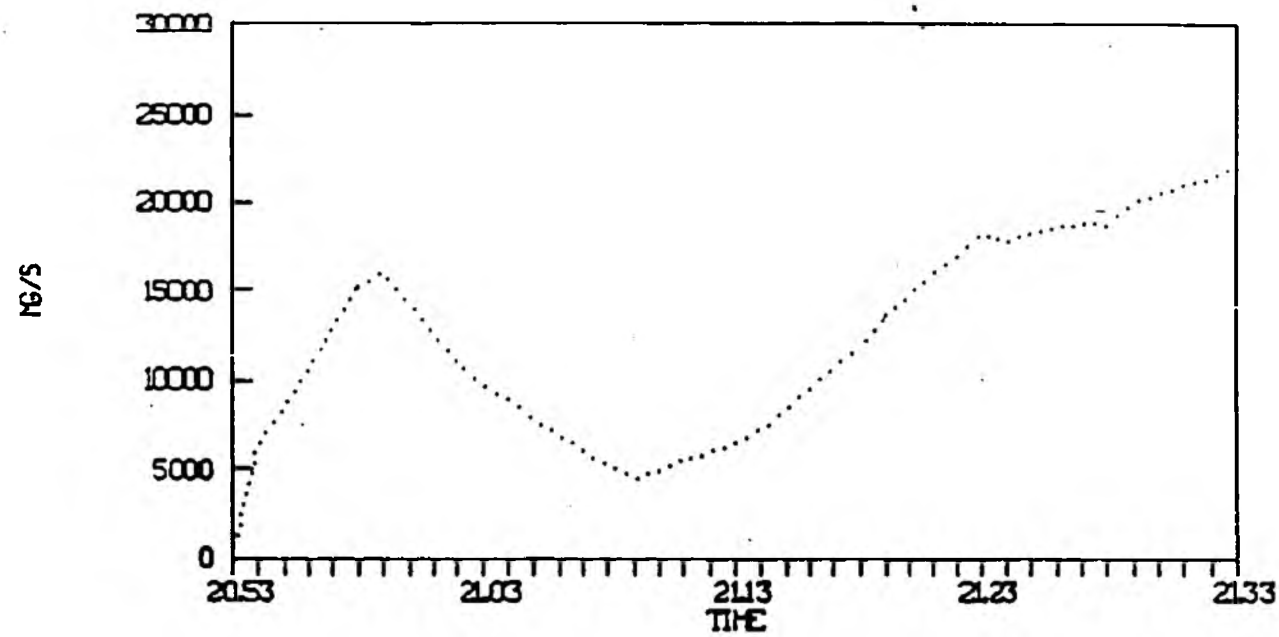
GARNDIFFAITH SSO EVENT 4 30-04-88

TSS CONCENTRATIONS IN OVERFLOW



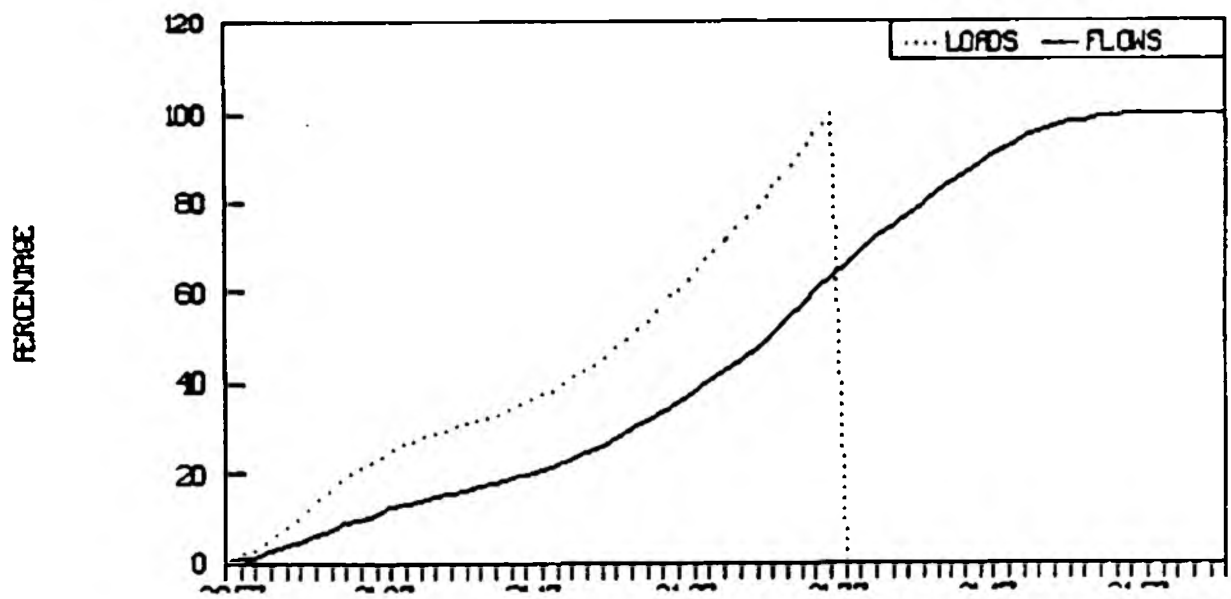
GARNDIFFAITH SSO EVENT 4 30-04-88

TSS LOADS IN OVERFLOW.

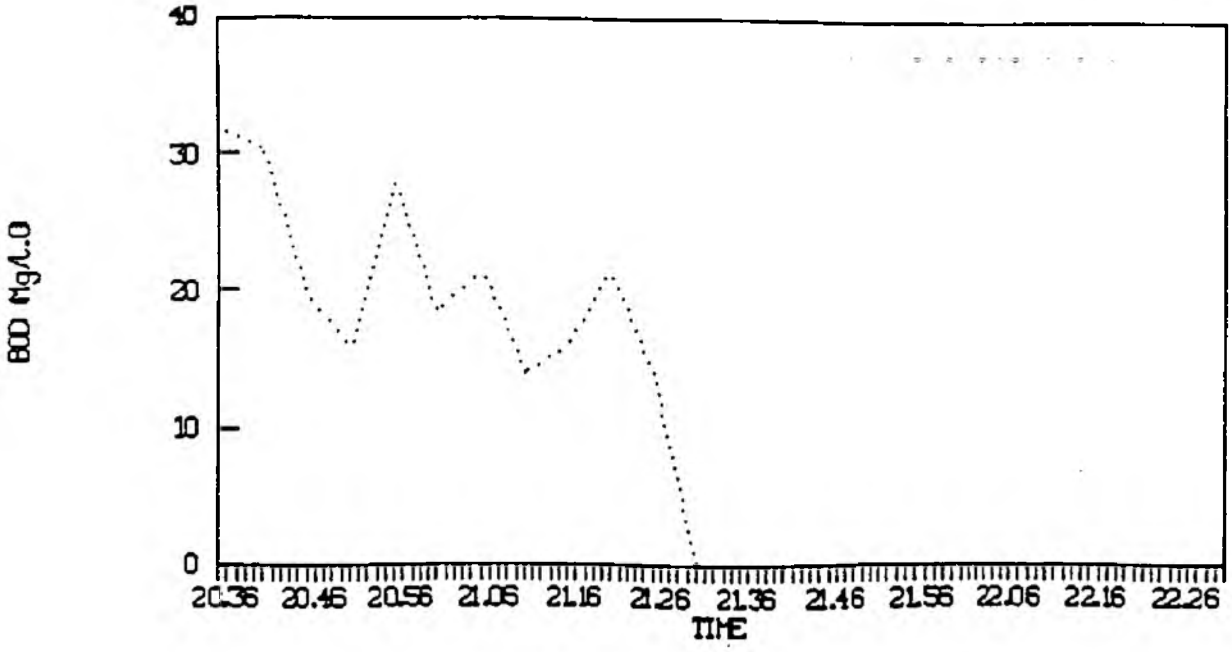


GARNDIFFAITH SSO EVENT 4 30-04-88

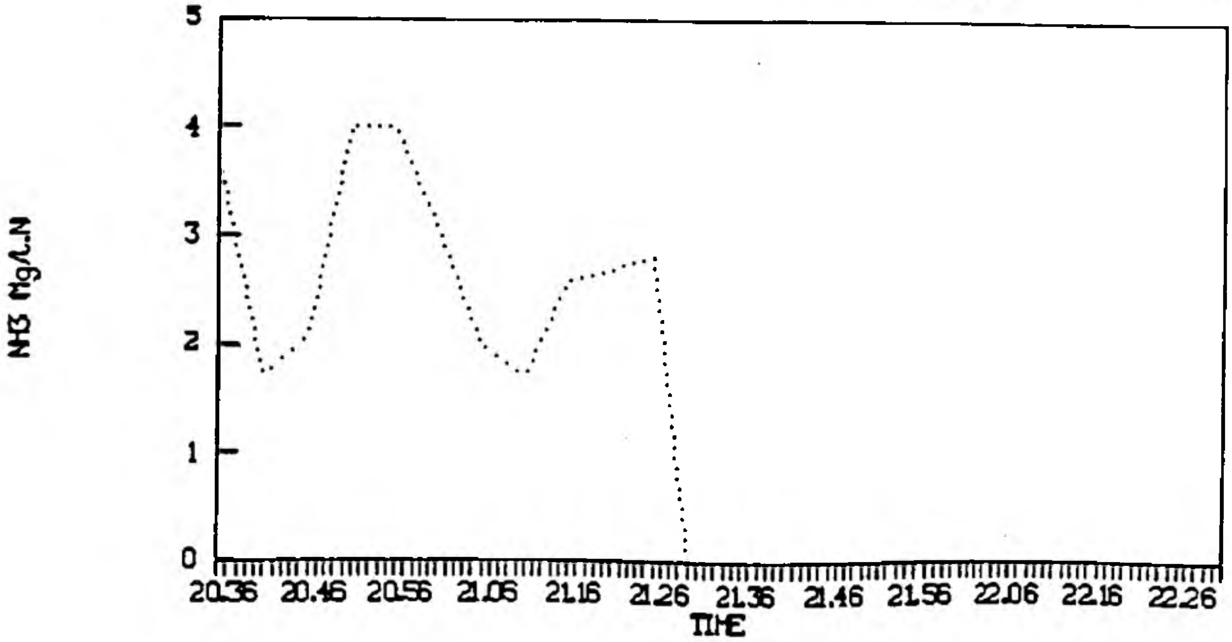
CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW.



GARNDIFFAITH SSO EVENT 6 08-06-88.
BOD CONCENTRATIONS IN SEWER.



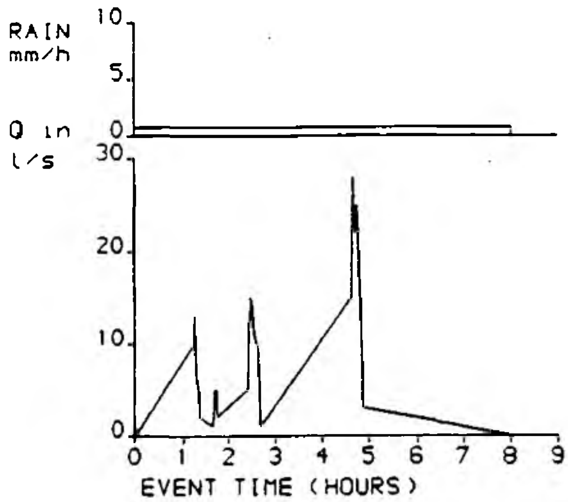
GARNDIFFAITH SSO EVENT 6 08-06-88.
NH3 CONCENTRATIONS IN SEWER.

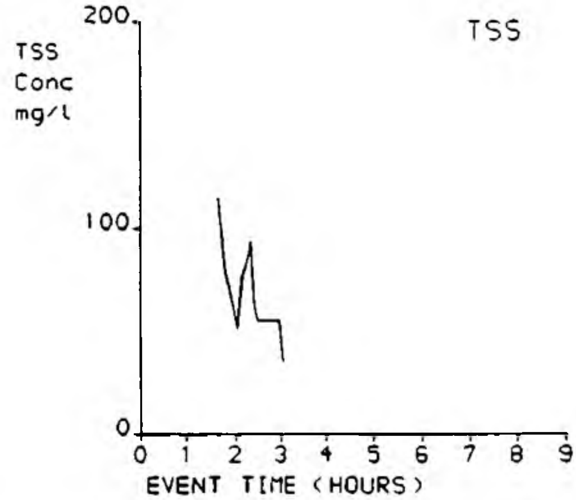


Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880608SO.DAT

Grid Ref: 262044
Storm Date: 880608
Start Time (R/F): 1857
Rainfall Depth (mm): 15.4

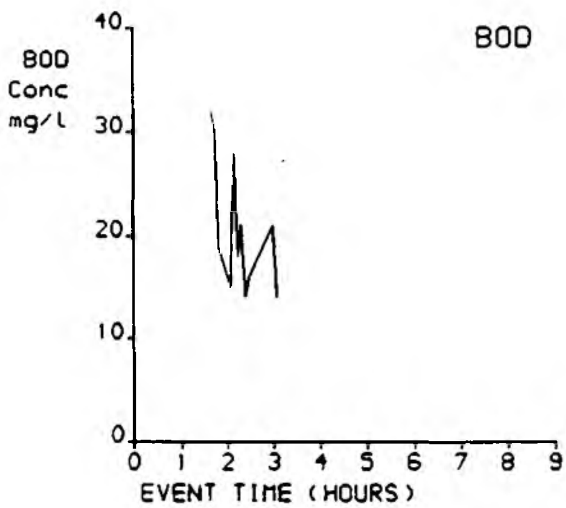
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 478.

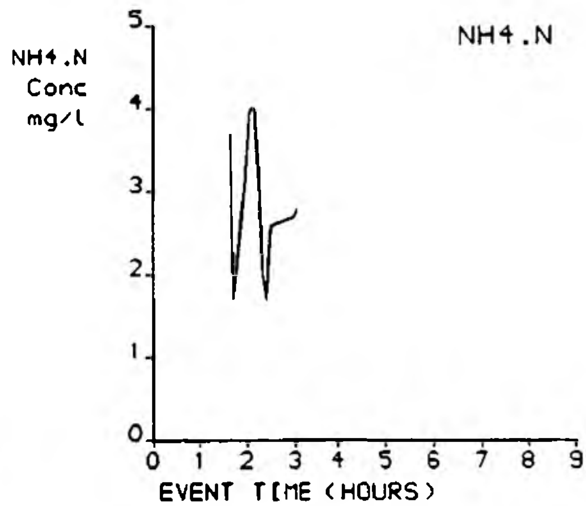




NO DATA FOR COD

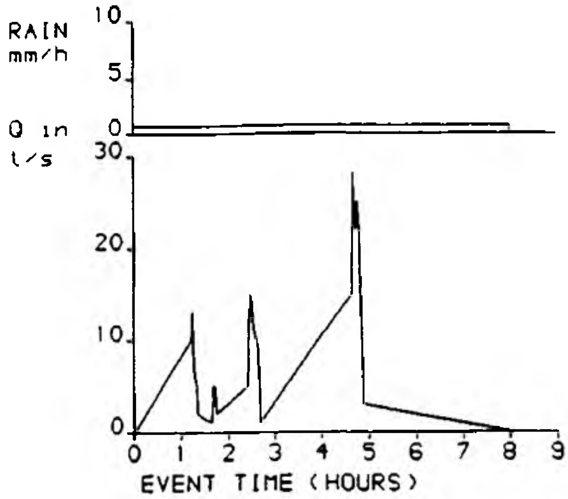
NO DATA FOR TDS





Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880608SO.DAT

Grid Ref: 262044 Weather Conditions:
Storm Date: 880608 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1857 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 15.4 Rainfall Event Duration (mins): 478.



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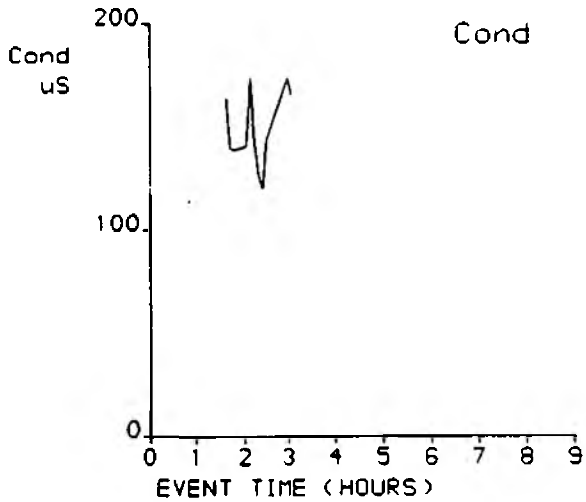
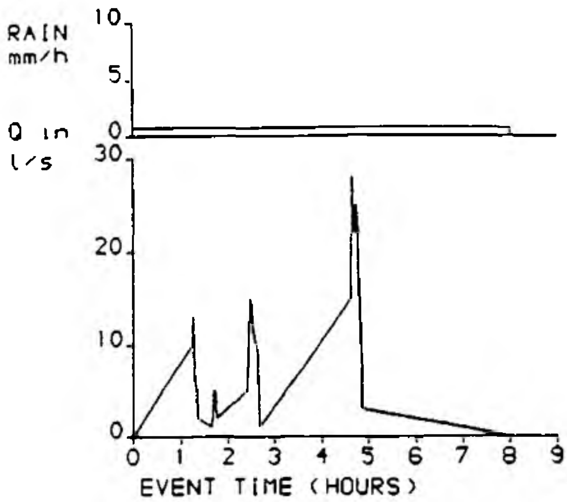


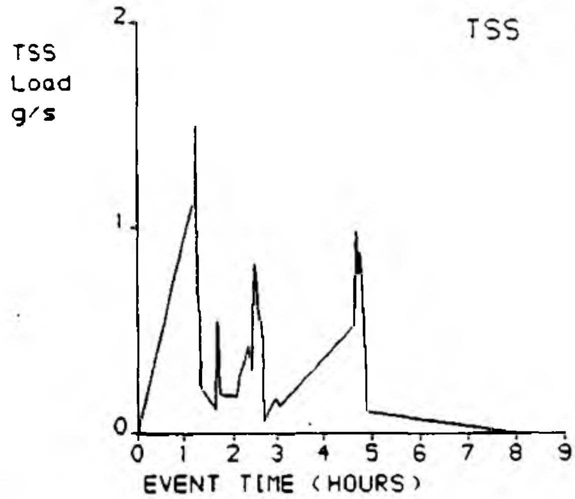
NO DATA FOR TEMP

NO DATA FOR pH

Site: STORM SEWAGE OVERFLOW TO NANT FFR GN88060850.DAT

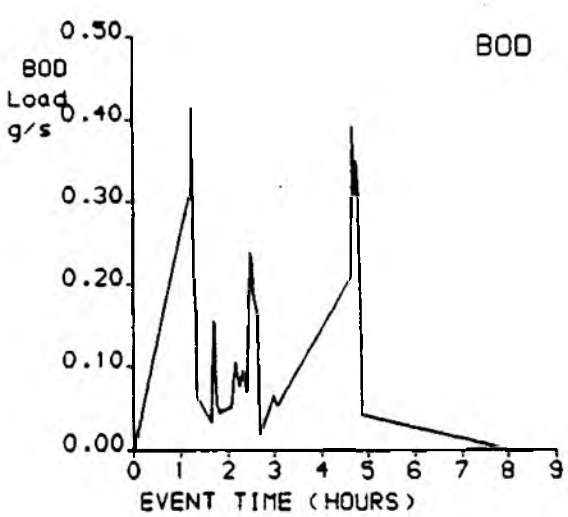
Grid Ref: 262044	Weather Conditions:
Storm Date: 880608	Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1857	Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 15.4	Rainfall Event Duration (mins): 478.

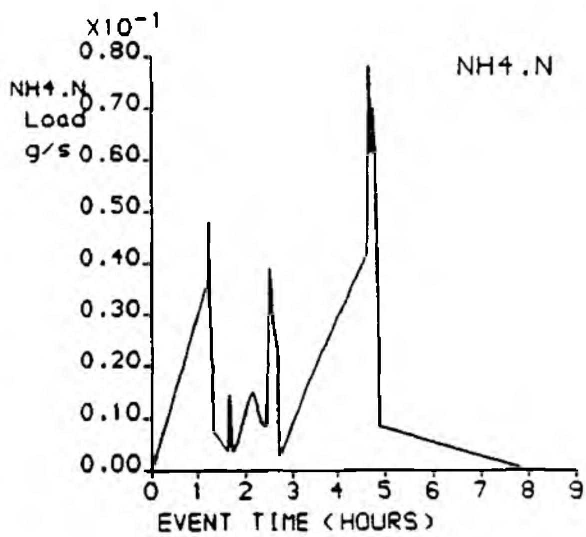




NO DATA FOR COD

NO DATA FOR TDS

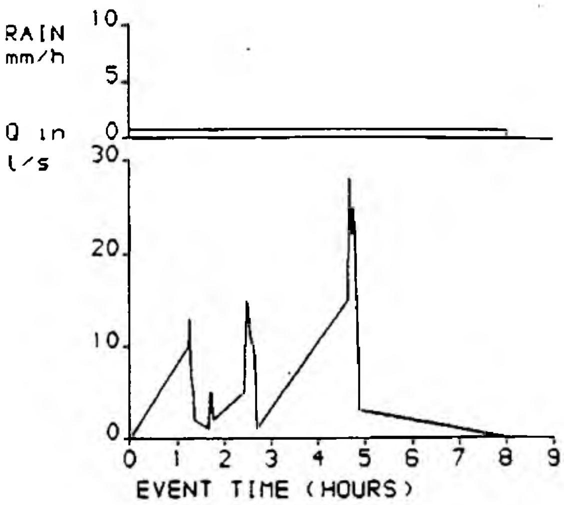


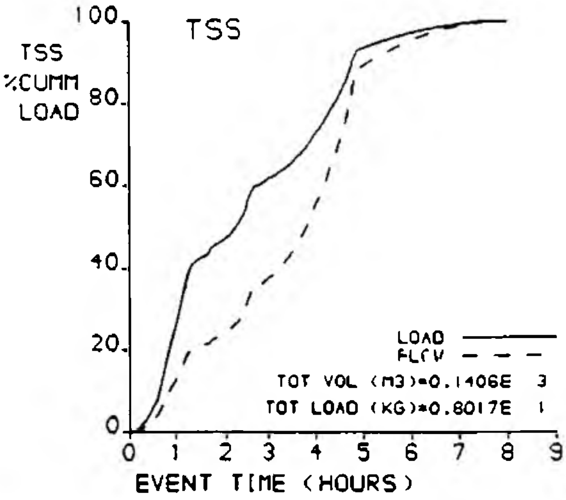


Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880608SO.DAT

Grid Ref: 262044
Storm Date: 880608
Start Time (R/F): 1857
Rainfall Depth (mm): 15.4

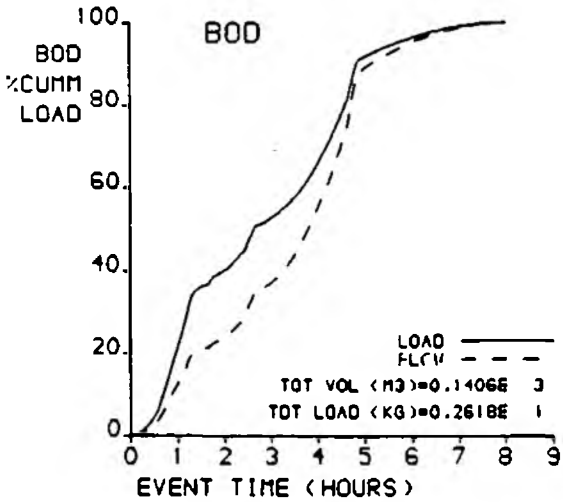
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 478.

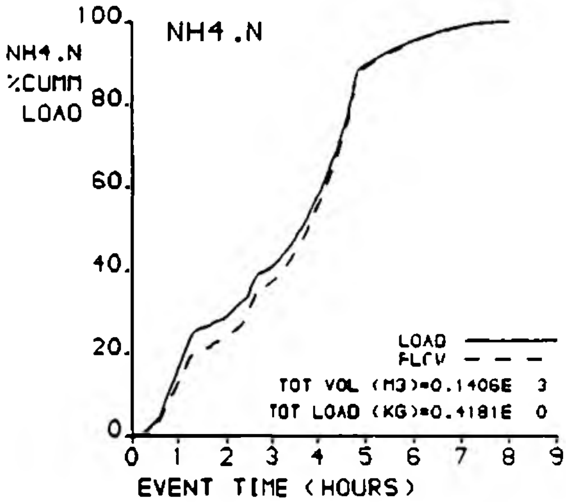




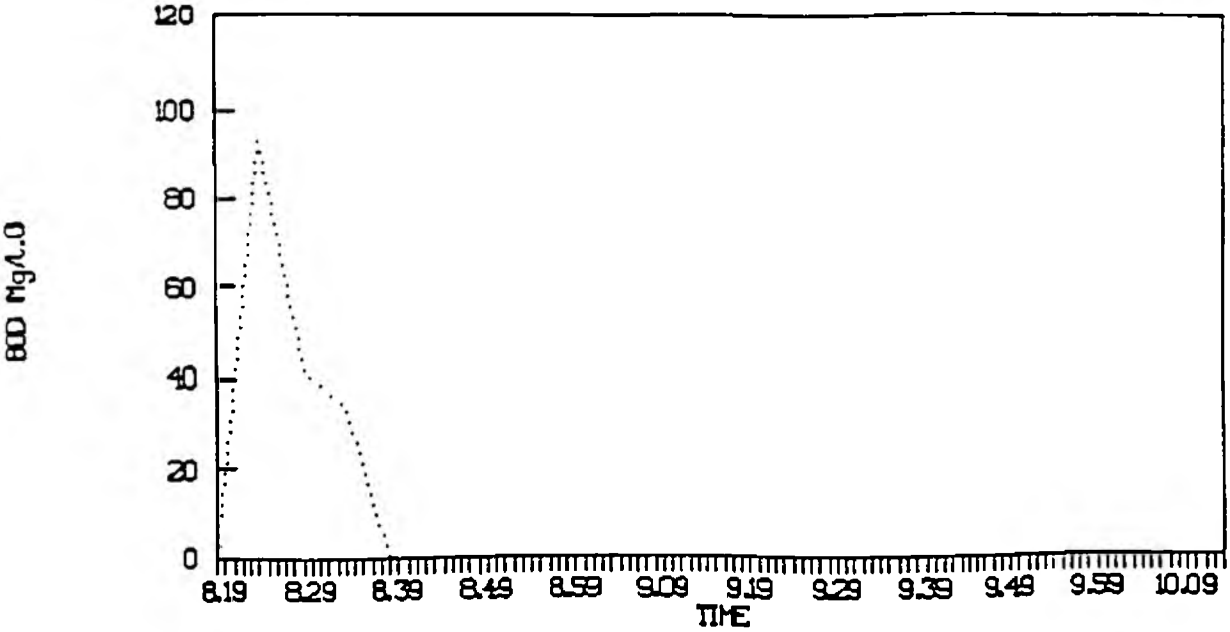
NO DATA FOR COD

NO DATA FOR TDS

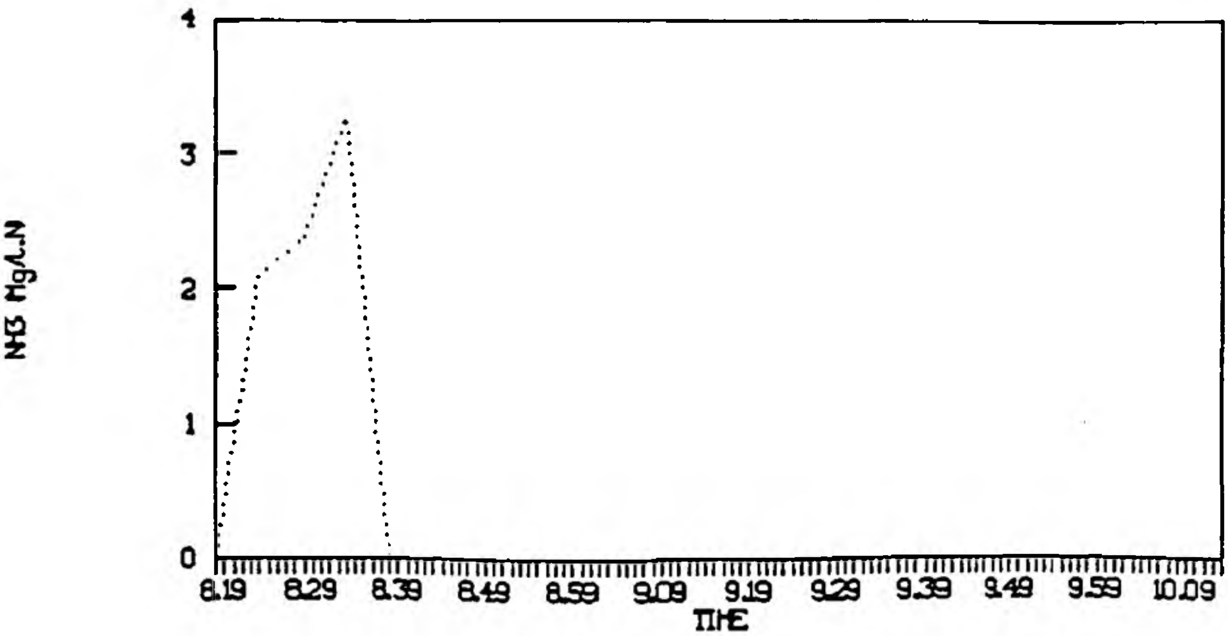




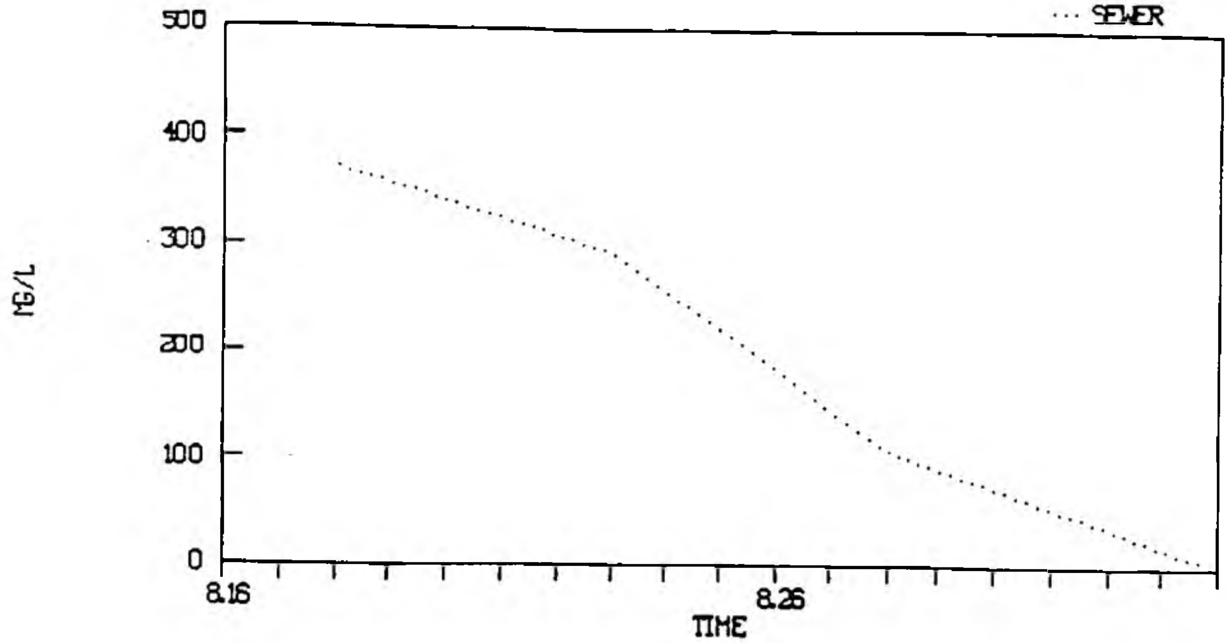
GARNDIFFAITH SSO EVENT 11 13-09-88.
BOD CONCENTRATIONS IN SEWER.



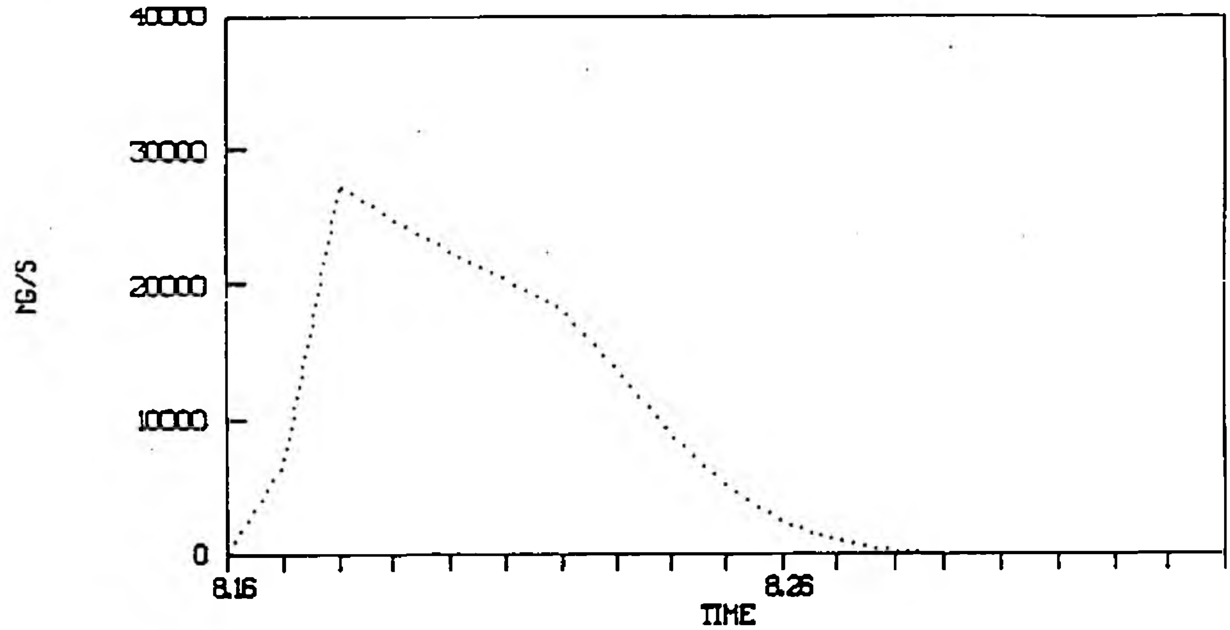
GARNDIFFAITH SSO EVENT 11 13-09-88.
NH3 CONCENTRATIONS IN SEWER.



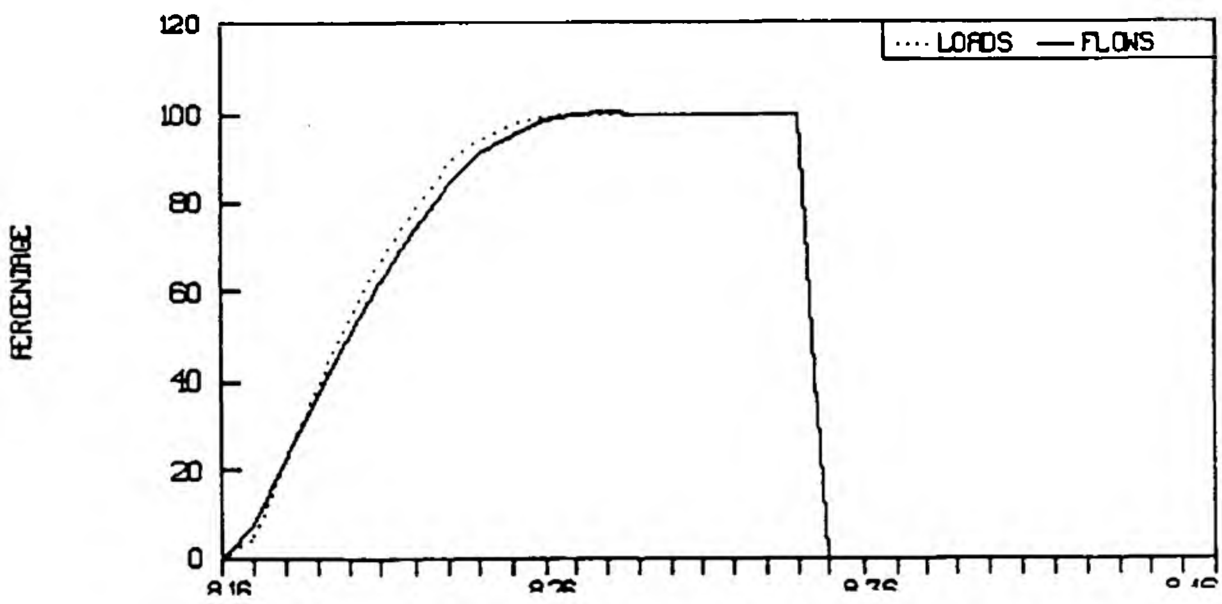
GARNDIFFAITH SSO EVENT 11 13-09-88
TSS CONCENTRATIONS IN OVERFLOW



GARNDIFFAITH SSO EVENT 11 13-09-88
TSS LOADS IN OVERFLOW.

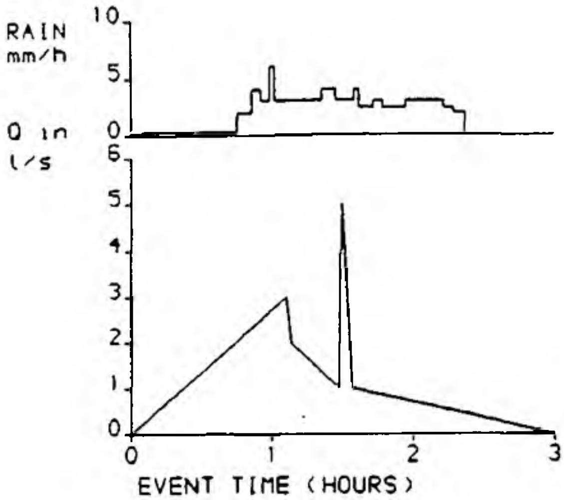


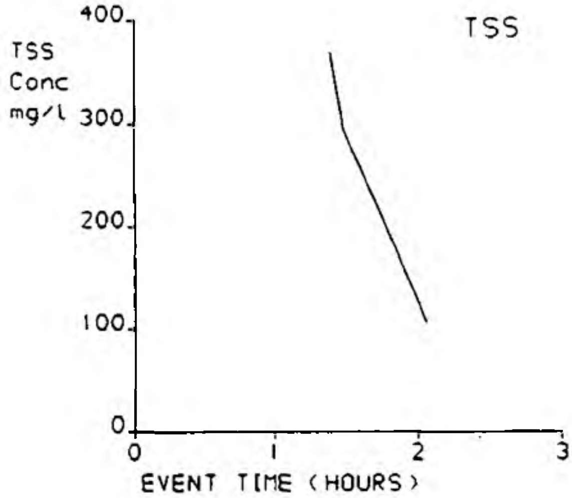
GARNDIFFAITH SSO EVENT 11 13-09-88
CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW.



Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880913SO.DAT

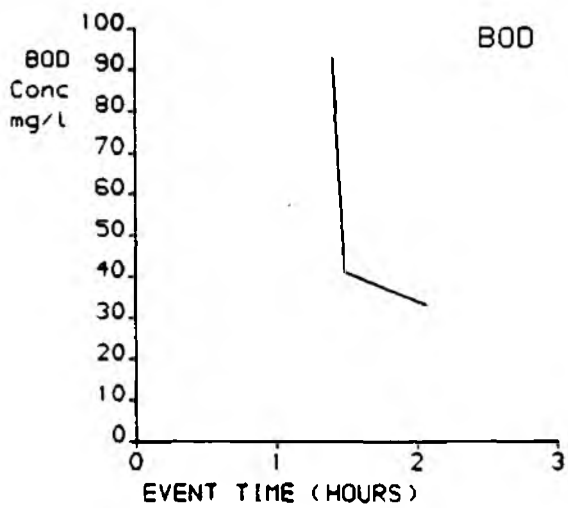
Grid Ref: 262044 Weather Conditions:
Storm Date: 880913 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 700 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 5.2 Rainfall Event Duration (mins): 137.

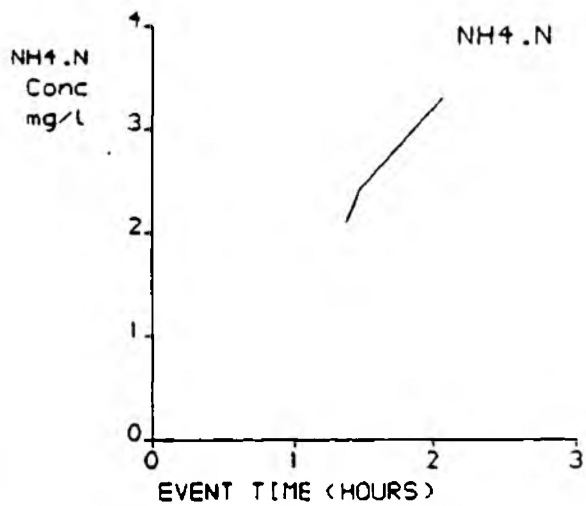




NO DATA FOR COD

NO DATA FOR TDS

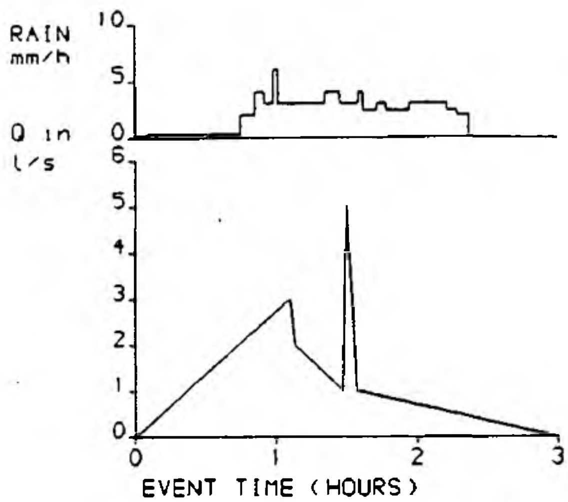


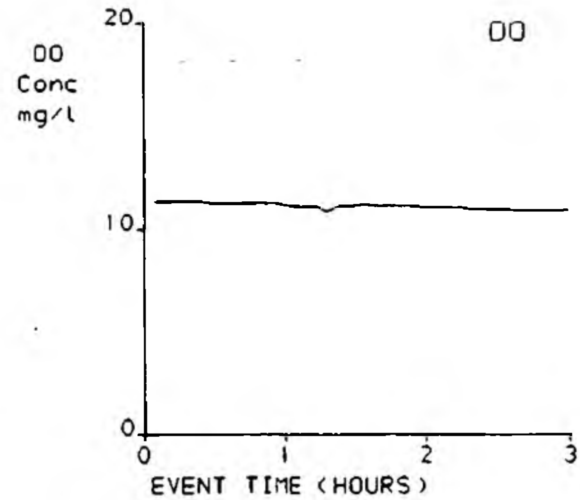


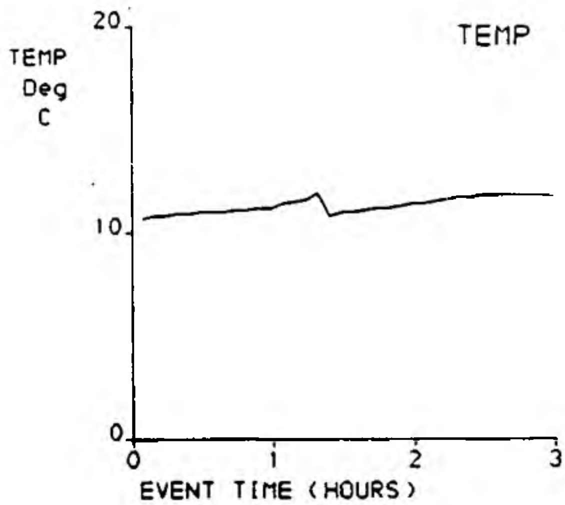
Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880913SO.DAT

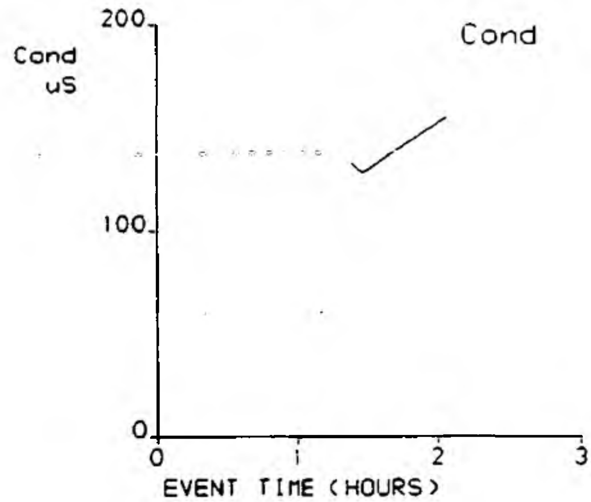
Grid Ref: 262044
Storm Date: 880913
Start Time (R/F): 700
Rainfall Depth (mm): 5.2

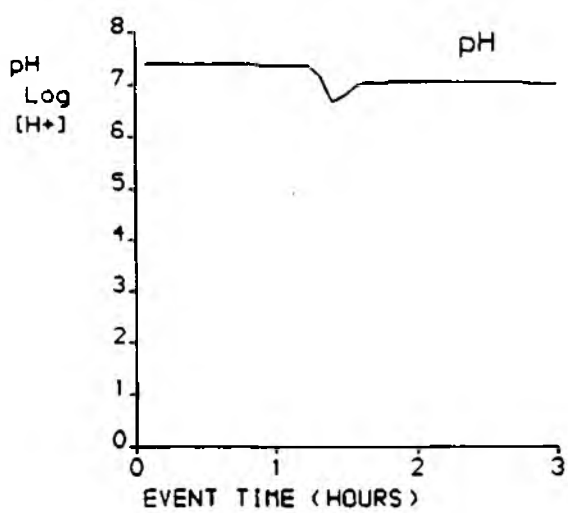
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 137.







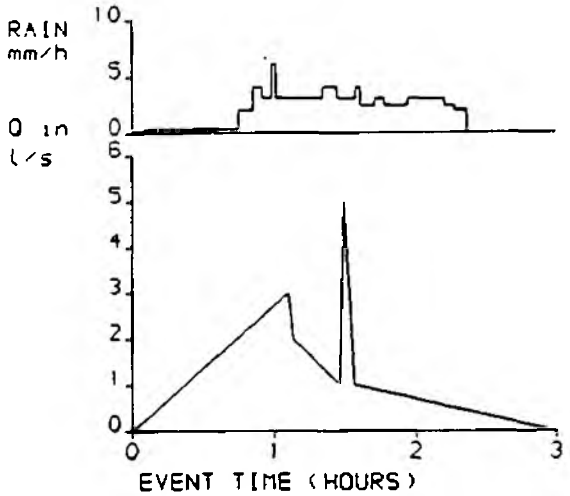


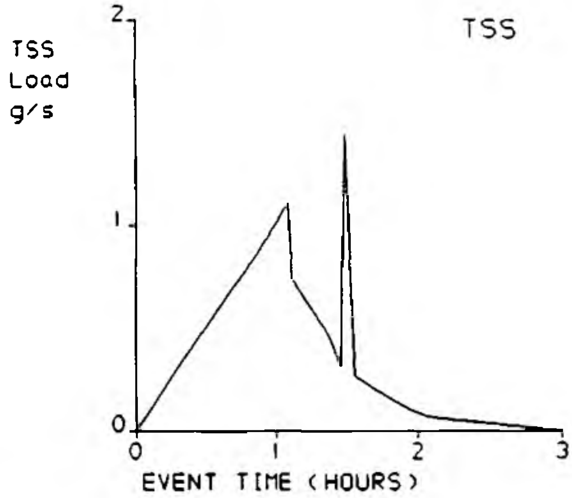


Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880913SO.DAT

Grid Ref: 262044
Storm Date: 880913
Start Time (R/F): 700
Rainfall Depth (mm): 5.2

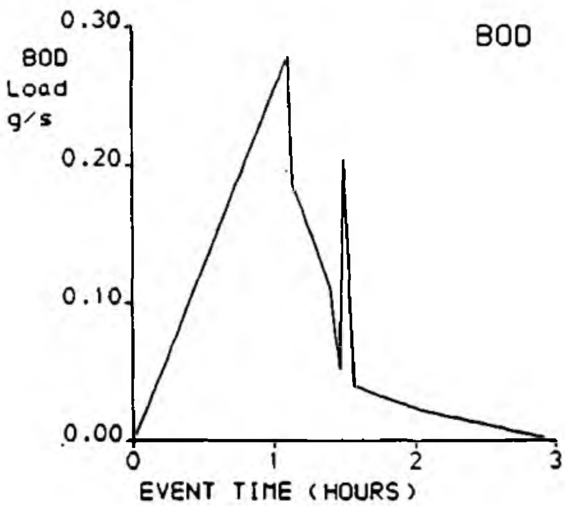
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 137.

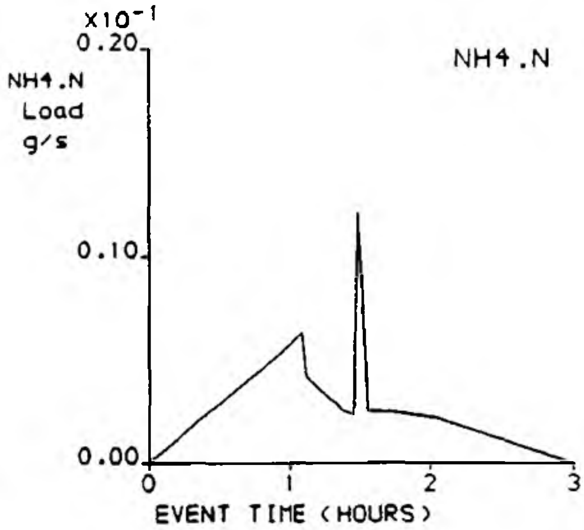




NO DATA FOR COD

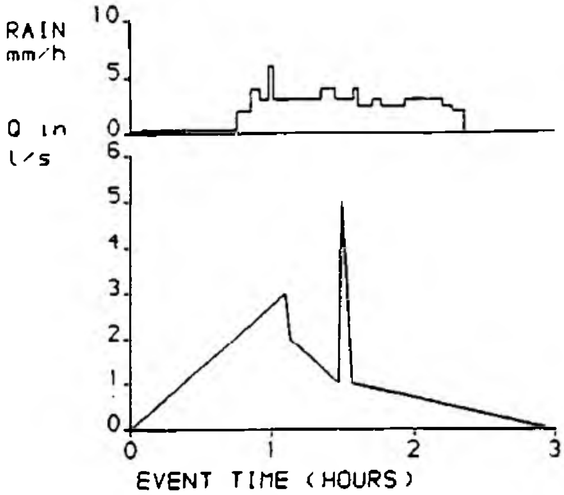
NO DATA FOR TDS

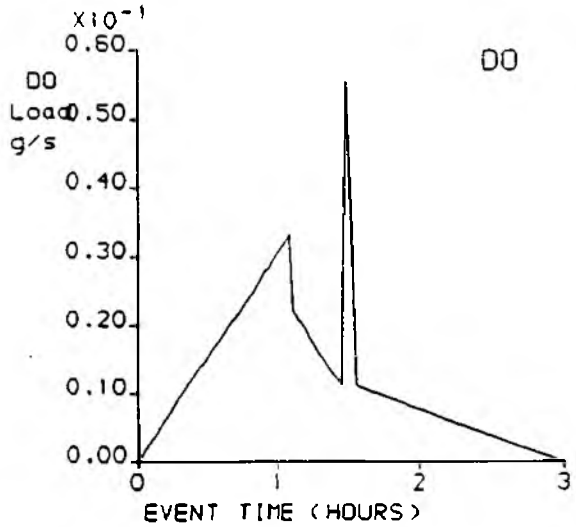




Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880913SO.DAT

Grid Ref: 262044 Weather Conditions:
Storm Date: 880913 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 700 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 5.2 Rainfall Event Duration (mins): 137.





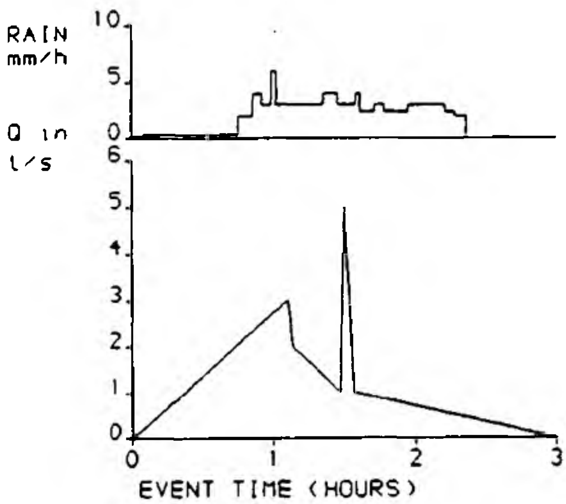
NO DATA FOR TEMP

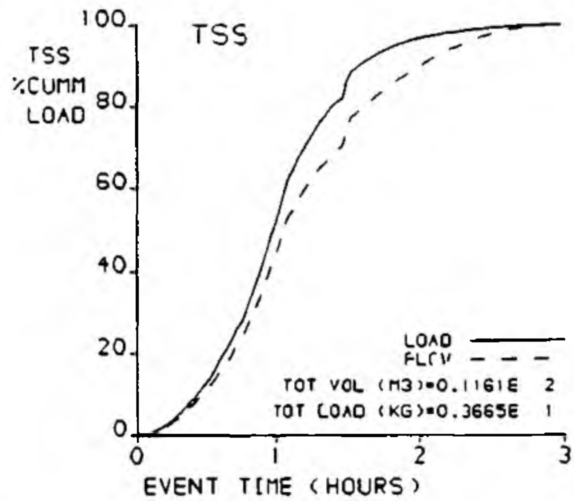
NO DATA FOR Cond

NO DATA FOR pH

Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880913SO.DAT

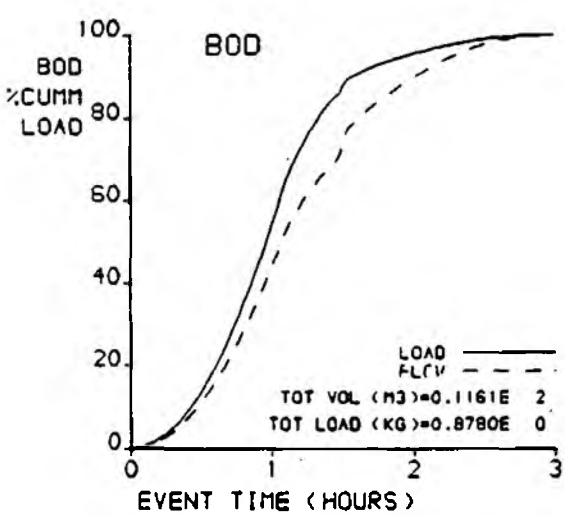
Grid Ref: 262044 Weather Conditions:
Storm Date: 880913 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 700 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 5.2 Rainfall Event Duration (mins): 137.

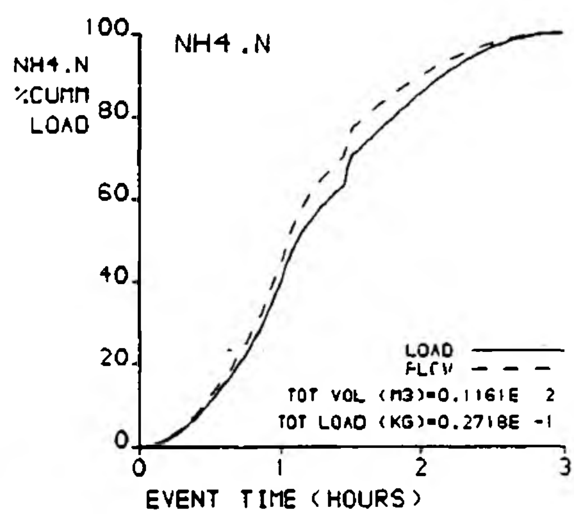




NO DATA FOR COD

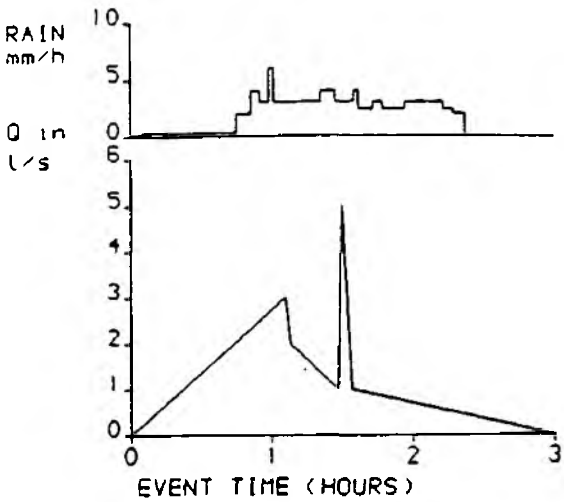
NO DATA FOR TDS

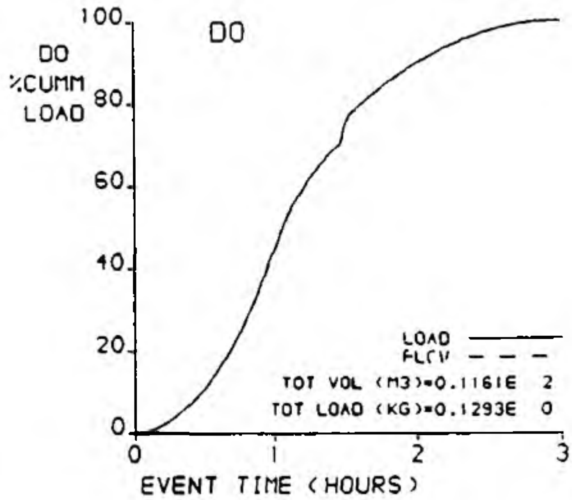




Site: STORM SEWAGE OVERFLOW TO NANT FFR GN880913SO.DAT

Grid Ref: 262044 Weather Conditions:
Storm Date: 880913 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 700 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 5.2 Rainfall Event Duration (mins): 137.





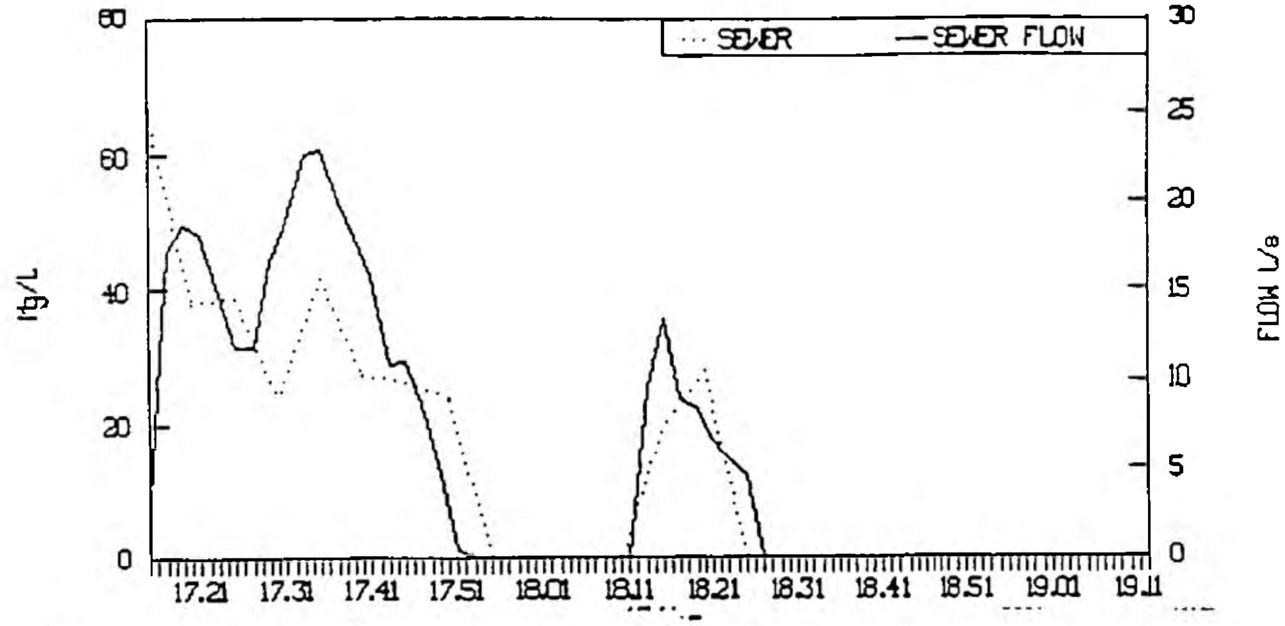
NO DATA FOR TEMP

NO DATA FOR Cond

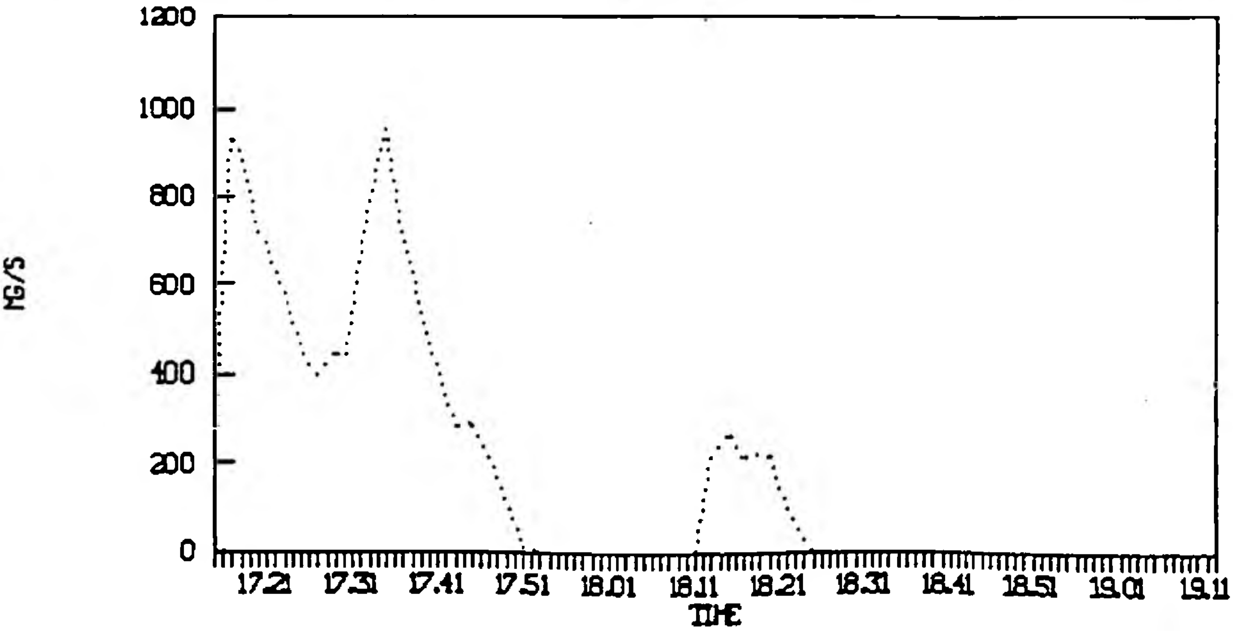
NO DATA FOP

GARNDIFFAITH SSO EVENT 12 18-10-88.

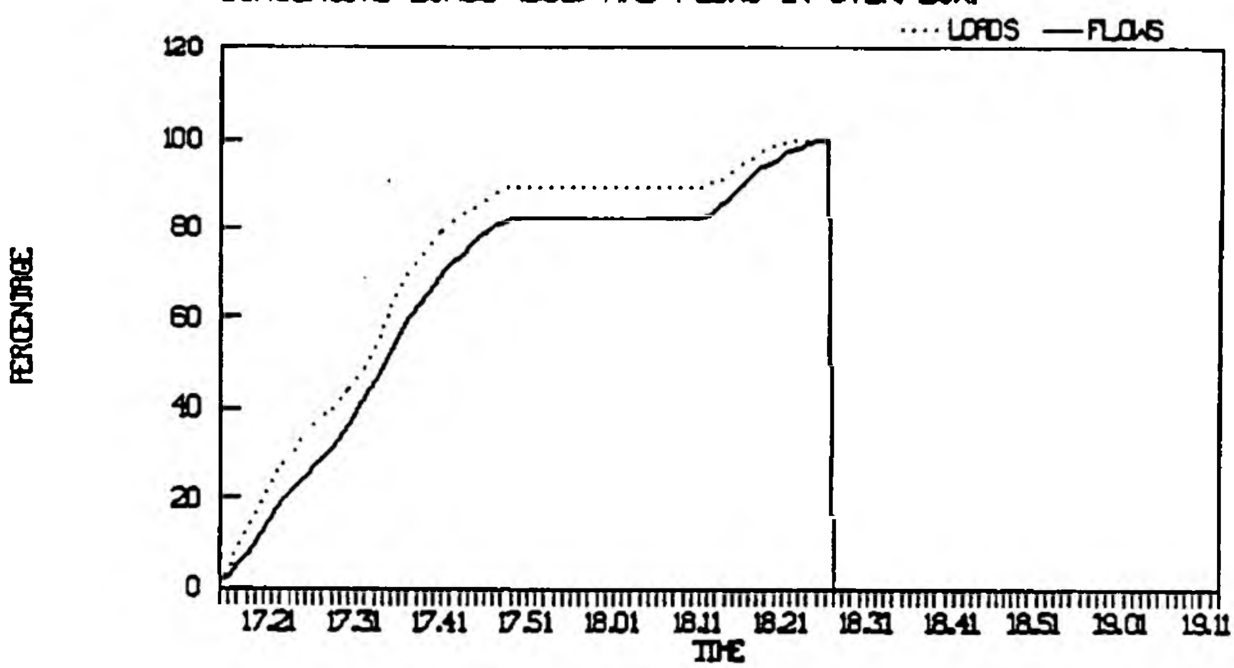
BOD CONCENTRATIONS AT SEWER.



BOD LOADS AT SEWER.

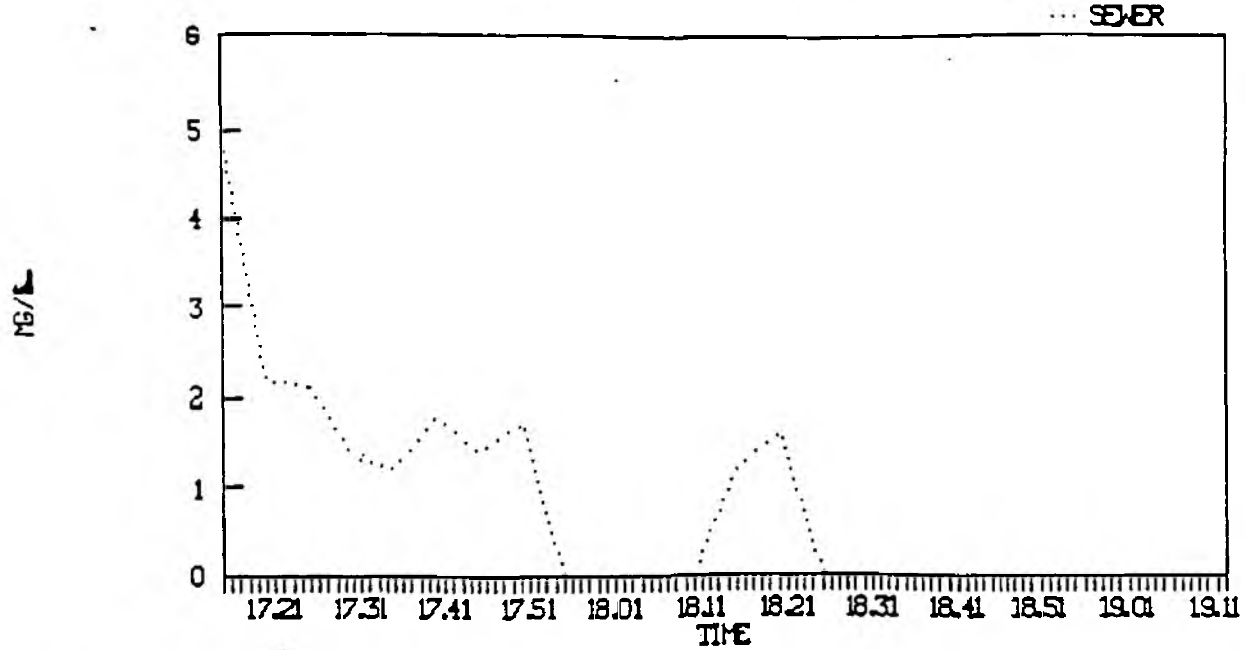


CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW.

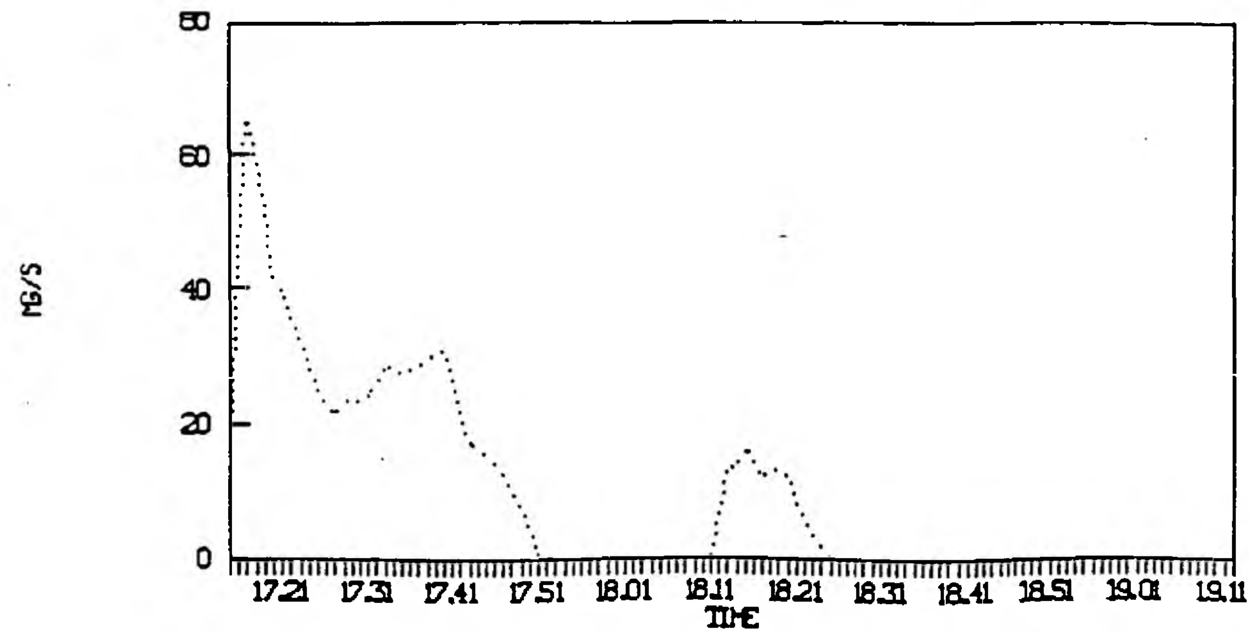


GARNDIFFAITH SSO EVENT 12 18-10-88

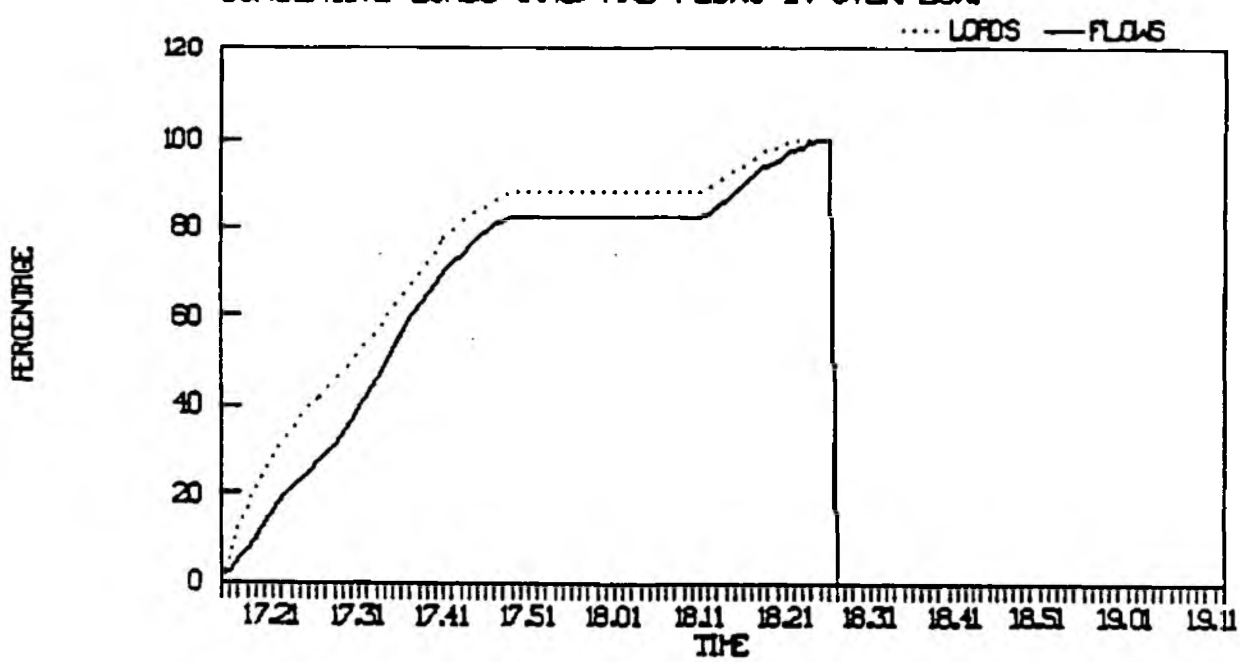
NH3 CONCENTRATIONS AT SEWER.



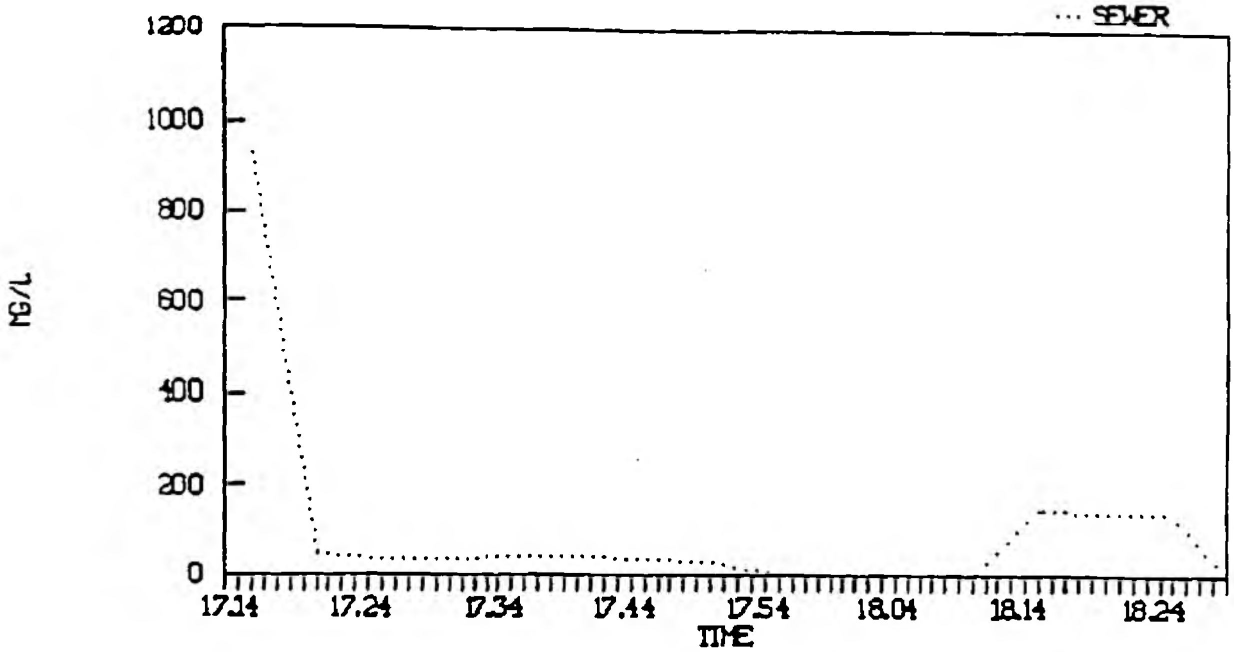
NH3 LOADS AT SEWER.



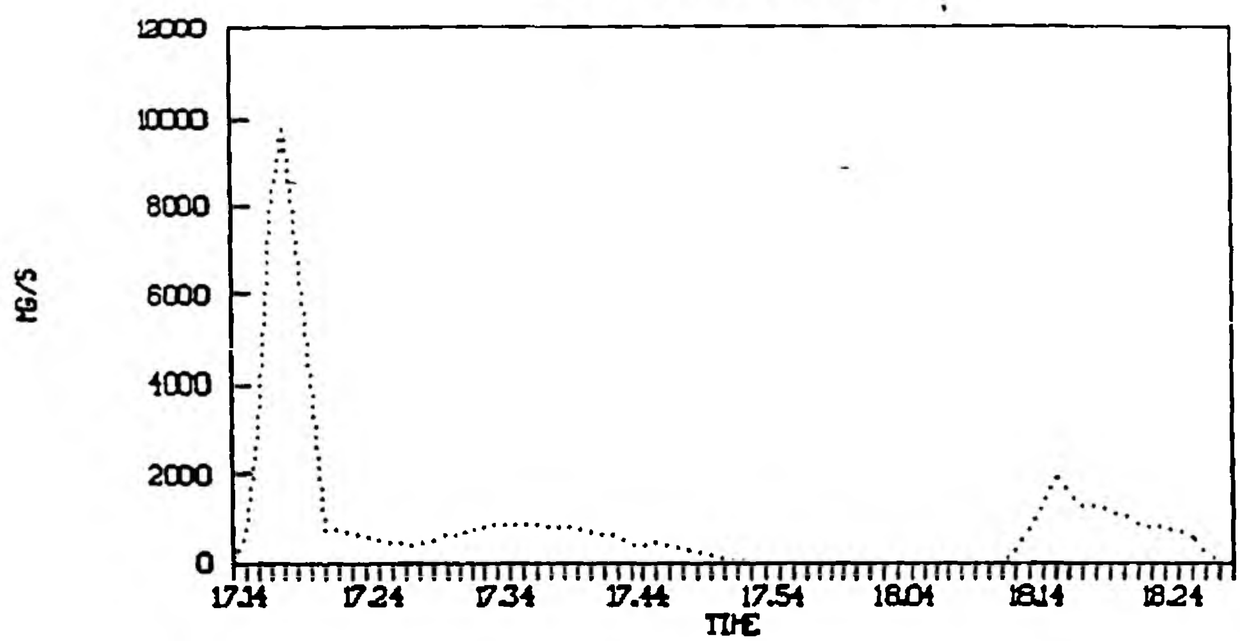
CUMULATIVE LOADS (NH3) AND FLOWS IN OVERFLOW.



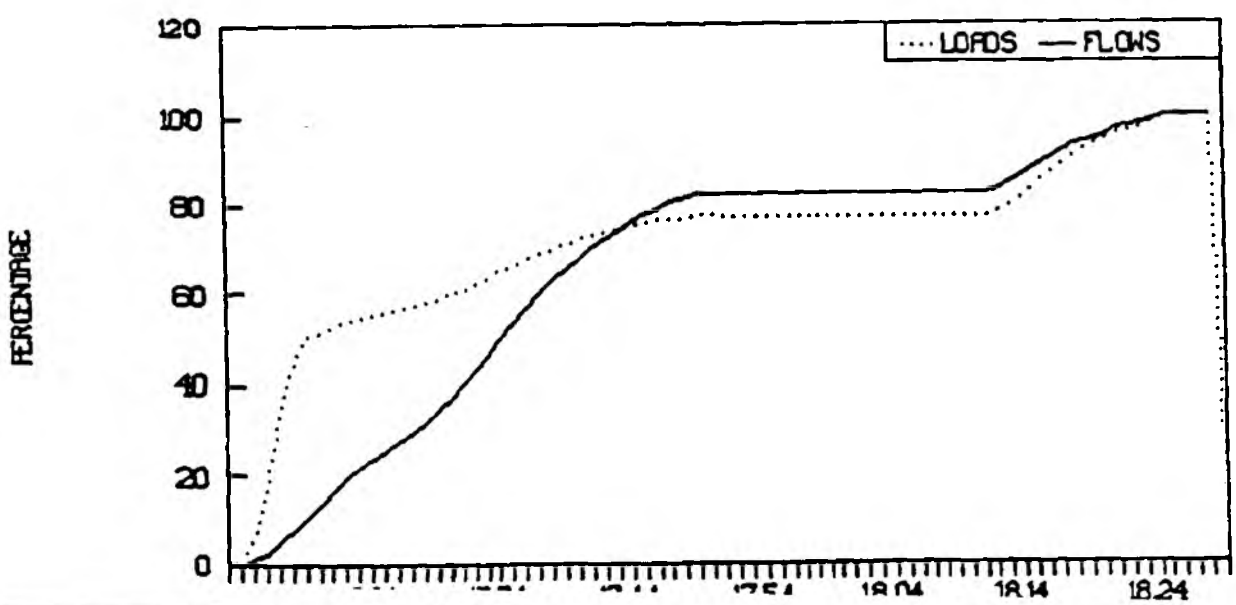
GARNDIFFAITH SSO EVENT 12 18-10-88
TSS CONCENTRATIONS IN OVERFLOW



GARNDIFFAITH SSO EVENT 12 18-10-88
TSS LOADS IN OVERFLOW

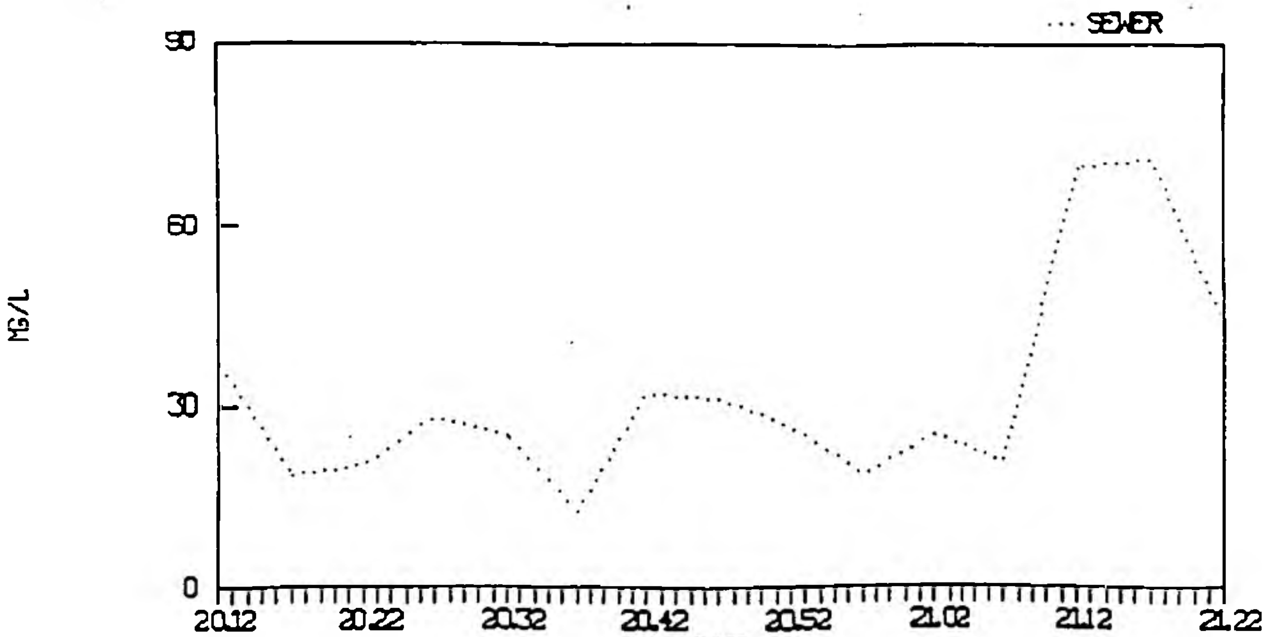


GARNDIFFAITH SSO EVENT 12 18-10-88
CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW

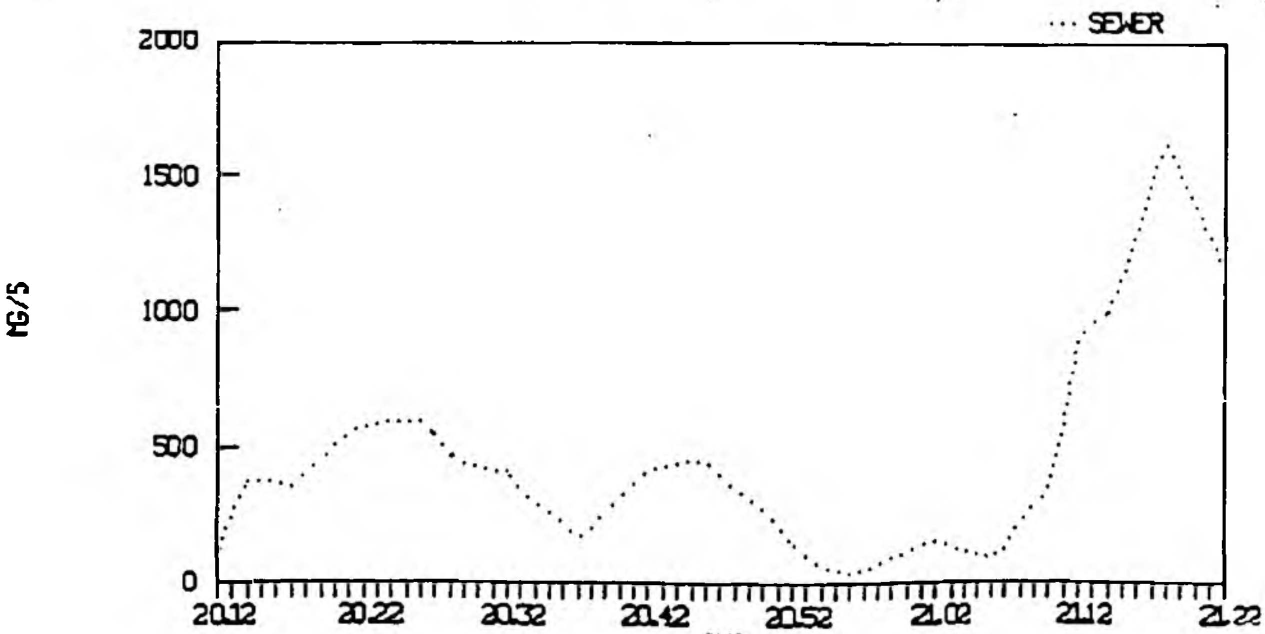


GARNDIFFAITH SSO EVENT 14 23-02-89

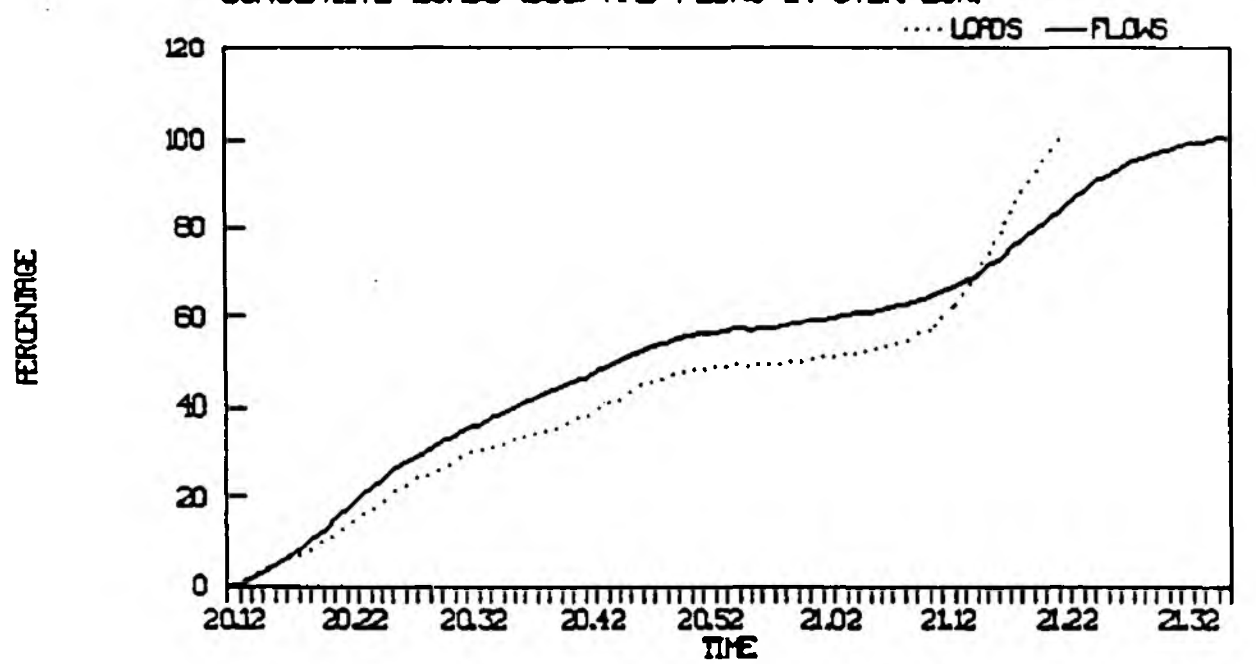
BOD CONCENTRATIONS



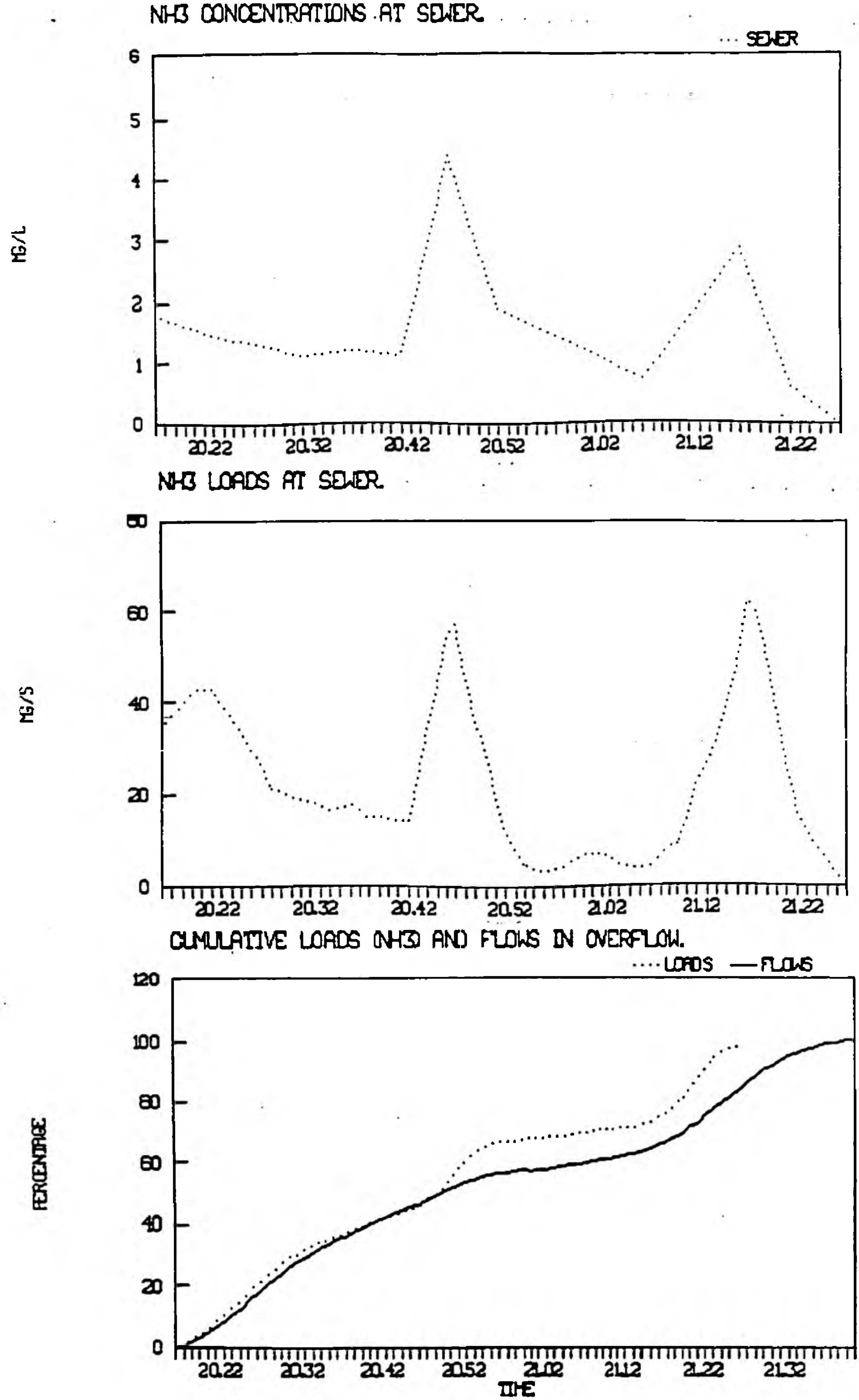
BOD LOADS



CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW

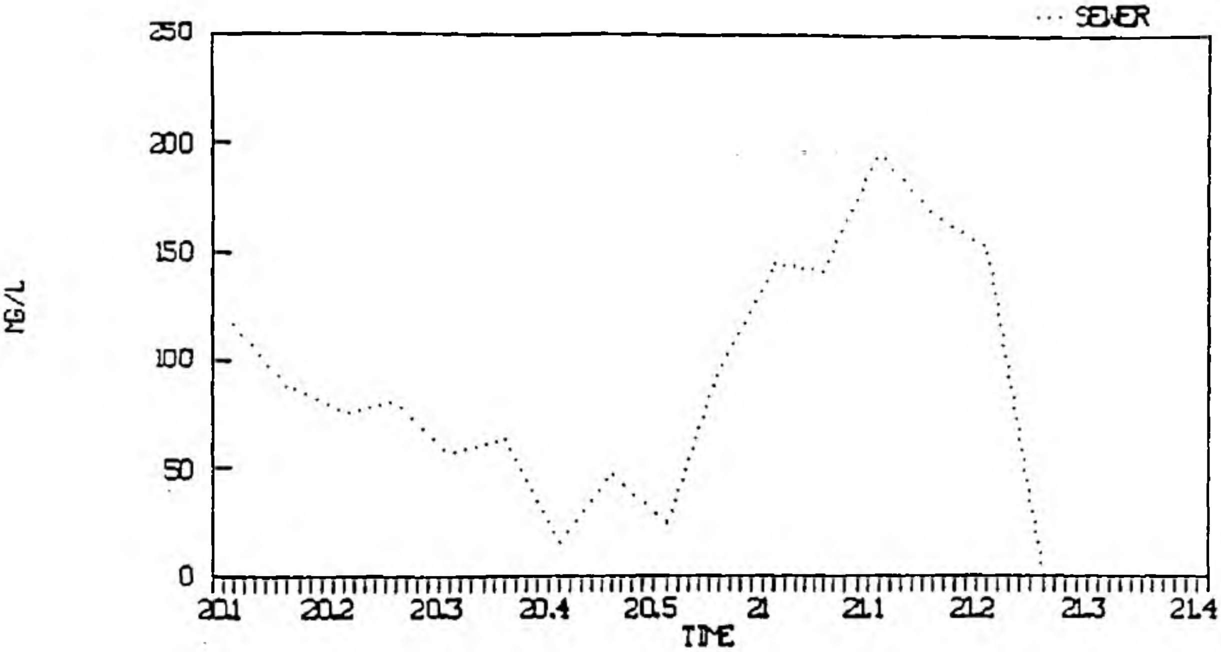


GARNDIFFAITH SSO EVENT 14 23-02-89

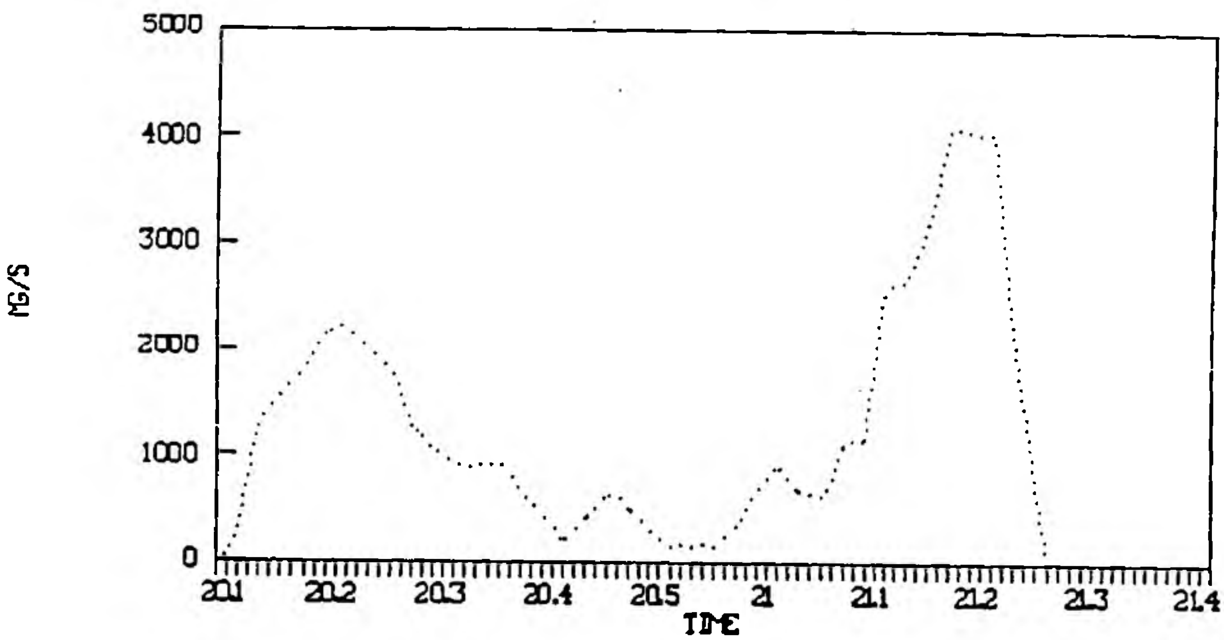


GARNDIFFAITH SSO EVENT 14 23-02-89

TSS CONCENTRATIONS IN OVERFLOW

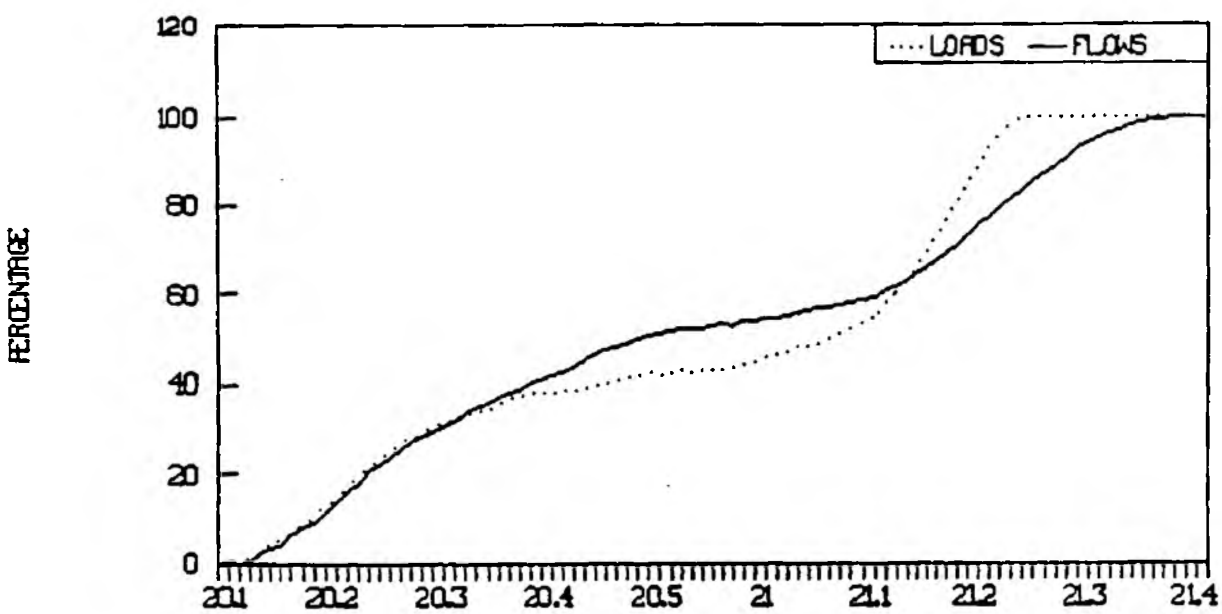


TSS LOADS IN OVERFLOW



GARNDIFFAITH SSO EVENT 14 23-02-89

CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW

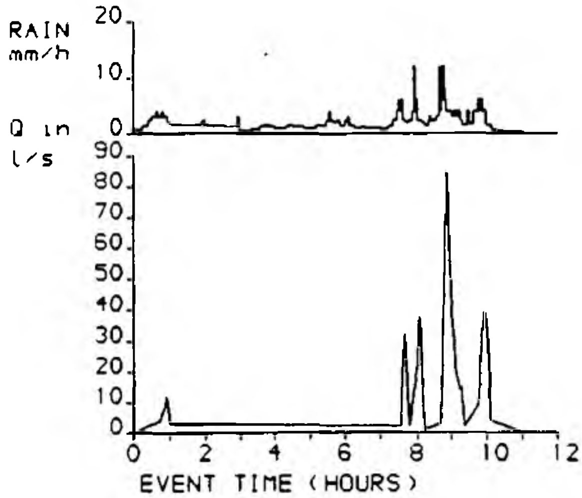


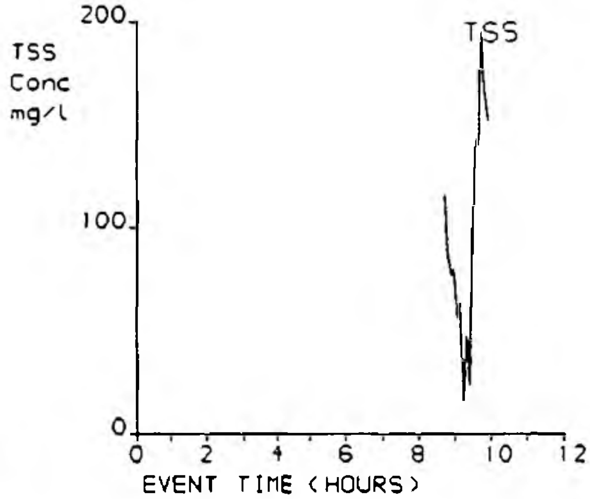
Site: SSO TO NANT FFRWD

GN890223SO.DAT

Grid Ref: 262044
Storm Date: 890223
Start Time (R/F): 1128
Rainfall Depth (mm): 20.8

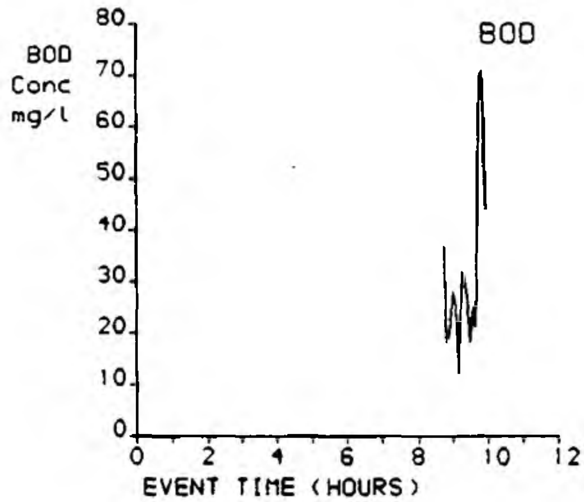
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 659.

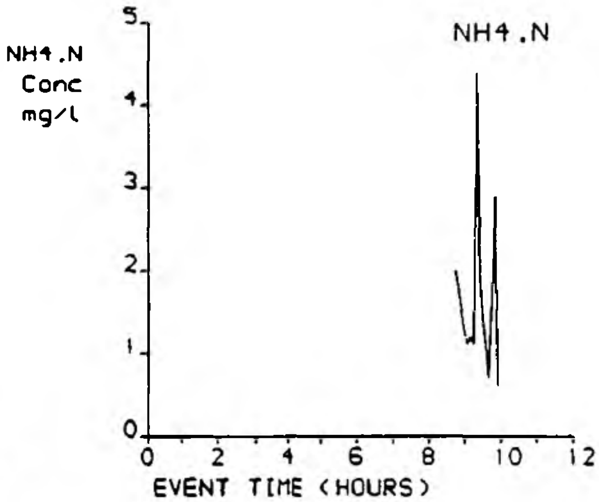




NO DATA FOR COD

NO DATA FOR TDS



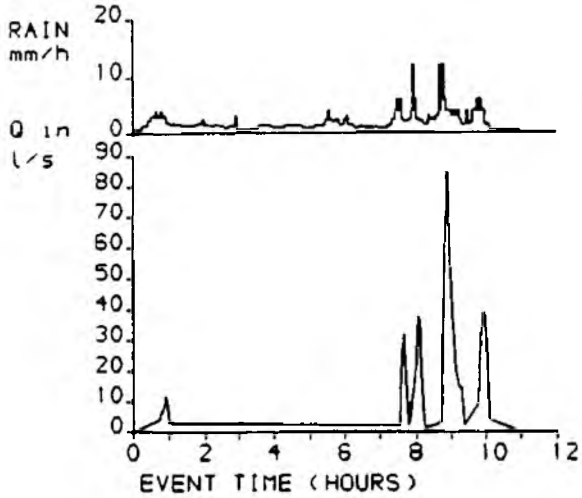


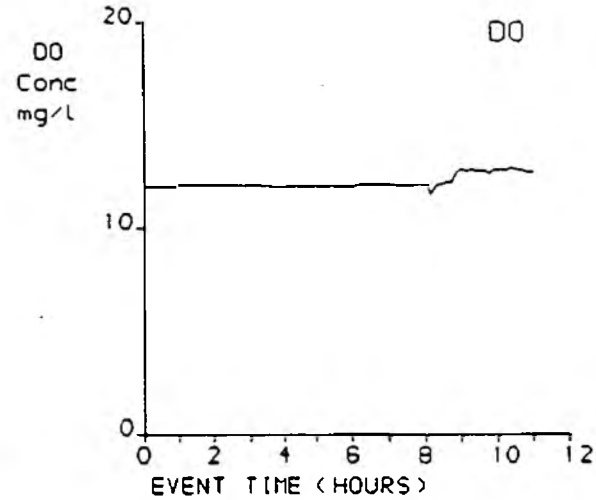
Site: SSO TO NANT FFRWD

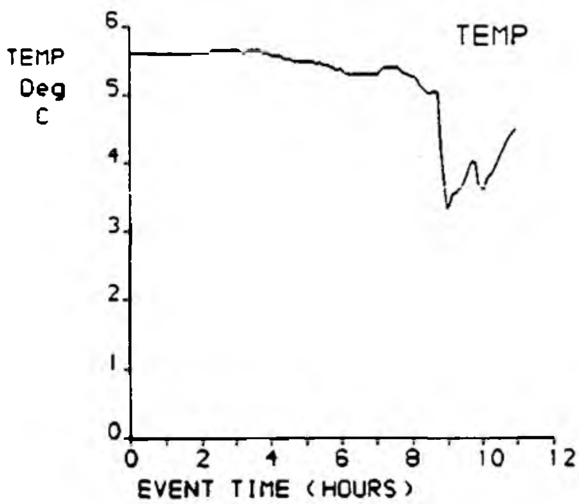
GN890223SO.DAT

Grid Ref: 262044
Storm Date: 890223
Start Time (R/F): 1128
Rainfall Depth (mm): 20.8

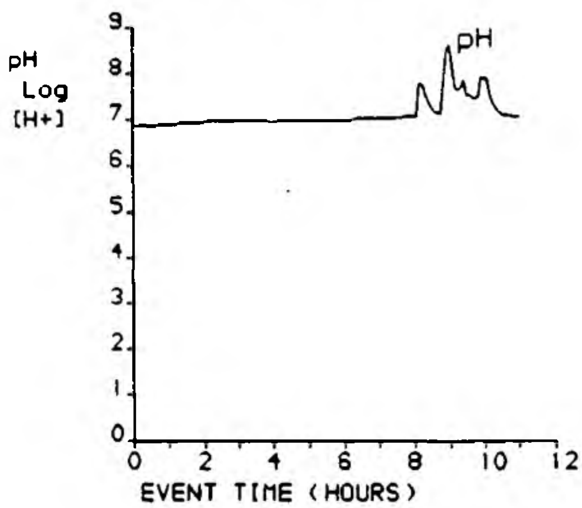
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 659.







NO DATA FOR Cond

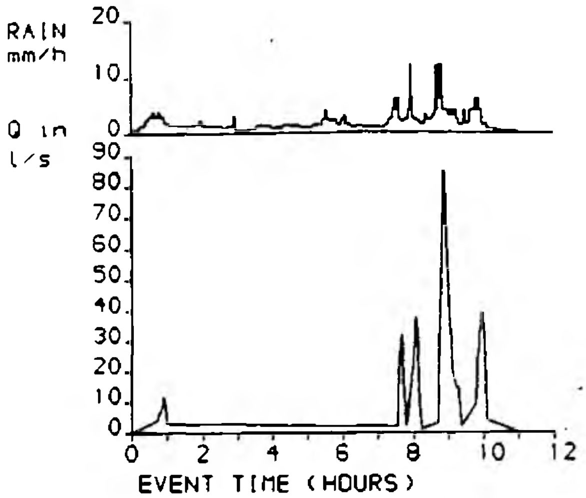


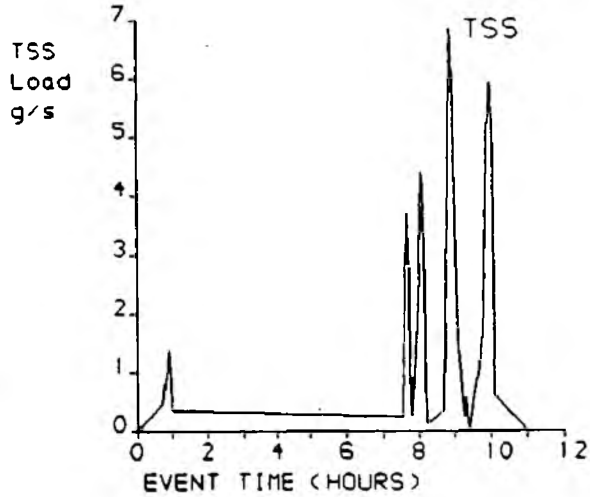
Site: SSO TO NANT FFRWD

GN890223SO.DAT

Grid Ref: 262044
Storm Date: 890223
Start Time (R/F): 1128
Rainfall Depth (mm): 20.8

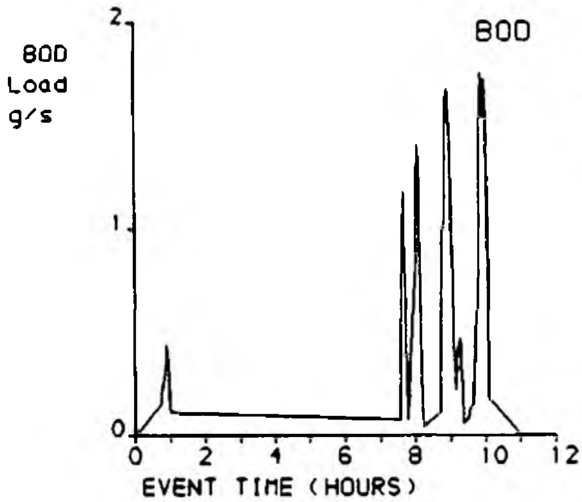
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 659.

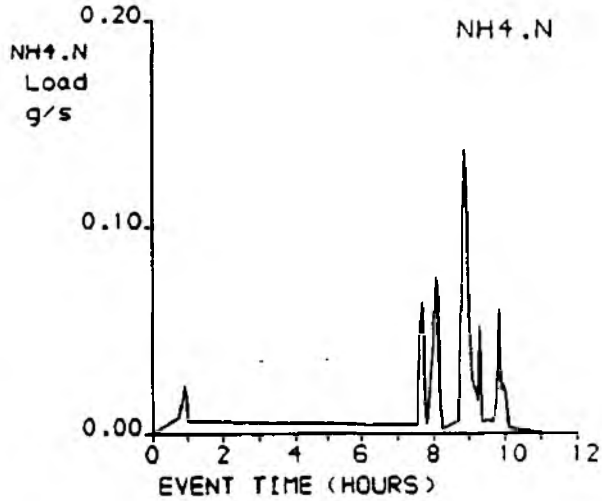




NO DATA FOR COD

NO DATA FOR TDS



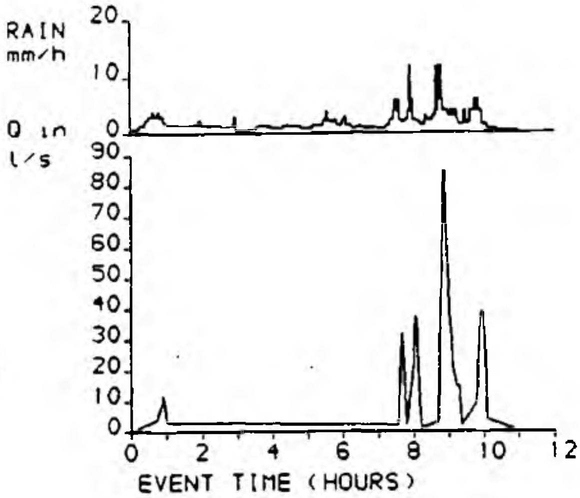


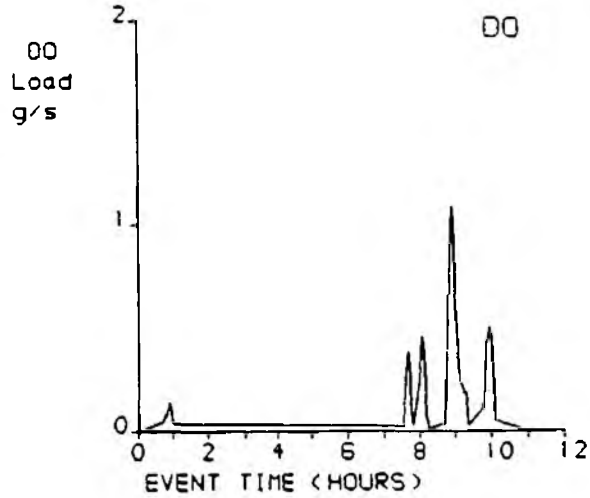
Site: SSO TO NANT FFRWD

GN890223SO.DAT

Grid Ref: 262044
Storm Date: 890223
Start Time (R/F): 1128
Rainfall Depth (mm): 20.8

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 659.





NO DATA FOR TEMP

NO DATA FOR Cond

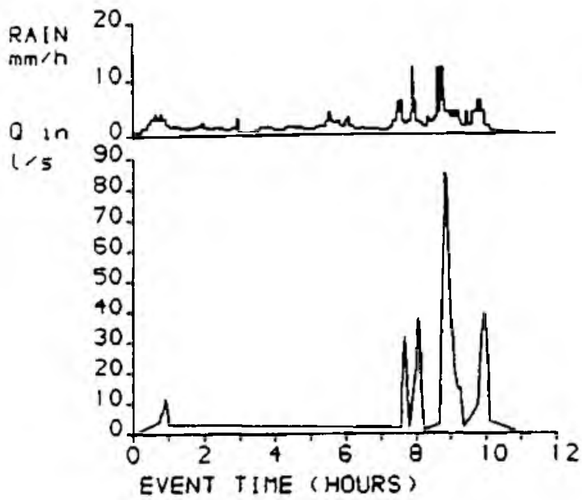
NO DATA FOR pH

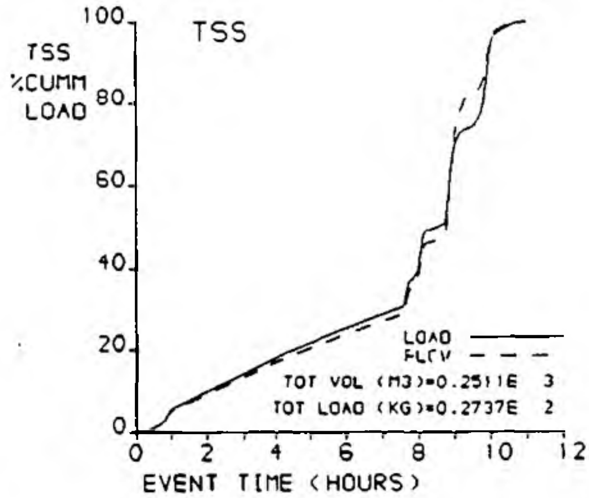
Site: SSO TO NANT FFRWD

GN890223SO.DAT

Grid Ref: 262044
Storm Date: 890223
Start Time (R/F): 1128
Rainfall Depth (mm): 20.8

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 659.





NO DATA FOR COD

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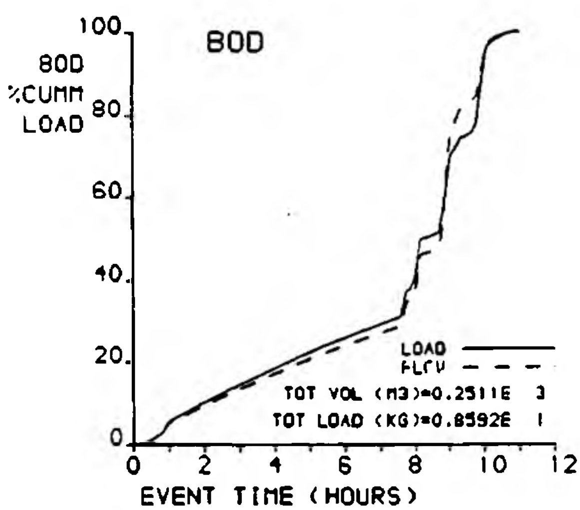
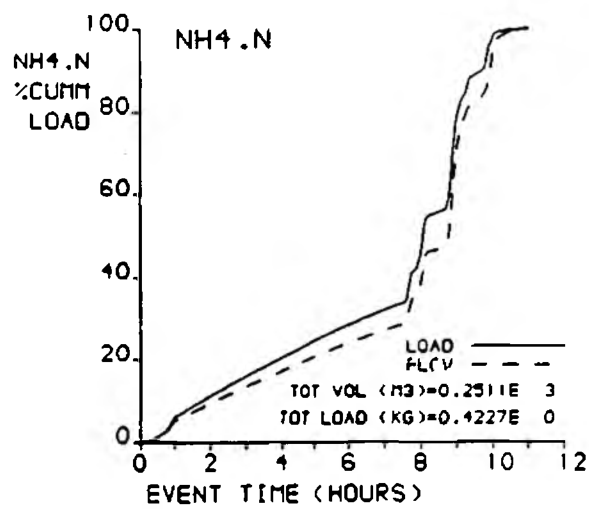


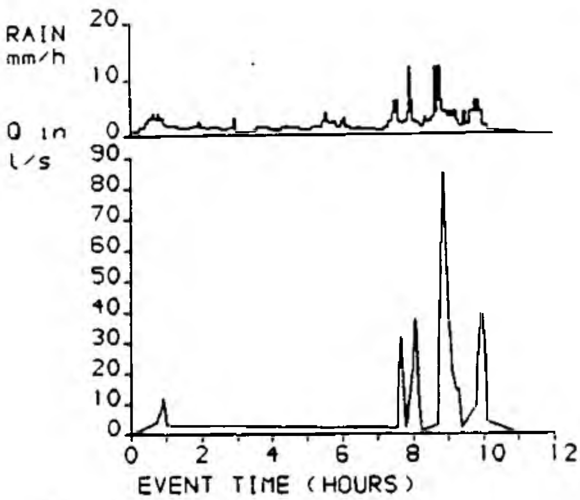


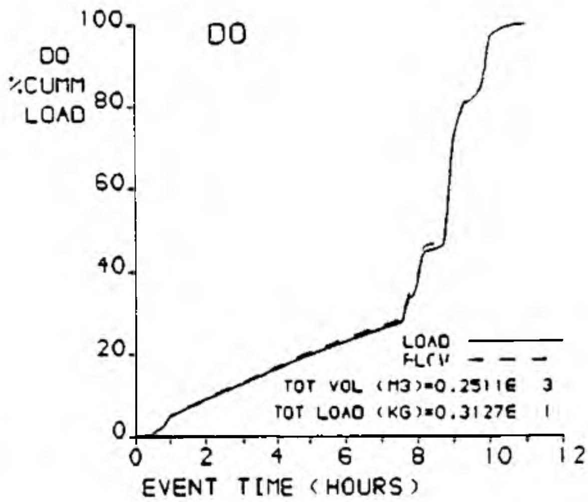
Site: SSO TO NANT FFRWD

GN890223SO.DAT

Grid Ref: 262044
Storm Date: 890223
Start Time (R/F): 1128
Rainfall Depth (mm): 20.8

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 659.





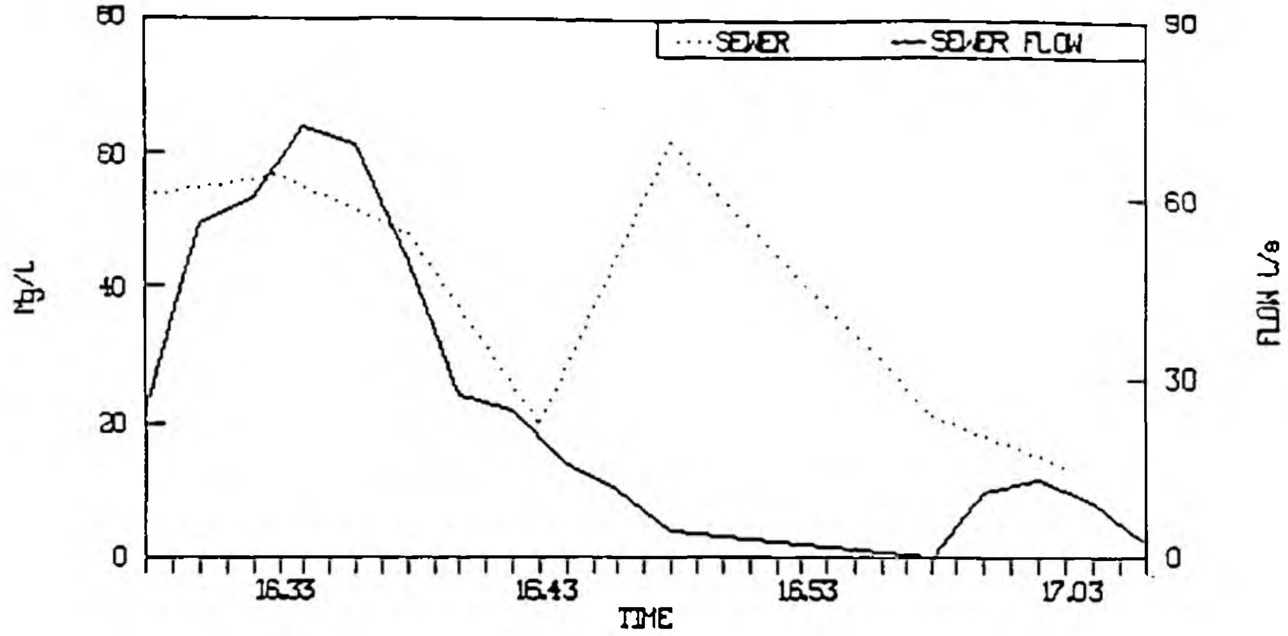
NO DATA FOR TEMP

NO DATA FOR Cond

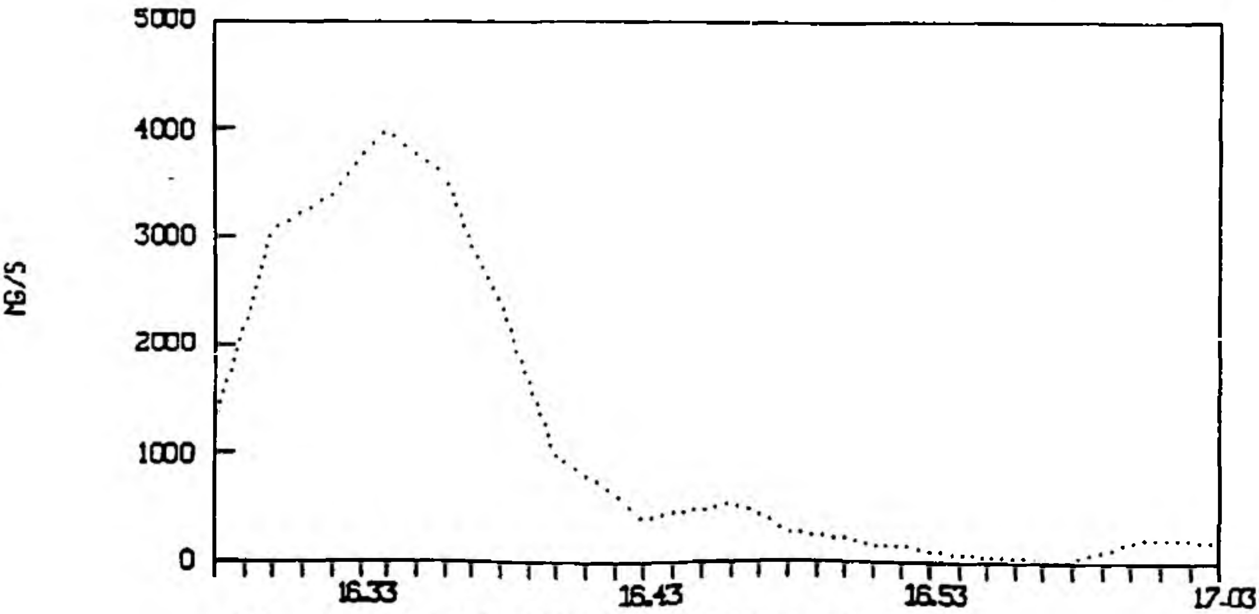
NO DATA FOR ɔ

GARNDIFFAITH SSO EVENT 15 06-03-89

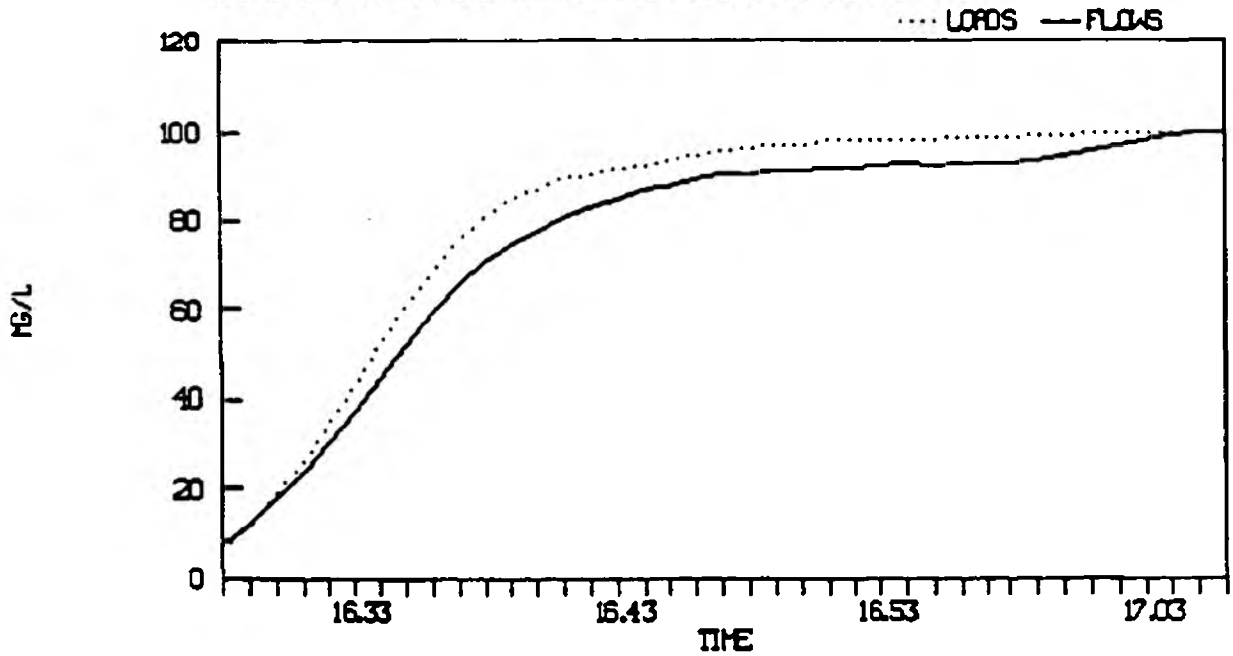
BOD CONCENTRATIONS AT SEWER.



BOD LOADS AT SEWER.

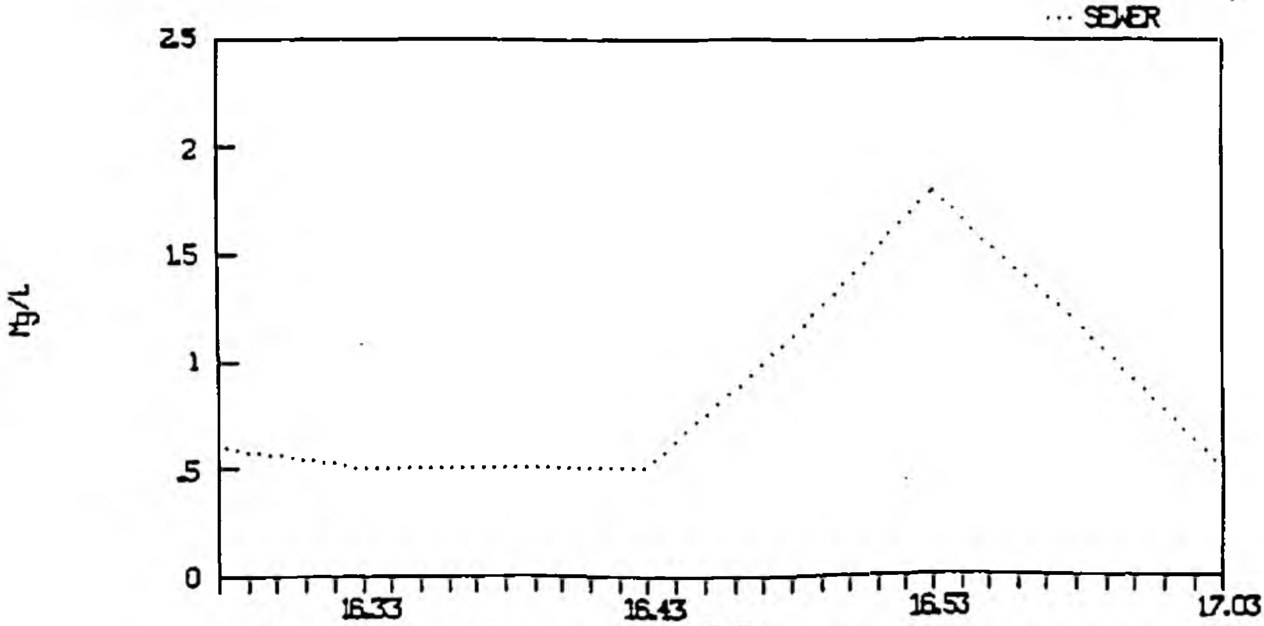


CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW.

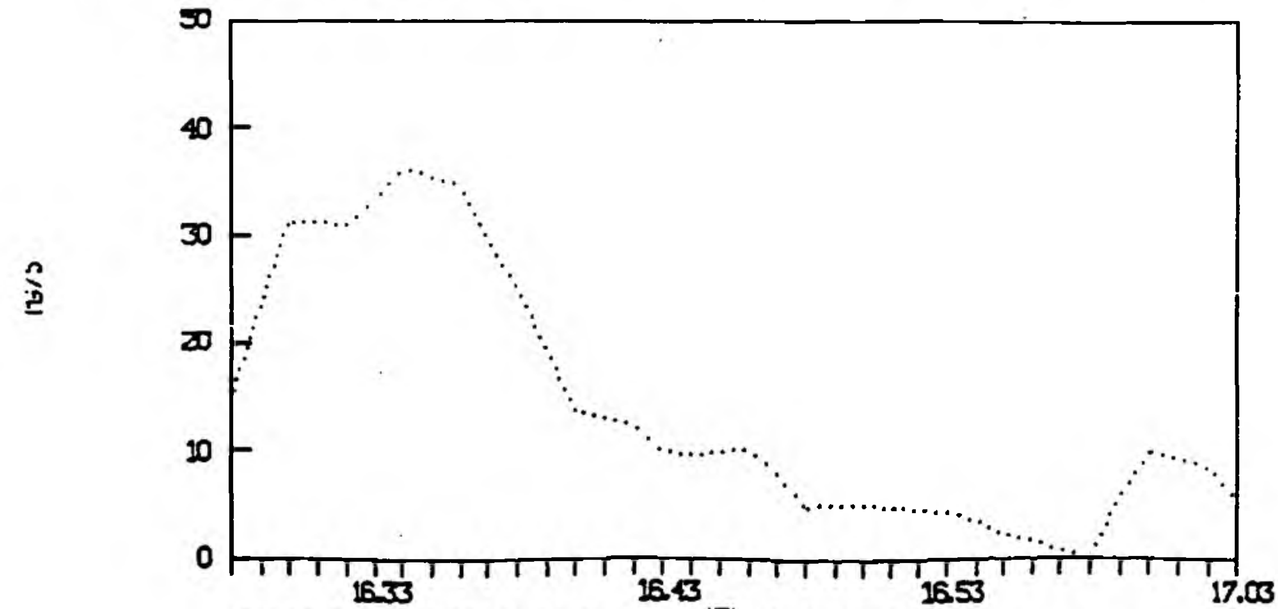


GARNDIFFAITH SSD EVENT 15 06-03-89

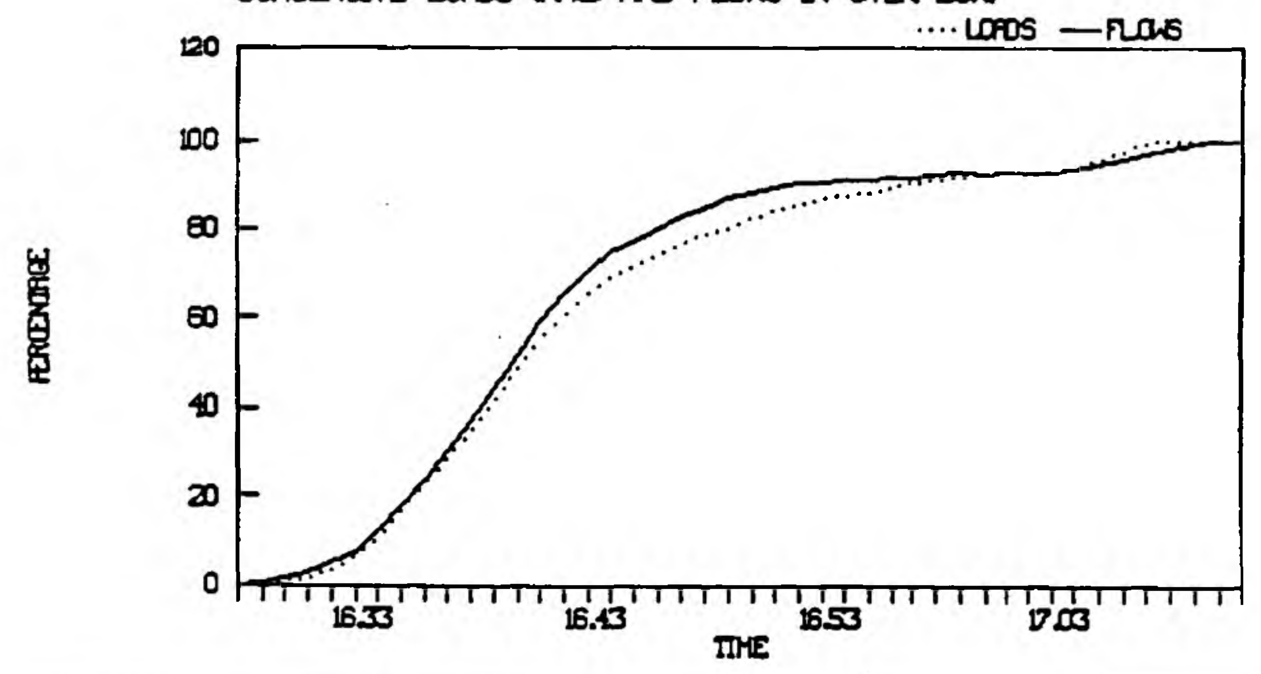
NH3 CONCENTRATIONS AT SEWER



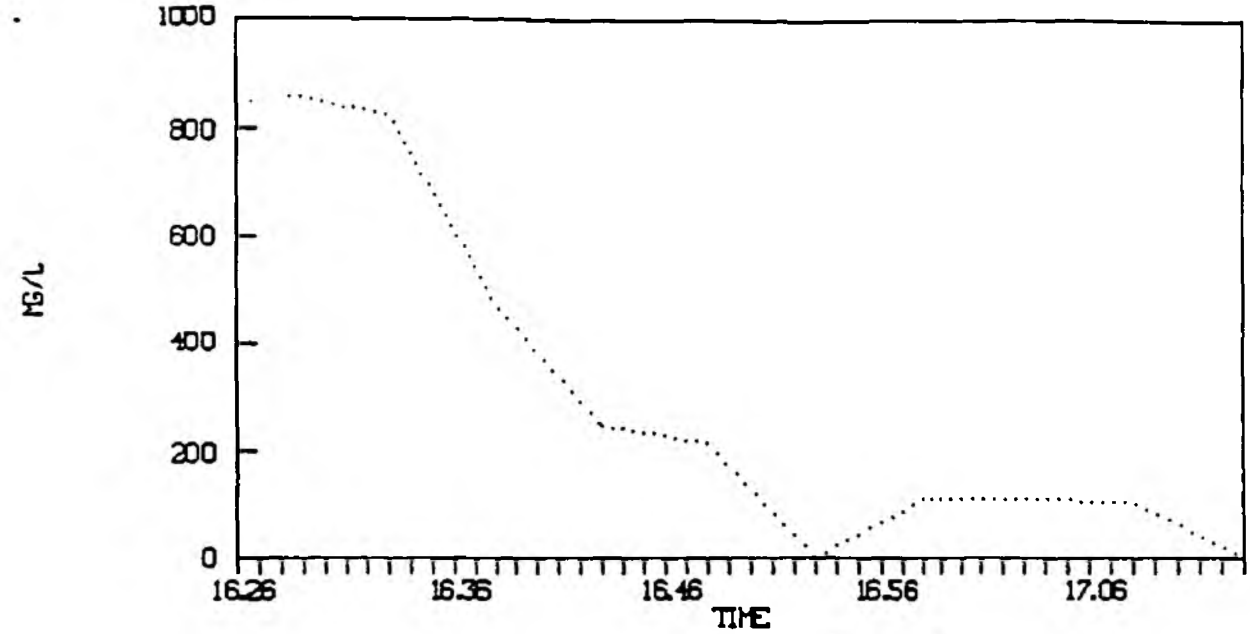
NH3 LOADS AT SEWER.



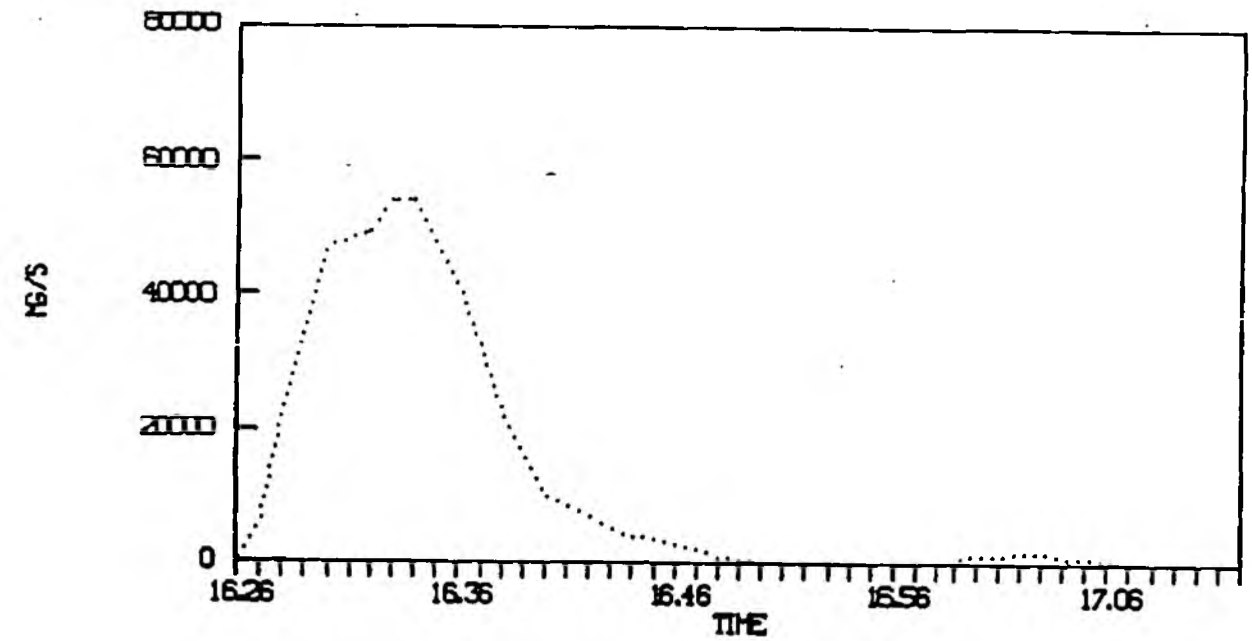
CUMULATIVE LOADS (NH3) AND FLOWS IN OVERFLOW.



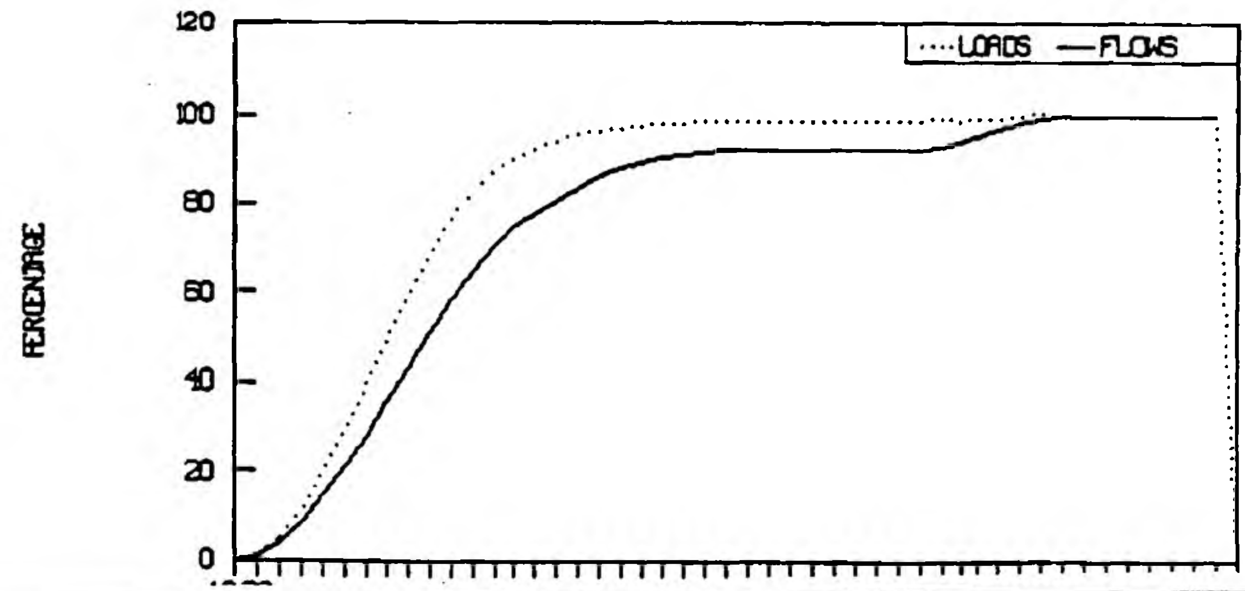
GARNDIFFAITH SSO EVENT 15 06-03-89
TSS CONCENTRATIONS IN OVERFLOW



GARNDIFFAITH SSO EVENT 15 06-03-89
TSS LOADS IN OVERFLOW



GARNDIFFAITH SSO EVENT 15 06-03-89
CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW

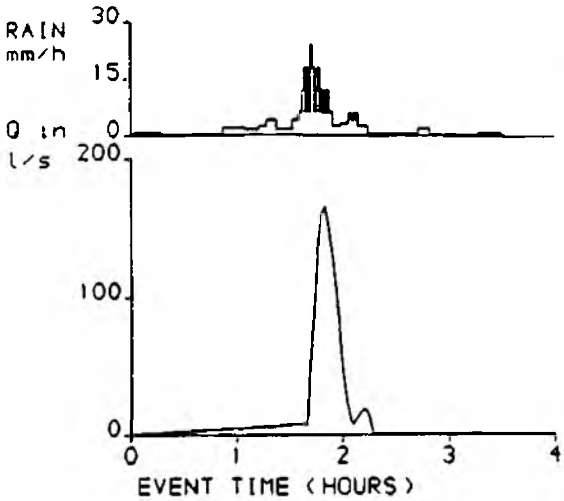


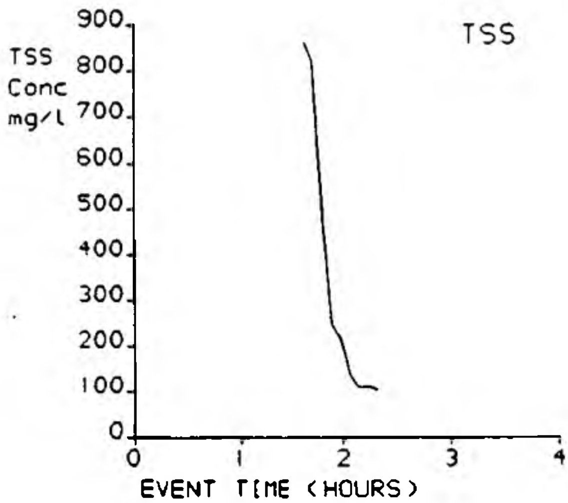
Site: SSO TO NANT FFRWD

GN89030650.DAT

Grid Ref: 262044
Storm Date: 890306
Start Time (R/F): 1450
Rainfall Depth (mm): 7.6

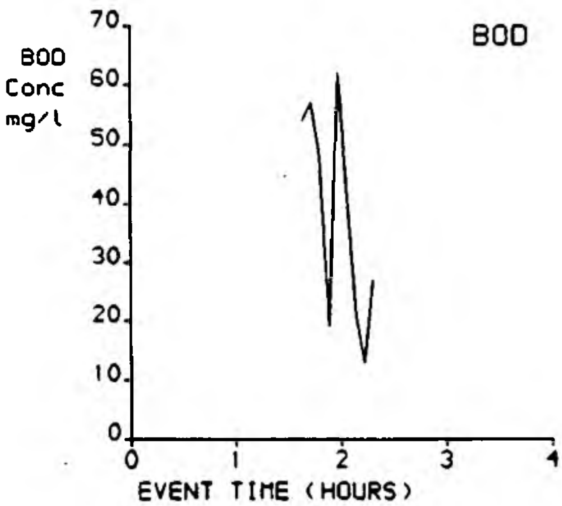
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 209.

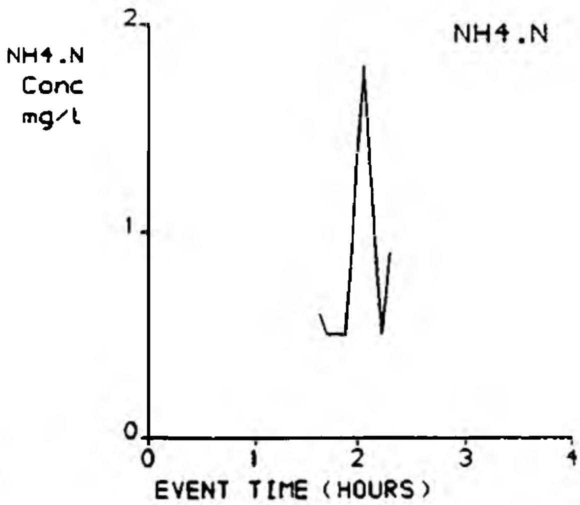




NO DATA FOR COD

NO DATA FOR TDS



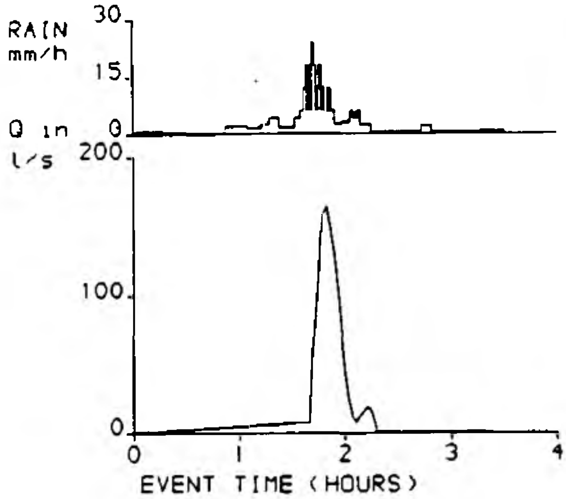


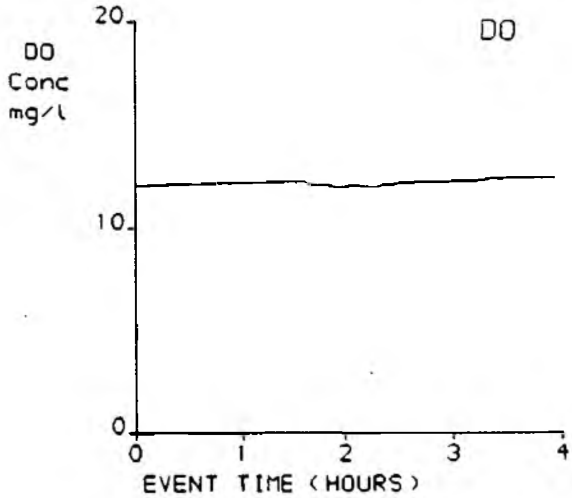
Site: SSO TO NANT FFRWD

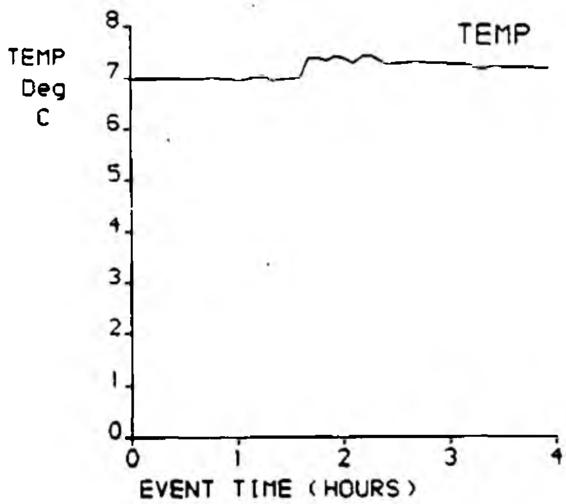
GN890306SO.DAT

Grid Ref: 262044
Storm Date: 890306
Start Time (R/F): 1450
Rainfall Depth (mm): 7.6

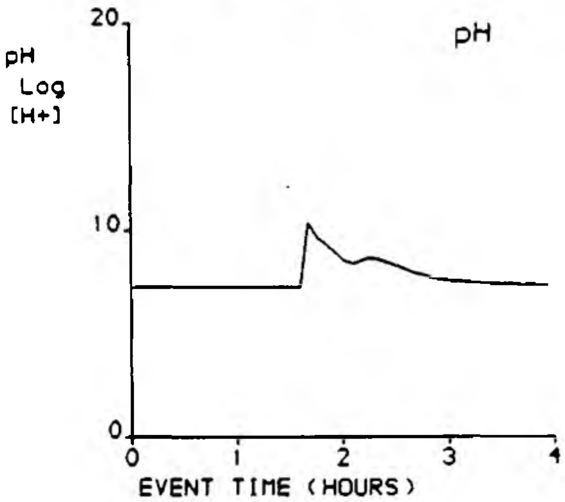
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 209.







NO DATA FOR Cond

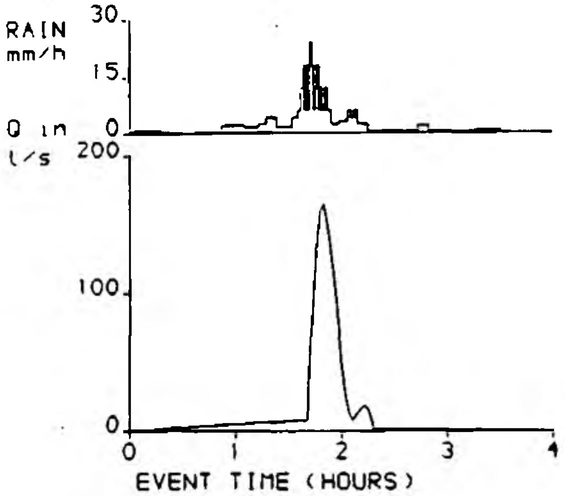


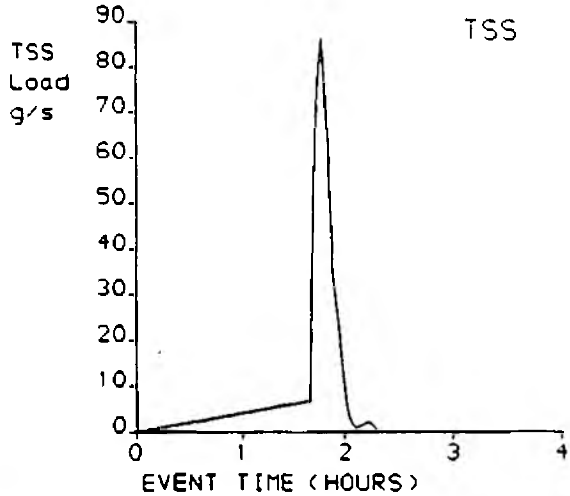
Site: SSO TO NANT FFRWD

GN890306SO.DAT

Grid Ref: 262044
Storm Date: 890306
Start Time (R/F): 1450
Rainfall Depth (mm): 7.6

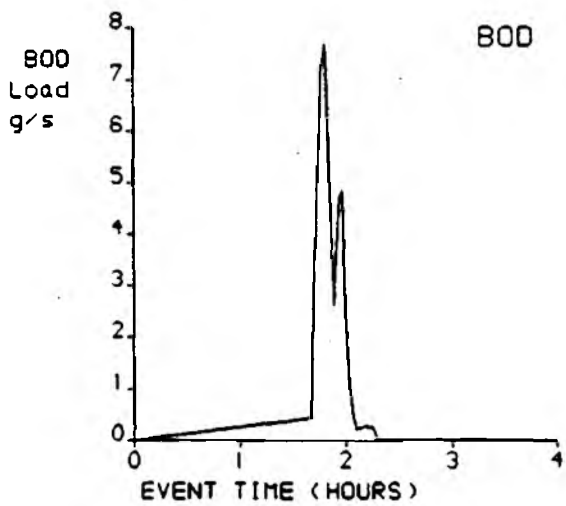
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 209.

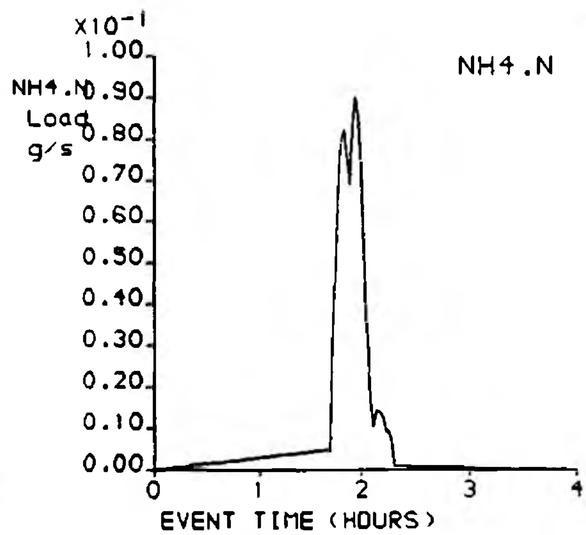




NO DATA FOR COD

NO DATA FOR TDS



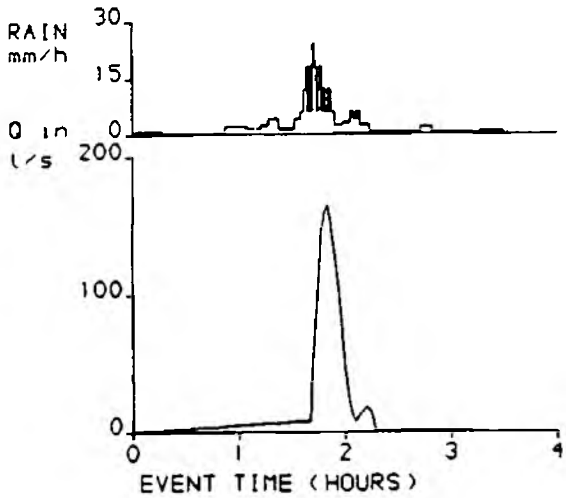


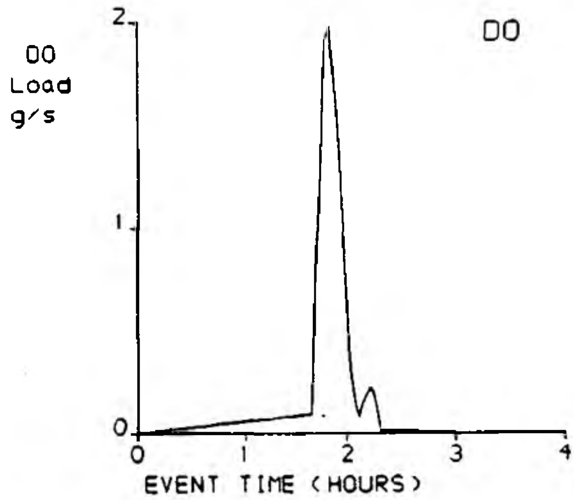
Site: SSO TO NANT FFRWD

GN890306SO.DAT

Grid Ref: 262044
Storm Date: 890306
Start Time (R/F): 1450
Rainfall Depth (mm): 7.6

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 209.





NO DATA FOR TEMP

NO DATA FOR Cond

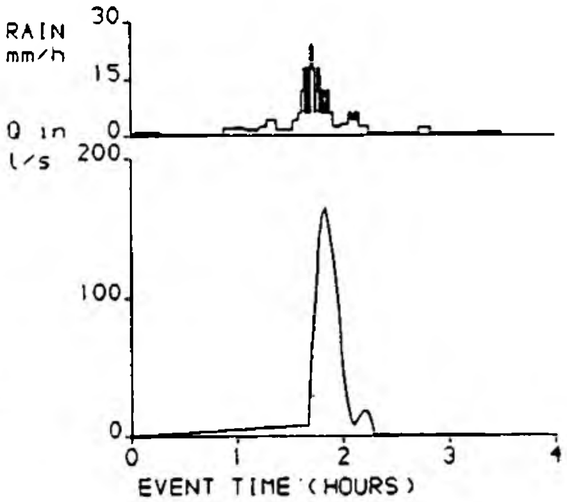
NO DATA FOR pH

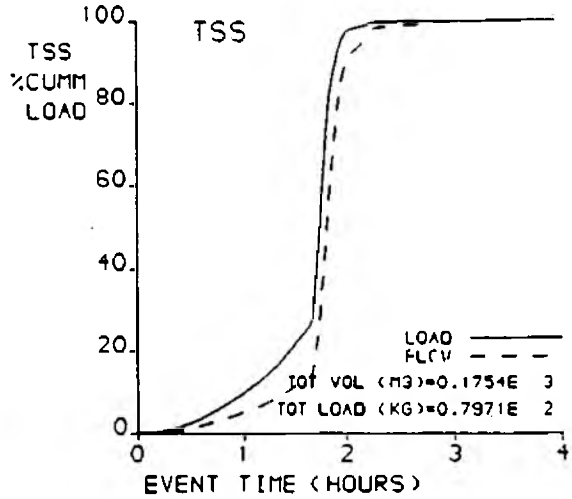
Site: SSO TO NANT FFRWD

GN890306SO.DAT

Grid Ref: 262044
Storm Date: 890306
Start Time (R/F): 1450
Rainfall Depth (mm): 7.6

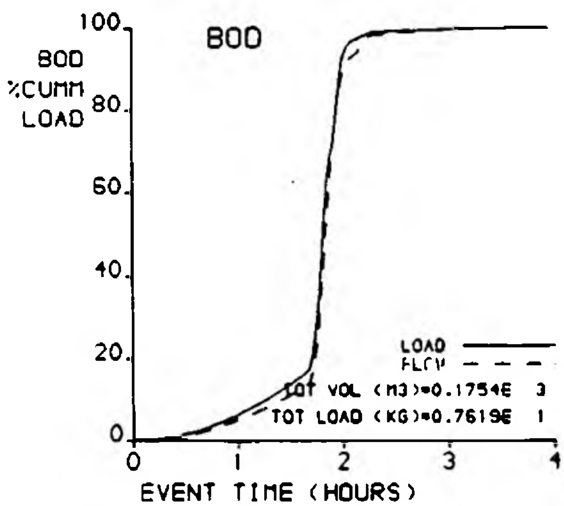
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 209.

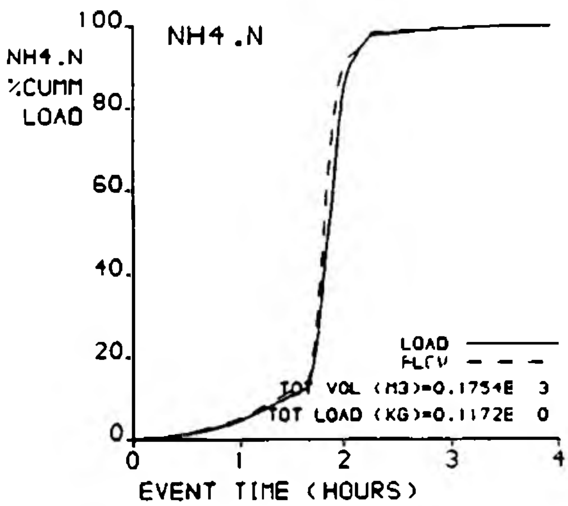




NO DATA FOR COD

NO DATA FOR TDS



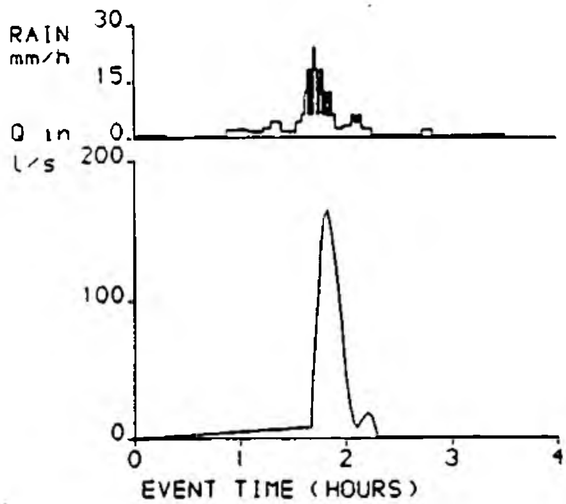


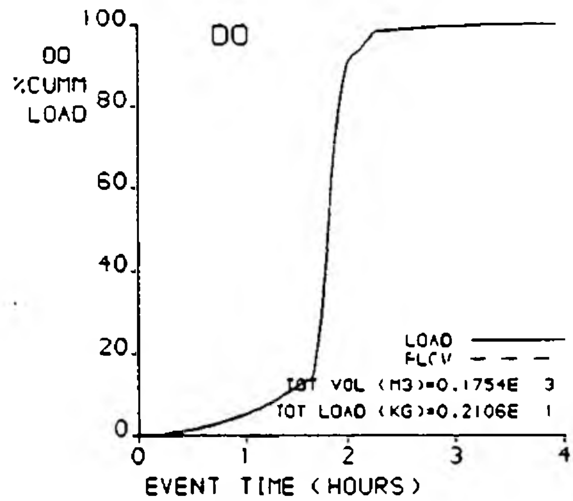
Site: SSO TO NANT FFRWD

GN890306SO.DAT

Grid Ref: 262044
Storm Date: 890306
Start Time (R/F): 1450
Rainfall Depth (mm): 7.6

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 209.





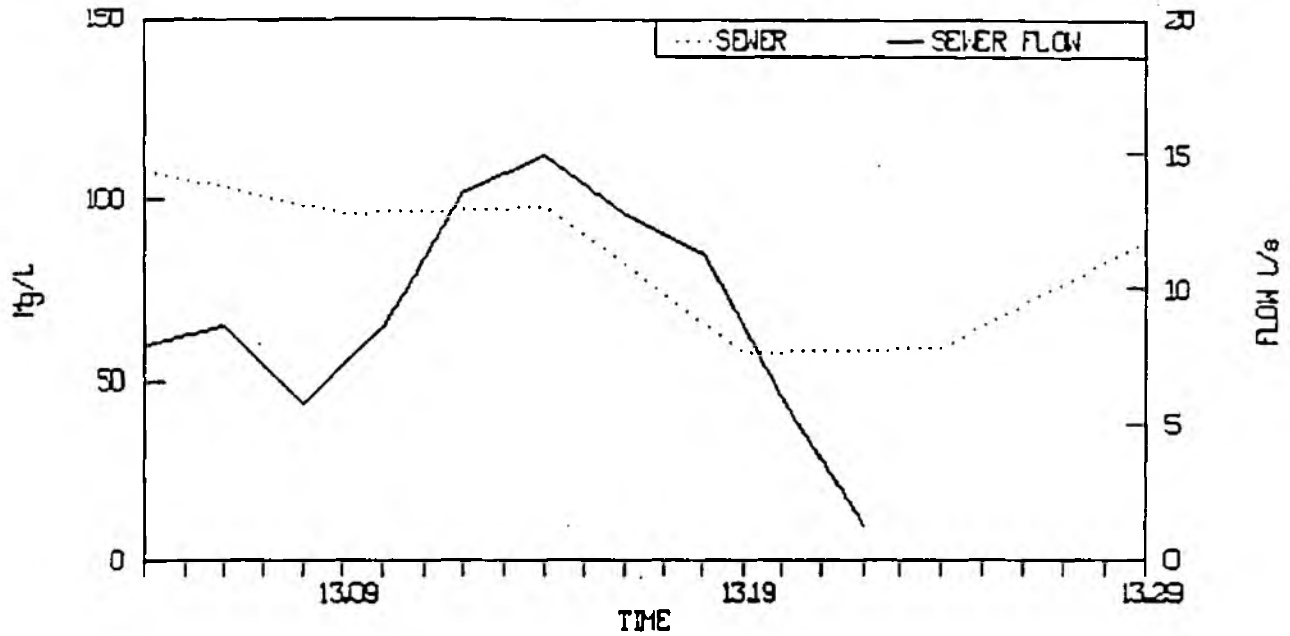
NO DATA FOR TEMP

NO DATA FOR Cond

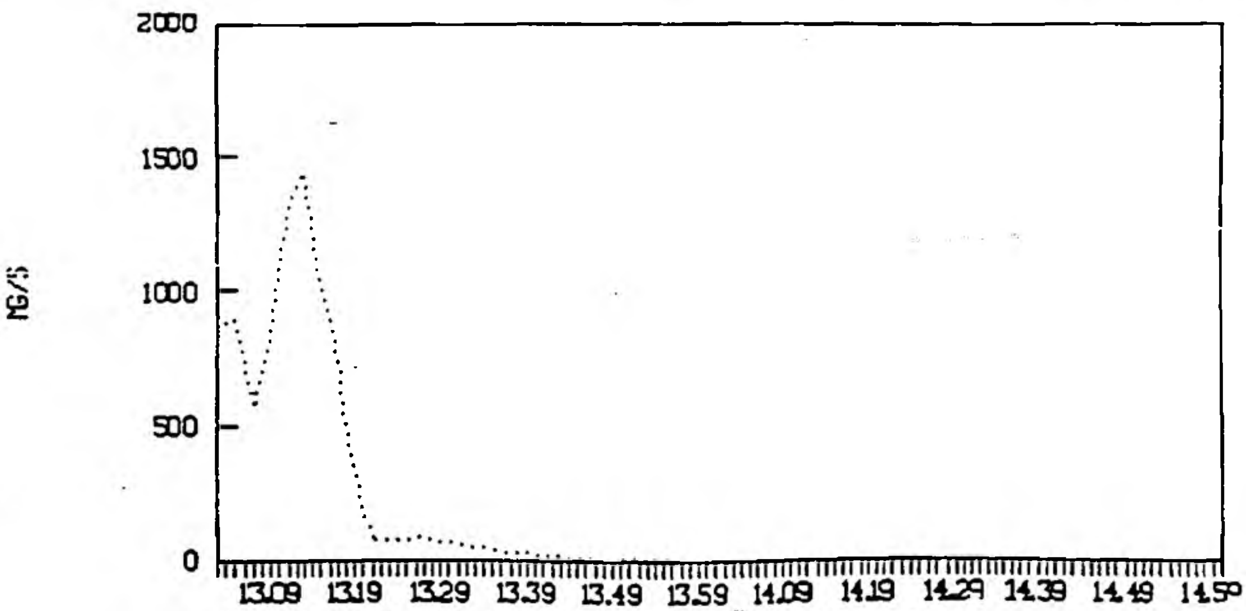
NO DATA FOR ɔ

GARNDIFFAITH SSO EVENT 16 19-03-89

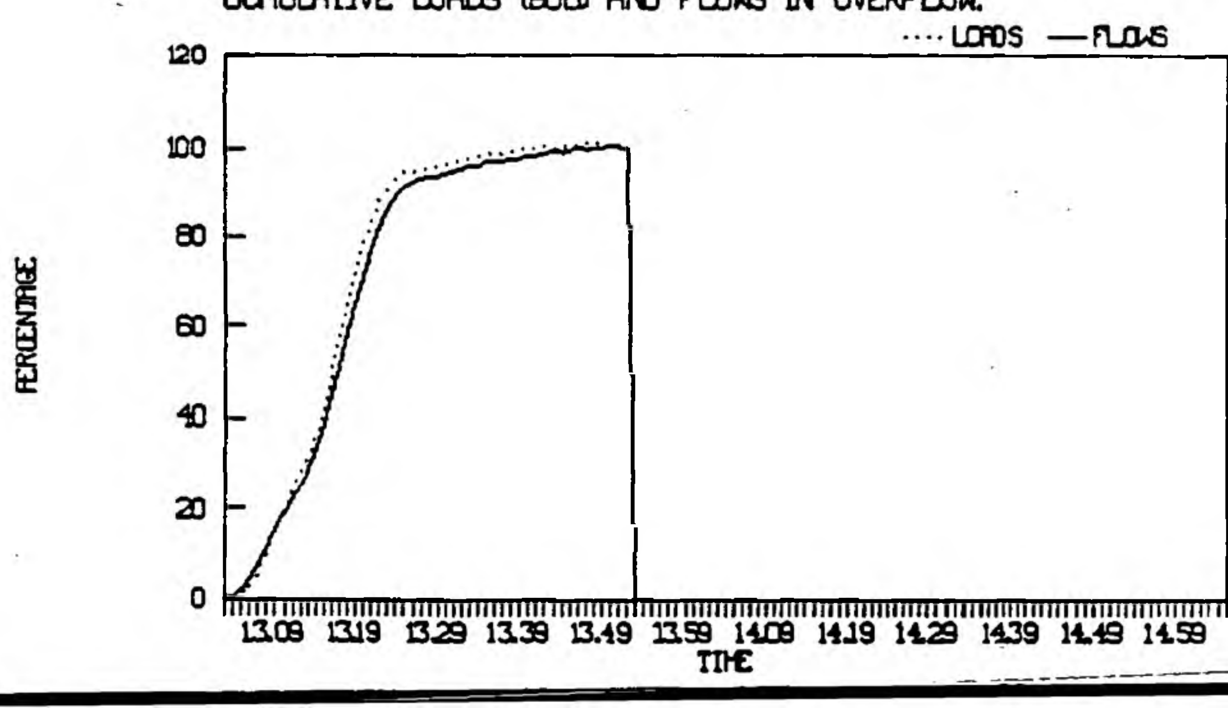
BOD CONCENTRATIONS AT SEWER



BOD LOADS AT SEWER.

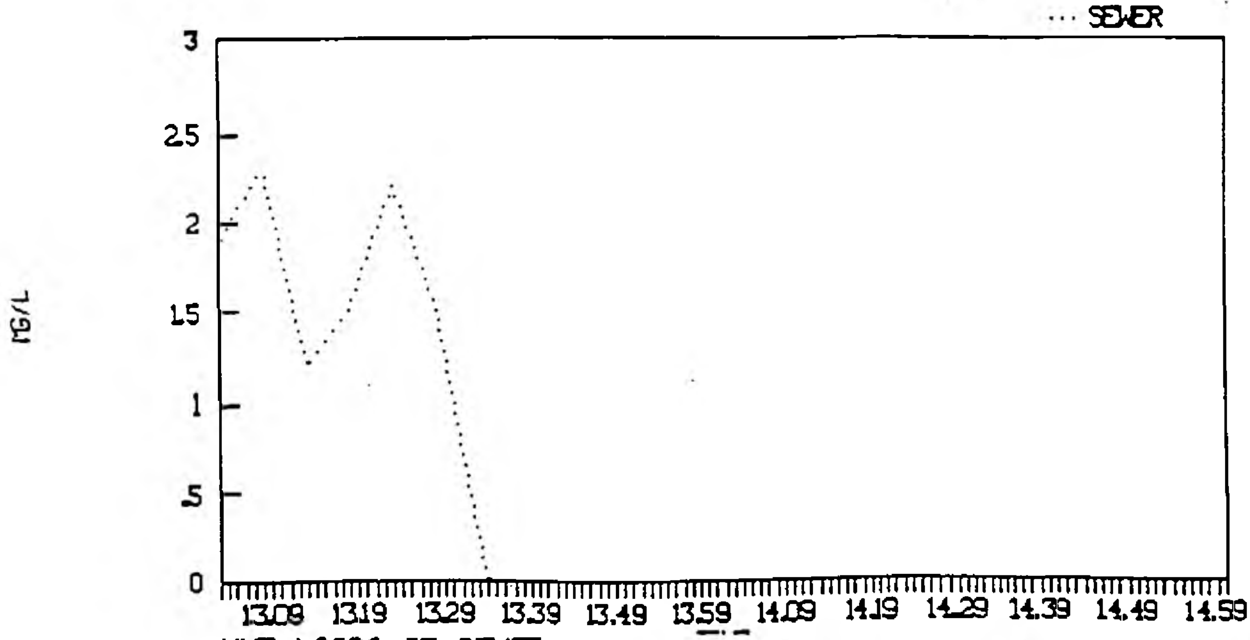


CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW.

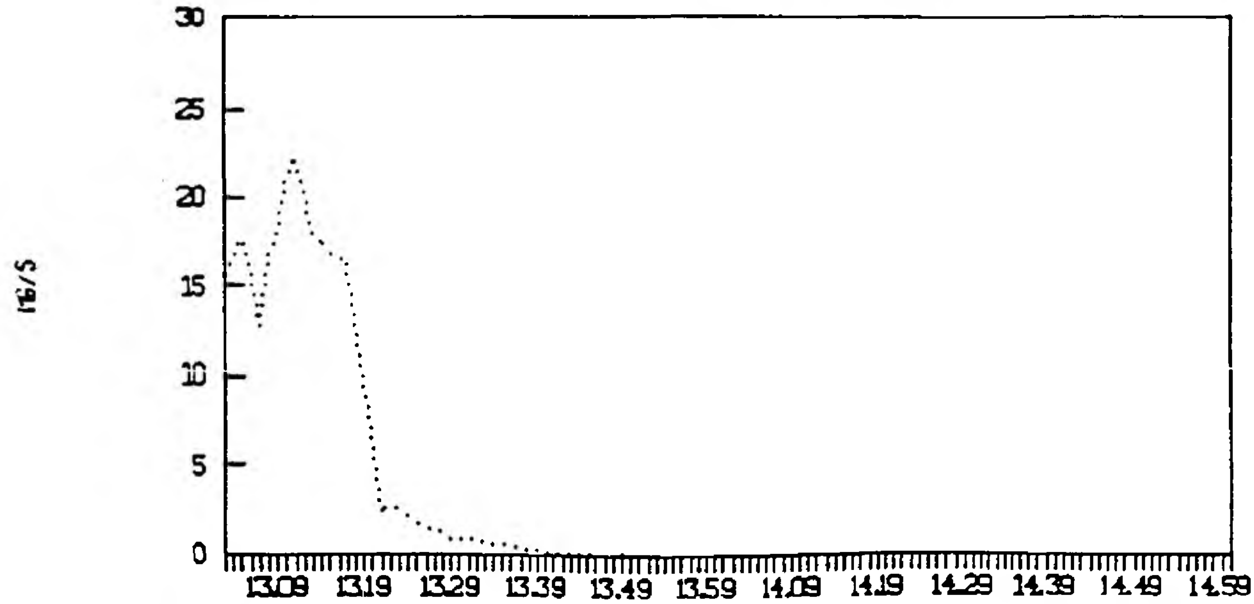


GARNDIFFRAITH SSO EVENT 16 19-03-89

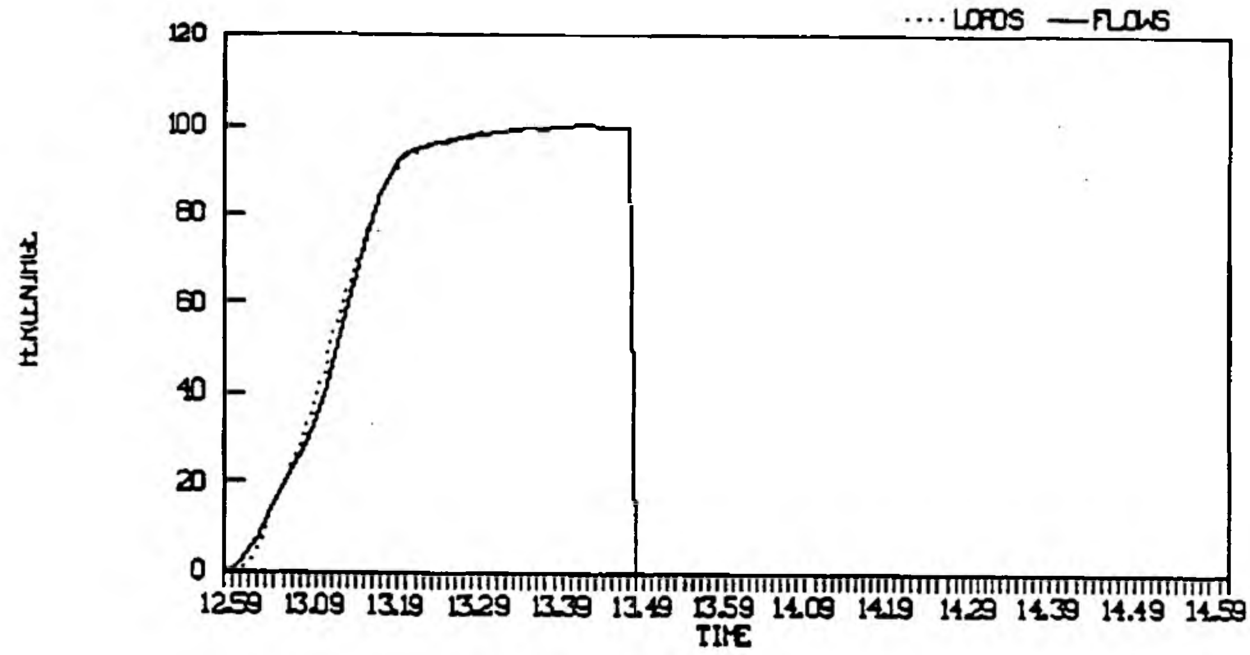
NH3 CONCENTRATIONS AT SEWER

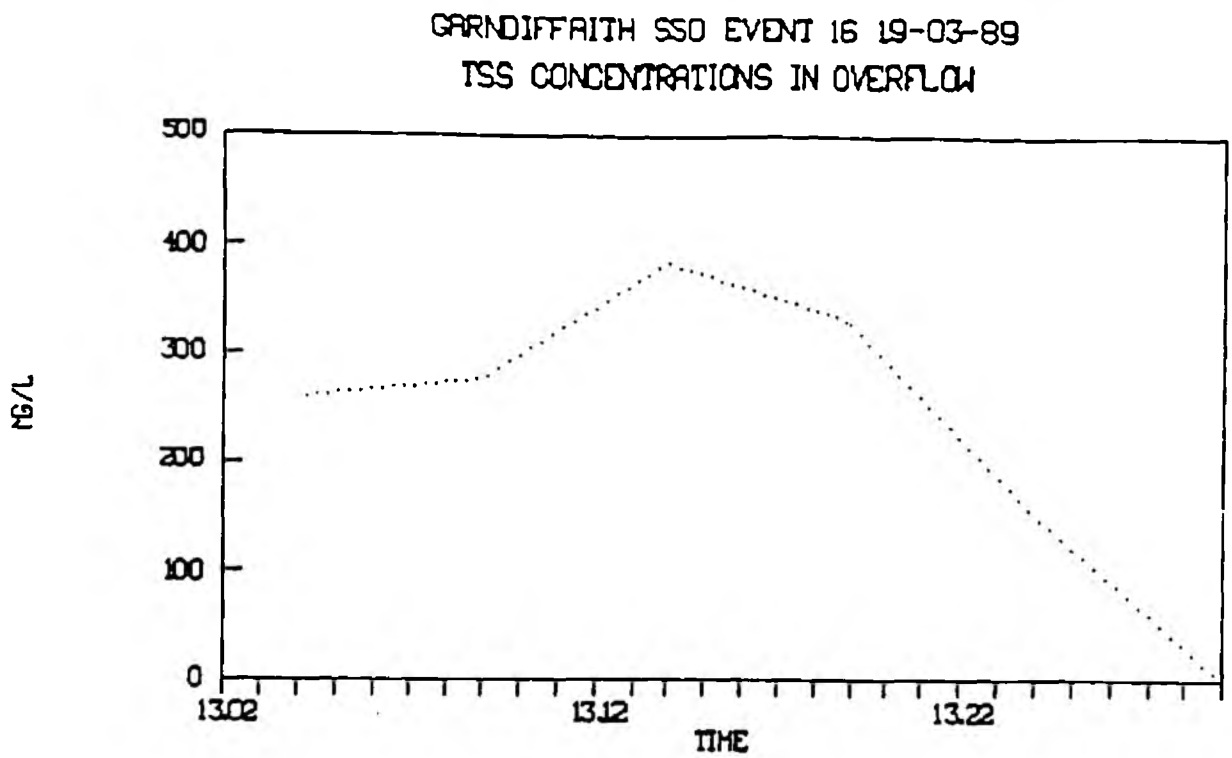


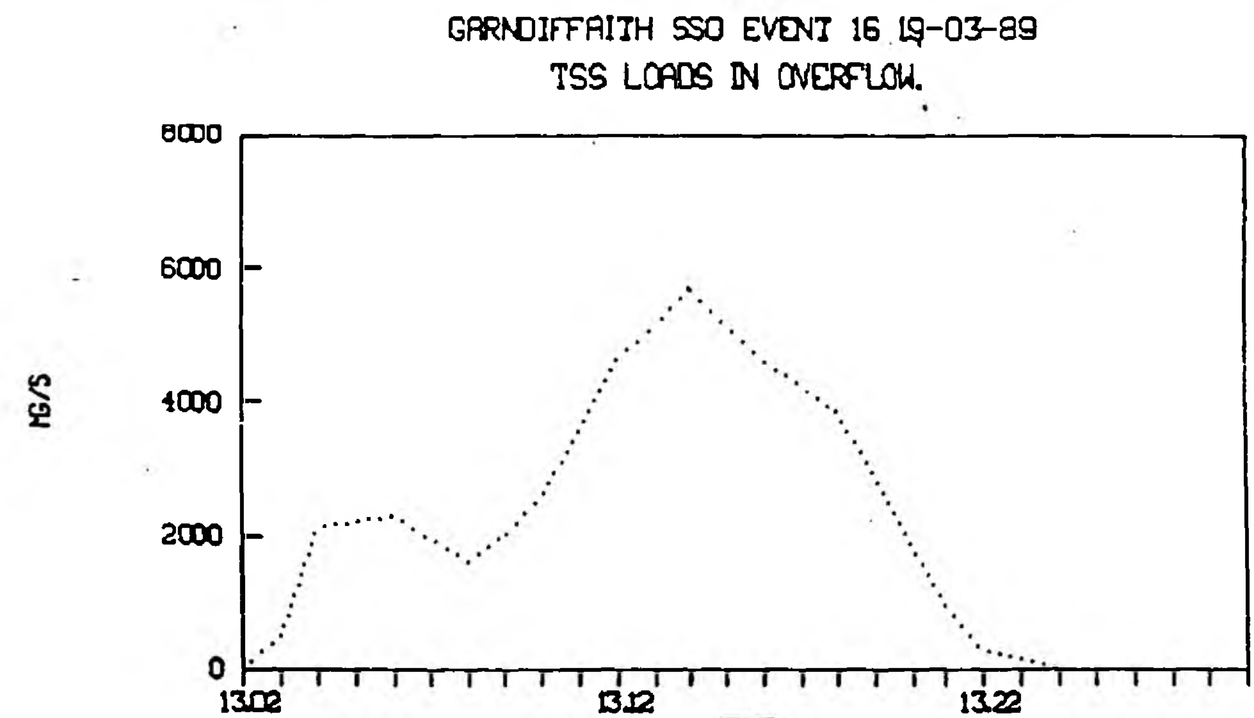
NH3 LOADS AT SEWER.

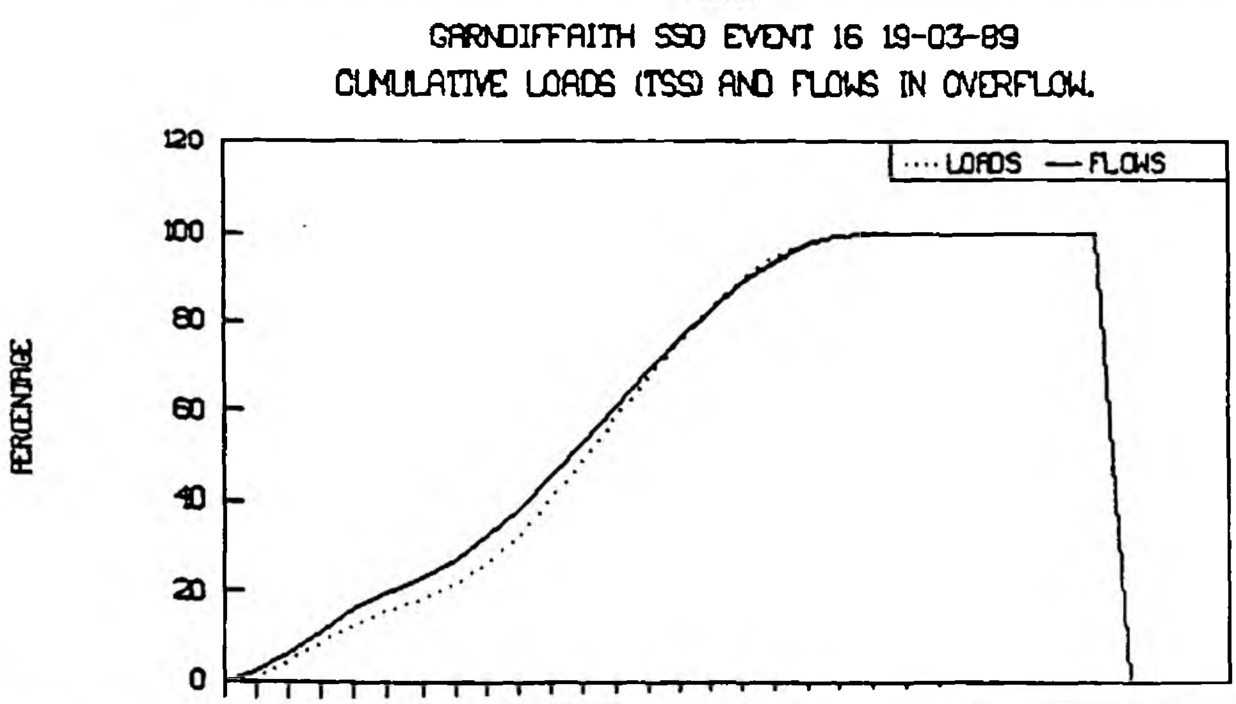


CUMULATIVE LOADS (NH3) AND FLOWS IN OVERFLOW.




GARNDIFFAITH SSO EVENT 16 19-03-89
TSS CONCENTRATIONS IN OVERFLOW
MG/L
TIME
13.02
13.12
13.22


GARNDIFFAITH SSO EVENT 16 19-03-89
TSS LOADS IN OVERFLOW.
MG/S
13.02
13.12
13.22

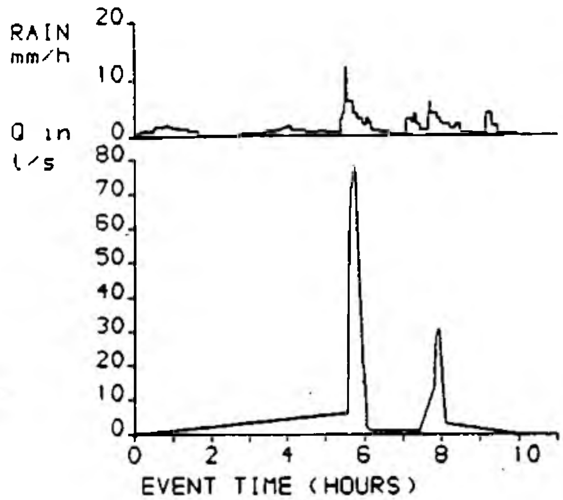

GARNDIFFAITH SSO EVENT 16 19-03-89
CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW.
LOADS
FLOWS
PERCENTAGE

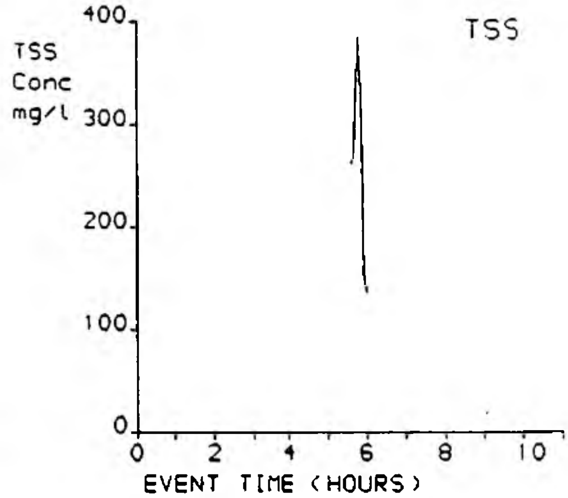
Site: SSO TO NANT FFRWD

GN890319SO.DAT

Grid Ref: 262044
Storm Date: 890319
Start Time (R/F): 730
Rainfall Depth (mm): 12.2

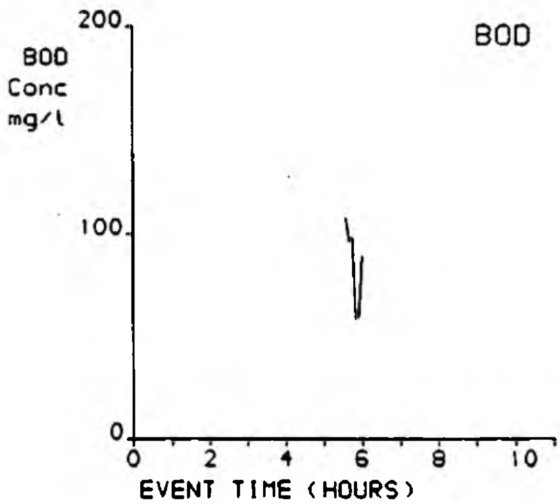
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 593.

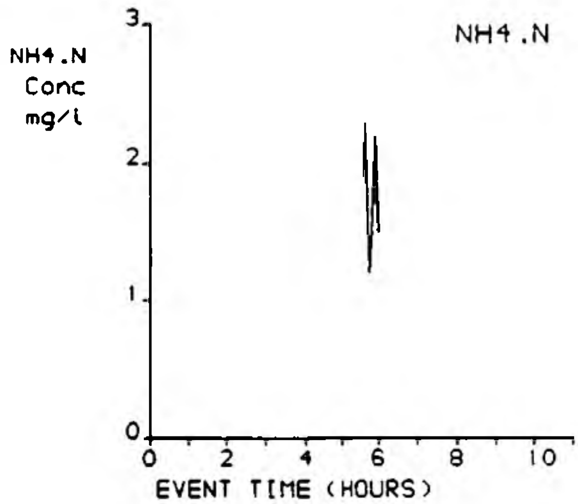




NO DATA FOR COD

NO DATA FOR TDS



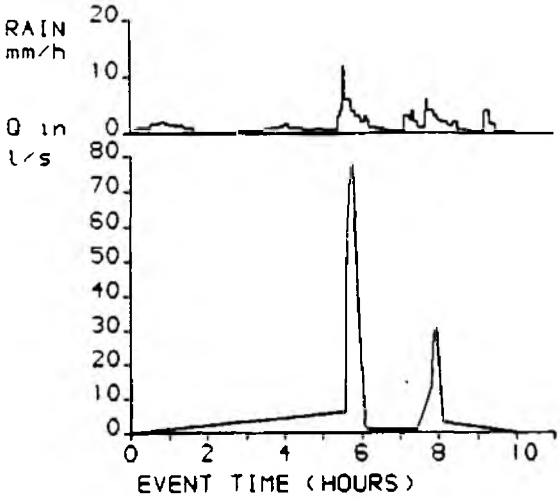


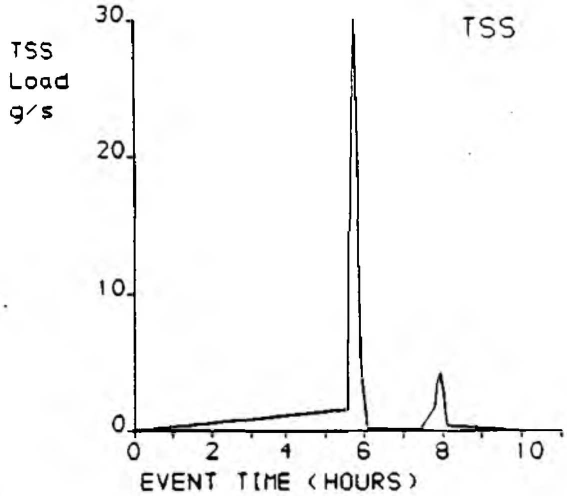
Site: SSO TO NANT FFRWD

GN890319SO.DAT

Grid Ref: 262044
Storm Date: 890319
Start Time (R/F): 730
Rainfall Depth (mm): 12.2

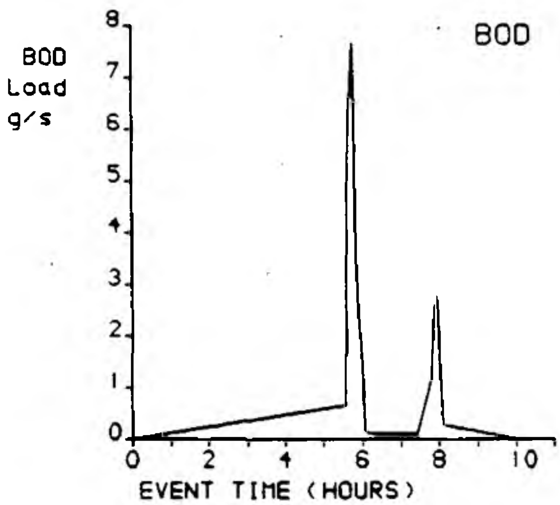
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 593.

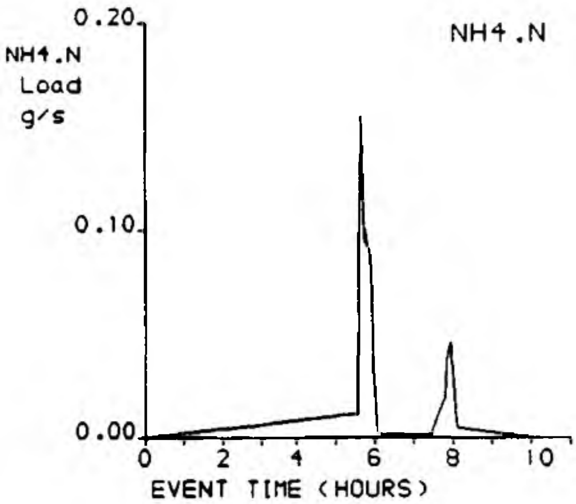




NO DATA FOR COD

NO DATA FOR TDS



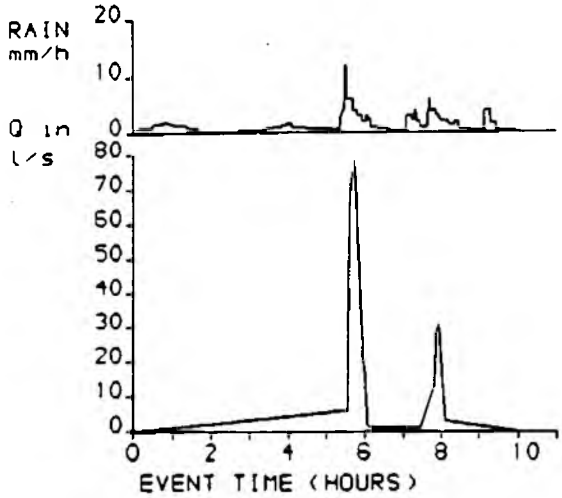


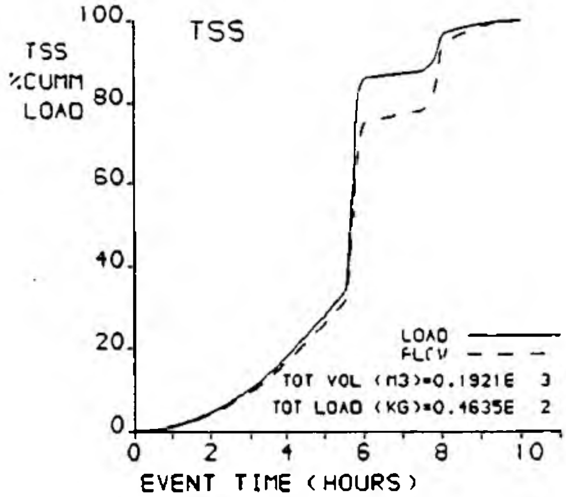
Site: SSO TO NANT FFRWD

GN890319SO.DAT

Grid Ref: 262044
Storm Date: 890319
Start Time (R/F): 730
Rainfall Depth (mm): 12.2

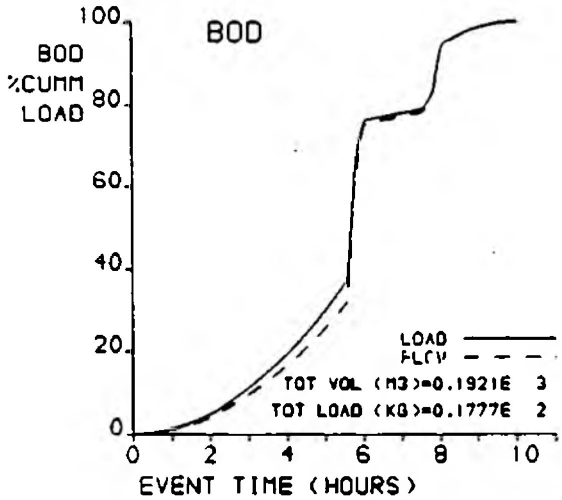
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 593.

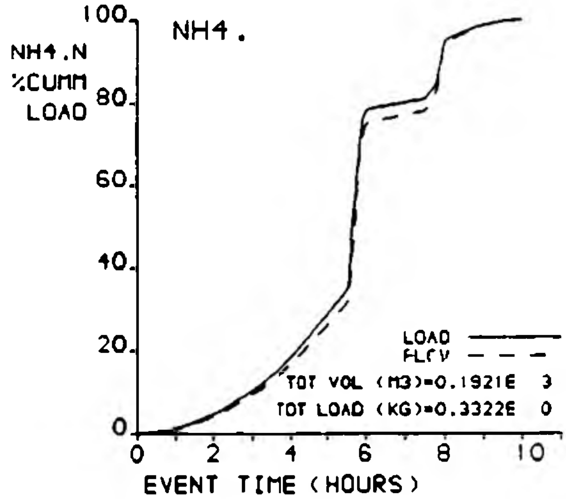




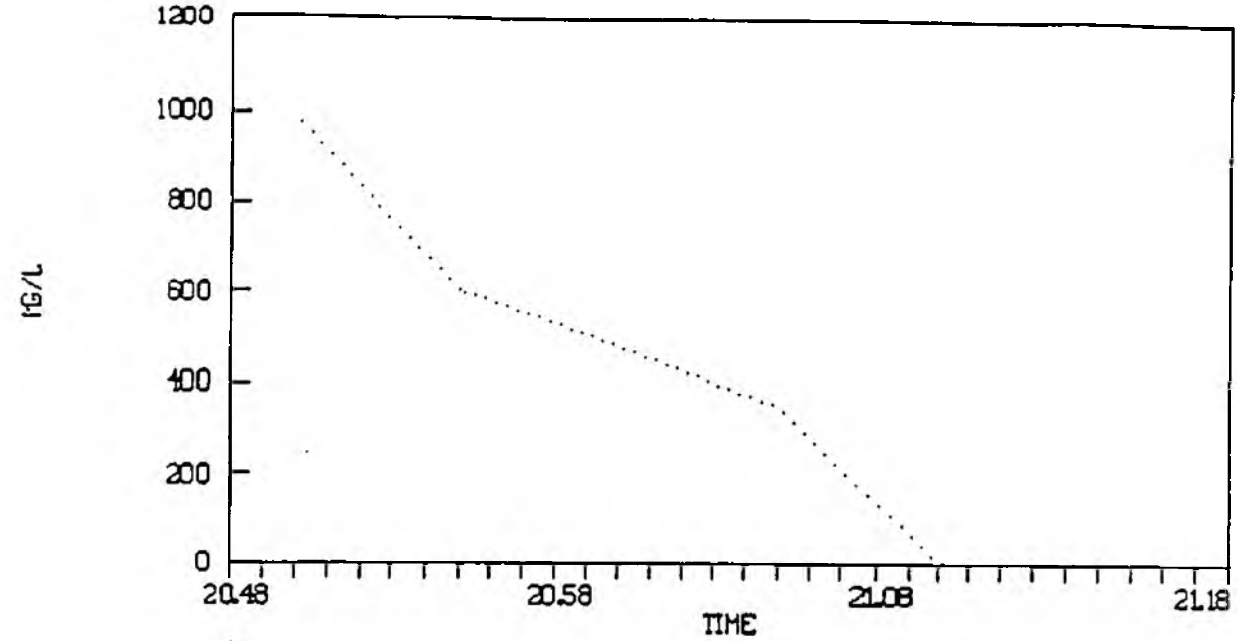
NO DATA FOR COD

NO DATA FOR TDS

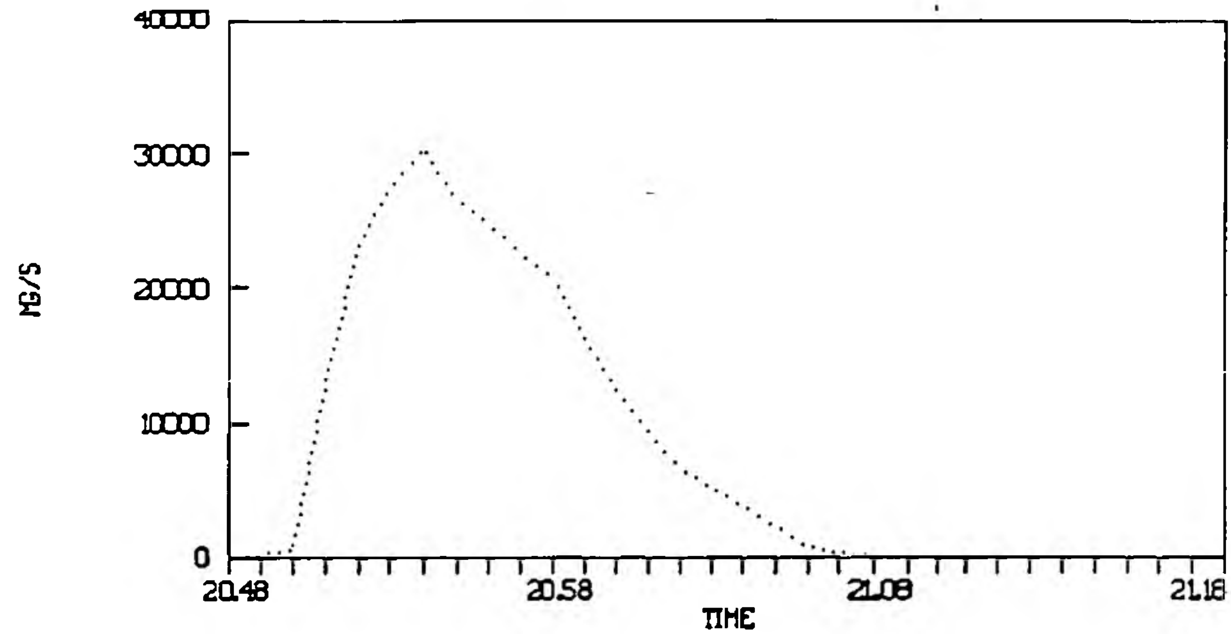




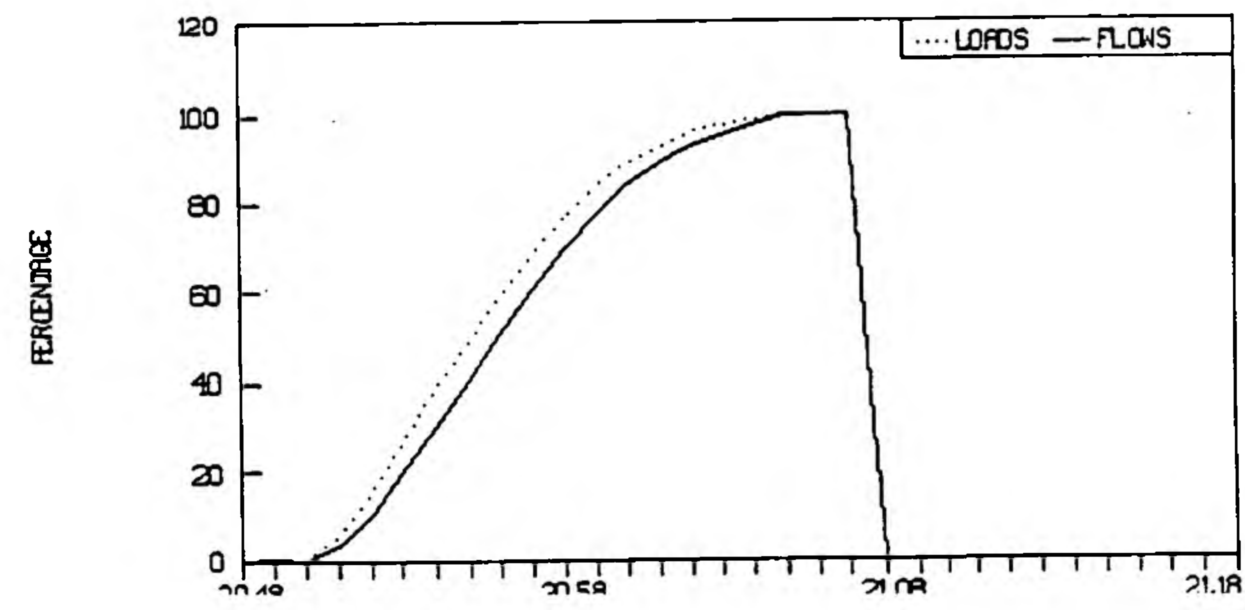
GARNDIFFAITH SSO EVENT 17 26-04-89
TSS CONCENTRATIONS IN OVERFLOW



GARNDIFFAITH SSO EVENT 17 26-04-89
TSS LOADS IN OVERFLOW.

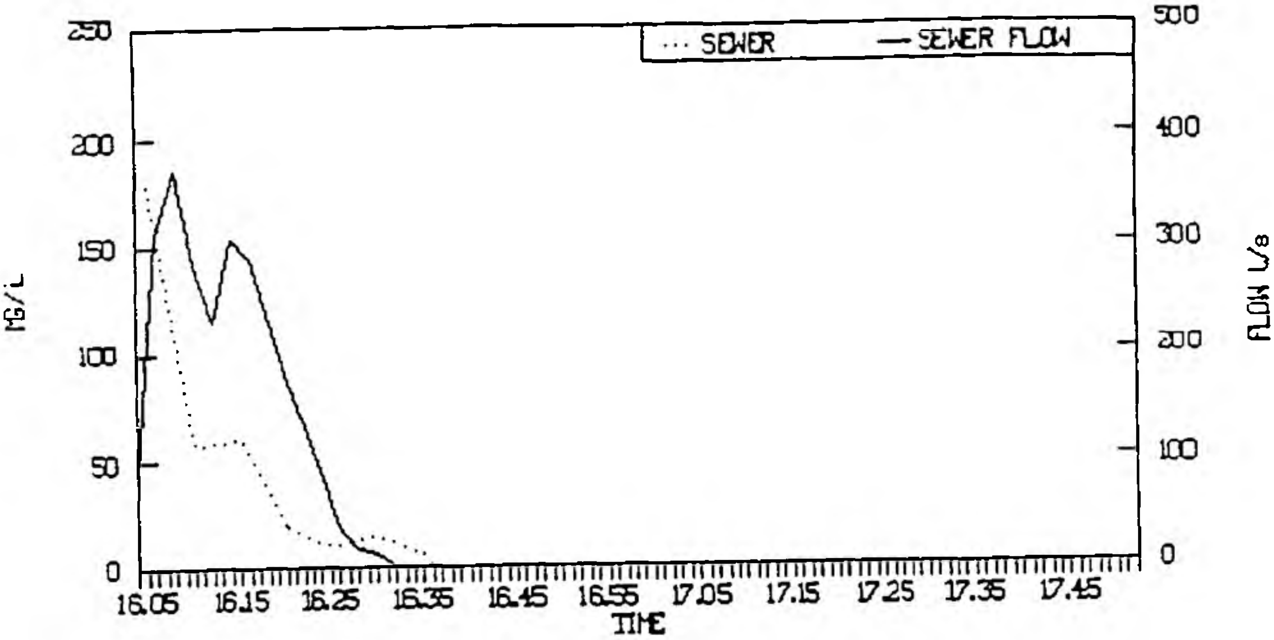


GARNDIFFAITH SSO EVENT 17 26-04-89
CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW.

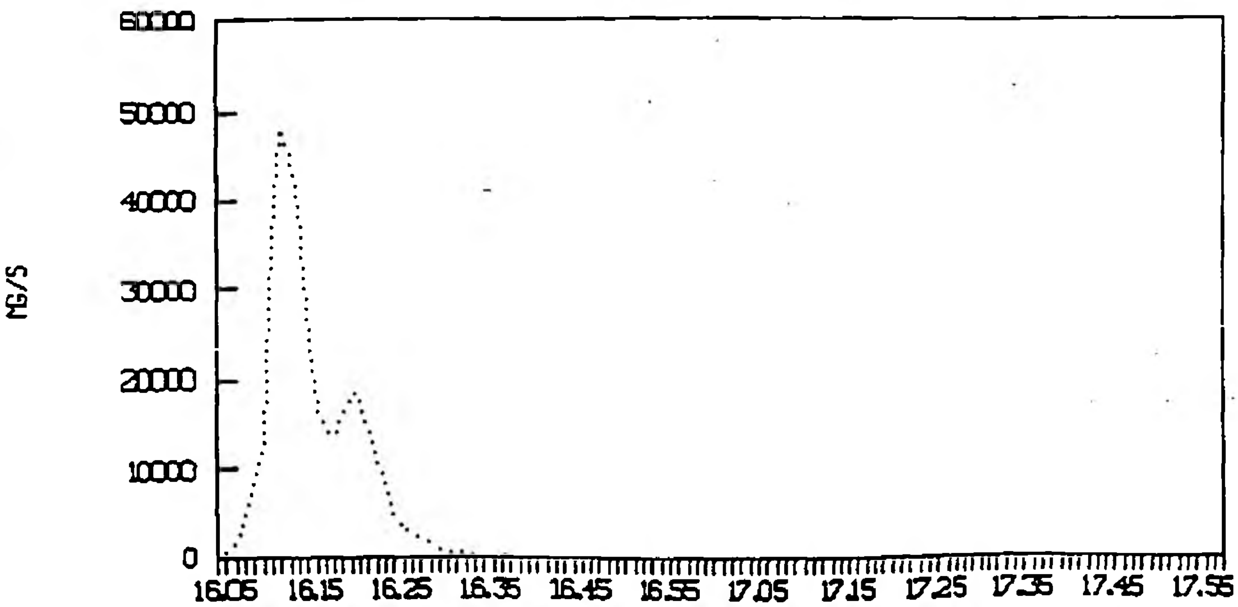


GARNDIFFAITH SSO EVENT 18 24-05-89

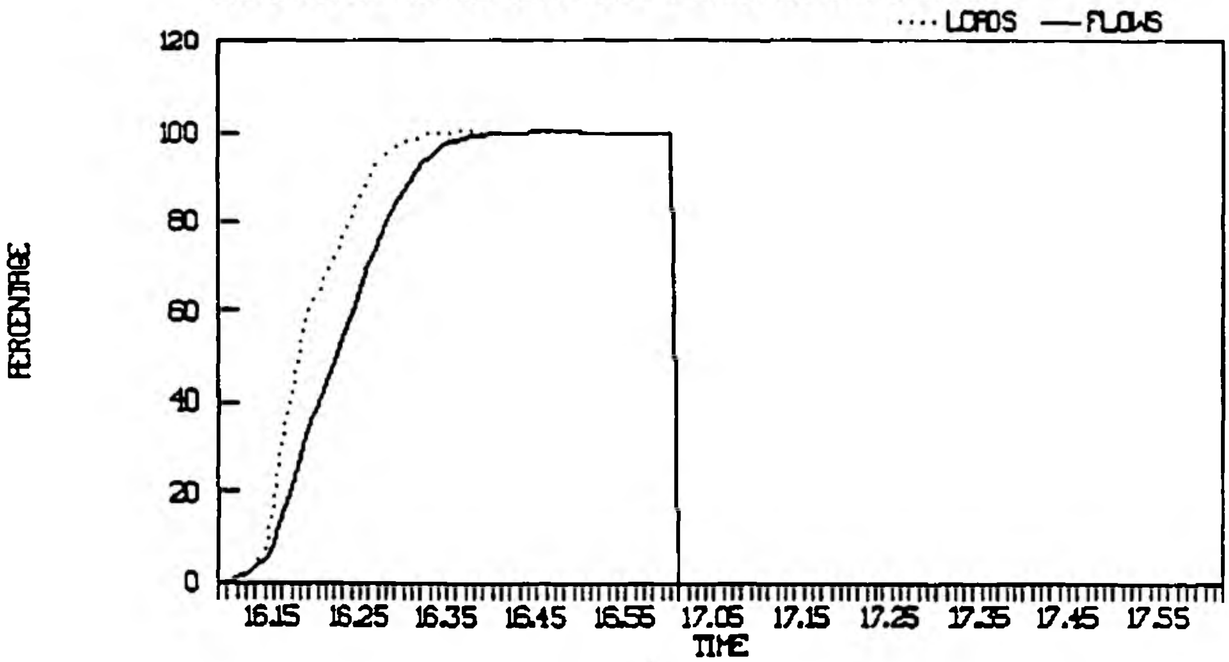
BOD CONCENTRATIONS AT SEWER.



BOD LOADS AT SEWER.

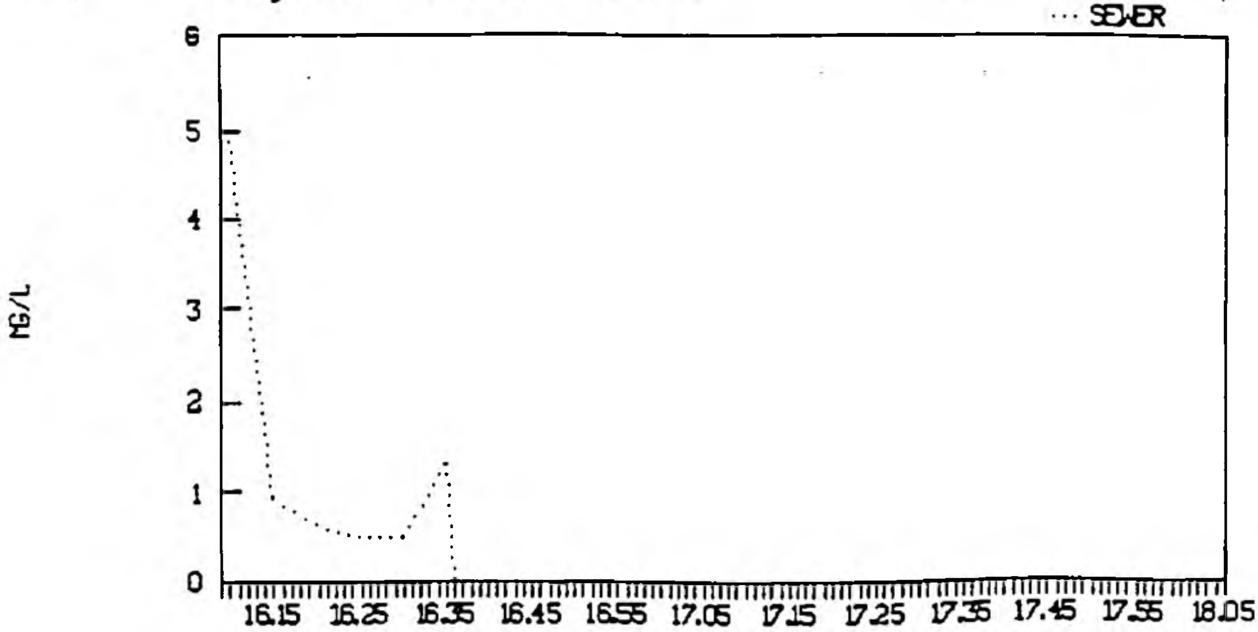


CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW.

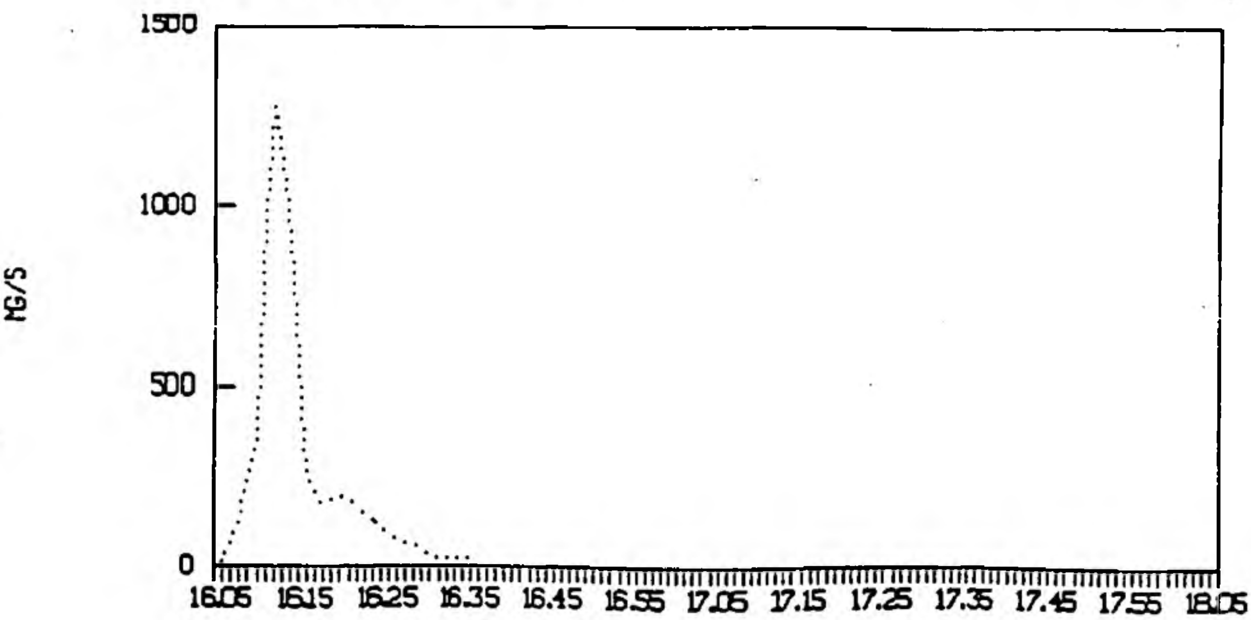


GARNDIFFAITH SSO EVENT 18 24-05-89

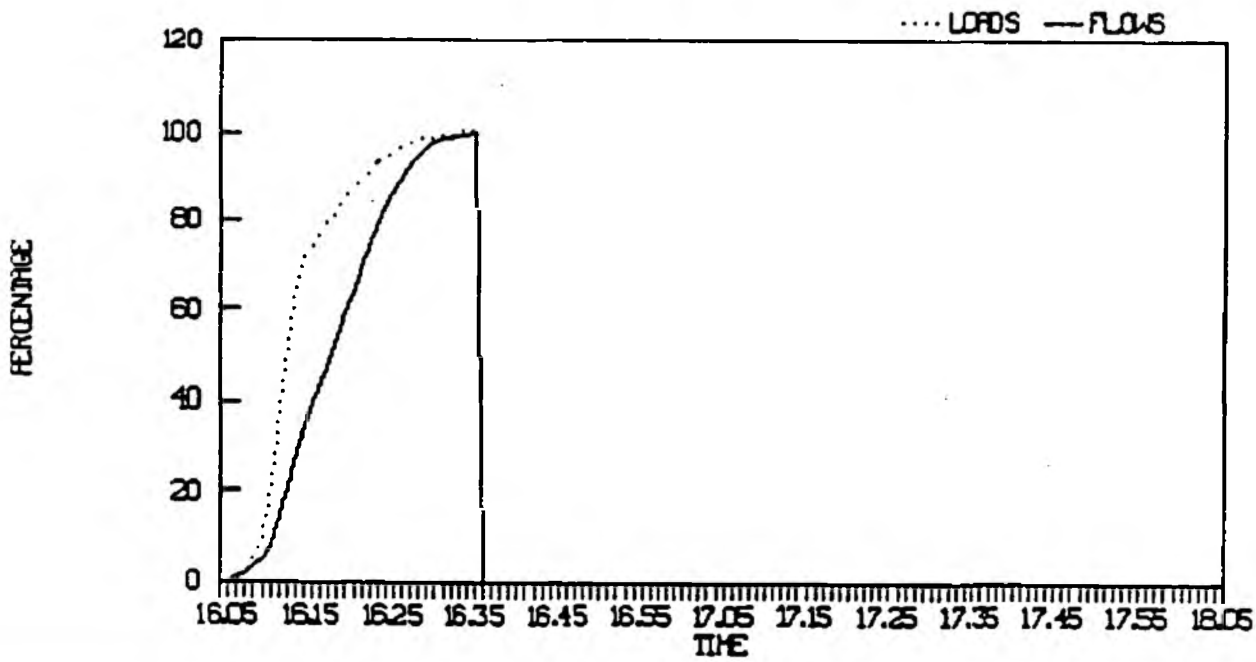
NH_3 CONCENTRATIONS AT SEWER.

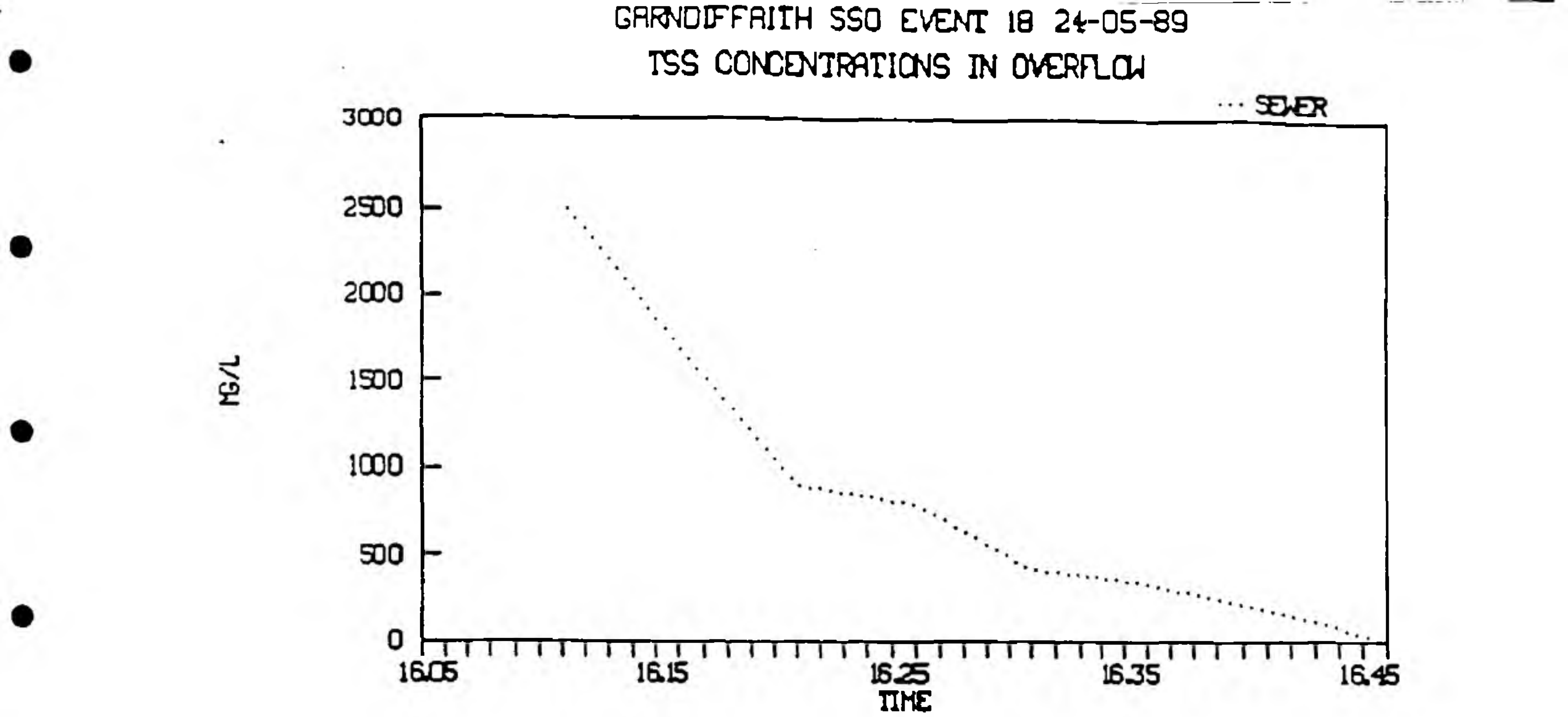


NH3 LOADS AT SEWER.

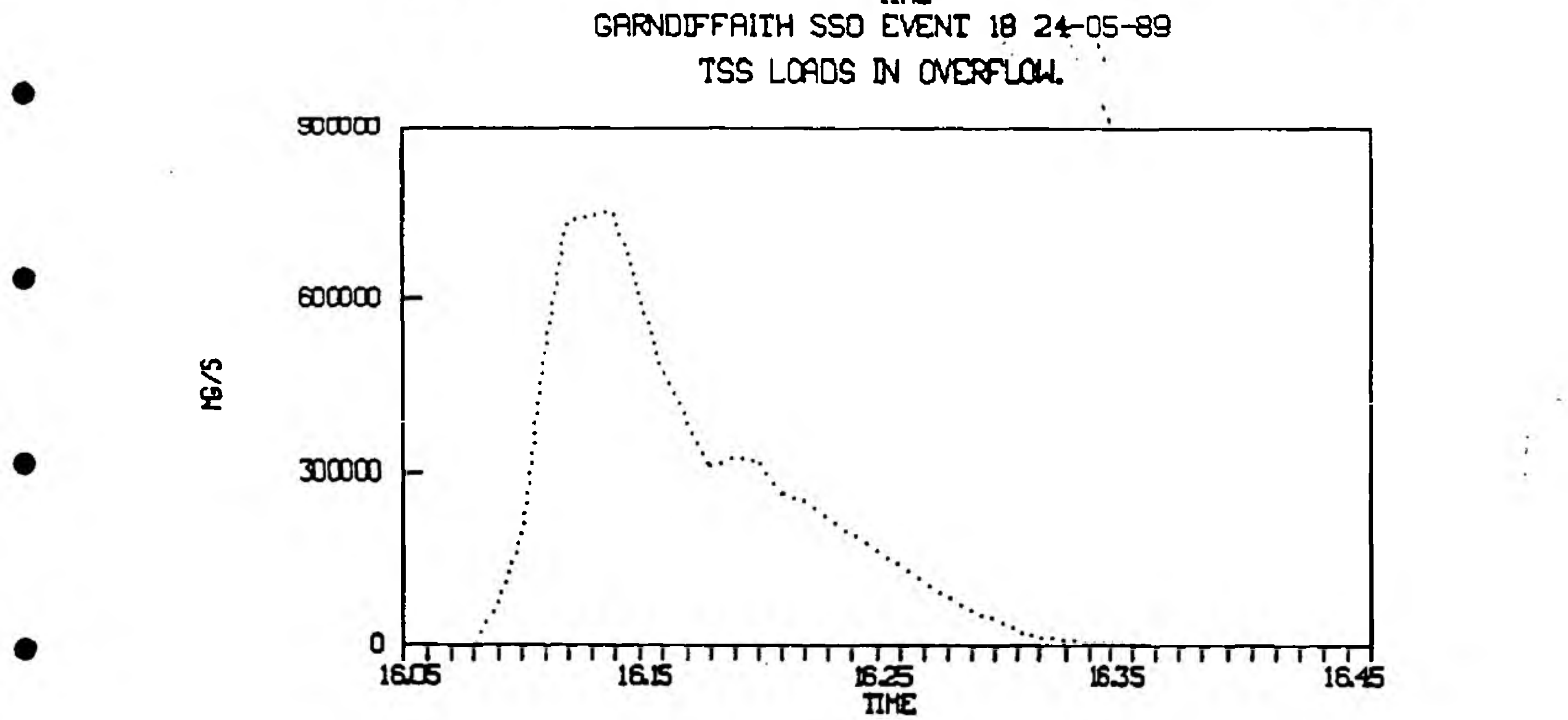


CUMULATIVE LOADS (NH3) AND FLOWS IN OVERFLOW.

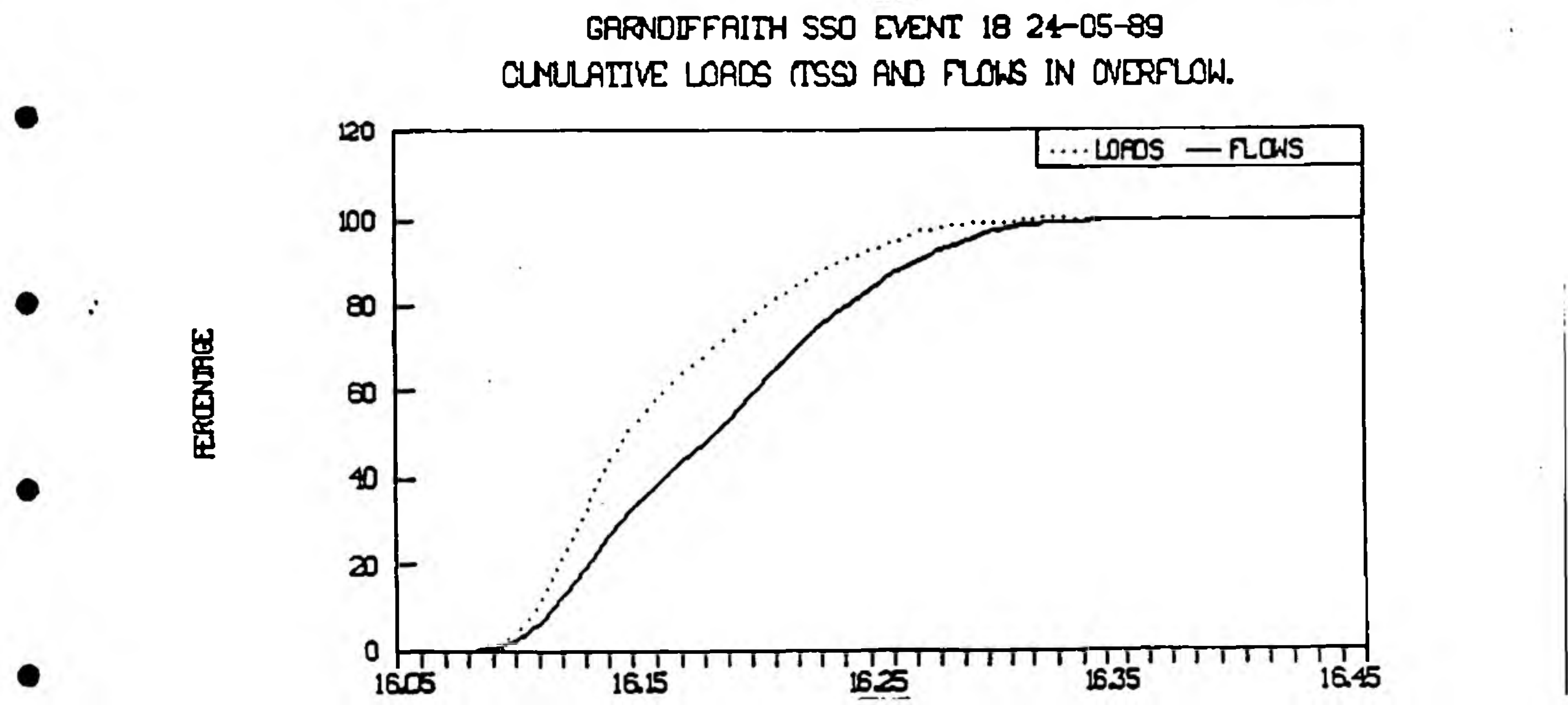




GARNDIFFAITH SSO EVENT 18 24-05-89
TSS CONCENTRATIONS IN OVERFLOW
SEWER
MG/L
TIME



GARNDIFFAITH SSO EVENT 18 24-05-89
TSS LOADS IN OVERFLOW.
MG/S
TIME



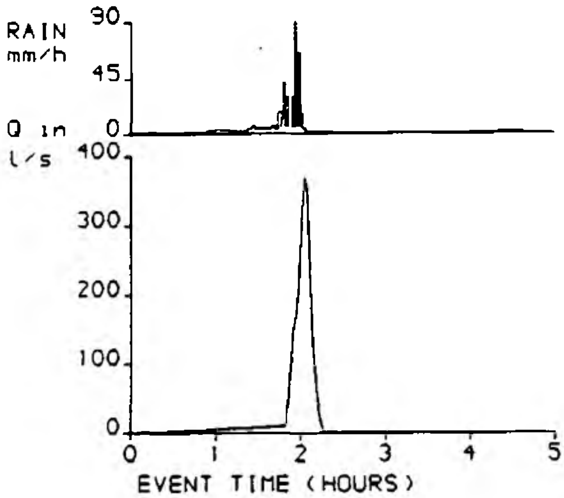
GARNDIFFAITH SSO EVENT 18 24-05-89
CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW.
LOADS
FLOWS
PERCENTAGE

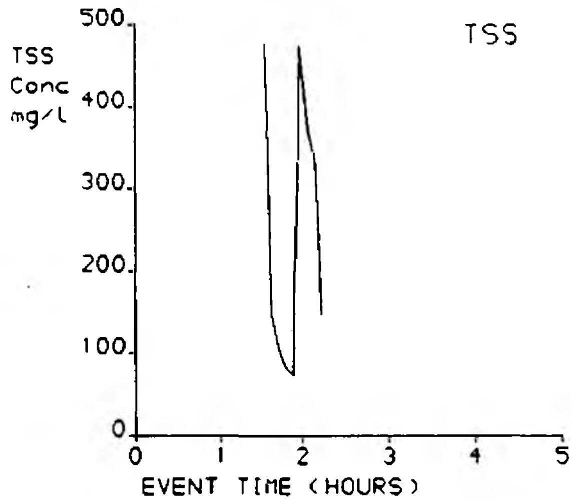
Site: SSD TO NANT FFRWD

GN890814SD.DAT EVENT 19

Grid Ref: 262044
Storm Date: 890814
Start Time (R/F): 1859
Rainfall Depth (mm): 13.4

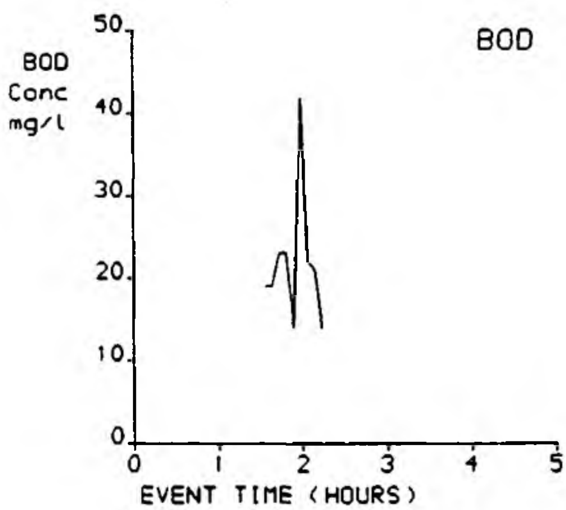
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 286.

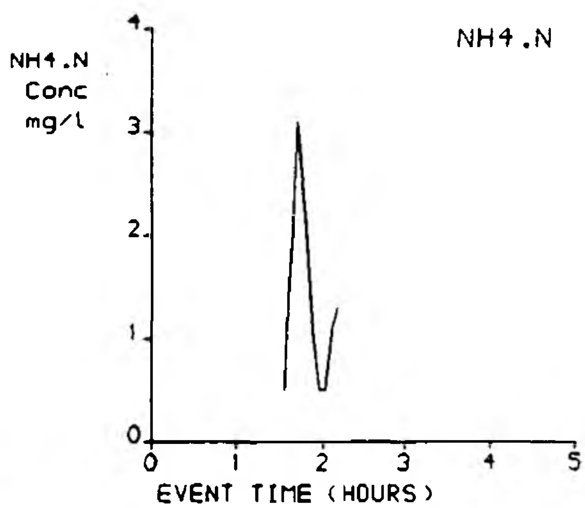




NO DATA FOR COD

NO DATA FOR TDS



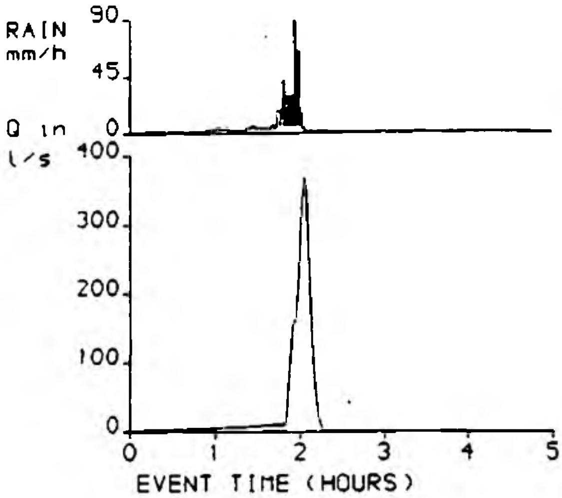


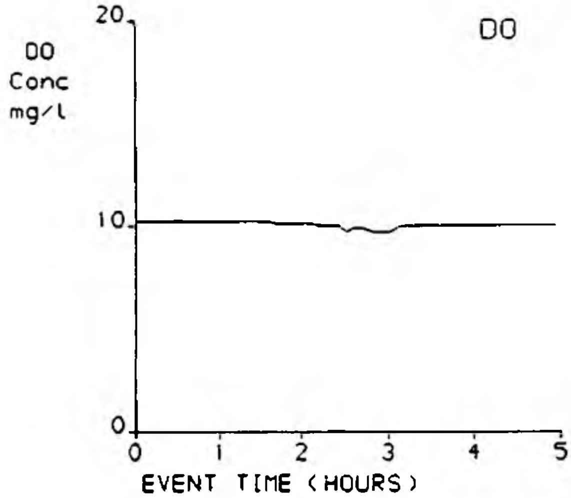
Site: SSO TO NANT FFRWD

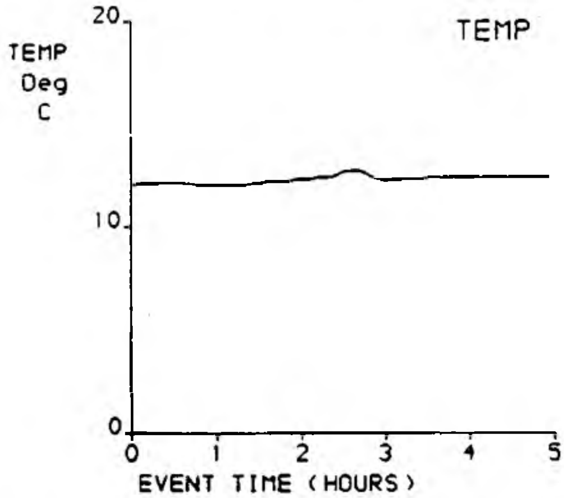
GN890814SO.DAT

Grid Ref: 262044
Storm Date: 890814
Start Time (R/F): 1859
Rainfall Depth (mm): 13.4

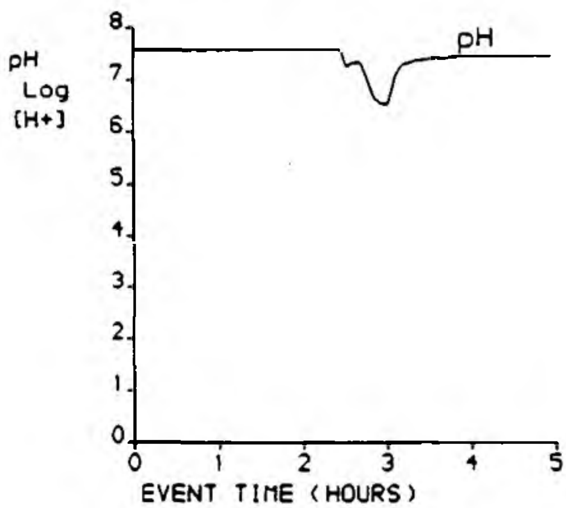
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 286.







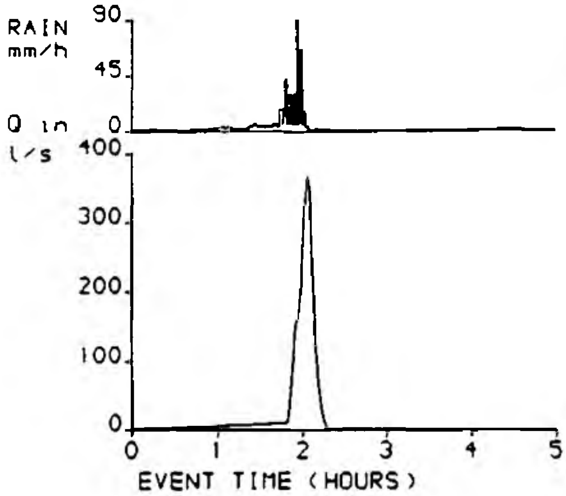
NO DATA FOR Cond

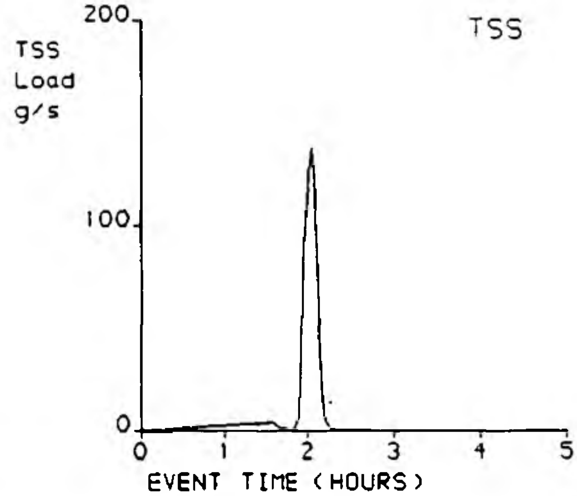


Site: SSO TO NANT FFRWD

GN890814SO.DAT

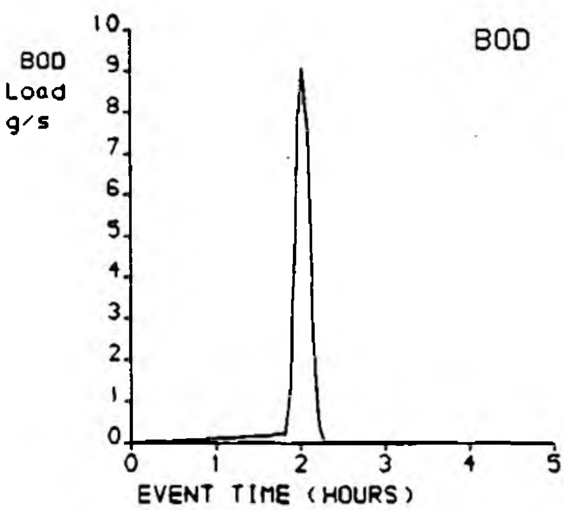
Grid Ref: 262044	Weather Conditions:
Storm Date: 890814	Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1859	Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 13.4	Rainfall Event Duration (mins): 286.

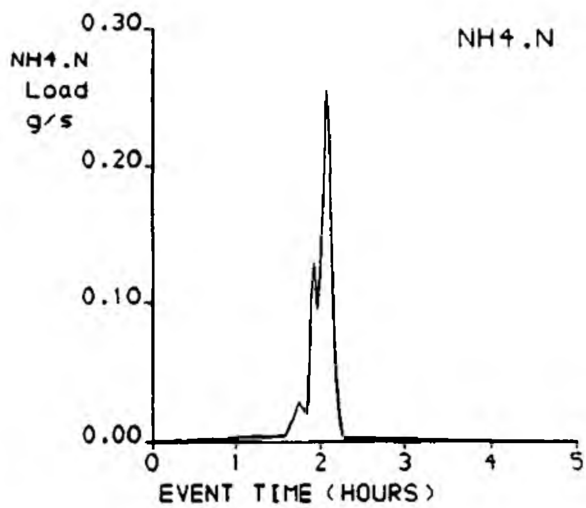




NO DATA FOR COD

NO DATA FOR TDS



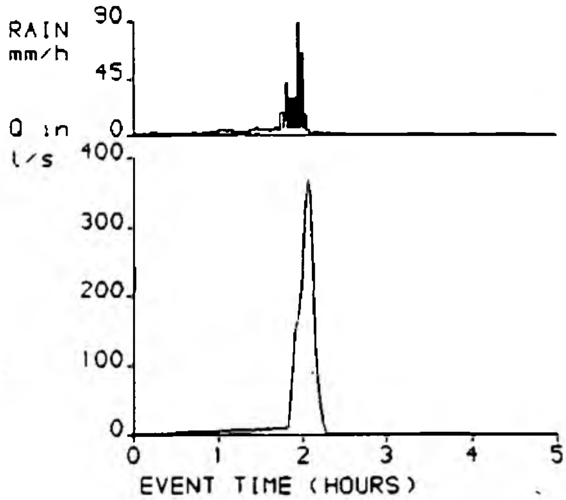


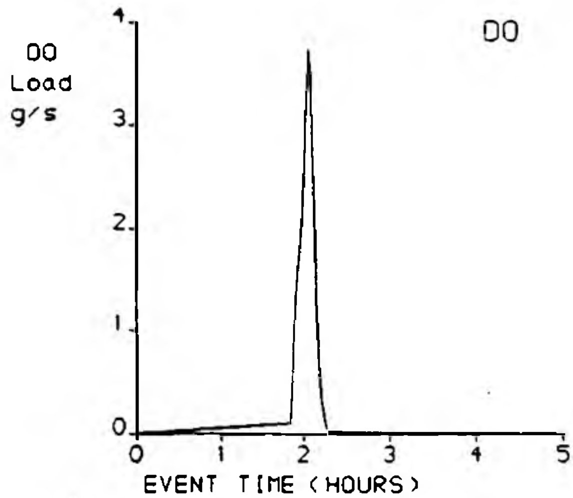
Site: SSO TO NANT FFRWD

GN890814SO.DAT

Grid Ref: 262044
Storm Date: 890814
Start Time (R/F): 1859
RainFall Depth (mm): 13.4

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
RainFall Event Duration (mins): 286.





NO DATA FOR TEMP

NO DATA FOR Cond

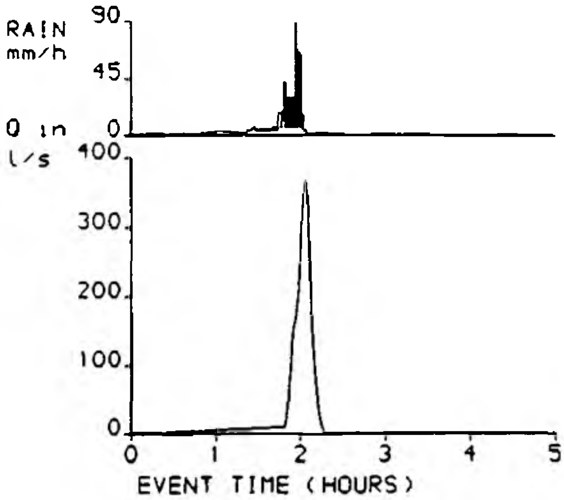
NO DATA FOR pH

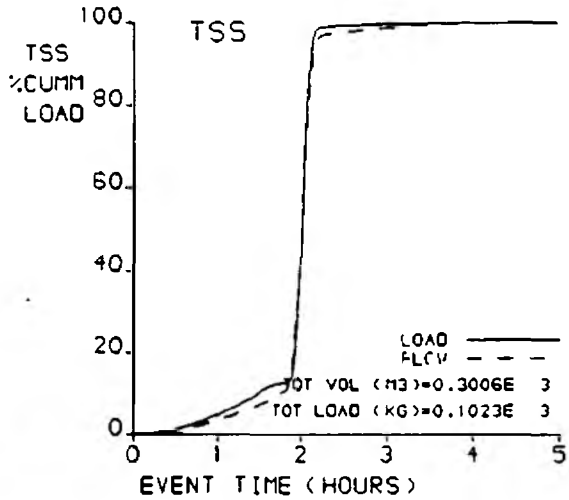
Site: SSO TO NANT FFRWD

GN890814SO.DAT

Grid Ref: 262044
Storm Date: 890814
Start Time (R/F): 1859
Rainfall Depth (mm): 13.4

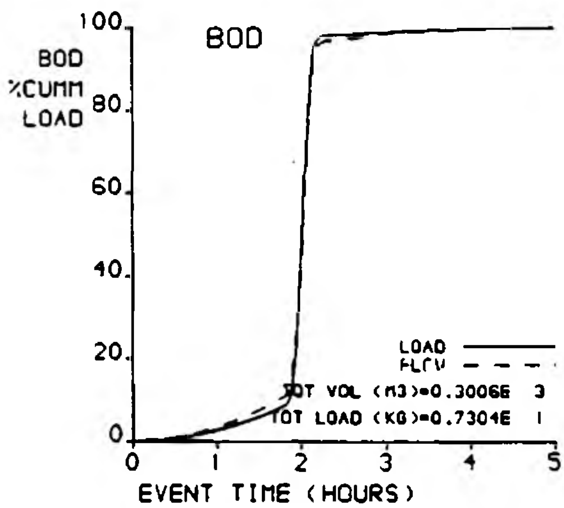
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 286.

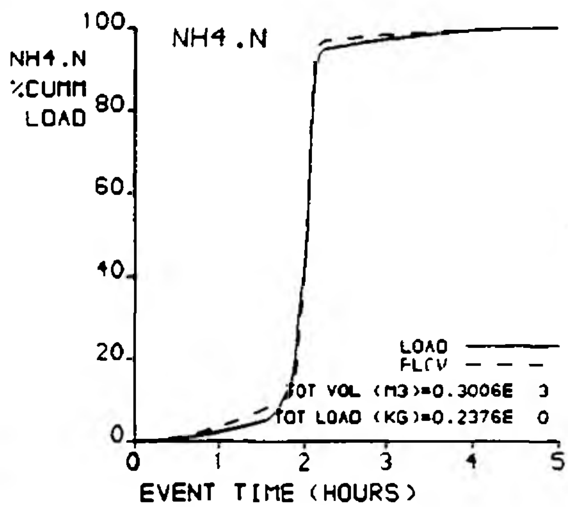




NO DATA FOR COD

NO DATA FOR TDS



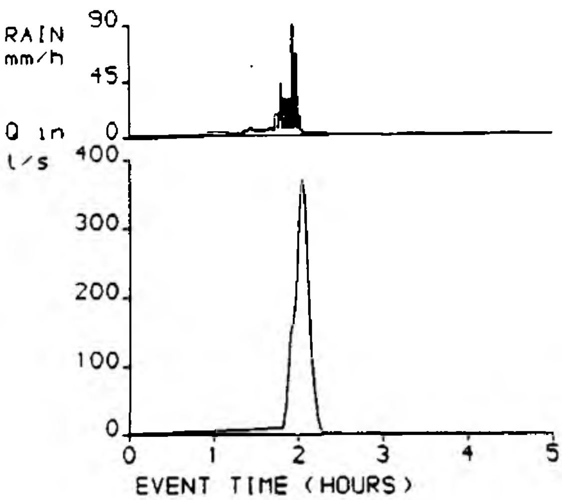


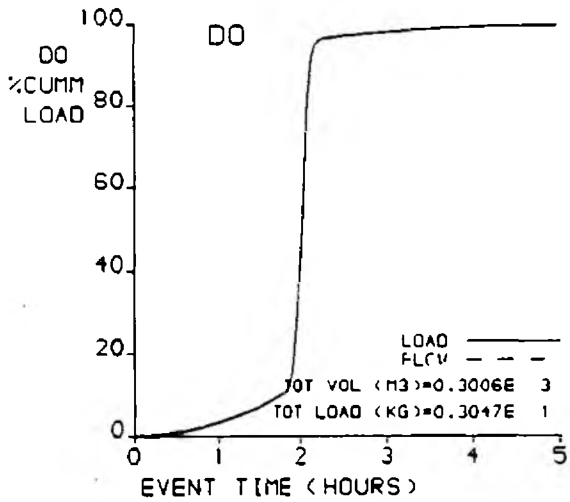
Site: SSO TO NANT FFRWD

GN890814SO.DAT

Grid Ref: 262044
Storm Date: 890814
Start Time (R/F): 1859
Rainfall Depth (mm): 13.4

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 286.





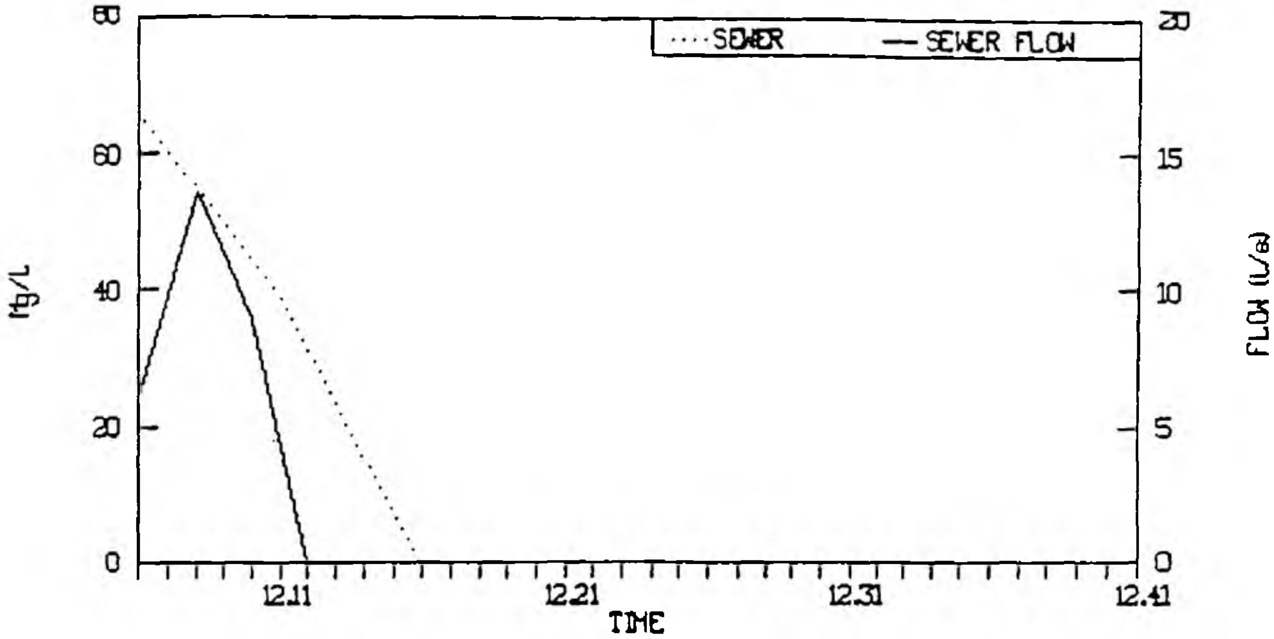
NO DATA FOR TEMP

NO DATA FOR Cond

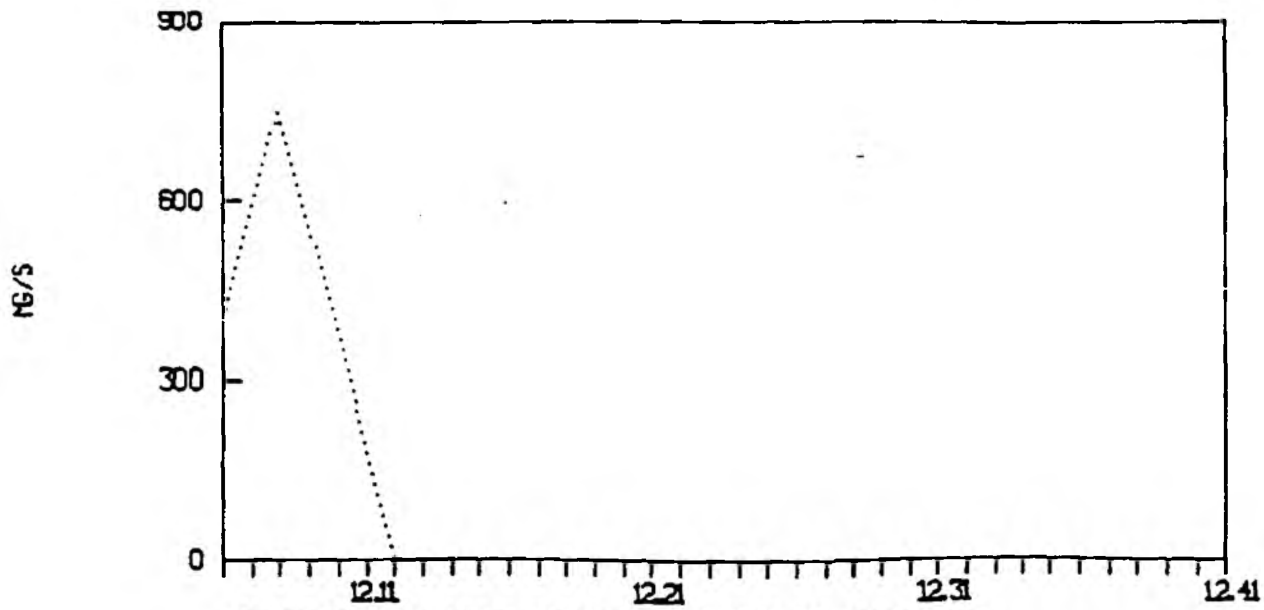
NO DATA FOR pH

GARNDIFFAITH SSO EVENT 21 20-10-1989

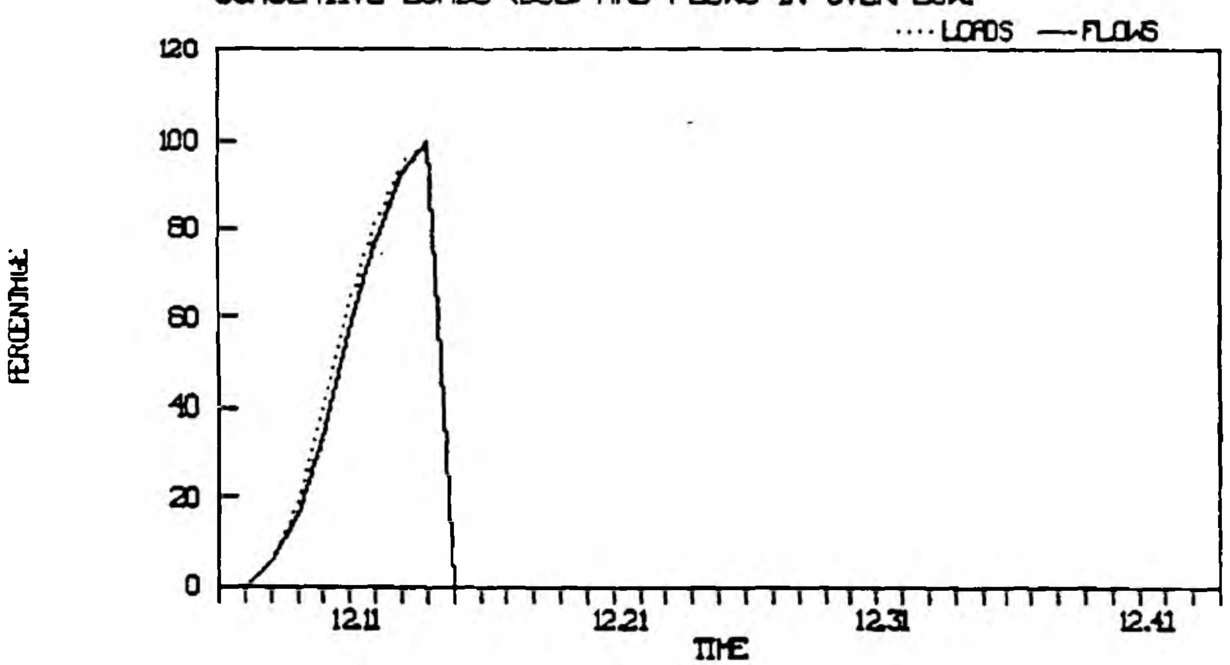
BOD CONCENTRATIONS AT SEWER.



BOD LOADS AT SEWER.

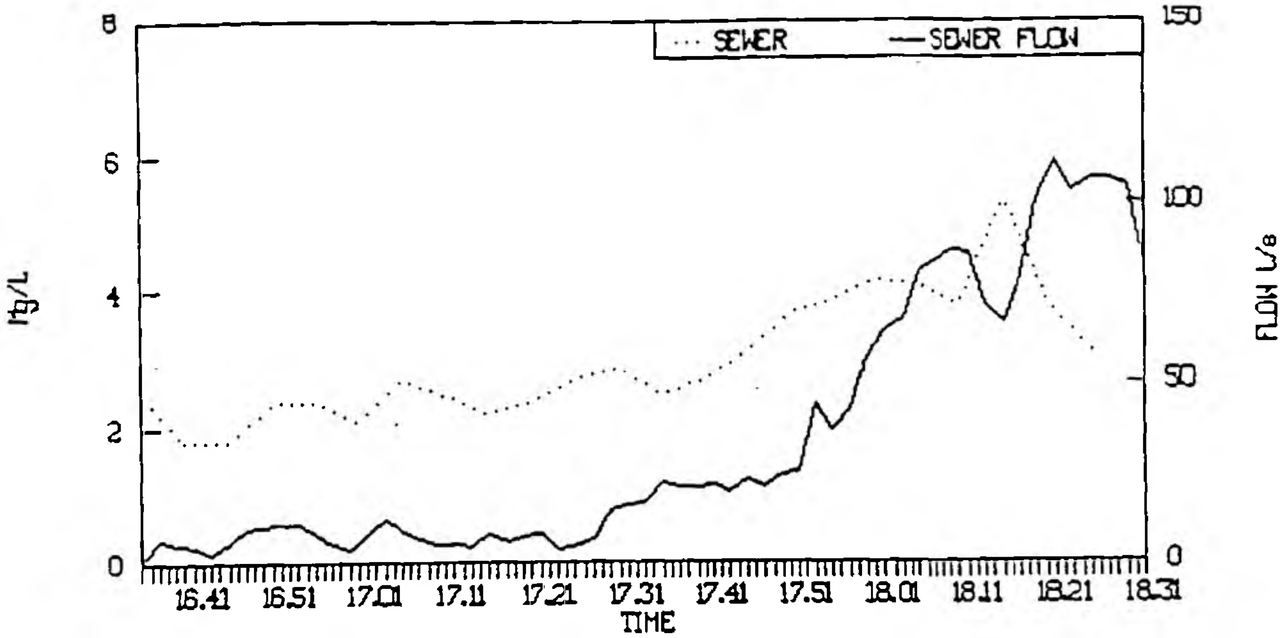


CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW.

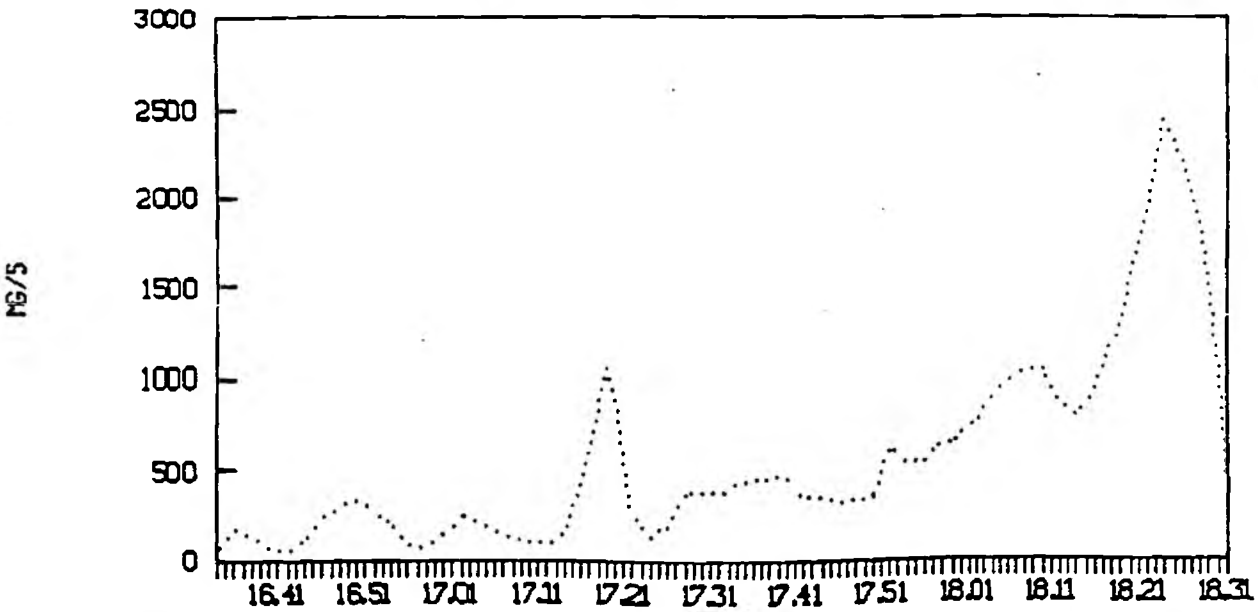


GARNDIFFAITH SSO EVENT 22 20-10-1989

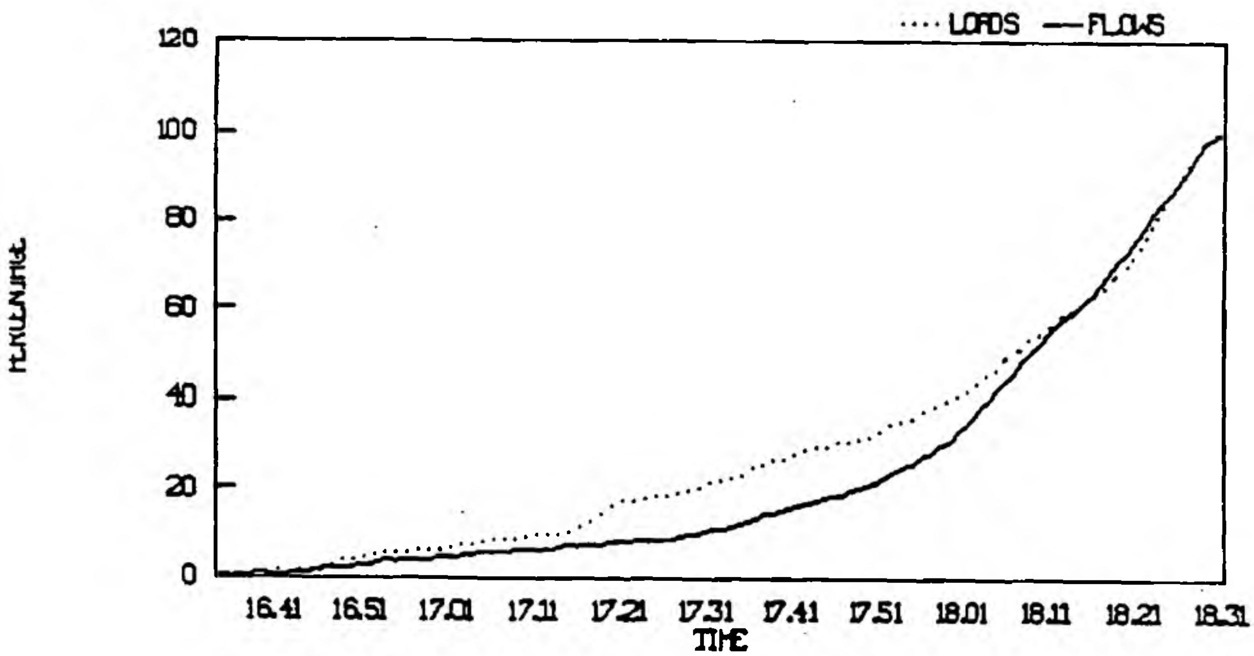
BOD CONCENTRATIONS AT SEWER.



BOD LOADS AT SEWER.

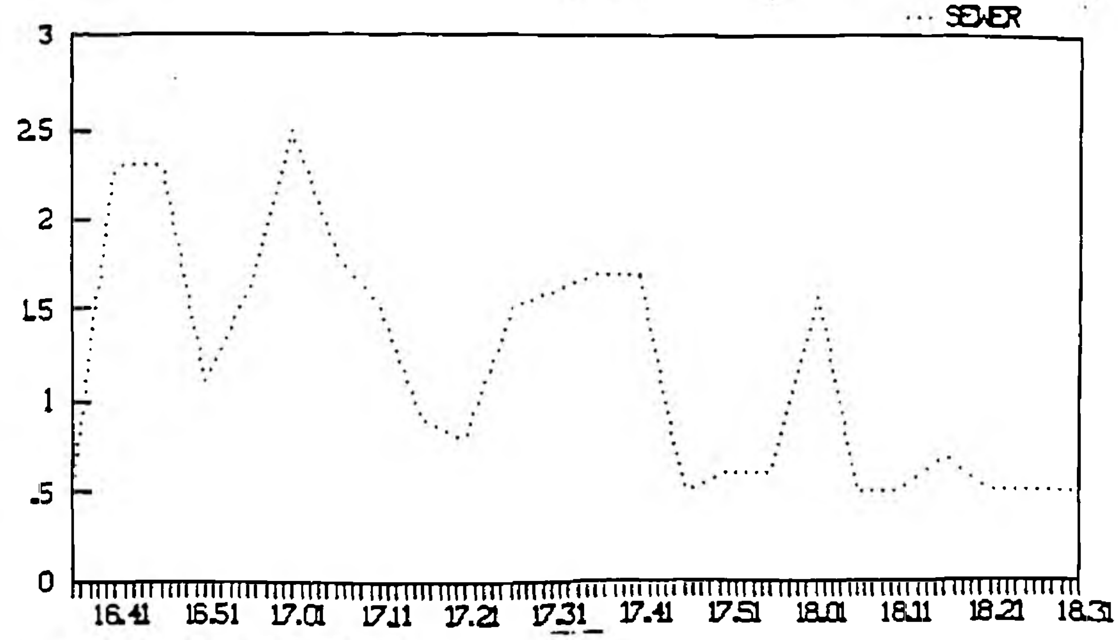


CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW.

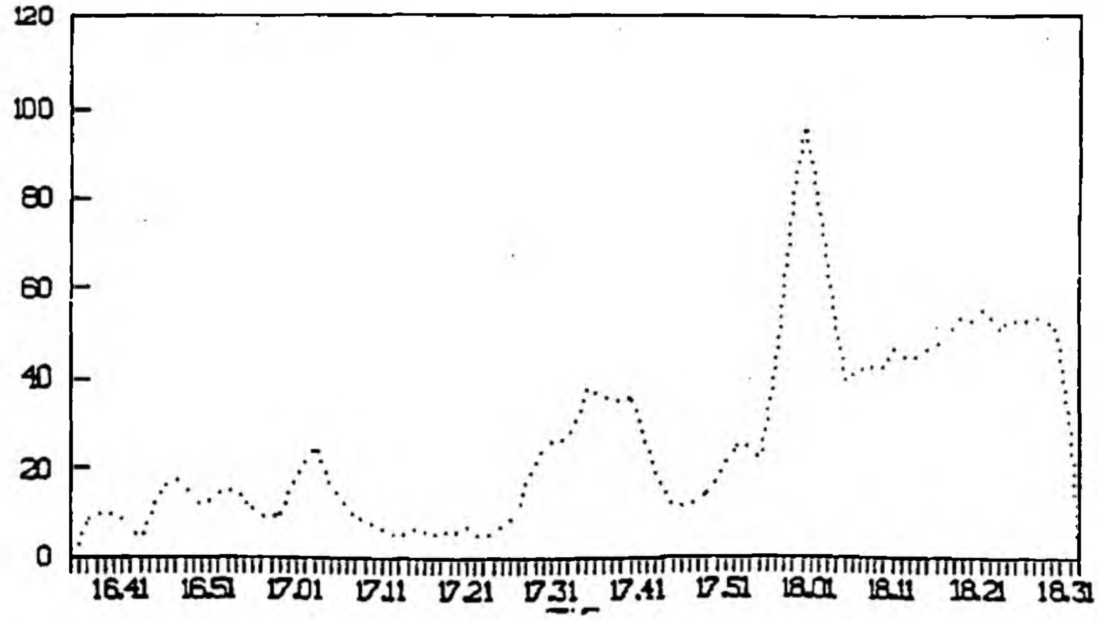


GARNDIFFAITH SSO EVENT 22 20-10-89

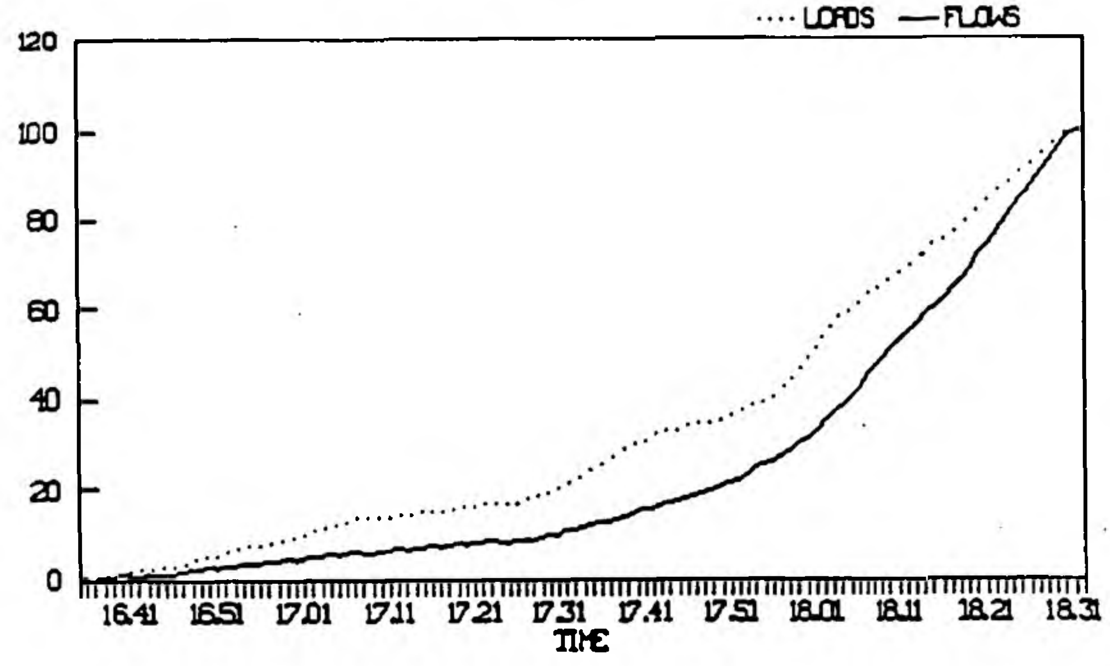
NH3 CONCENTRATIONS. AT SEWER.



NH3 LOADS AT SEWER.

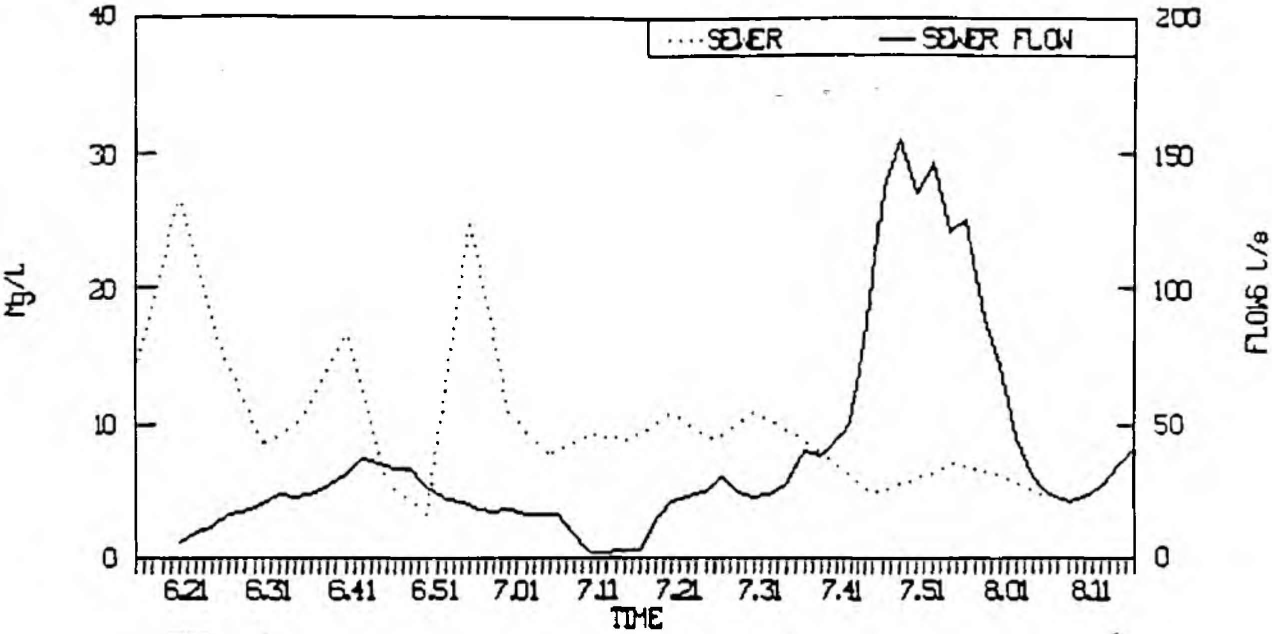


CUMULATIVE LOADS AND FLOWS

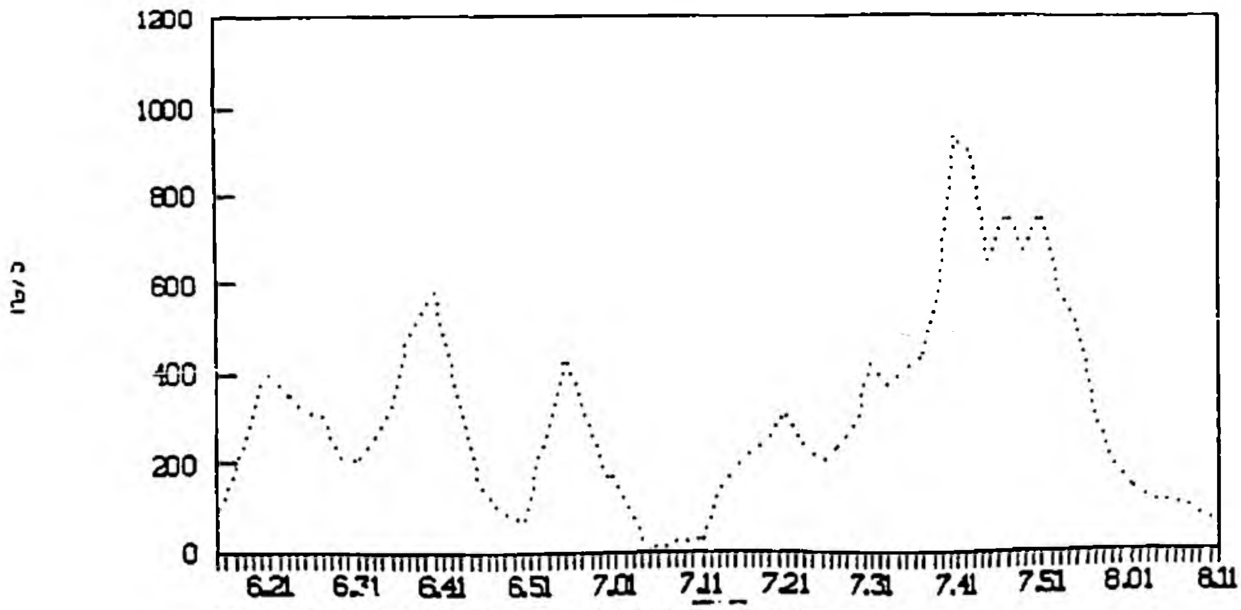


GARNDIFFAITH SSO EVENT 23 08-11-1989

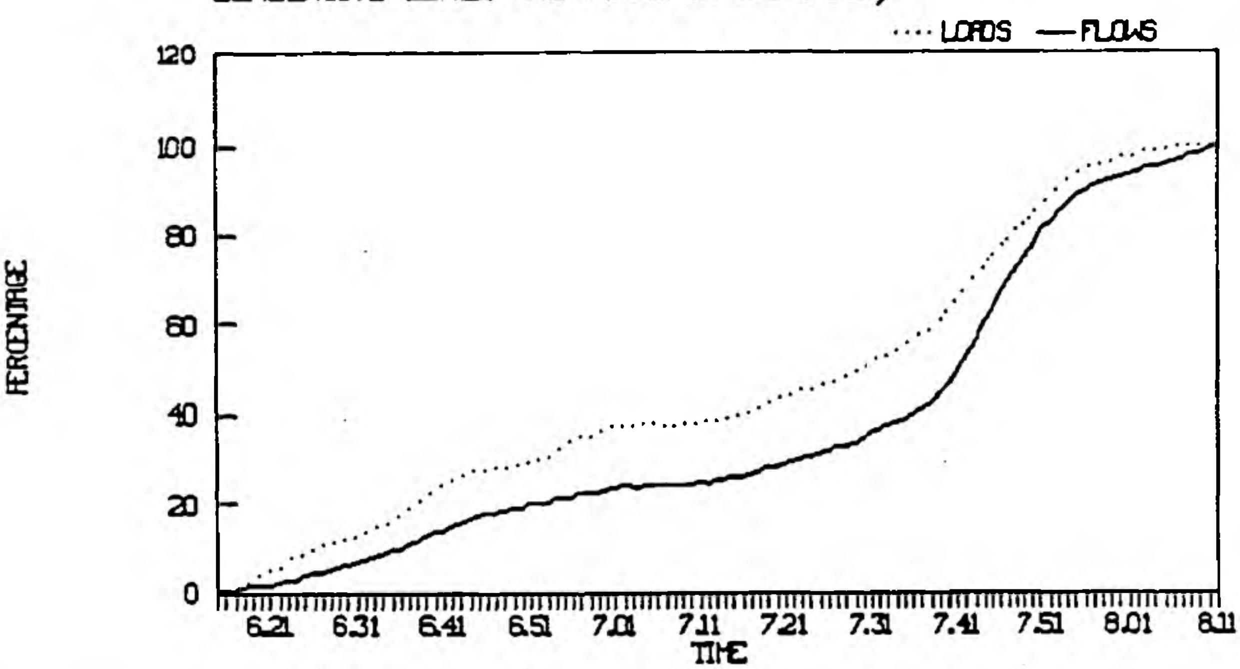
BOD CONCENTRATIONS AT SEWER.



BOD LOADS AT SEWER.

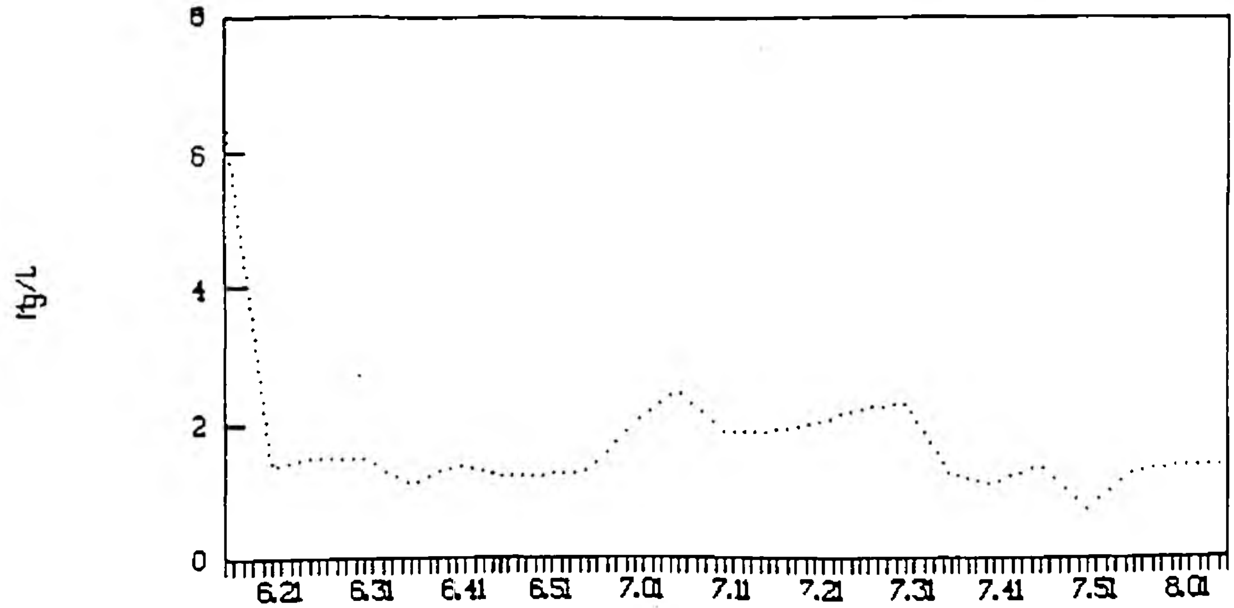


CUMULATIVE LOADS AND FLOWS IN OVERFLOW,

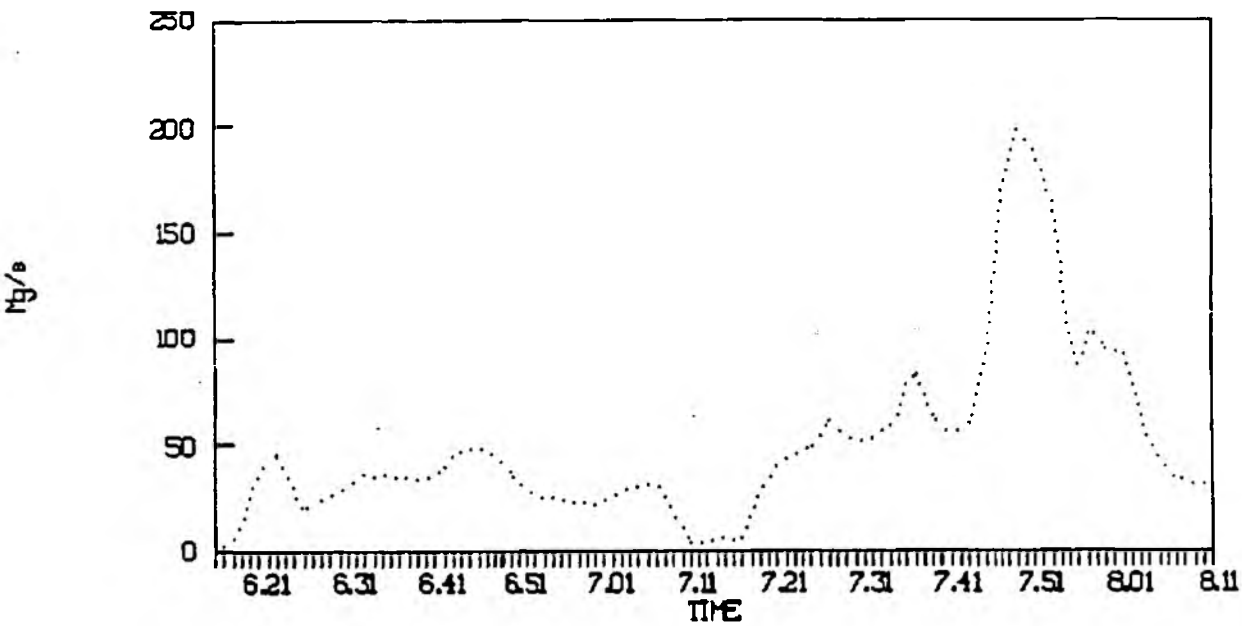


GARNDIFFAITH SSO EVENT 23 08-11-1989

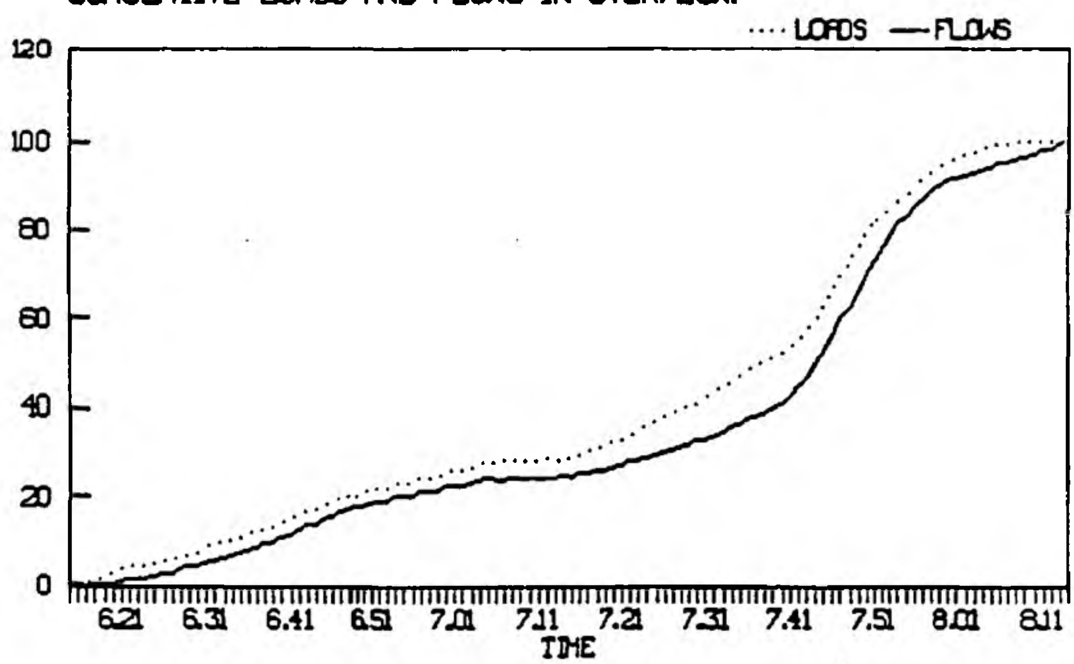
NH3 CONCENTRATIONS AT SEWER.



NH3 LOADS AT SEWER.

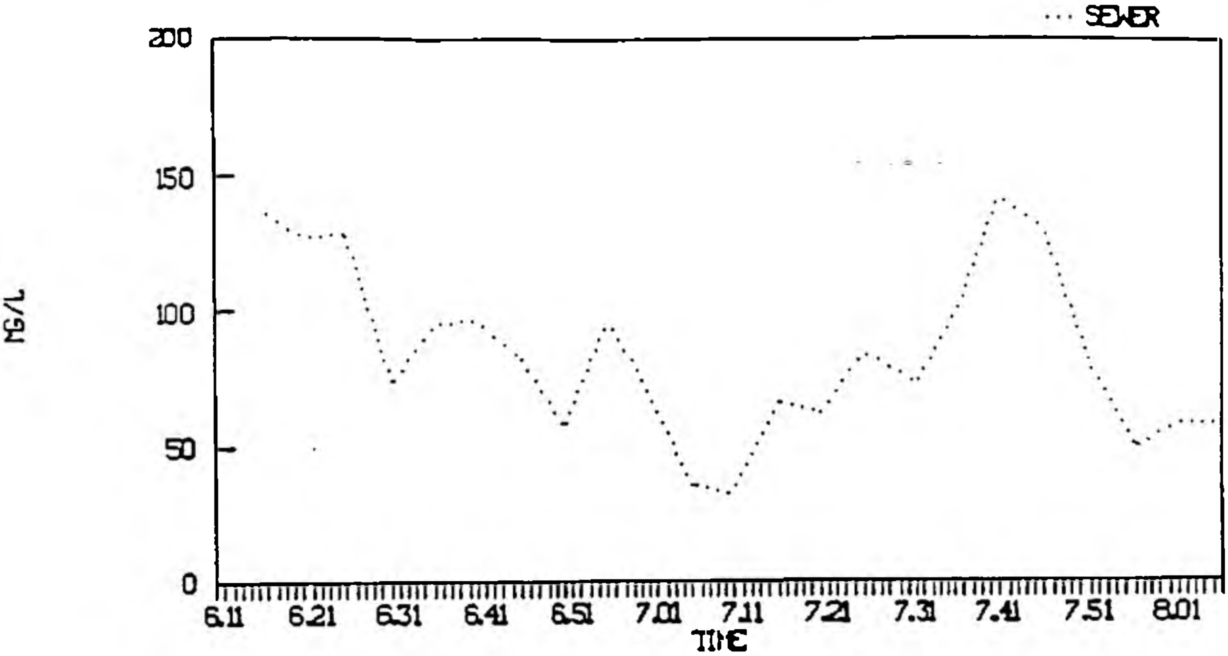


CUMULATIVE LOADS AND FLOWS IN OVERFLOW.



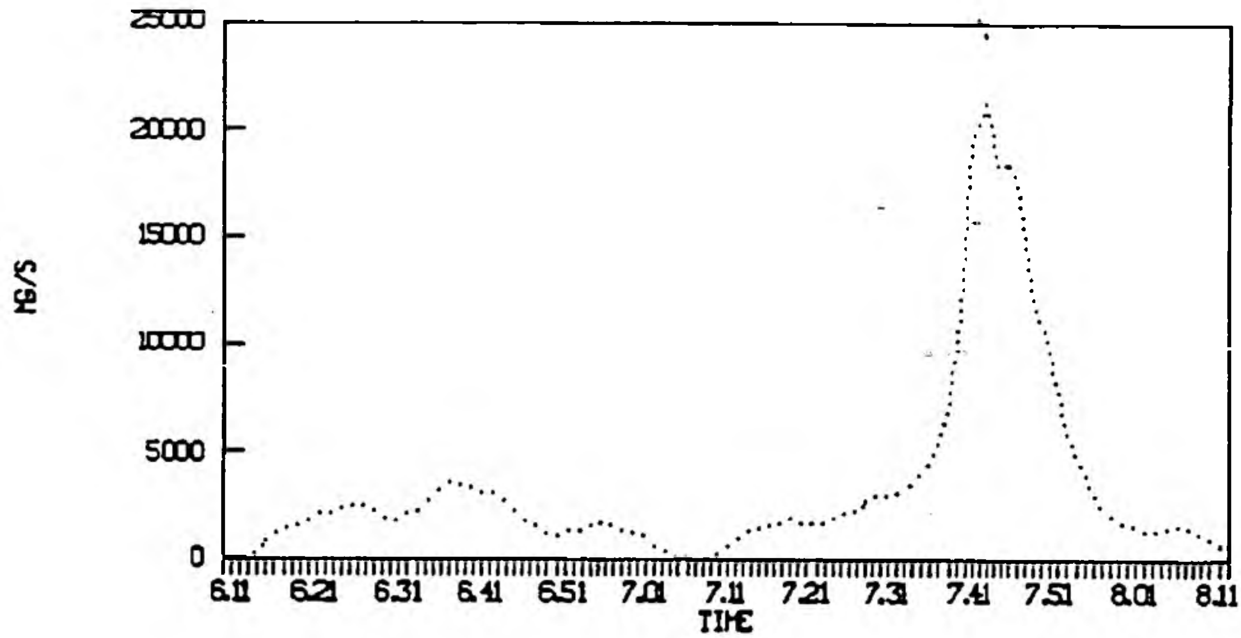
GARNDIFFAITH SSO EVENT 23 08-11-89

TSS CONCENTRATIONS IN OVERFLOW



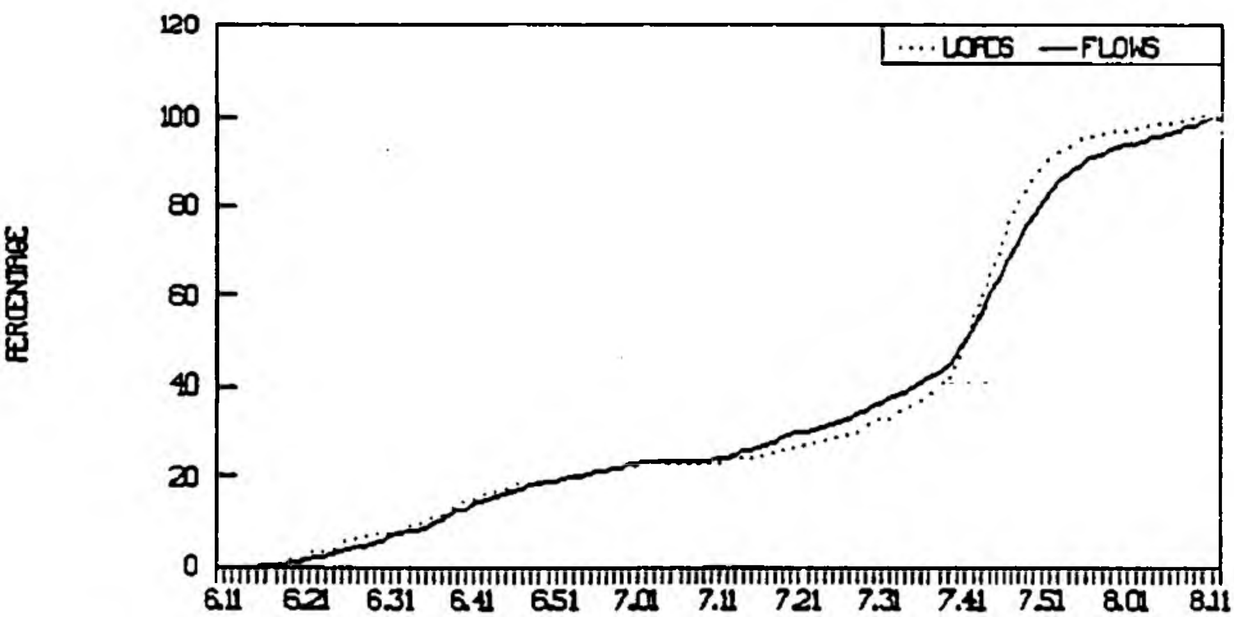
GARNDIFFAITH SSO EVENT 23 08-11-89

TSS LOADS IN OVERFLOW



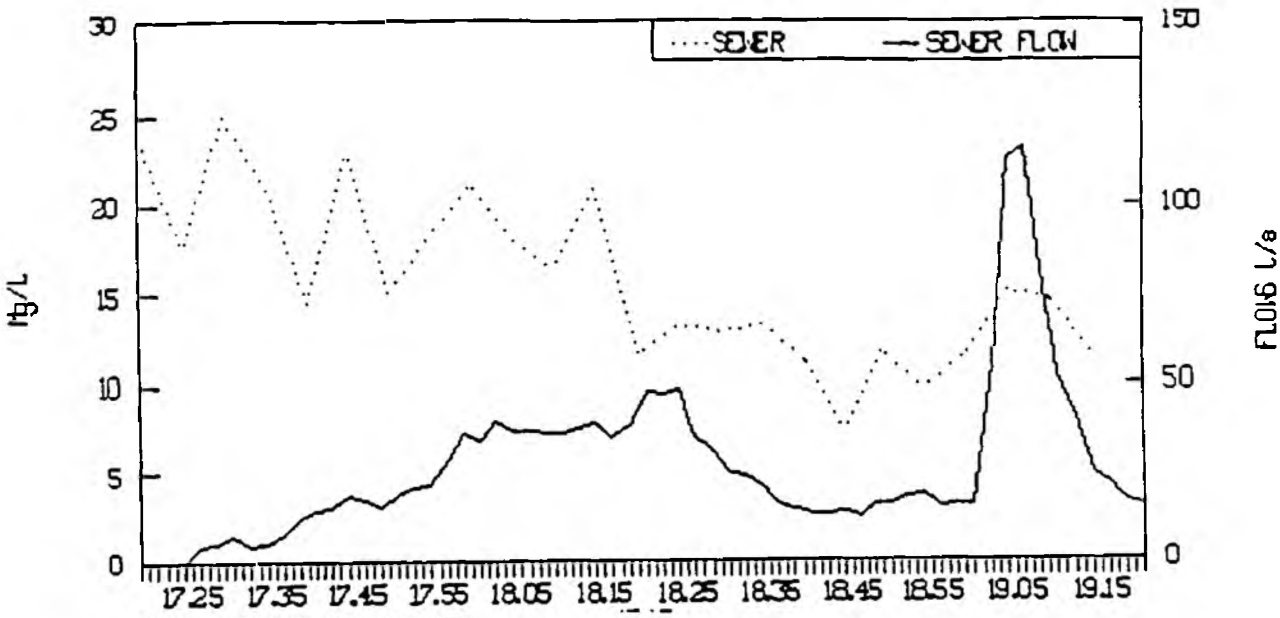
GARNDIFFAITH SSO EVENT 23 08-11-89

CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW.

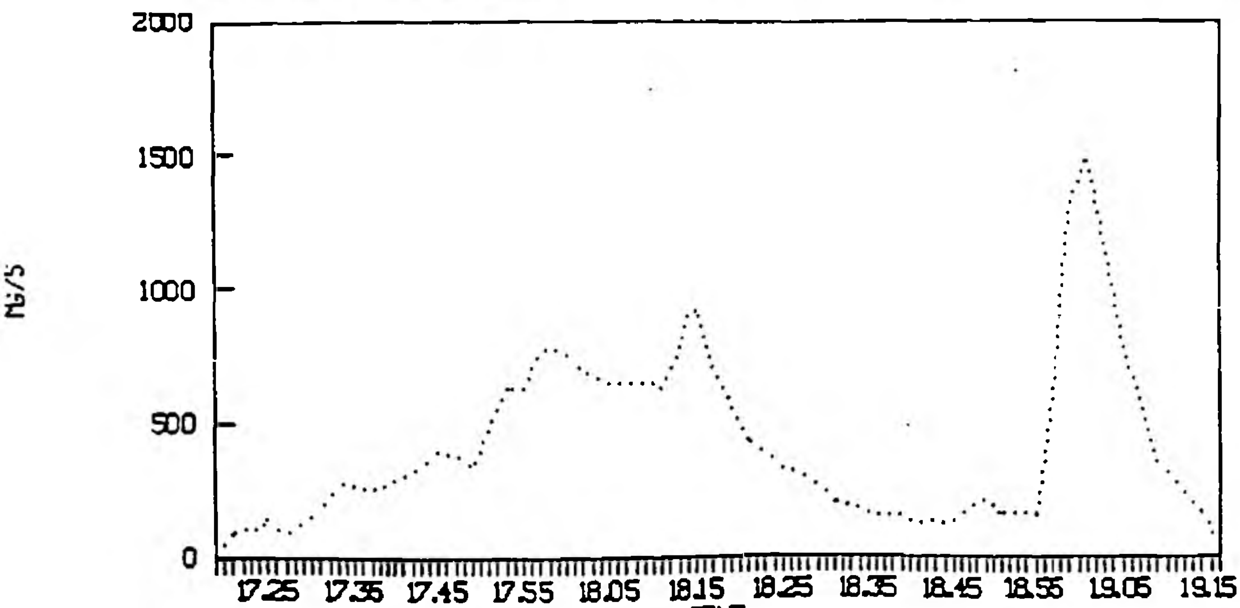


GARNDIFFAITH SSO EVENT 24 09-11-1989

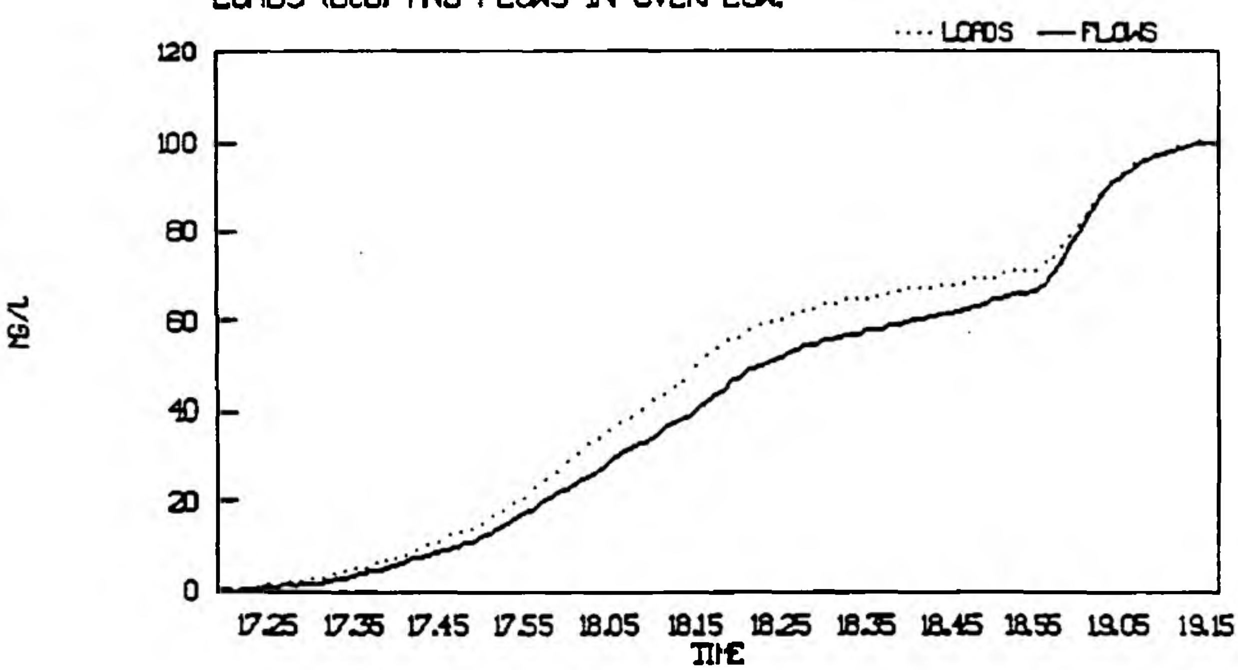
BOD CONCENTRATIONS AT SEWER.



BOD LOADS AT SEWER.

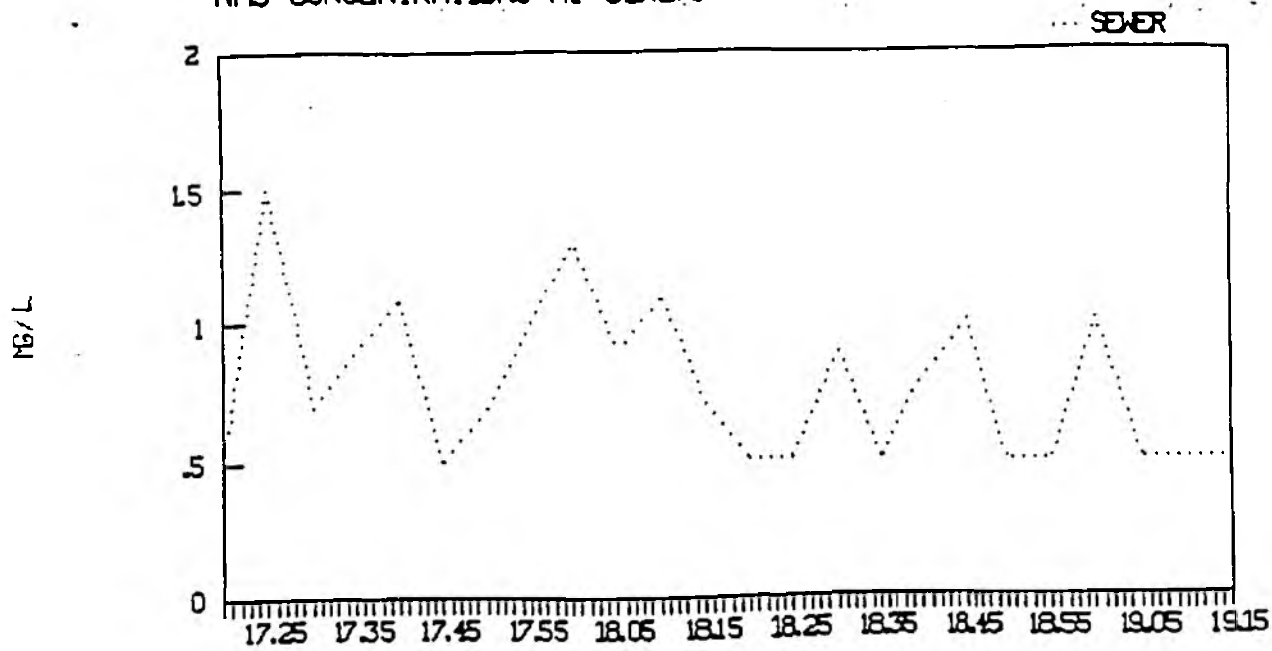


LOADS (BOD) AND FLOWS IN OVERFLOW.

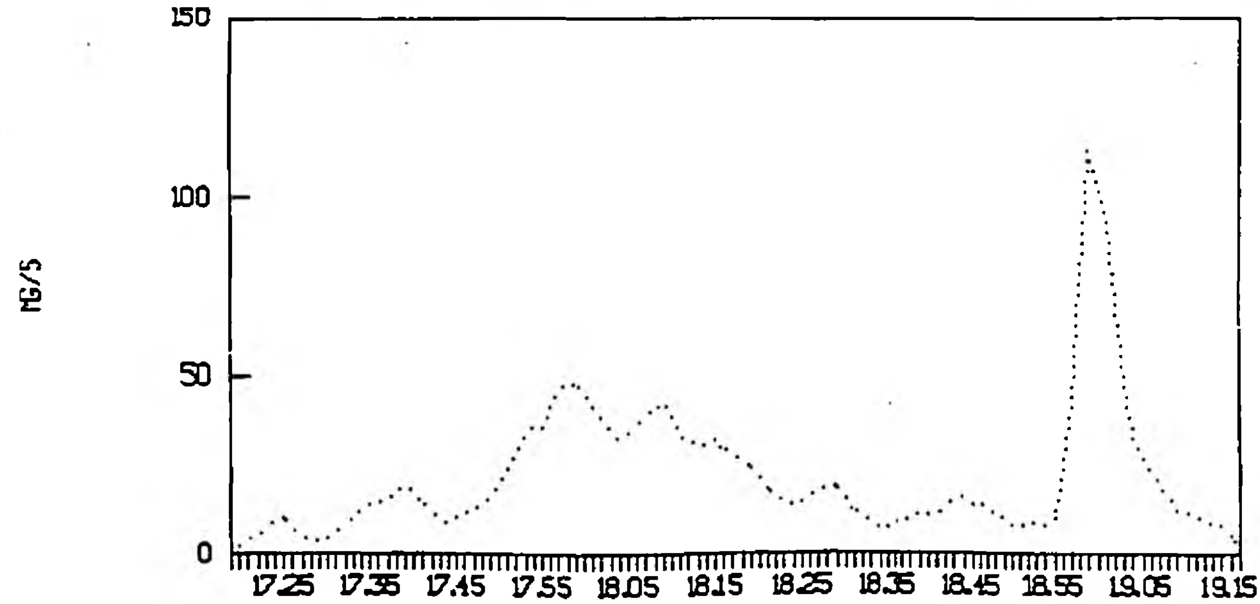


GARNDIFFAITH SSO EVENT 24 09-11-1989

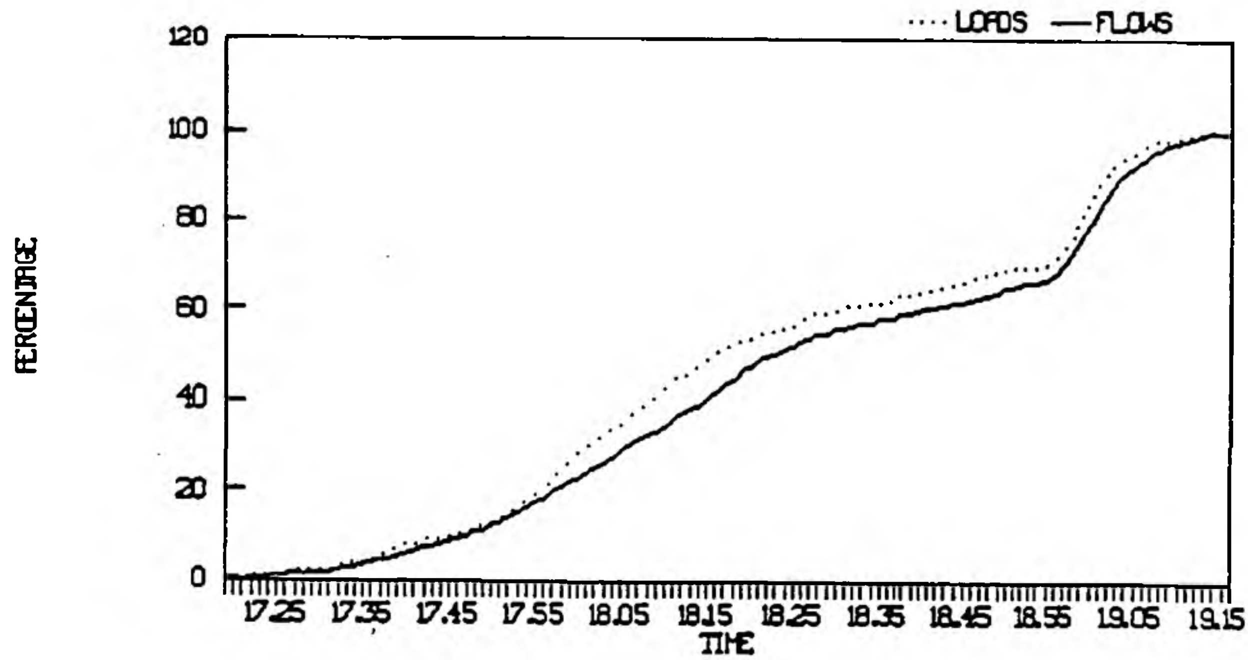
NH3 CONCENTRATIONS AT SEWER.



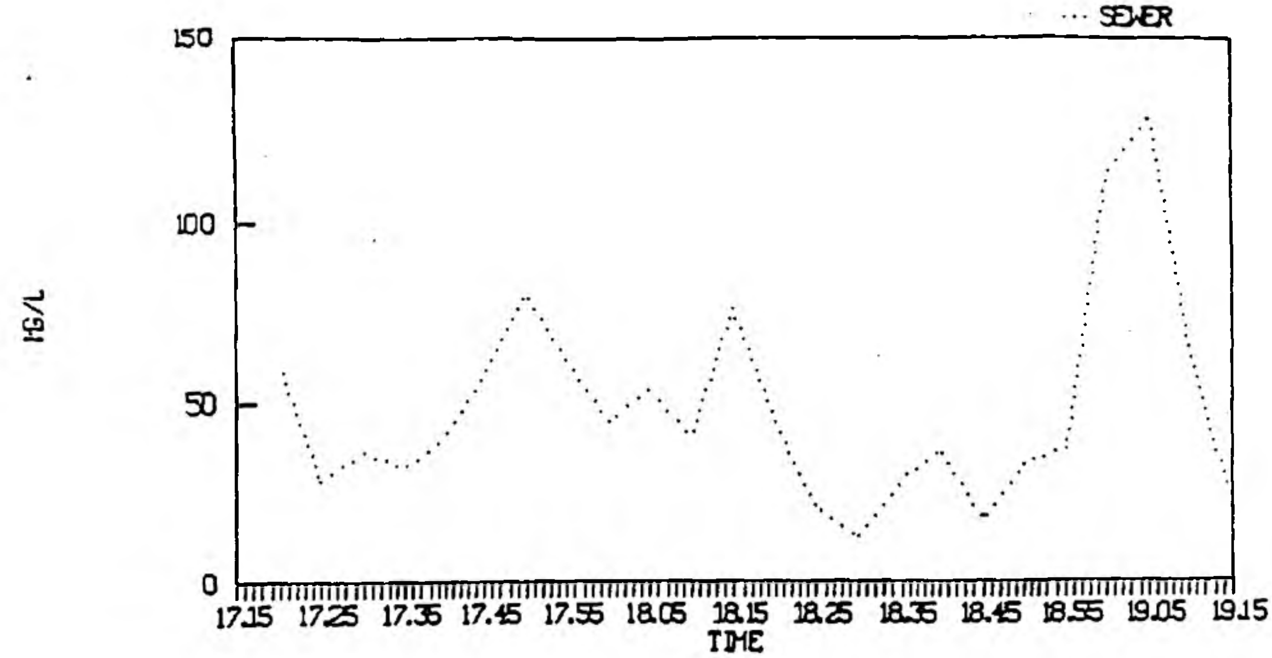
NH3 LOADS AT SEWER.



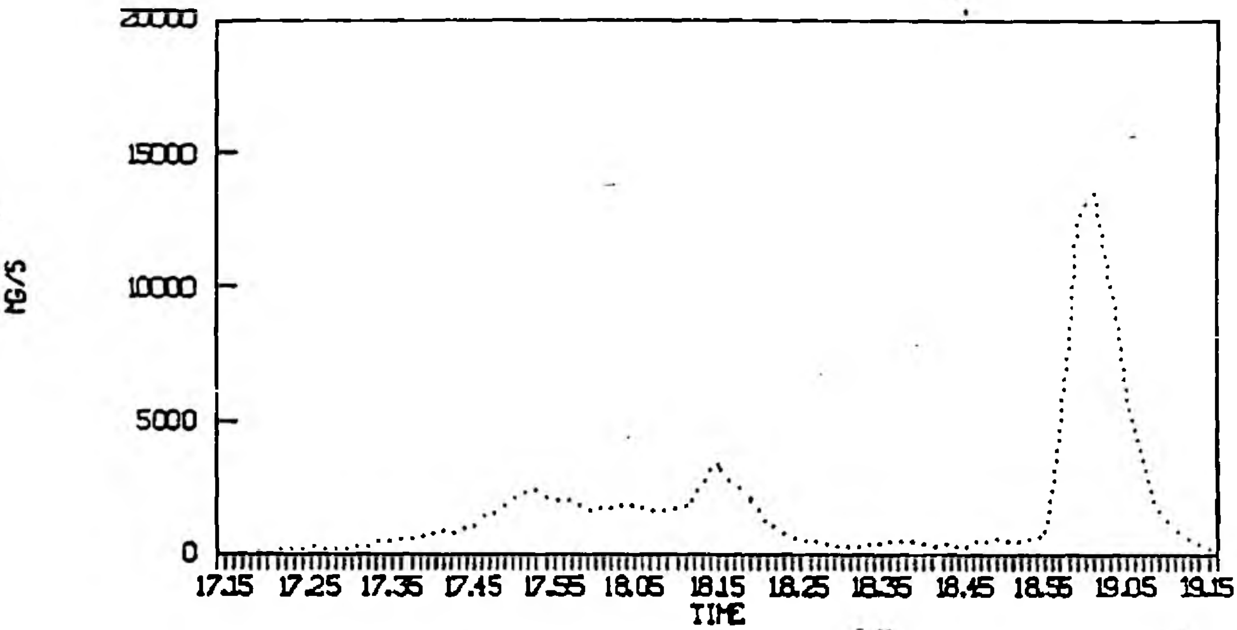
CUMULATIVE LOADS (NH3) AND FLOWS IN OVERFLOW.



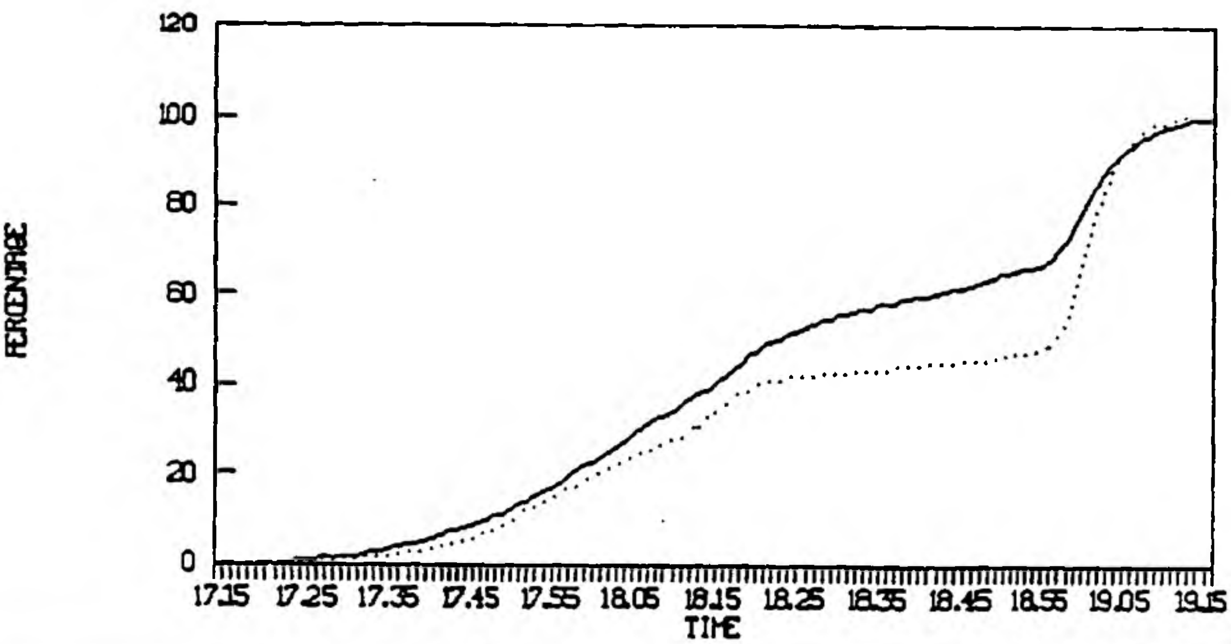
GARNDIFFAITH SSO EVENT 24 09-11-89
TSS CONCENTRATIONS IN OVERFLOW



GARNDIFFAITH SSO EVENT 24 09-11-89
TSS LOADS IN OVERFLOW

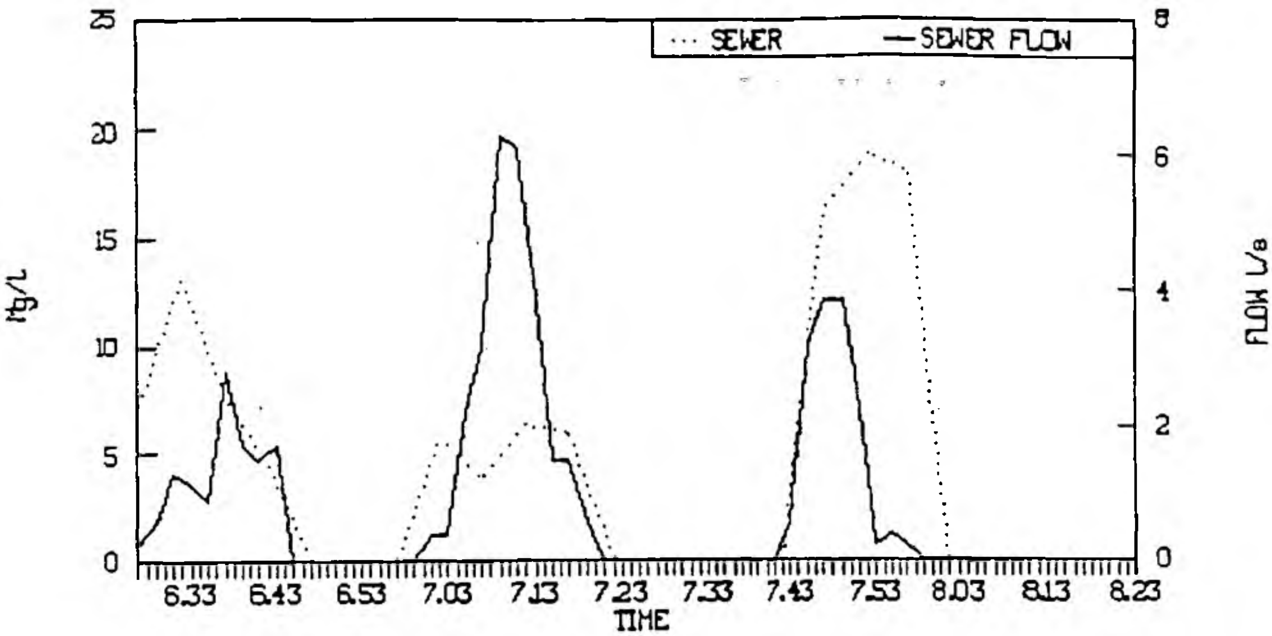


GARNDIFFAITH SSO EVENT 24 09-11-89
CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW

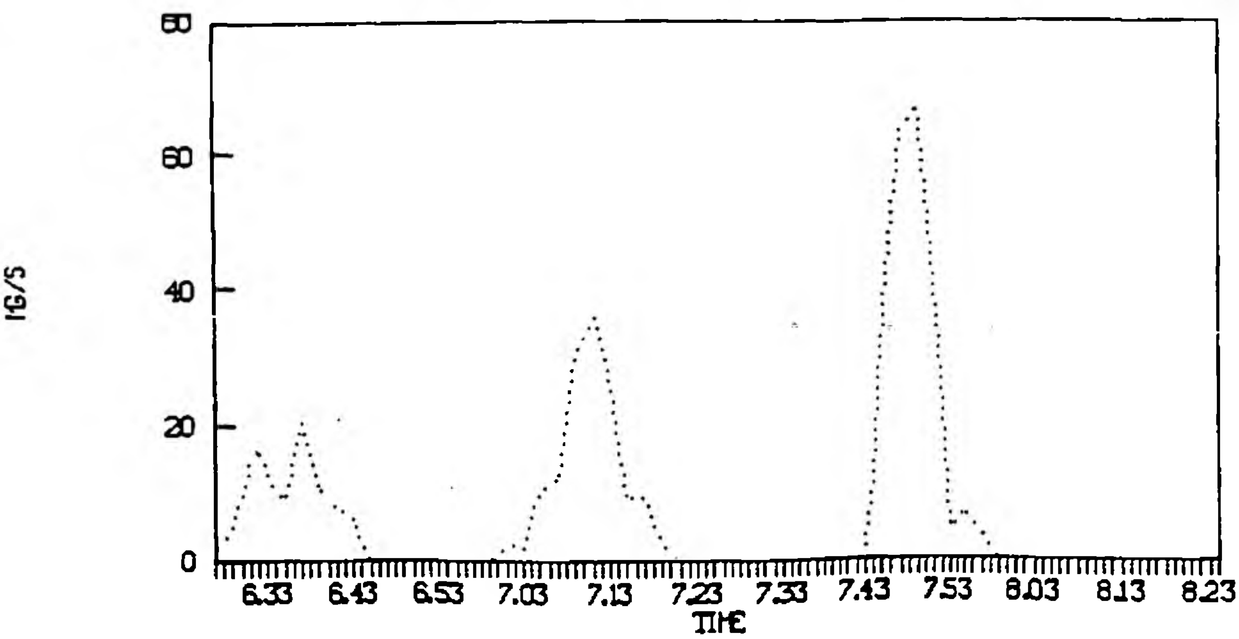


GARNDIFFAITH SSO EVENT 25 13-12-89

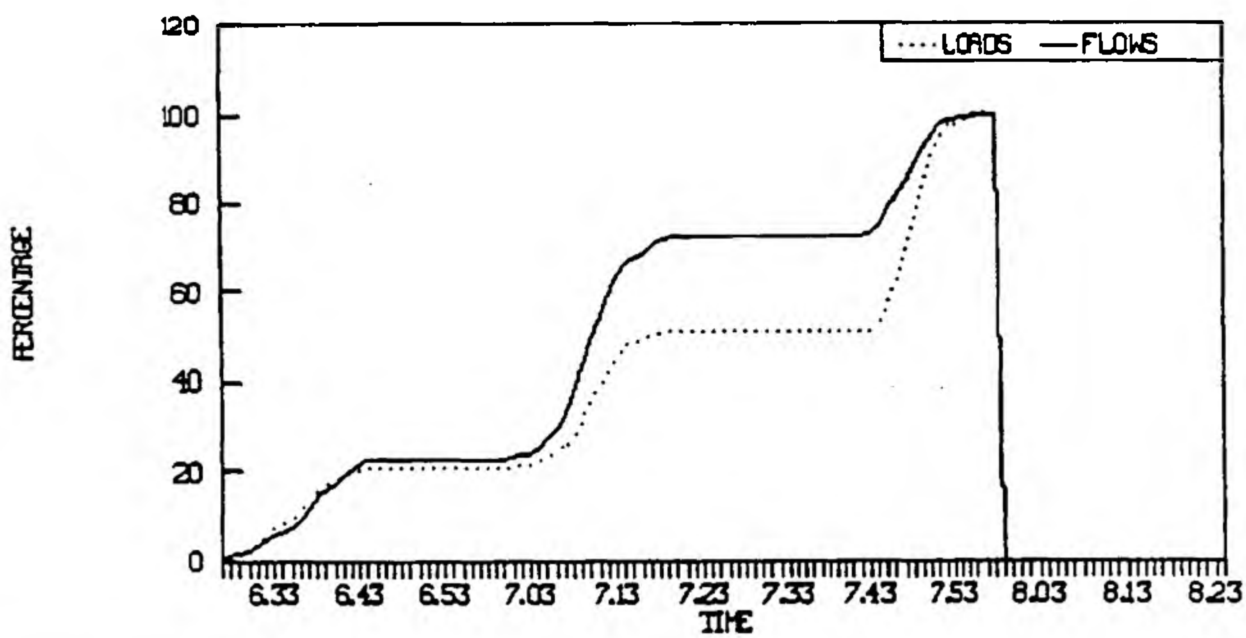
BOD CONCENTRATIONS AT SEWER



BOD LOADS AT SEWER.

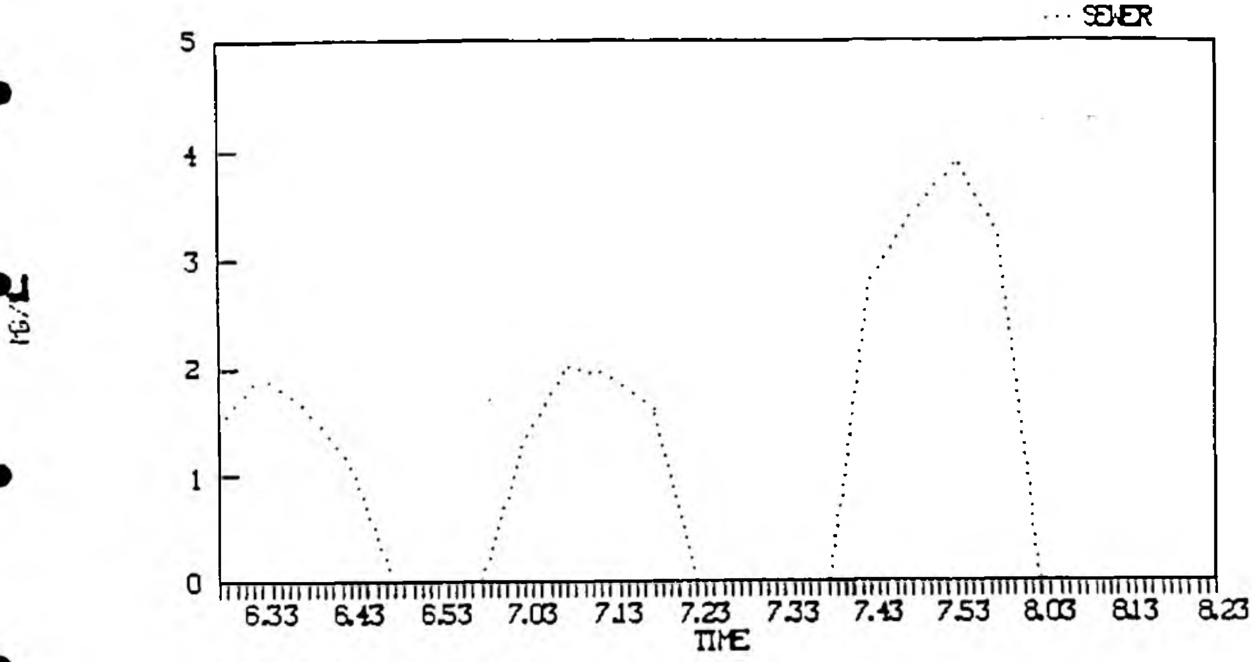


CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW

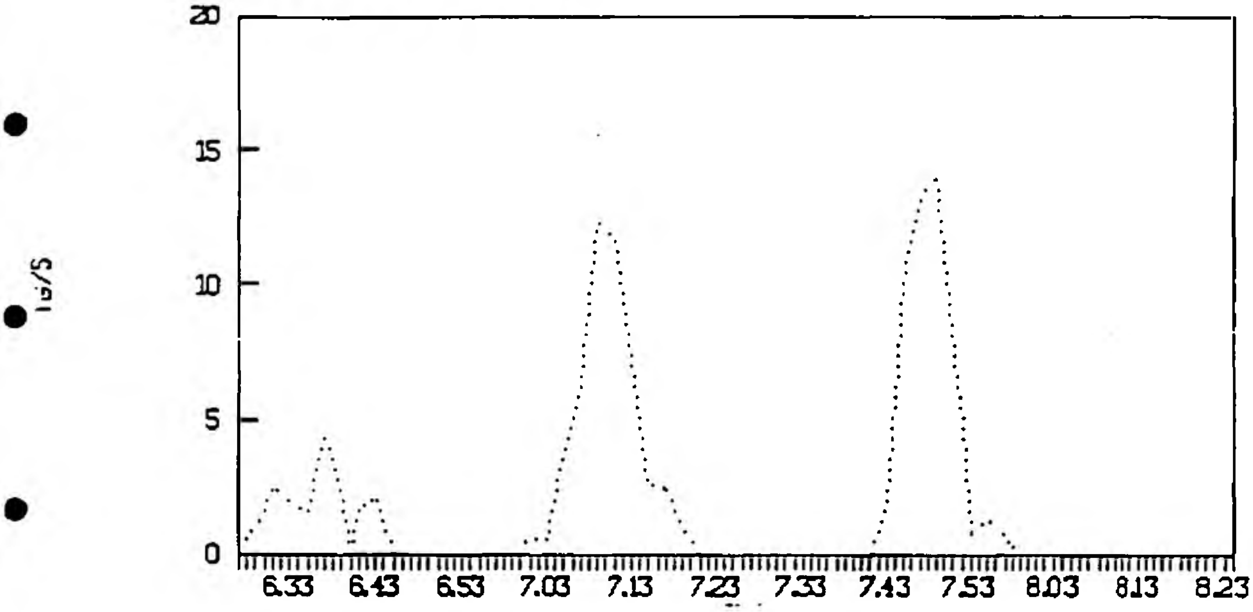


GARNDIFFAITH SSO EVENT 25 13-12-89

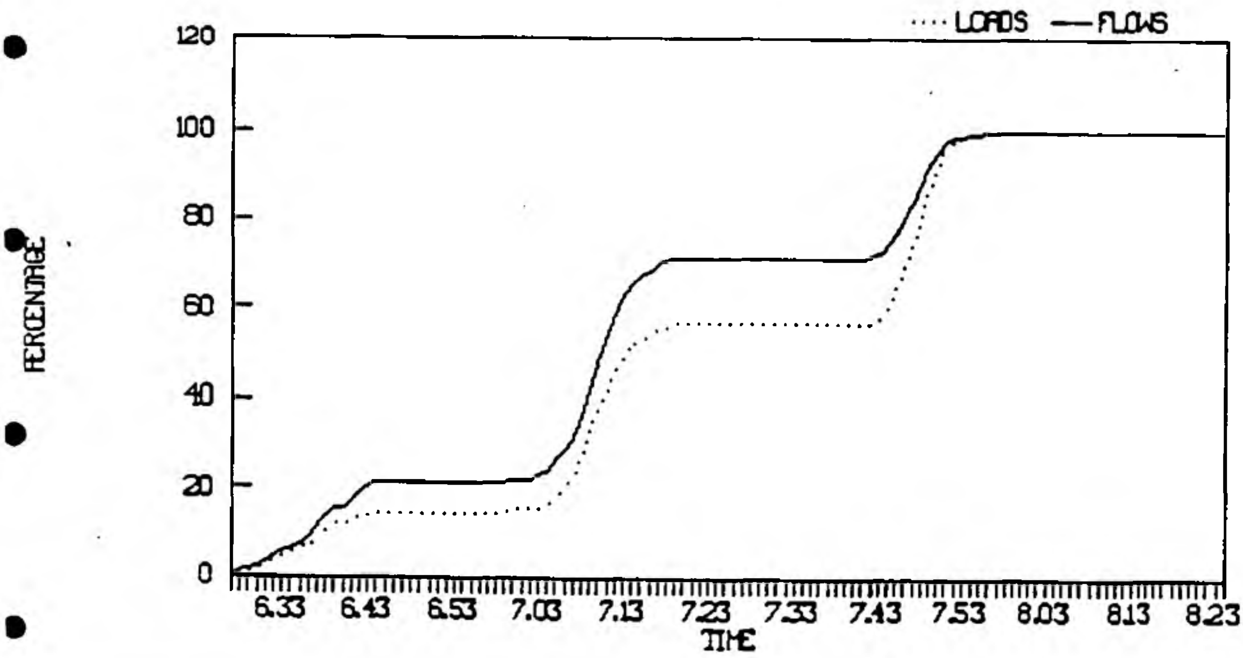
NH3 CONCENTRATIONS AT SEWER.



NH3 LOADS AT SEWER.

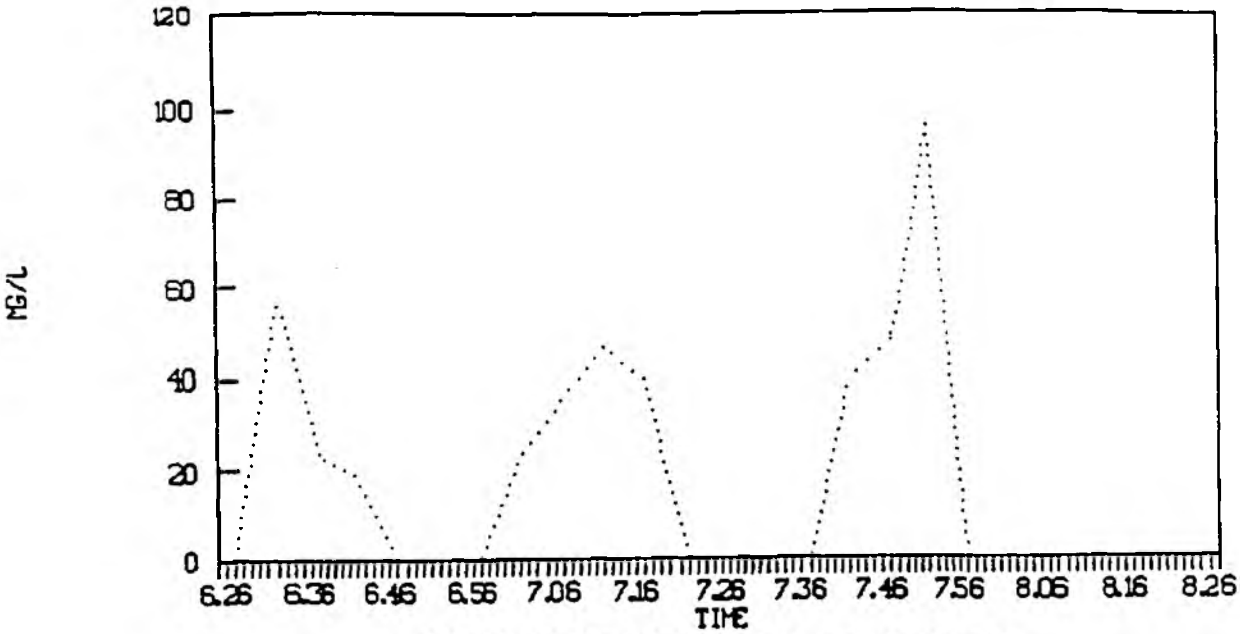


CUMULATIVE LOADS AND FLOWS



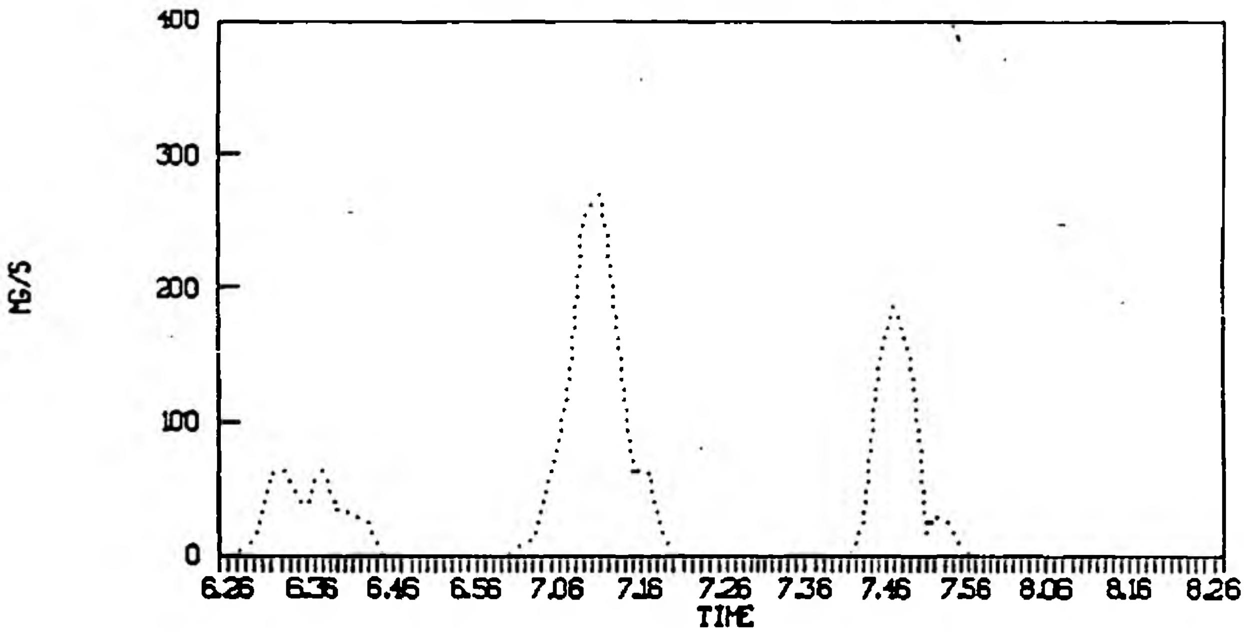
GARNDIFFAITH SSO EVENT 25 13-12-89

TSS CONCENTRATIONS IN OVERFLOW



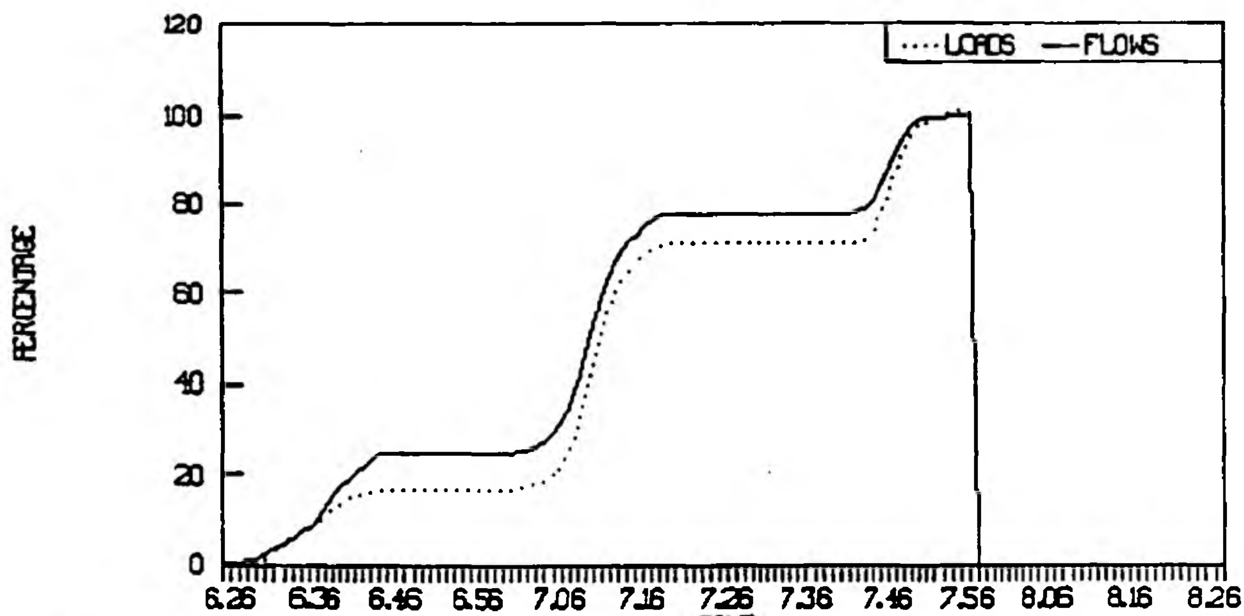
GARNDIFFAITH SSO EVENT 25 13-12-89

TSS LOADS IN OVERFLOW



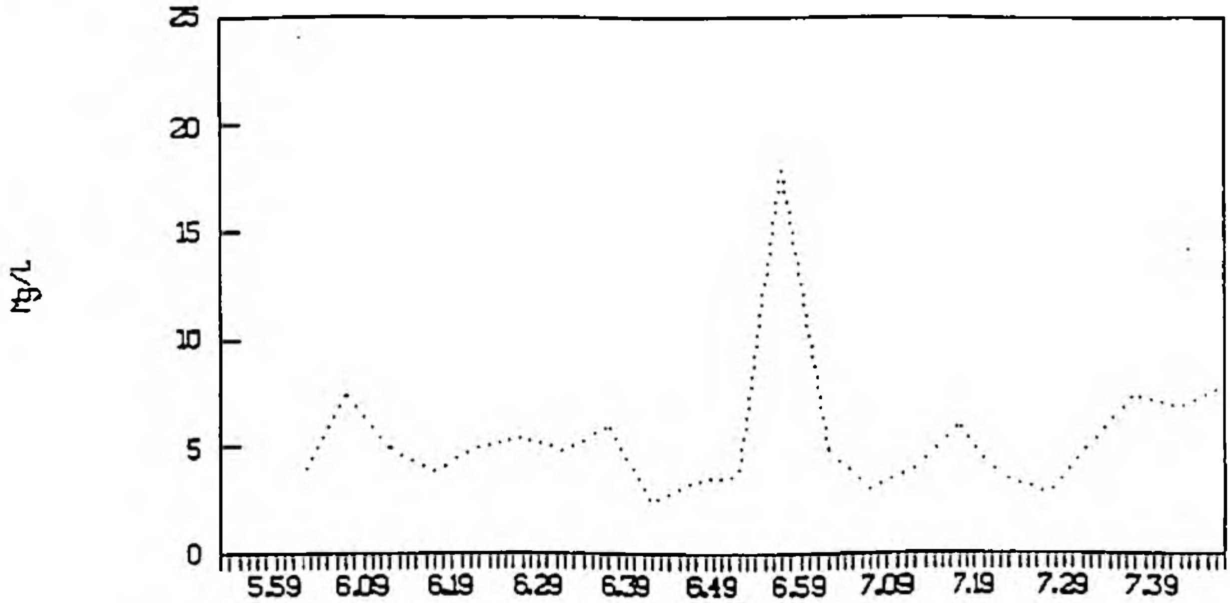
GARNDIFFAITH SSO EVENT 25 13-12-89

CUMULATIVE LOADS (TSS) AND FLOWS IN OVERFLOW

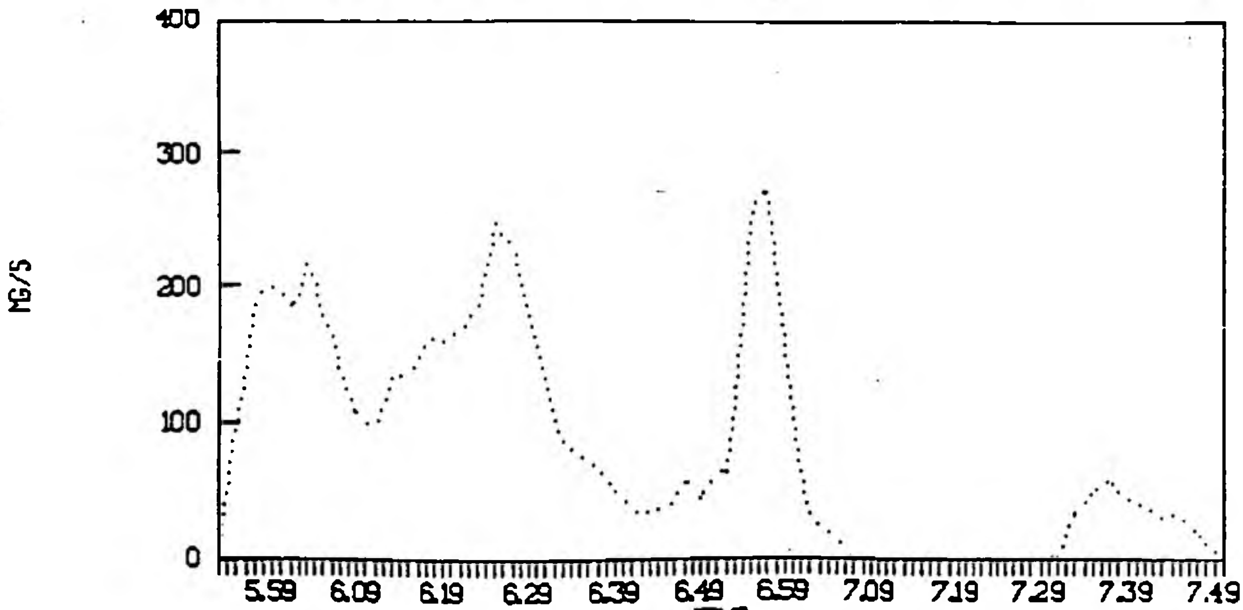


GARNDIFFAITH SSO EVENT 26 16-12-1989

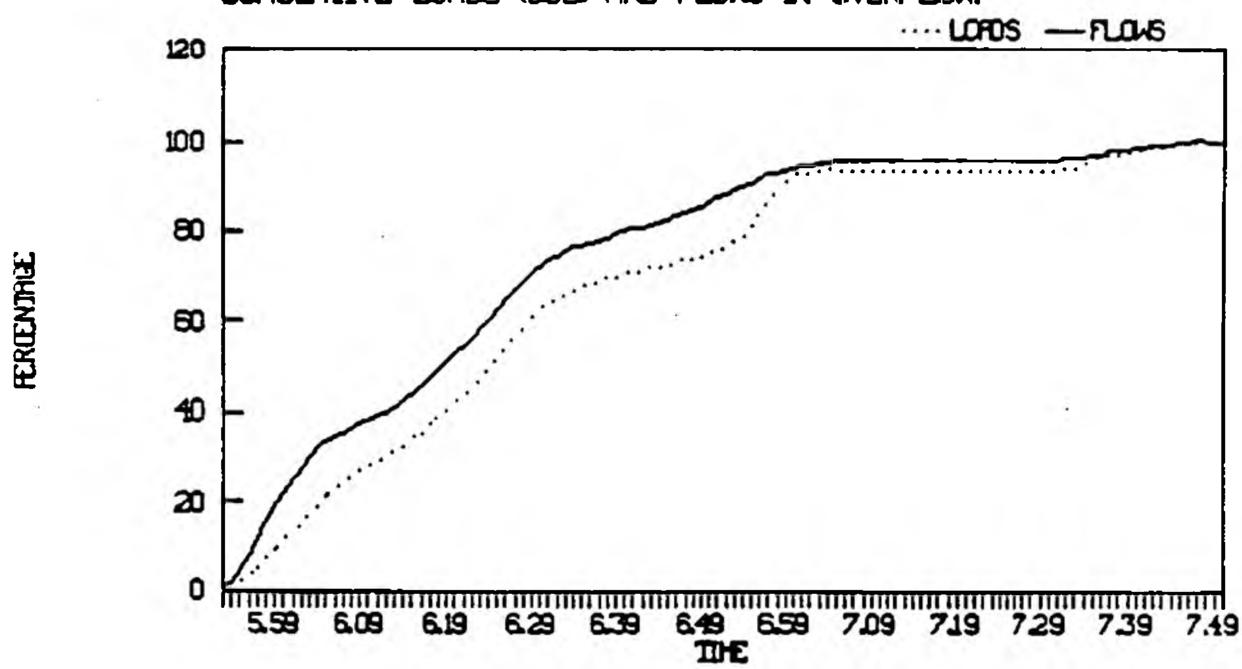
BOD CONCENTRATIONS AT SEWER.



BOD LOADS AT SEWER.

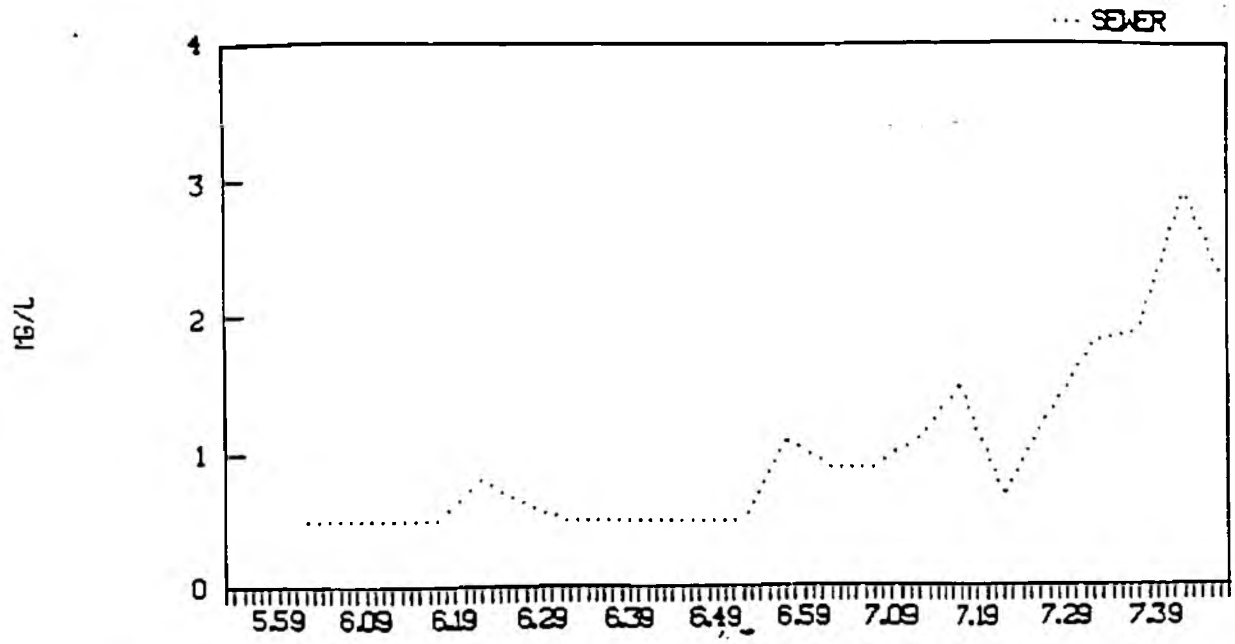


CUMULATIVE LOADS (BOD) AND FLOWS IN OVERFLOW.

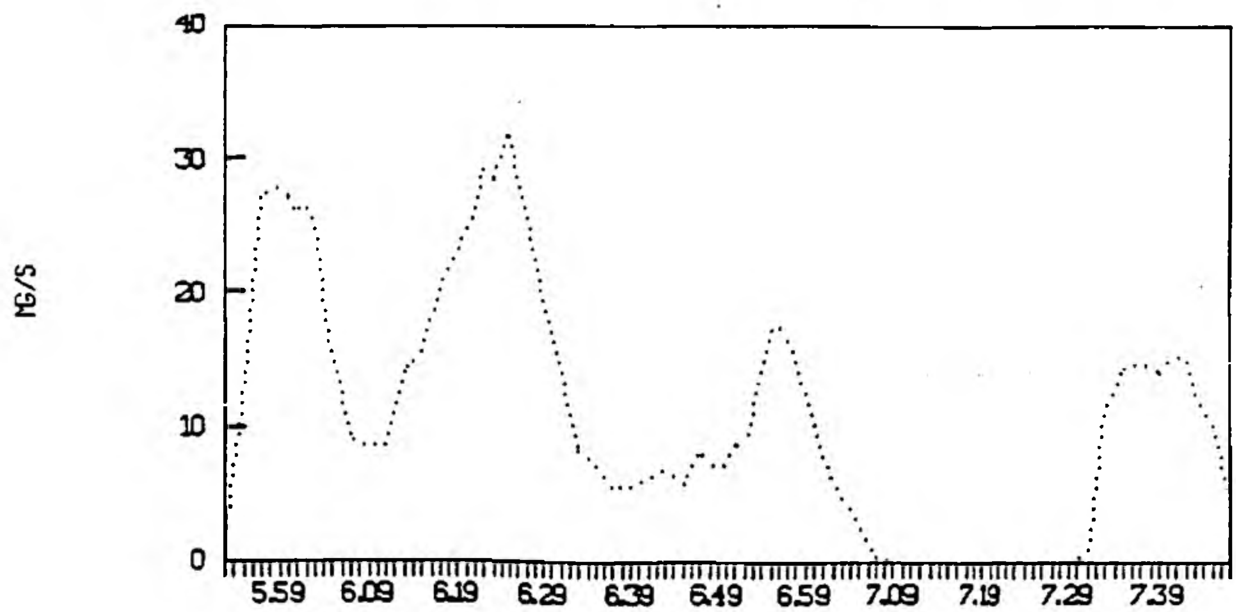


GARNDIFFRAITH SSO EVENT 26 16-12-89

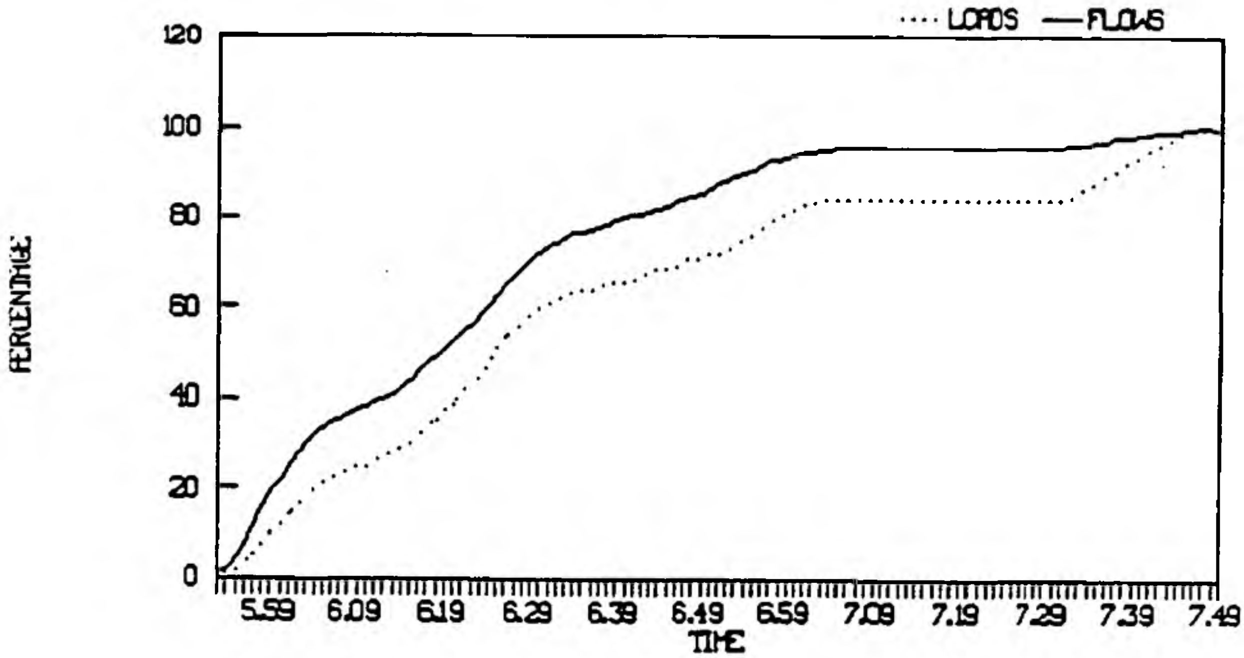
NH3 CONCENTRATIONS AT SEWER.



NH3 LOADS AT SEWER.



CUMULATIVE LOADS (NH3) AND FLOWS IN OVERFLOW.

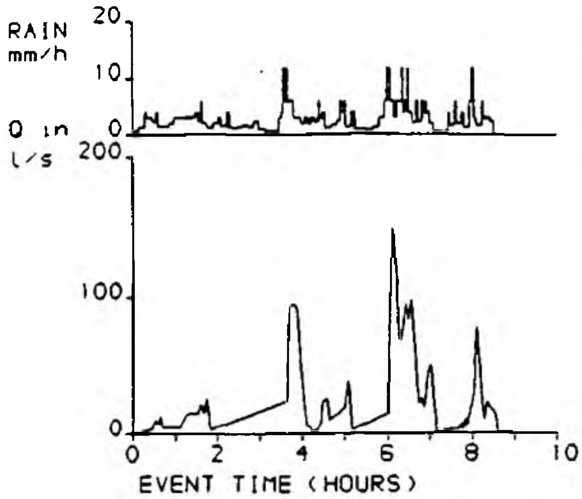


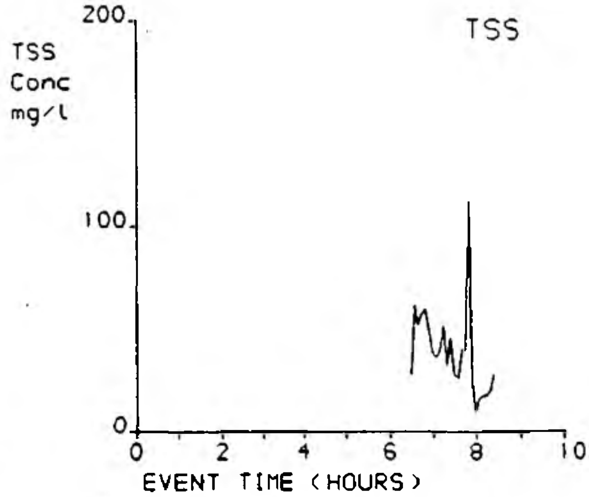
Site: SSO TO NANT FFRWD

GN891216SO.DAT

Grid Ref: 262044
Storm Date: 891216
Start Time (R/F): 0
Rainfall Depth (mm): 23.0

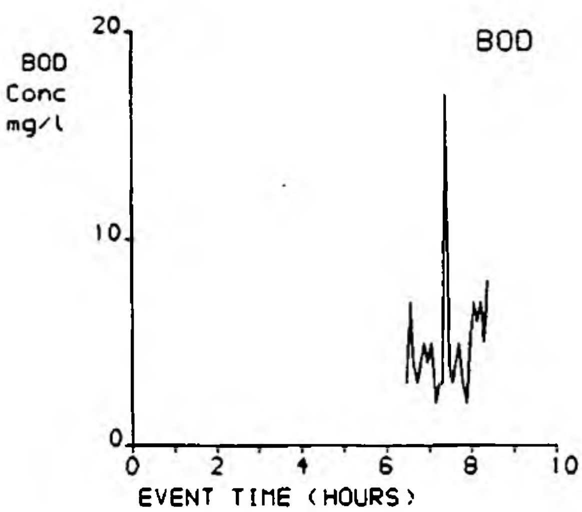
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 504.

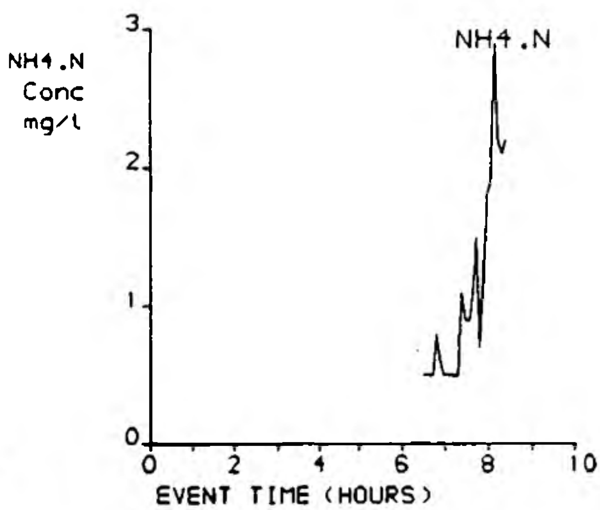




NO DATA FOR COD

NO DATA FOR TDS



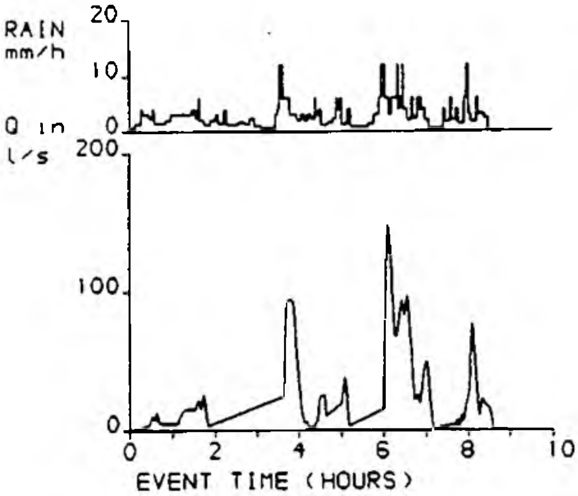


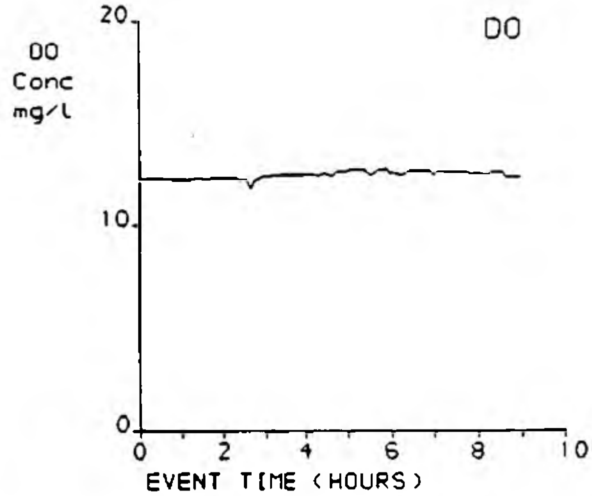
Site: SSO TO NANT FFRWD

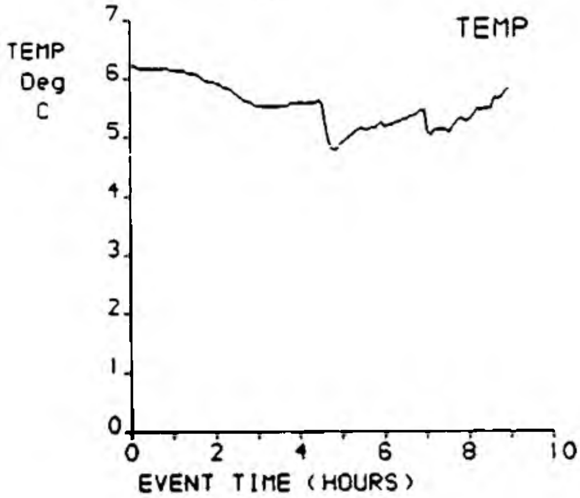
GN891216SO.DAT

Grid Ref: 262044
Storm Date: 891216
Start Time (R/F): 0
Rainfall Depth (mm): 23.0

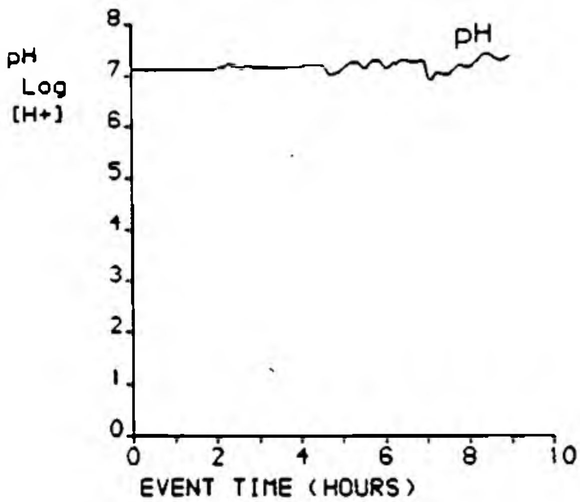
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 504.







NO DATA FOR Cond

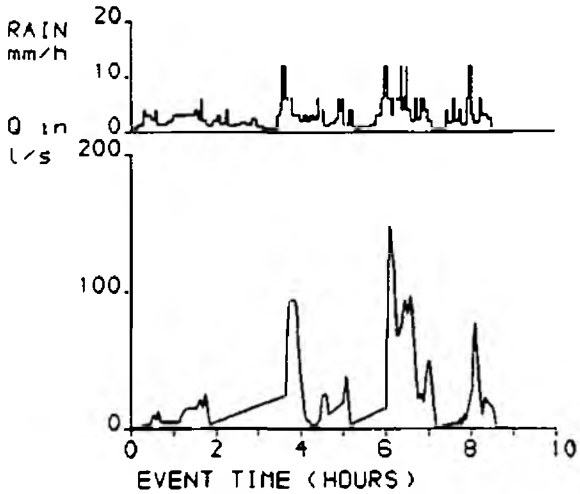


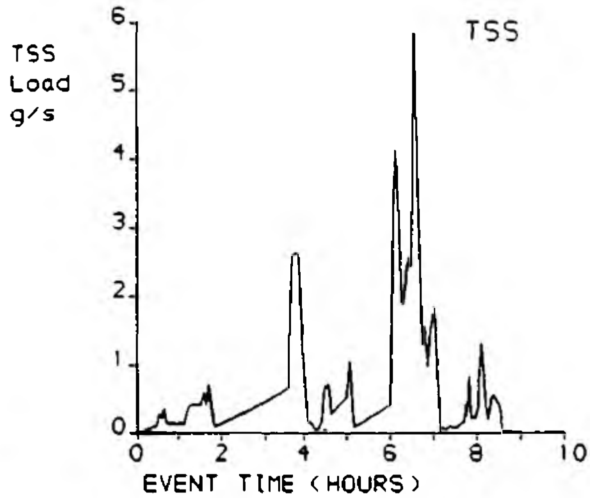
Site: SSO TO NANT FFRWD

GN891216SO.DAT

Grid Ref: 262044
Storm Date: 891216
Start Time (R/F): 0
RainFall Depth (mm): 23.0

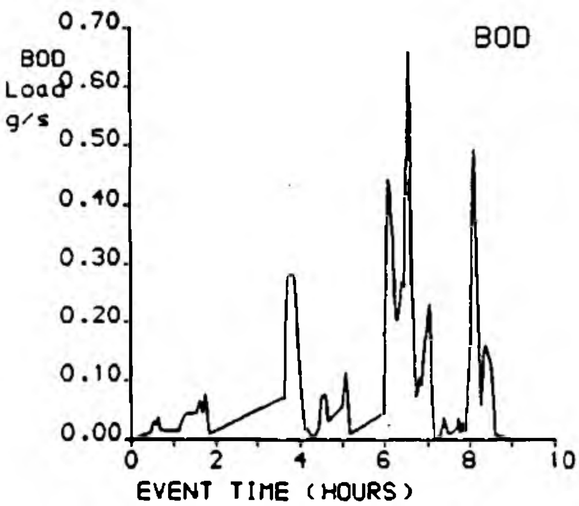
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
RainFall Event Duration (mins): 504.

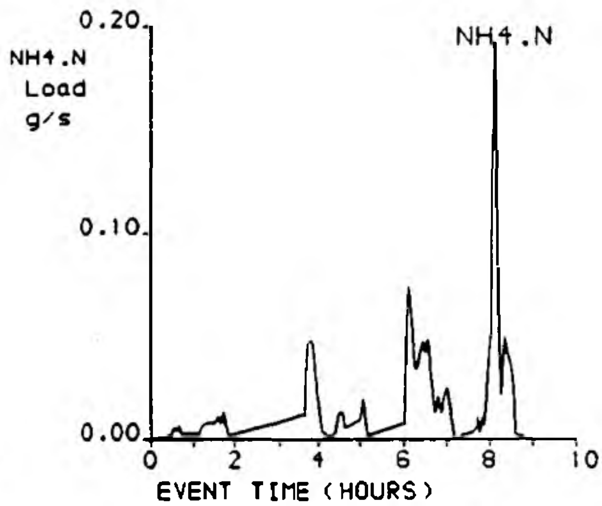




NO DATA FOR COD

NO DATA FOR TDS



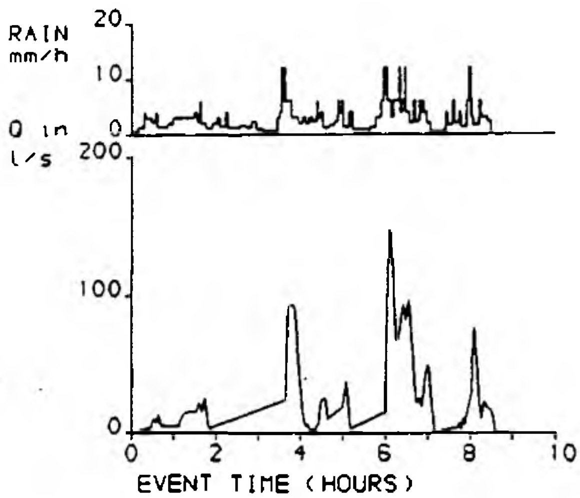


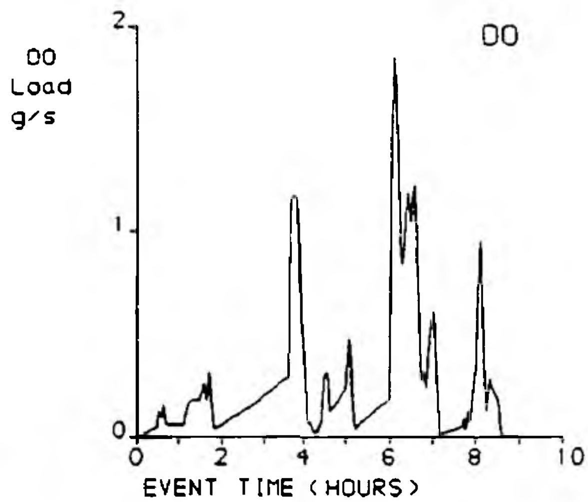
Site: SSO TO NANT FFRWD

GN891216SO.DAT

Grid Ref: 262044
Storm Date: 891216
Start Time (R/F): 0
Rainfall Depth (mm): 23.0

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 504.





NO DATA FOR TEMP

NO DATA FOR Cond

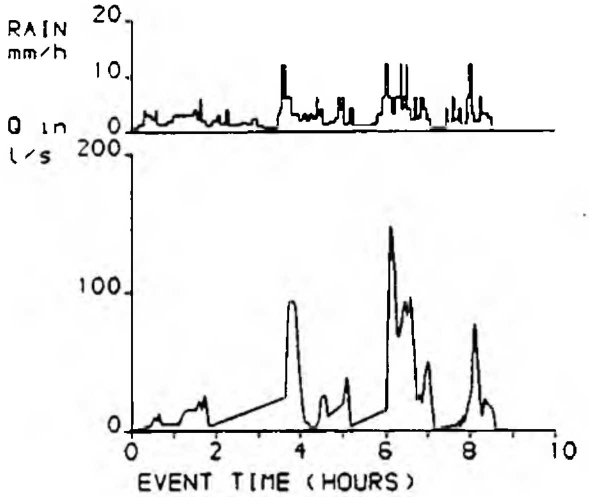
NO DATA FOR pH

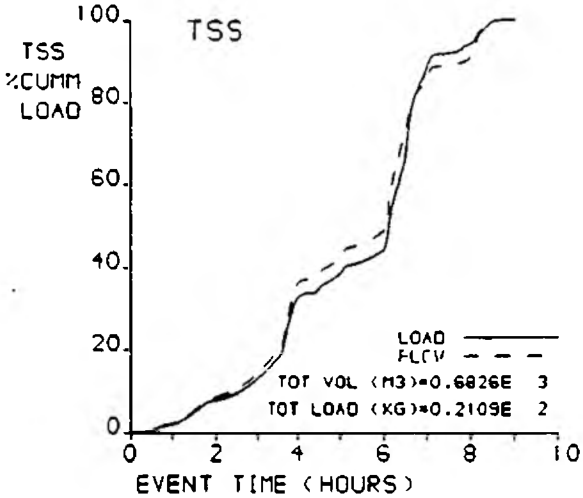
Site: SSO TO NANT FFRWD

GN891216SO.DAT

Grid Ref: 262044
Storm Date: 891216
Start Time (R/F): 0
Rainfall Depth (mm): 23.0

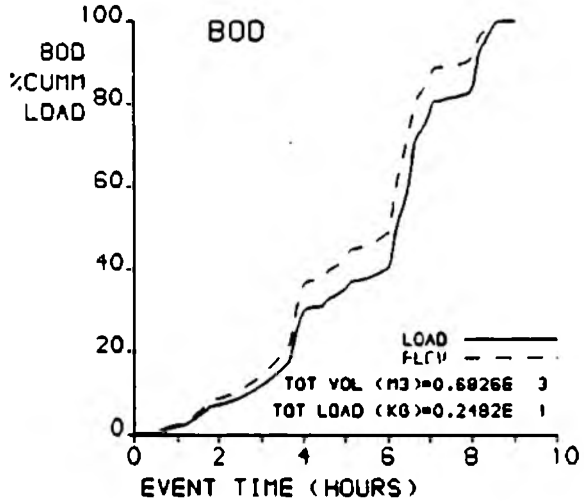
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 504.

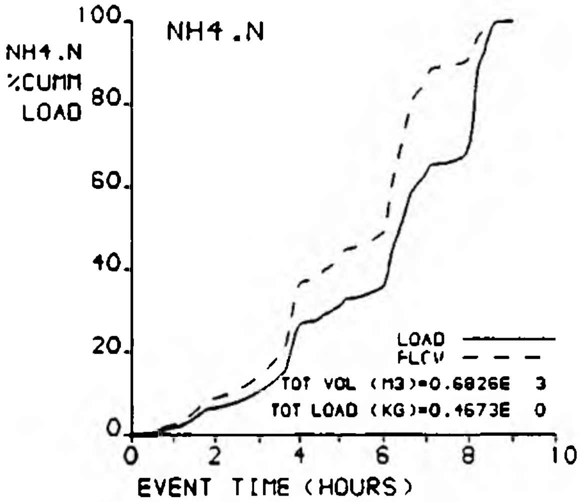




NO DATA FOR COD

NO DATA FOR TDS



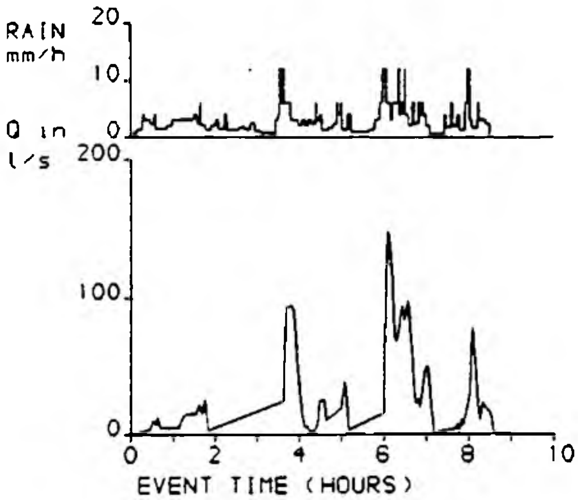


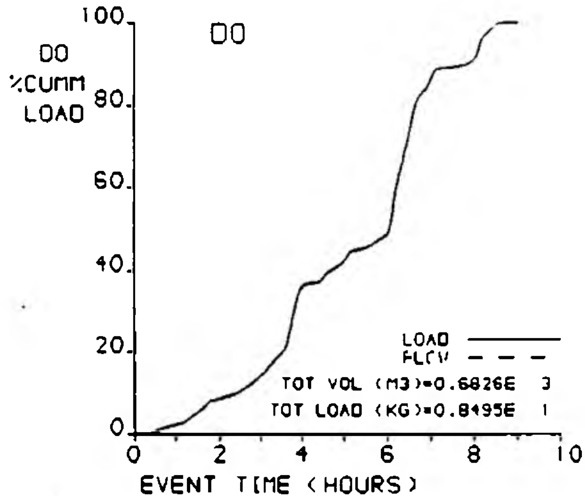
Site: SSO TO NANT FFRWD

GN891216SO.DAT

Grid Ref: 262044
Storm Date: 891216
Start Time (R/F): 0
Rainfall Depth (mm): 23.0

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 504.





NO DATA FOR TEMP

NO DATA FOR Cond

NO DATA FOR pl

RAINFALL AND FLOW SUMMARY DATA Site: SSO TO NANT FFRWD

Catchment area (ha) = 26.40 Rainfall Summary

Event File Name	Start Time	Durtn mins	Depth mm	Peakd	aver	Intensity (mm/hr 1max	5max	15max
GN880315SO.DAT	8	240.	3.00	0.7	0.75	0.8	0.8	0.8
GN880416SO.DAT	138	239.	5.49	3.8	1.38	6.0	4.2	3.5
GN880528SO.DAT	1338	780.	7.15	0.5	0.55	0.6	0.6	0.6
GN880608SO.DAT	1857	480.	6.00	0.7	0.75	0.8	0.8	0.8
GN880626SO.DAT	400	338.	7.75	6.4	1.38	12.0	8.4	6.3
GN880702SO.DAT	400	321.	3.06	3.4	0.57	4.0	4.0	3.4
GN880802SO.DAT	1604	30.	7.00	80.2	14.00	96.2	40.1	23.0
GN880913SO.DAT	700	142.	5.02	3.7	2.12	6.0	4.2	3.7
GN880923SO.DAT	120	180.	7.79	10.0	2.60	12.0	12.0	7.5
GN881018SO.DAT	1640	114.	6.36	7.9	3.35	12.0	8.4	6.5
GN890121SO.DAT	2230	326.	16.56	5.8	3.05	12.0	7.2	5.7
GN890223SO.DAT	1128	658.	20.78	5.4	1.90	12.0	9.6	6.8
GN890306SO.DAT	1450	210.	7.39	12.9	2.11	24.0	15.6	12.0
GN890319SO.DAT	730	596.	13.07	5.5	1.32	12.0	8.4	6.7
GN890523SO.DAT	300	174.	7.46	7.8	2.57	12.0	9.6	8.4
GN890814SO.DAT	1859	296.	13.66	28.4	2.77	89.2	43.2	27.6
GN890916SO.DAT	850	300.	7.12	6.5	1.42	12.0	7.2	6.4
GN891020SO.DAT	0	318.	7.92	8.2	1.49	15.9	10.0	8.0
GN891213SO.DAT	300	540.	26.23	5.7	2.91	12.0	8.4	6.3
GN891216SO.DAT	0	510.	23.07	6.8	2.71	12.0	12.0	7.8

Flow Summary (cumecs)

)	%	Start	Drtn	Volume		Maximum		Initial	
30max	Run	time	mins	m**3	aver	Flow	Time	Flow	Time
0.8	31	101	187.	246.8	0.02	0.11	107.	0.00	53.
2.8	1	531	7.	15.3	0.04	0.01	234.	0.01	234.
0.6	19	1549	649.	376.4	0.01	0.25	220.	0.01	134.
0.8	8	2011	406.	140.6	0.01	0.03	280.	0.01	74.
4.7	1	904	56.	27.4	0.01	0.03	308.	0.03	308.
1.8	12	535	264.	104.5	0.01	0.05	99.	0.05	99.
15.6	25	1607	57.	470.6	0.14	0.54	6.	0.54	6.
3.4	0	806	113.	11.6	0.00	0.00	90.	0.00	64.
6.1	4	250	147.	102.7	0.01	0.08	172.	0.00	88.
5.4	4	1726	74.	73.3	0.02	0.06	64.	0.04	58.
5.1	6	2332	298.	278.0	0.02	0.05	202.	0.03	80.
5.2	4	1212	616.	251.1	0.01	0.09	532.	0.01	46.
8.0	8	1630	136.	175.4	0.02	0.17	110.	0.16	109.
5.1	5	1304	266.	192.1	0.01	0.08	344.	0.08	343.
7.2	5	412	102.	102.2	0.02	0.06	100.	0.06	100.
16.9	8	2048	189.	300.6	0.03	0.37	123.	0.37	123.
4.8	3	900	290.	67.9	0.00	0.05	18.	0.05	18.
6.2	7	130	270.	165.9	0.01	0.11	102.	0.11	102.
5.4	5	502	418.	411.4	0.02	0.06	368.	0.02	124.
6.6	11	28	512.	682.6	0.02	0.15	366.	0.01	30.

BOD LOAD, CONCENTRATION AND FFF SUMMARY DATA Site: SSO TO NANT

Load Summary (g/s)

Event File Name	Cumulative Load Kg	Average Load	Peak Load	Time Load	Diff Peak	Flow Init
GN880315SO.DAT	2.51	0.22	1.73	92.	15.	-39.
GN880416SO.DAT	0.21	0.50	0.13	234.	0.	0.
GN880528SO.DAT	22.61	0.58	20.25	221.	-1.	-87.
GN880608SO.DAT	2.62	0.11	0.42	75.	205.	-1.
GN880626SO.DAT	0.00	0.00	0.00	0.	308.	308.
GN880702SO.DAT	0.00	0.00	0.00	0.	99.	99.
GN880802SO.DAT	0.00	0.00	0.00	0.	6.	6.
GN880913SO.DAT	0.88	0.13	0.28	66.	24.	-2.
GN880923SO.DAT	0.00	0.00	0.00	0.	172.	88.
GN881018SO.DAT	2.22	0.50	1.51	56.	8.	2.
GN890121SO.DAT	0.00	0.00	0.00	0.	202.	80.
GN890223SO.DAT	8.59	0.23	1.75	592.	-60.	-546.
GN890306SO.DAT	7.62	0.93	7.68	108.	2.	1.
GN890319SO.DAT	17.77	1.11	7.64	344.	0.	-1.
GN890523SO.DAT	0.00	0.00	0.00	0.	100.	100.
GN890814SO.DAT	7.30	0.64	9.09	121.	2.	2.
GN890916SO.DAT	0.00	0.00	0.00	0.	18.	18.
GN891020SO.DAT	0.00	0.00	0.00	0.	102.	102.
GN891213SO.DAT	3.36	0.13	0.58	368.	0.	-244.
GN891216SO.DAT	2.48	0.08	0.66	393.	-27.	-363.

FFRWD

Average Conc	Peak Conc	Time Conc	Diff Peak	Flow Init	Event Mean	No Read	Divergence 20%	Max%
	Conc Summary (mg/l)						FFF Summary	
10.16	23.00	0.	107.	53.	7.86	13	25.3	31.8
13.58	34.00	215.	19.	19.	20.86	5	-3.8	0.0
60.06	204.00	264.	-44.	-130.	105.80	18	-9.1	12.8
18.62	32.00	0.	280.	74.	17.79	11	14.4	16.4
0.00	0.00	0.	308.	308.	0.00	0	0.0	0.0
0.00	0.00	0.	99.	99.	0.00	0	0.0	0.0
0.00	0.00	0.	6.	6.	0.00	0	0.0	0.0
75.61	93.00	0.	90.	64.	41.88	3	4.6	10.8
0.00	0.00	0.	172.	88.	0.00	0	0.0	0.0
30.27	66.00	0.	64.	58.	28.64	14	7.7	9.0
0.00	0.00	0.	202.	80.	0.00	0	0.0	0.0
34.22	71.00	589.	-57.	-543.	27.94	15	1.6	3.9
43.45	62.00	118.	-8.	-9.	41.59	9	5.2	9.3
92.49	108.00	0.	344.	343.	82.03	6	3.4	6.3
0.00	0.00	0.	100.	100.	0.00	0	0.0	0.0
24.30	42.00	118.	5.	5.	24.98	9	-4.3	7.0
0.00	0.00	0.	18.	18.	0.00	0	0.0	0.0
0.00	0.00	0.	102.	102.	0.00	0	0.0	0.0
8.17	25.00	282.	86.	-158.	9.58	24	-5.3	0.0
3.64	17.00	443.	-77.	-413.	5.13	24	-3.5	0.0

H4.N LOAD, CONCENTRATION AND FFF SUMMARY DATA Site: SSO TO NANT

Load Summary (g/s)

Event File Name	Cumulative Load Kg	Average Load	Peak Load	Time Load	Diff Peak	Flow Init
GN880315SO.DAT	0.20	0.02	0.09	97.	10.	-44.
GN880416SO.DAT	0.02	0.05	0.01	234.	0.	0.
GN880528SO.DAT	1.11	0.03	1.21	220.	0.	-86.
GN880608SO.DAT	0.42	0.02	0.08	280.	0.	-206.
GN880626SO.DAT	0.00	0.00	0.00	0.	308.	308.
GN880702SO.DAT	0.00	0.00	0.00	0.	99.	99.
GN880802SO.DAT	0.00	0.00	0.00	0.	6.	6.
GN880913SO.DAT	0.03	0.00	0.01	90.	0.	-26.
GN880923SO.DAT	0.00	0.00	0.00	0.	172.	88.
GN881018SO.DAT	0.12	0.03	0.09	62.	2.	-4.
GN890121SO.DAT	0.00	0.00	0.00	0.	202.	80.
GN890223SO.DAT	0.42	0.01	0.14	532.	0.	-486.
GN890306SO.DAT	0.12	0.01	0.09	116.	-6.	-7.
GN890319SO.DAT	0.33	0.02	0.16	339.	5.	4.
GN890523SO.DAT	0.00	0.00	0.00	0.	100.	100.
GN890814SO.DAT	0.24	0.02	0.26	125.	-2.	-2.
GN890916SO.DAT	0.00	0.00	0.00	0.	18.	18.
GN891020SO.DAT	0.00	0.00	0.00	0.	102.	102.
GN891213SO.DAT	0.84	0.03	0.15	368.	0.	-244.
GN891216SO.DAT	0.47	0.02	0.19	486.	-120.	-456.

FFRWD

Average Conc	Conc Summary (mg/l) Peak Conc	Time Conc	Diff Peak	Flow Init	Event Mean	No Read	FFF Summary Divergence 20%	Max%
0.82	1.10	0.	107.	53.	0.73	13	6.9	9.8
1.39	1.60	0.	234.	234.	1.00	7	3.1	7.6
2.95	5.80	229.	-9.	-95.	4.87	18	-6.3	13.8
2.97	4.00	124.	156.	-50.	2.67	11	4.9	5.5
0.00	0.00	0.	308.	308.	0.00	0	0.0	0.0
0.00	0.00	0.	99.	99.	0.00	0	0.0	0.0
0.00	0.00	0.	6.	6.	0.00	0	0.0	0.0
2.34	3.30	124.	-34.	-60.	2.53	3	-2.1	0.0
0.00	0.00	0.	172.	88.	0.00	0	0.0	0.0
1.65	4.90	0.	64.	58.	1.52	14	5.6	8.5
0.00	0.00	0.	202.	80.	0.00	0	0.0	0.0
1.68	4.40	559.	-27.	-513.	1.59	15	3.8	9.2
0.67	1.80	123.	-13.	-14.	0.66	9	-2.8	0.0
1.73	2.30	339.	5.	4.	1.73	6	2.0	6.0
0.00	0.00	0.	100.	100.	0.00	0	0.0	0.0
0.79	3.10	103.	20.	20.	0.77	9	6.1	6.2
0.00	0.00	0.	18.	18.	0.00	0	0.0	0.0
0.00	0.00	0.	102.	102.	0.00	0	0.0	0.0
2.05	3.90	297.	71.	-173.	2.32	24	-5.4	0.0
0.68	2.90	488.	-122.	-458.	1.10	24	-5.4	0.0

TSS LOAD, CONCENTRATION AND FFF SUMMARY DATA Site: SSO TO NANT

Load Summary (g/s)

Event File Name	Cumulative Load Kg	Average Load	Peak Load	Time Load	Diff Peak	Flow Init
GN880315SO.DAT	22.70	2.02	14.55	92.	15.	-39.
GN880416SO.DAT	1.01	2.42	0.63	234.	0.	0.
GN880528SO.DAT	83.96	2.16	74.50	220.	0.	-86.
GN880608SO.DAT	8.02	0.33	1.50	75.	205.	-1.
GN880626SO.DAT	0.00	0.00	0.00	0.	308.	308.
GN880702SO.DAT	0.00	0.00	0.00	0.	99.	99.
GN880802SO.DAT	0.00	0.00	0.00	0.	6.	6.
GN880913SO.DAT	3.67	0.54	1.44	90.	0.	-26.
GN880923SO.DAT	0.00	0.00	0.00	0.	172.	88.
GN881018SO.DAT	6.40	1.44	4.83	64.	0.	-6.
GN890121SO.DAT	0.00	0.00	0.00	0.	202.	80.
GN890223SO.DAT	27.37	0.74	6.87	532.	0.	-486.
GN890306SO.DAT	79.71	9.77	86.24	106.	4.	3.
GN890319SO.DAT	46.35	2.90	29.95	344.	0.	-1.
GN890523SO.DAT	0.00	0.00	0.00	0.	100.	100.
GN890814SO.DAT	102.27	9.02	137.63	123.	0.	0.
GN890916SO.DAT	0.00	0.00	0.00	0.	18.	18.
GN891020SO.DAT	0.00	0.00	0.00	0.	102.	102.
GN891213SO.DAT	24.96	1.00	5.40	140.	228.	-16.
GN891216SO.DAT	21.09	0.69	5.86	393.	-27.	-363.

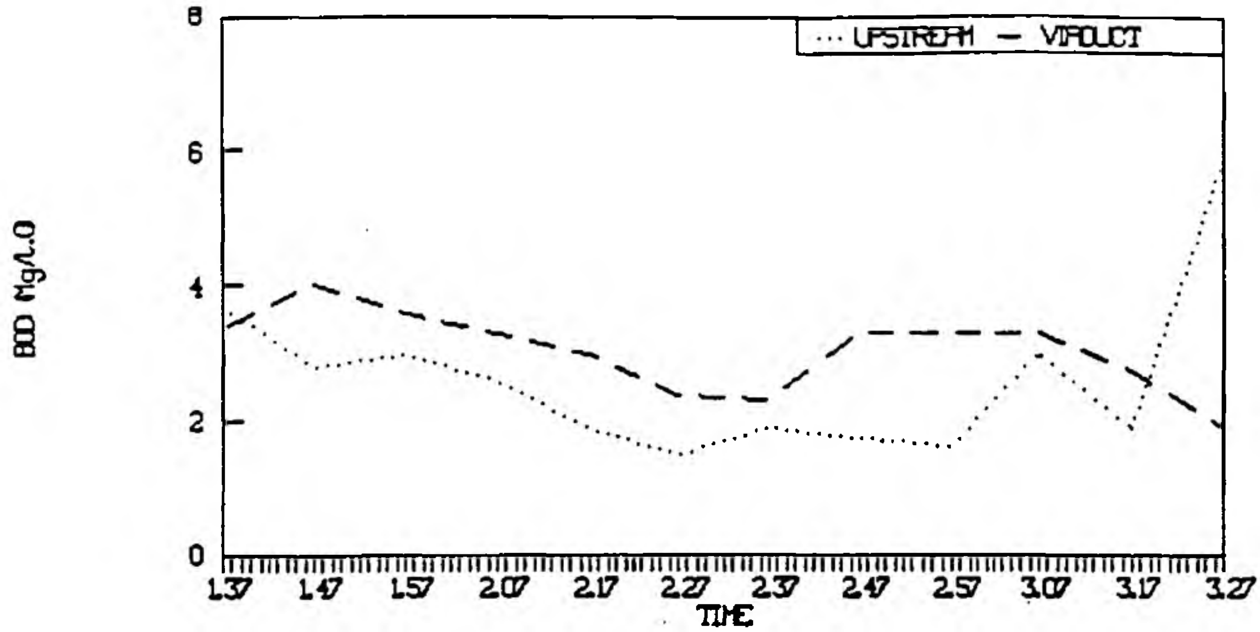
FFRWD

	Conc Summary (mg/l)						FFF Summary	
Average Conc	Peak Conc	Time Conc	Diff Peak	Flow Init	Event Mean	No Read	Divergence 20%	Max%
91.96	194.00	0.	107.	53.	82.32	13	22.2	31.5
66.19	127.00	215.	19.	19.	84.82	5	-2.8	0.0
223.05	614.00	0.	220.	134.	309.89	18	18.3	33.1
57.00	115.00	0.	280.	74.	61.40	11	20.3	24.5
0.00	0.00	0.	308.	308.	0.00	0	0.0	0.0
0.00	0.00	0.	99.	99.	0.00	0	0.0	0.0
0.00	0.00	0.	6.	6.	0.00	0	0.0	0.0
315.63	370.00	0.	90.	64.	268.42	3	3.4	8.1
0.00	0.00	0.	172.	88.	0.00	0	0.0	0.0
87.42	271.00	0.	64.	58.	79.62	14	13.4	15.4
0.00	0.00	0.	202.	80.	0.00	0	0.0	0.0
109.01	196.00	584.	-52.	-538.	88.75	15	1.3	3.1
454.50	866.00	0.	110.	109.	396.11	9	17.6	24.6
241.27	384.00	344.	0.	-1.	299.17	6	1.6	6.0
0.00	0.00	0.	100.	100.	0.00	0	0.0	0.0
340.19	478.00	0.	123.	123.	339.89	9	-4.0	3.3
0.00	0.00	0.	18.	18.	0.00	0	0.0	0.0
0.00	0.00	0.	102.	102.	0.00	0	0.0	0.0
60.67	120.00	0.	368.	124.	45.13	23	19.6	31.5
30.90	112.00	468.	-102.	-438.	39.06	24	-1.9	0.0

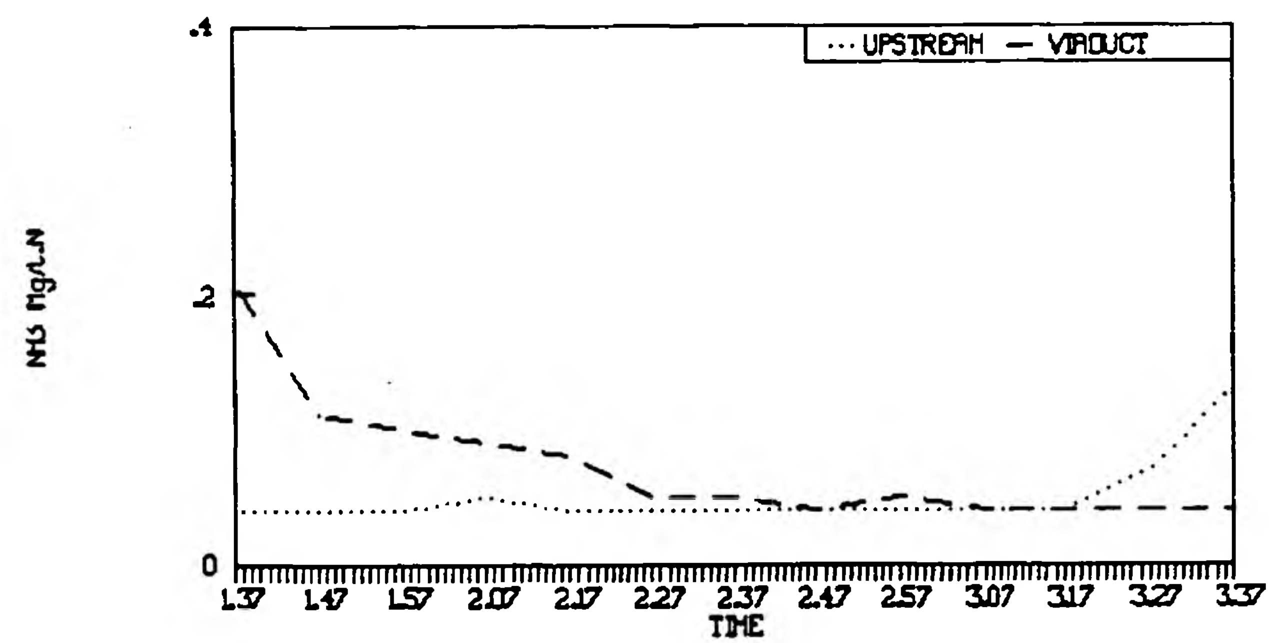
APPENDIX 2

CSO RIVER IMPACTS

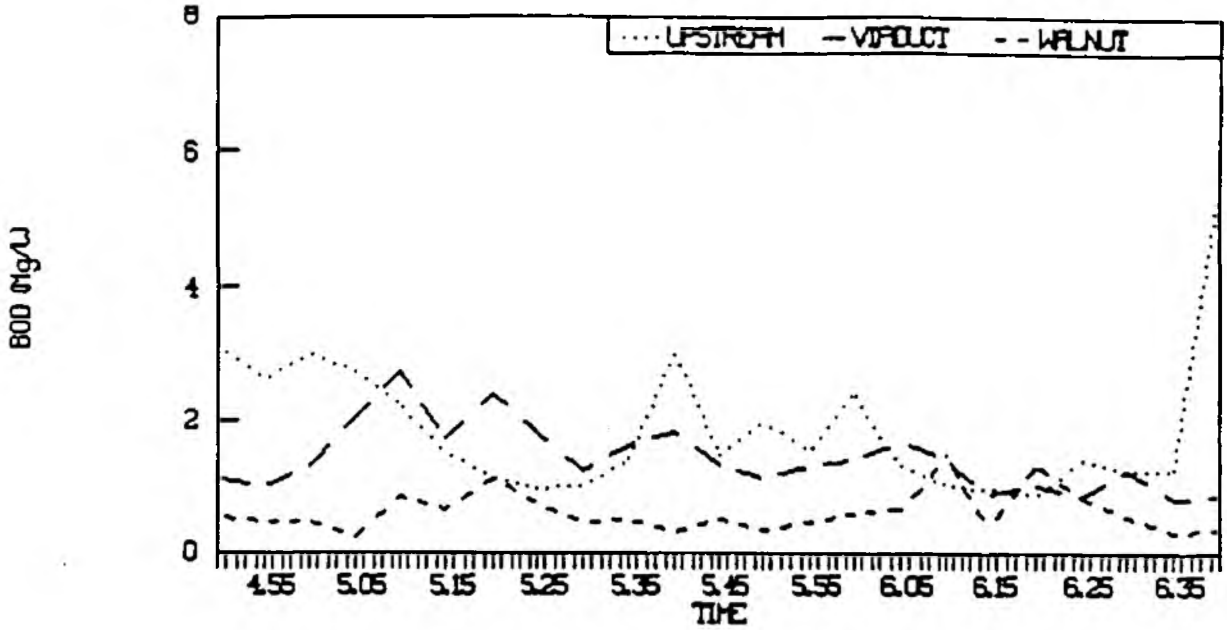
GARNDIFFAITH SSO EVENT 2 15-03-88.
BOD CONCENTRATIONS.



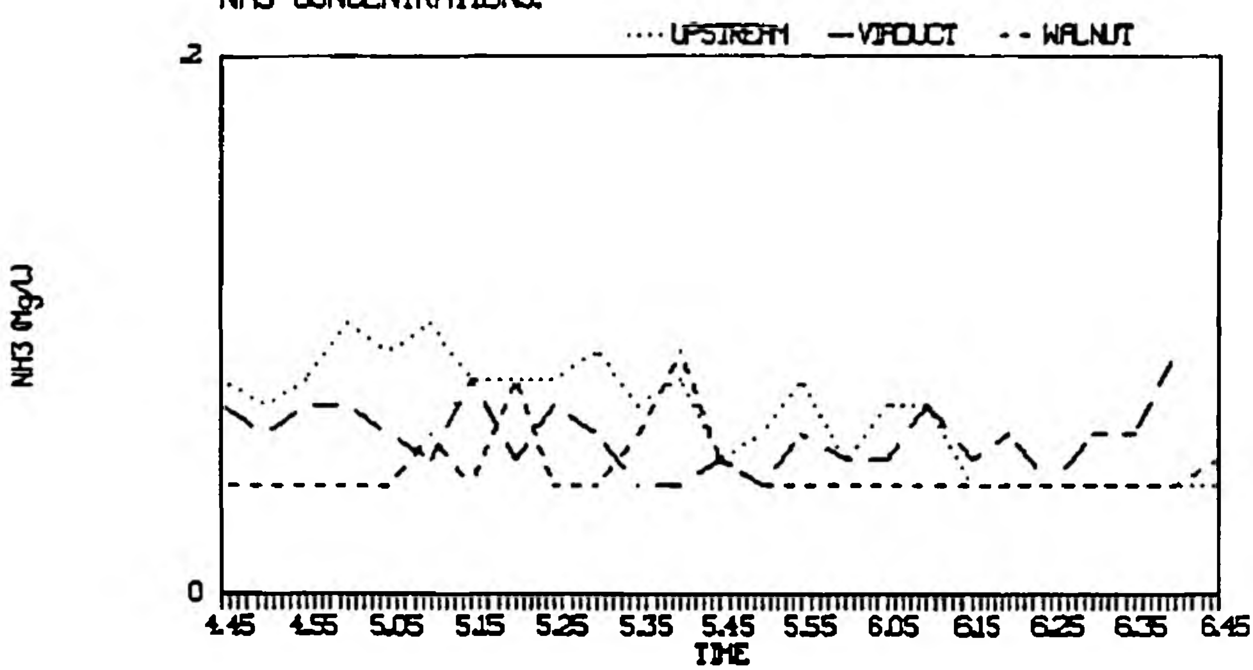
GARNDIFFAITH SSO EVENT 2 15-03-88.
NH3 CONCENTRATIONS.



GARNDIFFAITH SSO EVENT 3 16-04-88
BOD CONCENTRATIONS



GARNDIFFAITH SSO EVENT 3 16-04-88.
NH3 CONCENTRATIONS.

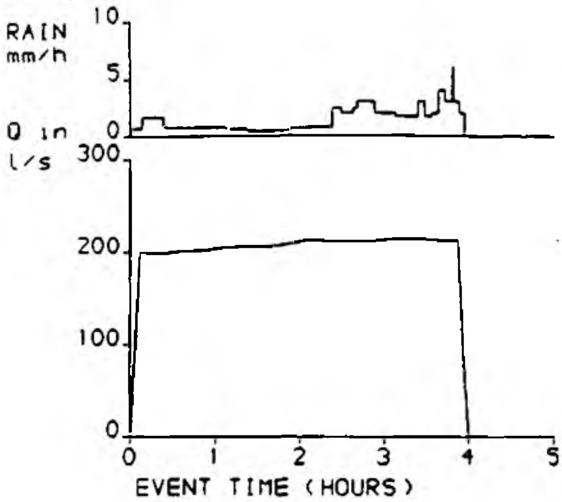


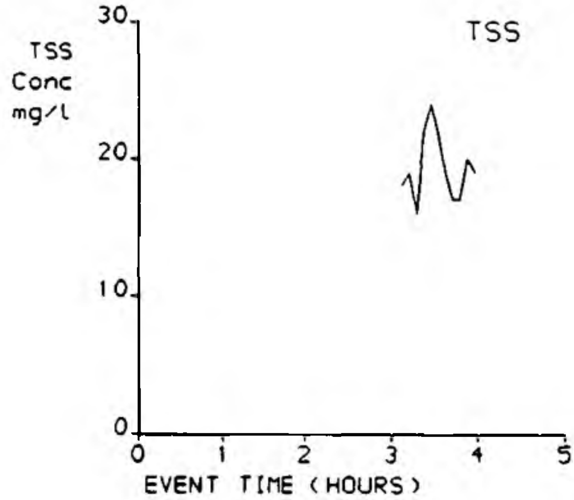
Site: NANT FFRWD, U/S SSO GRNDIFFAITH

GN880416U1.DAT

Grid Ref: 262045
Storm Date: 880416
Start Time (R/F): 138
RainFall Depth (mm): 5.6

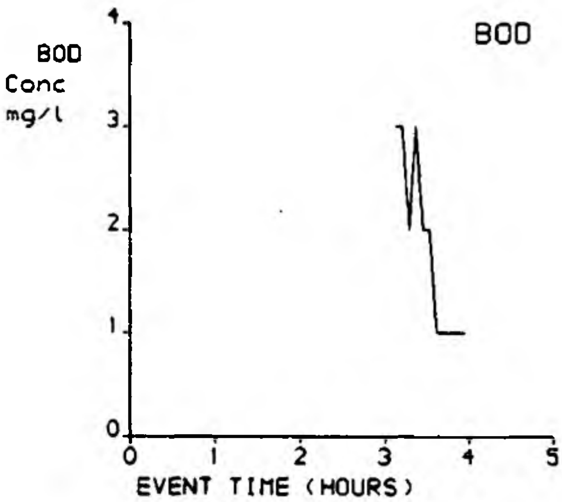
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
RainFall Event Duration (mins): 239.

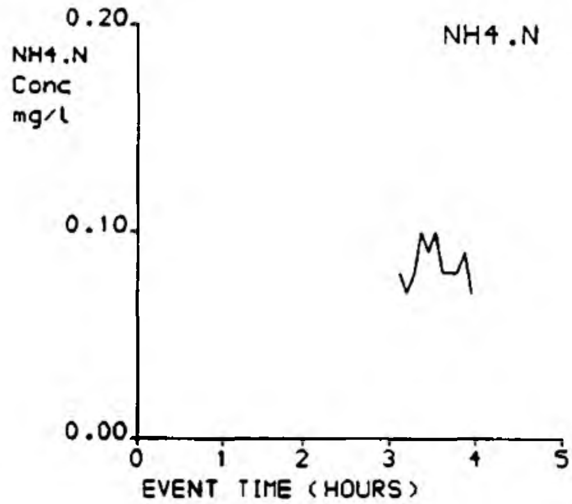




NO DATA FOR COD

NO DATA FOR TDS

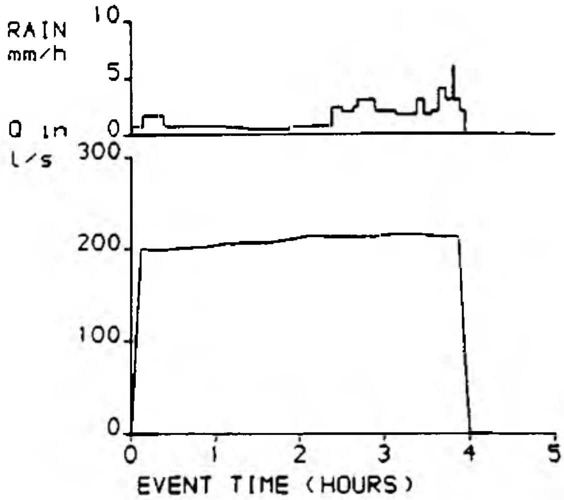




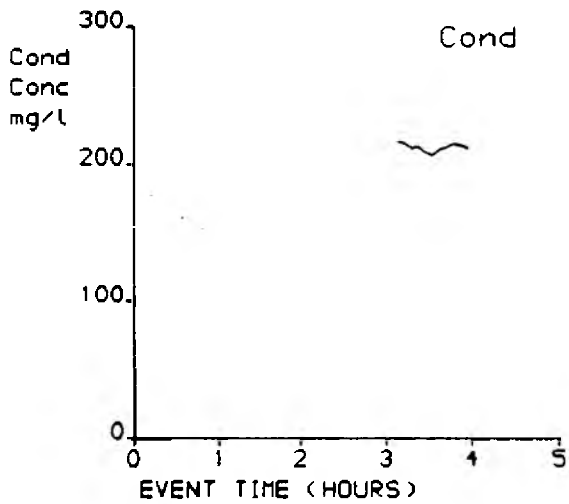
Site: NANT FFRWD,U/S SSO GRNDIFFAITH GN880416U1.DAT

Grid Ref: 262045
Storm Date: 880416
Start Time (R/F): 138
Rainfall Depth (mm): 5.6

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 239.



NO DATA FOR DO



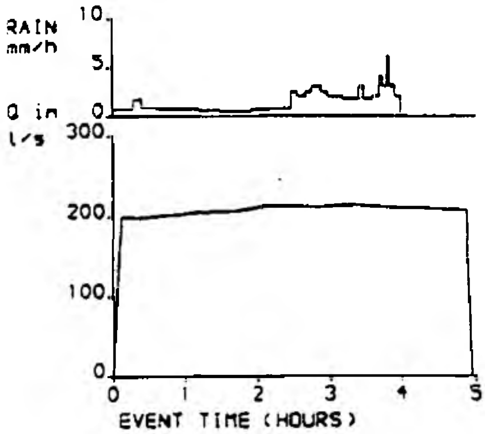
NO DATA FOR TEMP

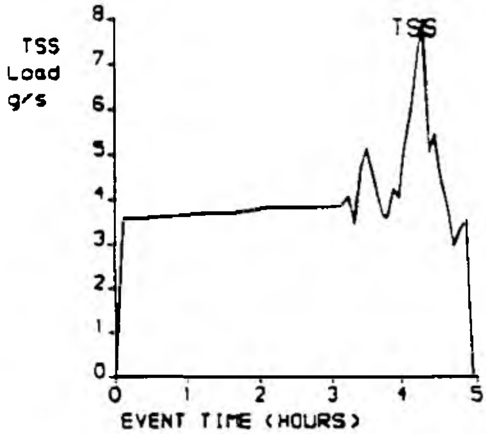
NO DATA FO

Site: NANT FFRWD, U/S SSO, GARNDIFFAITH GN880416U1.DAT

Grid Ref:
Storm Date: 880416
Start Time (R/F): 138
Rainfall Depth (mm): 5.5

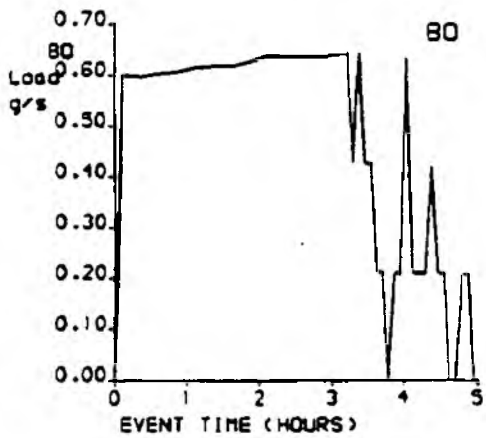
M/H Identification: //////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 239.

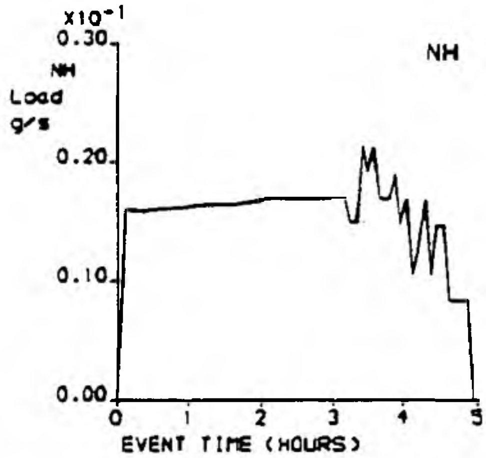




NO DATA FOR CO

NO DATA FOR TDS

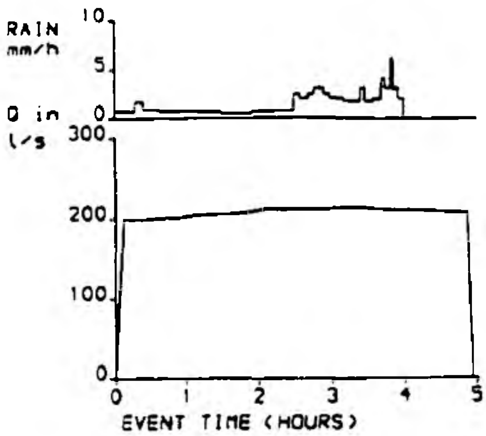


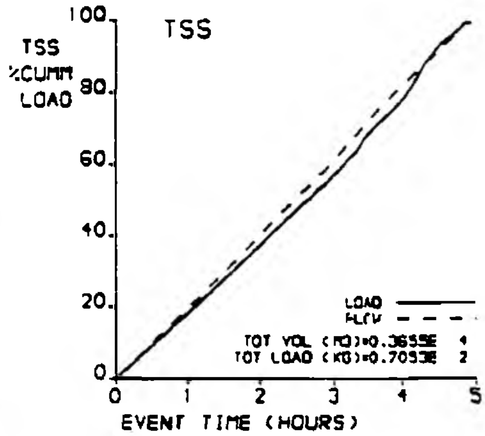


Site: NANT FFRWD, U/S SSO, GARNDIFFAITH GN880416U1.DAT

Grid Ref:
Storm Date: 880416
Start Time (R/F): 138
Rainfall Depth (mm): 5.6

M/H Identification: /////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 239.





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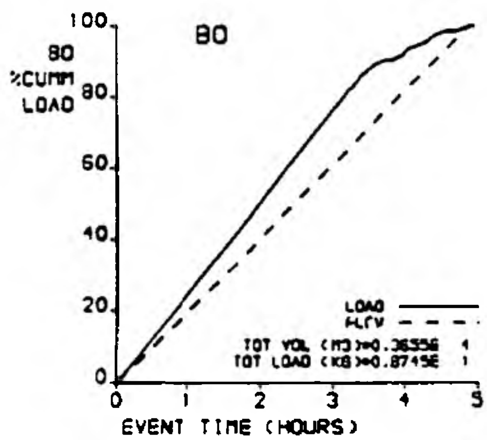
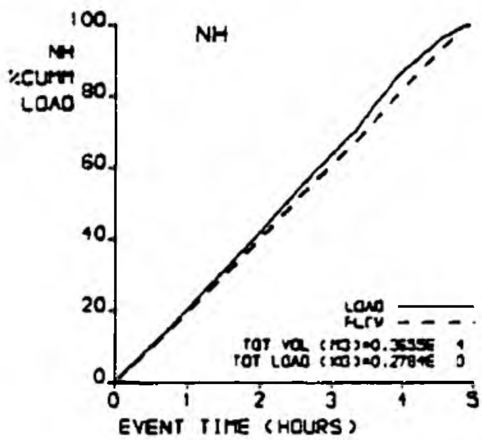
NO DATA FOR TDS

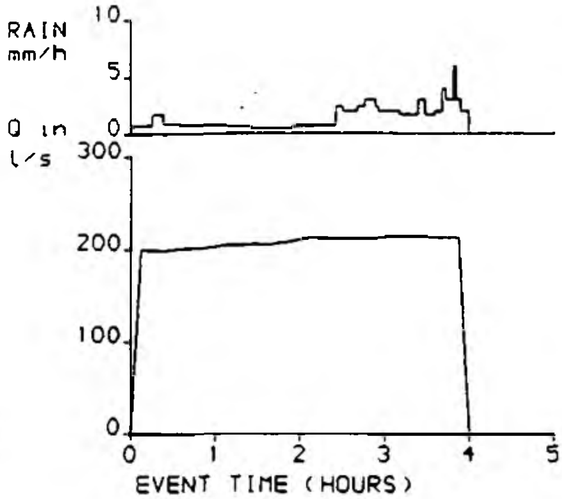


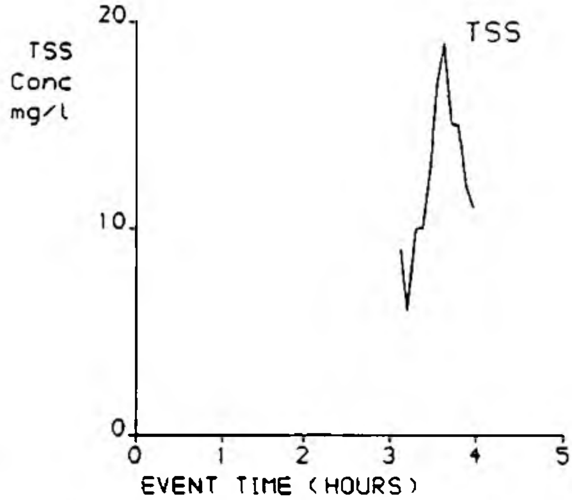


Site: NANT FFRWD, VIADUCT ROAD, UNDER VIADUCT GN8804160I.DAT

Grid Ref: 262043
Storm Date: 880416
Start Time (R/F): 138
Rainfall Depth (mm): 5.6

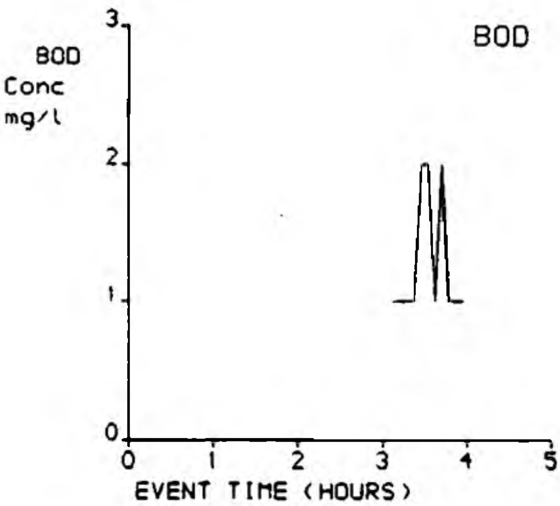
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 239.

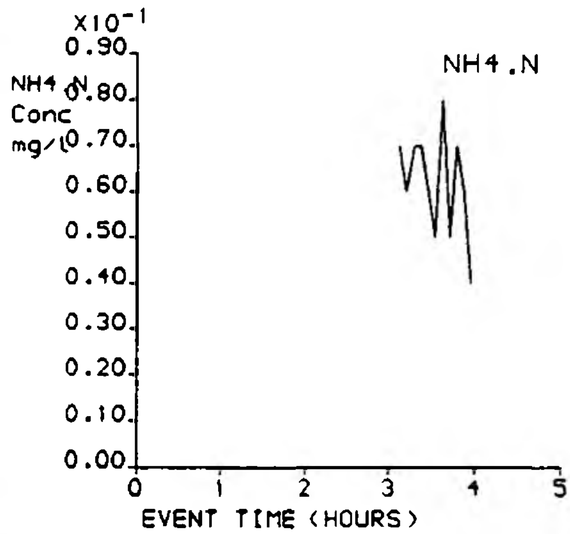




NO DATA FOR COD

NO DATA FOR TDS



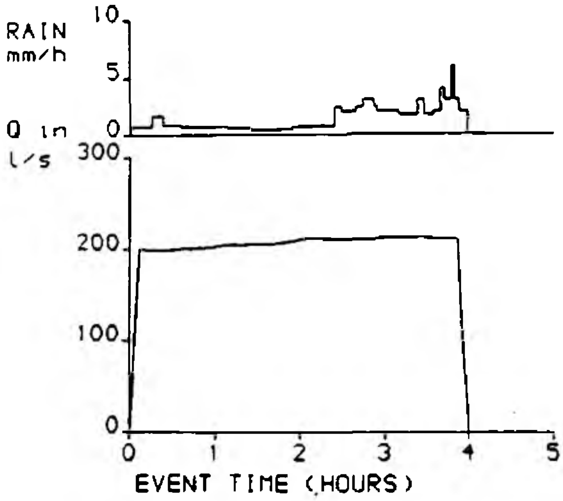


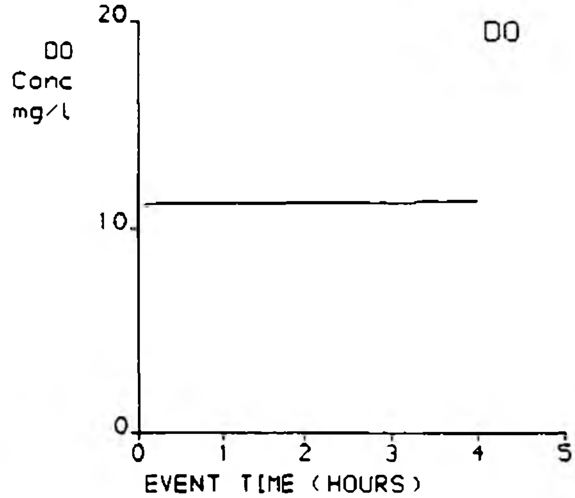
Site: NANT FFRWD, VIADUCT ROAD, UNDER VIADUCT

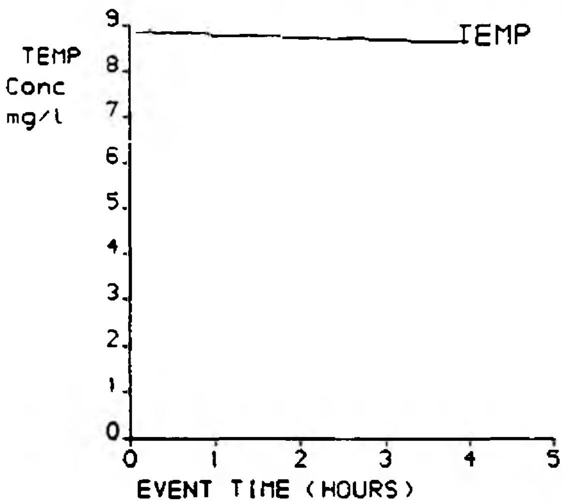
GN88041601.DAT

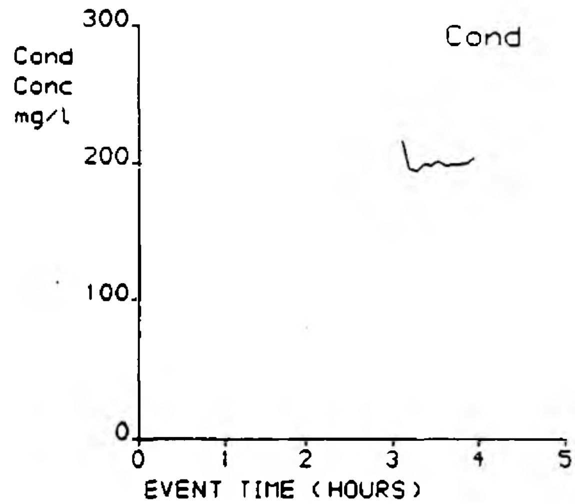
Grid Ref: 262043
Storm Date: 880416
Start Time (R/F): 138
RainFall Depth (mm): 5.6

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
RainFall Event Duration (mins): 239.





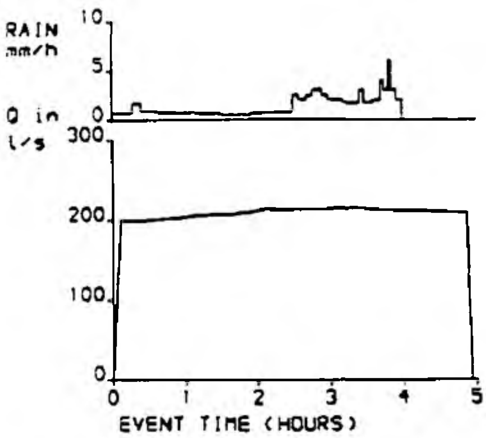


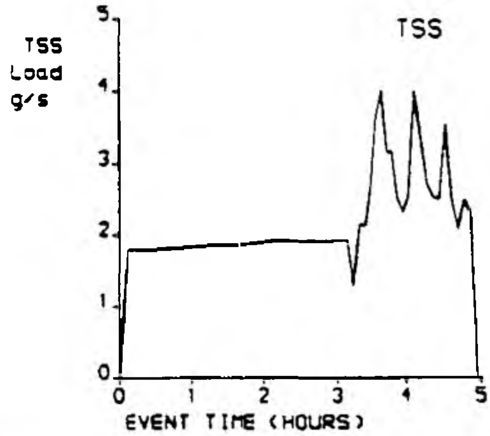


NO DATA FO

Site: NANT FFRWD, UNDER VIADUCT, VIADUC GN88041601.DAT

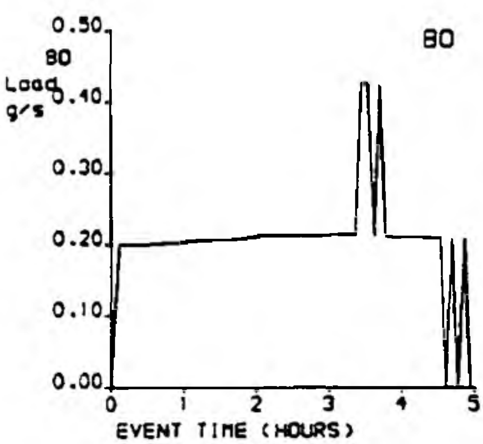
Grid Ref:
M/H Identification: /////
Storm Date: 880416
Date/Time of last monitored storm:
Start Time (R/F): 138
Antec. Dry Weather Period (hours):
Rainfall Depth (mm): 5.6
Rainfall Event Duration (mins): 239.

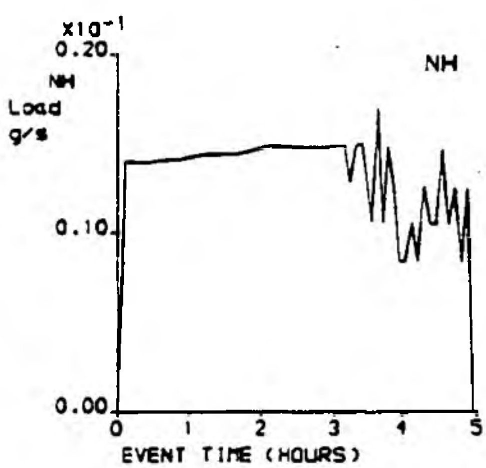




NO DATA FOR CO

NO DATA FOR TDS

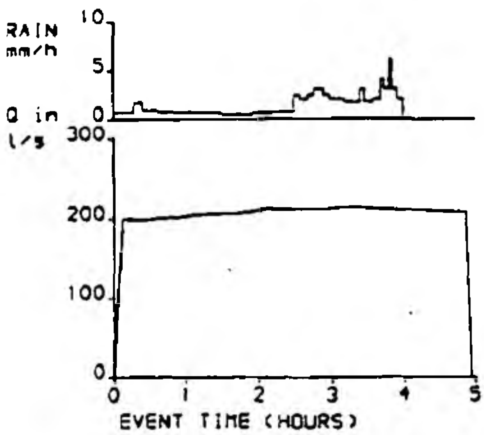


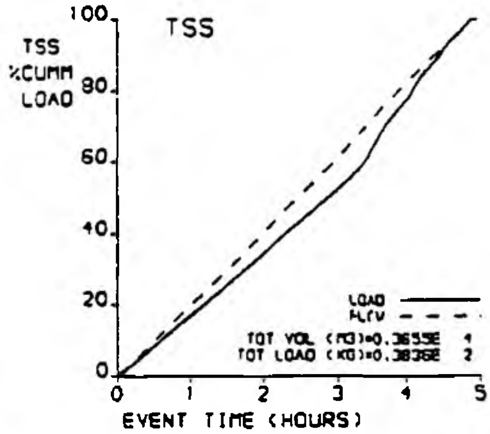


Site: NANT FFRWD, UNDER VIADUCT, VIADUC GN880416D1.DAT

Grid Ref:
Storm Date: 880416
Start Time (R/F): 138
Rainfall Depth (mm): 5.6

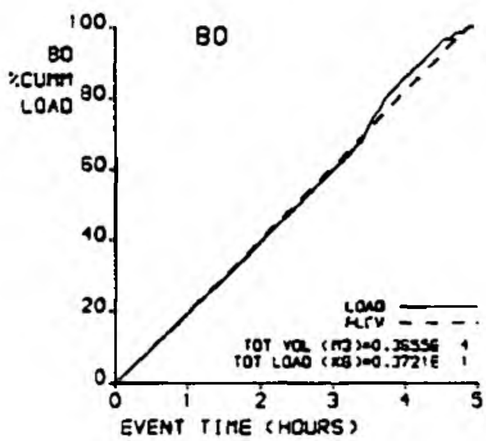
M/H Identification: /////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 239.

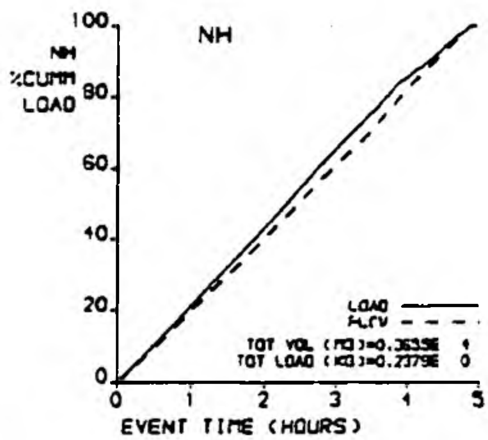




NO DATA FOR CO

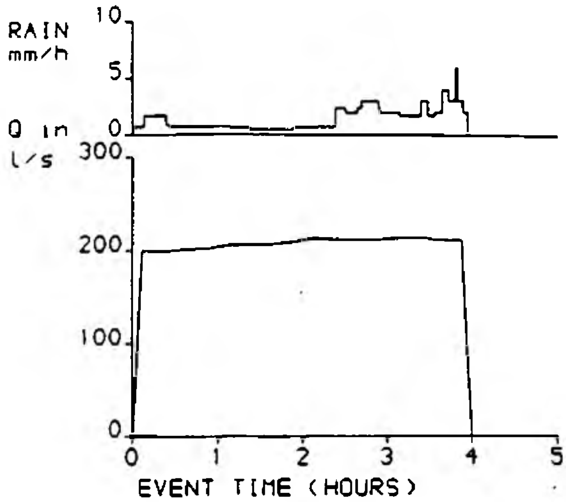
NO DATA FOR TDS

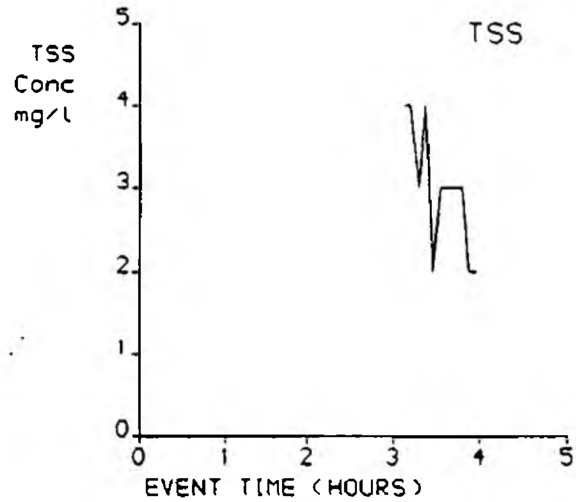




Site: NANT FFRWD,U/S VICTORIA RD BRIDGE GN880416D2.DAT

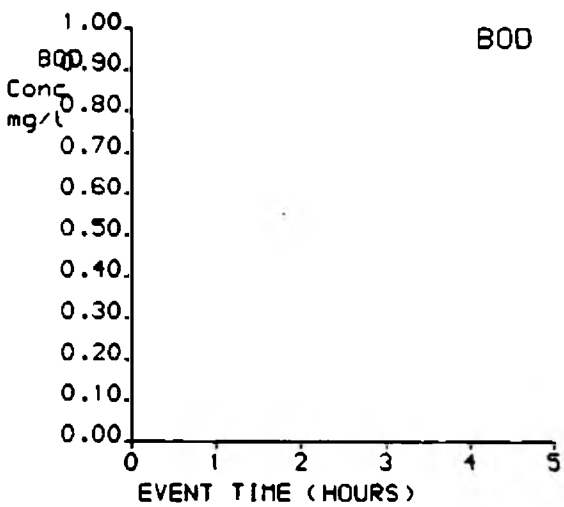
Grid Ref: 264042 Weather Conditions:
Storm Date: 880416 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 138 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 5.6 Rainfall Event Duration (mins): 239.

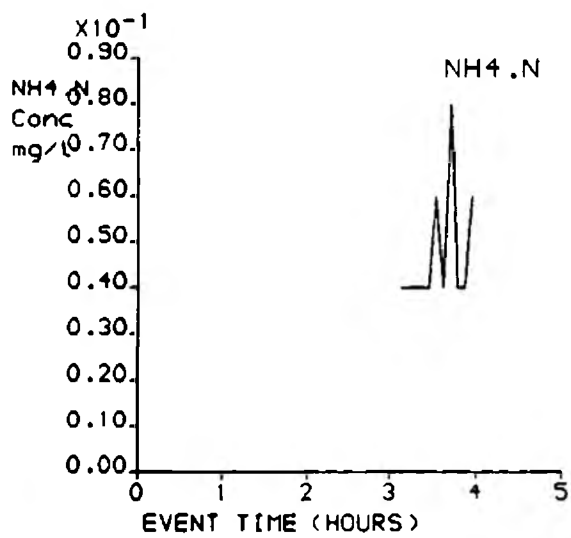




NO DATA FOR COD

NO DATA FOR TDS

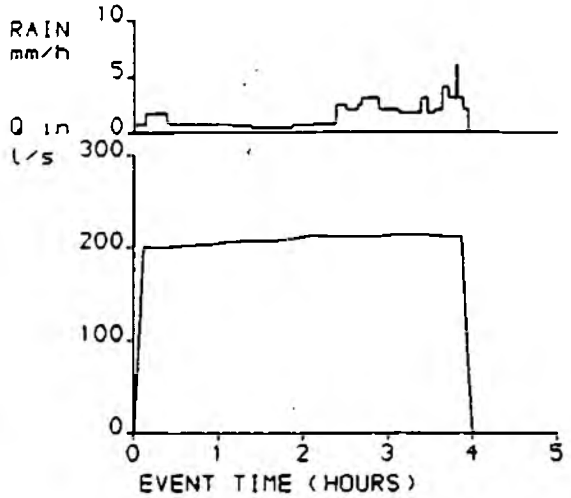




Site: NANT FFRWD, U/S VICTORIA RD BRIDGE GN88041602.DAT

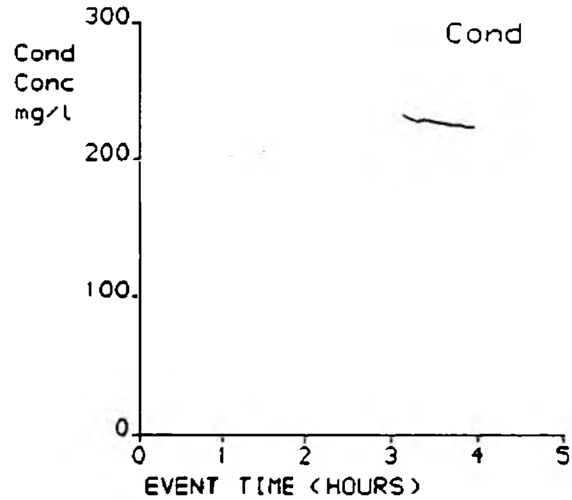
Grid Ref: 264042
Storm Date: 880416
Start Time (R/F): 138
Rainfall Depth (mm): 5.6

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 239.



NO DATA FOR DO

NO DATA FOR TEMP

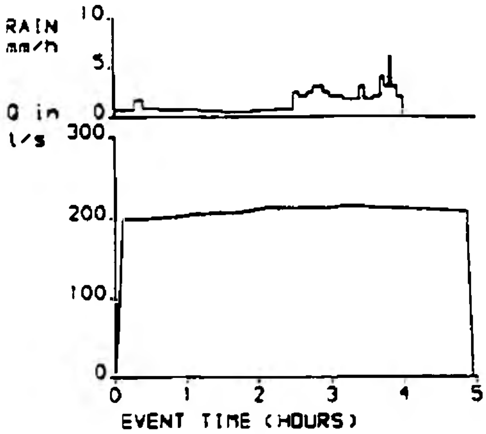


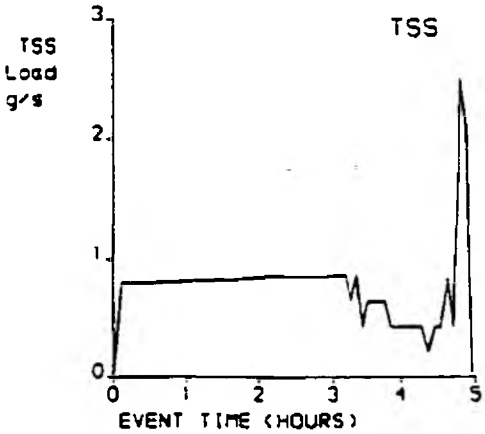
NO DATA FOR pl

Site: NANT FFRWD, U/S VICTORIA ROAD BRI GN880416D2.DAT

Grid Ref:
Storm Date: 880416
Start Time (R/F): 138
Rainfall Depth (mm): 5.6

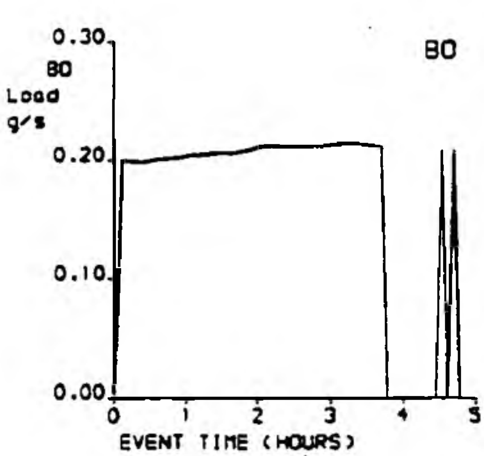
M/H Identification: /////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 239.

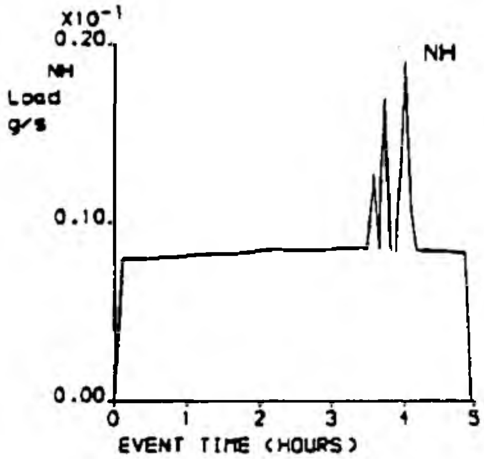




NO DATA FOR CO

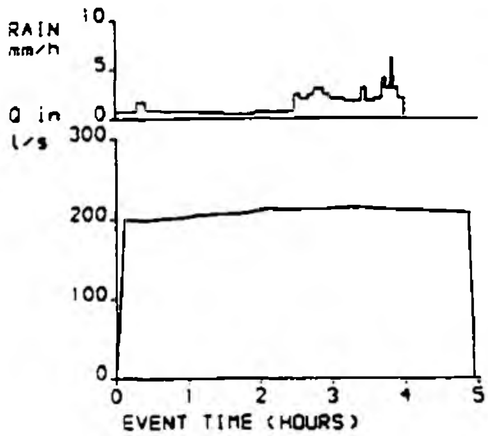
NO DATA FOR TDS

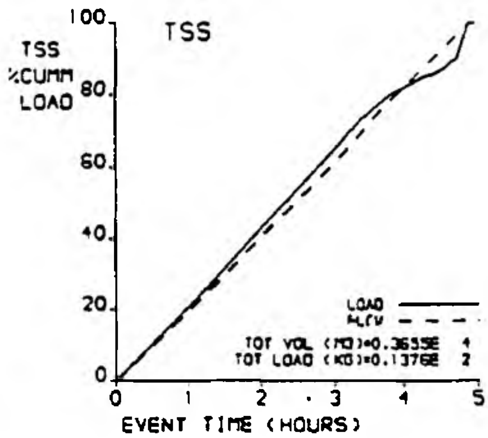




Site: NANT FFRWD, U/S VICTORIA ROAD BRI GN88041602.DAT

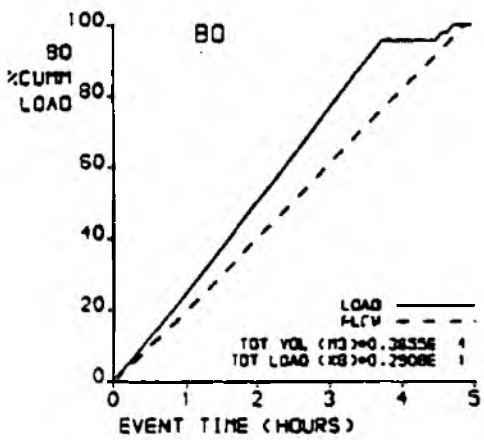
Grid Ref:
M/H Identification: /////
Storm Date: 880416
Date/Time of last monitored storm:
Start Time (R/F): 138
Antec. Dry Weather Period (hours):
Rainfall Depth (mm): 5.6
Rainfall Event Duration (mins): 238.

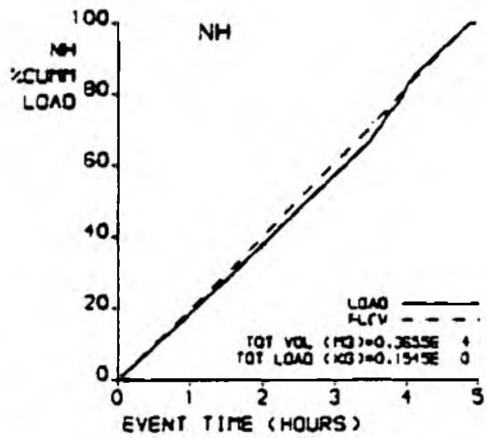




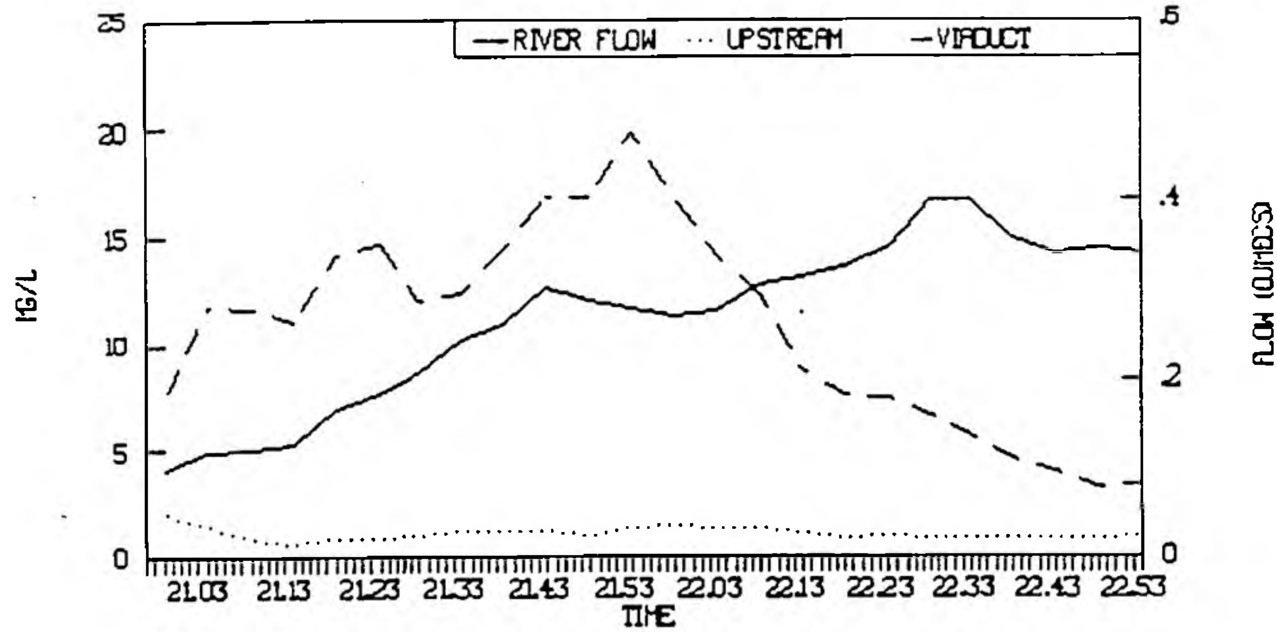
NO DATA FOR CO

NO DATA FOR TDS

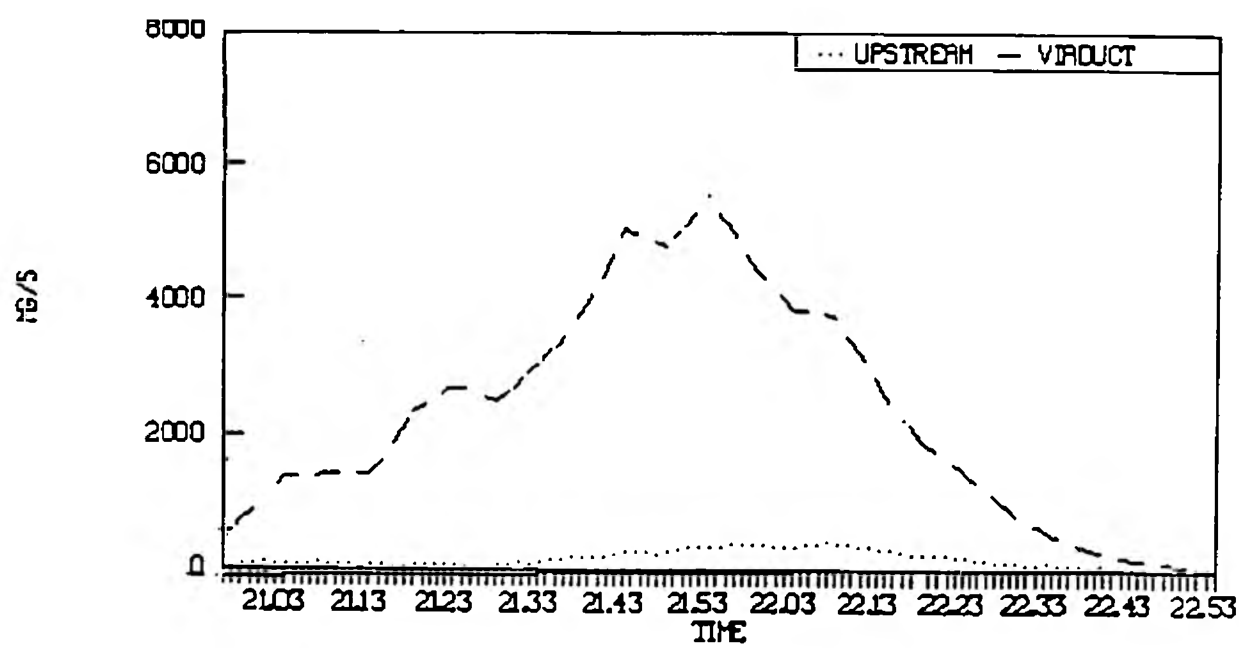




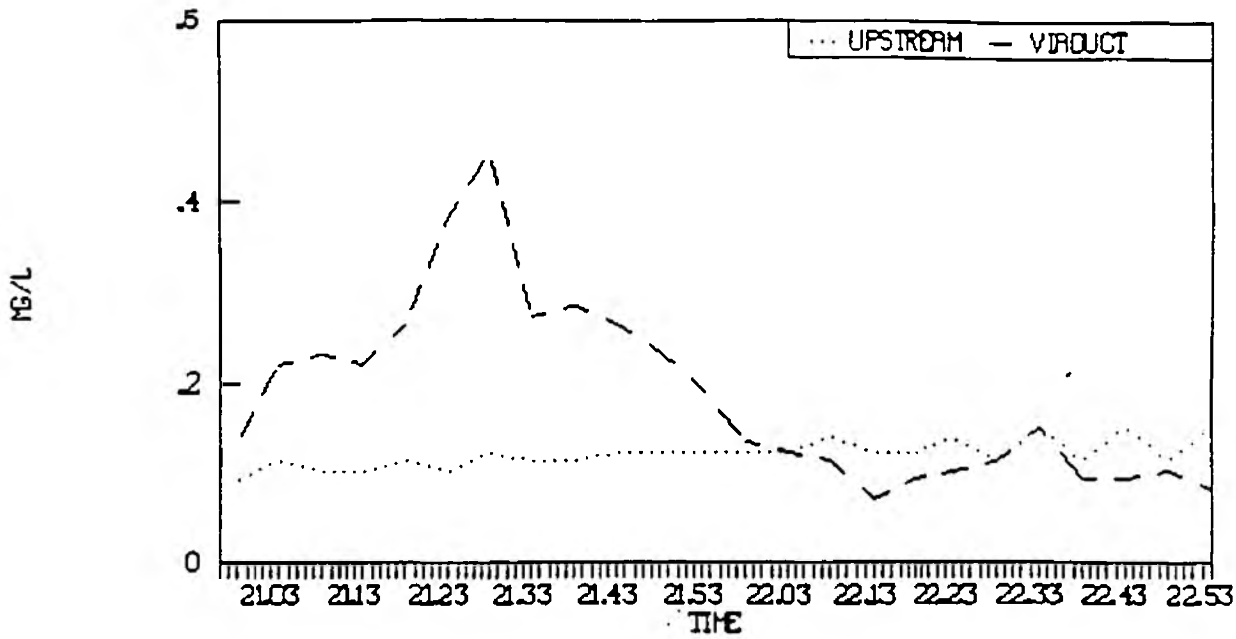
GARNDIFFAITH SSO EVENT 4 30-04-88
BOD CONCENTRATIONS



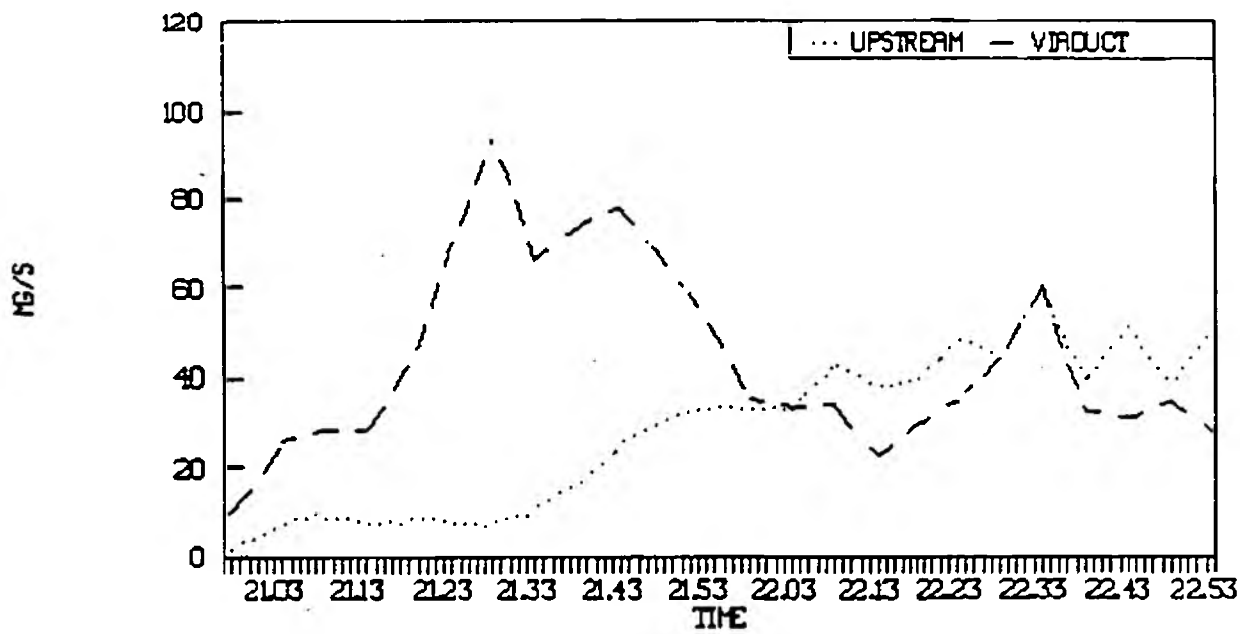
GARNDIFFAITH SSO EVENT 4 30-04-88
BOD LOADS



GARNDIFFAITH SSO EVENT 4 30-04-88
NH3 CONCENTRATIONS

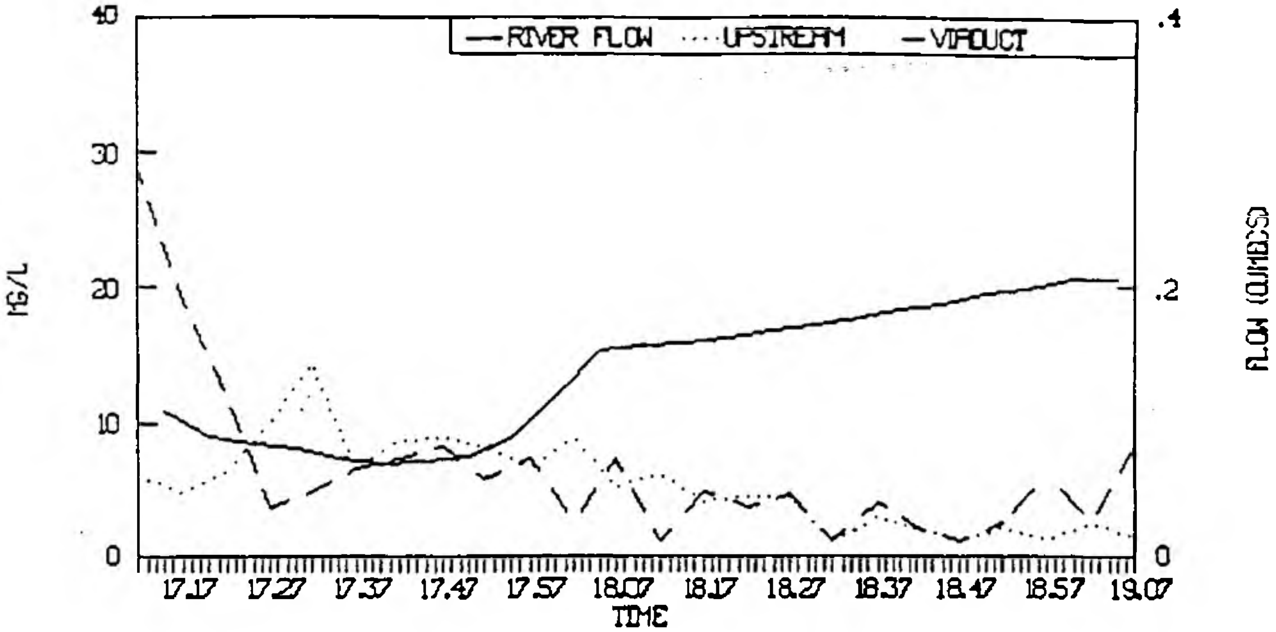


GARNDIFFAITH SSO EVENT 4 30-04-88
NH3 LOADS



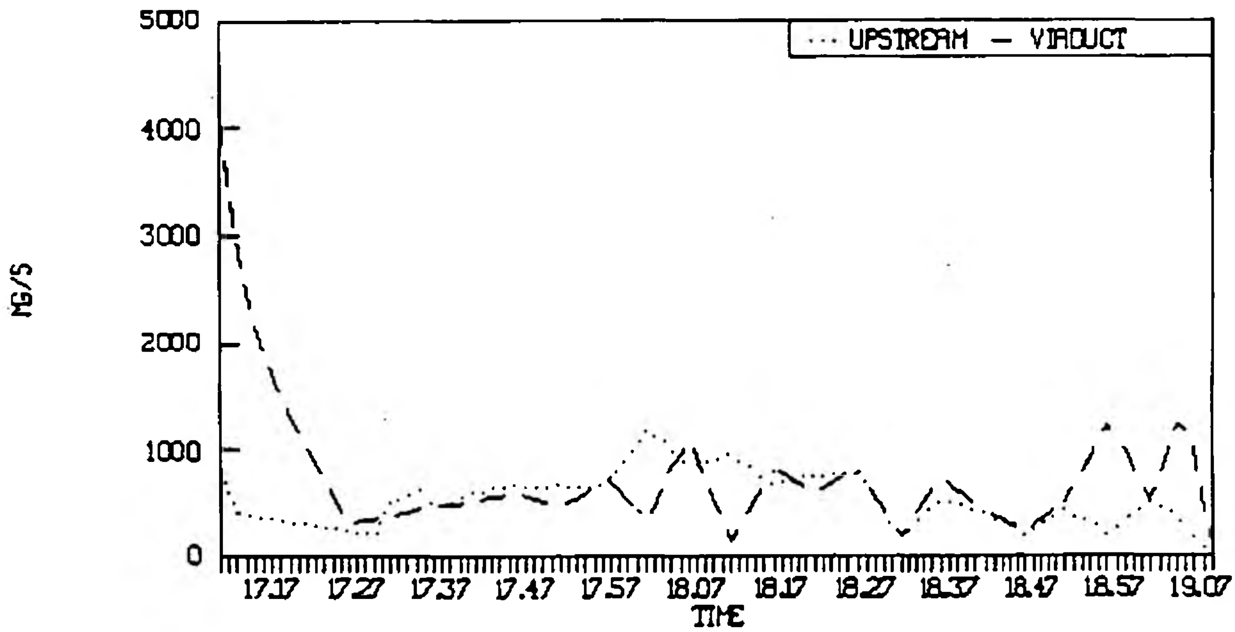
GARNDIFFAITH SSO EVENT 5 28-05-88

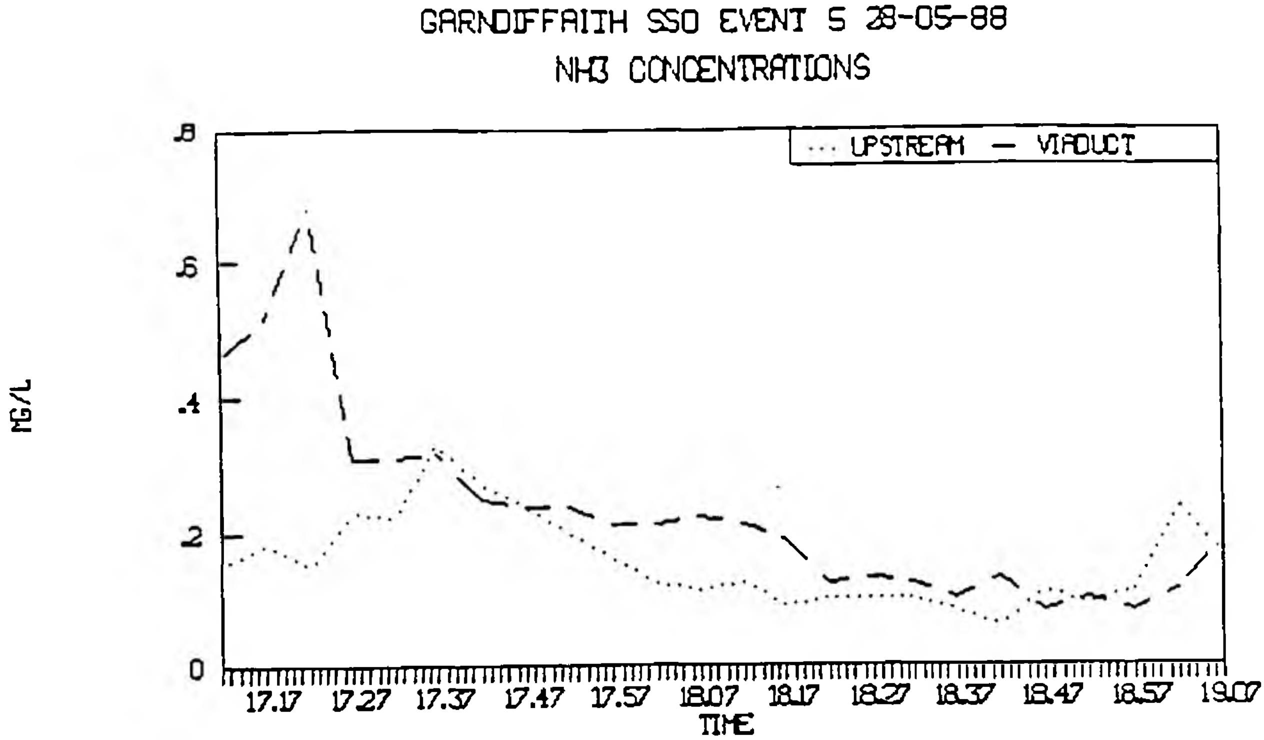
BOD CONCENTRATIONS

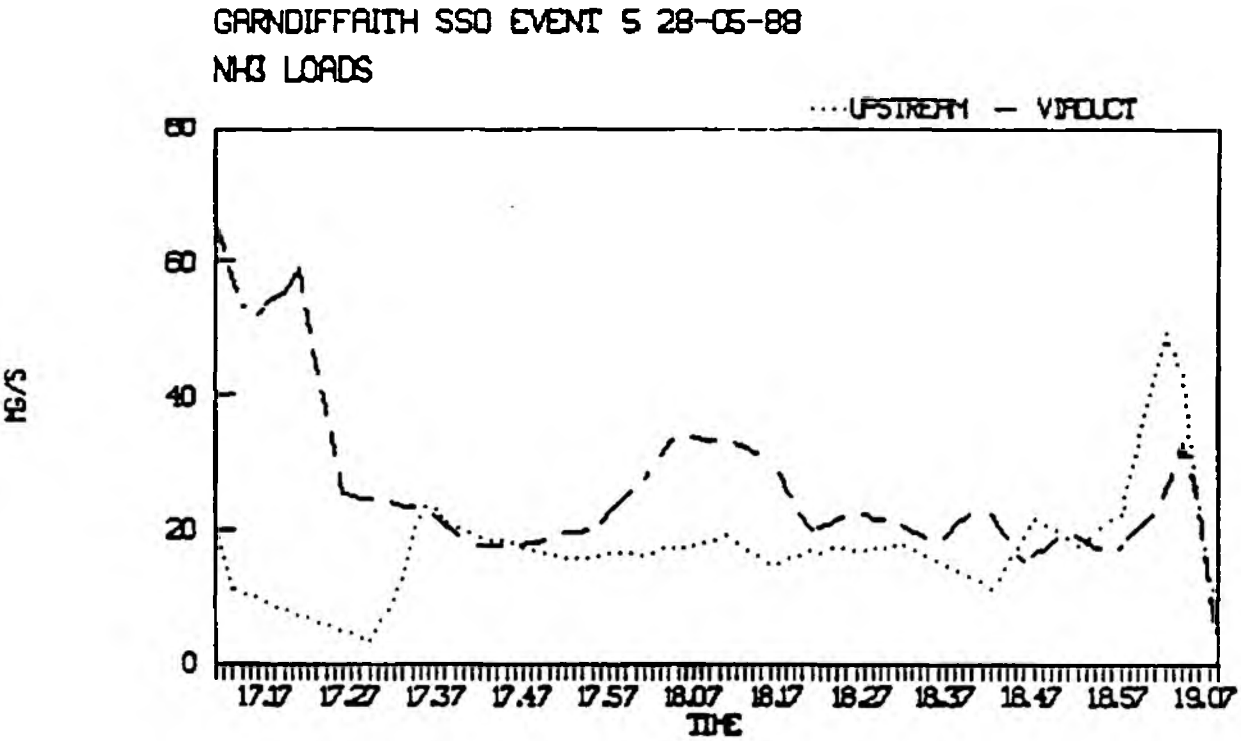


GARNDIFFAITH SSO EVENT 5 28-05-88

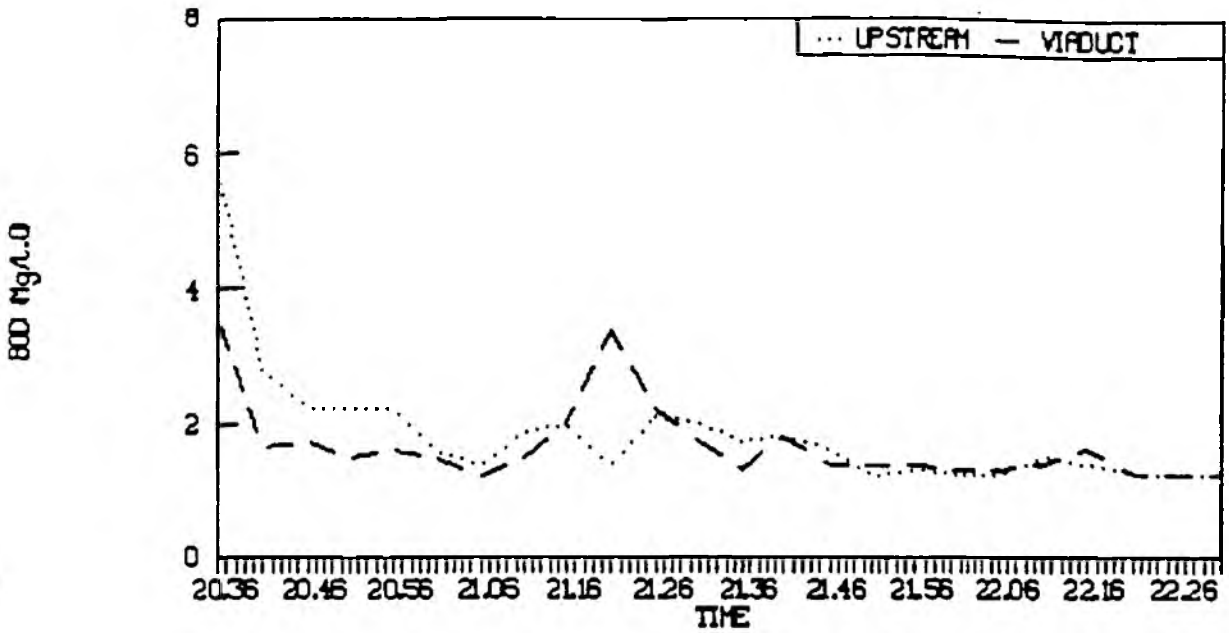
BOD LOADS



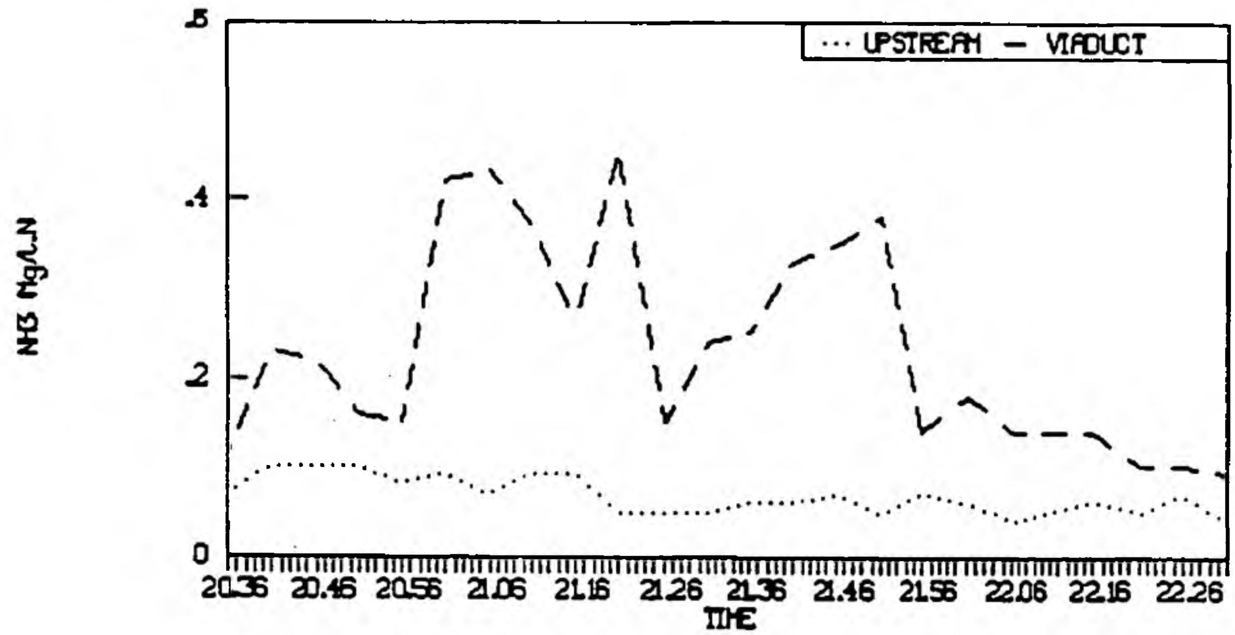

GARNDIFFAITH SSO EVENT 5 28-05-88
NH3 CONCENTRATIONS
UPSTREAM
VIADUCT
MG/L
.8
.6
.4
.2
0
17.17
17.27
17.37
17.47
17.57
18.07
18.17
18.27
18.37
18.47
18.57
19.07
TIME


GARNDIFFAITH SSO EVENT 5 28-05-88
NH3 LOADS
UPSTREAM
VIADUCT
MG/S
80
60
40
20
0
17.17
17.27
17.37
17.47
17.57
18.07
18.17
18.27
18.37
18.47
18.57
19.07
TIME

GARNDIFFAITH SSO EVENT 6 08-06-88.
BOD CONCENTRATIONS.



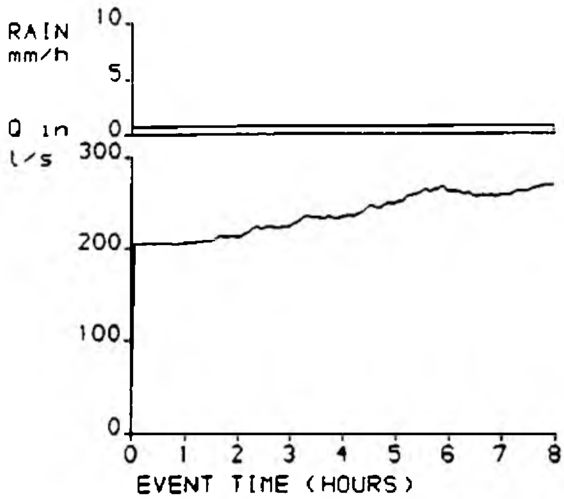
GARNDIFFAITH SSO EVENT 6 08-06-88.
NH3 CONCENTRATIONS.

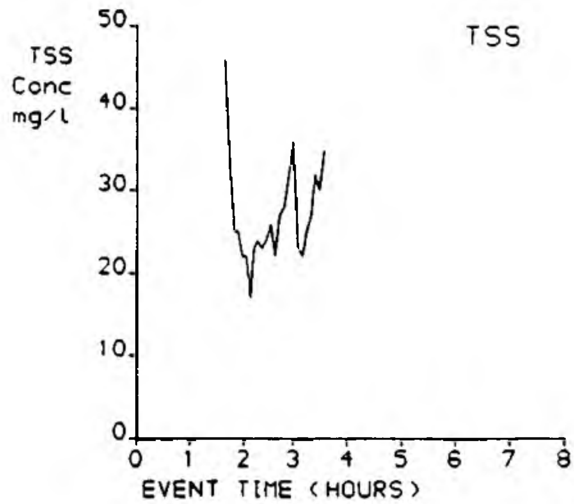


Site: NANT FFRWD, U/S SSO GARNDIFFAITH GN880608U1.DAT

Grid Ref: 262045
Storm Date: 880608
Start Time (R/F): 1857
Rainfall Depth (mm): 15.4

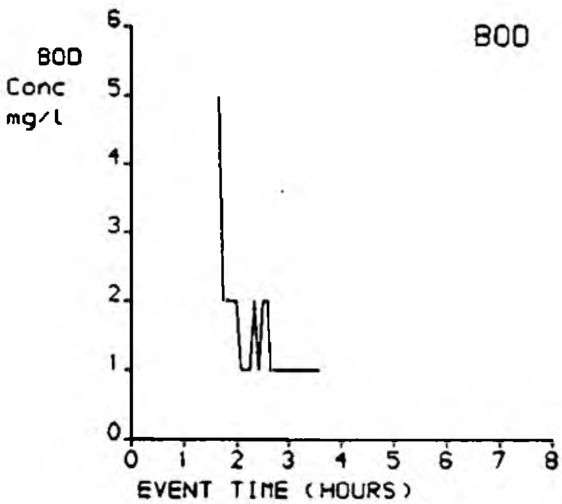
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 478.

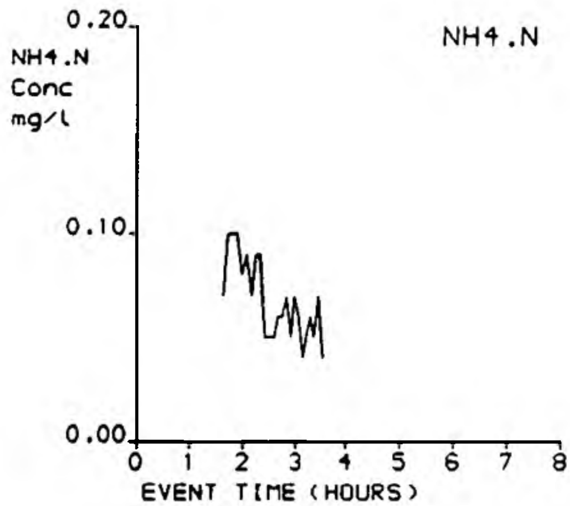




NO DATA FOR COD

NO DATA FOR TOS

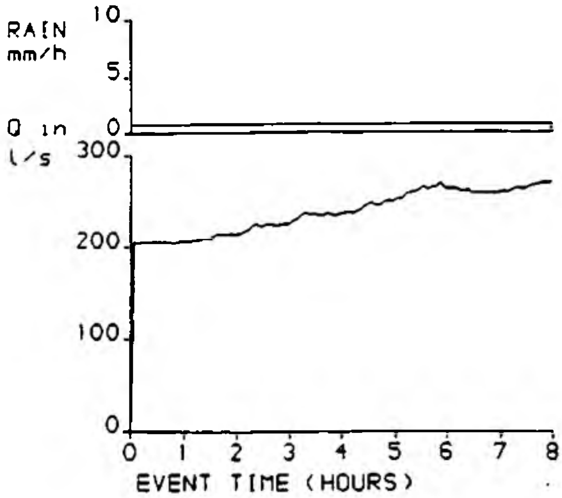




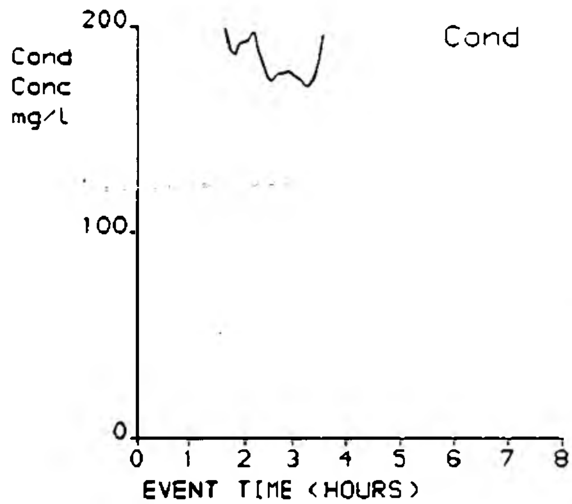
Site: NANT FFRWD, U/S SSO GARNDIFFAITH GN880608U1.DAT

Grid Ref: 262045
Storm Date: 880608
Start Time (R/F): 1857
Rainfall Depth (mm): 15.4

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 478.



NO DATA FOR DO



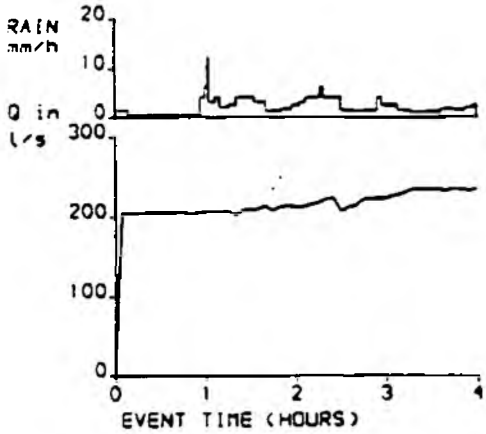
NO DATA FOR TEMP

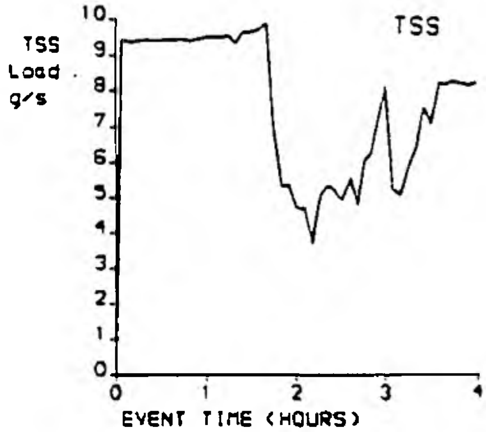
NO DATA FOR

Site: NANT FFRWD, U/S SSO, GARNDIFFAITH GN880608U1.DAT

Grid Ref:
Storm Date: 880608
Start Time (R/F): 1856
Rainfall Depth (mm): 15.2

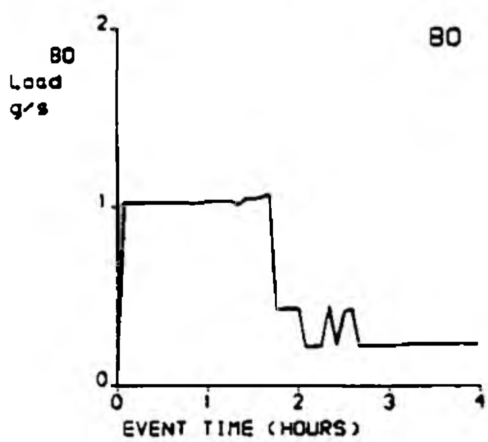
M/H Identification: /////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 3338.

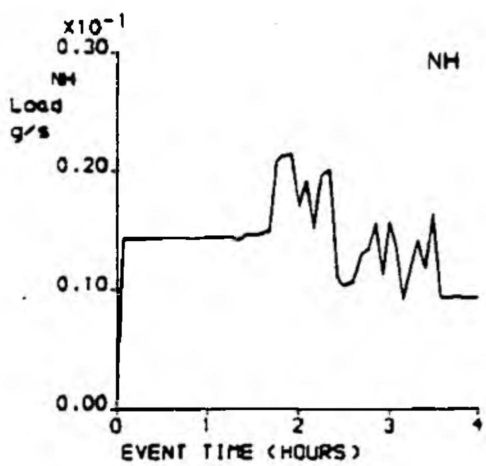




NO DATA FOR CO

NO DATA FOR TDS

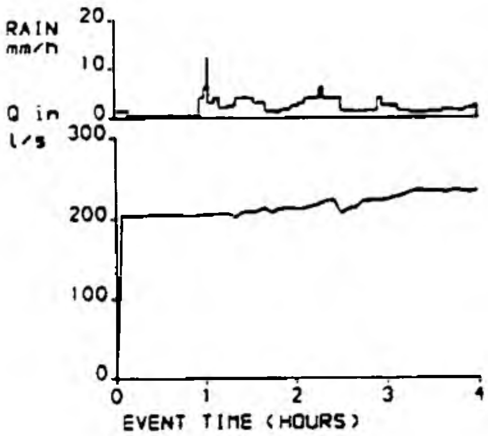


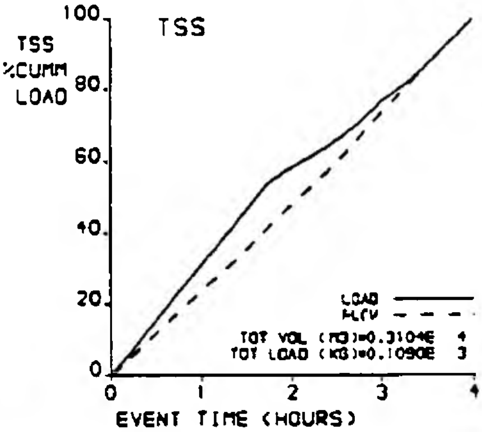


Site: NANT FFRWD, U/S SSO, GARNDIFFAITH GN880608U1.DAT

Grid Ref:
Storm Date: 880608
Start Time (R/F): 1856
Rainfall Depth (mm): 15.2

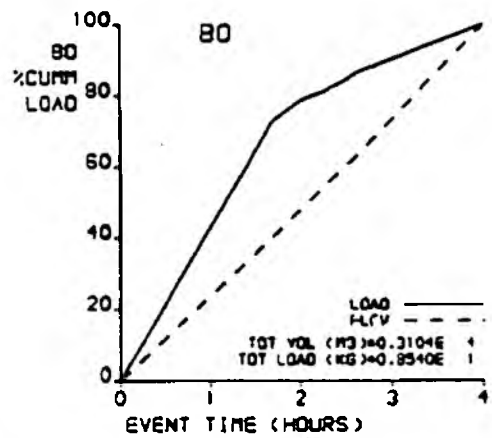
M/H Identification: /////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 3338.

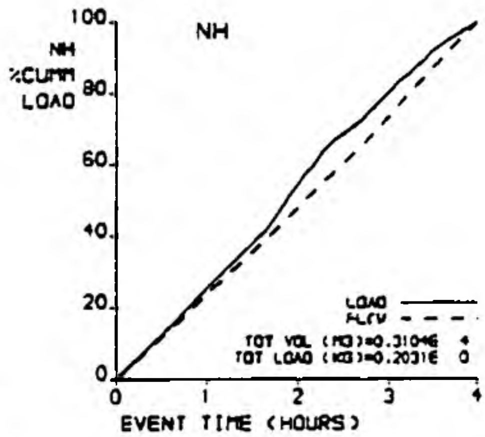




NO DATA FOR CD

NO DATA FOR TDS

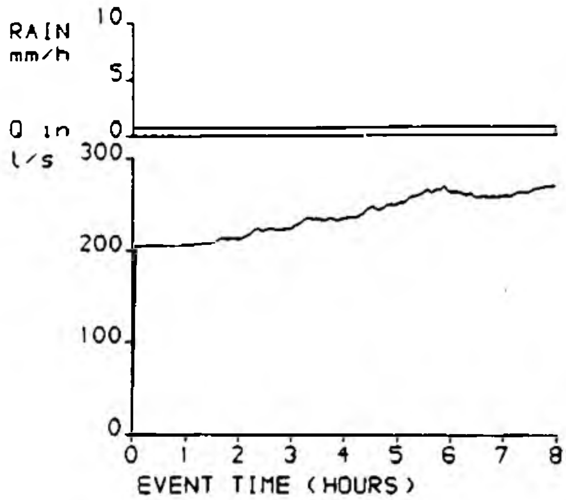


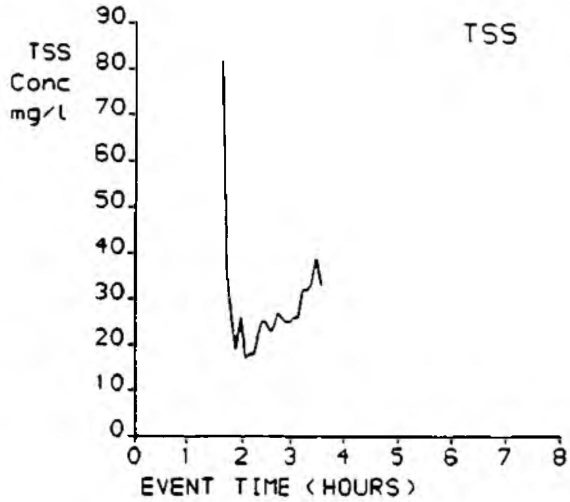


Site: NANT FFRWD, VIADUCT RD, UNDER VIADUCT GN880608D1.DAT

Grid Ref: 262043
Storm Date: 880608
Start Time (R/F): 1857
Rainfall Depth (mm): 15.4

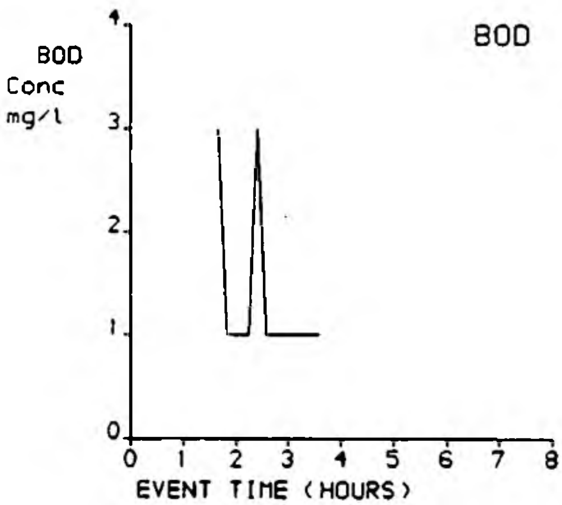
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 478.

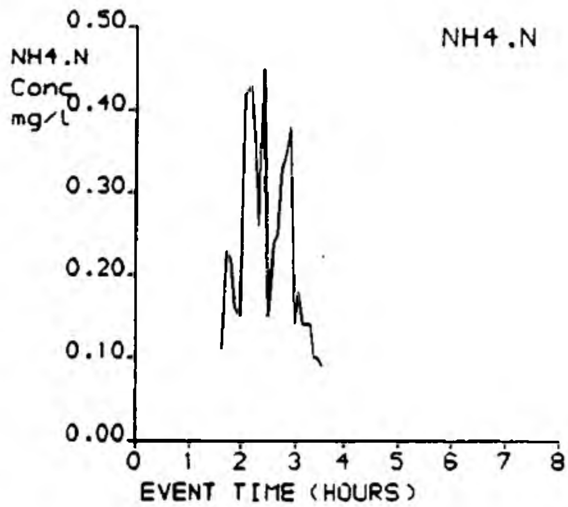




NO DATA FOR COD

NO DATA FOR TDS

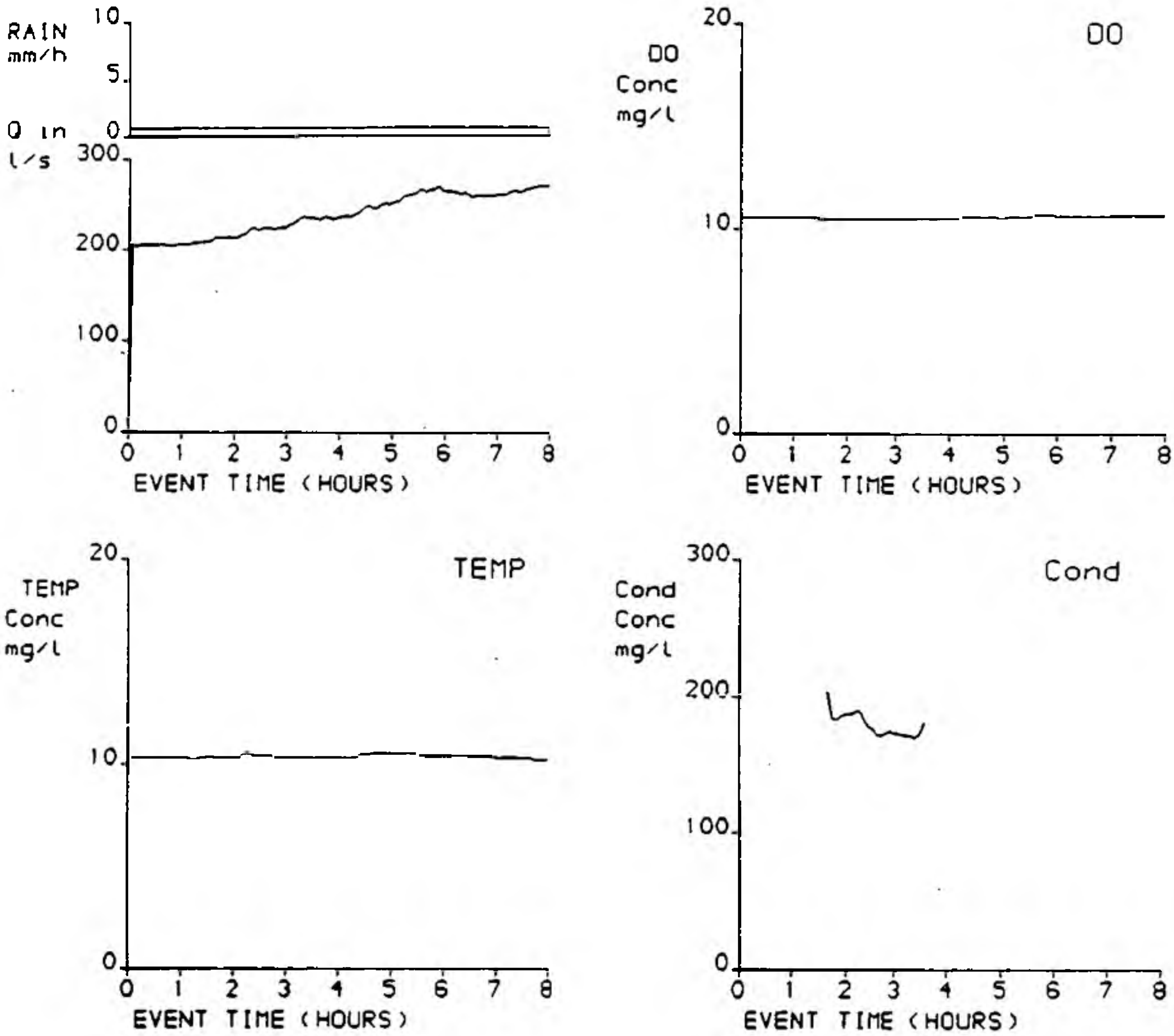




Site: NANT FFRWD, VIADUCT RD, UNDER VIADUCT GN88060801.DAT

Grid Ref: 262043
Storm Date: 880608
Start Time (R/F): 1857
Rainfall Depth (mm): 15.4

Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 478.

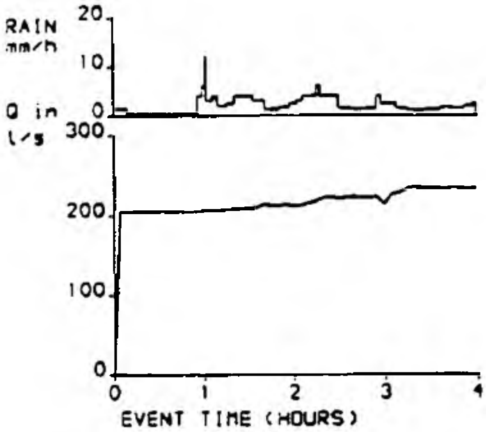


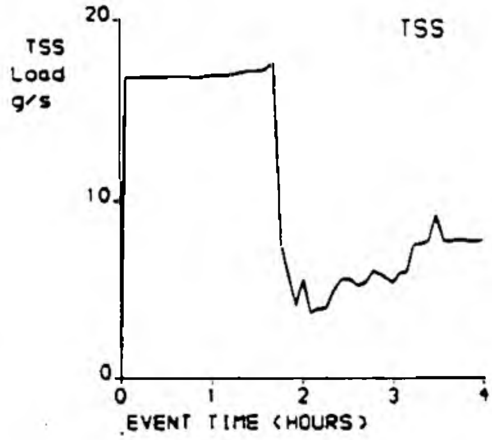
NO DATA FOR pl

Site: NANT FFRWD, VIADUCT ROAD, UNDER V GN880608D1.DAT

Grid Ref:
Storm Date: 880608
Start Time (R/F): 1856
Rainfall Depth (mm): 15.2

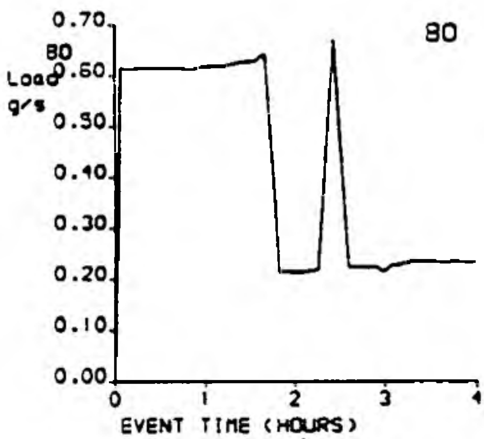
M/H Identification: /////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 3338.

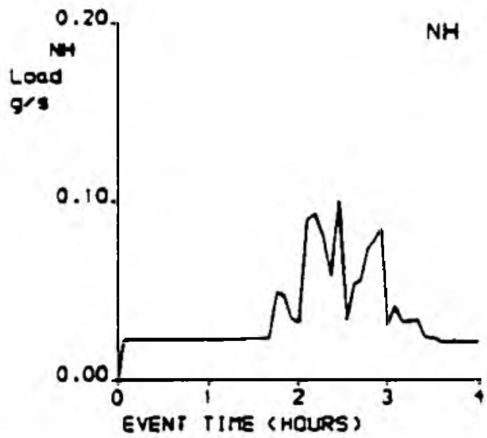




NO DATA FOR CD

NO DATA FOR TDS

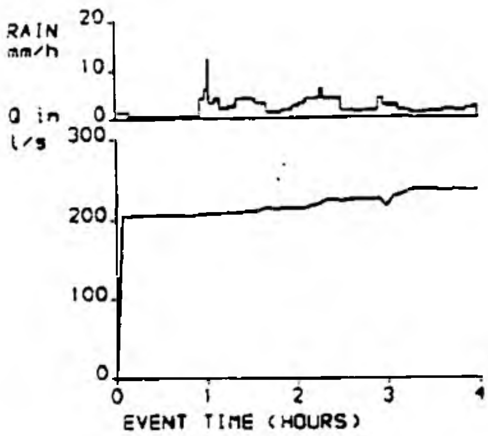


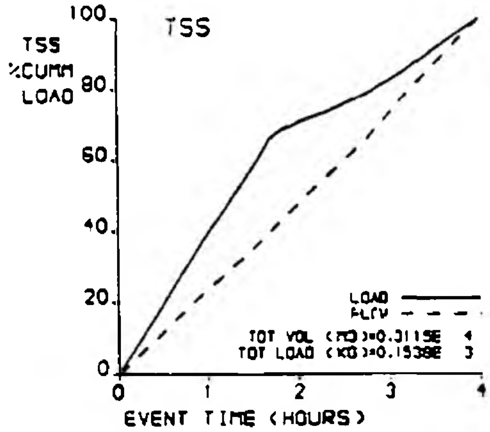


Site: NANT FFRWD, VIADUCT ROAD, UNDER V GN880608D1.DAT

Grid Ref:
Storm Date: 880608
Start Time (R/F): 1856
Rainfall Depth (mm): 15.2

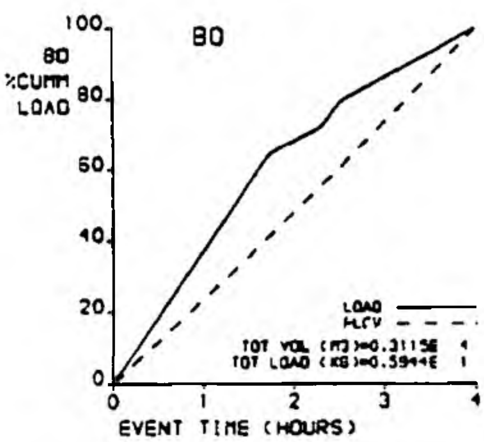
M/H Identification: //////
Date/Time of last monitored storm:
Antec. Dry Weather Period (hours):
Rainfall Event Duration (mins): 3338.

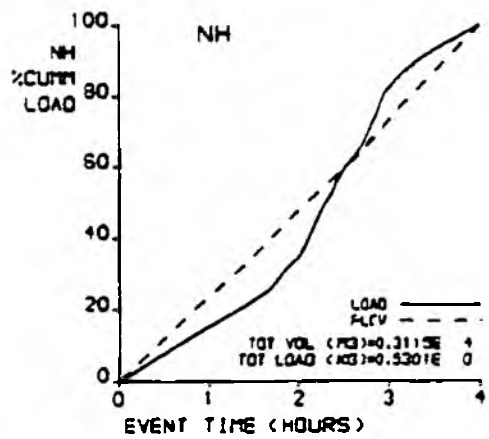




NO DATA FOR CO

NO DATA FOR TDS

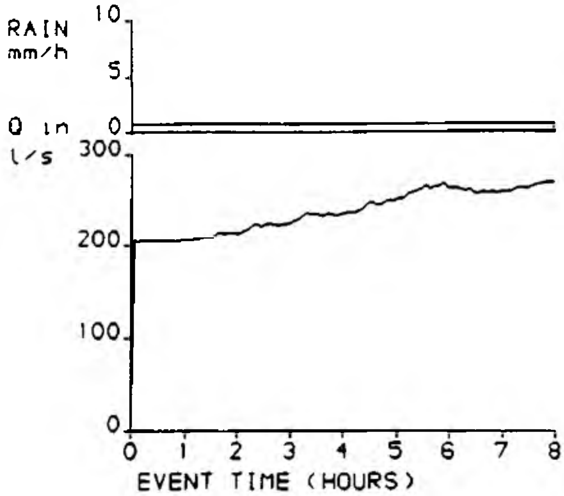


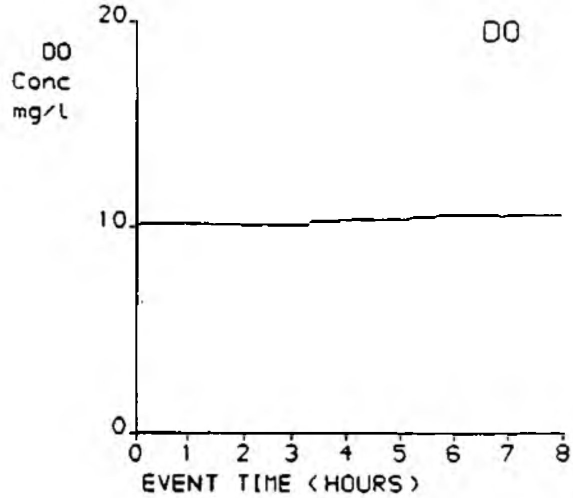


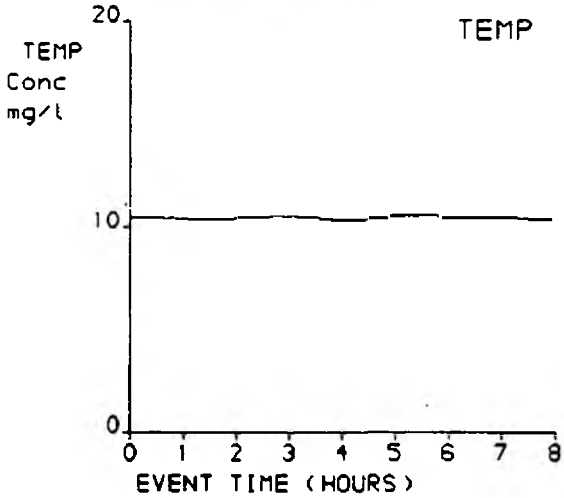
Site: NANT FFRWD, U/S VICTORIA RD BRIDGE GN88060802.DAT

Grid Ref: 264042
Storm Date: 880608
Start Time (R/F): 1857
Rainfall Depth (mm): 15.4

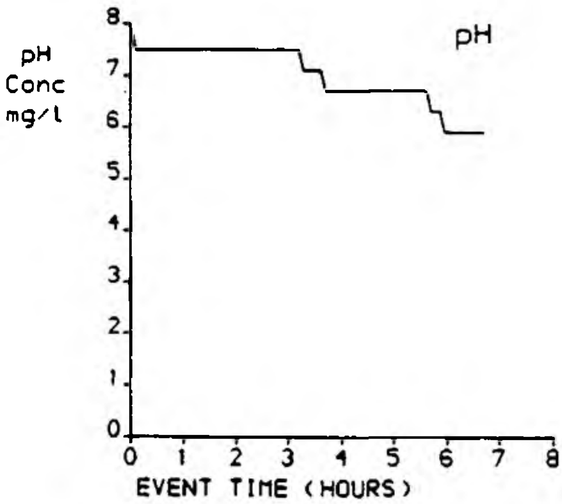
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 478.



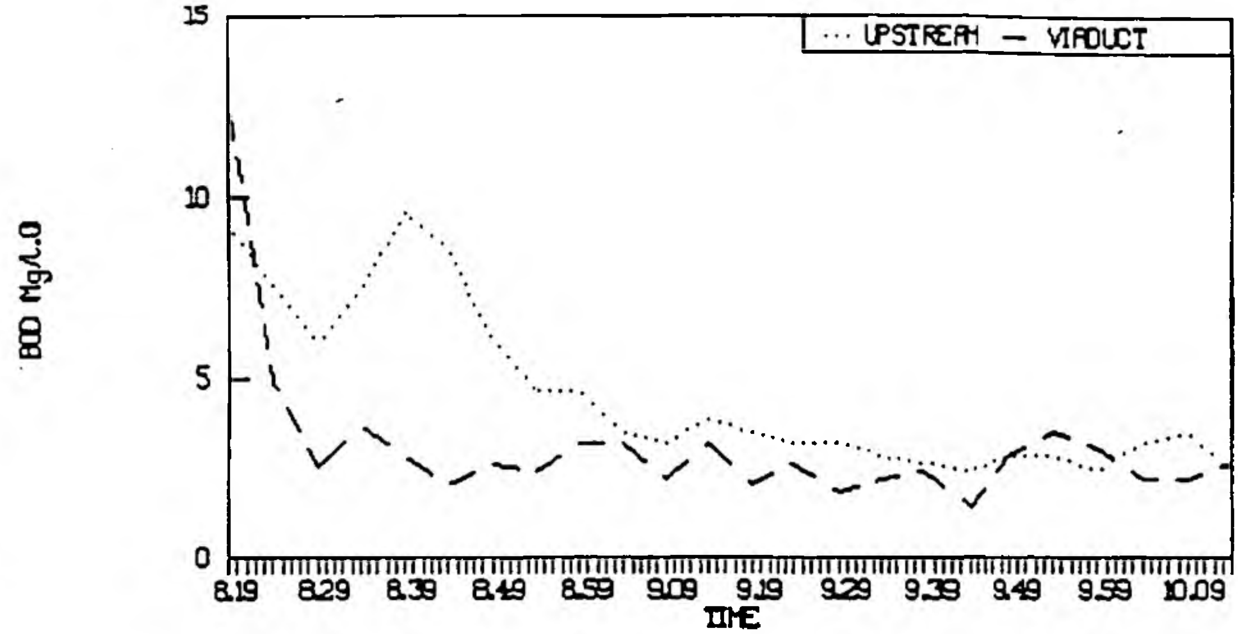




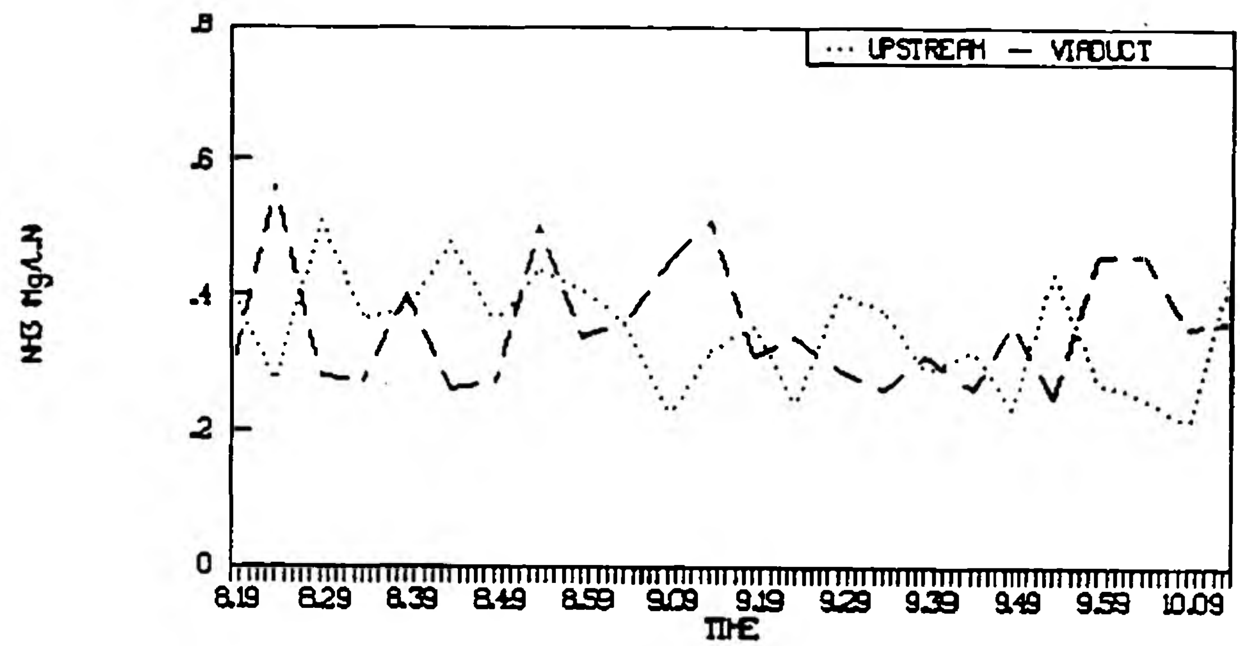
NO DATA FOR Cond



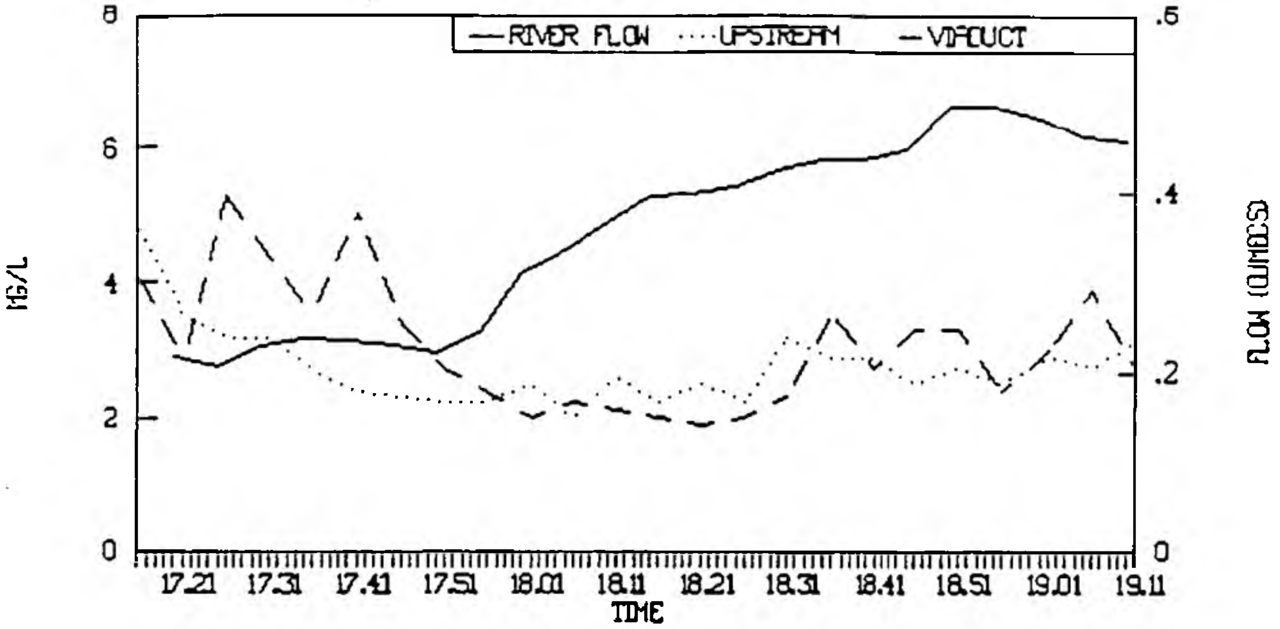
GARNDIFFAITH SSO EVENT 11 13-09-88.
BOD CONCENTRATIONS.



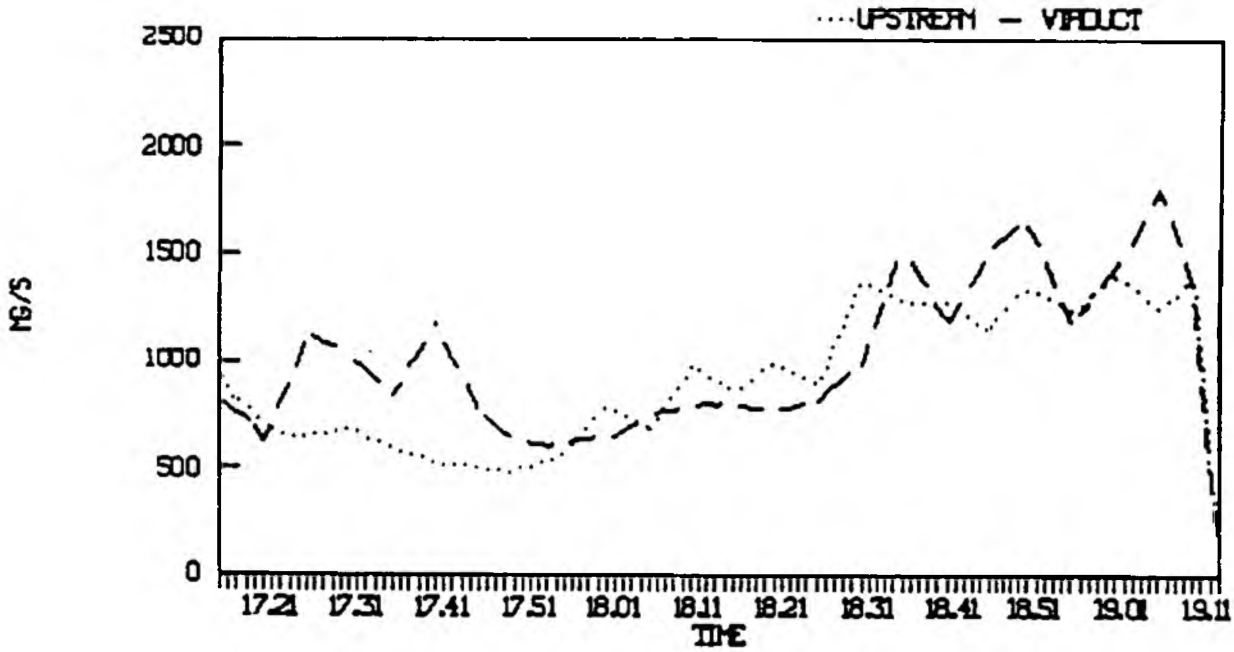
GARNDIFFAITH SSO EVENT 11 13-09-88.
NH3 CONCENTRATIONS.



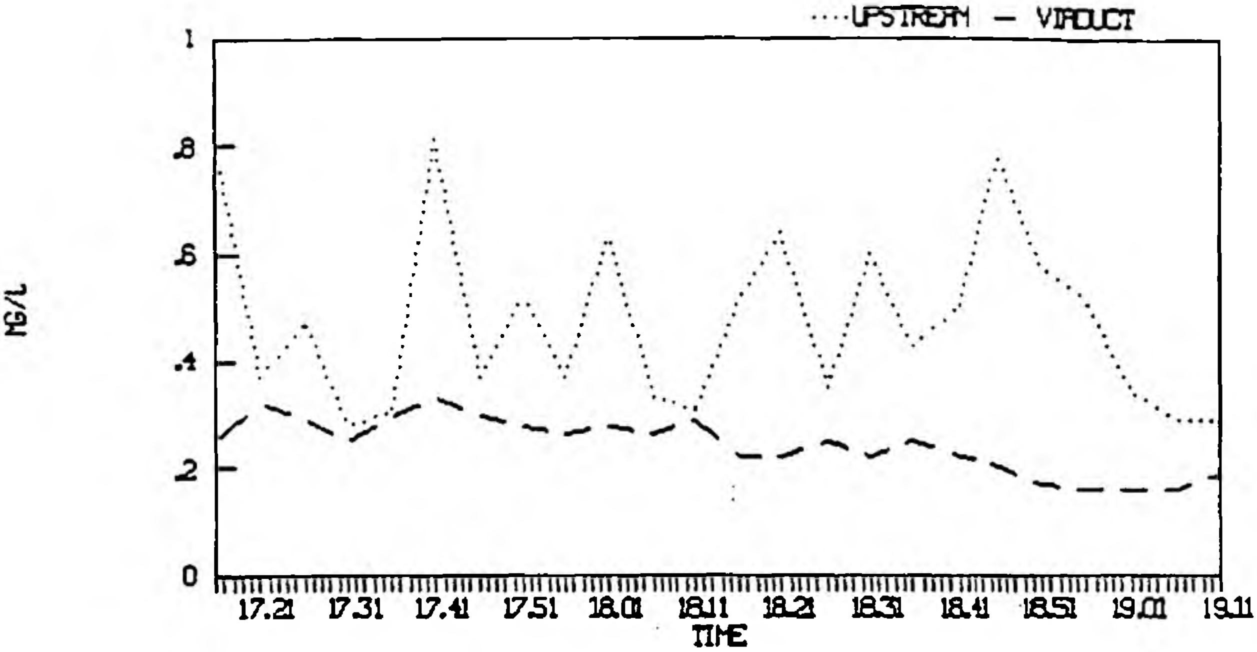
GARNDIFFAITH SSO EVENT 12 18-10-88.
BOD CONCENTRATIONS



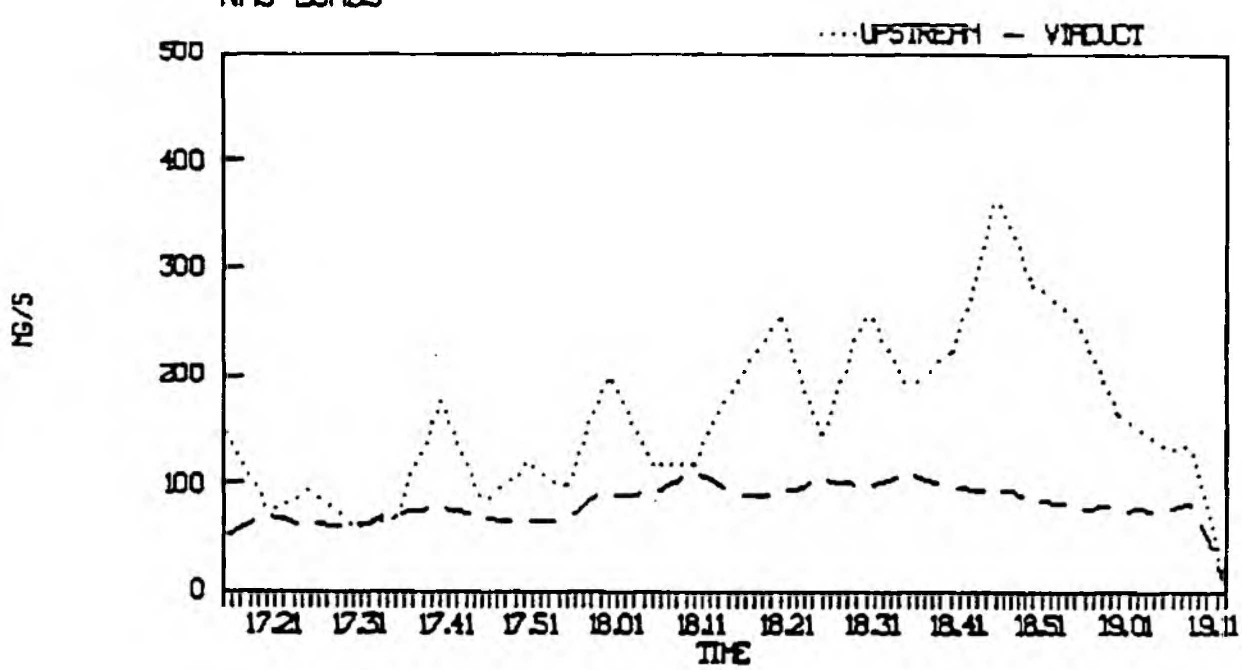
GARNDIFFAITH SSO EVENT 12 18-10-88.
BOD LOADS



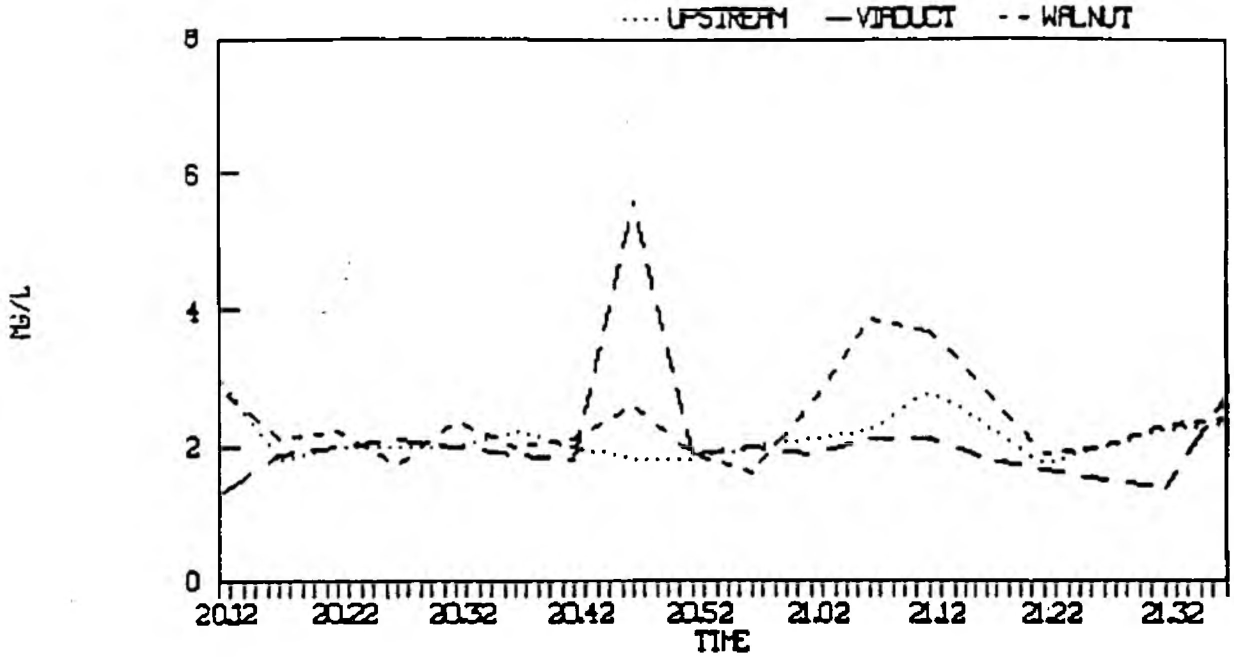
GARNDIFFAITH SSO EVENT 12 18-10-88
NH3 CONCENTRATIONS



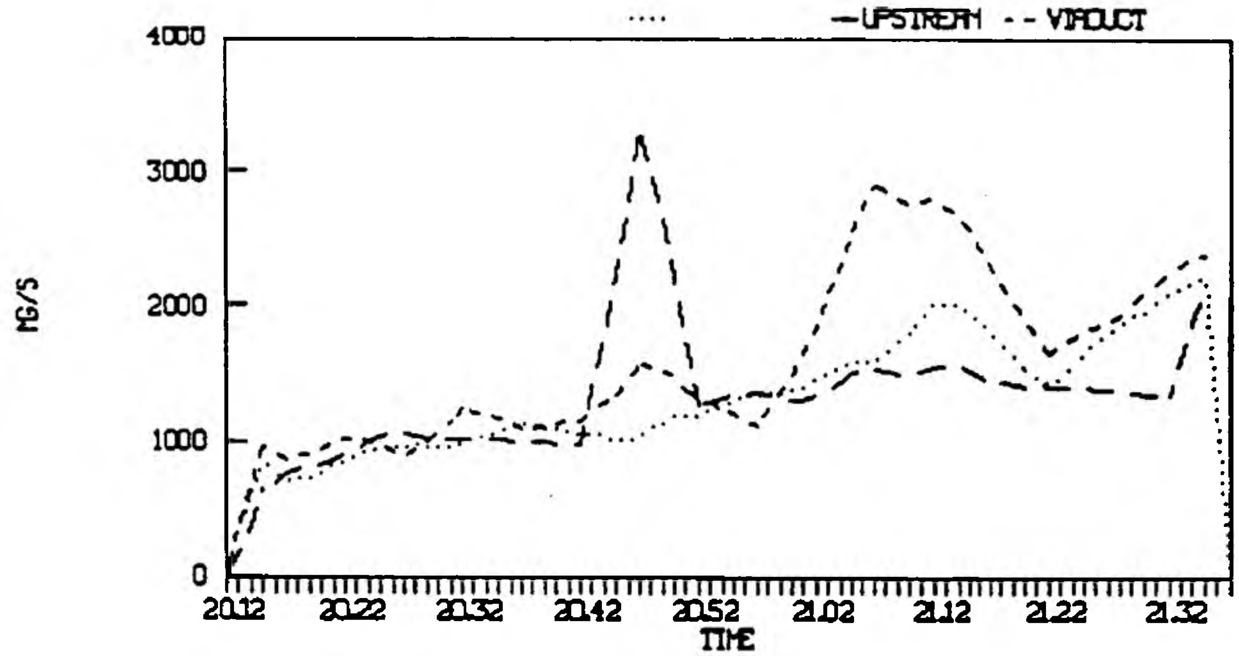
GARNDIFFAITH SSO EVENT 12 18-10-88
NH3 LOADS



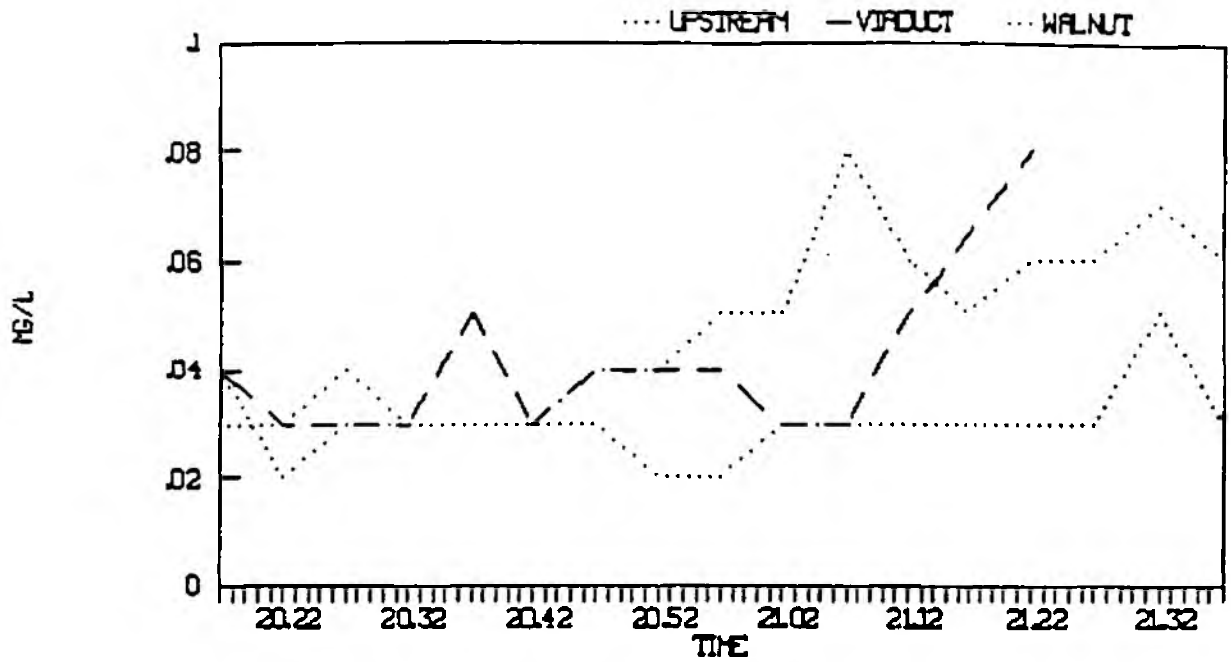
GARNDIFFAITH SSO EVENT 14 23-02-89
BOD CONCENTRATIONS



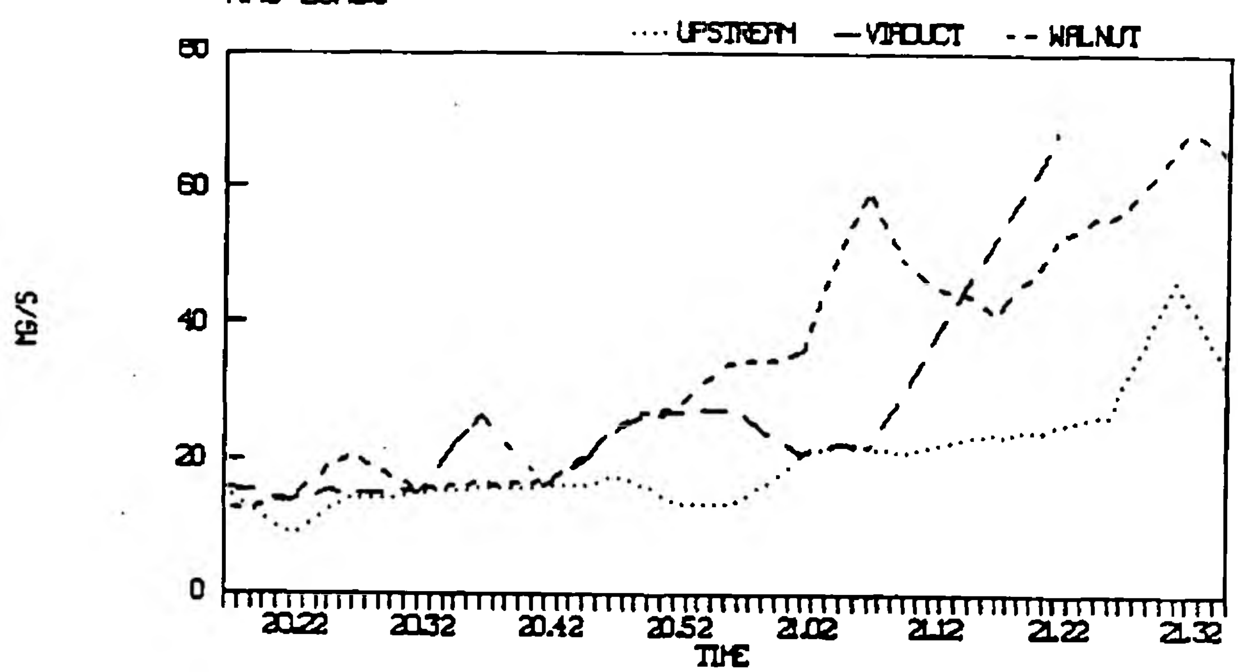
GARNDIFFAITH SSO EVENT 14 23-02-89
BOD LOADS



GARNDIFFAITH SSO EVENT 14 23-02-89
NH3 CONCENTRATIONS



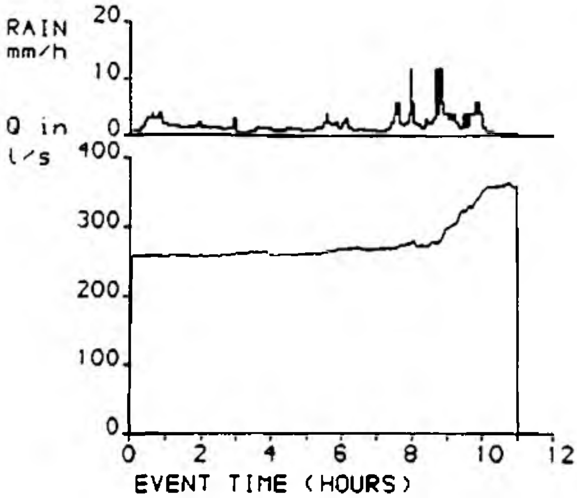
GARNDIFFAITH SSO EVENT 14 23-02-89
NH3 LOADS

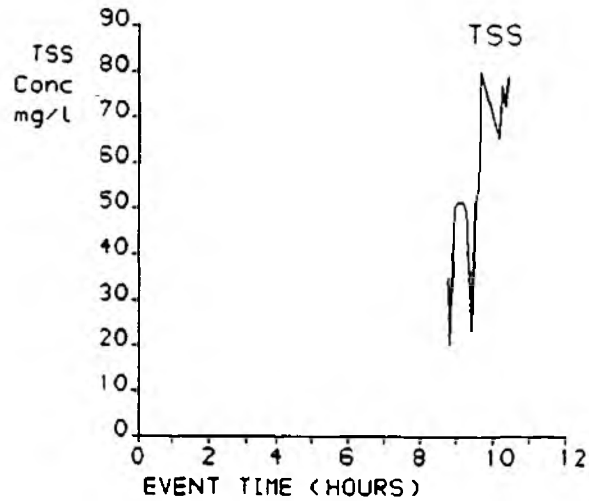


Site: NANT FFRWD,U/S SSO GARNDIFFAITH GN890223U1.DAT

Grid Ref: 262045
Storm Date: 890223
Start Time (R/F): 1128
Rainfall Depth (mm): 20.8

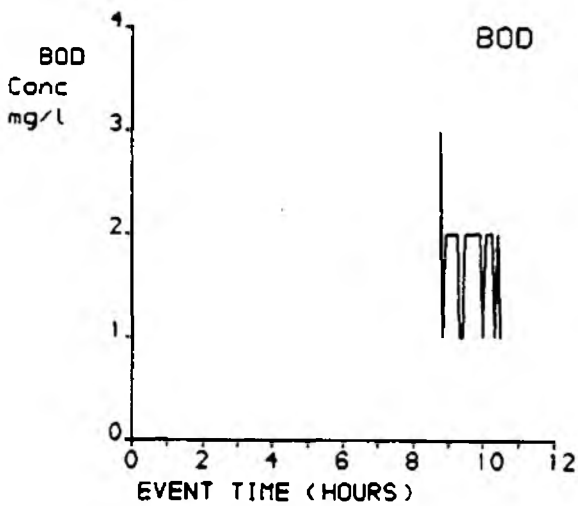
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 659.

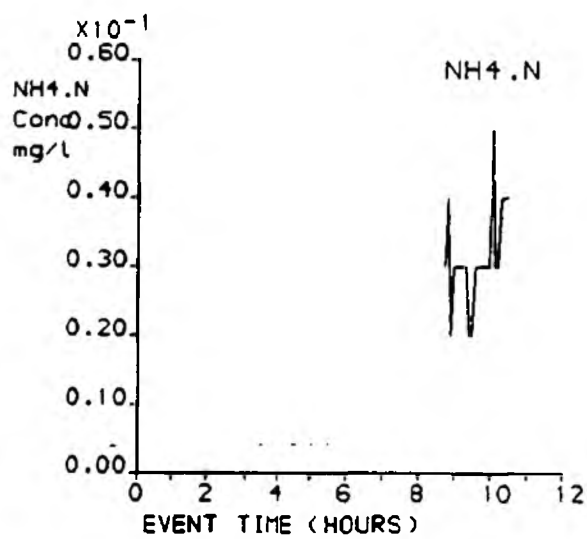




NO DATA FOR COD

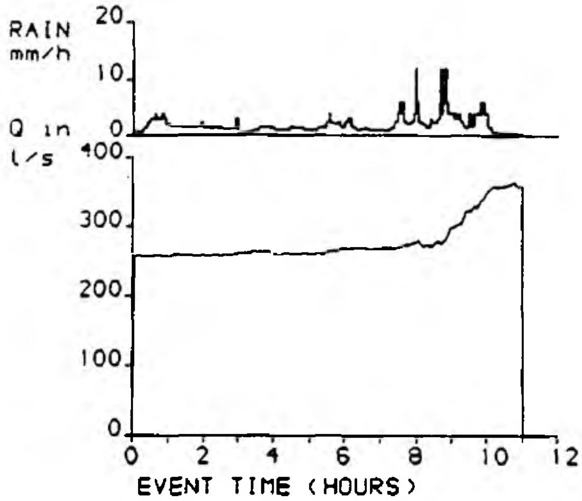
NO DATA FOR TDS

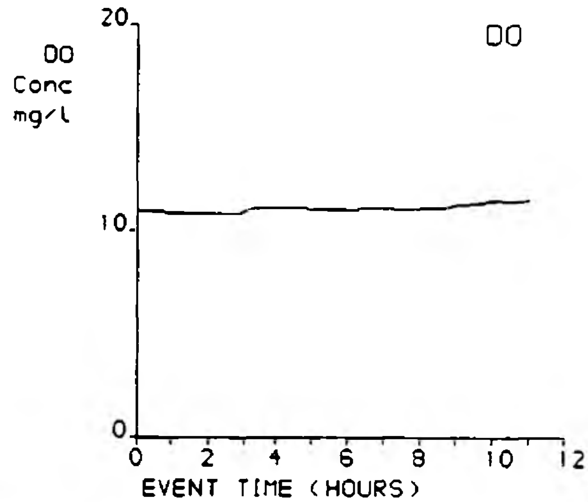


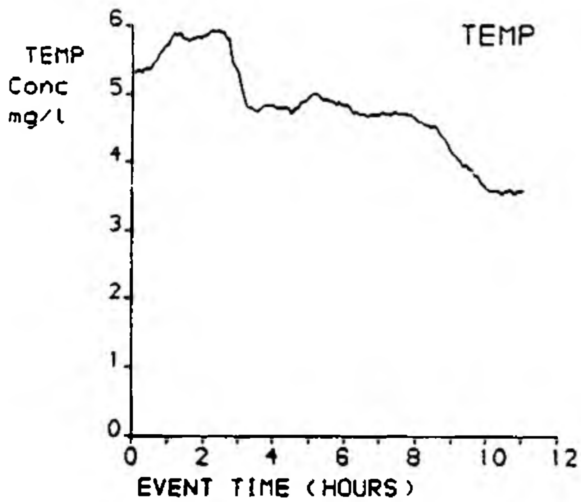


Site: NANT FFRWD,U/S SSO GARNDIFFAITH GN890223U1.DAT

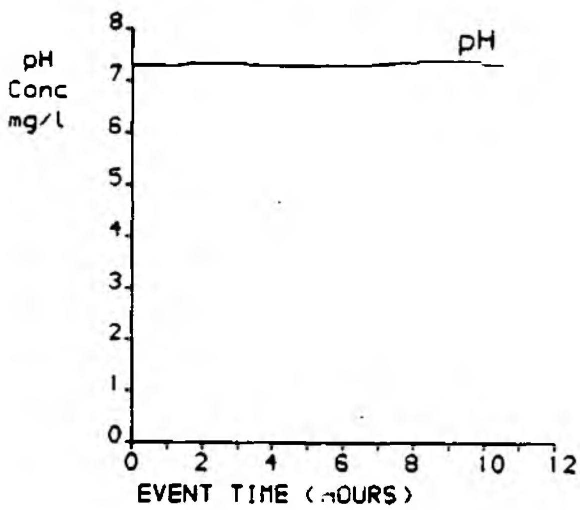
Grid Ref: 262045 Weather Conditions:
Storm Date: 890223 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1128 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 20.8 Rainfall Event Duration (mins): 659.







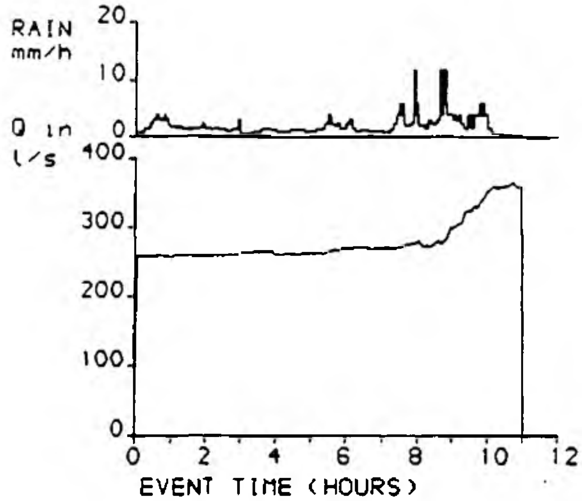
NO DATA FOR Cond

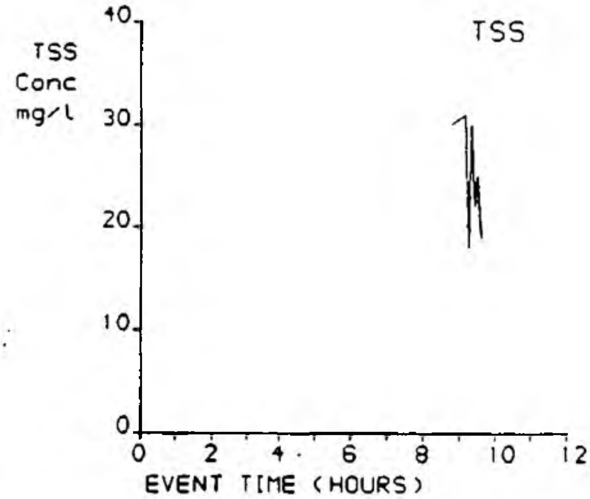


Site: NANT FFRWD, UNDER VIADUCT

GN89022301.DAT

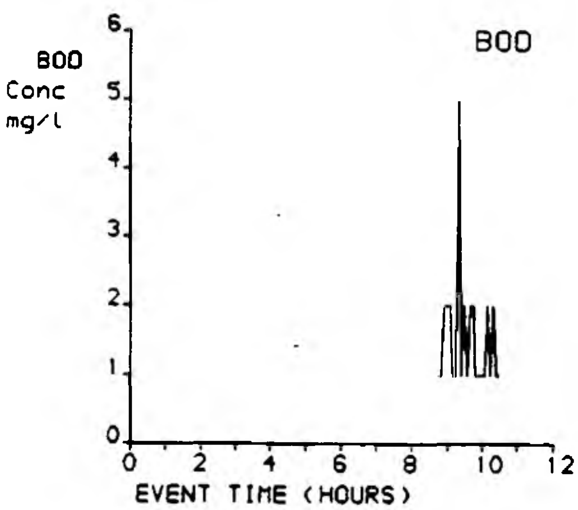
Grid Ref: 262043 | Weather Conditions:
Storm Date: 890223 | Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1128 | Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 20.8 | Rainfall Event Duration (mins): 659.

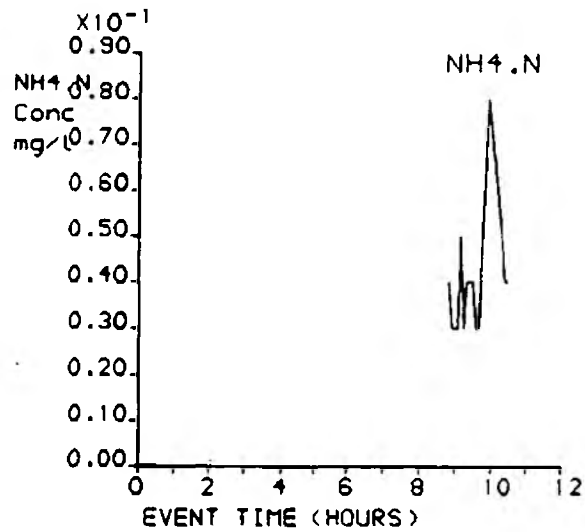




NO DATA FOR COD

NO DATA FOR TDS



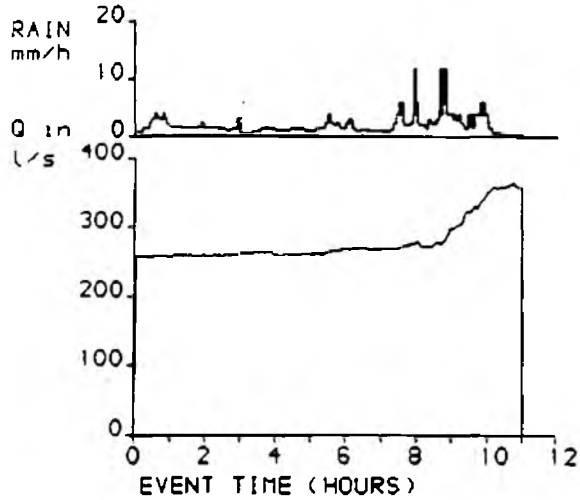


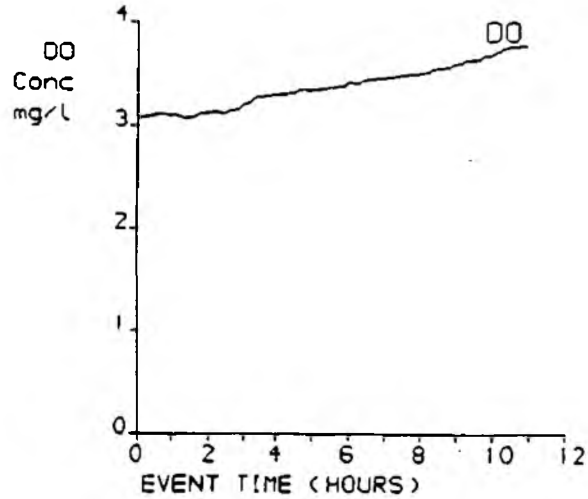
Site: NANT FFRWD, UNDER VIADUCT

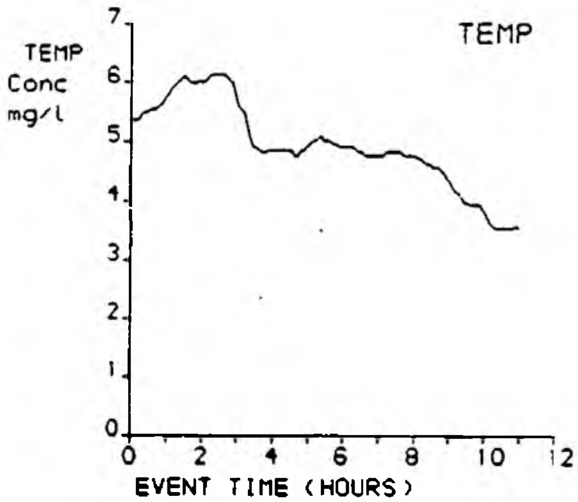
GN8902230I.DAT

Grid Ref: 262043
Storm Date: 890223
Start Time (R/F): 1128
Rainfall Depth (mm): 20.8

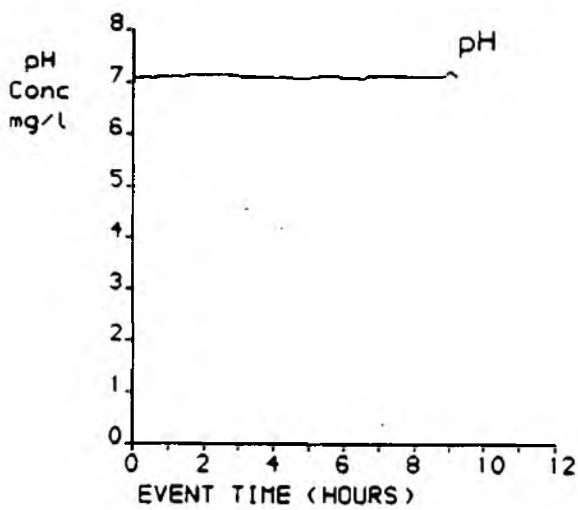
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 659.







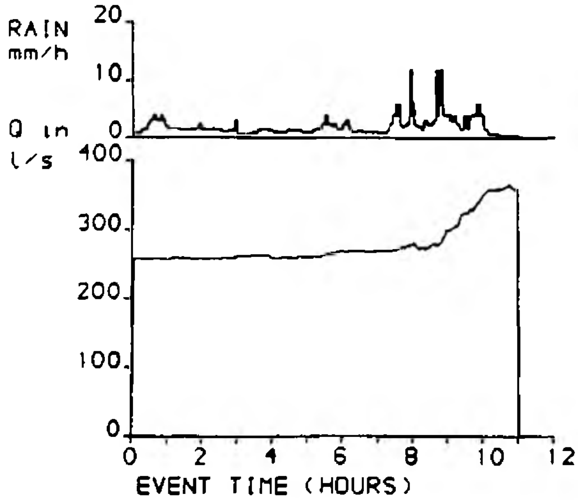
NO DATA FOR Cond

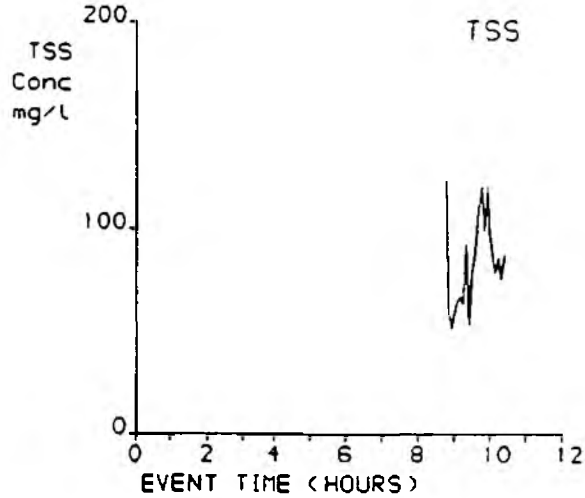


Site: NANT FFRWD, U/S VICTORIA RD BRIDGE GN89022302.DAT

Grid Ref: 264042
Storm Date: 890223
Start Time (R/F): 1128
RainFall Depth (mm): 20.8

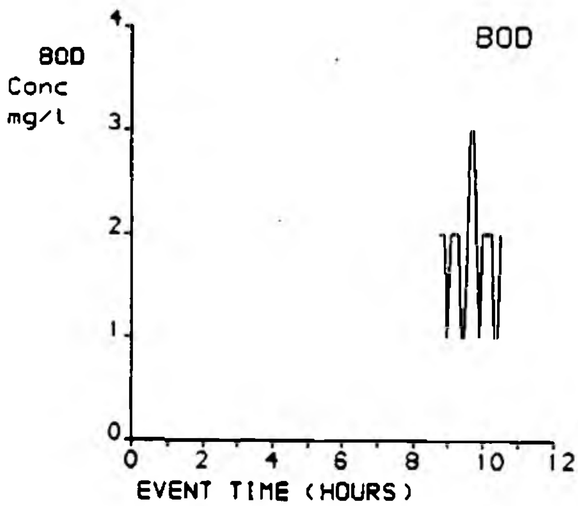
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
RainFall Event Duration (mins): 659.

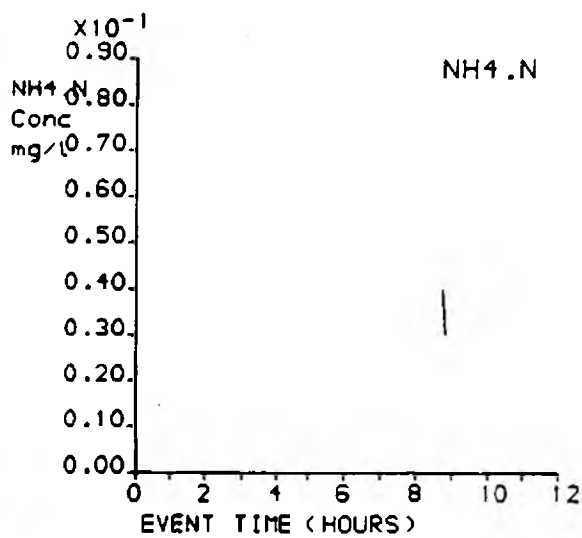




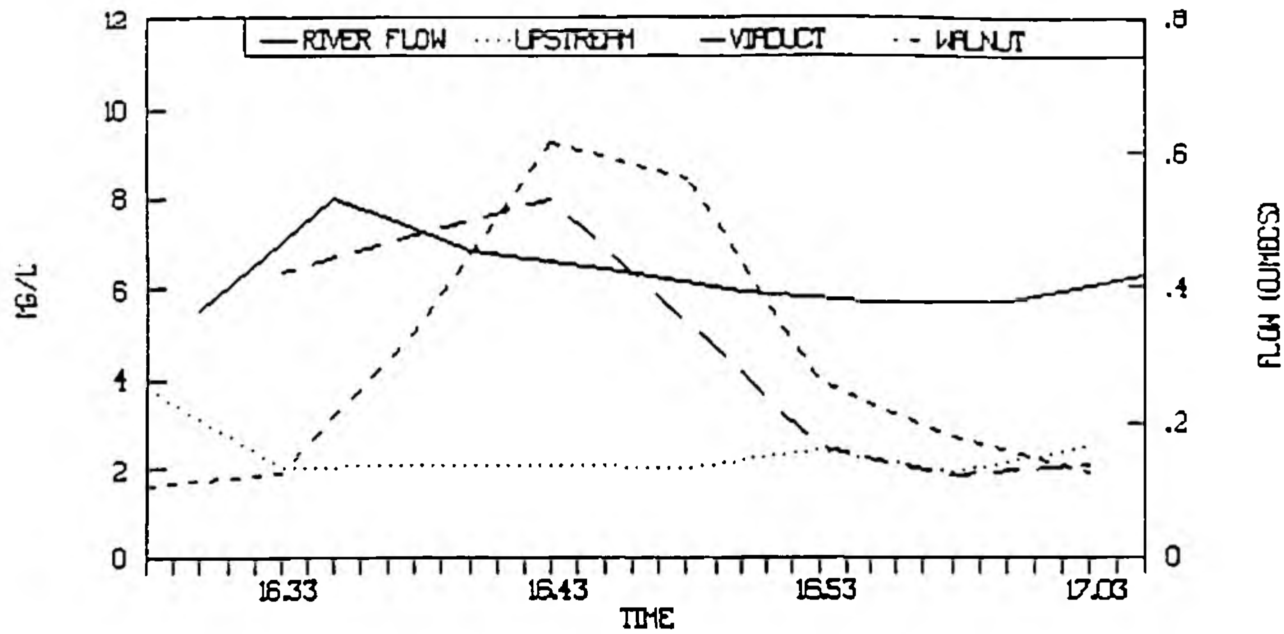
NO DATA FOR COD

NO DATA FOR TDS

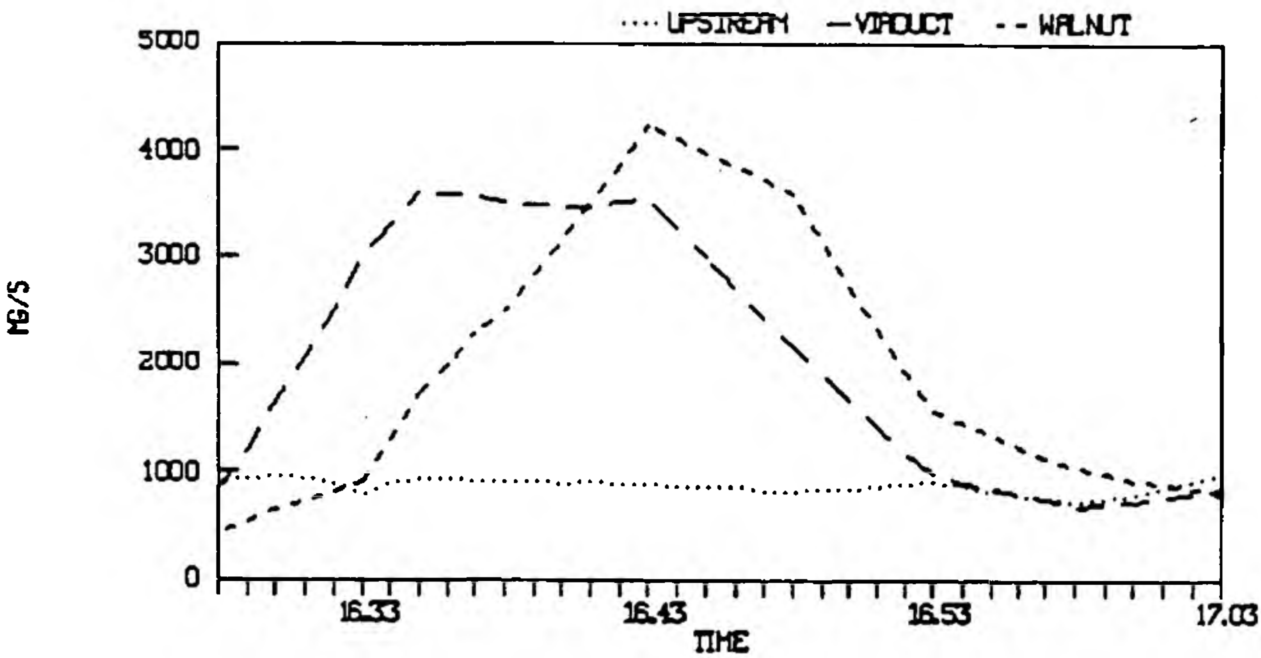




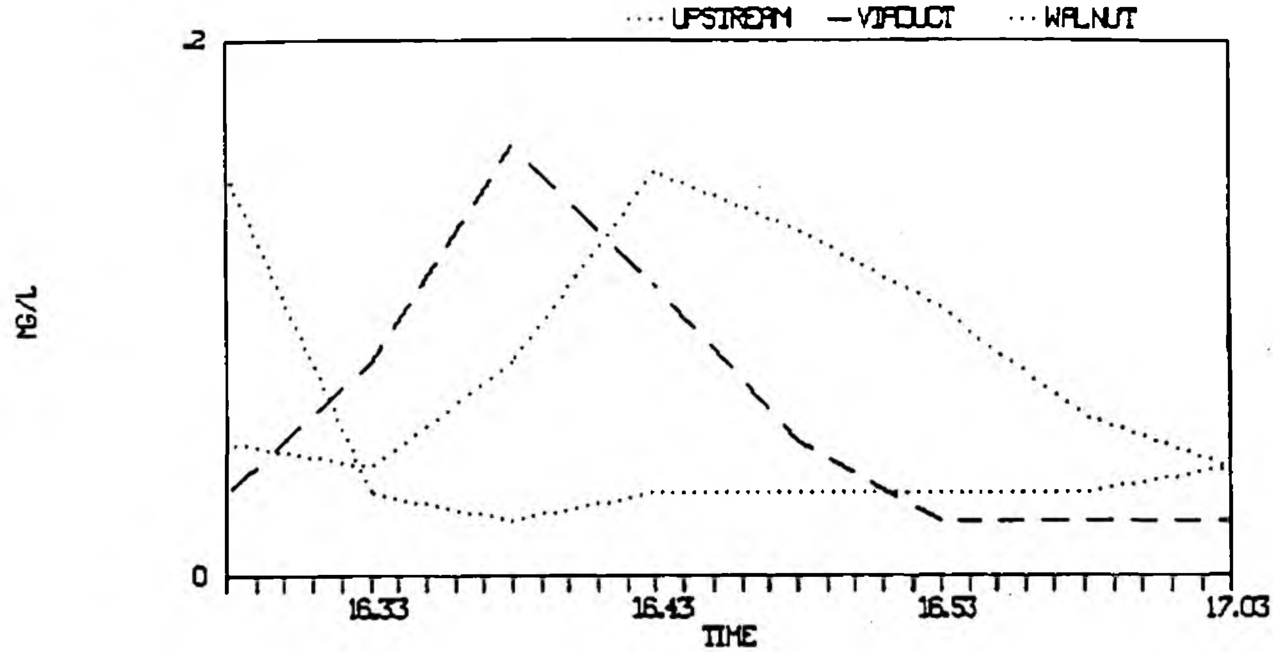
GARNDIFFAITH SSO EVENT 15 06-03-89
BOD CONCENTRATIONS



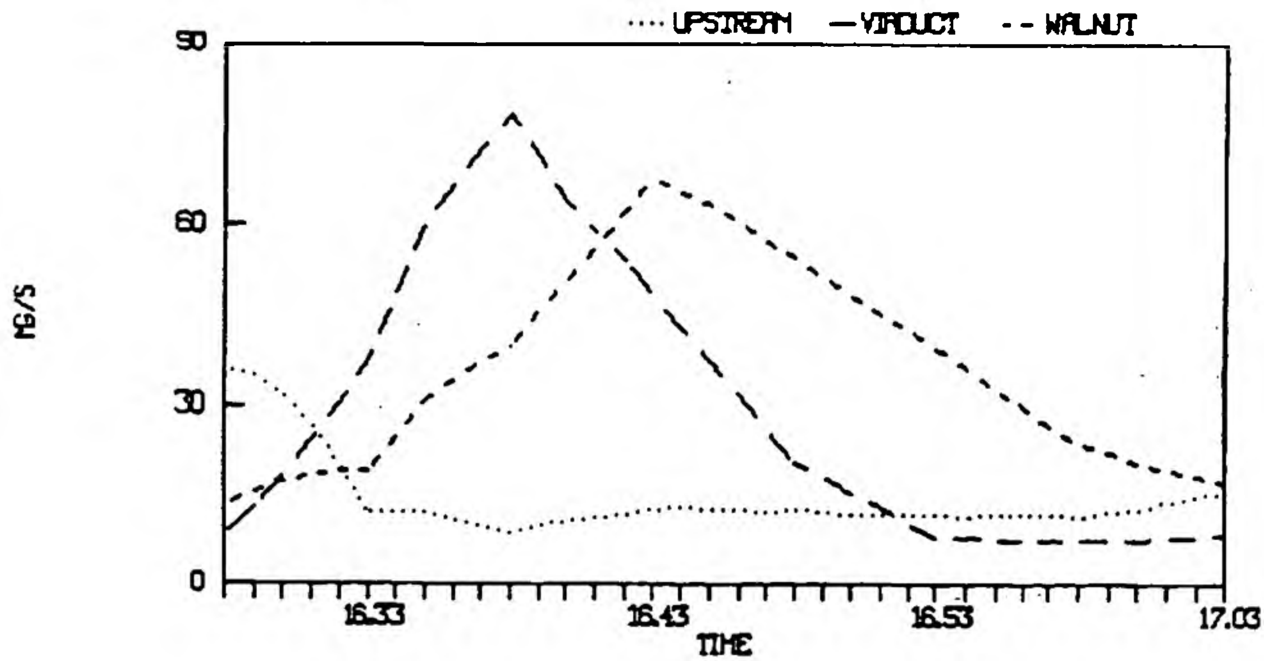
GARNDIFFAITH SSO EVENT 15 06-03-89
BOD LOADS



GARNDIFFAITH SSO EVENT 15 06-03-89
NH3 CONCENTRATIONS



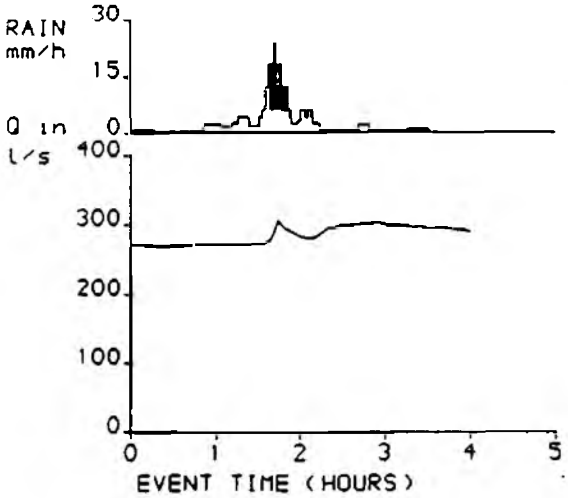
GARNDIFFAITH SSO EVENT 15 06-03-89
NH3 LOADS

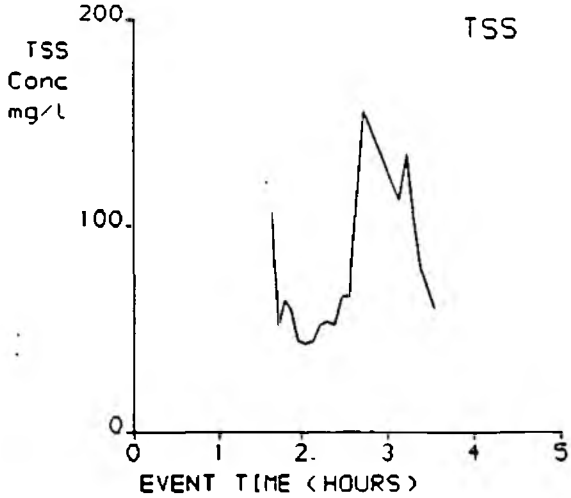


Site: NANT FFRWD, U/S SSO GARNDIFFAITH GN890306U1.DAT

Grid Ref: 262045
Storm Date: 890306
Start Time (R/F): 1450
Rainfall Depth (mm): 7.6

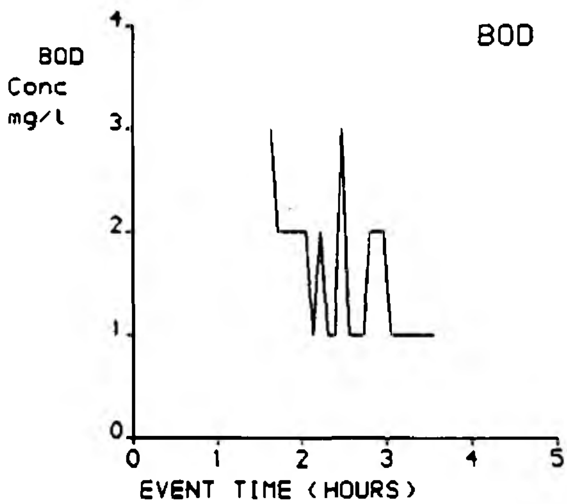
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 209.

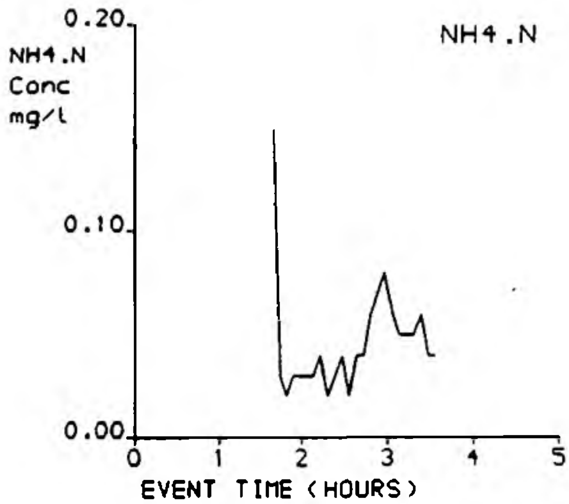




NO DATA FOR COD

NO DATA FOR TDS

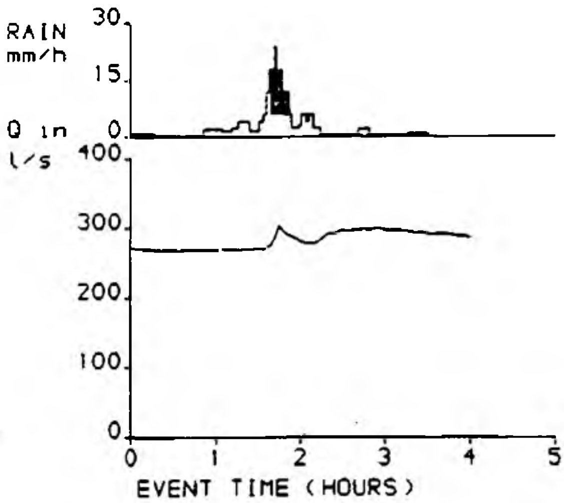


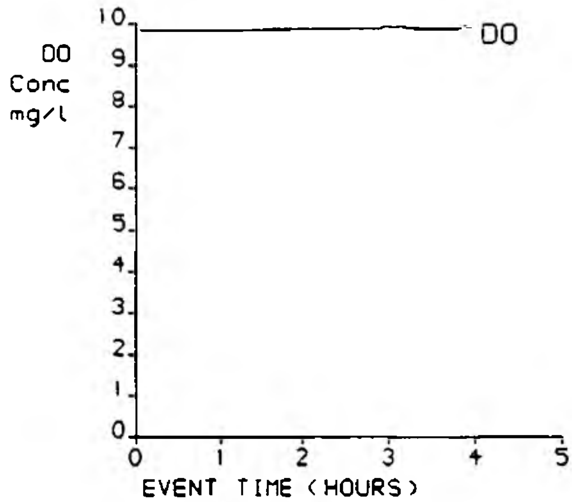


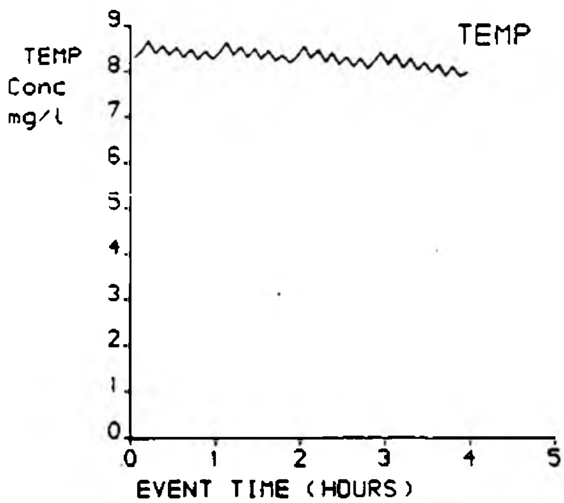
Site: NANT FFRWD, U/S SSO GARNDIFFAITH GN890306U1.DAT

Grid Ref: 262045
Storm Date: 890306
Start Time (R/F): 1450
Rainfall Depth (mm): 7.6

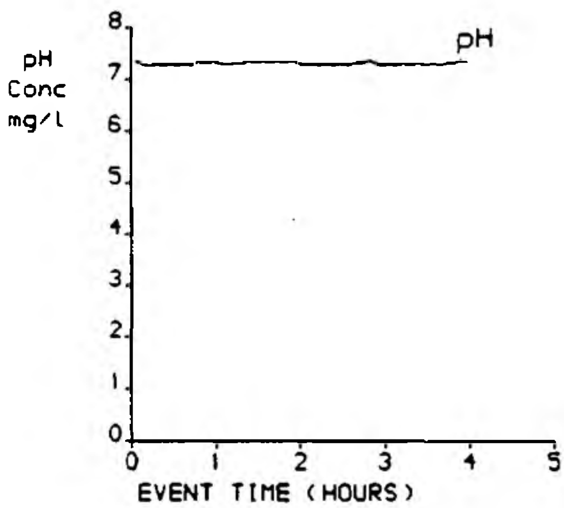
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 209.







NO DATA FOR Cond

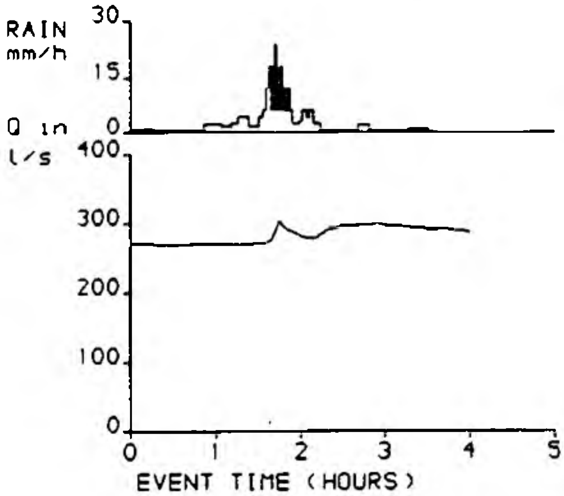


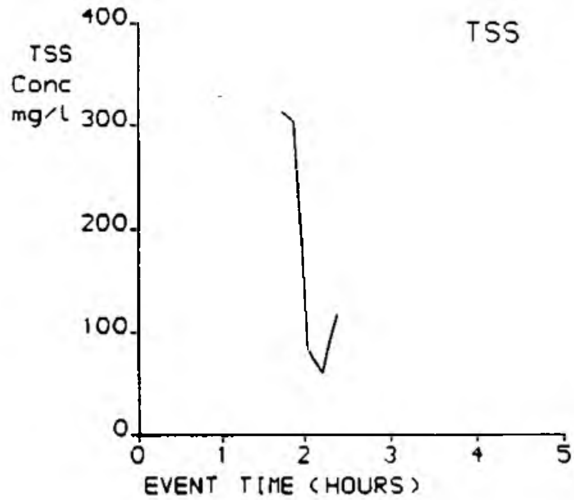
Site: NANT FFRWD, UNDER VIADUCT

GN89030601.DAT

Grid Ref: 262043
Storm Date: 890306
Start Time (R/F): 1450
Rainfall Depth (mm): 7.6

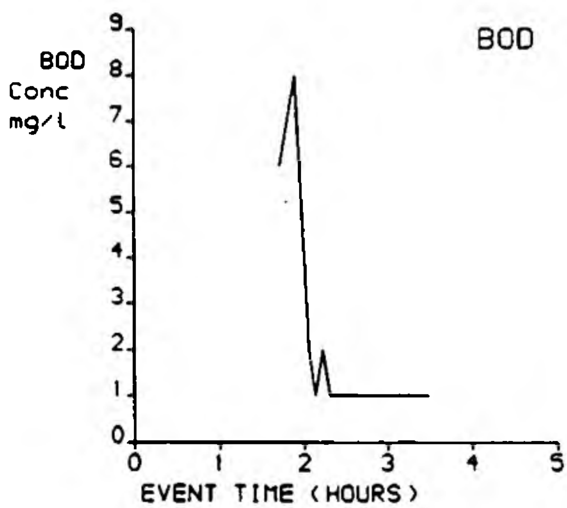
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 209.

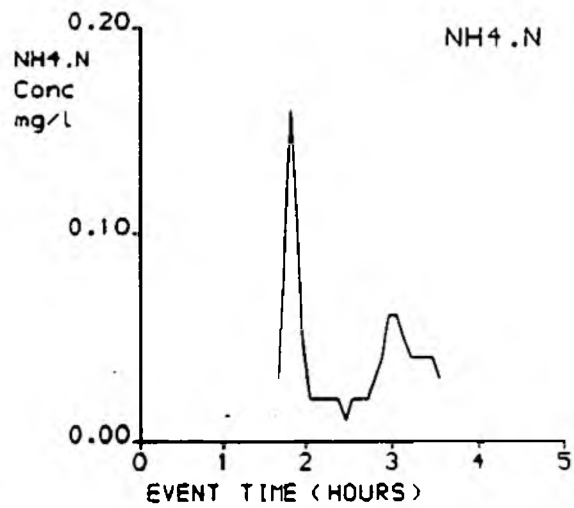




NO DATA FOR COD

NO DATA FOR TDS

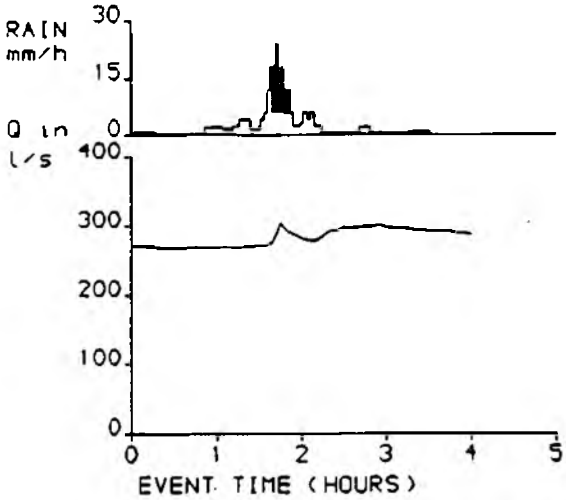


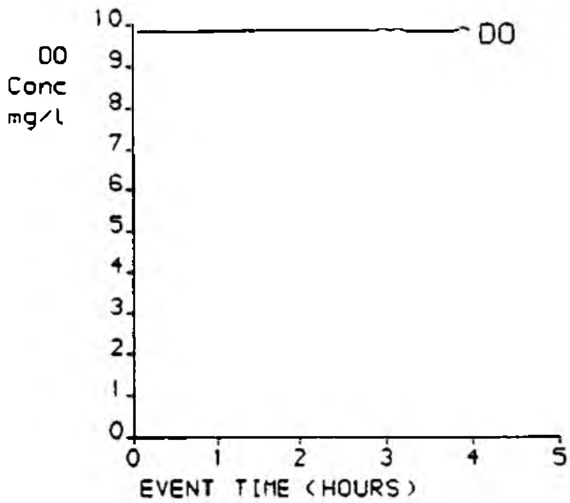


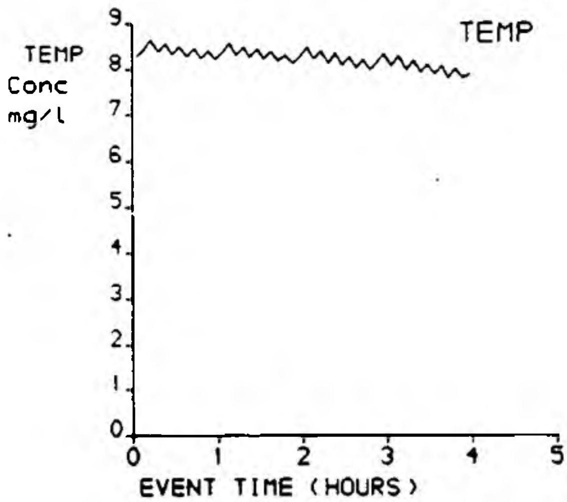
Site: NANT FFRWD, UNDER VIADUCT

GN890306D1.DAT

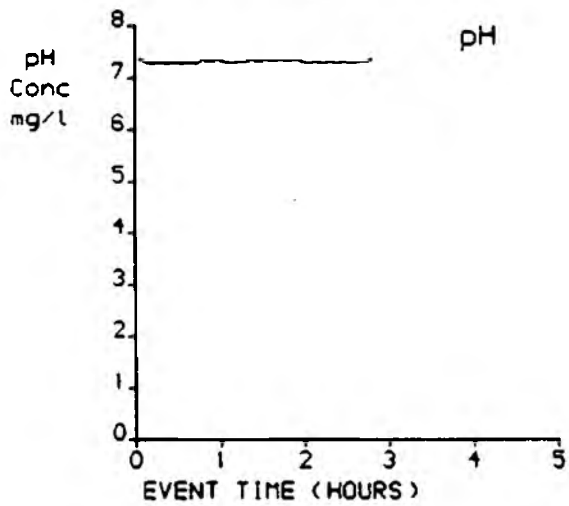
Grid Ref: 262043
Storm Date: 890306
Start Time (R/F): 1450
Rainfall Depth (mm): 7.6
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 209.







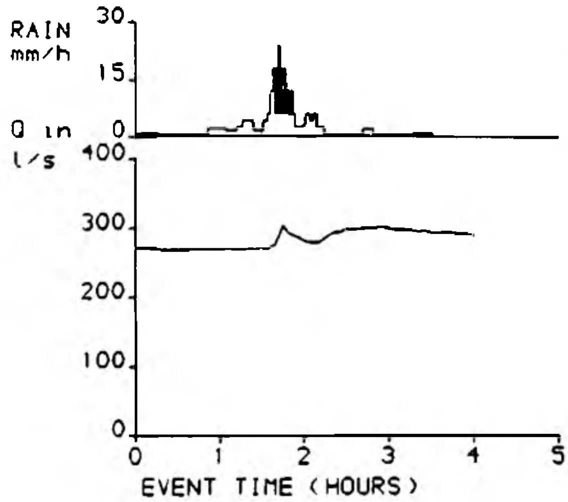
NO DATA FOR Cond

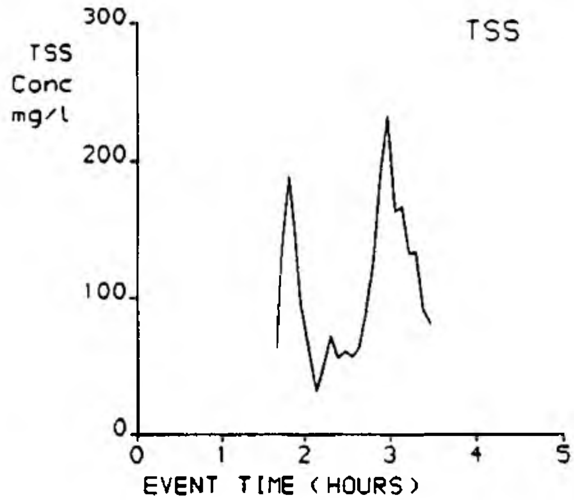


Site: NANT FFRWD, U/S VICTORIA RD BRIDGE GN89030602.DAT

Grid Ref: 264042
Storm Date: 890306
Start Time (R/F): 1450
Rainfall Depth (mm): 7.6

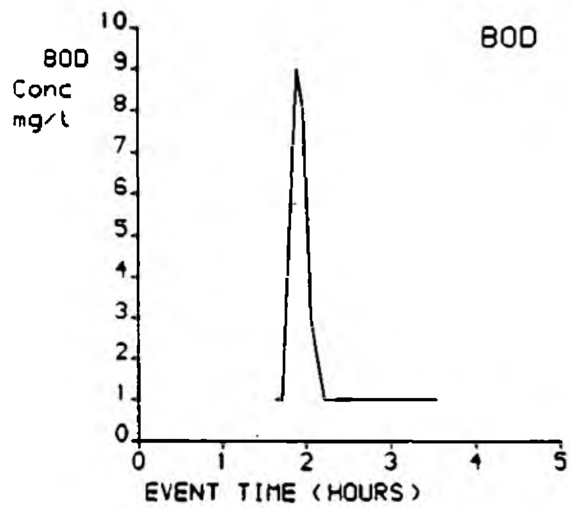
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 209.

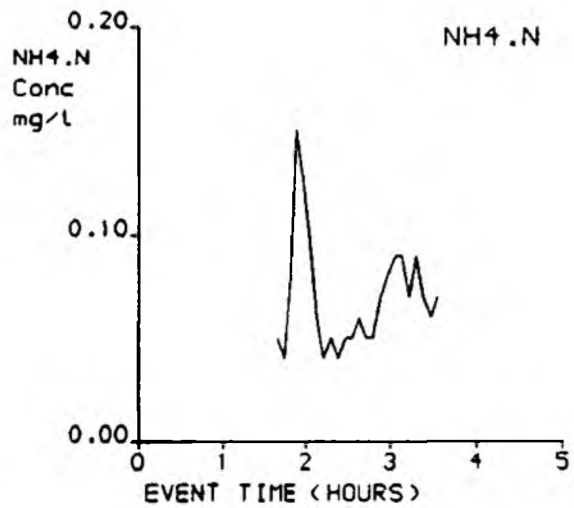




NO DATA FOR COD

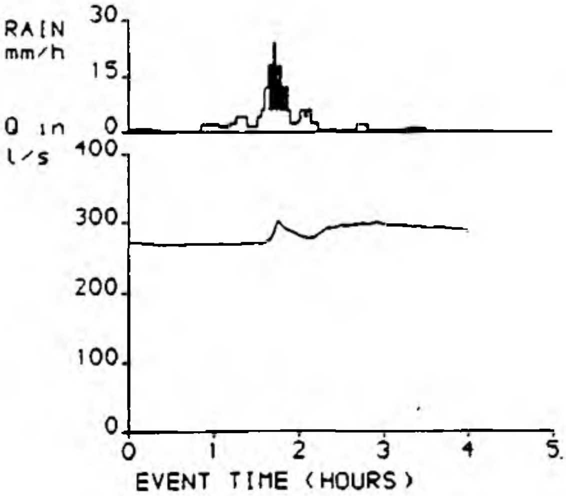
NO DATA FOR TDS

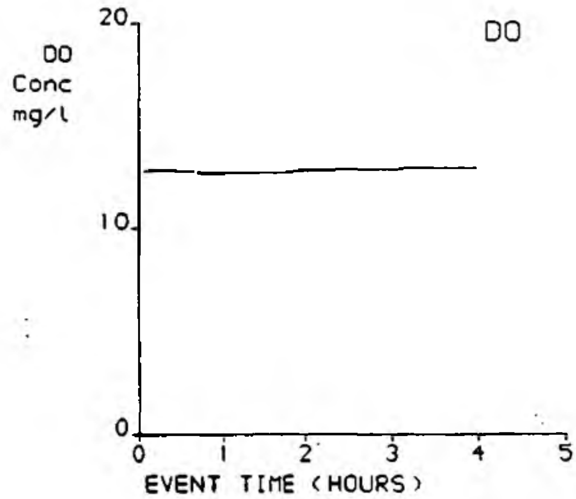


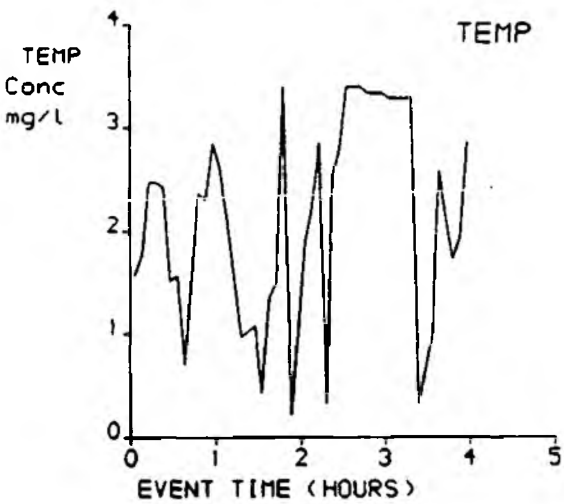


Site: NANT FFRWD,U/S VICTORIA RD BRIDGE GN89030602.DAT

Grid Ref: 264042 Weather Conditions:
Storm Date: 890306 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 1450 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 7.6 Rainfall Event Duration (mins): 209.





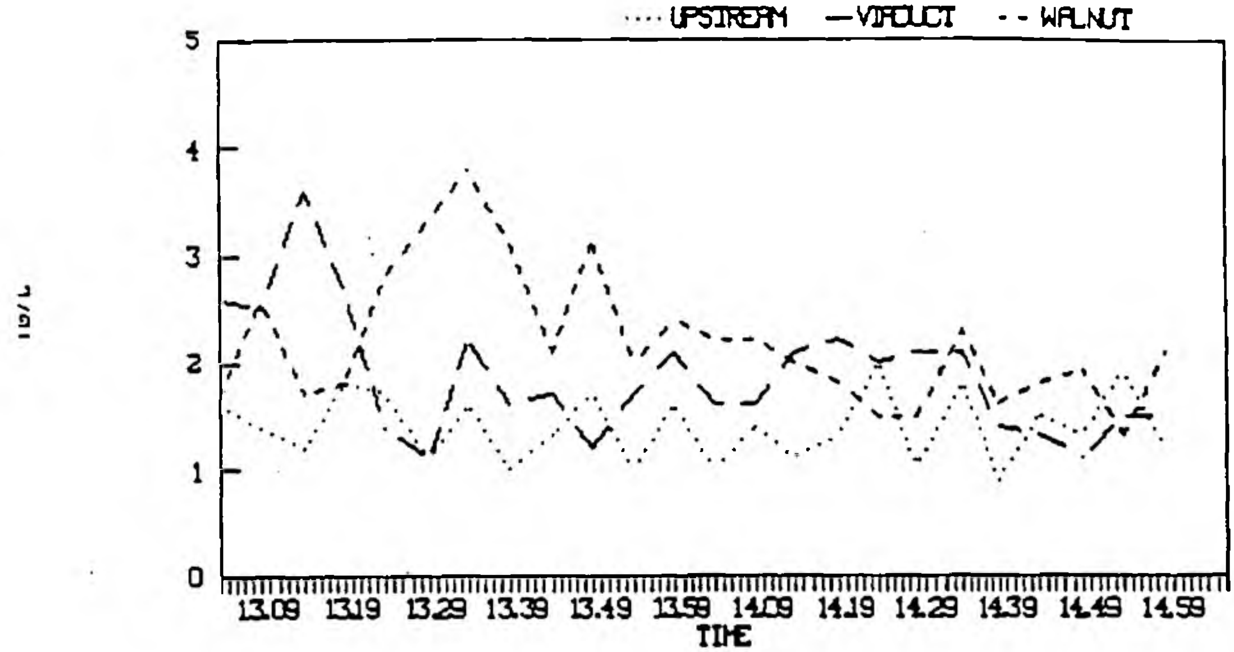


NO DATA FOR Cond

NO DATA FOr

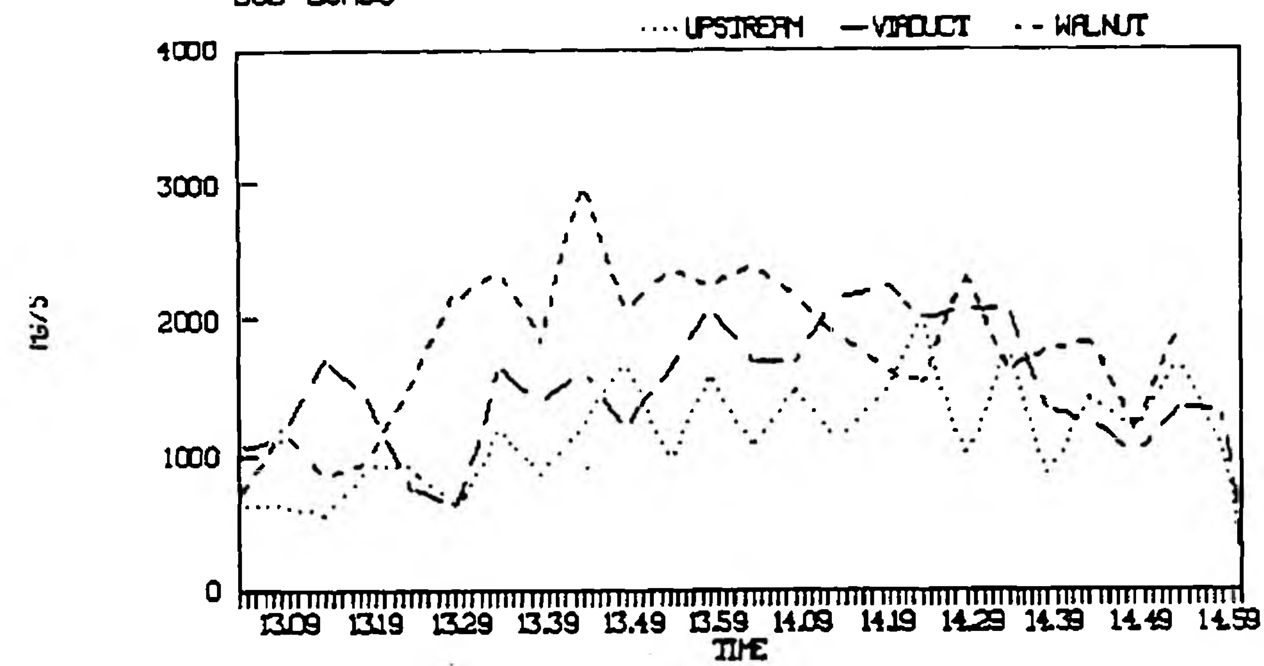
GARNDIFFAITH SSO EVENT 16 19-03-89

BOD CONCENTRATIONS



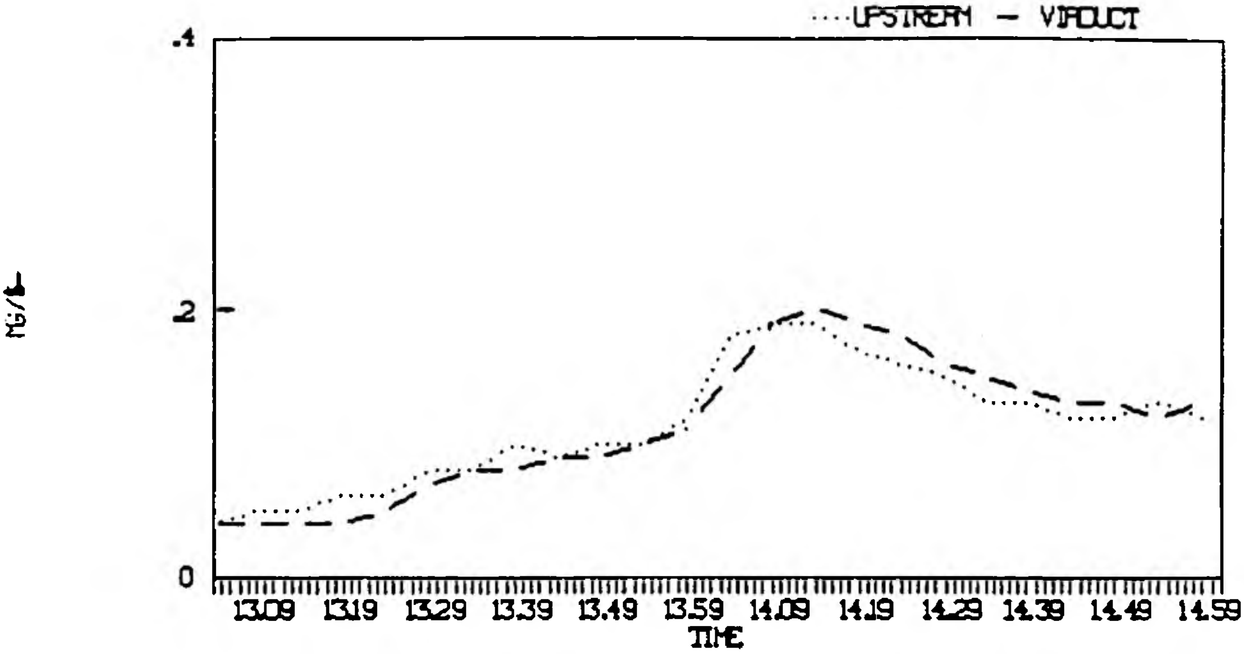
GARNDIFFAITH SSO EVENT 16 19-03-89

BOD LOADS



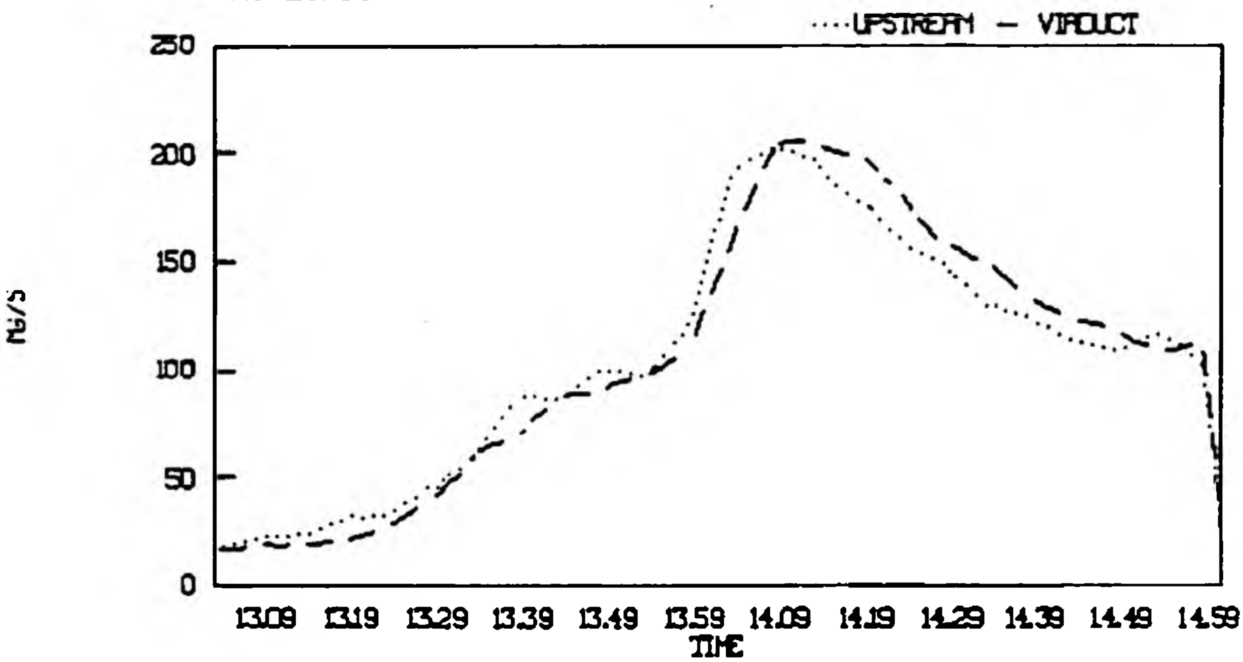
GARNDIFFAITH SSO EVENT 16 19-03-89

NH3 CONCENTRATIONS



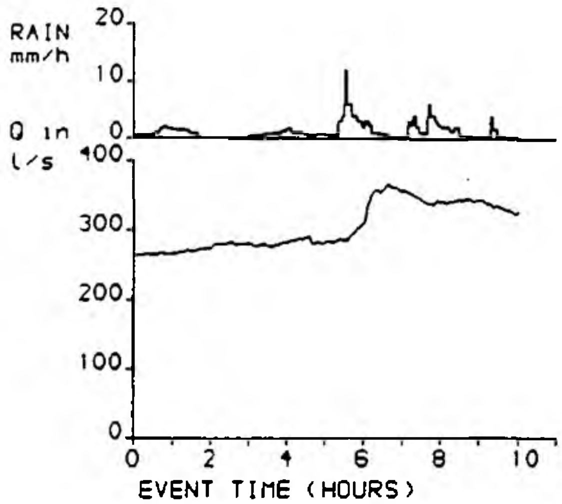
GARNDIFFAITH SSO EVENT 16 19-03-89

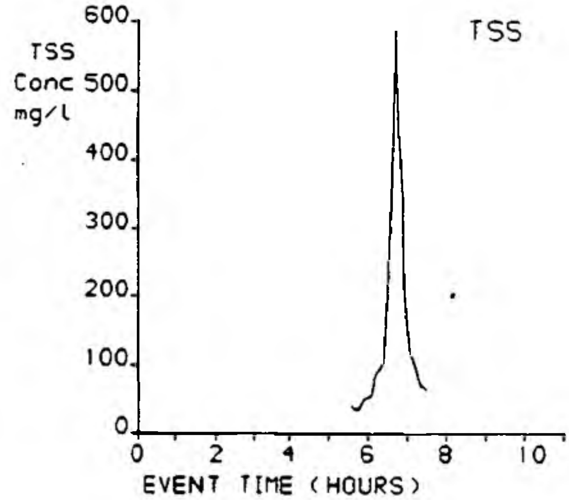
NH3 LOADS



Site: NANT FFRWD, U/S SSO GARNDIFFAITH GN890319U1.DAT

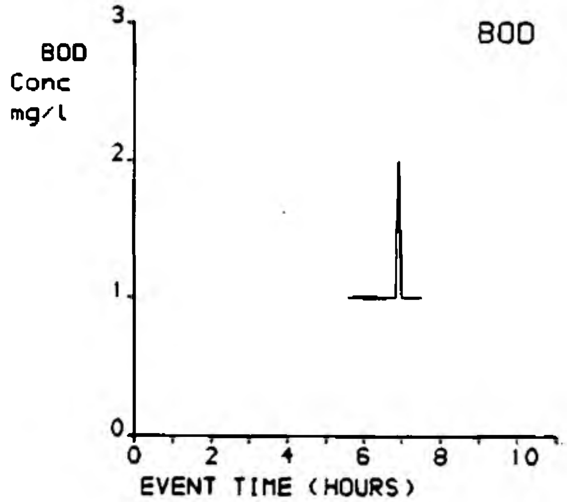
Grid Ref: 262045	Weather Conditions:
Storm Date: 890319	Date/Time last recorded storm: 0/ 0
Start Time (R/F): 730	Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 12.2	Rainfall Event Duration (mins): 593.

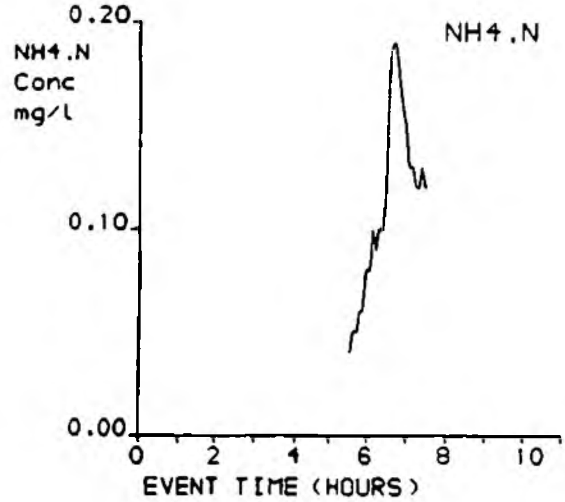




NO DATA FOR COD

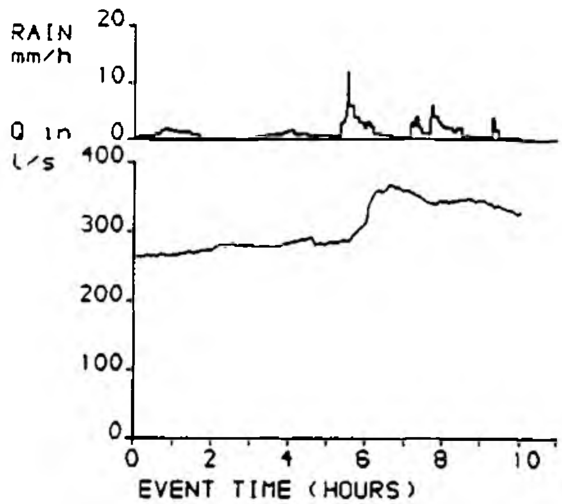
NO DATA FOR TDS

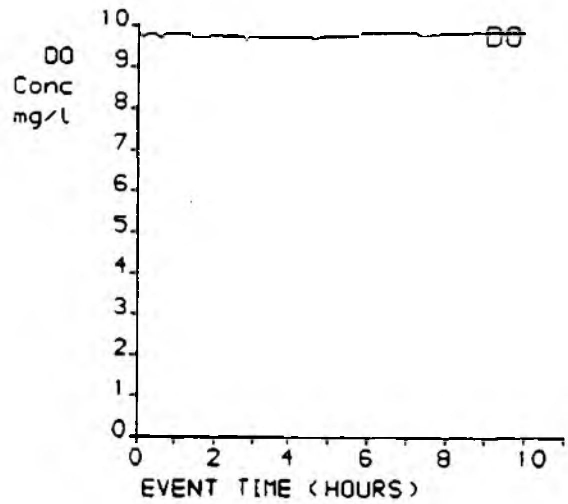


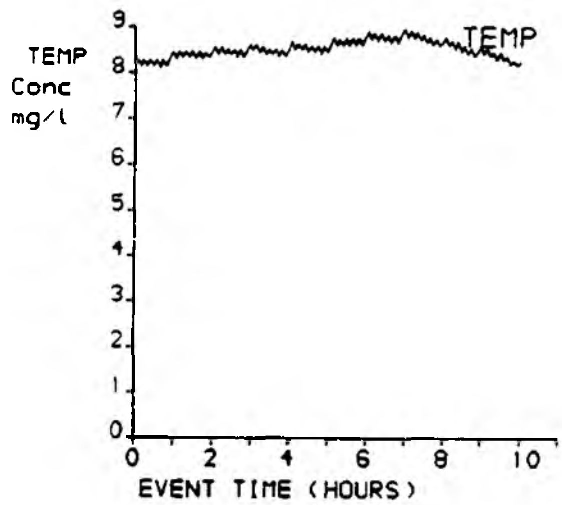


Site: NANT FFRWD, U/S SSO GARNDIFFAITH GN890319U1.DAT

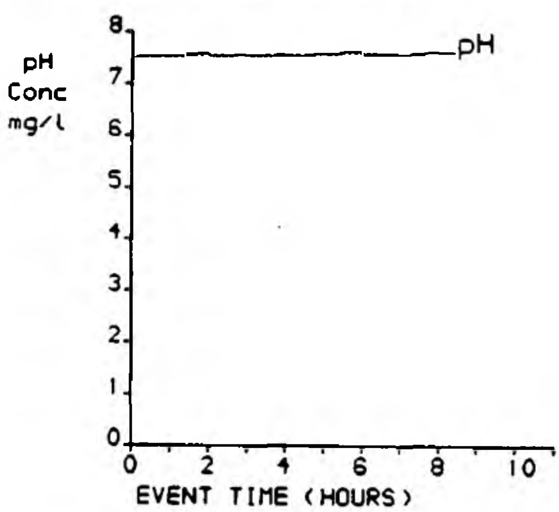
Grid Ref: 262045 Weather Conditions:
Storm Date: 890319 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 730 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 12.2 Rainfall Event Duration (mins): 593.







NO DATA FOR Cond

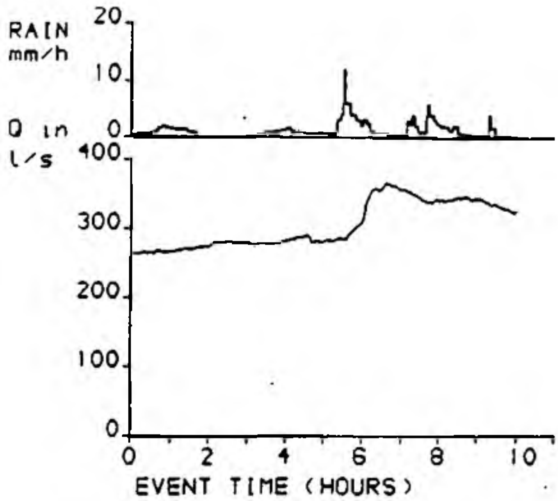


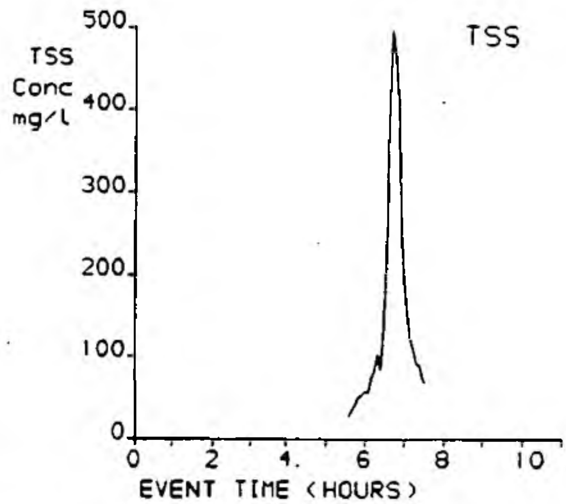
Site: NANT FFRWD, UNDER VIADUCT

GN89031901.DAT

Grid Ref: 262043
Storm Date: 890319
Start Time (R/F): 730
RainFall Depth (mm): 12.2

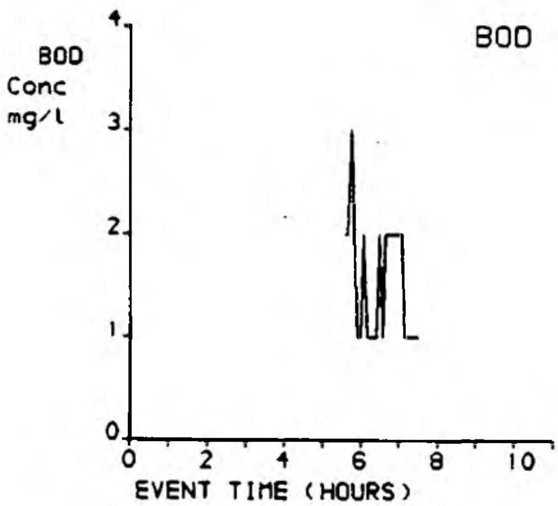
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
RainFall Event Duration (mins): 593.

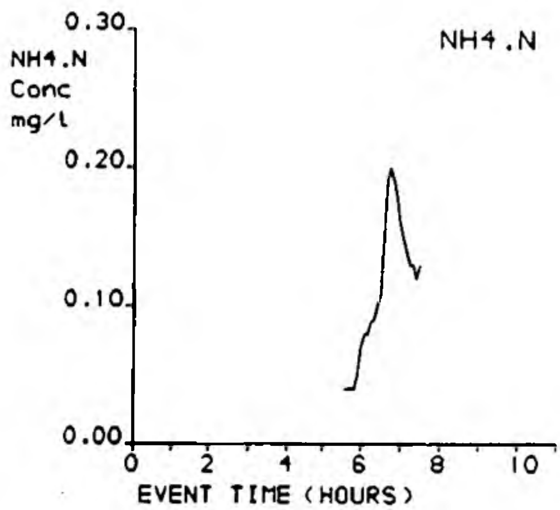




NO DATA FOR COD

NO DATA FOR TDS



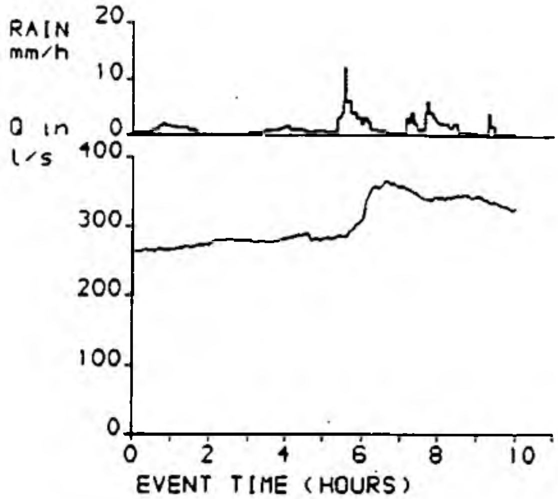


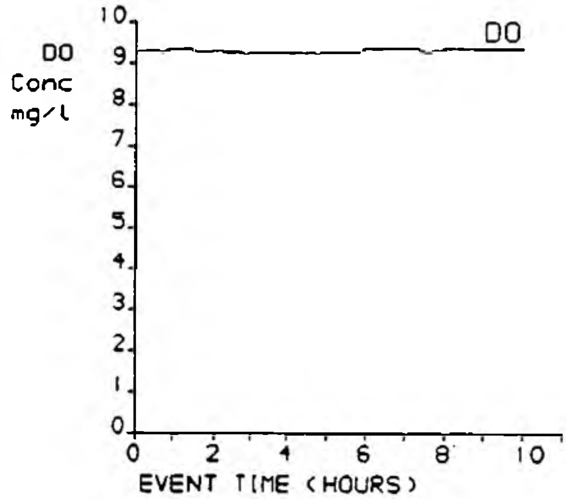
Site: NANT FFRWD, UNDER VIADUCT

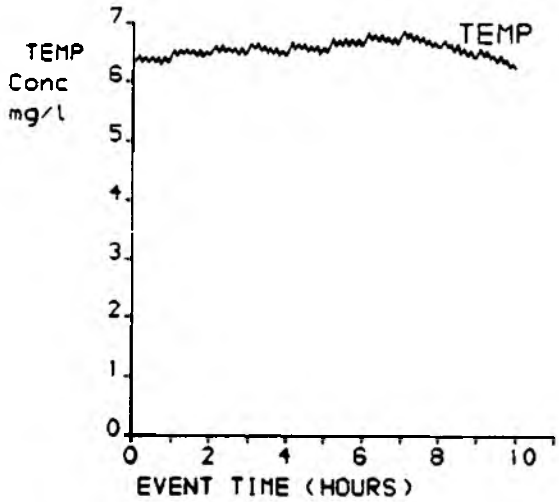
GN890319DI.DAT

Grid Ref: 262043
Storm Date: 890319
Start Time (R/F): 730
RainFall Depth (mm): 12.2

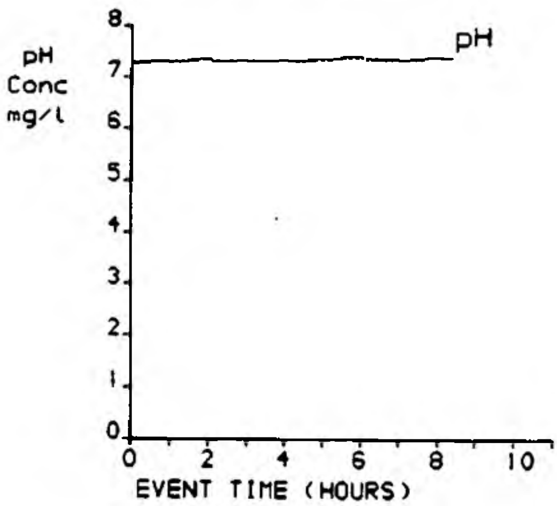
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
RainFall Event Duration (mins): 593.







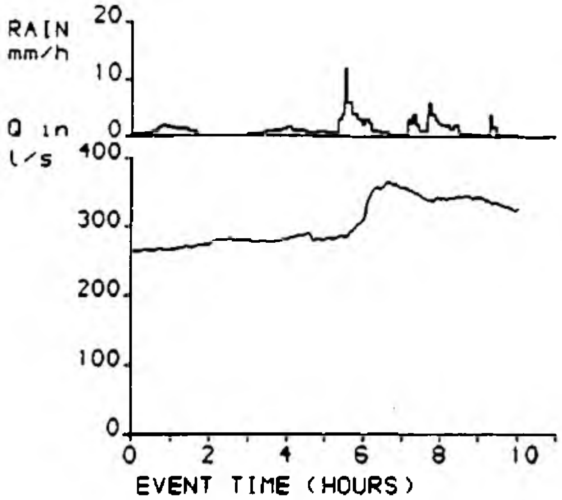
NO DATA FOR Cond

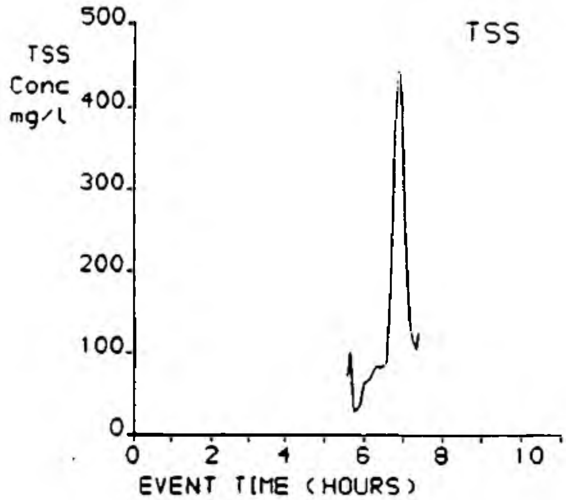


Site: NANT FFRWD,U/S VICTORIA RD BRIDGE GN89031902.DAT

Grid Ref: 264042
Storm Date: 890319
Start Time (R/F): 730
Rainfall Depth (mm): 12.2

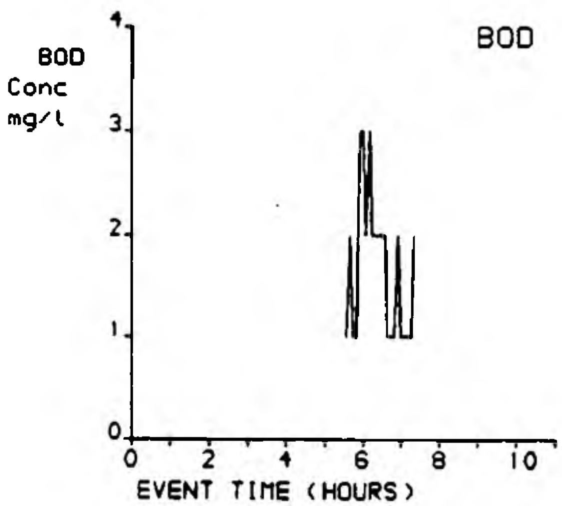
Weather Conditions:
Date/Time last recorded storm: 0/ 0
Antec. Dry Weather Period (hours): 0
Rainfall Event Duration (mins): 593.

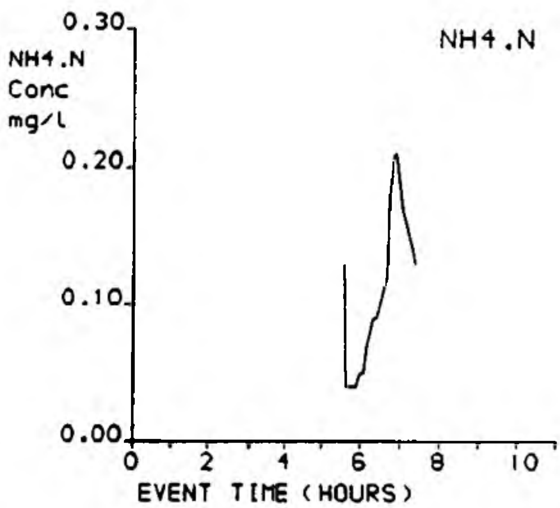




NO DATA FOR COD

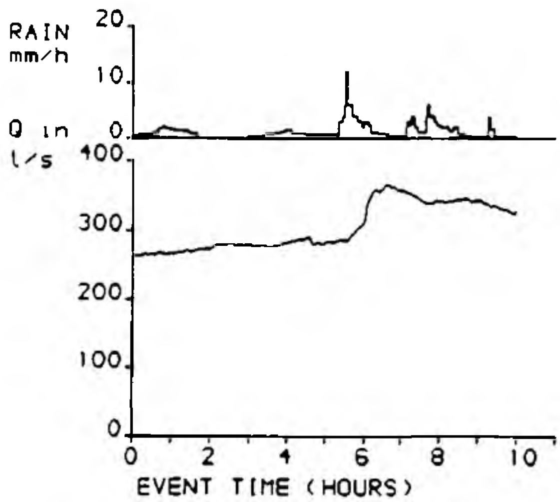
NO DATA FOR TDS

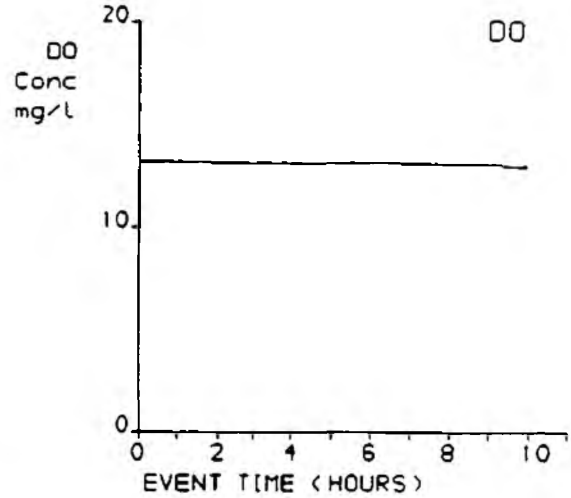


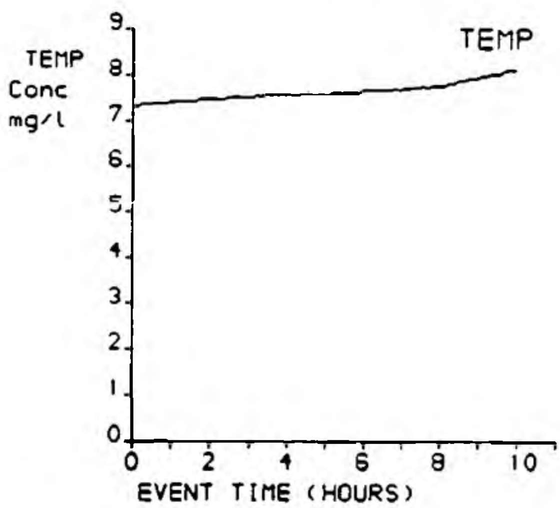


Site: NANT FFRWD,U/S VICTORIA RD BRIDGE GN89031902.DAT

Grid Ref: 264042 Weather Conditions:
Storm Date: 890319 Date/Time last recorded storm: 0/ 0
Start Time (R/F): 730 Antec. Dry Weather Period (hours): 0
Rainfall Depth (mm): 12.2 Rainfall Event Duration (mins): 593.



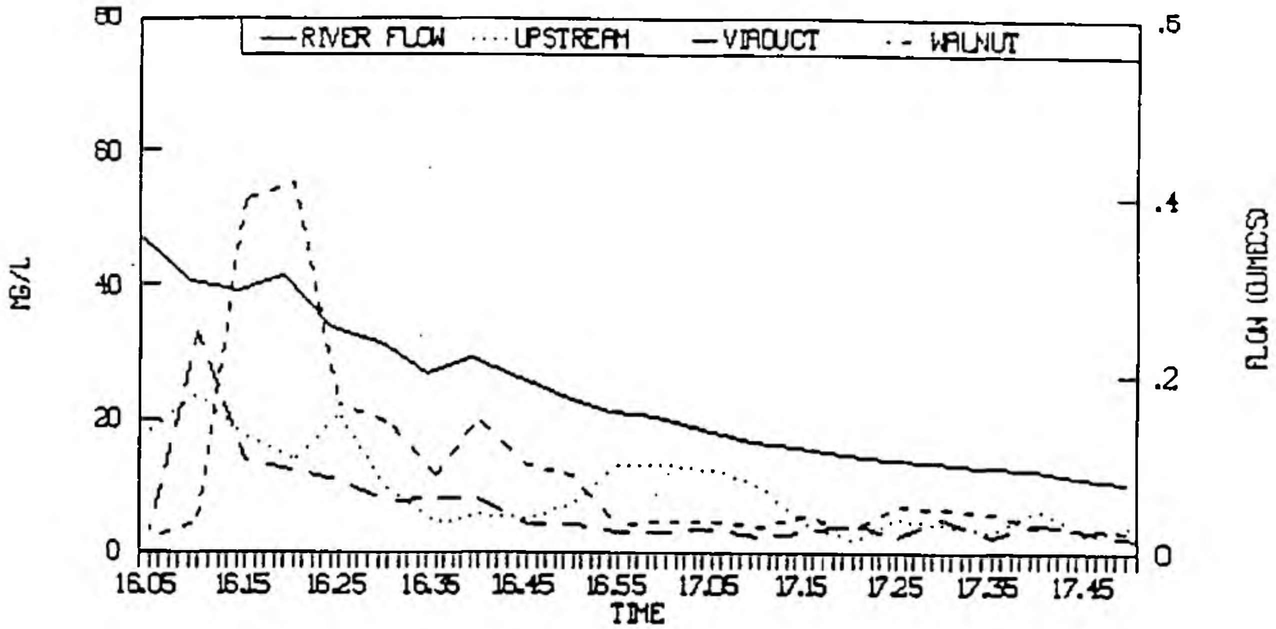




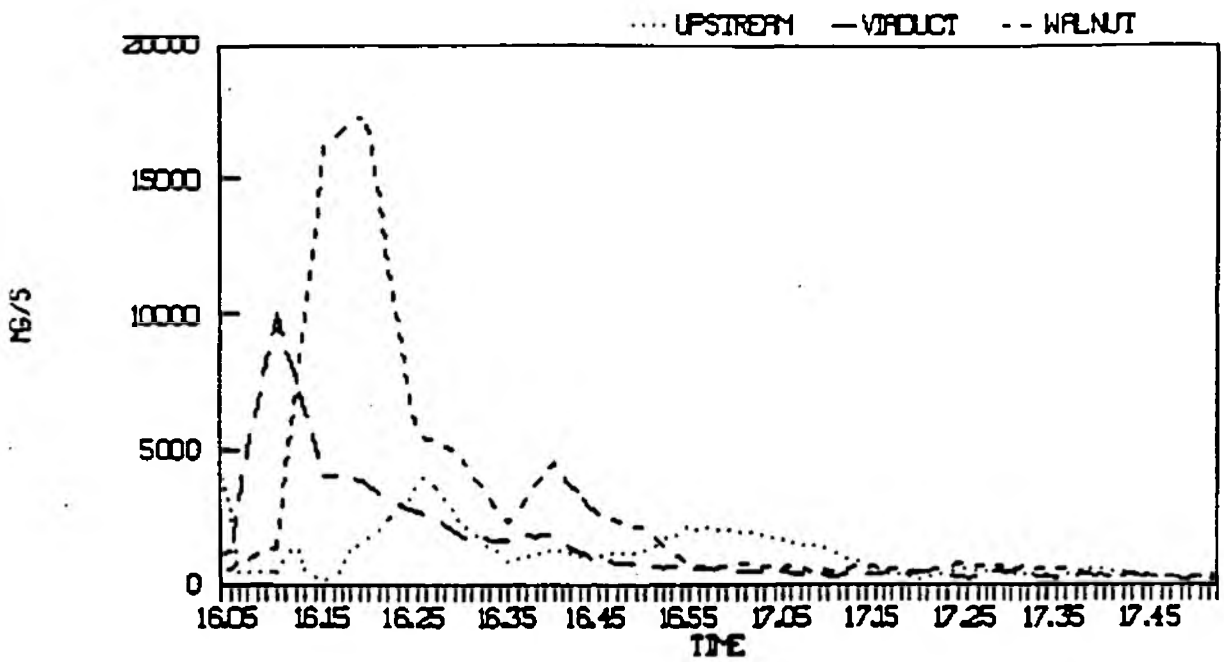
NO DATA FOR Cond

NO DATA FOR pl

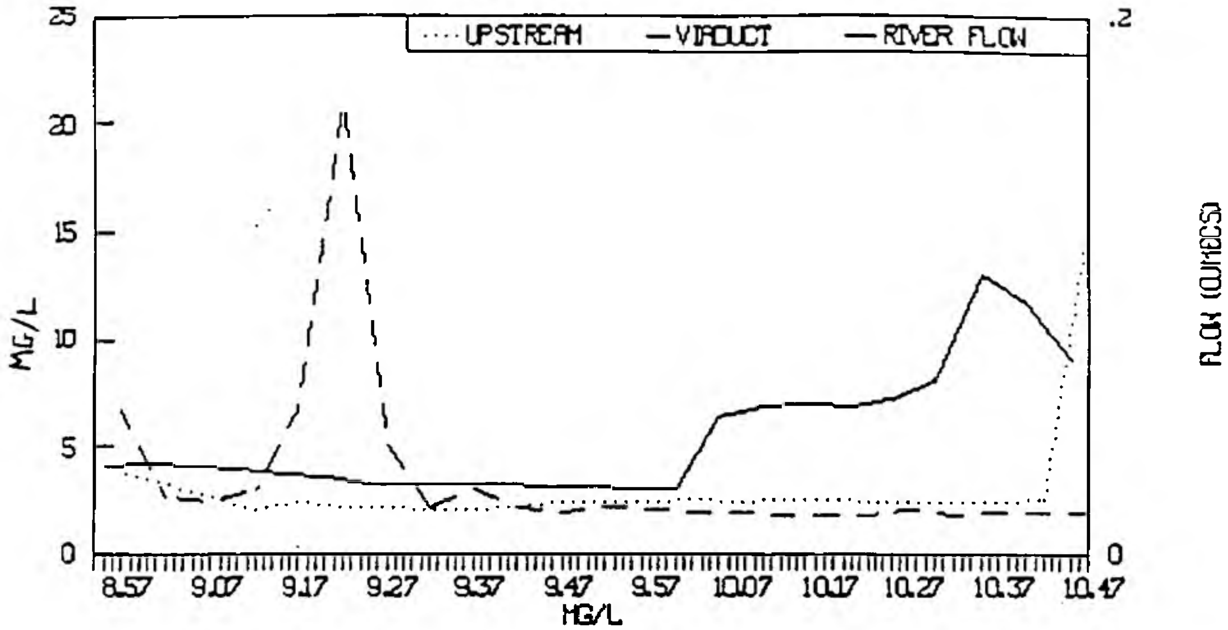
GARNDIFFAITH SSO EVENT 18 24-05-89
BOD CONCENTRATIONS



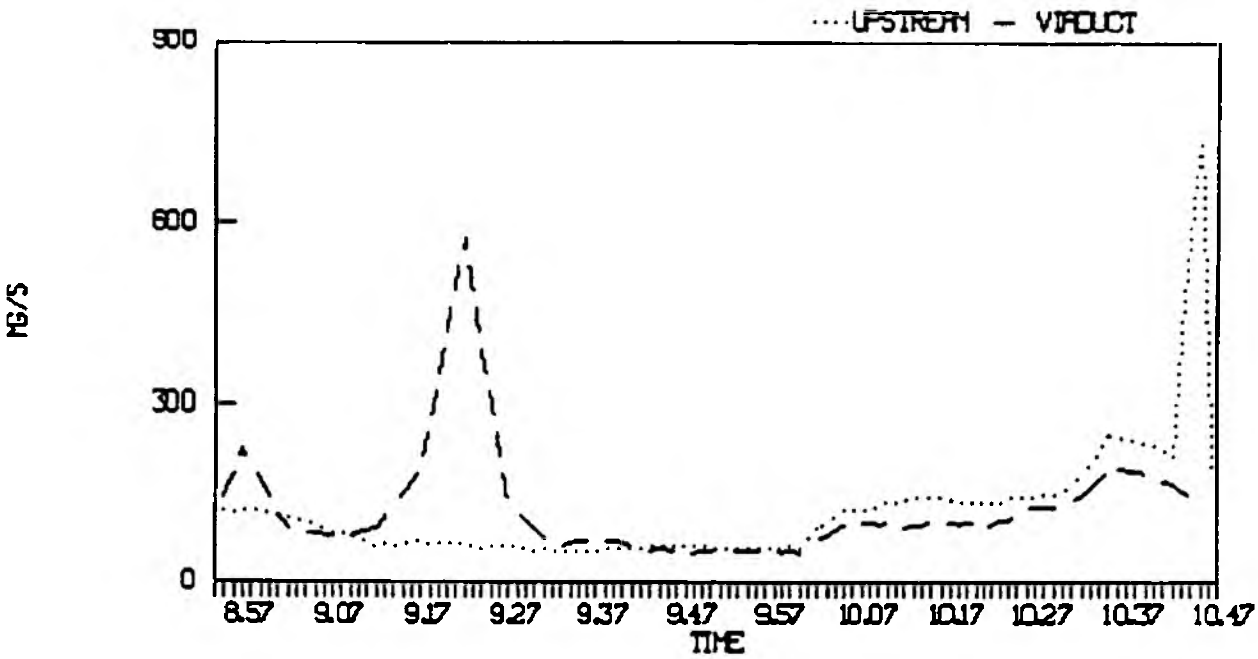
GARNDIFFAITH SSO EVENT 18 24-05-89
BOD LOADS



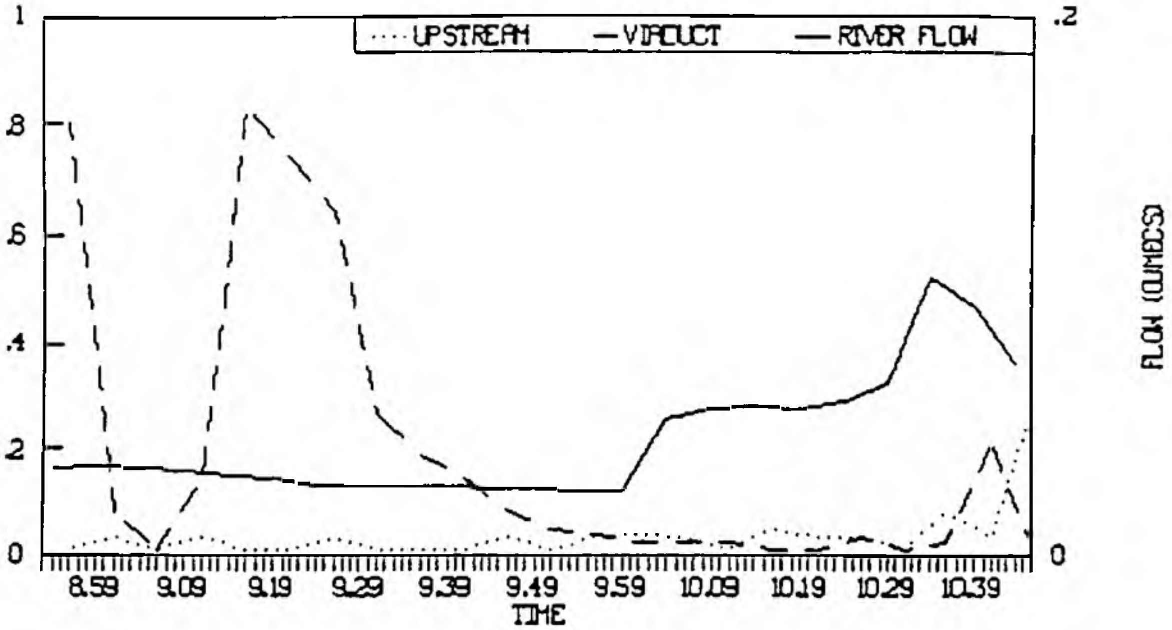
GARNDIFFAITH SSO EVENT 20 16-09-89
BOD CONCENTRATIONS



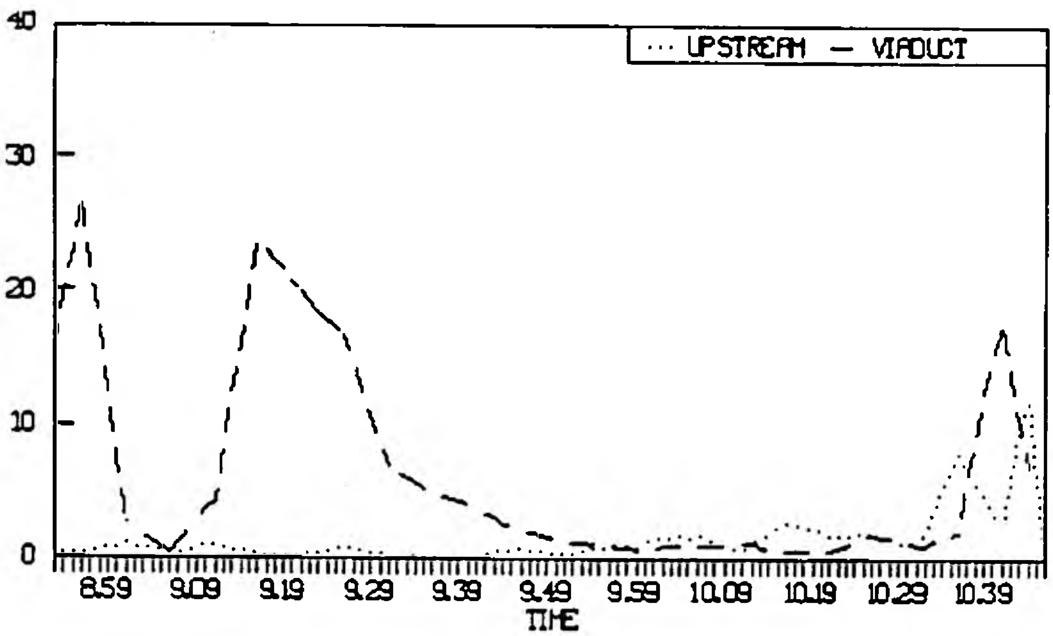
GARNDIFFAITH SSO EVENT 20 16-09-89
BOD LOADS

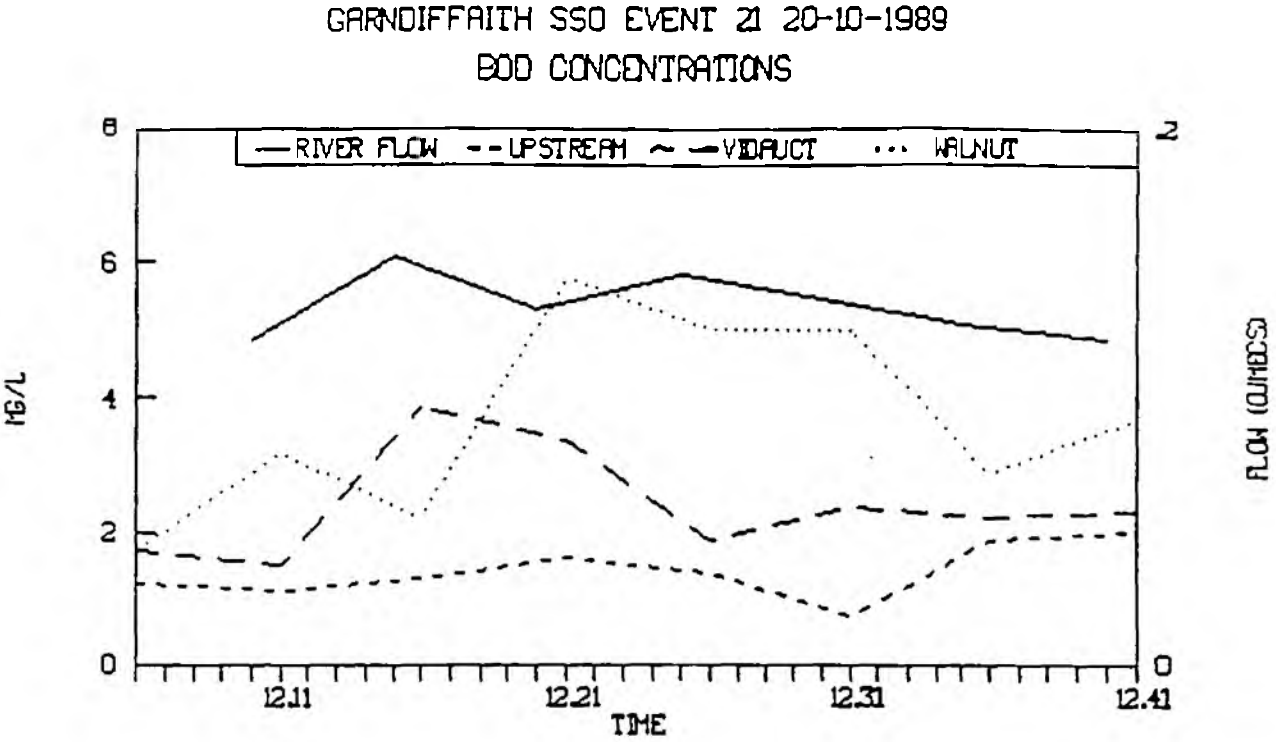


GARNDIFFAITH SSO EVENT 20 16-09-89
NH3 CONCENTRATIONS



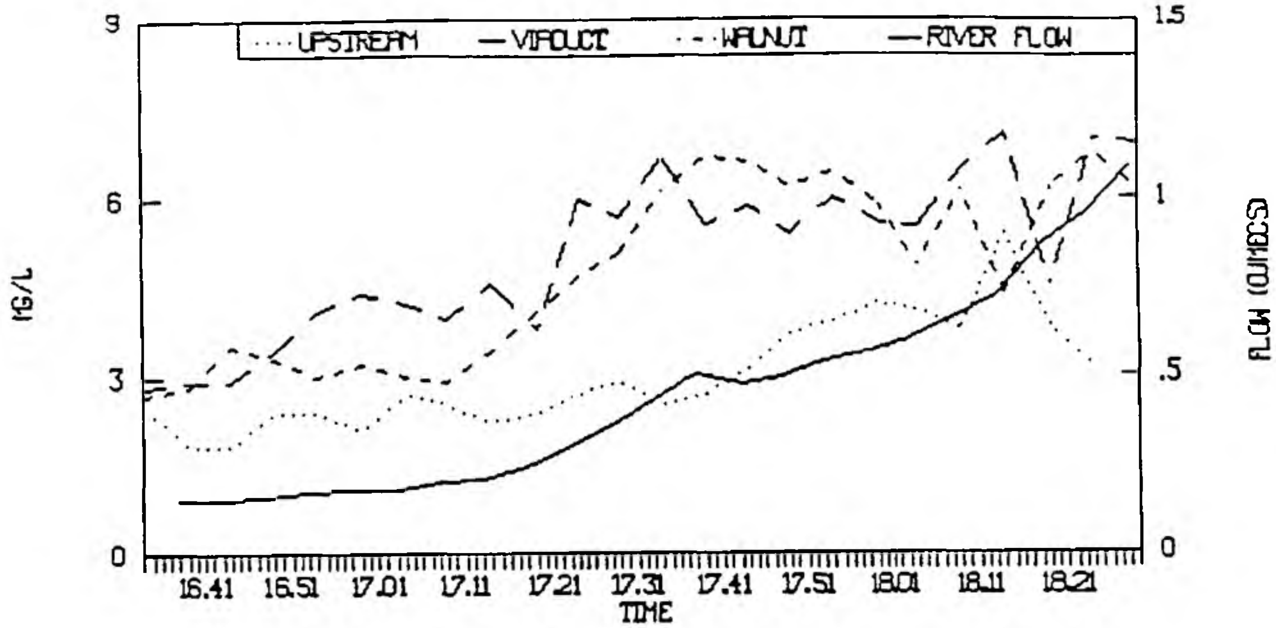
GARNDIFFAITH SSO EVENT 20 16-09-89
NH3 LOADS



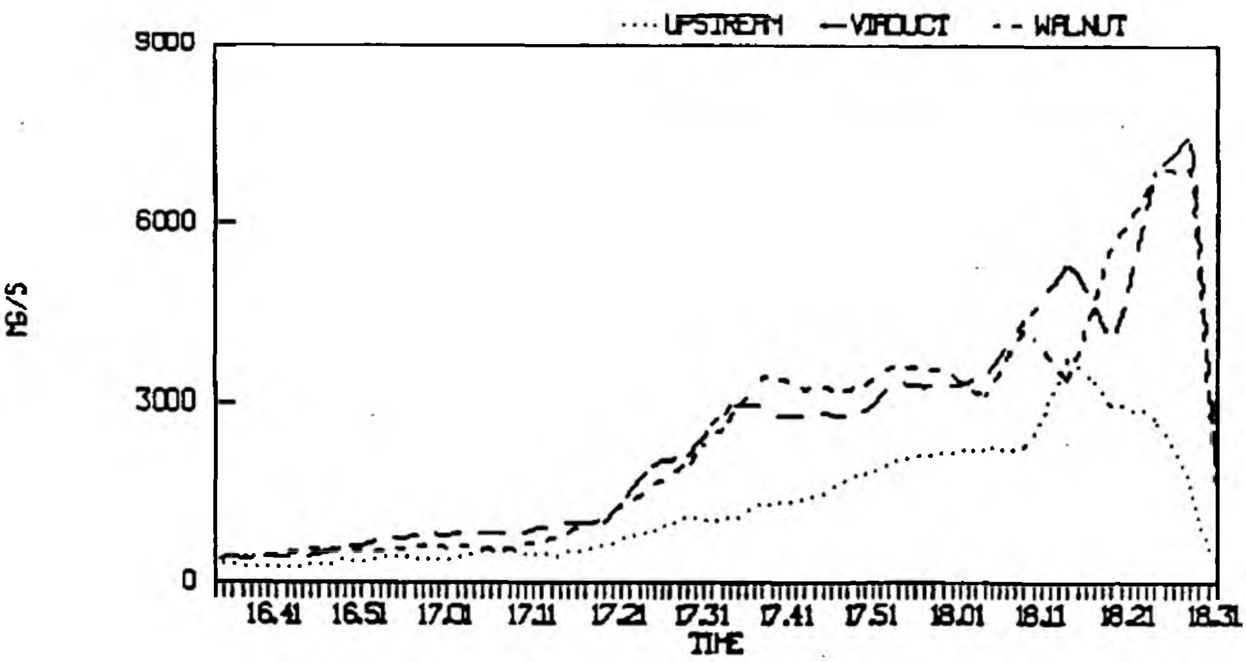


GARNDIFFAITH SSO EVENT 21 20-10-1989
BOD CONCENTRATIONS
RIVER FLOW
UPSTREAM
VIADUCT
WALNUT
MG/L
FLOW (CUMECS)
TIME
0
2
4
6
8
12.11
12.21
12.31
12.41

GARNDIFFAITH SSO EVENT 22 20-10-1989
BOD CONCENTRATIONS

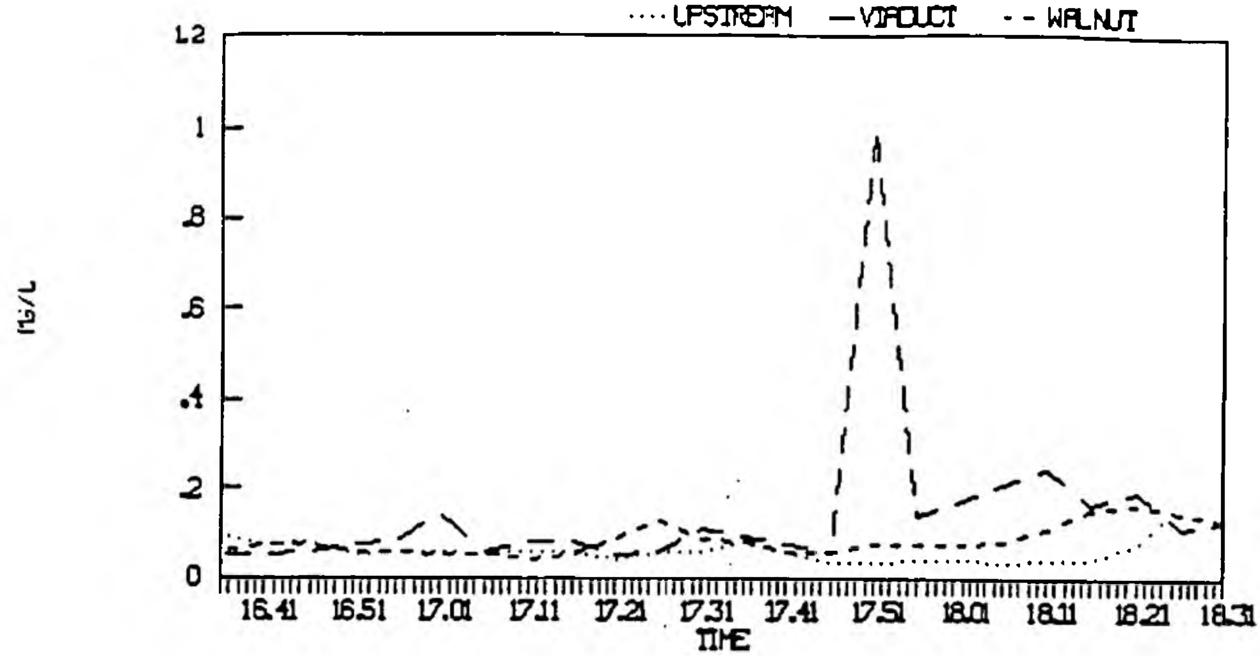


GARNDIFFAITH SSO EVENT 22 20-10-1989
BOD LOADS



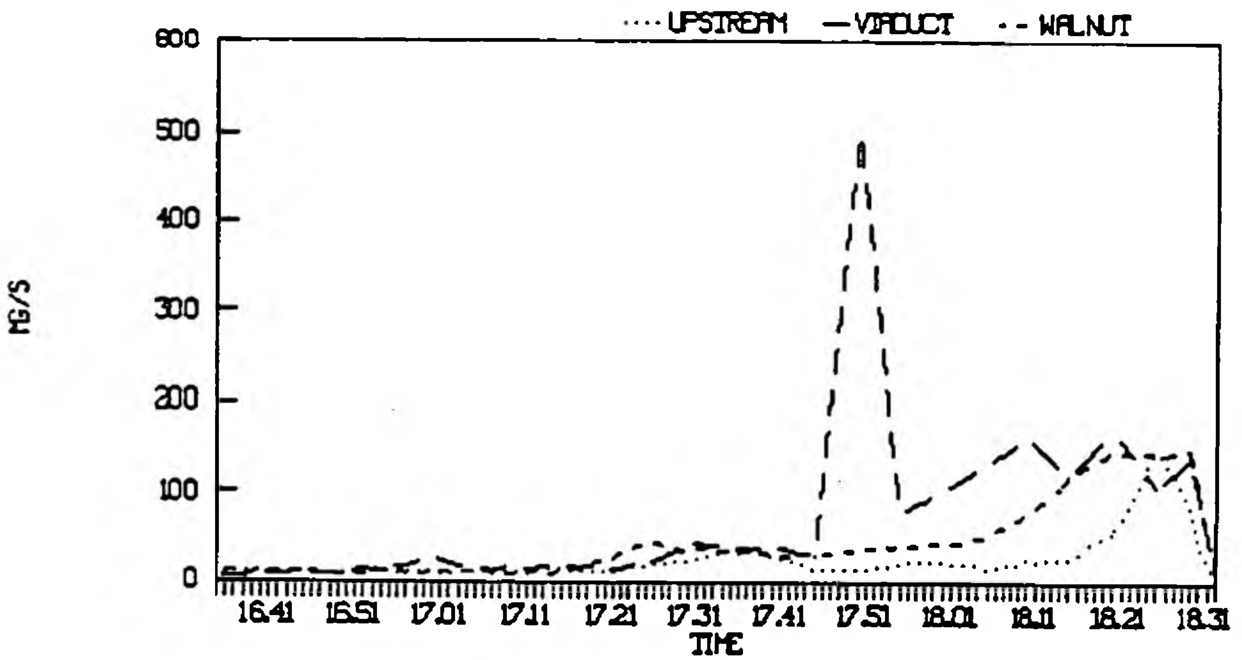
GARNDIFFAITH SSO EVENT 22 20-10-89

NH3 CONCENTRATIONS

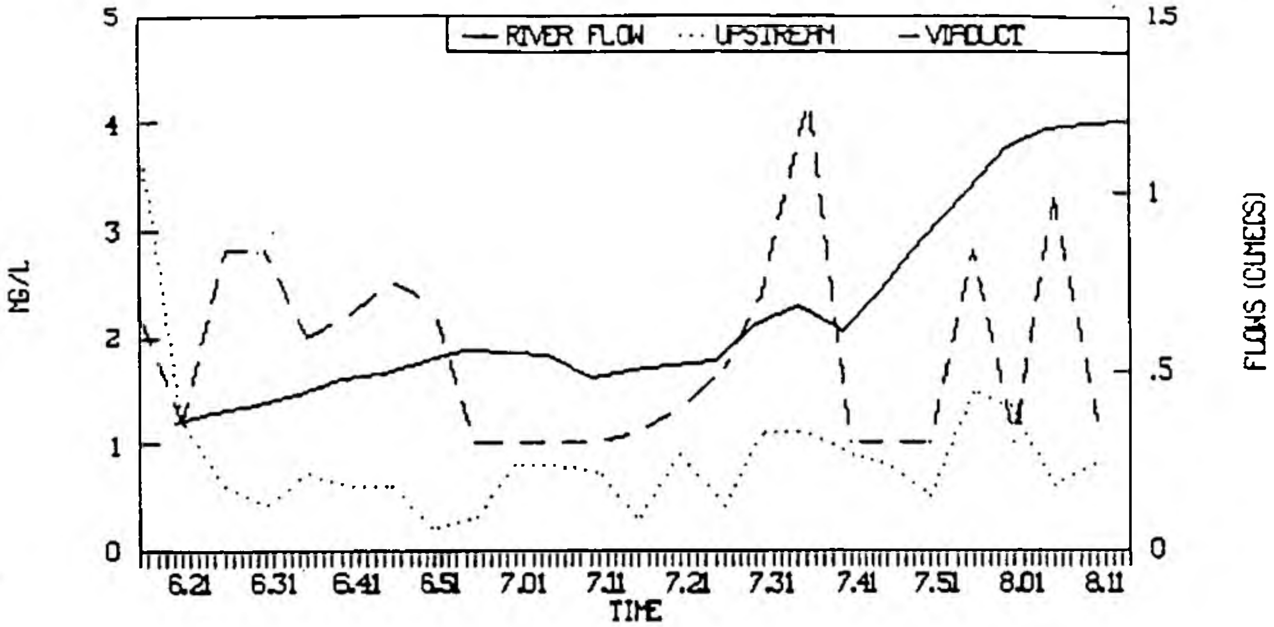


GARNDIFFAITH SSO EVENT 22 20-10-89

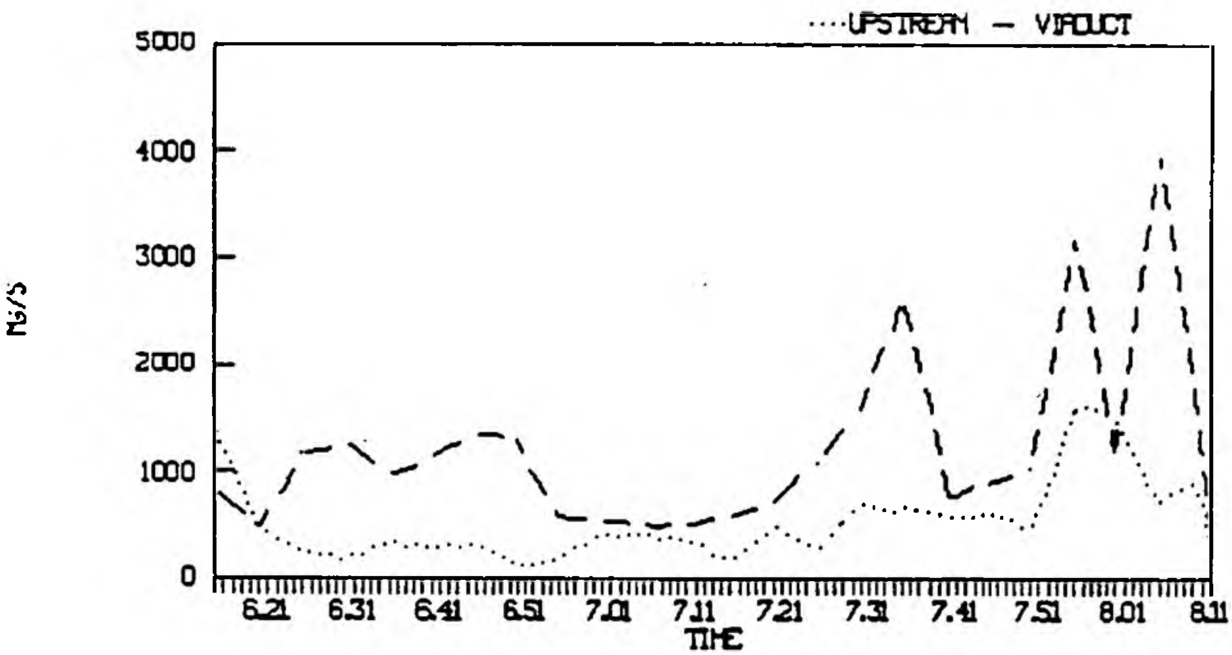
NH3 LOADS



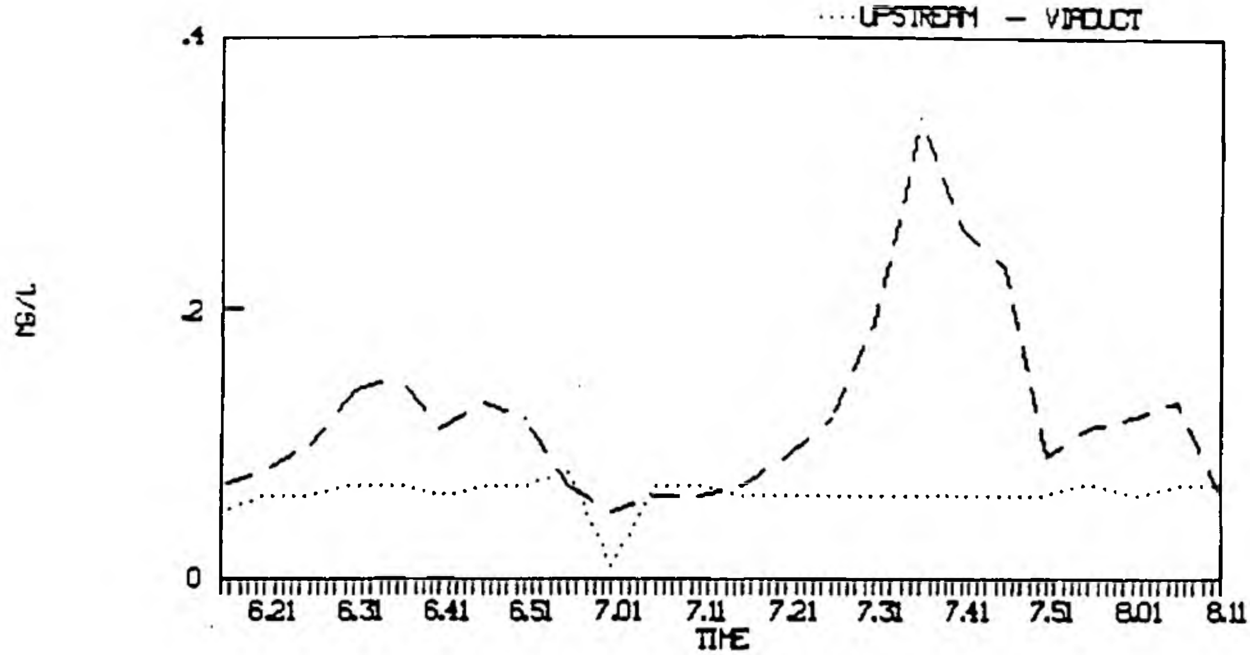
GARNDIFFAITH SSO EVENT 23 08-11-1989
BOD CONCENTRATIONS



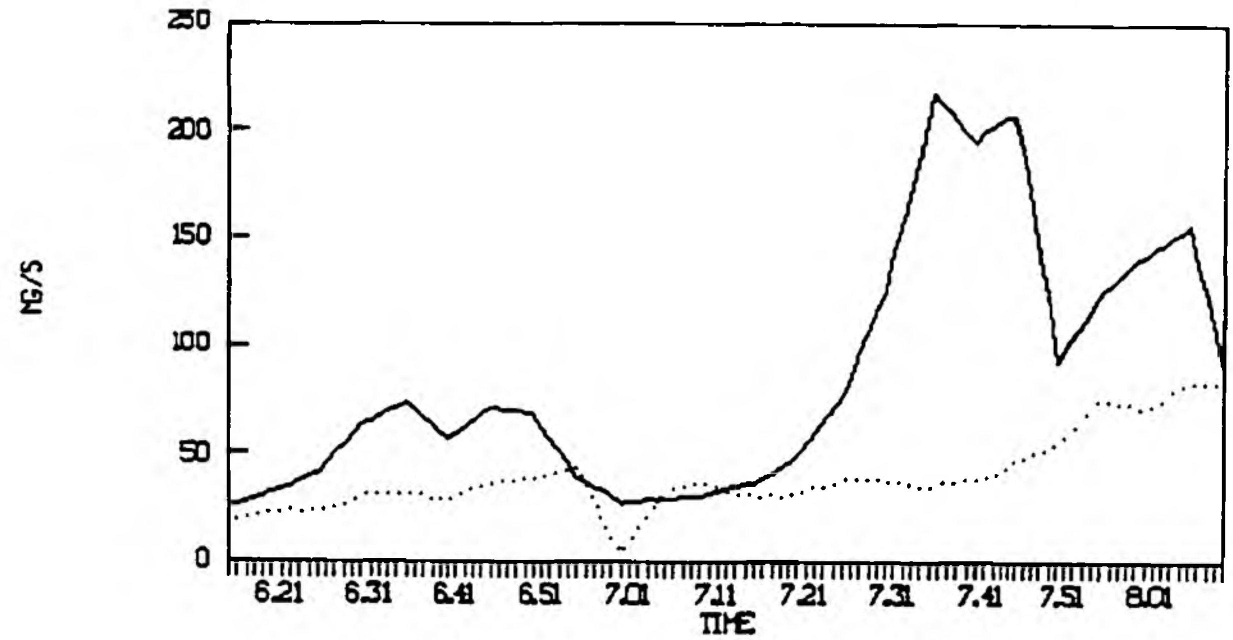
GARNDIFFAITH SSO EVENT 23 08-11-1989
BOD LOADS



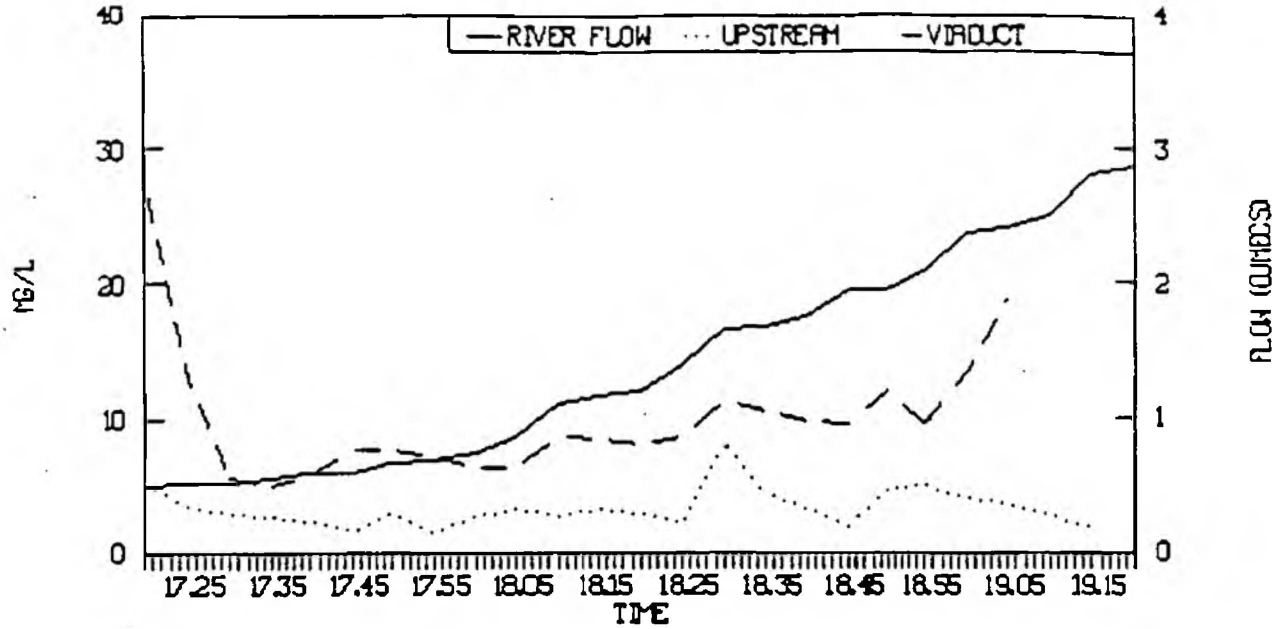
GARNDIFFAITH SSO EVENT 23 08-11-1989
NH3 CONCENTRATIONS



GARNDIFFAITH SSO EVENT 23 08-11-1989
NH3 LOADS



GARNDIFFAITH SSO EVENT 24 09-11-1989
BOD CONCENTRATIONS



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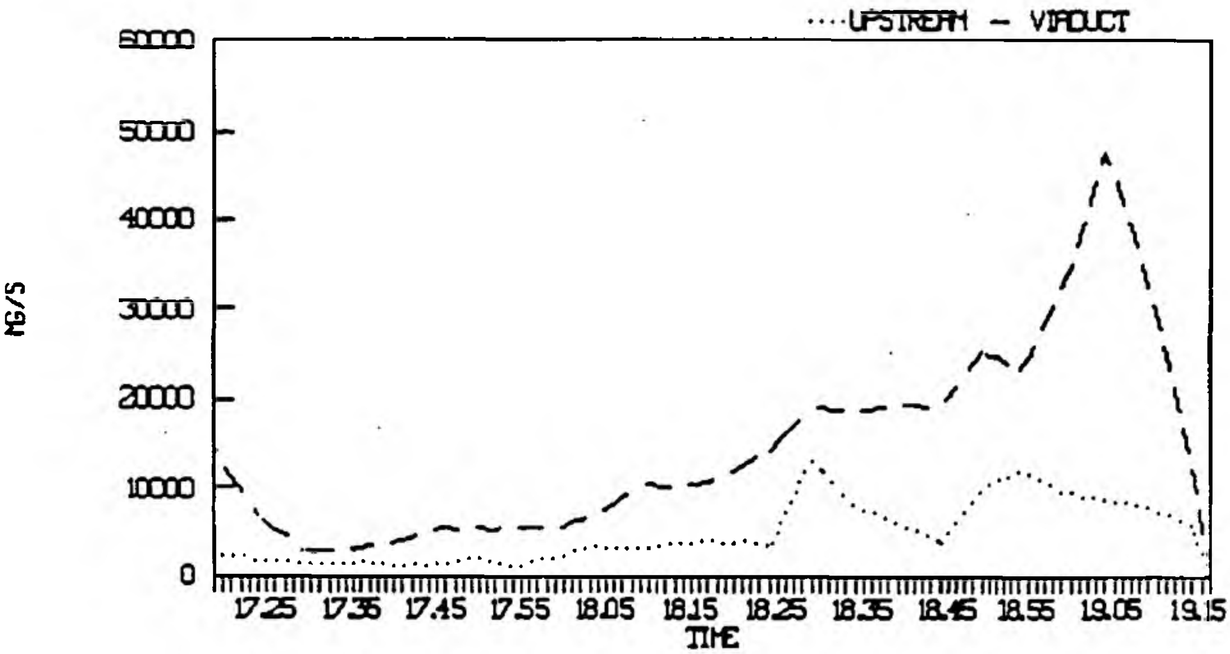

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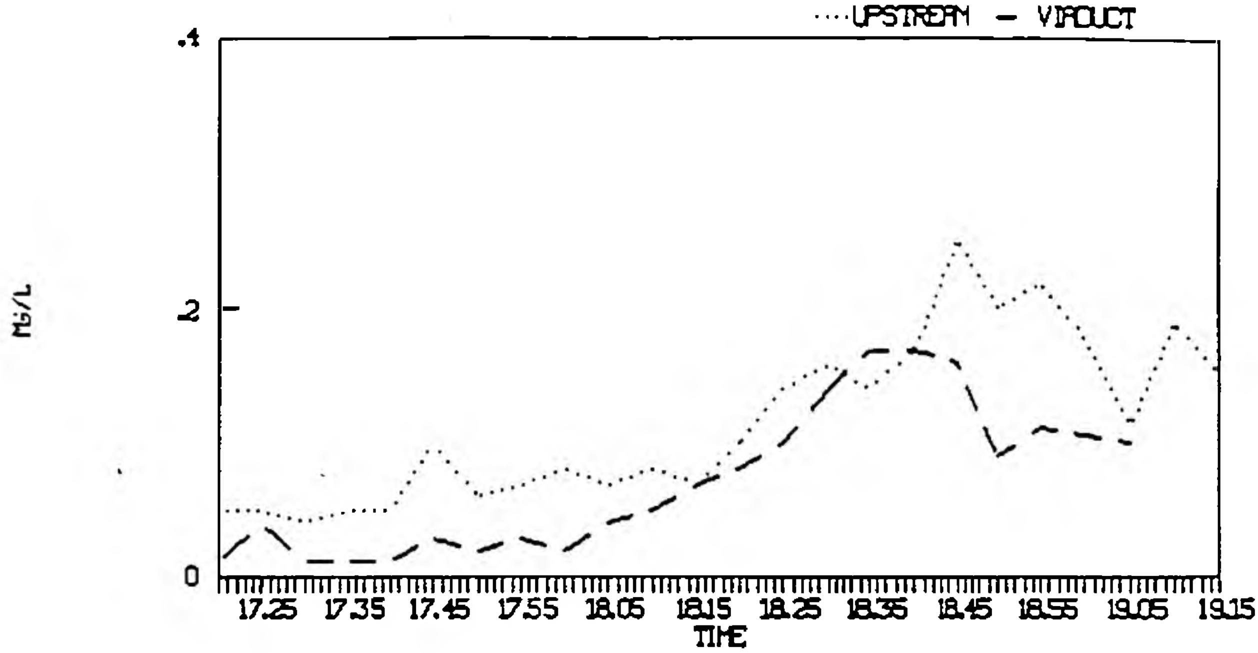

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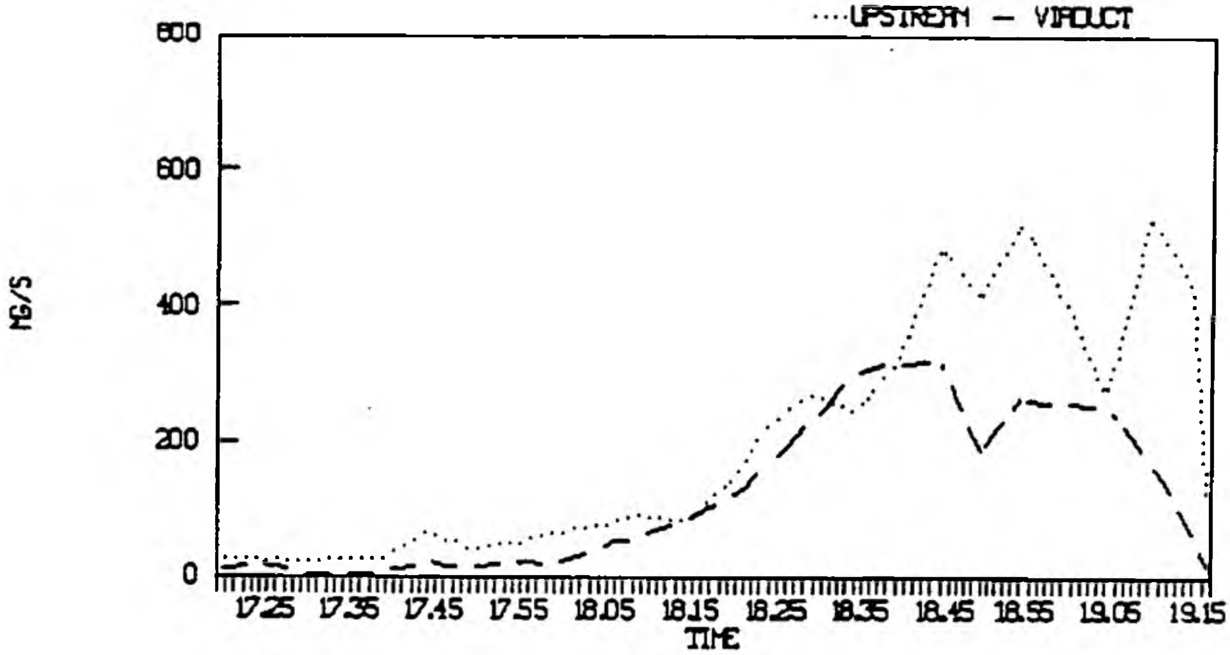

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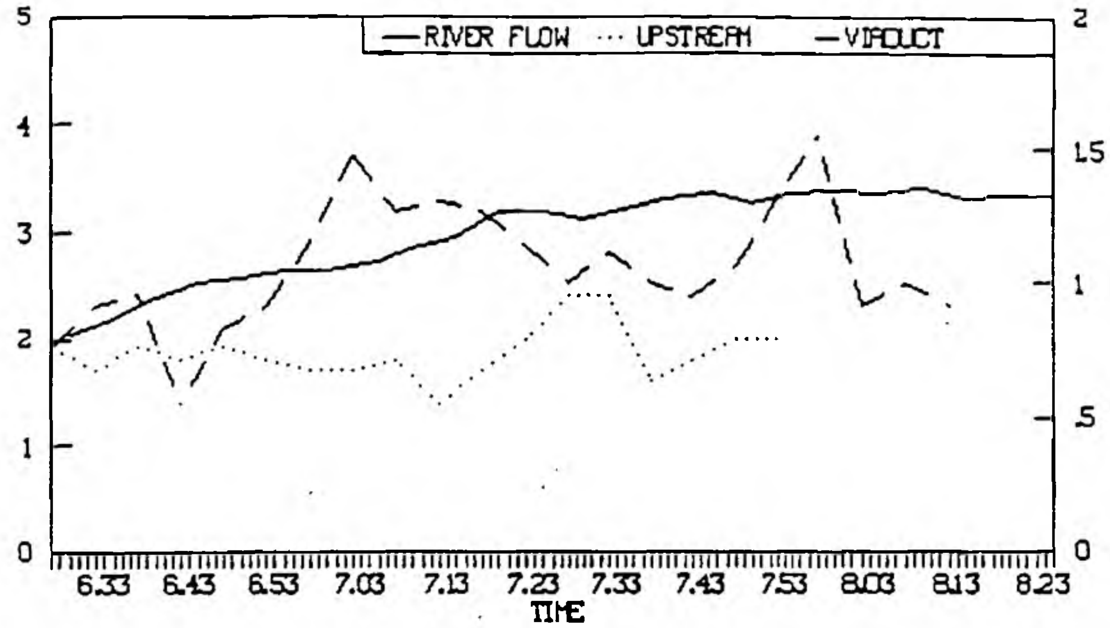
BOD CONCENTRATIONS



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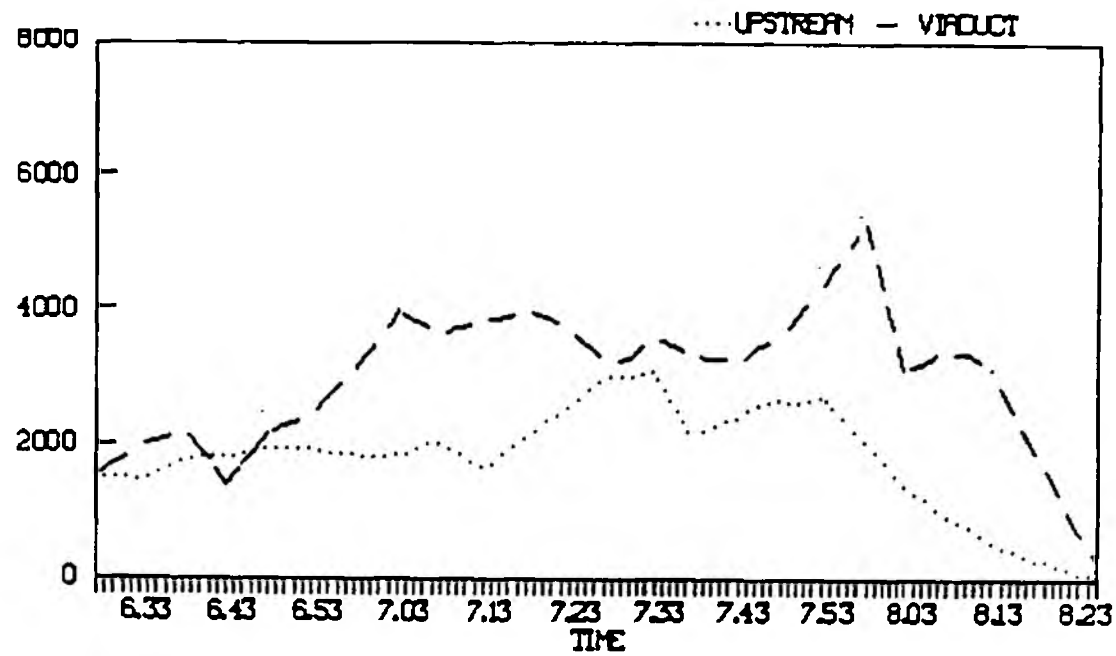

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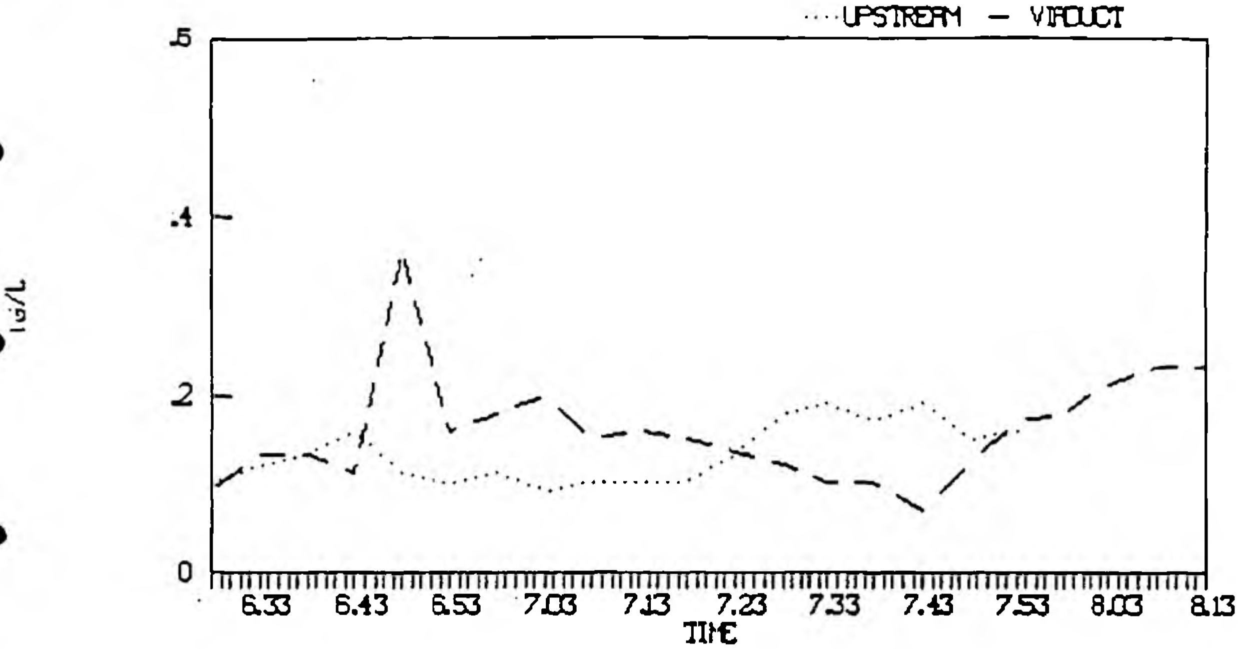

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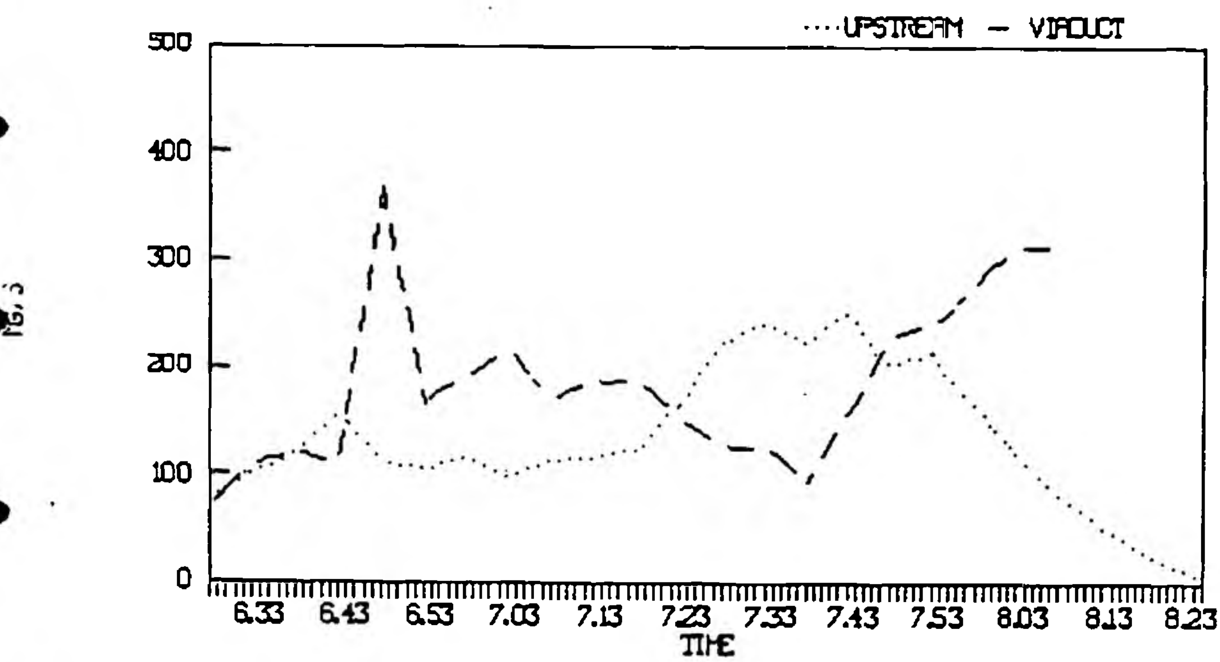

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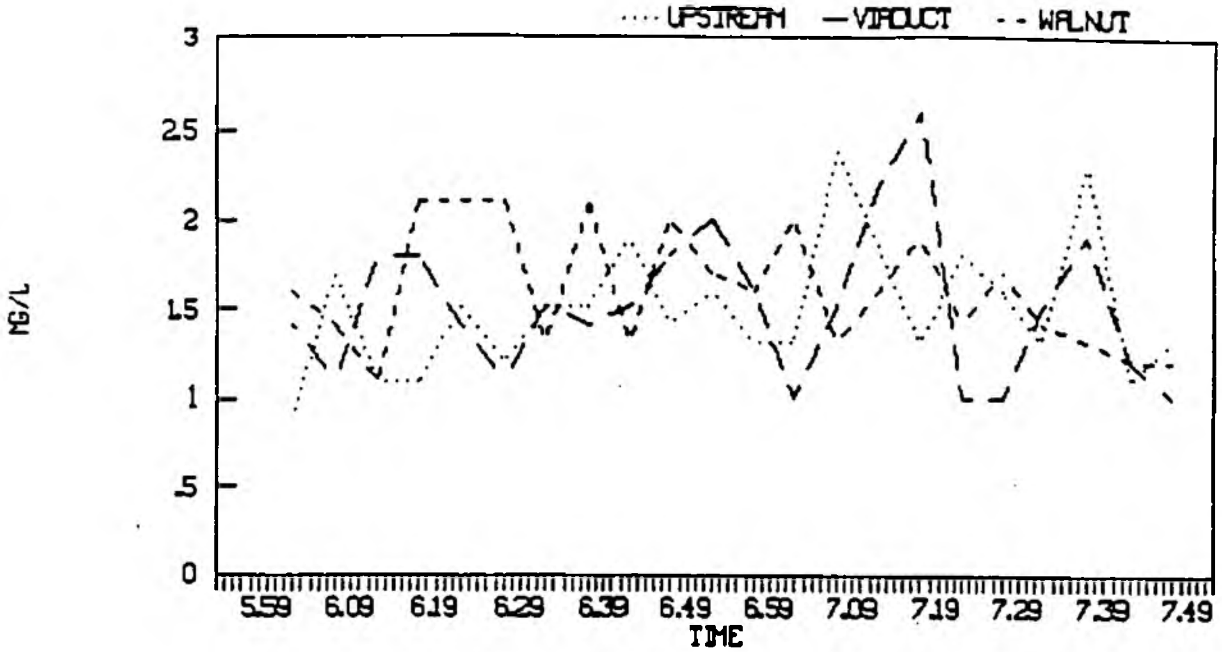

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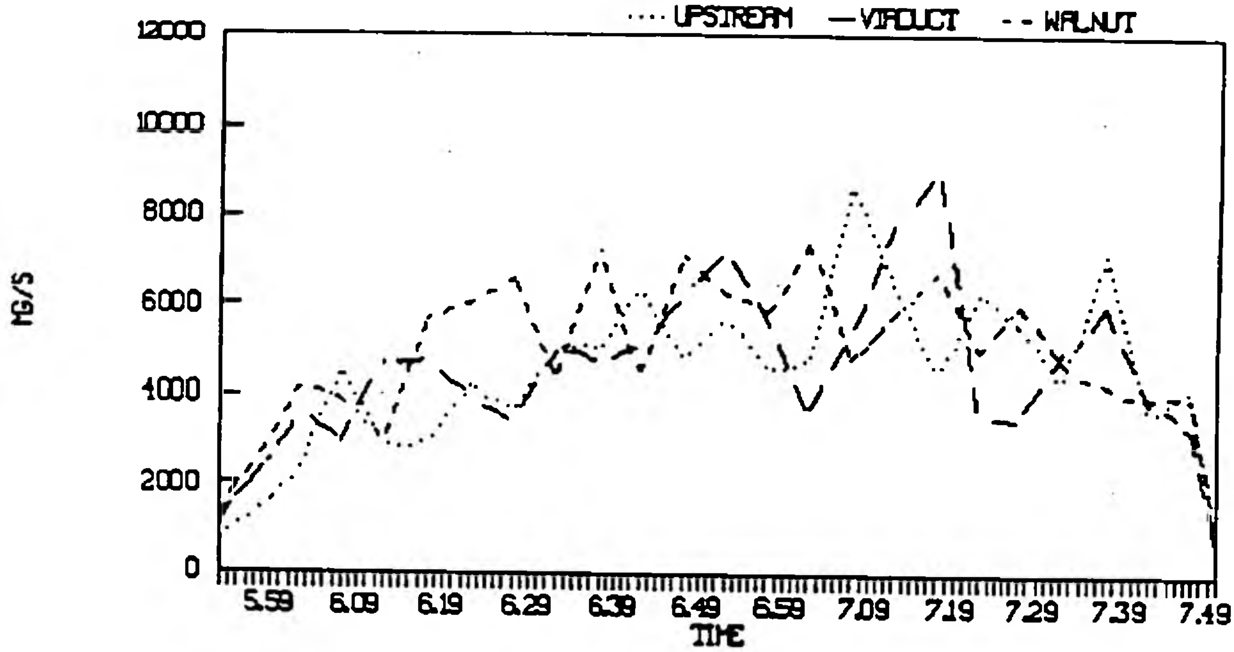

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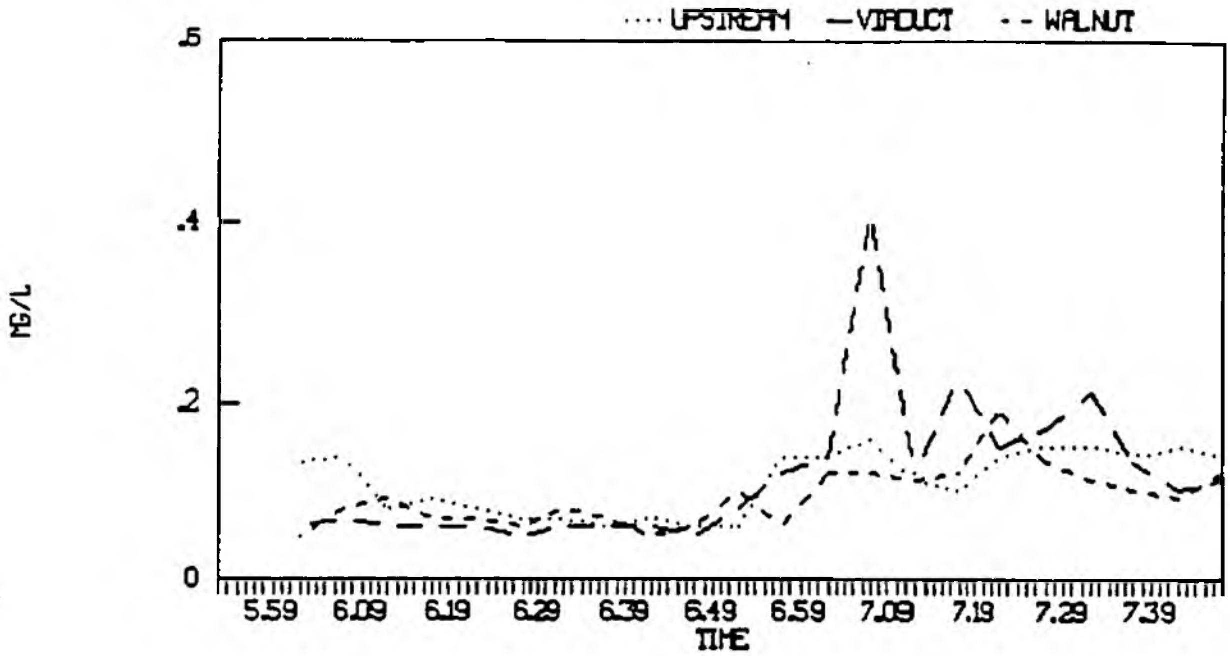
NH3 CONCENTRATIONS



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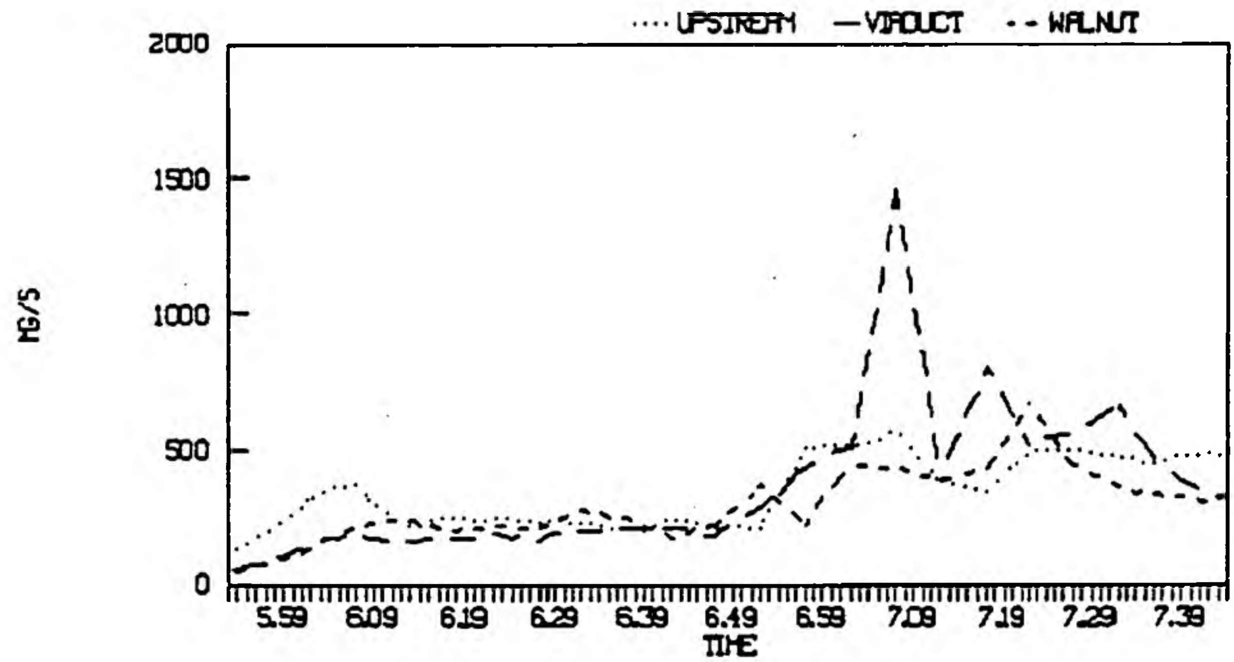

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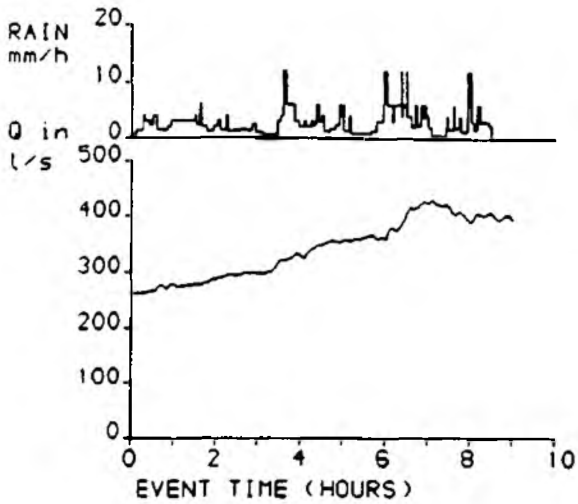

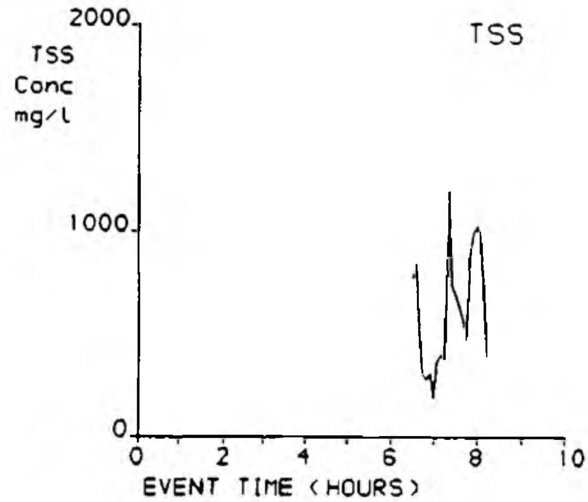

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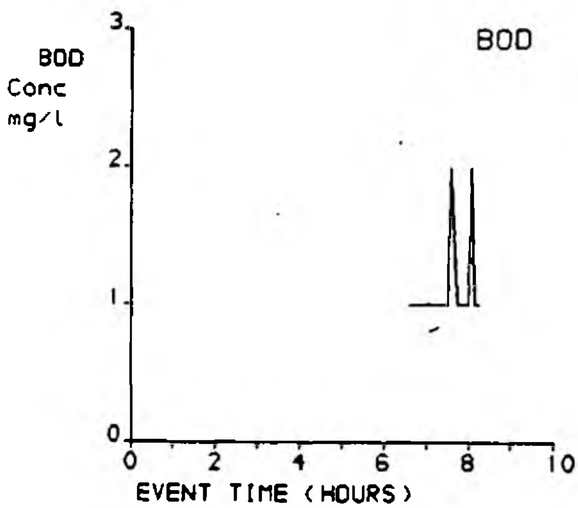

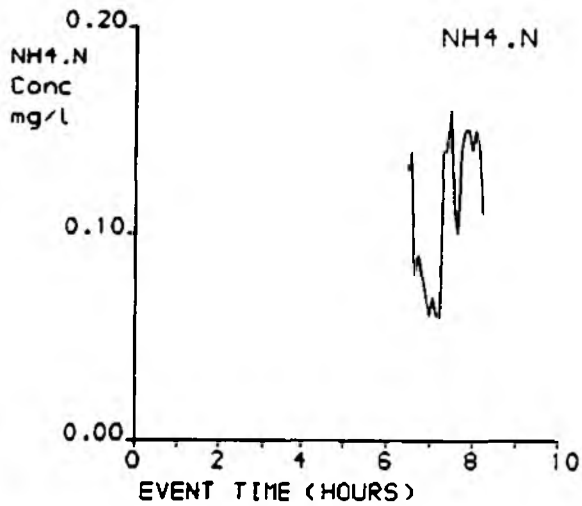

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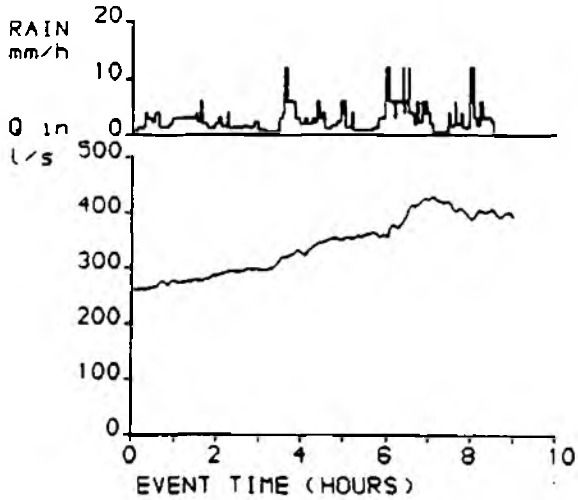

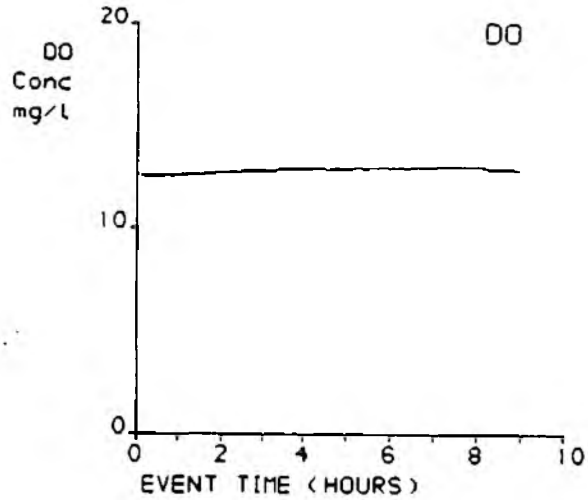

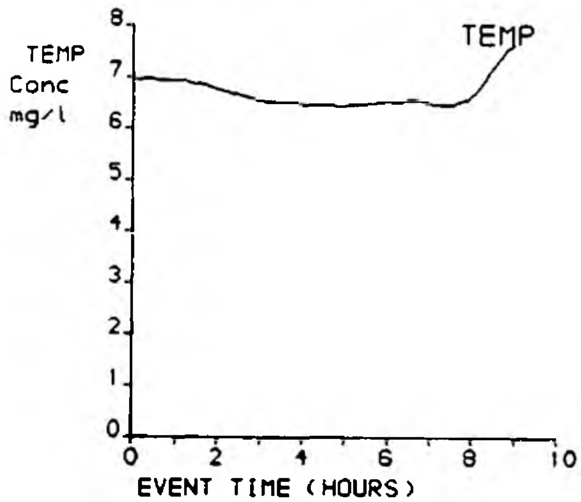

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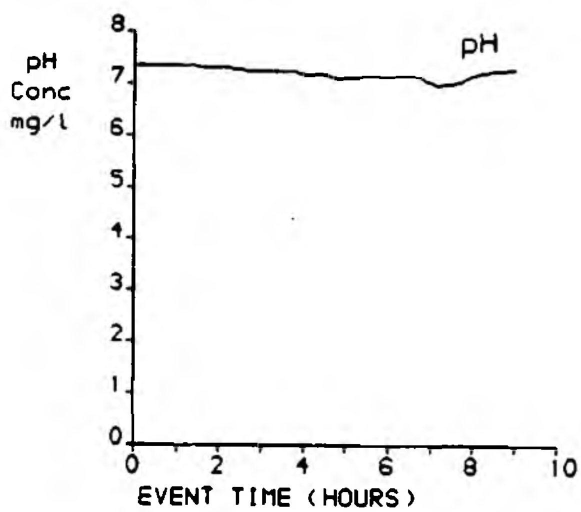

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GN89121601.DAT

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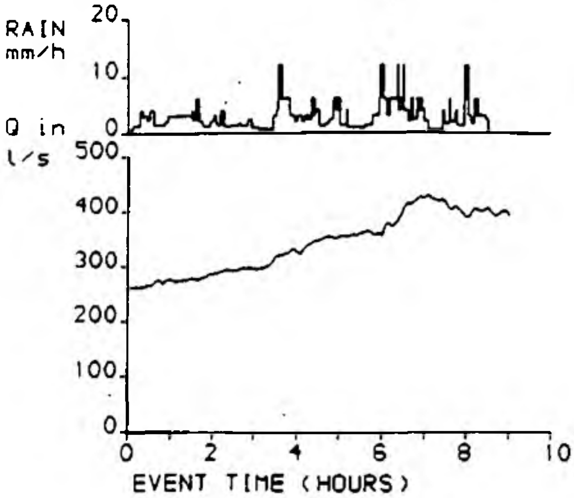

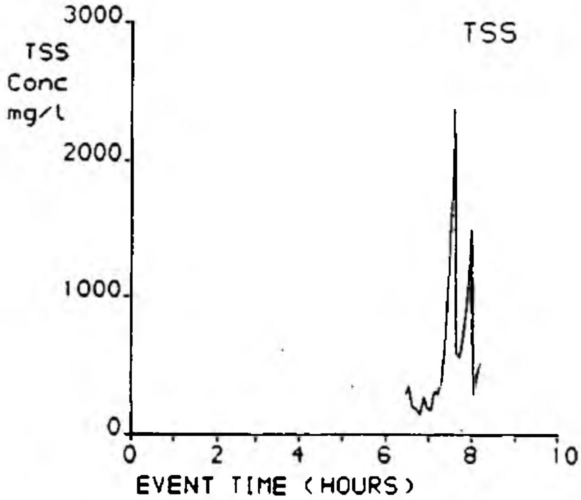

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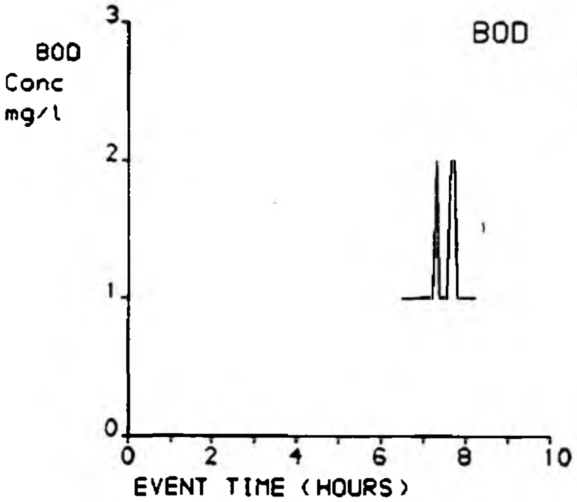

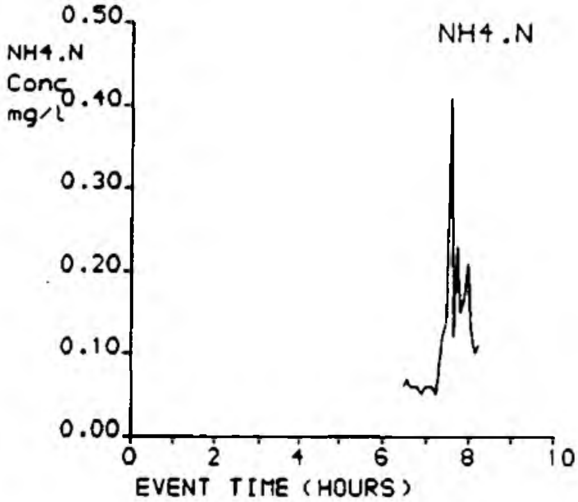

Site: NANT FFRWD, UNDER VIADUCT

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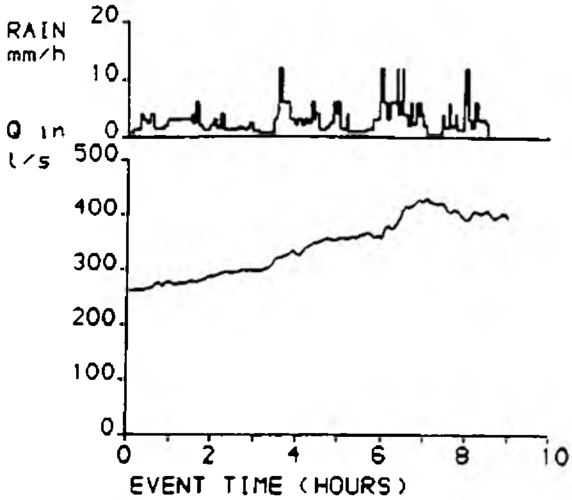
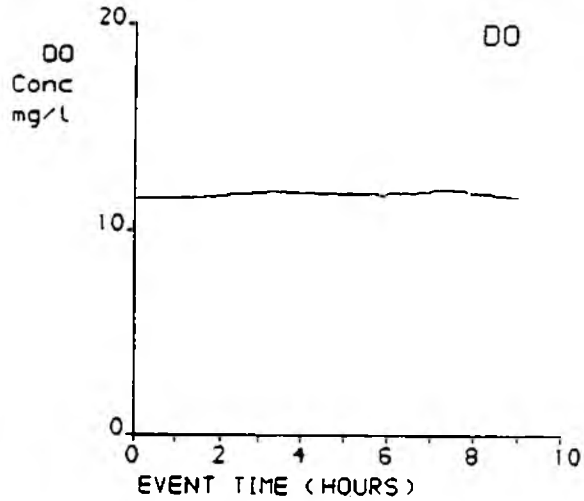
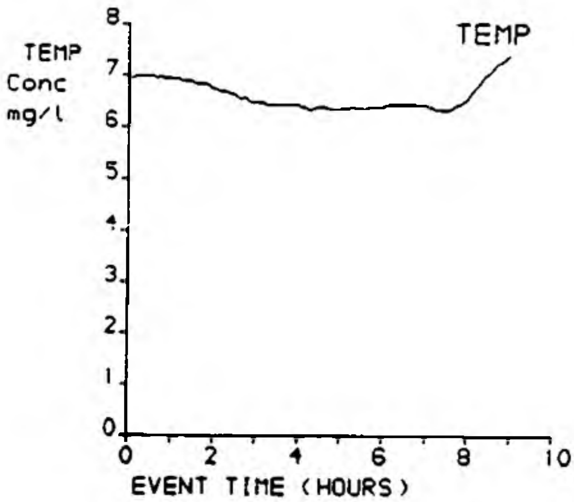
Rainfall Event Duration (mins): 504.







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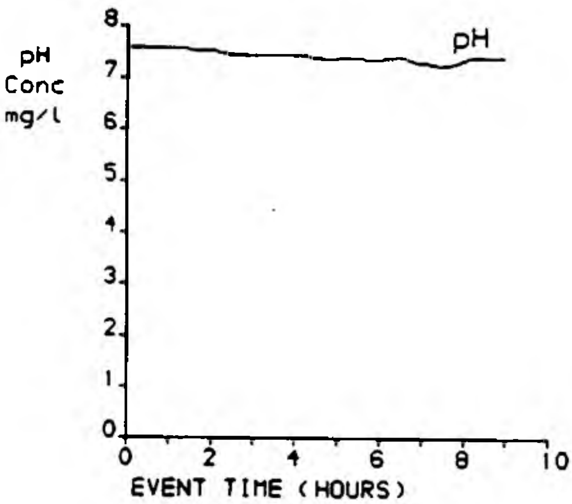

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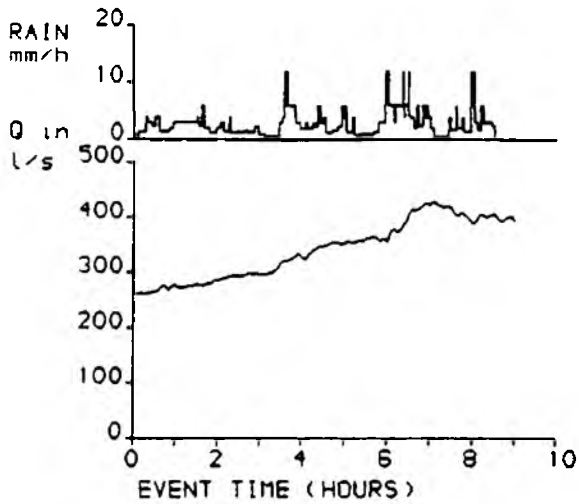
Rainfall Event Duration (mins): 504.



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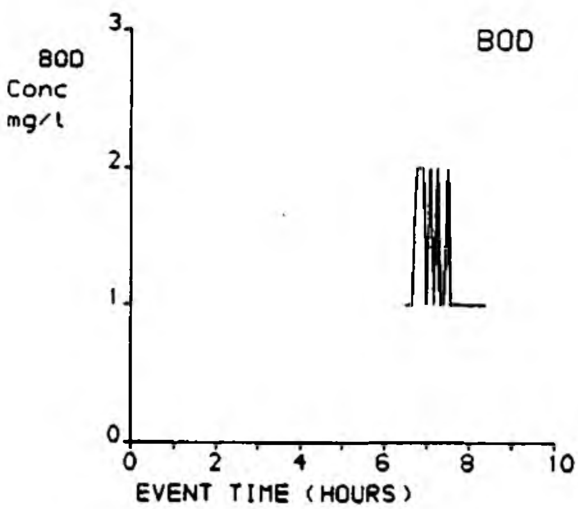

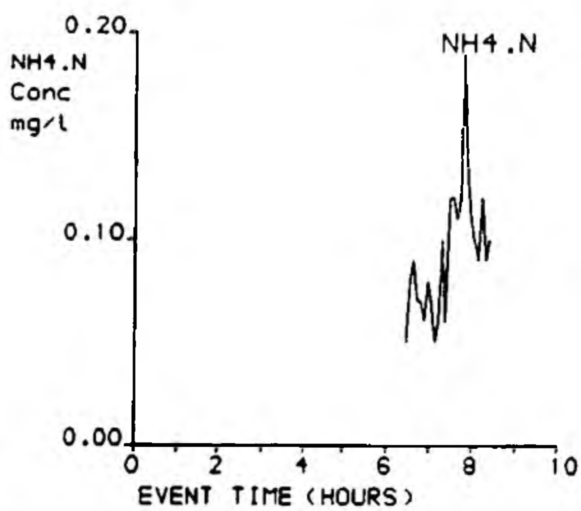

Site: NANT FFRWD,U/S VICTORIA RD BRIDGE GN8912I6D2.DAT

Grid Ref: 264042 Weather Conditions:
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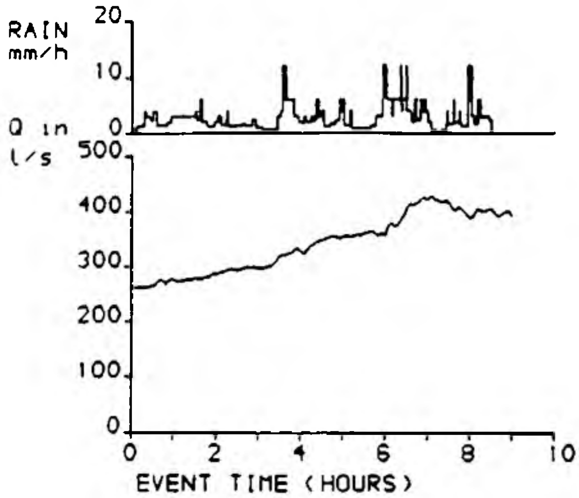

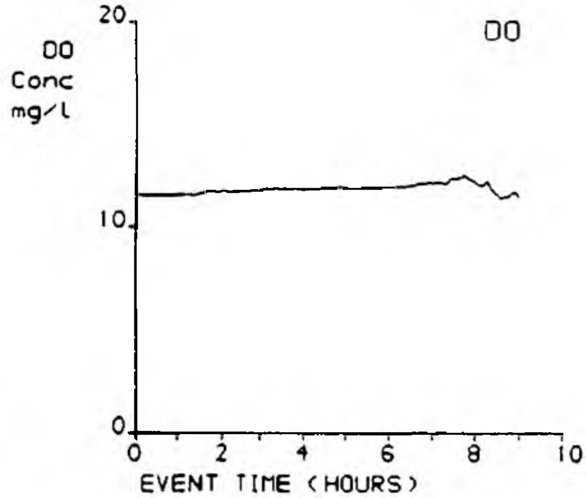

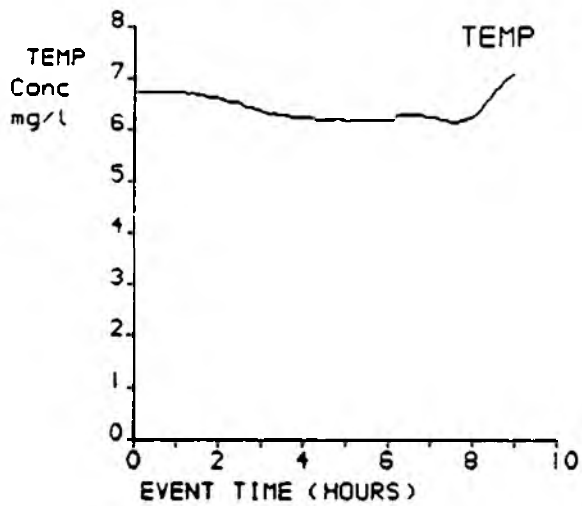

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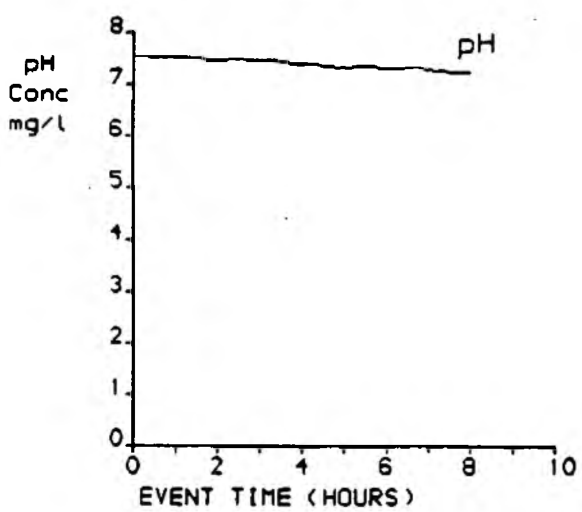

APPENDIX 3

APPENDIX 3

The Biological Monitoring Working Party (B.M.W.P.) scoring system can be used as a broad assessment of the quality of a river. The organisms present are identified to family level but no measure of abundance is made. Each family group present is given a score (see table overleaf); sensitive familities are placed higher in the table whilst species less affected by pollution are placed lower in the table and scores for each family are summed and the greater the number of families present at a site (particularly pollution sensitive ones) the higher the total score. Five quality classes ranging from very poor to very good have developed from this system.

B.M.W.P. CLASS	B.M.W.P. SCORE RANGE
1. VERY GOOD	>150
2. GOOD	100 - 149
3. MODERATE	50 - 99
4. POOR	25 - 49
5. VERY POOR	<25

APPENDIX 3

BMWP SCORE SYSTEM

Family	Common Group Name	BMWP Score
Siphlonuridaie, Heptageniidae, Potamanthidae, Ephemerellidae, Ephemeridae, Leptophlebiidae	Mayflies	
Taeniopterygidae, Leuctridae, Capniidae, Perlidae, Perlodidae, Chloroperlidae	Stoneflies	10
Aphelocheiridae	Water Bugs	
Beraeidae, Odontoceridae, Leptoceridae, Goeridae, Leptostomatidae, Brachycentidae, Sericostomatidae, Phryganeidae, Molannidae	Caddis Flies	
Agriidae, Cordulegasteridae Lestidae, Gomphidae, Aeshnidae, Corduliidae, Libellulidae	Dragonflies	
Astacidae	Crayfish	8
Psychomyiidae, Philopotamidae	Caddis Flies	
Caenidae	Mayflies	
Nemouridae	Stoneflies	7
Rhyacophilidae, Polycentropodidae, Limnephilidae	Caddis Flies	
Ancylidae, Neritidae, Viviparidae, Unionidae	Molluscs	
Hydroptilidae	Caddis Flies	6
Platycnemididae, Coenagriidae	Dragonflies	
Gammaridae, Corophiidae	Crustacea	
Mesovelidae, Veliidae, Gerridae, Pleidae Hydrometridae, Nepidae, Naucoridae, Notonectidae, Corixidae	Water Bugs	
Halliplidae, Dytiscidae, Gyrinidae, Helodidae Hygrobiidae, Chrysomelidae, Clambidae, Hydrophilidae, Elminthidae, Curculionidae, Dryopidae	Beetles	5
Hydropsychidae	Caddis Flies	
Tipulidae, Simuliidae	Fly Larva	
Planariidae, Dentrocoelidae	Flat Worms	
Baetidae	Mayflies	
Piscicolidae	Leeches	4
Sialidae	-	

Family	Common Group Name	BMWP Score
Hydrobiidae, Lymnaeidae, Sphaeriidae, Valvatidae, Physidae, Planorbidae	Molluscs	
Glossiphoniidae, Hirudidae, Erpobdellidae	Leeches	3
Asellidae	Crustacea	
Chironomidae	Midge Larva	2
Oligochaeta (whole class)	Worms	1

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MONITORING EFFECTS OF A STORM SEWER OVERFLOW UPON THE NANT FFRWD, SOUTH WALES

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INTRODUCTION

The pollution of watercourses by storm sewage overflows has long been identified as a significant problem (MHLG 1970; SDD 1977). However, at present the mechanisms and processes by which storm sewage overflows impact upon water-courses are still not clearly understood. Furthermore, it has been generally recognised within the Water Industry that if future capital investment in sewerage systems and sewerage rehabilitation is to be both efficient and effective, this understanding needs to be extended. To this end, the Welsh Water Authority (WWA) and Water Research Centre (WRC) have established a detailed investigation into the effects of intermittent discharges from a storm sewage overflow (SSO) on a small river course in South Wales. The study forms part of the larger Water Industry River Basin Management Research Programme described elsewhere (Cliffords et al. 1986), and is designed to identify the conditions under which overflow occurs and the consequent effect upon the Nant Ffrwd, 1.2 km downstream to its confluence. The results are also to be used in the future development of sewer quality and river impact models designed to aid management decisions about the acceptability of such intermittent discharges.

THE STUDY

The Garndiffaith combined sewer overflow, described in Table 1, forms the only significant point-source effluent discharge into the Nant Ffrwd.

TABLE 1 Sewered catchment and chamber characteristics of the Garndiffaith SSO

Catchment Details		Chamber Details	
Population	3000	High sided weir	
Total Area	26.4 ha	Peak Inflow	250 l s^{-1}
Impermeable Area	9.2 ha	Carry on flow	60 l s^{-1}
Domestic only		Peak Overflow	190 l s^{-1}
		Dimensions	7x2.7x1.5 m
		Inlet	530 mm
		Outlet	230 mm

The system under investigation responds rapidly to rainfall, normally within 30 minutes, so that increases in river flow in response to the same rainfall input often lag significantly behind the SSO response (Figure 1).

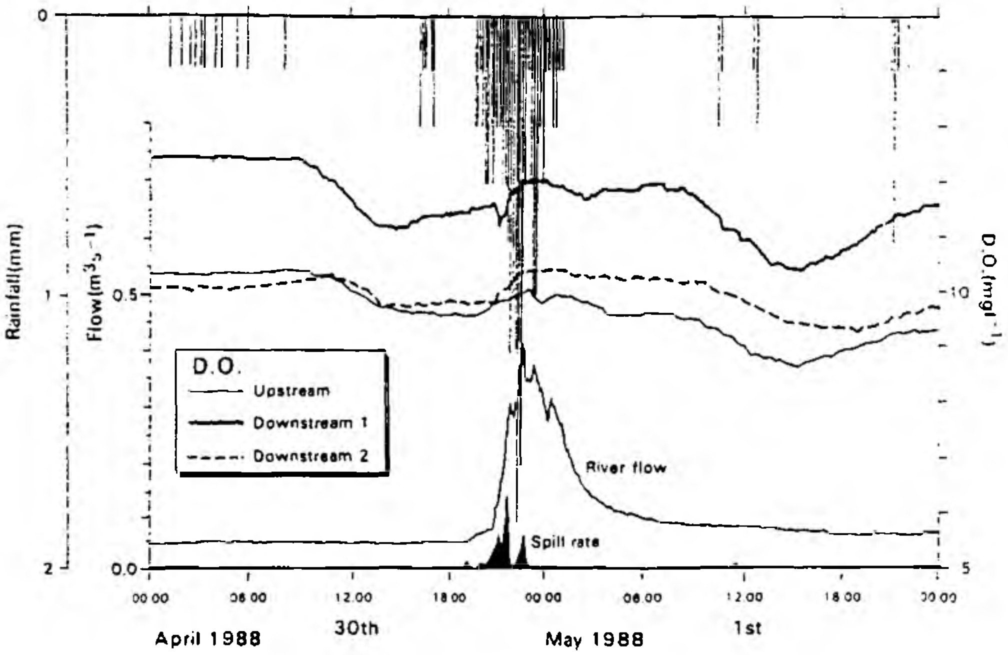

Fig. 1. Typical SSO response timing and D.O. impact

Sampling and Monitoring

At the commencement of a storm event, the rising water level in the overflow chamber activates an Authority designed pressure switch system, which is linked by a programmable controller, to a series of relays. The controller activates sampling at the overflow site, whilst simultaneously triggering via a radio link, samplers located at the upstream and three downstream river sites. Within-chamber quality sensors continuously record pH, temperature, ammonia and dissolved oxygen levels. The river monitoring sites are located: 50m upstream of the SSO, 80m downstream of the SSO, 500m downstream of the SSO and 1.2km downstream at its confluence with the Afon Llwyd. Quality sensors are located at each site. Continuous river flow and rainfall intensity data are gathered in order to provide a comprehensive picture of the consequences of each storm event of interest.

Monitoring work is also being undertaken to examine the impacts on stream biology. This includes the application of novel in-situ macroinvertebrate survival tests involving the exposure of known numbers and species. Fish-egg bioassay tests and fish survival and growth characteristics are also being undertaken.

RESULTS

Early results indicate a range of peak SSO pollutant concentrations of between 20 mg l^{-1} and 200mg l^{-1} BOD_5 depending on whether the spill occurs in the early hours of the morning, or at times of peak dry weather flow strength and/or volume. Correspondingly, ammoniacal nitrogen concentrations vary between 1.0 and 10.0mg l^{-1}. Even during relatively insignificant spills occurring in the early hours, first foul flush concentrations have accorded with observations elsewhere (Pearson et al. 1986). However, these only persist for periods of 10 minutes or less, typical spill durations being of the order of no more than 2 hours in total.

In-stream ammoniacal nitrogen concentrations are increased during every spill (Figure 2), with even minor events causing river concentrations to rise to 0.7mg l^{-1} or more in the first foul flush (insignificant levels being recorded above the SSO). BOD impacts vary more widely with events causing BOD peaks of up to 20mg l^{-1} (Figure 2), as opposed to levels of around 5.0mg l^{-1} or less recorded consistently above the SSO. Clearly other factors such as the antecedent weather conditions, the spill duration, magnitude and timing, all significantly affect the level of impact monitored.

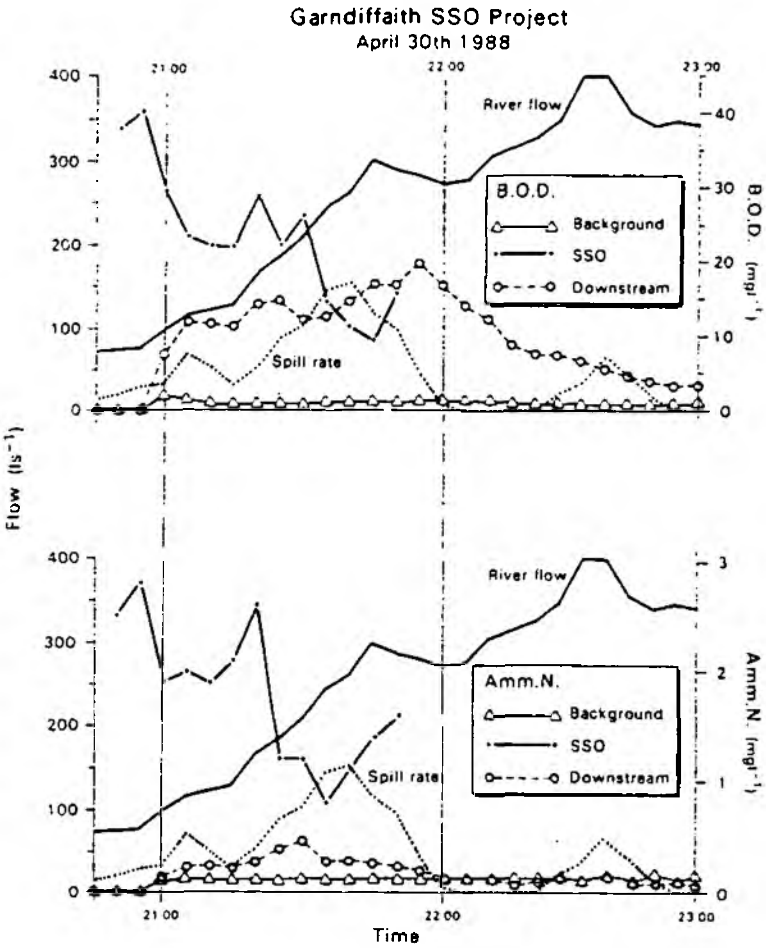

Fig. 2. Typical SSO spill impacts

Interestingly, typical impacts upon river dissolved oxygen levels are minimal and confined to the stretch immediately downstream of the overflow (Figure 1), probably due to the high reaeration and dispersion characteristics of the Nant Ffrwd.

Early survival experiments (July/August 1987) using caged macroinvertebrates, **Gammarus pulex** (freshwater shrimp) and **Ephemera danica** (mayfly), at the four river sites indicated significant mortalities at all downstream sites (of up to 40%), (Figure 3). In all, the indicator species have been studied over three periods to date and **Ephemera** was found to be the more sensitive species in all cases.

Fisheries investigations to date have included the monitoring of stocked swim-up Danish rainbow trout fry. Survival and growth rates are being determined by repetitive surveys. Fish stocked in April 1987 revealed higher trout densities **downstream** of the SSO during subsequent surveys. A repeat survey conducted in April 1988 revealed far higher densities (34/100 m^2) immediately above the SSO, compared with below (16/100 m^2). However, there was some suggestion of human interference, although by that time the stocked fish had also been exposed to more than 40 spill events since April 1987. Further stocking in July 1988 again revealed higher densities above than below the SSO, although both sites exhibited excellent populations. Native brown trout density surveys however, indicated poor populations both above and below.

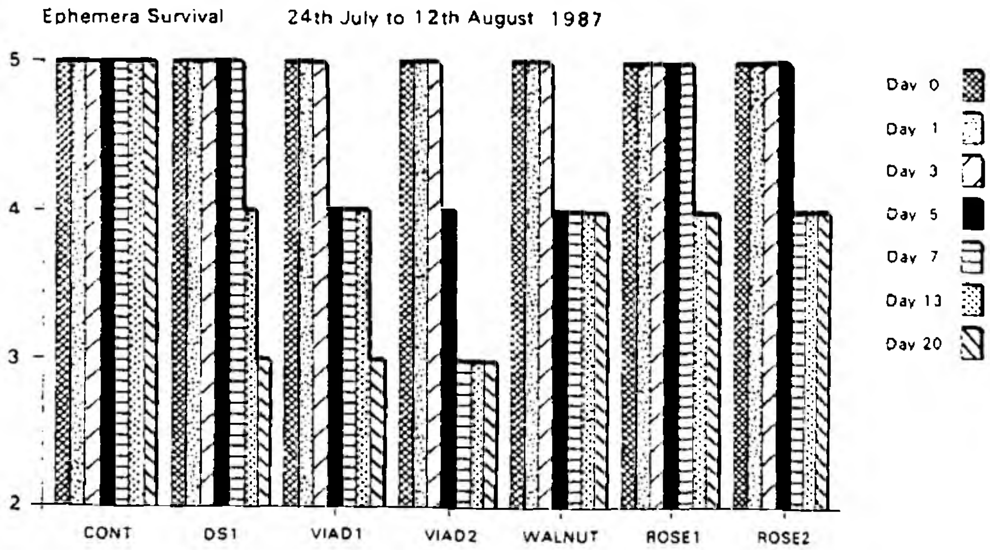

Fig. 3. Some Ephemera survival experiment results

Finally, rainbow trout egg bioassay experiments undertaken in July 1988 revealed no obvious impact specific to the overflow, cumulative mortalities averaging only 25% near the overflow and 46% further downstream. Hence, the impacts of such an SSO spill regime on the resident population remain inconclusive at present.

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